



PCT

(10) International Publication Number
WO 2006/062425 A1

(51) International Patent Classification:

F02G 1/04 (2006.01) **F02F 3/10** (2006.01)
F02F 1/42 (2006.01) **F02F 3/02** (2006.01)

(21) International Application Number:

PCT/PL2005/000079

(22) International Filing Date:

9 December 2005 (09.12.2005)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

P-371689 10 December 2004 (10.12.2004) PL

(71) Applicant and

(72) **Inventor:** **HARDT, Piotr** [PL/PL]; ul. Debowa 28,
PL-62-006 Debogóra (PL).

(74) **Agent:** SZYKULA, Mirosław; DR Andrzej Au & Co.,
P.O. Box 85, PL-60-967 Poznań 9 (PL).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV,
LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI,
NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG,
SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US,
UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH,

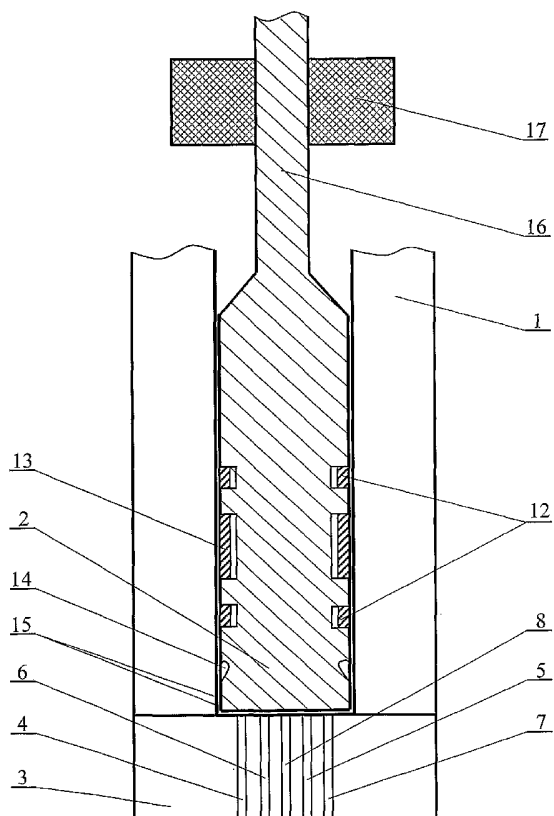
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GO, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: THERMAL MULTI-VALVE PISTON ENGINE AND A METHOD OF CONTROL OF THERMAL MULTI-VALVE PISTON ENGINE OPERATION



(57) Abstract: The subject-matter of this invention is thermal multi-valve piston engine (TMPE) of external combustion, characterized in that the head (3) of the engine, next to standard inlet valve (4) and outlet valve (7) connected hydraulically with heater (9) and cooler (10) respectively, is fitted with at least one extra inlet valve (5), through which the cylinder interior is hydraulically connected to cooler (10), and at least one extra outlet valve (6), through which the cylinder interior is hydraulically connected to heater (9), furthermore, with regard to the adopted parameters of engine operation, the function of compressor or pressure pump compressing the agent directly before feeding it to heater (9), is performed by the same cylinder (1) capped with head (3), with piston (2) inside. The another subject matter of invention is a method of control of thermal multi-valve piston engine (TMPE) operation, characterized in that the isobaric filling of cylinder (1) from heater (9) during the first phase of the working stroke, with heated agent in gaseous form, with temperature, pressure and specific volume higher than critical for that agent.

Thermal multi-valve piston engine and a method of control of thermal multi-valve piston engine operation.

The subject of invention is thermal multi-valve piston engine of external combustion and internal pressure cooling, and a method of control of thermal multi-valve piston engine operation.

There is one known solution for thermal engines with at least one cylinder capped with a cylinder head and with the piston inside. In this solution, the cylinder head is connected hydraulically with a heater and a cooler, by means of a valve system controlled by a gear system. Heater and cooler are connected hydraulically by means of pressure pump or compressor.

The lowest volume occupied by working agent in the engine cylinder refers to the external piston return point and the highest volume of agent refers to the internal piston return point. With vertical placement of the cylinder, with the cylinder head on top, the external piston return point is called top dead position (TDP), and the internal piston return point is called bottom dead position (BDP). Change in the volume of ultra-piston space in the cylinder between TDP and BDP is called cylinder displacement volume.

There are two valves, one inlet valve and one outlet valve, in the cylinder head. They are connected hydraulically with a heater and a cooler, respectively. The working agent works in a closed cycle. The working agent in steam engines is water, which during circulation undergoes two phase changes of vaporization /in heater/ and condensation /in cooler/.

