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

(11) **EP 0 794 329 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
10.09.1997 Bulletin 1997/37

(51) Int Cl.⁶: **F02M 59/44**

(21) Application number: **97301475.6**

(22) Date of filing: **05.03.1997**

(84) Designated Contracting States:
DE ES FR GB IT

(30) Priority: **07.03.1996 GB 9604897**

(71) Applicant: **LUCAS INDUSTRIES public limited company**
Solihull, West Midlands B90 4LA (GB)

(72) Inventor: **Felton, George Nicholas**
Gillingham, Kent (GB)

(74) Representative: **Lawrence, John**
Barker, Brettell & Duncan
138 Hagley Road
Edgbaston
Birmingham B16 9PW (GB)

(54) **Fuel injection pump for internal combustion engine**

(57) An apparatus and method for measuring the temperature of diesel fuel within a fuel injection pump (1) is disclosed. The pump (1) has wet (12) and dry (9) sides. The dry side (9) contains the electronics (6) necessary to run the pump (1), and has no diesel fuel within it. Fuel is present in the wet side (12). Pins (14, 16, 18, 20) pass, in a sealed manner, from the wet (12) side to the dry side (9), and are provided for the purpose of passing electrical signals from the electronics (6) in the dry side to sensors (29) in the wet side (12). The pins (14, 16, 18, 20) are metallic, and are in contact with the fuel in the wet side (12). A thermistor (50) is mounted on one of the pins (14) and is used to measure the temperature of the fuel.

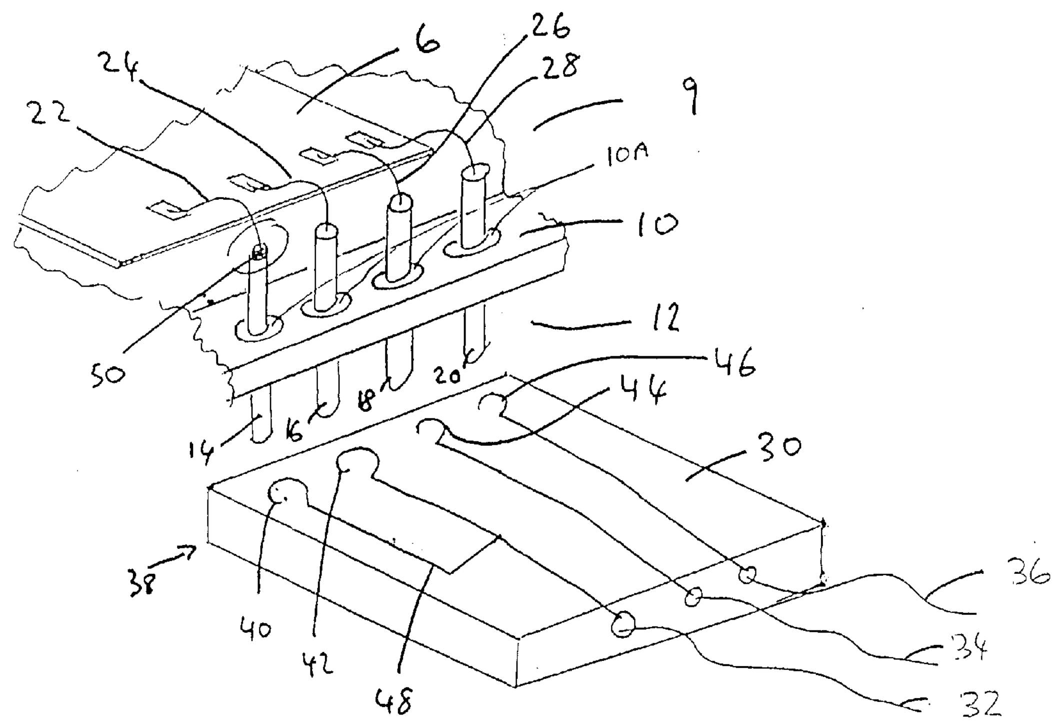

FIGURE 3

EP 0 794 329 A1

Description

This invention relates to an improved apparatus and method for measuring the temperature of fuel within an internal combustion engine's fuel injection pump, especially, but not exclusively, within diesel engines, especially (but not exclusively) vehicle diesel engines.

