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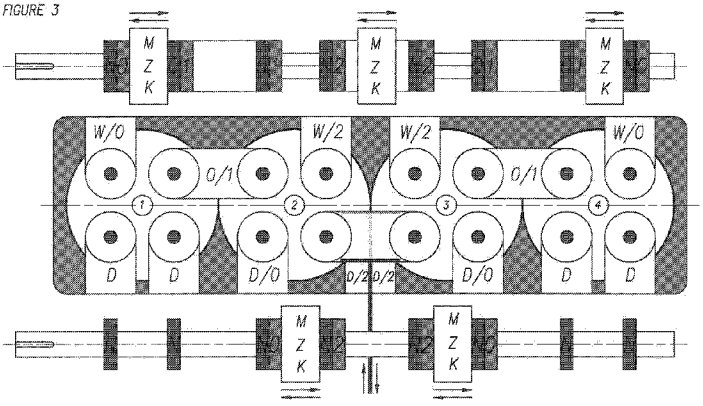
(54) Title: MULTI-PURPOSE INTERNAL COMBUSTION ENGINE

FIGURE 3



(57) Abstract: The object of the invention is a multi-purpose internal combustion engine, which is a 4-stroke engine with or without a turbocharger with a spark ignition or compression ignition, which can work interchangeably in 2 different ways: 1. - normal operation, by using all cylinders as shown in Fig. 1A and 6A; 2.- in an economical way, when some of its cylinders are switched off and with expansion of the exhaust gases in these cylinders from the cylinders working as in Fig. 1B, 2C and 2D as well as 6B, 7C and 7D. The exhaust gas pressure in the cylinders at the time of opening the exhaust valves is even up to 6 bar above the atmospheric pressure. This engine differs from a normal engine mainly by the construction of the head and timing. When the vehicle gains speed and when the demand for power is much smaller, the engine control unit switches off the operation in some of its cylinders and changes the control of the valves. Then, the engine works in an economical way. The expected increase in efficiency is up to 15% compared with the engine in which the power is switched off only in some of the working cylinders.

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Multi-purpose internal combustion engine

The present invention is a multi-purpose internal combustion engine having three or four cylinders in line, including its multiple engine, as B6, B8, V6, V8, R6 and R8, which is a four-stroke engine with or without a turbocharger, with a spark ignition or compression ignition, characterized in that it has the ability to turn off the operation of central cylinders:2 and 3 in the 4-cylinder engine, and the central cylinder in a 3-cylinder engine and to convert them into 2-stroke auxiliary engine driven alternately by the combustions exhaust gas pressure of the outer working cylinders. The invention is described in the embodiments, where Fig. 1 and Fig. 2 as well as 6 and 7 show the construction and operation of the engine. This engine can operate in 2 ways: **1** – normal, using all cylinders as shown in Fig. 1A and 6A or **2**- in an economical way, when some of its cylinders are switched off and with expansion of the exhaust gases in these cylinders from the cylinders working as in Fig. 1B, 2C and 2D as well as 6B, 7C and 7D. All working strokes of the pistons are extended to their lower turning points and last half the revolution of the crankshaft. These engines differ from conventional engines mainly by the construction of the head and timing. This is shown on Fig. 3, 4, 5, 6, 7 and 8. In a 3-cylinder engine, the piston of the middle cylinder has the largest possible diameter and surface area relative to the pistons of the outer cylinders and the crank on the crankshaft is offset by 180° relative to the cranks for the other pistons. When the vehicle gains speed and when the demand for power is much smaller, the engine control unit switches off the operation in some of its cylinders and changes the control of the valves. Then, the engine operates in an economical way. The exhaust gas pressure in the cylinders at the time of opening the exhaust valves is even up to 6 bar above the atmospheric pressure. The expected advantage from the maximum use of the use of exhaust gas pressure and form extending them during an economical operation of the engine is an increase in its efficiency of up to 15% compared with the engine in which the power is switched off only in some of the working cylinders.

The current state of the technology. Currently the engines that are known and produced are engines with a system of switching off the operation of some of the cylinders. These engines are made by such concerns as VW and GM and others. I hereby present an engine made by VW: 1.4 TSI ACT (Active Cylinder Technology). It is a gasoline 4-cylinder engine with a turbocharger, which delivers an output of 140 hp / 4500 – 6000 rpm. The reduction of fuel combustion in the engine after turning off the operation of two middle cylinders is due to a decrease in the resistances of the flow of air-fuel mixture and an increase of the efficiency of combustion in the other cylinders. VW states that the savings in the fuel consumption are 20%. "Ilmor Engineering" developed an engine, where 2 cylinders operate and the additional, third cylinder positioned in the middle of the piston of a larger diameter and surface is driven by the exhaust pressure from the outer cylinders. Additional work of exhaust gases gives 20% power.

A multi-purpose internal combustion engine can be an ordinary 4-stroke engine, which gives all its power, or an engine that operates with some of its cylinders switched off and expands in them exhaust gases from the working cylinders. Further expansion occurs in the turbocharger. This engine combines the features and benefits of the engine in which some of its cylinders are switched off and an engine, which additionally expands gases. It can be assumed that the multi-purpose internal combustion engine are these two engines in one! The combination of the features of these two engines is only possible:

- by connecting the adjacent cylinders of the engine by ducts with valves located in them.
- by the use of control with valves in the head, which has two alternative variants **A** or **B**.
- when the engine controller turns off the operation of the middle cylinders and changes the control of the valves.

The first way to change the variants of valve control in the cylinder head from variant **A** to variant **B**, and vice versa, is possible by changing the cams **A**, marked in blue to cams **B**, marked in red, by moving them on the camshaft by the cams changing mechanism - **CCM**. This is illustrated in Fig. 3. **Another way** to change the variants of valve control, shown in Fig. 4 and 5, consists in an appropriate alternating switching off and on of the operation of the valves by varying the height of the support levers of the valves. The height of the support location is adjusted by the shaft with an adequate cam for each support of the valve lever, placed under the support and swivelled with an actuator. In this method, in a 4-cylinder engine the exhaust valves 2 and 3 of the cylinder and the valves in the duct connecting them have two additional levers, marked in red, and two cams marked by the number 2 for controlling the latter only during the economical method of the engine operation. In the 3-cylinder engine, the additional leverage and the cam can only be found in outlet valves of the middle cylinder. In addition to the ways of controlling valves presented here that allow an alternate use of two variants of their operation: **A** or **B**, there is also possible a hydraulic or a pneumatic system, as well as a combination of different systems.

