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(54) **CAMERA MODULE FOR A VEHICLE**

KAMERAMODUL FÜR EIN FAHRZEUG

MODULE DE CAMÉRA POUR UN VÉHICULE

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a camera module for a vehicle.

DESCRIPTION OF THE BACKGROUND ART

[0002] International patent application WO 2019/164724 A1 discloses a camera module assembly. An outer housing for the camera module includes a front shell with a window and a rear shell. The camera core includes a lens assembly, a sensor assembly, and a sensor housing. The sensor assembly is disposed within the sensor housing, and the sensor housing is fixed to the lens assembly.

[0003] International patent application WO 2018/219951 A1 relates to a camera module for a motor vehicle. The camera module is used for driver monitoring in the passenger compartment. The camera module has at least one printed circuit board and a shield for enclosing said printed circuit board. The shield comprises at least a first shielding part and a second shielding part.

[0004] U.S. patent application US 2019/208091 A1 discloses a camera module for a vehicular vision system. The camera module includes a metal front housing, a lens holder and a metal rear housing. The front housing houses a printed circuit board having an imager disposed thereat. The lens holder is attached at a front portion of the housing so that a lens assembly is optically aligned with the imager. U.S. patent application US 2017/0187931 A1 discloses a vehicle-mounted camera, which includes a camera main assembly with a lens assembly, an image sensor located behind the lens assembly, and a camera circuit board located behind the image sensor.

U.S. patent application US 2018/0054553 A1 discloses an electronic device is provided which includes an upper cover unit including at least one first camera that faces a first direction. Additionally, a plurality of second camera pairs are disposed to face a second direction.

[0005] U.S. patent application US 2018/222402 A1 discloses a camera housing portion which has an imaging sensor at a base portion of the camera housing portion. A lens system is at a first portion of the camera housing portion. A first circuit board is provided that includes circuitry associated with the imaging sensor, which is disposed at a second circuit board that is in board-to-board electrical connection with the first circuit board. The camera housing portion and a connector portion are joined together to encase the first and second circuit boards.

[0006] In general, vision cameras are more and more present in vehicles. They are used for scanning the environment of the vehicle and also the driver and passengers, sending the data to an ECU (electronic control unit) that is processing the data and sending out warnings to the driver or acting on the vehicle brakes. The most ad-

vance vision cameras use two cameras working in stereo configuration to output also the distance. An algorithm is used and the ECU receives the distance to the object.

[0007] The algorithm works well if the cameras are aligned. However, reading errors occur when the cameras lose alignment. At present, the camera is mounted directly in the camera housing, and then the printed circuit board is mounted and connected to the camera. This means that a very tight tolerance is required for the camera housing where the camera is mounted. This generates high costs for the production of the housing. A thermal deformation of the housing, made from aluminium, is caused by thermal changes. The thermal deformation translates in a deviation of the visual axis, which leads to errors in reading. Furthermore, the mounting process of the camera to the housing takes a lot of time.

[0008] At present, vision systems use a vee-groove design, which is integrated in the housing, and three spheres in the camera module, which generate problems in mounting and in use, especially at thermal changes. For driver monitoring systems, a camera is used, which has a lens integrated in the housing and an image sensor which is installed on the printed circuit board, which generate assembly problems.

SUMMARY OF THE INVENTION

[0009] It is an object of the present invention to provide a camera module for a vehicle, the camera module having at least one camera, wherein the alignment of the at least one camera is not affected by temperature changes and the camera module is easy to manufacture and inexpensive.

[0010] The above object is achieved by a camera module for a vehicle which comprises the features of claim 1.

[0011] According to the invention set-out in claim 1, the camera module for a vehicle comprises a printed circuit board. The printed circuit board carries a carrier for at least one camera, wherein the carrier is mounted directly to the printed circuit board. Electronic components and a connector are mounted as well to the printed circuit board. In an embodiment of the invention, the carrier for the at least one camera carries at least one illumination device. For example, the at least one illumination device comprises at least one IR (infra red) light emitting diode.

[0012] The advantage of the present invention is that with the carrier for the at least one camera, the camera module and therefore the alignment of each camera is not affected by temperature changes.

[0013] According to the invention set-out in claim 1, the carrier has a mounting structure for the at least one camera. The mounting structure comprises a pair of rails and at least a pair of flexible wings. The camera has a chip housing, which cooperates with the rails of the carrier in a form fitting manner. A lens body of the camera cooperates with the flexible wings of the carrier in a form and force fitting manner.

[0014] The advantage is that each camera can be

mounted to the carrier in a simple manner and the mounted camera is aligned as well in a simple manner, which saves time and money for the assembly.

