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(71) Applicant *(for all designated States except US)*: **INTERNATIONAL ENGINE INTELLECTUAL PROPERTY COMPANY, LLC** [US/US]; 4201 Winfield Road, Warrenville, Illinois 60555 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **BARTKOWICZ, Michael D.** [US/US]; 307 Greenwood Pl, Oswego, Illinois 60543 (US). **CATTANI, Luis Carlos** [US/US]; 1163 Shoreline Drive, Aurora, Illinois 60504 (US). **GRAVANTE, Steve** [US/US]; 2639 Sunnyside Ave., Westchester, IL 60154 (US). **XIN, Qianfan** [CN/US]; 739 Foxmoor Lane, Lake Zurich, Illinois 60047 (US). **ZIELKE, Martin R.** [US/US]; 14203 S. King Road, Lockport, Illinois 60441 (US).

(74) Agent: **NIMZ, Jack D.**; 4201 Winfield Road, Warrenville, Illinois 60555 (US).

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(54) Title: ENGINE BRAKE USING BRAKE VALVE AND PARTIAL ADMISSION FLOW TURBINE TURBOCHARGER

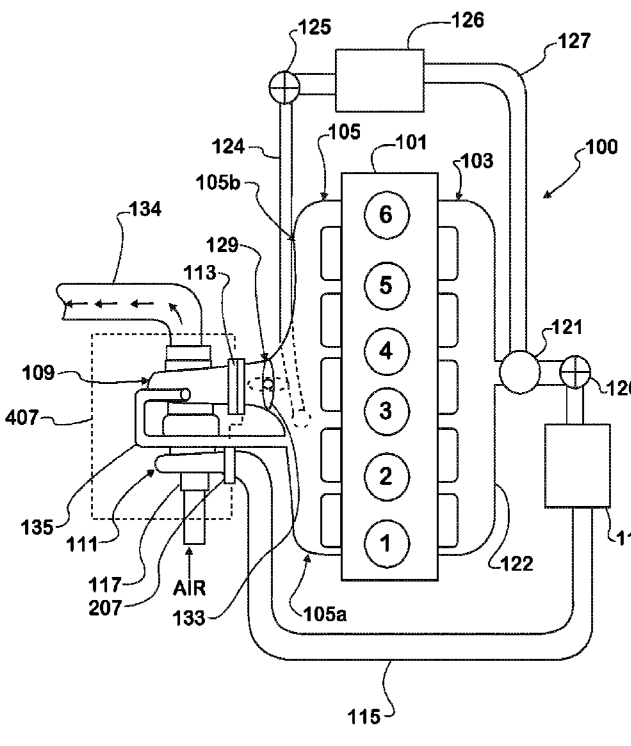


FIG. 1

(57) Abstract: An engine braking system includes a butterfly valve located in the exhaust system upstream of a partial admission engine turbocharger. A bypass exhaust gas passage is used to supply exhaust gas to the turbine when the flap valve is in the closed position. By using a backpressure butterfly valve located upstream of the turbocharger, the valve can be closed completely to generate high levels of backpressure. By using the external bypass exhaust gas supply to the turbine housing, the turbine continues to spin, the engine mass flow is not choked off, and improved brake performance will result.

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**(84) Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17**:

— *as to the identity of the inventor (Rule 4.17(i))*

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

**Published**:

— *with international search report (Art. 21(3))*

# ENGINE BRAKE USING BRAKE VALVE AND PARTIAL ADMISSION FLOW TURBINE TURBOCHARGER

## FIELD OF THE INVENTION

[0001] This invention relates to internal combustion engines, including but not limited to control and operation of a turbocharger, EGR system and engine braking for an internal combustion engine.

## BACKGROUND OF THE INVENTION

[0002] Adequate and reliable braking for vehicles, particularly large tractor-trailer vehicles, is desirable. While drum or disc wheel brakes are capable of absorbing a large amount of energy over a short period of time, the absorbed energy is transformed into heat in the braking mechanism. An engine braking system can be used to assist in braking the vehicle.

[0003] Multi-cylinder internal combustion engines, particularly diesel engines for large tractor-trailer trucks, may include an exhaust-gas turbocharger. The turbocharger includes a turbine that drives a compressor via a shaft, which generates an increased intake air pressure in the intake duct during normal operation.

[0004] Braking systems are known which include exhaust brakes which inhibit the flow of exhaust gases through the exhaust system, and compression release systems wherein the energy required to compress the intake air during the compression stroke of the engine is dissipated by exhausting the compressed air through the exhaust system.

[0006] One method disclosed in U.S. Patent No. 4,395,884 includes employing a turbocharged engine equipped with a double entry turbine and a compression release engine retarder in combination with a diverter valve. During engine braking, the diverter valve directs the flow of gas through one scroll of the divided volute of the turbine. When engine braking is employed, the turbine speed is maximized, and the inlet manifold pressure is also maximized, thereby maximizing braking horsepower developed by the engine.

[0007] Other methods employ a variable geometry turbocharger (VGT). When engine braking is commanded, the variable geometry turbocharger is “clamped down” which means the turbine vanes are closed and used to generate both high exhaust manifold pressure and high turbine speeds, resulting in high compressor speeds. Increasing the turbocharger speed in turn increases the engine airflow and available engine brake power. The method disclosed in U.S. Patent No. 6,594,996 includes controlling the geometry of the turbocharger for engine braking as a function of engine speed and pressure (exhaust or intake, preferably exhaust). U.S. Patent 6,148,793 describes a brake control for an engine having a variable geometry turbocharger which is controllable to vary intake manifold pressure. The engine is operable in a braking mode using a turbocharger geometry actuator for varying turbocharger geometry, and using an exhaust valve actuator for opening an exhaust valve of the engine.

[0008] Other methods of using turbochargers for engine braking are disclosed in U.S. Patent Nos. 6,223,534 and 4,474,006.

