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Wilson

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[54] **FUEL INJECTION ENGINE**

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[52] **U.S. Cl.** ..... **123/139 AY;** 123/139 AC; 123/139 B; 123/90.16

[51] **Int. Cl.²** **F02M 39/00**

[58] **Field of Search** ..... 123/32 JT, 139 B, 139 AB, 123/139 AC, 139 AR, 139 AD, 139 AE, 139 AG, 139 AK, 139 BG, 139 AY, 90.16, 90.2; 74/569

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Assistant Examiner—Daniel J. O'Connor
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[57] **ABSTRACT**

In a four cycle, reciprocating piston, internal combustion engine, a mixture of fuel and air is forcibly injected into the combustion chamber during the engine's compression stroke. A variation in the timing of such injection is effected through variation in the angular relationship of an injection controlling cam follower to its actuating cam on the engine's main camshaft. Plural cams on a manually actuated rock shaft control not only such variation of the fuel injection timing, but also control spark advance, and measure and limit the fuel volume in the fuel-air mixture which is injected.

5 Claims, 4 Drawing Figures

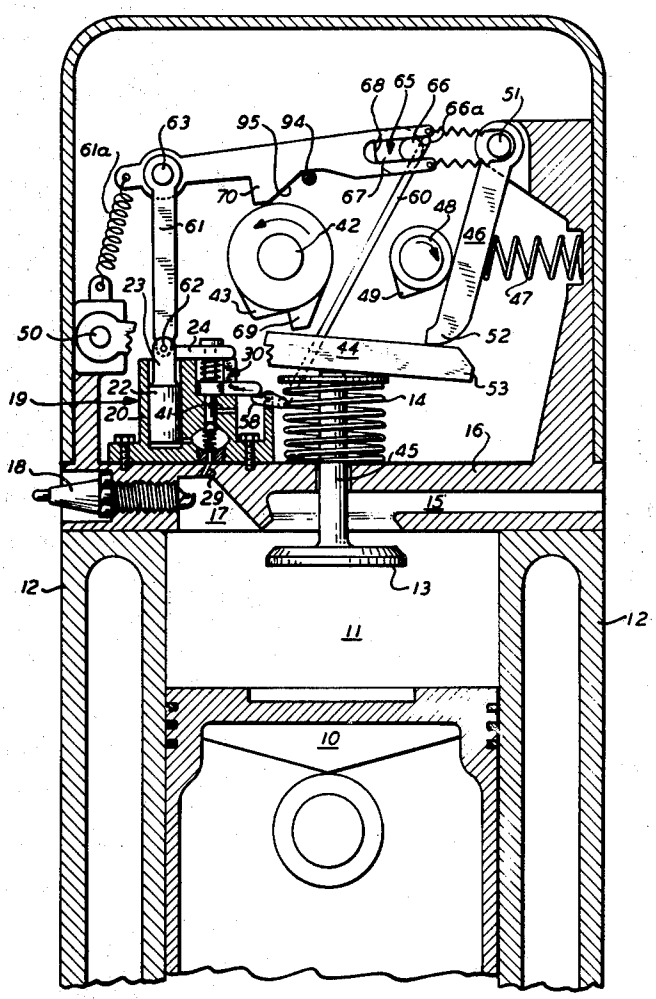


FIG. 1

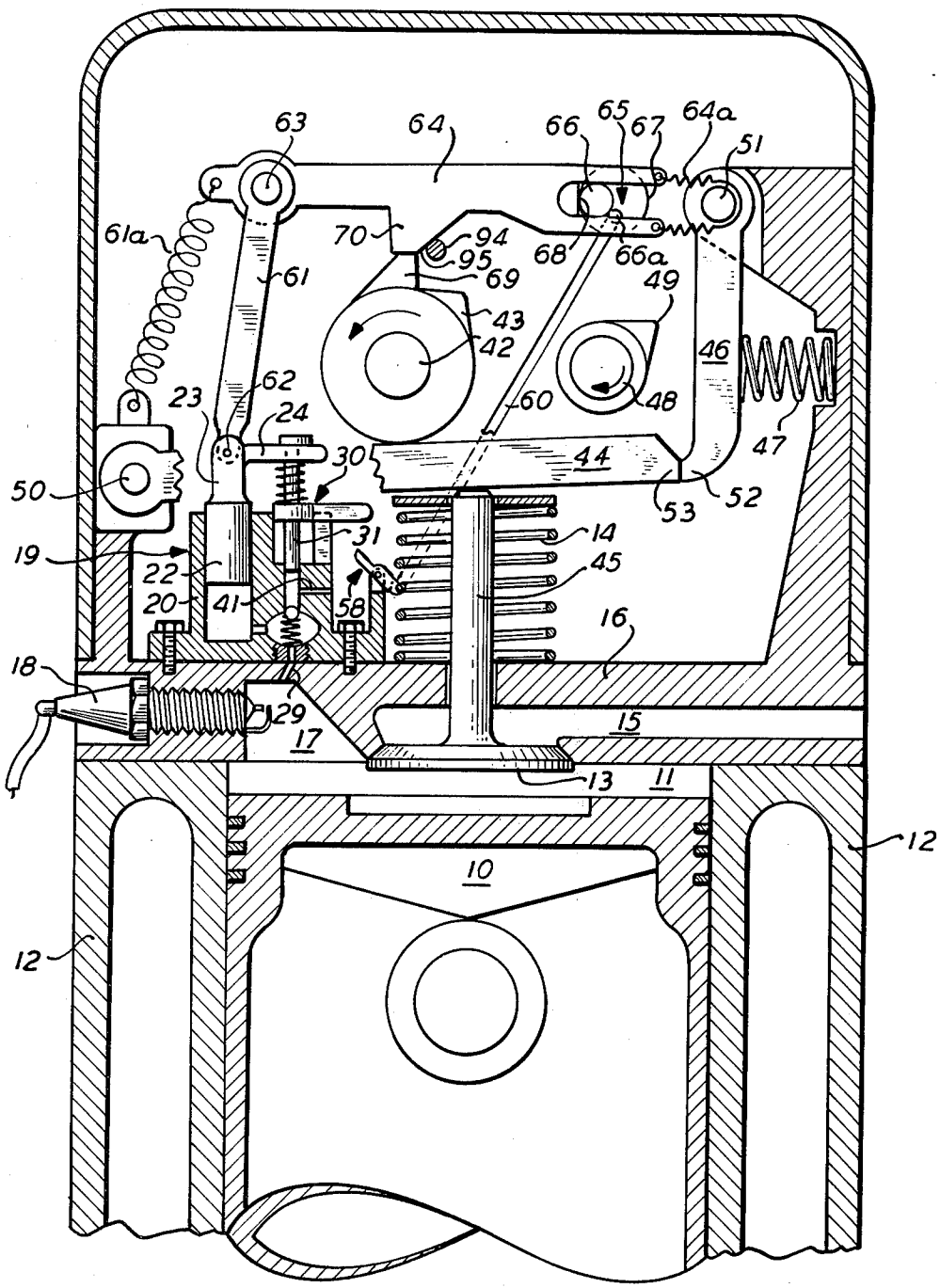

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FIG. 2

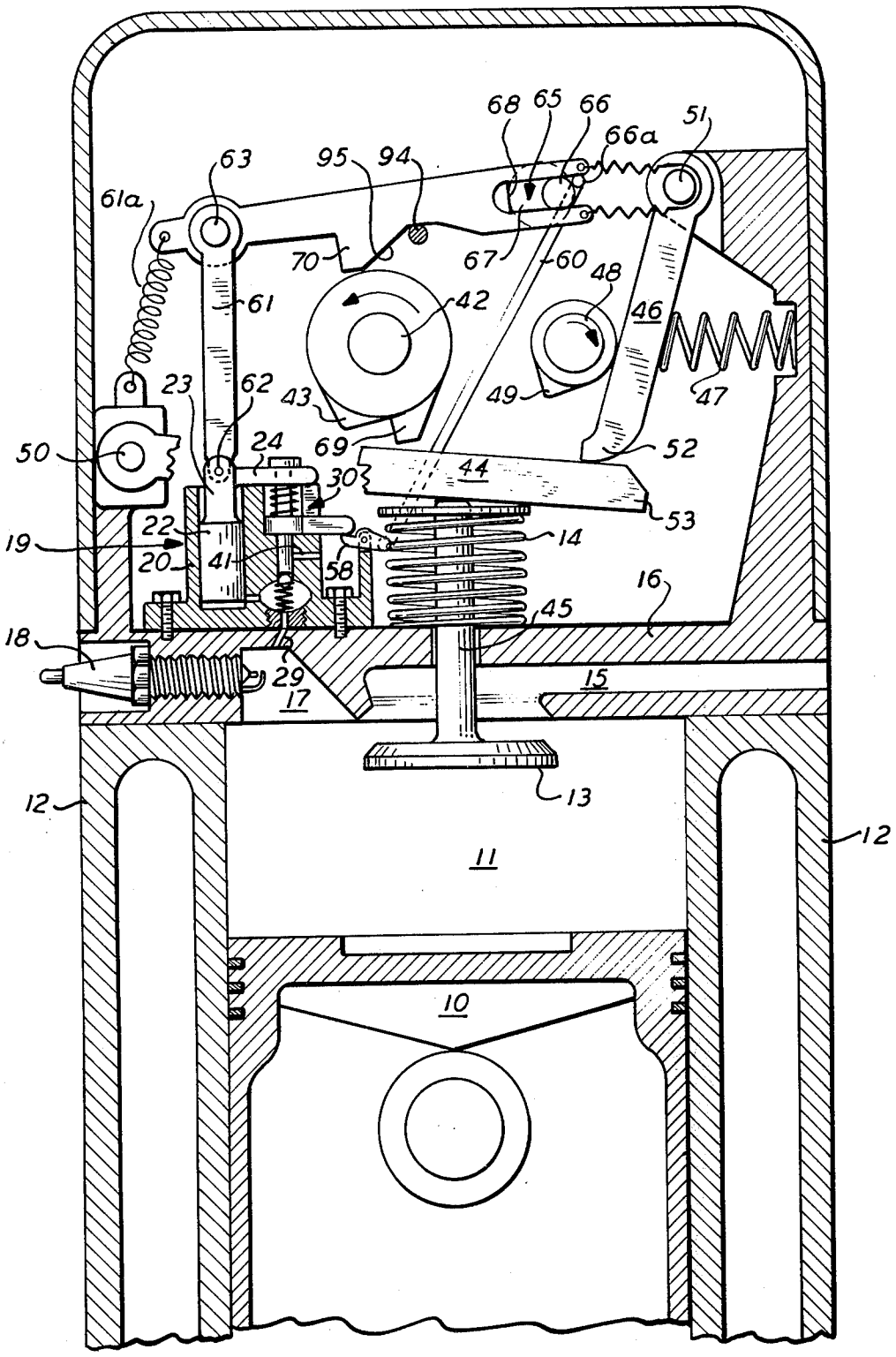

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FIG. 3

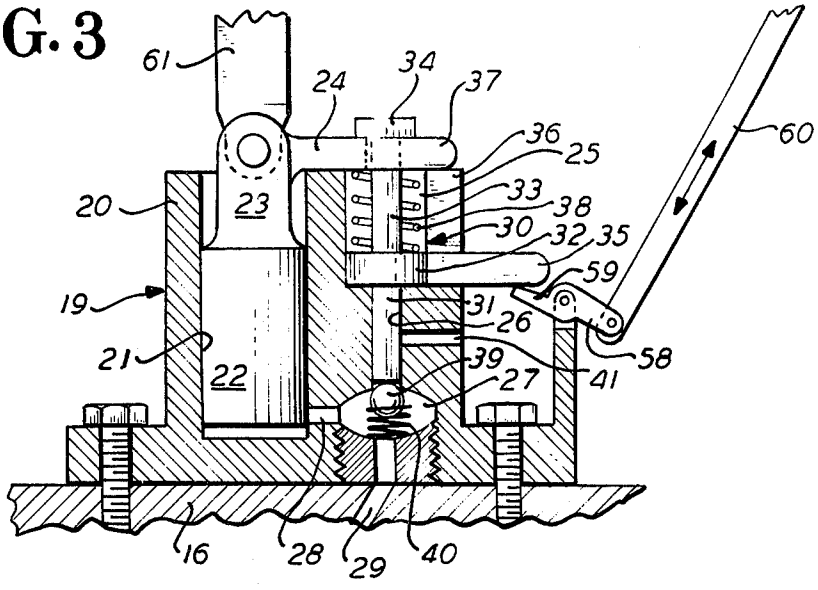
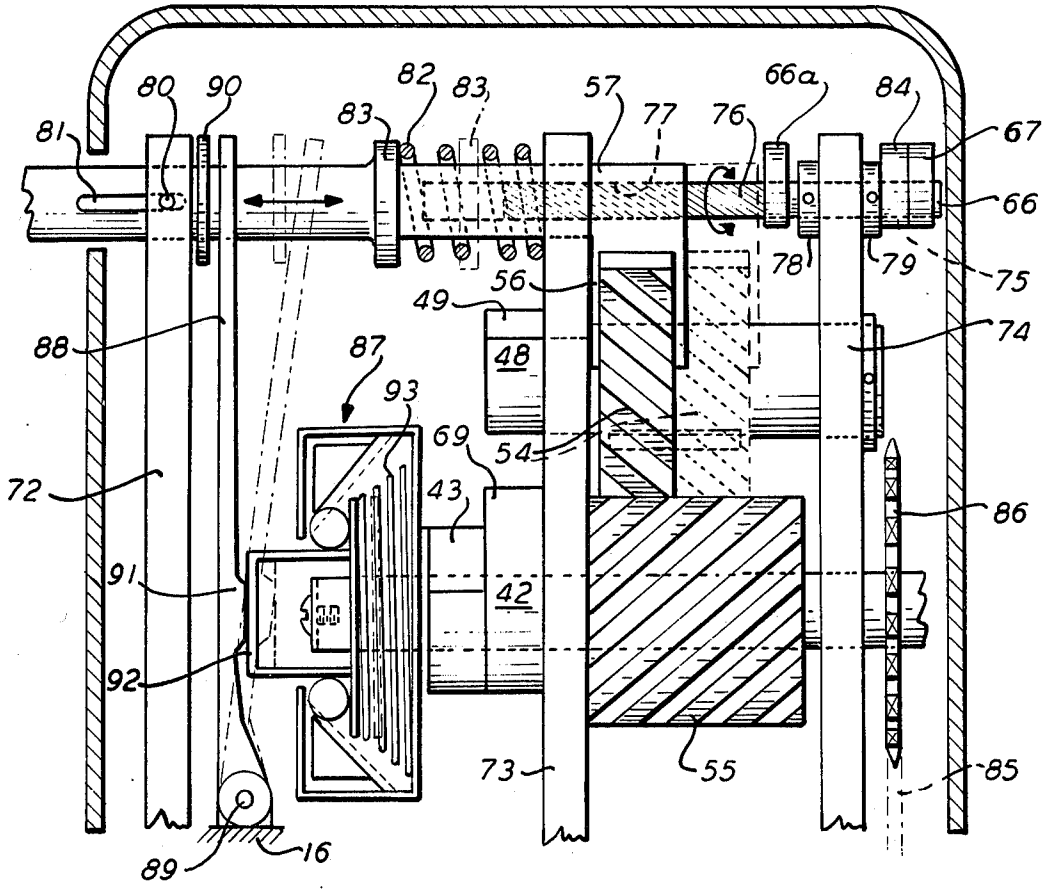

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FIG. 4


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FUEL INJECTION ENGINE

BACKGROUND OF THE INVENTION

In most internal combustion engines, the fuel is mixed with air and atomized in a carburetor from which the atomized mixture is drawn into the engine's combustion chamber by the action of the engine's piston on its intake stroke.

In most so-called fuel injection engines an injection pump delivers an atomized fuel charge into the intake manifold from which the charge is drawn into the combustion chamber by the