(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 846 848 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.06.1998 Bulletin 1998/24

(51) Int. Cl.[6]: **F02B 25/14**, F02B 69/06

(21) Application number: **97121239.4**

(22) Date of filing: **03.12.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **03.12.1996 IT TO960978**

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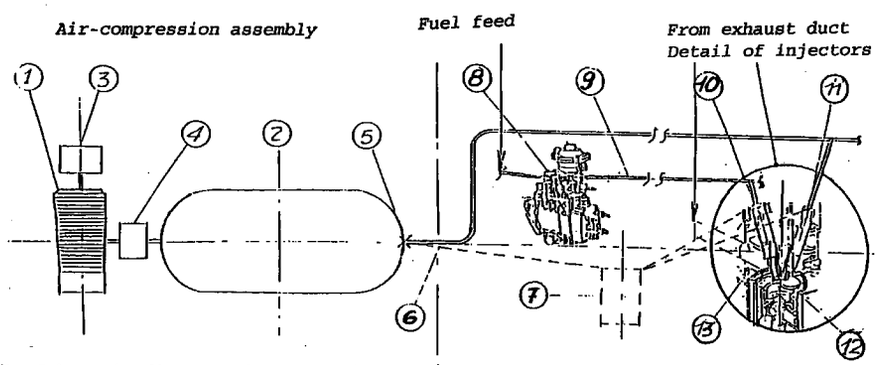
(54) Two-stroke Twin-injector-per-cylinder engine

(57) The two-stroke twin-injector-per-cylinder engine is characterized by the introduction of a compressed-air supplementary injector which enables the engine to operate as a two-stroke only engine and with the exhaust valves alone. This simplification makes it possible to achieve a higher power compared to the traditional four-stroke engine. The engine must be provided with a compressor-tank assembly combined with one or more turbosuperchargers in series with air intake and choke tube, a computerized electronic control unit and an injection fuel pump and electro-injection valves with different characteristics between Diesel engines and petrol engines. The materials, pressures, dimensions and electric wiring schemes adopted are appropriate for any type of vehicle and for the aforesaid purpose. The introduction of the compressed-air injector guarantees an increase in volumetric efficiency and in power of any type of internal combustion engine provided with compressor, with or without tank, or even only with a turbosupercharger or turbo-intercooler.

Simplified diagram of operation of engines with compressed-air injectors



1- *Schematic diagram of compression assembly*
2- *Tank*
3- *Compressor air filter*
4- *Settling filter*
5- *Valve connected to control unit*
6- *Compressed-air piping*
Scale: in proportion to vehicles

7- *Electronic control unit*
8- *Injection pump*
9- *Fuel piping*
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13- *Cylinder head*

FIG. 1

EP 0 846 848 A1

Description

The main characteristic of this engine consists in its being able to operate in a single cycle of only two-stroke phases and with only the exhaust valve.

This technical innovation enables a considerable increase in power as compared to the traditional four-stroke engine. But to achieve this result, it is necessary to calculate precisely the start of the injection of the fuel as a function of the injection of compressed air, of the opening of the exhaust valve, of the pressure, and of the volume of compressed air drawn into the cylinder (all controlled via the microcomputer of the electronic control unit) which enables instantaneous discharge of exhaust gas already in the expansion-stroke phase which becomes a true exhaust-stroke phase. The subsequent closing of the exhaust valve, with the continuation of the admission of the compressed air during the piston stroke, performs the necessary suction-stroke phase and enables supercharging (pressure and volume of the tank in accordance with the purpose) without any need for suction pipes and valves and related mechanical items.

To complete the engine cycle there remains only the compression-stroke phase.

In order to obtain the pressure and flow of air necessary for charging and supercharging of the engine in the widest possible range of conditions, the single-stage or two-stage screw compressor assembly - 1 - has been considered, with a transmission ratio, with respect to the driving pulley of the engine shaft and pulling; such as to enable, also by means of the tank - 2 - necessary for a fast start of the engine and for accumulating pressurized air and regulating its delivery, so as to meet the various demands for pressure and volume of air at low and medium r.p.m.

On the other hand, in order to meet the need for a greater air flow at high r.p.m. and during supercharging, it is necessary to add one or more turbosuperchargers in series - 3 - or a two-stage supercharger.

In addition, the pneumatic system in two-stroke or four-stroke engines equipped with compressed-air injectors (see diagram of pneumatic system) comprises also an air intake - 4 - necessary for exploiting the pressure exerted by the atmospheric air after a given speed, conveying it to a choke tube, so as to inject it already with a certain pressure, into the turbosuperchargers, thus improving the efficiency and cooling thereof. Other components of the pneumatic transmission are: the non-return valve - 5 -, the air filters - 6 -, the condensate trap - 7 -, the air-inflow regulation valve - a -, some metres of compressed-air piping - 9 -, and possible other items.