Features and mechanisms of a multi-purpose internal combustion engine:

- the engine has ducts connecting the adjacent cylinders that are appropriately opened and closed by the valves in them used in an economical way of engine operation.
- the duct connecting middle cylinders 2 and 3 in a 4-cylinder engine is equipped with an additional auxiliary valve which, when open, also makes this duct an intake duct. This valve is opened or closed by the actuator through the engine controller.
- outlet valves of the outer cylinders work alternately with valves in ducts connecting outer cylinders with the 2nd and 3rd cylinder in a 4-cylinder engine, and in the 3-cylinder engine alternately with the valves in ducts connecting with the middle cylinder.
- a 4-cylinder engine is characterized in that the outlet valves of the middle cylinders 2 and 3 and the valves in the duct that connects them have dual, independent and alternately switched control system which allows to turn these cylinders into a 2-stroke auxiliary engine driven alternately by the exhaust gases pressure from the outer working cylinders.
- a 3-cylinder engine is characterized in that the outlet valves of the middle cylinder have double, alternately switched and independent control system which allows to turn this cylinder into a 2-stroke auxiliary engine, driven alternately by the exhaust gases pressure from the outer operating cylinders.
- the intake valves of the middle cylinder a 3-cylinder engine, and in the 4-cylinder engine only intake valves of the middle cylinders: 2 and 3, adjacent to the cylinders 1 and 4, are closed and out of operation during the economical method of the engine operation.
- the engine is characterized in that the cams controlling the valves in the ducts connecting the outer cylinders with the middle cylinders, marked in Fig. 3, 4, 5 and 8 with number 1 or 1=90° as well as those which control the exhaust valves in the middle cylinders, and in the duct connecting them, marked as numeral 2 or 2 x 90°, used only during the economical method of operating the engine, have opening angle of the valves close or equal to but not greater than 90°.
- the engine is characterized in that its controller can disable the operation of two middle cylinders in a 4-cylinder engine, and the operation of the middle cylinder in a 3-cylinder engine, by switching off fuel injection in these cylinders, and in petrol engines also the ignition, can change by, appropriate actuators, the control of the intake and exhaust valves, and in a 4-cylinder engine also an auxiliary valve to make the engine operate in an economical way and additionally expand exhaust gases in the disabled cylinders and then the turbocharger.

The figures, attached to the description of the invention, show in order:
1A - shows the normal engine operation in a 4-stroke cycle. The order of operation: 1-3-4-2 cylinder. The valves in the ducts connecting the outer cylinders with middle cylinders marked in black are closed and out of operation. An auxiliary valve in the duct between the 2nd and 3rd cylinder is open. In the first cylinder, working stroke is performed.

1B - shows the operation of the engine on the outer cylinders. The exhaust valves of the outer cylinders and the intake valves of the middle cylinders marked in black are closed and out of operation. The operation in the middle cylinders is switched off. The auxiliary valve in the duct between cylinder 2 and 3 is closed. Cylinders 1, 2 and 3 are connected by open ducts. The stroke of the outlet of cylinder 1 is the working stroke of middle cylinders.

2C - shows the operation of the engine on the outer cylinders. The middle cylinders are connected and perform the outlet stroke. In cylinder 4 the working stroke takes place and in cylinder 1 – the inlet stroke.

2D - illustrates the operation of the engine on the outer cylinders as in Fig. 1B, except that now cylinders 4, 3 and 2 are connected. The outlet stroke of cylinder 4 is the working stroke of the middle cylinders.

3 - shows the arrangement of the valves and the ducts connecting the cylinders in the head and camshafts with sliding cams. Cams **A** - are marked in blue. Cams **B** –are marked in red. Letter **N** is applied to mark cams used for a normal engine operation in a 4-stroke cycle. Digit **0** signifies zero cams. Digit **1** – signifies cams with 90° valve opening angle. Digit **2** - represents two cams with 90° valve opening angle, shifted from each other by 180°. Letter **D** – signifies intake valves. Letter **W** – signifies exhaust valves. **CCM** is the cam changing mechanism.

4 - shows the construction of the head and the valve control by changing the height of the supports of valve levers. The upper position of the support of a valve **G** lever - means that the valve is working. The bottom position **D** - means that the valve is closed and is not working. Letters in blue show in what position the supports of the valve lever are when the engine is running on 4 cylinders. Letters in red show in what position the support of the valve lever are when the engine is running in an economical way, only on 2 cylinders.

5 - shows cross sections A - A, B - B and C - C marked in Fig.4. Cross-section A - A shows the control of valves by two separate levers which can press the valve shafts independently of each other. Additional levers, marked in red, press the two adjacent valves and are operated by a cam shown in section C - C. (2 x 90) – are two cams with a 90° valve opening angle, marked by number **2**. Cross-section B - B shows a method of pressing of cam **1** with a 90° valve opening angle (90°=1) on a roll positioned in the valve lever. The support of the valve lever is lowered or raised by revolution of the shaft placed underneath with cams to the left or right. When the support of the valve lever is lowered to the bottom position **D** - then the cam does not press on the roller located in the valve lever and the valve stops and is closed. The upper position of the support of the valve lever G - restores the operation of the valve.

6A - shows the normal operation of the 3-cylinder engine in a 4-stroke cycle. The order of operation: 1-2-3 cylinder. The valves in the ducts connecting the outer cylinders with the middle cylinders marked in black are closed and out of operation. In the first cylinder the working stroke is performed.

6B - shows the operation of the 3-cylinder engine on the outer cylinders. Exhaust valves of outer cylinders and the intake valves of the middle cylinder, marked in black, are closed and out of operation. The operation in the middle cylinder is turned off. The cylinders 1 and 2 are connected by the open connecting duct. The outlet stroke of cylinder 1 is the working stroke of the middle cylinder.

7C - shows the operation of a 3-cylinder engine on the outer cylinders. In the middle cylinder the outlet stroke takes place. In cylinder 3 the working stroke takes place.

7D - illustrates the operation of a 3-cylinder engine on the outer cylinders as in the description of Fig. 6B, except that now cylinders 3 and 2 are connected. The outlet stroke of the 3rd cylinder is a working stroke of the middle cylinder.

8 - shows the arrangement of the valves and ducts connecting the cylinders in the head of a 3-cylinder engine.

Fig. 1, 2, 6 and 7, which show the construction of the engines and their methods of operation, the strokes of the pistons in the cylinders are marked as follows: the intake stroke is marked with letter **D** and white colour. The compression stroke is marked with letter **S** and blue colour. The working stroke with the letter **P** and orange. The outlet stroke with letter **W** and in black dotted colour. The working stroke of middle cylinders, when the engine is running only on 2 cylinders, is marked as **W / P** and in black dotted colour. The ducts connecting the cylinders are marked by numbers. The duct between the 2nd and 3rd cylinder is shown in the figure as closed and as an open by an auxiliary valve, which looks like the letter **T**. Valves excluded from work are marked in black.

Table of pressures of the exhaust gases in a multi-purpose internal combustion engine 2/4c.

Cylinder displacement 400cm³. Volume of the combustion chamber 36cm³. Capacity of 2 connecting ducts 74cm³

Stroke	Capacity of 1 cylinder	Exhaust gas volume	Volume	5 bar	4.32 bar	3 bar
100%	36	982	2.25229	2.21996	1.91805	1.33198
90%	76	942	2.16055	2.31423	1.99949	1.38854
80%	116	902	2.06881	2.41685	2.08816	1.45011
70%	**156**	**862**	**1.97706**	**2.52901**	**2.18506**	**1.51740**
60%	196	822	1.88532	2.65207	2.29139	1.59124
50%	236	782	1.79358	2.78772	2.40859	1.67263
40%	276	742	1.70183	2.93801	2.53844	1.76281
30%	316	702	1.61009	3.10542	2.68308	1.86325
20%	356	662	1.51835	3.29305	2.84519	1.97583
10%	396	622	1.42661	3.50481	3.02816	2.10289
0%	436	582	1.33486	3.74571	3.23629	2.24743
1	2	3	4	5	6	7

Columns 1 to 7 represent and show respectively:

1. signifies as percentage the path of the piston of the first cylinder during the upward stroke.
2. shows the volume of exhaust gases in the first cylinder depending on the path of the piston of the first cylinder during the upward stroke.
3. shows the volume of the exhaust gas after opening the ducts connecting 1, 2 and 3 cylinders depending on the path of the piston of the first cylinder during the upward stroke.
4. shows the increase in the volume of exhaust gases after opening connecting ducts depending on the path of the piston of the first cylinder during the upward stroke.
5. shows the loss of gas pressure after opening the ducts connecting the cylinders depending on the path of the piston of the first cylinder during the upward stroke. Gas pressure before opening the ducts connecting the cylinders is 5 bar.
6. as in column 5, when the pressure of gases before opening the ducts connecting the cylinders is 4.32 bar.
7. as in column 6, when the pressure of gases before opening the connecting ducts is 3 bar.

