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Stinsa

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[54] **FUEL INJECTION SYSTEM FOR MULTIPLE CYLINDER INTERNAL COMBUSTION ENGINE**

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[51] **Int. Cl.** **F02d 1/02**, F02m 39/00

[58] **Field of Search** ... 123/139 R, 139 AR, 139 AP, 123/139 AE, 140

[56] **References Cited**

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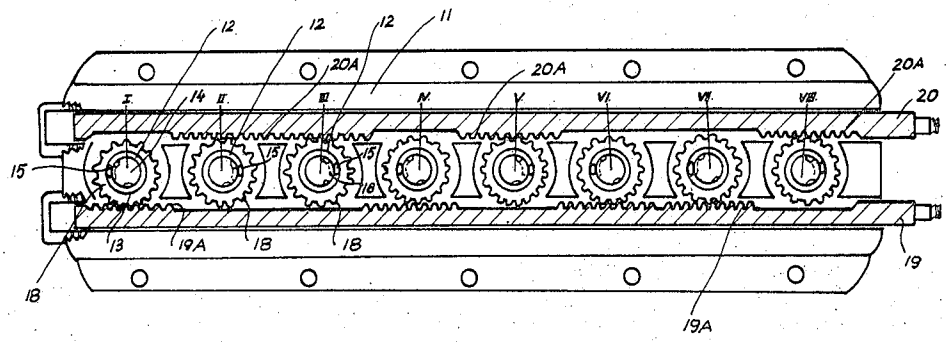
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Assistant Examiner—Cort Flint
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[57] **ABSTRACT**

This disclosure is directed to an improved fuel injection system for use with internal combustion engines comprising a plurality of plunger type injection pumps in which the operation of the respective pumps is controlled in a manner which selectively permits certain predetermined numbers of pumps to be shut-off to prohibit the delivery of fuel to the engine cylinders fed thereby while the remaining pumps may be operated to effect fuel delivery to the engine cylinders fed thereby or whereby all of the fuel injection pumps may be rendered operative or inoperative. An accelerator and governor are operatively connected to the respective pumps to vary the amount of fuel the operative fuel pumps deliver to the cylinders fed thereby in accordance to the load imposed on the operating cylinders.

1 Claim, 4 Drawing Figures



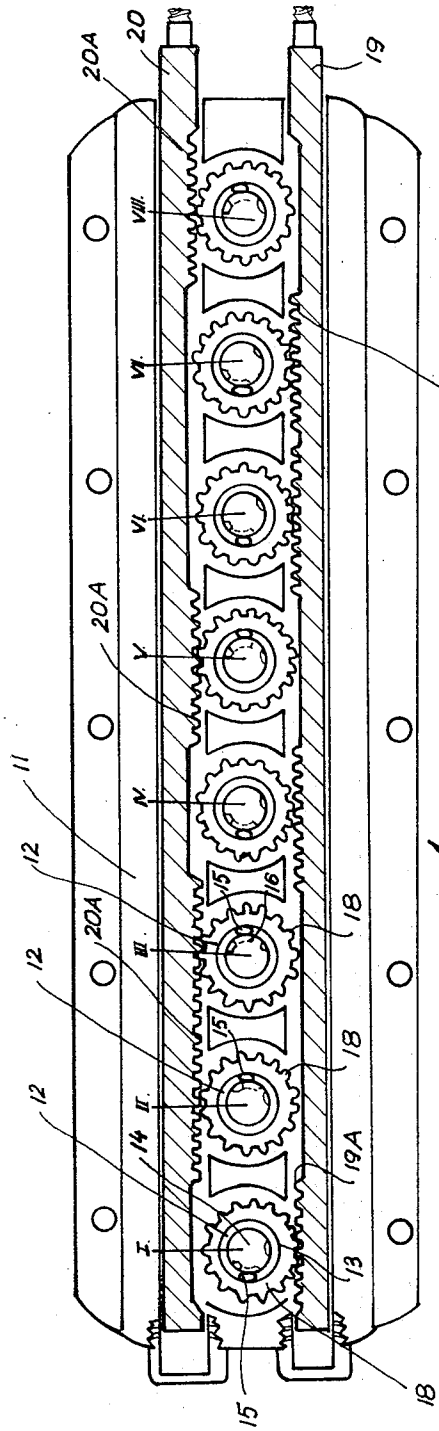

20A
20
19
VIII.
VII.
19A
VI.
V.
20A
IV.
11
12
15
16
18
III.
20A
12
18
12
II.
14
19A
I.
13
18
15

Fig. 1.

