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(72) Inventor; and
(71) Applicant: **WIJESINGHE, Sunil** [LK/LK]; 350/10 Kandy Road, Kurunegala (LK).

(74) Agent: **SANDIRIGAMA, Manjula**; 430/14 Amherstia Lane, Sarasavigama Road, Mahakanda, Peradeniya (LK).

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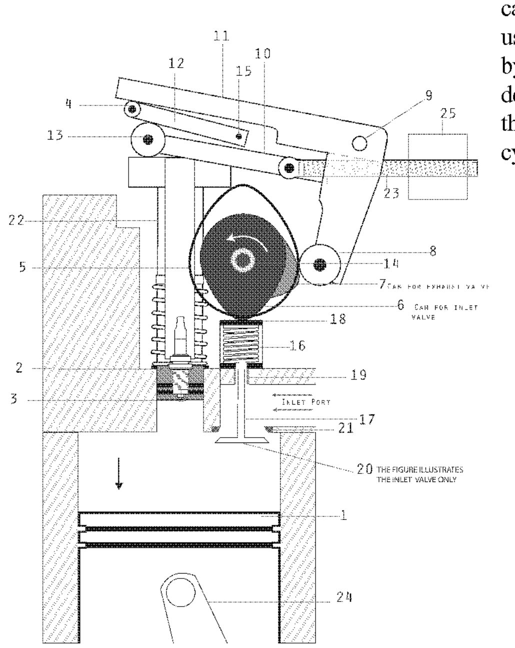
(54) **Title:** INTERNAL COMBUSTION ENGINE HAVING A VARIABLE COMPRESSION RATIO

FIGURE 1 INDUCTION STROKE



(57) Abstract: The combustion chamber of a conventional internal combustion engine of prior art is supplemented with a substantially small cylinder space located in the cylinder head. The volume of the said small cylinder can be varied using a piston which defines the variable top surface of the cylinder activated by a mechanism coupled to the crank motion, the the piston of the small cylinder being positioned at a predetermined location along its path, determined by the accelerator pedal position and the power demand. The changes of the small cylinder volume provides the variability of the compression ratio.

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INTERNAL COMBUSTION ENGINE HAVING A VARIABLE COMPRESSION RATIO

DETAILED DESCRIPTION OF THE INVENTION

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows the induction stroke and the general layout of the preferred embodiment of the invention which is an internal combustion engine where the compression ratio can be varied and the near zero clearance volume ensures zero dilution of the combustion mixture. The piston (1) moves in a cylinder placed vertically similar to that found in prior art designs. The said piston is connected to the crank shaft through the connecting rod (24) shown partially in Fig1. The cylinder bore of the said arrangement provides the major portion of the combustion chamber. The cylinder bore is covered on top by a cylinder head similar to the one found in the internal combustion engine system in prior art. The cylinder head will have an inlet valve and an exhaust valve. Only the inlet valve (20) is shown in Fig 1. The inlet valve is operated through the valve stem (17), which is pushed by the inlet cam (6) mounted on the cam shaft (14). The valve stem has to be pushed against the compression spring (16) which acts as the return spring. A substantially small cylinder is located in the piston head. The volume in the bore of the said small cylinder can be varied via the movement of the piston (2) and provides the minor portion of the combustion chamber. The aggregate combustion chamber consists of the two cylinder bores mentioned here in.

The following paragraphs will explain the operation of the four strokes of a single cycle of the preferred embodiment of the present invention.

During the exhaust stroke shown in Fig. 4, the piston (1) of the main cylinder will move upwards pushing the combustion products out through the exhaust valve (26) in its fully open position. The inlet valve (not shown in Fig. 4) has to be fully closed during the entire duration of this exhaust stroke. Simultaneously, the piston (2) of the said small cylinder moves downwards, operated by the extended portion (22) of the small piston (2). This movement is generated by the push of cam roller (13). The said cam roller (13) is pushed by the bell-crank shaped rocker arm (11) pivoted at pivot (9). The rocker arm (11) is operated by the rocker actuating cam (5). By the end of the exhaust stroke, the combustion chamber will have a near zero volume left, as both pistons are in close proximity of the cylinder head level. This ensures that all burnt gasses are expelled through the exhaust valve. This marks the beginning of the induction stroke.

The induction stroke will commence immediately with the closing of the exhaust valve (26) and the opening of the inlet valve (20). The piston (1) of the large main cylinder now starts to move downwards and creates a suction pressure drawing the air-fuel mixture in to the combustion chamber. Simultaneously the piston (2) of the small secondary cylinder moves upwards. This movement is restricted to a pre-determined position as determined by a combination of the throttle opening and engine load as transmitted by the accelerator pedal position and is determined by the connecting linkage and the screw rod (23). The combustion chamber will consist of the combination of the two volumes created by the main cylinder and the small secondary cylinder. This volume is now filled completely with the air-fuel mixture drawn in through the inlet valve (20). Since there was no burnt gas left from the previous cycle, there will be no dilution. The completion of the induction stroke will be the commencement of the compression stroke (Fig 2).

