(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 March 2011 (31.03.2011)

PCT

(10) International Publication Number
WO 2011/038240 A1

(51) International Patent Classification:
*F02B 37/22* (2006.01)

(21) International Application Number:
PCT/US2010/050214

(22) International Filing Date:
24 September 2010 (24.09.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/245,388 24 September 2009 (24.09.2009) US

(72) Inventor; and
(71) Applicant : **BLAYLOCK, Jimmy, L.** [US/US]; 3101 Military Avenue, Baxter Springs, Kansas 66713 (US).

(74) Agents: **ROSSLER, Paul, E.** et al; Gable Gotwals, 100 West 5th Street, 10th Floor, Tulsa, Oklahoma 74103 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(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).

**Published:**

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

(54) **Title:** TURBOCHARGER WITH ASSIST NOZZLE AND ADJUSTABLE THROAT

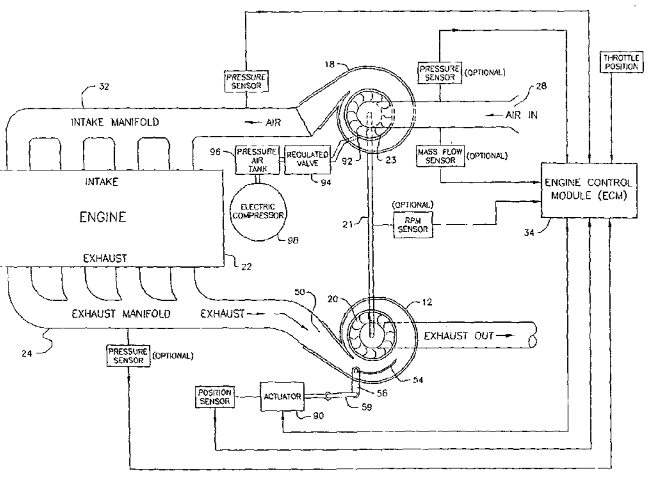


FIG. 1

(57) **Abstract:** **A** turbocharger made according to this invention has a volute-type housing with a nozzle; a nozzle on the compressor or exhaust side and a flow control gate on the exhaust side. The nozzle is directed to impinge air on demand and under pressure upon the compressor side rotor. The flow control gate is arranged to momentarily pivot on demand between a neutral first position and a closed second position toward the exhaust side rotor. The nozzle may provide air substantially instantaneously as the flow control gate moves into the second position. Further, the nozzle, when arranged on the compressor side, preferably directs air under the gate when the gate is in the second position.

WO 2011/038240 A1

# TURBOCHARGER WITH ASSIST NOZZLE AND ADJUSTABLE THROAT

## FIELD OF THE INVENTION

The present invention relates to a turbocharger for use with an internal combustion engine particularly where there is control over the rotational speed of an exhaust turbine rotor as a function of the boost pressure fed to the intake manifold.

## BACKGROUND OF THE INVENTION

Turbochargers are well known devices for supplying air to the intake of an internal combustion engine at pressures above atmospheric, commonly called "boost pressures," and are widely used in all forms of vehicles. A conventional turbocharger includes a turbine rotor or wheel with a plurality of fins or blades inside a volute turbine housing. The turbine rotor is rotated by exhaust gases from the engine which impinge upon the turbine blades. The rotor, via a connecting shaft, provides the driving torque to a compressor. Ambient air fed to the compressor creates a boost pressure that is fed to the intake manifold of the engine.

The flow capacity of the exhaust turbine is a function of the housing volute areas and the passage of the exhaust gases as it strikes the turbine blades. The flow of exhaust gas has to be regulated to control the compressor speed to create the desired boost in manifold pressure. A typical centrifugal compressor includes an impeller driven at high speed by the turbine rotor. A diffuser surrounding the impeller causes the ambient air to increase in pressure which is directed to the intake manifold.

