Jan. 16, 1968 G. L. FISHER 3,363,614

FUEL INJECTION SYSTEM

Filed Jan. 27, 1967 6 Sheets-Sheet 1

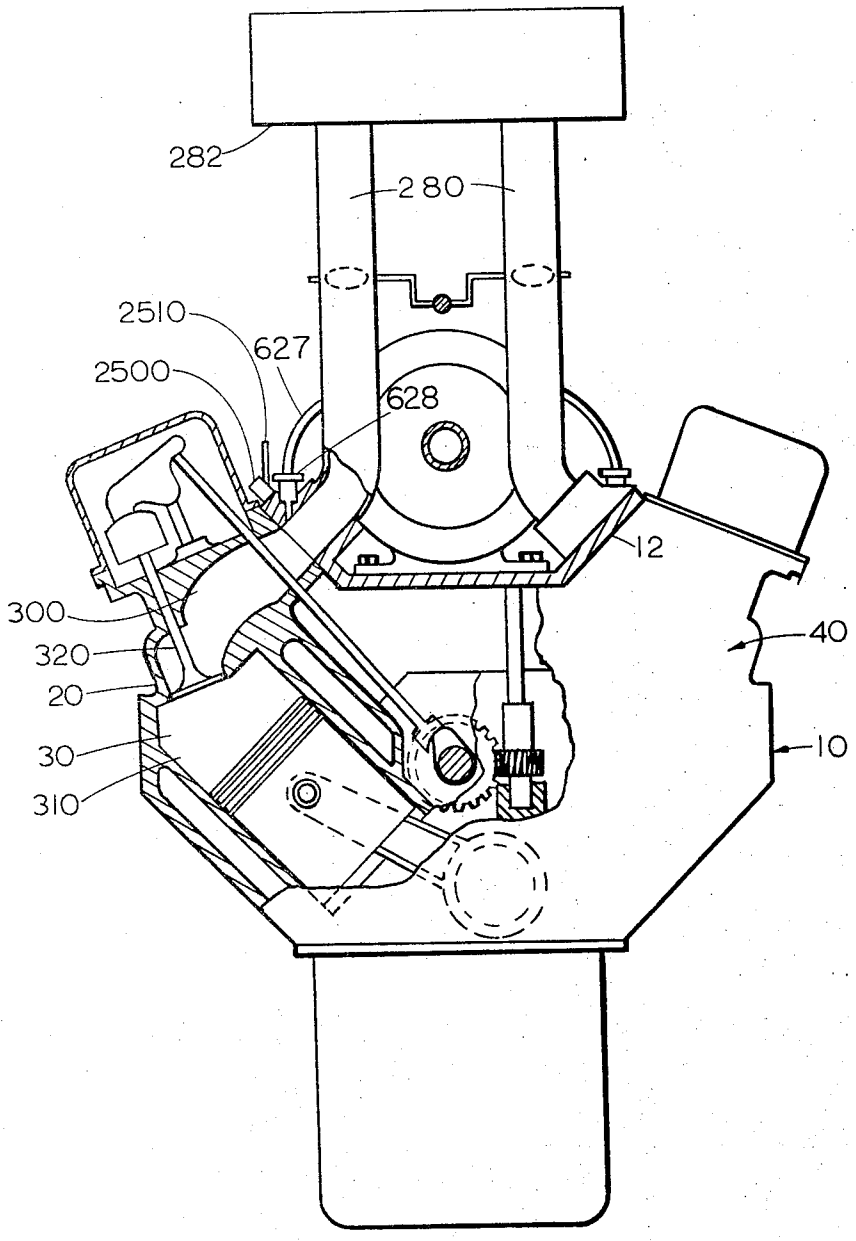


FIG. 1

INVENTOR.
GARY L. FISHER
BY Liam A. Sturges
Agent

Jan. 16, 1968 G. L. FISHER 3,363,614

FUEL INJECTION SYSTEM

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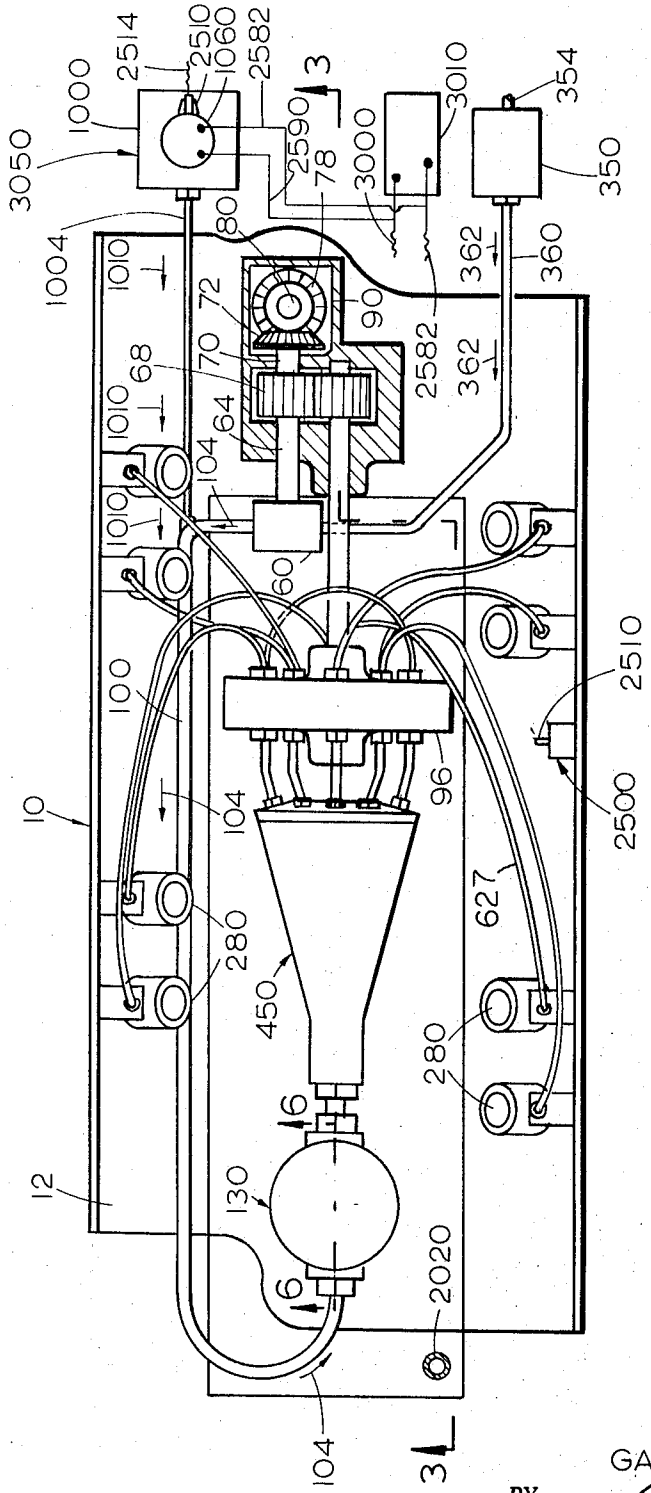