According to the table, we can theoretically calculate the average gas pressure on the piston:
for column 5 it is 2.86426 bar.
for column 6 it is 2.47472 bar.
for column 7 it is 1.71855 bar.

The row highlighted in bold means that: the piston of the first cylinder made 70% upward stroke. The volume of the gases in the first cylinder is 156 cc. The total volume of the exhaust gas is 862 cc. The increase in their volume is 1.97706 times. Columns 5, 6 and 7 show the gas pressure on the pistons when before connecting the cylinders it was as follows: 5; 4.32 and 3 bar. The practical pressure is lower due to the cooling of the engine. The actual pressure and the pressure-volume diagram will be shown by an engine indicator.

Additional work of combustion exhaust gases in a multi-purpose internal combustion engine.

We will obtain additional work of the combustion exhaust gases in this engine during the economical method of operation by the maximum use of their pressure, which at the time of opening the outlet valves is higher than the atmospheric pressure by even 6 bar.
This is possible if:

1. the working stroke in the engine is extended to the entire length of the stroke of the piston.
2. the exhaust gases from the working outer cylinders are directed to the middle cylinders, which will then work as a 2-stroke auxiliary engine driven by their pressure.

To calculate the work and capacity of combustion exhaust gases I use a 4-cylinder gasoline engine with the following parameters: displacement 1600 cc, compression ratio 1:12, power of 160 hp/5600 rpm, cylinder capacity 400 cc, the capacity of the combustion chamber 36 cc, the capacity of the connecting duct 37 cc, piston stroke 80 mm, and the surface of the piston 50 cm^2. The opening angle of the exhaust valve = 64° before BDC. The distance between the axis of symmetry between the shaft pivot and the piston pin is 133 mm. To calculate the additional working stroke, as in point 1, I calculate the path of the piston, which corresponds to the revolution of the shaft by 64°. It is 17.526 mm. In the engine running on 2 cylinders only, the

combustion efficiency increases, as well as the amount of the fuel burned, so I assumed that the pressure of the combustion exhaust gases at the opening of the outlet valve is 6 bar above the atmospheric pressure. An additional working stroke 17.526 mm is 28%. By this much the pressure of gases will be reduced when the piston is at the bottom dead centre and will amount to 4.32 bar. The average pressure of additional stroke: 5.16 bar. I assume that the exhaust gas pressure in the cylinder after the opening of the outlet valve in a normal working cycle of an engine is 1 bar above the atmospheric pressure and also performs work up to the bottom dead centre of the piston position. Therefore, by this much I reduce the exhaust gas pressure, which is needed to calculate the work of this stroke: 5.16 - 1 = 4.16 bar. 1 bar= 10 N/cm². The force exerted by the combustion exhaust gases on the piston, are: the piston surface x 50 cm² x the force of the gas pressure = 41.6 N and amounts to 2080 N. The engine makes one working stroke per one revolution of the engine shaft.

The additional power in KW that we will get during 1 second from an extended working stroke at 5600 rpm includes: the force of the exhaust gases exerted on the piston in Newton N x the path of the piston in meters per 1 revolution of the shaft x 5600 rpm divided by 1000 W and 60 seconds and will be:

$$M_1 = \frac{2080N \cdot 0{,}017526m \cdot 5600rpm/\min}{1000W \cdot 60\sec} = 3{,}4026KW$$

Additional work of the exhaust gases as in point **2** results from the fact that the surface area of the pistons in the middle cylinders is 2 times greater than the outer piston, and therefore the force of the exhaust gases exerted on these pistons is also two times greater and it dominates the force exerted by the exhaust gases on the outer piston which then performs the negative work since it moves in the opposite direction.
The power in KW of the additional work of gases, as in point **2**, in a 4-cylinder engine is the power of gases exerted on the piston x the path of the working stroke of one piston per one revolution of the crankshaft (because 2 outer cylinders work alternately) x the number of revolutions per minute, divided by 1000 and 60 sec. Gas pressure before connecting the cylinders is 4.32 bar.
The average pressure of the exhaust gases on the piston during the expansion stroke according to the attached table is 2.47472 bar. The force of the gases exerted on the piston = 24.7472 N x 50 cm² = 1237.36 N. The path of the piston = 0.08m. Revolutions: 5600 revolutions / sec. 1000 W = 1KW.

$$M_2 = \frac{1237{,}36N \cdot 0{,}08m \cdot 5600rpm/\min}{1000W \cdot 60\sec} = 9{,}23895KW$$

The total power of the additional work of gases: = 3.4026 KW + = 9.23895 KW and will be 12.64155 KW. I assume that cooling the engine will reduce the power by 30%. 12.64155 KW - 30% = 8.849085 kW or 12.035 hp. The engine under consideration reaches 160 hp/5600 rpm. The power of 2 cylinders = 80 hp. 1% of 80 hp is 0.8 hp. The power of the additional work of exhaust gases 12.035 hp: 0.8 hp 15%. This is only a theoretical calculation, I think close to reality. The exact increase in efficiency will be determined on an engine test stand by measuring the actual pressure of the exhaust gases in an engine with an indicator and on a engine test bed used to measure their power. A British company, "Ilmor Engineering", whose engine I have presented, states that the increase in power of their engine is 20%. It is 5% more than the calculations presented here. This is due to the fact that in the head of their engine there

is no combustion chamber for the middle cylinder, and there is also one duct connecting the cylinders less. Therefore, the pressure drop of exhaust gases after connecting the cylinders is reduced accordingly, and the work so much greater.

The use of the multi-purpose internal combustion engine.

A multi-purpose internal combustion engine, in addition to being used in cars, trucks and agricultural tractors can also be used in excavators, loaders, and especially in machines that need high power in temporary operation and in continuous operation it is enough for them to have 60% of power.

The benefits of a multi-purpose internal combustion engine are:

- the possibility of quick acceleration of the vehicle, and then economical driving.
- lower fuel consumption and therefore lower emissions of exhaust gases.
- faster heating of the engine in an economical method of working, which increases its durability and contributes to a better operation.
- lower temperature of the exhaust gas flowing into the turbocharger during the economical method of the operation increases durability and reduces the aging of the oil.
- better heating of the vehicle interior despite low fuel consumption.
- economical driving downhill, with the wind and without a load.
- quieter engine work during the economical mode of operation.
- competitiveness in relation to other engines.

