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

(11) Publication number: **0 231 155**
A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **87830016.9**

(22) Date of filing: **19.01.87**

(51) Int. Cl.³: **G 07 C 5/10**
F 02 D 41/26

(30) Priority: **23.01.86 IT 6705286**

(43) Date of publication of application:
05.08.87 Bulletin 87/32

(84) Designated Contracting States:
BE DE ES FR GB NL SE

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(54) **Processing system for the detection, control and diagnostic examination of the operating conditions of the internal combustion engine of a motor vehicle, particularly a commercial motor vehicle.**

(57) The processing system comprises a plurality of sensors (2), each of which detects a corresponding physical magnitude indicative of the operating conditions of the engine (M) and generates a respective detection signal, and a processing unit (3) which receives the detection signals. The processing unit comprises five processing modules (91 to 95) intended respectively to control the following functions:

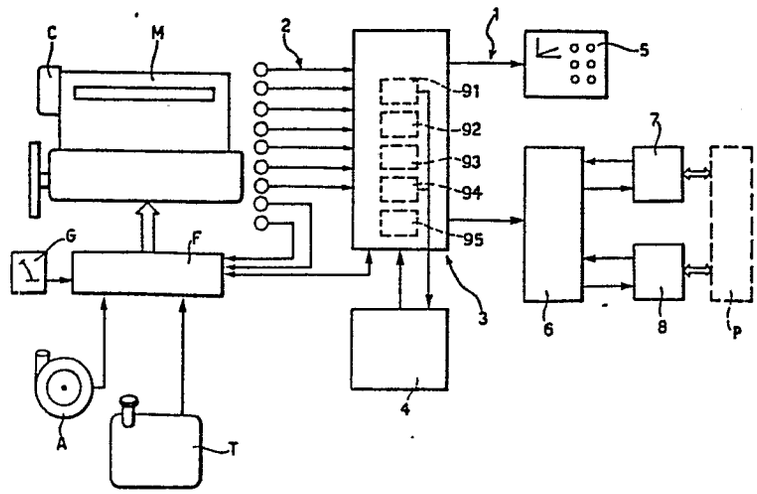
detection of the operation of the engine in conditions that are abnormal or harmful to the life of the engine itself (91);

limitation of critical uses of the engine (92);

monitoring of the operating conditions (93);

updated detection of the maintenance operations to be carried out on the engine (94), and

diagnosis of unsatisfactory engine performance (95).



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Processing system for the detection, control and diagnostic examination of the operating conditions of the internal combustion engine of a motor vehicle, particularly a commercial motor vehicle.

The present invention relates to processing systems and is particularly concerned with a processing system intended to be associated with the internal combustion engine of a motor vehicle such as, for example, a commercial motor vehicle.

The processing system according to the invention comprises a plurality of sensors, each of which detects a corresponding physical magnitude indicative of the operating conditions of the engine and generates a respective detection signal, and a processing unit to which the sensors are connected and which receives the detection signals.

Processing systems of this type are already used now for controlling the operation of the internal combustion engines in most up-to-date production motor vehicles.

As a general rule, it is known in this field to use specific processing systems, that is, processing systems each of which controls a specific function of the engine.

The present invention has the object of providing a single system which can carry out, in an integrated manner, the detection, control and diagnostic examination of the operating conditions of the internal combustion engine of a motor vehicle.

According to the present invention, this object is achieved by virtue of a processing system having the

characteristics indicated in Claim 1, which follows this description.

Briefly, the processing unit of the system according to the invention comprises five processing modules, each of which is connected to a respective group of sensors.

The first processing module controls the function of recording the "useful life" of the engine, receiving indications of anomalous or irregular operation to which the engine has been subjected.

The second processing module has essentially the function of identifying conditions of critical use of the engine, performing a function of automatic intervention for the limitation of such uses. The third processing module performs a function of overall monitoring of the operation of the engine, particularly with a view to the processing of visible and/or acoustical signals which are given to the driver of the motor vehicle. The fourth processing module performs a function of recording, with continuous updating, the maintenance operations to be carried out on the engine of the motor vehicle. The fifth processing module, however, performs the function of "diagnosing" the operation of the engine and can hold a dialogue with a more complex processing unit, not normally installed in the motor vehicle but available at technical service centres and garages, so as to permit an automatic identification of the anomalies of the engine operation and of the maintenance and/or adjustment necessary to remedy them.

The invention will now be described, purely by way of non-limiting example, with reference to the appended

drawing which illustrates the overall structure of the processing system according to the invention in the form of a block diagram.