action of the engine's piston on its intake stroke. Thus, in such prior fuel injection engines, the timing of injection is in fixed relation to the operation of the engine's piston, leading to relatively inefficient engine operation.

The preesent invention derives improved, highly efficient operation by providing means for controlling the ratio of fuel to air in an injected charge and for varying, according to engine speeds, of the timing of the fuel injection, the spark advance, and the closing of the engine's intake valve.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a largely schematic sectional view of a fuel injection engine according to this invention, the parts shown being largely limited to those having a direct relation to the improvements of this invention, and being shown as with the engine's inlet valve closed.

FIG. 2 is of a generally similar character as FIG. 1, but shows operating parts as with the engine's inlet valve open.

FIG. 3 is an enlarged vertical sectional view of the engine's injection pump.

FIG. 4 is a largely diagrammatic presentation, which, with the following description, will make clear to those familiar with the subject art, the operative relationship of parts directly under manual control and parts directly effecting timed operation of fuel injection and operation of the engine's intake valve as well as spark advance and conditioning of the injected fuel-air mixture.

DETAILED DESCRIPTION OF THE INVENTION

First, although not illustrated, it should be understood that, as with all four cycle engines, the engine with reference to which this invention is disclosed and described has an exhaust valve, a crankshaft, and certain other parts which function in a well understood manner in an engine which includes this invention in the same manner as such parts function in engines not including this invention. Such parts are omitted from this disclosure to focus attention upon the parts which constitute this invention and bring about the important operating improvements of this invention. This description now turns to the present disclosure.

GENERAL CHARACTERISTICS OF THIS INVENTION'S ENGINE.

