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Matsui et al.

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[45] **Mar. 26, 1974**

[54] **FLUIDIC PULSE GENERATOR FOR INTERNAL COMBUSTION ENGINES**

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[73] Assignee: **Nippondenso Kabushiki Kaisha**, Aichi-ken, Japan

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[21] Appl. No.: **125,641**

[30] **Foreign Application Priority Data**

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Dec. 27, 1970 Japan 45-136159

[52] **U.S. Cl.** ..... **137/830**, 123/119 R
[51] **Int. Cl.** **F15c 3/00**
[58] **Field of Search** 137/81.5; 123/DIG. 10

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Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

A fluidic pulse generator wherein a fluid passage in the form of a recess or through-hole is formed in a rotary shaft slidingly rotatable in a casing of an ignition interrupter but not movable axially, and two conduits which can be communicated with each other through said fluid passage are connected to said casing with one ends thereof open in said casing. When pressurized fluid is supplied into one of the conduits, the flow of pressurized fluid is interrupted intermittently, whereby fluidic trigger pulses are generated.

2 Claims, 11 Drawing Figures

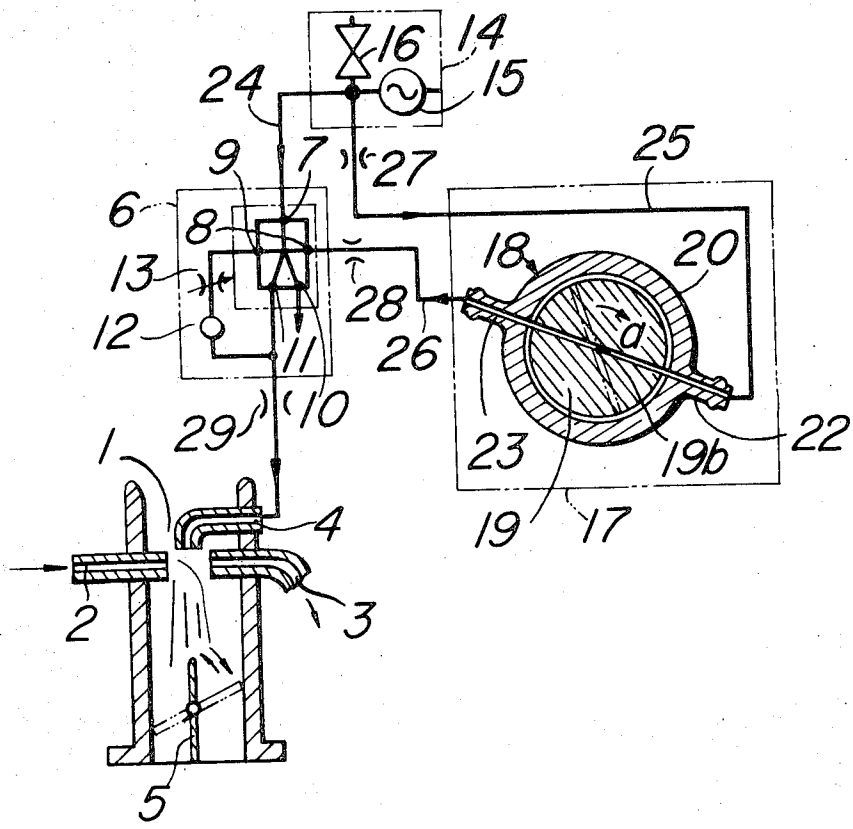


FIG. 1

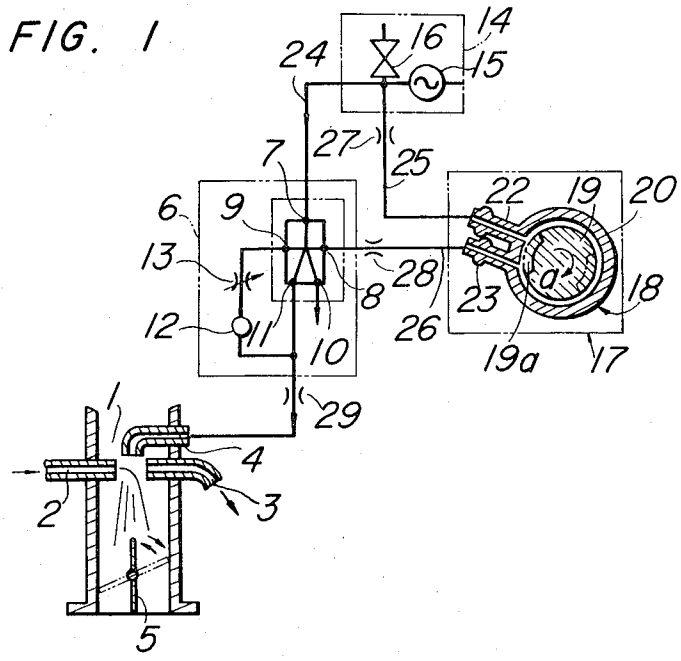


FIG. 2

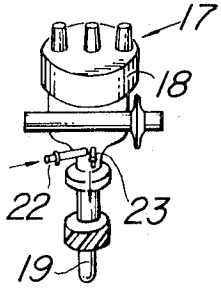


FIG. 3a

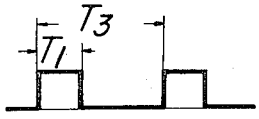


FIG. 3b

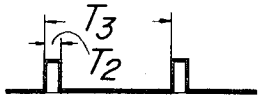
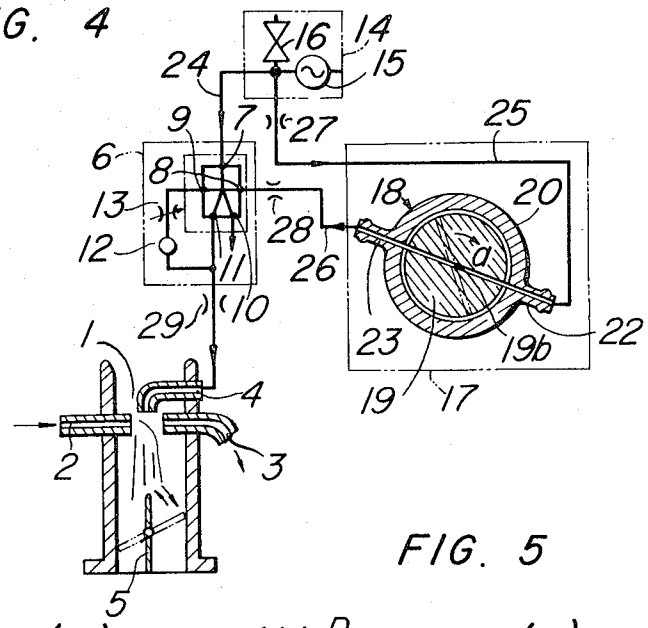


FIG. 4


16
14
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24
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27
25
6
8
13
12
11
28
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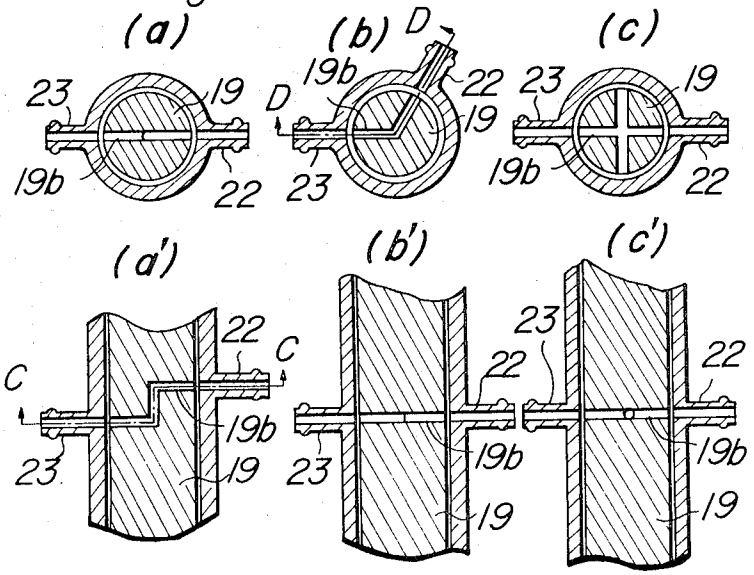
18
20
a
10
29
1
4
2
3
5
23
19b
22
19
17

FIG. 5


(a)
(b)
(c)
D
19b
22
23
19
(a')
(b')
(c')
C

FLUIDIC PULSE GENERATOR FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a fluidic pluse generator adapted for use in fuel feed devices for internal combustion engines.

