US 20250264785A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2025/0264785 A1

(43) Pub. Date: Aug. 21, 2025

CHANG et al.

(54) **LIGHT-FOLDED CAMERA MODULE AND ELECTRONIC DEVICE**

(71) Applicant: **LARGAN DIGITAL CO., LTD.**, Taichung City (TW)

(72) Inventors: **Lin-An CHANG**, Taichung City (TW); **Te-Sheng TSENG**, Taichung City (TW); **Wen-Hung HSU**, Taichung City (TW); **Ming-Ta CHOU**, Taichung City (TW)

(21) Appl. No.: **19/049,057**

(22) Filed: **Feb. 10, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/555,469, filed on Feb. 20, 2024.

Publication Classification

(51) **Int. Cl.**

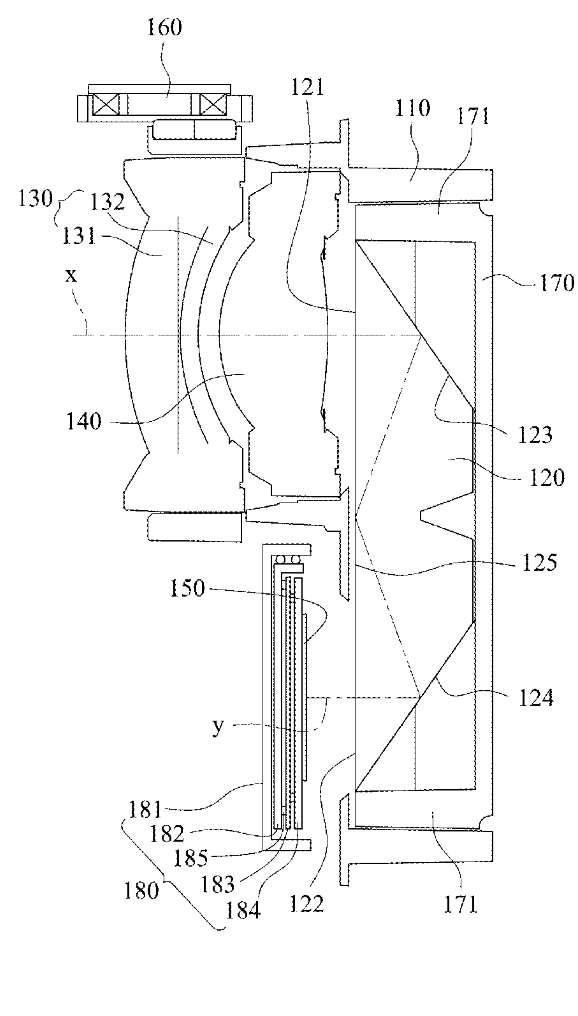
G03B 17/17	(2021.01)
G02B 1/04	(2006.01)
G02B 7/02	(2021.01)
G02B 7/10	(2021.01)
G03B 3/10	(2021.01)
G03B 17/12	(2021.01)
H04N 23/54	(2023.01)
H04N 23/55	(2023.01)
H04N 23/68	(2023.01)

(52) **U.S. Cl.**

CPC ***G03B 17/17*** (2013.01); ***G02B 1/041*** (2013.01); ***G02B 7/021*** (2013.01); ***G02B 7/10*** (2013.01); ***G03B 3/10*** (2013.01); ***G03B 17/12*** (2013.01); ***H04N 23/54*** (2023.01); ***H04N 23/55*** (2023.01); ***H04N 23/687*** (2023.01)

(57) **ABSTRACT**

A light-folded camera module has an incident axis and an exiting axis, and includes a fixing carrier, a reflecting element, a first lens assembly, a second lens assembly and an image sensor. The reflecting element is for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis. The reflecting element includes an incident surface and an exiting surface. The second lens assembly is for providing an optical refractive power of the light-folded camera module along with the first lens assembly. The image sensor is for receiving the imaging light of the light-folded camera module. The light-folded camera module further includes a focus driving device, and a degrees of freedom and a driving force for the first lens assembly to be moved along a direction parallel to the incident axis are provided.