[0009] Engine brakes require exhaust backpressure to create a pumping loss and develop retarding power. Some braking systems close a butterfly flap valve in the exhaust outlet housing downstream of the turbochargers to create the backpressure. However, with the valve in this location, mass air flow through the turbochargers can be choked off during high backpressure conditions and results in a loss of compressed air into the cylinders because the compressor wheel does not spin effectively.

[0010] In order to achieve a high engine-braking action a brake valve in the exhaust line upstream of the turbine may be closed during braking, and excess pressure is built up in the exhaust line upstream of the brake valve. The built-up exhaust gas flows at high velocity into the turbine and acts on the turbine rotor, whereupon the driven compressor increases pressure in the air intake duct. The cylinders are subjected to an increased charging pressure. In the exhaust system, an excess pressure develops between the cylinder outlet and the brake valve and counteracts the discharge of the air compressed in the cylinder into the exhaust tract via the exhaust valves. During braking, the piston performs compression work against the high excess pressure in the exhaust tract, with the result that a strong braking action is achieved. Patents which disclose valves upstream of the turbine include US 7,523,736 and US 4,395,884.

## SUMMARY OF THE INVENTION

[0011] According to an exemplary embodiment of the present invention, a valve, such as a butterfly valve or a flap valve, is located in the exhaust system upstream of a partial admission flow turbine of the engine turbocharger. An external bypass exhaust gas passage is used to supply exhaust gas to the turbine when the valve is in the completely closed position or a parlt closed position between open and completely closed.

[0012] According to another aspect, on turbochargers having non-divided turbine housings, one (1) bypass exhaust gas passage would be used. For divided turbine housings, two (2) bypass exhaust gas passages would be used with separate and distinct flow circuits.

[0013] By using a valve upstream of the turbocharger turbine, the valve can be closed completely, or partly closed, to generate high levels of backpressure. By using the bypass exhaust gas supply to the turbine housing, the turbine and compressor continue to spin, the engine mass flow is not choked off and improved engine brake performance will result.

[0014] Numerous other advantages and features of the present invention will be become readily apparent from the following detailed description of the invention and the embodiments thereof, from the claims and from the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 is a schematic diagram of an engine system that includes a turbocharger and an engine braking system in accordance with an exemplary embodiment of the invention;

[0016] FIG. 2 is an elevation view of a turbocharger system incorporating the braking system of Figure 1;

[0017] FIG. 3 is a right side view of the turbocharger system shown in Figure 2;

[0018] FIG. 4 is a sectional view of the turbocharger system taken generally along line 4-4 of Figure 2;

[0019] FIG. 5 is a fragmentary sectional view of the turbocharger system taken generally along line 5-5 of Figure 2 with portions removed for simplicity of explanation;

[0020] FIG. 6 is a fragmentary sectional view of the turbocharger system taken generally along line 6-6 of Figure 3 with portions removed for simplicity of explanation;
[0021] FIG. 7 is a fragmentary sectional view of the turbocharger system taken generally along line 6-6 of Figure 3 with portions removed for simplicity of explanation;
[0022]FIG. 8 is a fragmentary sectional view of the turbocharger system taken generally along line 8-8 of Figure 2 with portions removed for simplicity of explanation; and
[0023] FIG. 9 is a schematic diagram of an engine system that includes a turbocharger and an engine braking system in accordance with an alternate embodiment of the invention.

## DETAILED DESCRIPTION

[0024]While this invention is susceptible of embodiment in many different forms, there are shown in the drawings, and will be described herein in detail, specific embodiments thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.
[0025]An engine 100 is shown schematically in FIG. 1. The engine 100 has a block 101 that includes a plurality of cylinders. The cylinders in the block 101 are fluidly connected to an intake system 103 and to an exhaust system 105. The exhaust system includes a first pipe 105a from cylinders 1, 2 and 3 of one bank of cylinders and a second pipe 105b from cylinders 4, 5 and 6. Although an inline arrangement of six cylinders is illustrated, inline or V- arrangements or other arrangements of plural cylinders of any number of cylinders are also encompassed by the invention.
[0026] A turbocharger 107 includes a turbine 109. The turbine 109 shown has a single turbine inlet port 113 connected to the exhaust system 105. The turbocharger 107 includes a compressor 111 connected to the intake system 103 through an inlet air passage 115.
[0027] During operation of the engine 100, air may enter the compressor 111 through an air inlet 117. Compressed air may exit the compressor 111 through an outlet 207 (described below), pass through the inlet air passage 115, and pass through an optional charge air cooler 119 and an optional inlet throttle 120 before entering an intake air mixer

121 and an intake air manifold 122 of the intake system 103. The compressed air enters the engine cylinders 1-6.

[0028] A stream of exhaust gas from the exhaust system 105 may be routed through an EGR passage or conduit 124, through an exhaust gas recirculation (EGR) valve 125, through an exhaust gas recirculation (EGR) cooler 126 and pass through a further EGR conduit 127 before meeting and mixing with air from the inlet throttle 120 at the mixer 121.

[0029] The inlet port 113 of the turbine 109 may be connected to the exhaust pipes 105a, 105b in a manner that forms a distribution manifold 129 (Figure 4). Exhaust gas passing through the turbine 109 may exit the engine 100 through a tailpipe 134. Emissions and sound treating components can be arranged to receive the exhaust gas from the tailpipe, before exhausting to atmosphere, as is known.

[0030] At times when the EGR valve 125 is at least partially open, exhaust gas flows through the first pipe 105a, through the conduit 124, through the EGR valve 125, through the EGR cooler 126, through the further conduit 127 and into the mixer 121 where it mixes with air from the inlet throttle 120. An amount of exhaust gas being re-circulated through the EGR valve 125 may depend on a controlled opening percentage of the EGR valve 125.

[0031] A brake valve 133 is arranged within the distribution manifold 129. The brake valve is operable between a closed position, shown solid in Figure 1, or a partly closed position (not shown) during an engine braking operation, and an open position, shown dashed in Figure 1, or a partly open position (not shown) during a normally operating, non-engine braking operation. An external bypass conduit 135 is connected between the first pipe 105a and the turbine 109. The external bypass conduit 135 can be sized such that it is always open, i.e., has no valve element as shown, or a controllable valve could be located along the bypass conduit 135. The valve can be a butterfly valve, a flap valve or other type valve.

