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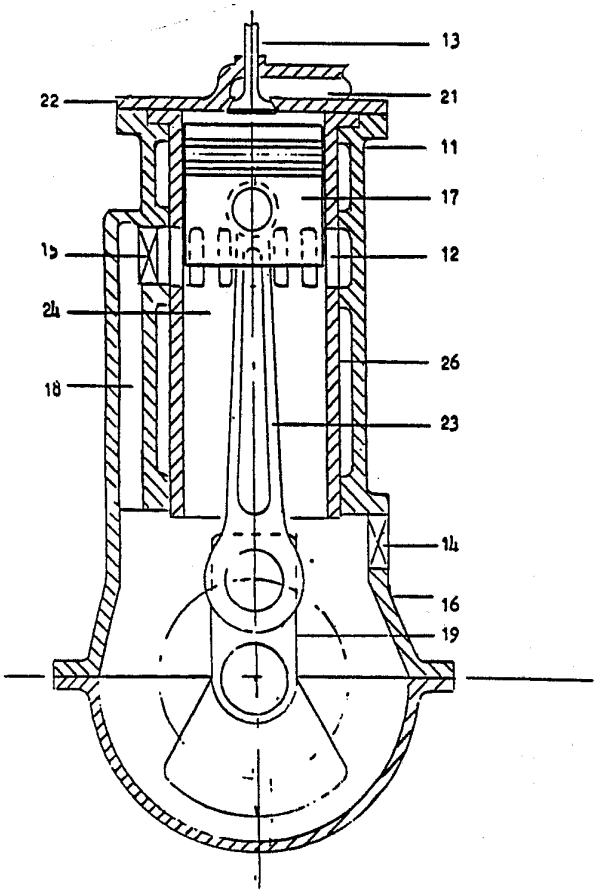
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Published
With international search report.
With amended claims.

(54) Title: A TWO-CYCLE INTERNAL COMBUSTION ENGINE

(57) Abstract

The improvement in the internal combustion engine of the two-cycle type flows primary from the location of the intake ports (12) and the exhaust valve (13). By locating the intake ports (12) at a point near the middle of the piston stroke and having the exhaust valve (13) in the cylinder head (22), the scavenging process of the engine is improved and the intake compression power loss is reduced and it further allows the engine to have substantial differences in the compression and expansion ratios. The construction of the improved engine allows a reduction in the stresses on the timing and operating mechanism for the valve system.



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DESCRIPTION

TITLE OF THE INVENTION

A Two-cycle Internal Combustion Engine

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The invention relates to an improved two-stroke engine of the internal combustion type.

(2) Description of Related Art

The prior art in this field includes many patents having ports in the cylinder wall and means for improving the scacing process, such as blowers, etc. Many such patents are filed in the United States Patent and Trademark Office, under the classification Class 123 Subclass 65, for example patent #2,658,487 which is cross referenced in this class and subclass and shows a cylinder with side inlet ports and an exhaust valve in the cylinder head.

SUMMARY OF INVENTION

The invention is a novel two-stroke internal combustion engine based on a new engine cycle. The engine comprises conventional structure, including a cylinder, a cylinder head, a piston reciprocal within the cylinder, a crankcase, a crank with a piston rod connecting the crank and the piston, an exhaust valve located in the cylinder head, and inlet ports in the wall of the cylinder. The improvement results basically from locating the inlet ports in the cylinder wall at a point corresponding approximately to the middle of the piston stroke.

By locating the inlet ports near the middle, instead of near the end of the piston stroke, the cycle of events in the engine cycle are greatly altered

and a new two-stroke engine cycle is obtained. The inlet ports at the new location divide the cylinder into an upper portion and a lower portion with respect to the piston stroke. When the piston moves over each portion as it progresses through the engine cycle, a different event in the cycle takes place. The new engine improves the scavenging process over that of a conventional two-stroke engine. It also reduces the intake-compression power loss. It provides an engine in which there may be substantial differences in the compression and expansion ratios. It provides a higher expansion ratio for high thermal efficiency. And by providing a lower compression ratio it is possible to limit the maximum pressure and temperature within the cylinder. With the new engine it is possible to provide a two-stroke cycle internal combustion engine with a much larger crank angle for the valve opening and closing to reduce the stresses on timing and operating mechanism for the valve system.

