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(54) **Internal combustion engine stroke identification system.**

(57) A system comprising:
a first sensor (107) for detecting the teeth (134) and a gap in the same on a pulley (108) fitted to the drive shaft (111);
a second sensor (112) for detecting interruptions (135 and 136), a first of which differs from the others, on a disk (109) rotating at half the speed of, but in time with, the drive shaft (111);
first means (156), which, upon startup of the engine, compute and memorise the actual relative angular position of the pulley (108) and the disk (109);
second means (152) for computing the absolute angular position of the drive shaft (111), for enabling the electronic ignition and injection systems; and
third means (153) which, in the event of failure of the first sensor (107), and on the basis of the second sensor (112) and the signal processed by the first means (156), compute a presumed angular position of the drive shaft (111) for enabling the electronic ignition and injection systems.

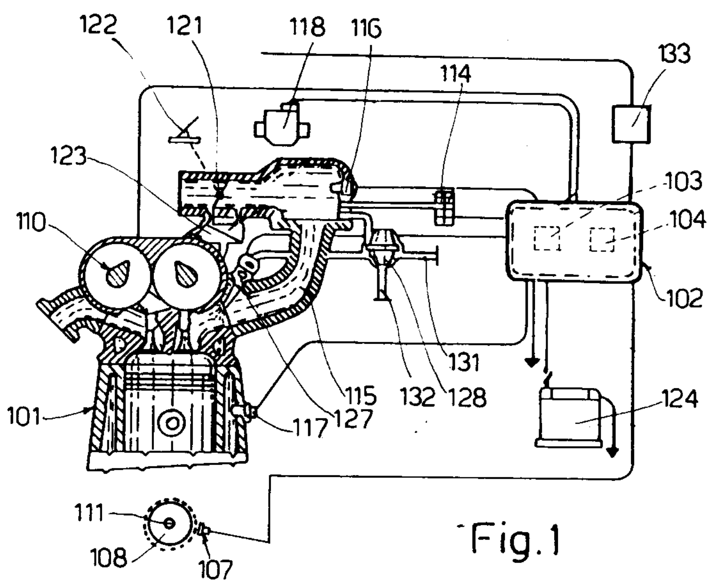

Fig.1

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The present invention relates to a stroke identification system for internal combustion engines featuring electronic ignition and injection systems.

The electronic ignition and injection systems of internal combustion engines feature an electronic control system, which, on the basis of signals received from various sensors (engine speed and stroke, intake air pressure and temperature), determines the spark lead and computes the stroke and fuel injection time to the injectors. Such systems employ angle references fitted to the drive and camshaft to enable the control system to identify the stroke (induction, compression, expansion, exhaust) of each cylinder. On known identification systems, the angle references on the drive shaft are equal to the number of cylinders, and consist, for example, of equally-spaced teeth. A first sensor facing the references provides, every two references, for enabling an ignition command via the control system. Such systems require a stroke sensor capable of detecting the angular position of an auxiliary shaft rotating at half the speed of, but strictly in time with, the drive shaft, and which usually consists of the camshaft.

In the event of failure of the stroke or drive shaft speed sensor, the electronic ignition and injection system is totally disabled, thus arresting the engine until operation of the sensor is restored. Patent Applications 67064A/90 and 67066A/90, entitled "Internal Combustion Engine Stroke Identification System" and "Perfected Internal Combustion Engine Stroke Identification System", filed by the present Applicant on 26/1/1990, relate to a system for overcoming startup or on-road failure of the stroke sensor.

It is an object of the present invention to provide an internal combustion engine stroke identification system designed to also overcome failure of the drive shaft speed sensor, and so provide, on the basis of the above patent applications, an overall system for overcoming failure of either one of the sensors.