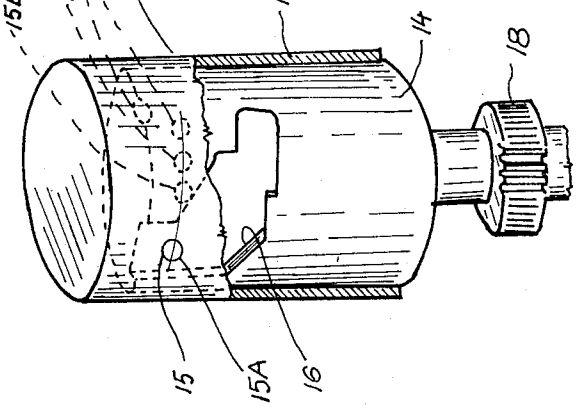

15B
15C
17
15D
12
13
14
18
15
15A
16

Fig. 2.

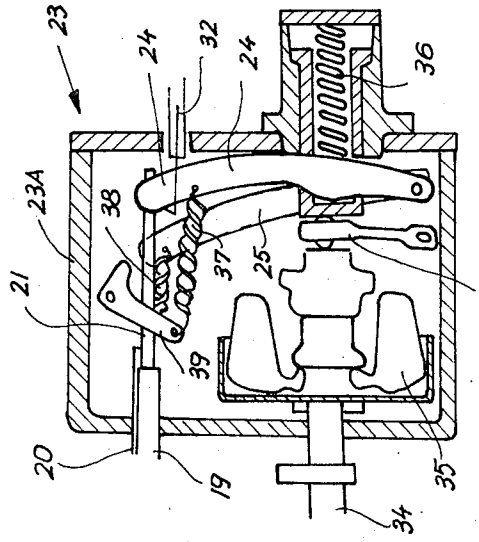

23
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32
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36
23A
38
37
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41
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19
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Fig. 4.

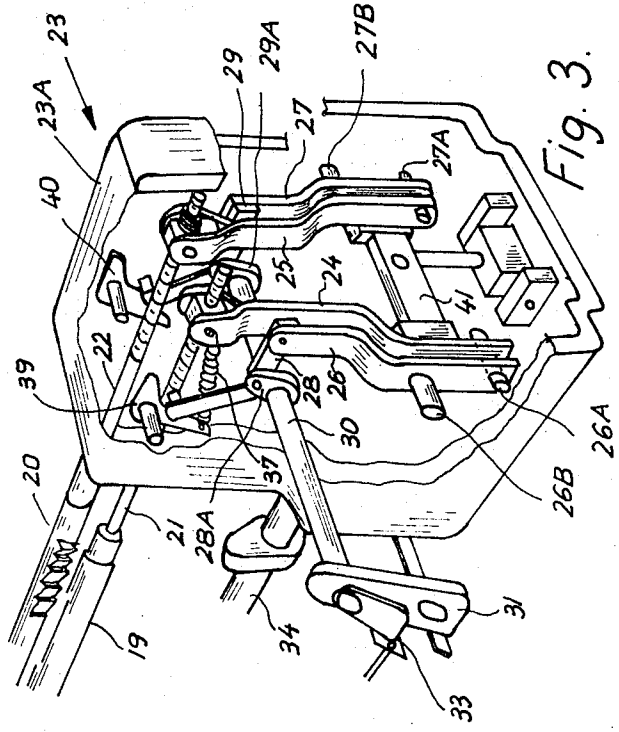

23
29
29A
27B
23A
27
27A
40
25
24
41
22
39
28
26
30
26A
26B
20
35
21
28A
34
31
19
33

Fig. 3.

