(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 484 479 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.12.2004 Bulletin 2004/50

(51) Int Cl.[7]: **F01L 13/00**, F01L 1/18

(21) Application number: **04102518.0**

(22) Date of filing: **04.06.2004**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL HR LT LV MK

(30) Priority: **06.06.2003 IT BO20030347**

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(54) Variable-lift timing system for an internal combustion engine

(57) A variable-lift timing system (10) for an internal combustion engine. The system (10) includes an actuating mechanism (12) for moving a valve (11). An intermediate assembly (15) is interposed between the valve (11) and the actuating mechanism (12), and includes a first contoured member (15a), a contoured surface (18) of which contacts the rod (11a) of the valve (11), and a second contoured member (15b), a contoured surface (22) of which contacts a cam (14) rotated by the actuating mechanism (12). A roller (20) is interposed between the first contoured member (15a) and the second contoured member (15b), and the spatial position of the roller is regulated by an actuating device (23, 25) to determine the law of movement of the valve (11).

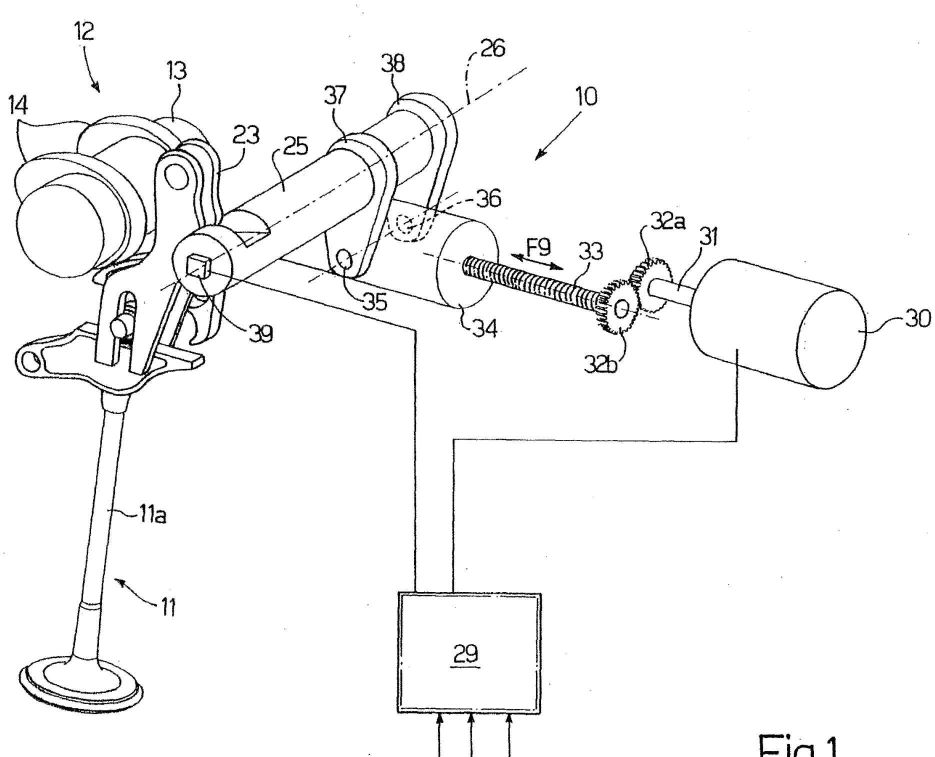

Fig.1

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Description

[0001] The present invention relates to a variable-lift timing system for an internal combustion engine.

[0002] As is known, the gas-dynamic phenomena which take place in the intake and exhaust systems of internal combustion engines have a considerable effect on engine performance, and, to exploit them to best advantage, intake of the fresh charge and exhaust of the burnt gases should be variable as a function of engine operating conditions. In four-stroke engines with conventional "fixed" timing systems, however, open-close timing and lift of the intake and exhaust valves cannot be varied, so that intake and exhaust system gas dynamics can only be optimized over a limited part of the engine operating range.

[0003] By way of a solution to the problem, devices have been devised enabling adjustment of the law of movement of the valves, and some of which are featured in currently manufactured engines.

[0004] One device of this sort is described in EP-1 234 968 (BMW Bayerische Motoren Werke).

[0005] In addition to the camshaft and the valve rocker arm, this device comprises an intermediate rocker arm located between the camshaft and the valve rocker arm, and which, activated by the cam, in turn activates the valve rocker arm, and therefore the valve, by means of an appropriately shaped shoe. The hinge location of the intermediate rocker arm is adjustable to vary the opening profile of the valve.

[0006] This system provides for considerable adjustment of the valve lift profile, but is debatable in terms of size, overall complexity, and by comprising a floating intermediate rocker arm (not hinged to the cylinder head) held in place by a return spring.

[0007] It is an object of the present invention to provide a variable-lift timing system for an internal combustion engine, designed to eliminate the aforementioned drawbacks.

[0008] According to the present invention, there is provided a variable-lift timing system for an internal combustion engine, as claimed in Claim 1.

[0009] A number of non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a three-dimensional view of a first embodiment of the timing system according to the invention; in this example, the system also comprises a number of actuators and control devices;

Figure 2 shows a front view of the Figure 1 timing system in the configuration producing a maximum lift profile (at the maximum lift point) of an internal combustion engine timing valve;

Figure 3 shows a three-dimensional view of the Figure 2 timing system;

Figure 4 shows a front view of the Figure 1 timing system in the configuration producing a minimum lift profile (at the maximum lift point) of an internal combustion engine timing valve;

Figure 5 shows a three-dimensional view of the Figure 4 timing system;

Figure 6 shows an exploded view of the main parts in the first embodiment of the timing system in Figures 1-5;

Figure 7 shows an exploded view of the main parts in a second embodiment of the timing system according to the present invention;

Figure 8 shows an exploded view of the main parts in a third embodiment of the timing system according to the present invention.

[0010] In the following description, only the parts essential to a clear understanding of the invention are indicated and described.

[0011] Number 10 in Figures 1 to 5 indicates a variable-lift timing system for an internal combustion engine 100.

