

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) Publication number:

0 638 707 A1

(12)

EUROPEAN PATENT APPLICATION(21) Application number: **94112110.5**(51) Int. Cl.⁶: **F01L 13/06**(22) Date of filing: **03.08.94**

(30) Priority: **04.08.93 JP 211050/93**
23.05.94 JP 108406/94

(43) Date of publication of application:
15.02.95 Bulletin 95/07

(84) Designated Contracting States:
DE FR GB IT SE

(71) Applicant: **HINO JIDOSHA KOGYO KABUSHIKI KAISHA**
1-1, Hinodai 3-chome
Hino-shi
Tokyo 191 (JP)

(72) Inventor: **Joko, Isao, c/o Hino Jidosha Kokyo Kabushiki Kaisha,**
3-1-1 Hinodai

Hino-shi,
Tokyo 191 (JP)
Inventor: **Kakegawa, Toshiaki, c/o Hino Jidosha Kogyo K.K.**
3-1-1 Hinodai,
Hino-shi
Tokyo 191 (JP)
Inventor: **Shundo, Seiji, c/o Hino Jidosha Kokyo Kabushiki Kaisha,**
3-1-1 Hinodai
Hino-shi,
Tokyo 191 (JP)

(74) Representative: **LOUIS, PÖHLAU, LOHRENTZ & SEGETH**
Postfach 3055
D-90014 Nürnberg (DE)

(54) **Internal combustion engine.**

(57)

[OBJECT]

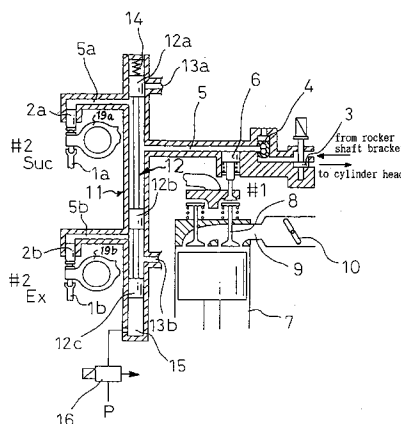
An engine brake device, which serves during engine braking to ensure a braking force by opening an exhaust valve of a cylinder near a top dead center in a compression stroke to discharge the compressed air, is utilized to provide an internal combustion engine which can attain exhaust gas recirculation.

[CONSTRUCTION]

In an internal combustion engine, in addition to an engine-braking master piston 2a for a cylinder actuated by a rocker arm 19a which in turn is actuated by a push rod 1a of another cylinder, an exhaust-gas-recirculation master piston 2b is provided which is actuated by a rocker arm 19b which in turn is actuated by a push rod 1b of the another cylinder to open an exhaust valve 8 in a suction stroke, thereby producing hydraulic pressure in the oil having been supplied to an oil passage 5. Further pro-

vided is an oil passage selector valve 11 for selectively switching over the hydraulic pressures produced by the engine-braking and exhaust-gas-recirculation master piston 2a to the oil passage.

FIG. 1



[DETAILED DESCRIPTION OF THE INVENTION]

[Field of the Invention]

The present invention relates to an internal combustion engine in which a compression engine brake device, which serves during engine braking to ensure a braking force by opening an exhaust valve of a cylinder near a top dead center in a compression stroke to discharge the compressed air, is utilized for exhaust gas recirculation.

[Prior Art]

In an internal combustion engine with an engine brake device as shown in Fig. 8, during engine braking with an exhaust brake valve 10 being closed, a master piston 2 for a cylinder 7 is actuated by a rocker arm 19 which in turn is actuated by a push rod 1 of another cylinder (not shown) to pressurize an oil having been supplied to an oil passage 5 from a rocker shaft bracket through solenoid and control valves 3 and 4. Due to the hydraulic pressure thus produced, an exhaust valve 8 of the cylinder 7 near a top dead center is opened via a slave piston 6 to discharge the compressed air through an exhaust port 9. As a result, force for pushing down the piston is prevented from generating and a braking force obtained in the compression stroke is effectively utilized with no loss.

In in-line 6-cylindered engines, three oil passages 5 are branched off from a single oil passage provided with a solenoid valve 3, a control valve 4 being disposed in each of the oil passages 5. This allows the volume of each oil passage 5 to be reduced and enhances responsiveness of the slave piston 6.

[Tasks to be Attained by the Invention]

An internal combustion engine having a conventional engine brake device described above may be effective for engine braking, but cannot attain recirculation of exhaust gases, failing to make improvement on the problems of NO_x and of white smoke at engine starting. Particularly in a turbo-intercooled engine, exhaust gas recirculation is difficult to carry out.

It is an object of the present invention to provide an internal combustion engine which can solve the above problems.

[Means or Measures for Attaining the Problems]

To attain the above object, the present invention is directed to an internal combustion engine wherein during engine braking, a master piston for

a cylinder is actuated by a rocker arm which in turn is actuated by a push rod of another cylinder to pressurize an oil having been supplied to an oil passage, an exhaust valve of the one cylinder near a top dead center in a compression stroke being opened through a slave piston by the hydraulic pressure thus produced to discharge the compressed air through an exhaust port, characterized in that

in addition to said engine-braking master piston actuated by the rocker arm which in turn is actuated by the push rod, an exhaust-gas-recirculation master piston is provided which is actuated by a rocker arm which in turn is actuated by a push rod of said another cylinder to open the exhaust valve in a suction stroke, thereby pressurizing said oil having been supplied to said oil passage, and that

an oil passage selector valve is provided which selectively switches over the hydraulic pressures produced by said master pistons to said oil passage.

[Action]

In the above arrangement, engine braking and exhaust gas recirculation can be selectively effected by switching over the hydraulic pressures produced by the engine-braking and exhaust-gas-recirculation master pistons by means of the oil passage selector valve.

[Embodiments]

Embodiments of the present invention will be described in conjunction with the drawings.

In Fig. 1, reference numeral 5 represents an oil passage to which oil is supplied from a rocker shaft bracket through solenoid and control valves 3 and 4; 6, a slave piston which opens an exhaust valve 8 of a cylinder 7 depending upon pressure in the oil passage 5; and 10, an exhaust brake valve.