One particular goal with any turbocharger is the need for a quick response, i.e., prevent "turbo lag," a delay between the time when high power output is first demanded of the engine by setting the throttle to a wide open position and the time when a boost in the inlet manifold air pressure is delivered by the compressor. In some instances turbo lag could result in a dangerous driving situation when substantially instantaneous response is desired. If the turbocharger is large enough to provide the maximum horsepower for an internal combustion engine, then it will have excessive and potentially unsafe lag when the throttle is increased. If the turbocharger is reduced in size to minimize turbo lag, then efficiency is lost at higher engine rpms.

Some early turbocharger designs sought to solve the problem of turbo lag within a certain range of low engine speeds, such as when the engine is idling, by adding a regulated air supply to increase the mass of air entering the turbocharger intake and being forced into the engine manifold. At idle speed, the engine exhaust is insufficient to maintain the speed and charging-air output of the compressor section of the turbocharger, causing the turbocharger to "lag behind" the engine in performance. To maintain the speed of the turbocharger, a pair of nozzles penetrates the housing in opposite directions and injects air generally tangentially to the outer tips of the rotor blades. The air pressure provided by the nozzles acts as a "jet assist" in the turbocharger compressor when the engine is at idling speed. See U.S. Pat. No. 3,190,068 to Williams et al., Turbocharger for Compressor Driving Engine, issued June 22, 1965, and U.S. Pat. No. 3,363,412, to Fisher et al., System for Maintaining Turbocharger Compressor Speed, issued January 16, 1968. Another design positions nozzles at preselected points about the turbine rotor and directs air through the nozzles to impinge the blades and, in addition to providing a jet assist, prevent resonant vibration conditions in the rotor for its entire rotational speed range. U.S. Pat. No. 3,396,534 to Bernson et al., Air Impingement Nozzle Arrangement for a Turbocharger Compressor and an Improved Method of Employing Air Impingement, issued August 13, 1968.

The air-assisted designs do not operate to minimize turbo lag when the turbocharger is already in a spun-up condition and the engine is at normal operating speed but requires additional horsepower. Furthermore, the air-assisted designs require a waste gate to handle the total exhaust flow at maximum horsepower.

Other designs have proposed variable geometry turbines; electrically driven turbines; and moveable vanes for guiding, dividing, or changing the direction the exhaust gases relative to the turbine rotor and thereby control its rotational speed. Electrically driven turbines essentially turn the shaft of the turbine rotor into an armature. Because the armature must be disengaged once the turbine rotor spins up to a certain speed, these designs entail complicated electro-mechanical structures and

A moveable or variable vane design, which is intended to minimize the occurrence of turbo lag, is described in U.S. Pat. No. 7,481,056 to Blaylock et al., Turbocharger with Adjustable Throat, issued January 27, 2009 ("Blaylock"). A flow control gate is positioned in the inlet to the housing on the exhaust side of the turbocharger and adapted, from a command, to momentarily rotate or pivot downstream about a transverse hinge from a neutral first position to a second position toward the blades of the turbine rotor. In the second position, the control gate reduces the volume of exhaust gas flowing along an inner flow path toward the turbine rotor and increases the air velocity and pressure upon the turbine rotor. This causes the turbocharger to reach optimal operating speed to substantially reduce or eliminate harmful emissions while increasing initial engine takeoff power and reducing lag time from when speedup was first signaled by the operator. Once the turbine is spun up, the control gate returns to a neutral position. When in the neutral position, the operation of the turbocharger is as a standard turbocharger. The typical time for the gate action is a very small part of a second before returning to the neutral position. A properly sized turbocharger could eliminate the need for a waste gate and the turbocharger could be large enough to handle the total exhaust flow at maximum horsepower.

Others have mechanically coupled the turbocharger to the engine. This type of arrangement, called "turbocompounding,' is described in the September 2010, North American edition of the trade magazine, Diesel Progress ("Could SuperTurbocharger Become the Hero on Fuel Economy?"). The turbocharger adds a small additional horsepower boost through the combination of the turbocharger and its transmission. However, turbocompounding entails complexity and involves additional production cost all in hopes of achieving at most a 7% fuel savings on diesel engines.