[0012] As shown in more detail in Figures 2 to 5, internal combustion engine 100 comprises a cylinder head 101, in which conduits 102, 103 are formed for feeding air, with or without fuel, into a combustion chamber 104, or for expelling burnt gases from combustion chamber 104 to an exhaust device (not shown).

[0013] Each conduit 102, 103 has a valve 11 (only the one relative to conduit 103 is shown in Figures 2 to 5) comprising a rod 11a terminating with a head 11b for closing an outlet 103a of conduit 103 into respective combustion chamber 104. Valve 11 is also acted on by known elastic return means (not shown) for restoring valve 11 to its initial position once valve 11 is acted on by an actuating mechanism 12 comprising a shaft 13 having one or more cams 14 in the first embodiment in Figures 1 to 6.

[0014] An intermediate assembly 15 is located between cam 14 and the end 11c of rod 11 opposite head 11b, and is divided into two separate contoured members 15a, 15b hinged about respective pivots 16, 17 fixed in known manner (not described) to cylinder head 101.

[0015] Member 15a comprises a contoured bottom surface 18 resting on end 11c of rod 11; and a top surface 19 (flat in the example shown in the accompanying drawings) on which a floating roller 20 rests for the reasons explained later on.

[0016] Floating roller 20 is free to rotate about its axis (a) and to translate along a trajectory determined by a fork-shaped member 23 described in detail later on.

[0017] Member 15b in turn comprises a bottom surface 21 (flat in the example shown in the accompanying drawings) which also contacts roller 20; and a top surface 22 acted on by cam 14.

[0018] Surfaces 19, 21 may be shaped to move roller 20 according to predetermined laws of motion, and in any event must be such that, when fork-shaped member 23 is rotated in the rest condition (valve 11 closed), roller

20 is moved while remaining in contact at all times with both surfaces 19, 21.

[0019] In actual use, when shaft 13 rotates in the direction of arrow F1, cam 14 rotates member 15b about pivot 17; which rotation is transmitted first to roller 20 and then to the other member 15a, which in turn, as stated, rotates about pivot 16. Since surface 18 of member 15a rests on end 11c, valve 11 is also moved in the direction and senses indicated by two-way arrow F2. The elastic return member (not shown) acting on valve 11 obviously ensures all the parts in the mechanism are maintained contacting throughout the travel of valve 11.

[0020] As is known, continuous rotation of cam 14 produces a continuous variation in the position of valve 11 or so-called lift movement or profile. By varying the imposed trajectory of axis (a) of roller 20 (by means of fork-shaped member 23 described later on), it is possible to vary the lift movement of the valve as a whole, which will always be characterized by being maximum for the same position of cam 14

[0021] For example, as shown in Figures 2 and 4, both showing the cam position producing maximum lift of valve 11, the maximum value Hmax1 or Hmax2 of the distance between head 11b and outlet 103a depends on the position of fork-shaped member 23 guiding roller 20.

[0022] Generally speaking, the valve movement profile as a whole can be said to be characterized by lifts which increase as the distance, when valve 11 is closed, between roller 20 and pivot 16 of member 15a gets smaller.

[0023] Fork-shaped member 23 is rotated about a pivot 24, also fitted to cylinder head 101, by, for example, a contoured shaft 25 rotated about an axis 26 by means described below with reference to Figure 1.

[0024] When contoured shaft 25 rotates about axis 26 in the direction of arrow F3, fork-shaped member 23 also rotates about pivot 24 in the direction of arrow F4. And since the two pins 20a projecting from roller 20 are housed inside the slot 23a (shown as a straight slot 23a by way of example) of fork-shaped member 23, rotation of fork-shaped member 23 in the direction of arrow F4 produces a movement of roller 20 in the direction of arrow F5, thus reducing the distance between roller 20 and pivot 16.

[0025] In another embodiment not shown, slot 23a, as opposed to being straight, is curved to impose a given trajectory on roller 20.

[0026] Similarly, again assuming the system employs a contoured shaft 25, the lift of valve 11 is reduced by simply moving roller 20 in the direction of arrow F6, either by continuing to rotate contoured shaft 25 in the direction of arrow F3 and exploiting the profile of contoured shaft 25, or by inversely rotating fork-shaped member 23 in the direction of arrow F7 by rotating contoured shaft 25 in the direction of arrow F8, thus moving roller 20 away from pivot 16 of member 15a and towards pivot 17 of member 15b.

[0027] In other words, the lift movement is varied by varying, by means of fork-shaped member 23, the trajectory roller 20 is permitted to describe by rotation of member 15b.

[0028] Fork-shaped member 23 may also be provided with an elastic retaining system for holding it in contact with its position adjusting system (contoured shaft 25 in the example shown) and preventing possible vibratory movements when fork-shaped member 23 is subjected to no load (in the rest position).

[0029] In Figure 6, the first embodiment shown in Figures 1 to 5 is actually modified slightly by the addition to top member 15b of an appendix 28 which provides for assisting assembly of the system.

[0030] That is, to keep the operating slack of the system constant alongside variations in the position of roller 20, surfaces 19 and 21 of members 15a and 15b, if flat, must be perfectly parallel in the rest position, which means the position of at least one of pivots 16 and 17 must be adjustable. Appendix 28 projects from surface 21 by a length equal to the diameter of roller 20, so that surfaces 19 and 21 are parallel when appendix 28 contacts surface 19, and roller 20 contacts surfaces 19 and 21.

[0031] The angular position of contoured shaft 25 may be determined using a system controlled by an electronic central control unit 29, as shown in Figure 1.

[0032] Central control unit 29 receives input data relative to the operating conditions, and to control of the regulating members, of internal combustion engine 100, and processes the input data to rotate contoured shaft 25 in the direction of arrow F3 or F8, and so move fork-shaped member 23, and position roller 20, accordingly.

[0033] As shown in the Figure 1 example, contoured shaft 25 may be rotated by means of an electric motor 30 controlled by electronic central control unit 29.

[0034] The output shaft 31 of electric motor 30 is fitted with a first gear 32a, which meshes with a second gear 32b integral with a worm 33.