Reference numerals 1a and 1b designate inlet and exhaust push rods of another cylinder, respectively; and 2a and 2b, engine-braking and exhaust-gas-recirculation master pistons actuated by rocker arms 19a and 19b which in turn are actuated by the inlet and exhaust push rods 1a and 1b, respectively. The master pistons 2a and 2b, when actuated, pressurize the oil which has been supplied to the oil passage 5 of the cylinder 7.

Reference numeral 11 represents an oil passage selector valve which selectively switches over the hydraulic pressures produced by the master pistons 2a and 2b to the oil passage 5. The selector valve 11 comprises a spool valve shaft 12 with a spool 12a for selectively communicating and cutting off an oil passage 5a for the engine-braking

master piston 2a with and from the oil passage 5, a spool 12b for selectively communicating and cutting off an oil passage 5b for the exhaust-gas-recirculation master piston 2b with and from the oil passage 5 and a piston 12c.

A switching mechanism for the oil passage selector valve 11 is constructed such that a spring 14 is loaded on one end of the spool valve shaft 12, a pressure source being connected through an electromagnetic selector valve 16 to a chamber 15 on a top surface of the piston 12c at the other end of the shaft 12. Switching of the selector valve 16 causes the shaft 12 to be axially displaced for selective opening and closing of the passages 5a and 5b. Reference numerals 13a and 13b represent discharge passages.

Fig. 2 exemplarily shows an application of the above embodiment to an in-line 6-cylindrical engine where the exhaust valves 8 of the first, second and third cylinders #1(7), #2 and #3 are opening-controlled by the inlet and exhaust push rods 1a and 1b of the second, third and first cylinders #2, #3 and #1(7), respectively.

Next referring to Figs. 1 and 2, the mode of operation of the above embodiment will be described with respect to the exhaust valve 8 of the first cylinder #1(7) opening-controlled by the push rods 1a and 1b of the second cylinder #2. During engine braking, i.e., when an exhaust brake switch (not shown) is on and a driver's foot is detached from an accelerator pedal during traveling, the selector valve 16 is so switched that pressure oil is supplied to the chamber 15 and the passage 5b for the exhaust-gas-recirculation master piston 2b is closed while the oil passage 5a for the engine-braking master piston 2a is communicated with the oil passage 5.

Under the above condition, the engine-braking master piston 2a is actuated by the inlet push rod 1a of the second cylinder #2 in a suction stroke to pressurize the oil having been supplied to the oil passage 5 from the rocker shaft bracket through the solenoid and control valves 3 and 4. Due to the hydraulic pressure thus produced, the exhaust valve 8 of the cylinder 7 (the first cylinder #1) in an expansion stroke is opened through the slave piston 6 to discharge the compressed air through the exhaust port 9. As a result, force for pushing down the piston is prevented from generating and the braking force is effectively utilized with no loss.

During exhaust gas recirculation (EGR), i.e., when the accelerator pedal is pressed to some extent and the engine is neither in idling state nor in high loading condition during traveling, the selector valve 16 is so switched that the pressure oil in the chamber 15 is discharged by resilient force of the spring 14. As a result, the oil passage selector valve 11 is so switched that the oil pas-

sage 5a for the engine-braking master piston 2a is closed while the oil passage 5b for the exhaust-gas-recirculation master piston 2b is communicated with the oil passage 5.

Under such condition, the exhaust-gas-recirculation master piston 2b is actuated by the exhaust push rod 1b of the second cylinder #2 in exhaust stroke to pressurize the oil having been supplied to the oil passage 5 from the rocker shaft bracket through the solenoid and control valves 3 and 4. Due to the hydraulic pressure thus produced, the exhaust valve 8 of the cylinder 7 (the first cylinder #1) is opened at the end of the suction stroke via the slave piston 6. Thus, because of the second cylinder #2 being in exhaust stroke and having high pressure in its exhaust pipe, part of the exhaust gases in the second cylinder #2 flow back to the cylinder 7 (the first cylinder #1) due to the pressure difference. Thus, the exhaust gas recirculation (EGR) is effected to reduce NO_x and improves the problem of white smoke at engine starting. This EGR is effective for turbo-inter-cooled engines in which exhaust manifold pressure pulsation owing to exhaust strokes of each cylinder is high.

Next referring to Fig. 3, the mode of operation of an in-line 6-cylindrical engine to which the above embodiment is applied will be described. Valve lift is shown in the order of ignition #1, #4, #2, #6, #3 and #5. The exhaust valve of the first cylinder #1 is opening-controlled by the exhaust push rod of the second cylinder #2 and is opened near bottom dead center (BDC) of the first cylinder #1 to effect the exhaust gas recirculation (EGR). The exhaust valve of the first cylinder #1 is opened near top dead center (TDC) in the compression stroke of the first cylinder #1 by means of the inlet push rod of the second cylinder #2 to discharge the compressed air. As a result, force for pushing down the piston is prevented from generating and the engine brake (BR) is actuated.

Exhaust gas recirculation may be also effected during engine starting for the purpose of air warming.

Fig. 4 shows a further embodiment of the present invention where the same component as in Fig. 1 is referred to by the same reference numeral as in Fig. 1 and basic arrangement is the same as in Fig. 1. In this embodiment, however, instead of providing a spring 14 (Fig. 1), the casing which forms the oil passage selector valve 11 is extended at its end and the spool valve shaft 12 is extended at its end closer to the spool 12a to have a piston 12d at its tip. Formed on a top surface of the piston 12d is a chamber 15' to which a pressure source is connected through an electromagnetic selector valve 16'.

In the embodiment of Fig. 4, during engine braking, i.e., when the exhaust brake switch (not shown) is on and the driver's foot is detached from the accelerator pedal during traveling, the selector valve 16 is switched over to supply the pressure oil to the chamber 15 and the electromagnetic selector valve 16' is switched over to discharge the pressure oil in the chamber 15'. As a result, the oil passage selector valve 11 is so switched that the oil passage 5b for the exhaust-gas-recirculation master piston 2b is closed while the oil passage 5a for the engine-braking master piston 2a is communicated with the oil passage 5. On the other hand, during exhaust gas recirculation (EGR), i.e., when the accelerator pedal is pressed to some extent and the engine is neither in idling state nor in high loading condition during traveling, the selector valve 16' is switched over to supply the pressure oil to the chamber 15' and the selector valve 16 is switched over to discharge the pressure oil in the chamber 15. As a result, the oil passage selector valve 11 is so switched that the oil passage 5a for the engine-braking master piston 2a is closed while the oil passage 5b for the exhaust-gas-recirculation master piston 2b is communicated with the oil passage 5.