**SUMMARY OF THE INVENTION**

The present invention is directed to a variable turbocharger which typically includes a volute-type housing and an exhaust driven turbine rotor which drives a compressor for providing boost pressure air to the intake manifold of an internal combustion engine. A nozzle, which is in communication with a pressurized air tank, is received by the housing on the intake or compressor side of the turbocharger, or on the exhaust side, and positioned relative to the blades of the rotor to direct air under pressure and on demand to rapidly "spin up" the turbine rotor. The nozzle provides air substantially instantaneously as a flow control gate closes.

Operation of the nozzle and flow control gate may include using a microcomputer-based electronic control module (ECM). Typically an ECM receives inputs relating to but not limited to vehicle speed, ambient air conditions, and engine parameters as to throttle position, fuel being injected and the actual and desired boost pressures and flow control gate position. Appropriate signal from the ECM may be directed to a valve to supply pressurized air to the nozzle and to an actuator which pivots the flow control gate. The actuator may be controlled pneumatically, hydraulically or electrically, e.g., solenoid. Under certain operating conditions, the gate may be in a partially closed position when air is provided by the nozzle.

Objects of this invention are to provide a turbocharger design that (1) operates to minimize or completely eliminate turbo lag when the turbocharger is already in a spun up condition and the engine is at normal operating speed but requires additional horsepower; (2) provides substantially immediate spin up of the turbine rotor until optimal boost pressure is obtained regardless of whether the engine is operating at low load conditions or at mid range conditions and cruising at highway speeds; (3) works in combination with a flow control gate to provide the required amount of air under pressure and on demand to rapidly spin up the turbine rotor; (4) requires only a single nozzle to provide the air assist; eliminates the need for a waste gate to handle the total exhaust flow at maximum horsepower; (5) eliminates the need for multiple nozzles and complicated rotor vane geometries or electro-mechanical structures to accomplish the above; (6) is simpler in construction and operation than turbocompounded devices; and (7) achieves significant fuel efficiency savings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a block diagram of an engine and turbocharger control system using an ECM in combination with other engine system sensors. The turbocharger includes a nozzle on the compressor side of the housing that directs air under pressure toward the blades of the turbine rotor and a flow control gate on the exhaust side of the housing that momentarily rotates toward the blades of the turbine rotor.

FIG. 2 is a schematic of a variable area turbocharger of FIG. 1 that includes a nozzle that is received by the compressor housing and positioned to direct air under pressure and on demand, in combination with a pivoting flow control gate of FIG. 1 or FIG. 3, to rapidly "spin up" the turbine rotor.

FIG. 3 is a schematic of a variable area turbocharger of FIG. 1 that illustrates an alternate embodiment of the pivoting flow control gate. The flow control gate momentarily rotates or pivots from a neutral first position to a second position toward the blades of the turbine rotor. In the second position, the control gate increases the air velocity and pressure upon the turbine rotor to rapidly "spin up" the turbine rotor.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring now to FIG. 1, the turbocharger 10 includes a spiral- or volute-type compressor housing 18 that includes a nozzle 92 and a volute-type exhaust housing 12 that includes a flow control gate 54. A shaft 21 connects the rotors 23, 20 of the compressor housing 18 and exhaust housing 12, respectively. In a typical operation, when speed up of the engine 22 is demanded, the vehicle operator will actuate the fuel throttle (not shown). The compressor housing 18 takes ambient air via intake 28, compresses the air, and discharges the air at greater than atmospheric pressure, called "boost pressure," into the engine intake manifold 32 via conduit 30. As the internal combustion engine 22 speeds up there is an increase in exhaust gas flow via conduit 24. Inlet 50 directs this increased engine exhaust flow into rotor 20 and its blades, thereby increasing the rotation of the turbine rotor 20 (and 23).