[0032] During engine braking, the valve 133 is completely closed, or partly closed, to generate an increased backpressure due to the restricted flow area of the bypass conduit. The valve can be a proportional control valve. The degree of the valve being closed can be optimized by the engine control. The exhaust gas passing through the bypass conduit

135 maintains the turbine speed at a high speed to maintain a high volume of compressed air from the compressor 111 into the intake system 103. A more complete description of engine braking can be found in U.S. Patent Nos. 6,594,996; 6,223,534; 6,148,793; 4,474,006 and 4,395,884; all herein incorporated by reference.

[0033] Figures 2-5 illustrate an exemplary embodiment of the system described in Figure 1. The compressor and turbine wheels, bearings, seals and other associated hardware are removed from Figure 4 for simplicity of description. The particular designs of turbocharger internal components can be derived from US Patents 6,715,288; 6,709,160; 6,925,805; 6,089,019; 4,389,845 all herein incorporated by reference to the extent that these disclosures are not inconsistent with the teachings of the present invention.

[0034] The compressor 111 includes a housing 201 having an axial inlet nozzle 203 and the tangential discharge nozzle 207.

[0035] Figure 5 illustrates the turbine 109 includes a turbine housing 215 defining an internal scroll or volute 215a, and having an axial discharge nozzle 216, a first tangential inlet nozzle 218 that forms the inlet 113, and a second tangential inlet nozzle 220. The turbine wheel is not shown for clarity of description. The nozzle 218 conducts gas along the direction V1. The nozzle 220 conducts gas along the direction V2. The angle A between V1 and V2 is greater than 180 degrees and preferably is about 240 degrees. The angle B between the intersection 220a of the nozzle 220 and the volute 215a and the intersection 218a of the nozzle 218 and the volute 215a is greater than 180 degrees and preferably about 200 degrees. The nozzle 220 is arranged to direct the gas flow into the volute tangentially to the turbine wheel therein. Advantageously, the cross section of the nozzle 220 is about equal to the cross section flow area within the volute at the intersection of the nozzle 220 and the volute 215a.

[0036] The bypass conduit 135 is connected to the pipe 105a by a flanged nozzle 236 and is connected to the turbine housing 215 by connection to the nozzle 220. As shown in Figure 5, the nozzle 220 is connected to the turbine housing 215 in a manner that conducts the exhaust gas at high speed in a substantially tangential fashion to the volute 215a within the housing 215.

[0037] The turbine shown is considered a partial admission turbine because the flow through the nozzle 220 does not circumscribe the entire 360 degrees of the scroll. In the illustrated embodiment, the flow through the nozzle 220 circumscribes about 160 degrees.

[0038] As shown in Figures 4 and 6-8, the valve 133 includes a butterfly valve element 246 that is pivotal with respect to the manifold 129 on a shaft 248. The shaft 248 penetrates the manifold 129 through a top thereof and is sealed within the penetration. A crank 252 is fixed to a top of the shaft 248 at a base end 254 of the crank 252 and is pivotally connected at a distal end 256 to a linear actuator 260. The actuator 260 can be an electric solenoid powered actuator for reciprocal movement of an actuator arm 262 into, and out of, an actuator body 264. A distal end 256 of the crank is connected to a ball joint or pivotal joint 266 of the arm 262. The actuator 260 is pivotally connected at a base end 268 thereof to a support plate 272 mounted on the manifold 129. The pivotal connection of the actuator 260 allows a small degree of pivoting of the actuator 260 as the arm 262 is moved into, or out of, the body 264. As the arm 262 moves with respect to the body 264 the crank 252 is turned and the valve element 246 opens or closes.

[0039] As alternatives to an electrical solenoid powered actuator, a pneumatic cylinder actuator, a hydraulic oil powered actuator, other types of electrical powered actuators, or other known actuators are possible.

[0040] Figure 9 illustrates an alternate embodiment wherein an alternate turbocharger 407 utilizes an alternate turbine 409 that incorporates a divided turbine housing. According to this embodiment separate external exhaust bypass conduits 135, 435 are utilized for each divided section of the turbine.

[0041] In addition to closing the valve 133, one or more exhaust valves of the engine can be opened, as described in U.S. Patents 6,594,996; 6,148,793; 6,779,506; 6,772,742 or 6,705,282, herein incorporated by reference, to maximizing braking horsepower developed by the engine.

[0042] Parts List

100 engine

101 block

103 intake system

105 exhaust system

105a first exhaust pipe

105b second exhaust pipe
107 turbocharger
109 turbine
111 compressor
115 inlet air passage
119 optional charge air cooler
120 optional inlet throttle
121 inlet air mixer
122 intake manifold
124 EGR conduit
125 EGR valve
126 cooler
127 further conduit
129 distribution manifold
133 brake valve
134 tailpipe
135 external exhaust gas bypass conduit
201 compressor housing
203 axial inlet nozzle
207 tangential discharge nozzle
215 turbine housing
215a internal volute or scroll
216 axial discharge nozzle
218 first tangential inlet nozzle
218a intersection of nozzle 218 and volute 215a
220 second tangential inlet nozzle
220a intersection of nozzle 220 and volute 215a
236 flanged nozzle
246 butterfly valve element
248 valve element shaft
252 crank

254 base end of crank

256 distal end of crank

260 linear actuator

262 actuator arm

264 actuator body

266 pivotal joint

268 base end of body 264

272 support plate

407 alternate turbocharger

409 alternate turbine

435 second external exhaust gas bypass conduit

240 first exhaust gas portion

242 EGR exhaust gas

246 second exhaust gas portion

300 central valve

304 base

306 valve seat

310 rotatable butterfly-type valve element

314 axle

[0043]From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred.