In the embodiment of Fig. 4, switching of the oil passage selector valve 11 from engine braking position to the exhaust gas recirculating position is effected, not by means of the spring 14 whose reaction force is changed according to the position of the spool valve shaft 12 as in Fig. 1, but by means of the hydraulic pressure so that the operation can be carried out in reliable and assured manner.

Fig. 5 shows a pattern of driving in the embodiment of Fig. 4. Here, the extent of pressing the accelerator pedal is detected by an accelerator sensor under the following three conditions: idling state (OFF) with the accelerator pedal being not pressed at all, low to moderate loading condition (ON; mild) with the accelerator pedal being pressed to some extent and high loading condition (ON; high) with the acceleration pedal being pressed strongly.

As it is evident from Fig. 5, when the exhaust brake switch is on and the driver's foot is detached from the accelerator pedal, the electromagnetic valve 16 is switched over to supply pressure oil to the chamber 15 and the electromagnetic valve 16' is switched over to discharge the pressure oil in the chamber 15'. As a result, the oil passage selector valve 11 is so switched that the oil passage 5a for the engine-braking master piston 2a is communicated with the oil passage 5, i.e., the valve 11 is switched into a position for engine braking mode. As described above, the exhaust valve 8 of the cylinder 7 in expansion stroke is opened to

discharge the compressed air through the exhaust port 9, whereby force for pushing down the piston is prevented from generating and the braking force is effectively utilized without loss. It is needless to say that EGR is not effected in this case.

When the condition of the driver's foot being detached from the accelerator pedal is changed into the low to moderate loading condition with the accelerator pedal being pressed to some extent, then the selector valve 16' is switched over to supply the pressure oil to the chamber 15' and the selector valve 16 is switched over to discharge the pressure oil in the chamber 15. As a result, the oil passage selector valve 11 is so switched that the oil passage 5a for the engine-braking master piston 2a is closed while the oil passage 5b for the exhaust-gas-recirculation master piston 2b is communicated with the oil passage 5, i.e. the valve 11 is switched into the position of EGR mode. Thus, EGR is effected as described above.

Further, when the condition of the accelerator pedal being pressed to some extent is changed into the high loading condition with the accelerator pedal being pressed strongly, then the pressures in the chamber 15' and 15 due to operation of the selector valves 16' and 16, respectively, are maintained without change and the oil passage selector valve 11 also remains at the position of EGR mode without change. However, a control signal is outputted from a controller (not shown) depending upon driving condition of the engine so that the solenoid valve 3 is switched over to relieve the pressure in the oil passage 5 and hydraulic pressure for opening the exhaust valve 8 is prevented from generating. Therefore, EGR is not effected.

In the case where the exhaust brake switch is off, the oil passage selector valve 11 is switched over to EGR mode regardless of the extent at which the accelerator pedal is pressed. EGR is effected only when the engine is neither in idling nor in high loading condition, i.e., only when it is in the low to moderate loading condition. Engine braking by opening the exhaust valve 8 is not effected.

As mentioned above, when the condition of the driver's foot being detached from the accelerator pedal is changed into the low to moderate loading condition with the accelerator pedal being pressed to some extent, i.e., in the case where the condition of the exhaust valve 8 being opened to effect engine braking is released and changed to the EGR mode, then the oil passage selector valve 11 is switched over from the position of engine braking mode to the position of EGR mode. Here, since a rotating speed of the engine is low and engine hydraulic pressure supplied to the chamber 15' is low, the spool valve shaft 12 of the oil passage selector valve 11 has deteriorated responsiveness so that engine braking, which is due to opening the

exhaust valve 8 near top dead center at the compression stroke, is continued for a slight while after the accelerator pedal is pressed, which fact may make the driver confused. The driver's confusion does not occur when the condition of the driver's foot being detached from the accelerator pedal is changed into the high loading condition with the accelerator pedal being pressed strongly and the selector valve 11 is switched over from the position of engine braking mode to the position of EGR mode since the solenoid valve 3 is switched over to relieve the pressure in the oil passage 5 and the engine braking due to opening the exhaust valve 8 near top dead center at the compression stroke is immediately released without being continued. No problem is also found in the case where EGR mode is changed into engine braking mode since the rotating speed of the engine is high and engine hydraulic pressure is ensured.

Figs. 6 and 7 shows an arrangement for eliminating such possible confusion in which a control signal 18 for switching over the solenoid valve 3 to relieve the pressure in the oil passage 5 is outputted from a controller 17 to the solenoid valve 3 when the condition of the driver's foot being detached from the accelerator pedal is changed into the low to moderate loading condition with the accelerator pedal being pressed to some extent, i.e., when the condition with the exhaust valve 8 being opened to effect engine braking is changed into the condition where engine braking mode is released and switched over to EGR mode.

According to this arrangement, when the condition of the exhaust valve 8 being opened to effect engine braking is changed into the condition where engine braking is released and switched over to EGR mode, the solenoid valve 3 is switched over by the control signal 18 from the controller 17 to relieve the pressure in the oil passage 5. Engine braking due to opening the exhaust valve 8 near top dead center at compression stroke is immediately released by the pressure relief. Therefore, there is no fear of the driver being confused.

Of course, also in the embodiment of Fig. 1, just like the embodiment shown in Figs. 6 and 7, the engine braking mode can be quickly switched over into the EGR mode to eliminate the driver's confusion by arranging such that the control signal 18 is outputted from the controller 17 to the solenoid valve 3 so as to switch over the solenoid valve 3 to relieve the pressure in the oil passage 5 when the condition of the driver's foot being detached from the accelerator pedal is changed into the low to moderate loading condition with the accelerator pedal being pressed to some extent, i.e., when the condition of the exhaust valve 8 being opened to effect engine braking is released and switched over to EGR mode.

