SUCTION SYSTEM FOR ROTARY PISTON INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The present invention relates to a suction system for rotary type internal combustion engines, preferably of trochoidal configurations, and more particularly to engines comprising a single stage carburetor and an auxiliary shutoff device in the induction passage anterior to the inlet port.

Conventional internal combustion engines with reciprocating pistons generally use a single-stage carburetor. In order to achieve an improved composition of the combustion mixture, rotary-type internal combustion engines employ almost exclusively, multistage carburetors. In engines of the latter type, wherein the inlet port admitting the mixture into the engine is alternately covered and exposed by the peripheral edges of the rotating piston, communication between the inlet port and the outlet port is unavoidable at a predetermined rotational angle of the piston, so that the sucked-in mixture is diluted by the exhaust gases.

The dilution results in a rough engine performance not only during idling but also when the engine is under partial load as when the car is accelerating which results from this dilution. The uneveness is felt as undesirable jolting.

A number of improvements have been suggested by the prior art to eliminate the shortcomings of the conventional devices. One system adds to the rotary type internal combustion engine a supplementary idle fuel passage, with a control port formed posteriorly of the main inlet port in the rotational direction of the piston. Such a system requires, however, a special carburetor and has the additional drawback that the exhaust gases in the induction manifold, between the inlet port and the throttle valve of the carburetor, are combined with the sucked-in mixture during the transition from idling to partial load operation which leads to misfiring of the engine. An arrangement of this type also needs an elaborate construction of the induction manifold or passage of the required length since the supplementary idle fuel passage must be included.

Another system provides for an additional channel for partial load operation through which the fuel-air mixture is supplied by the first stage of a register carburetor; the main induction passage is connected to the second stage of the multistage carburetor and remains closed, up to a 30 percent load, by a throttle valve disposed anteriorly of the inlet port. A multistage carburetor of this type improves the engine performance during idling and at partial loads. However, when a vehicle is in drive with the throttle valve closed, a large quantity of exhaust gases are admitted into the engine during the suction process, so that the vehicle becomes subject to shaking due to misfiring of the engine.

In yet another prior art solution, the fuel-air mixture for partial load operation of the engine is supplied by an auxiliary carburetor flanged to the housing, and transmitted to the engine through a secondary induction passage. In this construction, the main carburetor is spaced at a distance from the engine, respectively the inlet port thereto, because of the vibrations of the gas head. This solution, though advantageous, is very expensive since it requires two carburetors, a complicated air filter system, and a precise coordination of the two carburetors which is difficult to achieve.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to eliminate the drawbacks of prior art rotary engines and to provide a simple and compact suction system for a rotary type internal combustion engine of trochoidal configuration.

Another object is to provide this suction system in an engine comprising a single-stage carburetor and one induction passage.

Yet another object is to provide a uniform combustion mixture for idling, for the transition phase between idling and partial load operation, and for a vehicle while cruising so as to eliminate misfiring.

These objects and others which will become apparent hereinafter, are attained in accordance with the present invention, by adding to a rotary type internal combustion engine with an auxiliary shutoff device in the induction passage anteriorly of the inlet port leasing into the engine, a supplementary suction system disposed at the exterior of that portion of the body forming the induction passage which contains, in its interior, the shutoff device. In one preferred embodiment of the invention, the shutoff device and the supplementary suction system are housed in an adapter flange attached to the engine housing. In another preferred embodiment both the shutoff device and the suction system are enclosed in the wall of the housing itself. The suction system includes an idle fuel passage and means for controlling the amount of the fuel-air mixture passing from the idle fuel passage into the engine. Optionally, an air intake vent communicates with this passage and means are provided for adjusting the opening of this vent. A stop means juxtaposed with the shutoff device in the induction passage on the engine side thereof is part of the suction system.

Common actuation of a throttle valve journaled to the body of the induction passage proximate to the carburetor, and of the shutoff device journaled to that body proximate to the engine inlet port may result in minor differences in the cross section of the passage. The shutoff device may be formed as a conventional throttle valve, a rotary slide valve, or a gate-type slide valve.