It is well known to measure the temperature of diesel fuel within a diesel injection pump. As the fuel temperature varies, the fuel's viscosity, density and other physical properties vary and thus, unless the temperature variation is compensated for, the amount of fuel injected into the engine's cylinders on each injection cycle will vary with the temperature.

By monitoring the temperature of the fuel it is possible to achieve better performance.

It will be realised that the operating conditions within a diesel injection pump present a particularly harsh operating environment for electronic devices. Diesel fuel degrades the physical properties of plastics, and the temperatures and pressures within the pump are detrimental to the proper functioning of the electronic devices Thus, if an electronic / electrical means is to be used to measure the temperature of the diesel fuel then steps need to be taken to protect the device from the environment of the interior of the injection pump.

Previous systems have measured the temperature of the fuel by embedding a thermistor within a plastics housing. Such a housing allows the thermistor to be placed in the diesel fuel whilst keeping the fuel away from the thermistor and its associated wiring.

There are various problems associated with embedding the thermistor in plastics. Firstly, the housing introduces hysteresis into the temperature reading and thus affects the temperature reading taken by the thermistor.

To embed the thermistor into the plastics material it is necessary to use an encapsulated thermistor. Such encapsulated thermistors are relatively expensive, when compared to other types of thermistor. Obviously if a slight cost saving is made per pump, large savings will be made on a production run of pumps.

Also, embedding the thermistor within the plastics housing affects the type of plastics material which must be used for the housing. To embed the thermistor within the housing molten plastics must be passed around the thermistor. Traditionally plastics with a low injection temperature have been used. If the temperature of the molten plastics is too high then the thermistor can be damaged or destroyed. However, plastics materials with relatively low injection temperatures are more readily degraded by diesel fuel. Thus, the selection of the plastics material for the housing is a compromise between one having a low enough injection temperature for moulding so as not to destroy the thermistor and one having a good resistance to degradation by diesel fuel.

An aim of this invention is to provide an alternative way of providing a temperature sensor.

According to a first aspect of the invention we provide a pump adapted to pump fuel, which has a wet side and a dry side, and which contains a temperature sensor, the temperature sensor being mounted in the dry side of the pump, and there being heat conduction means provided to conduct heat from the fuel of the wet side of the pump to the temperature sensor.

Such an arrangement removes the necessity to embed the temperature sensor within a plastics housing. It is of course realised that in the dry side of the pump there is no fuel to attack the sensor.

Preferably the pump is a diesel fuel injection pump.

Preferably the temperature sensor is not encapsulated in a protective plastics block.

The pump is preferably electronically controlled.

Preferably the temperature sensor is surface mountable. Some advantages of using such a surface mountable device are that such devices are relatively cheap, being simple and not encapsulated in a protective surround, and occupy a small volume when compared to other types of temperature sensor, and can be fitted in a restricted space.

Preferably there is a dividing member which separates the wet side of the pump from the dry side of the pump. Such a dividing member serves to ensure that no fuel can enter into the dry side of the pump.

The temperature sensor is preferably provided at, or close to, the dividing member. This reduces hysteresis in temperature measuring (of the fuel).

The dividing member may have one or more electrically conducting members connecting the wet side of the pump to the dry side of the pump. Such conducting members may allow electrical signals to be passed from the wet side of the pump to the dry side of the pump (for example electrical signals from other sensors in the pump, such as a position sensor).

The heat conduction means may comprise the, or one of the, electrically conducting member(s).

The electrically conducting members may comprise pins. The electrically conducting member or members may pass through the dividing member. The electrically conducting member(s) may be moulded into the dividing member. An advantage on moulding the pins (electrically conducting member(s)) into'the dividing member is that an effective seal is formed between the pin and the dividing member which prevents fuel from passing between the wet side and the dry side of the pump. Also the pin is thermally insulated from, for example, the casing of the fuel injection pump.

Alternatively only part of the conducting member may be a pin.

Preferably the electrical conducting members are metal. The temperature sensor is preferably mounted on at least one conducting member.

Metallic conducting members will also conduct heat well. Since the electrically conducting members pass from the wet side of the pump to the dry side of the pump, the end of the conducting member in the wet side of the pump will be in contact with the fuel. Thus, heat from the fuel may be conducted to the dry side of the pump via the electrically and thermally conducting member and the temperature sensor may be able to measure the temperature of the fuel by measuring the temperature of the electrically and thermally conducting member.