[Meritorious Effects of the Invention]

As described above, according to an internal combustion engine of the present invention which has a compression engine brake device adapted to ensure a braking force by opening an exhaust valve of a cylinder near a top dead center in a compression stroke to discharge the compressed air, an oil passage selector valve is arranged for selectively switching over the hydraulic pressures produced by the engine-braking and exhaust-gas-recirculation master pistons. Therefore, in addition to engine braking, exhaust gas recirculation can be effected. Reduction of NO_x and improvement of the problem of white smoke at engine starting are attained.

[BRIEF DESCRIPTION OF THE DRAWING]

[Fig. 1]

A sectional view of an embodiment of the present invention.

[Fig. 2]

A view showing an arrangement with related cylinders in the embodiment of the present invention.

[Fig. 3]

A diagram showing operation processes in the embodiment of the present invention.

[Fig. 4]

A sectional view of a further embodiment of the present invention.

[Fig. 5]

A chart showing a pattern of driving in the embodiment of Fig. 4.

[Fig. 6]

A sectional view of a still further embodiment of the present invention.

[Fig. 7]

A chart showing a pattern of driving in the embodiment of Fig. 6.

[Fig. 8]

A sectional view showing an internal combustion engine with a conventional engine brake device.

5

[Description of Reference Numerals]

1	push rod	
1a	inlet push rod (push rod)	10
1b	exhaust push rod (push rod)	
2	master piston	
2a	engine-braking master piston	
2b	exhaust-gas-recirculation master piston	
5	oil passage	15
5a	oil passage	
5b	oil passage	
6	slave piston	
7	cylinder	
8	exhaust valve	20
9	exhaust port	
11	oil passage selector valve	
19	rocker arm	
19a	rocker arm	
19b	rocker arm	25

Claims

1. An internal combustion engine wherein during engine braking, a master piston for a cylinder is actuated by a rocker arm which in turn is actuated by a push rod of another cylinder to pressurize an oil having been supplied to an oil passage, an exhaust valve of the one cylinder near a top dead center in a compression stroke being opened through a slave piston by the hydraulic pressure thus produced to discharge the compressed air through an exhaust port, characterized in that
in addition to said engine-braking master piston actuated by the rocker arm which in turn is actuated by the push rod, an exhaust-gas-recirculation master piston is provided which is actuated by a rocker arm which in turn is actuated by a push rod of said another cylinder to open the exhaust valve in a suction stroke, thereby pressurizing said oil having been supplied to said oil passage, and that
an oil passage selector valve is provided which selectively switches over the hydraulic pressures produced by said master pistons to said oil passage.

