United States Patent [19]

Miyoshi et al.

[11] **3,847,130**

[45] **Nov. 12, 1974**

[54] **ELECTRICAL FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES**

[75] Inventors: **Takeo Miyoshi,** Toyota; **Kazu Majima; Tetsuo Yamagata,** both of Kariya; **Susumu Harada,** Okazaki; **Motoharu Sueishi,** Kariya, all of Japan

[73] Assignees: **Nippondenso Co., Ltd.,** Aichi-ken; **Toyota Jidosha Kogyo Kabushiki Kaisha,** Toyota-shi, both of, Japan

[22] Filed: **Aug. 22, 1972**

[21] Appl. No.: **282,663**

[30] **Foreign Application Priority Data**

Aug. 23, 1971 Japan 46-64293

[52] **U.S. Cl.** ..... **123/179 L,** 123/32 EA, 123/179 G

[51] **Int. Cl.** **F02n 17/00,** F02b 3/00

[58] **Field of Search** ..... 123/32 CA, 32 AE, 179 G, 123/179 L

[56] **References Cited**

UNITED STATES PATENTS

3,533,381	10/1970	Schmid	123/32 CA
3,534,723	10/1970	Tramontini	123/32 CA
3,614,945	10/1971	Schlagmuler	123/179 G
3,646,918	3/1972	Wagy	123/32 CA
3,680,532	8/1972	Omori	123/179 G
3,704,702	12/1972	Aono	123/32 CA
3,716,034	2/1973	Schmid	123/32 CA

FOREIGN PATENTS OR APPLICATIONS

1,288,846	2/1969	Germany	123/179 G

Primary Examiner—Charles J. Myhre
Assistant Examiner—Ronald B. Cox
Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

An electrical fuel injection system for internal combustion engines, in which the operation of regular electromagnetic fuel injection valves is forcibly prevented so long as a starting electromagnetic fuel injection valve is in operation, whereby the engine can be started smoothly and positively without wetting the spark plug only with a readily atomizable fuel injected from the starting electromagnetic injection valve.