FUEL INJECTION SYSTEM FOR MULTIPLE CYLINDER INTERNAL COMBUSTION ENGINE

PROBLEM AND PRIOR ART

In internal combustion engines, e.g., in diesels and in certain gas engines, fuel is delivered to the respective cylinders by means of fuel injection pumps. Generally a fuel injection pump is operatively associated with each cylinder of a multiple cylinder internal combustion engine to regulate the fuel flow of the respective cylinder controlled thereby.

Heretofore, the fuel injection pumps were operatively associated with the engine so that the fuel was delivered to all of the cylinders throughout the entire operating range of the engine, i.e., on start-up and from idle to peak load or maximum torque operating conditions. In such systems the respective fuel pumps were operatively controlled to act at all times in unison, and were usually controlled by accelerators and governors to control the amount of fuel delivered to each of the respective cylinders according to the operating loads imparted on the engine. Consequently in the prior known arrangement, by operating all cylinders of an internal combustion engine, the engine would develope such heat so as to increase pollutant emissions to atmosphere. As a result the exhaust emission under such conditions has been determined to be a factor which greatly contributed to the increase of atmospheric pollution. This problem of air pollution resulting from engine emissions is particularly aggravated in the operation of diesel engines generally used to power large motor vehicles such as trailer trucks, buses, and heavy duty vehicles of all types.

Another disadvantage of fuel injection systems which deliver fuel to all cylinders of an internal combustion engine, over the entire operating range of the engine is the relatively large amount or increase in fuel consumption resulting therefrom.

It has been discovered that under certain operating conditions, e.g. during start-up, or idling, or under normal operating conditions, e.g., during cruising speed, it is not necessary that all cylinders of an internal combustion engine be required to operate. For example on start-up or idling, the engine can be effectively operated by having only a portion of the cylinders supplied with fuel. Also under cruising conditions sufficient power can be attained by supplying fuel to only certain of the cylinders of an internal combustion engine.

OBJECTS

It is therefore an object of this invention to provide an improved fuel injection system for use with a multiple cylinder internal combustion engine which can be controlled in a manner to permit selective operation of the fuel pumps during engine operation so that only a predetermined number of cylinders are rendered operative.

Anober object is to provide an improved fuel injection system for use with a multiple cylinder internal combustion engine which permits engine operation in which pollution emission is reduced to a minimum.

Another object is to provide a fuel injection system for multiple cylinder internal combustion engines which permits economy of fuel consumption.

Another object is to provide an improved fuel injection system for use with multiple cylinder internal combustion engines whereby the respective fuel pumps can be selectively operated so as to render either a portion or all of the cylinders of an engine operative in synchronization and rendered responsive to an accelerator lever and limiting action of an associated governor.

Another object of this invention is to provide an improved fuel injection system for use with a multiple cylinder internal combustion engine which will permit certain predetermined cylinders to operate under power while other of the cylinders are operating as an air compressor.

BRIEF SUMMARY OF THE INVENTION

The foregoing objects and other features and advantages of this invention are attained by an improved fuel injection system which includes a plurality of plunger type fuel pumps in which a particular pump is operatively connected to a given cylinder of a multiple cylinder internal combustion engine to control the delivery of fuel thereto during varying operating load conditions. The respective fuel pumps comprise a barrel portion in which a fuel pump plunger is reciprocally and rotatably mounted. A spill port disposed in the wall portion of the barrel is cooperatively associated with a helical slot or groove formed in the plunger whereby the relative rotatable position of the helical groove to the spill port determines the amount of fuel delivered to the engine cylinder fed thereby. Rotation of the plunger relative to the spill port is attained by a control means in the form of a timing gear connected to each plunger and a rack disposed in meshinging relationship therewith.