FIG. 2

INVENTOR.
GARY L. FISHER
BY
Thomas A. Sturges, Agent

Jan. 16, 1968 G. L. FISHER 3,363,614

FUEL INJECTION SYSTEM

Filed Jan. 27, 1967 6 Sheets-Sheet 3

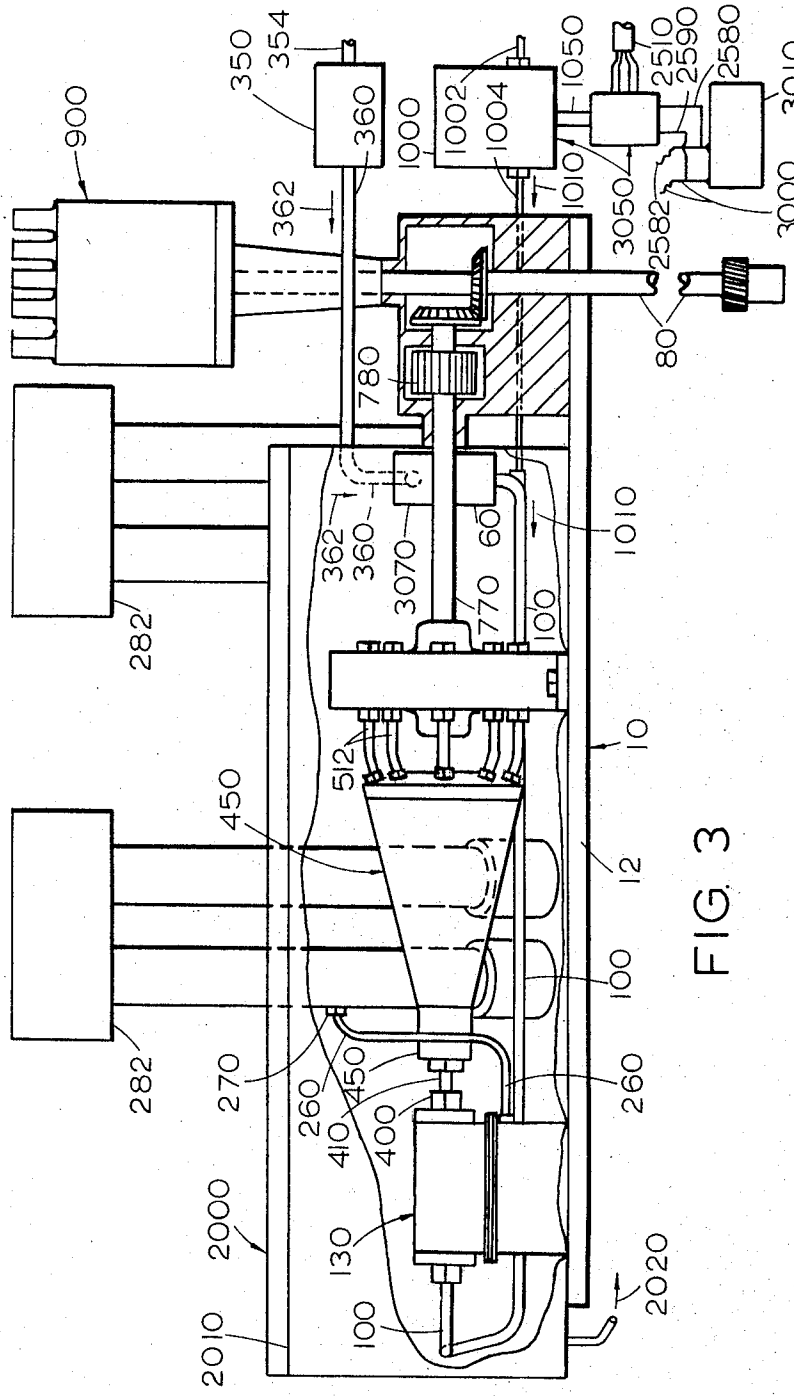


FIG. 3

INVENTOR.
GARY L. FISHER

BY Harris A. Steinger, Agent

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FUEL INJECTION SYSTEM

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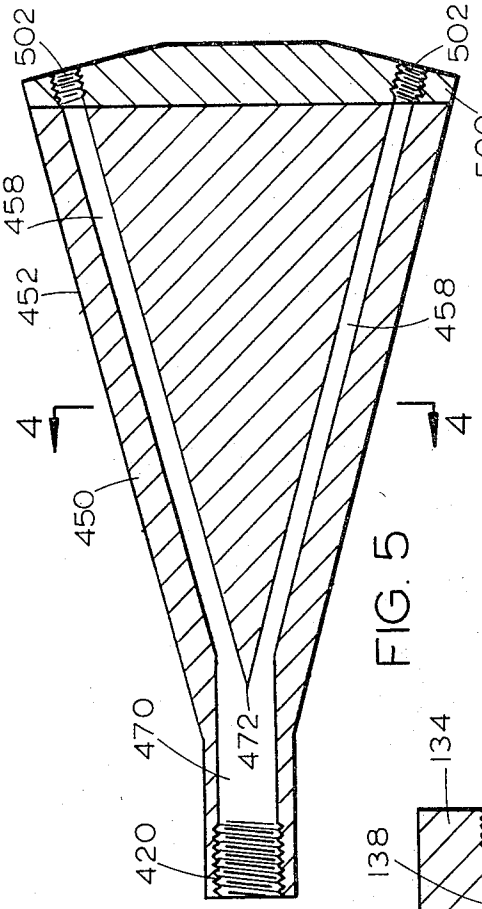