The supplementary suction system, according to the invention permits a more precise adjustment of the mixture during idling; the stop means in the main induction passage blocks transmission of fuel when the throttle valve and the shutoff device are closed. The fuel, attached as a capillary film to the walls of the induction passage, is drawn into the idle fuel passage where it may be mixed with auxiliary air admitted through an air vent. Thus, a rich fuel-air mixture is available for the transmission phase between idling and partial load operation since the suction system is open even when the shutoff device is in a closed position, preventing the admission of exhaust gases into the induction passage and a dilution of the sucked-in mixture.

When a vehicle is cruising at a very low pressure, the engine draws from the supplementary suction system a uniform fuel-air mixture, so that the vehicle is not exposed to unsmooth vibrations due to misfiring of the engine.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a rotary type internal combustion engine according to the present invention; the plane of FIG. 1 being taken normal to the axis of the mainshaft and centrally through the engine housing midway between the opposed sides thereof;

FIG. 2 shows at an enlarged scale the detail A enclosed within the dot-dash line circle of FIG. 1, with an additional air intake vent communicating with the idle passage and regulating means for said intake vent; and

FIG. 3 shows at an enlarged scale in a view similar to that of FIG. 2, an alternate embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings there is shown in FIG. 1 the housing 1 of a rotary type internal combustion engine comprising two end plates (not shown), formed with a central opening (not shown) through which an eccentric shaft 2 extends. A polygonal piston 3 mounted on shaft 2 is adapted to rotate along the approximately trochoidal inner wall surface 1*a* of the housing 1. A plurality of sealing strips 5 are radially disposed on the periphery of the piston 3. An inlet port 6 communicating with the induction manifold or passage 9 and an exhaust port 7 are formed in the housing 1. Reference number 28 indicates the spark plug. A single stage carburetor 8 of con-

FIG. 1.

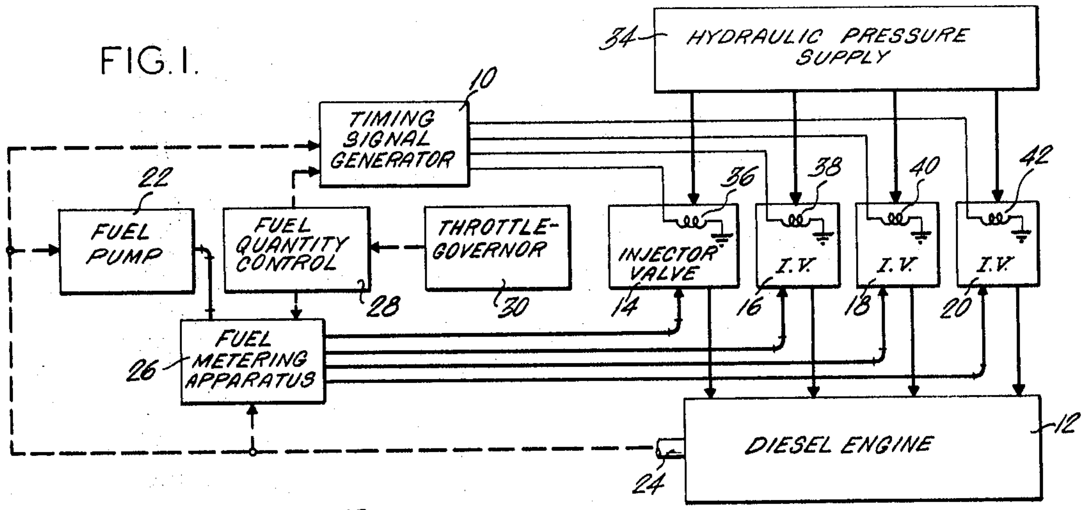


FIG. 2.

