

[54] **ELECTRONIC FUEL INJECTION TRIGGERING MEANS**

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[51] Int. Cl. **F02b 3/00**

[58] Field of Search **123/148 E, 32 EA**

[56] **References Cited**

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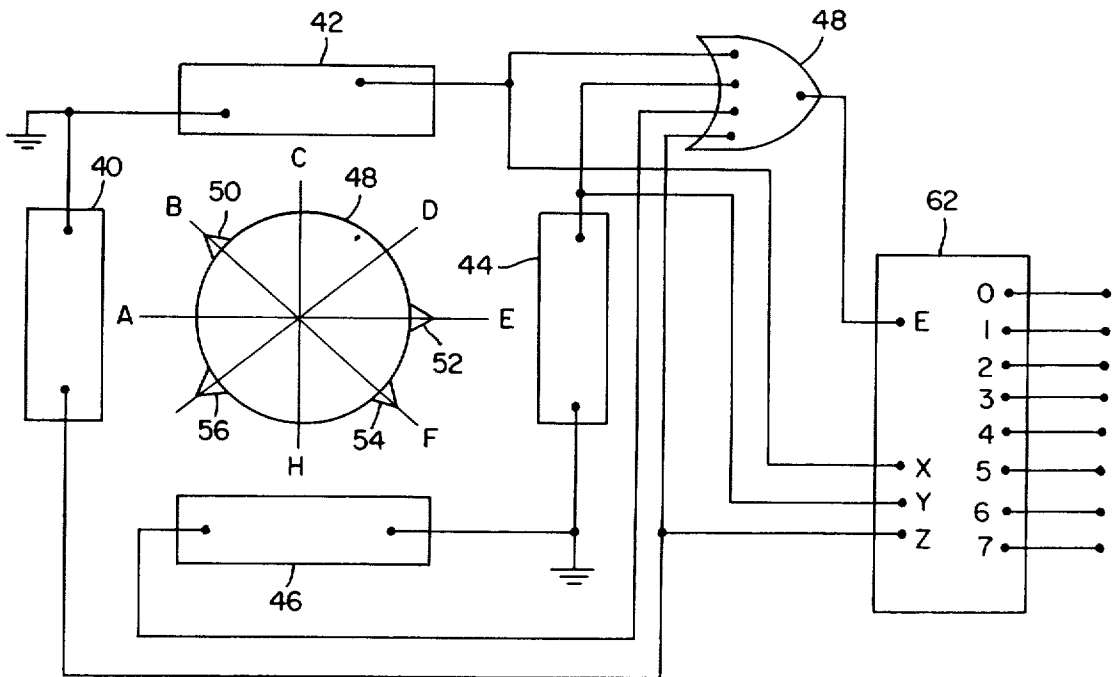
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[57] **ABSTRACT**

Electronic fuel injection triggering means includes four switches disposed 90° apart in the same plane and arranged with a rotor rotating with an engine crankshaft and having four magnets strategically disposed for determining fuel injection timing in accordance with a binary code, whereby the interval from engine starting to the first fuel injection is minimized and the proper injection sequence is continuously maintained.

