

Feb. 5, 1963

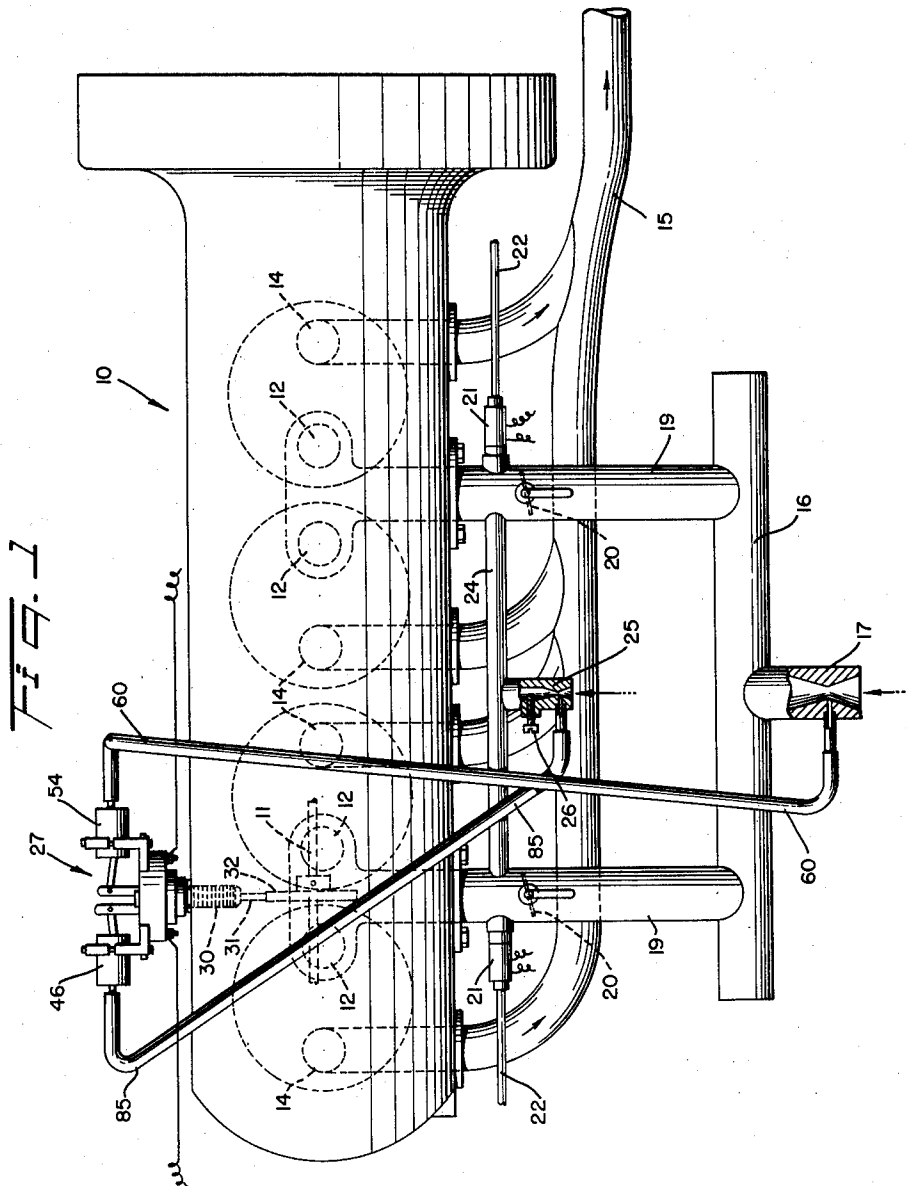
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3,076,447