According to the present invention, there is provided an internal combustion engine stroke identification system, characterised by the fact that it comprises:

an electronic ignition system;

an electronic injection system;

a pulley fitted to the drive shaft of said engine, and defined by a toothed wheel having a number of first teeth and a gap defined by the absence of some of said first teeth;

a first sensor for detecting said first teeth and, therefore, predetermined angular positions of said drive shaft;

a second shaft rotating at half the speed of, but in time with, said drive shaft;

a disk fitted to said second shaft, and having a number of equally-spaced interruptions equal to the number of cylinders on said engine, and a first of which is identifiable by virtue of differing from the others;

a second sensor for detecting said interruptions and, therefore, predetermined angular positions of said second shaft;

first means for computing, upon startup of said engine, the actual relative angular position of said pulley and said disk, by simultaneously detecting said gap on said pulley and said first interruption on said disk; and for storing said actual angular position in a permanent memory;

second means for computing the absolute angular position of said drive shaft, on the basis of the signals from said sensors, and enabling said electronic ignition and injection systems; and

third means, which, in the absence of a signal from said first sensor, and on the basis of the signal from said second sensor and the signal processed by said first means, provides for computing a presumed angular position of said drive shaft, for enabling said ignition and injection systems.

A preferred, non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Fig.1 shows a schematic view of an electronic ignition and injection system for an internal combustion engine featuring the engine stroke identification system according to the present invention;

Fig.2 shows a schematic view of a number of components in the Fig.1 system;

Fig.3 shows an operating block diagram of the identification system according to the present invention;

Fig.4 shows a longitudinal development of the Fig.2 components.

Fig.1 shows, schematically, an electronic ignition and injection system for an internal combustion engine 101, conveniently a four-cylinder engine, shown partially in cross section. Said system comprises an electronic control system 102 having counters and memory maps relative to various operating conditions of engine 101, in particular, a counter 103 and a permanent memory 104 as described later on. Control system 102 receives signals from an engine speed sensor 107 opposite a pulley 108 fitted to the drive shaft 111; an engine stroke sensor 112 opposite a disk 109 fitted to the camshaft 110 of a distributor (not shown); a sensor 114 for detecting the absolute pressure in intake manifold 115; a sensor 116 for detecting the air temperature in manifold 115; a sensor 117 for detecting the water temperature in the cooling jacket of engine 101; and a sensor 118 consisting of a potentiometer, for detecting the angular position of a throttle valve 121 located in manifold 115 and controlled by accelerator pedal 122. An additional air supply valve 123 is fitted parallel to valve 121. Shaft 110 rotates at half the speed of, but in time with, shaft 111.

Control system 102 is connected to a power battery 124 and to ground. On the basis of the signals received by control system 102, engine speed and air density are used for determining fuel supply as a function of the required strength. System 102 controls the opening time of injectors 127 housed in manifold 115 close to the intake valve of each cylinder, for controlling fuel supply to the various cylinders of engine 101; and controls fuel injection in relation to the stroke (induction, compression, expansion, exhaust) of engine 101. Injector 127 is supplied with fuel via a pressure regulator 128 sensitive to the pressure in manifold 115, and having a fuel inlet conduit 131 connected to a pump (not shown), and a return conduit 132 connected to a tank (not shown). System 102 is connected to an ignition pulse control unit 133 connected to the distributor.

As shown in Fig.s 2 and 4, pulley 108 consists of a toothed wheel having 60 minus 2 equally-spaced teeth 134 numbered 1 to 58 as of a gap formed by two missing teeth. Teeth 134 therefore present 58 gaps, one of which is three times the width of the others, i.e. extends over an angle of 18°. Sensor 107 is located facing the passage of teeth 134. Disk 109 presents two teeth 135 and a third tooth 136 at 120° to one another; teeth 135 both extending over an arc of 30°, and tooth 136 over an arc of 90°. Fig.s 4a, 4b and 4c show respective longitudinal developments of teeth 134 of pulley 108, teeth 135 and 136 of disk 109, and a further embodiment of disk 109.

In the embodiment described, sensor 112 is so positioned that, when the twentieth tooth 134 (114° arc as of the first tooth 134) is positioned facing speed sensor 107, sensor 112 faces the trailing edge of tooth 136 (Fig.s 4a and 4b). The above angular position of pulley 108 and disk 109 in relation to sensors 107 and 112 corresponds to the top dead center position of cylinder 1. When sensor 112 is positioned facing the trailing edge of tooth 135 following tooth 136, i.e. when disk 109 is rotated 90°, sensor 107 faces the fiftieth tooth 134, i.e. pulley 108 has rotated 180°. This position of pulley 108 and disk 109 in relation to sensors 107 and 112 corresponds to the top dead center position of cylinder 3. The rotation direction of pulley 108 and disk 109 is, of course, as shown in Fig.2.