6 Claims, 6 Drawing Figures



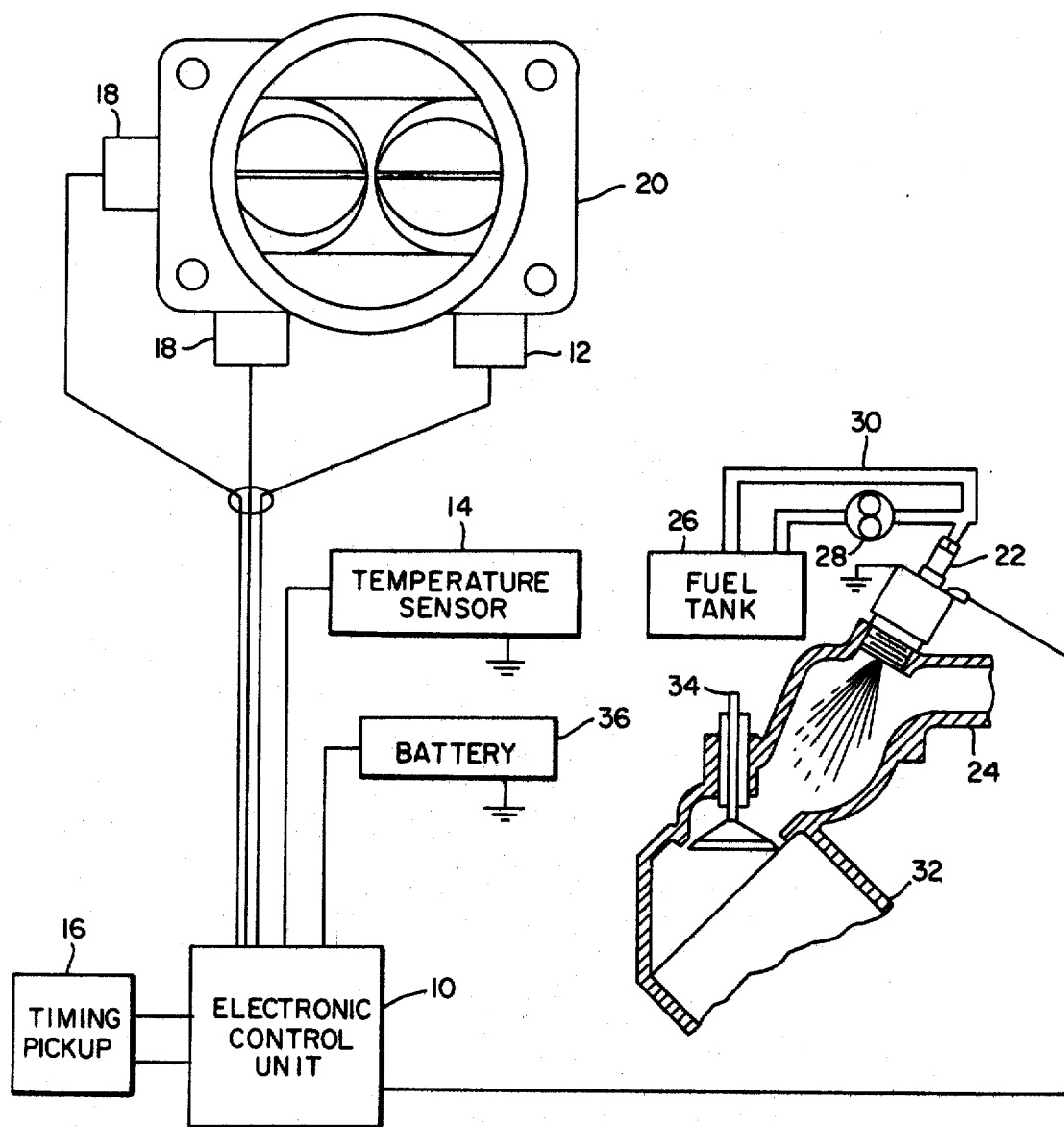


FIG. 1

SHEET 2 OF 4

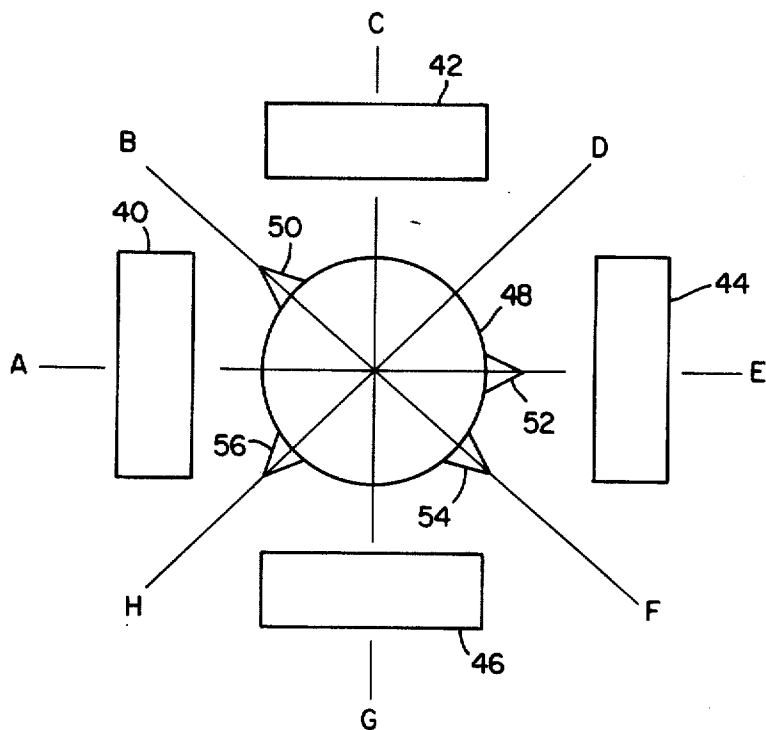


FIG. 2

ROTOR POSITION	SWITCH 40	SWITCH 42	SWITCH 44	SWITCH 46
A	I	I	O	I
B	O	O	I	O
C	I	I	I	O
D	O	O	O	I
E	O	I	I	I
F	I	O	O	O
G	I	O	I	I
H	O	I	O	O