[0035] Worm 33 engages an internal thread formed in a bush 34, to which two cranks 37, 38, both integral with contoured shaft 25, are hinged by respective pins 35, 36.

[0036] Rotation of contoured shaft 25 may be controlled using a known position sensor 39 connected electrically to electronic central control unit 29.

[0037] In actual use, depending on the data acquired by the sensors (not all shown) on engine 100, electronic central control unit 29 supplies electric motor 30 with a signal indicating the direction in which gear 32a is to be rotated.

[0038] Rotation of gear 32a obviously rotates worm 33 and moves bush 34 in either one of the senses indicated by two-way arrow F9, thus rotating contoured shaft 25, and so rotating fork-shaped member 23, resting against contoured shaft 25, about pivot 24. Since pins 20a are housed inside the slot 23a defined by the prongs 27 of fork-shaped member 23, rotation of fork-shaped member 23 produces a shift in the trajectory along which the axis (a) of roller 20 can move, thus changing the lever ratios and therefore the lift movement of valve 11 (compare Figures 2 and 4).

[0039] Figure 7 shows a second embodiment, in which the same camshaft 13 activates two separate valves 111 and 112, and which comprises one contoured shaft 25, one fork-shaped member 23, and one roller 20 astride two intermediate assemblies 150, 151, each relative to a corresponding valve 111, 112. Operation is practically the same as described with reference to the first embodiment in Figures 1 to 6.

[0040] Figure 8 shows a third embodiment of the present invention, which simultaneously activates two valves 111, 112, as in the second embodiment in Figure 7, but which comprises two fork-shaped members 130, 131 integral with each other and rotating about the same pivot 24. Operation is the same as described with reference to the other embodiments.

[0041] Compared with similar variable-lift systems, the timing system according to the present invention has the following advantages:

- very little increase in height;
- few additional components;
- very little sliding friction, which means better overall efficiency and less wear of component parts;
- very little increase in reciprocating masses.

Claims

1. A variable-lift timing system (10) for an internal combustion engine (100), the system (10) comprising:

    - at least one valve (11; 111, 112) subjected to the action of cam actuating means (13, 14) to open and close an opening (103a) for admitting a fresh charge into, or expelling exhaust gas from, a combustion chamber (104); and
    - an actuating mechanism (12) for moving said at least one valve (11; 111, 112);

    the system (10) being **characterized in that** an intermediate assembly (15; 150, 151) is interposed between said at least one valve (11; 111, 112) and said actuating mechanism (12);

    and **in that** said intermediate assembly (15; 150, 151) is divided into a first contoured member (15a), a contoured surface (18) of which contacts the rod (11a) of said valve (11), and into a second contoured member (15b), a contoured surface (22) of which contacts a cam (14) rotated by said actuating mechanism (12); a floating third member (20) being interposed between said first contoured member (15a) and said second contoured member (15b), and contacting a surface (19) of said first contoured member (15a) and a surface (21) of said second contoured member (15b); the trajectory imposed on said third member (20) being variable by actuating means (23, 25) to determine the law of movement of said at least one valve (11; 111, 112).

2. A system (10) as claimed in Claim 1, wherein said actuating means (23, 25) comprise a fork-shaped member (23), a slot (23a) of which is engaged by said third member (20); the position of said fork-shaped member (23) determining the law of movement of said valve (11).

3. A system (10) as claimed in Claim 2, and also comprising a contoured shaft (25), on which a surface of said fork-shaped member (23) rests; rotation of said contoured shaft (25) determining the position of said fork-shaped member (23) to establish the law of movement of said valve (11).

4. A system (10) as claimed in any one of the foregoing Claims, wherein said surfaces (19, 21) of said first and second contoured member are also contoured to move the third member (20) according to predetermined laws of motion.

5. A system (10) as claimed in Claim 4, wherein said surfaces (19, 21) of said first and second contoured member are such that, when said fork-shaped member (23) is rotated in rest conditions, with said valve (11) closed, said third member (20) moves while remaining in contact at all times with both said surfaces (19, 21) of said first and second contoured member.

6. A system (10) as claimed in any one of Claims 2 to 5, wherein, as opposed to being straight, the axis of said slot (23a) of said fork-shaped member (23) is curved to impose a given trajectory on said third member (20).

7. A system (10) as claimed in Claim 1, wherein a single fork-shaped member (23) regulates the law of movement of more than one valve (111, 112).

8. A system (10) as claimed in Claim 1, wherein two fork-shaped members (23) regulate the laws of movement of two valves (111, 112).