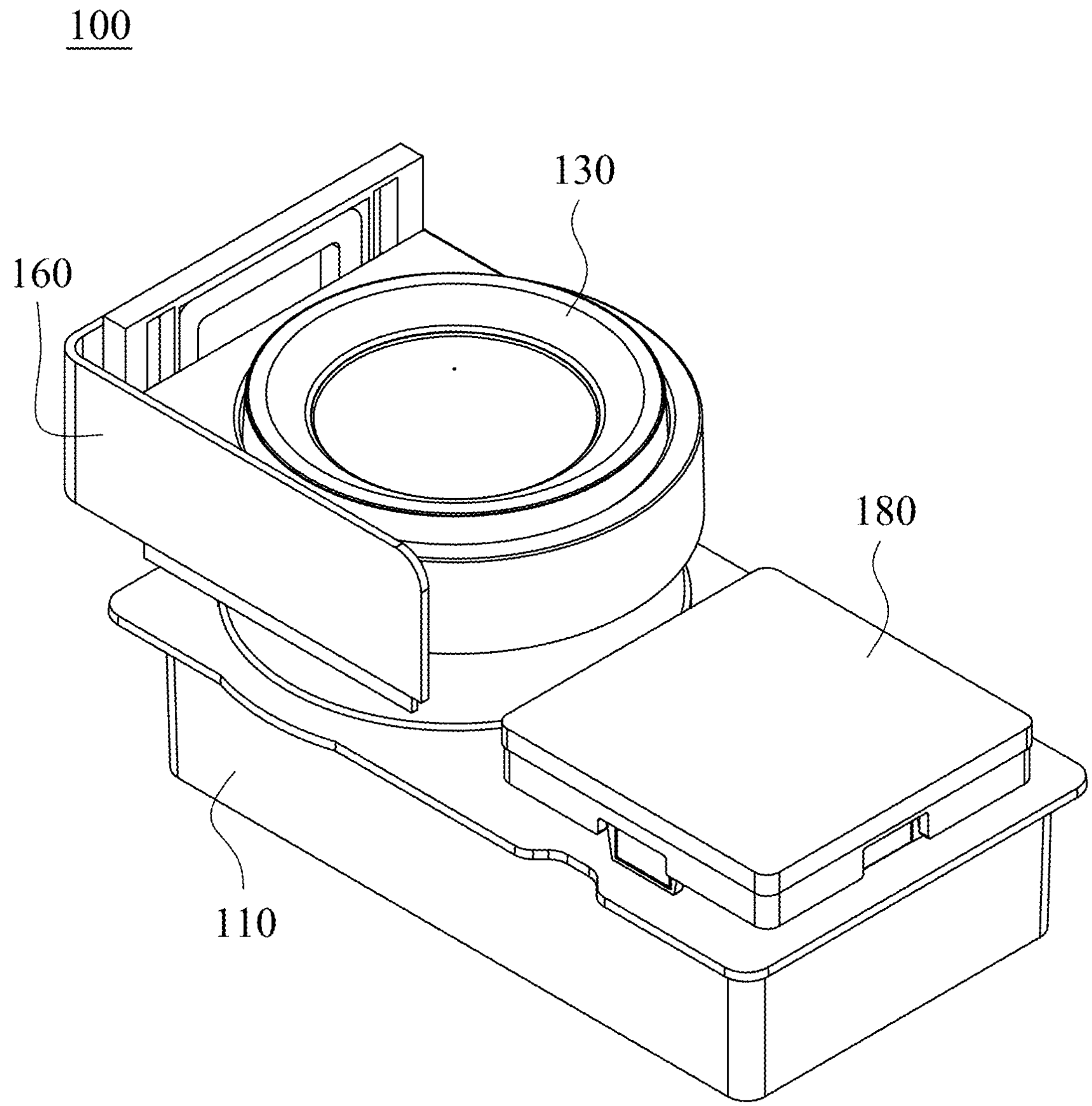


Fig. 1A

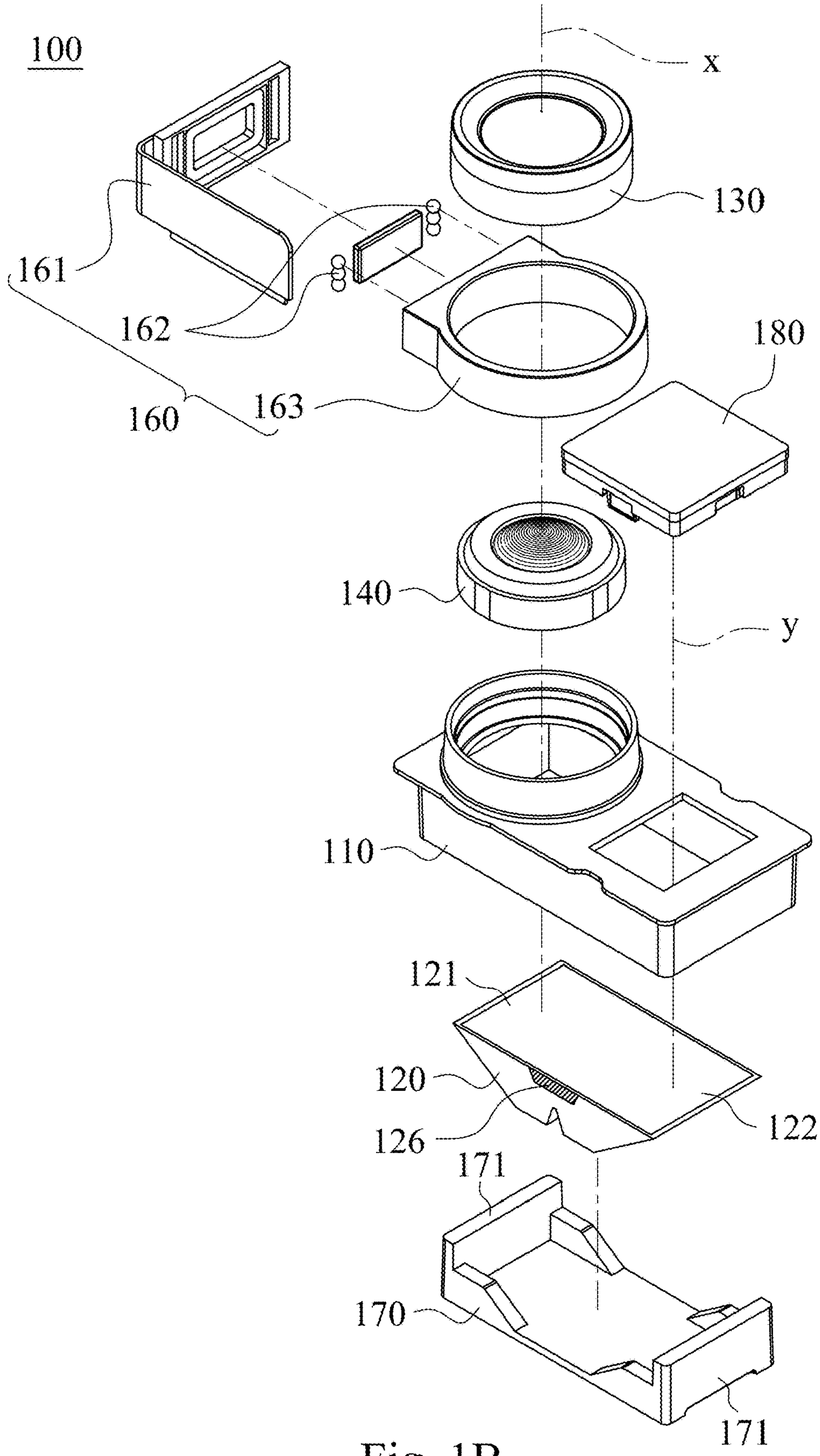

100
x
130
161
162
180
163
160
140
y
110
121
120
126
122
171
170
171

Fig. 1B

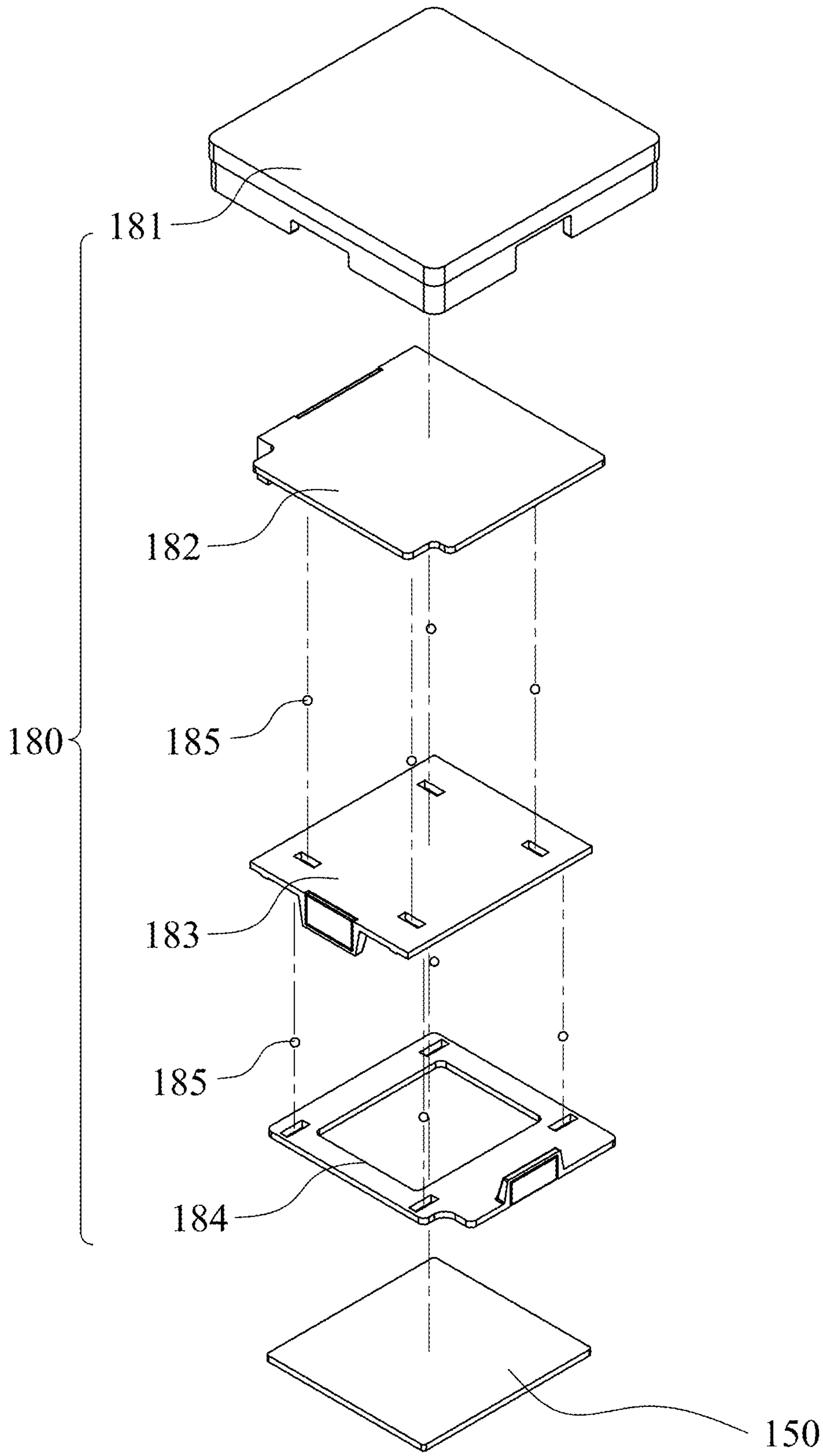


Fig. 1C

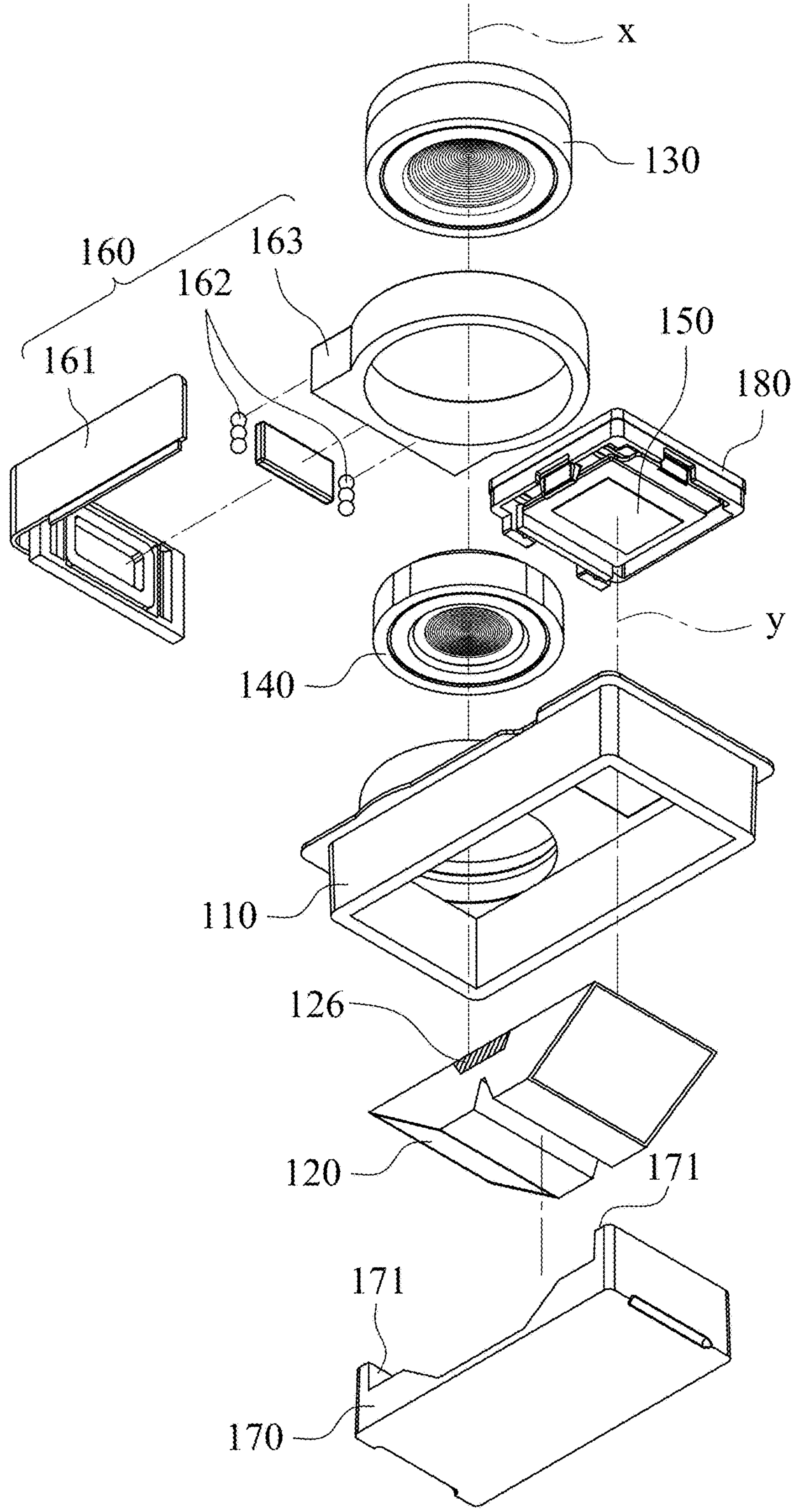


Fig. 1D

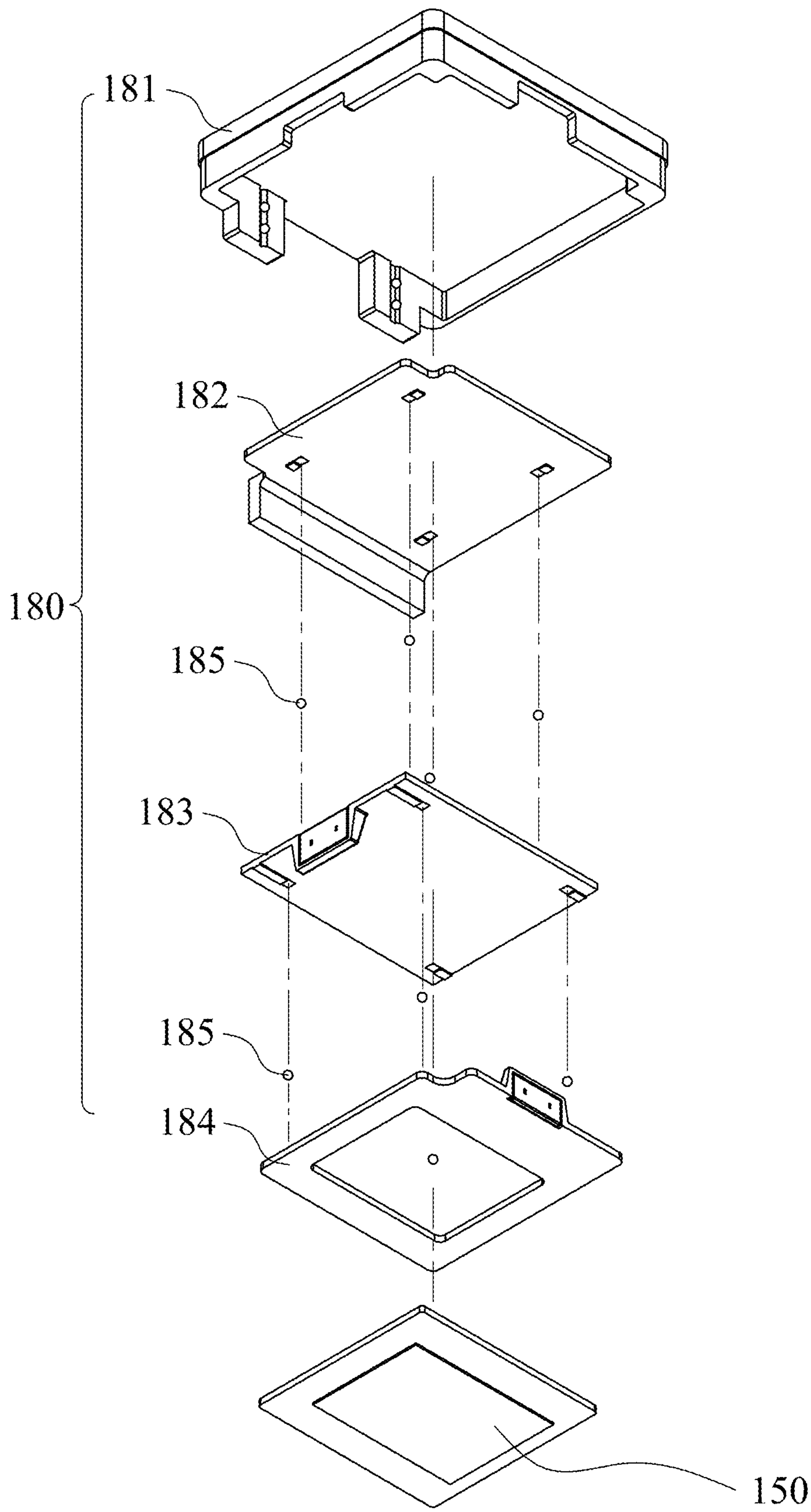


Fig. 1E

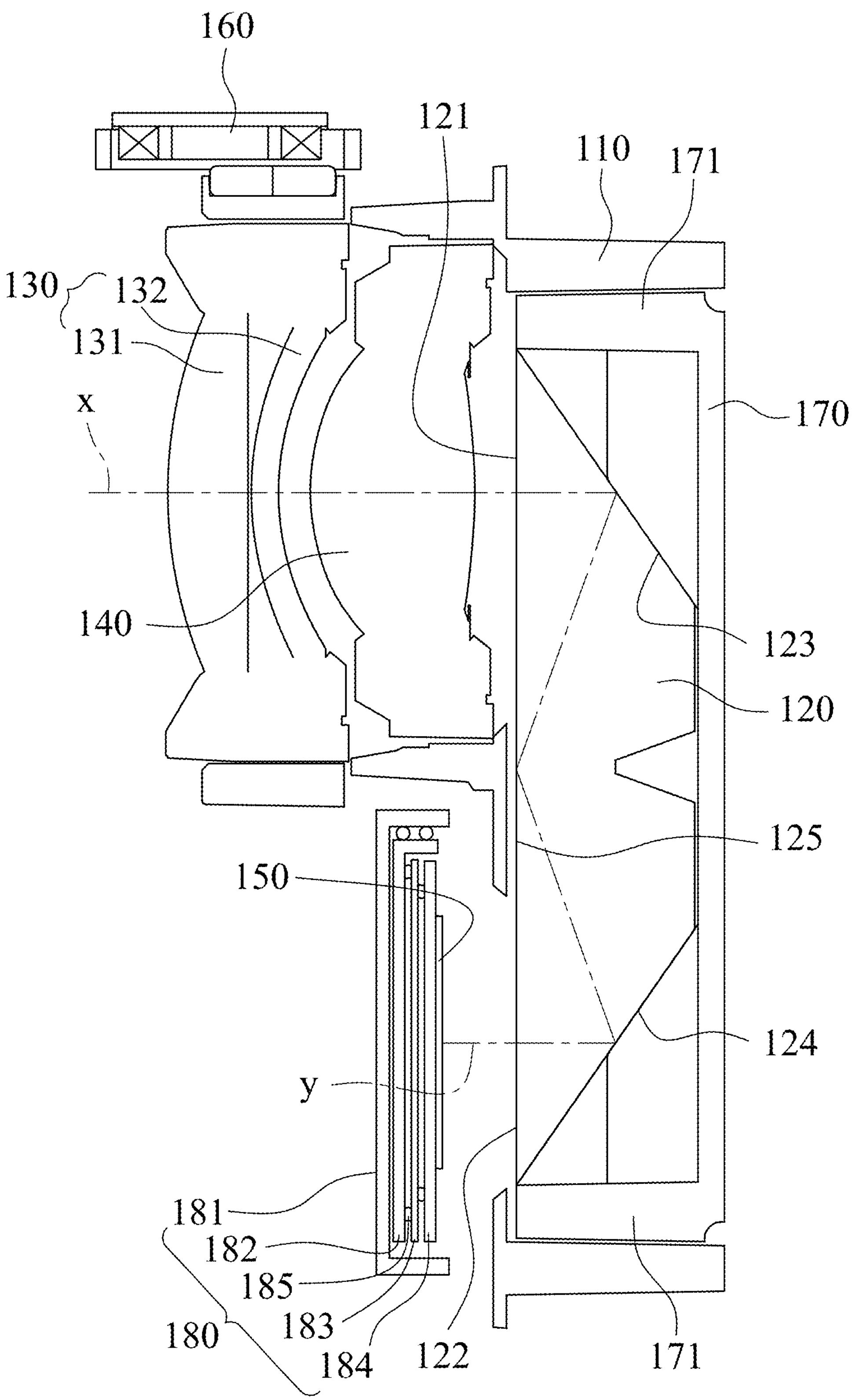

160
121
110
171
130
132
131
x
170
140
123
120
125
150
124
y
181
182
185
183
180
184
122
171

Fig. 1F

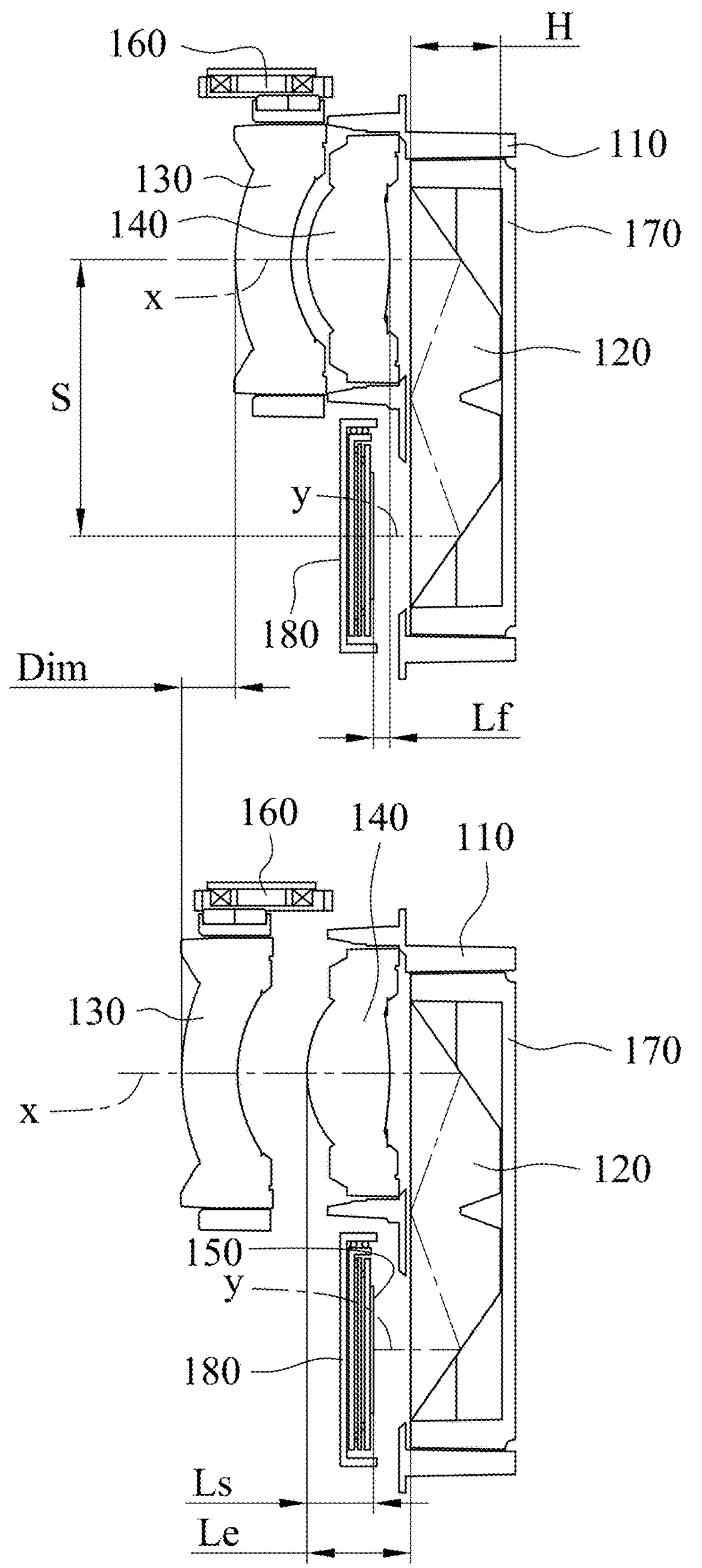

160
H
110
130
140
170
x
120
S
y
180
Dim
Lf
160
140
110
130
170
x
120
150
y
180
Ls
Le

Fig. 1G

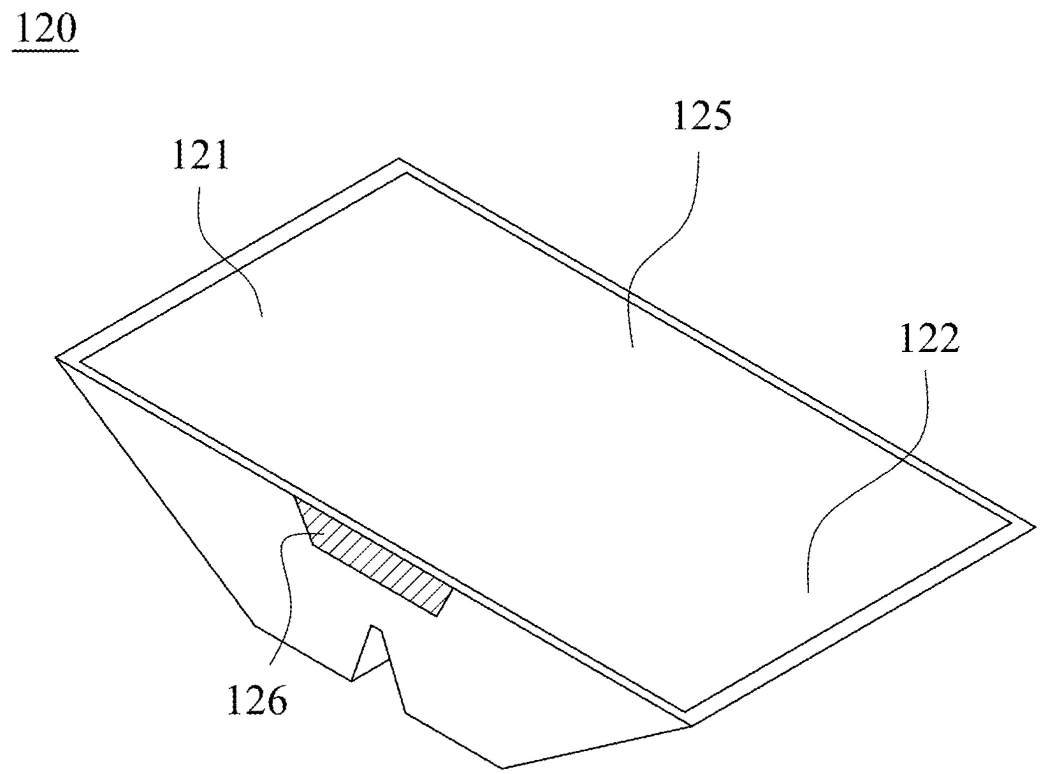


Fig. 1H

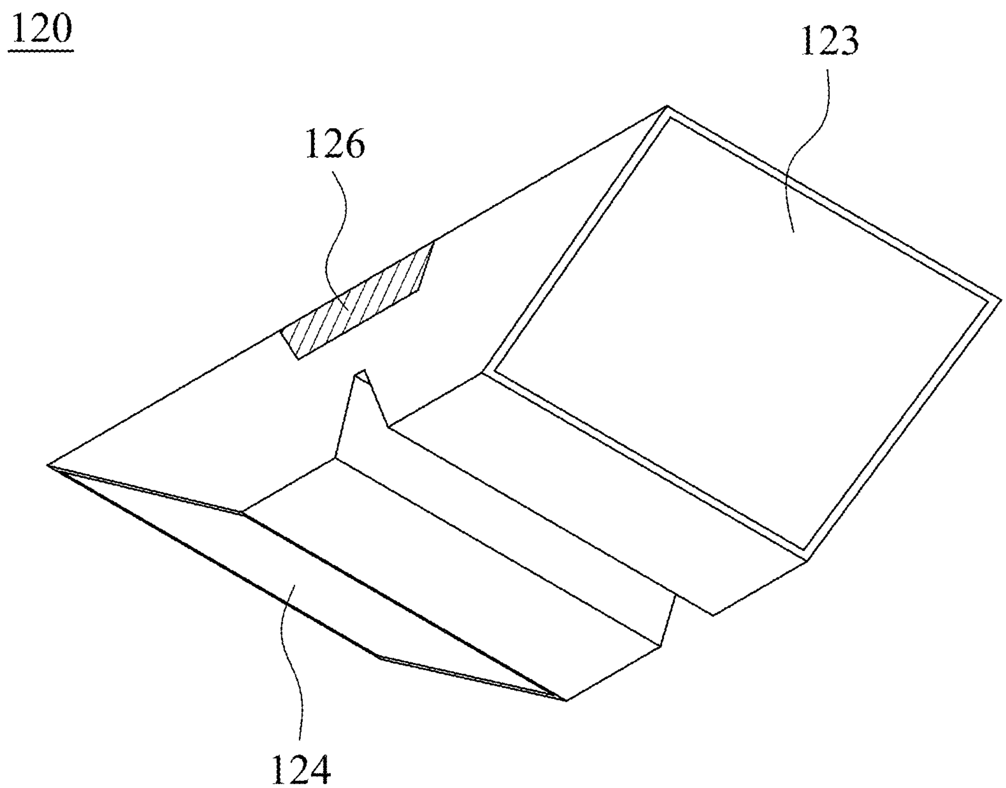


Fig. 1I

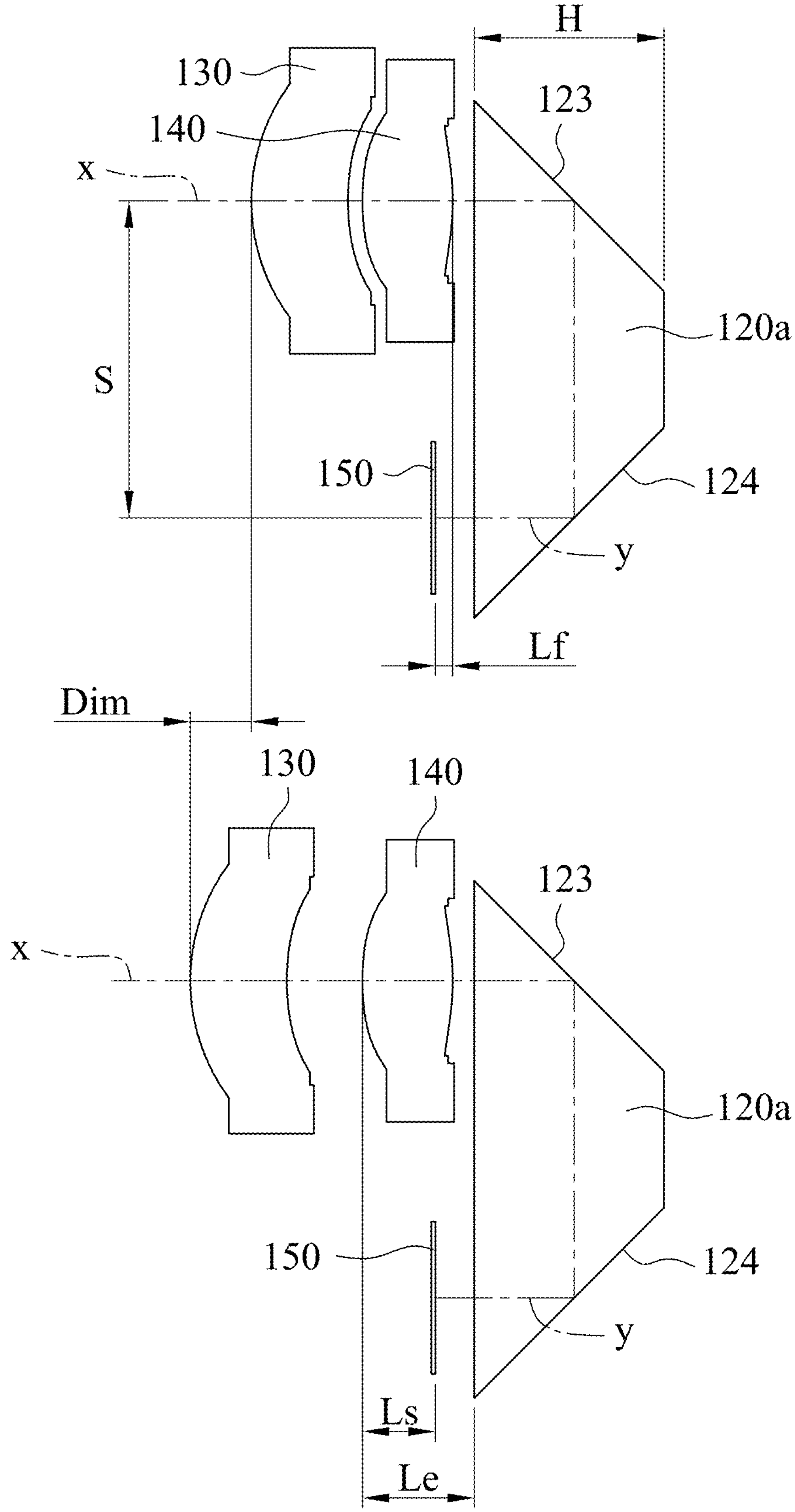

H
130
140
123
x
120a
S
150
124
y
Lf
Dim
130
140
123
x
120a
150
124
y
Ls
Le

Fig. 2

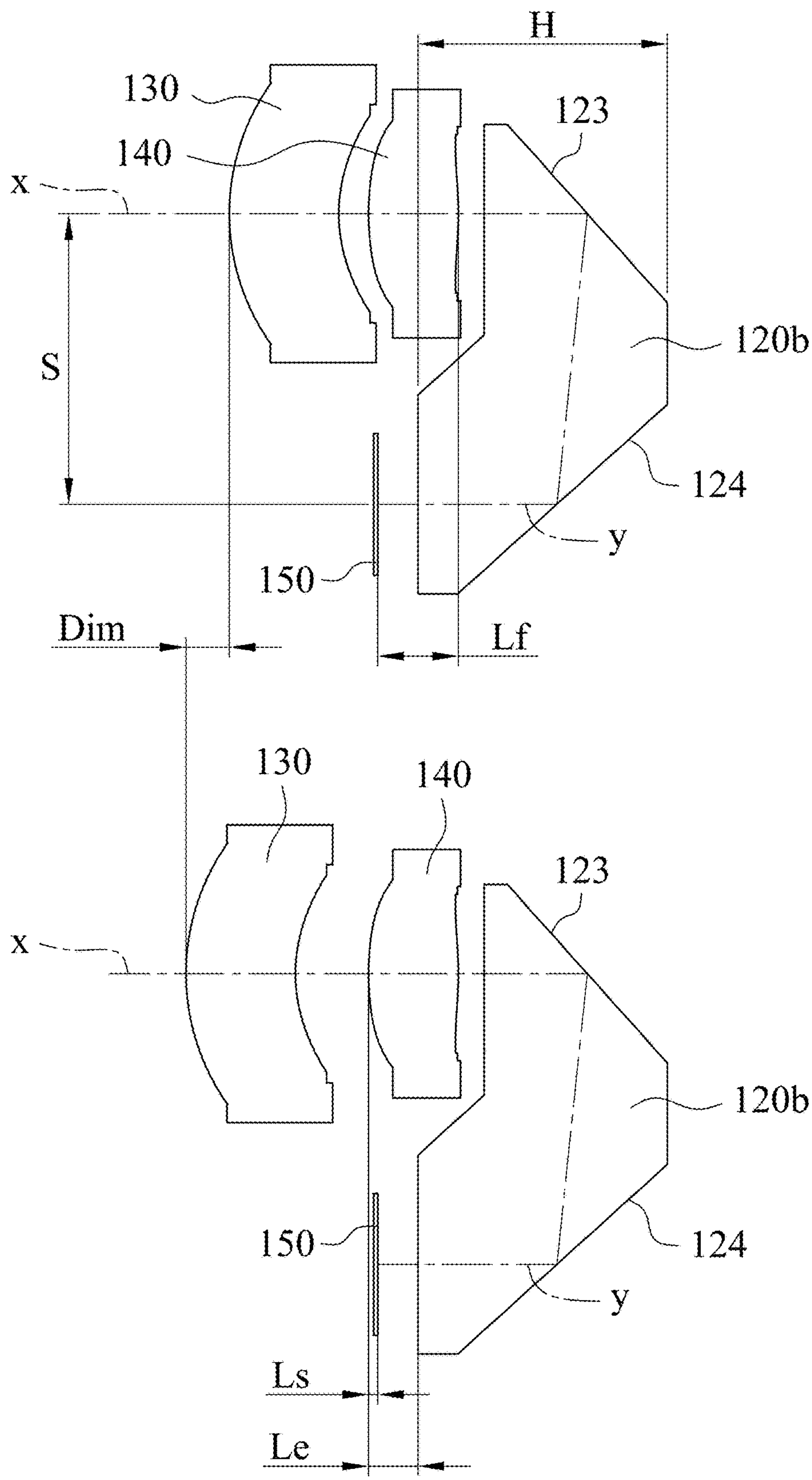

H
130
123
140
x
S
120b
124
y
150
Dim
Lf
130
140
123
x
120b
150
124
y
Ls
Le

Fig. 3

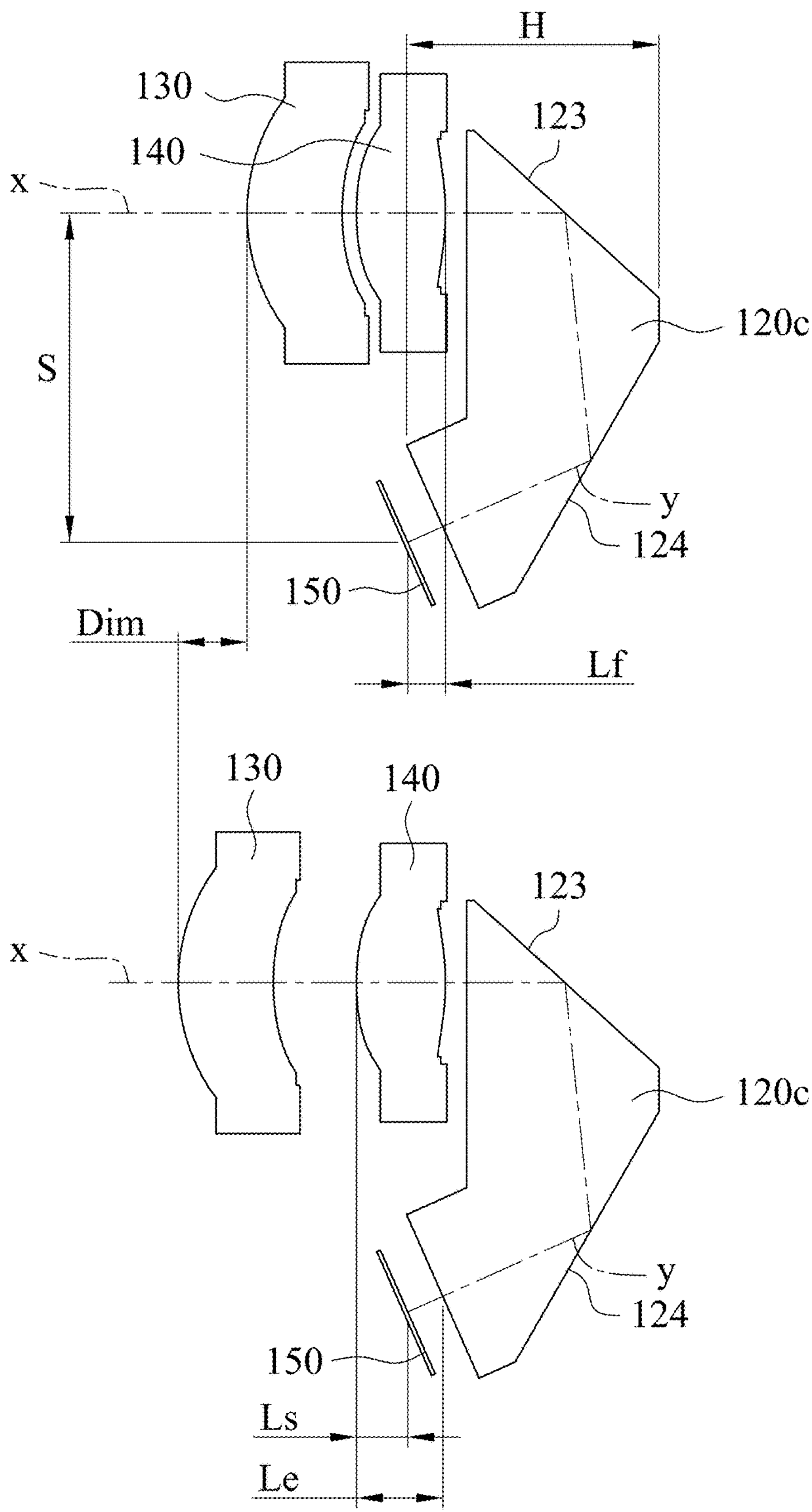

H
130
140
123
x
S
120c
y
124
150
Dim
Lf
130
140
123
x
120c
y
124
150
Ls
Le

Fig. 4

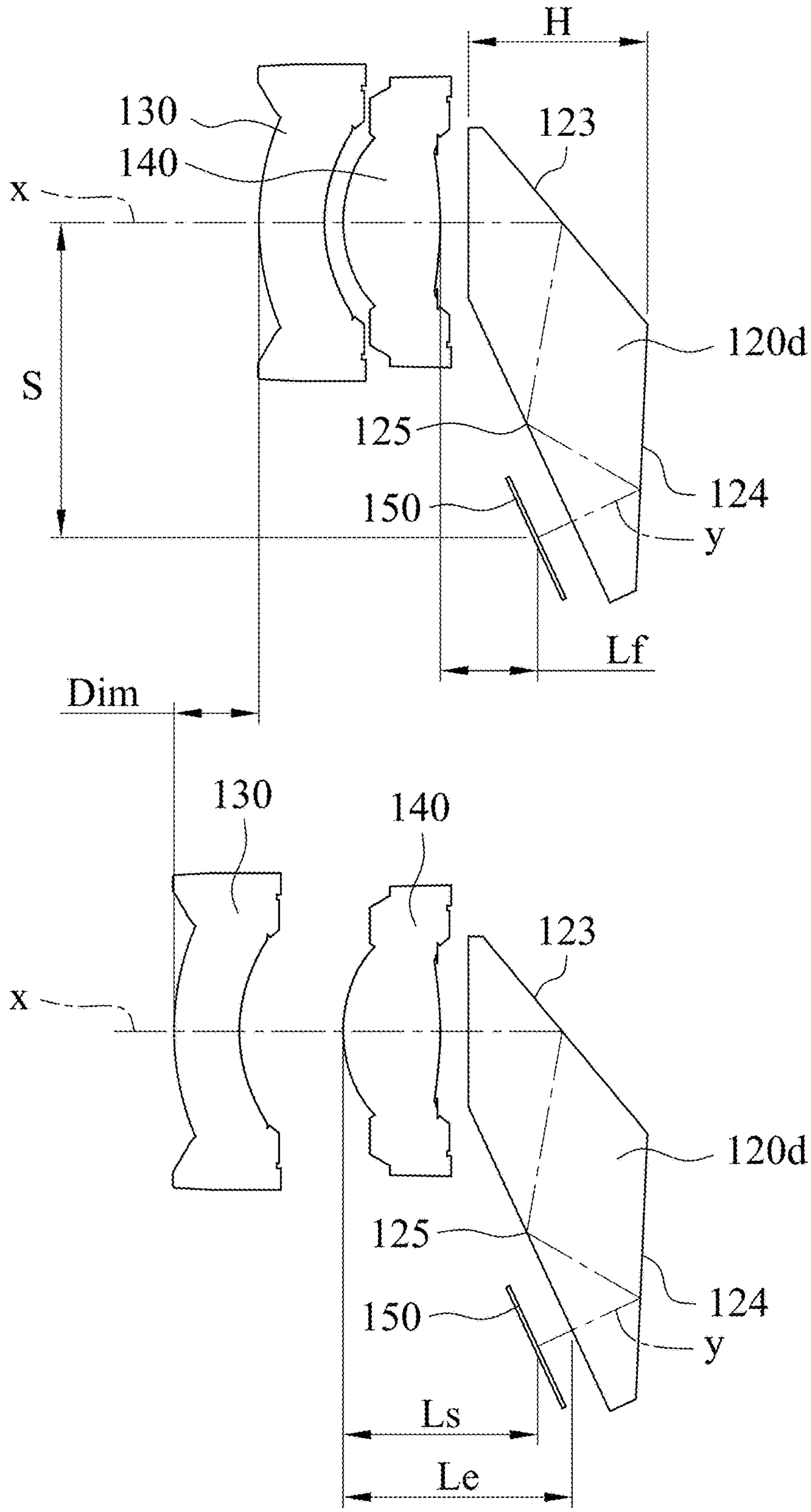

H
130
140
123
x
S
120d
125
124
150
y
Lf
Dim
130
140
123
x
120d
125
124
150
y
Ls
Le

Fig. 5

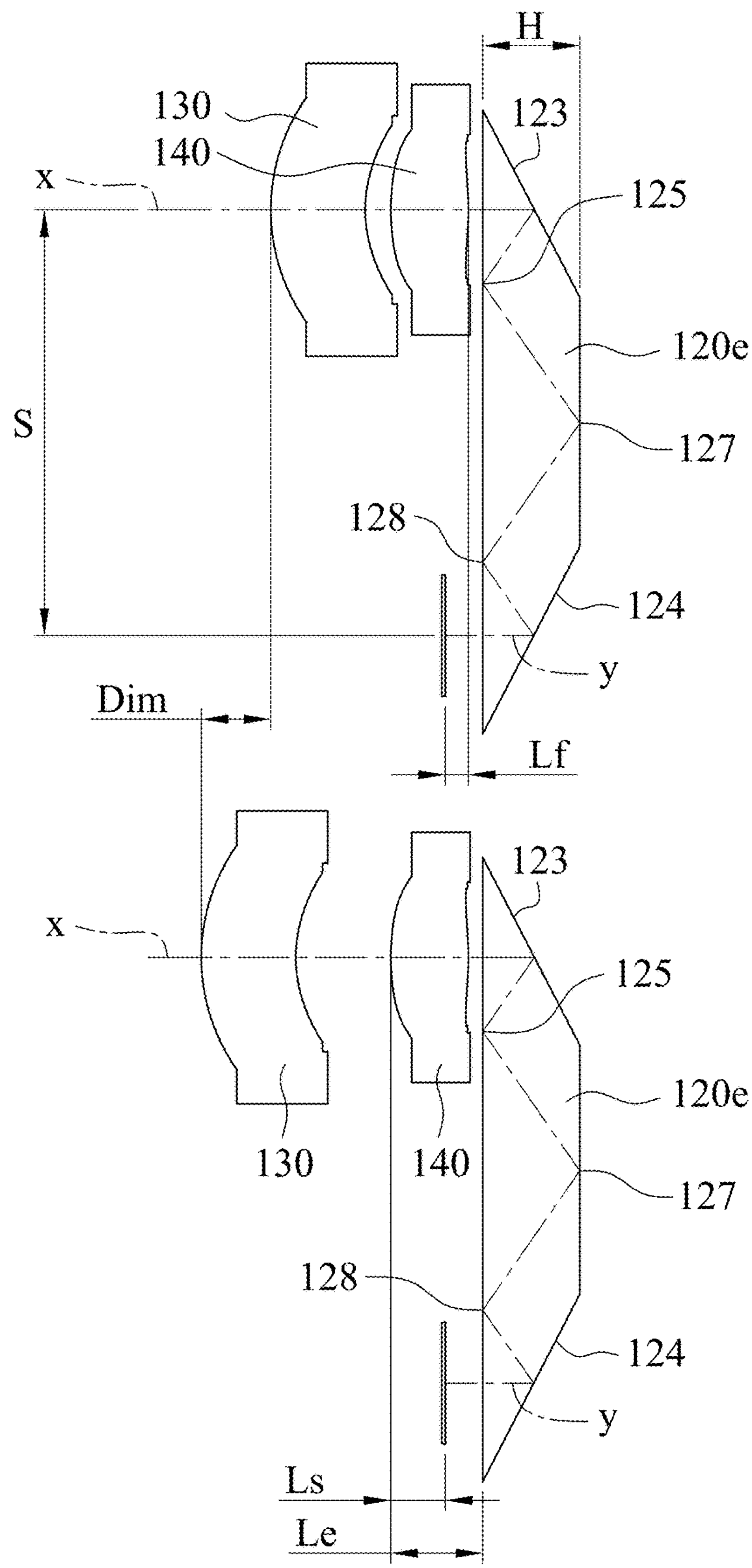

H
130
140
123
x
125
120e
S
127
128
124
y
Dim
Lf
123
x
125
120e
130
140
127
128
124
y
Ls
Le