CODE: O = SWITCH CLOSED
I = SWITCH OPEN

FIG. 3

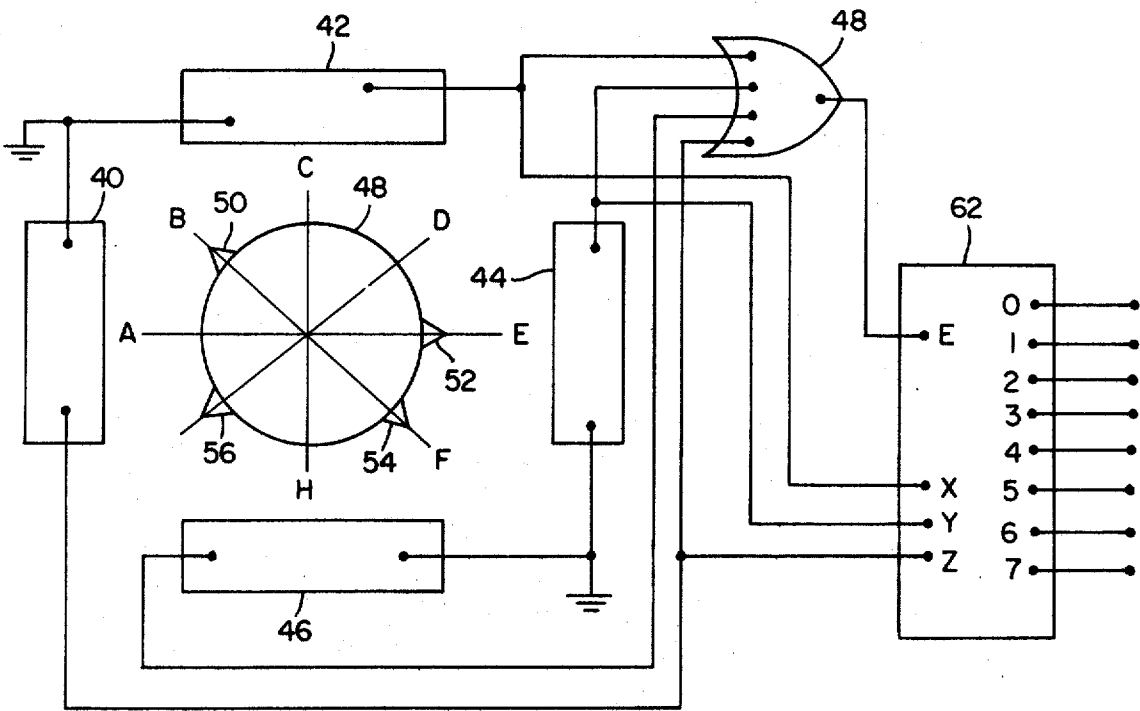


FIG. 4

X	Y	Z	0	1	2	3	4	5	6	7
0	0	0	0	1	1	1	1	1	1	1
1	0	0	1	0	1	1	1	1	1	1
0	1	0	1	1	0	1	1	1	1	1
1	1	0	1	1	1	0	1	1	1	1
0	0	1	1	1	1	1	0	1	1	1
1	0	1	1	1	1	1	1	0	1	1
0	1	1	1	1	1	1	1	1	0	1
1	1	1	1	1	1	1	1	1	1	0