FIG. 5

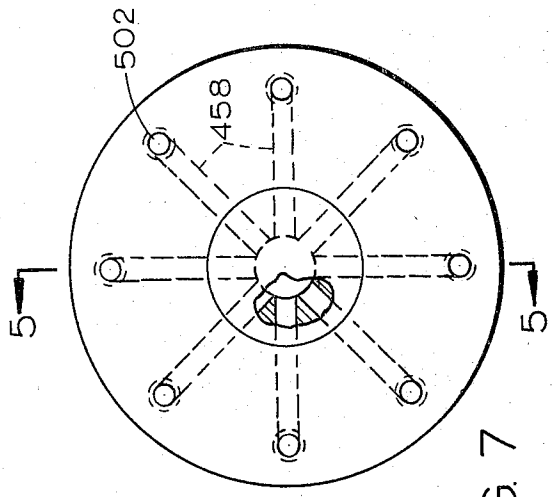


FIG. 7

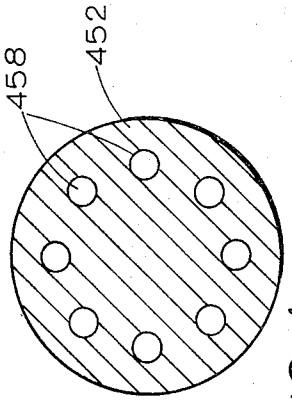


FIG. 4

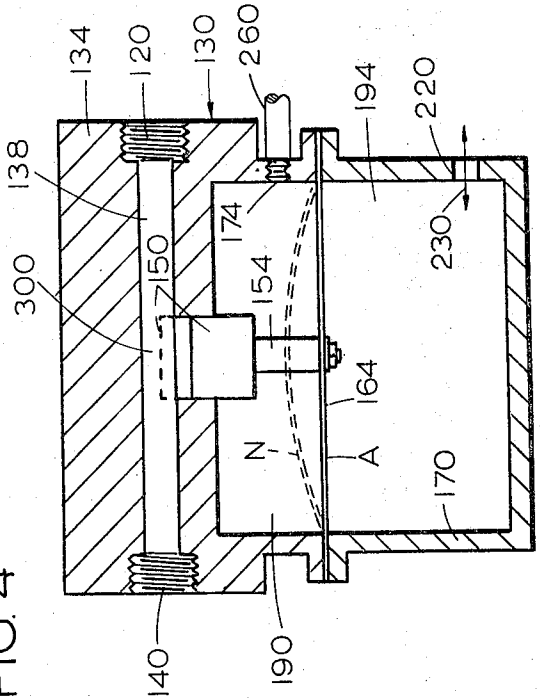


FIG. 6

INVENTOR.
GARY L. FISHER

BY Thomas A. Sturges, Agent

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FUEL INJECTION SYSTEM

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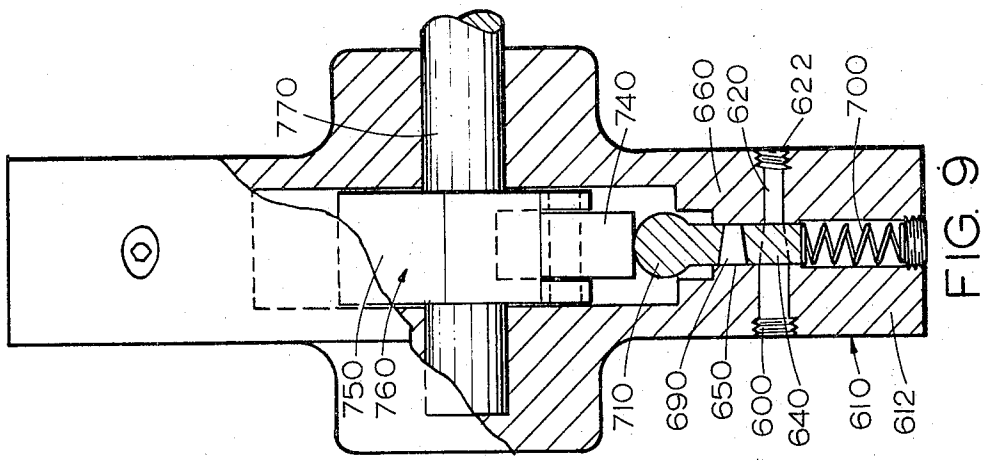