Now the air-fuel mixture is ready for compression. It should be noted that the combustion chamber comprises the two spaces of the two cylinders. The volume of the small cylinder will remain un-changed during this stroke as the piston (2) will remain stationary. The combustion chamber is now filled with the fresh air-fuel mixture fed to it. The upward movement of the piston (1) will cause the total volume of the combustion chamber to get compressed. As this movement completes at the end of the stroke, all the air-fuel mixture will get compressed in to the volume of the small secondary cylinder. The compression ratio is determined by the ratio of the volumes of the two cylinder bores. It must be noted here that the volume of the small cylinder is dependent on the positon of the piston (2), as determined by the cam roller (13), explained here in. Thus the volume of the small cylinder can be varied as needed. This facilitates a variability of the compression ratio. This ratio is determined by a combination of the rocker actuating cam (5) and the throttle opening required for the particular pulling power as requested by the driver through the accelerator pedal and the consequent throttle position.

The compressed mixture, with its stoichiometric ratio, is now ready for the ignition in the usual manner. The ignition is actuated by the spark plug placed at the centre of the small secondary piston (2) and ignition timing is actuated at a pre-determined. Since the spark is generated at the centre of the compressed volume, it will spread evenly in the compressed air-fuel mixture.

This will be the commencement of the power stroke (Fig 3). The increased pressure in the combustion chamber will generate the mechanical power of the engine, manner well known in prior art. The piston will get pressed causing the power to be delivered to the crank shaft through the connecting rod. Eventually, when the piston (1) reaches the bottom dead centre, the power stroke is complete. The combustion chamber will be filled with burnt mixture. At the completion of the power stroke, the exhaust stroke will commence (Fig 4).

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In the present embodiment of the invention, the bore of the conventional cylinder is supplemented with a bore of a small secondary cylinder placed in the engine head, thereby making a larger combustion chamber. The volume of the small secondary cylinder appended to the combustion chamber of prior art, can be varied as needed, during the four strokes of the cycle. This mechanism described in the present embodiment, describes the mechanical means of changing the effective volume of the engine's combustion chamber to control the engine's compression ratio as a function of engine load. The small secondary cylinder volume at any stage is determined by the position of the movable piston (2). This position is determined by the bell-crank shaped rocker arm (11) operated by the cam (5). The throttle position also gives a feedback signal to determine the volume of the small cylinder. The inlet and exhaust valves are activated by two separate cams mounted on same the cam shaft, similar to the traditional four stroke engine.

During the exhaust stroke, the piston of the conventional large main cylinder moves upwards pushing the burnt mixture out of the combustion chamber. The exhaust valve (26) is fully open and the inlet valve (20) is fully closed. The piston (2) of the small secondary cylinder moves downwards and reaches its lowest position by the end of the exhaust stroke eventually leaving no space in the combustion chamber. This ensures that all burnt gases are exhausted.

Induction stroke will commence immediately after that with the closing of the exhaust valve and opening of the inlet valve. By the time the piston (1) reaches the bottom dead centre position, the small cylinder piston (2) too would reach its top most position. This position is determined by a combination of the throttle position and engine load as transmitted by linear actuator from the accelerator pedal position as shown in Fig 5. The combustion chamber will consist of the combination of the two volumes inside the two bores of the main cylinder and small cylinder.

Next is the compression stroke. During this stroke, the small cylinder volume will not change. The main piston (1) will gradually move up and eventually will ensure a near zero volume to the combustion chamber. The combustion chamber will comprise only the volume of the small cylinder. The compression ratio is determined by the volumes of the two cylinders. Variability of the compression ratio is obtained by the variability of the small cylinder volume as described here in.

The compressed air fuel mixture is ready for ignition in the usual manner. Once the combustion takes place, the piston will gradually get pressed causing the power to be delivered to the crank shaft through the connecting rod as usual. At the completion of the power stroke, the exhaust stroke will commence.

The four stroke cycle will complete in the manner described.

Primary objective of this invention is optimizing the fuel efficiency of an internal combustion engine by varying the compression ratio. This is achieved by varying the engine's compression ratio by varying the combined effective volume of its combustion chamber.

It enables the complete emptying of the combustion chamber of all burnt gasses before in induction of the air fuel mixture with a pre-determined air-fuel ratio. This eliminates the fuel dilution that is found in the internal combustion engines of prior art. This results in complete combustion of the compressed air fuel mixture with a stoichiometric ratio. Apart from producing more power, the exhaust emission also is environmentally acceptable

Since the present design ensures the efficient exhaust emission, it eliminates the need for multiple valves.

The mechanism described here is replicated at each of the cylinders in the case of multi-cylinder engines.

The preferred embodiment described here refers to the simplest design that incorporates the present inventive concept. It can very well be adapted to the fuel injection type with minor changes. It is also applicable to variable valve timing engines and compression ignition type. Basically all types of internal combustion engines could incorporate the concept given in the present invention.