Description of the Drawings:

Fig. 1 shows a pressure-volume relationship of the engine of this invention.

Fig. 2 shows a cross section view through the a centerline of a cylinder of the invention with the piston positioned at the beginning of the expansion period.

Fig. 3 is a cross section as in Fig. 2 with the piston at the bottom end of the stroke.

Fig. 4 is a diagram showing the crank angles for the different cycle events.

DESCRIPTION OF THE INVENTION:

Throughout the figures like reference numerals and letters designate like or corresponding parts. Refering now to Fig. 1, the new air cycle is shown by the solid line. At the start of the cycle the cylinder contains air at the pressure and volume indicated at point -a-. As the air is compressed by movement of the piston, the air is compressed reversibly and adiabatically to point -b-. Then heat is added at constant volume to increase the pressure to point -c-. Then reversable adiabatic expansion takes place from point -c- to point -d-. At point -d- the air is cooled at a constant volume to point -e- and then at a constant pressure to point -a- to complete the cycle. As shown the adiabatic expansion is carried beyond the original volume to obtain a higher expansion ratio than the compression ratio. A point -d'- is added to Fig. 1, with the volume at point -d'- equal to the starting volume at point -a-. The cycle a-b-c-d'-a is the well known constant volume cycle for reciprocating spark ignition engines. The area d'-d-e-a-d' represents an extra output of the new cycle to give a higher thermal efficiency. If the engine's exhaust valve closing is advanced, the constant pressure cooling is shortened to point -a'- instead of point -a- to begin the adiabatic compression. The additional output, as indicated by the dotted line in Fig. 1, is obtained from an increased volume at the beginning of the compression.

Refering to Fig. 2, there is shown a cylinder -11- of the engine with inlet ports -12-, the cylinder having a cylinder liner -26-, cylinder head -22- an exhaust valve -13- located in the cylinder head -22-, a piston -17- reciprocal within the cylinder -11-, a crankcase -16-, a crank shaft -19- mounted in the crankcase -16-, and connected to the piston -17- by a connecting rod -23-. In the crankcase wall there is a one-way valve -14-, such as a reed valve; there is another one-way valve -15- in the passage -18- from

crankcase -16- to the inlet ports -12- to prevent back-flow from the cylinder -11- into the crankcase -16-.

In operation, after the combustion the high pressure gas expands to push the piston -17- downward from the top dead center adjacent the cylinder head -22-. During its downward motion the piston -17- compresses the gas trapped within the crankcase -16- to provide compressed air or gas for the scavenging process. In Fig. 4 this is denoted as the expansion period.

At the end of the expansion period the exhaust valve -13- is opened by a suitable valve mechanism and the inlet ports -12- are uncovered by the movement of the piston -17- to commence the scavenging process which consists of a flow of pressurized gas or air from the crankcase -16- into the cylinder -11-, by way of passage the -18- one-way valve -15- and ports -12- the pressure within the cylinder -11- having been lowered by the opening of the exhaust valve -13- to a pressure lower than that of the gas or air within the crankcase -16-. After the initial scavenging process, instead of reverseing its direction of motion after opening the inlet ports, as in a conventional two-stroke engine, the piston continues to move downward and at this point in its downward motion the piston -17- begins the intake period and at the same time continues to compress the gas or air within the crankcase and to draw the gas or air into the lower portion -24- of the cylinder -11- through the passage -18- through valve 15 and inlet ports -12-. Due to the location of the inlet ports the gas within the upper portion -25- of the cylinder remains substantially undisturbed during this operation.

After reaching the bottom dead center, at the end of the stroke, the piston -17- moves upward to begin an exhaust period. During this period the piston -17- pushes the air or gas in the lower portion -24- of the cylinder

-11- bodily upward to force out the combusted gases remaining in the upper portion -25- of the cylinder -11-. At the same time it draws fresh air or gas into the crankcase -16- through valve -14- in the crankcase wall. The valve -15-functions to prevent backflow from the cylinder -11- into the crankcase -16-.