An electrically conducting member passing through the dividing member may be provided for a purpose in addition to that of sensing the temperature of the fuel. An advantage of this is that more efficient use is made of the components and thus the pump is more economical to construct.

The electrically conducting members may be provided to conduct electrical signals from and/or to other sensors situated in the wet side of the pump. Other sensors may be required by electronics provided to run the pump in a manner so as to achieve the desired operation of the engine.

The conducting member on which the temperature sensor is mounted may provide power to one or more of the sensor(s) mounted in the wet side of the pump. The performance of the sensor, in the wet side of the pump, is not affected by the addition of the temperature sensor to the same voltage regulated power supply.

Preferably the temperature sensor is a thermistor. Thermistors may be more robust and/or cheaper than other known suitable temperature sensors.

The pump may have a position sensor adapted to detect one or more points in the fuel injection cycle.

According to a second aspect of the invention we provide a diesel internal combustion engine provided with a pump according to the first aspect of the invention.

The diesel engine is preferably a vehicle diesel engine, and most preferably an automobile engine.

According to the third aspect of the invention we provide a method of obtaining a temperature sensor signal in a diesel fuel injection pump which has a wet side and a dry side, the method comprising mounting the temperature sensor in the dry side of the pump, and conducting heat from the fuel of the wet side of the pump to the sensor.

Preferably the method further comprises using a communication member to connect the wet and dry sides thermally and electrically, and using the communication member as part of a power circuit to power the temperature sensor which is in thermal contact with the communication member.

According to a fourth aspect of the invention we provide pump control electronics comprising a barrier, thermal bridge means, and electric coupling means, and which is adapted to be fitted to a diesel fuel injection pump.

Preferably temperature sensing means are provided and preferably the temperature sensing means are adapted to measure the temperature of the thermal bridge means.

Preferably the temperature sensing means are in a dry side of the pump. An advantage of this is that the temperature sensing means can be made simpler and cheaper because the operating conditions in the dry side of the pump are less severe.

One embodiment of the first aspect of the invention will now be described in detail, by way of example only, with reference to the accompanying drawings of which:-

Figure 1 shows a cross section of an injection pump for a diesel engine utilising the invention;

Figure 2 shows a second cross section of the injection pump taken along line AA of Figure 1;

Figure 3 shows a temperature sensor mounted according to the invention; and

Figure 4 shows the temperature sensor of Figure 3 in more detail.

Figures 1 to 4 show a compact electronically controlled rotary diesel fuel injection pump designed to be used in diesel engines.

The pump 1 as best seen in Figures 1 and 2, is provided with three solenoid actuated valves one of which controls the collapse of pressure within the pump and injector (2), and one which controls the injection timing (not shown). The third solenoid (3) is for the engine stopping. Four pistons 52, 54, 56, 58 are provided which pressurise the fuel and pressures in excess of 100MPa can be generated. The rotor 60 in which the pistons are mounted rotates and rotation of the rotor 60 causes the pistons 52, 54, 56, 58 to be moved inwards by the cam ring 62. Fluid pressure causes the pistons 52, 54, 56, 58 to follow the cam ring 62.

The cam ring 62 can itself be rotated over a limited range and such rotation affects the point in the engine cycle in which the diesel fuel is injected in to the engine (that is advances or retards the start of combustion).

Other notable features of the pump, which will be obvious to a person skilled in the art are: a spill accumulator 200, a low pressure transfer pump 202, a transfer pressure regulator 204, a spill valve 208 and an aluminium housing 210.

A pump control unit (PCU) electronics 6 is constructed using bare chip wire technology and is therefore small and robust enough to be mounted within a housing 8. The components of the PCU are mounted on ceramic substrates which are bonded to a metal (in this case aluminium) casting. The casting also forms the top enclosure for the mechanical parts of the pump. A first region 9 around the control electronics 6 comprises a portion of a dry side of the pump 1. No diesel fuel is present in the dry side of the pump 1. The PCU electronics comprise electronic components mounted as described above.