Nozzle 92 and flow control gate 54 work in combination to provide substantially immediate spin up of the turbine rotor 23, 20 until optimal boost pressure is obtained regardless of whether the engine 22 is operating at minimal or low load conditions or at mid range conditions and cruising at highway speeds. Flow control gate 54 is described in Blaylock as referenced previously, which is herein incorporated by reference for the purpose of explaining the operation of flow control gate 54.

Referring now to FIGS 1 & 2, nozzle 92 is arranged in compressor housing 18 so that nozzle 92 may be a relatively shorter length nozzle and direct air preferably generally normal to the blades of rotor 23. Nozzle 92 injects pressurized air on demand to rapidly spin up the blades of rotor 23 (and therefore 20) in combination with flow control gate 54. The pressurized air to nozzle 92 is provided by a pressure air tank 96 and electric compressor 98. The timing, amount, velocity and pressure of air flowing through nozzle 92 are controlled by an ECM 34 that regulates a valve 94. ECM 34 is typically a programmable computer module containing algorithms to optimize the engine's performance under all variable load and speed requirements along with information received from a variety of engine performance sensors.

Referring now to FIGS. 1 & 3, flow control gate 54—which may be attached to the downstream end of a fixed flow splitter 52 in inlet 50 (see FIG. 1)—is actuated by an electric, pneumatic or hydraulic actuator 90 also controlled by ECM 34. Information fed to ECM 34 is used to control the position of the flow control gate 54 by means of actuator 90. Actuator 90 preferably includes at least two position means, for timely closing and opening the flow control gate 54. Suitable actuators for actuator 90 include, but are not limited to, linear actuators and position sensors such as sold by MPC Products Corp. (Skokie, IL); Accent Bearings Co. (Addison, IL); ETI Systems (Ft. Worth, TX); PFA pneumatic linear actuators of Fabco-Air, Inc.

(Gainsville, FL); and LVDT electro-mechanical transducers as sold by Macro Sensors division of Howard A. Schaevitz Tech. Inc. (Pennsauken, NJ). A preferred actuator 90 is Delphi Corp. (Troy, MI). These products are listed here by way of example only.

In a preferred embodiment, actuator 90 controls flow control gate 54 by way of a linear actuated rod 59 in communication with a crank arm 58. The movement of the crank arm 58 actuates flow control gate 54, pivoting the flow control gate 54 toward and contiguous to the turbine rotor 20. This causes a substantially immediate speed up of the rotor 20 and a buildup of boost pressure, thereby greatly reducing turbo time lag.

A position sensor would feed information to the ECM 34 as to the position of the flow control gate 54. Based on this and information from other sensors—such as, for example, a pressure sensor, throttle position sensor, mass flow sensor, rpm sensor—appropriate correction as to the position of flow control gate 54 can be made as well as the amount, duration, and pressure of air flow provided by nozzle 92.

Nozzle 92 works in combination with flow control gate 54 so that nozzle 92 provides the required amount of air under pressure and on demand to rapidly "spin up" the turbine rotor 23 substantially instantaneously with the closing (or partial closing) of flow control gate 54. Other "on-off' combinations of nozzle 92 and flow control gate 54 may be practiced. For example, ECM 34 may signal nozzle 92 to provide pressurized air immediately prior to (or following) actuation of flow control gate 54. Note that, unlike prior art designs, only a single nozzle 92 is required when used in combination with flow control gate 54 and no waste gate is required.

An analog actuator 90 along with sensor input to the ECM 34 would allow the flow control gate 54 to be in an optimal position (not necessarily fully closed) to accelerate the turbine alone or in combination with nozzle 92 to a desired boost at any speed and load condition. The ECM 34 could respond to small throttle position changes to supply pressurized air through nozzle 92 and move the flow control gate 54 only as required to make smaller changes to achieve the desired boost. This would minimize exhaust back pressure that robs horsepower and hurts fuel efficiency.