2. Description of the Prior Art

Fuel feed devices for internal combustion engines which have heretofore been used for practical applications, include a suction-type carburetor which utilizes the intake pressure of an engine, a mechanical fuel injection device which injects fuel directly into a cylinder or intake manifold without using a carburetor, and an electronic fuel injection device which has electronic means in the fuel control unit.

However, such mechanical and electronic fuel injection devices are not only complicated in construction but also high in production cost, and are rarely used for internal combustion engines other than those which are used for special purposes. On the other hand, the suction-tpe carburetor mentioned above sucks fuel by the effect of pressure lowering of a suction flow at a fixed Venturi or variable Venturi, and injects the same. A carburetor of the fixed Venturi type, as is well known, necessitates the provision of an injection mechanism for each of a low speed system, an intermediate speed system and a high speed system, according to the velocity range of the suction flow, and has the disadvantage that shifting from one system to another renders a smooth operation of the engine difficult. A carburetor of the variable Venturi type is free of such disadvantage but is disadvantageous not only in that a mechanism operatively connecting a variable throttle valve provided in the fuel passage with the variable Venturi and a mechanism operatively associating said variable Venturi with the back pressure of the suction gas, etc. call for high machining precision, but also in that the mechanism becomes complicated and large in size, and hence the production cost becomes high.

Under the circumstances, the present inventor conducted numerous experiments and studies, and found that fuel can be fed continuously, smoothly and properly from a low speed to a high speed operation of an engine and a fuel feed device for internal combustion engines, of a very simple construction can be obtained at a low cost, by providing in an air conduit leading to the intake port of an engine a fuel injection nozzle which injects fuel with a constant pressure, a fuel receiving conduit for receiving the fuel from said fuel injection nozzle through a certain gap therebetween and a compressed air conduit communicating with a source of compressed air so as to atomize the fuel passing through said gap by the effect of compressed air; providing a fluidic multivibrator element intermediary of said compressed air conduit for controlling intermittently the compressed fluid passing through said conduit; connecting a fluidic pulse generator with said fluidic multivibrator element, which gives said fluidic multivibrator element fluidic pulses of an operating medium, such as air, in synchronized relation to the rate of rotation of the engine; and controlling the time constant of a time limiting element in accordance with the load, etc. of the engine, which time limiting element determines the pulse width of the output air of said fluidic multivibrator element.

However, as the above-mentioned fluidic pulse generator, one which is simple in construction, inexpensive and capable of generating fluidic pulses having a predetermined correlation with the rate of rotation of the engine, has not been proposed heretofore, whatsoever, and this has been one of the subject matters in the art.

The present invention aims to solve such subject matter, and according to the invention there is provided a fluidic pulse generator which is so constructed that a fluid passage in the form of a recess or through-hole is formed in a rotary shaft which is slidably rotatably but not axially movably extends through a sealed casing of an ignition interrupter of an engine and pressurized fluid is supplied through one of two conduits which are communicated with each other through said fluid passage, whereby the flow of the pressurized fluid is interrupted intermittently incident to rotation of said rotary shaft and thus fluidic trigger pulses are obtained.

SUMMARY OF THE INVENTION

The present invention provides a fluidic pulse generator so constructed that a fluid passage in the form of a recess or through-hole is formed in a rotary shaft which is slidably rotatably but not axially movably extends through a sealed casing of an ignition interrupter of an engine, and two conduits are opened in said casing which can be communicated with each other through said fluid passage, and pressurized fluid is supplied into one of said two conduits, whereby the flow of said pressurized fluid is interrupted intermittently incident to rotation of said rotary shaft and thereby fluidic pulses are obtained.

A primary object of the invention is to provide a fluidic pulse generator of the character described which is of small size and simple construction and can be produced at a low cost.

Another object of the invention is to provide a fluidic pulse generator of the character described which is adapted for use with internal combustion engines and capable of easily generating fluidic pulses having an optional correlation with the rate of rotation of the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram, partially in cross section, showing an embodiment of the fluidic pulse generator of the invention as applied to the fuel feed device of an internal combustion engine;

FIG. 2 is a perspective view of the ignition interrupter of the engine in which the fluidic pulse generator of the invention is provided;

FIGS. 3(*a*) and 3(*b*) are diagrams respectively showing the wave forms of the fluidic trigger pulses obtained from the fluidic pulse generator of the invention through the fluidic multivibrator;

FIG. 4 is a diagram, partially in cross section, showing another embodiment of the fluidic pulse generator of the invention as applied to the fuel feed device of an internal combustion engine;