**The Invention Claimed Is:**

1. An engine braking system, comprising:

a turbocharger having a turbine and a compressor, the turbine having a turbine housing with a first inlet, a second inlet and an outlet, the turbine operatively connected to the compressor to spin a compressor wheel within the compressor to pressurize intake air into the engine;

a brake valve having an open and a closed position;

an exhaust manifold receiving exhaust gas from the engine and having a first outlet flow connected to the first inlet of the turbine through the brake valve, and a second outlet flow connected by an external bypass conduit to the second inlet, bypassing the brake valve.

2. The engine braking system according to claim 1, wherein the exhaust manifold comprises a distribution manifold that conducts exhaust gas from the engine to the turbine, from the engine to an EGR valve, and from the engine to the bypass conduit that is flow-connected between the second outlet and the second inlet.

3. The engine braking system according to claim 1, wherein the turbine comprises a undivided turbine housing.

4. The engine braking system according to claim 1, wherein the turbine comprises a divided housing turbine having two volutes and further comprising a second bypass conduit, the bypass conduit and the second bypass conduit are arranged to be connected between the exhaust manifold and to a respective one of the volutes.

5. The engine braking system according to claim 1, wherein the brake valve comprises a butterfly valve rotatable between two positions corresponding to the open and closed positions.

6. An exhaust and air intake system for an engine, comprising:

a first exhaust pipe channeling a first portion of exhaust gas generated by the engine, having a first outlet and a second exhaust pipe channeling a second portion of the exhaust gas generated by the engine, having a second outlet;
an air intake system including an air compressor, an air inlet to the air compressor, and a compressed air intake manifold flow connected to the air compressor;
a turbine driving the air compressor, the turbine having a housing defining a volute with a first inlet for flow-connecting the first and second outlets of the first and second pipes respectively to the volute, and a second inlet arranged angularly offset from the first inlet;
at least one brake valve arranged in a first mode of operation, to open exhaust gas flow from the first pipe and the second pipe to the turbine inlet, and in a second mode of operation, to close exhaust gas flow from the first pipe and the second pipe to the turbine inlet; and
at least one external bypass conduit flow connecting one of the first pipe or the second pipe to the second inlet..

7. The exhaust and air intake system according to claim 6, wherein the first inlet and the second inlet are offset by an angle of greater than 180 degrees.

8. The exhaust and air intake system according to claim 6, wherein the first inlet and the second inlet are offset by an angle of about 200 degrees.

9. The exhaust and air intake system according to claim 6, first inlet is provided by a first inlet nozzle and the second inlet is provided by a second inlet nozzle and the first and second inlet nozzles conduct gas in a substantially tangential direction to the volute.

10. The exhaust and air intake system according to claim 6, wherein the first and second inlet nozzles conduct gas at directions that are directed at greater than 180 degrees apart.

11. The exhaust and air intake system according to claim 10, wherein the first and second inlet nozzles conduct gas at directions that are directed at about 240 degrees apart.

12. The exhaust and air intake system according to claim 6, wherein the brake valve comprises one butterfly valve that is alternately movable to open both the first pipe and the second pipe or close both the first pipe and the second pipe.

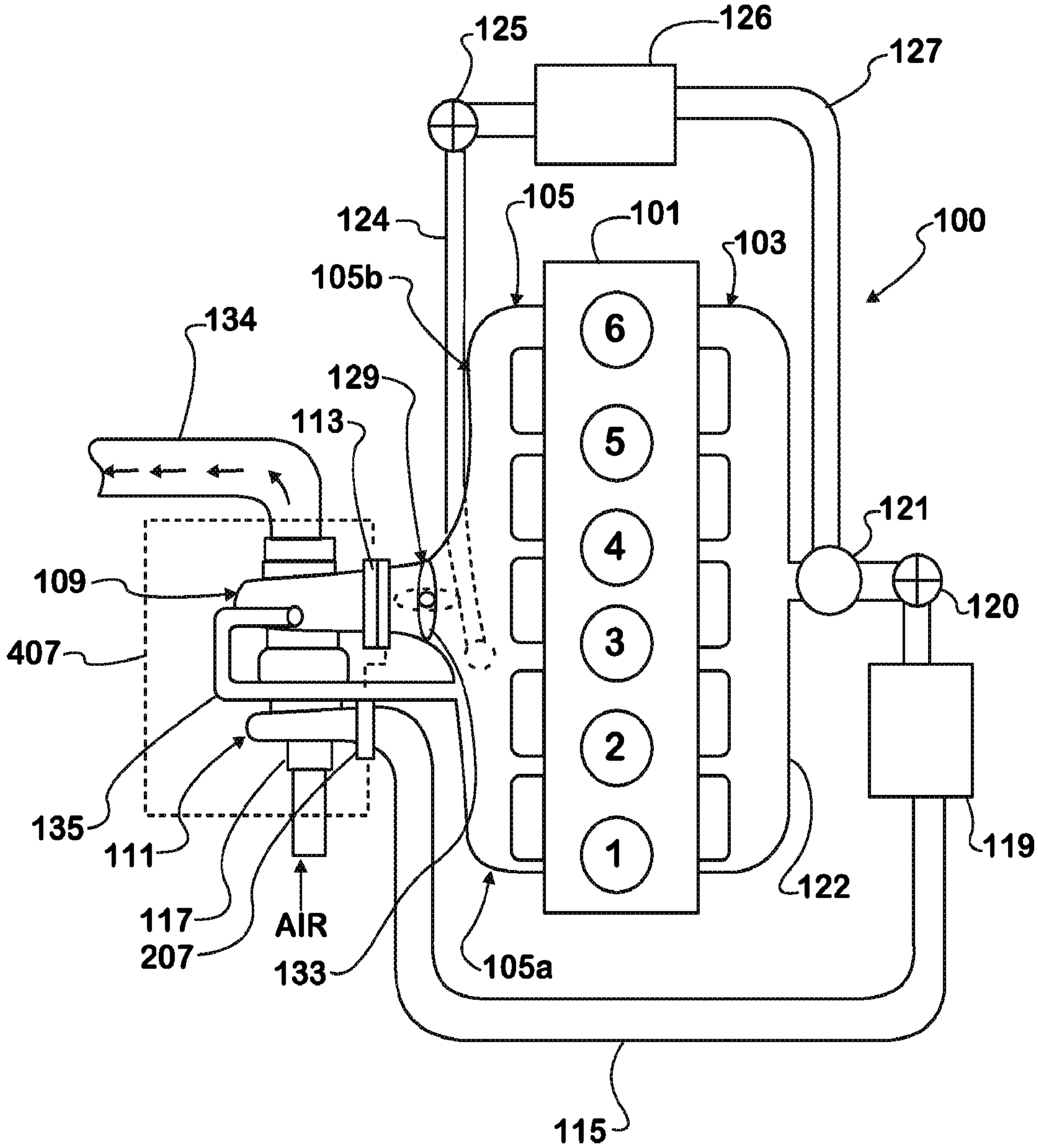
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FIG. 1

