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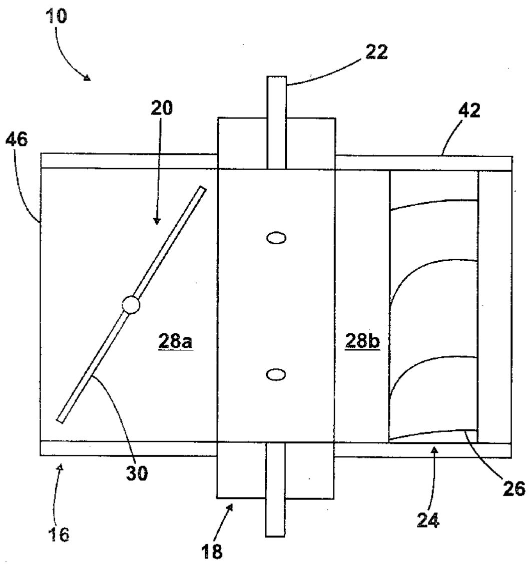

Fig. 1

(57) **Abstract:** A control assembly (10) for a dual fuel engine system (100) comprising: an inlet (12) and an outlet (14); an air control unit (16) positioned between the inlet (12) and the outlet (14), adapted to control air flow between the inlet (12) and the outlet (14); and a gas injector assembly (18) adapted to be positioned between the air control unit (16) and the outlet (14), the gas injector assembly (18) having an injector point (22) adapted to inject a gas into an air flow path in communication with the outlet (14).

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CONTROL ASSEMBLY

This invention relates to a control assembly for use with an engine system, and in particular, relates to a control assembly for a dual fuel engine system.

Dual fuel engines are adapted to use a conventional fuel such as petrol or diesel and an alternative fuel. The conventional fuel is used in varying quantities to *inter alia* produce a heat source to ignite an alternative fuel in the form of a gas.

The invention relates particularly, but not exclusively to a control assembly for a dual fuel engine system comprising an engine that runs on diesel and another fuel such as natural gas.

Diesel engines have been used for decades in industrial power generation, cogeneration power systems, locomotives, marine applications, and other engine markets. However, as environmental standards become stricter, users of diesel engines are looking for ways to lower emissions without reducing engine power.

Dual fuel systems are therefore gaining in popularity because they have the potential to reduce the amount of diesel fuel used.

It is possible to convert a traditional diesel engine into a dual fuel engine capable of running on natural gas as well as diesel, with little or no loss of power. It is becoming increasingly popular for users of diesel engines to convert their engines to dual fuel engines adapted to use natural gas as well as diesel. This is because an engine running on natural gas has various advantages including the fact that it is a much cleaner engine, and therefore is environmentally friendly.

In contrast to engines having a dedicated gaseous fuel supply, and therefore requiring a spark to cause ignition, a dual fuel engine uses a flame caused by the combustion of diesel to ignite the gaseous fuel.

Most engines operate in a four-stroke combustion cycle comprising an intake phase, a compression phase, a combustion phase and an exhaust phase. During the intake phase, fuel and air are supplied into a combustion chamber of an engine cylinder via an intake manifold. Air flow into the intake manifold is provided by means of an air intake system in fluid communication with the intake manifold. The fuel is provided by means of a fuel injector connected to a fuel reservoir.

The fuel and air mixture is then compressed during the compression phase before being ignited during the combustion phase. The expended fuel is then expelled from the combustion chamber during the exhaust phase via an exhaust manifold.

In all engine types, oxygen (usually in the form of air) is required to mix with a fuel to provide the correct conditions for efficient combustion.

In known dual fuel engines the mixing of air with a gaseous fuel is achieved by injecting gas into an airstream in the intake system in an un-controlled manner, then drawing the gas and air into the combustion chambers of the engine during the intake phase of the combustion cycle. The mixture is then ignited during the combustion process of the engine.

Effective mixing of the gas and air prior to ignition is, however, not guaranteed as any mixing of the gas and air in the combustion chamber prior to combustion is achieved by means of diffusion. The rate and extent to which the gas and air are mixed will depend on a number of factors including the amount of time in which mixing occurs, the flow rates of the gas and air, the temperature of the gas and air etc. As such the rate and extent to which the gas and air are mixed, and hence the combustion properties prior to ignition, will vary from cycle to cycle.

According to a first aspect of the invention there is provided a control assembly for a dual fuel engine system comprising:

an inlet and an outlet;

an air control unit positioned between the inlet and the outlet, adapted to control air flow between the inlet and the outlet; and

a gas injector assembly adapted to be positioned between the air control unit and the outlet, the gas injector assembly having an injector point adapted to inject a gas into an air flow path in communication with the outlet.

A control assembly according to the invention may be connected to an intake manifold of a dual fuel engine in order to improve the mixing of gas and air prior to ignition.

The control assembly, in use, may be connected to an intake manifold of a dual fuel engine such that the gas injector assembly is positioned between the air control unit and the intake manifold. As such any gas injected via the injector point will be injected into a flow path of air flowing into the intake manifold. In other words, gas injection will occur upstream of the intake manifold.

By positioning the gas injector assembly upstream of the intake manifold, rather than within an intake manifold as is known in the art, the mixing of the gas and the air may be achieved prior to entry into the combustion chamber during the intake phase of the combustion cycle. This means that more effective mixing of the gas and air will occur before ignition as the gas and air are given more time to mix. Thus better combustion will be achieved than in a case where unmixed fuel is drawn into the combustion chamber.

Advantageously, the gas injector assembly comprises a plurality of injector points, preferably located around a periphery of the gas injector assembly.

The provision of a plurality of injector points positioned around the periphery of the gas injector assembly also facilitates the mixing of the gas and air. This is because less time will be required to inject a predetermined amount of gas into the flow path of air flowing into the intake manifold than if a single injector point were used. As such, the time over which the mixing of the gas and air takes place before entry into the combustion chamber is increased.

In addition, the provision of a plurality of injector points means that concentrations of gas may be injected into the flow path of air flowing into the intake manifold at each of a plurality of locations in a stream of air. Thus facilitating the mixing of the gas and air before entry into the combustion chamber.