The improvement resides in the provision of a dual rack control wherein one rack is operatively disposed in meshing relationship with the timing gears of certain predetermined pumps and the other rack is operatively disposed in meshing relationship with the timing gears of the remaining pump means. By selective operation of the control racks, the respective fuel pumps can be operated to deliver fuel only to the cylinder controlled by the pumps operated thereby. The arrangement is such that the group of pumps controlled by the respective racks can be independently operated and/or operated in unison so that the engine cylinder may be supplied fuel accordingly. The respective rack controls are also independently connected through balance levers to a common accelerator lever which provides for either independent or simultaneous control of the respective racks in response to the operation of an accelerator lever. The arrangement is such that one or the other of the control racks may be operated via the accelerator lever while the other can be manually actuated to dispose the respective pumps controlled thereby in a fuel shutoff position.

FEATURES

A feature of this invention resides in the provision of a fuel injection system including a plurality of fuel pumps which can be selectively controlled whereby either some or all of the respective pumps can be operated to deliver fuel to the respective engine cylinder controlled thereby.

Another feature of this invention resides in the provision of a fuel injection system having dual control means for controlling a certain predetermined number of fuel pumps between operative and inoperative position.

Another feature of this invention resides in the provision of a fuel injection system having dual control means for effective control over a plurality of predetermined fuel pumps which are connected through balance levers to a common accelerator lever whereby either one or both of the control means is rendered responsive to the accelerator lever.

Another feature resides in the provision of a fuel injection system which will permit a multi-cylinder engine to run cooler throughout the range of operating conditions so as to minimize the amount of pullution emitted to the atmosphere.

Another feature resides in the provision of a fuel injection system which permits certain of the engine cylinders to be rendered inoperative when operating under normal conditions, e.g., during cruising speeds, to result in a maximum economy of fuel.

Another feature resides in the provision of a fuel injection system which permits certain cylinders of a multiple cylinder engine to be operating under fuel firing conditions while other cylinders are operating under non-firing conditions to function as an air compressor.

Other features and advantages will become more readily apparent when considered in view of the drawings and description in which:

FIG. 1 is a top plan view of a fuel injection system embodying the present invention having parts shown in section.

FIG. 2 is a fragmentary perspective view, shown partly in section, of one of the plunger type injection pumps utilized in the fuel injection system of FIG. 1.

FIG. 3 is a fragmentary perspective view of a governor assembly utilized in conjunction with the fuel injection means of FIG. 1 in which certain components of the governor assembly have been removed for clarity.

FIG. 4 is a detailed sectional view of the governor assembly of FIG. 3 illustrating component parts of the fly weight assembly, thrust bear assembly and high speed governor spring not shown in FIG. 3.

Referring to the drawings, there is shown in FIG. 1 the fuel injection system 10 embodying the present invention. It comprises a pump housing 11 in which there is disposed a plurality of plunger type fuel injectors 12. It will be understood that each of the plunger type fuel injectors 12 is operatively connected to a corresponding cylinder of a multi-cylinder internal combustion engine (not shown), as for example, a diesel engine or a gasoline engine, in which fuel is directly injected into the individual cylinders.

In the illustrated embodiment the fuel injector pumps 12 are disposed in alignment within the fuel injector housing 11. Eight such pumps are illustrated to feed fuel to an eight cylinder engine. However, it will be understood that the number of pumps may vary depending upon the number of cylinders in a particular operating engine. Each of the respective fuel injector pumps 12 is similarly constructed. As diagrammatically shown in FIG. 2, each pump 12 is generally of a conventional construction comprising a barrel portion 13 in which a plunger 14 is reciprocally and rotatably received. A fuel spill port 15 is located in a wall portion of the pump barrel 13. A helical notch or groove 16 is formed in a side portion of the plunger 14 which is adapted to be in open communication with the spill port 16 in a fuel shut off position as indicated in position A. Consequently the fuel pump is rendered operative by effecting rotation of the plunger 14, so as to dispose the helical groove 16 relative to the spill port 15 as indicated by positions 15A, B, C and D. Upon a reciprocating movement of the plunger, fuel is pumped into the corresponding engine cylinder when the port 15 is in predetermined relationship to groove 16. Spill port positions B, C. and D relative to the helical groove 16 represent the relative position therebetween for the idle, full throttle and start positions respectively. It will be understood that the plunger 14 and the helical groove 16 rotate relative to the fixed spill port 15, and that the positions A, B, C and D of the spill port, as shown in FIGS. 2, are merely for showing the relative positions of the groove 16 relative to the spill port during various engine operating conditions. A usual retard notch 17 may be provided in the head end of the plunger. Operatively connected to the plunger is a timing gear 18.