Patent Claims

1. A **multi-purpose internal combustion engine** having three or four cylinders in line, including its multiple engine, as B6, B8, V6, V8, R6 and R8, which is a four-stroke engine with or without a turbocharger, with a spark ignition or compression ignition, characterized in that it has the ability to turn off the operation of middle cylinders: 2 and 3 in the 4-cylinder engine, and the middle cylinder in a 3-cylinder engine and to convert them into 2-stroke auxiliary engine, driven alternately by the combustion exhaust gas pressure of the outer working cylinders.

2. Multi-purpose internal combustion engine according to claim 1, characterized in that it comprises ducts connecting the adjacent cylinders that are opened and closed by the valves in them during the efficient engine operation process.

3. Multi-purpose internal combustion engine according to claim 1, characterized in that the duct connecting cylinders 2 and 3 of the 4-cylinder engine has an additional auxiliary valve which, when open it becomes also the intake duct.

4. Multi-purpose internal combustion engine according to claim 1, characterized in that the outlet valves of the outer cylinders work alternately with valves in ducts connecting the outer cylinders with cylinders: 2 and 3 in the 4-cylinder engine and in a 3-cylinder engine alternately with the valves in ducts connecting with the middle cylinder.

5. Multi-purpose internal combustion engine according to claim 1, characterized in that in the 4-cylinder engine the outlet exhaust valves 2 and 3 of the cylinder as well as the valves in the duct that connects them and in a 3-cylinder engine only the outlet valves of the middle cylinder have dual, independent and alternately working control system which enables to convert these cylinders into a 2-stroke auxiliary engine driven alternately by combustion exhaust gas pressure of the working outer cylinders.