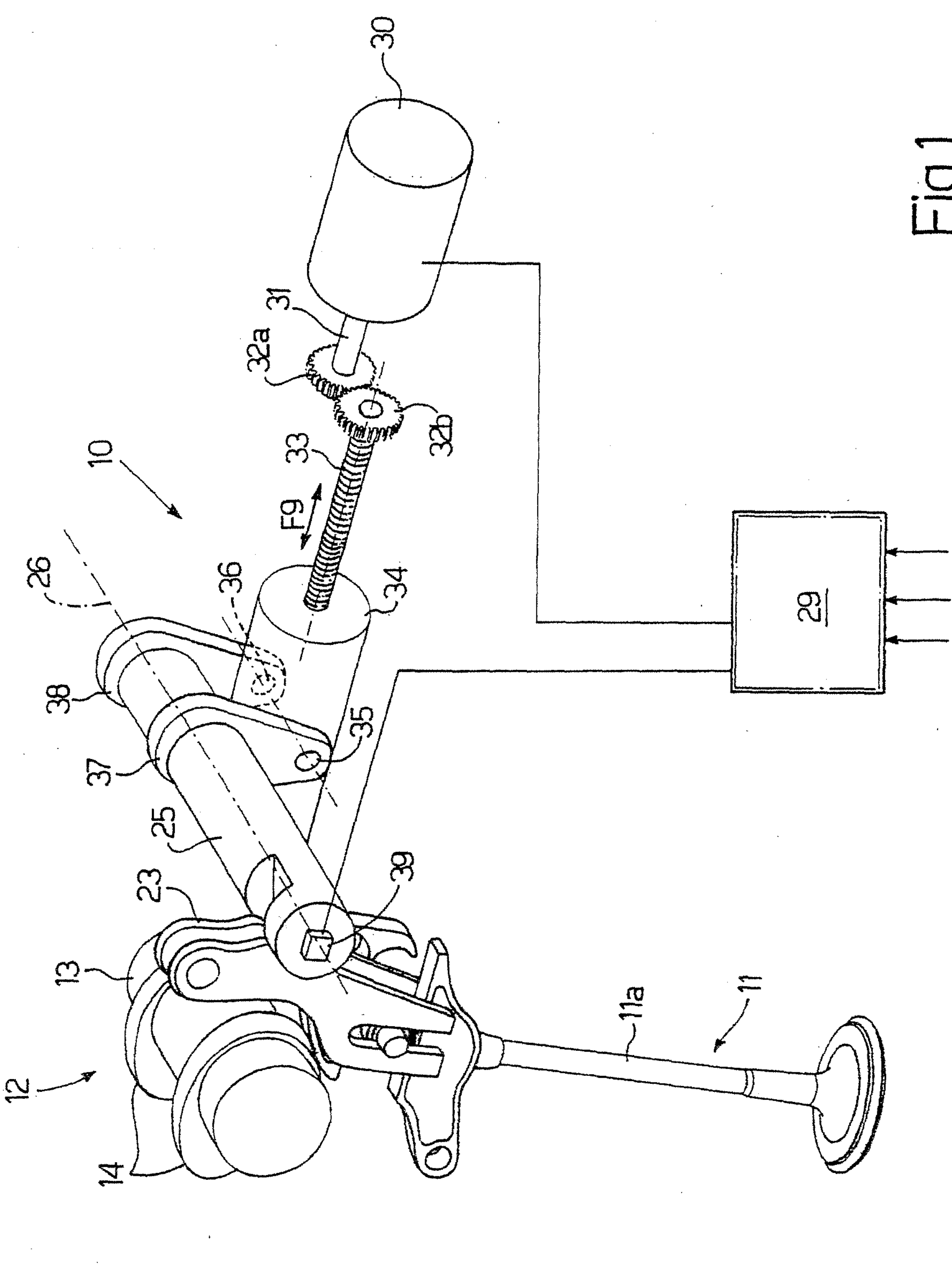
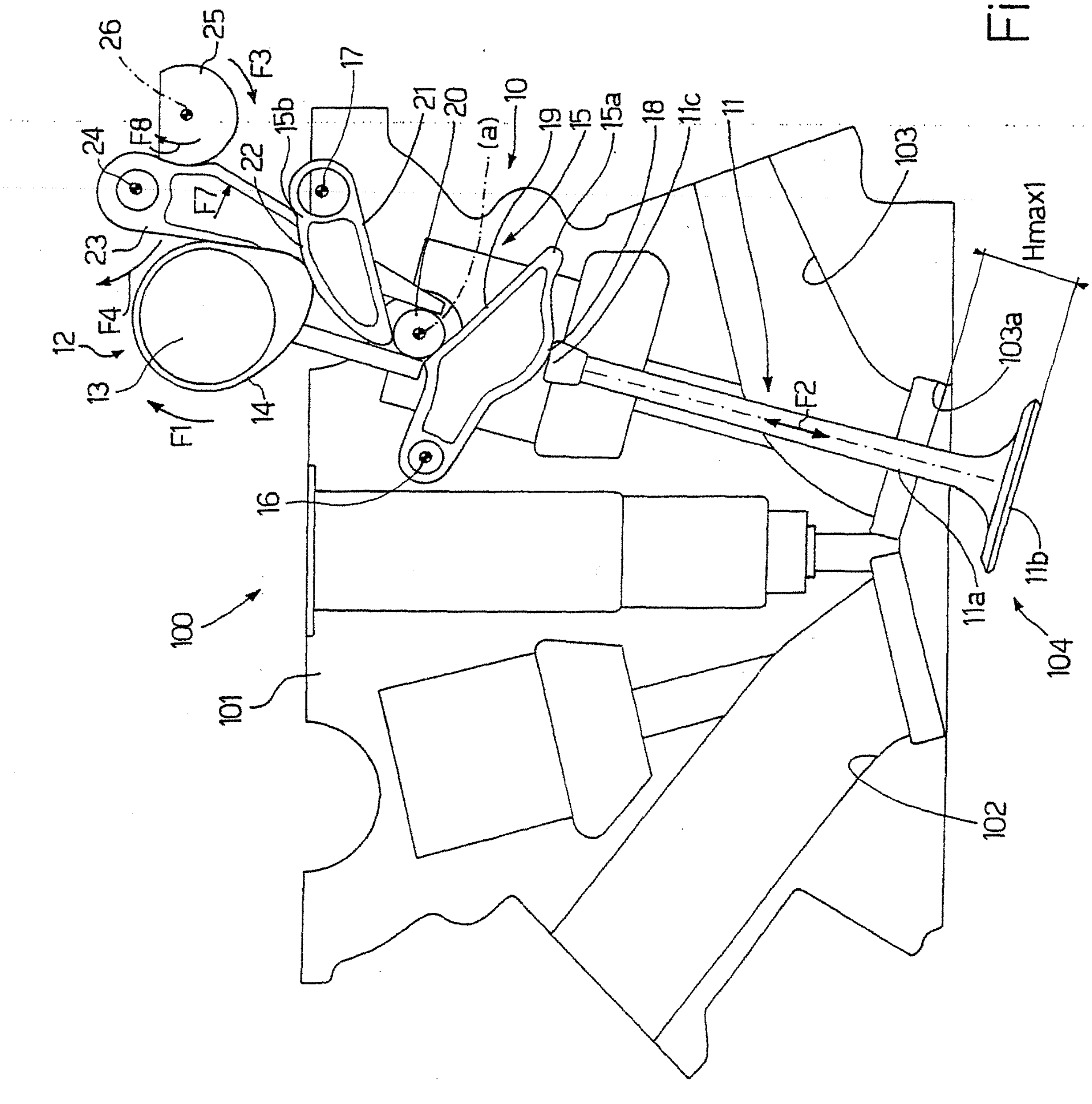