As a basic premise, it is observed that the subject of the present invention is the so-called "architecture" of the processing system, which can be realized, to advantage, by combining a plurality of sensors, normally already available on the market, with a processing unit constituted by a mini-computer or a microprocessor installed in the motor vehicle.

In the present description, the specific characteristics of operation of the individual sensors will not be examined in detail since, as stated, they are generally sensors of known type for which an understanding of the criteria and aspects of operation is not of fundamental importance for the purpose of understanding the invention. For this purpose, it will be sufficient to recall that each of these sensors produces at its output a signal which, after a possible interfacing and conversion operation, appears in the form of an electric signal which can be read and interpreted by the processing unit.

As stated, the processing unit is arranged as a plurality of processing modules. It is stressed that these processing modules can be made either in the form of physically distinct circuit blocks, or - in a more advantageous embodiment - in the form of functional blocks defined within a single processing structure. In this connection it is stressed that - as will be better seen below - one sensor may also be connected to several processing modules.

Moving on to an examination of the appended drawing, an internal combustion engine, such as, for example, the compression ignition engine mounted or, at any rate, intended to be mounted in a commercial motor vehicle, is generally indicated M.

In particular,the supercharging compressor (of the turbine or lobe type) which may be mounted on the engine M is indicated C.

An actuator (central control) of electro-mechanical type for controlling the feed to the engine M is generally indicated F.

In particular, the central control F is able to control the flow of fuel to the engine M from a tank T and of the air flowing to the external environment through an air filter A. The actuator F may be of the type already currently in use on a motor vehicle to enable the feed to the engine to be controlled as a function of commands given by the driver, for example, through the accelerator pedal G, integrated so as also to be able to perform the same function in dependence on the signals output by some sensors also connected to the modules of the processing system of the invention, generally indicated 1.

The description of the engine M given above is obviously diagrammatic and purely indicative. This description is implicitly comprehensive of all the members normally included in and associated with an internal combustion engine, such as, for example, the cylinders with pistons reciprocating therein, the driving shaft, the ignition and fuel injection devices, the coolant circulation system, the oil circulation system, the filters

associated with these systems, etc.

The processing system 1 comprises, as essential parts, a plurality of sensors, generally indicated 2, and a processing unit 3 with which the sensors are associated.

To advantage, a permanent or semi-permanent memory 4 and a display unit 5 for presenting messages to the driver of the motor vehicle are associated with the processing unit 3, which is usually in the form of a mini-computer or a microprocessor. An interface unit indicated 6, is adapted to communicate, through an optical fibre transmission system 7 and/or a cable transmission system 8, with a further processing unit P which may be on the vehicle or made available at technical service centres and/or garages.

The criteria for the connection of the sensors 2, the memory 4, the processing unit 5 and the interface 6 to the processing unit 3 may be developed easily at the project stage by the expert in the field familiar with the specific requirements of use. Therefore, such criteria will not be described here, since they are not essential for an understanding of the invention which, as stated, relates specifically to the architecture according to which the processing unit 3 is arranged.

For this purpose, the processing unit is arranged in five processing modules, indicated by the progressive reference numerals 91 to 95.

Each processing module 91-95 is connected to a respective group of sensors on the basis of the criteria which will be described below.

The central control F is connected to one or more sensors selected from the group constituted by the following sensors:

- a sensor G for the speed of rotation of the engine;
- a sensor of the passage of one or more of the engine pistons into top dead centre;
- a coolant temperature sensor, and
- a sensor of the moment when combustion starts in one or more of the combustion chambers of the engine,
- a sensor of the mean temperature of the exhaust gases,
- a sensor of the temperature of the air drawn into the engine, and
- a fuel temperature sensor.

In the case (which is the one to which the attached drawing refers) in which a supercharging compressor C is also associated with the engine, a sensor of the air pressure downstream of compressor C is also connected to the central control F.

The central control F receives the signals generated by the sensors connected to it and provides - according to known criteria - for the carrying out of operations aimed at continuously maintaining optimum operating conditions of the engine M, particularly by regulating the fuel supply flow in the engine so as to optimize consumption and limit the emission of polluting compounds at the exhaust of the engine. In particular, the regulating action permits the fuel supply to be adjusted in such a manner as to compensate for the variations of the external ambient pressure which occur upon variations of the altitude of the vehicle in which the engine is fitted.

In particular, when sophisticated fuel injection systems are used, it is also possible to control in the long term the amount of fuel going to each engine cylinder so as to obtain uniform distribution of the torque achieved among all cylinders.