6. Multi-purpose internal combustion engine according to claim 1, characterized in that the intake valves of the middle cylinder in a 3-cylinder engine, and in a 4-cylinder engine only the intake valves of middle cylinders: 2 and 3 adjacent to the cylinders: 1 and 4, while using the efficient way of operating the engine, are closed or disabled from work.

7. Multi-purpose internal combustion engine according to claim 1, characterized in that the cams, controlling the valves in the ducts that connect outer cylinders with middle cylinders, indicated in Fig. 3, 4, 5 and 8 as - (1) or (1 = 90°) and those which control the exhaust valves in middle cylinders, and those in the duct that connects them, designated as - (2) or (2 x 90°) used only during the economical way of operating the engine, have an opening angle of the valves close or equal to, but not greater than, 90°.

8. Multi-purpose internal combustion engine according to claim 1, characterized in that the controller can disable the operation of two middle cylinders in a 4-cylinder engine, and the middle cylinder in a 3-cylinder engine, by switching off fuel injection in them, and in petrol engines also the ignition, as well as change, by appropriate actuators, the control of the intake and the outlet valves, and in a 4-cylinder engine also the auxiliary valve so that the engine can operate in a cost-effective manner and additionally expand exhaust gases in cylinders excluded from the operation and then in the turbocharger.

FIGURE 1

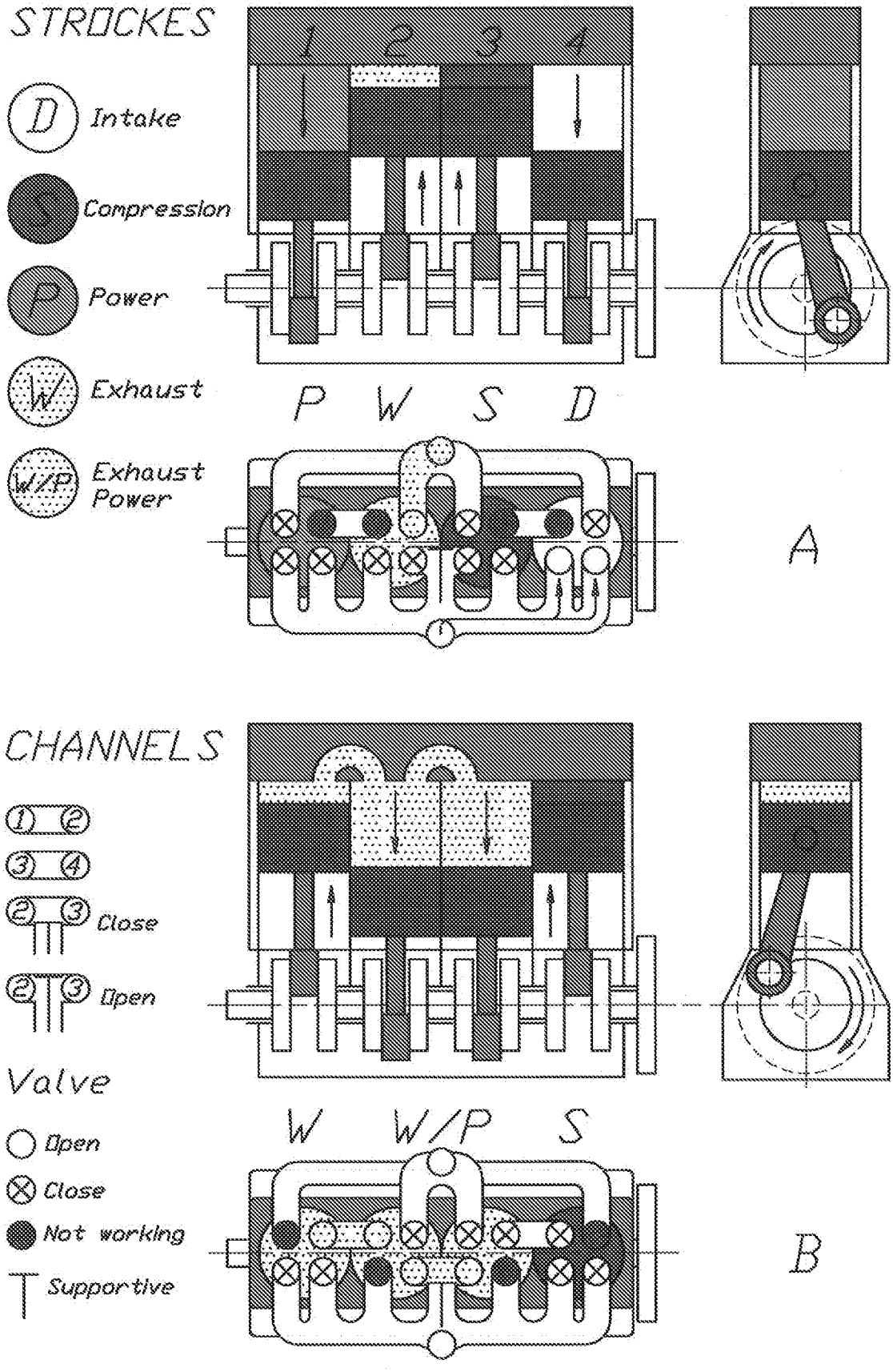
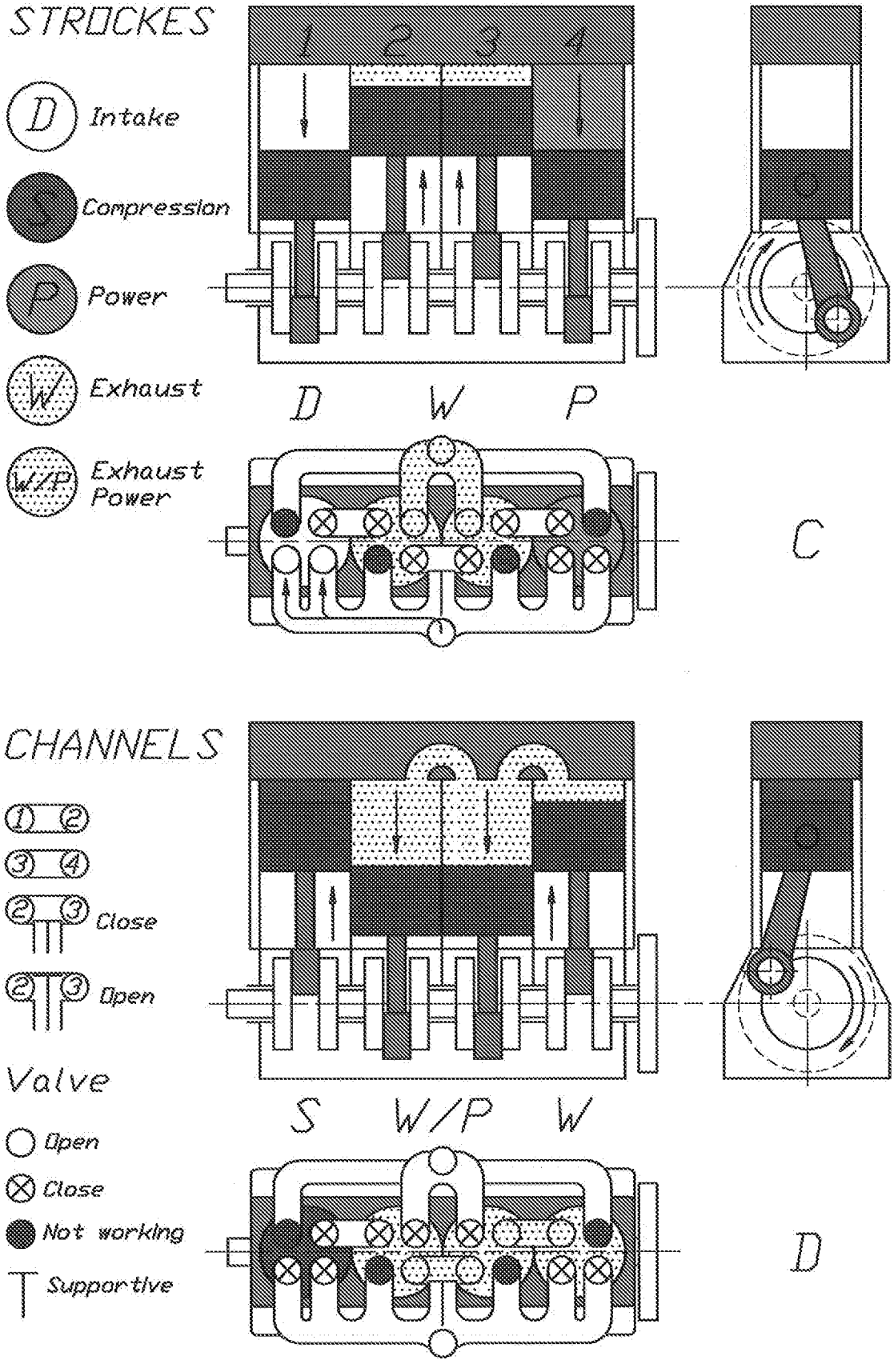