6 Claims, 3 Drawing Figures

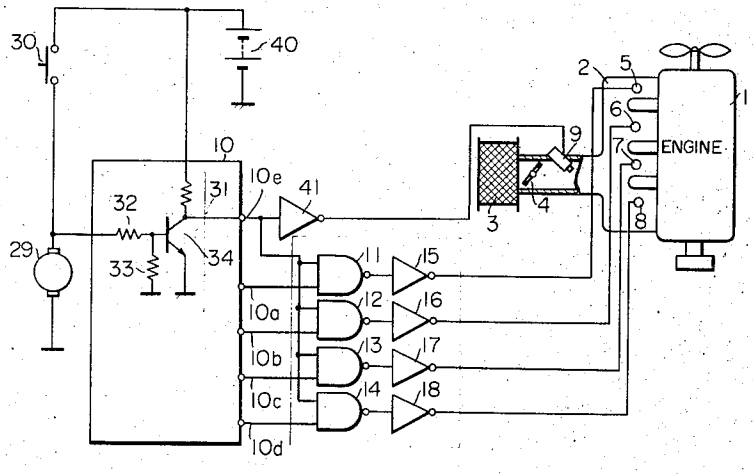


FIG. 1

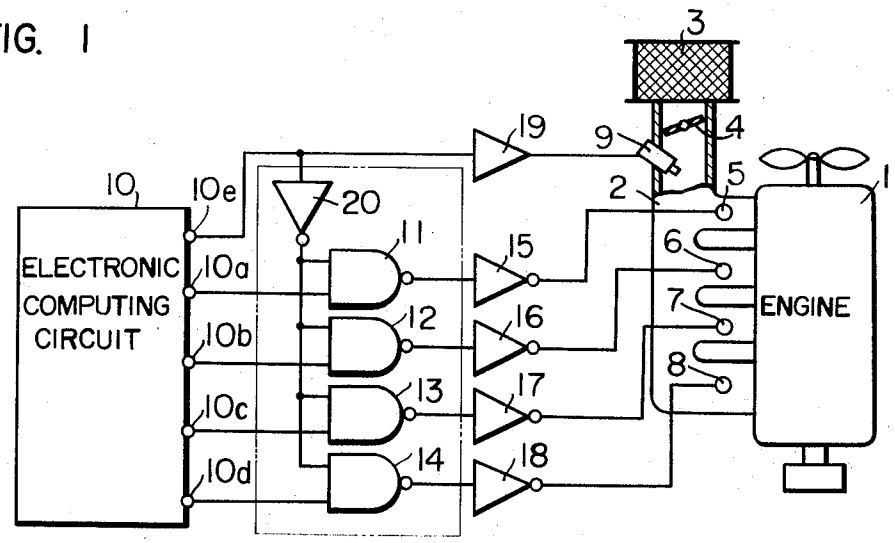

3
19
9
4
10
10e
20
5
1
2
11
15
6