When the inlet ports -12- and the exhaust valve -13- are closed, a compression period begins. As the piston continues its upward movement it compresses the air or gas in the upper portion -25- of cylinder -11- while at the same time, it continues to draw air or gas into the crankcase -16- through valve -14-. At the end of the compression period as the piston reaches the top of the stroke and at the maximum compression of the gas within cylinder by the piston, combustion is initiated and the expansion period follows for a complete engine cycle. Thus the new cycle consists of all the cycle events of a two-stroke engine and of a four-stroke engine, i.e. compression, combustion, expansion, scavenging, intake and exhaust.

For a conventional two stroke engine the compression ratio is defined as the maximum cylinder volume divided by the minimum cylinder volume, and the expansion ratio is equal to the compression ratio. In the new engine cycle, the compression ratio is defined as the cylinder volume at the beginning of the compression period divided by the minimum cylinder volume. The expansion ratio is defined as the cylinder volume at the end of the expansion period divided by the minimum cylinder volume. An effective stroke is defined as the distance traveled by the piston during the compression period and the engine displacement is computed from the affective stroke while the displacement of the crankcase compressor i.e. the displacement of the piston during the period it functions to compress the gas in the crankcase, is computed from the full stroke. The scavenging ratio is the ratio between the compressor displacement

and the engine displacement. This ratio for the usual crankcase scavenging is always less than one. For the new engine this ratio may be much greater than one. If the volume of the passage between the inlet ports -12- and the one-way valve -15- is small, the cycle of events is essentially controlled by the exhaust valve -13-. The opening of the exhaust valve -13- may be controlled by a cam on the crankshaft and determines the end of the expansion period and the closing of valve -13- determines the beginning of the compression period. If the opening and closing of valve -13- are symetrical with respect to the dead center at the cylinder head end of the cylinder, the compression period and the expansion period are equal. If the opening of valve -13- is delayed, the expansion period is longer than the compression period and a more complete expansion is obtained. If the closing of valve -13- is advanced, the compression period starts earlier in the cycle and more air is trapped within the cylinder for combustion and a supercharged condition is obtained. These adjustments to the timing of the exhaust valve operation may be accomplished by suitable mechanisms.

The engine of this invention can be operated either as a spark-ignited system or as a compression ignited system. Adding to the flexability of operation, fuel may be injected into the cylinder or the fuel may be introduced through the crankcase -16-. It is also to be understood that more than one cylinder may be utilized with the other pistons driving a common crank shaft if certain minor modifications are made to the engine such as hermetically isolating the crankcase volume associated with each cylinder, or other suitable arrangements can be made to accomplish the proper operation of the engine.

WHAT IS CLAIMED

1. A two-stroke internal combustion engine having a cylinder with a cylinder head, a piston reciprocal within the cylinder, an exhaust valve mounted in the cylinder head, a plurality of inlet ports circumferentially spaced around the cylinder wall at a point near the middle of the stroke of the piston whereby the events in the engine cycle are functionally related to the timing of the opening and closing of the exhaust valve.

2. An engine as claimed in claim 1 which further includes a crankcase, means, including the piston, for pressurizing the gas within the crankcase.

3. An engine as claimed in claim 2 wherein the means includes a one-way valve in the crankcase wall to admit gas into the crankcase.

4. An engine as claimed in claim 2, which further includes passage means for conducting the pressurized gas from the crankcase to the inlet ports.

5. An engine as cliamed in claim 4 which includes a one-way valve in the passage from the crankcase to the inlet ports to prevent back-flow from the ports into the crankcase.

6. An engine as claimed in 1 in which the engine cycle includes a compression period, an expansion period, an intake period and an exhaust period wherein the engine includes means to make the expansion period longer than the compression period.

7. An engine as claimed in claim 6 in which the means for making the expansion period longer than the compression period is the exhaust whose closing valve is delayed relative to its closing when the compression and expansion are equal.

8. An engine as claimed in claim 1 which has in the engine cycle a compression period, an expansion period, an intake period and an exhaust period wherein the engine includes means to make the compression period longer than the expansion period thereby provide a supercharged condition in the cylinder.