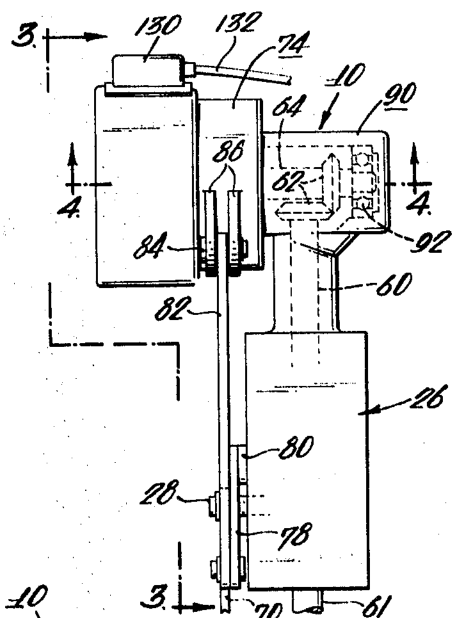


FIG. 3.

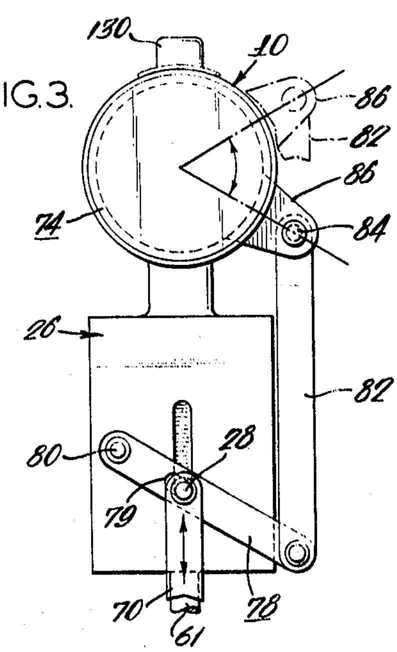
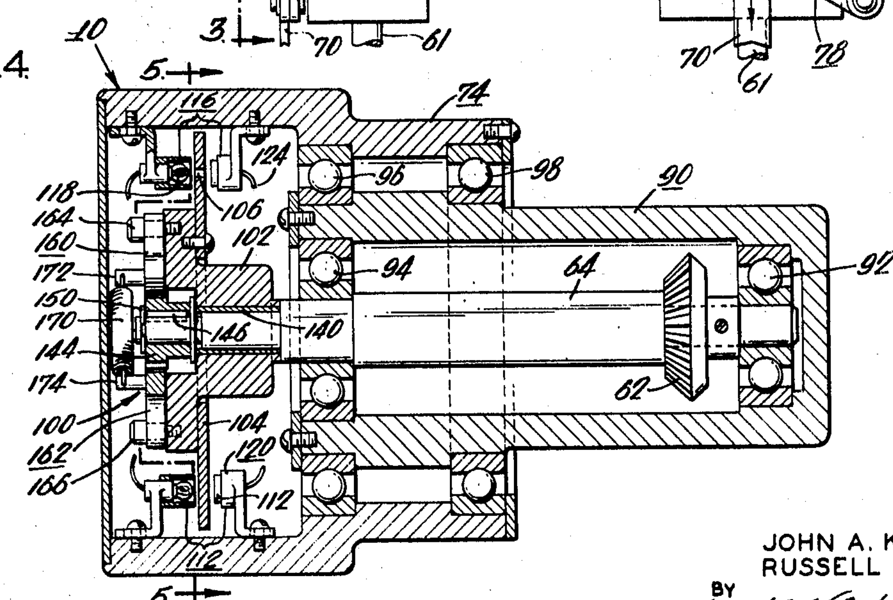


FIG. 4.



INVENTORS:
JOHN A. KIMBERLEY
RUSSELL B. HUSSEY
BY Howson & Howson
ATTYS.

FIG. 5.