[0015] The carrier may as well have a mounting structure for the at least one illumination device. For example, the mounting structure for the at least one illumination device comprises a flat abutting surface with a surrounding rim. The illumination device is held by a snap fit to the mounting structure.

[0016] In an embodiment, a housing is used, which surrounds the camera module with all the mounted components. The camera module is mounted in the housing with by the printed circuit board. In an embodiment, the housing comprises a housing base and a housing cover, both of which are joined together and form the housing. In an embodiment, the joined housing base and housing cover define a cutout for the at least one camera, a cutout for the at least one illumination device and a cutout for the connector. After mounting the printed circuit board in the housing, the at least one camera, the at least one illumination device and the connector of the camera module are aligned with the respective cutouts.

[0017] The camera module with the carrier of the at least one camera and the at least one illumination device (for example, IR light emitting diode), the connector and the electronic components are arranged on the printed circuit board. The printed circuit board fits for mounting to the vehicle in the exterior housing of the vehicle.

[0018] According to a preferred embodiment, the printed circuit board and the housing of the camera module have positioning features to center and guide both of which into one another. The housing, for example the housing base, may have screw holes for fixing the printed circuit board directly to the housing, i.e. the housing base in this example. In an embodiment, the housing, i.e. the joined housing base and housing cover, has a cutout feature for the at least one camera, a cutout for the illumination device (for example, at least one IR-LED) and a cutout for the connector. According to a further embodiment, the housing may have only one big cutout for the carrier on which the at least one camera and the at least one illumination device (for example, at least one IR-LED) are mounted.

[0019] According to a preferred embodiment, the housing is made from an EMI (electromagnetic interference) shielding material or has a coating of an EMI shielding material. The housing may have cooling towers for the electronic components, which produce a lot of heat. Additionally, the housing may have cooling fins on its surface. A thermal paste can be used as a contact bridge between the electronic components that need to be cooled and the thermal towers. The housing may have a fan mounted on its surface; in this case, a cutout for the fan connector is preferably provided in the housing. In an embodiment, the housing is fixed to the ECU through a vehicle interface by mounting bolts. The mounting of the housing is not limited to holes for mounting bolts. The housing may have also special holes or pins

for guiding to the vehicle interface. The housing may have special clipping features for mounting it to the vehicle interface.

[0020] According to a further embodiment, the at least one camera and the at least one illumination device (for example, at least one IR-LED) have, for protection reason, an exterior cover, which also covers the assembly of the housing and the printed circuit board. The printed circuit board itself carries the carrier, the connector, the electronic components, the at least one camera and the at least one illumination device (IR-LEDs). If additional cooling is needed, a thermal pad can be used between the printed circuit board and the housing cover. The housing cover can be mounted and fixed to the housing base by using screws, but also clipping features or other suitable fixation means may be used. Additionally, a glue/silicone can be dispensed on the housing cover or housing base before mounting them together.

[0021] According to an embodiment of the invention, the carrier for at least one camera with at least one IR-LED is an integrated part of an active safety protection system. In an embodiment, the carrier for at least one camera with at least one IR-LED is mounted on a vehicle. In an embodiment, the carrier for at least one camera with at least one IR-LED is assembled directly to a printed circuit board. In an embodiment, the carrier for at least one camera with at least one IR-LED can carry one or more cameras. In an embodiment, the carrier for at least one camera with at least one IR-LED can carry one or more IR-LEDs. In an embodiment, the carrier for at least one camera with at least one IR-LED has traces within the carrier through which traces an electrical connection between the at least one camera and the printed circuit board and between the at least one illumination device and the printed circuit board is provided. In an embodiment, the carrier for at least one camera with at least one IR-LED has a connection interface to the camera. In an embodiment, the carrier for at least one camera with at least one IR-LED has a connection interface to the at least one IR-LED. In an embodiment, the carrier for at least one camera with at least one IR-LED has a connection interface to the printed circuit board. In an embodiment, the carrier for at least one camera with at least one IR-LED is mounted in the assembly with the printed circuit board, the camera, the at least one IR-LED, the electronic components and the connector. In an embodiment, the carrier for at least one camera with at least one IR-LED is able to communicate with other safety ECUs in the vehicle. In an embodiment, the carrier for at least one camera with at least one IR-LED is able to send signals to another ECU in the vehicle. In an embodiment, the carrier for at least one camera with at least one IR-LED has a housing base and a housing cover.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The numerous advantages of the disclosure may be better understood by those skilled in the art by

reference to the accompanying figures in which:

Figure 1 is a plan view of a motor vehicle having at least one forward looking camera module according to an embodiment of the invention.

Figure 2 is schematic representation of the placement of a camera module according to another embodiment of the invention looking at the driver of the motor vehicle.