Referring to FIG. 1, the engine's power piston 10 reciprocates within a cylindrical combustion chamber 11, formed in the engine's block 12. The piston 10 is suitably connected by a connecting rod to the engine's crank shaft (neither being shown) in a well known manner.

An intake valve 13, held closed be a compression coil spring 14, controls passage of air from an air intake duct 15 into the combustion chamber 11 formed in the block 12 and an engine head 16. Toward one side of the engine head it is formed with a combustion chamber recess 17 into which projects the firing end of a spark plug 18 suitably fixed in the wall of the head 16. The spark plug is connected through a distributor to a source of electric energy in a well understood manner.

THE ENGINE'S FUEL INJECTION PUMP

An injection pump 19 is suitably bolted onto the head 16, preferably directed over the spark plug 18 and the combustion chamber recess 17.

As best seen in FIG. 3, the pump 19 comprises a housing 20 formed toward one side with a relatively large upwardly opening air cylinder 21 within which is carried a piston 22. Rigidly integral with a projecting, reduced upper end portion 23 of the piston 22 is a laterally projecting arm 24.

Toward the opposite side of the housing 20 is formed an upwardly opening bore 25, parallel to the cylinder 21, and a counterbore 26 extending downwardly from the bore 25 and opening into a mixing chamber 27 which is connected by a side passage 28 to the lower portion of air cylinder 21 and by a bottom passage 29 to the combustion chamber's recess 17.

The bore 25 and counterbore 26 carry therewithin a fuel pumping plunger element 30 comprising the following rigidly integral parts, to wit: a fuel pumping piston 31 at its lower end working in the counterbore 26, an intermediate shoulder portion 32 sliding in and guided by the bore 25, a neck portion 33 extending upwardly from shoulder portion 32, a cap 34 at the upper end of said neck portion, and a finger 35 extending laterally from the shoulder portion 32 through and beyond a vertical slot 36 formed in the side wall of the pump's housing 20.

The lateral arm 24 is formed with a bifurcated end portion 37 which underlies and engages the underside of the cap 34, and the neck portion 33 is encircled by a coil spring 38 which is compressed between the shoulder portion 32 of the fuel pumping plunger element 30 and the under side of the arm 24 of the piston 22.

A check valve ball 39, yieldably held by a spring 40 against the lower end of the counterbore 26 substantially prevents upward flow of fluid in the counterbore. A fuel duct 41 extending through a wall of the pump's housing 20 is suitably connected to a fuel supply (not shown) and opens intermediately into the counterbore 26.

THE MEANS FOR OPERATING THE ENGINE'S INTAKE VALVE

While the spring 14 normally holds the valve 13 closed, that valve is opened through cam action and, under varying engine speeds, is held open for time durations depending upon the engine's operating speed.

The engine is provided with a primary camshaft 42, one camming lobe 43 of which engages an upper surface of a pivotal valve opening arm 44 and forcefully presses said arm downwardly; and, as said arm is in engagement with the upper end of stem 45 of the intake valve 13, the downward movement of the arm 44 results in downward movement of the valve 13, thereby opening the latter.

The duration of the holding of the intake valve 13 open is controlled by a releasable lock mechanism

which includes the pivotal arm **44.** That lock mechanism also includes a pivotal locking arm **46,** a compreessed coil spring **47** normally urging the arm **46** toward a secondary camshaft **48** carrying a cam lobe **49** arranged to actuate the locking arm **46** against the force of spring **47.**

The two arms **44** and **46** are so pivoted at fixed points **50** and **51** respectively as to pivot in a common plane, enabling the end portions of said arms to interact for locking and unlocking of the valve **13** with respect to its open condition.

During closed condition of said valve, as in FIG. **1,** an end portion **52** of the arm **46** engages an end portion **53** of the arm **44** with no material operational effect upon the latter. When cam lobe **43** presses arm **44** downwardly to open the valve **13,** the arm **46** is urged by spring **47** into engaagement with a concentric portion of the secondary camshaft **48,** as in FIG. **2,** with the end portion **52** of arm **46** in engagement with an upper surface of arm **44** to lock the latter and the valve **13** in open condition of said valve until such locking means are released.