55

FIG. 1

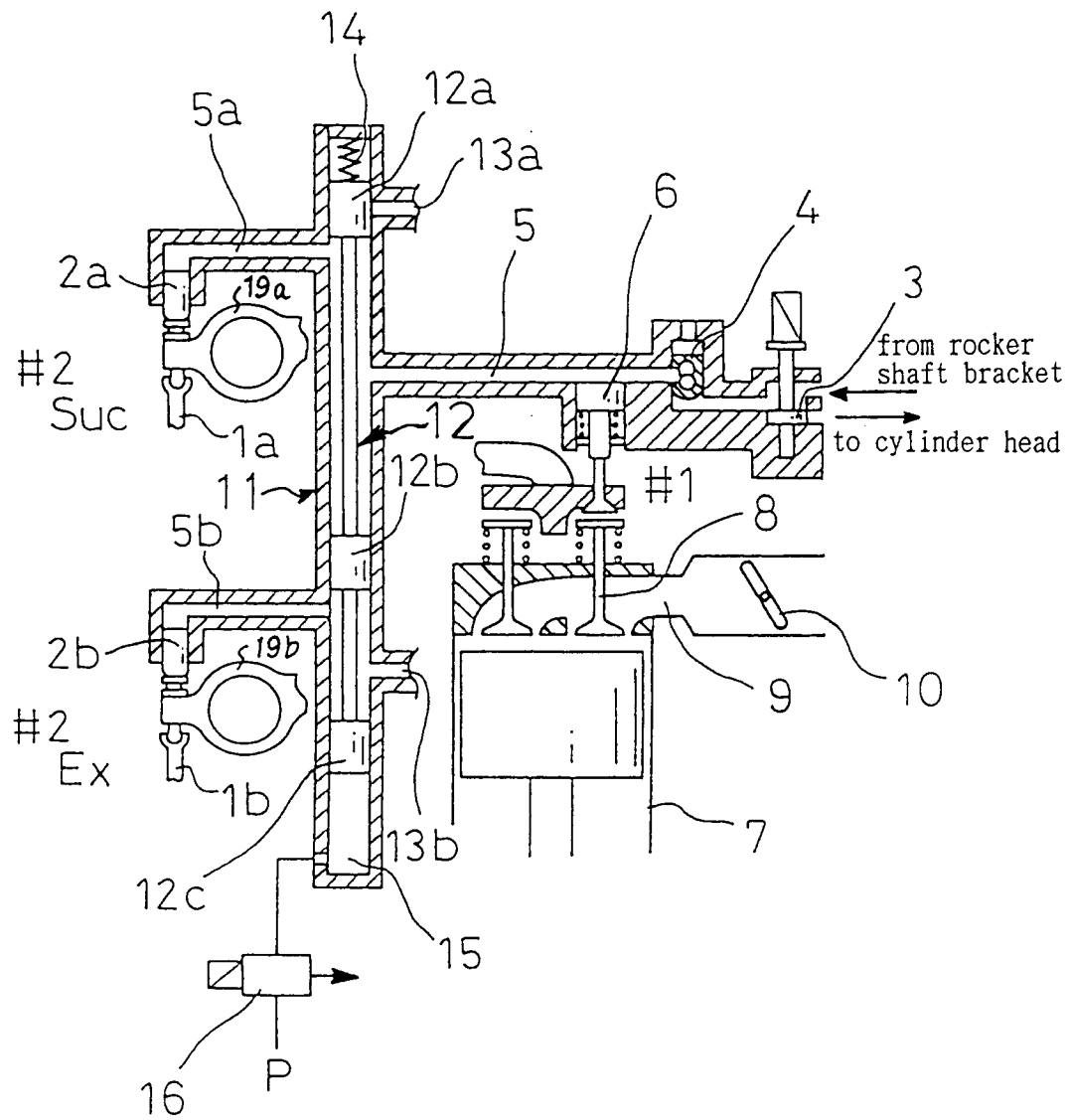


FIG. 2

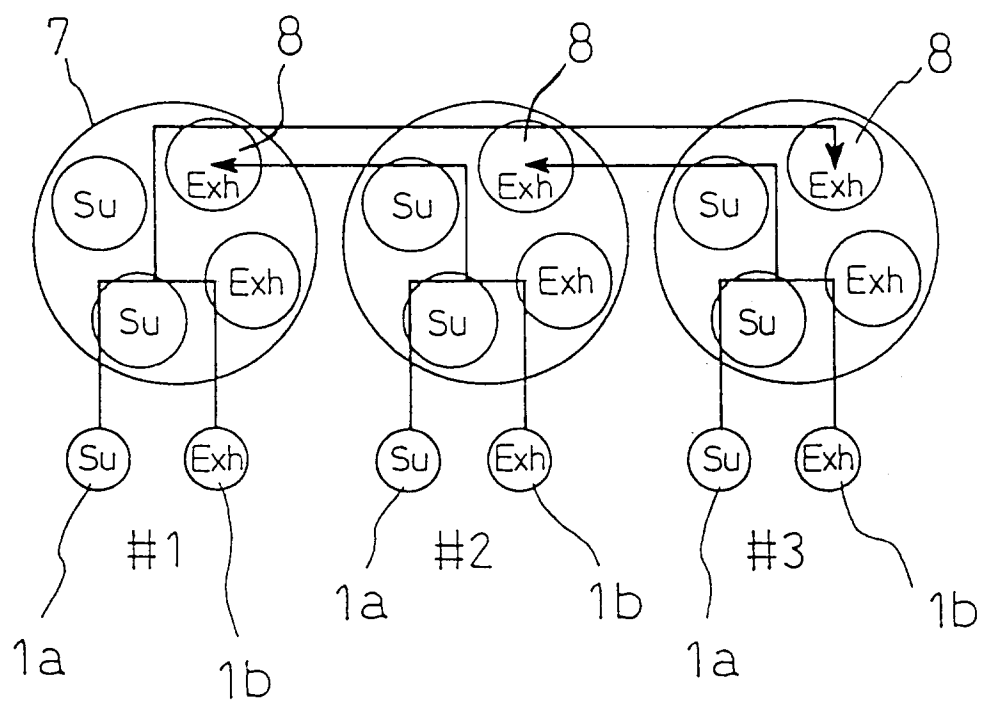


FIG. 3

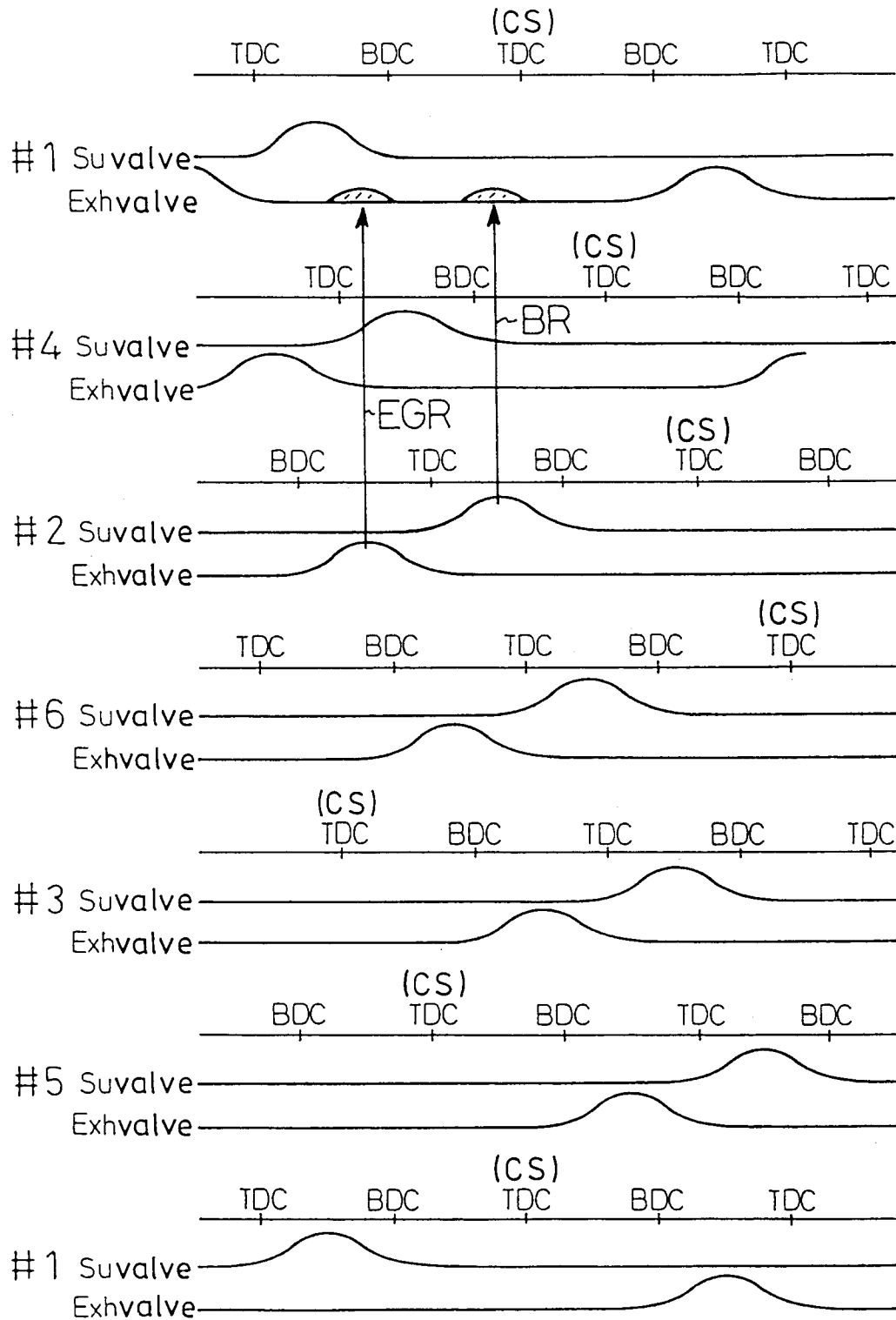


FIG. 4

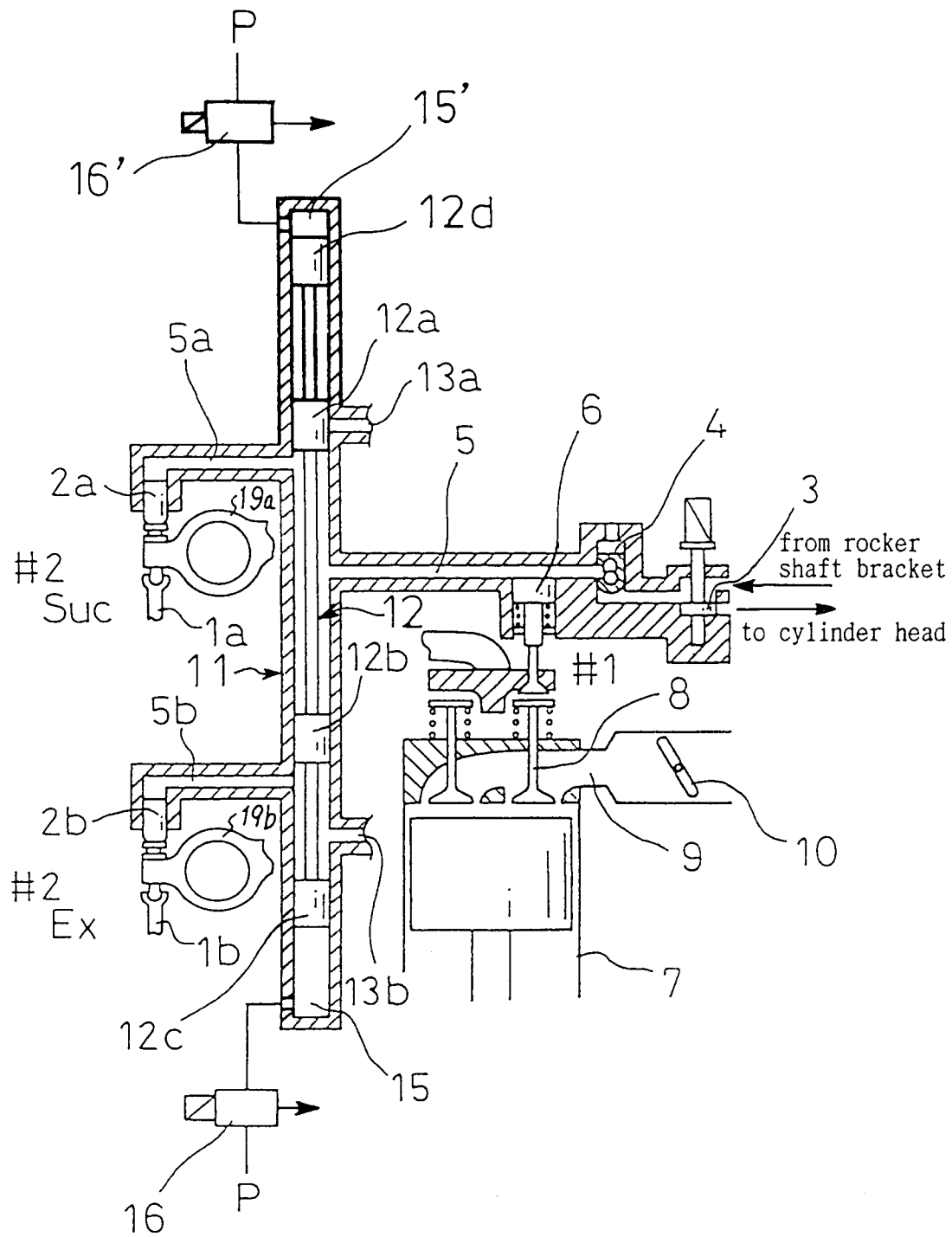


FIG. 5