FUEL FEED CONTROL FOR INTERNAL COMBUSTION ENGINES

Original Filed Aug. 19, 1958

2 Sheets-Sheet 1



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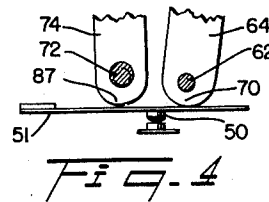
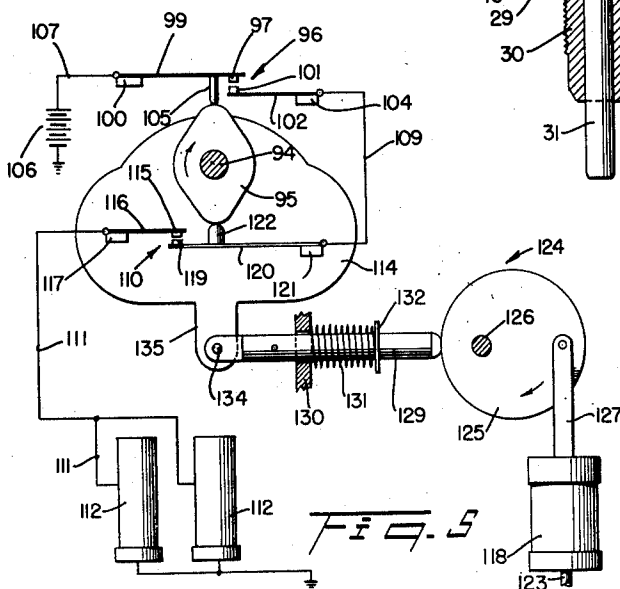
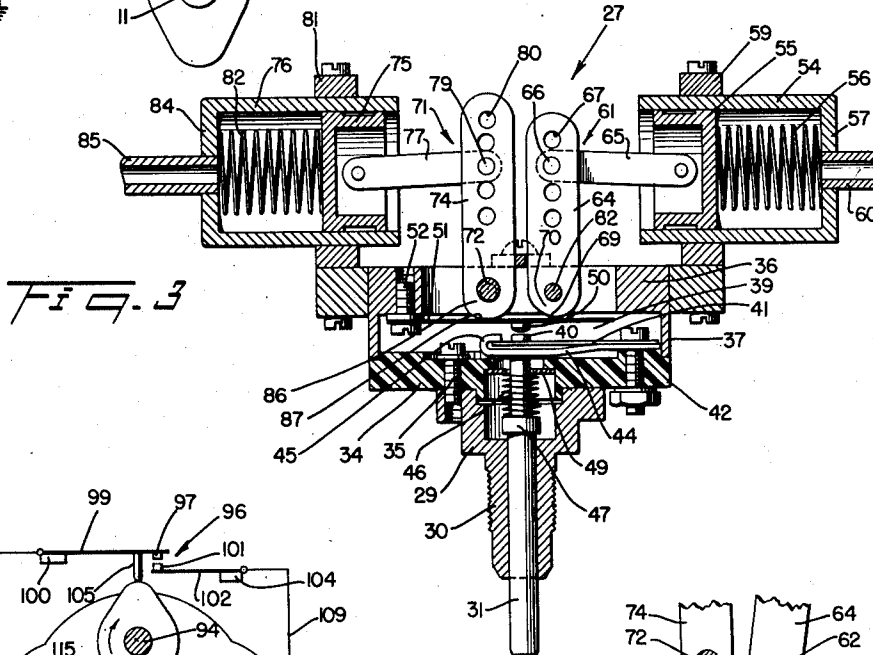
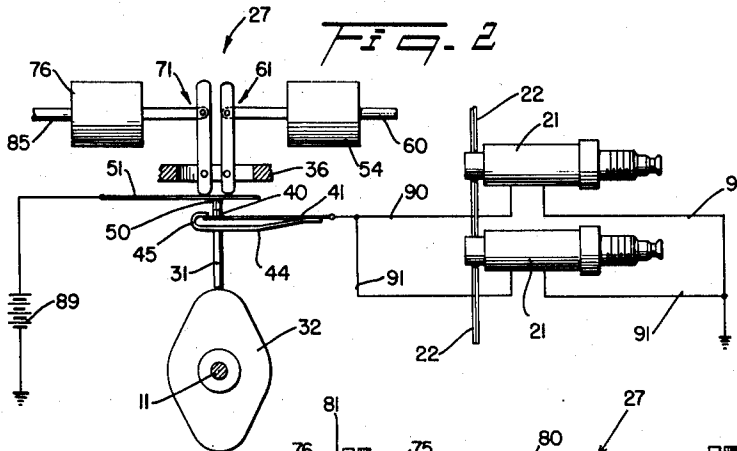
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FUEL FEED CONTROL FOR INTERNAL COMBUSTION ENGINES

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Original application Aug. 19, 1958, Ser. No. 756,024, now Patent No. 2,992,642, dated July 18, 1961. Divided and this application Mar. 7, 1961, Ser. No. 93,929
8 Claims. (Cl. 123-119)

This invention relates to mechanism for controlling the fuel feeding mechanism for internal combustion engines of the fuel injection type.