Fig.1



26
25
F3
F8
24
23
F4
12
13
F1
14
22
F7
15b
21
17
20
(a)
10
19
15
15a
18
11c
11
103
Hmax1
103a
F2
16
100
101
11a
11b
104
102

Fig.2

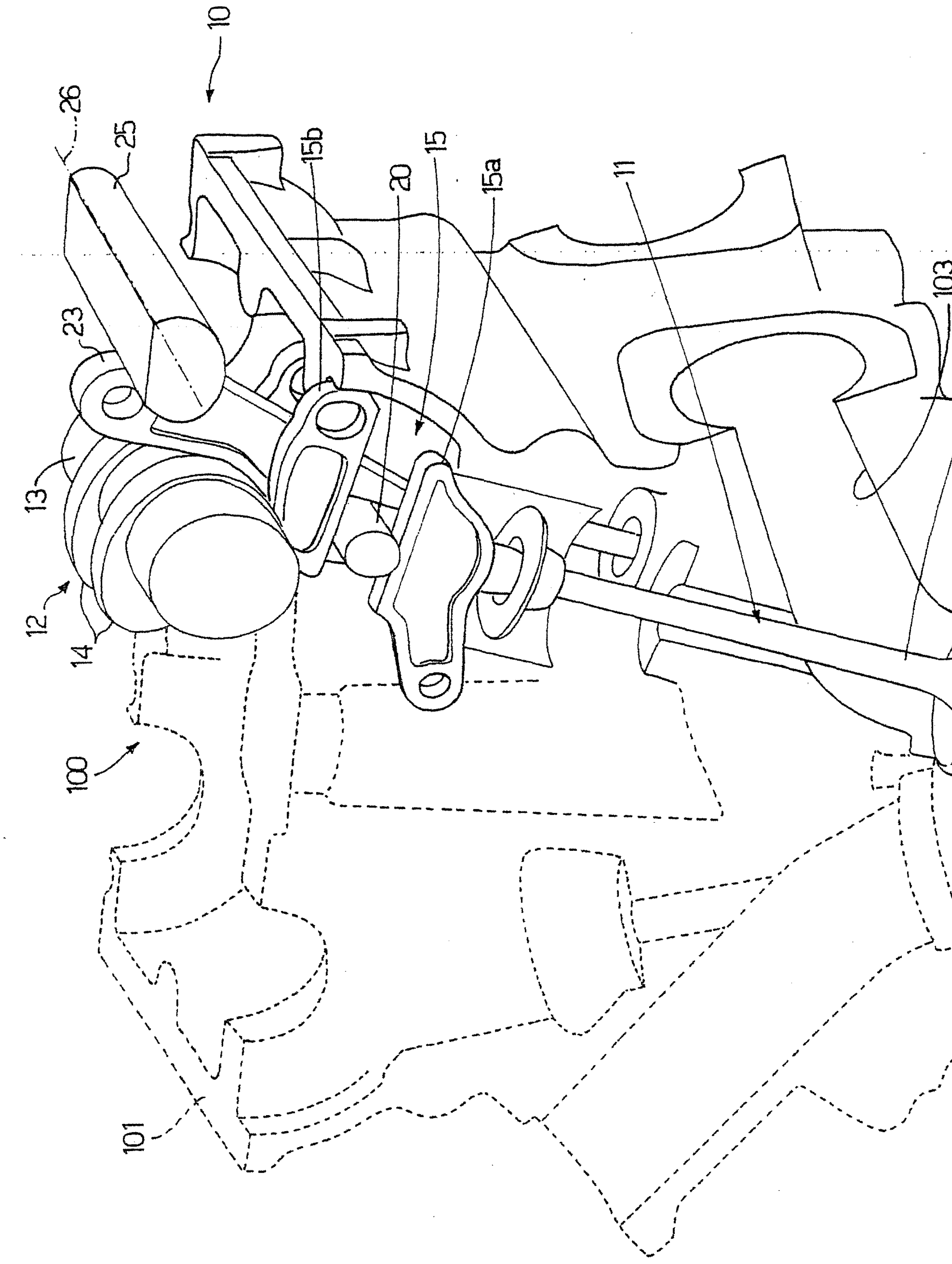
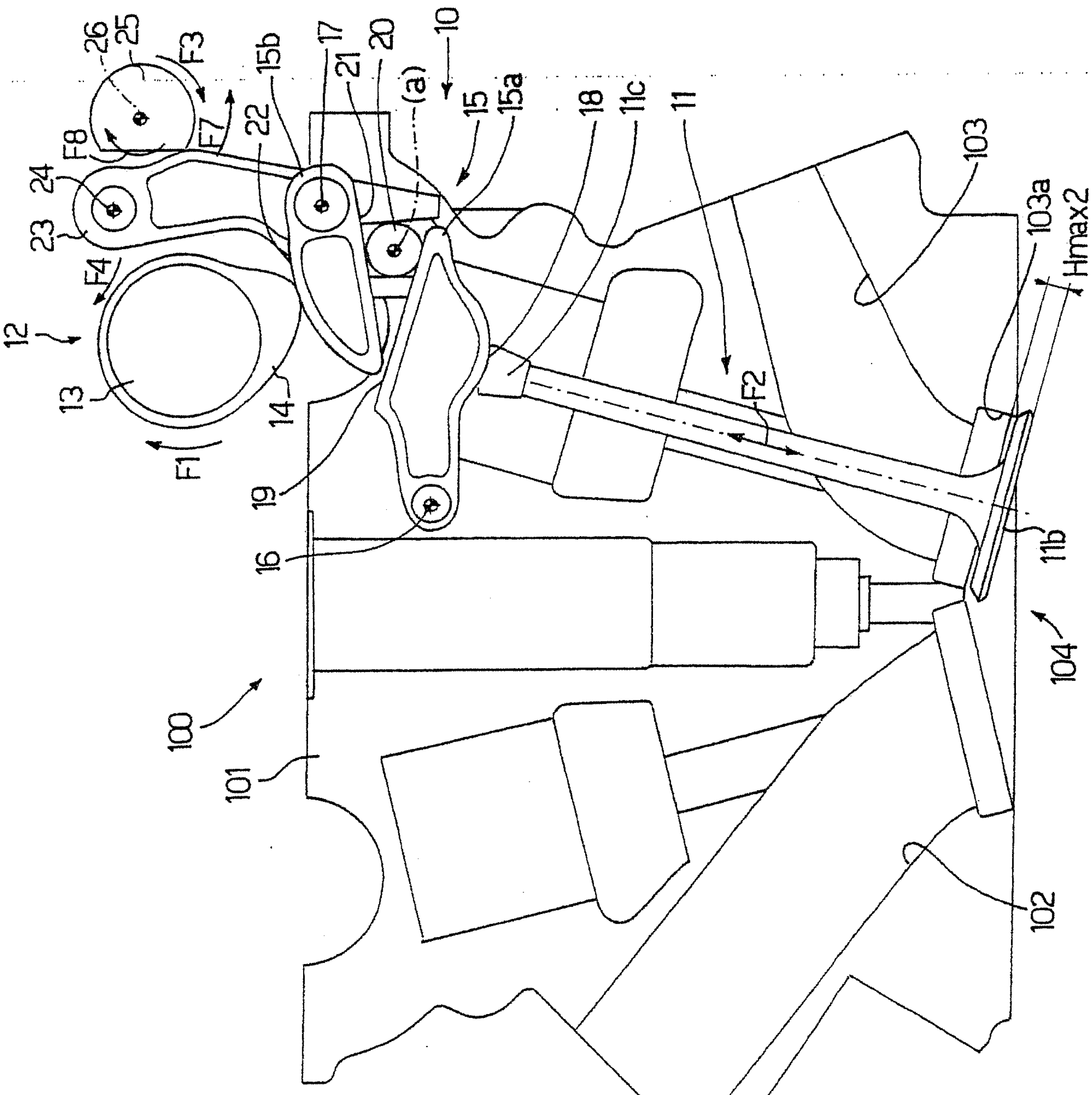