Preferably, the control assembly further comprises a flow disruptor adapted to disrupt the flow of a fluid through the outlet.

Preferably, the fluid disruptor comprises a fluid swirling device positioned between an injector point of the gas injector assembly and the outlet.

The mixing of the gas and the air is facilitated by the positioning of the swirling device between an injector point and the outlet. In other words, the fluid swirling device is preferably positioned downstream of the injector point. The swirling device will induce a resultant swirling motion in the gas and air as it passes through the swirling device. This swirling motion will increase the rate of mixing between the gas and the air, and facilitate thorough mixing of the gas and air before entry into the combustion chamber.

Advantageously, the fluid swirling device comprises a plurality of vanes adapted to induce a swirling motion in a fluid passing between one or more vanes.

Preferably, the fluid swirling device is housed within the gas injector assembly, advantageously proximate an injection point.

The housing of the swirling device proximate an injector point means that accelerated mixing of the gas and the air by means of an induced swirling motion occurs soon after injection of a gas into the flow path of air flowing into the intake manifold from the air intake system.

Alternatively, the flow disruptor may comprise one or more perturbations positioned across the flow path of the gas and air mixture rather than a fluid swirling device. The perturbations may be in the form of, for example, bars or tubes positioned across the flow path downstream of the gas injector point.

In other embodiments of the invention, the flow disruptor may also comprise paddles or blades positioned downstream of the injector point.

Preferably the air control unit comprises a butterfly valve member.

Preferably the air control unit is detachably coupled to the gas injector assembly. This means that in the event of failure of either the air control unit or the gas injector assembly, the failed component may be readily repaired or replaced without having to replace the whole control assembly.

Preferably, the control assembly further comprises a first fluid conduit in fluid communication with the air control unit in order to define the path of air flowing from the air intake system into the air control unit.

Advantageously, the control assembly according the invention further comprises a second fluid conduit in fluid communication with the gas injector assembly, and having a first end defining the output of the control assembly and a second end connected to the gas injector assembly.

The second fluid conduit facilitates mixing of the gas and air before entry into the intake manifold, as part of the mixing will take place in the second fluid conduit. In addition the second fluid conduit assists in directing the mixed gas and air into the intake manifold of the dual fuel engine.

The second fluid conduit may be integrally formed with the gas injector assembly or may be detachably coupled to the gas injector assembly.

The relative amounts of air and fuel in the combustion chamber at the time of ignition is known as the air fuel ratio (AFR). It is important to be able to control the AFR in order to ensure that an engine is operating at an optimal level.

Advantageously, the control assembly further comprises a dual fuel engine control unit for controlling the AFR of the gas and air mixture injected into the combustion chamber of the dual fuel engine.

The dual fuel engine control unit may be connected to the gas injector assembly in order to control the amount of gas entering the intake manifold. Alternatively or in addition, the dual fuel engine control unit may be connected to the air control unit in order to control the amount of air flow entering the intake manifold.

The dual fuel engine control unit will thus have the capability to control the amount of gas/air in the mixture entering the combustion chamber by controlling the amount of air allowed to flow into the intake manifold, or the amount of gaseous fuel injected into the air flow path. Controlling these parameters ensures that the AFR is at, or close to its optimum value, and that combustion temperatures within the engine cylinder are maintained close to, or within the original equipment manufacturer's specification.

Preferably the control assembly comprises an oxygen sensor in communication with the dual fuel engine control unit for providing data in relation to the amount of oxygen present in the expended fuel expelled from the combustion chamber of an engine. The data provided by the oxygen sensor can then be used by the dual fuel engine control unit to adjust the AFR by varying the supply of gas or air as required, in order to ensure that the AFR is as close as possible to its optimum.

According a second aspect of the invention there is provided a dual fuel engine system comprising

a dual fuel engine including a combustion chamber;

an air intake system;

an intake manifold adapted to supply a fluid into the combustion chamber;

an exhaust manifold adapted to expend a fluid from the combustion chamber;

an exhaust system in communication with the exhaust manifold; and

a control assembly according to the first aspect of the present invention wherein the inlet of the control assembly is connected to the air intake system, and the outlet of the control assembly is connected to the intake manifold.

According to a third aspect of the present invention there is provided a method of mixing air and gaseous fuel in a dual fuel engine system comprising the steps of:

(a) connecting a mixture control assembly according to the first aspect of the invention to an intake manifold of a dual fuel engine;

(b) directing air towards the intake manifold via the air control unit;

(c) injecting gas into the air by means of an injector point of the gas injector assembly; and

(d) mixing the gas and air together upstream of the intake manifold and prior to entry into a combustion chamber of a dual fuel engine.

Preferably a ratio of gas and air in a mixture to be mixed in step (d) is calculated according to data obtained from an oxygen sensor in a vehicle exhaust system.

The oxygen sensor will detect the amount of oxygen present in the exhaust gases and indicate to the dual fuel engine control unit the AFR at that time. The dual fuel engine control unit will then use this information to control the amount of gas and the amount of air in the mixture.

The invention will now be described by way of non-limiting example with reference to the accompanying drawings in which:

Figure 1 is a partial cross sectional view of a control assembly according to the invention;

Figure 2 is an end view of the control assembly of Figure 1;

Figure 3 is a perspective view of a control assembly according to the invention;

Figure 4 is an exploded view of the control assembly of Figure 3;

Figure 5 is a schematic view of a dual fuel engine system according to the invention; and

Figure 6 is a schematic view of the interface the sensors and control systems of the dual fuel engine system of Figure 5.

Referring to the figures, a dual fuel engine system 100 according to a second aspect of the invention comprising a control assembly 10 according to a first aspect of the invention is shown. The dual fuel engine system 100 is adapted to run on either diesel, or diesel and natural gas.

The dual fuel engine system 100 further comprises a diesel engine 102 having an engine block 104 including a plurality of cylinders 106 each defining a combustion chamber 108; an air intake system 110; an intake manifold 112 adapted to supply fluid into the combustion chambers 108; an exhaust manifold 114 adapted to expend fluid from the combustion chambers; an exhaust system 116; a diesel engine control unit 124; and a dual fuel engine control unit 128.

