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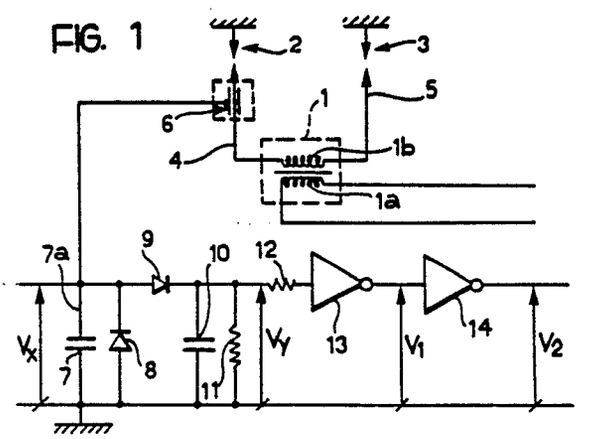
(54) Electrical monitoring device for enabling the identification of the working phases of a cylinder of a controlled-ignition internal combustion engine.

(57) The device enables the identification of the working phases of a cylinder of an internal combustion engine having a spark ignition system (1-5) with a conductive line (4) for the spark plug (2) of each cylinder, through which a high-voltage pulse is applied periodically to the plug (2) to generate a spark. The monitoring device includes a signal pick-up member (6) of electrically conductive material which can be coupled to a portion of the conductive line (4) in a capacitive coupling relationship.

FIG. 1



EP 0 272 225 A1

Electrical monitoring device for enabling the identification of the working phases of a cylinder of a controlled-ignition internal combustion engine.

The present invention relates to an electrical monitoring device for enabling the identification of the working phases of a cylinder of an internal combustion engine having a spark ignition system with a conductive line for the spark plug of each cylinder, through which a high-voltage pulse is applied periodically to the plug to generate a spark.

Modern electronic ignition and fuel injection systems require the precise identification of the working phases of each cylinder of the engine. This may be achieved, for example, with the use of electromagnetic detection (pick-up) devices for detecting the passage of references, such as notches or teeth, on rotary members, for example,the flywheel of the engine or the camshaft, due to the rotation of the engine shaft. Such electromagnetic pick-ups are very expensive.

The object of the present invention is to provide a monitoring device for enabling the direct detection of the working phases of one cylinder (and hence the indirect identification of the working phases of all the other cylinders) in a controlled-ignition internal combustion engine, which has an extremely simple structure, which can be installed quickly and easily, and which is very reliable in operation, while being much cheaper than electromagnetic pick-ups in current use.

This object is achieved according to the invention by means of an electrical monitoring device of the type specified above, characterised in that it includes a signal pick-up member of electrically conductive material which can be coupled in a capacitive coupling relationship to a portion of the conductive line through which a high-voltage pulse is applied periodically to the plug to generate a spark.

According to another characteristic, an auxiliary capacitor is connected between the signal pick-up member and earth and, together with the capacitor formed by the pick-up member and the corresponding portion of the conductive line, constitutes a capacitive divider.

The terminal of the auxiliary capacitor connected to the pick-up member is, according to the invention, connected to the input of a threshold comparator circuit.

Usually, the conductive line for the application of the high voltage to the plug comprises a high - voltage electrical cable having one end connected to the plug of a cylinder and its other end connected to an output terminal of an ignition coil or distributor. In both cases, however, this output terminal is of standard shape and has a socket -like connecting member of electrically-conductive material surrounded by a covering of insulating material. Conveniently, in a preferred embodiment of the device of the invention, the pick-up member includes a ring of metal which can be fitted over the covering of the socket connecting member of the output terminal of the ignition coil or distributor.

Further characteristics and advantages of the device according to the invention will become apparent from the detailed description which follows with reference to the appended drawings, provided purely by way of non-limiting example, in which:

Figure 1 is a circuit diagram showing part of the ignition system of an internal combustion engine provided with a monitoring device according to the present invention,

Figure 2 is a series of four graphs showing the changes in the signals generated in the device of Figure 1 as a function of the time t given on the abscissa,

Figure 3 is a partial axial section of an output terminal of one of the coils of the ignition system of an engine, provided with a monitoring device according to the invention, and

Figure 4 shows schematically a four-cylinder internal combustion engine having an ignition system of the static type with two coils, including a monitoring device according to the invention.

Figure 1 shows schematically part of an ignition system for an internal combustion engine. In this drawing, an ignition coil of the so-called double type for controlling the ignition of two different cylinders (not illustrated) provided with respective spark plugs, indicated 2 and 3, is generally indicated 1. The coil 1 includes a primary winding connected, in a manner not illustrated, to an electronic ignition control and operating unit, and a secondary winding 1b connected to the plugs 2 and 3 in the manner illustrated. In particular, this secondary winding is connected to the plugs through respective conductive lines, indicated 4 and 5. These lines usually comprise a high-voltage electrical conductor with a suitable covering of insulating material, one end of which is connected to a plug while its other end is coupled to an output terminal of the coils.

The device according to the invention includes a signal pick-up member 6 constituted by an element of electrically-conductive material having, for example, an annular shape and coupled to a portion of the conductive line connecting the plug of a cylinder to its operating coil in a capacitive coupling relationship. This element constitutes one plate of a capacitor the other plate of which is constituted by the conductive line in question. Fig-

ures 3 and 4, which will be described below, illustrate a particular embodiment of this signal pick-up member.

As shown in Figure 1, the member 6 is connected conveniently to a first terminal of a capacitor 7 whose other terminal is connected to earth. A protective diode 8 is connected in parallel with this capacitor for protecting it against polarity inversion. A further diode 9 is connected between the signal pick-up member 6 and a further capacitor 10.

When the unearthed terminal 7a of the capacitor 7 is at a positive potential relative to the earth potential, the circuit formed by the capacitors 7 and 10 and the diodes 8 and 9 is equivalent to a single capacitor having a capacity corresponding substantially to the sum of the capacities of the capacitors 7 and 10.

A resistor 11 is connected in parallel with the capacitor 10 and its unearthed terminal is connected through a resistor 12 to the input of an inverting threshold comparator 13 connected in cascade with a further inverting comparator 14. These comparators may be constituted by integrated inverters of the CMOS technology.

Figure 2 shows the changes in the voltages V_x, V_y, V_1 and V_2, indicated in Figure 1, as a function of the time t, in the case in which the engine to which the device according to the invention is fitted is a four-stroke, four-cylinder engine.

The signal V_x reproduces the changes in the voltage output by the coil 1 to the plug 2 on a reduced scale. With the type of ignition system shown in Figure 1, therefore, the signal V_y has a main pulse, indicated a in Figure 2, each time the plug 2 produces a spark and hence every two revolutions of the engine shaft. The signal V_x also has an extremely low level secondary pulse, indicated b in Figure 2, which also has a periodicity of two revolutions of the engine but is 180° out of phase relative to the pulses a.

By virtue of the presence of the diode 9 and the capacitor 10, there is a corresponding prolonged pulse in the period of the signal V_y for each pulse a of the signal V_x.

The comparator 13 compares the signal V_y with a threshold level (indicated s in Figure 2) and outputs a corresponding signal V_1 the changes in which are also shown in Figure 2. This signal has a negative pulse corresponding to each pulse of the signals V_x and V_y.

The signal V_1 is inverted by the inverter-comparator 14 and the signal V_2 output by the latter thus changes, as shown in Figure 2, to provide a positive pulse for each pulse a of the signal V_x.

The signal V_2 may be supplied to the electronic unit which controls and commands the operation of the ignition system. This signal, as seen, allows the extremely precise identification of the ignition phase in the cylinder to the plug of which the signal pick-up member 6 has been coupled capacitively.

Usually, the high-voltage output terminals of single-or double-output ignition coils, as well as of distributor caps, have a standard form which is shown in axial section in Figure 3. These standard terminals include a socket-like metal connecting member 20 connected to the ignition coil or to a terminal of the distributor by a conductor 21. The socket connecting member 20 is surrounded by a covering of electrically-insulating material 22. There is inserted into the socket 20 in use the cable terminal at one end of a high-voltage cable the other end of which is connected to a plug.

Conveniently, as shown in Figure 3, the member 6 is shaped as a ring which is force-fitted onto the covering 22 of the socket connecting member 20. The ring 6 and the connecting member 20 constitute the two plates of a capacitor the dielectric of which is constituted by the insulating material forming the covering of the connecting member 20. The capacity of this capacitor may be calculated analytically to a first approximation by applying the known formulae relating the capacity of cylindrical capacitors. By the application of these formulae, it can be verified that the capacitor thus made has a capacity of the order of several picofarads. Such theoretical values have been fully confirmed by experimental measurements carried out by the inventors.

The voltage for causing the spark has a peak value of the order of one or two tenths of a kilovolt. Hence, if the capacitor formed by the ring 6 of Figure 3 is connected to a capacitor 7 having a capacity of the order of several nanofarads, a capacitive voltage divider is formed which makes available a signal with a form analogous to the signal causing the spark but with a peak value of the order of a tenth of a volt, which can thus be supplied without problems to a trigger circuit such as the comparator 13 of Figure 1.

Figure 4 illustrates schematically a four-stroke internal combustion engine M having four cylinders A - D with a static-distribution ignition system of the so-called "lost spark" type. This system includes two ignition coils 1 and 101 with two outputs for controlling ignition in the cylinders A and D and in the cylinders B and C, respectively. The primary windings of the coils 1 and 101 are connected to an electronic unit for controlling and commanding the ignition, indicated 30. This unit is also connected to a magnetic pick-up 31, for example of the proximity-effect type, associated with the flywheel V of the engine M to detect a reference (notch or tooth) when the piston in one of the cylinders A or D (or B or C) is at top dead centre.

The information provided to the electronic unit

30 by the sensor 31 does not enable the unit to tell which cylinder A or D (or B or C) the piston effectively at top dead centre is in.

This ambiguity can be resolved by the use of a monitoring device of the invention, the annular signal pick-up member 6 of which is fitted, for example, onto the output terminal of the coil 1 connected to the plug of the cylinder A.

As shown in Figure 4, in order to simplify assembly and attachment of the cables, all the circuit parts relating to the processing of the signal picked up by the pick-up member 6 can be incorporated in the electronic unit 30. Thus, the device of the invention only involves the coupling of the signal pick-up member 6 to an output terminal of a coil or the distributor during assembly. This member is connected to the electronic control unit, which may be the ignition and/or the injection control unit, by a simple conductor, preferably of the screened type.

The device according to the invention thus allows the information relating to the ignition phase of a cylinder to be obtained extremely simply and cheaply. Moreover, with reference to Figures 1 and 2, it may be seen that, in addition to the information that the cylinder with which the sensor is associated is in an ignition or combustion phase, the rising front of the signal V_2 or the descending front of the signal V_1 also provides a good indication of the moment of initiation of exhaust. In effect, as indicated in Figure 2, the rising front of the signal V_2 corresponds essentially to the descending front of each pulse of the signal V_x . The rising front of the signal V_2 is always within the pre-arc period and, if necessary, by means of simple circuit devices, may be brought close to both the instant of initiation of the pre-arc phase and to the instant of initiation of exhaust, depending on the type of monitoring circuit adopted.

The device also makes available a signal which, on a reduced scale, faithfully reproduces the waveform of the high-voltage signal for causing the ignition.

Claims

1. Electrical monitoring device for enabling the identification of the working phases of a cylinder of an internal combustion engine having a spark (2,3) ignition system (1-5) including a conductive line (4) for the spark plug (2) of each cylinder, through which a high-voltage pulse is applied periodically to the plug (2) to generate a spark, the monitoring device being characterised in that it includes a signal pick-up member (6) of electrically conductive material which can be coupled to a portion of the conductive line (4) in a capacitive coupling relationship.

2. Device according to Claim 1, characterised in that an auxiliary capacitor (7) is connected between the signal pick-up member (6) and earth and, together with the capacitor formed by the pick-up member (6) and the corresponding portion of the conductive line (4), constitutes a capacitive divider.

3. Device according to Claim 2, characterised in that the terminal of the auxiliary capacitor (7) connected to the pick-up member (6) is connected to the input of a threshold comparator (13).

4. Device according to any one of the preceding claims, particularly for an engine in which the conductive line comprises a high-voltage electrical cable (4) having one end connected to the spark plug (2) of a cylinder and its other end connected to an output terminal (20-22) of an ignition coil or distributor, the output terminal having a socket-like connecting member (20) made from an electrically conductive material and surrounded by a covering (22) of insulating material, characterised in that the pick-up member includes a ring (6) which can be fitted over the covering (22) of the connecting member (20).

5. Device according to any one of Claims 2 to 4, characterised in that a protection diode (8) is connected in parallel with the auxiliary capacitor (7).

6. Device according to Claim 5, characterised in that a further capacitor (10) is connected in parallel with the auxiliary capacitor (7) through a second diode (9).

FIG. 1

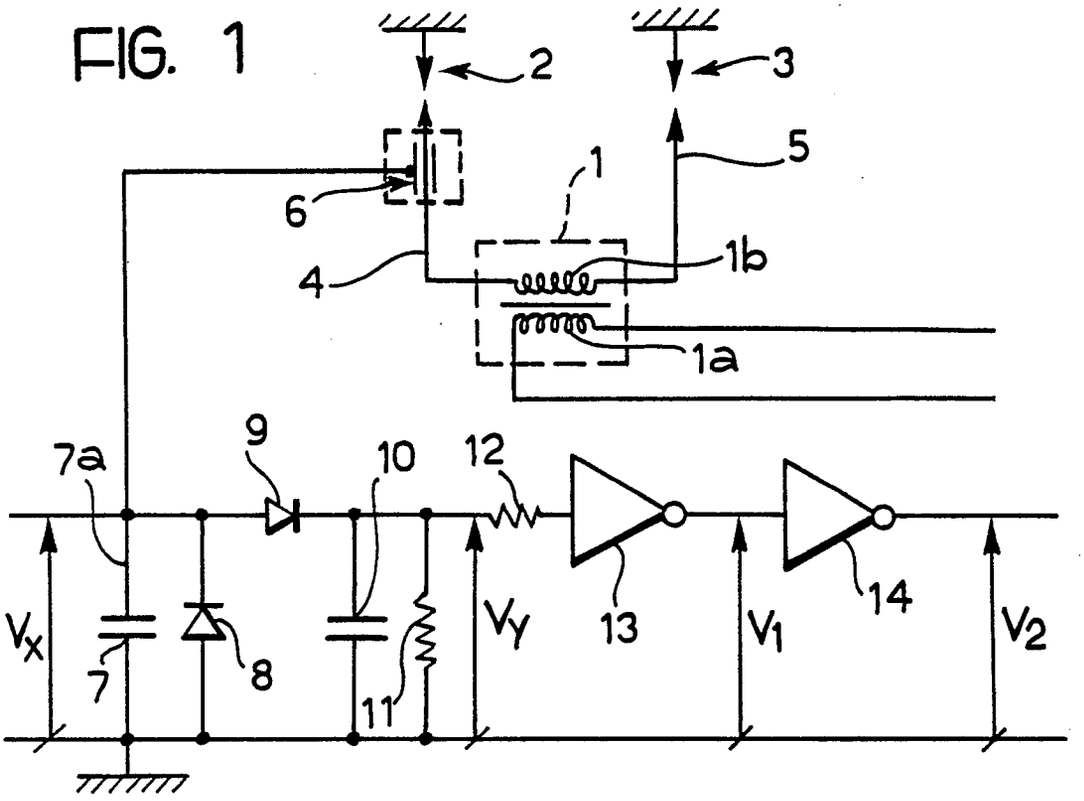


FIG. 4

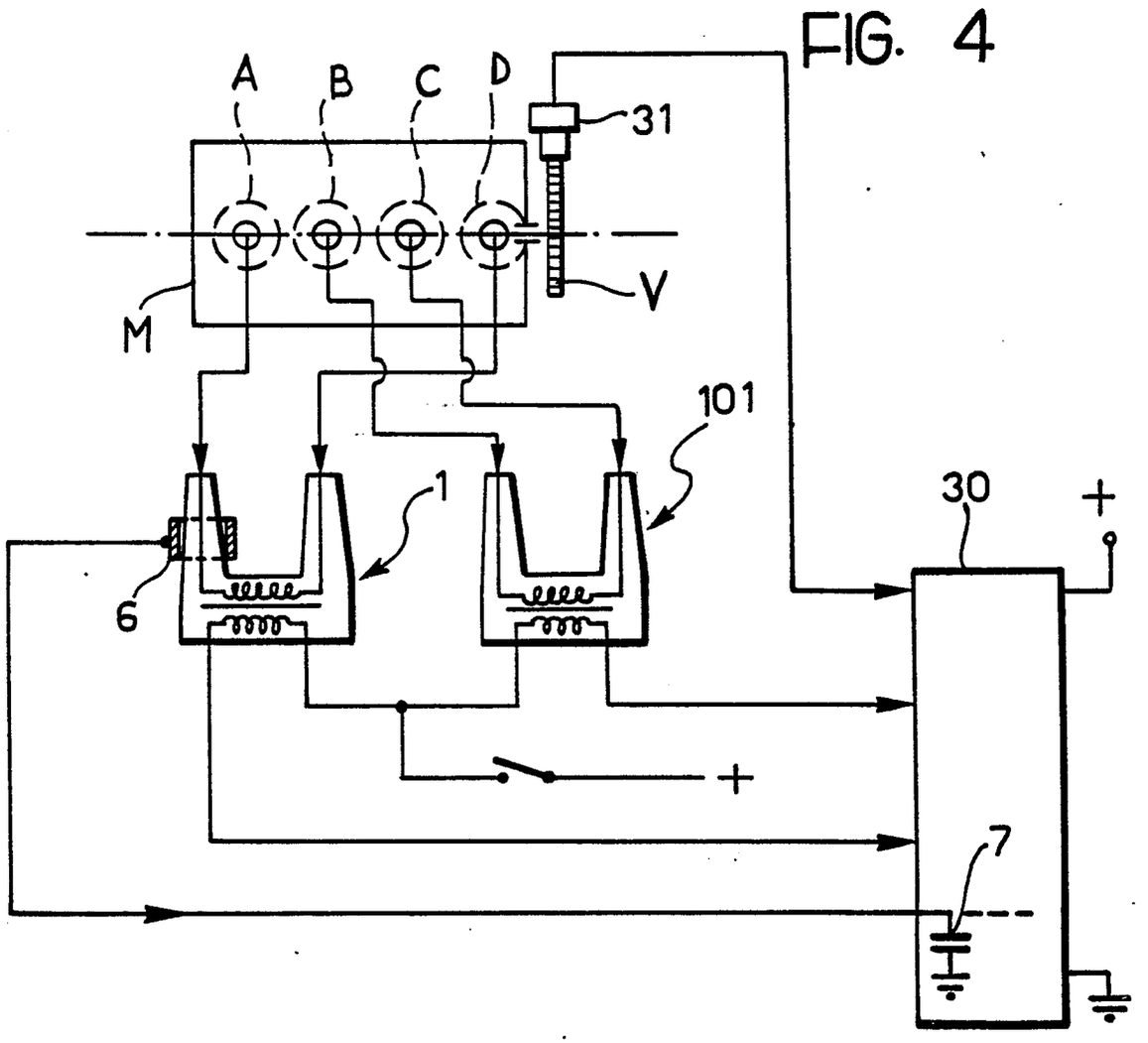


FIG. 2

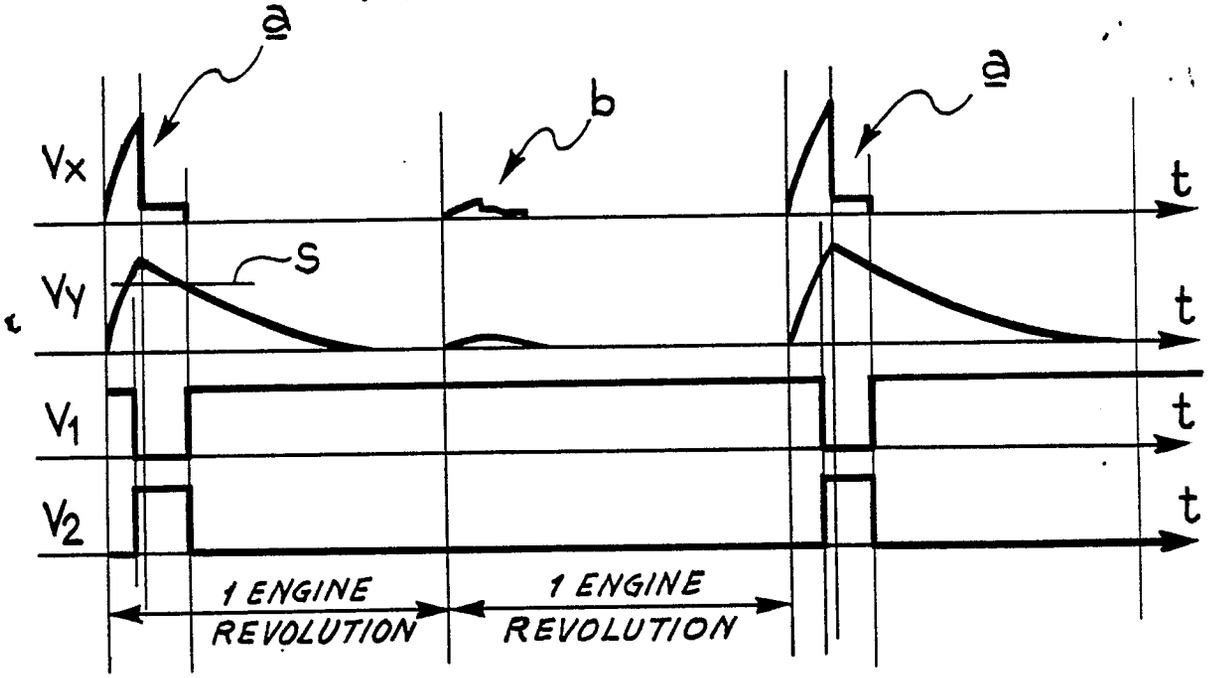

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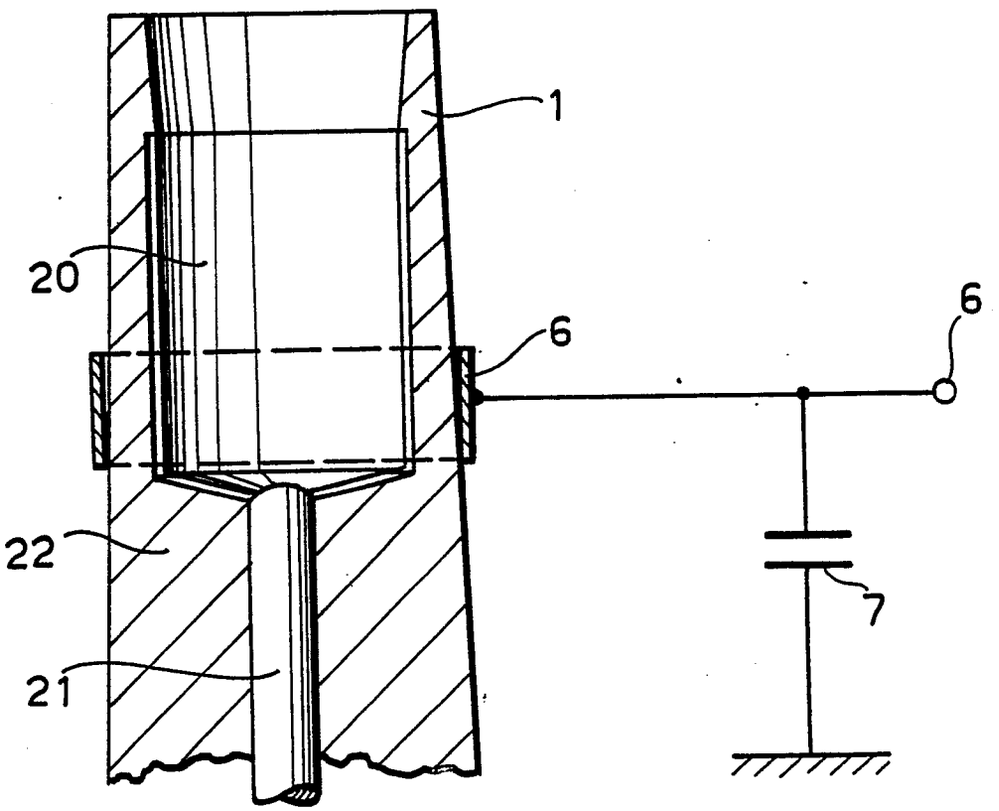
FIG. 3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EUROPEAN SEARCH REPORT

Application Number

EP 87 83 0413

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)
X	FR-A-2 192 612 (SIEMENS) * Figures 1-8; page 1, line 7 - page 6, line 9 *	1,2,4,6	F 02 P 17/00
X	FR-A-2 129 715 (TIP INSTRUMENTS) * Figures 3,4; page 8, line 20 - page 11, line 20 *	1,5,6	
A	US-A-3 961 240 (R. BOSCH) * Figure 6; column 3, line 62 - column 4, line 50 *	1,3	
A	DE-A-2 640 121 (SUN ELECTRIC)		
A	US-A-3 763 421 (ALLEN ELECTRIC & EQUIPMENT)		
A	US-A-3 771 047 (VOLKSWAGENWERK)		
A	US-A-3 839 671 (M.E. GERRY)		

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

F 02 P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09-02-1988	LEROY C.P.

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