Actuation of the respective pumps 12 to effect relative rotation of their respective plungers to position the helical groove 16 relative to the spill port 15 during variable operating conditions is effected by a control means in the form of a rack means designed in meshing relationship with the timing gear 18 of a given pump 15. In accordance with this invention the rack means includes a pair of control racks 19 and 20, disposed to extend along opposed sides of the timing gears 18 of the respective fuel pumps 15. Referring to FIG. 1, the illustrated eight fuel pumps 12 are further identified by numbers I, II, III, IV, V, VI, VII and VIII, to illustrate the specific engine cylinder to which the fuel pumped thereby is supplied.

As seen in FIG. 1 the respective control racks 19 and 20 are provided with spaced apart tooth sectors 19A and 20A respectively, so that the tooth sectors of one rack are disposed in meshing relationship with the timing gears 18 of a selected group of pumps, whereas the tooth sectors on the other control rack are disposed in meshing relationship with timing gears 18 of another group of pumps 15. As best seen pumps I, IV, VI and VII are controlled by rack 19 and pumps II, III, V and VIII are controlled by rack 20. Thus it will be noted that when rack 19 is moved to the left as viewed in FIG. 1, the timing gears 18 of injector pumps I, IV, VI and VII rotate in a clockwise direction. When rack 20 is displaced to the left as viewed in FIG. 1 the timing gears 18 of pumps II, III, V and VIII are rotated in a counterclockwise direction. It will thus be noted that in fuel injector pumps I, IV, VI and VII the spill port 15 is located at the 9 o'clock position as viewed in FIG. 1, whereas the spill port 15 in injector pumps II, III, V and VIII is located directly opposed, or in the 3 o'clock position. Accordingly in the shut-off position the helical groove 16 of pumps I, IV, VI and VII is likewise located at the 9 o'clock position and in the shut-off position of plungers of pumps II, III, V and VIII the respective helical grooves thereof are located at the 3 o'clock position. When racks 19 and/or 20 are actuated only the plunger operatively connected to the timing gears disposed in meshing relationship with the tooth portion of the particular rack is rotated to position the corresponding helical groove relative to its respective spill port to control and/or vary the flow of fuel from the pump to its corresponding engine cylinder.

In the illustrated arrangement the position of the spill port 15 in pumps I, IV, VI and VII relative to the position of the spill port 15 in pumps II, III, V and VIII and

the relative locations of the respective helical grooves 16 provides for balanced fuel delivery to the respective engine cylinder supplied thereby when one or both of the control racks 19 and 20 are displaced either manually or by action of an accelerator and governor, as will be hereinafter described. For example, forward movement of the left control rack 19 or displacement of control rack 19 to the left as viewed in FIG. 1, moves the helical groove of the plungers 14 controlled thereby away from the spill port 15 in pumps I, IV, VI and VII. Movement of the helical groove 16 away from its respective spill port 15 thus provides a relative position therebetween, e.g., on start-up, to a setting which provides for maximum fuel delivery as indicated at 15D, or to intermediate setting as indicated by an idle position 15B or to a full throttle setting as indicated at 15C. The arrangement thus insures that actuation of both racks 19 and 20 in the same direction will effect uniform displacement of the plungers 14 of the fuel pumps activated thereby accordingly.

As best seein in FIGS. 3 and 4, one end of the respective control racks 19 and 20 is connected through an appropriate extension links 21 and 22 respectively, to an accelerator and governor assembly 23 so that the operation of one or both of the respective control racks 19 and 20 may be operated by a common accelerator lever 31 which is rendered responsive to a governing means according to the varying load conditions being imposed upon the engine.