FIG. 9

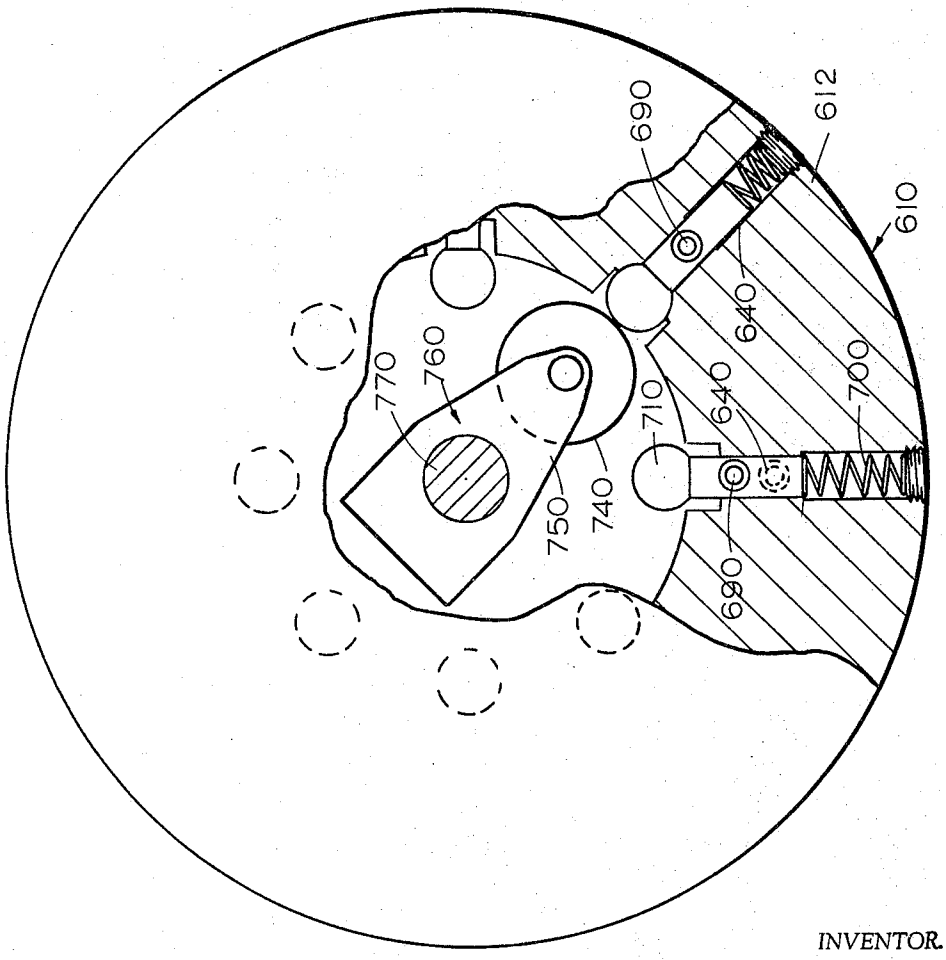


FIG. 8

INVENTOR.
GARY L. FISHER

BY Hiram A. Sturges
Agent

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FUEL INJECTION SYSTEM

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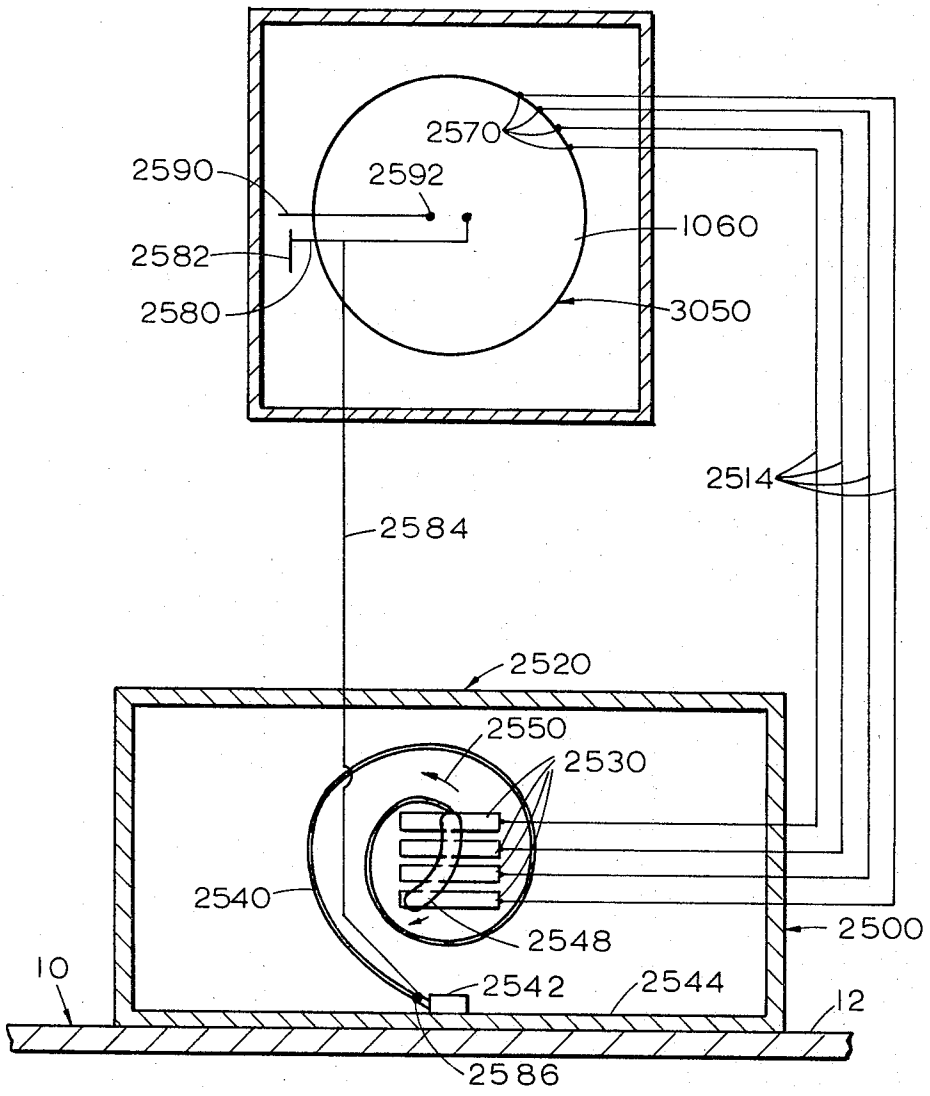


FIG. 10

INVENTOR.
GARY L. FISHER
BY Hiram A. Sturges, Agent

United States Patent Office 3,363,614 Patented Jan. 16, 1968

3,363,614

FUEL INJECTION SYSTEM

Gary L. Fisher, 314 W. Piedmont, Ravenna, Nebr. 68869

Continuation-in-part of application Ser. No. 398,293, Sept. 22, 1964. This application Jan. 27, 1967, Ser. No. 621,385

4 Claims. (Cl. 123—139)

This application is a continuation-in-part of the applicant's co-pending patent application Ser. No. 398,293, filed Sept. 22, 1964, and titled, Fuel Injection System, now abandoned.

This invention relates to fuel injection systems for internal combustion engines and more particularly it is an object to provide a system which is very simple and inexpensive and yet provides adjustment for the rate of fuel injection proportional to engine speed.

An important object is to provide a system as described in which the fuel flow reaching the engine block openings varies substantially with the varying speeds of the engine and the distributor shaft as modified by the effect on a valve in the line from the main fuel pump of an acceleration responsive means, the acceleration responsive means being preferably a vacuum line in communication with the intake manifold.