The power stroke begins when the piston is in its TDP and, with outlet valve closed, the inlet valve opens and heated steam flows from the heater into the cylinder, at possibly constant pressure, moving the piston to a preselected position /with regard to adopted working parameters and cylinder geometry /, in which the cylinder's inlet valve is closed.

After closure of the inlet valve, the power stroke continues and expanding and cooling steam moves the piston even further until it reaches its BDP where the power stroke ends.

At BDP, the outlet valve opens and the piston's direction of movement changes to the opposite direction and the exhaust stroke begins. When the piston travels from BDP to

TDP, steam of constant pressure is removed from the cylinder, and when the piston reaches TDP, the engine's working cycle ends.

Steam removed from the cylinder flows to the cooler, where it is condensed. Then, cooler water is pumped with a pressure pump to the heater, where it is turned to steam, and the agent's circulation cycle ends.

In the further part of the description, as well as in the patent claims, the expressions **TDP** and **BDP** shall be used as generally understood. This should not, however, be interpreted as a limitation of the engine's working positions to these two.

Furthermore, for identification of thermodynamic transformations, the names of perfect transformations shall be used, which are practically impossible to achieve, though the actual transformations are very close. Hence, e.g. 'adiabatic expansion', is in practice an expansion possibly closer to adiabatic. Expression "**agent**" used in the description and in the patent claims, means the engine working agent works in a closed cycle.

In addition to the above, such expressions as "**preselected value**" or "**preselected values**" shall be used, meaning the values resulting from the adopted parameters of the engine's operation.

In the further part of the description and patent claims, the expression "thermal multi-valve piston engine" is replaced with the acronym "**TMPE**" or, should context allow, is referred to simply as "**engine**".

The nature feature of the invented construction of the thermal multi-valve piston engine (TMPE), with at least one cylinder capped with a cylinder head and with the piston inside, connected hydraulically with a heater and a cooler, by means of a valve system controlled by a gear system, with the working agent working in a closed cycle, is **that** in the engine head, next to the standard inlet valve and outlet valve connected hydraulically with a heater and a cooler, respectively, there is at least one extra inlet valve, connecting the interior of the cylinder hydraulically with a cooler, and at least one extra outlet valve, connecting the cylinder interior hydraulically with a heater, and in addition, with regard to the adopted parameters of the engine's operation, the function of compressor or pressure pump, compressing the working agent directly before feeding it to the heater, is performed by the same head-capped cylinder with piston inside.

The second important feature of the invented engine's construction is **that** the hydraulic connection between at least one extra inlet valve, located in the cylinder head, and the cooler, is not a direct one, but is effected through a compression unit that contains, with regard to the adopted parameters of the engine's operation, at least one compressor or pressure pump, at least one cooler, and at least one outlet pressure compensation tank stabilising agent .

The third important feature of the invented engine's construction is **that** all its inlet and outlet valves are electronically controlled, based on analysis of data supplied from pressure, location, fill and temperature sensors.

The fourth important feature of the invented engine's construction is **that** each engine piston, with regard to the maximum value of pressure in the cylinder, is fitted with at least one sealing ring that does not require lubrication.

The fifth important feature of the invented engine's construction is **that** each engine piston is fitted with at least one guiding ring that does not require lubrication.

The sixth important feature of the invented engine's construction is **that** each engine piston has at least one groove engraved on its side surface, with a profile preventing and inhibiting the inflow of the agent to the rings, around the whole perimeter, on a section between the external bottom of the piston and the first ring.

The seventh important feature of the invented engine's construction is **that** the walls of the engine's cylinders, head and piston are ceramic-coated or lined with ceramic insertions.

The eighth important feature of the invented engine's construction is **that** each engine piston is attached to the connecting-rod via a piston rod led through the crosshead.

The ninth important feature of the invented engine's construction is **that** it contains a counter-current heat exchanger in its heater, fitted at the working agent inlet or outlet, with a compensation tank stabilising agent outlet pressure.

The tenth important feature of the invented engine's construction is **that** it contains a counter-current heat exchanger in its cooler, fitted at the working agent inlet or outlet with a compensation tank stabilising agent outlet pressure.

A method of control of TMPE's operation, in which the power stroke begins when the piston is in its TDP and its first phase is effected by filling the engine

cylinder with heated working agent - at possibly constant pressure - from the heater through the standard inlet valve - with a closed standard outlet valve, and then in the second phase the stroke continues upon closure of standard inlet valve, with standard outlet valve still closed, through the process of working agent expansion, which continues until the piston reaches BDP. Then, upon changing at BDP the direction of movement of the piston to the opposite and opening the standard outlet valve, the exhaust stroke to the cooler is effected which ends when the piston reaches its TDP, **wherein according to nature of the invention**, in the first phase of the working stroke, the engine cylinder is isobarically filled from the heater with heated agent in the form of gas, with temperature, pressure and specific volume higher than critical for such agent.