Figure 3 is a schematic view of an electronic control unit which can be applied to at least one camera of the camera module according to an embodiment of the invention.

Figure 4 is a perspective view of a carrier used for mounting the at least one camera according to an embodiment of the invention.

Figure 5 is a perspective view of components of a camera module according to an embodiment of the invention mounted on a printed circuit board.

Figure 6 is a perspective and exploded view of the camera module and the housing, which encloses the camera module shown in Figure 4 and 5.

DETAILED DESCRIPTION

[0023] Same reference numerals refer to same elements or elements of similar function throughout the various figures. Furthermore, only reference numerals necessary for the description of the respective figure are shown in the figures. The shown embodiments represent only examples of how the invention can be carried out. This should not be construed as a limitation of the invention.

[0024] **Figure 1** shows a plan view of a motor vehicle **2**. A camera module **1** according to an embodiment of the invention is mounted at a windshield **3** of the vehicle **2**, so that the camera (see Figure 3) of the camera module **1** is looking into the direction **D** of driving.

[0025] **Figure 2** shows an arrangement of a camera module **1** according to another embodiment of the invention. A lens **4** of the camera module **1** is looking at a driver **5** of the vehicle **2**.

[0026] **Figure 3** shows a schematic view of an electronic control unit **12** which can be applied to at least one camera **14₁, 14₂, ..., 14_N** of the camera module **1** according to an embodiment of the invention. Electronic control unit **12** can be applied to a camera module **1**, wherein the camera module **1** comprises at least one external view camera **14₁, 14₂, ..., 14_N** (see Figure 1) or at least one driver **5** (see Figure 2) viewing camera **14₁, 14₂, ..., 14_N**. The camera module **1** is composed of the printed circuit board **11** on which a carrier **10**, a connector **19** and electronic components **18** are mounted. In the context of the present invention, a micro controller unit (not shown) is as well a part of the electronic components **18**. In an embodiment, the carrier **10** has traces (not shown) through which an electrical connection between the at least one camera **14₁, 14₂, ..., 14_N** and the printed

circuit board **11** and between the at least one illumination device **16₁, 16₂, ..., 16_M** and the printed circuit board **11** is provided. The carrier **10** is designed for mounting the at least one camera **14₁, 14₂, ..., 14_N** which are as well fixed in position by the carrier **10**. In the case that the camera module **1** is used to monitor the driver, the carrier **10** also has space for at least one illumination device **16₁, 16₂, ..., 16_M**. The at least one illumination device **16₁, 16₂, ..., 16_M** can be configured as an IR (infrared) light emitting diode (IR-LED).

[0027] The electronic connection **13** between the at least one camera **14₁, 14₂, ..., 14_N** and the carrier **10** can be made by means of the surface mount technology (SMT) but it is not limited thereto. The electronic connection **13** between the carrier **10** and the printed circuit board **11** can also be made through SMT, but it is not limited thereto. In an embodiment, the printed circuit board **11** has guiding features (not shown) and holes (not shown) both of which facilitate the mounting of the printed circuit board **11**. For protection reason, the camera module **1** is enclosed within a housing base **8₂** and a housing cover **8₁** both of which form a housing **7** when joined.

[0028] **Figure 4** is a perspective view of a carrier **10** used for mounting the at least one camera **14₁, 14₂, ..., 14_N**, according to an embodiment of the invention. The carrier **10**, can be made from, but is not limited to, plastic, composite materials, casting alloys or sheet metal. The carrier **10** shown here is configured for mounting and fixing at least one camera **14₁, 14₂, ..., 14_N** and at least one illumination device **16₁, 16₂, ..., 16_M**. According to the embodiment shown here, a mounting structure **20** for the at least one camera **14₁, 14₂, ..., 14_N** comprises a pair of rails **21** and at least a pair of flexible wings **22**. A mounting structure **25** of the carrier **10** for the at least one illumination device **16₁, 16₂, ..., 16_M** comprises a flat abutting surface **26** with a surrounding rim **27**.

[0029] **Figure 5** is a perspective view of components of the camera module **1** according to an embodiment of the invention, mounted on a printed circuit board **11**. The carrier **10**, the connector **19** and the electronic components **18** are mounted on the printed circuit board **11**. The carrier **10** mounts and fixes the at least one camera **14₁, 14₂, ..., 14_N** and at least one illumination device **16₁, 16₂, ..., 16_M**. In the embodiment shown, the at least one camera **14₁, 14₂, ..., 14_N** has a chip housing **17** and a lens body **15**. The chip housing **17** cooperates with the rails **21** of the carrier **10** in a form fitting manner. The lens body **15** cooperates with the flexible wings **22** of the carrier **10** in a form and force fitting manner. The at least one illumination device **16₁, 16₂, ..., 16_M** is held in the mounting structure **25** by a snap fit of the rim **27** in the carrier **10**. The illumination device **16₁, 16₂, ..., 16_M** comprises at least one light emitting diode **30** which is configured to emit IR light. The camera module **1** fully works when it has above mentioned components assembled and the electronic components **18**, for example the microcontroller (MCU), has the required firmware flashed.