A second important objective is to provide a system as described which has means, preferably an auxiliary pump, for temporarily delivering fuel to the engine in addition to fuel delivered by a main fuel pump, for providing amounts of fuel sufficient for starting the engine.

A particular object is to make use of the fuel pump as a means of varying the rate of fuel injection whereby as the engine speed increases, the fuel pump speed increases proportionally.

It is my concept that since the fuel pump rotates at a speed proportional to engine speed, it is, therefore, only necessary to utilize this proportionality to gain the variation in fuel injection speed, which is desired for different engine speeds.

Possibly the reason my solution to this problem has not been conceived before is because there is a subtlety in using the speed of the engine itself to control the speed of the engine. Although the control is accomplished through my invention proportional to the speed of the fuel pump, which latter is in turn controlled by the speed of the engine, yet in the broader sense, the present speed of the engine is through my system controlling the future speed of the engine. In my system, the speed that the engine is running determines the speed of immediate future fuel injection.

This of itself would be impractical because there would be nothing to start the engine off as its lack of present speed at the start would foredoom to failure and impossibility any immediate change in future speed. This is a subtlety, a stumbling block which has baffled the industry.

So to start the engine off, my invention provides an auxiliary starting fuel pump which, by my concept, runs only during the period the starting motor is operating. As soon as the starting motor stops, my auxiliary starting fuel pump stops. There is no need to shut off the main fuel pump while my starting fuel pump is operating because there is not enough pressure coming from the main fuel pump to interfere with proper injection because at the start the main fuel pump and the engine driving it are not turning fast enough yet to cause fuel to be injected.

There is a problem involved in the use of the auxiliary fuel supply during starting arising from the factor that

a motor being started may be still hot from an earlier running and needing only minimum auxiliary fuel or it may be cool because the last earlier running was many, many hours earlier, thereby requiring greater amounts of fuel. It may be that earlier researchers had failed to see what is an object of this invention to provide, namely, thermostatically controlled regulation of the proportional energizing of the field coils of a motor controlling the auxiliary starting fuel pump with the thermostat operating proportional to the heat of the engine for giving ideal auxiliary fuel input proportional to the heat of the engine.

In the drawings:

FIGURE 1 is the front elevational view of an engine showing the fuel injection system of this invention mounted thereon, a portion of the forward side of the engine being broken away for purposes of illustrating the interior shown in section.

FIGURE 2 is a top plan view of a center portion of the engine of FIGURE 1 showing only parts of the lower ends of air intake pipes, with the remainder of the air intake pipes removed and with the air cleaner removed for better showing parts of this invention disposed therebeneath in actual practice. Side portions of the engine of FIGURE 1 are not shown in FIGURE 2.

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 2, but with the air cleaners and air cleaner pipes in place and with a distributor of the engine in place, the latter not being shown in FIGURE 2, certain branch fuel lines to engine intake pipes not being shown in this view for clarity of illustration.

FIGURE 4 is a sectional view taken along the line 4—4 of FIGURE 5.

FIGURE 5 is a vertical section taken along the line 5—5 of FIGURE 7.

FIGURE 6 is a vertical section taken along the line 6—6 of the vacuum control valve assembly of FIGURE 2.

FIGURE 7 is a frontal elevation of the flow divider of FIGURES 2 and 5 as it would be seen from the right-hand side in FIGURE 2.

FIGURE 8 is a side elevation of the selector valve assembly of FIGURES 2 and 9 as it would be seen from the right-hand side thereof, with a portion of the housing broken away to illustrate the interior construction.

FIGURE 9 is a top plan view of the selector valve assembly of FIGURES 2 and 8, a portion of the housing and of a slidable valve member being broken away and the remainder being shown in section for clarity of illustration.

FIGURE 10 is a diagrammatic view showing an electrical thermostat and its connection to the extra electrical starting fuel pump motor of my system.

The system of this invention is for use with an internal combustion engine generally indicated at **10** in FIGURE 2 having an upper central cover portion **12** seen in FIGURES 1 and 3 and seen in top view in FIGURE 2, the cover portion **12** being a cover for an engine block **20** in which are disposed a plurality of piston-receiving cavities, one of which is shown at **30** in FIGURE 1, and as such cavities are conventional, only one is shown by way of illustration, although it will be understood that in the engine **10**, shown in FIGURE 1, other cavities are disposed on an opposite side of the engine and generally behind an arrow indicated by the numeral **40**.

A conventional or first or main fuel pump is shown at **60** in FIGURE 2 and is driven by a shaft **64** connected to an intermediate gear **68** driven by a shaft **70** which is in turn driven by a driven pinion **72** thereon, which latter is driven by a distributor shaft gear **78** mounted on a distributor shaft **80**.

In accordance with this invention, the said gears and

pinion above described are mounted in a gear housing **90**, although it will be understood that variations in this arrangement can be made.

The engine **10** has a main fuel line generally indicated at **100**, which latter extends outwardly from the outlet side of the main fuel pump **60** in a conventional manner extending rearwardly for fuel flow in the direction of the arrows **104**.

The rearward end of the main fuel line **100** is, in accordance with this invention, connected to an inlet port **120** of a vacuum control valve assembly **130** of this invention, whereby as thus described, the main fuel line **100** can also be called the post-pump fuel line **100**. The vacuum control valve assembly **130** can be best seen in FIGURES 2 and 6, and referring to FIGURE 6, it will be seen that the valve assembly **130** has an upper or valve block portion **134** through which a fuel passage **138** extends having the inlet port **120** and an exit port **140** between which a fuel flow control valve **150** is disposed, the valve **150** being adapted to make the passage **138** more closed or open, as later described.

The valve assembly **130** is not a device to regulate fuel pressure. The valve assembly **130** is a device to regulate fuel flow rate. When the valve assembly **130** opens with less vacuum from the engine, it gives added fuel by giving less obstruction to fuel flow.

The valve **150** is connected to a rod **154** which has a lower end attached to a diaphragm **164** which is mounted between the valve block or valve housing **134** and the lower housing **170**.

An opening **174** through the sides of the valve housing **134** permits access from the exterior thereof to a vacuum cavity **190** disposed on the valve **150** side of the diaphragm **164**, and it will be seen that a lower cavity **194** exists in the lower housing **170**.