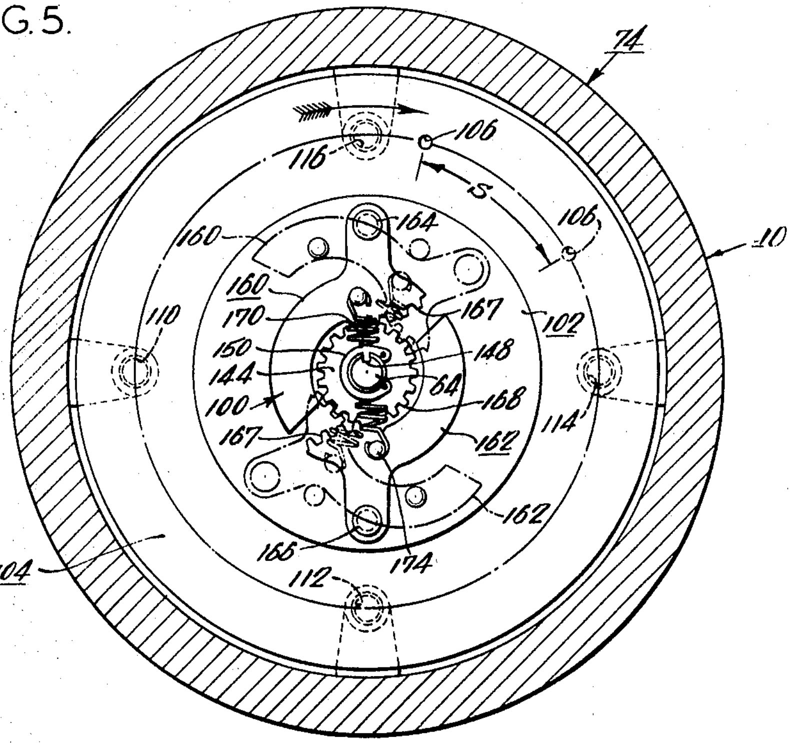
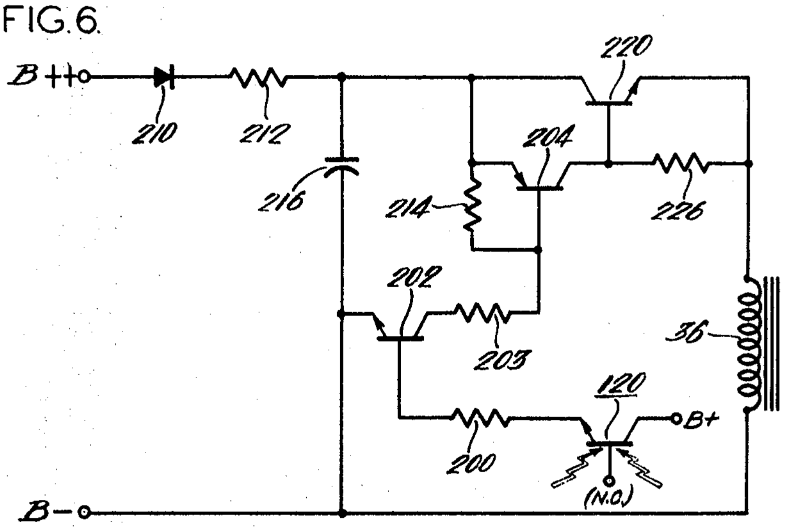


FIG. 6.



INVENTORS:
JOHN A. KIMBERLEY
RUSSELL B. HUSSEY
BY
Howson & Howson
ATTYS.

TIMING SIGNAL GENERATOR

BACKGROUND OF THE INVENTION

The invention herein described was made in the course of or under a Contract DAAE07–67–C–4023(T) with the Department of the Army.

This invention relates to timing signal generators for producing electrical signals in controlled time relation to the phase of operation of an engine, and particularly to such a timing signal generator for producing electrical timing signals to control the times at which the injection of fuel occurs in an internal combustion engine and for providing automatic variation in the phase of such timing signals in response to variations in certain operating conditions of the engine. In the preferred embodiment the invention relates to a timing signal generator for producing automatic timing advance in response to variations in rate of delivery of fuel to the engine.

There are a variety of applications in which fuel is to be supplied to an engine and to be injected therein at a particular point in the engine cycle. For example, in a diesel engine the time at which fuel ignition occurs is commonly controlled by control of the time of injection of the fuel with respect to the engine cycle. As is also known, for best operation it is often desirable to provide automatic variation in the timing of injection as a function of one or more engine operating conditions such as engine speed, engine load or fuel delivery rate, as examples.