In another preferred embodiment, nozzle 92 is positioned on the exhaust side along with flow control gate 54. Typically, the blades of the compressor side are designed to pull air in and sling it outward rather than to catch air, whereas the blades on the exhaust side are designed to catch the exhaust much like a pinwheel catches air. Nozzle 92 may be a relatively shorter length nozzle and preferably directs air under the gate 54 and toward the blades of rotor 20. Flow control gate 20 is designed, when in the partially closed or closed position, to increase the pressure and velocity of the exhaust flow to rapidly spin up the turbine rotor 20. Nozzle 92, when arranged in the above matter, augments the gate 20, thereby providing even more rapid spin up of turbine rotor 20.

The embodiments and modes of operation of the invention should not be construed as limiting to the particular forms as described. Variations and changes, as for example in the overall control of various types of internal combustion engines, e.g., gas, diesel and various vehicle types, e.g., highway, off-road, motorcycles, etc. may be made by those skilled in the art without departing from the scope and spirit of the present invention and the appended claims.

**WHAT IS CLAIMED IS:**

1. A turbocharger comprising:

   a volute-type housing having a compressor side and an exhaust side, each of the sides having a rotor, each rotor being in communication with the other;

   a nozzle; and

   a flow control gate;

   the flow control gate being on the exhaust side and arranged to momentarily pivot on demand between a first position and a second position toward the exhaust side rotor;

   the nozzle being directed to impinge air on demand and under pressure upon a rotor.

2. A turbocharger according to Claim 1 further comprising the nozzle being positioned on the exhaust side.

3. A turbocharger according to Claim 1 further comprising the nozzle being positioned on the compressor side.

4. A turbocharger according to Claim 3 further comprising the nozzle being directed to impinge air on demand and under pressure below an underside of the flow control gate and upon a rotor.

5. A turbocharger according to Claim 1 further comprising the nozzle providing air under pressure when the flow control gate is in one of the first position and the second position.

6. A turbocharger according to Claim 1 further comprising the nozzle providing air under pressure substantially instantaneously with the flow control gate moving between the first position and the second position.

7. A turbocharger according to Claim 1 further comprising the nozzle not providing air under pressure when the flow control gate is in one of the first position and the second position.

8. A turbocharger according to Claim 1 further comprising the nozzle not providing air under pressure substantially instantaneously with the flow control gate moving between the first position and the second position.

9. A turbocharger according to Claim 1 further comprising an electronic control module in communication with the nozzle and the flow control gate.

10. A turbocharger according to Claim 1 further comprising the turbocharger not including a waste gate.

11. A turbocharger having no waste gate and comprising:

a volute-type housing having a compressor side and an exhaust side, each of the sides having a rotor, each rotor being in communication with the other;

a single nozzle; and

a flow control gate;

the single nozzle being on at least one of the compressor side and exhaust side and directed to impinge air on demand and under pressure upon a rotor;

the flow control gate being on the exhaust side and arranged to momentarily pivot on demand between a first position and a second position toward the exhaust side rotor.