Referring to FIG. 3, the end of extension links 21 and 22 of the respective control racks 19 and 20 is adjustably connected to a corresponding control lever 24 and 25 located within the governor housing 23A. Control levers 24 and 25 in turn are respectively pivotally connected to a corresponding balance lever 26, 27 above pivot 26A, 27A. The corresponding balance levers 26, 27 are pivoted at 26B, 27B and are connected through a linkage 28, 29 respectively which is pivotally connected to a link 28A, 29A which is fixed to a common accelerator lever shaft 30. The accelerator shaft 30 in turn is rotatably journalled in a suitable bearing to the governor housing 23A. Suitably connected to the accelerator shaft 30 is an accelerator lever 31. The arrangement is such that actuation of the accelerator lever 31 may provide for simultaneous control of the rack members 19 and 20 when actuated.

As best seen in FIG. 4, a manual control is provided for control racks 19, 20 to effect independent manual operation of the respective racks 19 and 20 independent of the accelerator. The manual control comprises a cable 32 connected to each of the respective control levers 24, 25. It will be understood that the operating end of the respective control cables 32—32 will be located near the operator, e.g., in the cab or a truck so that the same can be readily operated by the driver to permit the respective fuel pumps I–VIII to be selectively grouped and controlled by the operator independently of the accelerator. The arrangement is such that maximum rearward movement, i.e., movement to right as seen in FIG. 1, of either one or both of control racks 19 and 20, will index the respective plunger helical grooves 16 of the injection pumps controlled thereby with its respective spill port. Such alignment of the respective helical grooves 16 of the respective injector pumps I–VIII with their respective spill port 15 will effect fuel shut-off to the engine cylinder supplied thereby.

The arrangement of the dual control rack 19 and 20 described will enable one control rack 19 to be operated through the actuation of the accelerator lever 31 while the other control rack may be manually pulled rearwardly into a shut-off position by means of the connected auxiliary manual shut-off cable 32 which is extended through the rear cover of the governor housing 23.

A complete shut-off lever 33 is operatively connected to the common accelerator shaft 30 so that complete shut off of fuel to all the cylinders can be obtained through the actuating of the main shut-off lever 33. As shown in FIG. 1 the respective racks 19 and 20 are shown in complete fuel shut-off position. In FIG. 3 the racks 19 and 20 and associated ports are shown in an idling fuel feed position.

Operatively associated with the respective control levers 24 and 25 and associated control racks 19 and 20 is a governor assembly to render the operation of the respective control racks 19 and 20 automatic under varying load conditions which are imposed on the engine. The governor means operates conventionally on centrifugal force transmitted from a cam shaft 34 to a fly weight assembly 35. The centrifugal force of the fly weight assembly 35 is opposed by a spring force of the governor high speed spring 36. In addition two low idle springs 37, 38 are connected between the respective control levers 24, 25 and a corresponding low idle lever 39 and 40 to act as a spring bias on racks 19, 20 forward toward the position of maximum fuel supply. Thus it would be noted that forward movement of the accelerator lever 31 drives the control racks 19, 20 forward into a maximum fuel position. The centrifugal force of the fly weight assembly 35 thus exerts a force on a bearing torsion bar 41 which forces the operating control lever 24 and/or 25 back away from a maximum fuel position. In this position the control levers' 24, 25 rearward movement is being opposed by spring force of the high spring 36. Consequently centrifugal force of the fly weight assembly 35 is constantly being opposed by a spring 36 in order to provide the governing action. When the centrifugal force overcomes the collapsed rate of the governor's spring 36, the operating control rack is forced further rearwardly into a lesser fuel position. At this point the centrifugal force overcomes spring force and provides the governing action. The collapse rate of spring 36 can be predetermined by the use of shims and/or springs having different collapse rates.