The introduction into each cylinder of a compressed-air injector enables an increase in efficiency and power in any type of internal combustion engine provided with a compressor with or without tank, or equipped even only with a turbosupercharger or turbointercooler.

In fact, before the bottom dead centre, during the expansion-stroke phase and as soon as the exhaust valve is about to start opening, a jet of pressurized air is drawn into the cylinder by means of the injector; this jet of air instantaneously increases the pressure and exerts an active force on the piston, thus simultaneously facilitating the discharge of exhaust gas and enabling a reduction in the temperature of the cylinder during the subsequent exhaust-stroke phase, with consequent increase in efficiency of the turbosupercharger and a higher engine power.

A further improvement in the efficiency and power of the engine is obtained during supercharging effected directly by the injector by eliminating the significant pressure losses and other losses due to friction in the intake pipes and in the intersection with the suction valve.

The two-stroke twin-injector-per-cylinder engine differs from the traditional four-stroke engine in the following mechanical members:

1 cylinder head - 13 -, with two injectors per cylinder and with only the exhaust valves and ducts;
1 cam-shaft with only the exhaust cams;
1 instrumented injector - 10 - for each cylinder which must guarantee an optimal nebulization and diffusion of the fuel;
1 compressed-air injector for each cylinder - 11 - with different positioning with respect to the instrumented injector and with electrical actuation for opening/closing of the compressed-air duct upon command from the control unit;
1 injection pump - 8 (the petrol-driven engine has a fuel supply system with different characteristics also in the injection pump), which must guarantee the required amount of fuel at a given pressure to be sent to the instrumented injector;
1 electronic control unit - 7 -, which must co-ordinate (via microcomputer) the start of fuel injection in relation to the start of injection of a given volume of compressed air, as well as the opening/closing of the exhaust valve according to the number of engine revs and the power required, the pressure and the temperature;
1 compressed-air tank - 2 - for accumulating a volume of air at the required pressure and for an optimal operation of the engine in the widest range of conditions;
1 single-stage or two-stage screw compressor - 1 - combined with a tank - 2 - and one or more turbosuperchargers in series - 3 - with air intake and choke tube - 4 -.

The design of a two-stroke twin-injector-per-cylinder engine differs from the traditional four-stroke engine (given the same materials and the same various machining-production systems) in the following particu-

lars:

- Cylinder head - with only exhaust ducts and valves and precise positioning of the two injectors so as to ensure maximum engine efficiency;
- Camshaft - with only the cam needed for opening and closing of the exhaust valves according to the emission of fuel and compressed air;
- Exhaust valve - appropriate shape and dimensions to ensure optimal discharge of exhaust gases;
- Single-stage or two-stage screw compressor combined with a tank and turbosuperchargers in series with an air intake and choke tube designed according to the pressure and volume of air required to carry out the engine stroke phases and supercharging in an optimal way;
- Compressed-air tank - necessary for starting and for accumulating volumes of air at high pressure, both for better regulation of delivery and for greater engine efficiency; it also serves as a compressed-air cooler and purifier of certain anti-pollution substances. It is built of galvanized steel and has an accumulation capacity and thickness of metal calculated according to pressure and delivery at low and medium r.p.m.;
- Electronic control unit (with microcomputer) to coordinate the engine stroke phases according to start of fuel injection, compressed air, opening of exhaust values, engine r.p.m. power, temperature, etc.

Various tests both in the laboratory and on the road will lead to continuous improvements and to an ideal solution.

Claims

1. Cylinder head - 13 -, characterized by a single exhaust valve, a double seat for insertion of fuel-injector and compressed air-injector bushings, with mutual optimal positioning;

   - provided with special attachments for fixing of compressor and possible turbosuperchargers, on the cylinder-head side in the position of the intake manifold;
   - material, shape and dimensions identical to those of a four-stroke engine to enable possible replacement using the same engine block (only for engines with camshaft overhead).

2. Exhaust valve - 12 - shape and dimensions suitable for facilitating discharge of exhaust gases (operates as an exhaust valve during opening, whereas performs suction-stroke (air-intake) phase and compression-stroke phase during closing of the exhaust duct).

3. Camshaft, characterized by a single exhaust cam. The opening/closing of the exhaust valve must be calculated according to the intake of fuel and compressed air so as to obtain an optimal volumetric efficiency;

   - materials - as previous ones, for camshaft

4. Electronic control unit with minicomputer - 7

   - which must co-ordinate start of fuel admission according to the start of compressed-air inflow at opening/closing of the exhaust valve, according to the r.p.m. and power required, according to the temperature and pressure, and according to any possible additional item.