0 = SIGNAL PROVIDED

FIG. 5

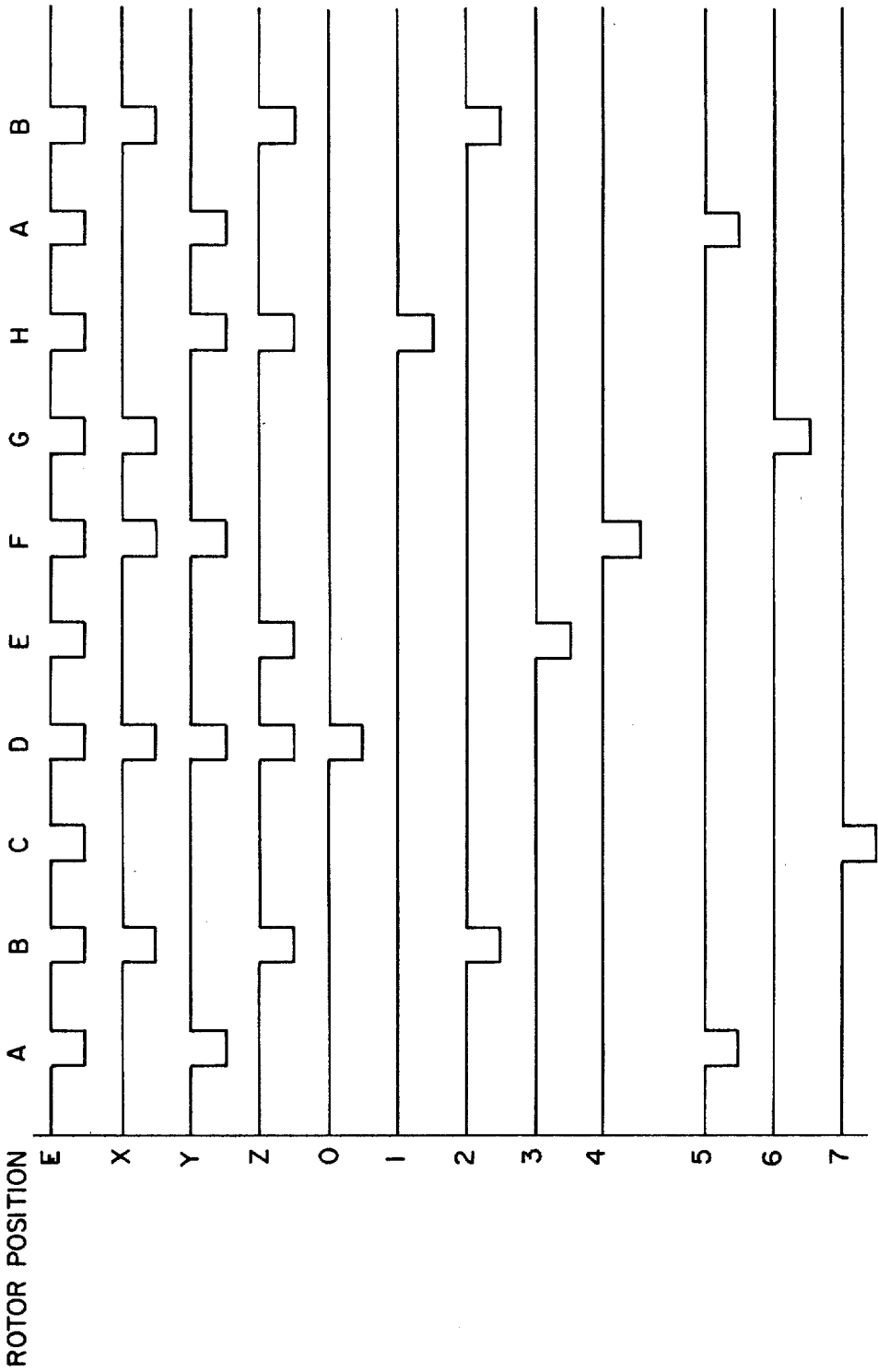


FIG. 6

ELECTRONIC FUEL INJECTION TRIGGERING MEANS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to electronic fuel injection systems for internal combustion engines and particularly, to fuel injection triggering means. More particularly, this invention relates to triggering means for timing and sequencing the fuel injection.