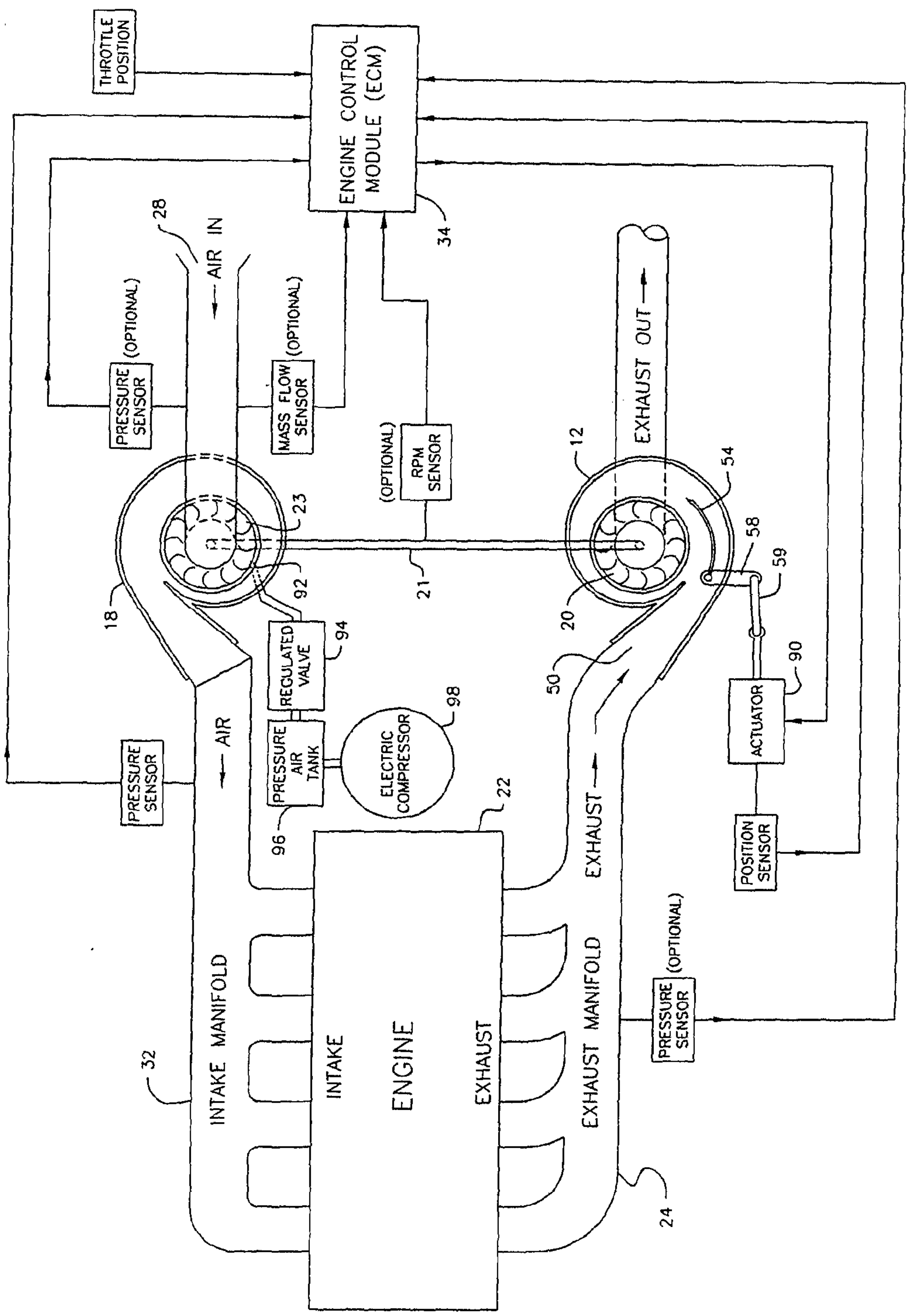
THROTTLE POSITION
ENGINE CONTROL MODULE (ECM)
34
28
AIR IN
PRESSURE SENSOR
(OPTIONAL)
MASS FLOW SENSOR
(OPTIONAL)
(OPTIONAL)
RPM SENSOR
EXHAUST OUT
12
54
23
58
59
18
92
21
20
REGULATED VALVE
94
50
ACTUATOR
90
ELECTRIC COMPRESSOR
98
PRESSURE AIR TANK
96
PRESSURE SENSOR
AIR
22
EXHAUST
POSITION SENSOR
INTAKE MANIFOLD
32
INTAKE
ENGINE
EXHAUST
EXHAUST MANIFOLD
PRESSURE SENSOR
(OPTIONAL)
24