5. Single-stage or two-stage screw compressor;

   - sizing and delivery to be calculated according to the tank capacity, the pressure, and delivery, at high r.p.m., of the turbosuperchargers, as well as the type of engine;
   - suction from the choke tube set beneath the front cross-members of the bodywork in order to improve cooling of the compressor and to obtain a greater compression, beyond certain speeds;
   - fixed, if possible together with the turbosuperchargers, on the cylinder-head side in the position of the intake manifold;
   - materials and technical and constructional characteristics identical to those of the compressors of the same type.

6. Compressed-air injectors, with electrical operation for opening and closing for the compressed air, governed by the electronic control unit. The compressed air is discharged vertically or expands by fanning-out to enable a more uniform cooling and better engine efficiency;

   - screwed into the bushings of the cylinder heads, with dimensions according to the type of engine;
   - materials and technical-manufacturing characteristics similar to those of the injectors of the same type.

Simplified diagram of operation of engines with compressed-air injectors

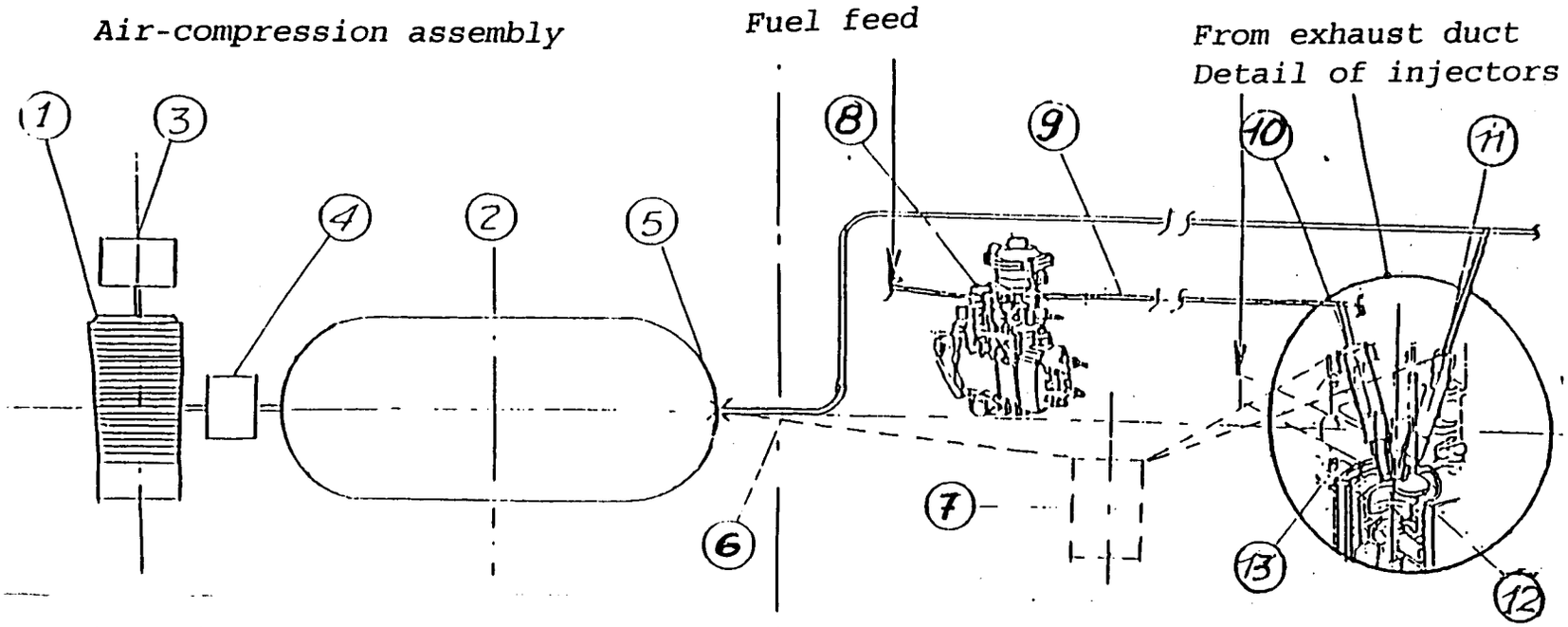

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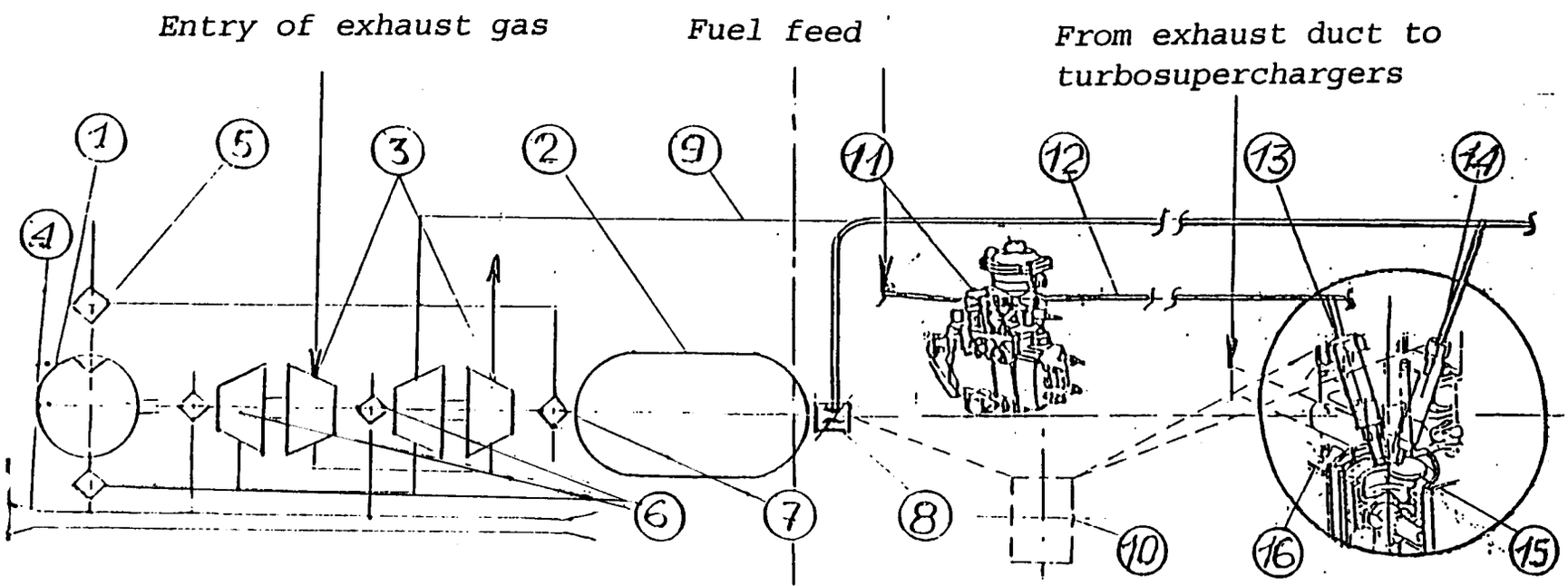
FIG. 1

Diagram of pneumatic system for operation of engines with compressed-air injectors



1- *Single-stage or two-stage compressor*
2- *Compressed-air tank*