FIGS. 5(*a*), 5(*b*) and 5(*c*) are transverse cross-sectional views of the fluidic pulse generators having different numbers of fluid passages respectively; and

FIGS. 5(*a'*), 5(*b'*) and 5(*c'*) are longitudinal cross-sectional views, through the axis, of the fluidic pulse generators of FIGS. 5(*a*), 5(*b*) and 5(*c*) respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The fluidic pulse generator of the invention will be described with reference first to an embodiment which is applied to the fuel feed device of a four-cycle internal combustion engine. In FIG. 1, reference numeral 1 designates an intake pipe having one end open in the atmosphere, with the other end connected to the intake port of the engine not shown. A fuel injection nozzle 2 is projected into the intake pipe 1 to inject fuel with a constant pressure. A fuel receiving pipe 3 is projected into the intake pipe 1 in opposed relation to the fuel injection nozzle 2 with a certain gap therebetween, for receiving the fuel injected from said fuel injection nozzle. A compressed air pipe 4 is provided projecting into the intake pipe 1, with its inner end located in the vicinity of the gap between the fuel injection nozzle 2 and the fuel receiving pipe 3. A throttle valve 5 is provided in the intake pipe 1 at a location downstream of the fuel injection nozzle 2, etc. Reference numeral 6 generally designates a mono-stable fluidic multivibrator element having an inlet port 7, control ports 8, 9 and outlet ports 10, 11. The outlet port 10 is open in the atmosphere and the other outlet port 11 is communicated with the compressed air pipe 4. Air pulses shown in FIGS. 3(*a*), 3(*b*) are generated at the outlet port 11, which are transmitted through the compressed air pipe 4 and applied to the fuel passing through the gap between the fuel injection nozzle 2 and the fuel receiving pipe 3. An air tank 12 and a variable throttle 13 constitute time limiting elements respectively. An arrangement is made such that the variable throttle 13 is operated by the back pressure of the suction gas, whereby the time constants of both of the time limiting elements are controlled according to the back pressure of the suction gas and the width of the aforesaid air pulse is controlled according to the load of the engine. Reference numeral 14 designates a source of compressed air, 15 an air compressor and 16 a pressure regulating valve by which the pressure of the compressed air from the air compressor 16 is maintained constant. Reference numeral 17 generally designates the fluidic pulse generator according to the instant invention and 18 designates an ignition interrupter mounted on the engine. The rotary shaft 19 of the ignition interrupter 18 makes one revolution on every half revolution of the crank shaft as the engine is a four-cycle engine. Further, the rotary shaft 19 has a recess 19*a* formed in the peripheral surface thereof and is rotatable in a sealed casing 20 of the ignition interrupter in the direction of the arrow *a* but not movable axially. An inlet pipe 22 and an outlet pipe 23 are connected to the casing 20 at circumferentially spaced locations, for communication with the recess 19*a* of the rotary shaft 19. The air compressor 15 is communicated with the inlet port 7 of the fluidic multivibrator element 6 through a first pipe 24, and also with the inlet pipe 22 of the fluidic pulse generator 17 through a second pipe 25. The outlet pipe 23 of the fluidic multivibrator 17 is communicated with one of the control ports 8 of the fluidic multivibrator element 6 through a third pipe 26. The second pipe 25 and the third pipe 26 are provided therein with stationary throttles 27, 28 respectively. Likewise, the compressed air pipe 4 is provided with a stationary throttle 29 therein.