FIG. 1

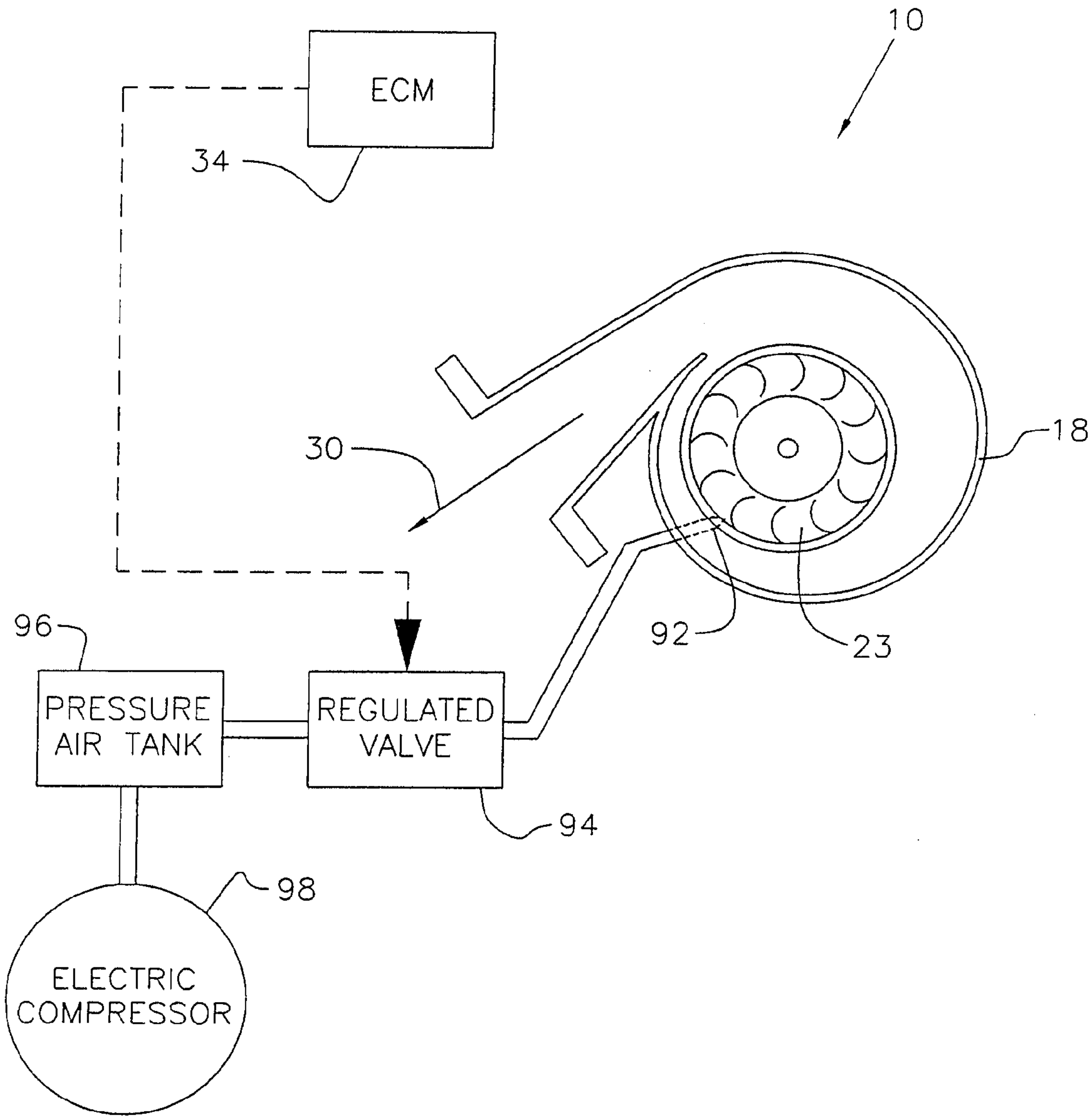
ECM
10
34
30
18
92
23
96
PRESSURE AIR TANK
REGULATED VALVE
94
98
ELECTRIC COMPRESSOR