The top dead center position of all four cylinders occurs for every two turns of shaft 11, so that, at the second turn of shaft 11, when sensor 112 is positioned facing the leading edge of tooth 135 preceding tooth 136, sensor 107 faces the twentieth tooth 134. This position of pulley 108 and disk 109 in relation to sensors 107 and 112 corresponds to the top dead center position of cylinder 4. When disk 109 is rotated another 90° and pulley 108 another 180°, sensor 112 faces the leading edge of tooth 136 and sensor 107 faces the fiftieth tooth 134. This position of pulley 108 and disk 109 in relation to sensors 107 and 112 corresponds to the top dead center position of cylinder 2. In other words, disk 109 presents a number of equally-spaced interruptions equal to the number of cylinders. In the example shown, the interruptions are represented by the leading or trailing edge of a tooth, but may also be represented, as shown in Fig. 4c, by a first opening every 90° of disk 109. Fig. 4c also presents a second opening corresponding with the 2-toothed gap on pulley 108, to enable identification of a first opening in relation to the others. Instead of said second opening, a single opening differing from the others in length may be defined together with a first opening.

Counter 103 counts and memorises the number of teeth 134 over 720° rotation of shaft 111, commencing with the first tooth 134 with sensor 107 positioned facing the 2-toothed gap on pulley 108, and sensor 112 simultaneously facing tooth 136. At the end of tooth 136, counter 103 supplies the tooth 134 count to system 102 to enable it to determine the actual relative angular position of pulley 108 and disk 109, which does not normally correspond to the ideal angular position, due to errors caused by the mechanical connection of the various components of engine 101. System 102 compares the previously stored ideal position with the actual position to determine the mechanical error, which is memorised for processing the ignition and injection signals in the event of failure of sensor 107.

In the event of failure of stroke sensor 112, the electronic ignition system is totally disabled. Italian Patent Applications n.67064A/90 and 67066A/90 entitled "Internal Combustion Engine Stroke Identification System" and "Perfected Internal Combustion Engine Stroke Identification System", and filed by the present Applicant on 26/1/1990, relate to a system for overcoming startup and on-road failure of the stroke sensor. The content of the above applications is therefore included herein purely by way of reference as required.

Operation of the stroke identification system according to the present invention will be described with reference to Fig.3. Block 151, to which the signal from sensor 107 is supplied, determines the presence of said signal, i.e. whether sensor 107 is operating normally or not. In the event of normal operation, block 151 goes on to block 152, whereas, in the event of failure of sensor 107, block 151 goes on to block 153. Blocks 152 and 153 are supplied with the signal from sensor 112. Block 152 checks the relative angular position of pulley 108 and disk 109, and supplies blocks 154 and 155 with a signal corresponding to the absolute angular position of shaft 111 between 0 and 720°. Upon startup of engine 101, this signal is also supplied to block 156, which computes and stores in memory 104 the mechanical error of the stroke signal mentioned previously.

Blocks 157 and 158 are supplied with signals relative to quantities and operating conditions of engine 101, in this case, from sensors 114, 116, 117 and 118. Block 157 computes the spark lead, and is connected to block 154, which, on the basis of the signals supplied to it, enables electronic ignition via the distributor or by controlling a coil for each cylinder or each pair of cylinders. Block 158 computes injection time cylinder by cylinder, and supplies block 155 with an injection time signal, and a signal relative to the stroke of the cylinder to be injected, for enabling electronic injection accordingly. Blocks 154 and 157 represent an electronic ignition system, and blocks 155 and 158 an electronic injection system. Block 153 computes a presumed angular position of shaft 111 between 0 and 720°, on the basis of the signals received from sensor 112 and corrected in accordance with the stored mechanical error. The output signal from block 153 is sent to blocks 154 and 155, and, though obviously not as accurate as the output signal from block 152, nevertheless provides for enabling ignition and injection and running the vehicle.

The advantages of the present invention will be clear from the foregoing description.

In particular, it provides for an engine stroke identification system designed to overcome failure of the drive shaft speed sensor, and which, combined with the system described in the aforementioned patent applications, provides for overcoming failure of either of sensors 107 and 112.

To those skilled in the art it will be clear that changes may be made to the system described and illustrated herein without, however, departing from the scope of the present invention.

In particular, changes may be made to the design of disk 109 in terms of both the design and number of interruptions, which, though obviously equally spaced, need not necessarily equal the number of cylinders.

Claims

1. An internal combustion engine stroke identification system, characterised by the fact that it comprises:

an electronic ignition system (155 and 157);

an electronic injection system (156 and 158);

a pulley (108) fitted to the drive shaft (111) of said engine (101), and defined by a toothed wheel having a number of first teeth (134) and a gap defined by the absence of some of said first teeth (134);

a first sensor (107) for detecting said first teeth (134) and, therefore, predetermined angular positions of said drive shaft (111);

a second shaft (110) rotating at half the speed of, but in time with, said drive shaft (111);

a disk (109) fitted to said second shaft (110), and having a number of equally-spaced interruptions (135 and 136) equal to the number of cylinders on said engine (101), and a first of which is identifiable by virtue of differing from the others;

a second sensor (112) for detecting said interruptions (135 and 136) and, therefore, predetermined angular positions of said second shaft (110);

first means (156) for computing, upon startup of said engine (101), the actual relative angular position of said pulley (108) and said disk (109), by simultaneously detecting said gap on said pulley (108) and said first interruption (136) on said disk (109); and for storing said actual angular position in a permanent memory (104);

second means (152) for computing the absolute angular position of said drive shaft (111), on the basis of the signals from said sensors (107 and 112), and enabling said electronic ignition system (155 and 157) and said electronic injection system (156 and 158); and

third means (153), which, in the absence of a signal from said first sensor (107), and on the basis of the signal from said second sensor (112) and the signal processed by said first means (156), provides for computing a presumed angular position of said drive shaft (111), for enabling said ignition system (155 and 157) and said injection system (156 and 158).

2. An identification system as claimed in Claim 1, characterised by the fact that it comprises fourth means (151) for determining correct operation of said first sensor (107), and enabling said second means (152) in the event of correct operation, and said third means (153) in the event of failure of said first sensor (107).

3. An identification system as claimed in Claim 1 and/or 2, characterised by the fact that it comprises a counter (103) for counting and storing the number of said first teeth (134) over 720° rotation of said drive shaft (111); said count commencing from the first of said first teeth (134), with said first sensor (107) positioned facing said gap on said pulley (108) and said second sensor (112) simultaneously facing said first interruption (136).

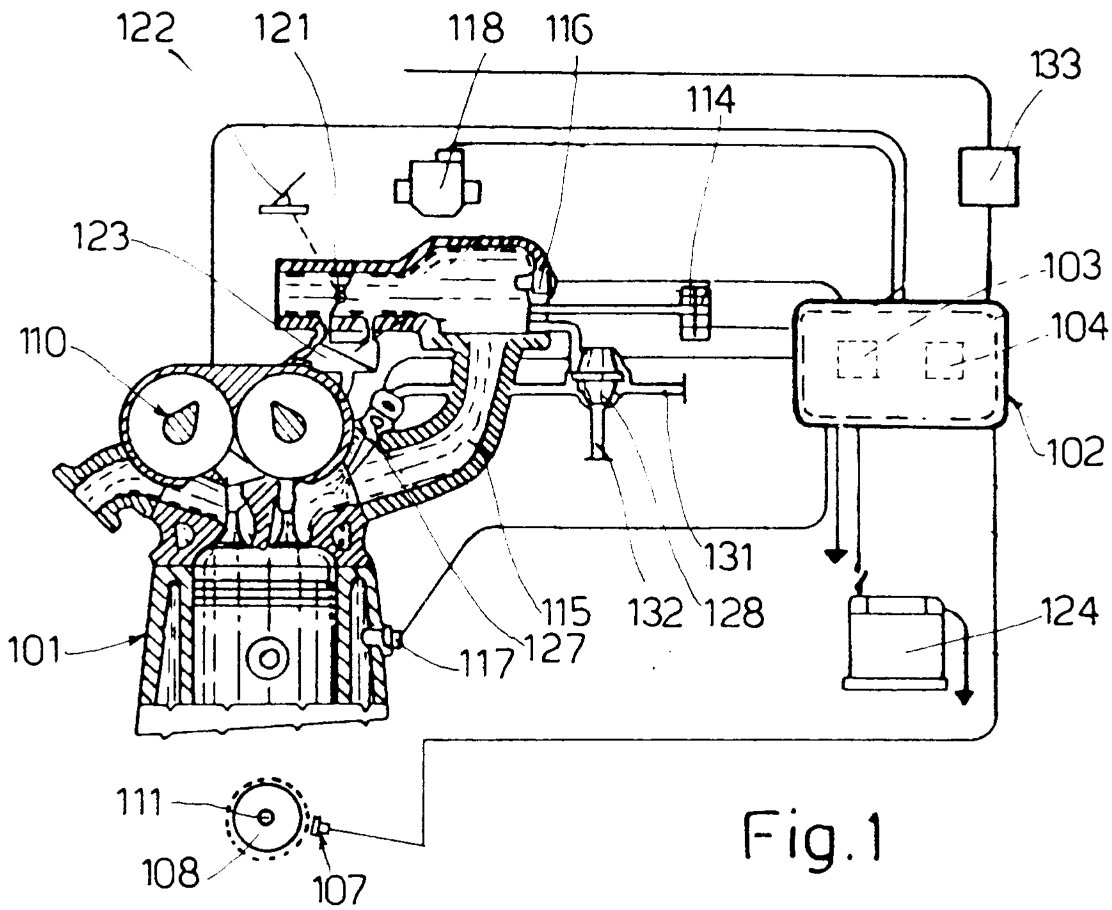
4. An identification system as claimed in Claim 3, characterised by the fact that said pulley (108) consists of a toothed wheel having 60 minus 2 equally-spaced first teeth (134); said gap being defined by the absence of two said first teeth (134).