In addition, the central control F sends the data corresponding to the signals generated by the sensors connected therewith to the modules of the unit 3, for example along a series-type connection line.

With regard to the selection of the sensing devices (the indications given here apply also to the processing modules of the unit 3), it is considered preferable at this moment to choose wire, film or semi-conductor thermoresistors to detect medium-level temperatures. For the detection of high temperatures, such as those of the exhaust gases, however, it is considered preferable to select sensors constituted by thermocouples. To detect pressures, the Applicant presently regards as optimum the performance of ceramic extensometers (strain gauges). To detect the position or speed of moving parts (shafts, pistons) use may be made of electro-magnetic detectors, Hall-effect sensors, or (if it is desired to obtain positional data of particular accuracy and slow dynamics) sealed plastics-film potentiometers or induction-type sensors.

With regard to the possibility, referred to above, of performing an action of rebalancing the torque produced by the individual cylinders, it is possible to use the detection unit described in Italian patent application no. 67354-A/84 in the name of Fiat Auto S.p.A.

The function of first processing module 91 is substantially that of supplying a record (which may be stored advantageously in the memory 4) of the "life" of the engine with an indication of the abnormal or irregular operating conditions (operational stress) to which the engine has been unduly subjected.

The possibility of such information being available, and being transferable to the exterior through the interface 6, is very important from numerous points of view.

For example, in the event of a breakdown, it is possible to explain without any doubt whether this is due to misuse of the vehicle or to a not-fully-satisfactory design of the engine or of parts thereof, whereby the power unit is not up to the requirements of use.

The first processing module 91 is connected to sensors selected from the group constituted by the following sensors:

- a sensor of the speed of rotation of the engine;
- a lubricant temperature sensor;
- a sensor of an inadequate level of liquid in the cooling system of the engine;
- a coolant temperature sensor;
- a lubricant pressure sensor;
- a sensor of the amount of engine lubricant;
- an engine load sensor;
- an exhaust-gas temperature sensor;
- a sensor of the air supply pressure.

With regard to the selection of the types of sensors, that which was said above with respect to the sensors connected to the central control F applies.

With regard to the sensors for detecting the level of a liquid, such as the coolant or the lubricant, the selection of capacitive-type sensors considered preferable at present.

Advantageously, it is also possible to connect the vehicle speed sensor and a sensor which supplies an indication of the total amount of fuel consumed by the engine to the first processing nucleus 91. In other words, this is the fuel level sensor whose signal is integrated with time by the processing nucleus. This is a very valuable indicator for an appraisal of the age of the engine, and is presently regarded as the preferable one (in terms of ease of procurement) with respect to that supplied by the integral of speed of rotation of the integral of the power demanded of the engine, obtained from the speed of rotation of the engine or other operating parameters thereof.

The second processing module 92 is connected to sensors selected from the group constituted by the following sensors:

- an engine exhaust gas temperature sensor;
- a sensor of the speed of rotation of the engine;
- an engine lubricant temperature sensor;
- a coolant temperature sensor;
- an engine lubricant pressure sensor;
- a vehicle speed sensor.

The second processing module 92 is designed in such a manner as to process, from the detection signals supplied by the sensors connected thereto, a control signal which is transmitted to the central control F in order to cut-off, at least in part, the supply of fuel to the engine M so as automatically to bring the engine

down to lower speeds of operation. If the central control F is not present, this signal is used only to supply a warning signal to the driver.

The third processing module 93 is intended to perform the function of monitoring the general operating conditions of the engine and displaying corresponding visual (and possibly acoustic) signals on the unit 5.

In this way, the driver of the motor vehicle (and also the inspector who tests a vehicle just produced or a vehicle brought in only for maintenance or repairs) can perform a complete picture of the operating conditions of the engine.

For this purpose, sensors selected from the group constituted by the following sensors may be connected to the third processing module 93;

- a sensor of the speed of rotation of the engine;
- a coolant temperature sensor;
- a sensor of the level (amount) of coolant;
- a lubricant pressure sensor;
- a sensor for the level of lubricant in the sump (normally operating only when the engine is stopped);
- a lubricant temperature sensor, and
- a sensor of the level of fuel in the tank T.

The fourth processing module 94 has the object of preventing the need to have recourse, as far as possible, to forms of programmed maintenance of the engine M. For this purpose, the fourth processing module 94 identifies, by the emission of a corresponding signal (for example, by means of the display unit 5), the occurrence of situations which require the carrying out of a maintenance operation. In

this way, it is possible to avoid the need to carry out such operations at fixed times as a precautionary measure with the risk of carrying out, from time to time, overhauls which were not necessary at that moment.

The sensors connected to the fourth processing module 94 are chosen from the group constituted by the following sensors:

- a sensor of any clogging of the air filter A;
- a sensor of the attainment of a lower limit level by the coolant, whereupon a refilling operation is necessary;
- a sensor of the need to top up the lubricant; in this case also, as with the coolant, this is a level sensor preferably of capacitive type;
- a sensor of the need to replace the oil filter: this may be constituted, to advantage, by a diaphragm valve combined with a Hall-effect sensor which measures the pressure drop across the filter;
- a sensor of the need to change the oil: this is a sensor of combined type which can detect simultaneously the presence of impurities in the oil, the lubricating capacity on the boundary layer, and the viscosity of the lubricant;
- a sensor of the need to replace the fuel filter, which, to advantage, may consist, as with the oil filter, of a sensor that detects the pressure drop across the fuel filter, and
- a sensor of anomalies, which can sense anomalous knocking in the engine due to the tappet clearance being out of adjustment.

The sensing devices connected to the fifth processing module 95 are chosen from the group constituted by the following sensors:

- a sensor which detects the general operating conditions of the engine, with particular regard to the torque produced; this may be a matter, for example, of the sensor or, more precisely, the detection system described Italian patent application no. 67354-A/84 mentioned above;
- a sensor for detecting breakage of the drive belt of the auxiliary equipment;
- a sensor which detects the presence of small abrasive particles in the lubricant;
- a sensor which detects the exhaust gas temperature;
- at least one sensor of anomalous conditions of rotation of the engine, such as, an uneven distribution of the torque produced by the individual cylinders,etc.;
- a sensor which detects the operating conditions of the battery;
- a sensor of anomalies for detecting knocking in the engine due to incipient seizure;
- a sensor of the angle of ignition advance or injection advance, for detecting irregularities in the adjustment of the angle of advance;
- a sensor of the flow from the fuel feed pump, for detecting irregularities in the fuel flow in the engine;
- one or more sensors which detect incorrect settings of the fuel injectors;
- one or more sensors which detect compression losses from the engine cylinders;
- one or more sensors which detect the existence of "blowing" of the valves, and
- one or more sensors which detect, in the case of supercharged engines, defects in the supercharging system.

The fifth processing module 95 has essentially the object of receiving the detection signals generated by the sensors, storing and processing them, and supplying warning signals to the driver. At the time of the final adjustment of the engine in the workshop, the processing module transmits the signals received from the sensors and pre-processed to the processing unit P by means of the interface 6 and the physical connection vectors 7 and/or 8.

On the basis of these signals, and perhaps other signals supplied by the other processing modules of the unit 3, the processing unit P is able to carry out an exhaustive analysis of the present condition and previous conditions of operation of the engine, supplying to technicians precise and detailed indications of the maintenance and repairs to be carried out.

The reference conditions for determining the need for repairs following a malfunction relate to the individual engine and may be stored in the memory 4 or in the central memory of the processing unit P and may accompany the engine in the form of a magnetic card.

CLAIMS

1. A processing system intended to be associated with the internal combustion engine (M) of a motor vehicle and comprising a plurality of sensors (2), each of which detects a corresponding physical magnitude indicative of the operating conditions of the engine (M) and generates a respective detection signal, and a processing unit (3) to which the sensors (2) are connected and which receives the detection signals, characterised in that the processing unit (3) comprises:

a) - a first processing module (91) to which there are connected sensors (2) able to detect at least one of the physical magnitudes included in the group constituted by:

- the speed of rotation of the engine (M);
- the lubricant temperature of the engine (M);
- the presence of an insufficient amount of coolant for the engine (M);
- the temperature of the coolant for the engine (M);
- the lubricant pressure of the engine (M);
- the amount of lubricant in the engine (M);
- the load of the engine (M);
- the pressure of the air supply to the engine (M), and
- the total amount of fuel consumed by the engine (M) during its useful life;

b) - a second processing module (92) to which there are connected sensors able to detect at least one of the physical magnitudes included in the group constituted by:

- the temperature of exhaust gases of the engine (M);
- the speed of rotation of the engine (M);
- the lubricant temperature of the engine (M);
- the coolant temperature of the engine (M);
- the pressure of lubricant in the engine (M);

c) - a third processing module (93) to which there are connected sensors able to detect at least one of the physical magnitudes included in the group constituted by:

- the speed of rotation of the engine (M);
- the temperature of the coolant of the engine (M);
- the amount of coolant in the engine (M);
- the pressure of the lubricant in the engine (M);
- the amount of lubricant in the engine (M);
- the temperature of the lubricant in the engine (M);
- the amount of fuel in the tank (T).

d) - a fourth processing module (94) to which there are connected sensors (2) able to detect at least one of the physical magnitudes included in the group constituted by:

- clogging of the air filter (A) of the engine (M);
- insufficient coolant for the engine (M);
- insufficient lubricant for the engine (M);
- clogging of the oil filter;
- the presence of impurities in the engine (M) lubricant;
- inadequate boundary layer lubricating capacity of the lubricant of the engine (M);
- the viscosity of the lubricant of the engine (M);
- clogging of the filter for the fuel fed to the engine (M), and
- the generation of anomalous knocking due to the tappet clearance of the engine (M) being out of adjustment,

e) - a fifth processing module (95) to which there are connected sensors (2) able to detect at least one of the physical magnitudes included in the group constituted by:

- the torque developed by the engine (M);
- the breakage of at least one of the belts associated

with the engine (M);

- the existence of abrasive particles in the lubricant of the engine (M);
- the temperature of the exhaust gases of the engine (M);
- the presence of an uneven distribution of the torque generated by the various cylinders of the engine (M);
- an inadequate level of the electrolyte in the battery associated with the engine (M);
- the generation of anomalous knocking due to incipient seizure of the engine (M);
- the operation of the engine (M) with an angle of advance different from that pre-set;
- the operation of the feed pump for the fuel (T) at a delivery different from that pre-set;
- irregular operation of the fuel injectors;
- compression losses from the cylinders of the engine (M);
- irregular operation (blowing) of the valves of the engine (M);
- irregular operation of the supercharging system of the engine (M),

and in that the processing system (1) includes at least one interface (6) for the transmission of the detection signals received by the processing modules (91-95) and is selectively connectible (7,8) to a further processing unit (P) for processing the detection signals transmitted by the interface (6).

2. A processing system according to Claim 1, characterised in that the second processing module (92) has associated therewith an actuator (F) able to cut off, at least in part, the feed to the engine (M) in order to reduce the speed of rotation of the engine (M) as a function of the detection signals generated by the

sensors (2) connected to the second processing module (92).

3. A processing system according to Claim 1, characterised in that the processing unit (3) can produce warning signals for the driver of the motor vehicle, in dependence on the detection signals generated by the sensors (2) connected to the processing unit (3) itself.

4. A processing system according to any one of Claims 1 to 3, characterised in that it includes memory means (4) for storing, at least in part, the detection signals received by the processing modules (91-95).

5. A processing system according to any one of Claims 1 to 3, characterised in that it has an associated memory carrier, preferably a magnetic card, able to accept reference data relating to a specific internal combustion engine.

6. A processing system according to any one of the preceding claims, characterised in that it includes a visual display unit (5) for the presentation of at least some of the detection signals received by the processing unit (3).

7. A programmable electronic circuit used as a processing unit (3) in a processing system according to any one of Claims 1 to 6.

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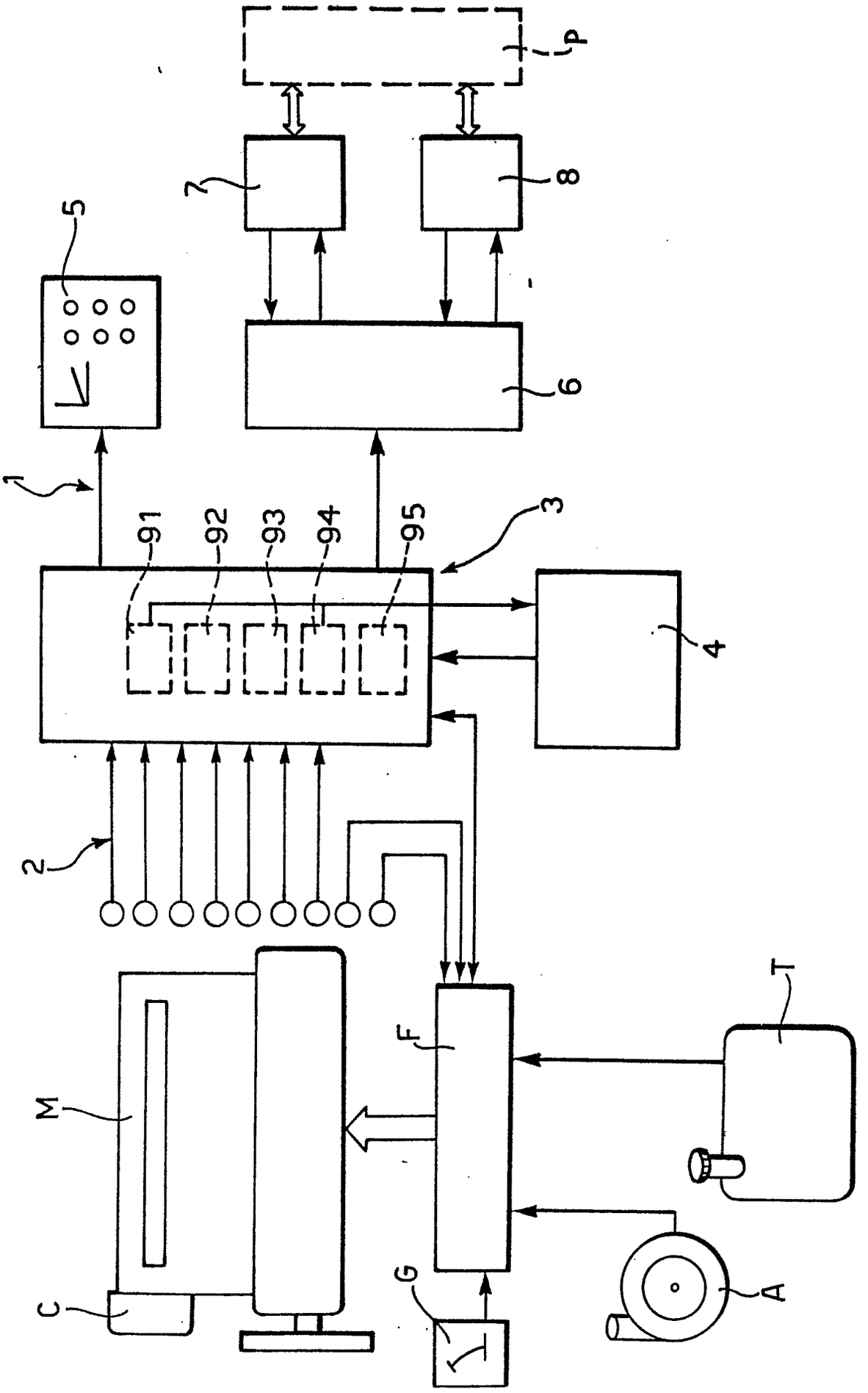

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EUROPEAN SEARCH REPORT

0231155
Application number

EP 87 83 0016

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.4)
A	EP-A-0 072 000 (NIPPONDENSO et al.) * Abstract; page 7, line 4 - page 11, line 14; figures *	1,3,4, 6,7	G 07 C 5/10 F 02 D 41/26
A	GB-A-2 104 247 (NISSAN) * Page 1, lines 6-37; page 2, line 66 - page 3, line 17, 108 - page 4, line 107; figures *	1-4,6, 7	
A	US-A-4 053 868 (COX et al.) * Abstract; column 2, lines 3-41; claim 1; figures *	1,3,6	
A	GB-A-2 130 752 (FUJI) * Abstract; page 1, line 74 - page 2, line 41; figures *	1-3,7	TECHNICAL FIELDS SEARCHED (Int Cl 4)
A	EP-A-0 127 789 (THE BENDIX CORP.) * Page 5, line 3 - page 7, line 24; figure 1 *	1,2	B 60 Q G 07 C F 02 B F 02 D G 01 M G 01 H
A	GB-A-2 125 578 (NISSAN) * Page 2, lines 36-126; page 4, line 117 - page 7, line 25; figures *	1	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06-05-1987	MEYL D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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EUROPEAN SEARCH REPORT

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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.4)
A	US-A-4 344 136 (PANIK) * Abstract; column 1, line 29 - column 4, line 23; figures *	1,3,4,6	
A	US-A-4 475 498 (HURNER)		
A	FR-A-2 546 975 (MITSUBISHI)		
A	WO-A-8 201 354 (MASSEY-FERGUSON)		
A	IEEE SPECTRUM, vol. 12, no. 6, June 1975, pages 73-77; R.K. JURGE: "The microprocessor: in the driver's seat ?"		TECHNICAL FIELDS SEARCHED (Int. Cl.4)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06-05-1987	MEYL D.

CATEGORY OF CITED DOCUMENTS

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