Fig. 2

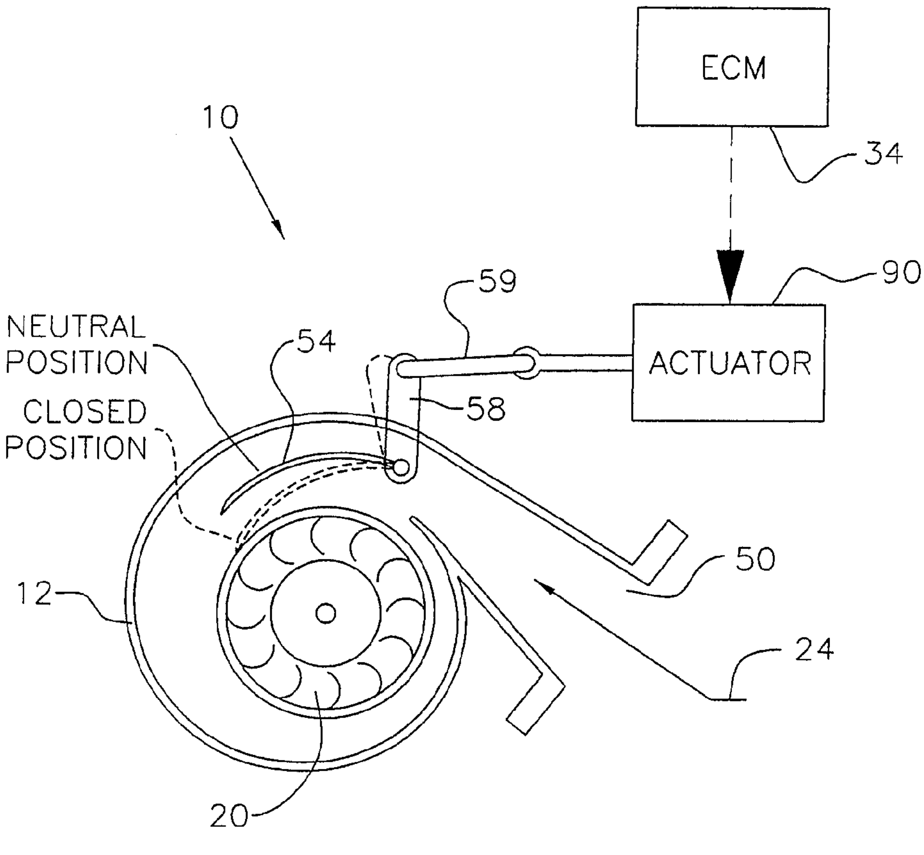
ECM
34
10
90
59
ACTUATOR
NEUTRAL
POSITION
54
58
CLOSED
POSITION
50
12
24
20

Fig. 3

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/050214

A. CLASSIFICATION OF SUBJECT MATTER
**IPC(8) - F02B 37/22 (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) - F02B 37/22; F02D 23/00 (2010.01)
USPC - 60/600, 602, 605.1, 624

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)
MicroPatent, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 2007/0227142 A1 (BLAYLOCK et al) 04 October 2007 (04.10.2007) entire document | 1-11 |
| A | US 2007/0144172 A1 (SUMSER et al) 28 June 2007 (28.06.2007) entire document | 1-11 |
| A | US 2006/0127242 A1 (MARTIN et al) 15 June 2006 (15.06.2006) entire document | 1-11 |
| A | US 5,214,920 A (LEAVESLEY) 01 June 1993 (01.06.1993) entire document | 1-11 |

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 27 October 2010 | 15 NOV 2010 |

| Name and mailing address of the ISA/US | Authorized officer: |
|---|---|
| Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-3201 | Blaine R. Copenheaver<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |