(19) Europäisches Patentamt
European Patent Office
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(11) **EP 2 317 111 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.05.2011 Bulletin 2011/18

(51) Int Cl.:
F02M 25/07 *(2006.01)*

(21) Application number: **10189227.1**

(22) Date of filing: **28.10.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **28.10.2009 IT BO20090702**

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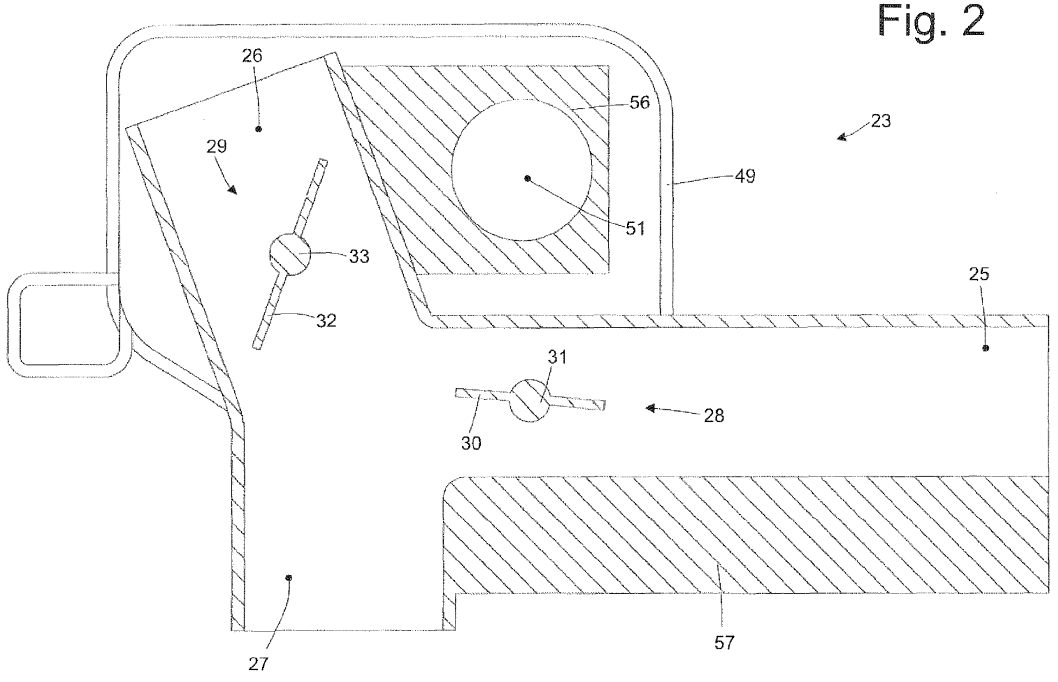
(54) **Mixing device for a low pressure EGR system of an internal combustion engine**

(57) A mixing device (23) for a low pressure EGR system (21) of an internal combustion engine (1); the mixing device (23) has: a first inlet conduit (25), which can be connected to an EGR conduit (22); a second inlet conduit (26), which can be connected to an intake of fresh air from outside; an outlet conduit (27), which can be connected to an intake conduit (6); a main butterfly valve (28), which is arranged within the first inlet conduit (25) to vary the section of the first inlet conduit (25) itself; and a secondary butterfly valve (29), which is arranged within the second inlet conduit (26) to vary the section of the second inlet conduit (26).

Fig. 2



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Description

TECHNICAL FIELD

[0001] The present invention relates to a mixing device for a low pressure EGR system of an internal combustion engine.

PRIOR ART

[0002] An EGR (Exhaust Gas Recirculation) system is often present in modern internal combustion engines, which system feeds part of the exhaust gases produced by the combustion into the intake conduit so as to mix the exhaust gases with the fresh air in order to uniform the temperature in each combustion chamber, and consequently reduce the polluting substances present in the exhaust gases which are released into the atmosphere.

[0003] An EGR system comprises an EGR conduit, which connects the exhaust conduit to the intake conduit, and a mixing device which is arranged at the intersection between the EGR conduit and the intake conduit, and which has the function of adjusting the mixing of exhaust gas from the exhaust conduit with the fresh air present in the intake conduit. Typically, the mixing device comprises a butterfly valve, which is arranged at the EGR conduit, is actuated by an electrical motor and has the function of varying the section of the EGR conduit to vary the flow of exhaust gases which are introduced into the intake conduit.

[0004] The above-described structure of the mixing device has the advantage of being cost-effective and at the same of allowing to rather accurately adjust the exhaust gas flow rate introduced into the intake conduit; however, the above-described structure of the mixing device does not allow to accurately adjust the exhaust gas flow rate introduced into the intake conduit in all operative conditions, and in particular when the introduction of a particularly high exhaust gas flow rate into the intake conduit is required. Furthermore, the known mixing devices have problems of reliability over time, because the electrical motor may be subjected to excessive overheating caused by the heat coming from the EGR conduit, which in turn is heated by the exhaust gases which flow through the EGR conduit itself, and which indicatively have a temperature of at least 350-400 °C.

[0005] US2005145229A1 describes a mixing device for a low pressure EGR system of an internal combustion engine as described in the preamble of independent claim 1.

DESCRIPTION OF THE INVENTION

[0006] It is the object of the present invention to provide a mixing device for a low pressure EGR system of an internal combustion engine, which device is free from the above-described drawbacks, and in particular, is easy and cost-effective to implement.

[0007] According to the present invention, a mixing device for a low pressure EGR system of an internal combustion engine is provided as disclosed in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention will now be described with reference to the appended drawings, which illustrate a non-limitative embodiment thereof, in which:

- figure 1 is a diagrammatic view of a supercharged internal combustion engine provided with an EGR system using a mixing device made according to the present invention;
- figure 2 is a section view of the mixing device in figure 1;
- figure 3 is a view with parts removed for clarity of an actuating device of the mixing device in figure 1;
- figure 4 is a chart illustrating the positions of two butterfly valves of the mixing device in figure 1;
- figure 5 is a perspective view of the mixing device in figure 1;
- figures 6 and 7 are two different perspective, exploded views of the mixing device in figure 1; and
- figure 8 is a perspective view of an insert made of refractory material arranged along a shaft of a main butterfly valve of the mixing device in figure 1.

PREFERRED EMBODIMENTS OF THE INVENTION

[0009] In figure 1, numeral 1 indicates as a whole an internal combustion engine supercharged by a turbocharger supercharging system 2.

[0010] The internal combustion engine 1 comprises four cylinders 3, each of which is connected to an intake manifold 4 by means of at least one respective intake valve (not shown) and to an exhaust manifold 5 by means of at least one respective exhaust valve (not shown). The intake manifold 4 receives fresh air (i.e. air coming from the external environment) through an intake conduit 6, which is provided with an air cleaner 7 and is adjusted by a butterfly valve 8. An intercooler 9 for cooling the intake air is arranged along the intake conduit 6. An exhaust conduit 10, which feeds the exhaust gases produced by the combustion to an exhaust system, is connected to the exhaust manifold 5, which exhaust system emits the gases produced by the combustion into the atmosphere and normally comprises at least one catalyzer 11 and at least one silencer (not shown) arranged downstream of the catalyzer 11.