Fig.3


10
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11b
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(a)
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F7
F8
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101
102
103
103a
104
Hmax2

Fig.4

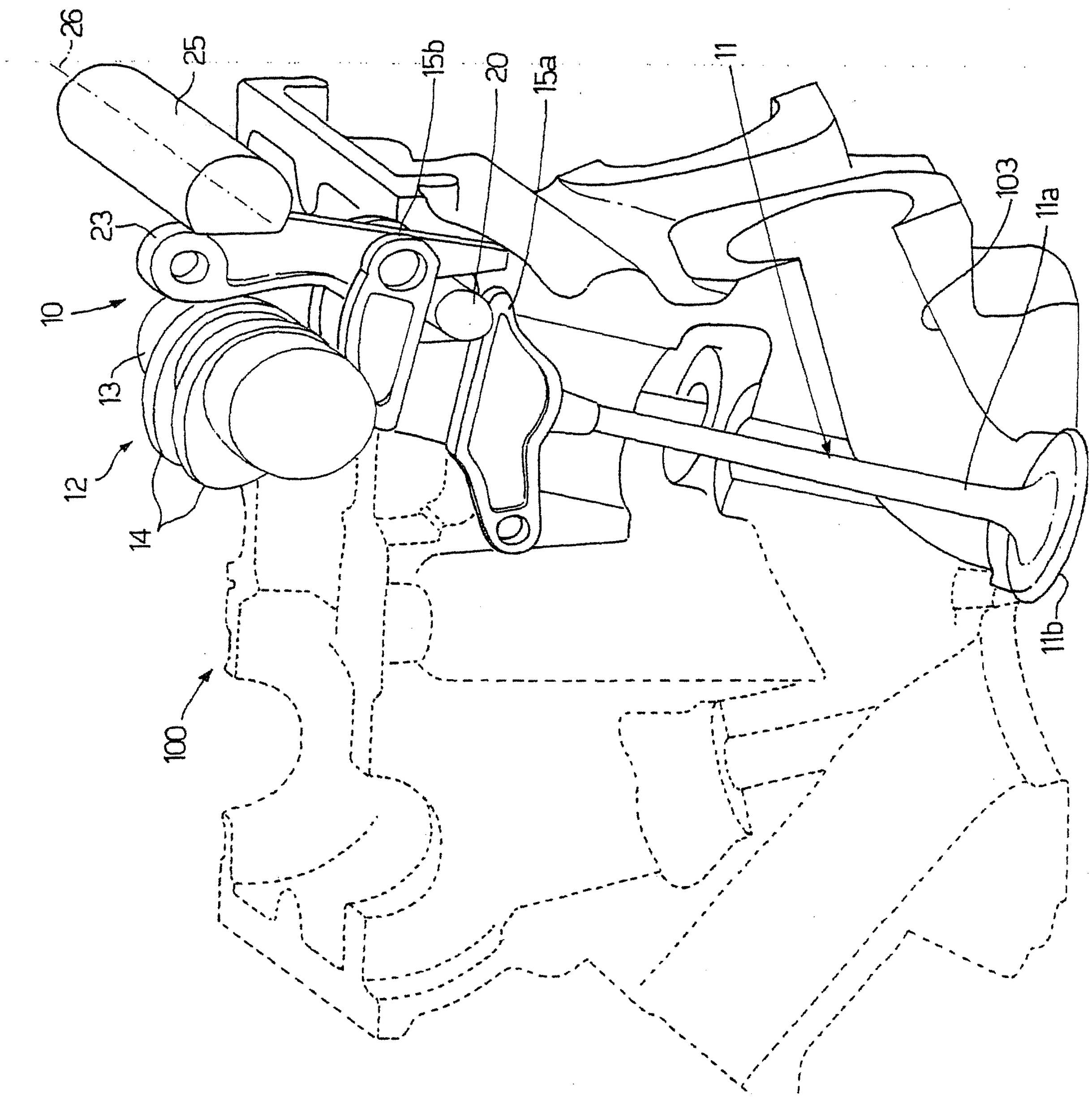
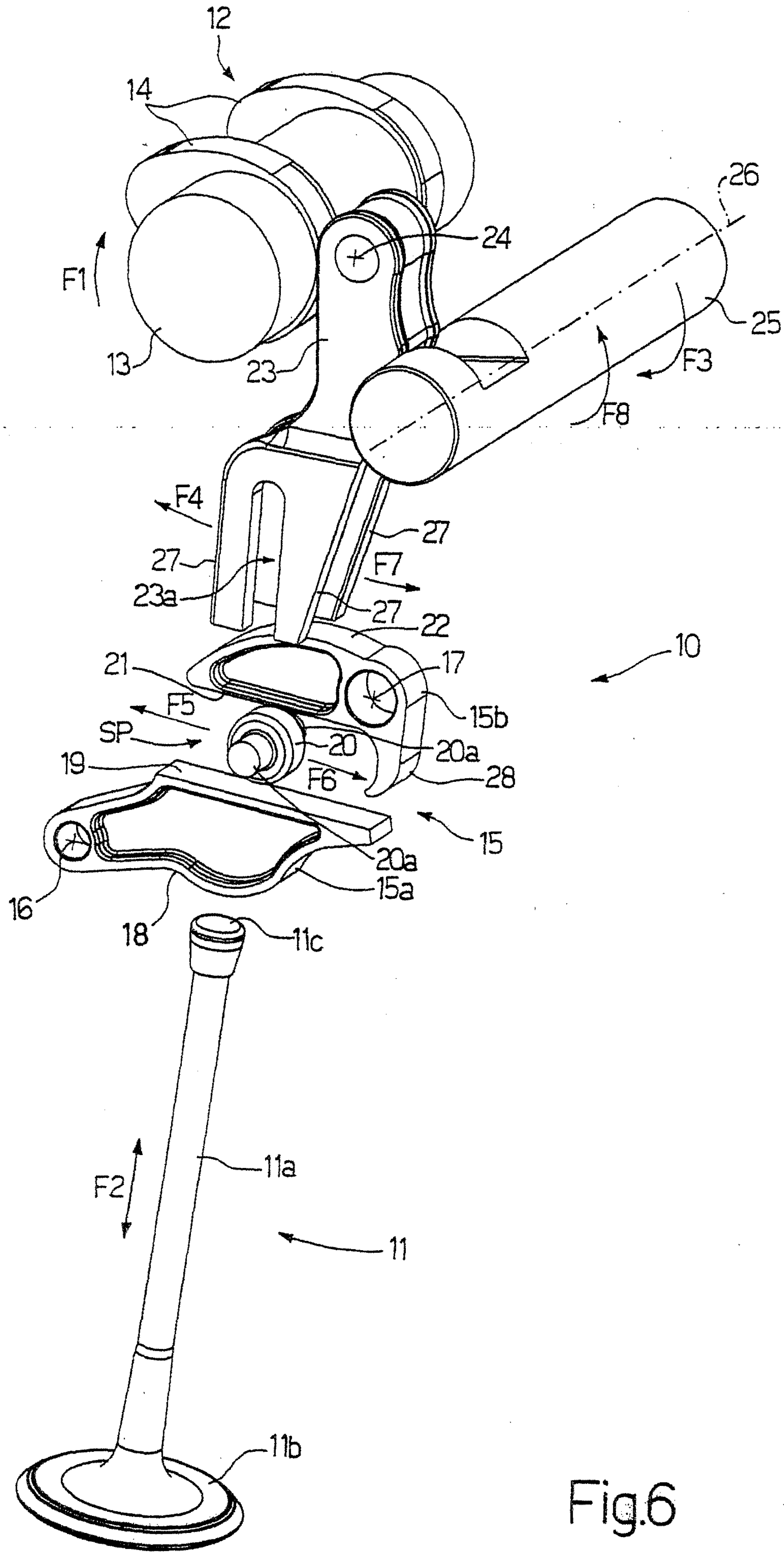