Fig. 6

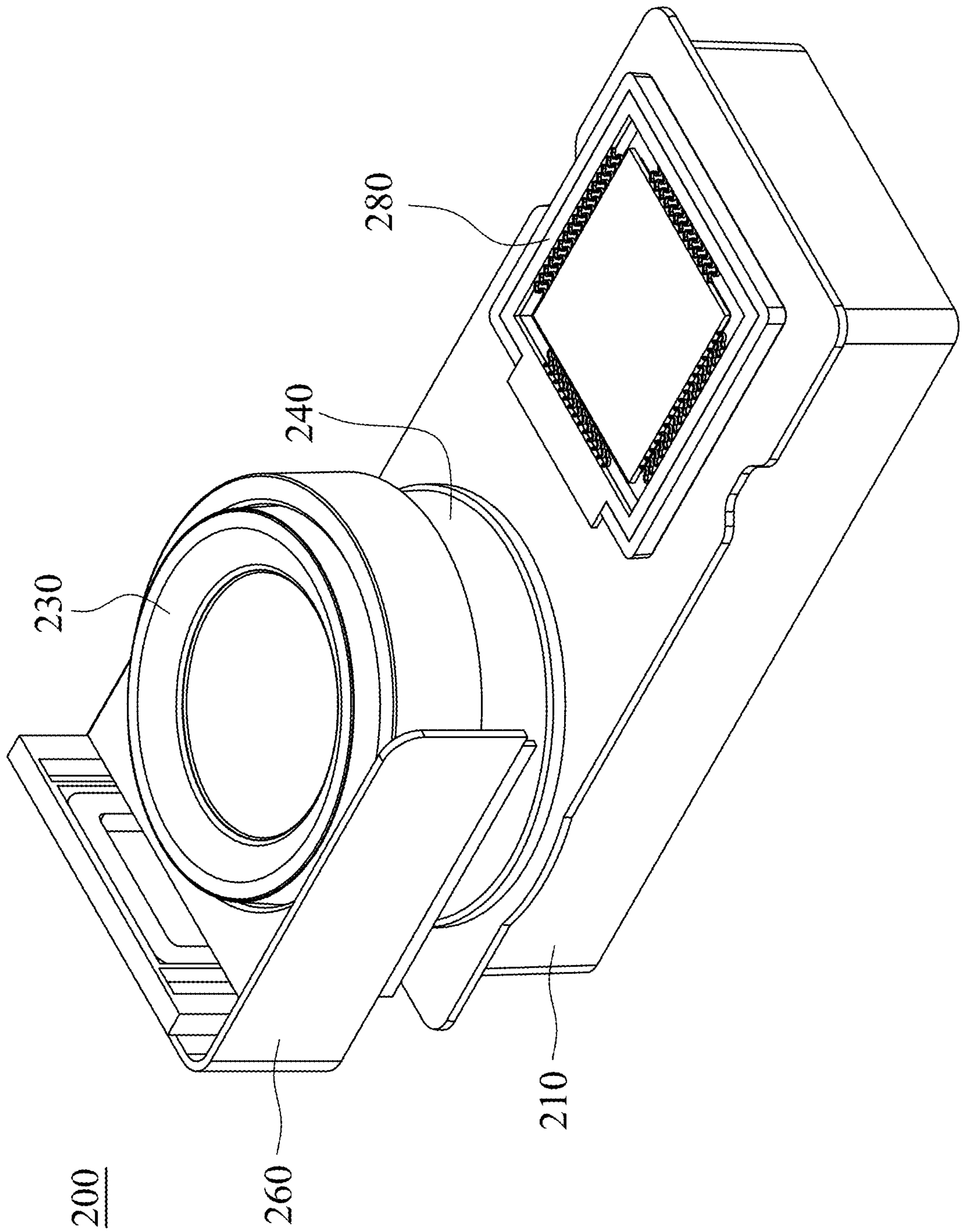


Fig. 7A

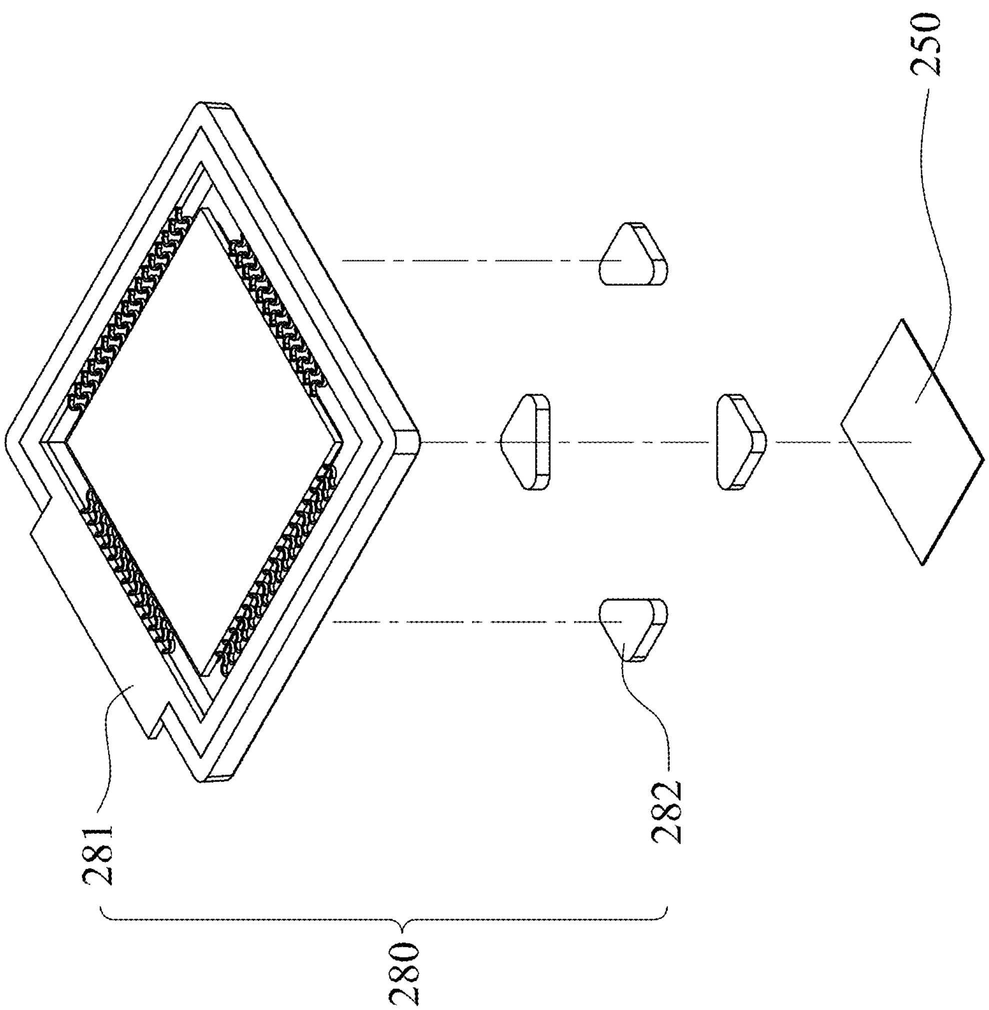


Fig. 7B

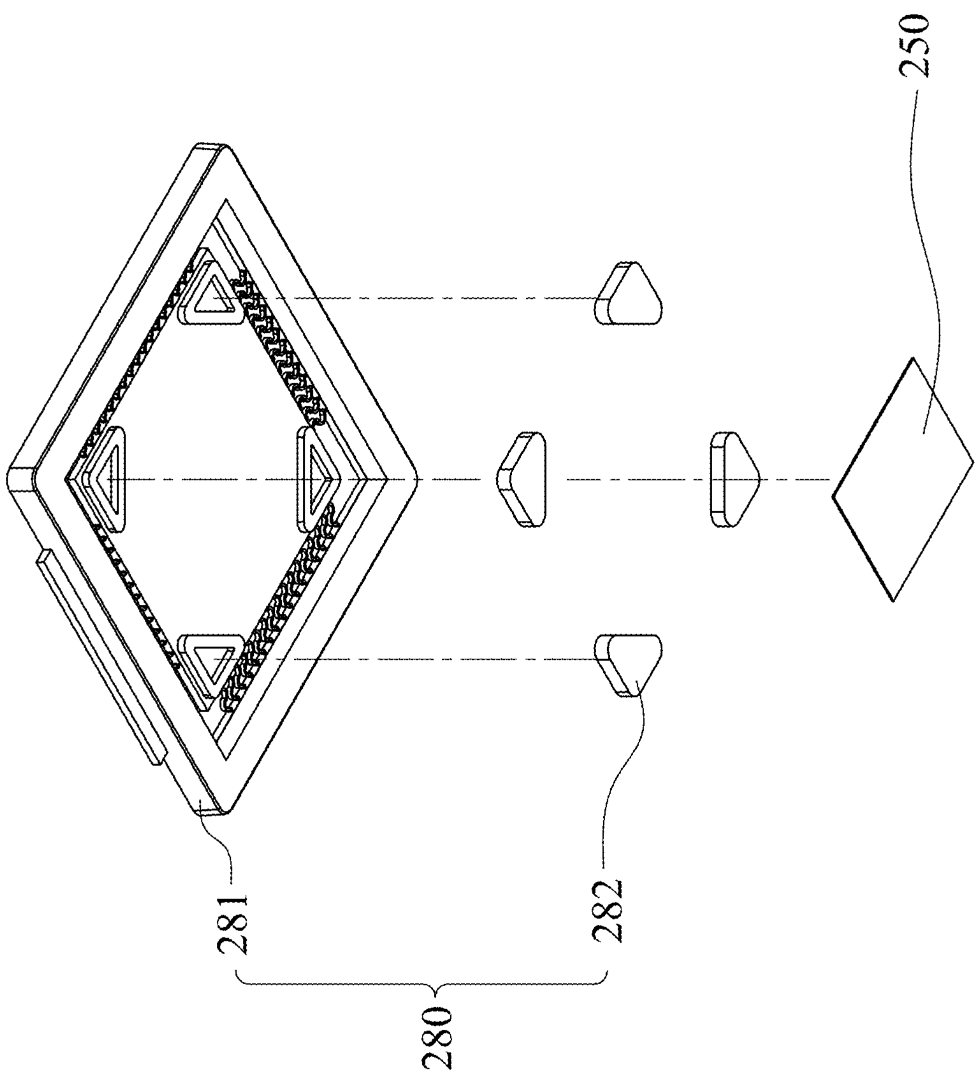
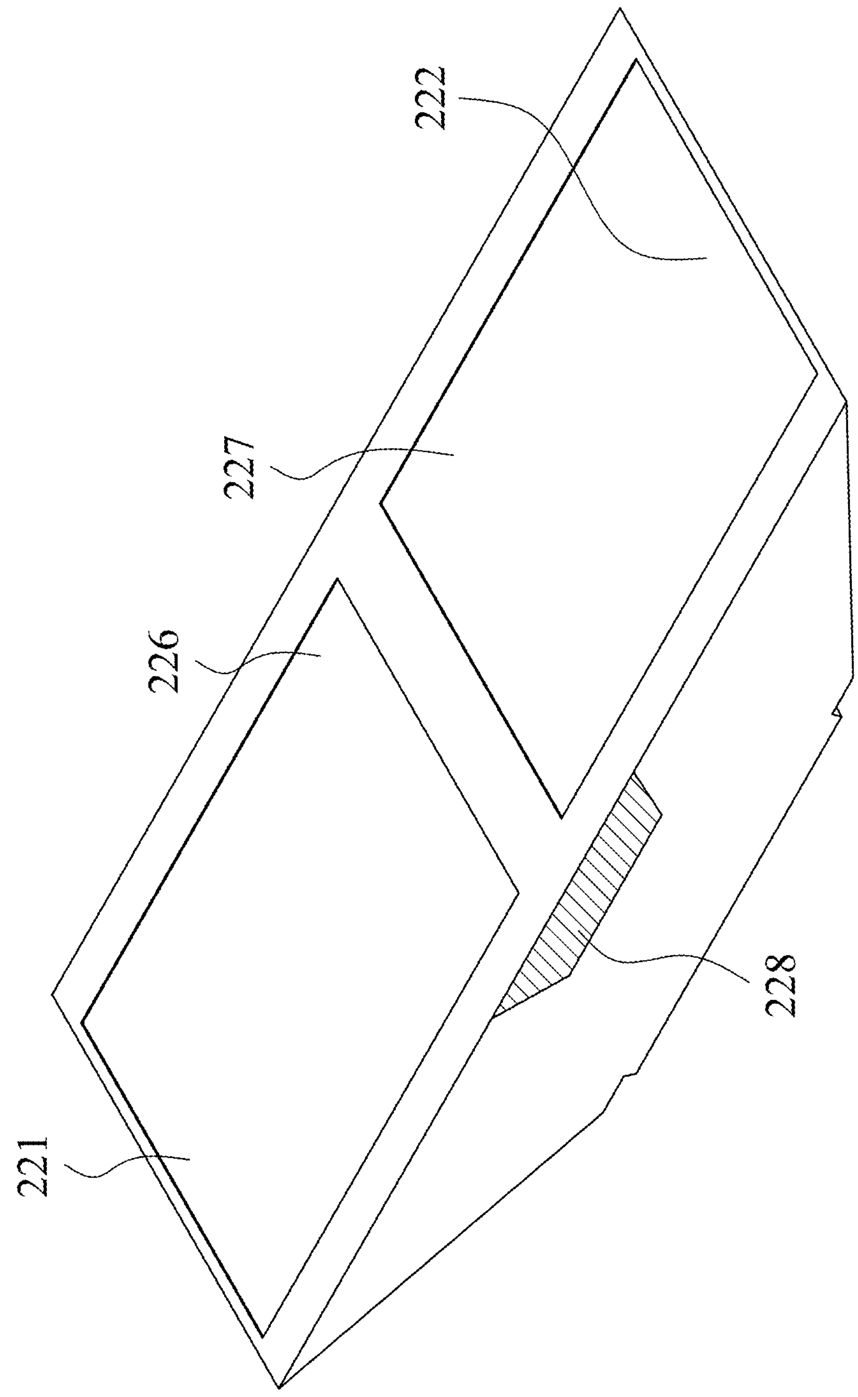