Referring to FIGURE 6, it will be seen that the housing **170** has an opening **220** therethrough and entering upon the cavity **194** for permitting air to move in either of two directions in accordance with the double arrow **230**.

The aperture or port **174** providing access to the upper vacuum chamber **190** is best seen in FIGURE 3 to be connected to a vacuum line **260** which leads to a connection at **270** to one of a plurality of intake pipe **280** which are conventional parts of the engine **10** leading from air cleaners **282** downwardly with communication to air intake passages **300**, one of which is shown in FIGURE 1 extending through the engine block **20** with access of communication to the combustion portion or area **310** of a piston-receiving cavity **30** in the engine block, each cavity **30** being commonly called a cylinder of the engine, such access being possible at times when conventional valves **320** are not in positions for closing the passages **300**.

When the engine **10** is accelerated by the pushing down on the gas pedal by an operator of an automobile, for example, in which the engine **10** is mounted, then the relative amount of vacuum in the combustion area **310** of each cylinder **30** will be lesser and the amount of vacuum in the vacuum chamber **190** will be proportionally lesser to the end that the diaphragm **164** will then assume the acceleration position A in which it is bowed the lesser degree, and in the acceleration A, the valve **150** will be seen to be withdrawn from the passage **138**, as best seen in FIGURE 6, whereby the flow of fuel to the engine through the passage **138**, as later described will be greater, giving the engine a great gulp of gas at the moment it needs it most during acceleration.

Likewise, an ideal opposite condition is attained in which whenever the engine is not being accelerated, the valve **150**, being connected to the diaphragm **164**, will be disposed in the upper position shown in FIGURE 6, whereby it closes the passage **138** proportionally to the end that the amount of remaining enclosed space will be found to be just the right amount of space for an ideal amount of fluid for normal operaiton of the automobile at times when it is not being accelerated.

Hereinafter will be described means, in accordance with this invention, for properly delivering this flow of fuel from the passage **138** to the various cylinders of the engine.

Referring now to FIGURE 3, it will be seen that the fuel pump **60** of the engine **10**, which is also called the first fuel pump herein, has assistance from a booster pump **350** of this invention, which latter receives gasoline from a fuel tank through a line **354**, partially shown in FIGURE 3, the booster pump **350** delivering fuel along a line **360** whereby the flow therefrom moves in the direction of the arrows **362** to the inlet of the fuel pump **60** to which the line **360** is connected, whereby the booster pump **350** assists the first fuel pump **60** in supplying fuel to the main fuel line **100**. The booster pump **350** may not be needed on engines when the main pump **60** provides adequate flow of fuel.

Referring now to the left-hand side of FIGURE 3 and also to FIGURE 6, it will be seen that the outlet port **140** in FIGURE 6 is connected to an outlet fitting **400**, shown in FIGURE 3 leading through a conduit **410** to an inlet port **420** of a flow divider assembly **450**, seen in FIGURE 5, the latter having a housing **452** provided with a plurality of flow passages **458** therethrough, each of which is connected to the inlet port **420** by means of a flow channel **470**, the flow from which is divided between the various passages **458** by a pointed portion **472** of the flow divider housing **452**, as best seen in FIGURE 5.

The passages **458** are eight in number in the illustration, but it will be understood to be proportional to the number of cylinders in the engine **10**, one passage **458** to each cylinder.

Referring to FIGURE 5, it will be seen that the flow divider housing **452** has a cap **500** having a plurality of passages **502** therethrough which latter are each in communication with a passage **458** of the flow divided housing **452** and each passage **502** is connected to a fuel supply header **512**, each of which is connected to a respective inlet port **600** of a selector valve assembly generally indicated at **610** having a housing **612** provided with a plurality of valve passages **620** therethrough having outlet ports **622**, each connected by one of many branch fuel lines **627** to fittings **628** extending through a respective one or ones of the intake manifolds or intake pipes **280**, the fittings **628** providing communication for fuel injection into the engine **10** through the intake pipes **280**, as best seen in FIGURES 1 and 2 and not shown in FIGURE 3, each passage **620** being at times blocked by sliding reciprocating valves **640**, there being one valve **640** for each passage **620**, each valve **640** being reciprocally mounted in a valve-receiving passage **650** whereby portions of the housing **612** surrounding the valve passages **650** can be called valve seats, if desired, one of which is indicated at **660** in FIGURE 9.

Each sliding valve member **640** has a valve passage **690** extending therethrough and having a larger and a smaller end with its larger end facing the inlet port **600** at times, each valve **640** being held in its inner position under the urging of the spring **700** at times when the passage **620** is shut off, and excepting at times when the valve **640** is moved outwardly into open position for placing its passage **690** opposite the passage **620**, which latter occurs when an inner end **710** of the valve **640** is urged outwardly by being struck by a roller **740** on a rotating control member or controller **750** of a control assembly generally indicated at **760** in FIGURE 8.

The rotating controller **750** is connected to a controller shaft **770**, which latter is journaled in the housing **612** for rotation, as best seen in FIGURE 9, extending outwardly therefrom, as best seen in FIGURE 3, whereby the shaft **770** is connected to a gear **780**, best seen in FIGURE 3 in side elevation, the gear **780** being driven, as best seen in FIGURE 2, by the gear **68**, whereby rotation of the controller **760** of FIGURE 8 is proportional to rotation of the distributor shaft **80** and is preferably at

exactly the same speed as rotation of the distributor shaft **80**.

In operation of the control assembly **760**, as seen in FIGURE 8, rotation of the controller **760** will cause respective valve **640** to be alternately depressed in sequence as the valves **640** are arranged in equidistantly spaced apart positions extending radially around the center axis of the housing **612**, which latter is the axis of rotation of the shaft **770**, whereby, as thus described, fuel is injected into the engine and into each respective cylinder thereof at ideal moments during brief moments of valve open condition at each valve **640**, which latter at brief moments coincide with the optimum fuel injections timing for the engine **10**.

Referring to FIGURE 3, a distributor is there shown at **900** and the distributor shaft is there seen in side view at **80** the distributor shaft **80** being a conventional part of the engine **10**, as in any automobile.