This application is a division of application Serial No. 756,024, filed August 19, 1958, now Patent No. 2,992,642.

The invention has among its objects the provision of an improved simplified fuel injection control mechanism for internal combustion engines.

Another object of the invention is the provision of fuel injection control mechanism which is primarily mechanical in its construction, and which is rugged and substantially maintenance-free.

Yet another object of the invention lies in the provision of fuel injection control mechanism wherein the volume of fuel injected into the cylinders of the engine is automatically varied in accordance with the flow of combustion air into the engine.

A further object of the invention, in one illustrative embodiment thereof, resides in the provision of a novel switching mechanism for controlling the duration of the pulses of fuel injecting mechanism.

The above and further objects and novel features of the invention will more fully appear from the following description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

FIG. 1 is a schematic view generally in horizontal section through an internal combustion engine provided with fuel injection control mechanism made in accordance with one embodiment of the present invention;

FIG. 2 is a schematic view showing the main parts of the fuel injection control mechanism incorporated in the engine shown in FIG. 1, FIG. 2 showing the manner of connection and interaction of such elements;

FIG. 3 is an enlarged view in vertical axial section through the vacuum-responsive device of the fuel injection control mechanism of FIGS. 1 and 2 showing the parts thereof in the engine-stopped position.

FIG. 4 is a fragmentary view in side elevation showing parts of the device of FIG. 3 in the positions they assume under moderate and high engine speed conditions; and

FIG. 5 is a somewhat schematic view of a second embodiment of vacuum-responsive device which may be incorporated in fuel injection control mechanism made in accordance with the invention.

The fuel injection control mechanism of the present invention may be employed to advantage, for example, in spark ignition piston type internal combustion engines wherein the fuel is fed to the cylinders by injection. The fuel may be injected in a conventional manner directly into the cylinders or manifolds of the engine, or it may be introduced into the cylinders in other manners, of which one is disclosed and claimed in applicant's prior application Serial No. 687,418, filed October 1, 1957, now Patent No. 2,933,073, granted April 19, 1960. In fuel injection internal combustion engines which during use must run at varying speeds and under varying loads not only must

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the fuel be injected at the proper time in the operating cycle of each cylinder, but the amount of fuel must be varied to meet the power and speed requirements, and consequently the air requirements, of the engine at any particular time. To provide such latter control, fuel injection systems are customarily provided with devices sometimes called "brain boxes" which are responsive to a variety of engine conditions. One such "brain box" is shown schematically at 17 in applicant's prior application, Serial No. 707,365, filed January 6, 1958.

The conventional "brain box" is a complicated system incorporating a plurality of potentiometers, condensers, resistors, and the like. They are thus delicate in construction, easily damaged, and difficult to service. The fuel injection control mechanism of the present invention is essentially mechanical in nature and is simple and rugged in construction. Its installation is simple, and a conventional fuel injection engine is readily adaptable to receive it.

The fuel injection control mechanism of the present invention depends in its operation upon the fact that as engine speed increases the rate of air intake of the engine at a given throttle setting increases in a predetermined manner. The period of engagement of contacts driven in synchronism with the engine and controlling an electrically energized pulse type fuel injecting mechanism, on the other hand, decreases as engine speed increases. The control mechanism of the invention, in certain embodiments thereof, incorporates a device responsive to variations in the rate of air intake of the engine so as to allow such contacts to remain in engagement for the required length of time to inject the requisite amount of fuel under conditions of varying engine speed.

Turning now to the drawings, a first embodiment of fuel injection control mechanism is shown in FIGS. 1-4, inclusive. The engine 10 shown in FIG. 1 is a four cylinder gasoline engine having spark ignition. Engine 10 has a crank shaft (not shown), an overhead cam shaft of which a portion is shown at 11, which operates the overhead intake valves 12 and exhaust valves 14 of the engine in a conventional manner. The cam shaft is driven in timed relationship with the crank shaft by conventional mechanism not shown. It will be assumed that the engine is of the four stroke cycle type, and that thus the cam shaft 11 rotates at one-half the speed of the engine shaft.