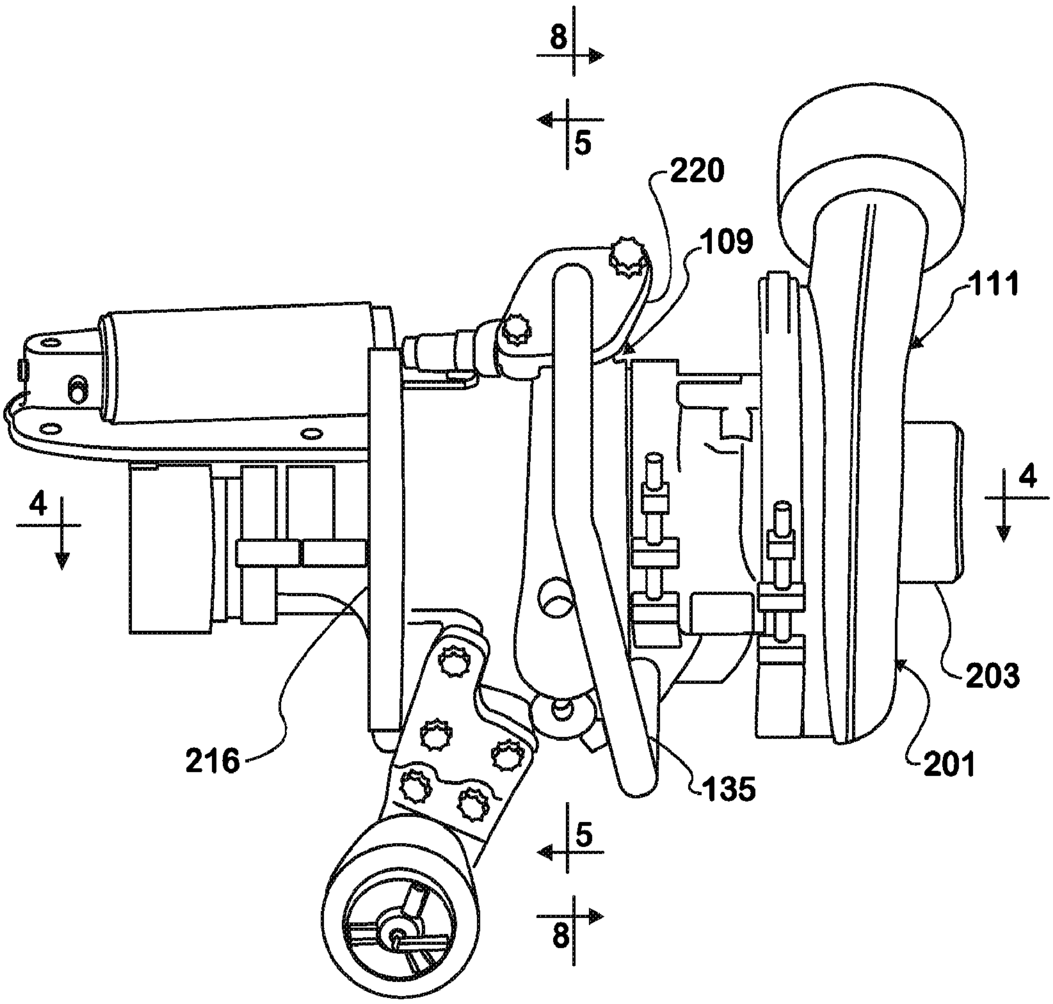


FIG. 2

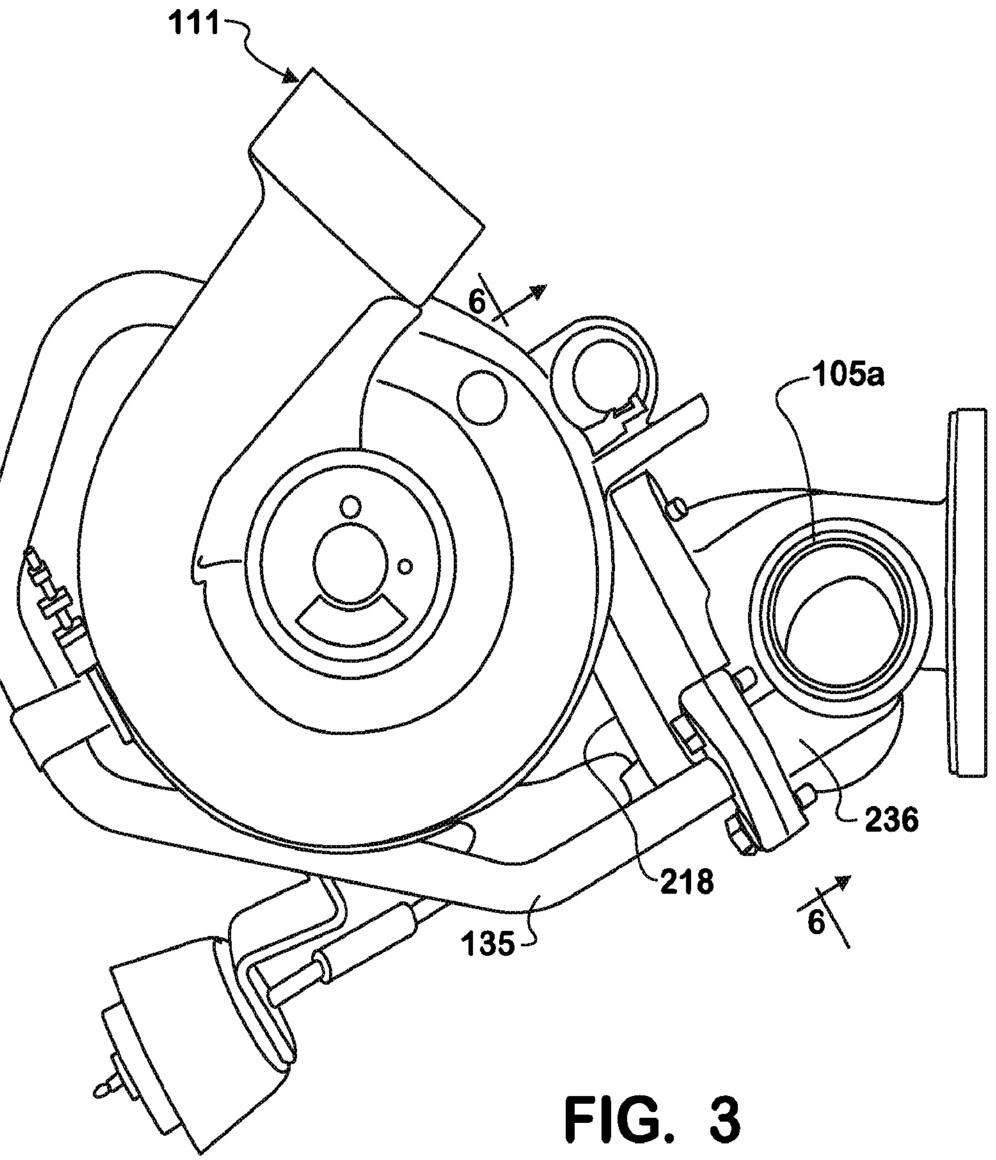


FIG. 3

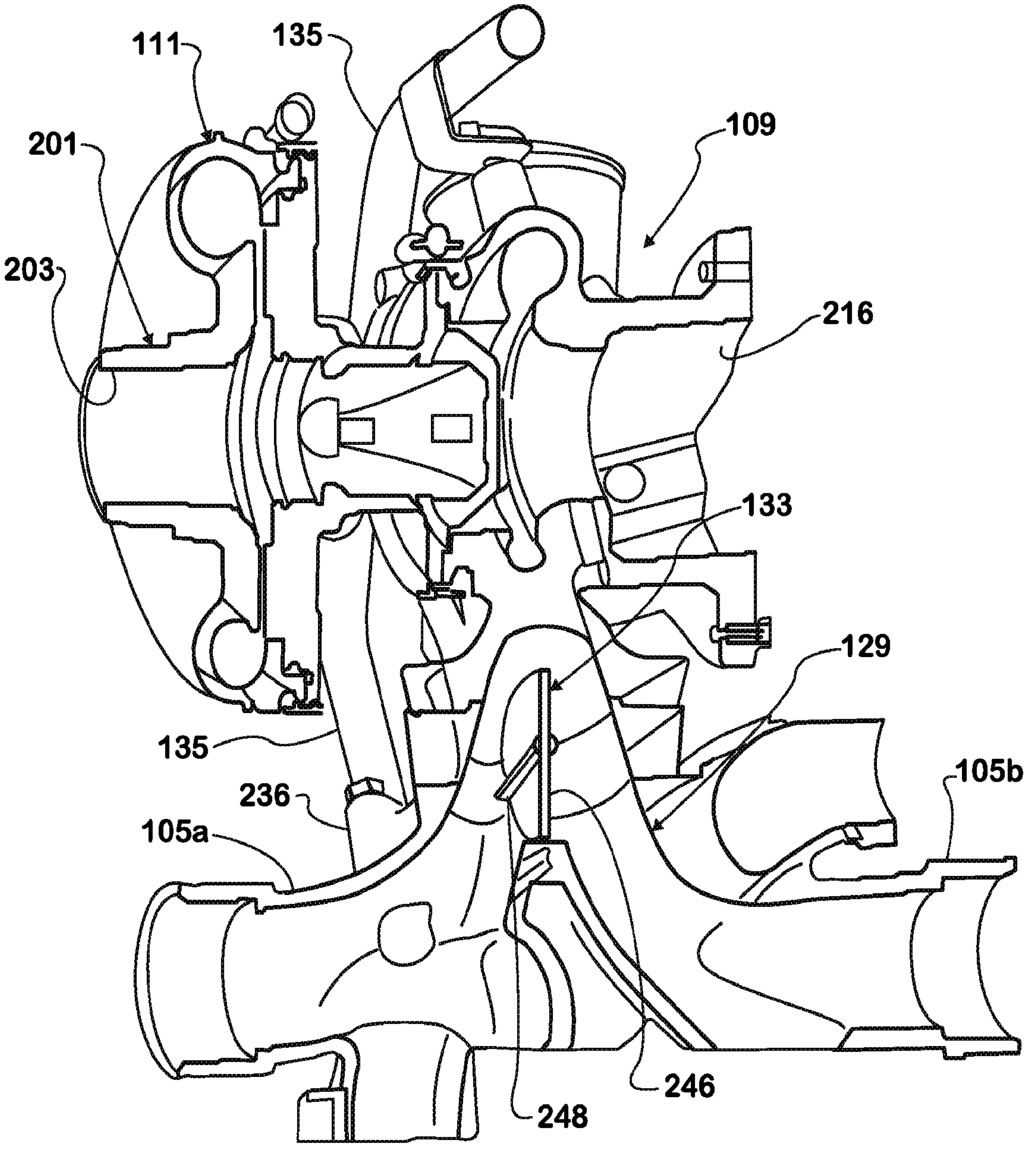


FIG. 4

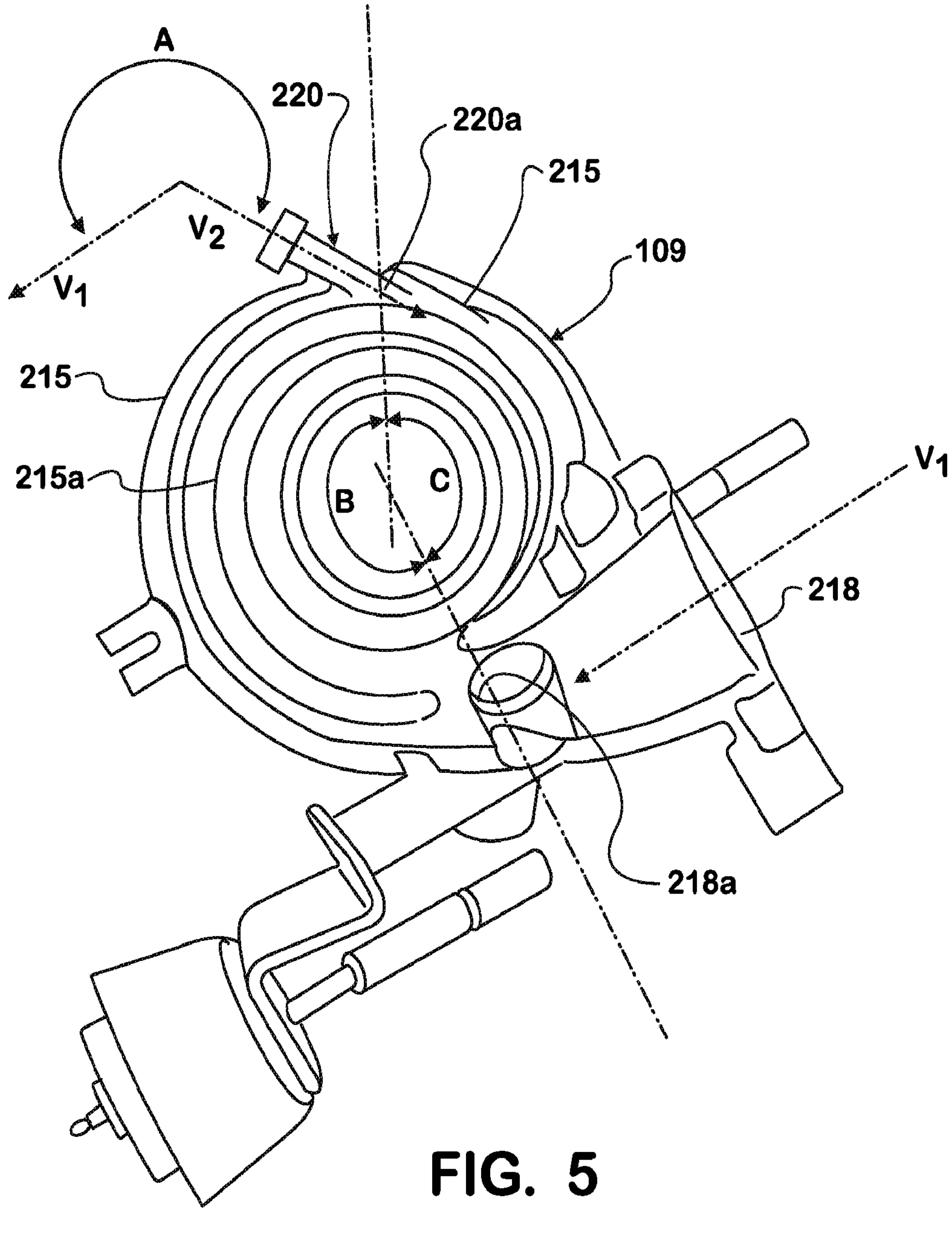


FIG. 5

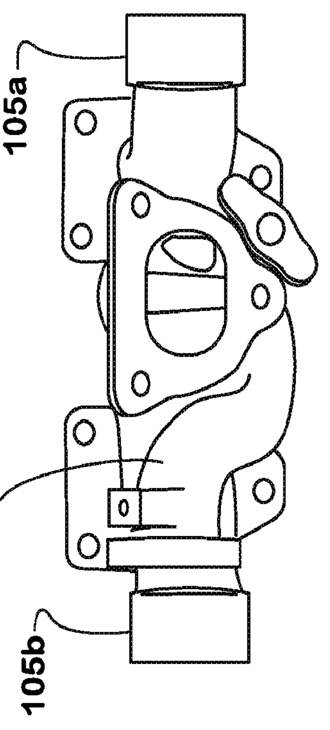


FIG. 6

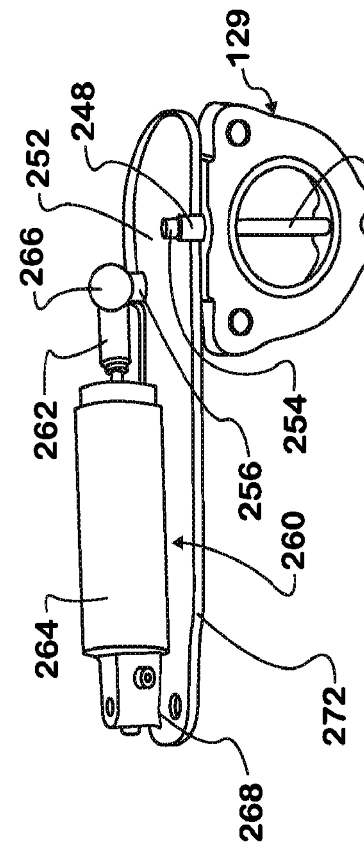


FIG. 7

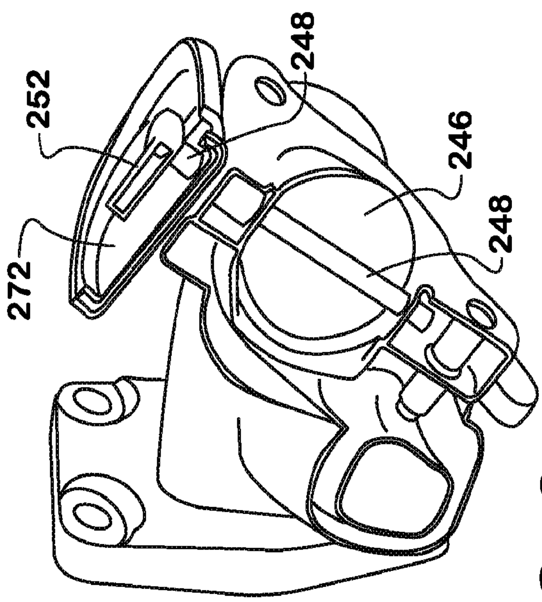


FIG. 8

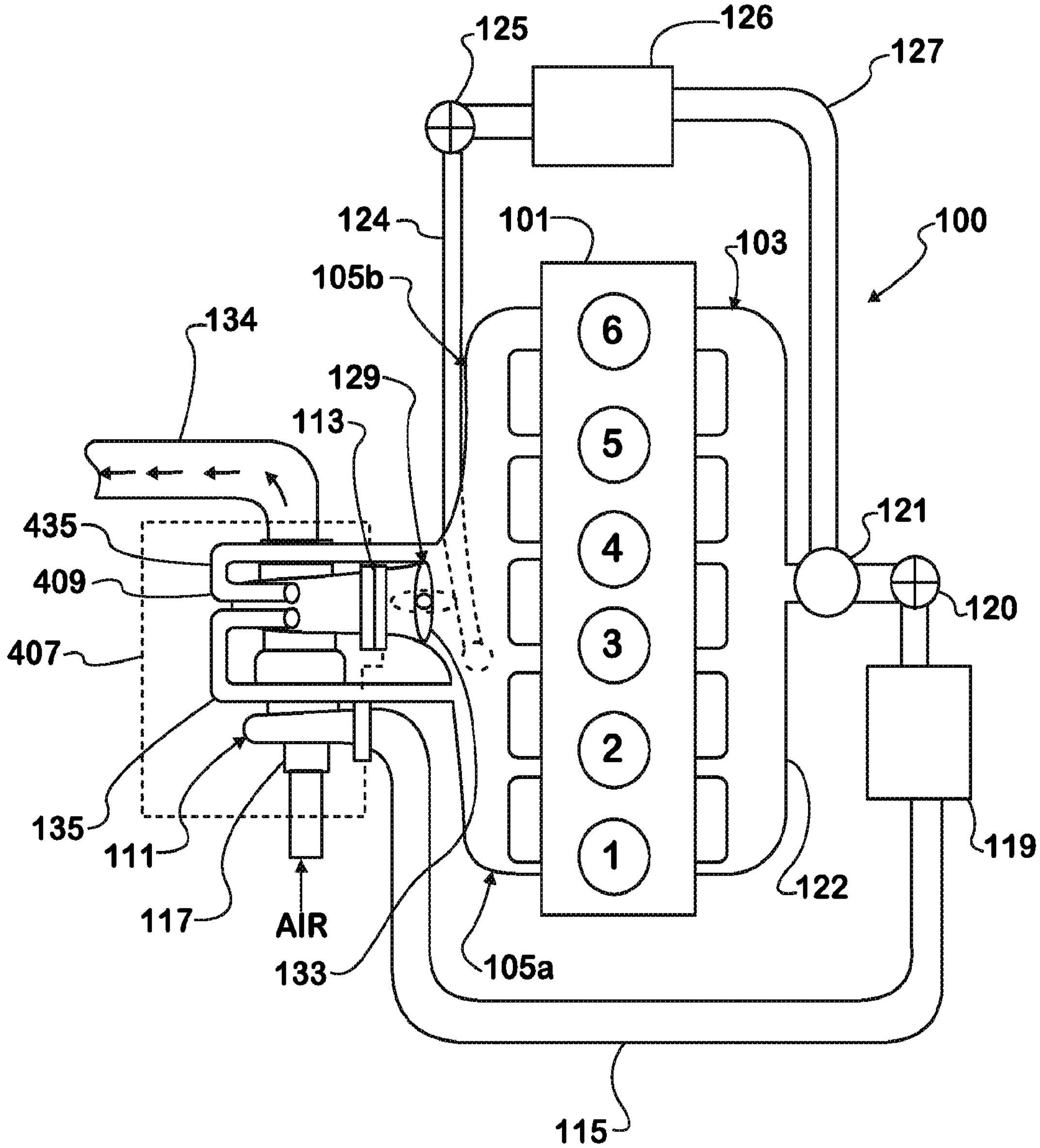
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FIG. 9