[0030] **Figure 6** is a perspective and exploded view of

the camera module **1** and the housing **7**, which encloses the camera module **1** as shown in Figure 4 and 5. The carrier **10** with the at least one camera **14** (see Figure 5) and the at least one illumination device **16** (see Figure 5) is enclosed in a housing **7** for protection reason. The housing **7** comprises a housing base **8₂** and a housing cover **8₁**. According to the embodiment shown here, the housing base **8₂** and the housing cover **8₁** are joined together to form the housing **7** with a cutout **31** for the at least one camera **14** and a cutout **32** for the at least one illumination device **16**. Additionally, the housing base **8₂** and the housing cover **8₁** have a cutout **33** for the connector **19**.

[0031] It is believed that the present disclosure and many of its attendant advantages will be understood by the foregoing description, and it will be apparent that various changes may be made in the form, construction and arrangement of the components without departing from the disclosed subject matter or without sacrificing all of its material advantages. The form described is merely explanatory. Accordingly, the scope of the invention should be limited only by the claims appended hereto.

LIST OF REFERENCE NUMERALS

[0032]

1	Camera module
2	Vehicle
3	Windshield
4	Lens
5	Driver
7	Housing
8 ₁	Housing cover
8 ₂	Housing base
10	Carrier
11	Printed circuit board
12	Electronic control unit
13	Electronic connection
14 ₁ , 14 ₂ ,..., 14 _N	Camera
15	Lens body
16 ₁ , 16 ₂ ,..., 16 _M	Illumination device
17	Chip housing
18	Electronic component
19	Connector
20	Mounting structure
21	Rail
22	Wing
25	Mounting structure
26	Abutting surface
27	Rim
30	Light emitting diode
31	Cutout
32	Cutout
33	Cutout
D	Direction of driving

Claims

1. A camera module (1) for a vehicle (2), comprising
 - at least one camera (14, 14₁, 14₂,..., 14_N),
 - a printed circuit board (11),
 - a carrier (10) for the at least one camera (14, 14₁, 14₂,..., 14_N) mounted directly to the printed circuit board (11), electronic components (18) and a connector (19) mounted to the printed circuit board (11);
 - characterized by**
 - a mounting structure (20) of the carrier (10) for the at least one camera (14, 14₁, 14₂,..., 14_N) comprises a pair of rails (21) and at least a pair of flexible wings (22);
 - a chip housing (17) of the camera (14, 14₁, 14₂,..., 14_N) cooperates with the rails (21) of the mounting structure (20) in a form fitting manner; and
 - a lens body (15) of the camera (14, 14₁, 14₂,..., 14_N) cooperates with the flexible wings (22) of the mounting structure (20) in a form and force fitting manner.
2. The camera module (1) as claimed in claim 1, comprising at least one illumination device (16, 16₁, 16₂,..., 16_M) carried by the carrier (10) for the at least one camera (14, 14₁, 14₂,..., 14_N).
3. The camera module (1) as claimed in claim 2, wherein the at least one illumination device (16, 16₁, 16₂,..., 16_M) comprises at least one IR-light emitting diode (30).
4. The camera module (1) as claimed in any of claims 1 to 3, wherein the carrier (10) has a mounting structure (25) for the at least one illumination device (16, 16₁, 16₂,..., 16_M).
5. The camera module (1) as claimed in claim 4, wherein the mounting structure (25) for the at least one illumination device (16, 16₁, 16₂,..., 16_M) comprises a flat abutting surface (26) with a surrounding rim (27) and the illumination device (16, 16₁, 16₂,..., 16_M) is held by a snap fit to the mounting structure (25).
6. The camera module (1) according any of the preceding claims, comprising a housing (7) which surrounds the camera module (1).
7. The camera module (1) according claim 6, wherein the housing (7) comprises a housing base (8₂) and a housing cover (8₁), both of which are joined together and form the housing (7).
8. The camera module (1) according claim 7, wherein the joined housing base (8₂) and the housing cover

(8₁) have a cutout (31) for the at least one camera (14, 14₁, 14₂,...,14_N), a cutout (32) for the at least one illumination device (16, 16₁, 16₂,...,16_M) and a cutout (33) for the connector (19), wherein the at least one camera (14, 14₁, 14₂,...,14_N), the at least one illumination device (16, 16₁, 16₂,...,16_M) and the connector (19) of the camera module (1) are aligned with the respective cutouts (31, 32, 33).