ELECTRONIC
COMPUTING
CIRCUIT
10a
12
16
7
ENGINE
10b
13
17
8
10c
14
18
10d

FIG. 2

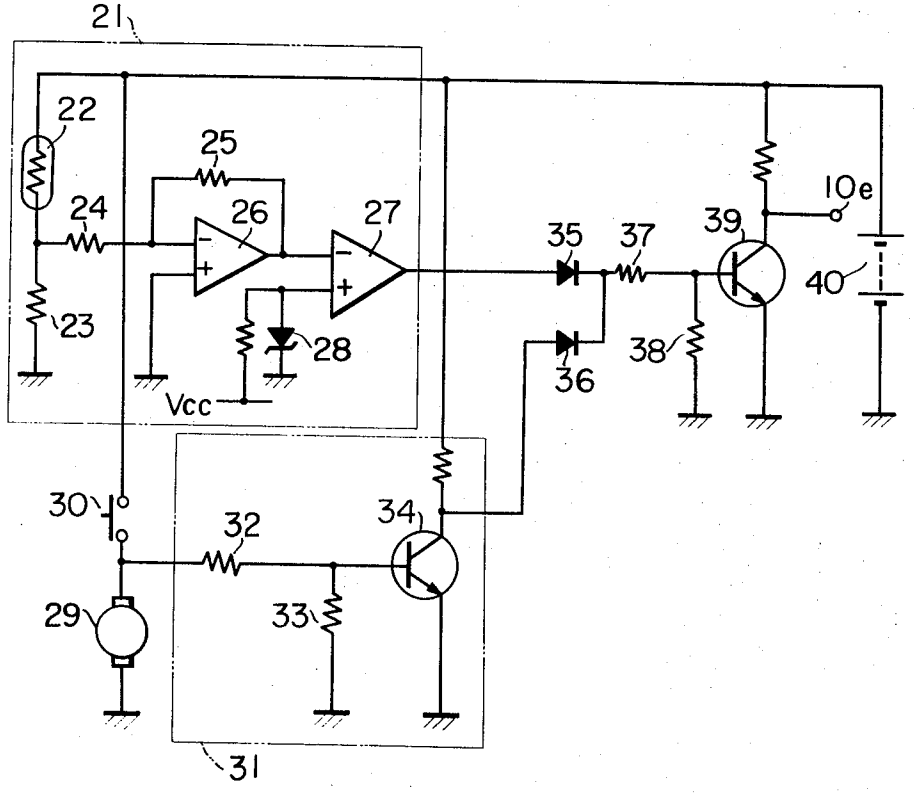
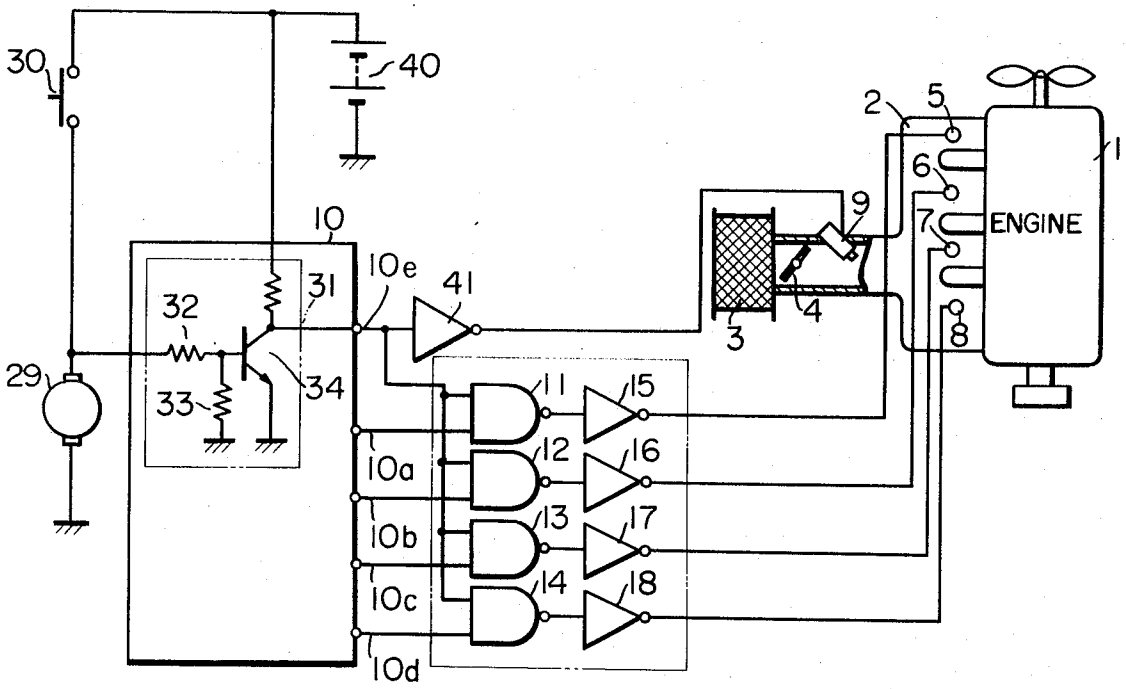