The device of the invention constructed as described above operates as follows: Namely, when the rotary shaft 19 of the ignition interrupter 18 of the fluidic pulse generator 17 is in the position indicated by the alternate long and two short dashes line and the communication between the inlet pipe 22 and outlet pipe 23 is shut down by the peripheral surface of said rotary shaft 19, or in other words, when the engine is in the period wherein fuel need not be fed, the compressed air supplied from the air compressor 15 through the second pipe 25 and the stationary throttle 27 flows into the inlet pipe 22 but is prevented from entering the outlet pipe 23 by the peripheral surface of the rotary shaft 19. Therefore, no air trigger pulses are applied to the control port 8 of the fluidic multivibrator element 6 and the compressed air flowing into the inlet port 7 of the fluidic multivibrator element 6 from the air compressor 15 is released to the atmosphere from the outlet port 10 and not directed into the other outlet port 11. Consequently, the fuel injected from the fuel injection nozzle 2 entirely flows into the fuel receiving pipe 3 to be returned to a fuel tank. Thereafter, when the rotary shaft 19 of the fluidic pulse generator 17 is located in the position indicated by the solid line and the communication between the inlet pipe 22 and outlet pipe 23 is established through the recess 19*a* of said rotary shaft 19, or in other words, when the engine is in the period wherein fuel need be fed, the compressed air from the air compressor 15 flows into the outlet pipe 23 through the second pipe 25, the stationary throttle 27, the inlet pipe 22 and the recess 19*a* of the rotary shaft 19. The compressed air, i.e., air trigger pulses, entering the outlet pipe 23 flows into the control port 8 of the fluidic multivibrator element 6 through the third pipe 26 and the stationary throttle 28. Therefore, the compressed air flow passing through the inlet port 7 is directed into the outlet port 11 by being urged by the compressed air from said control port 8 and the compressed air is jetted into the gap between the fuel injection nozzle 2 and the fuel receiving pipe 3 through the compressed air pipe 4 and the stationary throttle 29, to atomize the fuel passing through said gap. At the same time, the compressed air from the outlet port 11 partially flows into the control port 9 through the air tank 12 and the variable throttle 13, with a time constant as determined by the volume of said air tank and the amount of restriction of said variable throttle 13. When the flow rate of the compressed air entering the control port 9 reaches a level to urge the compressed air flow, entering the outlet port 11 from the inlet port 7, toward the outlet port 10, said compressed air flow is shifted from the outlet port 11 into the outlet port 10 and released into the atmosphere. Therefore, the compressed air from the outlet port 11 produces pulses as shown in FIGS. 3(*a*), 3(*b*). The widths T_1, T_2 of the output air pulses, that is, the feed rate of fuel, are determined by the time constant which in turn is determined by the capacity of the air tank 12 and the amount of restriction of the variable throttle 13, and said time constant is determined according to the back pressure of the suction gas of the engine. Thus, it will be understood that the period T_3 of the output air pulses from the outlet port 11 is determined by the rate of rotation of the engine and the width thereof is determined in accordance with the load of the engine. Further, the fuel is fed to the engine in synchronism with the output air pulses which are generated each on every two revolutions of the en-

gine crank shaft. Therefore, the starting time of fuel feeding coincides with the opening time of the intake valve, and yet further the feeding rate of fuel is in accordance with the load of the engine. The above-described operation can be obtained continuously from a low speed operation to a high speed operation of the engine.

Another embodiment of the fluidic pulse generator of the invention will be described hereunder:

In FIG. 4, the same reference numerals as in FIG. 1 indicate same parts or elements. Reference numeral 17 generally designates another embodiment of the fluidic pulse generator according to the invention, 18 an ignition interrupter mounted on the engine, and 19 a rotary shaft of said ignition interrupter which makes one revolution on every half revolution of the engine crank shaft as the engine is a four-cycle engine.

In this embodiment, the rotary shaft 19 has a through-hole 19*b* formed therein and is rotatable in a sealed casing 20 of the ignition interrupter 19 in the direction of the arrow *a* in sliding engagement therewith but not movable axially. The fluidic pulse generator 17 has the inlet pipe 22 and the outlet pipe 23 connected thereto at circumferentially spaced locations, for communication with the through-hole 19*b* of the rotary shaft 19. The air compressor 15 is communicated with the inlet port 7 of the fluidic multivibrator element 6 through the first pipe 24, and also communicated with the inlet pipe 22 of the fluidic pulse generator 17 through the second pipe 25. The third pipe 26 has one end connected with the outlet pipe 23 of the fluidic pulse generator 17, with the other end connected with the control port 8 of the fluidic multivibrator element 6.