[0011] The supercharging system 2 of the internal combustion engine 1 comprises a turbocharger 12 provided with a turbine 13, which is arranged along the exhaust conduit 10 for rotating at high speed under the bias of the exhaust gases expelled from the cylinders 3, and a turbocharger 14, which is arranged along the intake conduit 6 and is mechanically connected to the turbine

13 in order to be rotatably fed by the turbine 13 itself so as to increase the pressure of the air fed into the intake conduit 6.

[0012] A bypass conduit 15 is provided along the exhaust conduit 10, which bypass conduit is connected in parallel to the turbine 13 so that the ends thereof are connected upstream and downstream of the turbine 13 itself; a wastegate 16 is arranged along the bypass conduit 15, which wastegate is adapted to adjust the exhaust gas flow rate through the bypass conduit 15 and is controlled by a pneumatic actuator 17. A bypass conduit 18 is provided along the intake conduit 6, which bypass conduit is connected in parallel to the turbocharger 14 so that the ends thereof are connected upstream and downstream of the turbocharger 14 itself; a Poff valve 19 is arranged along the bypass conduit 18, which Poff valve is adapted to adjust the exhaust gases which flow through the bypass conduit 18 and is controlled by an electrical actuator 20.

[0013] The internal combustion engine 1 comprises a low pressure EGR system 21, which recalculates part of the exhaust gas present in the exhaust conduit 10 by reintroducing such exhaust gases into the intake conduit 6. An EGR system 21 comprises an EGR conduit 22, which connects the exhaust conduit 10 to the intake conduit 6, and a three-way mixing device 23, which is arranged at the intersection between the exhaust conduit 10 and the intake conduit 6, and which has the function of adjusting the mixing of the exhaust gases from the exhaust conduit 10 with the fresh air present in the intake conduit 6. According to a preferred embodiment, a heat exchanger 24 is arranged along the EGR conduit 22 for cooling the exhaust gases from the exhaust conduit 10.

[0014] The low pressure EGR system 21, i.e. the EGR conduit 22, originates from the exhaust conduit 10 downstream of the catalyzer 11 so as to take the exhaust gases which have been already treated by the catalyzer 11 itself and which have a pressure only slightly higher than the atmospheric pressure; in this manner, the exhaust gases recirculated by the EGR conduit 22 are more "clean", i.e. have a lower content of polluting substances. Such a configuration is also named "Long-Route" EGR, because the EGR conduit 22 must be longer than normal to reach downstream of the catalyzer 11.

[0015] The three-way mixing device 23 connects the intake manifold 6 to the EGR conduit 22. As shown in greater detail in figure 2, the mixing device 23 comprises an inlet conduit 25, which is connected in series to the EGR conduit 22, an inlet conduit 26, which is connected in series to a conduit coming from the air cleaner 7, and an outlet conduit 27, which is connected in series to the intake conduit 6.

[0016] As shown in figure 3, the inlet conduit 25 forms a square angle with the outlet conduit 27 and forms an obtuse angle with the inlet conduit 26, and the inlet conduit 26 forms an acute angle with the outlet conduit 27. A main butterfly valve 28, which varies the section of the inlet conduit 25 itself, is arranged along the inlet conduit 25, and a secondary butterfly valve 26, which varies the section of the inlet conduit 26 itself, is arranged along the inlet conduit 26. The main valve 28 comprises a butterfly cap 30 and a shaft 31, which supports the butterfly cap 30 and is rotationally mounted. Similarly, the secondary butterfly valve 28 comprises a butterfly cap 32 and a shaft 33, which supports the butterfly cap 32 and is rotationally mounted.

[0017] As shown in figure 3, the mixing device 23 comprises a common actuating device 34 which controls both the main butterfly valve 28 and the secondary butterfly valve 29. In particular, the common actuating device 34 comprises a single common electrical motor 35, which impresses motion to both butterfly valves 28 and 29, and a connecting element 36, which establishes a mechanical connection between the secondary butterfly valve 29 and the main butterfly valve 28 so that the reciprocal positions between the two butterfly valves 28 and 29 are mechanically linked to one another.

[0018] According to a preferred embodiment, the common electrical motor 35 transmits motion to the main butterfly valve 28 and thus directly controls the position of the main butterfly valve 28 itself; in turn, the main butterfly valve 28 transmits motion to the secondary butterfly valve 29 by means of the connection element 36, which links the position of the main butterfly valve 28 to the position of the secondary butterfly valve 29. In other words, the main butterfly valve 28 acts as "master" valve when the secondary butterfly valve 29 acts as "slave" mimicking the position of the main butterfly valve 28 by virtue of the connecting element 36. In particular, the actuating device 34 comprises a gear transmission 37, which transmits motion from a shaft of the electrical motor 35 to the shaft 31 of the main butterfly valve 28.

[0019] The gear transmission 37 comprises an initial toothed wheel 38, integral with the electrical motor shaft 35, a final toothed wheel 39, integral with the shaft 31 of the main butterfly valve 28, and an intermediate toothed wheel 40, idly interposed between the initial toothed wheel 38 integral with the shaft of the electrical motor 35 and the final toothed wheel 39 integral with the shaft 31 of the main butterfly valve 28. The intermediate toothed wheel 40 has a first small diameter teeth crown, which is coupled to the initial toothed wheel 38, and a second larger diameter teeth crown, which is coupled to the final toothed wheel 39. As a whole, the geared transmission 37 has a transmission ratio which de-multiplies the rotation speed of the electrical motor 35 (i.e. the electrical motor 35 turns faster than the shaft 31 of the main butterfly valve 28).

[0020] According to a preferred embodiment shown in the appended figures, the connecting element 36 comprises a rigid arm 41 having one end 42, which is eccentrically connected to the shaft 31 of the main butterfly valve 28 and which is opposite to the end 42 and is eccentrically connected to the shaft 33 of the secondary butterfly valve 29. The end 43 of the arm 41 has an elongated seat 44, which is rotationally and slidingly engaged

by an eccentric pin 45 which is integral with the shaft 33 of the secondary butterfly valve 29 and is supported by a plate 46 integral with the shaft 33 itself; furthermore, the end 42 of the arm 41 is eccentrically hinged to the shaft 31 of the main butterfly valve 28, and in particular is hinged to the final toothed wheel 39, which is integral with the shaft 31 itself. The rigid arm 41 has a first segment, which comprises the end 42, and a second segment, which comprises the end 43 and the elongated seat 44, is shorter than the first segment and forms an obtuse angle with the first segment. According to a different embodiment (not shown), the connecting element 36 comprises a gear set, which links the angular position of the shaft 33 of the secondary butterfly valve 29 to the angular position of the shaft 31 of the main butterfly valve 28.

[0021] In the illustrated embodiment, the actuating device 34 imparts to the butterfly valves 28 and 29 a law of motion in which the main butterfly valve 28 is completely closed when the secondary butterfly valve 29 is completely open and vice versa; furthermore, the actuating device 34 keeps the secondary butterfly valve 29 all open until the main butterfly valve 28 does not reach a predetermined partial opening position. The description above is illustrated in figure 4, in which the pattern of the position (i.e. of the opening/closing degree) of the secondary butterfly valve 29 is shown by a dashed line and the pattern of the position (i.e. of the opening/closing degree) of the main butterfly valve 28 is shown with a solid line according to the position α of the shaft of the electrical motor 35 (shown in abscissa). In figure 4, it is apparent that the main butterfly valve 28 is all closed when the secondary butterfly valve 29 is all open and vice versa; furthermore, the secondary butterfly valve 29 remains all open until a predetermined partial opening position of the main butterfly valve 28 is reached and starts to close only afterwards.

[0022] It is important to observe that the relationship between the position of the main butterfly valve 28 and the position of the secondary butterfly valve 29 can be easily modified by varying the conformation (shape and/or size) of the arm 41 of the connecting element 36; thus the relationship between the position of the main butterfly valve 28 and the position of the secondary butterfly valve 29 shown in figure 4 is only an example of the many relationships which can be obtained by means of the actuating device 34. For example, the relationship between the position of the main butterfly valve 28 and the position of the secondary butterfly valve 29 may be easily modified, simply by varying the angle between the two segments of the arm 41 and/or by varying the length of the two segments of the arm 41. In this manner, with a simple modification of the arm 41 of the connecting element 36, it is possible to even substantially modify the mixing features of the exhaust gas present in the inlet conduit 25 with the fresh air in the inlet conduit 26.

[0023] According to a possible embodiment (not shown), the actuating device 34 also comprises a return spring which tends to push the butterfly valves 28 and 29 towards a neutral position in which the secondary butterfly valve 29 is all open and the main butterfly valve 28 is all closed and thus in complete absence of exhaust gas recirculating in the intake conduit 6. In case of malfunction of the electrical motor 35, the return spring guarantees that the butterfly valves 28 and 29 are moved and kept in neutral position free from recirculated exhaust gases in the intake conduit 6.

[0024] As shown in figure 6, the shaft 31 of the main butterfly valve 28 has an external portion 47, which protrudes from the inlet conduit 25 (through a through hole provided with a seal) to be coupled to the actuating device 34; similarly, the shaft 33 of the secondary butterfly valve 29 also has an external portion 48, which protrudes from the inlet conduit 26 (through a through hole provided with a seal) to couple to the actuating device 34. The actuating device 34 comprises a box 49, inside which the external portion 47 of the shaft 31 of the main butterfly valve 28 and the external portion 48 of the shaft 33 of the secondary butterfly valve 29 penetrate. The electrical motor 35 and the gear transmission 37 are further accommodated in the box 49. The box 49 is provided with a removable cover 50, which is provided with an annular seat for ensuring an adequate tightness. Furthermore, the box 49 has a cylindrical housing 51, which extends perpendicularly to a bottom wall 52 of the box 49 and accommodates the electric motor 35 therein. The bottom wall 52 of the box 49 has two through holes (not shown) for allowing the passage of the shafts 31 and 23 of the butterfly valves 28 and 29.

[0025] According to a preferred embodiment, the box 49 is only supported by the inlet conduit 26 (i.e. does not touch the inlet conduit 25 in any manner and is instead arranged at a given distance from the inlet conduit 25 itself). Furthermore, the box 49 is independent and separable from the inlet conduit 26 and is fixed to the inlet conduit 26 by means of screws.

[0026] By virtue of the fact that the box 49 is separate from the inlet conduit 25, the heat of the inlet conduit 25 may be transmitted to the box 49 only by radiation or convection and not by conduction; the overheating of the box 49 can be limited in this manner. In order to further reduce the transmission of heat from the inlet conduit 25 to the box 49 and to the gear transmission 37, at least one part of the external portion 47 of the shaft 31 of the main butterfly valve 28 is made of a heat-insulating material; in particular, the external portion 47 of the shaft 31 of the main butterfly valve 28 comprises an insert 53 made of heat-insulating material, and in particular of refractory material (typically ceramic). It is worth noting that the insert 53 has the function of both heat insulation (i.e. of obstructing the transmission of heat by conduction along the shaft 31 and towards the box 49 and the gear transmission 37) and motion transmission (i.e. of transmitting rotation motion along the shaft 31 between butterfly cap 30 and gear transmission 37).

[0027] As shown in figure 8, the insert 53 made of heat-

insulating material constitutes part of the external portion 47 of the shaft 31 of the main butterfly valve 28 and is arranged between two sections of the external portion 47 so as to thermally separate the two sections of the external portion 47 (i.e. preventing a heat transmission by conduction) maintaining a mechanical continuity of the shaft 31 to transmit the rotation movement along the shaft 31 between the butterfly cap 30 and the gear transmission 37. The heat-insulating material insert 53 is mechanically fitted on both sides of the corresponding sections of the external portion 47; the fixed joints between the insert 53 and the two sections of the external portion 47 also have an angular bond so as to prevent the relative rotation between the insert 53 and the two sections of the external portion 47 to transmit rotary movement along the shaft 31 between the butterfly cap 30 and the gear transmission 37. According to the embodiment shown in figure 8, each fixed joint between the insert 53 and the section of the external portion 47 comprises a cross-shaped protuberance 54, which axially rises from the insert 53 and is inserted in a seat 55, which is obtained in the section of the external portion 47 which negatively reproduces the shape of the protuberance 54.

[0028] As shown in figures 5, 6 and 7, in order to increase the cooling of the electrical motor 35 (which is heated both by effect of the heat from the inlet conduit 25 and by effect of the heat generated in use within the electrical motor 35 itself), the cylindrical housing 51 is provided with a plurality of cooling fins 56, which thermally connect a wall of the cylindrical housing 51 to a wall of the inlet conduit 26. In particular, each cooling fin 54 is radially arranged with respect to the cylindrical housing 51 and fully envelops the cylinder housing 51 itself.

[0029] Furthermore, in order to attempt to cool the inlet conduit 25 in proximity of the box 49 in order to reduce the transmission of heat from the inlet conduit 25 to the box 49 (and thus to the gear transmission 37, and above all to electric motor 35), the inlet conduit 25 is provided with a plurality of cooling fins 57 preferably arranged axially (i.e. parallel to the central axis of the inlet conduit 25).

[0030] The above-described mixing device 23 has many advantages.

[0031] Firstly, the above-described mixing device 23 is simple and cost-effective to make, because a single electrical motor 35 allows to suitably control both the main butterfly valve 28 and the secondary butterfly valve 29.

[0032] Furthermore, by virtue of the presence of the main butterfly valve 28 along the inlet conduit 25 and of the secondary butterfly valve 29 along the inlet conduit 26, it is possible to always optimally adjust the mixing of the fresh air present in the inlet conduit 26 with the exhaust gases present in the inlet conduit 25. In particular, by either completely closing or nearly closing the secondary butterfly valve 29, a particularly high exhaust gas flow rate can be introduced into the intake conduit 6, and always adjustable with extreme accuracy.

[0033] In the above-described mixing device 23, modifying the mixing features of the exhaust gases in the EGR conduit 22 with the fresh air present in the intake conduit 6 is simple by modifying the relationship between the portion of the main butterfly valve 28 and the position of the secondary butterfly valve 29 by means of a simple replacement of the arm 41 of the connecting element 36 (arm 41 which has a very low replacement cost).

[0034] The above-described mixing device 23 is very reliable over time, because the electrical motor 35 is adequately protected from excessive overheating essentially caused by the heat transmitted by the inlet conduit 25, which is heated by the exhaust gases which indicatively have a temperature of 350-400 °C. The thermal protection of the electrical motor 35 is obtained by creating a separation between the box 49 and the inlet conduit 25, by inserting the insert 53 made of heat-insulating material in the external portion 47 of the shaft 31 of the main butterfly valve 28, thus making the cooling fins 56 between the housing 51 and the inlet conduit 26 and making the cooling fins 57 of the inlet conduit 25.

[0035] Finally, the mixing device 23 has a modular structure, because the actuating device 34 is completely contained in the box 49 which can be separated from the inlet conduits 25 and 26 and from the outlet conduit 27; in this manner, the box 49 itself (i.e. the actuating device 34 itself) may be fitted on conduits 25, 26 and 27 of variable size so as to make a wide range of mixing devices 23 which differ from one another by the active flow rate.

Claims

1. A mixing device (23) for a low pressure EGR system (21) of an internal combustion engine; the mixing device (23) comprises:

a first inlet conduit (25), which can be connected to an EGR conduit (22);
a second inlet conduit (26), which can be connected to an intake of fresh air from outside;
an outlet conduit (27), which can be connected to an intake conduit (6);
a main butterfly valve (28), which is arranged within the first inlet conduit (25) to vary the section of the first inlet conduit (25);
a secondary butterfly valve (29), which is arranged within the second inlet conduit (26) to vary the section of the second inlet conduit (26); and
an actuating device (34), which controls the main butterfly valve (28) and the secondary butterfly valve (29) and is provided with a connecting element (36), which establishes a mechanical connection between the main butterfly valve (28) and the secondary butterfly valve (29), so that the positions of two butterfly valves (28, 29) are mechanically linked to one another;

wherein the main butterfly valve (28) comprises a

first butterfly cap (30) and a first shaft (31) that supports the first butterfly cap (30) and has a first external portion (47) protruding from the first inlet conduit (25) to mate with the actuating device (34);
wherein the secondary butterfly valve (29) comprises a second butterfly cap (32) and a second shaft (33) supporting the second butterfly cap (32) and has a second external portion (48) which protrudes from the second inlet conduit (26) to mate with the actuating device (34); and
wherein the actuating device (34) comprises a box (49), in which the first external portion (47) of the first shaft (31) of the main butterfly valve (28) and the second external portion (48) of the second shaft (33) of the secondary butterfly valve (29) penetrate, and an electric motor (35) which is inserted in a cylindrical housing (51) of the box (49);
the mixing device (23) is **characterized in that**:

the actuating device (34) comprises single common electrical motor (35), which is inserted in an cylindrical housing (51) of the box (49); and
the cylindrical housing (51) is fitted with a plurality of first cooling fins (56), which thermally connect a wall of the cylindrical housing (51) to a wall of the second inlet conduit (26).

2. A mixing device (23) according to claim 1, wherein the connecting element (36) comprises a rigid arm (41) having a first end (43) eccentrically connected to a second shaft (33) of the secondary butterfly valve (29), and a second end (42) which is opposite to the first end (43) and is eccentrically connected to a first shaft (31) of the main butterfly valve (28).

3. A mixing device (23) according to claim 2, wherein:

the first end (43) of the arm (41) has an elongated seat (44), which is rotationally and slidingly engaged by an eccentric pin (45) integral with the second shaft (31) of the main butterfly valve (28); and
the first end (42) of the arm (41) is eccentrically hinged to the first shaft (31) of the main butterfly valve (28).

4. A mixing device (23) according to claim 3, wherein the rigid arm (41) has a first segment comprising the first end (43) and the elongated seat (44), and a second segment comprising the second end (42); the second segment is longer than the first segment, and forms an obtuse angle with the first segment.

5. A mixing device (23) according to claims 2, 3 or 4, wherein by changing the conformation of the arm (41) of the connecting element (36) it is possible to change the relationship between the position of the main butterfly valve (28) and the position of the secondary butterfly valve (29) in order to change the mixing features of the exhaust gases in first inlet conduit (25) with fresh air in the second inlet conduit (26).

6. A mixing device (23) according to one of claims 1 to 5, wherein by virtue of the effect of the actuating device (34) the secondary butterfly valve (29) is fully open when the main butterfly valve (28) is fully closed and vice versa.

7. A mixing device (23) according to claim 6, wherein the actuating device (34) keeps the secondary butterfly valve (29) fully open until the main butterfly valve (28) reaches a predetermined partial opening position.

8. A mixing device (23) according to one of claims 1 to 7, wherein the main butterfly valve (28) comprises a first butterfly cap (30) and a first shaft (31) supporting the first butterfly cap (30) and has a first external portion (47) which protrudes from the first inlet conduit (25) in order to mate with the actuating device (34); at least part of the first external portion (47) of the first shaft (31) of the main butterfly valve (28) is made of thermally insulating material.

9. A mixing device (23) according to claim 8, wherein the first external portion (47) of the first shaft (31) of the main butterfly valve (28) comprises an insert (53) made of heat-insulating material, and in particular, refractory material.

10. A mixing device (23) according to claim 9, wherein the insert (53) made of heat-insulating material is a part of the first external portion (47) of the first shaft (31) of the main butterfly valve (28) and is interposed between two sections of the first external portion (47) in order to thermally separate the two sections of the first external portion (47) maintaining mechanical continuity on the first shaft (33).

11. A mixing device (23) according to claim 10 wherein the insert (53) made of heat-insulating material mechanically fits in the corresponding sections of the first external portion (47) on both sides by means of fixed joints, which also have an angular bond so as to prevent the relative rotation between the insert (53) and the two sections of the first external portion (47) to transmit the rotational movement along the first shaft (31).

12. A mixing device (23) according to one of claims from 1 to 11, wherein the box (49) is supported by the second inlet conduit (26) only.

13. A mixing device (23) according to claim 12, wherein the box (49) is independent and separable from the second inlet conduit (26) and is fixed to the second

inlet conduit (26) by means of screws.

14. A mixing device (23) according to one of claims from 1 to 13, wherein each first cooling fin (56) is arranged radially with respect to the cylindrical housing (51) and fully envelops the cylindrical housing (51) itself.

15. A mixing device (23) according to one of claims from 1 to 14, wherein the first inlet conduit (25) is provided with a plurality of second cooling fins (57) preferably in axial arrangement.

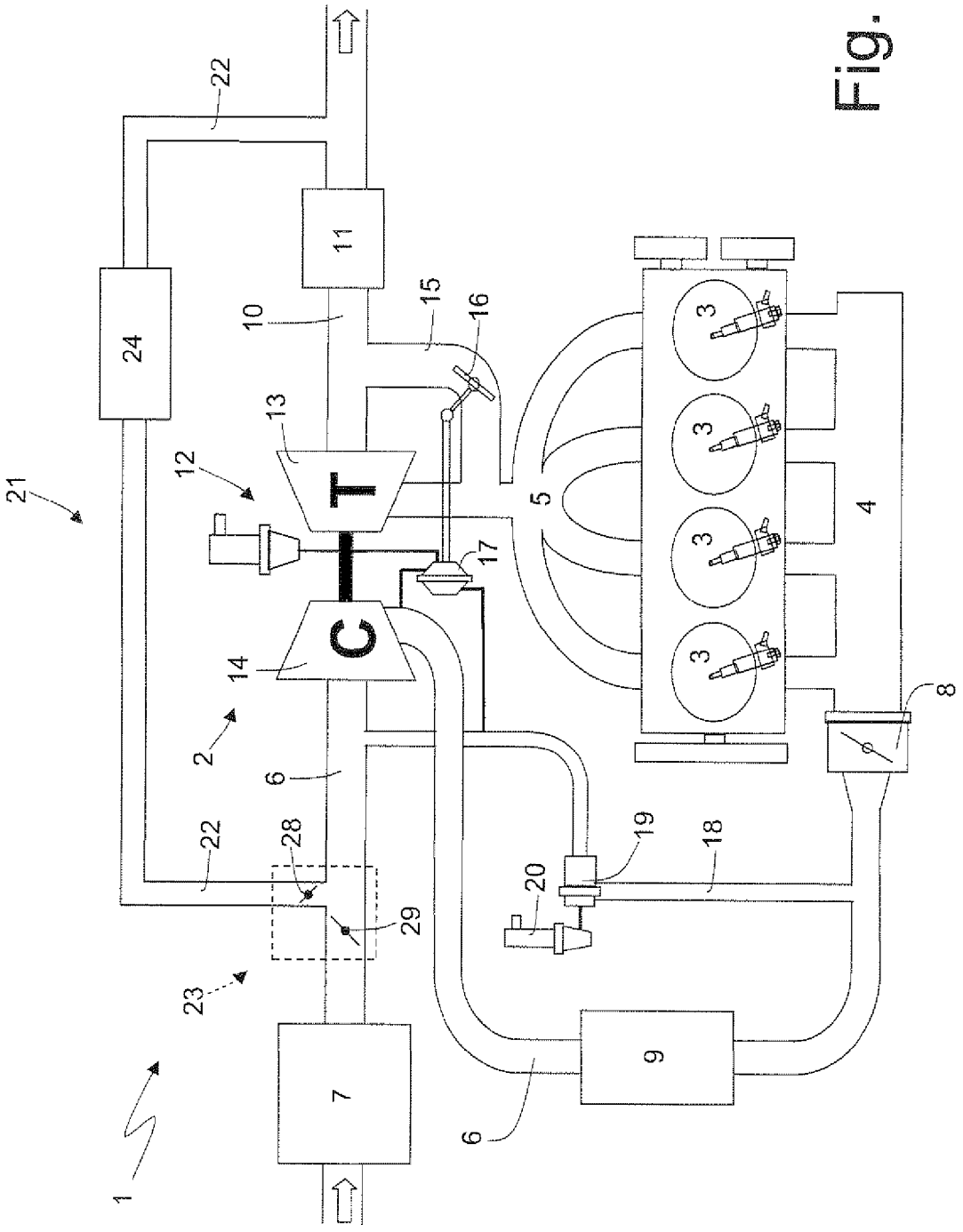
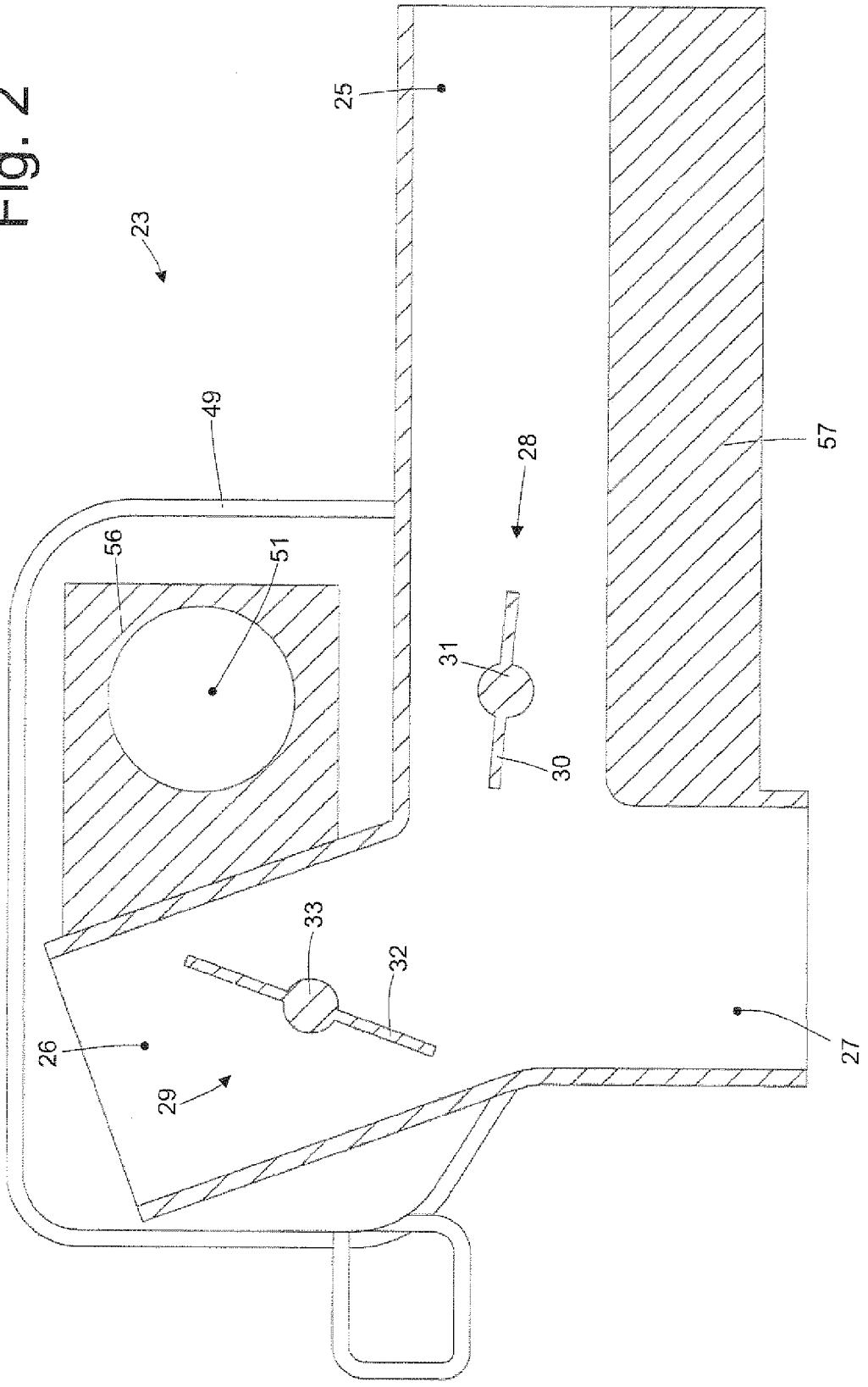


Fig. 1

Fig. 2



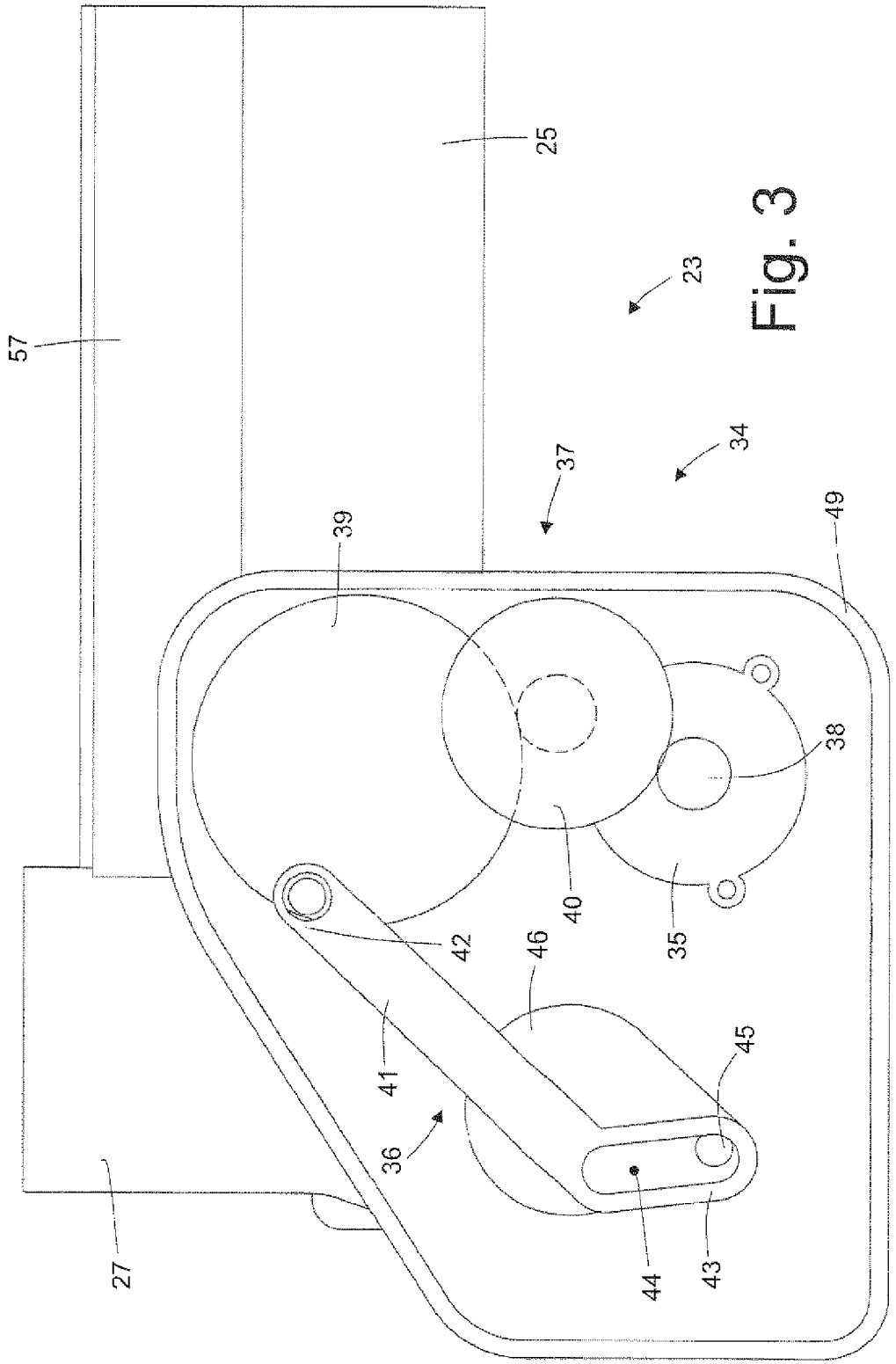


Fig. 3

Fig. 4

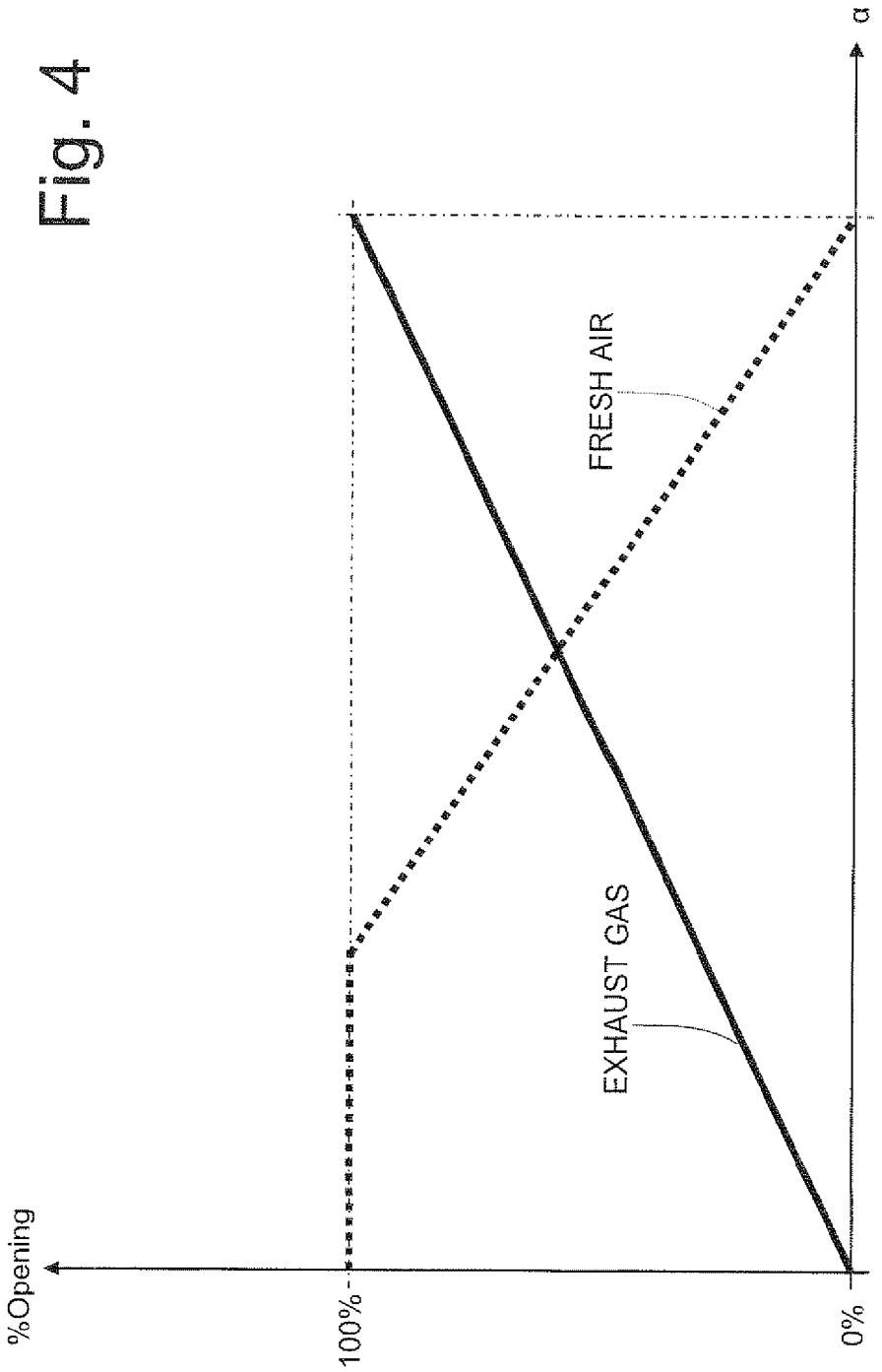
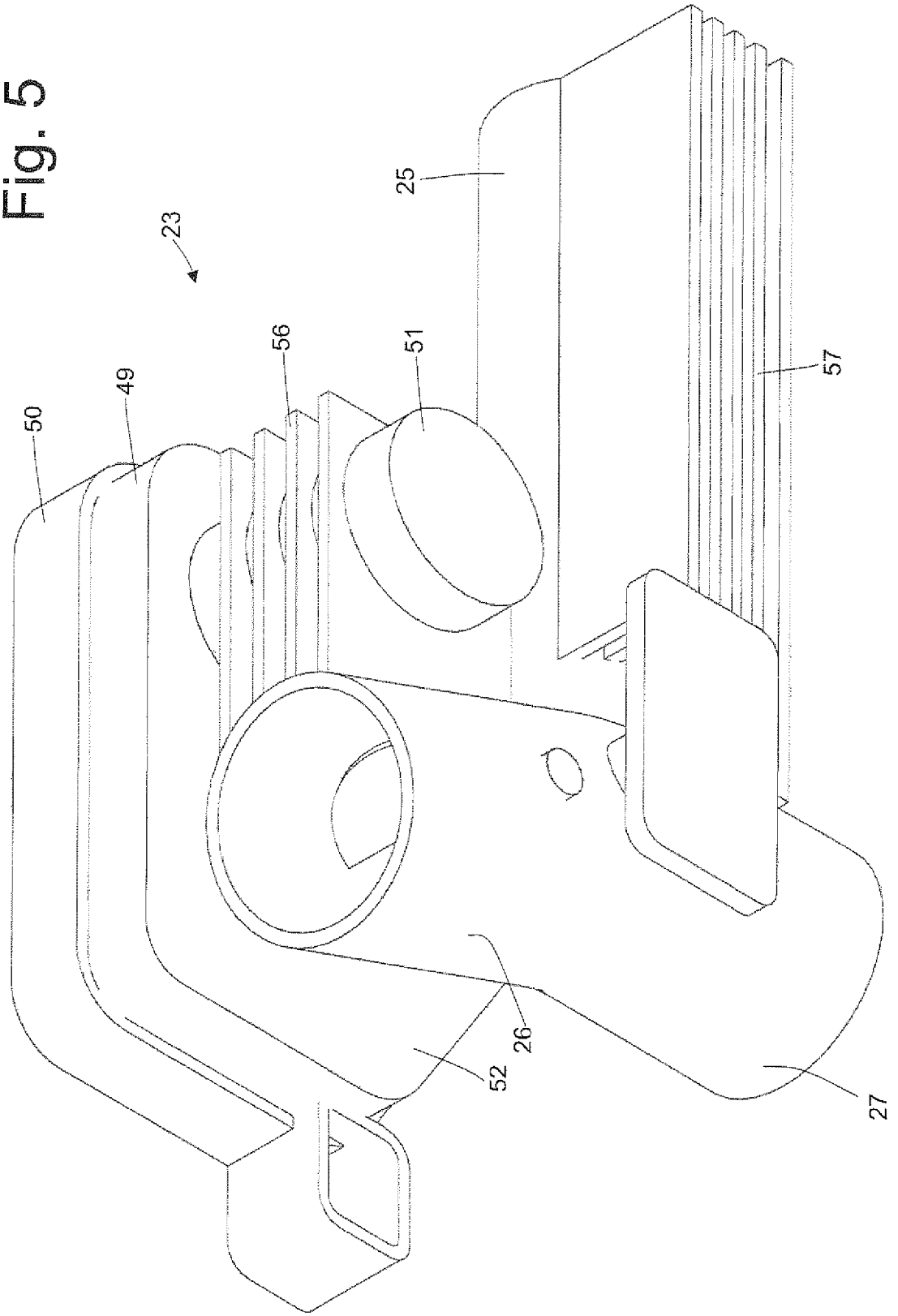