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 10/36042

**A. CLASSIFICATION OF SUBJECT MATTER**
IPC(8) - F02D 23/00 (2010.01)
USPC - 60/602
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)
IPC(8) - F02D 23/00 (2010.01)
USPC - 60/602

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 60/598, 597, 615, 614, 611, 605 (text search - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(USPT,PGPB,EPAB,JPAB); Google Scholar; Google Patents
Search Terms: engine, braking, charger, turbine, compressor, valve, bypass, brake, divide, housing, EGR, manifold, exhaust, intake, second, pipe, flow, path, nozzle, turbocharger

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 6,223,534 B1 (Erdmann et al.) 01 May 2001 (01.05.2001), Fig 1-3, col 1, ln 59-63, col 3, ln 45-57, col 4, ln 57-64 | 1-12 |
| Y | US 2003/0230085 A1 (Sumser et al.) 18 December 2003 (18.12.2003), Fig 1-2 and 4, para [0020], [0022]-[0023] and [0025] | 1-12 |
| Y | US 6,484,499 B2 (Coleman et al.) 26 November 2002 (26.11.2002), col 4, ln 2-6 | 9-11 |

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

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"A" document defining the general state of the art which is not considered to be of particular relevance
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 13 July 2010 (13.07.2010) | 28 JUL 2010 |

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