STROCKES
D Intake
S Compression
P Power
W Exhaust
W/P Exhaust Power
1 2 3 4
P W S D
A
CHANNELS
1 2
3 4
2 3 Close
2 3 Open
Valve
Open
Close
Not working
Supportive
W W/P S
B

FIGURE 2


STROCKES
D Intake
S Compression
P Power
W Exhaust
W/P Exhaust Power
1 2 3 4
D W P
C
CHANNELS
1 2
3 4
2 3 Close
2 3 Open
Valve
Open
Close
Not working
Supportive
S W/P W
D

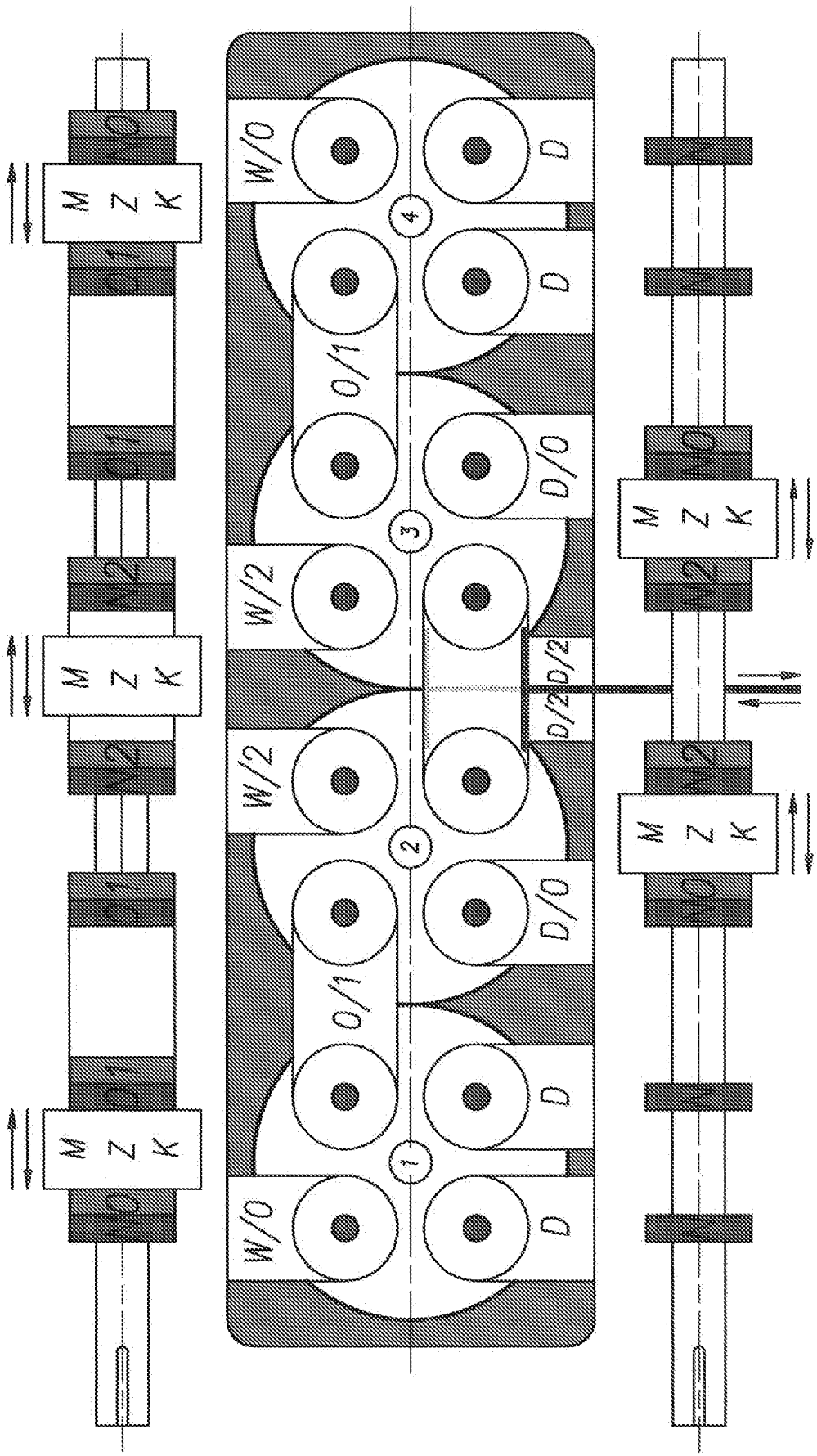
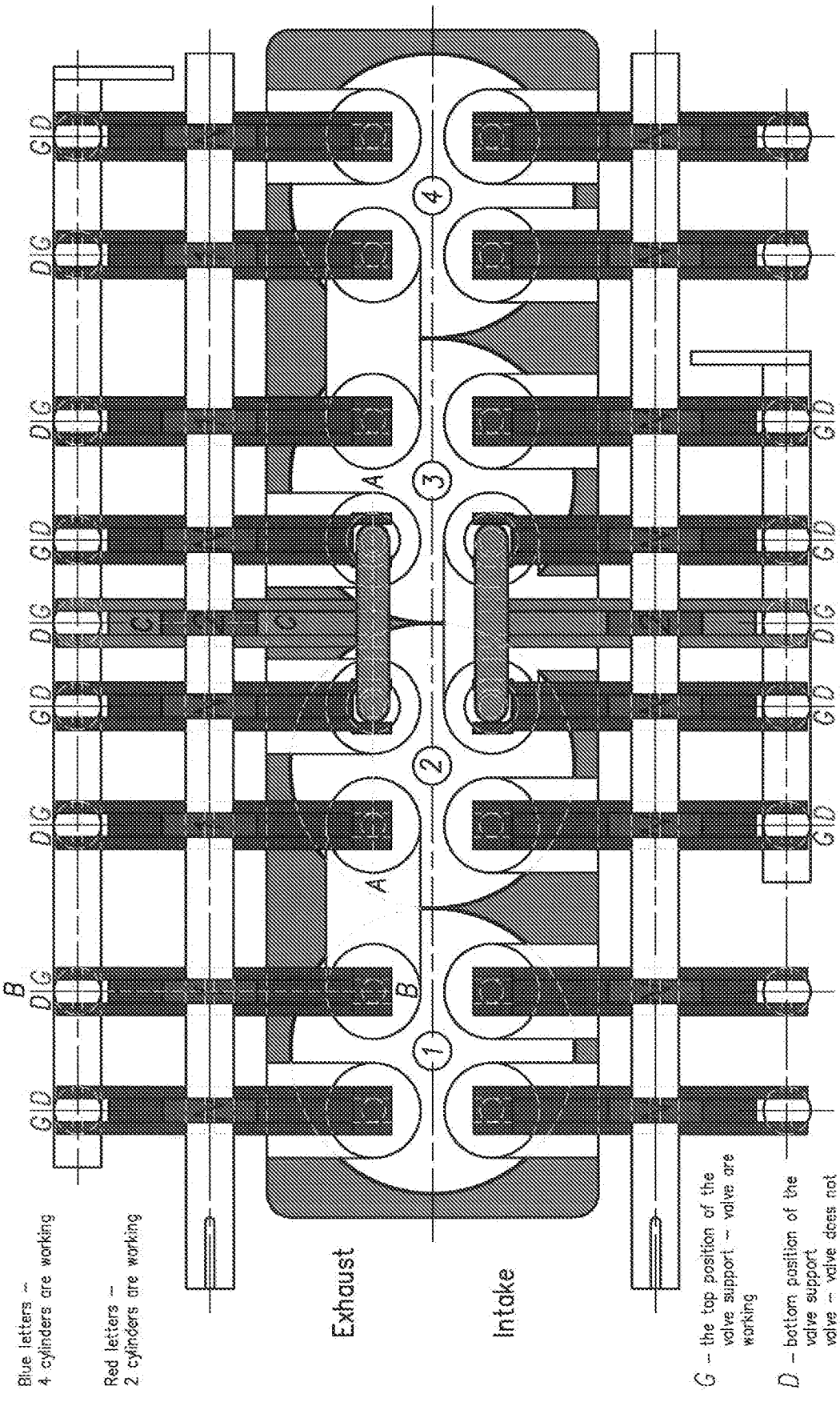


FIGURE 3

FIGURE 4


Blue letters –
4 cylinders are working
Red letters –
2 cylinders are working
Exhaust
Intake
G – the top position of the valve support – valve are working
D – bottom position of the valve support valve – valve does not work
GID
DIG
A
B
1
2
3
4