Various expedients are known in the prior art for providing automatic control of timing advance where the timing is mechanically produced and controlled. The present invention is concerned with automatic control of timing in engine systems in which the timing is electrically controlled. Such systems include, for example, diesel engine systems in which fuel injection is accomplished by solenoid-actuated fuel injector devices, the injection timing being controlled by the time-phase of control signals applied to the solenoids with respect to the cycle of engine operation. One specific engine system to which this invention is directly applicable is that described and claimed in copending application Ser. No. 840,266 of R. B. Hussey, J. A. Kimberley and W. E. Snyder, filed July 9, 1969, entitled Fuel Injection System and Apparatus for Use Therein, and of common assignee herewith. In the latter type of system, injection of fuel into a diesel engine cylinder is initiated by electrical pulses applied to a solenoid valve, and the time at which fuel injection starts is therefore determined by the time-phase of the pulses applied to the winding of the solenoid valve, with respect to the engine cycle.

Accordingly it is an object of this invention to provide new and useful apparatus for controlling fuel injection in an engine system.

Another object is to provide a new and useful timing signal generator for generating timing signals to control ignition in an engine.

A further object is to provide such apparatus suitable for controlling the times of injection of fuel into the cylinders of diesel engines.

It is also an object to provide such apparatus in which timing is automatically controlled as separate and different functions of engine speed and fuel quantity.

SUMMARY OF INVENTION

These and other objects of the invention are achieved by the provision of a timing signal generator comprising first means which is rotatable about a predetermined axis in predetermined angular phase relation to the phase of operation of an engine; second means mounted on said first means for rotation therewith, and for angular displacement with respect thereto about said axis; third means mounted for angular displacement about said axis; means for comparing the angular position of said s second means, about said axis, with that of said third means and for producing an electrical signal having a phase indicative of the times at which said second and third means are in a predetermined angular relation to each other about said axis; means responsive to variations in the rate of rotation of said first means about said axis for varying the angular position of said second means with respect to said first means, thereby to shift the phase of said signal with respect to the engine cycle in response to engine speed changes; and means responsive to variations in another engine operating condition for varying the angular position of said third means about said axis, thereby to shift the phase of said signal with respect to the engine cycle in response to changes in said other engine operating condition.

In a preferred embodiment the apparatus of the invention may comprise a shaft journaled in a bearing and driven by the engine through fixed gearing, on which shaft are mounted centrifugal speed-sensing means including an output member which rotates with the shaft but is angularly displacable with respect thereto as a function of the speed of rotation of the shaft. Photoelectric means are utilized to compare the relative angular positions of the output member with respect to another member which is mounted on the engine frame and which is angularly displacable with respect to the frame. The fuel-quantity control for the engine is linked to the latter member to displace it angularly as a predetermined function of the quantity of fuel supplied to the engine. Accordingly, the electrical timing signals produced by the photoelectric comparison system are synchronized with engine operation but have a time phase dependent upon both the speed of engine operation and the rate of fuel supply thereto. The relation between engine speed and timing, and the relation between fuel supply and timing, are independently selectable to provide the type of advance-retard operation preferred for the particular application.

BRIEF DESCRIPTION OF DRAWINGS

Other objects and features of the invention will be more readily understood from a consideration of the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a block diagram illustrating an engine system to which the invention is applicable;

FIG. 2 is a plan view of apparatus in accordance with the invention;

FIG. 3 is a view taken along lines 3–3 of FIG. 2;

FIG. 4 is a section taken along lines 4–4 of FIG. 2;

FIG. 5 is a section taken along the lines 5–5 of FIG. 4; and

FIG. 6 is an electrical schematic diagram illustrating circuitry useful in practicing the invention in one of its preferred forms.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring now to the embodiment of the invention shown in the drawings by way of example only, FIG. 1 illustrates schematically a diesel engine system employing a timing signal generator 10 constructed in accordance with the invention. In this application of the invention the diesel engine 12 is assumed to have four cylinders into which fuel is injected by way of the individual solenoid-controlled injector valves 14, 16, 18 and 20, one for each engine cylinder. Fuel is supplied to each of the injector valves by a fuel pump 22 mechanically driven from the output shaft 24 of engine 12, by way of the fuel metering apparatus 26. The quantity of fuel so supplied to the injector valves by the fuel metering apparatus is controlled by a suitable fuel quantity control 28, which in this example is assumed to be controlled, in turn, by a mechanical linkage to a throttle-governor 30. Fuel quantity control 28 is movable along fuel-metering apparatus 26, as described more fully hereinafter, to move a fuel control element inside of apparatus 26 to vary the quantity of metered fuel delivered to the injection valves. It is understood that the throttle governor, in general, may produce different engine speeds at different times, due for example to use of a variable-speed governor or because of load changes. The fuel metering apparatus 26 is also driven from the output shaft 24 of engine 12.