21
22
25
10e
24
26
27
35
37
39
40
23
28
38
36
Vcc
30
32
34
29
33
31

FIG. 3


30
40
10
10e
41
32
31
34
33
29
2
5
6
7
8
9
4
3
1
ENGINE
11
12
13
14
15
16
17
18
10a
10b
10c
10d

ELECTRICAL FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a fuel injection system for internal combustion engines and more particularly to an electrical fuel injection system for a spark-ignition type internal combustion engine which employs no carburetor and in which the quantity of fuel required for the engine is electrically computed so that the electromagnetic injection valves are energized to inject fuel by pulse signals whose time width corresponds to the quantity of fuel required.

2. Description of the Prior Art

In known systems of this type, in addition to the regular electromagnetic injection valves designed to inject an electrically computed quantity of fuel during normal operation of the engine, a starting electromagnetic injection valve is provided to inject a readily atomizable fuel, i.e., a fuel which is easily vaporized, to thereby ensure a good starting of the engine particularly at low temperatures of the engine.

Also the known electrical fuel injection systems generally employ a so-called warming-up enrichment method by which the quantity of fuel injected from the regular electromagnetic injection valves is increased in accordance with the temperatures of an engine until the temperature of the engine attains a predetermined value after the starting thereof.

With the conventional electrical fuel injection systems of the type described above, however, there is a drawback in that while both the starting electromagnetic injection valve and regular electromagnetic injection valves inject the fuel upon starting the engine, unlike the starting electromagnetic injection valve, the regular electromagnetic injection valves place great importance on their high-speed response characteristics and are adapted to limit the spray angle of injected fuel so as to allow the injected fuel to be drawn into the cylinders without falling along the inner walls of the intake manifold. This fact has the effect of making the atomization of the injected fuel poor. Consequently, if the driver cranks over and over again owing to his lack of experience or the ignition spark is weak owing to the lowered voltage of the battery while the bad atomization fuel injected from the regular electromagnetic injection valves to increase the amount of fuel for warming up of the engine and the fuel injected from the starting electromagnetic injection valve is being drawn into the cylinders, the amount of the fuel remaining in the cylinders without being ignited and burned would be increased wetting the spark plug and rendering the ignition difficult and hence the starting of the engine impossible.

SUMMARY OF THE INVENTION

To overcome the foregoing difficulties, it is an object of the present invention to provide an electrical fuel injection system for internal combustion engines in which, noting the fact that at the operating temperatures of the starting electromagnetic injection valve, a large quantity of poorly atomizable fuel injected from the regular electromagnetic injection valves only tends to wet the spark plug and thus gives rise to an inconvenience instead of contributing to a smooth starting of the engine, the operation of the regular electromagnetic injection valves is forcibly prevented during the time that the starting electromagnetic injection valve is in operation, so that the engine is started only with a readily atomizable fuel injected from the starting electromagnetic injection valve in a smooth and positive manner without wetting the spark plug.

It is another object of the present invention to provide an electrical fuel injection system for internal combustion engines of the type in which the quantity of fuel required for an internal combustion engine is electrically calculated and the regular electromagnetic injection valves are energized to inject fuel by means of pulse signals whose time width corresponds to the said fuel quantity required and there is provided a starting electromagnetic injection valve designed to inject an engine starting fuel when starting the engine independent of the regular electromagnetic injection valves, the system comprising a start detector for detecting the start of the internal combustion engine to produce an output signal, and a circuit for receiving the output signal of the start detector to prevent the operation of the regular electromagnetic injection valves and to energize only the starting electromagnetic injection valve.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is an electrical circuit diagram showing a first embodiment of the electrical fuel injection system for an internal combustion engine according to the present invention.

FIG. **2** is an electrical circuit diagram showing an embodiment of the temperature detector and the start detector employed in the electronic computing circuit of the system of the present invention.

FIG. **3** is an electrical circuit diagram showing a second embodiment of the system according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. **1** illustrating a first embodiment of the present invention, numeral **1** designates an internal combustion engine with four cylinders; **2** an air intake manifold; **3** an air cleaner; **4** a throttle valve. Numerals **5, 6, 7** and **8** designate regular electromagnetic injection valves adapted, when energized, to open and inject fuel and located opposite to and adjacent the air inlet valves in the respective cylinders. Numeral **9** designates a starting electromagnetic injection valve located at a position more remote from the intake manifold **2** than the regular electromagnetic injection valves **5** to **8** and directed toward the intake manifold **2.** Numeral **10** designates an electronic computing circuit for electrically detecting the number of revolutions of the engine **1,** the pressure in the intake manifold **2** and the like to electrically compute from these inputs the quantity of fuel required for the engine and thus produce successively at its output terminals **10***a*, **10***b*, **10***c* and **10***d* pulse signals whose time width corresponds to the computed fuel requirement of the engine. The electronic computing circuit **10** also includes therein a temperature detector for detecting the temperature of the engine and a start detector for detecting the starting of the engine, whereby when the temperature of the engine detected at the start thereof is below a preset value of 20°C, for example, a signal is produced at the output

terminal **10** *e*. Numerals **11, 12, 13** and **14** designate NAND gates having one input thereof respectively connected to the output terminals **10***a*, **10***b*, **10***c* and **10***d* of the electronic computing circuit **10.** Numerals **15, 16, 17** and **18** designate inverter amplifiers wherein the outputs of the NAND gates **11, 12, 13** and **14** are inverted and amplified for application to the magnetic coils of the regular electromagnetic injection valves **5, 6, 7** and **8.** Numeral **19** designates a non-inverter amplifier wherein the signal produced at the output terminal **10***e* of the electronic computing circuit **10** is amplified and then applied to the magnetic coil of the starting electromagnetic injection valve **9**; **20** an inverter for inverting the signal produced at the output terminal **10***c* and then applying the inverted signal to the other input terminals of the NAND gates **11, 12, 13** and **14.**