The control assembly 10 comprises an inlet 12 and an outlet 14, and is positioned within the dual fuel engine system 100 with the inlet 12 connected to, and in fluid communication with, the air intake system 110; and the outlet 14 connected to, and in fluid communication, with the intake manifold 112.

Air required to mix with a fuel to provide the correct conditions for efficient combustion will therefore flow from the air intake system 110 to the intake manifold 112 through the control assembly 10. The control assembly 10 may thus be used to control an air fuel ratio of a fuel and air mixture to be ignited in the combustion chambers 108 by controlling the air flow to the intake manifold 112.

The control assembly 10 further comprises a first fluid conduit 32 defining the input 12, a second fluid conduit 34 defining the output 14, an air control unit 16 positioned between the inlet 12 and the outlet 14, a gas injector assembly 18 adapted to be positioned between the air control unit 16 and the outlet 14, and a flow disruptor in the form of a fluid swirling device 24.

The air control unit 16, the gas injector assembly 18, and the fluid swirling device 24 will be described in more detail hereinbelow.

The input 12 is defined by a first end 54 of the first fluid conduit 32, and the output 14 is defined by a second end 38 of the second fluid conduit 34.

A second end 56 of the first fluid conduit 32 is in fluid communication with the air control unit 16 and is connected to a connector 48 coupled to the air control unit 16.

The connector 48 comprises a first section 50 that is receivable within the first fluid conduit 32 and a second section 52 that is adapted to abut a first end 44 of the air control unit 16.

The air control unit 16 is in fluid communication and detachably coupled to the gas injector assembly 18. In the embodiment shown, the gas injector assembly 18 comprises a first coupling member 40 adapted to receive a second end 46 of the air control unit 16 in order to detachably couple the gas injector assembly 18 to the air control unit 16.

In order to prevent unintentional disconnection, the connector 48, the air control unit 16 and the gas injector assembly 18 may be securely fastened together. These components may be fastened together by any suitable means, for example by means of a plurality of bolts 58 as shown in Figures 3 and 4.

The gas injector assembly 18 is in fluid communication with second fluid conduit 34, and is connected to a first end 36 of the second fluid conduit. The first end 36 of the second fluid conduit 34 and the gas injector assembly 18 may be connected together by any suitable means. In the embodiment shown, gas injector assembly 18 comprises a second coupling member 42 that is receivable within the first end 36 of the second fluid conduit 34 in order to connect the gas injector assembly 18 to the second fluid conduit 34.

The control assembly 10 includes a passageway 28 between the inlet 12 and outlet 14 through which fluid may pass. Air flowing from the air intake system 110 to the intake manifold 112 passes through the control assembly 10 via the passageway 28. In the embodiment shown, the passageway 28 is substantially circular in cross-section and extends through the first fluid conduit 32, the air control unit 16, the gas injector assembly 18, the fluid swirling device 24, and the second fluid conduit 34.

The passageway 18 thus provides a flow path between the components of the control assembly, such that air flowing from the air intake system 110 to the intake manifold 112 will pass through each of the components.

The air control unit 16 is adapted to control air flow through the passageway 28 as air passes from the inlet 12 to the outlet 14.

The air control unit 16 comprises a butterfly valve member 20 defined by a substantially circular disc 30 pivotally mounted within the air control unit 16 such that it is moveable between a fully open position O_p and a closed position O_c.

In the fully open position O_p, the disc 30 lies substantially parallel to a central axis of a portion of the passageway 28a that extends through the air control unit 16. In the closed position O_c, the disc 30 lies substantially perpendicular to the central axis of the portion of the passageway 28a that extends through the air control unit 16.

Movement of the disc 30 between the fully open position O_p and a closed position O_c will thus adjust the air flow between the inlet 12 and the outlet 14 through the passageway 28.

The disc 30 has a diameter that is the same as, or slightly smaller, than an internal diameter of the portion of the passageway 28a that passes through the air control unit 16. This means that when the butterfly valve member 20 is moved to its closed position O_c, it blocks the flow of air through the passageway 28. Thus movement of the disc 30 towards the closed position O_c will result in a reduction in air flow between the inlet 12 and the outlet 14, while movement of the disc 30 towards the fully open position O_p will allow an increase in air flow between the inlet 12 and the outlet 14.

The positioning of the butterfly valve member 20 is controlled by the dual fuel engine control unit 128 which is connected to the air control unit 16. The dual fuel engine control unit 128 may therefore vary the air fuel ratio of a gas and air mixture to be ignited in the combustion chambers 108 by increasing or decreasing the air flow between the inlet 12 and the outlet 13 as required.

The gas injector assembly 18 comprises a plurality of injector points 22, each adapted to inject a gas into a flow path of air flowing through the passageway 28 from the inlet 12 to the outlet 14 into the intake manifold 112.

By injecting a gas into the flow path of the air flowing through the passageway 28, mixing of the gas and air will occur prior to entry into the inlet manifold 112. This reduces the possibility of the gas and air not being sufficiently mixed prior to ignition.

The gas injector assembly 18 is connected to a gas injector driver 120 controlled by the dual fuel engine control unit 128. In another embodiment the dual fuel engine control unit and injector driver are combined in one unit.

The gas injector points 22 are connected to a delivery pipe 118 connected to a gas reservoir (not shown) adapted to contain within it the gaseous fuel for use in the dual fuel engine system 100.

Since the dual fuel control unit is connected to both the air control unit 16 and the gas injector assembly 18, the dual fuel control unit 128 is able to control the air fuel ratio of a gas and air mixture to be ignited by adjusting either the quantity of air or the quantity of gas entering the combustion chambers 108 through the intake manifold 112.

The fluid swirling device 24 is positioned within the passageway 28 between an injector point 22 of the gas injector assembly 18 and the outlet 14 and is adapted to facilitate the mixing of the gas and air before entry into the intake manifold 112 by increasing the rate of mixing of the gas and air.