The second important feature of the invented method of control **is that** during the working stroke - best at the end of the stroke - an additional portion of cold, compressed working agent, in a continuous liquid-gaseous phase and at the preselected values of pressure and temperature, is fed, at least once, to the cylinder from the compressing unit through the extra inlet valve, keeping the jet stream value and quantity, so that after the final closure of said inlet valve the agent /now with increased mass/ expands adiabatically further in cylinder, but following the adiabat of lower value of specific entropy than before. Such adiabatic expansion is continued until the agent reaches in cylinder the preselected values of pressure and temperature.

The third important feature of the invented method of control **is that** at the end of the second power stroke /i.e. at the end of adiabatic expansion/, when the cylinder pressure value is equal or nearly equal to the preselected minimum value, an additional portion of cold, compressed working agent, in a liquid form or continuous liquid-gaseous phase and at the preselected values of pressure and temperature /parameters at cooler outlet/, is fed to the cylinder from the cooler through a next extra inlet valve, at least once, keeping the jet stream value and quantity, so that after final closure of said inlet valve and completion of power stroke, the agent /now with increased mass/ in cylinder, has a lower value of specific entropy than before and reaches preselected values of pressure and temperature.

The fourth important feature of the invented method of control **is that** when the power stroke ends and the piston is at BDP and the direction of movement of the piston changes to the opposite, all outlet valves remain closed and the adiabatic compression

stroke begins, which, upon opening of the first of two outlet valves, proceeds to the isobaric exhaust stroke and upon closure of said valve is continued until the beginning of the second isobaric exhaust stroke. This occurs upon opening of the second outlet valve and continues until the piston reaches TDP.

The sequence of outlet valves opening- /the relations between the pressure of agent fed to the cooler and the pressure of agent fed to the heater/- and values of pressure at which they open, depend on the adopted parameters of engine operation.

The fifth important feature of the invented method of control **is that** the working agent is heated isobarically in the heater until it reaches the preselected value of temperature and takes gaseous form.

The sixth important feature of the invented method of control **is that** the working agent is cooled isobarically in the cooler until it reaches the preselected value of temperature, at which, with regard to the adopted parameters of engine operation, it takes liquid form or continuous liquid-gaseous form.

The seventh important feature of the invented method of control **is that** the working agent that is isobarically exhausted from cylinder to cooler, through standard outlet valve, is then taken from the cooler and fed to the compression unit, where it is compressed and cooled until it reaches preselected values of pressure and temperature. Later, it is stored in a vessel mounted at the unit's outlet.

The eighth important feature of the invented method of control **is that** carbon dioxide is utilised as a working agent.

Advantages of the invention: improved thermal efficiency of the engine; possibility of lowering the temperature of the piston and cylinder walls; a technically acceptable value of ultra-piston pressure in cylinder at a relatively high maximum temperature of the working agent.

Examples of the invented engine are shown as a block diagram in fig.1, and as a diagram depicting head-cylinder-piston system of the engine in fig.2. Fig. 3 shows control of TMPE operation as per the invention, and also the example of thermodynamic

circulation of working agent in the engine. The left part of agent circulation is effected in the cylinder and the cooler, whereas the right part is effected in the cylinder and the heater. During the compression stroke in the cylinder, those two parts of circulation are effected simultaneously, hence the bold compression line in the diagram. The part of circulation that is effected in the compression unit is not shown in the diagram.

Example of the TMPE.

The TMPE is composed of an engine cylinder 1 with piston 2 and head 3 with five valves: standard inlet valve 4, extra inlet valve 5, extra outlet value 6, standard outlet valve 7 and next extra inlet valve 8, and furthermore heater 9, cooler 10 and electronic control circuit 11.

The piston is fitted with two sealing rings 12 and one guiding ring 13, all rings are made of composites and do not require lubrication.

Engine piston 2 has one groove 14, with profile preventing and inhibiting the inflow of agent to sealing rings 12 and guiding ring 13, engraved on its side surface around the whole perimeter, on a section between the external bottom of the piston and the first sealing ring 12.

Cylinder 1, piston 2 and cylinder head 3 have ceramic coating 15, allowing them to work at high temperatures with reduced thermal loss. Piston 2 is attached to piston rod 16, going further through crosshead 17, to a typical system of crankshaft.