9. An engine as claimed in claim 5 which includes means for improving the scavenging efficiency of the engine.

10. An engine as claimed in claim 9 in which the said means for improving the scavenging include the exhaust valve, the inlet ports and the pressurized gas in the crankcase which cooperate to open the exhaust valve and the inlet ports to allow the pressurized gas to sweep the cylinder of substantially all combusted gases said means further includes the piston which during the exhaust period forces the remaining combusted gases out the exhaust valve.

11. A method of operating a two stroke internal combustion engine:

Comprising the steps of compression the gas within the cylinder for about one half the piston stroke, introducing fuel into the cylinder at the compression end of the stroke, opening the exhaust and the inlet of the cylinder at substantially the same point in the expansion movement of the piston, moving the piston in continuation of its expansion stroke a distance substantially equal to the distance of the expansion stroke at the opening of the exhaust, forceably exhausting the combusted gases by the initial movement of the piston on its return stroke from the end of the expansion stroke, closing the inlet ports and the exhaust valve to cause compression of the gas within the cylinder as the piston moves past the inlet ports.

AMENDED CLAIMS

[received by the International Bureau on 24 October 1987 (24.10.87); original claims 3,5 and 7 cancelled; other claims amended (2 pages)]

Claim 1. A two-stroke internal combustion engine having a cylinder with a cylinder head, a piston reciprocating within the cylinder, an exhaust valve mounted in the cylinder head, a plurality of inlet ports circumferentially spaced around the cylinder wall near the middle of the stroke of the piston, whereby after the piston moves to open the inlet ports the piston continues to move a substantial distance beyond the inlet ports such that the events in the engine cycle are functionally related to the timing of the opening and closing of the exhaust valve and the positioning of the piston in its stroke such that the expansion process can be made longer than the compression process.

Claim 2. An engine is claimed in claim 1 which further includes a crankcase compressor means, including the piston for pressurizing the gas within the crankcase wherein the piston continues its stroke substantially beyond the inlet ports to further compress the gas in the crankcase to produce a scavenging ratio greater than one.

Cancel claim 3.

Claim 4. An engine as claimed in claim 2 which includes a passage mean for conducting the pressurized gas from the crankcase to the inlet ports and includes a one-way valve in the passage to prevent backflow from the cylinder through the ports and passage into the crankcase said one-way valve being mounted in the passage adjacent to the inlet ports to minimize the effect of the passage volume on the engine cycle.

Cancel claim 5.

Claim 6. An engine as claimed in claim 1 in which the engine cycle includes a compression process, an expansion process, an intake process and an exhaust process wherein the engine includes means to make the expansion process longer than the compression process said means including the movement of the piston as it continues the exhaust process after closing the inlet ports.

Cancel claim 7.

Claim 8. An engine as claimed in claim 1 which has in the engine cycle a compression process, an expansion process, an intake process and an

exhaust process wherein the engine includes means to make the compression process longer than the expansion process thereby to provide a supercharged condition in the cylinder said means incorporating closing exhaust valve before the piston moves to close the inlet ports.

Claim 9. An engine as claimed in claim 1 wherein the engine cycle includes a scavenging process and which includes means for improving the scavenging efficiency of the engine said means including the extended stroke of the piston to provide a large crank angle thereby permitting the devotion of a larger portion of the engine cycle to scavenging than is possible with prior art engines of this type and thus to permit higher piston speeds without sacrificing the scavenging efficiency of the engine or increasing the stress on the valve gearing.

Claim 10. An engine as claimed in claim 9 in which said means for improving the scavenging process includes the exhaust valve, the inlet ports and the pressurized gas in the crankcase which cooperate when the exhaust valve and inlet ports are opened to allow the pressurized gas from the crankcase to sweep the cylinder clear of substantially all combusted gases; said means further includes the piston which, during the exhaust process forces the remaining combusted gases out the exhaust valve as the piston moves toward the compression process.