2. Description of the Prior Art

Prior art triggering means for an electronic fuel injection system for an internal combustion engine has included, for example, two switches and nine magnets mounted on a rotor. When the rotor rotates with the engine crankshaft, one of the switches is actuated by eight of the magnets which are equally spaced in one plane to provide injection triggering signals. The other switch, which is in another plane, is actuated by the remaining magnet between the eighth and first injections to provide a signal which is used as a phase signal to insure proper injection timing. A major disadvantage of this and similar prior art apparatus is that during starting, fuel injection will occur randomly until the first phase signal is received to establish proper timing, and which signal may not occur for up to two crankshaft revolutions. If sequential main injector cold starting is employed, this random injection could adversely affect engine operation.

SUMMARY OF THE INVENTION

The timing apparatus of the present invention contemplates using four switches disposed 90° apart in the same plane. A rotor having four magnets strategically disposed provides triggering signals in accordance with a binary code when the rotor is rotated with the engine crankshaft. The signals are applied to an OR gate which provides an enable signal. When a decoder receives at least one triggering signal and/or the enable signal, it provides signals for sequentially initiating fuel injections so that the interval from the start of the engine to the first injection is a maximum of one-quarter of an engine crankshaft revolution, with the proper injection sequence being constantly maintained.

One object of this invention is to eliminate the effect of random injection during main injection cold starting of an engine equipped with an electronic fuel injection system.

Another object of this invention is to provide fuel injection in accordance with a binary code which determines proper injection timing.

Another object of this invention is to minimize the time from the start of the engine to the first fuel injection.

Another object of this invention is to continuously maintain the proper injection sequence.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation of an electronic fuel injection system and showing generally the device of the invention.

FIG. 2 is a schematic representation showing the specific arrangement of switches and rotor magnets in the timing means shown generally in FIG. 1.

FIG. 3 is a Truth Table showing the opening and closing of the switches of FIG. 2 to provide triggering signals in accordance with a binary code.

FIG. 4 is a block diagram showing a gating and decoding arrangement for providing sequential fuel injection signals in accordance with the invention.

FIG. 5 is a Truth Table for the signals provided in accordance with FIG. 4.

FIG. 6 is a timing diagram of the inputs to and the outputs from the decoder shown in FIG. 4.

DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, an electronic fuel injection system is shown in diagrammatic form. The system is comprised of a main computing means or electronic control unit 10, a manifold pressure sensor 12, a temperature sensor 14, input timing means 16 and various other sensors denoted as 18.

Timing means 16 provides signals indicative of engine speed. These signals may be derived from any source indicative of engine crank angle but are preferably from the engine distributor. Manifold pressure sensor 12 and the associated other sensor 18 are illustrated mounted on throttle body 20 but it will be understood that other mounting locations are possible. The output of computing means 10 is coupled to an electromagnetic injector valve member 22 mounted in intake manifold 24 and arranged to provide fuel from tank 26 via pumping means 28 and suitable fuel conduits 30 for delivery to a combustion chamber 32 of but one of several forms of an internal combustion engine, otherwise not shown. While the injector valve member 22 is illustrated as delivering a spray of fuel toward an open intake valve 34, it will be understood that this representation is merely illustrative and that other delivery arrangements are known and utilized. Furthermore, it is well known in the art of electronic fuel injection systems that computing means 10 may control injector valve members arranged to be actuated singly or in groups of varying numbers in a sequential fashion as well as simultaneously. Computing means 10 is shown as energized by battery 36 which could be a vehicle battery and/or battery charging system as well as a separate battery. Timing pickup 16 and sensors 12, 18 may also be energized by battery 36 as may be required.

The construction of timing pickup 16 according to the invention is best shown in FIG. 2. Thus, four magnetic switches, commonly known in the art and referred to as reed switches and designated by the numerals 40, 42, 44 and 46 are disposed 90° apart on the same plane. Switches of this type are more fully described in U.S. Pat. No. 3,456,628 issued on July 22, 1969 to J. Bassot, et al. A rotor 48 arranged for rotation with the engine crankshaft has four magnets 50, 52, 54 and 56 suitably secured thereto and strategically disposed so as to open and close switches 40-46. To this end magnets 50 and 56 are disposed 90° apart, magnet 52 is disposed 135° from magnet 50, magnet 54

is disposed 45° from magnet 52 and magnet 56 is disposed 90° from magnet 54.