The triple advantage achieved here, namely achieving the optimum combustion ratio, complete combustion of fuel and absolute zero fuel dilution, make this invention stand ahead of all internal combustion engine technologies described in prior art. Ultimate result of having zero emission of unburnt and partially burnt fuel will be a major advantage of this mechanism with respect to emission.

In the present embodiment, the required control system for the variable compression ratio is achieved pure mechanical means, with the use of cams and levers. The same objectives can be achieved using a hydraulic, electronic or electrical means or a combination of these with the mechanical means described in this embodiment.

SUMMARY OF THE INVENTION

In this invention, the bore of the conventional cylinder is supplemented with a bore of a small cylinder placed in the engine head, thereby making an enhanced combustion chamber. The volume inside the small cylinder can be varied as per demand, during the four strokes of the cycle. This mechanism described in the present embodiment, describes the mechanical means of changing the effective volume of the engine's combustion chamber to control the engine's compression ratio as a function of engine load demand. The small cylinder volume at any point is determined by the position of the movable piston and its position is determined by the bell-crank shaped rocker arm operated by the cam mounted on the cam shaft. The throttle position also gives a feedback signal to determine the volume of the small cylinder. The inlet and exhaust valves are activated by two separate cams, operated by the cam shaft, similar to the conventional four stroke engine of prior art.

INTERNAL COMBUSTION ENGINE HAVING A VARIABLE COMPRESSION RATIO

Claims:

Claim1 A four stroke spark ignition internal combustion engine comprising, a combustion chamber formed by the bore of a vertical cylinder and a bore of a small cylinder placed in the engine head, the said small cylinder volume being made variable by means of a movable piston that is pushed by a roller cam located on top of the cylinder head, position of the said roller cam being determined by a combination of the throttle position and crank position as transmitted using the angular orientation of the cam shaft coupled to the crank shaft and rotating at half engine speed, a spark plug being located centrally on the said small piston, an inlet valve and an exhaust valve operated using the said cam shaft, the combined effect of these being that the engine always operates at compression ratio defined by the engine speed and throttle position.

Claim2 An internal combustion engine as claimed in claim 1, having an additional small cylinder placed in the engine head providing a comparatively small variable volume, supplementing the combustion chamber in addition to the bore of the said vertical cylinder, to achieve a variable volume.

Claim3 An internal combustion engine as claimed in claim 1, in which the engine head and the piston crown have flat surfaces.

Claim4 An internal combustion engine as claimed in claim 1, in which a small cylinder with a slidable piston, located at the cylinder head enables the compression chamber volume to vary.

Claim5 An internal combustion engine as claimed in claim 1, in which the spark plug is mounted centrally at the bottom of the said slidable piston of the small cylinder.

Claim6 An internal combustion engine as claimed in claim 1, where, at the end of the exhaust stroke the said slidable piston is made to reach the bottom surface of the engine head to coincide with the top-dead-centre of the piston of the said vertical cylinder, so that all the combustion products in the combustion chamber are expelled once the exhaust stroke is completed.

Claim7 An internal combustion engine as claimed in claim 1, in which there is zero space in the combustion chamber at the commencement of the induction stroke, enabling the maintenance of the proper air fuel ratio due to the non-existence of dilution.

Claim8 An internal combustion engine as claimed in claim 1, where, at the end of the compression stroke, the said small piston is made to reach the top most position, to coincide with the top-dead-centre of piston of the vertical cylinder, corresponding to the pre-determined compression ratio.

Claim9 An internal combustion engine as claimed in claim 1, where the high voltage required for firing the spark plug is transmitted to the spark plug terminal through an air gap, maintained between a series of peaks located on an extension fitted to the terminal and an insulated sleeve fitted to the bore of the said small cylinder.

Claim10 An internal combustion engine as claimed in claim 1, where the inlet and exhaust valves are operated by two cams mounted on the cam shaft, and a bell-crank lever determining the operation of the small cylinder system.

Claim11 An internal combustion engine as claimed in claim 1, where the said action, of the small cylinder and the supplementary systems, is achieved by means of a mechanical, hydraulic, electronic or electrical system or a combination of such means.