Fig. 7C



220

Fig. 7D

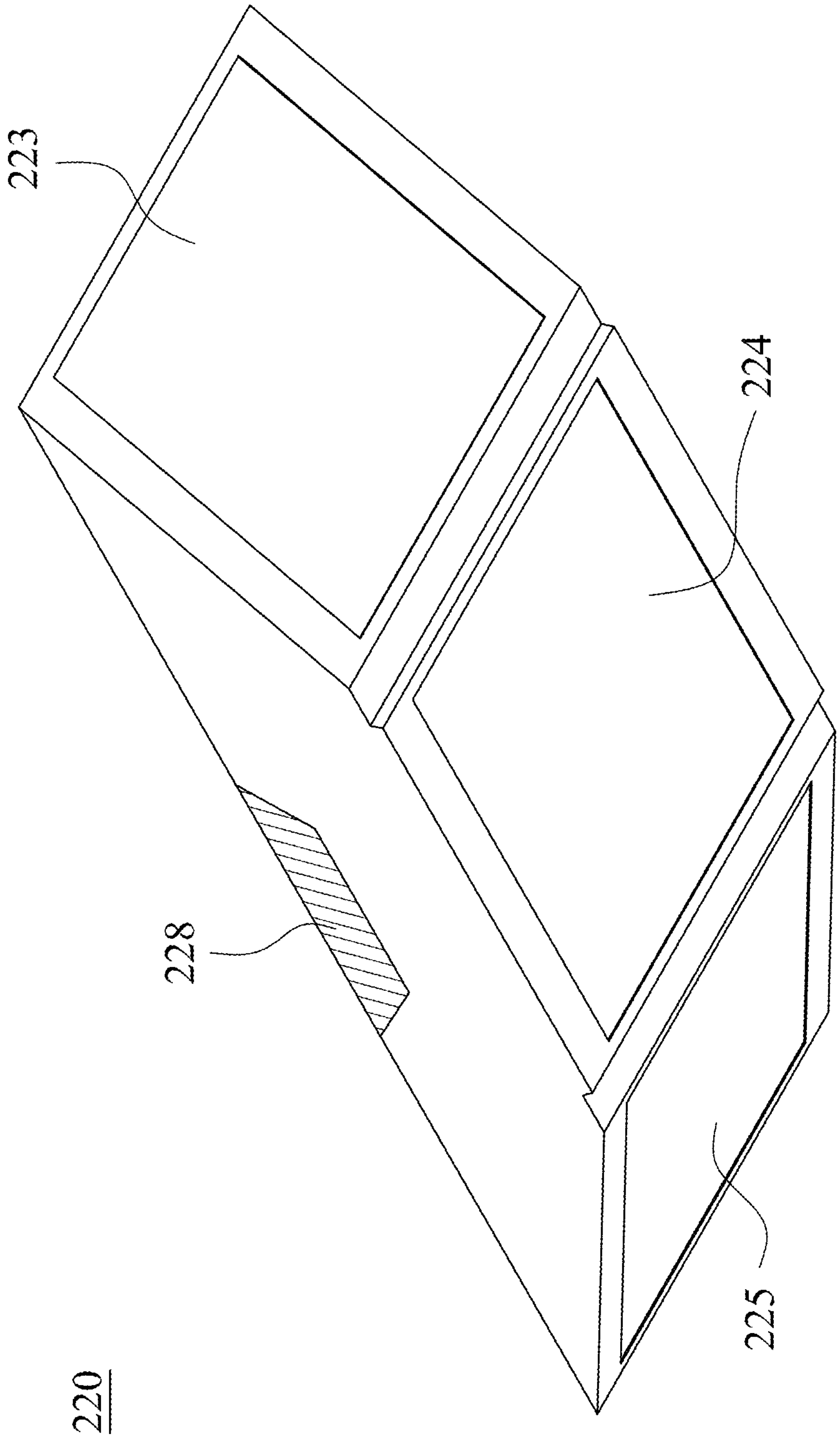


Fig. 7E

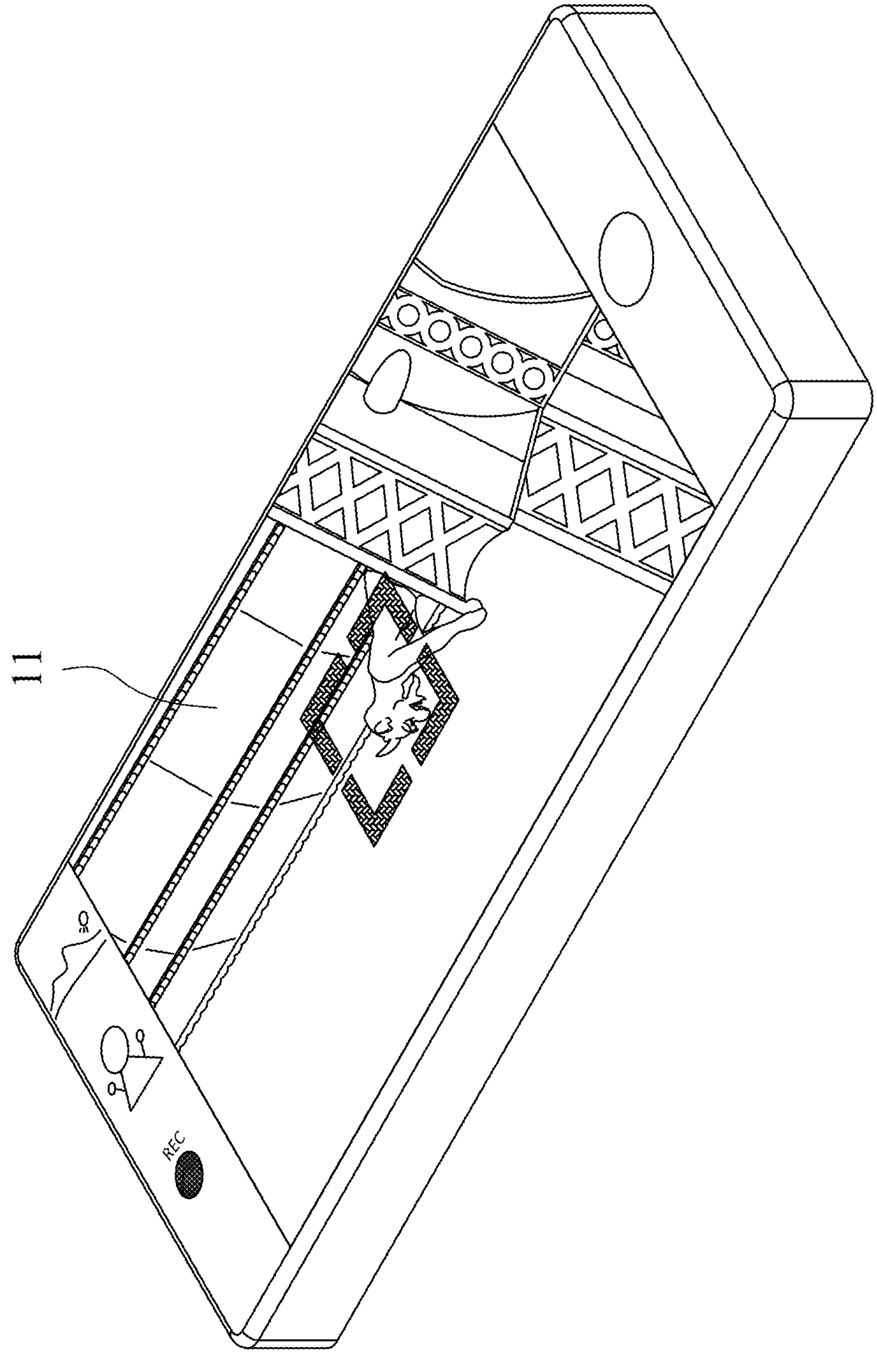


Fig. 8A

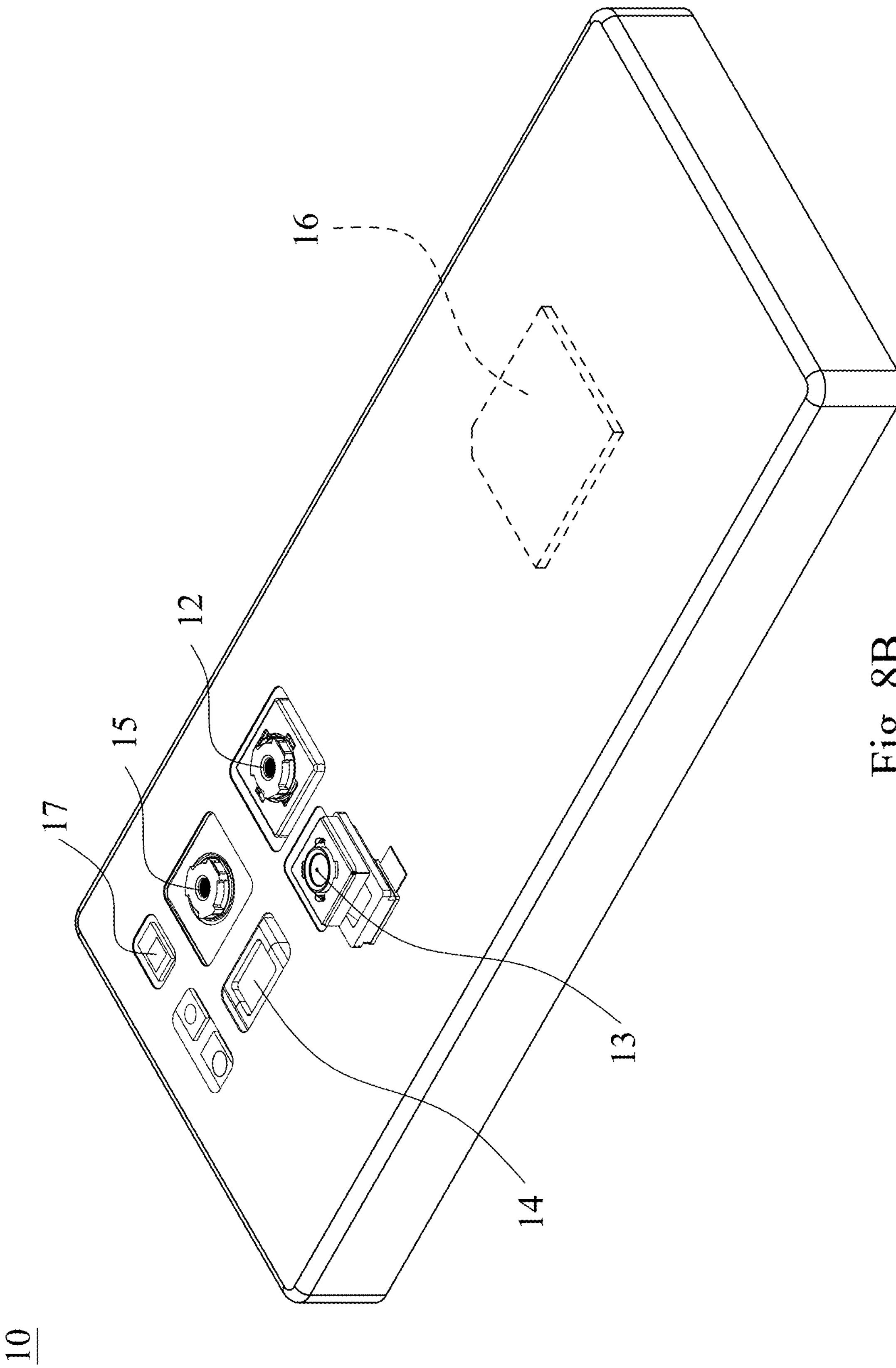


Fig. 8B

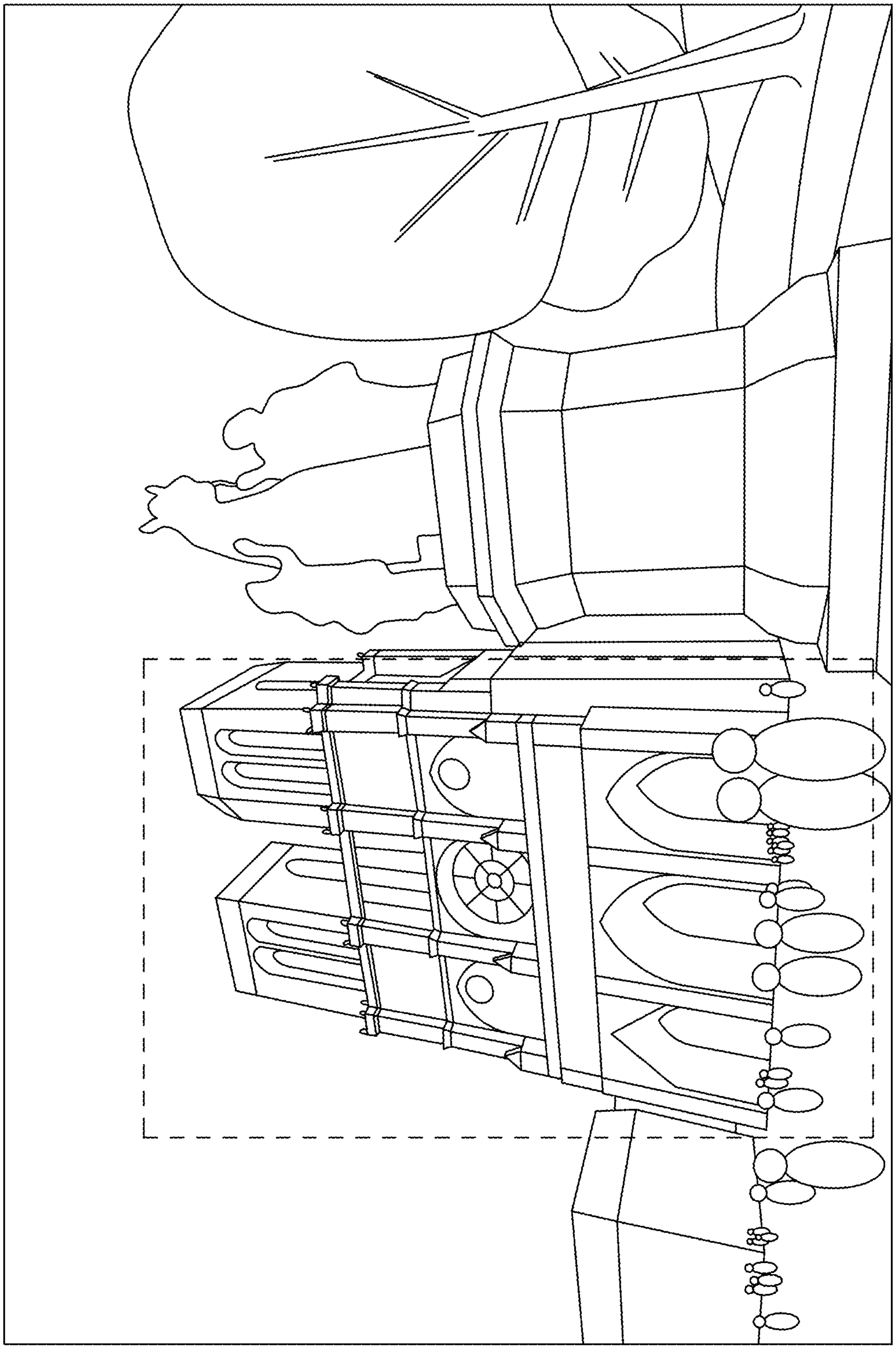


Fig. 8C

Fig. 8D

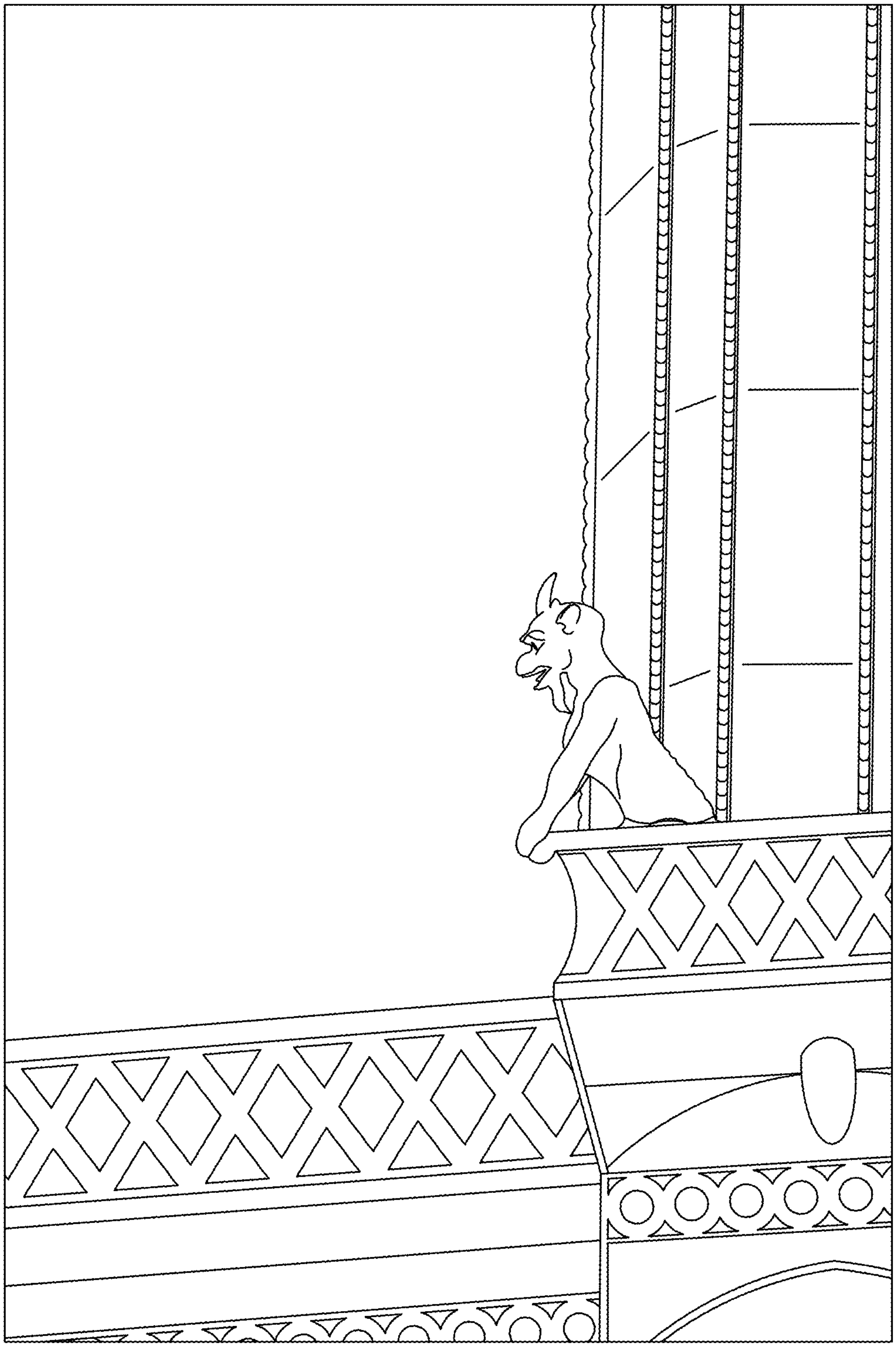


Fig. 8E

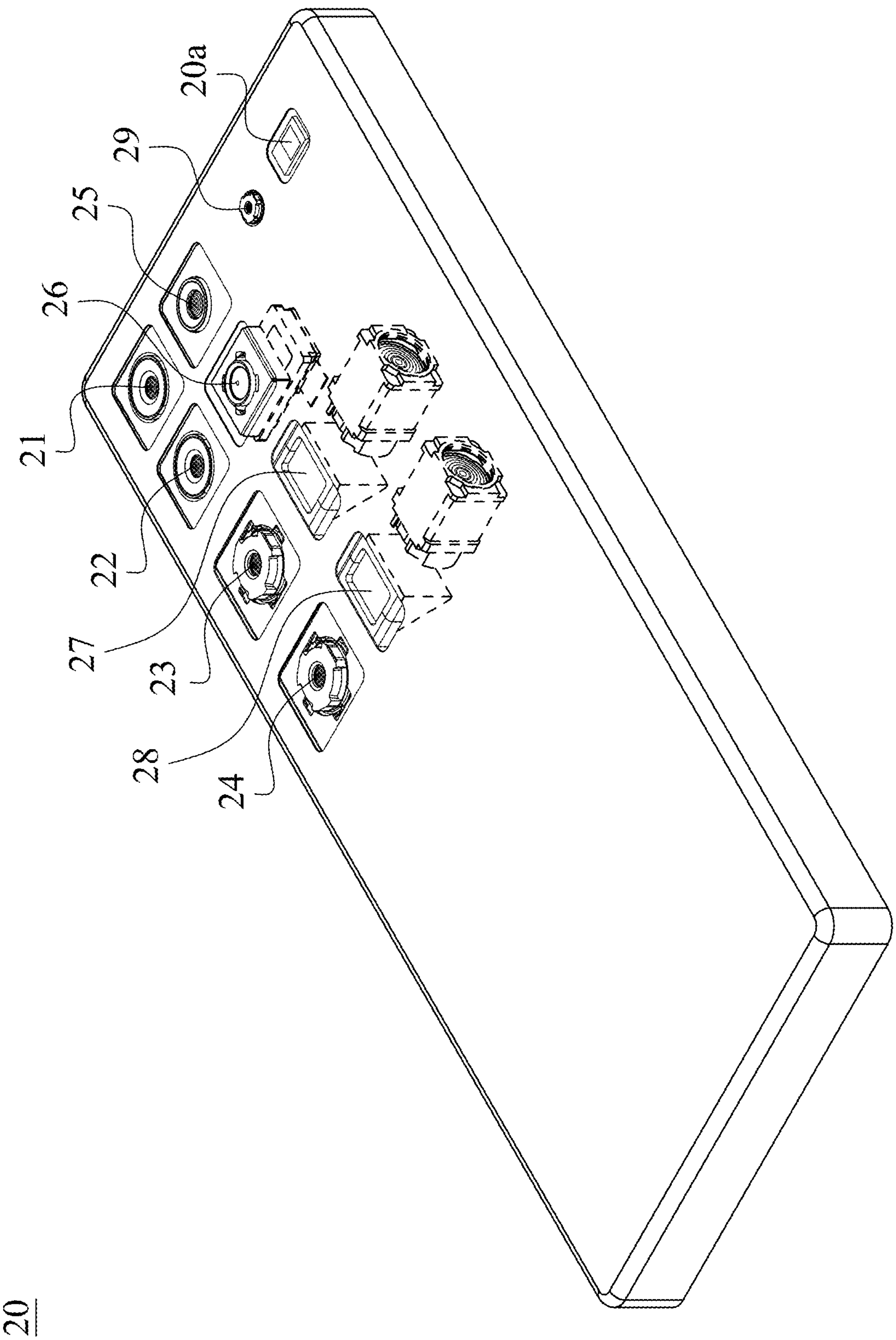
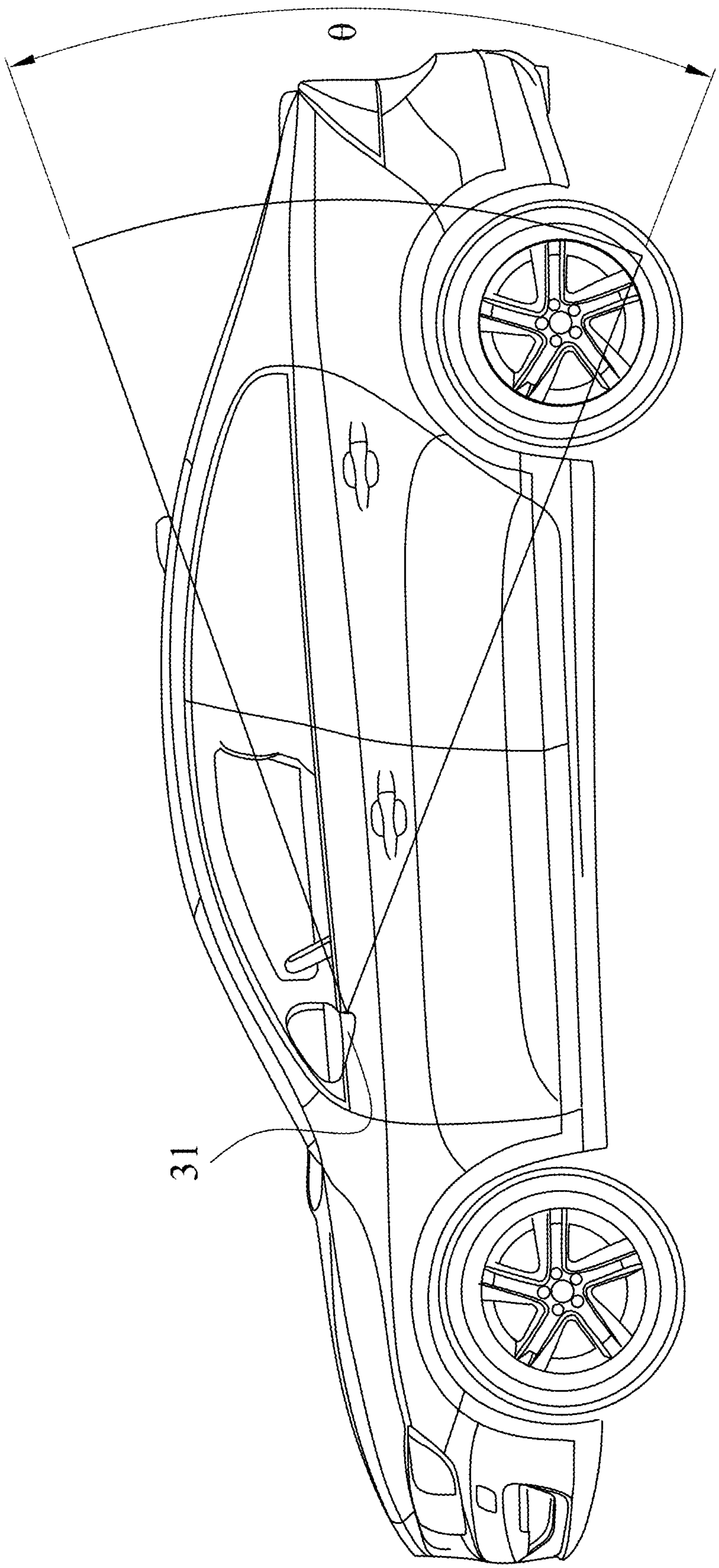


Fig. 9



30

Fig. 10A

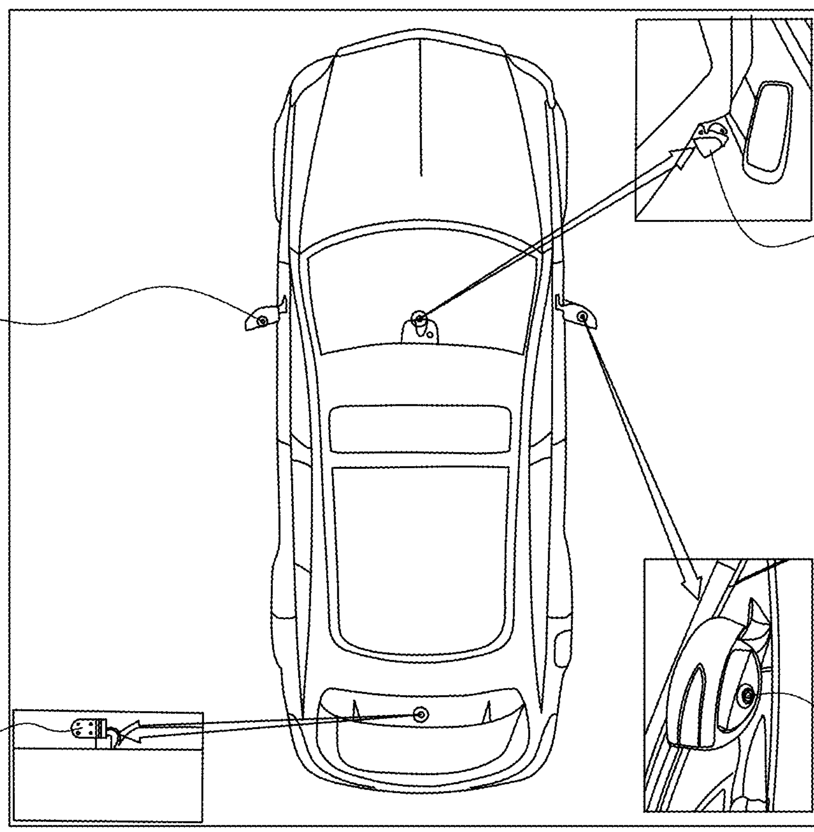


Fig. 10B

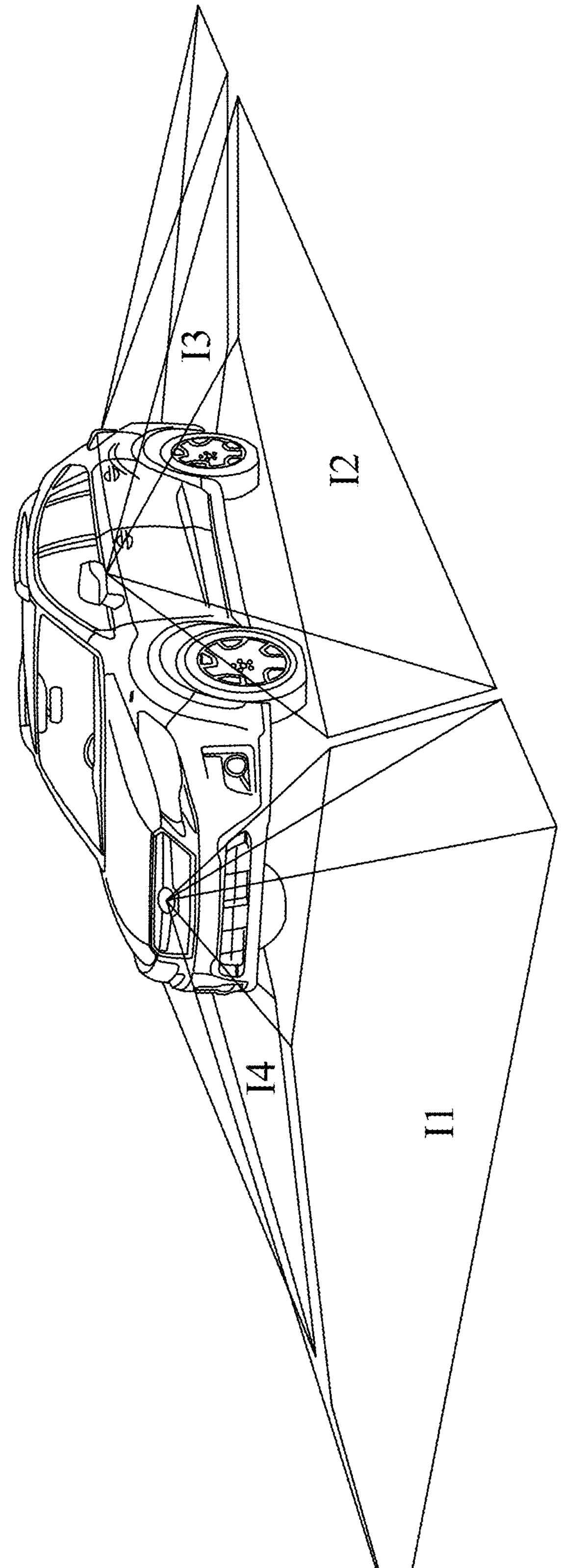


Fig. 10C

LIGHT-FOLDED CAMERA MODULE AND ELECTRONIC DEVICE

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Ser. No. 63/555,469, filed Feb. 20, 2024, which is herein incorporated by reference.

BACKGROUND

Technical Field

[0002] The present disclosure relates to a light-folded camera module. More particularly, the present disclosure relates to a light-folded camera module applicable to portable electronic devices.

Description of Related Art

[0003] In recent years, portable electronic devices have developed rapidly. For example, intelligent electronic devices and tablets have been filled in the lives of modern people, and camera modules mounted on portable electronic devices have also prospered. However, as technology advances, the quality requirements of the camera module are becoming higher and higher. Therefore, a camera module, which can improve the image quality, needs to be developed.

SUMMARY

[0004] According to one aspect of the present disclosure, a light-folded camera module has an incident axis and an exiting axis, and includes a fixing carrier, a reflecting element, a first lens assembly, a second lens assembly and an image sensor. The reflecting element is for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis. The reflecting element is fixed on the fixing carrier, and the reflecting element includes an incident surface and an exiting surface. The second lens assembly is for providing an optical refractive power of the light-folded camera module along with the first lens assembly. The first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially. The image sensor is for receiving the imaging light of the light-folded camera module. The image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis. The second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element. The light-folded camera module further includes a focus driving device, the focus driving device includes a fixed component, a movable component and a spherical element. The first lens assembly is disposed on the movable component. The spherical element is disposed between the fixed component and the movable component, so that a degrees of freedom and a driving force for the first lens assembly to be moved along a direction parallel to the incident axis are provided. When a longest driving distance range of the first lens assembly from the focus driving device is Dim, a height of the reflecting element along the direction parallel to the incident axis is H, and a distance between a center of an image-side surface of the second lens assembly and a center of the image sensor along the direction parallel to the incident axis is Lf, the following conditions are satisfied: $0.8\ \text{mm}<\text{Dim}<3.9\ \text{mm}$; and $0\leq\text{Lf}<\text{H}$.

[0005] According to another aspect of the present disclosure, an electronic device includes the light-folded camera module of the aforementioned aspect.

[0006] According to another aspect of the present disclosure, a light-folded camera module has an incident axis and an exiting axis, and includes a fixing carrier, a reflecting element, a first lens assembly, a second lens assembly and an image sensor. The reflecting element is for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis. The reflecting element is fixed on the fixing carrier, and the reflecting element includes an incident surface and an exiting surface. The second lens assembly is for providing an optical refractive power of the light-folded camera module along with the first lens assembly. The first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially. The image sensor is for receiving the imaging light of the light-folded camera module. The image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis. The second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element. The light-folded camera module further includes a focus driving device, the focus driving device includes a fixed component, a movable component and a spherical element. The first lens assembly is disposed on the movable component. The spherical element is disposed between the fixed component and the movable component, so that a degrees of freedom and a driving force for the first lens assembly to be moved along a direction parallel to the incident axis are provided. When a perpendicular distance between a center of the image sensor and the incident axis is S, a height of the reflecting element along the direction parallel to the incident axis is H, and a distance between a center of an image-side surface of the second lens assembly and the center of the image sensor along the direction parallel to the incident axis is Lf, the following conditions are satisfied: $4.5\ \text{mm}<\text{S}<20\ \text{mm}$; and $0\leq\text{Lf}<\text{H}$.

[0007] According to another aspect of the present disclosure, a light-folded camera module has an incident axis and an exiting axis, and includes a fixing carrier, a reflecting element, a first lens assembly, a second lens assembly and an image sensor. The reflecting element is for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis. The reflecting element is fixed on the fixing carrier, and the reflecting element includes an incident surface and an exiting surface. The second lens assembly is for providing an optical refractive power of the light-folded camera module along with the first lens assembly. The first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially. The image sensor is for receiving the imaging light of the light-folded camera module. The image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis. The second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element. The light-folded camera module further includes a focus driving device and an image stabilizing device, the focus driving device is for providing a driving force for the first lens assembly to be moved along a direction parallel to the incident axis, the image stabilizing device is for providing another driving force for the image sensor to be moved within a plane perpendicular to the exiting axis. When a height of the reflecting element along the direction parallel to the incident axis is H, and a distance between a center of an image-side surface of the second lens assembly and a center of the image sensor along the direction parallel to the incident axis is Lf, the following condition is satisfied: $0 \leq Lf < H$.

[0008] According to another aspect of the present disclosure, an electronic device includes the light-folded camera module of the aforementioned aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present disclosure can be more fully understood by reading the following detailed description of the embodiment, with reference made to the accompanying drawings as follows:

[0010] FIG. **1**A is a three-dimensional schematic view of a light-folded camera module according to the 1st embodiment of the present disclosure.

[0011] FIG. **1**B is an exploded view of the light-folded camera module according to the 1st embodiment of FIG. **1**A.

[0012] FIG. **1**C is an exploded view of the three-dimensional image stabilizing device and the image sensor of the light-folded camera module according to the 1st embodiment of FIG. **1**B.

[0013] FIG. **1**D is another exploded view of the light-folded camera module according to the 1st embodiment of FIG. **1**A.

[0014] FIG. **1**E is an exploded view of the three-dimensional image stabilizing device and the image sensor of the light-folded camera module according to the 1st embodiment of FIG. **1**D.

[0015] FIG. **1**F is a cross-sectional view of the light-folded camera module according to the 1st embodiment of FIG. **1**A.

[0016] FIG. **1**G is a schematic view of the first lens assembly of the light-folded camera module according to a 1st example of the 1st embodiment of FIG. **1**F, while the first lens assembly moves along a direction parallel to the incident axis.

[0017] FIG. **1**H is a schematic view of the reflecting element of the light-folded camera module according to the 1st example of the 1st embodiment of FIG. **1**B.

[0018] FIG. **1**I is another schematic view of the reflecting element of the light-folded camera module according to the 1st example of the 1st embodiment of FIG. **1**D.

[0019] FIG. **2** is a schematic view of the first lens assembly of the light-folded camera module according to a 2nd example of the 1st embodiment of FIG. **1**F, while the first lens assembly moves along a direction parallel to the incident axis.

[0020] FIG. **3** is a schematic view of the first lens assembly of the light-folded camera module according to a 3rd example of the 1st embodiment of FIG. **1**F, while the first lens assembly moves along a direction parallel to the incident axis.

[0021] FIG. **4** is a schematic view of the first lens assembly of the light-folded camera module according to a 4th example of the 1st embodiment of FIG. **1**F, while the first lens assembly moves along a direction parallel to the incident axis.

[0022] FIG. **5** is a schematic view of the first lens assembly of the light-folded camera module according to a 5th example of the 1st embodiment of FIG. **1**F, while the first lens assembly moves along a direction parallel to the incident axis.

[0023] FIG. **6** is a schematic view of the first lens assembly of the light-folded camera module according to a 6th example of the 1st embodiment of FIG. **1**F, while the first lens assembly moves along a direction parallel to the incident axis.

[0024] FIG. **7**A is a three-dimensional schematic view of a light-folded camera module according to the 2nd embodiment of the present disclosure.

[0025] FIG. **7**B is an exploded view of the two-dimensional image stabilizing device and the image sensor of the light-folded camera module according to the 2nd embodiment of FIG. **7**A.

[0026] FIG. **7**C is another exploded view of the two-dimensional image stabilizing device and the image sensor of the light-folded camera module according to the 2nd embodiment of FIG. **7**A.

[0027] FIG. **7**D is a schematic view of the reflecting element of the light-folded camera module according to the 2nd embodiment of FIG. **7**A.

[0028] FIG. **7**E is another schematic view of the reflecting element of the light-folded camera module according to the 2nd embodiment of FIG. **7**A.

[0029] FIG. **8**A is a schematic view of an electronic device according to the 3rd embodiment of the present disclosure.

[0030] FIG. **8**B is another schematic view of the electronic device according to the 3rd embodiment of FIG. **8**A.

[0031] FIG. **8**C is a schematic view of an image captured via the ultra-wide-angle camera module of the electronic device according to the 3rd embodiment of FIG. **8**B.

[0032] FIG. **8**D is another schematic view of the image captured via the high-pixel camera module of the electronic device according to the 3rd embodiment of FIG. **8**A.

[0033] FIG. **8**E is the other schematic view of the image captured via the telephoto camera module of the electronic device according to the 3rd embodiment of FIG. **8**B.

[0034] FIG. **9** is a schematic view of an electronic device according to the 4th embodiment of the present disclosure.

[0035] FIG. **10**A is a schematic view of a light-folded camera module applied to a vehicle instrument according to the 5th embodiment of the present disclosure.

[0036] FIG. **10**B is a schematic view of the light-folded camera module configured in the vehicle instrument according to the 5th embodiment in FIG. **10**A.

[0037] FIG. **10**C is another schematic view of the light-folded camera module configured in the vehicle instrument according to the 5th embodiment in FIG. **10**A.

DETAILED DESCRIPTION

[0038] The present disclosure provides a light-folded camera module having an incident axis and an exiting axis, and including a fixing carrier, a reflecting element, a first lens assembly, a second lens assembly and an image sensor. The reflecting element is for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis. The reflecting element is fixed on the fixing carrier, and the reflecting element includes an incident surface and an exiting surface. The second lens assembly is for providing an optical refractive power of the light-folded camera module along with the first lens assembly. The first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially. The image sensor is for receiving the imaging light of the light-folded camera module. The image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis. The second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element. The light-folded camera module further includes a focus driving device, the focus driving device includes a fixed component, a movable component and a spherical element. The first lens assembly is disposed on the movable component. The spherical element is disposed between the fixed component and the movable component, so that a degrees of freedom and a driving force for the first lens assembly to be moved along a direction parallel to the incident axis are provided. When a longest driving distance range of the first lens assembly from the focus driving device is Dim, a height of the reflecting element along the direction parallel to the incident axis is H, and a distance between a center of an image-side surface of the second lens assembly and a center of the image sensor along the direction parallel to the incident axis is Lf, the following conditions are satisfied: 0.8 mm<Dim<3.9 mm; and 0≤Lf<H. The present disclosure provides a light-folded camera module with compact size by a mechanism configuration, which can fold the entire light path more than 90 degrees, and the grouping lens assemblies can focus inside an enough space. It is favorable for reducing the bearing load of the focus driving device, providing a focus driving device consuming lower electricity, with high controlling precision, and providing a feasibility of the inner focus lens assemblies to drive in long-driving-path by fixing the reflecting element and a part of the lens assemblies, and only focusing by another part of the lens assemblies. Moreover, it is favorable for reducing the physical back focal space of the light-folded camera module of the present disclosure.

[0039] In detail, the incident surface and the exiting surface of the reflecting element can be coplanar, but the present disclosure is not limited thereto. The longest driving distance range of the first lens assembly represents a displacement between a position of the first lens assembly when the light-folded camera module focuses at infinity and a position of the first lens assembly when the light-folded camera module focuses at a minimum object-distance. The minimum object-distance of the light-folded camera module can be other values, and is depended on an optical specification design value of the light-folded camera module, but the value in the present disclosure is not limited thereto. Further, the measurement of the distance is a non-negative scalar, and the distance between two points can be zero when the measuring positions of the two points are on a same reference positon. Therefore, it is favorable for providing a sufficient space for group focusing by reducing the total height of the light-folded camera module of the present disclosure.

[0040] When the longest driving distance range of the first lens assembly from the focus driving device is Dim, the following condition is satisfied: 0.9 mm<Dim<3.2 mm. Thus, it is favorable for obtaining higher image quality at both of distance shooting and close up shooting.

[0041] Furthermore, the following condition is satisfied: 1.0 mm<Dim<2.6 mm. Therefore, it is favorable for reducing the sensitivity of the assembling tolerance, and ensuring high image quality while the light-folded camera module is focusing.

[0042] When a perpendicular distance between the center of the image sensor and the incident axis is S, the following condition is satisfied: 4.5 mm<S<20 mm. Thus, it is favorable for achieving an optical design project of the telephoto imaging system in the limited geometrical space. Moreover, the following condition is satisfied: 6.0 mm<S<17 mm. Therefore, it is favorable for preventing the image sensor from impacting with the lens assemblies and the focus driving device while assembling so as to increase the assembling efficiency.

[0043] The reflecting element is made of plastic, and has at least one gate trace. Thus, it is favorable for increasing the manufacturing precision and the mass production efficiency.

[0044] The reflecting element includes at least two reflecting surfaces. Therefore, it is favorable for providing a larger folded angle for the reflecting element.

[0045] A number of the at least two reflecting surfaces is an odd number. Thus, it is favorable for providing the reflecting element with compact size. Moreover, the reflecting surface of the reflecting element and the incident surface can be coplanar, the reflecting surface and the exiting surface can be coplanar or the reflecting surface can be an independent surface, but the present disclosure is not limited thereto.

[0046] The first lens assembly includes at least one glass lens element and at least one plastic lens element. Therefore, it is favorable for increasing the environment tolerance and providing stable optical quality.

[0047] When a distance between a center of an object-side surface of the second lens assembly and the center of the image sensor along the direction parallel to the incident axis is Ls, and a distance between the center of the object-side surface of the second lens assembly and a position where the exiting axis passes through the exiting surface of the reflecting element along the direction parallel to the incident axis is Le, the following condition is satisfied: 0≤Ls<Le. Thus, it is favorable for reducing physical space of the back focal telephoto camera module, and providing a miniaturized optical system configuration.

[0048] The light-folded camera module can further include a two-dimensional image stabilizing device. The two-dimensional image stabilizing device is for providing a driving force for the image sensor to be moved within a plane perpendicular to the exiting axis. Therefore, it is favorable for obtaining the optical image stabilization of the light-folded camera module.

[0049] The light-folded camera module can further include a three-dimensional image stabilizing device. The three-dimensional image stabilizing device is for providing a driving force for the image sensor to be moved within a three-dimensional space. Thus, it is favorable for obtaining the optical image stabilization of the light-folded camera module. In detail, the image stabilizing device can provide a preloading force and the degrees of freedom for the image sensor via a spherical element or an elastic element, but the present disclosure is not limited thereto.

[0050] The present disclosure provides a light-folded camera module having an incident axis and an exiting axis, and including a fixing carrier, a reflecting element, a first lens assembly, a second lens assembly and an image sensor. The reflecting element is for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis. The reflecting element is fixed on the fixing carrier, and the reflecting element includes an incident surface and an exiting surface. The second lens assembly is for providing an optical refractive power of the light-folded camera module along with the first lens assembly. The first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially. The image sensor is for receiving the imaging light of the light-folded camera module. The image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis. The second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element. The light-folded camera module further includes a focus driving device, the focus driving device includes a fixed component, a movable component and a spherical element. The first lens assembly is disposed on the movable component. The spherical element is disposed between the fixed component and the movable component, so that a degrees of freedom and a driving force for the first lens assembly to be moved along a direction parallel to the incident axis are provided. When a perpendicular distance between a center of the image sensor and the incident axis is S, a height of the reflecting element along the direction parallel to the incident axis is H, and a distance between a center of an image-side surface of the second lens assembly and the center of the image sensor along the direction parallel to the incident axis is Lf, the following conditions are satisfied: 4.5 mm<S<20 mm; and 0≤Lf<H.

[0051] When the perpendicular distance between the center of the image sensor and the incident axis is S, the following condition is satisfied: 6.0 mm<S<17 mm. Thus, it is favorable for preventing the image sensor from impacting with the lens assemblies and the focus driving device while assembling so as to increase the assembling efficiency.

[0052] The reflecting element includes at least two reflecting surfaces. Therefore, it is favorable for providing a larger folded angle for the reflecting element.

[0053] A number of the at least two reflecting surfaces is an odd number. Thus, it is favorable for providing the reflecting element with compact size.

[0054] The first lens assembly includes at least one glass lens element and at least one plastic lens element. Therefore, it is favorable for increasing the environment tolerance and providing stable optical quality.

[0055] The reflecting element is made of plastic, and has at least one gate trace. Thus, it is favorable for increasing the manufacturing precision and the mass production efficiency.

[0056] The light-folded camera module can further include a two-dimensional image stabilizing device. The two-dimensional image stabilizing device is for providing a driving force for the image sensor to be moved within a plane perpendicular to the exiting axis. Therefore, it is favorable for obtaining the optical image stabilization of the light-folded camera module.

[0057] The light-folded camera module can further include a three-dimensional image stabilizing device. The three-dimensional image stabilizing device is for providing a driving force for the image sensor to be moved within a three-dimensional space. Thus, it is favorable for obtaining the optical image stabilization of the light-folded camera module.

[0058] The present disclosure provides a light-folded camera module having an incident axis and an exiting axis, and including a fixing carrier, a reflecting element, a first lens assembly, a second lens assembly and an image sensor. The reflecting element is for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis. The reflecting element is fixed on the fixing carrier, and the reflecting element includes an incident surface and an exiting surface. The second lens assembly is for providing an optical refractive power of the light-folded camera module along with the first lens assembly. The first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially. The image sensor is for receiving the imaging light of the light-folded camera module. The image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis. The second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element. The light-folded camera module further includes a focus driving device and an image stabilizing device, the focus driving device is for providing a driving force for the first lens assembly to be moved along a direction parallel to the incident axis, the image stabilizing device is for providing another driving force for the image sensor to be moved within a plane perpendicular to the exiting axis. When a height of the reflecting element along the direction parallel to the incident axis is H, and a distance between a center of an image-side surface of the second lens assembly and a center of the image sensor along the direction parallel to the incident axis is Lf, the following condition is satisfied: 0≤Lf<H.