In general summary of the operations already above described:

When the operator of a vehicle having an interval combustion engine **10** accelerates the engine, an increased supply of fuel is instantaneously needed and it is desired that this supply of increased fuel cease the minute acceleration has ceased, when for example, the automobile has finished passing another vehicle.

In operation, the acceleration will cause decreased vacuum in the engine causing operation of the diaphragm **164**, as above described, for opening the valve **150** to allow increased flow of fuel to the cylinders. Thereafter, upon the operator letting up on the accelerator pedal, the automobile and its engine **10** will be operating at a normal and even rate of speed, whether a high speed or a low speed, and since at that time, normal operation requires only a normal amount of gas flow, as represented by the flow that can be achieved through the remainder of the passage **138** remaining open in the constricted area **300** at times when the valve **150** is in a partially closing position, an ideal normal flow of fuel is thus achieved automatically.

However, it will be seen that in the above description of operation acceleration causes decreased vacuum which then causes increased fuel flow. But acceleration itself cannot be held, unless the engine is first running. For this reason, a starting fuel pump **1000** is provided in accordance with this invention having an inlet pipe **1002** leading to a fuel supply, not shown, such as a fuel tank. The starting fuel pump **1000** has an outlet pipe **1004** through which fuel flows in the direction of arrows **1010**, as best seen in FIGURES 2 and 3, the line **1004** entering the main fuel line **100** whereby the starting fuel pump **1000** adds fuel to give a starting acceleration so that the rest of my system can work as above described.

The starting fuel pump **1000** runs only during the period the conventional starter motor **990** of the engine **10** is operating and the starting fuel pump **1000** is driven by a shaft **1050** which is, in turn, drivably connected to and driven by an extra electrical starting fuel pump motor **1060** of my system.

Thus the auxiliary starting fuel pump **1000** operates only during the period the starter motor **990** is operating. As soon as the engine is started, the starting motor **990** stops and the auxiliary starting fuel pump **1000** stops.

There is no need to shut off the main fuel pump **60** while the auxiliary starting fuel pump **1000** is operating because there is not enough pressure coming through the main fuel pump **60**, at that time during starting, to interfere with the proper fuel inection because the main fuel pump **60**, is at that time, not turning fast enough because the engine itself is at that time not turning fast enough to cause excessive pressure from the main fuel pump **60**.

A box or housing **2000** is provided having a lid **2010** and enclosing the vacuum control valve assembly **130**, the flow divider assembly **450**, the fuel pump **60**, and the selector valve assembly **610** and connecting parts. The box or housing **2000** has a drain line **2020** leading from its bottom, as best seen in FIGURE 3, to the fuel tank, not shown, of the engine **10**, whereby the box **2000** tends to catch and return any fuel leakage.

Referring to FIGURE 1, an electrical thermostat is there shown at **2500** which has an electrical cable **2510** leading from it and containing a plurality of conductors **2514**, best seen in FIGURE 10, and which lead to the extra starting fuel pump motor **1060**.

The thermostat or electrical switching means **2500** has a housing **2520**, diagramatically shown in FIGURE 10, within which are a plurality of engageable electrical contacts **2530** which are disposed in spaced parallelism, each connected to one of the conductors **2514**.

A bimetallic thermostat element **2540** is anchored to an anchor **2542** at the bottom **2544** of the housing **2520** and the element **2540** is adapted to uncoil when the temperature of the engine **10** is lower causing a bimetallic mounted electrical contact **2548** to move from the position shown in FIGURE 10 upwardly and to the left in the direction of an arrow **2550**, to the end that the contact **2548** moves from a first position bridging all four contacts **2530** progressively to a position in which it secondly bridges only the uppermost three contacts **2530**, then thirdly, the uppermost two, and fourthly, only the uppermost one of the contacts **2530**.

The bimetallic thermostatic element **2540** winds or unwinds gradually with the engine heat. Depending on this heat, it will contact one, two, three, four, or all contacts. It will always contact at least one contact no matter what the temperature.

The flow divider **458** is always maintained full of fuel by the pump **60**. When the engine is stopped or shut off, the engine rotation slows down until it stops. Since the pump **60** will not pump enough pressure at this slow rotation speed, it is either not putting out any pressure or is putting out very little pressure. Therefore, the pressure gradually subsides as the pump speed subsides.

When there is very low or no pressure, the fuel just sets in all of the fuel line and the line still remains full. Therefore, the engine has stopped and the fuel flow has stopped. There is no movement of engine or fuel. This is the reason for the importance of the starting fuel pump, namely, to bring the fuel pressure up to operating pressures.

The motor **1060** is a variable speed motor having variable field flux terminals or variable armature voltage terminals **2570**, each terminal being connected to one of the terminals **2514**. The windings of the motor **1060** are such that when contact is made between the contact **2548** and all four of the contacts **2530**, then the field windings of motor **1060** will all receive current coming originally from wire **2580** leading to a lead-in wire **2582**, which latter is one of the lead-in wires to a conventional starter motor **3010**. A wire **2584** leads from wire **2580** to a connection **2586** with the bimetallic element **2540**, the current thereby reaching the field winding contacts **2530**, conductors **2514**, and terminals **2570**.

Other current reaching the field windings motor **1060** reaches them through a wire **2590** which leads to the motor terminal **2592** from the other terminal of the lead-in wire **3000** of the conventional starter motor **3010**.

It is to be understood that the motor windings of the motor **1060** receive their current directly from the wires **2580** and **2590**.

As the engine **10** heats up, the thermostatic bimetallic element **2540** will uncurl causing progressively lesser numbers of the field windings of motor **1060** to receive current because progressively lesser numbers of contacts **2530** are being contacted by contact **2548**.

Gradually, as the engine **10** heats up, the starter motor **1060** slows down because less of its field windings are in operation.

As thus described, the electrical thermostat **2500** is

operably correlated with the engine **10** and responsive to the temperature thereof. An electrically controllable fuel flow regulator means generally indicated at **3050** is provided, the means **3050** comprising the motor **1060**, the auxiliary starting pump **1000** and interconnecting parts, whereby the said electrical starting fuel flow regulator means **3050** is operably correlated with the thermostat **2500** for causing a greater rate of fuel flow to the engine when the engine temperature is lower and a progressively lesser rate of fuel flow to said engine as the engine temperature increases.