Figure 1 INDUCTION STROKE

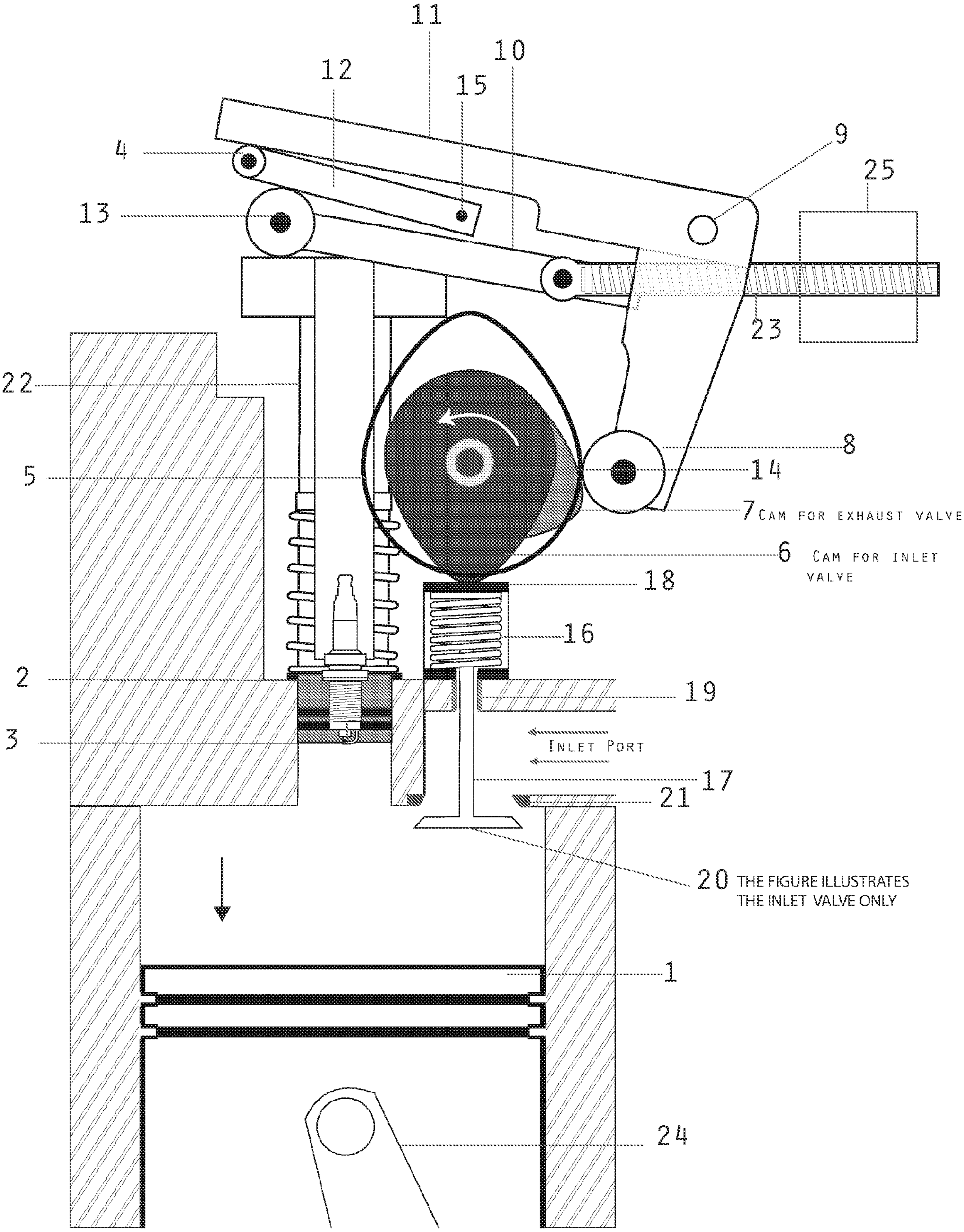


Figure 2 COMPRESSION STROKE