Standard inlet valve 4, extra inlet valve 8 and next extra inlet valve 5 are hydraulically connected to heater outlet 9, compressing unit outlet 18 and cooler outlet 10.

Extra outlet valve 6 and standard outlet valve 7 are hydraulically connected to heater inlet 9 and cooler inlet 10, respectively.

Heater 9 is a boiler, fueled with any kind of fuel, with counter-current heat exchanger fitted at the inlet with outlet pressure compensation tank stabilising agent. Cooler 10 is a counter-current heat exchanger fitted at the inlet and outlet with the outlet pressure compensation tank stabilising agent.

The cooling agent is water. Circulation of the working agent, carbon dioxide, is closed. It is certain that solution above can be realized with double-sided acting piston.

The engine power stroke begins when piston 2 is at TDP. Then standard inlet valve 4 opens, with the remaining valves closed, and a portion of heated working agent flows in to cylinder 1 from heater 9. Agent temperature T_g , pressure p_g and volume v_g .

The jet of agent and engine load are so adjusted that cylinder 1 is filled isobarically. When ultra-piston volume is v_g , standard inlet valve 4 closes and the power stroke proceeds to the next phase - adiabatic expansion of the agent. The moment when the value of pressure in cylinder 1 drops to p_w , extra inlet valve 8 opens, and agent is injected from compressing unit 18. Agent pressure p_{us} and temperature T_{us} .

Agent jet and quantity are so adjusted that, for a moment, agent pressure in the cylinder drops more slowly, and the temperature rises faster than before the injection.

Thanks to this solution, upon closure of additional extra inlet valve 8, the further phase of the power stroke continues in-line with a more favorable adiabat.

When agent in cylinder 1 reaches minimum pressure p_0 and temperature T_0 and becomes dry saturated steam, next extra inlet valve 5 opens and another portion of cold agent, with temperature T_c and pressure $p_c = p_g$, flows from cooler 10 into cylinder 1.

Agent jet and quantity are this time so adjusted that the last phase of the power stroke is nearly isobaric at pressure p_0 , and isothermic at temperature T_0 . Upon injection, the cold agent expands to p_0 and cools down to T_0 becoming highly saturated, highly moisturised steam. After closure of extra inlet valve 5, stabilisation of pressure p_0 and agent moisture level, piston 2 reaches BDP and the power stroke ends.

Agent in cylinder 1 has the same temperature and pressure as before injection of the cold agent, but higher moisturisation and lower specific volume.

At BDP, piston 2's direction of movement changes to the opposite direction and the adiabatic compression stroke begins. The compression stroke is continued until the agent reaches pressure $p_g = p_c$.

At the same moment, extra inlet valve 6 opens and agent is isobarically exhausted to heater 9. In heater 9 the agent is isobarically heated, at the pressure p_g , to temperature T_g . Upon exhaustion of a sufficient quantity of agent from cylinder 1, extra outlet valve 6 closes and simultaneously, standard outlet valve 7 opens, and the remaining part of agent is isobarically exhausted from cylinder 1 to cooler 10.

In cooler 10, the agent is isobarically cooled to temperature T_c , at pressure $p_c = p_g$, and part of it is taken to compression unit 18, where it is compressed to p_{us} and cooled to T_{us} .

The exhaustion stroke ends when piston 2 reaches TDP and standard outlet valve 7 closes. At that point, the cycle of engine's operation ends.

Example for method of control of TMPE operation

Circulation begins when piston 2 is at TDP, marking the beginning of the first phase of the power stroke, when standard inlet valve 4 opens, with remaining valves closed, and heated agent, with high temperature T_g and high pressure p_g , is isobarically fed to cylinder 1 from heater 9.

The agent is in the form of gas and values T_g and p_g are higher than critical values of those parameters for this agent.

The jet of agent filling cylinder 1 and the load of the engine during filling are so adjusted, that pressure in cylinder 1 is not changing during filling and is p_g . Cylinder 1 is filled until reaching the ultra-piston volume v_g equal to agent specific volume at pressure p_g and temperature T_g .

Immediately upon reaching the ultra-piston volume of value v_g standard inlet valve 4 closes.

During the second phase of the power stroke, adiabatic expansion of agent is effected, which becomes disturbed when extra inlet valve 8 opens, feeding in the portion of cooled, highly compressed agent from compression unit 18 to cylinder 1.

Pressure of the new portion of agent is p_{us} and its mass equals the mass of agent already in the cylinder. Additional extra inlet valve 8 opens as soon as pressure in cylinder 1 drops to $p_w = (p_g - p_0)/2$.