The exhaust ports of the engine, which are opened and closed by valves 14, are connected to an exhaust manifold 15. The intake ports of the respective cylinders, which are opened and closed by valves 12, are fed with a fuel-air mixture through a system as shown in FIG. 1. Such system includes an air-intake header 16, which is fed with air through a large venturi 17, and branch pipes 19 which lead from header 16 to the manifold branches in the engine block leading to the intake ports of the respective forward and rear pairs of cylinders. An air throttling valve 20 is positioned in each intake pipe 19, the valves 20 being connected by linkage (not shown) to operate in unison. Between each throttle valve 20 and the engine and electromagnetically operated fuel injecting mechanism 21 is mounted on each of pipes 19 so as to discharge fuel thereinto at timed intervals. Each of mechanisms 21 is fed with fuel under pressure from a fuel line 22. A pressure-equalizing cross pipe 24 extends between pipes 19 inwardly of throttle valves 20 and generally at the location of mechanisms 21. Combustion air for the engine at idling speeds is fed to pipe 24 through a second, small venturi 25. The area of the effective passage through venturi 25 may be varied by a cross screw 26, the inner end of which extends into the venturi passage.

The fuel injection control mechanism of FIGS. 1-4,

inclusive, includes a unit 27 which is mounted upon the engine and includes contacts driven in synchronism therewith for energizing the electro-magnetically operated mechanisms 21. The contacts of unit 27 are interposed in the circuit for energizing mechanisms 21, and control the duration of the fuel-injecting portion of the cycle of such mechanisms. Unit 27 includes intake venturi-responsive means whereby the period of engagement of the contacts is automatically varied in accordance with engine air flow.

The construction and function of unit 27 will be clear upon consideration of FIG. 3. As there shown, the unit has a metal base portion 29 from which extends an externally threaded hollow mounting stem 30. Stem 30 is designed to be threaded into the valve cover of the engine 10. An electrically insulating reciprocable plunger rod 31 is slidably mounted in stem 30 so as to cooperate with a two lobed cam 32 on cam shaft 11. In the embodiment shown, cam 32 is a cam, provided for the operation of unit 27, which is additional to the usual cylinder valve-operating cams described above. An insulating plate 34 is secured to the upper end of body 27 as by machine screws, one of which is shown at 35 in FIG. 3. Unit 27 has a cap 36, made for example of metal, which is provided with a skirt 37 which interfits in a recess in the outer edge of plate 34. Plate 34 and cap 36 are of such shape as to provide a contact-receiving cavity 39 between them.

A first contact 40 is disposed on the outboard end of a cantilever mounted leaf spring 41, the other end of the spring being fixedly held on insulating plate 34 by a terminal-providing bolt 42. Contact 40 lies substantially aligned with and above the upper end of plunger rod 31. Also held at one end by bolt 42 is a relatively stiff leaf spring 44 which underlies spring 41. Spring 44 inclines downwardly from bolt 42 and then lies generally horizontal, so that the outboard end of spring 44 normally lies spaced from and generally parallel to the outboard portion of spring 41. The outer end of spring 44 is curled up and over the outer end of spring 41 at 45. Portion 45 is normally in engagement with the outer end of spring 41 when contact 40 does not engage the upper contact 50 to be described.

Plunger rod 31 is urged downwardly, so as to follow cam 32, by a coil compression spring 46 surrounding the upper end of the rod and acting between a collar 47 fixed to the rod and a washer 49 affixed to plate 34 and forming a seat for the upper end of the spring 46. The described mechanism causes contact 40 to be raised and lowered twice during each revolution of cam 32.

Confronting and aligned with lower contact 40 is an upper contact 50. Contact 50 is mounted intermediate the length of an upper leaf spring 51, one end of which is fixedly secured to cover 36 as by a machine screw 52. Contact 50 is so spaced from contact 40 that it engages the latter for only a predetermined interval as the top of each lobe of cam 32 passes the lower end of plunger rod 31. The extent of such interval of contact, assuming that stem 30 has been screwed into the engine cover a predetermined distance and is held in such position as by a lock nut on the stem (not shown), is determined by the venturi-responsive mechanism now to be described.