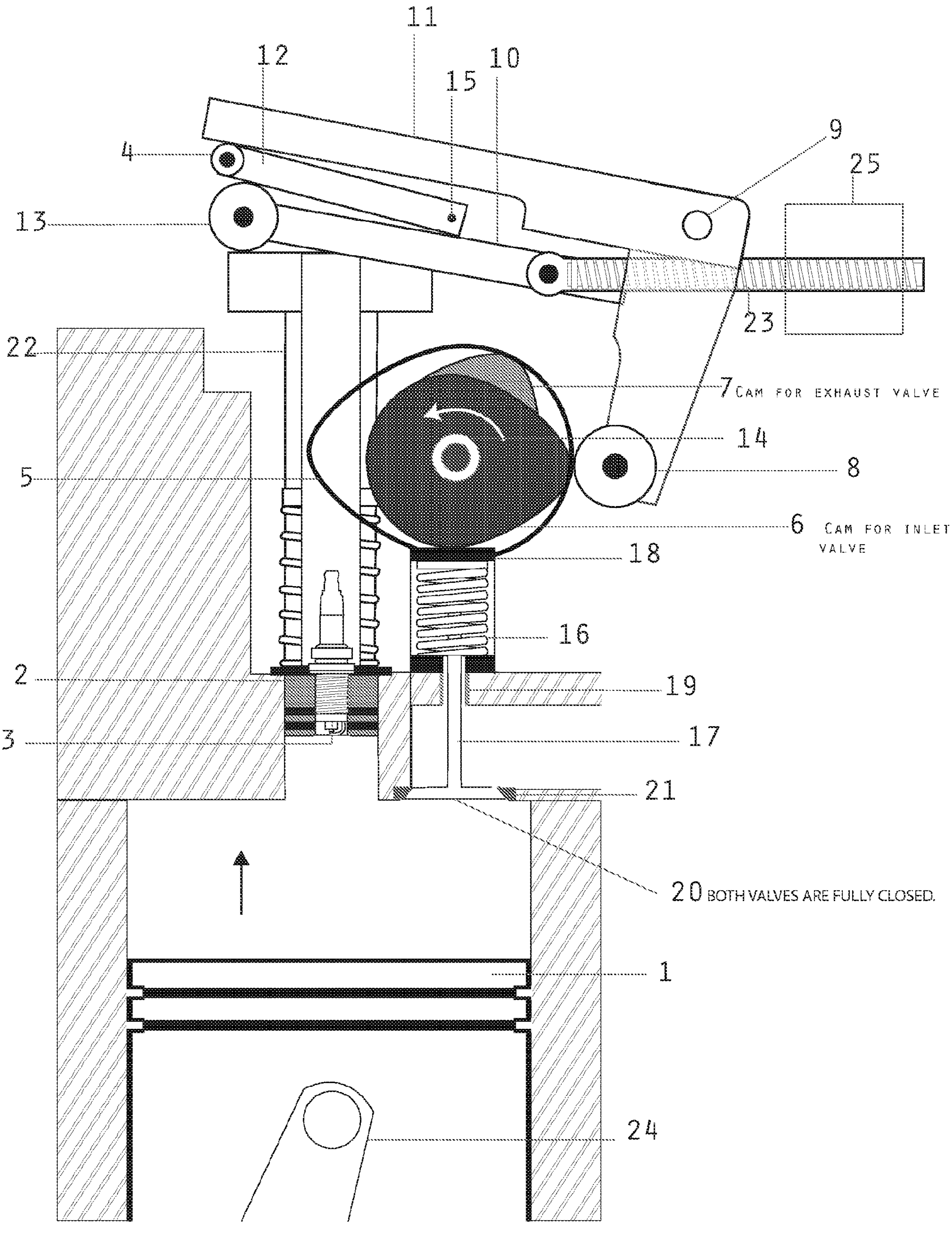


FIGURE 3 POWER STROKE

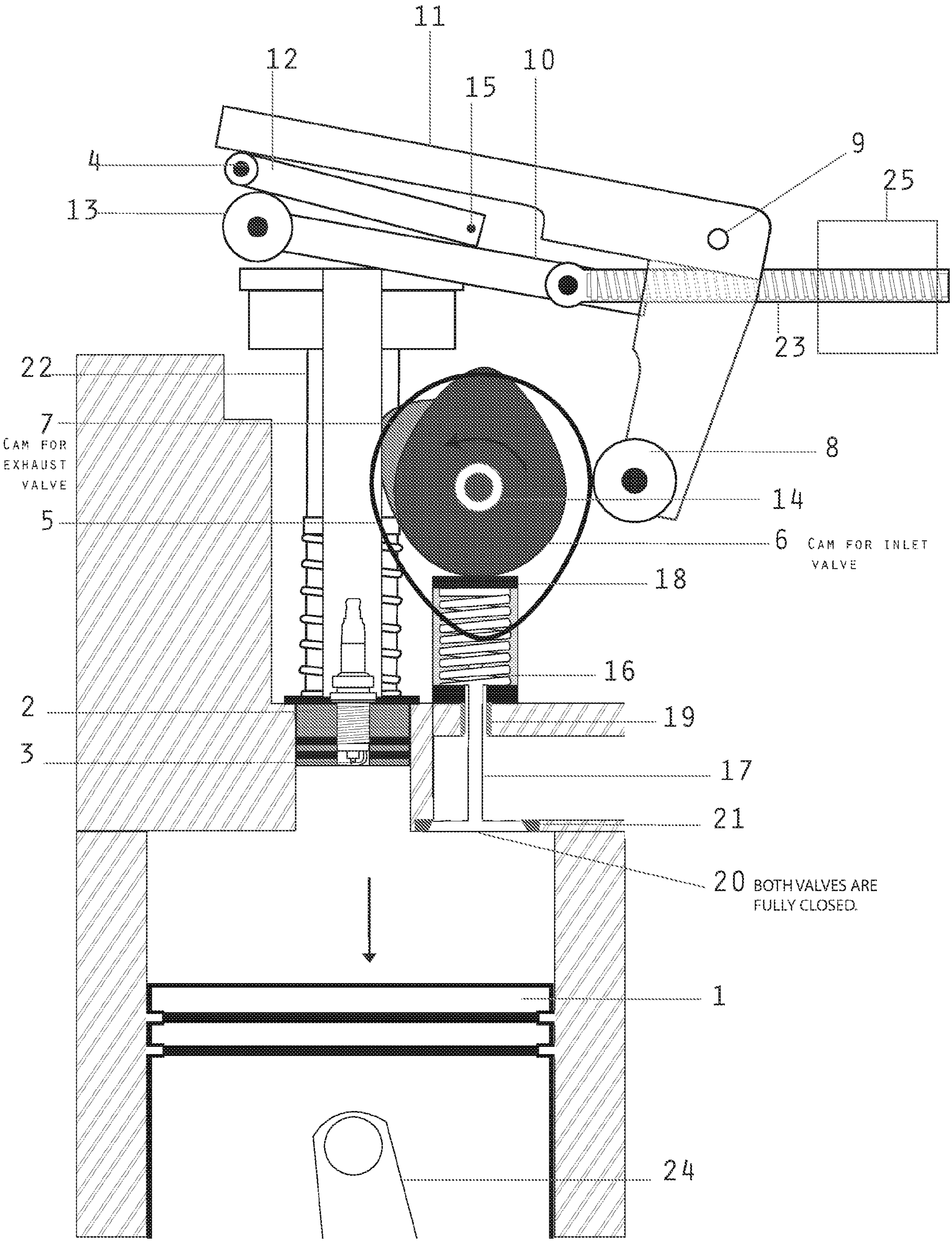