The jet of this portion should be such that pressure in cylinder 1 drops for a moment more slowly than before the opening of extra inlet valve 8 occurs, and temperature drops faster. Thanks to this solution, the value of the agent's entropy falls.

Upon closure of extra inlet valve 8, the second phase of the power stroke and adiabatic expansion of agent /in accordance with corrected adiabate/ continues until reaching the pressure of p_0 in cylinder 1.

Adopted correction of adiabate is obtained by determination of sufficiently high value of p_{us} . At the moment when pressure of agent in cylinder 1 reaches p_0 , next extra inlet valve 5 opens and another portion of cold agent is fed to cylinder 1 from cooler 10. Portion pressure is $p_c = p_g$ and temperature T_c , and its mass equals the mass of agent already in cylinder 1.

Said portion is injected to cylinder 1 in such a jet that the pressure of agent in cylinder 1 during the end phase of the power stroke would finally stabilise, without major fluctuations, at the value of p_0 and temperature T_0 .

Then the agent is in the form of saturated, wet steam, and its specific entropy value is lower again. In this last phase of the power stroke, agent expansion is continued, possibly isobarically, until closure of extra inlet valve 5 and the reaching of the piston to BDP.

We select pressure $p_c = p_g$ so that it is a couple of times higher than the critical value typical for the agent, and that at p_c and T_c the cold portion of the agent at the cooler 10 outlet was in a continuous liquid-gaseous phase.

The temperature of agent at the cooler 10 outlet and compression unit 18 outlet, i.e. T_c and T_{us} , is so selected that they can be maintained and obtained by means of cooling the agent with water from natural water intakes.

At BDP, piston 2's direction of movement changes to the opposite direction, and the compression stroke begins. During the compression stroke, the adiabatic compression of agent to pressure $p_g = p_c$ is effected, accompanied by a temperature rise from T_0 to T_s .

When the agent reaches pressure $p_g = p_c$, extra outlet valve 6 opens and the exhaust stroke begins, during which the agent is removed isobarically from cylinder 1 at pressure $p_g = p_c$.

Agent is exhausted to heater 9. Extra outlet valve 6 closes when the same portion of agent as was taken before, returns to heater 9. After closure of extra outlet valve 6, the standard outlet valve 7 opens immediately and the exhaust stroke is continued. The portion of agent still remaining in cylinder 1 is isobarically exhausted to cooler 10 at an unchanged pressure of $p_c = p_g$.

The exhaust stroke ends when piston 2 reaches TDP. Agent being removed from cylinder 1 is in a continuous liquid-gaseous phase.

In heater 9, the agent is counter-currently heated until its temperature raises from T_s to T_g and it is therefore ready for utilisation in the subsequent cycle of engine operation.

In cooler 10, the agent is counter-currently cooled with water from natural intakes until its temperature drops from T_s to T_c and it is therefore ready for utilisation in the subsequent cycle of engine operation.

The portion of agent cooled in cooler 10 is taken to compression unit 18, where it is compressed to pressure p_c to p_{us} , cooled to temperature T_{us} and stored in vessel 19 mounted at the outlet of unit 18.

Agent is stored in vessel 19, ready for use in the subsequent cycle of engine operation. This ends circulation of the working agent in the engine.

Claims

1. Thermal multi-valve piston engine (TMPE) of external combustion, containing at least one cylinder (1) capped with head (3), with piston (2) inside, connected hydraulically with heater (9) and cooler (10) by means of the system of valves (4-8) controlled by gear system, with closed circulation of working agent, characterized in that in the said head (3) of the engine, next to standard inlet valve (4) and outlet valve (7) connected hydraulically with heater (9) and cooler (10) respectively, is fitted with at least one extra inlet valve (5), through which the cylinder interior is hydraulically connected to cooler (10), and at least one extra outlet valve (6), through which the cylinder interior is hydraulically connected to heater (9), furthermore, with regard to the adopted parameters of engine operation, the function of compressor or pressure pump compressing the agent directly before feeding it to heater (9), is performed by the same cylinder (1) capped with head (3), with piston (2) inside.
2. The engine according to claim 1, wherein said hydraulic connection between at least one extra inlet valve (8), located in the head (3) of cylinder (1) and cooler (10) is not a direct one, but is effected through compression unit (18), which contains, regarding the adopted parameters of engine operation, at least one compressor or pressure pump, at least one cooler, and at least one compensation tank at the unit outlet to stabilise agent pressure.
3. The engine, as according to any one of claims 1 to 2, wherein said inlet valves (4, 5, 8) and outlet valves (6, 7), all electronically controlled based on the analysis of data supplied from pressure, position, fill and temperature sensors.
4. The engine according to any one of claims 1 to 3, wherein said engine piston (2) fitted, regarding maximum value of cylinder (1) pressure, with at least one sealing ring (12) which does not require lubrication.
5. The engine according to any one of claims 1 to 4, wherein said engine piston (2) fitted with at least one guiding ring (13) which does not require lubrication.
6. The engine according to any one of claims 1 to 5, wherein the said engine piston (2) having engraved on its side surface at least one groove (14), with a profile preventing and inhibiting the inflow of agent to those rings, around the whole perimeter, on a section between piston (2)'s external bottom and first sealing ring (12).