Such release occurs when the rotation of the secondary camshaft **48** brings the latter's cam lobe **49** operationally against the arm **46,** moving the latter, against the force of spring **47,** to disengage the top of arm **44,** thereby enabling the arm **44** to rise, permitting valve **13** to be closed and held closed by the force of spring **14** until the next succeeding engagement of cam lobe **43** with the arm **44.**

VARIABLE TIMING OF CLOSING OF THE INTAKE VALVE

Contrary to the common practice of causing opening and closing of an engine's intake valve under control of a single cam lobe on the engine's camshaft, the present invention includes means, dependent upon the engine's speed, for varying the time of closing of the intake valve.

Variation in the mentioned closing time of intake valve **13** arises from the fact that the secondary camshaft **48** is driven by the primary camshaft **42** through two intermeshing spirailly-tooth gears **54** and **55** (see FIG. **4**) respectively keyed upon the camshafts **48** and **42.** The gear **55** is fixedly keyed to the primary camshaft **42,** but gear **54** is so slideably keyed to the secondary camshaft **54** as to be slideable therealong to some extent, while, nevertheless, the being constrained to turn with the secondary camshaft.

Such sliding of gear **54** from its full line position to its broken line position, or vice versa, is effected by a yoke **56** which is an integral part of a control plunger **57.** The yoke **56** engages opposite sides of the gear **54** without interfering with the latter's rotation and is capable of shifting the gear **54** between its two mentioned positions on the secondary camshaft **48** in reponse to purely longitudinal shifting of the control plunger **57** by the operator of the engine. Thus, the operator may change the angular relationship of the two gears **54** and **55** to vary the timing of engagement of cam lobe **49** with the locking arm **46** and thereby vary the timing of the closing of valve **13** relatively to the operation of the engine's piston **10.**

MEANS FOR TIMING THE OPERATION OF THE FUEL INJECTION PUMP

As this specification includes a comprehensive explanation of the engine's operation, it shoudl suffice here to note that the piston **22** and plunger **31** of pump **19** rise to take air and fuel into the pump and descend to discharge a mixture of air and fuel through passage **29** into the recess **17** area of combustion chamber **11.** The extreme upper and lower limits of movement of piston **22** and plunger **31** are shown respectively in FIGS. **1** and **2.**

It should be observed, however, that while piston **22** uninhibitedly pursues its down stroke, the storke of plunger **31** may be controllably limited in its downward movement by means of a rockable fuel control lever **58** or equivalent mechanical device operable by a linkage rod **60.** Said rod is schematically shown as pivoted at one end to a crank **66***a* on a rock shaft **66** and at its other end to the lever **58.** Rocking movement of the rock shaft **66** under the operator's control, as hereinafter explained, causes the rod **60** to pivot said lever's free end **59** upwardly, as in FIG. **1,** into position to engage the underside of finger **35** to variably shorten the storke of plunger **31,** which shortening is possible because of the fact that said plunger is only yieldably urged downwardly by the spring **38.**

The means for actuating the piston **22** and plunger **31,** best understood from FIGS. **1** and **2,** comprise an assembly of a substantially verticala push rod **61,** pivoted at **62** at its lower end to the reduced upper end portion **23** of piston **22,** and pivoted at its upper end at **63** to a substantially horizontal rod **64.** The other end of rod **64** is formed as a yoke **65** extending about a concentric portion of a manually controllable rock shaft **66** which supports said other end of rod **64** while, nevertheless, being slideable within said yoke. The push rod **61** is yieldably urged downwardly by a tensioned spring **61***a*, and rod **64** is yieldably urged rightwardly by a tensioned spring **64***a.*

The rod **64** responds as a follower for two cams. One cam is in the form of an eccentric portion **67** of the rock shaft **66,** being disposed at one side of the yoke **65** and aligned with a follower in the form of a side projection **68** fixed upon said yoke at the latter's inner end. Rocking movement of the rock shaft **66,** if done, as seldom, to the extent of 180° from its FIG. **1** angular position to its FIG. **2** position, thus causes the eccentric **67** to engage the follower **68** to shift the rod **64** leftwardly from its FIG. **1** position to its FIG. **2** position. Less than 180° rocking movement of the rock shaft **66,** as is usually the case, results, of course, in a reduced shifting of the rod **64.**

The left end of the rod **64** (as viewed in the drawing) is caused to rise and fall to operate the pump **19** through rod **61** by a cam lobe **69** on primary camshaft **42,** which lobe engages a cam following projection **70** on the underside of rod **64.** It will be understood, by comparing FIG.S **1** and **2,** that turning of the rock shaft **66** under control of the operator of the engine causes eccentric **67** to modify the timing of operation of the pump **19** by varying the angular relationship of the projection **70** with respect to the axis of the camshaft **42.**