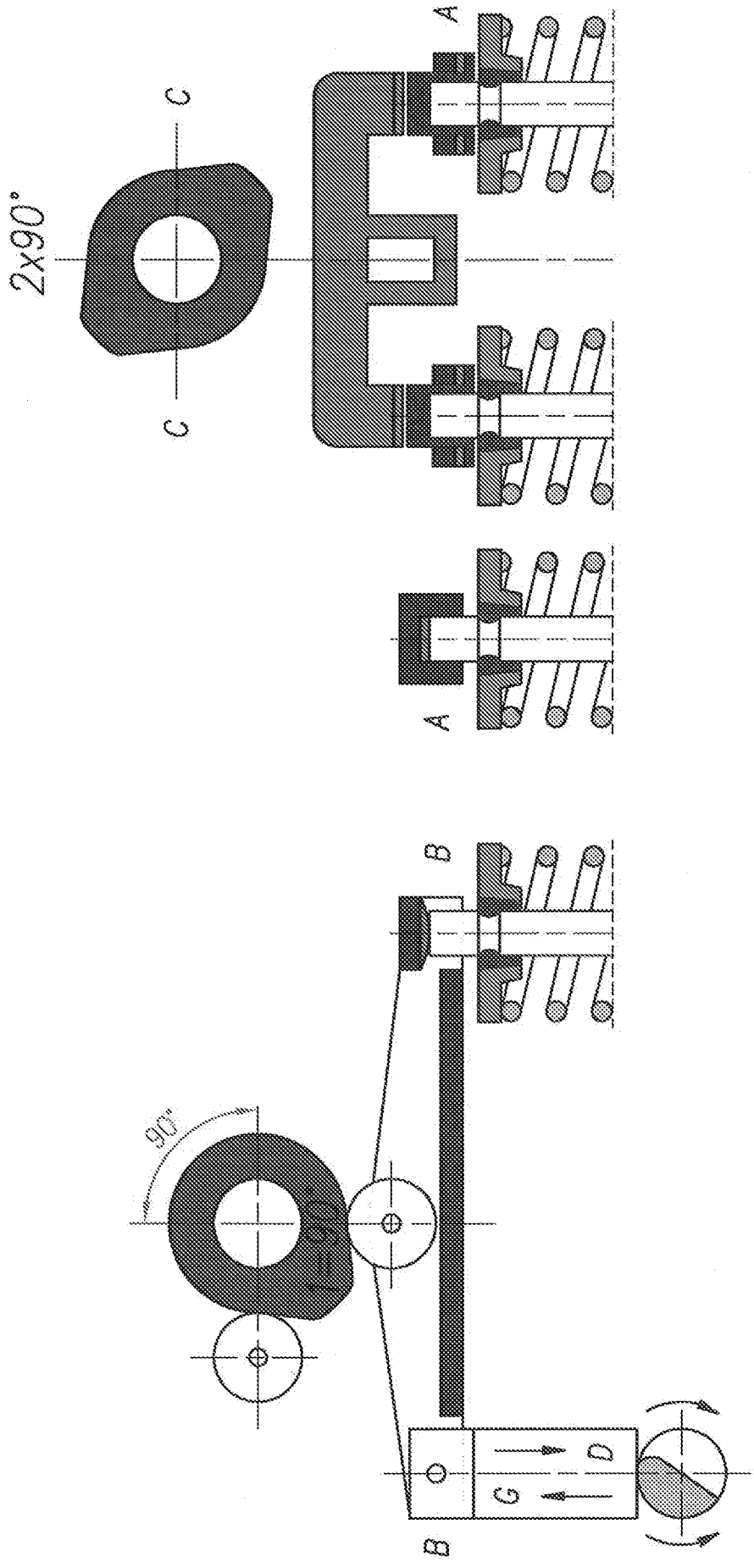


FIGURE 5

FIGURE 6

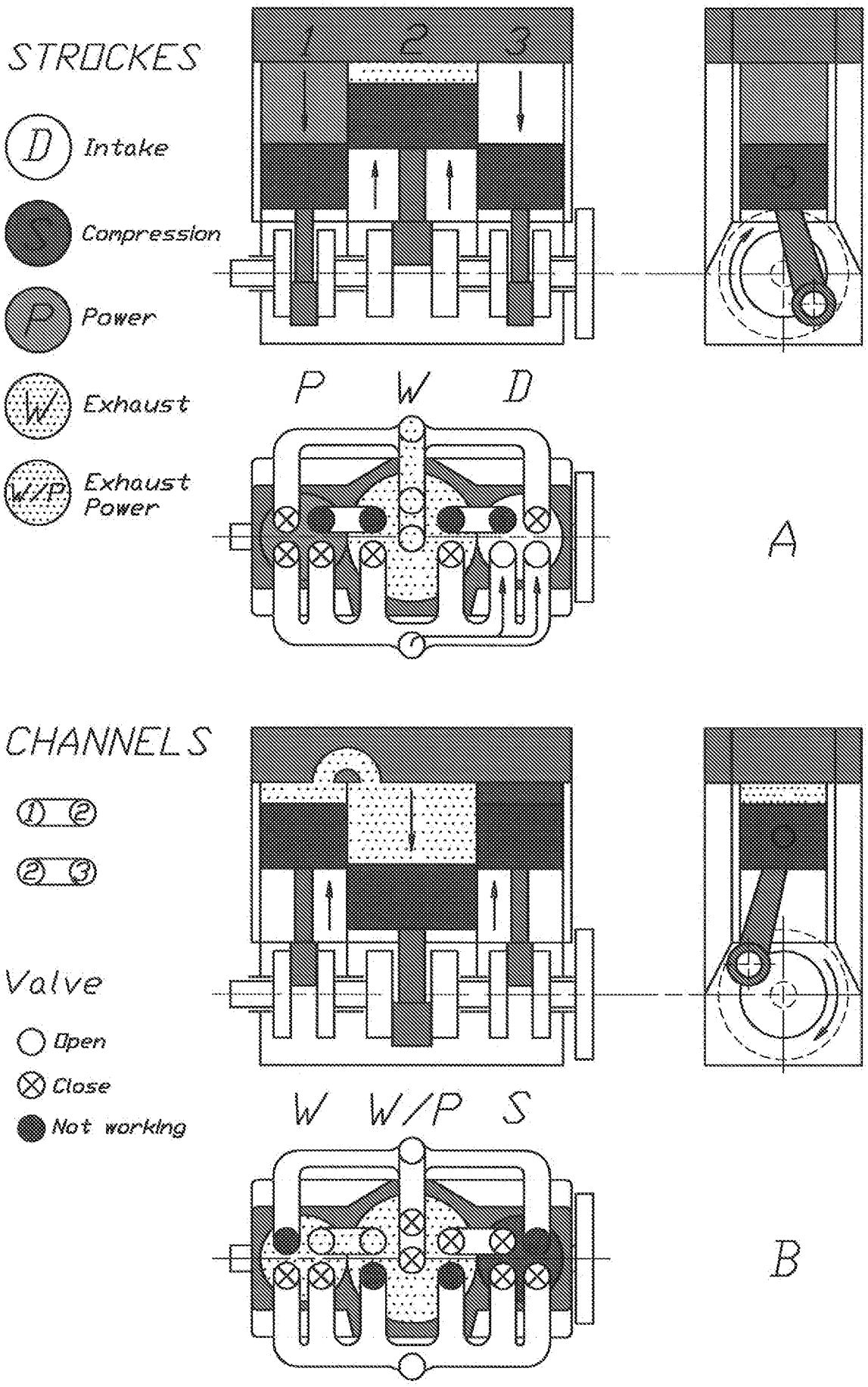

STROCKES
D Intake
Compression
P Power
W Exhaust
W/P Exhaust Power
1 2 3
P W D
A
CHANNELS
1 2
2 3
Valve
Open
Close
Not working
W W/P S
B