Such venturi-responsive mechanism includes a first vacuum cylinder 54 having a piston 55 reciprocable therein. The piston is urged to the left (FIG. 3) by a coil compression spring 56 acting between the head of the piston and the closed end 57 of the cylinder 54. The cylinder 54 is conveniently mounted on the cover 36 of device 27 by a clamping ring 59 secured to the cap. A tube 60 connects the right hand end of the cylinder 54 to the venturi 17 of the engine, so that piston 55 is thrust to the right when venturi vacuum is highest, occupies the position shown in FIG. 3 when the engine is at rest or idling, and lies intermediate such two positions

when the engine is operating with an intermediate rate of air flow thereto. The piston 54 occupies a predetermined intermediate position for each of the intermediate venturi vacua, and thus for each of the intermediate engine combustion air flows.

The "rest" position of contact 50 relative to contact 40 is automatically adjusted by means which is responsive to air flow conditions in venturis 17 and 25. A first portion of such means is responsive to venturi 17, which as we have seen, provides the predominant portion of the combustion air to the engine in its intermediate and high speed operation. Such first portion of the air flow-responsive means includes a generally vertically disposed rocker member 61 which is pivotally attached to cap 36 by a pivot pin 62 so as to lie above leaf spring 51 outwardly beyond contact 50. The upper arm 64 of rocker member 51 is connected to piston 54 by a connecting rod or link 65 pivotally connected to the piston 54 as shown and to arm 64 by pivot pin 66. Arm 64 of rocker 61 is provided with a plurality of pivot pin-receiving holes 67 spaced therealong to permit selection of a desired range of angular motion of rocker 61 corresponding to the length of travel of piston 55. The lower end 69 of the rocker member, below pivot pin 62, is in the form of a cam having a lower cam surface 70 engaging leaf spring 51. The configuration of the cam surface 70 is such that as the piston 55 moves to the right in response to an increased vacuum in the intake venturi 17 the contact 50 occupies an increasingly lower "rest" position, that is, lies closer to the movable contact 40 when the latter contact lies in its retracted "contact open" position.

It will thus be seen that during intermediate and high speed operation of the engine, during which air flows at high speed through venturi 17, the described means functions to adjust the position at which contact 40 engages contact 50 on the upstroke of plunger rod 31, and also the position at which contacts 40 and 50 open on the downstroke of rod 31. The interval during which contacts 40 and 50 remain closed, and thus the fuel injecting mechanism 21 controlled thereby remains open to inject fuel into the intake manifold, is therefore adjusted by the positioning of cam surface 70 on rocker 61 by the venturi vacuum responsive cylinder 54.

Contact 40 is mounted on leaf spring 41 as above described; spring 41 may yield downwardly with respect to carrier spring 44 which contacts the upper end of plunger rod 31. Accordingly, further travel of the plunger rod 31 and the outboard end of carrier spring 44 upwardly after initial engagement of contacts 40 and 50 does not place any undue strain upon the contacts or their respective mounting springs 41 and 51.

A second portion of the air flow responsive means is responsive to air flow conditions in venturi 25 during idling and low speed operation of the engine, during which throttles 20 are closed or substantially closed and all or most of the combustion air flows through venturi 25. Such second portion of the air flow-responsive means includes a generally vertically disposed rocker member 71 which is pivotally attached to cap 36 by a pivot pin 72 so as to lie above leaf spring 51 inwardly of contact 50. The upper arm 74 of rocker member 71 is connected to a piston 75 of a second vacuum cylinder 76 by a connecting rod or link 77 connected to the piston 75 as shown and to arm 74 by pivot pin 79. Arm 74 of rocker 71 is provided with a plurality of pivot pin-receiving holes 80 spaced therealong to permit selection of a desired range of angular motion of rocker 71 corresponding to the length of travel of piston 75.

Cylinder 76 is attached to cap 36 of device 27 by a clamp 81 in the same manner as cylinder 54. The cylinders 54 and 76 are aligned and face in the opposite direction. Piston 75 is constantly urged to the right (FIG. 3) by a coil compression spring 82 acting between the piston and the closed end 84 of cylinder 76. A pipe

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85 connects the closed end of cylinder 76 to the venturi 25.

The construction of the device is such that piston 75 is thrust to the right by spring 82 into the position shown in FIG. 3 when the engine is at rest. When the engine is idling, and substantially all the intake air flows through venturi 25, the vacuum in pipe 85 causes piston 75 to be thrust by atmospheric pressure to the left to an intermediate position, and when the vacuum in pipe 85 is high, corresponding to a high rate of flow of air through venturi 25, the piston 75 is thrust still further to the left.