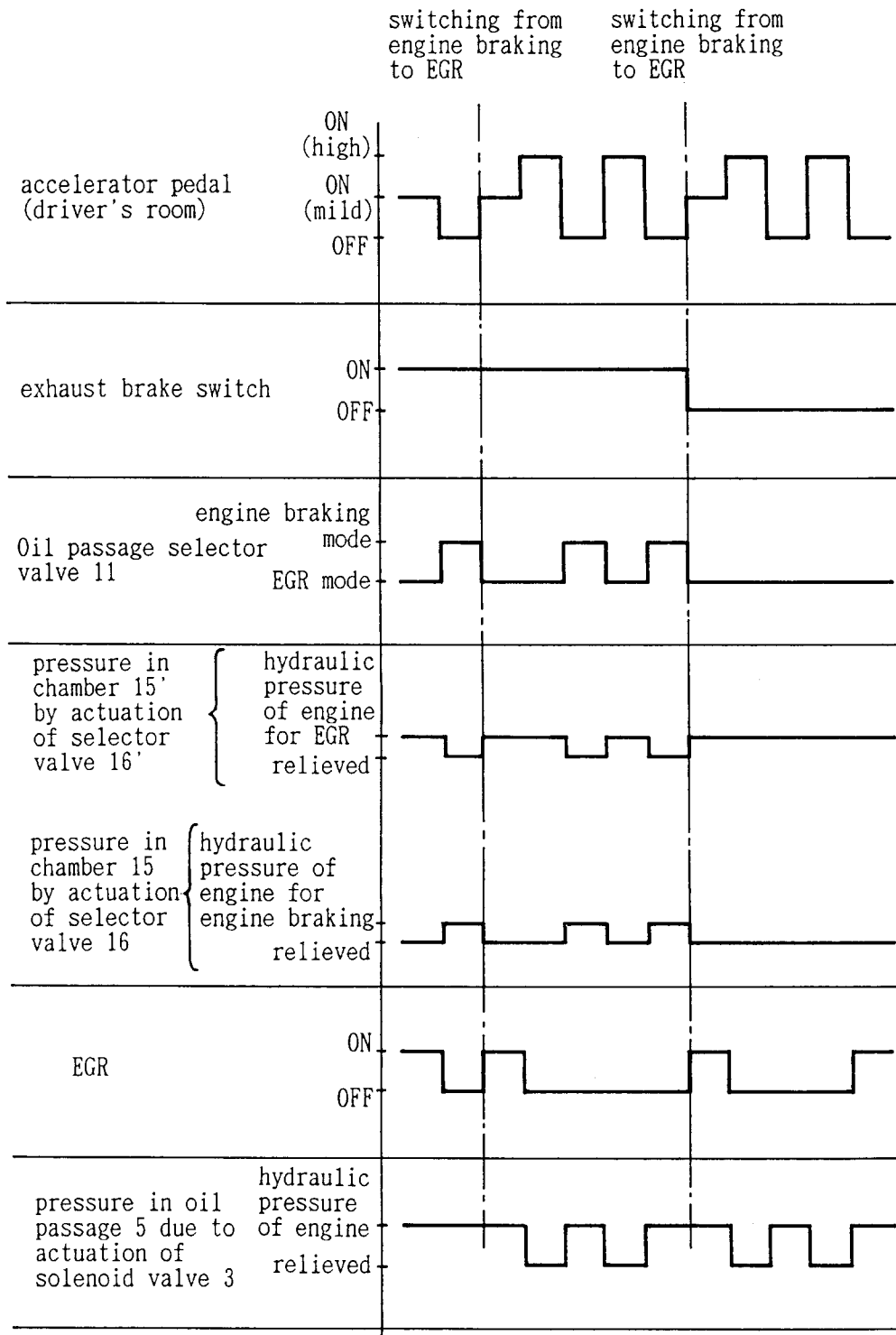


FIG. 6

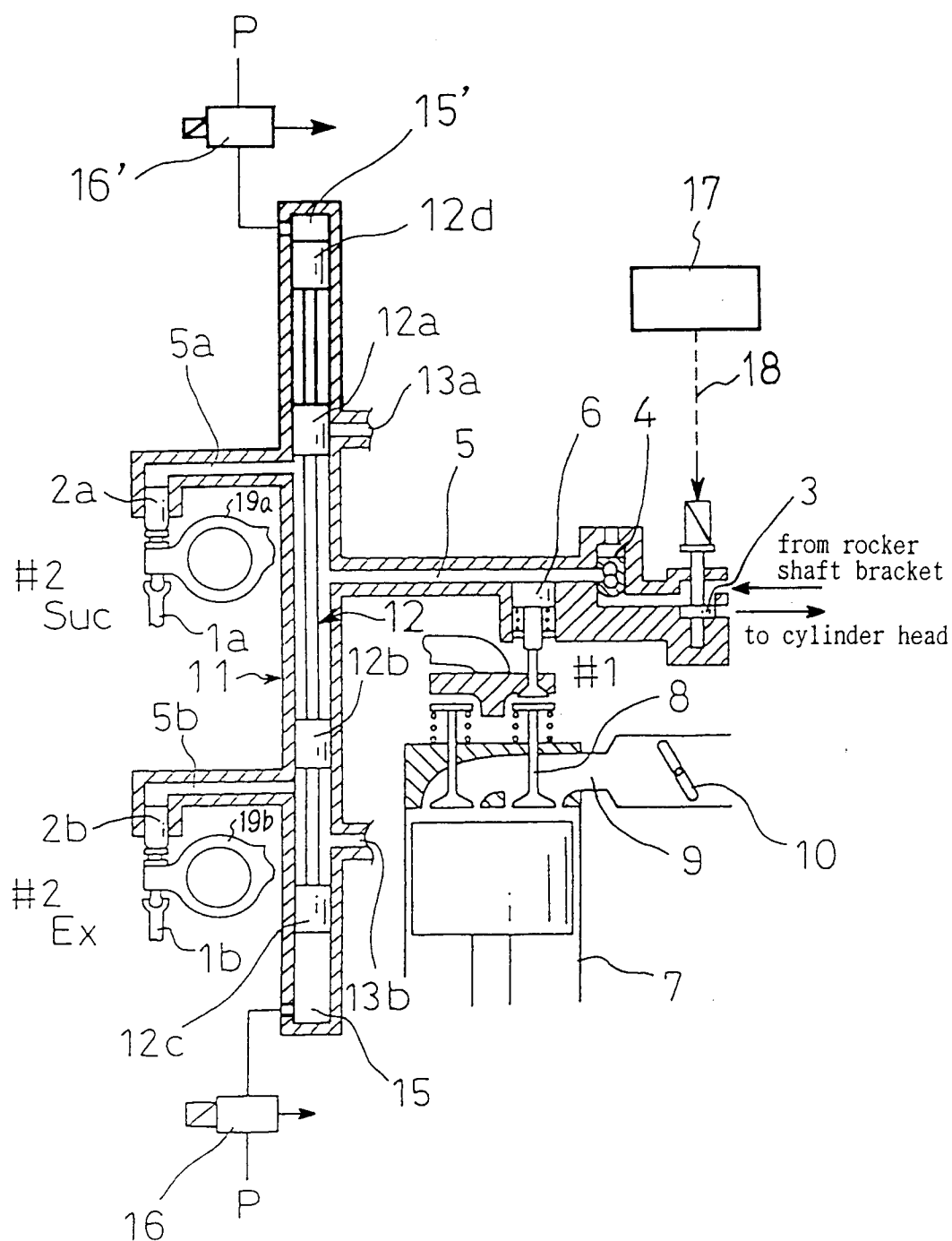


FIG. 7

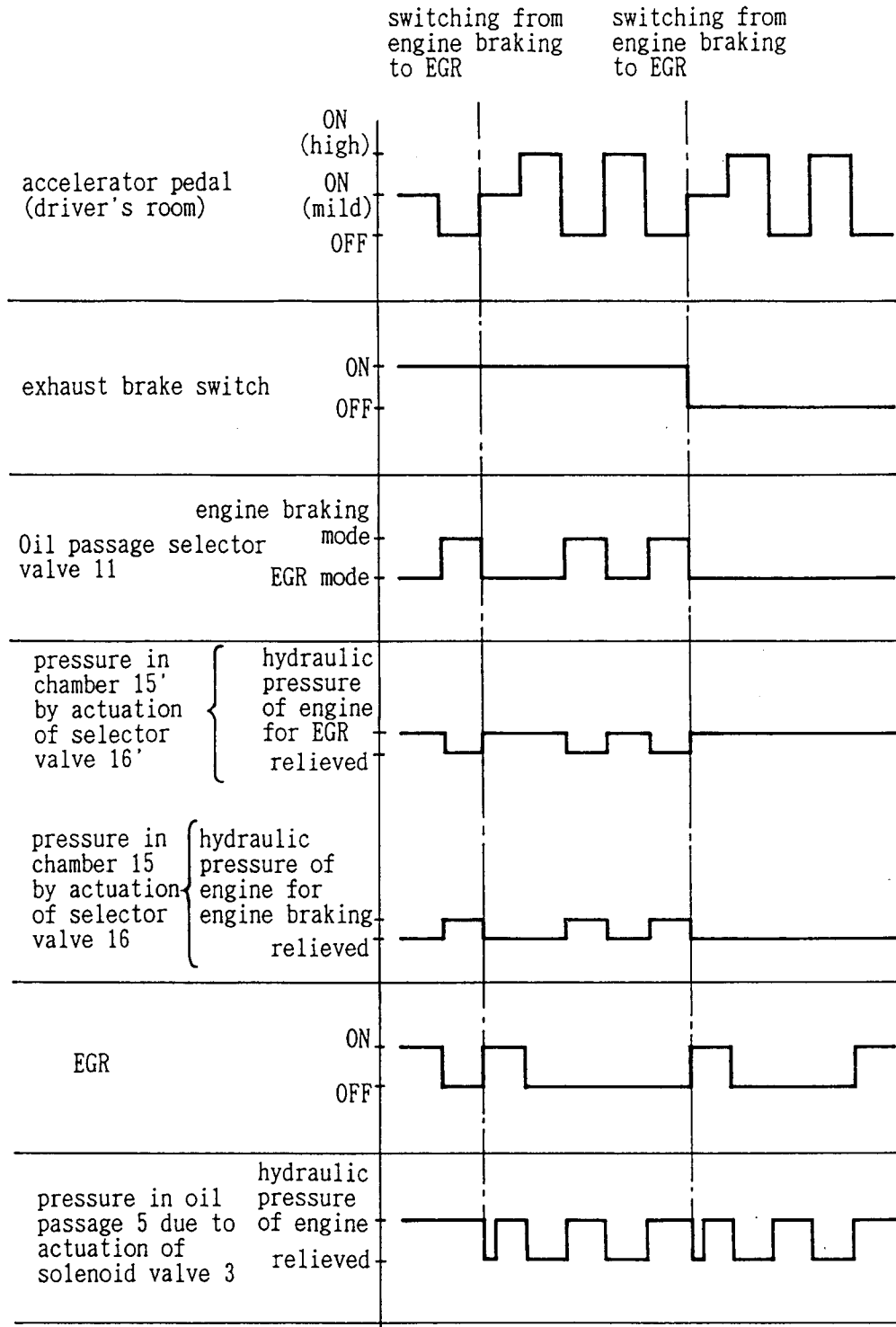
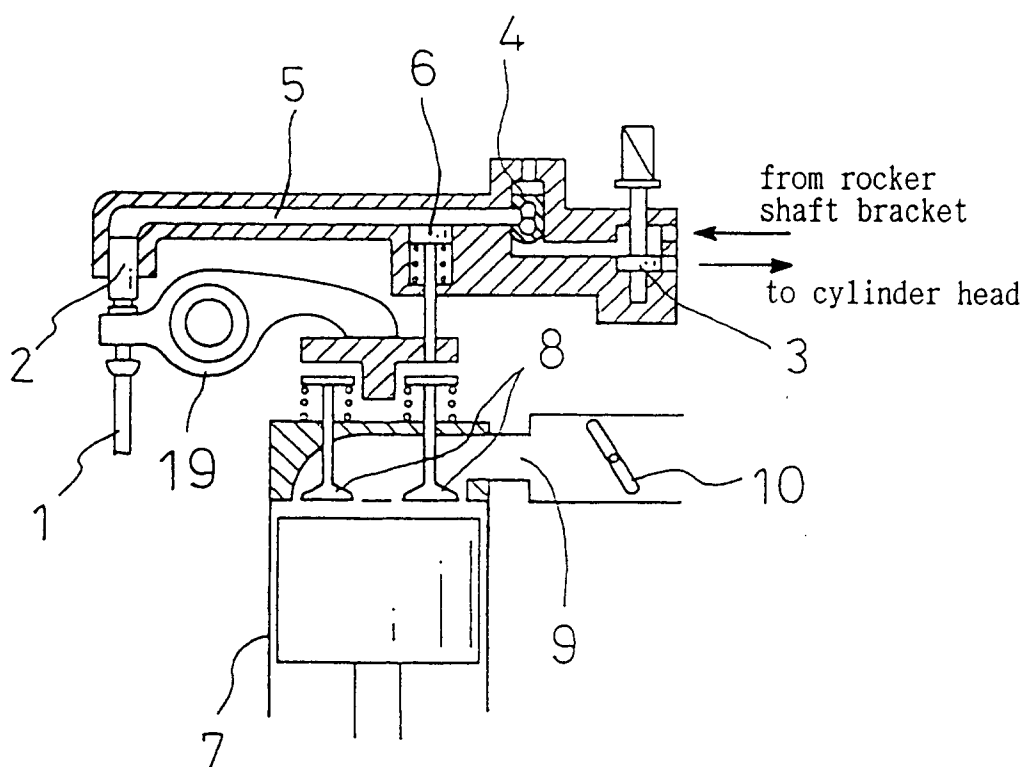


FIG. 8





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 11 2110

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	FR-A-1 269 428 (CUMMINS) * the whole document * ---	1	F01L13/06
A	EP-A-0 167 267 (THE JACOBS MANUFACTURING COMPANY) * the whole document * ---	1	
A	US-A-4 936 273 (MYERS) -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F01L
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 November 1994	Examiner Klinger, T
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			