FIGURE 4 EXHAUST STROKE

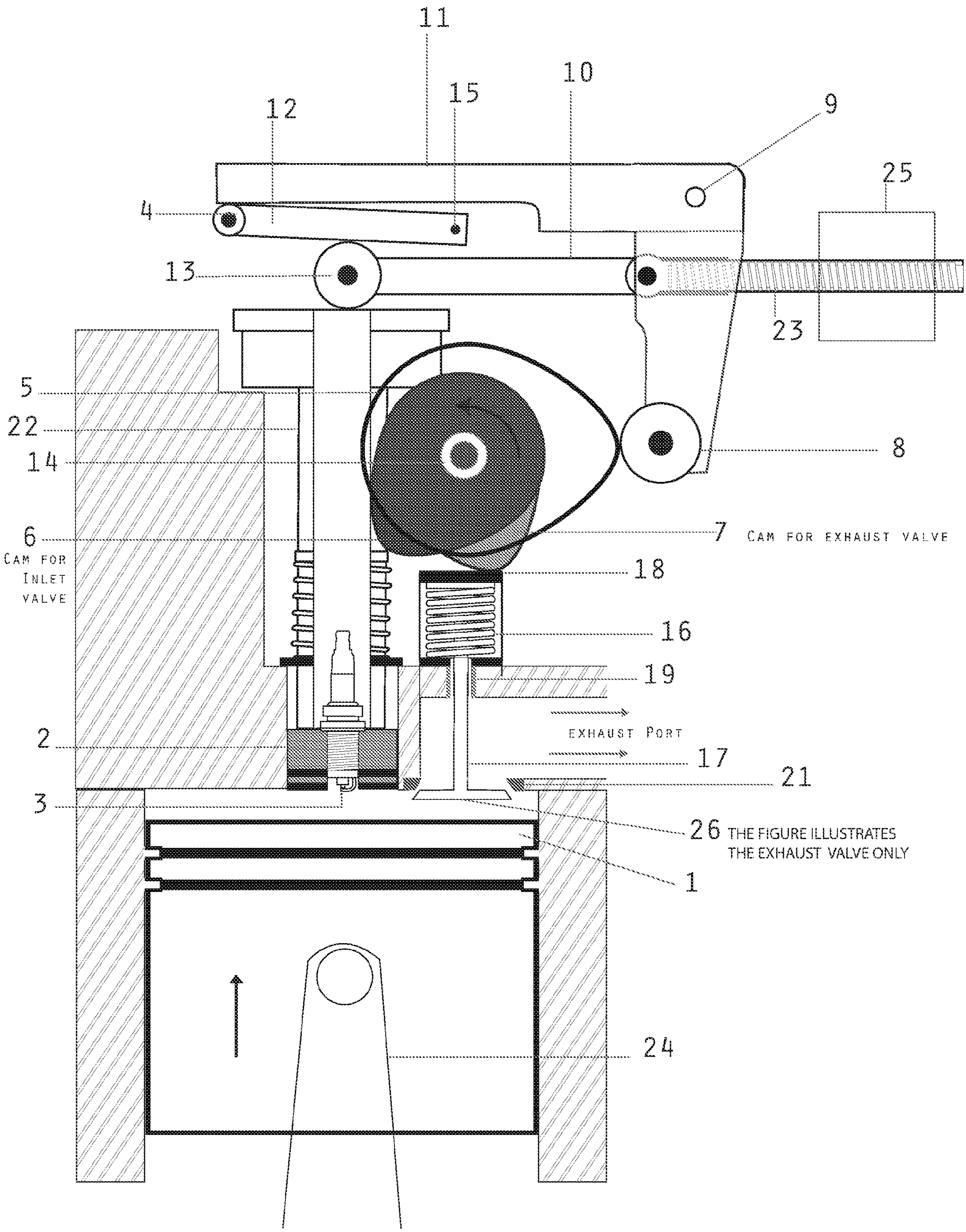


Figure 5 WITH ACCELERATOR PEDAL AT