7. The engine according to any one of claims 1 to 6, wherein the surfaces of cylinder (1), head (3) and piston (2) being ceramic-coated or lined with ceramic insertions (15).
8. The engine according to any one of claims 1 to 7, wherein the said engine piston (2) attached to connecting-rod by means of piston-rod (16), led through the crosshead (17).
9. The engine according to any one of claims 1 to 8, wherein said a counter-current heat exchanger located in heater (9), fitted at the inlet or outlet of working agent with compensation tank stabilising agent pressure.
10. The engine according to any one of claims 1 to 9, wherein said a counter-current heat exchanger located in cooler (10), fitted at the inlet or outlet of working agent with compensation tank stabilising agent pressure.
11. A method of control of thermal multi-valves piston engine (TMPE) operation, in which the power stroke begins when the piston is at (TDP) and its first phase is effected by filling of the engine cylinder, at possibly constant pressure, with heated working agent from the heater through the standard inlet valve with the standard outlet valve closed and then in its second phase, the stroke is continued after closure of said inlet valve, with standard outlet valve still closed, by continued expansion of the working agent until the piston reaches (BDP), and then, upon changing at (BDP) the piston's direction of movement to the opposite direction and opening the standard outlet valve, an exhaust stroke of agent to cooler is effected, which ends when the piston reaches (TDP), characterized in that the isobaric filling of cylinder (1) from heater (9) during the first phase of the working stroke, with heated agent in gaseous form, with temperature, pressure and specific volume higher than critical for that agent.
12. A method of control according to claim 11, wherein during the working stroke - best at the end of the stroke - an additional portion of cold, compressed working agent, in a continuous liquid-gaseous phase and at the preselected values of pressure and temperature, is fed, at least once, to the cylinder (1) from the compressing unit (18) through the extra inlet valve (5), keeping the jet stream value and quantity, so that after the final closure of said inlet valve the agent /now with increased mass/ expands adiabatically further in cylinder (1), but following the adiabat of lower value of specific entropy than before and such adiabatic expansion is continued until the agent reaches in cylinder (1) the preselected values of pressure and temperature.

13. A method of control according to any one of claims 11 to 12, wherein at the end of the second phase of the power stroke /i.e. at the end of adiabatic expansion/, when the cylinder pressure value is equal or nearly equal to the preselected minimum value, an additional portion of cold, compressed working agent, in a liquid form or continuous liquid-gaseous phase and at the preselected values of pressure and temperature /parameters at cooler outlet/, is fed to the cylinder (1) from the cooler (10) through a next extra inlet valve (5), at least once, keeping the jet stream value and quantity, so that after final closure of said inlet valve and completion of power stroke, the agent /now with increased mass/ in cylinder (1), has a lower value of specific entropy than before and reaches preselected values of pressure and temperature.

14. A method of control according to any one of claims 11 to 13, wherein when the power stroke ends and the piston (2) is at (BDP) and the direction of its movement changes to the opposite, all outlet valves remain closed and the adiabatic compression stroke begins, which, after the opening of the first of two outlet valves (6 and 7), proceeds to the isobaric exhaust stroke, and after closure of said valve the compression stroke is continued until the beginning of the second isobaric exhaust stroke, which begins after opening the second outlet valves (6, 7) and continues until the piston (2) reaches its TDP, wherein the sequence of outlet valves (6, 7) opening /hence relations between values of pressure of agent exhausted to cooler (10) and to heater (9)/ and values of pressure at which they open, are related to adopted parameters of engine operation.

15. A method of control according to any one of claims 11 to 14 wherein the working agent being heated isobarically in heater (9) until reaching the preselected value of temperature and taking gaseous form.

16. A method of control according to any one of claims 11 to 15 wherein said the working agent being cooled isobarically in cooler (10) until reaching the preselected value of temperature, at which point it takes, with regard to the adopted parameters of engine operation, a liquid form or continuous liquid-gaseous phase.