The fluid swirling device 24 comprises a plurality of vanes 26 adapted to induce a swirling motion in a fluid passing between one or more vanes 26. The fluid swirling device 24 is adapted to fit within the passageway 28 such that the vanes 26 extend into the passageway 28 in order to disrupt the flow of fluid passing through the passageway 28. This may be achieved by vanes 26 which are spaced apart from each other and curved towards a centre of the fluid swirling device 24 as shown in Figure 2. Other configurations may however be used to disrupt the flow of fluid passing through the passageway 28.

The fluid swirling device 24 may be housed within a portion of the passageway 28 that extends through the gas injector assembly 18 proximate and downstream of the gas injector points 22. This will facilitate the mixing of the gas and the air as a swirling motion in the gas and air mixture will be induced soon after injection of the gas into the flow path of air flowing through the passageway 28.

In the embodiment shown the fluid swirling device 24 is housed within a portion of the passageway 28b that extends through the second coupling member 42.

As can be seen in Figure 5, each combustion chamber 108 has a diesel injector point 121 for injecting a quantity of diesel into the combustion chamber 108. The diesel is supplied to the injector points via a diesel delivery pipe (not shown), . The amount of diesel injected into each combustion chamber 108 is controlled by the diesel engine control unit 124, via electrical signals along the injector wires 122.

The engine system 100 comprises a plurality of performance sensors 126 including, but not limited to, an accelerator pedal sensor, an engine temperature sensor, an air temperature sensor, a cam sensor, a crank sensor and a vehicle speed sensor. The form of the performance sensors 126 is known in the art and will therefore not be described in detail.

During the operation of the engine system 100, data from the performance sensors 126 is constantly transmitted to the dual fuel and the diesel engine control units 128, 124 while the diesel engine 102 is running.

The interface of the performance sensors 126 with the engine control units 124, 128 is shown in Figure 6.

The data measured by the performance sensors 126 are inputted into the diesel engine control unit 124 and the dual fuel control unit 128. The diesel engine control unit 124 and the dual fuel control unit 128 use this data to control the timing, and the quantity of fuel and air injected into each combustion chamber 108 during a combustion cycle.

If the diesel engine 102 is running on diesel only, the quantity of fuel will be determined solely by the diesel engine control unit 124. The dual fuel control unit 128 will be dormant, and the butterfly valve member 20 of the air control unit 16 will be fully open.

Where the diesel engine 102 is running on diesel and natural gas, the dual fuel control unit 128 will instruct the gas injector driver 120 to inject a quantity of gas into the flow path of air flowing into intake manifold 112 from the air intake system 110. It will also reduce the amount of diesel injected by the diesel engine control unit 124, by modifying the signals received from the sensors 126, to avoid over-fuelling. The injection of gas will occur downstream the air control unit 16.

The gas and air mixture will then pass through the fluid swirling device 24 positioned downstream the gas injector points 22. The fluid swirling device 24 will induce a swirling motion in the gas and air mixture which will increase the rate of mixing of the gas and air, as explained hereinabove.

The mixed gas and air will pass into the intake manifold 112 via the first fluid conduit 32, and be drawn into a combustion chamber 108 at the intake phase of the combustion cycle.

The diesel engine control unit will inject an amount of diesel into the combustion chamber 108 to produce a heat source to ignite the gas and air mixture.

During the exhaust phase of the combustion cycle, the expended gas and air mixture is expelled from the combustion chamber 108 into the exhaust system 116 via the exhaust manifold 114.

An oxygen sensor 130 is positioned within the exhaust system 116 for measuring the amount of oxygen present in the expelled mixture. The oxygen sensor 130 provides data in relation to the amount of oxygen present in the expelled fuel. This data is fed to the dual fuel engine control unit 128 and is used to adjust the air fuel ratio of the gas and air mixture to be ignited in the combustion chambers 108.

CLAIMS

1. A control assembly for a dual fuel engine system comprising:

an inlet and an outlet;

an air control unit positioned between the inlet and the outlet, adapted to control air flow between the inlet and the outlet; and

a gas injector assembly adapted to be positioned between the air control unit and the outlet, the gas injector assembly having an injector point adapted to inject a gas into an air flow path in communication with the outlet.

2. A control assembly according to Claim 1 wherein the gas injector assembly comprises a plurality of injector points.

3. A control assembly according to Claim 2 wherein the plurality of injector points are located around a periphery of the gas injector assembly.

4. A control assembly according to any one of the preceding claims further comprising a flow disruptor adapted to disrupt the flow of a fluid through the outlet.

5. A control assembly according to any one of the preceding claims wherein the flow disruptor comprises a fluid swirling device positioned between an injector point of the gas injector assembly and the outlet.

6. A control assembly according to Claim 5 wherein the fluid swirling device comprises a plurality of vanes adapted to induce a swirling motion in a fluid passing between one or more vanes.

7. A control assembly according to Claim 5 or Claim 6 wherein the fluid swirling device is housed within the gas injector assembly.

8. A control assembly according to any one of the preceding claims wherein the air control unit comprises a butterfly valve member.

9. A control assembly according to any one of the preceding claims wherein the air control unit is detachably coupled to the gas injector assembly.

10. A control assembly according to any one of the preceding claims further comprising a first fluid conduit in fluid communication with the air control unit.

11. A control assembly according to any one of the preceding claims further comprising a second fluid conduit in fluid communication with the gas injector assembly, and having a first end defining the output, and a second end connected to the gas injector assembly.

12. A control assembly according to any one of the preceding claims further comprising a dual fuel engine control unit.

13. A control assembly according to Claim 12 wherein the dual fuel engine control unit is connected to the air control unit.

14. A control assembly according to Claim 12 or Claim 13 wherein the dual fuel engine control unit is connected to the gas injector assembly.

15. A control assembly according to any one of Claims 11 to 13 further comprising an oxygen sensor in communication with the dual fuel engine control unit.

16. A dual fuel engine system comprising
a dual fuel engine including a combustion chamber;
an air intake system;
an intake manifold adapted to supply fluid into the combustion chamber;
an exhaust manifold adapted to expend fluid from the combustion chamber;
an exhaust system in communication with the exhaust manifold; and
a control assembly according to any one of the preceding claims wherein the inlet of the control assembly is connected to the air intake system, and the outlet of the control assembly is connected to the intake manifold.