Electrical paths are defined through the aluminium casting (for various sensors and actuators needed to operate the pump) by means of connectors using glass to metal hermetic sealing technology. A moulded lead frame surrounds the perimeter of the PCU and provides electrical paths from external connectors to the wire bonds to the components.

A dividing member 10 separates the first region 9 from a second region 12, which comprises a portion of a wet side of the pump 1. Diesel fuel is free to flow within the wet side of the pump 1. A seal 13 is provided to seal the dividing member to the casting 999.

The dividing member 10 is best seen in Figure 3 and comprises a substantially rectangular member of metal. Four metallic pins 14,16,18,20 are sealingly moulded with glass 10A into the dividing member 10 and pass through the dividing member 10. Thus the four pins 14,16,18,20 pass from the first region 9 (the dry side of the pump) to the second region 12 (the wet side of the pump). It will be realised that four pins are shown only by way of example and any other number of pins may also be used.

A sensor 29 (which in this example is a hall effect sensor) is provided in the second region 12 and senses the position of a rotatable cam 62 in relation to the drive shaft. It also indicates the speed of the drive shaft and which cylinder the pump is injecting into. Signals from this sensor are passed to the PCU via one of the pins. Power for the sensor 29 is also provided by one of the pins.

Four connecting wires 22, 24, 26, 28 connect each of the four pins to the pump control electronics 6 and are attached to the control electronics 6 using conventional techniques, for example wire bonding, welding, etc.

A connector 30 of plastics material is provided which contains three sensor wires 32, 34, 36 which pass to the sensor 29. (The wires 32, 34, 36 are shown only in Figure 3 for reasons of clarity.) The three sensor wires 32, 34, 36 are embedded into the connector 30 at the time of manufacture.

At an end region 38 of the connector 30 there are provided four holes (not shown) of complementary size to the lower end portions of the pins 14, 16, 18, 20. Within the connector 30 there are provided electrical contacts 40, 42, 44, 46 which communicate with the holes in the end region of the connector 30.

The sensor wire 32 conducts power to the sensor 29 and is branched to form a branched wire 48 within the connector 30. The branched wire 48 connects the sensor wire 32, carrying power to the sensor 29, to the electrical contact 40. The sensor wires 32, 34, 36 connect to the electrical contacts 42, 44, 46 respectively.

On an upper portion of pin 14, within the first chamber 9, is a surface mountable thermistor 50 (shown in greater detail in Figure 4) which is soldered to the pin 14. The connecting wire 22 connects the thermistor 50 to the control electronics 6, a further electrical supply connection being provided through the pin 14.

In the completed pump 1 the connector 30 is positioned next to the dividing member 10 so that the lower portions of the pins 14, 16, 18, 20 are within the complementary holes in the end region of the connector 30. The pins 14, 16, 18, 20 are in electrical contact with the electrical contacts 40,42,44,46. Power is provided to the sensor 29 via connecting wire 24, pin 16, electrical contact 42 and sensor wire 32. The pump control electronics receives signals from the sensor 29 via connecting wires 26,28, pins 18,20, electrical contacts 44,46 and sensor wires 34,36.

From the preceding paragraph it will be clear that the branched wire 48, the electrical contact 40, the pin 14, and the connecting wire 22 do not communicate any signal to the sensor 29. Thus, any variation imposed, by the thermistor 50, on the current passing through the pin 14 will not affect any reading taken, by the PCU electronics 6, of the sensor 29.

The holes in the connector 30 which receive the lower portions of the pins 14, 16, 18, 20 are large enough to allow fuel to pass into the holes and thus contact the pins 14, 16, 18, 20. Thus, the pins 14, 16, 18, 20 are in contact with the fuel in the second chamber 12. As the pin 14 is metallic it is a good conductor of heat as well as a conductor of electricity. Thus, heat from the fuel is conducted along pin 14 to the thermistor 50. The PCU electronics 6 can, by analysing the thermistor 50, determine the temperature of the pin 14 and thus, the temperature of the fuel which the pin is in contact with.

The PCU electronics 6 are connected to engine control electronics via an electrical interface 52A.

Prior art temperature sensors have relied on embedding a thermistor within the connector 30 in the branched wire 48. As discussed in the preamble of the specification embedding a thermistor in a housing of plastics material has many disadvantages which are overcome by mounting the thermistor to the dry side of the pump, and preferably on the portion of a pin that projects through to the dry side from the wet side.