The rocker 71, which is turned about pivot pin 72 by piston 75, governs the "rest" position of contact 50 during the stopped, idling, and slow speed conditions of the engine. This is accomplished by making the lower end 86 of rocker 71 in the form of a cam 87 which cooperates with leaf spring 51 to change the vertical adjustment of the latter. The configuration of the cam surface 87 is such that as the piston 75 moves to the left in response to an increased vacuum in the venturi 25 the contact 50 occupies an increasingly lower "rest" position, that is, lies closer to the movable contact 40 when the latter contact lies in its retracted "contact open" position.

The cam surfaces 70 and 80 on rockers 61 and 71, respectively, are of such configuration and are so located vertically that under conditions in which the engine is stopped or is idling the cam surface 70 on rocker 61 lies spaced above spring 51, as shown in FIG. 3, and the effective "rest" position of contact 50 is governed by cam surface 87 on rocker 71. When the engine is running at moderate or high speeds, however, the cam surface 70 contacts spring 51 and governs the "rest" position of contact 50, the spring 51 being thrust downwardly by cam surface 70 so as to be spaced below cam surface 87. To permit the suitable initial vertical positioning of rocker 71 and thus of cam surface 87, the pivot pin 72 mounting such rocker is made so as to have the portions thereof engaging cap 36 eccentric relative to the portion engaging rocker 71. Thus suitable turning of the pivot pin adjusts the rocker 71 in the described manner.

The above described fuel injection control mechanism is connected as shown in FIG. 2. The device is powered as by a battery 89, one terminal of which is connected to ground and the other of which is connected to contact 50 through leaf spring 51. Lead wires 90 from the spring 41 extend to the respective electromagnetically operated valves of mechanisms 21. The other terminal of each of mechanisms 21 is connected to ground through wires 91.

The embodiment of fuel injection control mechanism shown in FIG. 5 may be employed in some instances as an alternative to that of FIG. 3. The mechanism of FIG. 5 displays advantages by reason of its increased sensitivity of response to varying intake venturi vacuum conditions. Such mechanism may also be employed to advantage in various other applications which require a circuit or circuits to be repeatedly energized for predetermined periods of time.

The mechanism of FIG. 5 includes a driven shaft 94 having a cam 95 thereon. Shaft 94 may be an engine cam shaft or a shaft driven in timed relationship with the engine. Cam 95 controls a first pair of contacts 96 so that they open and close periodically. Contacts 96 include a first, fixed contact 97 mounted on a leaf spring 99 attached to a fixed support 100, and a second, movable contact 101 cooperating therewith. Contact 101 is mounted on a leaf spring 102, one end of such spring being fixedly secured to a fixed support 104. Supports 100 and 104 may conveniently be mounted on a common fixed member (not shown) such as a plate. A cam follower 105 riding on cam 95 opens contacts 97 and 101 when the zones adjacent the peaks of the cam lobes

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contact the cam follower. At other times such contacts are closed.

Contact pair 96 is connected to a current source such as a battery 106 through a wire 107. A wire 109 leads from the contacts to a second contact pair 110 connected in series with contacts 96. Respective electromagnetically operated fuel injection valves 112 are connected to the contact pair 110 by wires 111. The times of opening and closing of contacts 96 are fixed relative to the angular position of cam 95. The times of opening and closing of contacts 110, however, may be adjusted in the manner to be described. Since valves 112 are energized only when both sets of contacts 96 and 110 are closed, the length of the energization of valves 112 may be varied by changing the time at which contacts 110 are closed relative to the angular position of cam 95.

Contacts 110 are mounted on a plate 114 which is rotatable throughout a limited angular range about the axis of shaft 94. Contacts 110 include a first, fixed contact 115 mounted on the inner end of a leaf spring 116. Spring 116 has its outer end secured to a support 117 fixedly attached to plate 114. A second contact 119, cooperating with contact 115, is mounted on the inner end of a leaf spring 120. The outer end of the spring 120 is secured to a support 121 fixedly attached to plate 114. A cam follower 122, secured to spring 120 intermediate the length thereof, rides on cam 95. Contacts 115 and 119 are thus opened when the zones adjacent the peaks of the cam lobes contact the cam follower. At other times such contacts are closed.