Patentansprüche

1. Kameramodul (1) für ein Fahrzeug (2), umfassend:

mindestens eine Kamera (14, 14₁, 14₂,..., 14_N), eine Leiterplatte (11), einen Träger (10) für die mindestens eine Kamera (14, 14₁, 14₂,..., 14_N), der direkt an der Leiterplatte (11) montiert ist, elektronische Komponenten (18) und einen Verbinder (19), der an der Leiterplatte (11) montiert ist;

gekennzeichnet durch

eine Montagestruktur (20) des Trägers (10) für die mindestens eine Kamera (14, 14₁, 14₂,..., 14_N), die ein Paar Schienen (21) und mindestens ein Paar flexible Flügel (22) umfasst;

ein Chipgehäuse (17) der Kamera (14, 14₁, 14₂,..., 14_N), das mit den Schienen (21) der Montagestruktur (20) formschlüssig zusammenwirkt; und

ein Linsenkörper (15) der Kamera (14, 14₁, 14₂,..., 14_N), der mit den flexiblen Flügeln (22) der Montagestruktur (20) form- und kraftschlüssig zusammenwirkt.

2. Kameramodul (1) nach Anspruch 1, umfassend mindestens eine Beleuchtungsvorrichtung (16, 16₁, 16₂,..., 16_M), die von dem Träger (10) für die mindestens eine Kamera (14, 14₁, 14₂,..., 14_N) getragen wird.

3. Kameramodul (1) nach Anspruch 2, wobei die mindestens eine Beleuchtungsvorrichtung (16, 16₁, 16₂,..., 16_M) mindestens eine IRlichtemittierende Diode (30) umfasst.

4. Kameramodul (1) nach einem der Ansprüche 1 bis 3, wobei der Träger (10) eine Montagestruktur (25) für die mindestens eine Beleuchtungsvorrichtung (16, 16₁, 16₂,..., 16_M) aufweist.

5. Kameramodul (1) nach Anspruch 4, wobei die Montagestruktur (25) für die mindestens eine Beleuchtungsvorrichtung (16, 16₁, 16₂,..., 16_M) eine flache angrenzende Fläche (26) mit einem umlaufenden Rand (27) umfasst und die Beleuchtungsvorrichtung (16, 16₁, 16₂,..., 16_M) durch einen Schnappverschluss an der Montagestruktur (25) gehalten wird.

6. Kameramodul (1) nach einem der vorhergehenden Ansprüche, umfassend ein Gehäuse (7), das das Kameramodul (1) umgibt.

7. Kameramodul (1) nach Anspruch 6, wobei das Gehäuse (7) eine Gehäusebasis (8₂) und eine Gehäuseabdeckung (8₁) umfasst, die beide miteinander verbunden sind und das Gehäuse (7) bilden.

8. Kameramodul (1) nach Anspruch 7, wobei die mit der Gehäusebasis (8₂) verbundene Gehäuseabdeckung (8₁) einen Ausschnitt (31) für die mindestens eine Kamera (14, 14₁, 14₂,..., 14_N), einen Ausschnitt (32) für die mindestens eine Beleuchtungsvorrichtung (16, 16₁, 16₂,..., 16_M) und einen Ausschnitt (33) für den Verbinder (19) aufweisen, wobei die mindestens eine Kamera (14, 14₁, 14₂,..., 14_N), die mindestens eine Beleuchtungsvorrichtung (16, 16₁, 16₂,..., 16_M) und der Verbinder (19) des Kameramoduls (1) an den jeweiligen Ausschnitten (31, 32, 33) ausgerichtet sind.

Revendications

1. Module de caméra (1) pour un véhicule (2), comprenant :

au moins une caméra (14, 14₁, 14₂, ..., 14_N),

une carte de circuit imprimé (11),

un support (10) pour l'au moins une caméra (14, 14₁, 14₂, ..., 14_N) monté directement sur la carte de circuit imprimé (11), des composants électroniques (18) et un connecteur (19) montés sur la carte de circuit imprimé (11) ;

caractérisé par

une structure de montage (20) du support (10) pour l'au moins une caméra (14, 14₁, 14₂, ..., 14_N) comprenant une paire de rails (21) et au moins une paire d'ailettes flexibles (22) ;

un boîtier à puce (17) de la caméra (14, 14₁, 14₂, ..., 14_N) coopérant en ajustement de forme avec les rails (21) de la structure de montage (20) ; et

un corps d'objectif (15) de la caméra (14, 14₁, 14₂, ..., 14_N) coopérant en ajustement de forme et serré avec les ailettes flexibles (22) de la structure de montage (20).