17. A dual fuel engine system according to Claim 16 when dependent on Claim 14, wherein the oxygen sensor is positioned within the exhaust system.

18. A method of mixing air and gaseous fuel in a dual fuel engine system comprising the steps of:

(a) connecting a control assembly according to any one of Claim 1 to Claim 15 to an intake manifold of a dual fuel engine;

(b) directing air towards the intake manifold via the air control unit;

(c) injecting gas into the air by means of an injector point of the gas injector assembly; and

(d) mixing the gas and air together upstream of the intake manifold and prior to entry into a combustion chamber of a dual fuel engine.

19. A method according to Claim 18 wherein a ratio of gas and air in a mixture to be mixed in step (d) is calculated according to data obtained from an oxygen sensor in a vehicle exhaust system.

20. A control assembly for a dual fuel engine system as substantially hereinbefore described with reference to and/or illustrated in the accompanying drawings.

21. A dual fuel engine system as substantially hereinbefore described with reference to and/or illustrated in the accompanying drawings.

22. A method of mixing air and gaseous fuel in a dual fuel engine system as substantially hereinbefore described with reference to and/or illustrated in the accompanying drawings.

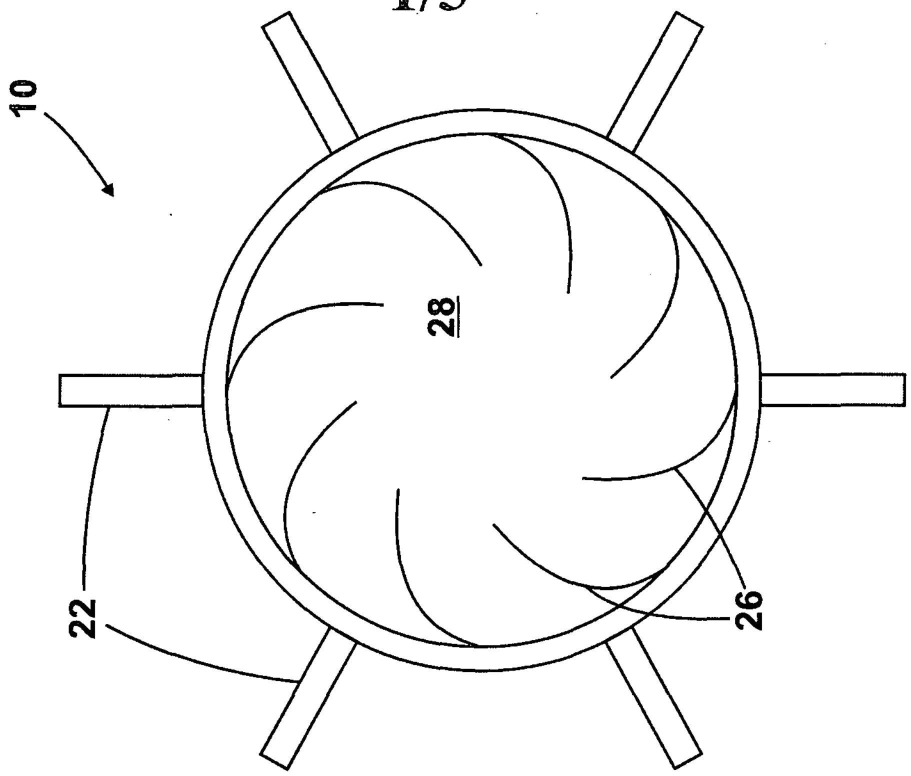


Fig. 2

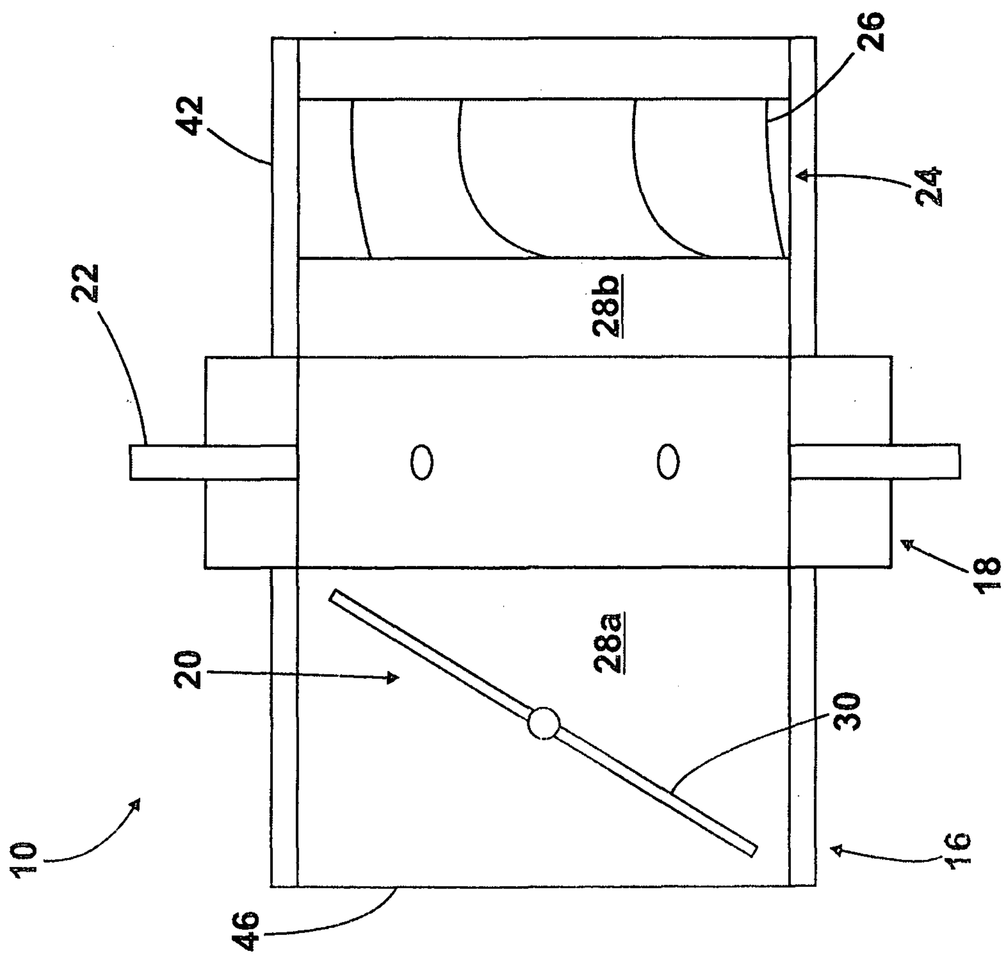


Fig. 1

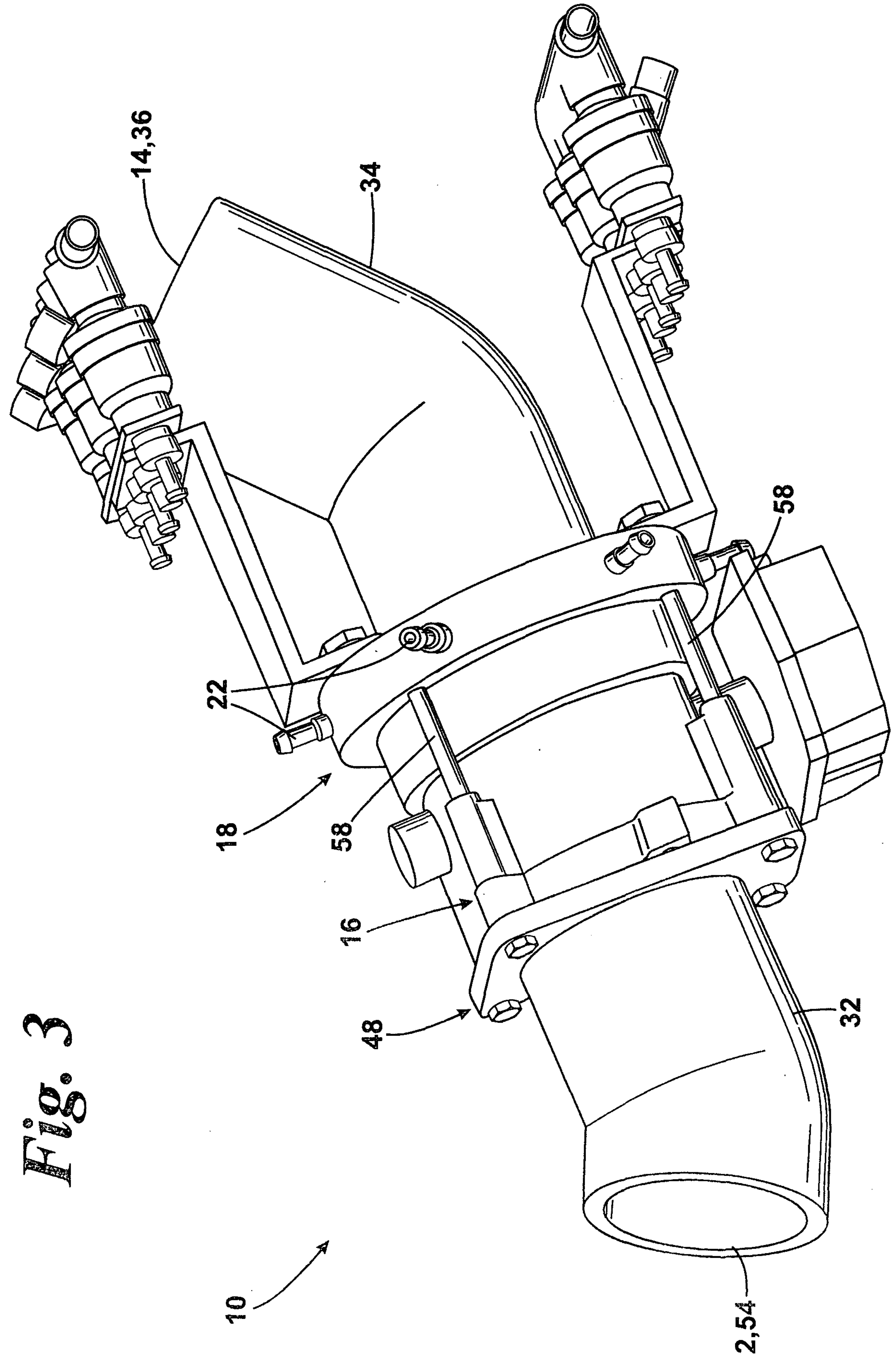


Fig. 3

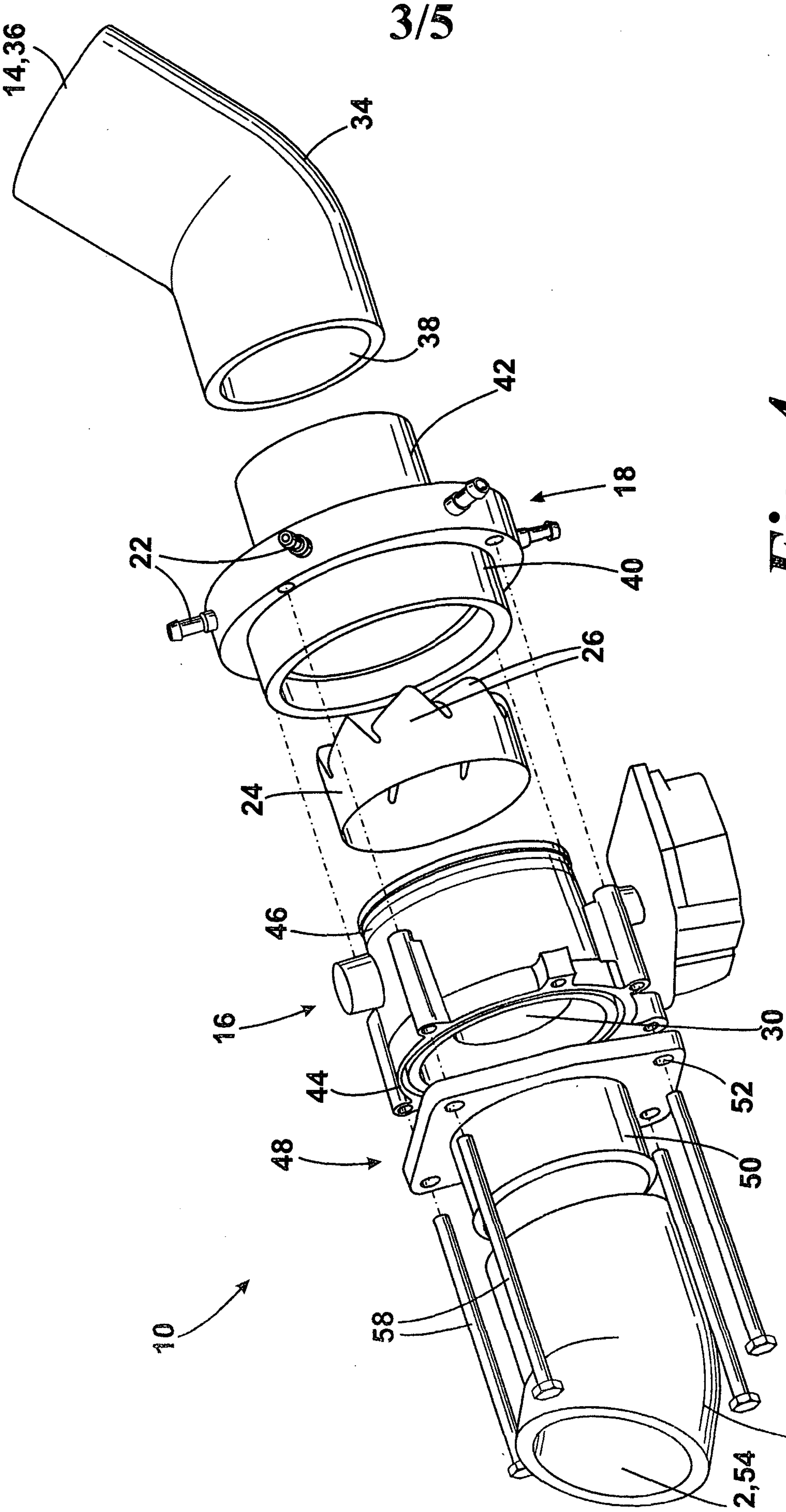


Fig. 4

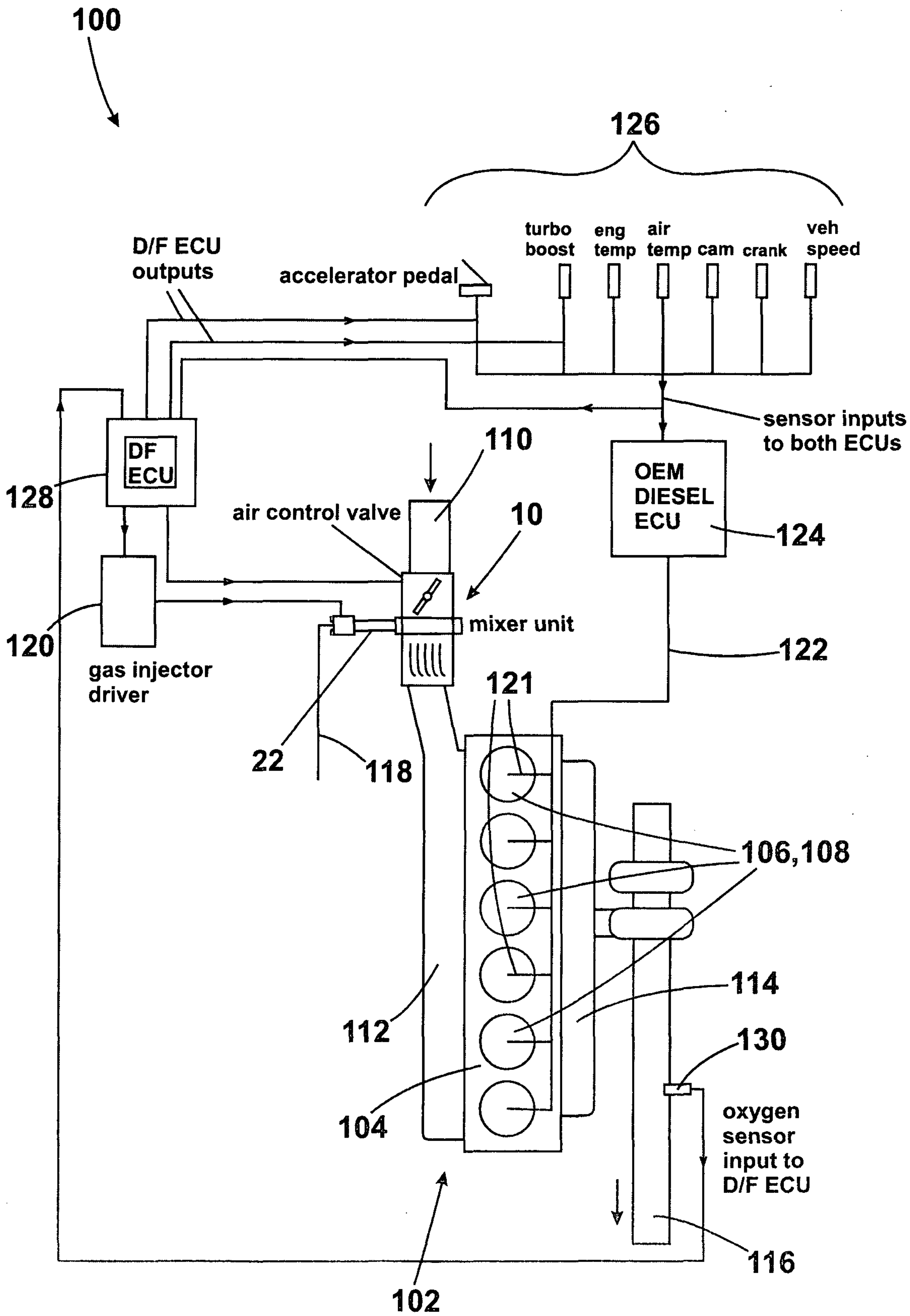
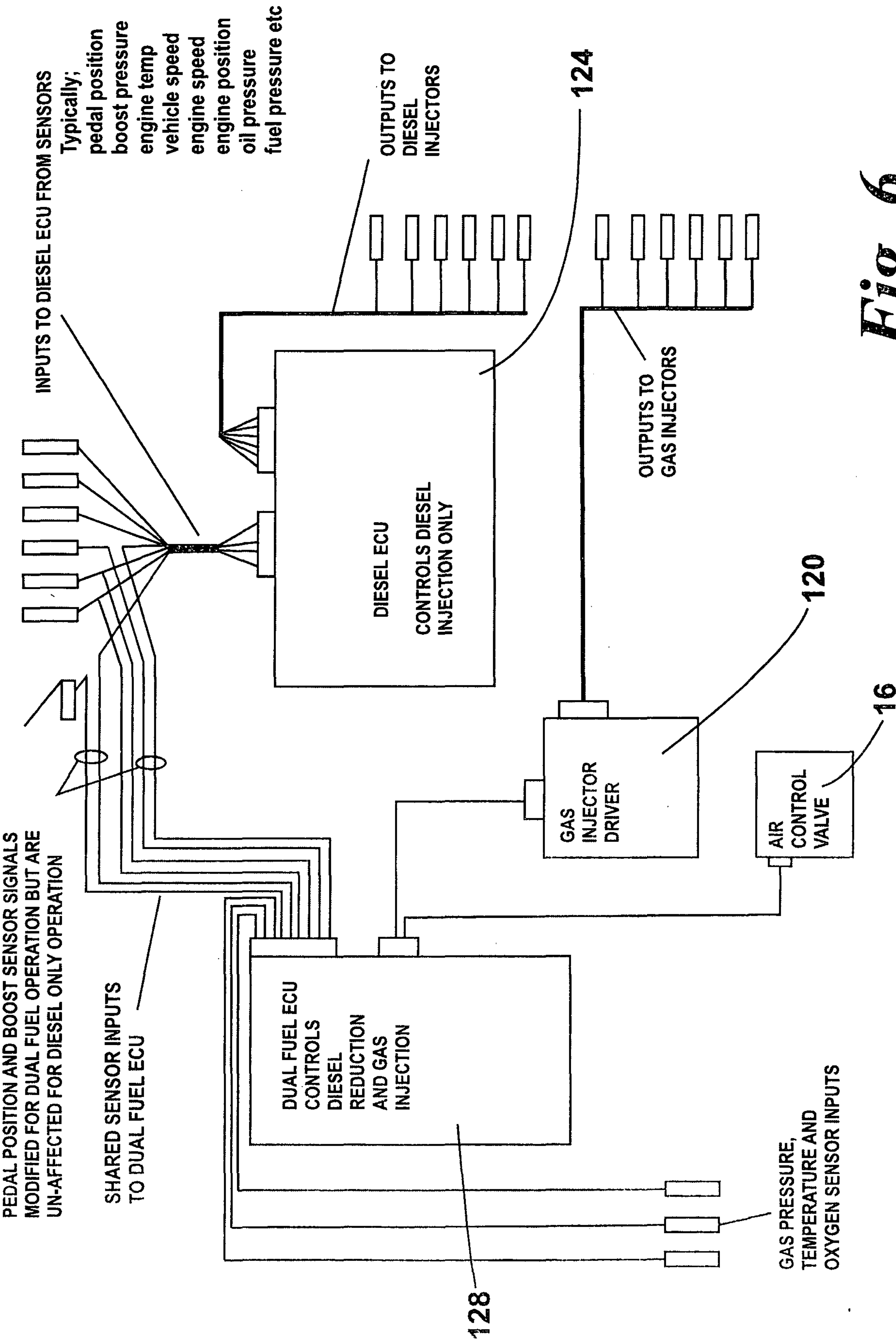