MEANS FOR ROCKING THEE ROCKSHAFT 66

The rockshaft **66** is given a limited degree of rocking movement uner control of the operator of the engine through the medium of the control plunger **57.** This control plunger is shown schematically as carried for sliding nonrotary movement upon two suitable supports represented at **72** and **73,** such supports being

suitably fixed upon the engine's head **16.** A third rigid support represented at **74,** rockably carries one end portion **75** of the rockshaft **66** while the other end of the rockshaft has external spiral teeth **76** which work within complemental internal spiral teeth **77** in the plunger **57.**

The rock shaft **66** is restrained against longitudinal shifting by collars **78** and **79** which are fixed upon said shaft at opposite sides of the support **74,** while the plunger **57** is held against rotary motion by a pin **80** in support **72** which pin extends slideably within a slot **81** in said plunger.

A compressed coil spring **82** encircles the plunger **57** between an integral shoulder **83** on the latter and an opposed face of the support **73.** Thus, by foot or hand operation of the plunger **57,** said plunger may be pushed rightwardly (as viewed in the drawing) from its indicated full line engine-idling position toward its broken line accelerating position, thereby turning the rockshaft **66** proportionately to the longitudinal movement of the plunger **57.**

GENERAL COMMENTS

In addition to the above-mentioned control means on the rockshaft **66,** the latter also carries an additional cam or eccentric **84** which may be employed in a well known manner (not shown) to control a distributor to suitably vary the timing of firing of the engine's spark plug **18.**

The engine's primary camshaft **42** is driven in direct relation to the engine's crankshaft (not shown) by a chain **85** (or equivalent belt) working over a sprocket wheel **86** (or equivalent pulley wheel) fixed upon the camshaft **42.**

It is preferable, for smoothe engine operation to provide a suitable governor **87** on the primary camshaft **42** with a control lever **88** for easing the governor's action as the engine is acclerated by the operator. This lever is shown in schematic FIG. **4** as pivoted at its lower end at **89** upon the engine's head **16** and constrained to swing toward the governor by a collar **90** fixed to plunger **57** as the latter is pushed by the operator to accelerate the engine. During such acceleration, a boss **91** located toward the lower end of the lever **88** depresses a spring retainer **92** of the governor and a related spring **93** to disable the governor until the engine operates at running speed.

This engine differs from conventional four cycle engines chiefly in having means (1) for varying the period of time during which the intake valve is held open, (2) for varying the time of injection of fuel into the combustion chamber, (3) for controlling the volume of fuel so injected, and (4) for disabling or easing the effect of a governor during acceleration of the engine.

The four just mentioned features as well as spark control all stem from operation of the assembly of the plunger **57** and the rockshaft **66.**

The engine is started in the usual manner by closing of an electric circuit (not shown) to the spark plug and operation of a starting motor (also not shown). The operator ccontrols further engine operation by pushing control plunger **57** rightwardly to derive the desired engine speed.

The rightward movement of the plunger **57** to an extent depending upon the engine speed desired causes the yoke **56** to shift gear **54** on the countershaft **48** thereby altering said gear's angular relationship to gear **55** to cause, for that engine speed, the most desirable timing of open duration of the intake valve **13** by the lobe **49** of the secondary camshaft **48.**

The rightward movement of the plunger **57** also turns the rockshaft **66,** thereby causing eccentric **67** to push horizontal rod **64** leftwardly to secure, for the particular speed of the engine, the most desirable timing of fuel injection by the pump **19.** Such operaton of the rockshaft **66** also controls the volume of the fuel charge by crank **66***a;* and also controls the spark timing, all as hereinbefore explained.

As it may sometimes occur, upon stopping of the engine, that, with other parts, the primary camshaft **42** may turn reversely for one revolution, more or less, it is desirable to provide a stationary tripping rod **94** which, upon reverse engagement of cam lobe **69** with extension portion **70** of the rod **64,** will cause the tripping rod **94** to engage tapering surface **95** of said extension portion and lift the rod **64** to enable the cam lobe **69** to pass underneath the extension portion **70** and thereby avoid damage to the rod **64** and perhaps to other related parts.

The precise sizes, shapes and angular positioning of the various cams, cranks, and/or eccentrics on their respective shafts is an ordinary engineering matter which those skilled in the subject art may handle with little or no difficulty. The same is true of the matter of properly correlating the parts shown in FIG. **4** with the parts shown in FIGS. **1** and **2.**

It should be noted that, in engines employing this invention, the ignition distributor should be one having no governor as, otherwise, ignition may not be properly timed in relation to fuel injection.