2. Module de caméra (1) selon la revendication 1, comprenant au moins un dispositif d'illumination (16, 16₁, 16₂, ..., 16_M) porté par le support (10) pour l'au moins une caméra (14, 14₁, 14₂, ..., 14_N).

3. Module de caméra (1) selon la revendication 2, dans lequel l'au moins un dispositif d'illumination (16, 16₁, 16₂, ..., 16_M) comprend au moins une diode émettrice de lumière IR (30).

4. Module de caméra (1) selon l'une quelconque des revendications 1 à 3, dans lequel le support (10) a une structure de montage (25) pour l'au moins un dispositif d'illumination (16, 16₁, 16₂, ..., 16_M).
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5. Module de caméra (1) selon la revendication 4, dans lequel la structure de montage (25) pour l'au moins un dispositif d'illumination (16, 16₁, 16₂, ..., 16_M) comprend une surface de butée plate (26) avec un rebord d'entourage (27) et le dispositif d'illumination (16, 16₁, 16₂, ..., 16_M) est tenu par un ajustement par emboîtement sur la structure de montage (25).
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6. Module de caméra (1) selon l'une quelconque des revendications précédentes, comprenant un boîtier (7) qui entoure le module de caméra (1).
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7. Module de caméra (1) selon la revendication 6, dans lequel le boîtier (7) comprend une base de boîtier (8₂) et un couvercle de boîtier (8₁), les deux sont joints ensemble et forment le boîtier (7).
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8. Module de caméra (1) selon la revendication 7, dans lequel la base de boîtier (8₂) et le couvercle de boîtier (8₁) joints ont une découpe (31) pour l'au moins une caméra (14, 14₁, 14₂, ..., 14_N), une découpe (32) pour l'au moins un dispositif d'illumination (16, 16₁, 16₂, ..., 16_M) et une découpe (33) pour le connecteur (19), dans lequel l'au moins une caméra (14, 14₁, 14₂, ..., 14_N), l'au moins un dispositif d'illumination (16, 16₁, 16₂, ..., 16_M) et le connecteur (19) du module de caméra (1) sont alignés avec les découpes (31, 32, 33) respectives.
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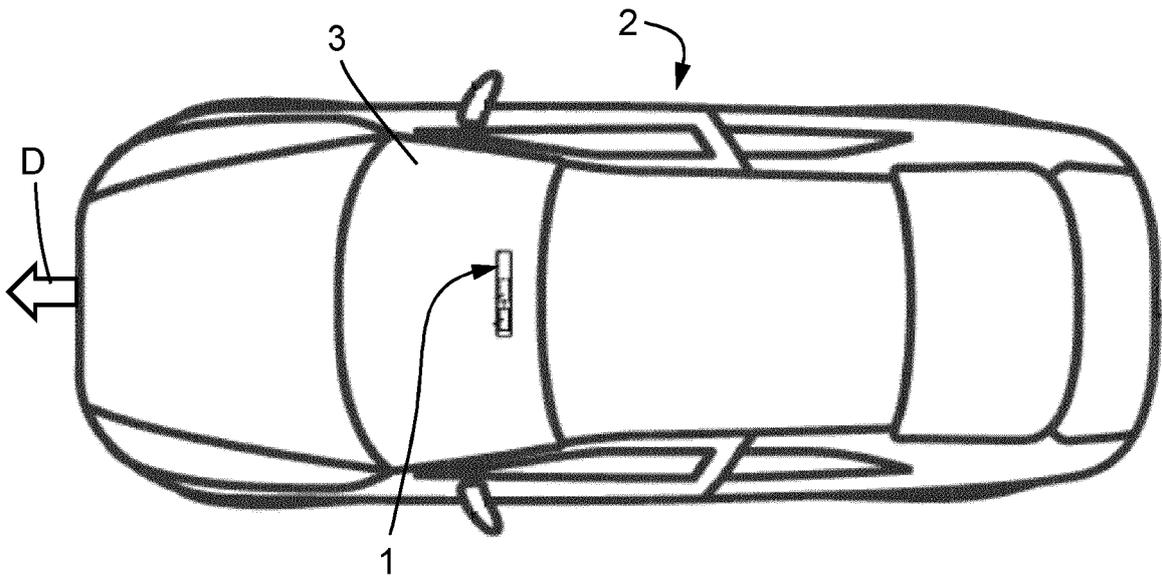