100
126
turbo boost
eng temp
air temp
cam
crank
veh speed
D/F ECU outputs
accelerator pedal
sensor inputs to both ECUs
DF ECU
128
110
air control valve
10
OEM DIESEL ECU
124
mixer unit
120
gas injector driver
122
121
22
118
106,108
114
112
130
104
oxygen sensor input to D/F ECU
116
102

Fig. 5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Typically;
pedal position
boost pressure
engine temp
vehicle speed
engine speed
engine position
oil pressure
fuel pressure etc
OUTPUTS TO DIESEL INJECTORS
124
DIESEL ECU
CONTROLS DIESEL INJECTION ONLY
OUTPUTS TO GAS INJECTORS
120
GAS INJECTOR DRIVER
16
AIR CONTROL VALVE
PEDAL POSITION AND BOOST SENSOR SIGNALS MODIFIED FOR DUAL FUEL OPERATION BUT ARE UN-AFFECTED FOR DIESEL ONLY OPERATION
SHARED SENSOR INPUTS TO DUAL FUEL ECU
DUAL FUEL ECU CONTROLS DIESEL REDUCTION AND GAS INJECTION
GAS PRESSURE, TEMPERATURE AND OXYGEN SENSOR INPUTS
128

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/001445

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M21/04

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)
F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CA 2 165 658 A1 (NISSAN DIESEL MOTOR CO [JP]) 9 November 1995 (1995-11-09) page 8, line 3 - page 8, line 26; figures 4,7	1-4,6-8, 10-22
X	GB 2 284 016 A (BRITISH GAS PLC [GB]) 24 May 1995 (1995-05-24) page 7, line 8 - page 9, line 10; figures 2,4	1-5, 7-14,16, 18,20-22
X	US 2007/074452 A1 (YATES KRISTIAN W [US]) 5 April 2007 (2007-04-05) paragraph [0037] - paragraph [0041]; figures 1,5	1,2, 4-14,16, 18,20-22

-/--

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 August 2008	02/09/2008

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Marsano, Flavio

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	US 2002/148451 A1 (YAMAMOTO TAKAYUKI [JP] ET AL) 17 October 2002 (2002-10-17) paragraph [0101] - paragraph [0104]; figures 1,16	1-7, 10-14, 16,18, 20-22

INTERNATIONAL SEARCH REPORT

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International application No
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