The operation of the fuel injection system described is such that an internal combustion engine (not shown) operatively connected to the injection system 10 described can be readily operated, under certain load conditions, by supplying fuel to only certain of the engine cylinders by control of the associated fuel injection pumps. As for example, start up may be obtained by advancing one of the control racks to effect displacement of the corresponding plungers to position the respective helical grooves 16 relative to the spill port 15 to a start position as indicated at 15B. The pumps controlled by the other rack are indexed to the shut position. For example, if rack 19 is actuated on start up only plungers of pumps I, IV, VI and VII are disposed in operative position. Accordingly the engine may be started by utilizing the power of four cylinders only, and may be maintained in an idle running condition on only the operating four cylinders. It is contem-

plated that when an engine is idling on less than all cylinders that the engine tends to run much cooler. As a result the amount of harmful noxious pollutants, e.g. the nitrogen compound emissions exhausted to the atmosphere is thereby substantially lessened to minimize pollution of the atmosphere which would otherwise result. In addition a further advantage is attained in that less fuel is being consumed. Under peak load conditions or during engine loads at maximum torque, the operator can readily activate the other cylinders of the engine by advancing the other control rack to operative position whereby the fuel pumps controlled thereby are activated to effect delivery of fuel to the non-firing engine cylinders. As the load on the engine peaks and reaches a constant operating or cruising load, it has been discovered that sufficient power can be maintained by cutting off the fuel supply to certain of the cylinders and operating only the remaining cylinders. Under such conditions, an operator may manually retract one of the control racks to effect a shut-off of the injector pumps controlled thereby. Under such operating conditions it has been noted that very little loss in power results, and that an engine may be efficiently operated when less than all cylinders are firing.

Another feature resulting from the system described, is that when the engine is operating on less than all cylinders, the non-firing cylinders, i.e., those cylinders not receiving fuel, will function as an air compressor. It is contemplated that the air being compressed by the non-firing cylinder can, if desired, be utilized to operate auxiliary pneumatic equipment which may or may not be part of such a vehicle. Thus the non-firing cylinders during such partial engine operation can be utilized as an air compressor which can be employed in relation to the vehicle itself and constitute a source of power for operating certain auxilliary systems, as for example, a lift for dumping, to fill tires and the like. Also if desired, the compressed air may be accumulated in a compressed air accumulator for subsequent use to operate various pneumatically operated tools. Thus a vehicle having a fuel injection system of the type described will enable an engine controlled thereby to be operated simultaneously as a means of driving a vehicle and as an air compressor which would be capable of powering any conventional tool or machine operating on pneumatic pressure whether constituting a part of the vehicle itself or external thereto. As an engine can be satisfactorily operated under certain load conditions by operating on less than all cylinders, substantial fuel economy can be accorded thereby.

While the invention has been described with respect to a particular embodiment thereof it will be readily understood and appreciated that variations and modifications may be made without departing from the spirit or scope of the invention.

What is claimed is:

1. A fuel injection system for supplying fuel to the respective cylinders of a multiple cylinder internal combustion engine comprising:

a pump housing,

a plurality of fuel injection pumping means corresponding to the number of cylinders of the multi cylinder engine disposed within said housing, each of said pumping means being operatively connected to a cylinder of said engine for controlling fuel delivery thereto,

said plurality of fuel injection pumping means being divided into a first group and a second group of pumping means,

each of said pumping means of said respective groups including a pump cylinder having a spill port formed therein, and a plunger having a helical groove formed therein,

said plunger being rotatably mounted within its respective pump cylinder whereby said groove formed therein is relatively disposed with respect to the spill port of the corresponding pump cylinder,

the relative position between the ports and helical grooves of the respective pump cylinder and corresponding plunger being normally uniform, with the spill ports formed in the pump cylinders of said first group being disposed in 180° out of phase relationship with respect to the spill ports formed in the pump cylinders of said second group,

a gear connected to the plunger of the respective pumping means,

a first rack disposed in meshing relationship with each of the gears only of said first group of pumping means,

and a second rack disposed in meshing relationship with each of the gears only of said second group of pumping means,

said first and second racks being oppositely disposed to one another,

and a control means operatively connected to each of the respective racks whereby each of said racks can be actuated completely independently of one another to render the delivery of fuel to one group of engine cylinders independent of the delivery of fuel to the other group of engine cylinders, and whereby displacement of the respective racks in the same direction and equal linear extent will effect uniform displacement of the respective pumps to result in balanced fuel delivery to the respective engine cylinders accordingly throughout the operating range of the engine.

* * * * *