RELEASED POSITION

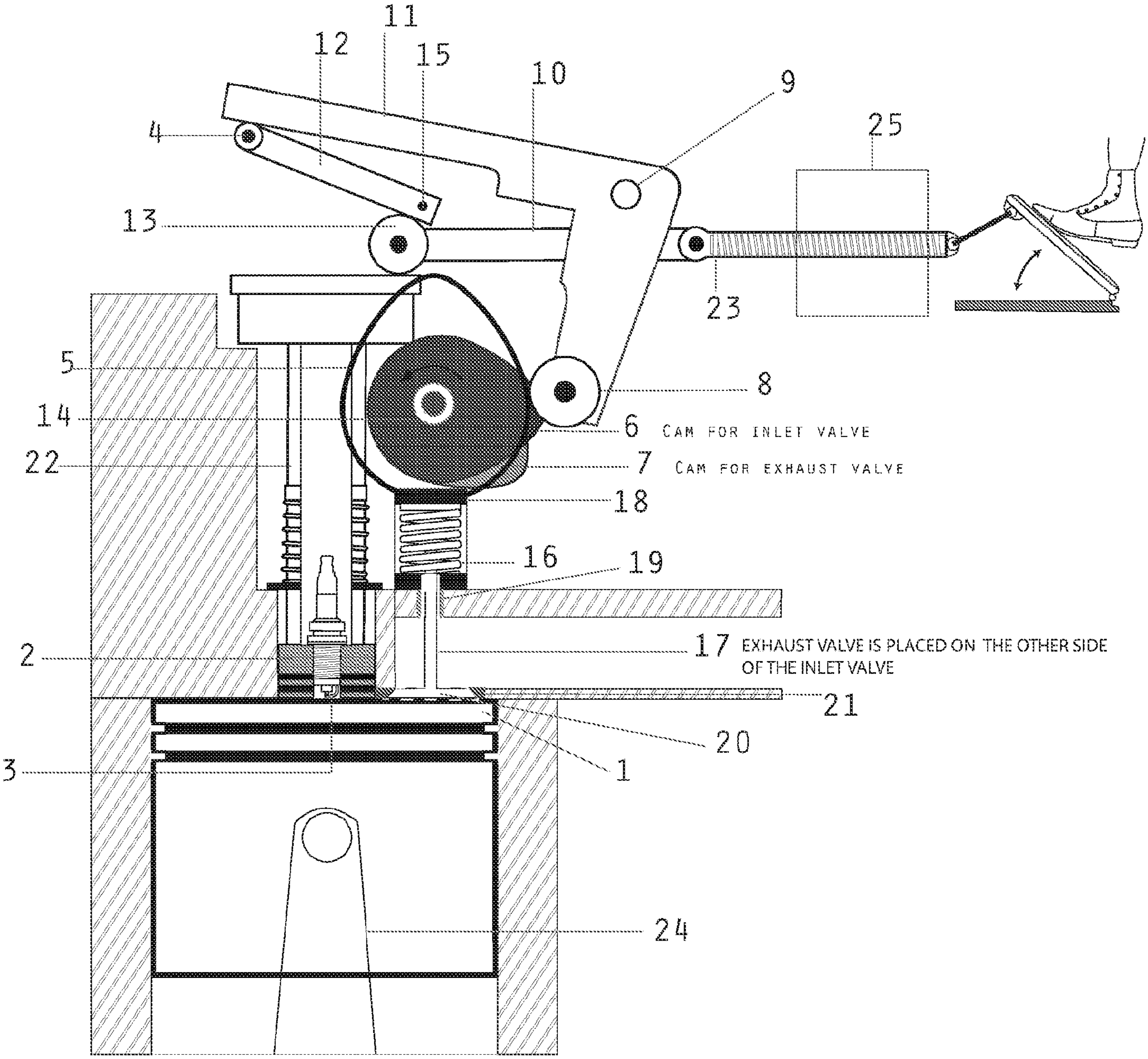
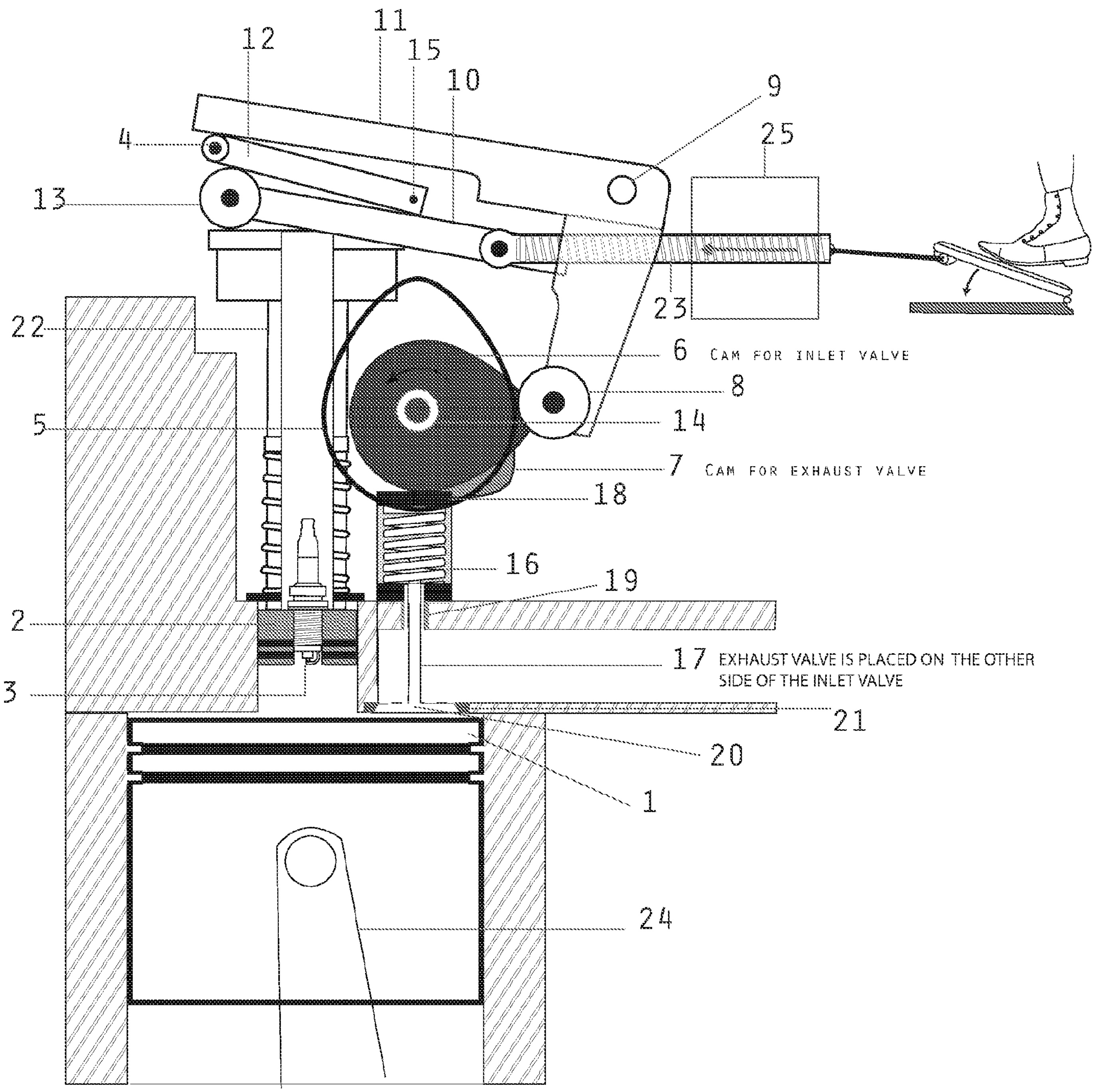