17. A method of control according to any one of claims 11 to 16 wherein said the working agent, fed isobarically from cylinder (1), through standard outlet valve (7), to cooler (10), taken from the cooler to compression unit (18), where it is compressed and cooled until it reaches the preselected values of pressure and temperature, and is then stored in the vessel (19) mounted at the unit outlet.

18. A method of control according to any one of claims 11 to 17, wherein carbon dioxide is being used as a working agent.

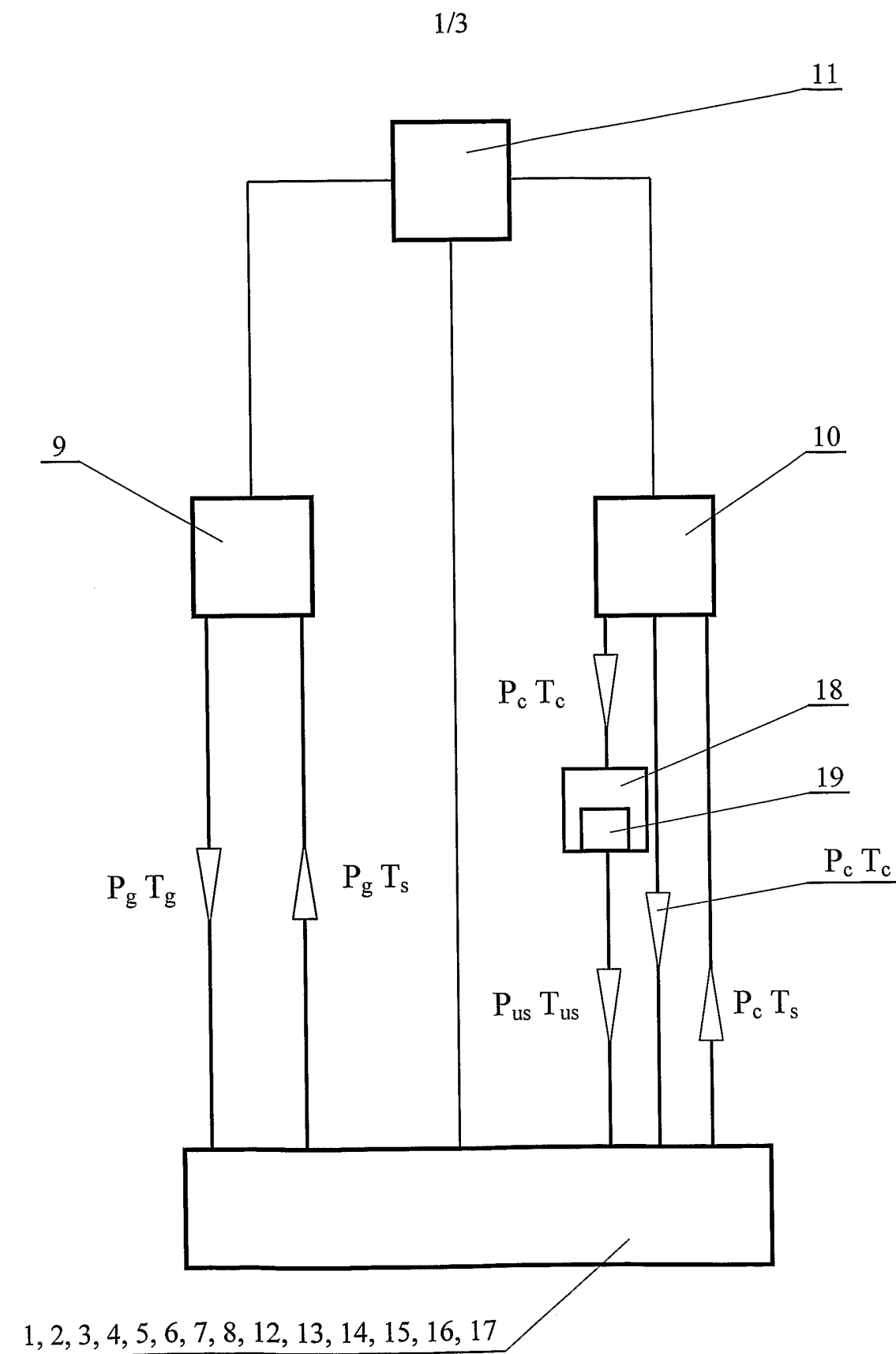


Fig. 1

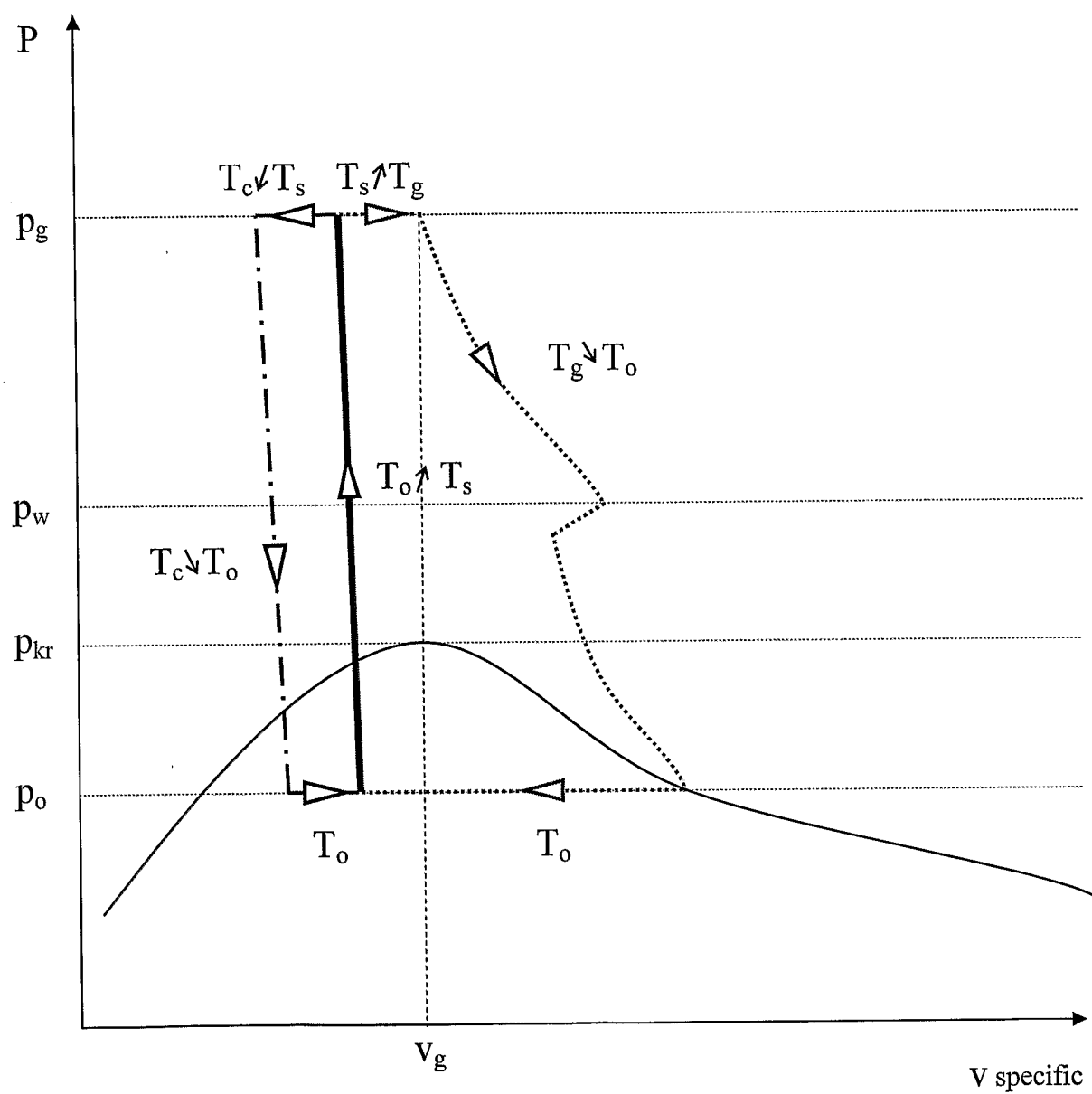


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2005/000079

A. CLASSIFICATION OF SUBJECT MATTER

F02G1/04 F02F1/42 F02F3/10 F02F3/02

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)

F02G F02F F01K

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 962 645 A (MORGAN ET AL) 16 October 1990 (1990-10-16) column 2, line 44 - column 3, line 40; figure 4 -----	1,10,11
A	US 4 077 221 A (MAEDA ET AL) 7 March 1978 (1978-03-07) column 1, line 47 - column 2, line 43; figure 2 -----	1
A	WO 85/01988 A (MITCHELL, MATTHEW, P) 9 May 1985 (1985-05-09) page 9, line 31 - page 10, line 12; figure 3 -----	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"E" earlier document but published on or after the international filing date
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Date of the actual completion of the international search

9 March 2006

Date of mailing of the international search report

17/03/2006

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Pileri, P

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/PL2005/000079

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