3- *Turbosupercharger in series*
4- *Air intake with choke tube*
5- *Non-return valve*
6- *Air filters*
7- *Condensate separator*
8- *Air-flow regulation valve*
9- *Compressed-air piping*
10- *Electronic control unit*
11- *Injection pump*
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13- *Fuel injector*
14- *Compressed-air injector*
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16- *Cylinder head*

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 12 1239

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y A	GB 1 065 264 A (BIANCHI) * page 1, line 56 - page 2, line 59; figures 1-4 *	1 2,3,6	F02B25/14 F02B69/06
Y A	US 5 515 675 A (BINDSCHATEL LYLE D) * abstract; figure 1 * * column 6, line 33 - line 45; figure 4 *	1 3	
Y	US 4 539 948 A (TOEPEL RICHARD R) * abstract; figure 1 *	1	
A	EP 0 385 189 A (MAN NUTZFAHRZEUGE AG) * abstract; figure 1 *	1,4	
A	PATENT ABSTRACTS OF JAPAN vol. 095, no. 009, 31 October 1995 & JP 07 145768 A (YAMAHA MOTOR CO LTD), 6 June 1995, * abstract *	1,4,6	
A	FR 2 233 493 A (HGN MOTOREN GMBH & CO) * claims 1-8; figure 1 *	1,4,6	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F02B
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 234 (M-334), 26 October 1984 & JP 59 115428 A (MITSUBISHI JUKOGYO KK), 3 July 1984, * abstract *	1,4,6	
A	EP 0 222 082 A (GUTEHOFFNUNGSHUETTE MAN) * abstract; figure 1 *	1,5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 February 1998	Wassenaar, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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