Fig. 5



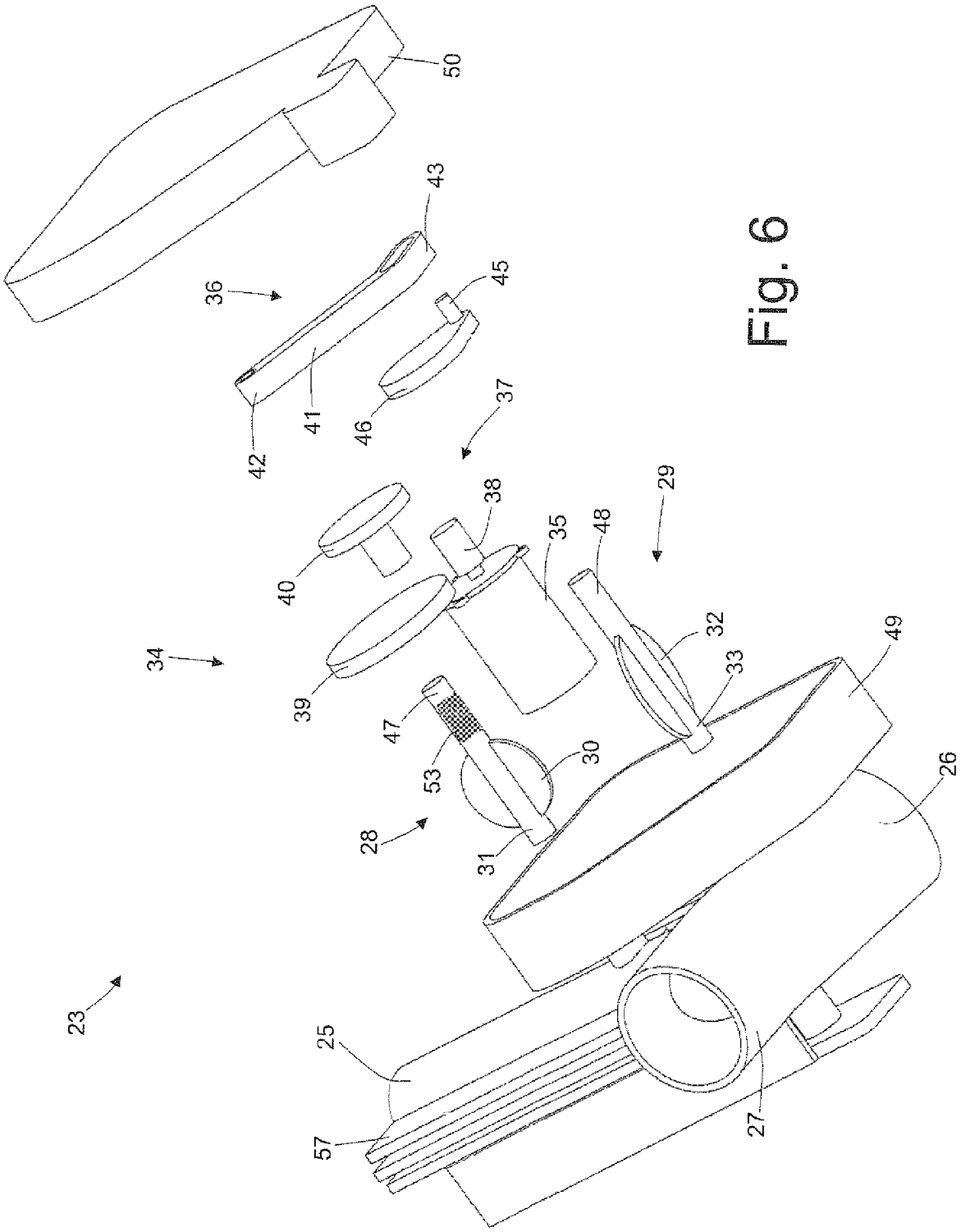

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Fig. 6

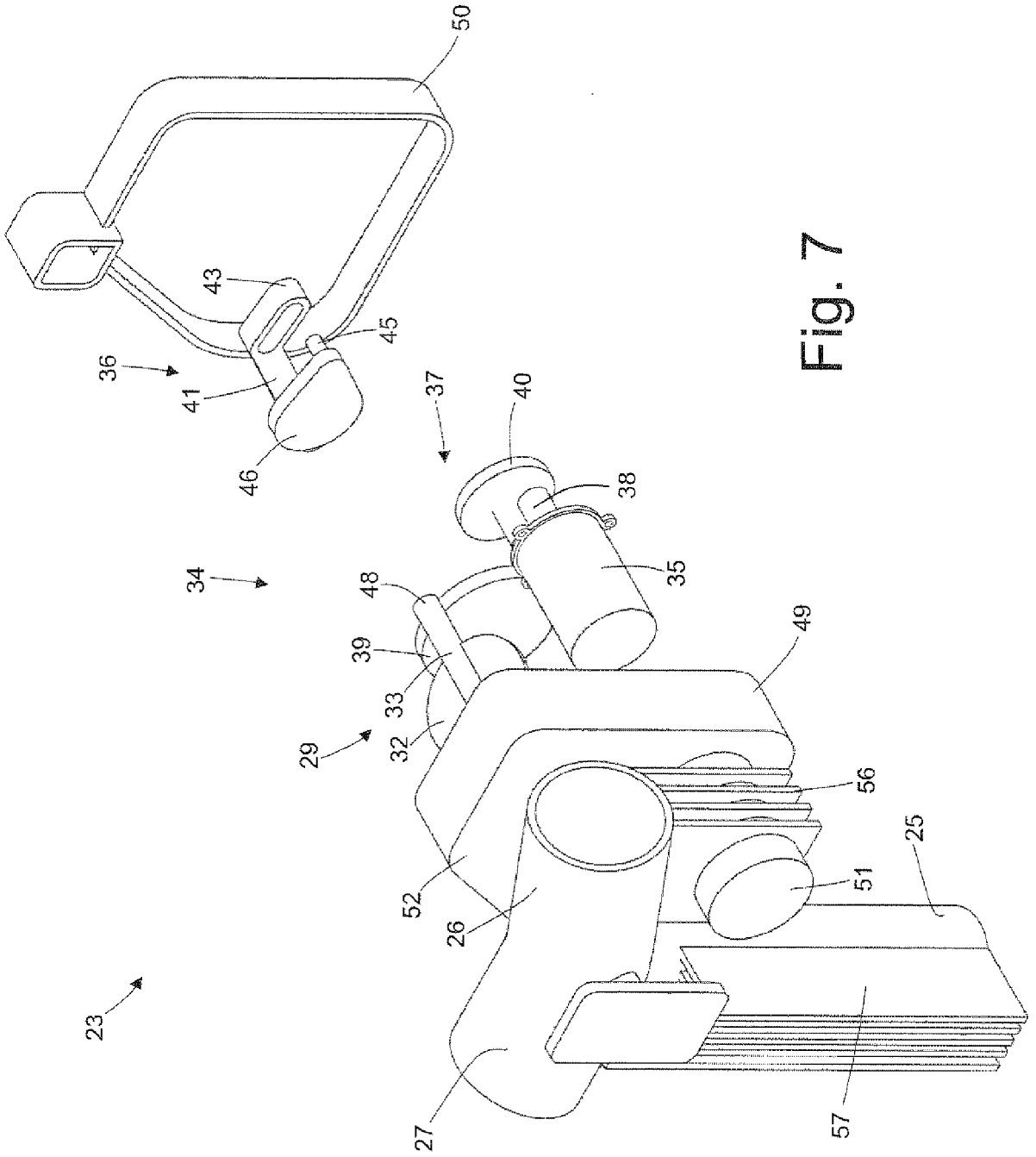
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Fig. 7

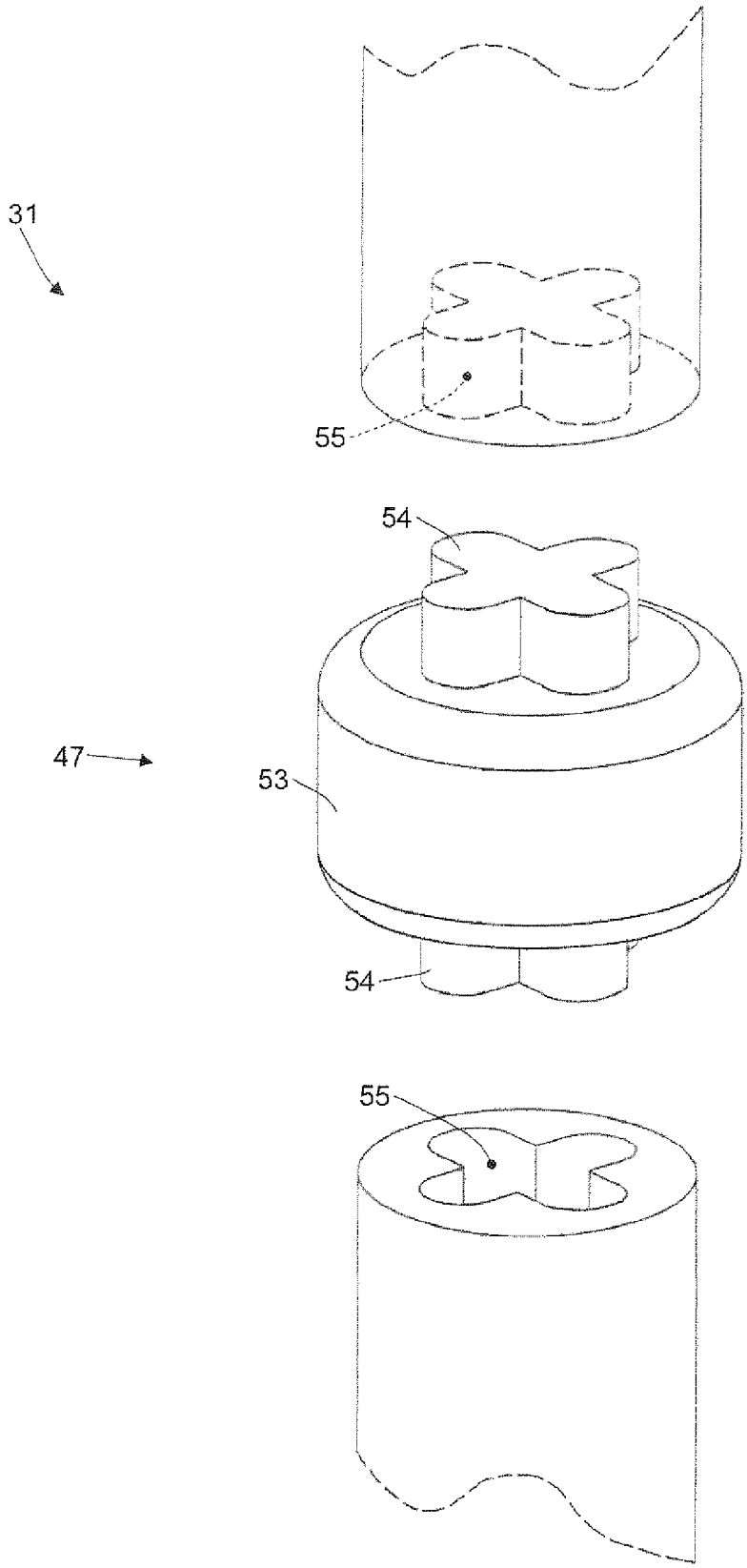

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 10 18 9227

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	25 February 2011	Döring, Marcus

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EUROPEAN SEARCH REPORT

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