Fig.5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14
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F1
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F3
F8
F4
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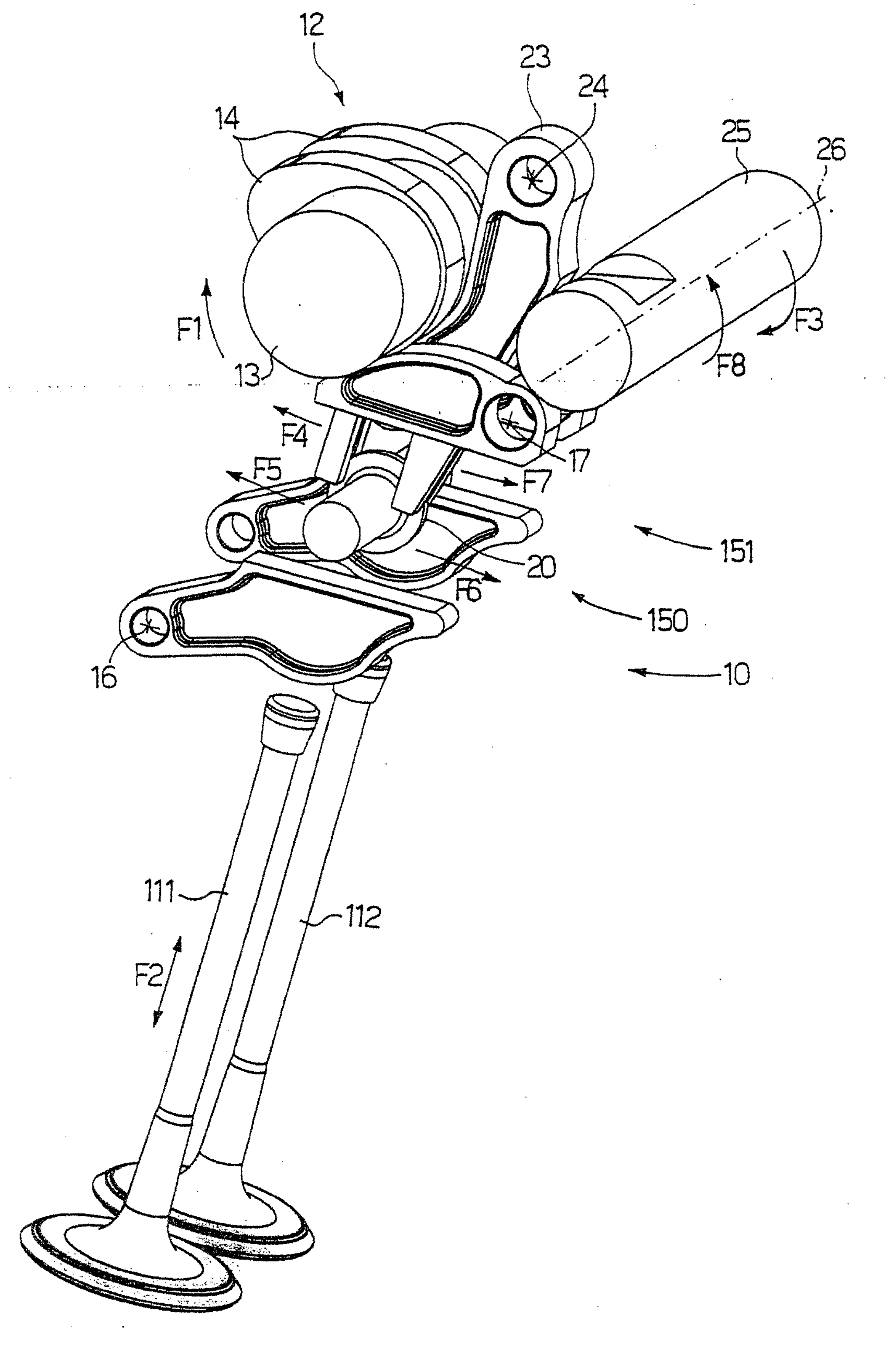
27
27
F7
23a
27
22
10
21
17
F5
15b
SP
20
20a
19
F6
28
15
20a
16
15a
18
11c
11a
F2
11
11b