The temperature detector and the start detector in the electronic computing circuit **10** are constructed as shown in FIG. **2,** in which numeral **21** designates the temperature detector; **22** a thermistor immersed in the cooling water of the engine **1**; **23, 24** and **25,** resistors; **26** an amplifier; **27** a comparator amplifier; and **28** a Zener diode for generating a reference voltage which determines a preset temperature. It is prearranged such that a 0 signal is generated at the output terminal of the comparator amplifier **27** when the voltage representing the temperature of the engine **1** detected by the thermistor **22** is lower than the reference voltage generated by the Zener diode **28** and representing the preset temperature, while a 1 signal is generated at said output terminal when the former voltage is higher than the latter reference voltage. Numeral **29** designates a starting motor for cranking the engine **1**; **30** a starter switch which is closed to operate the starting motor **29** for starting the engine **1**; **31** the start detector; **32** and **33,** resistors; **34** a transistor. It is prearranged such that when the starter switch **30** is open, that is, when the engine **1** is not being started, the transistor **34** is nonconducted producing a 1 signal at its collector, whereas when the starter switch **30** is closed, that is, when the engine **1** is being started, the transistor **34** is conducted producing a 0 signal at its collector. Numerals **35** and **36** designate diodes; **37** and **38,** resistors; **39** a transistor whose collector constitutes the output terminal **10***e*; **40** a battery installed in the vehicle.

With the arrangement described above, the operation of the fuel injection system according to the present invention will now be explained. Assuming now that the starter switch **30** is closed to start the engine **1** and the temperature of the engine **1** is then below the preset value, a 0 signal is generated at the collector of the transistor **34** of the start detector **31** and also a 0 signal is generated at the output terminal of the comparator amplifier **27** of the temperature detector **21,** so that the transistor **39** is rendered non-conductive producing a 1 signal at its collector, i.e., the output terminal **10***e* of the electronic computing circuit **10.** This 1 signal is amplified by the non-inverter amplifier **19** and it is then applied to the magnetic coil of the starting electromagnetic injection valve **9** to inject the fuel into the intake manifold **2.** On the other hand, the 1 signal produced at the output terminal **10***e* is inverted by the inverter **20** and the inverted 0 signal is then applied to the input terminals of the NAND gates **11, 12, 13** and **14.** This closes the NAND gates **11** to **14** and thus prevents the signals produced at the output terminals **10***a*, **10***b*, **10***c* and **10***d* of the electronic computing circuit **10** from passing through the NAND gates **11** to **14.** Consequently, if the temperature of the engine **1,** when starting is below the preset value, the operation of the regular electromagnetic injection valves **5, 6, 7** and **8** is forcibly prevented so that only the starting electromagnetic injection valve **9** is operated to inject therefrom a readily vaporable fuel thereby ensuring a smooth starting of the engine. As the engine **1** thus started eventually starts rotating by its own effort so that the cranking by the starting motor **29** is no longer required, the starter switch **30** is opened and thus the transistor **34** of the start detector **31** is rendered non-conductive producing a 1 signal at the collector thereof. When this occurs, independently of the output signal of the temperature detector **21,** the transistor **39** is rendered conductive thus producing an 0 signal at the output terminal **10***e* of the electronic computing circuit **10.** The occurrence of this 0 signal results in the de-energization of the starting electromagnetic injection valve **9** stopping the injection of the fuel therefrom, and simultaneously the 0 signal produced at the output terminal **10***e* is inverted by the inverter **20** so that the inverted 1 signal is applied to the NAND gates **11, 12, 13** and **14** causing them to open. After the engine has started positively in this manner, the pulse signals produced at the output terminals **10***a*, **10***b*, **10***c* and **10***d* of the electronic computing circuit **10** for normal operation of the engine are applied in a predetermined sequence to the magnetic coils of the regular electromagnetic injection valves **5, 6, 7** and **8** through the NAND gates **11, 12, 13** and **14** and through the inverter amplifier **15, 16, 17** and **18** where the pulse signals are inverted and amplified. This causes the regular electromagnetic injection valves **5, 6, 7** and **8** to inject the fuel as required by the engine **1.** At this time, as with the conventional systems, the regular electromagnetic injection valves **5, 6, 7** and **8** inject, if required, an additional amount of fuel so as to warm up the engine until the temperature of the engine **1** attains another preset value of 40°C, for example, which is different from the one determined by the temperature detector **21.** In this case, such an enrichment for warming up does not give rise to any inconvenience, since the engine has already started.