Assuming contact pairs 96 and 110 to be similarly constructed, the pairs of contacts will be closed at the same time and opened at the same time when the cam followers 105 and 122 lie diametrically opposite each other. Thus the contact pairs then function to produce a valve opening pulse of maximum duration. If plate 114 is turned clockwise from the position shown in FIG. 5, contact pair 110 will be opened and then closed later than the opening and closing of contact pair 96. This will result in the shortening of the period of energizing valves 112, and thus the injection of less fuel per cycle.

Automatic control of the positioning of plate 114 is effected by a vacuum cylinder 118 acting through the mechanism 124. Vacuum cylinder 118 is connected by pipe 123 to a venturi in the intake manifold of the engine; such connection and the venturi may, for example, be arranged similarly to the pipe 60 and the venturi 17 in the intake manifold 16 of the embodiment of FIG. 1. Such mechanism is made as follows: A cam or eccentric 125 is journaled to turn on a shaft 126. The outer end of the connecting rod or link 127 is connected to cam 125 so that the cam is turned clockwise as the vacuum in cylinder 118 increases. Interposed between cam 125 and plate 114 is a cam follower mechanism composed of a reciprocable plunger rod 129 having an end riding upon cam 125. Rod 129 is guided by a support 130 through which it extends, and is urged against the cam by a coil compression spring 131 acting between support 130 and a thrust collar 132 on rod 129. The rear end of rod 129 is pivotally attached to plate 114 by means of a pivot pin 134 extending through the forked end of the rod and an arm 135 on the plate. The use of a cam having an extended surface interposed between cylinder 118 and plate 114 allows the adjustment of the plate to be very smooth and exact.

It will be understood that the contact system of FIG. 5 may be mounted in a suitable protective casing, and that the cylinder 118 and the linkage interposed between the cylinder and plate 114 may be made as a unit, as is done in the case of the previously described unit 27.

Although only a limited number of embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing specification, it is to be expressly understood that various changes, such as in

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the relative dimensions of the parts, materials used, and the like, as well as in the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will be apparent to those skilled in the prior art.

What is claimed is:

1. An internal combustion engine of the piston type comprising a crankshaft, an air intake, an electrically operated mechanism for injecting fuel into the engine, an energizing circuit for said mechanism, means for operating such mechanism at predetermined intervals in the engine cycle, and means for adjusting the duration of operation of said mechanism during each said interval in the engine cycle, said last named means comprising a first pair of contacts and a second pair of contacts, said pairs of contacts being connected and interposed in the energizing circuit for said mechanism, means operated in timed relationship with the engine for moving the contacts of the first pair into and out of engagement with each other and the contacts of the second pair into and out of engagement with each other, and means for varying the timing of the period of engagement of the contacts of one of said pairs relative to the period of engagement of the contacts of the other of said pairs.

2. Apparatus as defined in claim 1, comprising means responsive to the rate of air intake of the engine to control the means for varying the timing of the period of engagement of the contacts of said one of the pairs of contacts relative to the period of engagement of the contacts of the other of said pairs.

3. Apparatus as defined in claim 2, wherein said means operated in timed relationship with the engine for moving the contacts of the two pairs of contacts into and out of engagement with each other comprises a shaft driven in synchronism with the crankshaft, and a contact operat-

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ing cam fixed on the shaft cooperating with said pairs of contacts.

4. Apparatus as defined in claim 3, comprising means responsive to the rate of air intake by the engine to control the means for varying timing of the period of engagement of the contacts of one of said pairs of contacts relative to the period of engagement of the contacts of the other of said pairs of contacts.

5. Apparatus as defined in claim 1, comprising means mounting the first pair of contacts so that they are fixed against rotation with respect to the axis of the shaft, and means mounting the second pair of contacts so that they may be angularly adjusted about the axis of the shaft.

6. Apparatus as defined in claim 5, comprising means responsive to the rate of air intake of the engine connected to the means mounting the second pair of contacts so as angularly to adjust the second pair of contacts about the axis of the shaft.

7. Apparatus as defined in claim 6, wherein the means mounting the second pair of contacts comprises a plate mounted to oscillate about the axis of the shaft, and comprising a control linkage connected to the plate to turn the plate to the desired angular position.

8. Apparatus as defined in claim 7, comprising means responsive to the rate of air intake of the engine connected to the plate so as angularly to adjust the second pair of contacts about the axis of the shaft.

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