[0059] The reflecting element further includes at least two reflecting surfaces. Therefore, it is favorable for providing a larger folded angle for the reflecting element.

[0060] A number of the at least two reflecting surfaces is an odd number. Thus, it is favorable for providing the reflecting element with compact size.

[0061] The reflecting element is made of plastic, and has at least one gate trace. Therefore, it is favorable for increasing the manufacturing precision and the mass production efficiency.

[0062] When a distance between a center of an object-side surface of the second lens assembly and the center of the image sensor along the direction parallel to the incident axis is Ls, and a distance between the center of the object-side surface of the second lens assembly and a position where the exiting axis passes through the exiting surface of the reflecting element along the direction parallel to the incident axis is Le, the following condition is satisfied: 0≤Ls<Le. Thus, it is favorable for reducing a physical space of the back focal telephoto camera module, and providing a miniaturized optical system configuration.

[0063] Each of the aforementioned features of the imaging lens assembly can be utilized in various combinations for achieving the corresponding effects.

[0064] The present disclosure provides an electronic device. The electronic device includes the aforementioned light-folded camera module.

[0065] According to the aforementioned embodiment, specific embodiments and examples are provided, and illustrated via figures.

1st Embodiment

[0066] Please refer to FIG. **1**A, FIG. **1**B, FIG. **1**C, FIG. **1**D and FIG. **1**E. FIG. **1**A is a three-dimensional schematic view of a light-folded camera module **100** according to the 1st embodiment of the present disclosure. FIG. **1**B is an exploded view of the light-folded camera module **100**

according to the 1st embodiment of FIG. **1**A. FIG. **1**C is an exploded view of the three-dimensional image stabilizing device **180** and the image sensor **150** of the light-folded camera module **100** according to the 1st embodiment of FIG. **1**B. FIG. **1**D is another exploded view of the light-folded camera module **100** according to the 1st embodiment of FIG. **1**A. FIG. **1**E is an exploded view of the three-dimensional image stabilizing device **180** and the image sensor **150** of the light-folded camera module **100** according to the 1st embodiment of FIG. **1**D. The light-folded camera module **100** has an incident axis x and an exiting axis y, and includes a fixing carrier **110**, a reflecting element **120**, a first lens assembly **130**, a second lens assembly **140**, an image sensor **150**, a focus driving device **160**, an assembly fixing element **170** and a three-dimensional image stabilizing device **180**. The reflecting element **120** is for folding an imaging light of the light-folded camera module **100** from the incident axis x to the exiting axis y.

[0067] The reflecting element **120** is fixed on the fixing carrier **110**, and the reflecting element **120** includes an incident surface **121** and an exiting surface **122**. The second lens assembly **140** is for providing an optical refractive power of the light-folded camera module **100** along with the first lens assembly **130**. The first lens assembly **130**, the second lens assembly **140** and the incident surface **121** of the reflecting element **120** are disposed along the incident axis x sequentially. The image sensor **150** is for receiving the imaging light of the light-folded camera module **100**. The image sensor **150** is disposed relative to the exiting surface **122** of the reflecting element **120** along the exiting axis y. The second lens assembly **140** is fixed in the fixing carrier **110**, so that there is no relative displacement between the second lens assembly **140** and the reflecting element **120**. The focus driving device **160** includes a fixed component **161**, a spherical element **162** and a movable component **163**. The first lens assembly **130** is disposed on the movable component **163**. The spherical element **162** is disposed between the fixed component **161** and the movable component **163**, so that a degrees of freedom and a driving force for the first lens assembly **130** to be moved along a direction parallel to the incident axis x are provided.

[0068] Thus, it is favorable for the grouping lens assemblies of the light-folded camera module **100** in the 1st embodiment of the present disclosure to focus inside an enough space by folding the entire light path more than 90 degrees. Moreover, it is favorable for reducing the bearing load of the focus driving device **160** and providing a focus driving device **160** consuming lower electricity, with high controlling precision, and providing a feasibility of the inner focus lens assemblies to drive in long-driving-path by fixing the reflecting element **120** and a part of the lens assemblies (i.e., the second lens assembly **140**), and only focusing by another part of the lens assemblies (i.e., the first lens assembly **130**).

[0069] In FIG. **1**B to FIG. **1**E, the three-dimensional image stabilizing device **180** is for providing a driving force for the image sensor **150** to be moved within a three-dimensional space. Specifically, the three-dimensional image stabilizing device **180** includes a base **181**, a first direction guiding member **182**, a second direction guiding member **183**, a third direction guiding member **184** and a plurality of spherical elements **185**. The first direction guiding member **182**, the second direction guiding member **183** and the third direction guiding member **184** are stacked in the base **181** sequentially, and the image sensor **150** is connected to the third direction guiding member **184**. The spherical elements **185** are disposed in the base **181**, the first direction guiding member **182**, the second direction guiding member **183** and the third direction guiding member **184**, respectively, so that the image sensor **150** can be displaced within a three-dimensional space, but the present disclosure is not limited thereto. In other embodiments, the spherical elements **185** can be replaced by elastic element to provide the preloading force and the degrees of freedom for the image sensor **150**, but the present disclosure is not limited thereto.

[0070] Please refer to FIG. **1**F and FIG. **1**G. FIG. **1**F is a cross-sectional view of the light-folded camera module **100** according to the 1st embodiment of FIG. **1**A. FIG. **1**G is a schematic view of the first lens assembly **130** of the light-folded camera module **100** according to a 1st example of the 1st embodiment of FIG. **1**F, while the first lens assembly **130** moves along a direction parallel to the incident axis x. In FIG. **1**F, the first lens assembly **130** can include two lens elements **131**, **132**. The two lens elements **131**, **132** include a glass lens element and a plastic lens element. Thus, it is favorable for increasing the environment tolerance and providing stable optical quality. Moreover, the assembly fixing element **170** positions the reflecting element **120** in the fixing carrier **110** along a direction toward to the fixing carrier **110**, and two sidewalls **171** of the assembly fixing element **170** are located between the fixing carrier **110** and the reflecting element **120**. Therefore, it is favorable for increasing the assembling stability.

[0071] An upper part of FIG. **1**G shows a positional relationship between the first lens assembly **130** and the focus driving device **160** when the light-folded camera module **100** focuses at infinity. A lower part of FIG. **1**G shows a positional relationship between the first lens assembly **130** and the focus driving device **160** when the light-folded camera module **100** focuses at a minimum object-distance. A longest driving distance range of the first lens assembly **130** from the focus driving device **160** is Dim. A height of the reflecting element **120** along the direction parallel to the incident axis x is H. A distance between a center of an image-side surface of the second lens assembly **140** and a center of the image sensor **150** along the direction parallel to the incident axis x is Lf.

[0072] The longest driving distance range Dim of the first lens assembly **130** represents a displacement between a position of the first lens assembly **130** when the light-folded camera module **100** focuses at infinity and a position of the first lens assembly **130** when the light-folded camera module **100** focuses at a minimum object-distance. The minimum object-distance of the light-folded camera module **100** can be other values, and is depended on an optical specification design value of the light-folded camera module **100**, and the value in the present disclosure is not limited thereto. Further, the measurement of the distance is a non-negative scalar, and the distance between two points can be zero when the measuring positions of the two points are on a same reference positon.

[0073] A distance between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at infinity is shorter than a distance between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at the minimum object-distance. Therefore, it is favorable for providing a sufficient space for group focusing by reducing the total height of the light-folded camera module **100** of the present disclosure.

[0074] A perpendicular distance between a center of the image sensor **150** and the incident axis x is S. Thus, it is favorable for achieving an optical design project of the telephoto imaging system in the limited geometrical space.

[0075] A distance between a center of an object-side surface of the second lens assembly **140** and a center of the image sensor **150** along the direction parallel to the incident axis x is Ls. A distance between a center of an object-side surface of the second lens assembly **140** and a position where the exiting axis x passes through the exiting surface **122** of the reflecting element **120** along the direction parallel to the incident axis x is Le. Therefore, it is favorable for reducing the physical space of the back focal telephoto light-folded camera module **100**, and providing a miniaturized optical system configuration.

[0076] In FIG. **1**G, in the 1st example of the 1st embodiment, when the height of the reflecting element **120** along the direction parallel to the incident axis x is H, the longest driving distance range of the first lens assembly **130** from the focus driving device **160** is Dim, the distance between the center of the image-side surface of the second lens assembly **140** and the center of the image sensor **150** along the direction parallel to the incident axis x is Lf, the distance between the center of the object-side surface of the second lens assembly **140** and the position where the exiting axis x passes through the exiting surface **122** of the reflecting element **120** along the direction parallel to the incident axis x is Le, the distance between the center of the object-side surface of the second lens assembly **140** and the center of the image sensor **150** along the direction parallel to the incident axis x is Ls, and the perpendicular distance between the center of the image sensor **150** and the incident axis x is S, the values thereof are listed in Table 1 as follow.

TABLE 1

1st example of the 1st embodiment			
H (mm)	2.7	Dim (mm)	1.61
Lf (mm)	0.492	Le (mm)	3.12
Ls (mm)	2	S (mm)	8.291

[0077] Please refer to FIG. **1**H and FIG. **1**I. FIG. **1**H is a schematic view of the reflecting element **120** of the light-folded camera module **100** according to the 1st example of the 1st embodiment of FIG. **1**B. FIG. **1**I is another schematic view of the reflecting element **120** of the light-folded camera module **100** according to the 1st example of the 1st embodiment of FIG. **1**D. In detail, the incident surface **121** and the exiting surface **122** of the reflecting element **120** can be coplanar, but the present disclosure is not limited thereto. The reflecting element **120** is made of plastic, and has at least one gate trace **126**. Further, the reflecting element **120** includes a plurality of reflecting surfaces **123**, **124**, **125**, the imaging light is folded by the reflecting surfaces **123**, **125**, **124** in sequence, and reaches to the image sensor **150**. A number of the reflecting surfaces **123**, **124**, **125** is an odd number. Furthermore, the reflecting surface **125** of the reflecting element **120** and the incident surface **121** can be coplanar, the reflecting surface **125** and the exiting surface **122** can be coplanar or the reflecting surface **125** can be an independent surface, but the present disclosure is not limited thereto.

[0078] Please refer to FIG. **2**. FIG. **2** is a schematic view of the first lens assembly **130** of the light-folded camera module **100** according to a 2nd example of the 1st embodiment of FIG. **1**F, while the first lens assembly **130** moves along a direction parallel to the incident axis x. In FIG. **2**, the difference between the 2nd example of the 1st embodiment and the 1st example of the 1st embodiment of the present disclosure is the shape of the reflecting element **120** in the 1st example and the shape of the reflecting element **120***a* in the 2nd example, other structures and features can be the same or similar to the 1st example, and will not be described again. Specifically, the reflecting element **120***a* includes two reflecting surfaces **123**, **124**. The imaging light is folded by the reflecting surfaces **123**, **124** in order, and reaches to the image sensor **150**.

[0079] An upper part of FIG. **2** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at infinity. A lower part of FIG. **2** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at a minimum object-distance. In FIG. **2**, in the 2nd example of the 1st embodiment, a height of the reflecting element **120***a* along the direction parallel to the incident axis x is H, a longest driving distance range of the first lens assembly **130** from the focus driving device **160** is Dim, a distance between a center of an image-side surface of the second lens assembly **140** and a center of the image sensor **150** along the direction parallel to the incident axis x is Lf, a distance between a center of an object-side surface of the second lens assembly **140** and a position where the exiting axis x passes through the exiting surface **122** of the reflecting element **120***a* along the direction parallel to the incident axis x is Le, a distance between the center of the object-side surface of the second lens assembly **140** and the center of the image sensor **150** along the direction parallel to the incident axis x is Ls, a perpendicular distance between the center of the image sensor **150** and the incident axis x is S, the values thereof are listed in Table 2 as follow.

TABLE 2

2nd example of the 1st embodiment			
H (mm)	4.753	Dim (mm)	1.53
Lf (mm)	0.433	Le (mm)	2.8
Ls (mm)	1.825	S (mm)	8.291

[0080] Please refer to FIG. **3**. FIG. **3** is a schematic view of the first lens assembly **130** of the light-folded camera module **100** according to a 3rd example of the 1st embodiment of FIG. **1**F, while the first lens assembly **130** moves along a direction parallel to the incident axis x. In FIG. **3**, the difference between the 3rd example of the 1st embodiment and the 1st example of the 1st embodiment of the present disclosure is the shape of the reflecting element **120** in the 1st example and the shape of the reflecting element **120***b* in the 3rd example, other structures and features can be the same or similar to the 1st example, and will not be described again. Specifically, the reflecting element **120***b* includes two reflecting surfaces **123**, **124**. The imaging light is folded by the reflecting surfaces **123**, **124** in order, and reaches to the image sensor **150**.

[0081] An upper part of FIG. **3** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at infinity. A lower part of FIG. **3** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at a minimum object-distance. In FIG. **3**, in the 3rd example of the 1st embodiment, a height of the reflecting element **120***b* along the direction parallel to the incident axis x is H, a longest driving distance range of the first lens assembly **130** from the focus driving device **160** is Dim, a distance between a center of an image-side surface of the second lens assembly **140** and a center of the image sensor **150** along the direction parallel to the incident axis x is Lf, a distance between a center of an object-side surface of the second lens assembly **140** and a position where the exiting axis x passes through the exiting surface **122** of the reflecting element **120***b* along the direction parallel to the incident axis x is Le, a distance between the center of the object-side surface of the second lens assembly **140** and the center of the image sensor **150** along the direction parallel to the incident axis x is Ls, a perpendicular distance between the center of the image sensor **150** and the incident axis x is S, the values thereof are listed in Table 3 as follow.

TABLE 3

3rd example of the 1st embodiment			
H (mm)	6.093	Dim (mm)	1.05
Lf (mm)	1.955	Le (mm)	0.199
Ls (mm)	0.224	S (mm)	7.009

[0082] Please refer to FIG. **4**. FIG. **4** is a schematic view of the first lens assembly **130** of the light-folded camera module **100** according to a 4th example of the 1st embodiment of FIG. **1**F, while the first lens assembly **130** moves along a direction parallel to the incident axis x. In FIG. **4**, the difference between the 4th example of the 1st embodiment and the 1st example of the 1st embodiment of the present disclosure is the shape of the reflecting element **120** in the 1st example and the shape of the reflecting element **120***c* in the 4th example, other structures and features can be the same or similar to the 1st example, and will not be described again. Specifically, the reflecting element **120***c* includes two reflecting surfaces **123**, **124**. The imaging light is folded by the reflecting surfaces **123**, **124** in order, and reaches to the image sensor **150**.

[0083] An upper part of FIG. **4** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at infinity. A lower part of FIG. **4** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at a minimum object-distance. In FIG. **4**, in the 4th example of the 1st embodiment, a height of the reflecting element **120***c* along the direction parallel to the incident axis x is H, a longest driving distance range of the first lens assembly **130** from the focus driving device **160** is Dim, a distance between a center of an image-side surface of the second lens assembly **140** and a center of the image sensor **150** along the direction parallel to the incident axis x is Lf, a distance between a center of an object-side surface of the second lens assembly **140** and a position where the exiting axis x passes through the exiting surface **122** of the reflecting element **120***c* along the direction parallel to the incident axis x is Le, a distance between the center of the object-side surface of the second lens assembly **140** and the center of the image sensor **150** along the direction parallel to the incident axis x is Ls, a perpendicular distance between the center of the image sensor **150** and the incident axis x is S, the values thereof are listed in Table 4 as follow.

TABLE 4

4th example of the 1st embodiment			
H (mm)	6.412	Dim (mm)	1.75
Lf (mm)	0.955	Le (mm)	2.194
Ls (mm)	1.303	S (mm)	8.33

[0084] Please refer to FIG. **5**. FIG. **5** is a schematic view of the first lens assembly **130** of the light-folded camera module **100** according to a 5th example of the 1st embodiment of FIG. **1**F, while the first lens assembly **130** moves along a direction parallel to the incident axis x. In FIG. **5**, the difference between the 5th example of the 1st embodiment and the 1st example of the 1st embodiment of the present disclosure is the shape of the reflecting element **120** in the 1st example and the shape of the reflecting element **120***d* in the 5th example, other structures and features can be the same or similar to the 1st example, and will not be described again. Specifically, the reflecting element **120***d* includes three reflecting surfaces **123**, **124**, **125**. The imaging light is folded by the reflecting surfaces **123**, **125**, **124** in order, and reaches to the image sensor **150**.

[0085] An upper part of FIG. **5** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at infinity. A lower part of FIG. **5** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at a minimum object-distance. In FIG. **5**, in the 5th example of the 1st embodiment, a height of the reflecting element **120***d* along the direction parallel to the incident axis x is H, a longest driving distance range of the first lens assembly **130** from the focus driving device **160** is Dim, a distance between a center of an image-side surface of the second lens assembly **140** and a center of the image sensor **150** along the direction parallel to the incident axis x is Lf, a distance between a center of an object-side surface of the second lens assembly **140** and a position where the exiting axis x passes through the exiting surface **122** of the reflecting element **120***d* along the direction parallel to the incident axis x is Le, a distance between the center of the object-side surface of the second lens assembly **140** and the center of the image sensor **150** along the direction parallel to the incident axis x is Ls, a perpendicular distance between the center of the image sensor **150** and the incident axis x is S, the values thereof are listed in Table 5 as follow.

TABLE 5

5th example of the 1st embodiment			
H (mm)	4.593	Dim (mm)	2.18
Lf (mm)	2.498	Le (mm)	5.874
Ls (mm)	4.99	S (mm)	8.047

[0086] Please refer to FIG. **6**. FIG. **6** is a schematic view of the first lens assembly **130** of the light-folded camera module **100** according to a 6th example of the 1st embodiment of FIG. **1**F, while the first lens assembly **130** moves along a direction parallel to the incident axis x. In FIG. **6**, the difference between the 6th example of the 1st embodiment and the 1st example of the 1st embodiment of the present disclosure is the shape of the reflecting element **120** in the 1st example and the shape of the reflecting element **120*e*** in the 6th example, other structures and features can be the same or similar to the 1st example, and will not be described again. Specifically, the reflecting element **120*e*** includes five reflecting surfaces **123**, **124**, **125**, **127**, **128**. The imaging light is folded by the reflecting surfaces **123**, **125**, **127**, **128**, **124** in order, and reaches to the image sensor **150**.

[0087] An upper part of FIG. **6** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at infinity. A lower part of FIG. **6** shows a positional relationship between the first lens assembly **130** and the second lens assembly **140** when the light-folded camera module **100** focuses at a minimum object-distance. In FIG. **6**, in the 5th example of the 1st embodiment, a height of the reflecting element **120*e*** along the direction parallel to the incident axis x is H, a longest driving distance range of the first lens assembly **130** from the focus driving device **160** is Dim, a distance between a center of an image-side surface of the second lens assembly **140** and a center of the image sensor **150** along the direction parallel to the incident axis x is Lf, a distance between a center of an object-side surface of the second lens assembly **140** and a position where the exiting axis x passes through the exiting surface **122** of the reflecting element **120*e*** along the direction parallel to the incident axis x is Le, a distance between the center of the object-side surface of the second lens assembly **140** and the center of the image sensor **150** along the direction parallel to the incident axis x is Ls, a perpendicular distance between the center of the image sensor **150** and the incident axis x is S, the values thereof are listed in Table 6 as follow.