When rotor 48 rotates through positions A-G shown in the figure, the opening and closing of switches provides signals in accordance with a binary code, the Truth Table for which is shown in FIG. 3. Thus, when rotor 48 is at position A, switch 44 provides a signal. Likewise, when the rotor is at position H, signals are provided by switches 40, 44 and 46, and so on for each rotor position as shown in FIG. 3.

With reference now to FIG. 4 the signals from switches 40, 42, 44, 46 are applied to an OR gate 48 and the signals from switches 40, 42 and 44 are applied to X, Y and Z terminals, respectively, of a conventional binary to one of eight decoder designated by the numeral 62. The signal from gate 58 is applied to an enable terminal E of decoder 62.

When decoder 62 receives a signal at at least one of its input terminals X, Y and Z and/or a signal at enable terminal E, it provides a triggering signal at one of its eight output terminals 0, 1, 2, 3, 4, 5, 6, and 7 in accordance with the Truth Table of FIG. 5 and the timing diagram of FIG. 6. Thus, when an enable signal is received at terminal E and a signal is received at Terminal X, a triggering signal is provided at output terminal 6. When only an enable signal is received at terminal E, a signal is provided at output terminal 7, and so on as shown in FIGS. 5 and 6.

It will now be seen that by using the triggering arrangement of the invention to determine injection timing, the maximum interval from start of the engine to the first fuel injection is reduced to one-quarter crankshaft revolution. Further, the proper injection sequence will be constantly maintained. The disadvantages of random injection during sequential main injection cold starting are eliminated to enhance the operation of the engine.

Although but a single embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes may also be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

What is claimed is:

1. In combination with a fuel system having computing means for providing a fuel injection command signal to control the actuation of injector valve means whereby the injection of fuel to an internal combustion engine is controlled, means for triggering the computing means comprising:

a rotor rotating with the engine crankshaft and having disposed thereon a first magnet, a second magnet disposed 90° from the first magnet, a third magnet disposed 135° from the second magnet and a fourth magnet disposed 45° from the third magnet; a plurality of magnetic switches surrounding the rotor and opened and closed by the magnets when

the rotor rotates so that signals are provided by the switches in accordance with a binary code; and means responsive to the signals from the switches for providing signals for triggering the computing means, said means operable to minimize the interval from the start of the engine rotation to the first fuel injection and for maintaining a desired injection sequence.

2. Triggering means as described by claim 1, wherein: the plurality of switches include four switches disposed 90° apart in the same plane.

3. Triggering means as described by claim 1, wherein the means responsive to the signals from the switches for providing signals for triggering the computing means said means operable to minimize the interval from the start of the engine rotation to the first fuel injection and for maintaining a desired injection sequence, includes:

a gate connected to the switches for providing a signal in response to the signals from the switches; and a decoder connected to the gate and to selected switches for providing the triggering signals in response to the signal from the gate and the signals from the selected switches.

4. Triggering means as described by claim 3, wherein: the triggering signals provided by the decoder in response to the signal from the gate and the signals from the selected switches are provided in accordance with a binary code.

5. Triggering means as described by claim 3, wherein: the signal from the gate is provided in response to at least one of the signals from the switches.

6. In combination with a fuel system having computing means for providing a fuel injection command signal to control the actuation of injector valve means whereby the injection of fuel to an internal combustion engine is controlled, means for triggering the computing means comprising:

a rotor rotating with the engine crankshaft and having four magnets strategically disposed thereon; four magnetic switches surrounding the rotor and equally spaced in the same plane, said switches being opened and closed by the magnets when the rotor rotates so that signals are provided by the switches in accordance with a binary code;

a gate connected to the switches for providing a signal in response to the signal from at least one of the switches;

a decoder connected to the gate and to three of the switches and responsive to the signal from the gate and the signals from the three switches for providing signals in accordance with a binary code for triggering the computing means said means operable to minimize the interval from the start of the engine to the first fuel injection and to maintain a desired injection sequence.

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