5. An identification system as claimed in Claim 4, characterised by the fact that, for a four-cylinder engine, said disk (109) presents three second teeth (135 and 136) at 120° to one another, of which two extend over the same arc, and the third over a larger arc of 90°.

6. An identification system as claimed in Claim 4, characterised by the fact that, for a four-cylinder engine, said disk (109) presents a first opening every 90°, and a second opening close to one of said first openings for enabling this to be identified by said second sensor (112).

7. An identification system as claimed in Claim 4, characterised by the fact that, for a four-cylinder engine, said disk (109) presents four openings, one of which differs in extension from the others.

8. An identification system as claimed in Claim 4, characterised by the fact that, for a four-cylinder engine, said disk (109) presents three openings at 120° to one another, of which two extend over the same arc, and the third over a larger arc of 90°.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121
118
116
133
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110
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128
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101
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124
111
108
107

Fig.1

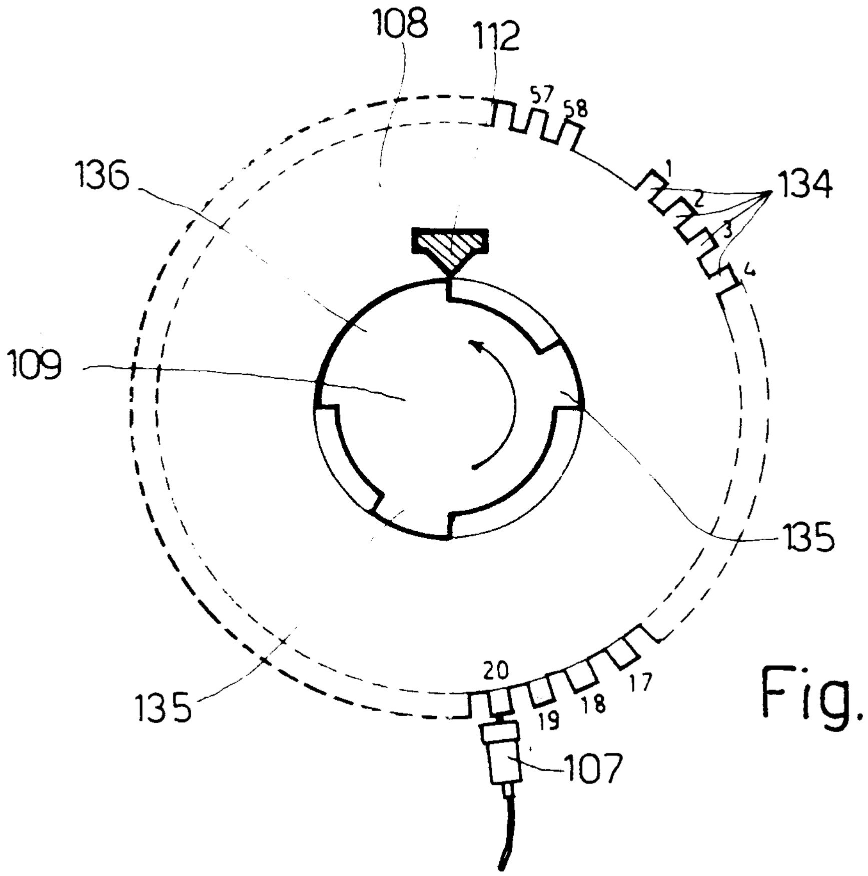

108
112
57
58
136
1
134
2
3
4
109
135
20
17
18
19
135
107

Fig. 2

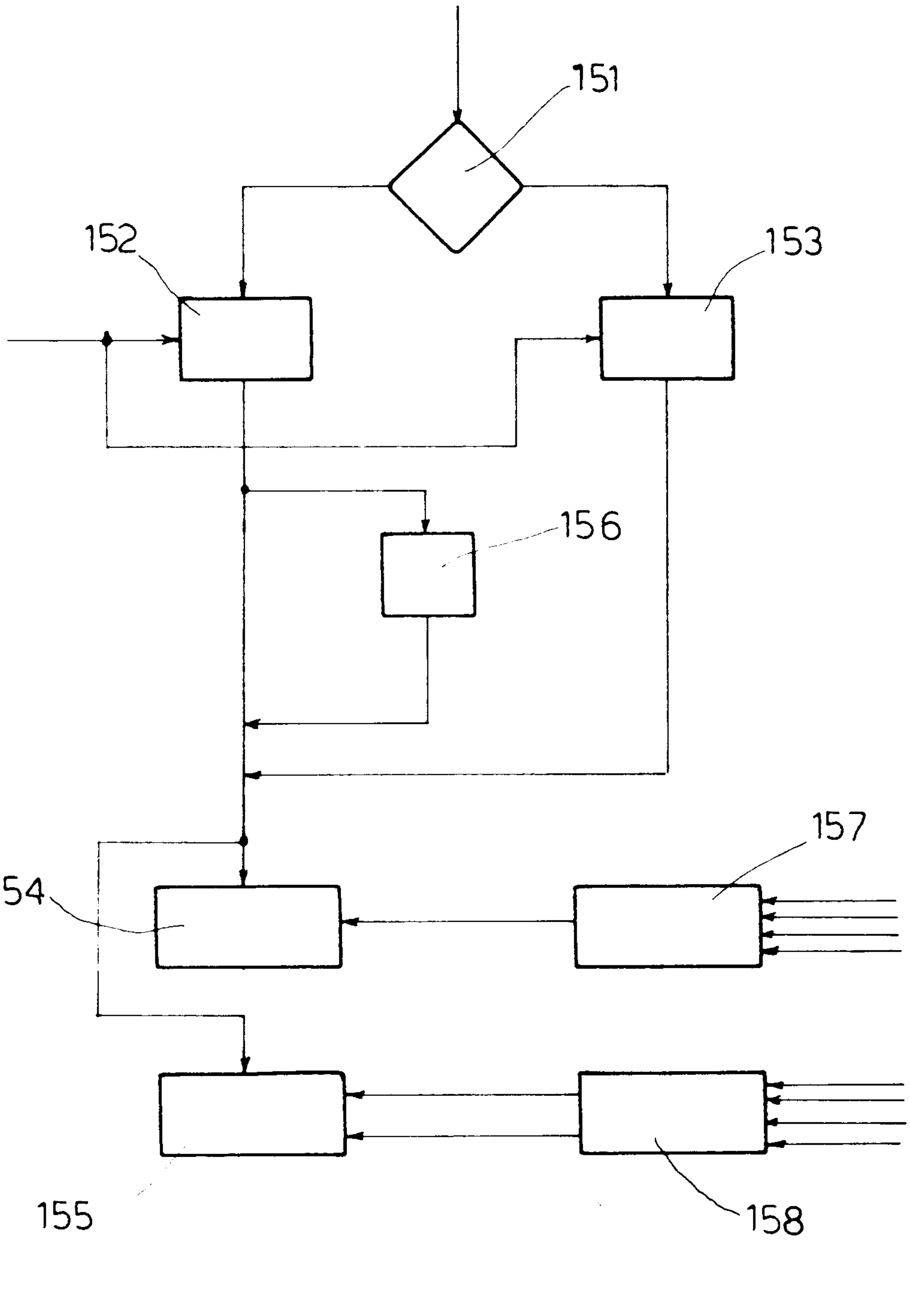
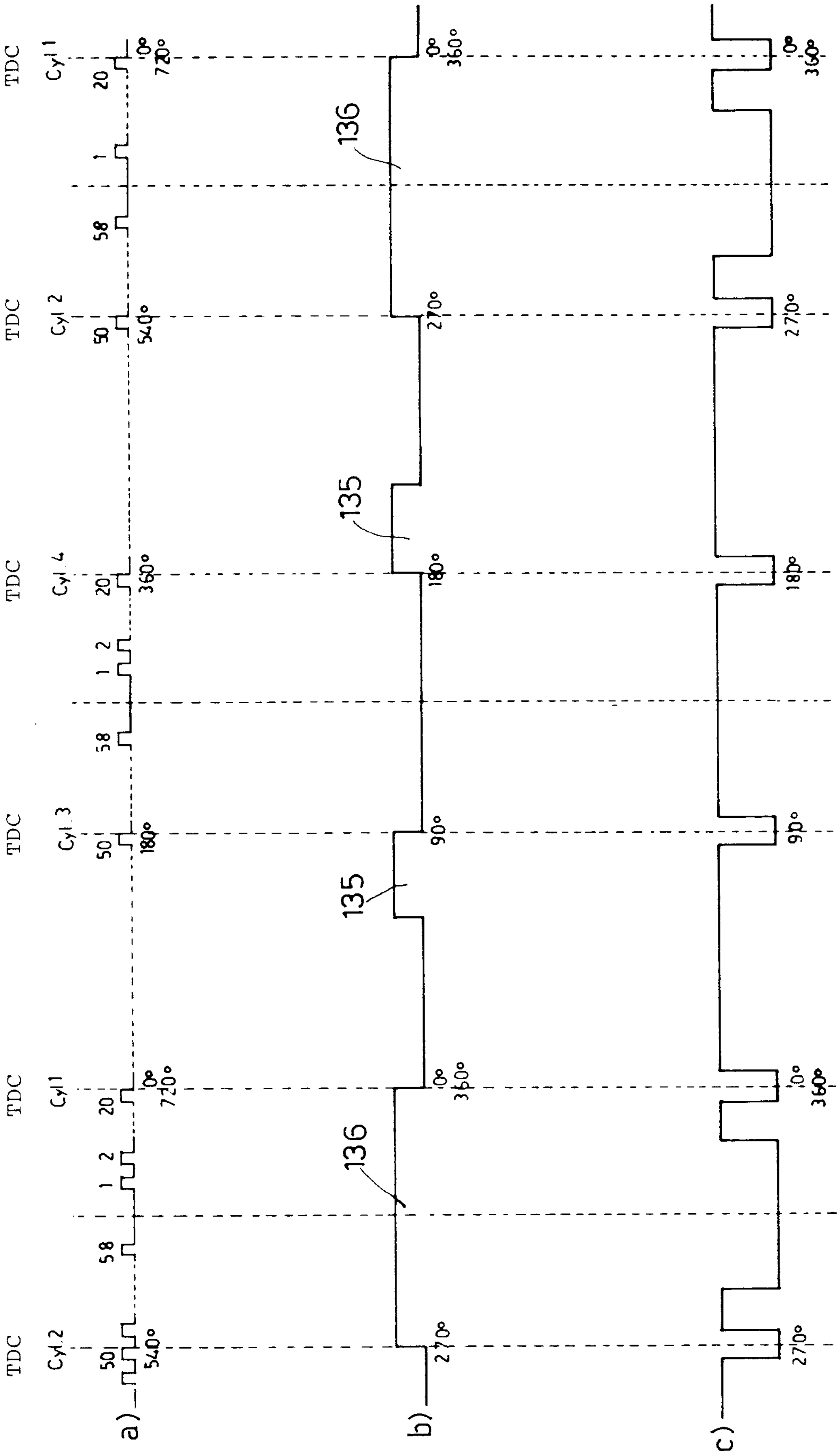


Fig.3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b)
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Cyl 1
Cyl 3
Cyl 4
50
58
1
2
20
540°
720°
0°
180°
360°
270°
90°
135
136

Fig. 4