FIGURE 6 WITH ACCELERATOR PEDAL AT FULLY PRESSED POSITION



Nomanclature
of the engine

1 Piston of main cylinder
2 Piston of secondary cylinder
3 Spark Plug
4 Upper roller
5 Rocker actuating cam
6 Cam for inlet valve
7 Cam for exhaust valve
8 Cam roller for rocker arm
9 Pivot for rocker arm
10 Sliding fork
11 Rocker arm
12 intermediate lever
13 Cam roller of sliding fork
14 Cam Shaft
15 Pivot for lever
16 return spring for inlet valve
17 Valve stem and push rod
18 Cam follower
19 Guide for compression spring
20 inlet Valve
21 Valve seat
22 secondary Piston extension
23 screw rod
24 connecting rod
25 linear actuator
26 Exhaust Valve

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/052020

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02B75/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 909 061 A (AMAURY) 29 April 1946 (1946-04-29) page 2, paragraph 92 - paragraph 104; figures 2-4	1-11
Y	WO 2016/150231 A1 (HAN PEIZHOU [CN]) 29 September 2016 (2016-09-29) figures 3,5	1-11
Y	DE 754 005 C (HOPF WILLY) 17 April 1952 (1952-04-17) figures 1,2	1-11
Y	US 2 970 581 A (RAYMOND GEORGES) 7 February 1961 (1961-02-07) column 1, line 70 - column 2, line 44; figures 1,2	1-11

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 August 2018	17/08/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Yates, John

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/052020

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 100 45 107 A1 (STINGL BERNHARD [DE]) 28 March 2002 (2002-03-28) paragraph [0005]; figure 1	1-11
Y	US 2015/369139 A1 (QUIX HANS GUENTER [DE] ET AL) 24 December 2015 (2015-12-24) paragraphs [0007], [0008], [0025], [0040]	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2018/052020

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			DE 102015210597	A1	24-12-2015
			US 2015369139	A1	24-12-2015