TABLE 6

6th example of the 1st embodiment			
H (mm)	2.724	Dim (mm)	1.95
Lf (mm)	0.648	Le (mm)	2.582
Ls (mm)	1.531	S (mm)	11.894

2nd Embodiment

[0088] Please refer to FIG. **7**A to FIG. **7**E. FIG. **7**A is a three-dimensional schematic view of a light-folded camera module **200** according to the 2nd embodiment of the present disclosure. FIG. **7**B is an exploded view of the two-dimensional image stabilizing device **280** and the image sensor **250** of the light-folded camera module **200** according to the 2nd embodiment of FIG. **7**A. FIG. **7**C is another exploded view of the two-dimensional image stabilizing device **280** and the image sensor **250** of the light-folded camera module **200** according to the 2nd embodiment of FIG. **7**A. FIG. **7**D is a schematic view of the reflecting element **220** of the light-folded camera module **200** according to the 2nd embodiment of FIG. **7**A. FIG. **7**E is another schematic view of the reflecting element **220** of the light-folded camera module **200** according to the 2nd embodiment of FIG. **7**A. The light-folded camera module **200** has an incident axis and an exiting axis, and includes a fixing carrier **210**, a reflecting element **220**, a first lens assembly **230**, a second lens assembly **240**, an image sensor **250**, a focus driving device **260** and a two-dimensional image stabilizing device **280**. The reflecting element **220** is for folding an imaging light of the light-folded camera module **200** from the incident axis to the exiting axis.

[0089] The reflecting element **220** is fixed on the fixing carrier **210**, and the reflecting element **220** includes an incident surface **221** and an exiting surface **222**. The second lens assembly **240** is for providing an optical refractive power of the light-folded camera module **200** along with the first lens assembly **230**. The first lens assembly **230**, the second lens assembly **240** and the incident surface **221** of the reflecting element **220** are disposed along the incident axis sequentially. The image sensor **250** is for receiving the imaging light of the light-folded camera module **200**. The image sensor **250** is disposed relative to the exiting surface **222** of the reflecting element **220** along the exiting axis. The second lens assembly **240** is fixed in the fixing carrier **210**, so that there is no relative displacement between the second lens assembly **240** and the reflecting element **220**. The focus driving device **260** includes a fixed component, a movable component and a spherical element. The first lens assembly **230** is disposed on the movable component. The spherical element is disposed between the fixed component and the movable component, so that a degrees of freedom and a driving force for the first lens assembly **230** to be moved along a direction parallel to the incident axis are provided.

[0090] In FIG. **7**B and FIG. **7**C, the two-dimensional image stabilizing device **280** includes a base **281** and a guiding member **282**. The guiding member **282** is disposed in the base **281**, so that the image sensor **250** can be displaced within the two-dimensional space, but the present disclosure is not limited thereto. The two-dimensional image stabilizing device **280** is for providing a driving force for the image sensor **250** to be moved within a plane perpendicular to the exiting axis. Thus, it is favorable for obtaining the optical image stabilization of the light-folded camera module **200**.

[0091] In FIG. **7**D and FIG. **7**E, the incident surface **221** and the exiting surface **222** of the reflecting element **220** can be coplanar, the reflecting element **220** is made of plastic, and has a gate trace **228**, but the present disclosure is not limited thereto. Further, the reflecting element **220** includes a plurality of reflecting surfaces **223**, **224**, **225**, **226**, **227**.

3rd Embodiment

[0092] FIG. **8**A is a schematic view of an electronic device **10** according to the 3rd embodiment of the present disclosure. FIG. **8**B is another schematic view of the electronic device **10** according to the 3rd embodiment of FIG. **8**A. As shown in FIG. **8**A and FIG. **8**B, the electronic device **10** is a smartphone. The electronic device **10** includes a plurality of camera modules and a user interface **11**. Further, the camera modules are an ultra-wide-angle camera module **12**, telephoto camera modules **13**, **14** and a high-pixel camera module **15**, and the user interface **11** is a touch screen, but the present disclosure is not limited thereto. Specifically, each of the camera modules can be any one of the light-folded camera module of the 1st embodiment to the 2nd embodiment, but the present disclosure will not be limited thereto.

[0093] A user enters a shooting mode via the user interface **11**. The user interface **11** is used to display the screen, and the shooting angle can be manually adjusted to switch between different camera modules. At this moment, the camera modules collect an imaging light on the respective image sensor and output electronic signals associated with images to an image signal processor (ISP) **16**.

[0094] As shown in FIG. **8**B, according to the camera specifications of the electronic device **10**, the electronic device **10** can further include an optical anti-shake mechanism (figure is omitted). Further, the electronic device **10** can further include at least one focusing assisting module (figure is omitted) and at least one sensing component (figure is omitted). The focusing assisting module can be a flash module **17**, an infrared distance measurement component, a laser focus module, etc. The flash module **17** is for compensating the color temperature. The sensing component can have functions for sensing physical momentum and kinetic energies, such as an accelerator, a gyroscope, and a Hall effect element, so as to sense shaking or jitters applied by hands of the user or external environments. Thus the autofocus function and the optical anti-shake mechanism of the imaging lens assembly disposed on the electronic device **10** can function to obtain a great image quality and facilitate the electronic device **10** according to the present disclosure to have a capturing function with multiple modes, such as taking optimized selfies, high dynamic range (HDR) with a low light source, 4K resolution recording, etc. Furthermore, the user can visually see the captured image of the camera through the user interface **11** and manually operate the view finding range on the user interface **11** to achieve the auto focus function of what you see is what you get.

[0095] Furthermore, the camera modules, the optical anti-shake mechanism, the sensing component and the focusing assisting module can be disposed on a flexible printed circuit board (FPC) (figure is omitted) and electrically connected to the image signal processor **16** and so on via a connector (figure is omitted) so as to operate a picturing process. Recent electronic devices such as smartphones have a trend towards thinness and lightness. The imaging lens assembly and the related elements are disposed on a FPC and circuits are assembled into a main board of an electronic device by a connector. Hence, it can fulfill a mechanical design of a limited inner space of the electronic device and a requirement of a circuit layout and obtain a larger allowance, and it is also favorable for an autofocus function of the camera modules obtaining a flexible control via a touch screen of the electronic device. In the 3rd embodiment, the electronic device **10** can include a plurality of the sensing components and a plurality of the focusing assisting modules, and the sensing components and the focusing assisting modules are disposed on an FPC and another at least one FPC (figure is omitted) and electrically connected to the image signal processor **16** and so on via a corresponding connector so as to operate a picturing process. In other embodiments (figure is omitted), the sensing components and auxiliary optical elements can be disposed on a main board of an electronic device or a board of the other form according to a mechanical design and a requirement of a circuit layout.

[0096] Furthermore, the electronic device **10** can further include, but not be limited to, a display, a control unit, a storage unit, a random-access memory (RAM), a read-only memory (ROM), or the combination thereof.

[0097] FIG. **8**C is a schematic view of an image captured via the ultra-wide-angle camera module **12** of the electronic device **10** according to the 3rd embodiment of FIG. **8**B. As shown in FIG. **8**C, a larger ranged image can be captured via the ultra-wide-angle camera module **12**, which has a function for containing more views.

[0098] FIG. **8**D is another schematic view of the image captured via the high-pixel camera module **15** of the electronic device **10** according to the 3rd embodiment of FIG. **8**A. As shown in FIG. **8**D, a certain ranged and high-pixel image can be captured via the high-pixel camera module **15**, which has a function for high resolution and low distortion.

[0099] FIG. **8**E is the other schematic view of the image captured via the telephoto camera module **13** of the electronic device **10** according to the 3rd embodiment of FIG. **8**B. As shown in FIG. **8**E, a far image can be captured and enlarged to a high magnification via the telephoto camera module **13**, which has a function for a high magnification.

[0100] As shown in FIG. **8**C to FIG. **8**E, when an image is captured via different camera modules having various focal lengths and processed via a technology of an image processing, a zoom function of the electronic device **10** can be achieved.

4th Embodiment

[0101] FIG. **9** is a schematic view of an electronic device **20** according to the 4th embodiment of the present disclosure. As shown in FIG. **9**, the electronic device **20** is a smartphone. The electronic device **20** includes a plurality of camera modules. Further, the camera modules are two ultra-wide-angle camera modules **21**, **22**, two wide angle camera modules **23**, **24**, four telephoto camera modules **25**, **26**, **27**, **28** and a Time-Of-Flight (TOF) module **29**, wherein the Time-Of-Flight (TOF) module **29** can be other types of camera module, which will not be limited to the present arrangement. Specifically, each of the camera modules can be any one camera module of the 1st embodiment to the 3rd embodiment, but the present disclosure will not be limited thereto.

[0102] Moreover, the telephoto camera modules **27**, **28** are configured to fold the light, but the present disclosure will not be limited thereto.

[0103] According to the camera specifications of the electronic device **20**, the electronic device **20** can further include an optical anti-shake mechanism (figure is omitted). Further, the electronic device **20** can further include at least one focusing assisting module (figure is omitted) and at least one sensing component (figure is omitted). The focusing assisting module can be a flash module **20***a*, an infrared distance measurement component, a laser focus module, etc. The flash module **20***a* is for compensating the color temperature. The sensing component can have functions for sensing physical momentum and kinetic energies, such as an accelerator, a gyroscope, and a Hall effect element, so as to sense shaking or jitters applied by hands of the user or external environments. Thus, the autofocus function and the optical anti-shake mechanism of the camera module disposed on the electronic device **20** can function to obtain a great image quality and facilitate the electronic device **20** according to the present disclosure to have a capturing function with multiple modes, such as taking optimized selfies, high dynamic range (HDR) with a low light source, 4K resolution recording, etc.

[0104] Further, all of other structures and dispositions according to the 4th embodiment are the same as the structures and the dispositions according to the 3rd embodiment, and will not be described again herein.

5th Embodiment

[0105] FIG. **10**A is a schematic view of a light-folded camera module **31** applied to a vehicle instrument **30** according to the 5th embodiment of the present disclosure. FIG. **10**B is a schematic view of the light-folded camera module **31** configured in the vehicle instrument **30** according to the 5th embodiment in FIG. **10**A. FIG. **10**C is another schematic view of the light-folded camera module **31** configured in the vehicle instrument **30** according to the 5th embodiment in FIG. **10**A. In FIGS. **10**A to **10**C, the vehicle instrument **30** includes a plurality of light-folded camera modules **31**. According to the 5th embodiment, a number of the light-folded camera modules **31** is six, and the light-folded camera modules **31** can be the light-folded camera module according to any one of the aforementioned 1st embodiment to 4th embodiment, but the present disclosure is not limited thereto.

[0106] In FIGS. **10**A and **10**B, the light-folded camera modules **31** are automotive camera modules, two of the light-folded camera modules **31** are located under rearview mirrors on a left side and a right side, respectively, and the aforementioned light-folded camera modules **31** are configured to capture the image information of a visual angle θ. In particular, the visual angle θ can satisfy the following condition: 40 degrees<θ<90 degrees. Therefore, the image information in the regions of two lanes on the left side and the right side can be captured.

[0107] In FIG. **10**B, another two of the light-folded camera modules **31** can be disposed in the inner space of the vehicle instrument **30**. In particular, the aforementioned two light-folded camera modules **31** are disposed on a location close to the rearview mirror inside the vehicle instrument **30** and a location close to the rear car window, respectively. Moreover, the light-folded camera modules **31** can be further disposed on the rearview mirrors of the vehicle instrument **30** on the left side and the right side except the mirror surface, respectively, but the present disclosure is not limited thereto.

[0108] In FIG. **10**C, another two of the light-folded camera modules **31** can be disposed on a front end of the vehicle instrument **30** and a rear end of the vehicle instrument **30**, respectively. By disposing the light-folded camera modules **31** on the front end and the rear end of the vehicle instrument **30** and under the rearview mirror on the left side of the vehicle instrument **30** and the right side of the vehicle instrument **30**, it is favorable for the drivers obtaining the external space information in addition to the driving seat, such as the external space information **I1**, **I2**, **I3**, **I4**, but the present disclosure is not limited thereto. Therefore, more visual angles can be provided to reduce the blind spot, so that the driving safety can be improved. Further, the traffic information outside of the vehicle instrument **30** can be recognized by disposing the light-folded camera modules **31** on the periphery of the vehicle instrument **30**, so that the function of the automatic driving assistance can be achieved.

[0109] The foregoing description, for purpose of explanation, has been described with reference to specific examples. It is to be noted that Tables show different data of the different examples; however, the data of the different examples are obtained from experiments. The examples were chosen and described in order to best explain the principles of the disclosure and its practical applications, to thereby enable others skilled in the art to best utilize the disclosure and various examples with various modifications as are suited to the particular use contemplated. The examples depicted above and the appended drawings are exemplary and are not intended to be exhaustive or to limit the scope of the present disclosure to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings.

What is claimed is:

1. A light-folded camera module, having an incident axis and an exiting axis, and comprising:

a fixing carrier;

a reflecting element for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis, wherein the reflecting element is fixed on the fixing carrier, and the reflecting element comprises an incident surface and an exiting surface;

a first lens assembly;

a second lens assembly for providing an optical refractive power of the light-folded camera module along with the first lens assembly, wherein the first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially; and

an image sensor for receiving the imaging light of the light-folded camera module, wherein the image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis;

wherein the second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element, the light-folded camera module further comprises a focus driving device, the focus driving device comprises a fixed component, a movable component and a spherical element, the first lens assembly is disposed on the movable component, the spherical element is disposed between the fixed component and the movable component, so that a degrees of freedom and a driving force for the first lens assembly to be moved along a direction parallel to the incident axis are provided;

wherein a longest driving distance range of the first lens assembly from the focus driving device is Dim, a height of the reflecting element along the direction parallel to the incident axis is H, a distance between a center of an image-side surface of the second lens assembly and a center of the image sensor along the direction parallel to the incident axis is Lf, and the following conditions are satisfied:

$$0.8\text{ mm} < Dim < 3.9\text{ mm; and}$$

$$0 \leq Lf < H.$$

2. The light-folded camera module of claim **1**, wherein the longest driving distance range of the first lens assembly from the focus driving device is Dim, and the following condition is satisfied:

$$0.9 \text{ mm} < Dim < 3.2 \text{ mm}.$$

3. The light-folded camera module of claim **2**, wherein the longest driving distance range of the first lens assembly from the focus driving device is Dim, and the following condition is satisfied:

$$1.0 \text{ mm} < Dim < 2.6 \text{ mm}.$$

4. The light-folded camera module of claim **1**, wherein a perpendicular distance between the center of the image sensor and the incident axis is S, and the following condition is satisfied:

$$4.5 \text{ mm} < S < 20 \text{ mm}.$$

5. The light-folded camera module of claim **4**, wherein the perpendicular distance between the center of the image sensor and the incident axis is S, and the following condition is satisfied:

$$6.0 \text{ mm} < S < 17 \text{ mm}.$$

6. The light-folded camera module of claim **1**, wherein the reflecting element is made of plastic, and has at least one gate trace.

7. The light-folded camera module of claim **1**, wherein the reflecting element further comprises at least two reflecting surfaces.

8. The light-folded camera module of claim **7**, wherein a number of the at least two reflecting surfaces is an odd number.

9. The light-folded camera module of claim **1**, wherein the first lens assembly comprises at least one glass lens element and at least one plastic lens element.

10. The light-folded camera module of claim **1**, wherein a distance between a center of an object-side surface of the second lens assembly and the center of the image sensor along the direction parallel to the incident axis is Ls, a distance between the center of the object-side surface of the second lens assembly and a position where the exiting axis passes through the exiting surface of the reflecting element along the direction parallel to the incident axis is Le, and the following condition is satisfied:

$$0 \leq Ls < Le.$$

11. The light-folded camera module of claim **1**, further comprising:

a two-dimensional image stabilizing device for providing a driving force for the image sensor to be moved within a plane perpendicular to the exiting axis.

12. The light-folded camera module of claim **1**, further comprising:

a three-dimensional image stabilizing device for providing a driving force for the image sensor to be moved within a three-dimensional space.

13. An electronic device, comprising:

the light-folded camera module of claim **1**.

14. A light-folded camera module, having an incident axis and an exiting axis, and comprising:

a fixing carrier;

a reflecting element for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis, wherein the reflecting element is fixed on the fixing carrier, and the reflecting element comprises an incident surface and an exiting surface;

a first lens assembly;

a second lens assembly for providing an optical refractive power of the light-folded camera module along with the first lens assembly, wherein the first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially; and

an image sensor for receiving the imaging light of the light-folded camera module, wherein the image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis;

wherein the second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element, the light-folded camera module further comprises a focus driving device, the focus driving device comprises a fixed component, a movable component and a spherical element, the first lens assembly is disposed on the movable component, the spherical element is disposed between the fixed component and the movable component, so that a degrees of freedom and a driving force for the first lens assembly to be moved along a direction parallel to the incident axis are provided;

wherein a perpendicular distance between a center of the image sensor and the incident axis is S, a height of the reflecting element along the direction parallel to the incident axis is H, a distance between a center of an image-side surface of the second lens assembly and the center of the image sensor along the direction parallel to the incident axis is Lf, and the following conditions are satisfied:

$$4.5 \text{ mm} < S < 20 \text{ mm; and}$$

$$0 \leq Lf < H.$$

15. The light-folded camera module of claim **14**, wherein the perpendicular distance between the center of the image sensor and the incident axis is S, and the following condition is satisfied:

$$6.0 \text{ mm} < S < 17 \text{ mm}.$$

16. The light-folded camera module of claim **14**, wherein the reflecting element further comprises at least two reflecting surfaces.

17. The light-folded camera module of claim **16**, wherein a number of the at least two reflecting surfaces is an odd number.

18. The light-folded camera module of claim **14**, wherein the first lens assembly comprises at least one glass lens element and at least one plastic lens element.

19. The light-folded camera module of claim **14**, wherein the reflecting element is made of plastic, and has at least one gate trace.

20. The light-folded camera module of claim **14**, further comprising:

a two-dimensional image stabilizing device for providing a driving force for the image sensor to be moved within a plane perpendicular to the exiting axis.

21. The light-folded camera module of claim **14**, further comprising:

a three-dimensional image stabilizing device for providing a driving force for the image sensor to be moved within a three-dimensional space.

22. A light-folded camera module, having an incident axis and an exiting axis, and comprising:

a fixing carrier;

a reflecting element for folding an imaging light of the light-folded camera module from the incident axis to the exiting axis, wherein the reflecting element is fixed on the fixing carrier, and the reflecting element comprises an incident surface and an exiting surface;

a first lens assembly;

a second lens assembly for providing an optical refractive power of the light-folded camera module along with the first lens assembly, wherein the first lens assembly, the second lens assembly and the incident surface of the reflecting element are disposed along the incident axis sequentially; and

an image sensor for receiving the imaging light of the light-folded camera module, wherein the image sensor is disposed relative to the exiting surface of the reflecting element along the exiting axis;

wherein the second lens assembly is fixed in the fixing carrier, so that there is no relative displacement between the second lens assembly and the reflecting element, the light-folded camera module further comprises a focus driving device and an image stabilizing device, the focus driving device is for providing a driving force for the first lens assembly to be moved along a direction parallel to the incident axis, the image stabilizing device is for providing another driving force for the image sensor to be moved within a plane perpendicular to the exiting axis;

wherein a height of the reflecting element along the direction parallel to the incident axis is H, a distance between a center of an image-side surface of the second lens assembly and a center of the image sensor along the direction parallel to the incident axis is Lf, and the following condition is satisfied:

$$0 \leq Lf < H.$$

23. The light-folded camera module of claim **22**, wherein the reflecting element further comprises at least two reflecting surfaces.

24. The light-folded camera module of claim **23**, wherein a number of the at least two reflecting surfaces is an odd number.

25. The light-folded camera module of claim **22**, wherein the reflecting element is made of plastic, and has at least one gate trace.

26. The light-folded camera module of claim **22**, wherein a distance between a center of an object-side surface of the second lens assembly and the center of the image sensor along the direction parallel to the incident axis is Ls, a distance between the center of the object-side surface of the second lens assembly and a position where the exiting axis passes through the exiting surface of the reflecting element along the direction parallel to the incident axis is Le, and the following condition is satisfied:

$$0 \leq Ls < Le.$$

27. An electronic device, comprising:

the light-folded camera module of claim **22**.

* * * * *