I claim:

1. In a four cycle, fuel injection, reciprocating piston, internal combustion engine, camshaft means operating in fixed relation to the operating speed of the engine, injection timing means for timing the injection of a combustible fuel charge into the engine's combustion chamber, said injection timing means comprising pumping means for forcing said fuel charge into said combustion chamber, a pump-actuating cam lobe on said camshaft means, cam following means coacting with said cam lobe to cause reciprocation of said cam following means with respect to said camshaft means, connecting means between said cam following means and said pumping means for communicating said reciprocation to said pumping means, and manually operably control means for shifting said cam following means to move a cam engaging portion of the latter means to and fro between radially different points of its coaction with said cam lobe and thereby controllably vary the timing of such fuel injection relatively to the cyclic operation of the engine; said pumping means including a spring-closed air intake valve and valve control means coacting with said manually operable control means for varying the time of closing of said air intake valve in relation to the varying of timing of the fuel injection; said valve control means comprising a valve opening lobe on said camshaft means, a valve opening arm coacting between the latter lobe and the air intake valve to open the latter, a pivotal locking arm spring-pressed into locking interference with said valve opening arm to hold the latter in valve opening position; secondary camshaft means, intermeshing spiral gears coacting between the two said camshaft means to effect driving of the secondary camshaft means by the other camshaft

means, said spiral gear of the secondary camshaft means being slidable axially relatively to the latter to vary the angular relationships of the two said gears, a cam lobe on said secondary camshaft means, engageable with said locking arm to move the latter clear of such locking interference whereby to permit said valve to close; and a yoke portion of said manually operable means in engagement with said slideable gear to effect sliding thereof; the sliding movement of the latter gear by said yoke being proportionate to the mentioned to and fro movement of said cam following means, whereby to coordinate the timing of operation of said pumping means with the timing of closing of said valve.

2. Injection jection timing means according to claim **1,** said pumping means comprising a pump having separate, parallel, movable pistons for ingesting air and fuel into the pump, both said pistons being adapted for movement by said cam following means, said piston for fuel being yieldably moveable in its fuel charging stroke, and said manually operable control means including a fuel control lever manually operable to various intercepting positions relatively to said fuel control piston whereby to control the fuel component of a fuel-air mixture pumped into the engine's combustion chamber.

3. Injection timing means according to claim **1,** said manually operable control means comprising an eccentric mechanism including an eccentric manually turnable about an axis adjacent to said cam following means and an eccentric follower rigid with said cam following means and having a follower surfacee coacting with said eccentric to shift said cam following means to and fro between radially different points of its coaction with said pump-actuating cam lobe, said pumping means comprising a pump having separate, parallel, movable pistons for ingesting air and fuel into the pumping means, both said pistons being adapted for movement by said cam following means, said piston for fuel being yieldably movable in its fuel charging stroke, said manually operable control means including a fuel control lever manually operable to various intercepting positions relatively to said fuel control piston whereby to control the fuel component of a fuel-air mixture pumped into the engine's combustion chamber, said cam following means including a relatively straight rod extending tangentially in opposite directions relatively to said camshaft means, said rod being spring-urged at one end thereof in coaction with said eccentric mechanism to impart said to and fro movement to said rod endwisely of the latter, said rod at its other end being spring-urged in one direction approximately parallel to the line of movement of said pump's parallel pistons, and said pump-actuating cam lobe coacting with said rod to move said parallel pistons oppositely in direction.

4. Injection timing means according to claim **1,** said manually operable control means comprising a manually operable, longitudinally shiftable, control plunger, constrained against angular movement, a rock shaft constrained against longitudinal movement and coaxial with respect to said control plunger, intermeshing spiral gearing on said plunger and rock shaft constraining the latter to rock in response to longituddinal shifting of said plunger, cam means on said rock shaft coacting with said cam following means to impart said to and fro movement to the latter means, a fuel control lever coacting with said pump to control the mixture of air and fuel discharged by the pump into the engine's combustion chamber, and cam means on said rock shaft coacting with said fuel control lever, whereby operation of said control plunger and resultant rocking of said rock shaft proportionately regulate the air-fuel mixture, the timing of fuel injection, and the timing of opening of said air intake valve.

5. Injection timing means according to claim **4,** further including a governor, mounted upon said first-mentioned camshaft means, and governor-control means coacting between said manually operable control plunger and said governor to coordinate the latter's operation with the movement of said control plunger.

* * * * *