On the other hand, if the temperature of the engine **1,** when starting, is higher than the preset value established by the temperature detector **21,** a 0 signal is produced at the output terminal **10***e* of the electronic computing circuit **10** so that the starting electromagnetic injection valve **9** does not operate and instead the regular electromagnetic injection valves **5, 6, 7** and **8** come into operation. In other words, since the engine **1** has already warmed up, with no fuel injected from the starting electromagnetic injection valve **9,** the engine **1** can be smoothly started without wetting the spark plug by means of the fuel injected from the regular electromagnetic injection valves **5, 6, 7** and **8.**

While, in the first embodiment described above, the operation of the regular electromagnetic injection valves **5, 6, 7** and **8** is prevented and the starting electromagnetic injection valve **9** alone is operated only in case the temperature of the engine **1,** when starting, is below the present value, in practice, whenever the engine **1** is to be started, the operation of the regular electromagnetic injection valves **5** to **8** may be forcibly prevented to allow the starting electromagnetic injection valve **9** to operate alone independently of the temperature of the engine **1.** One form of the arrangement for

this purpose will be explained with reference to FIG. 3 illustrating a second embodiment of the present invention. In FIG. 3, reference numerals identical with those which are used in FIGS. 1 and 2 designate the identical parts or their equivalents, and the collector of the transistor 34 of the start detector 31, i.e., the output terminal 10*e* is connected to one input of the NAND gates 11, 12, 13 and 14 and the output terminal 10*e* is also connected to the starting electromagnetic injection valve 9 through an inverter amplifier 41.

The operation of this embodiment is as follows: as the starter switch 30 is closed so that the starting motor 29 is operated to start the engine 1, the transistor 34 of the start detector 31 is rendered conductive producing at its collector a 0 signal which is applied to and closes the NAND gates 11, 12, 13 and 14. When this occurs, the operation of the regular electromagnetic injection valves 5, 6, 7 is forcibly prevented allowing the starting electromagnetic injection valve 9 to operate alone so as to inject a readily atomizable fuel. After the engine 1 has started, the starter switch 30 is opened so that the transistor 34 of the start detector 31 is rendered nonconductive producing a 1 signal at its collector. This 1 signal is applied to stop the operation of the starting electromagnetic injection valve 9 and simultaneously the NAND gates 11, 12, 13 and 14 are opened. Thereafter, the pulse signals generated at the output terminals 10*a*, 10*b*, 10*c* and 10*d* of the electronic computing circuit 10 energize the regular electromagnetic injection valves 5, 6, 7 and 8 to inject the fuel to meet the fuel requirement of the engine 1.

It should be noted that the present invention is not limited to the embodiments described hereinabove and that various modifications and embodiments can be devised that will fall within the spirit and scope of the present invention. For example, the NAND gates 11, 12, 13 and 14 and the inverter 20 may be incorporated in the electronic computing circuit 10 and moreover these circuit elements may be converted into configurations using negative logic.