The device of the invention constructed as described above operates as follows: Namely, when the rotary shaft 19 of the ignition interrupter 18 of the fluidic pulse generator 17 is in the position indicated by the alternate long and two short dashes line and the communication between the inlet pipe 22 and outlet pipe 23 is shut down by the peripheral surface of said rotary shaft 19, or in other words, when the engine is in the period wherein fuel need not be fed, the compressed air supplied from the air compressor 15 through the second pipe 25 and the stationary throttle 27, flows into the inlet pipe 22 but is prevented from flowing into the outlet pipe 23 by the peripheral surface of the rotary shaft 19. Therefore, no air trigger pulses are applied to the control port of the fluidic multivibrator element 6 and the compressed air flowing from the air compressor 15 into the inlet port 7 of the fluidic multivibrator element 6 is released into the atmosphere from the outlet port 10, no compressed air being supplied into the other outlet port 11. Consequently, the fuel injected from the fuel injection nozzle 2 entirely flows into the fuel receiving pipe 3 to be returned to the fuel tank. Thereafter, when the rotary shaft 19 of the fluidic pulse generator 17 is located to the position indicated by the solid line and the communication between the inlet pipe 22 and outlet pipe 23 is established through the through-hole 19*b* of said rotary shaft 19, or in other words, when the engine is in the period wherein the fuel need be fed, the compressed air from the air compressor 15 flows into the outlet pipe 23 through the second pipe 25, the stationary throttle 27, the inlet pipe 22 and the through-hole 19*b* of the rotary shaft 19. The compressed air, i.e., air trigger pulses, entering the outlet pipe 23 flows into the control port 8 of the fluidic multivibrator element 6 through the third pipe 26 and the stationary throttle 28. As a result, the compressed air flow from the inlet port 7 is directed into the outlet port 11 by being urged by the compressed air flow from the control port 8, and the compressed air passes through the compressed air pipe 4 and the stationary throttle 19 and is jetted into the gap between the nozzle 2 and the fuel receiving pipe 3, to atomize the fuel passing through said gap.

Although in the two embodiments described and illustrated herein, the feeding rate of fuel to the engine, i.e., the widths of the output air pulses of the fluidic multivibrator element 6, is determined according to the back pressure of the suction gas of the engine which is indicative of the loaded condition of the engine, said pulse widths may alternatively be controlled by the degree of opening of the air throttle valve 5, or the degree of opening of said air throttle valve 5 and the back pressure of the suction gas of the engine, which is or are similarly indicative of the loaded condition of the engine. It is also to be understood that the fluidic mutivibrator element 6 which is of the monostable type in the embodiments described herein, may be of the bistable type. It is also to be understood that, while in the embodiments described, the fluidic pulse generator 17 of the invention is intermittently opened and closed at a frequency twice as many as the rate of rotation of the rotary shaft 19, it may be opened and closed at a frequency equal to or three, four or even more times as many as the rate of rotation of said rotary shaft 19, by increasing the number of the recesses 19*a* shown in FIG. 1 or by forming the through-hole 19*b* in the shape, for example, as shown in FIG. 5(*a*), 5(*b*), 5(*c*), 5(*a'*), 5(*b'*) or 5(*c'*). It should also be understood that the operating fluid for the fluidic pulse generator 17 of the invention is not restricted only to compressed air as used in the embodiments described, but may be other gas or liquid, and the atmospheric air may be used as the operating fluid where negative pressure appears in the control port 8 of the monostable multivibrator element 6 due to the construction of said element. Further, the ignition interrupter 18 which constitutes the fluidic pulse generator 17 of the invention, may be of the type having a distributor, and still further, the fluidic pulse generator 17 of the invention can be applied, not only to the fuel feed device as described herein but also to many other devices.

In the fluidic pulse generator according to the instant invention, as described above, a recess or through-hole is formed in a rotary shaft slidingly rotatable in a sealed casing of an ignition interrupter but not movable axially and fluid is supplied into one of two pipes which are opened in said casing and intermittently communicated with each other through said recess or through-hole. Therefore, by rotating the rotary shaft it is possible to obtain fluidic pulses having a desired correlation with the rate of rotation of the associated engine, e.g., a frequency equal to or two, three, four or even more time as many as the rate of rotation of the engine, and these pulses can be very advantageously used as driving signals for fluid-type fuel feed devices, etc. The fluidic pulse generator of the invention is also advantageous in that it is small in size, simple in construction and can be provided at low cost.

We claim:

1. A fluidic pulse generator for use with a fluidic multivibrator in an internal combustion engine including an ignition spark distributor having a housing and a shaft which rotates in said housing in synchronism with the engine rotation; said housing having a member provided with inlet and outlet ports respectively coupling a supply of air under pressure from the inlet to the outlet port, and said shaft having a bore therethrough and airtightly but rotatably coupling with said member for intermittently communicating with the inlet and outlet ports simultaneously for each revolution of the distributor shaft.

2. The fluidic pulse generator of claim 1 wherein a plurality of bores is supplied to said distributor shaft for selectively communicating said inlet and outlet ports for a portion of the rotational cycle of said distributor shaft at different selected intervals.

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