Claim 11. A method of operating a two-stroke internal combustion engine: comprising the steps of compressing the gas within the cylinder for about one-half the total up stroke of the piston introducing fuel into the cylinder during the up stroke, opening the exhaust valve and inlet ports of the cylinder in predetermined relation to each other during the downward movement of the piston, moving the piston in continuation of its downward stroke to a point substantially beyond the end of the expansion process, which occurs at the opening of the exhaust valve, forceably exhausting the combusted gases by the initial movement of the piston as it begins its up stroke at the end of the downward stroke, closing the inlet ports and exhaust valve in predetermined sequence to cause compression of the gas within the cylinder by movement of the piston in its up stroke.

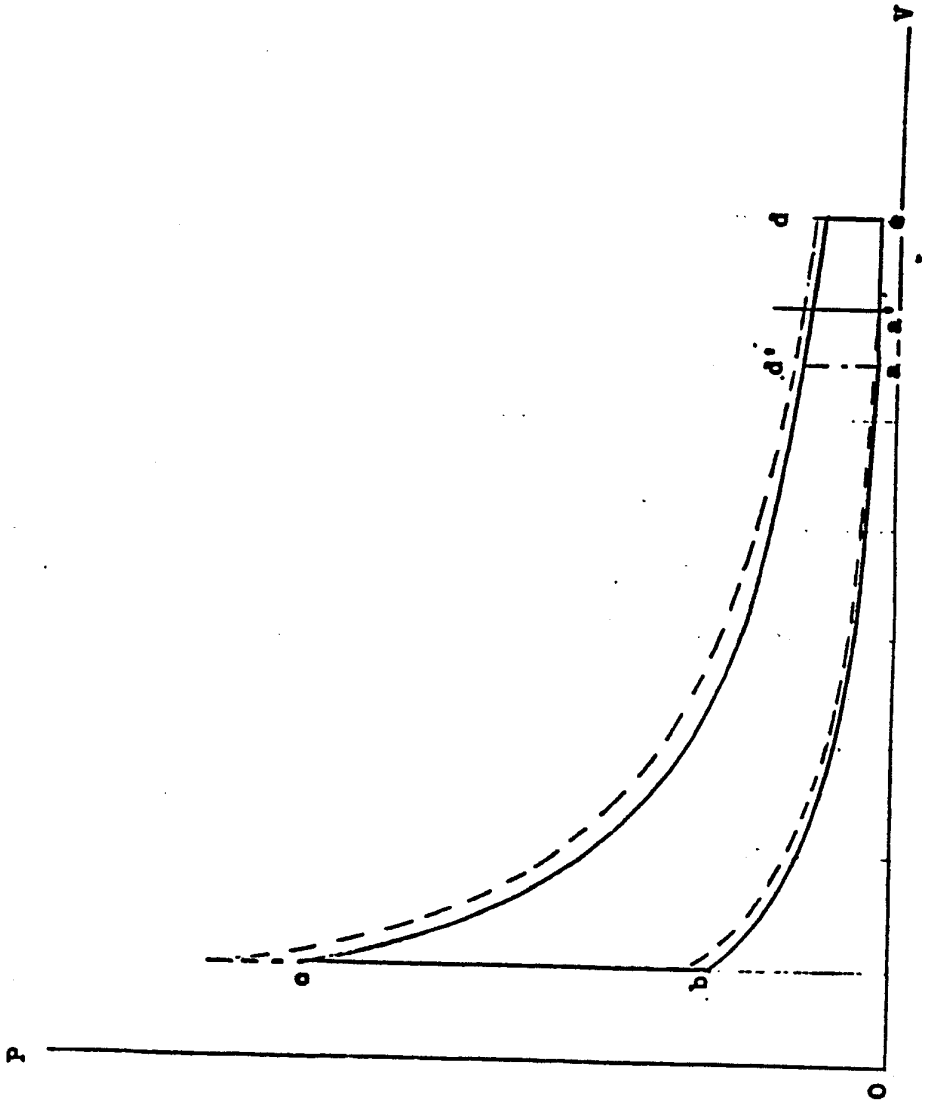


FIG. 1

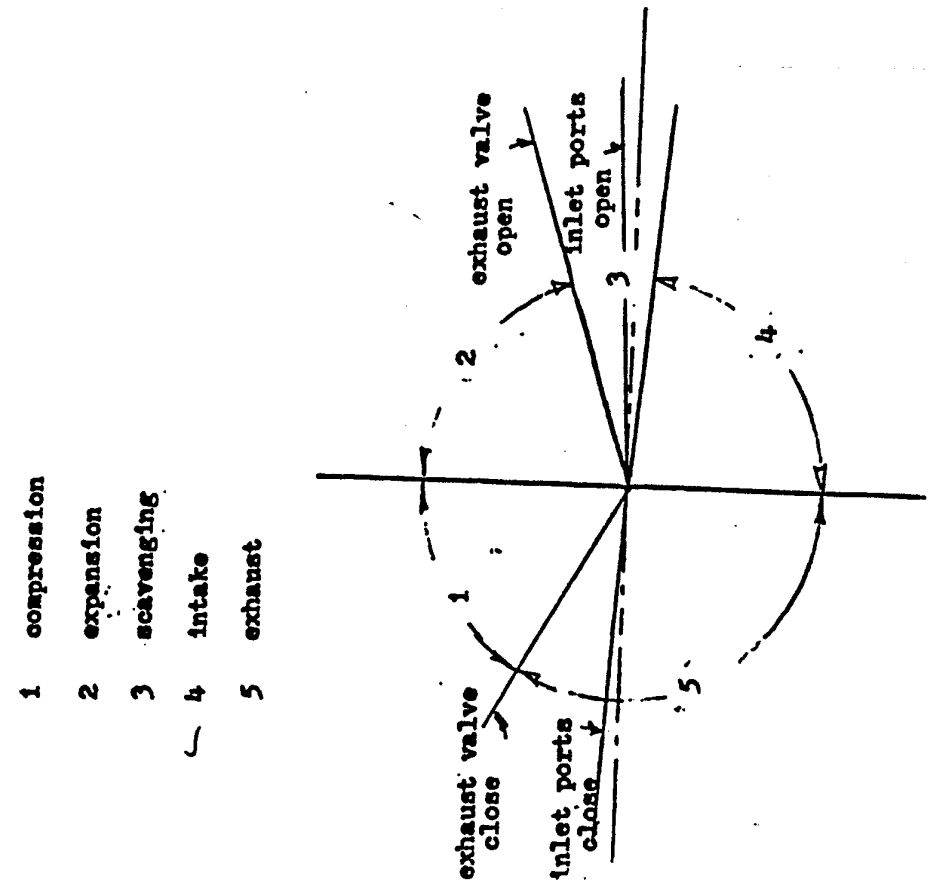

1 compression
2 expansion
3 scavenging
4 intake
5 exhaust
exhaust valve open
inlet ports open
exhaust valve close
inlet ports close
1
2
3
4
5