It will thus be seen that the present invention has a remarkable effect in that since the operation of the regular electromagnetic injection valves 5, 6, 7 and 8 is forcibly prevented while the starting electromagnetic injection valve 9 is in operation, if the temperature of the engine 1 is low and thus the atomization of the fuel injected from the regular electromagnetic injection valves 5, 6, 7 and 8 is poor, the engine 1 may be smoothly started without wetting the spark plug by means of a readily atomizable fuel injected from the starting electromagnetic injection valve 9. There is another remarkable effect in that if the engine 1 has warmed up to the extent that the fuel injected from the regular electromagnetic injection valves 5, 6, 7 and 8 can be vaporized satisfactorily, the engine can be readily and positively started only with the fuel injected from the regular electromagnetic injection valves 5, 6, 7 and 8 without operating the starting electromagnetic injection valve 9.

We claim:

1. In an electrical fuel injection system for internal combustion engines wherein the fuel requirement of an engine is electrically computed by an electronic computing circuit so that the regular electromagnetic injection valves are energized to inject the fuel by pulse signals the time width of which corresponds to the fuel requirement, and wherein a starting electromagnetic injection valve is provided to atomize and inject, independently and exclusively of the regular electromagnetic injection valves, an engine starting fuel when starting the engine, the combination comprising a start detector for detecting the start of the engine and for generating an output signal, and a circuit means connected with said start detector for receiving said output signal of said start detector for preventing the operation of the regular electromagnetic injection valves and for energizing only the starting electromagnetic injection valve to thereby provide an atomized fuel to said engine when said engine is starting.

2. In an electrical fuel injection system for internal combustion engines wherein the fuel requirement of an engine is electrically computed by an electronic computing circuit so that the regular electromagnetic injection valves are energized to inject the fuel by pulse signals the time width of which corresponds to the fuel requirement, and wherein a starting electromagnetic injection valve is provided to atomize and inject, independently and exclusively of the regular electromagnetic injection valves, an engine starting fuel when starting the engine, the combination comprising a start detector for detecting the start of the engine and for generating an output signal when said engine is being started, a temperature detector for detecting the temperature of the engine, said detector generating an output signal when the engine temperature is lower than a preset value, and a circuit means connected with said start detector and said temperature detector for preventing the operation of the regular electromagnetic injection valves and for energizing only the starting electromagnetic injection valve when said output signals of said start detector and said temperature detector are simultaneously generated.

3. An electrical fuel injection system according to claim 1, wherein said circuit comprises:

a logic gate circuit having a first input terminal connected to said electronic computing circuit, a second input terminal connected to said start detector, and a first output terminal connected to said regular electromagnetic injection valves; and

an inverter circuit having an input terminal connected to said start detector, and an output terminal connected to said starting electromagnetic injection valve.

4. The electrical fuel injection system of claim 1 wherein said circuit comprises:

gating means coupling the output of said electronic computing circuit with said regular electromagnetic injection valve;

means response to the output of said start detector for inhibiting said gating means when said internal combustion engine is being started and for enabling said gating means after said internal combustion engine is started, and

gating means responsive to the output signal of said start detector for energizing the starting electromagnetic valve.

5. The electrical fuel injection system of claim 2 wherein said circuit comprises:

a logic gating circuit having a first input terminal connected to said electronic computing circuit,

an inverter having an input terminal connected to said start detector and an output terminal connected to the other input terminals of said logic gating circuit, said logic gating circuit having an

output terminal connected to said regular electromagnetic injection valve wherein said logic gating circuits are inhibited when the output signals of said start detector and said temperature detector are simultaneously generated and wherein said logic gating circuits are enabled when said engine is started or said engine temperature goes above a preset level.

6. The electrical fuel injection system of claim 2 wherein said circuit comprises gating means coupling the output of said electronic computing circuit with said regular electromagnetic valve, means responsive to the output of said start detector and said temperature detector for inhibiting said gating means when said internal combustion engine is being started and the temperature of said engine is below a preset level, and for enabling said gating means after said engine is started or the temperature of said engine goes above said preset level, and means responsive to the output signal of said start detector and said temperature detector for energizing the starting electromagnetic valve when said engine is being started and when the temperature is below a preset level.

* * * * *