Fig.6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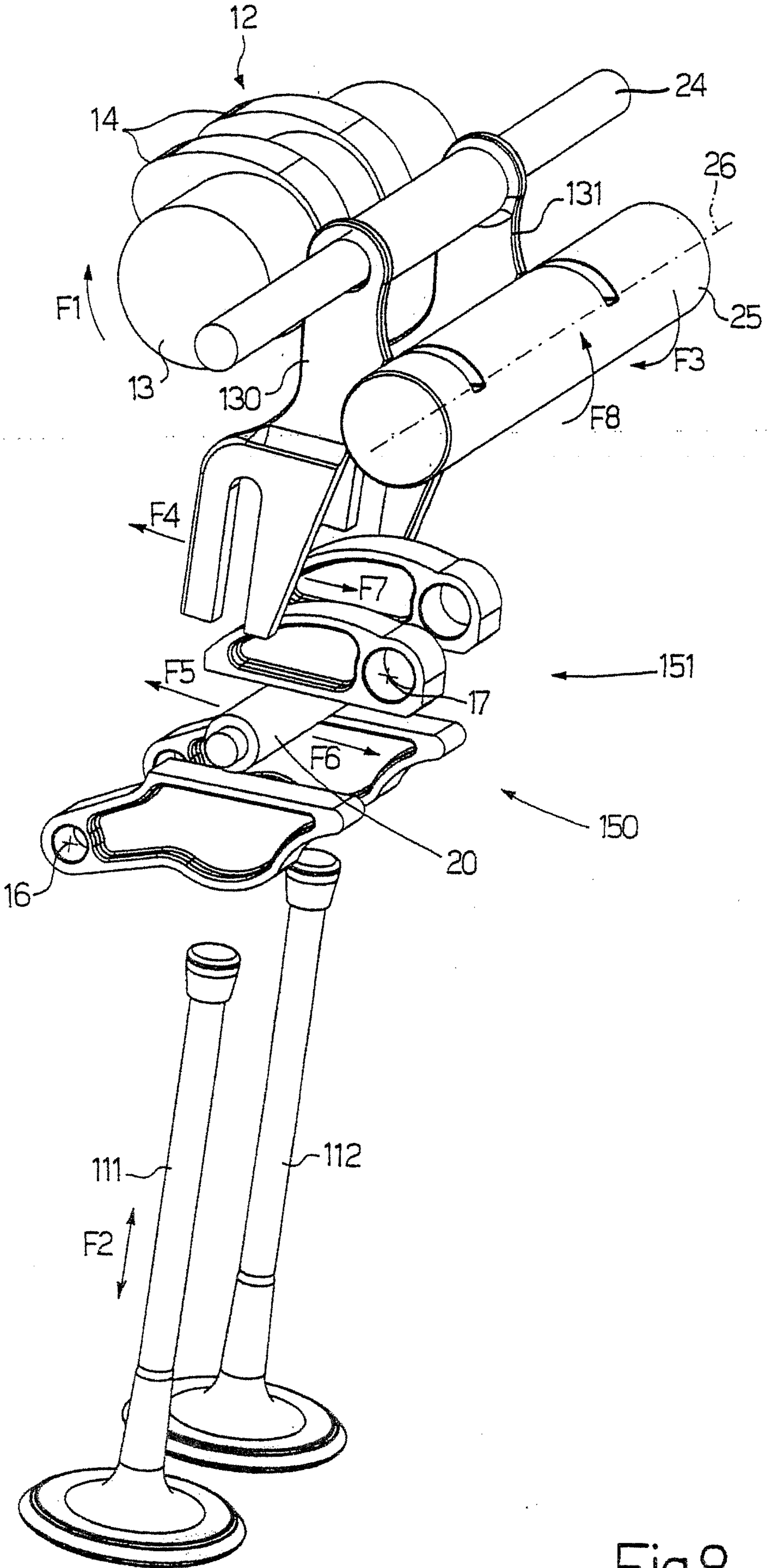
111
112
F2

Fig.7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16
111
112
F2

Fig.8