It will be realised that the invention may be performed with an embodiment other than that shown in Figures 1 to 4.

The PCU electronics 6 plays an important role in smooth running of the engine to which it is connected. To put the invention in context this role will now be briefly described.

The PCU 6 provides control of the pump in response to signals from the engine control unit and to pump operating conditions. Connection of the PCU 6 to the engine control unit is via a suitable interface/data link.

The PCU electronics 6 is programmed when the pump is calibrated, at the end of the assembly line, with pump and application specific data. Using the stored program, application specific data, and data from internal sensors including the thermistor as described herein the PCU electronics 6 controls the fuel delivery, advance position, and safety shut off actuators of the pump.

To allow the PCU electronics 6 to control the fuel quantity and timing, it has inputs of the position of the drive shaft and cam ring 62 at all times. To provide these a sensor 29, continuously, monitors a set of teeth formed on the outer surface of the drive shaft.

The pump is of a two stage design using the low pressure 202 (or transfer pump) to transfer fuel from a tank to the pump itself. A high pressure stage then produces a pressure necessary for injecting the fuel. The PCU electronics 6, operates the solenoid valve 2 to control the quantity of fuel injected into the engine on each cycle.

A regulator is provided, in an end plate, to control the transfer pressure generated at levels up to 2MPa.

The PCU electronics 6 calculates the angular position of the pump cam required to give the specified start of injection timing demanded by the engine control unit. The calculated position of the cam is compared with the actual angular position of the cam derived from the signals from sensor 29, and a pulse width modulated signal is applied to an advance control valve to adjust/modify a control pressure. This change of control pressure corrects the position of the advance and hence that of the cam ring.

The pump communicates over the data link and obtains data, including fuel quantity and timing requests from the engine control unit before each injection.

The pump can thus fit into a pre-determined engine management strategy as operated by an engine control unit.

The pump can also be configured to act as a stand alone engine controller, and in this mode the pump will communicate with the necessary sensors (for instance for determining the crankshaft position and operator demand) via a suitable interface.

The pump may be able to operate the engine at reduced operating conditions if the main engine control unit malfunctions, and thus allow the engine to continue operation.

Claims

1. A pump adapted to pump fuel, which has a wet side (12) and a dry side (9) and which contains a temperature sensor (50) characterised in that the temperature sensor (50) is mounted in the dry side (9) of the pump (1), and there being heat conduction means (14) provided to conduct heat from the fuel of the wet side (12) of the pump (1) to the temperature sensor (50).

2. A pump according to claim 1 characterised in that the pump (1) is a diesel fuel injection pump.

3. A pump according to claim 1 or claim 2 characterised in that a dividing member (10) is provided which ensures that the wet side (12) of the pump (1) is separated from the dry side (9) of the pump (1).

4. A pump according to claim 3 characterised in that the temperature sensor (50) is provided substantially at, or close to, the dividing member (10).

5. A pump according to claim 3 or claim 4 characterised in that the dividing member (10) has one or more electrically conducting members (14, 16, 18, 20) connecting the wet side (12) of the pump (1) to the dry side (9) of the pump (1).

6. A pump according to claim 5 characterised in that the heat conduction means comprise the, or at least one, electrically conducting member (14, 16, 18, 20).

7. A pump according to claim 5 or claim 6 characterised in that the temperature sensor (50) is mounted on this, or or at least one, conducting member (14, 16, 18, 20).

8. An internal combustion engine characterised in that said engine is provided with a pump according to any of claims 1 to 7.

9. A method of obtaining a temperature sensor signal in a fuel injection pump (1) having a wet side (12) and a dry side (9), characterised in that it comprises mounting a temperature sensor (50) in the dry side (9) of the pump (1), and conducting heat to the sensor (50) from fuel contained in the wet side (12) of the pump (1).

10. Pump control electronics adapted to be fitted to a fuel injection pump (1) characterised in that said electronics comprises a barrier (10), thermal bridge means (14, 16, 18, 20), and electronic coupling means.