FIG 4

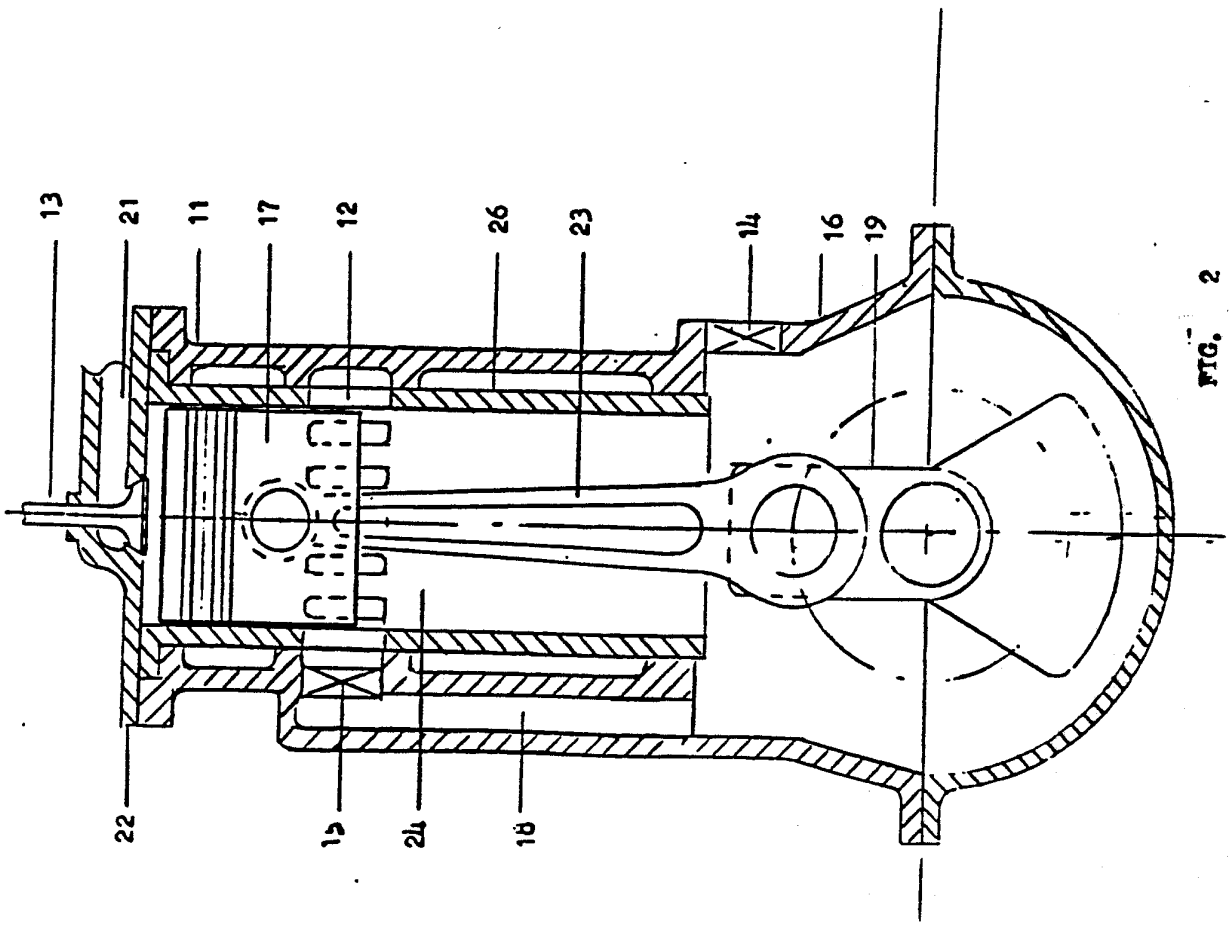

13
21
11
17
12
26
23
14
16
19
22
15
24
18

FIG. 2

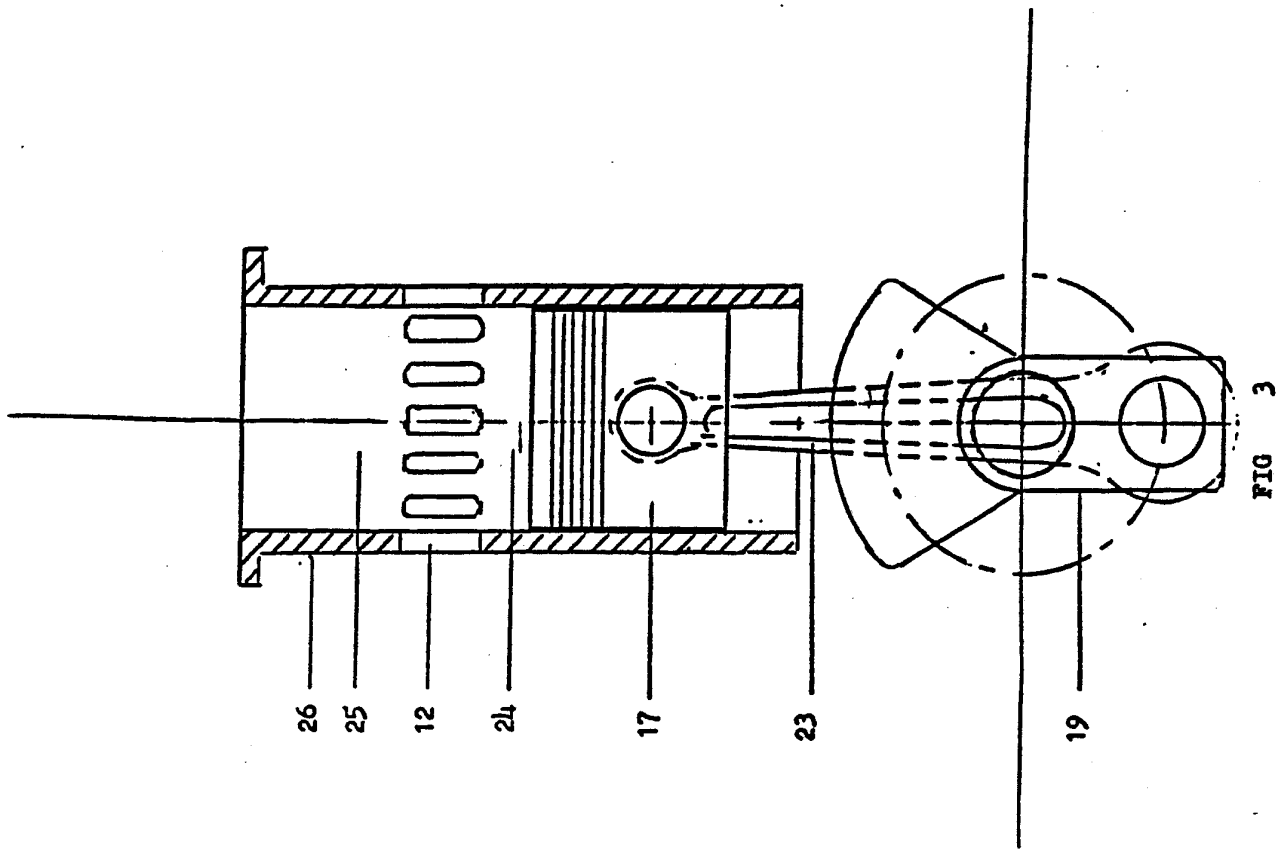


FIG 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/US86/01135

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): F02B 33/04, 75/02; F02D 39/04

U.S. CL. 123/65VC, 73R

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	123/64, 65R, 65A, 65VC, 73R, 73B, 257, 262, 275, 289

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 4,258,670, (THERY) 31 March 1981 see column 3, lines 28 to 32 and 35 to 38.	5, 9, 10
Y	US, A, 4,004,557, (ACKER) 25 January 1977 see paragraph bridging columns 1 and 2.	2-5, 9, 10
Y	US, A, 3,687,118, (NOMURA) 29 August 1972 see column 4, lines 28 to 44.	5, 9, 10
X Y	US, A, 2,991,616, (MILLER) 11 July 1961 see column 2, lines 8 to 16; column 4, lines 37 to 48.	1, 6-8, 11 2-5, 9, 10
X Y	US, A, 2,820,339, (GRIESHABER ET AL) 21 January 1958, see entire document.	1, 6-8, 11 2-5, 9, 10
X Y	US, A, 2,148,854, (BOKEMULLER) 28 February 1939, see entire document.	1, 6-8, 11 2-5, 9, 10
X Y	US, A, 1,100,975, (HARRINGTON) 23 June 1914 see page 2, lines 22 to 29 and 58 to 84; page 3, lines 21 to 31 and 43 to 52.	1, 2, 4, 6-8, 11 3, 5, 9, 10
X Y	US, A, 876,020, (SALTER) 07 January 1908 see entire document.	1, 2, 4, 6-8, 11 3, 5, 9, 10
Y	GB, A, 2,115,485, (HOOPER) 07 September 1983, see page 2, lines 73 to 81 and 92 to 107.	5, 9, 10
X Y	DE, A, 2,840,452, (KRIETER) 27 March 1980 see brief description (translated).	1, 6-8, 11 2-5, 9, 10

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
18 July 1986	20 AUG 1986
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	David A. Okonsky David A. Okonsky

Form PCT/ISA/210 (second sheet) (October 1981)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

X Y	JA, A, 0,151,020, (TOSA) 18 September 1982 see brief constitution (translated).	1, 6-8, 11 2-5, 9, 10
X Y	FR, B, 389,325, (DYCKHOFF) 05 September 1908, see entire document.	1, 6-8, 11 2-5, 9, 10

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers....., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.