The first fuel pump **60** and the main fuel line **100** define a main fuel supply system generally indicated at **3070** in FIGURE 3. The starting fuel flow regulator means **3050** is connected to the main fuel supply system **3070** in a manner for regulating fuel flow through said main fuel supply system for adding extra fuel flow to said main fuel system.

After a drive in an automobile and after the engine is shut off after the drive, then at a time of restarting the engine, the motor remains warm from the recent earlier running. The number of the contacts **2530** being contacted by the contact **2548** are proportional to the warmth of the engine. Because of this, the amount of extra fuel at starting delivered to the engine **10** by the auxiliary starting fuel pump **1000** will be proportional to the need of the engine as measured by the heat of the engine, all of which is controlled by the proportional energizing of the proportional numbers of field winding of the motor **1060**.

Thus the wiring described causes the auxiliary starting fuel pump **1000** to be shut off automatically when the starter motor is shut off. And yet, before the starter motor is shut off, an ideal amount of auxiliary fuel is pumped by the auxiliary pump **100** proportional to the need of the engine as measured by the heat of the engine.

The reason pump **60** can operate at engine idle speed but is inoperative at engine cranking speed is because at engine cranking speed the main fuel pump **60** has not yet reached a speed great enough to produce enough pressure to be able to inject fuel to each cylinder through the main fuel injection system herein.

The reason the flow divider **450** works is because the vacuum control valve **130** is connected to the air intake pipe **280** at **270**. The air rushing into the cylinder through air intake pipe **280** is controlled by a conventional butterfly valve, not shown, in the air intake pipe.

When the butterfly valve is partially closed, it restricts the air flow to the cylinder.

The cylinder is then trying to suck more air in than the butterfly valve will allow. This tends to create a vacuum. When the butterfly valve is opened and this restriction is removed, the vacuum decreases, therefore, allowing the diaphragm **164** to relax and move flow control valve **150** to its least restrictive position, as for example, when accelerating or increasing speed.

As the engine speed increases, the fuel pressure increases. The increased pressure would tend to offset the variation of the fuel flow at **640**, **690** as the open valve time decreases.

As best seen in FIGURE 1, the housing **2500** rests on the engine cover **12**. It is, therefore, disposed in a position such that the engine heat reaches the bimetallic strip **2540**. When the strip **2540** is heated by the engine heat, it expands and moves away from the fixed contacts **2530**, one by one, at first contacting all four, then all three, then two, then one, but always the strip contacts at least one fixed contact **2530**.

However, when the engine and the bimetallic strip **2540** are cold, the strip is in a position such that it has straightened out and will touch all of the fixed contacts **2530** for increased motor speed.

From the foregoing description, it is thought to be obvious that a fuel injection system constructed in accordance with my invention is particularly well adapted for use, by reason of the convenience and facility with which it may be assembled and operated, and it will also be obvious that my invention can be changed and modified without departing from the principles and spirit thereof, and for this reason, I do not wish to be understood as limiting myself to the precise arrangement and formation of the several parts herein shown in carrying out my invention in practice, except as claimed.

I claim:

1. In combination with an internal combustion engine having a crankshaft having an engine block, a plurality of piston-receiving cavities in said block, a distributor shaft, block-openings through said block to the combustion part of said piston-receiving cavities, a starter motor and means drivably connecting said starter motor to said crankshaft, the following fuel injection system parts: a first and main fuel pump, a main fuel line connected to said first fuel pump, means for driving said first fuel pump at a rate proportional to the speed of rotation of said distributor shaft, a post pump fuel line leading from said first fuel pump, a valve in said post pump fuel line, controllable means for controlling said valve, acceleration-responsive means connected to said engine and controllably connected to said controllable means for causing said controllable means to be operated for opening said valve to a greater extent whenever said engine is accelerated, a fuel injection selector having a controller movably mounted therein and drivably connected to said distributor shaft, a plurality of selector valve means each having an inlet and an outlet and each operably correlated with said controller for operating said valves to alternately operate each valve in a sequence for a brief moment of valve-open condition coinciding with optimum fuel injection timing for said engine, a flow divider having an inlet connected to said post-pump fuel line on the opposite side of said valve from said first pump and having outlets each connected to an inlet of one of said selector valve means, means connecting the outlet of each of said selector valve means to one of said engine block openings, powered means for at times temporarily delivering fuel to said piston-receiving cavities in addition to fuel delivered by said first fuel pump in amounts of fuel sufficient for starting said engine, means operably correlated with said starting motor and delivering power to said powered means only at times when said starting motor is operating, the rate of fuel flow reaching said engine block openings varying substantially with the varying speeds of said engine and distributor shaft as modified by the effect of said acceleration responsive means on said valve in said post pump fuel line.

2. The combination of claim **1** in which said acceleration responsive means comprises a vacuum line connected to one of said piston-receiving cavities of said engine, said vacuum line being connected to said controllable means, whereby vacuum in said engine is expressed in said vacuum line.

3. The combination of claim **1** in which said acceleration-responsive means comprises a vacuum-housing, a diaphragm in said housing and dividing said housing into two parts, means connecting one of said housing parts to one of said block openings.

4. The combination of claim **1** in which said means for temporarily delivering fuel is defined by the following combination: an electrical switching means operably correlated with said engine and responsive to the temperature thereof, said switching means comprising a bimetallic element adapted to change shape progressively in response to increased heat of said engine, said switching means having a movable switching contact attached to said bimetallic element for movement therewith as said shape changes, said switching means further having a plurality of engageable contacts some or all of which are engaged at times by said bimetallic-element-mounted contact, the movement of said engageable contacts which are engaged by said bimetallic-element-mounted contact

being progressively greater with increases in engine speed, electrically controllable starting fuel flow regulator means operatively correlated with said switching means for causing a greater rate of fuel flow to said engine when said engine temperature is lower and a progressively lesser rate of fuel flow to said engine as the engine temperature increases, said first fuel pump and said main fuel line defining a main fuel supply system, means connecting said starting fuel flow regulator means to said main fuel supply system for adding extra fuel flow to said main fuel supply system.

No references cited.

LAURENCE M. GOODRIDGE, *Primary Examiner.*