Fig. 1

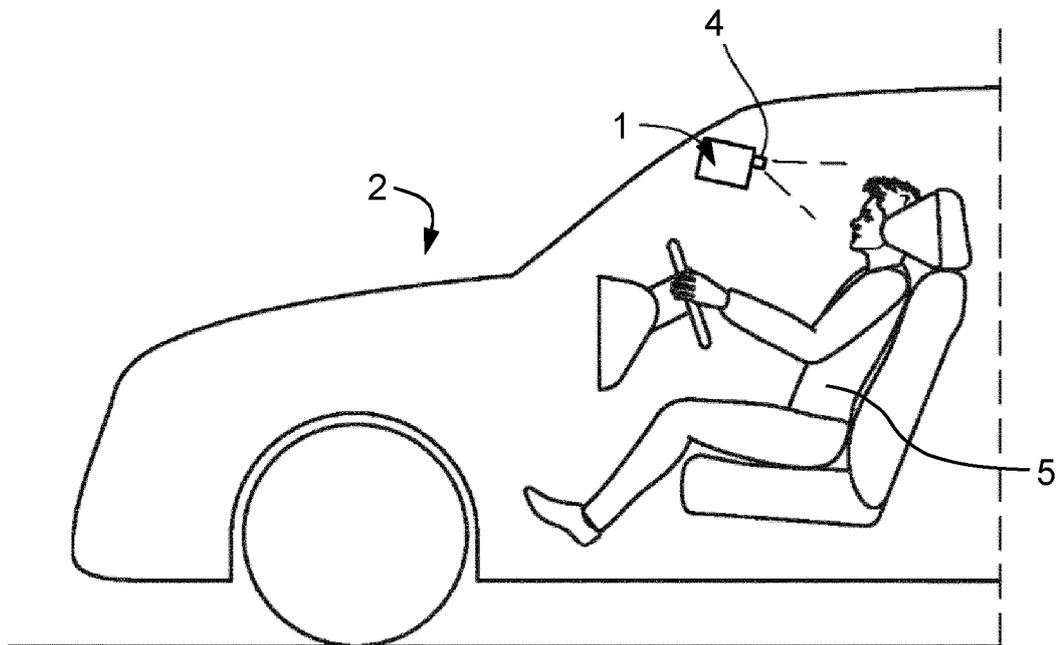


Fig. 2

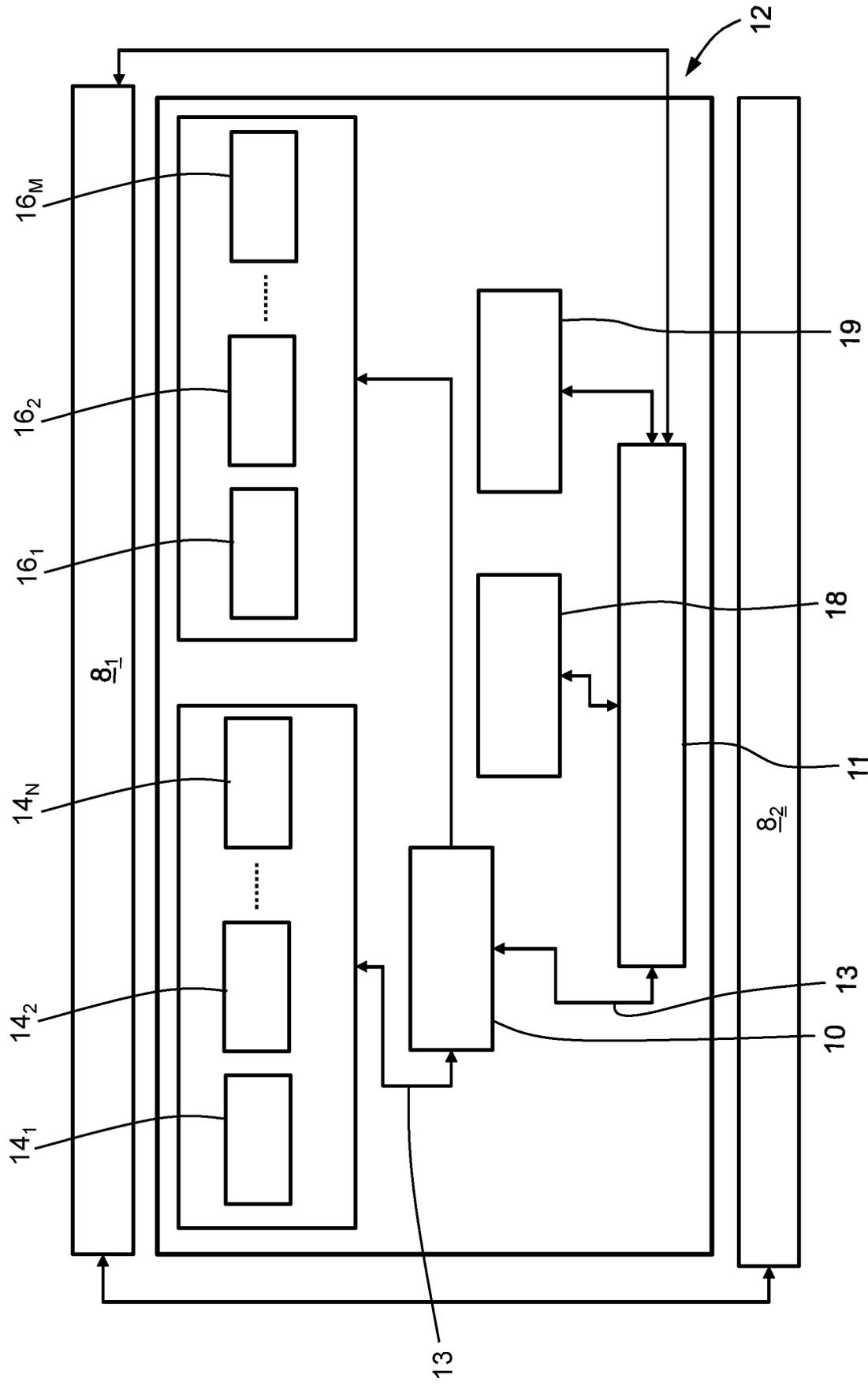


Fig. 3

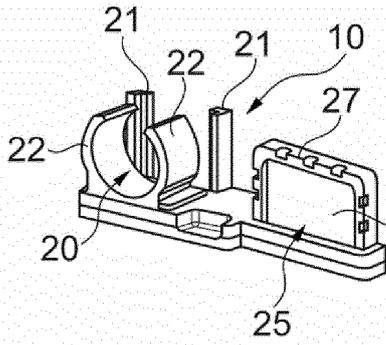


Fig. 4