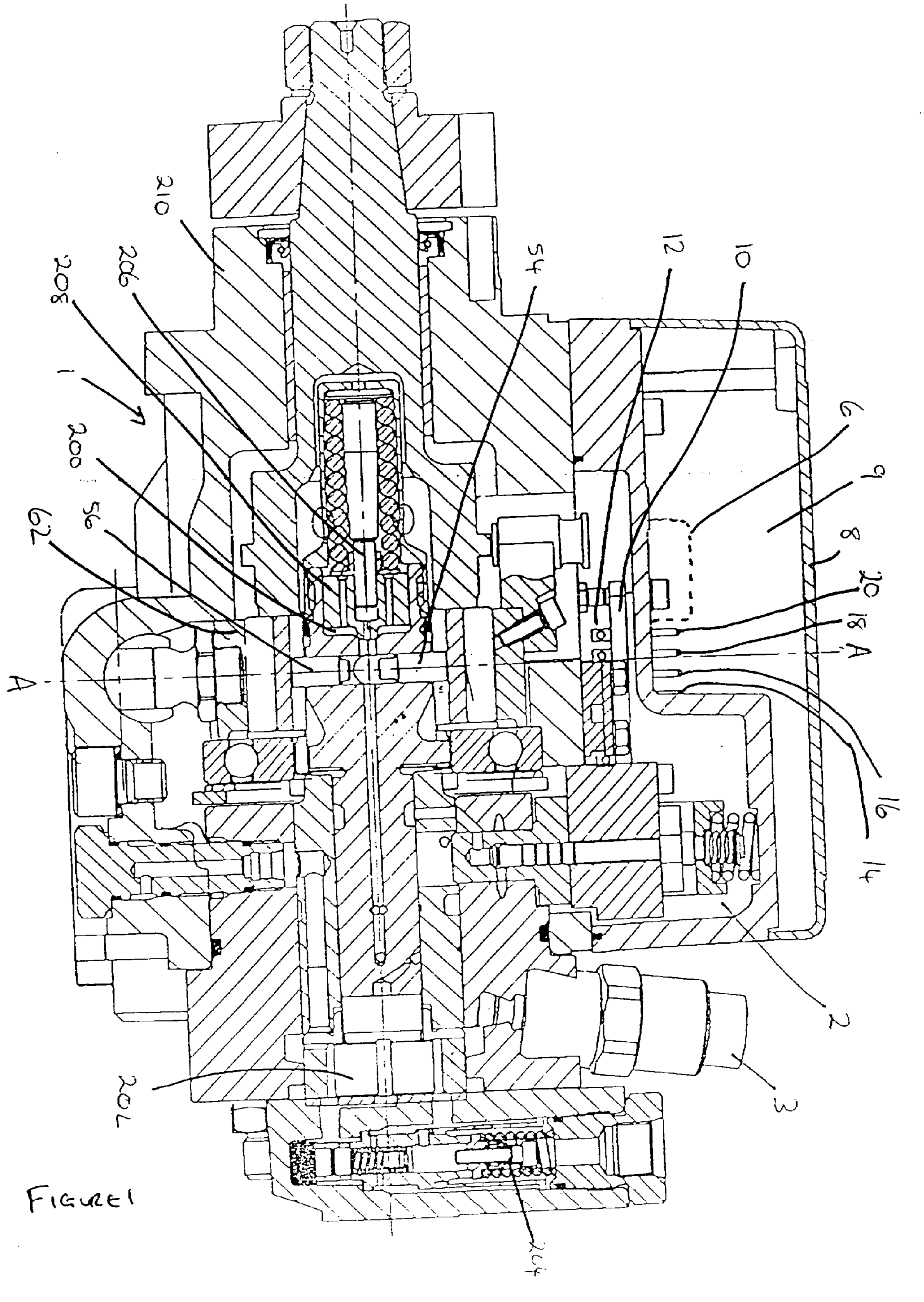

FIGURE 1

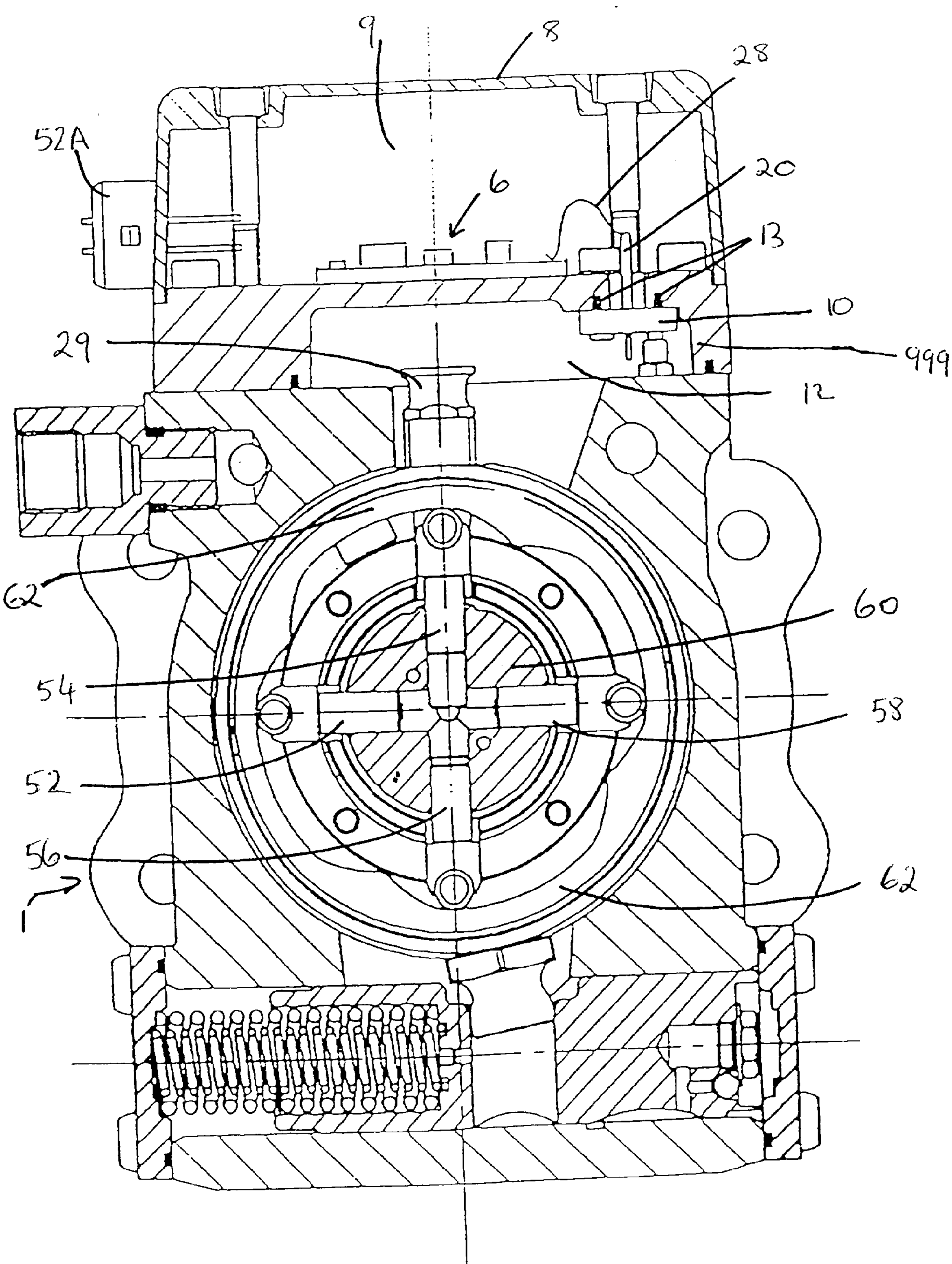

Figure 2

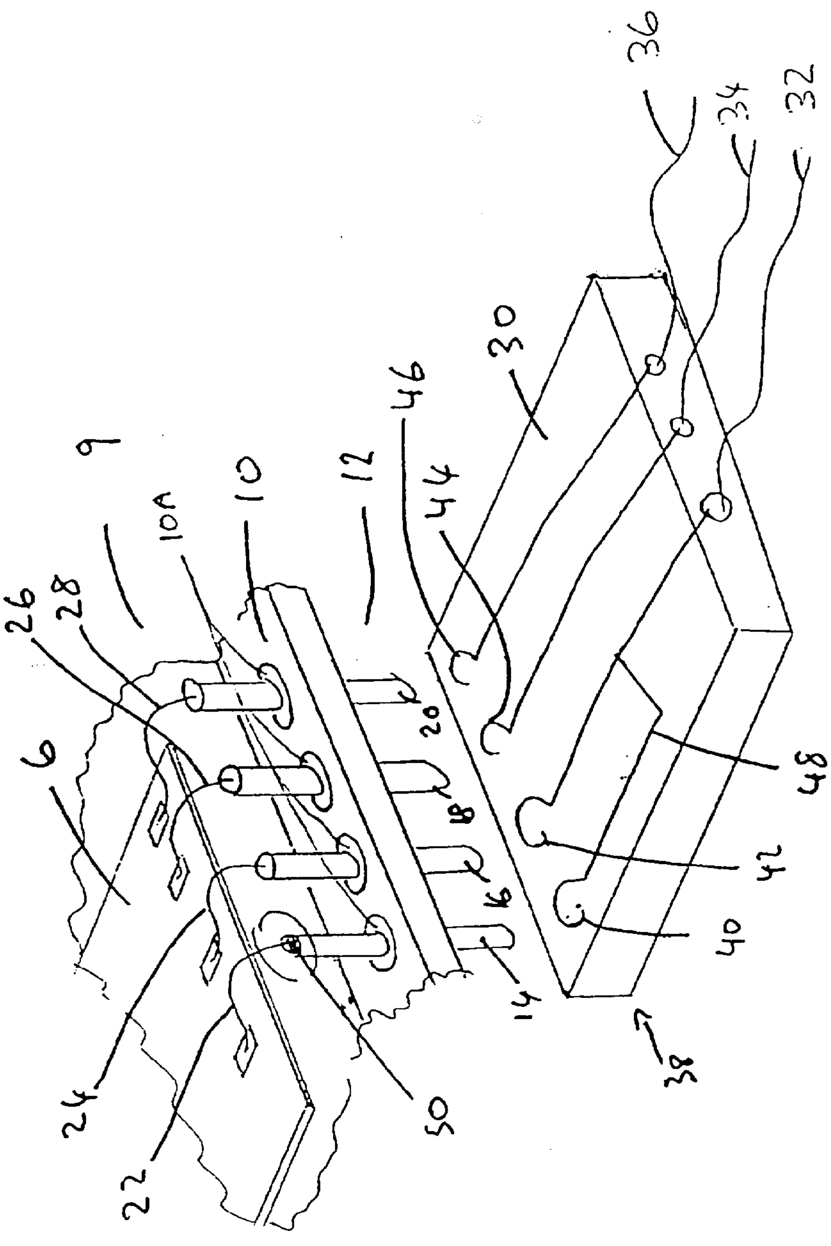

FIGURE 3

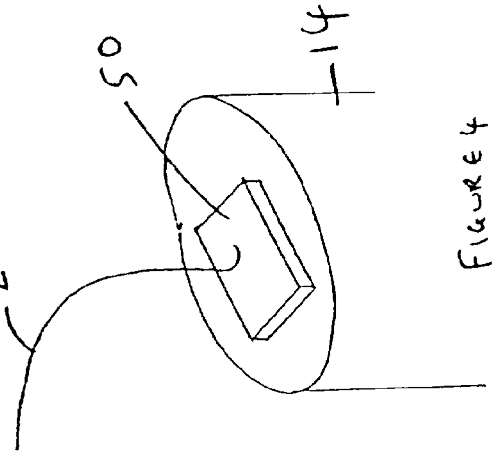

FIGURE 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 1475

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)
X	DE 42 11 810 A (BOSCH GMBH ROBERT) 14 October 1993	1-4,8-10	F02M59/44
Y	* page 2, line 46 - line 68 *	5	
	* page 3, line 48 - line 61; figure 1 *		
Y	PATENT ABSTRACTS OF JAPAN vol. 011, no. 050 (M-562), 17 February 1987 & JP 61 212661 A (NIPPON DENSO CO LTD), 20 September 1986,	5	
A	* abstract *	1-4	
A	US 4 768 024 A (HAUFF WERNER) 30 August 1988 * column 5, line 41 - line 45; figure *	6,7	
A	EP 0 316 581 A (BOSCH GMBH ROBERT) 24 May 1989		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F02M
F02D
H02G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 June 1997	Friden, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document