FIGURE 7

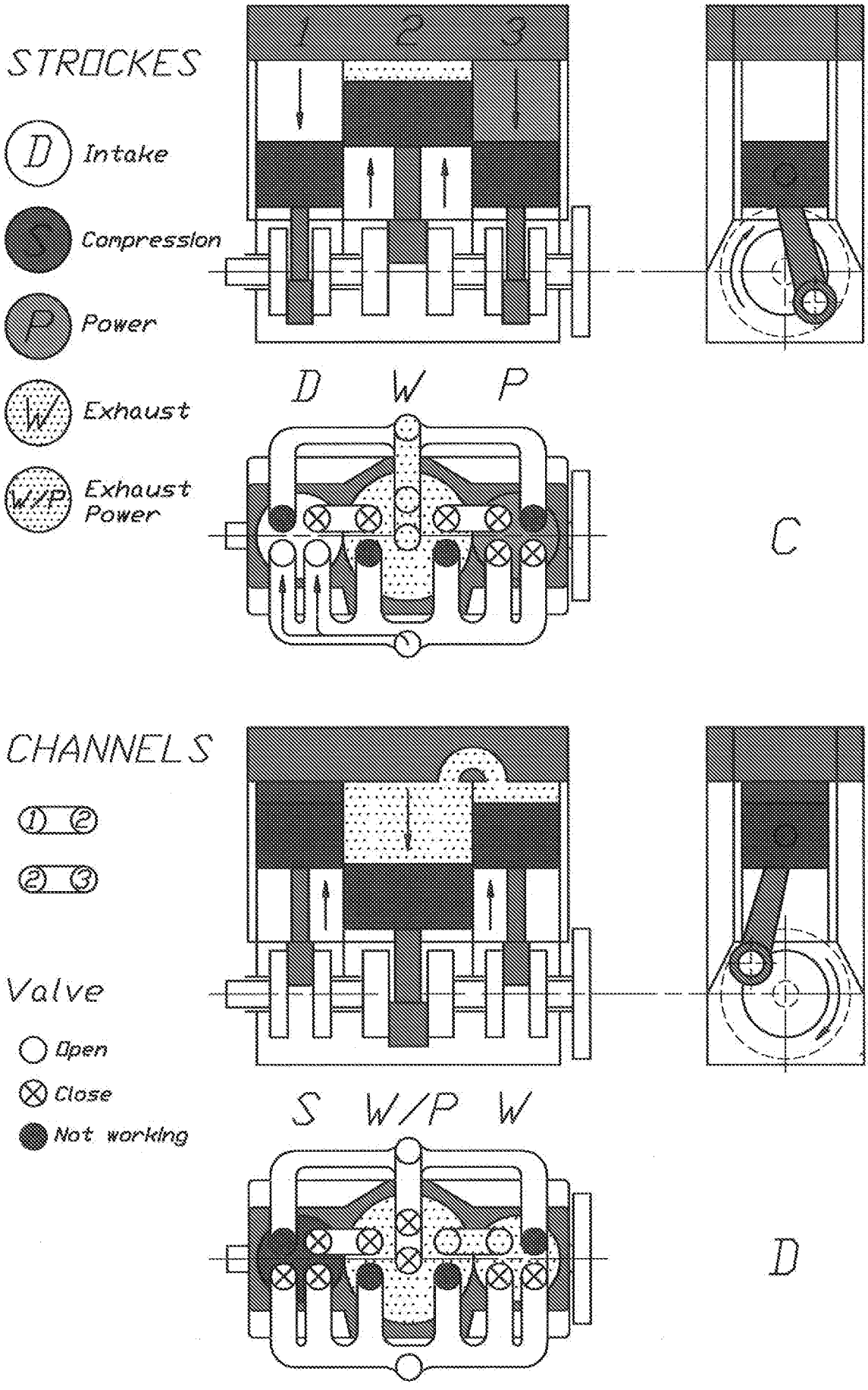
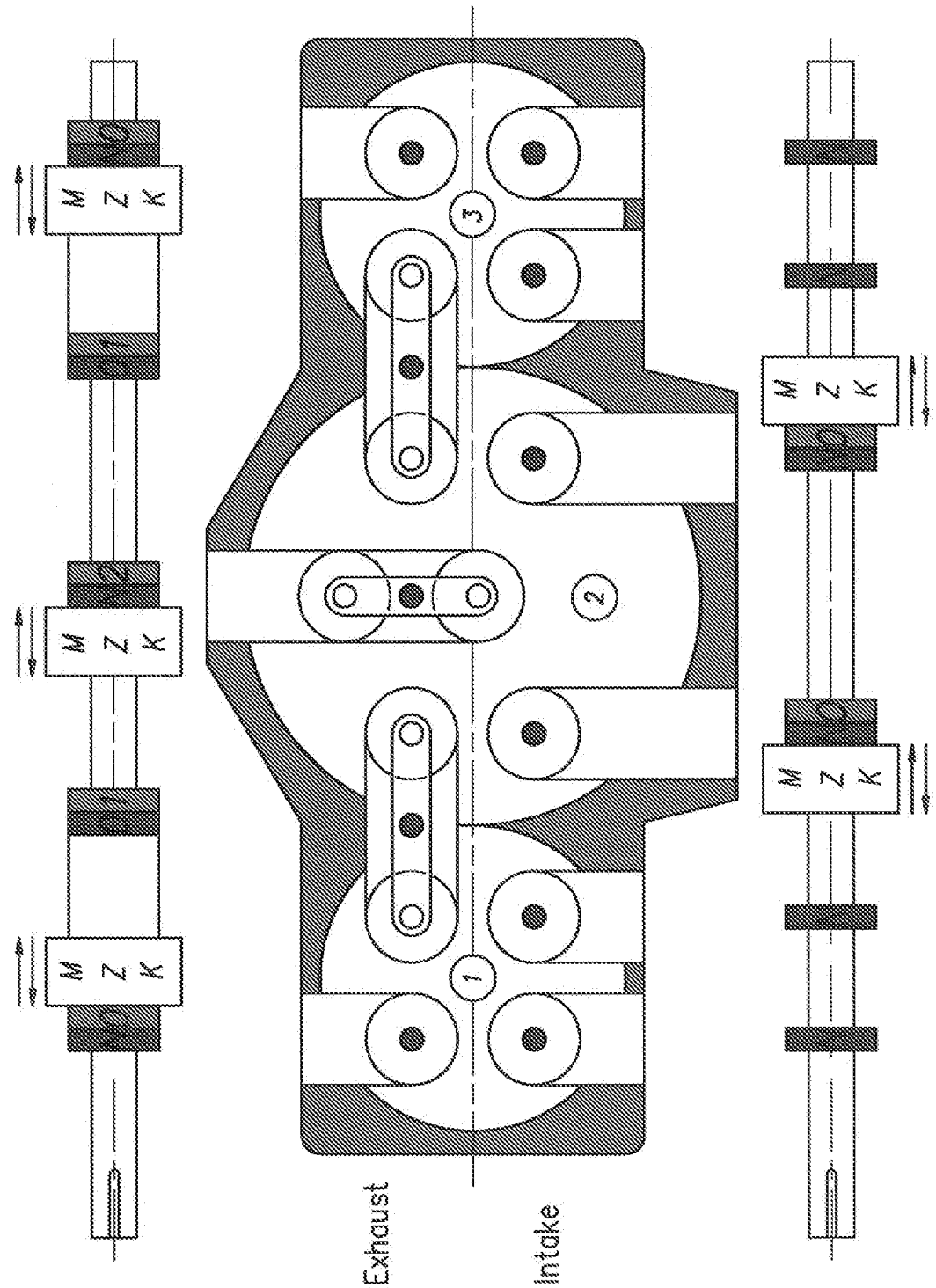

STROCKES
D Intake
S Compression
P Power
W Exhaust
W/P Exhaust Power
1 2 3
D W P
C
CHANNELS
1 2
2 3
Valve
Open
Close
Not working
S W/P W
D

FIGURE 8



INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2016/000076

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02B41/06 F02D13/02
ADD. F01L13/00

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 F02D F01L

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	US 2009/301086 A1 (RALSTON MARK DIXON [US]) 10 December 2009 (2009-12-10) paragraphs [0013], [0015] - [0018], [0080], [0081], [0085], [0086], [0089]; figures 1,8,10	1-8
X	DE 10 2012 206372 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 24 October 2013 (2013-10-24) paragraphs [0010], [0011], [0014], [0017] - [0020]; figures 1,5a-d	1-8
A	US 2011/303202 A1 (MOSER STEFAN [DE] ET AL) 15 December 2011 (2011-12-15) paragraph [0019] - paragraph [0020]; figures 5,6	1-8

-/--

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

[X] See patent family annex.

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

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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
22 November 2016	05/12/2016

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	Tietje, Kai

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INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2016/000076

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X,P	DE 20 2015 004589 U1 (KLAUSS TOBIAS [DE]; NEUMAIR MAXIMILIAN [DE]; QUECK NILS OLE [DE]) 3 September 2015 (2015-09-03) paragraph [0005] - paragraph [0006]; figures 1,2	1-8

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/PL2016/000076

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		DE 102012206372 A1	24-10-2013
		EP 2839131 A1	25-02-2015
		US 2015027116 A1	29-01-2015
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US 6318310 B1	20-11-2001	NONE	
DE 202015004589 U1	03-09-2015	NONE	