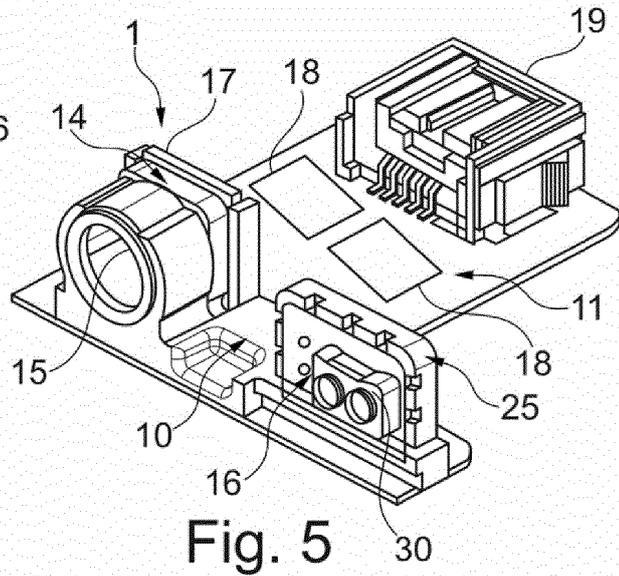


Fig. 5

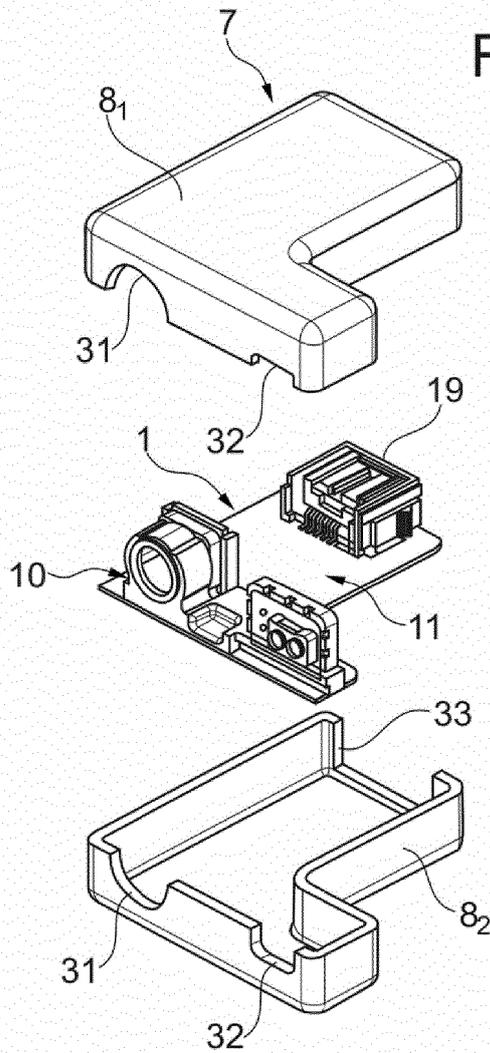


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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