Each of the injector valves, in addition to being supplied with metered fuel, is in this example supplied with hydraulic pressure from hydraulic pressure supply 34 to assist in operation of the valve once the valve has been triggered by electrical timing pulses supplied from generator 10 to the solenoid windings 36, 38, 40 and 42 of the valves 14, 16, 18 and 20 respectively. The latter solenoid windings are supplied with electrical pulses at the particular times appropriate for producing best engine operation.

As is further shown in FIG. 1, the timing signal generator 10 is mechanically linked to the output shaft 24 of engine 12 and to the fuel quantity control 28. The nature and purpose of these mechanical connections will become more apparent from the following description with particular reference to FIGS. 2—5, which illustrate one preferred form of timing signal generator 10 in accordance with the invention.

FIGS. 2 and 3 show the exterior of the timing signal generator 10 and the manner of its mechanical connection in the system. A rotatable shaft 60 is connected at its remote end 61 to the engine drive shaft 24 through any appropriate gearing, and acts through a pair of bevel gears 62 to drive the main support shaft 64 of the timing signal generator 10. In this example the fuel metering apparatus 26 is disposed about the shaft 60 and may be of any known conventional form but preferably is of the type described and claimed in copending application Ser. No. 805,251, filed Mar. 7, 1969, entitled Fluid Metering and Distributing System and of common assignee herewith. Also in this example, the fuel quantity control 28 comprises a pin extending outward from the fuel metering apparatus 26 and slidable thereon along the direction of the axis of shaft 60 to vary the quantity of fuel delivered to the injection valves and to the diesel engine. Fuel quantity control pin 28 is connected to linkage 70 which leads to the throttle-governor 30, so that the fuel quantity is automatically varied in response to operation of the throttle-governor through linear motion of pin 28.

Pin 28 is mechanically linked to the support 74 for the photoelectric measurement system to be described hereinafter, in such a manner that adjustment of the fuel-quantity control pin 28 produces a relative angular displacement of the support 74 and of the associated photoelectric system, about the axis of the main support shaft 64. In the present embodiment the linkage for accomplishing this coordinated motion comprises a crossbar 78 containing a slot 79 which surrounds the fuel-quantity control pin 28, one end of crossbar 78 being pivoted on a pivot 80 fixed to the exterior of fuel metering apparatus 26. The opposite end of crossbar 78 is pivotably secured to a linkage arm 82 which in turn is pivotably connected at its other end to another pivot 84 on an ear 86 extending from the support 74. In this way, operation of the throttle-governor 30 to move the fuel-quantity control pin 28 also produces a predetermined degree of angular displacement of the photoelectric system support 74, thereby to provide a predetermined advance in timing as described hereinafter.

Referring now particularly to the sectional views of the timing signal generator 10 shown in FIGS. 4 and 5, the main support shaft 64 is journaled in the frame member 90 by means of a first ball bearing assembly 92 at one end thereof and by a second ball bearing assembly 94 near the opposite end thereof. Another pair of ball bearing assemblies 96 and 98 mount the photoelectric support 74 for rotatable angular motion on the outside of frame member 90, about the axis of main support shaft 64. As described above, photoelectric support 74 is subject to controlled angular displacement through operation of the fuel-quantity control pin 28 and its associated mechanical linkages.

On the portion of main support shaft 64 to the left of bearing assembly 94, there is provided a centrifugal advance-retard device 100 having an output member 102 which rotates with shaft 64 but which is angularly displacable about the axis of shaft 64 as a function of speed of rotation of the latter shaft. An annular mask 104 is mounted on and about the periphery of the output member 102, the aperture 106 in mask 104 being positioned so as to pass in sequence through each of four photoelectric measuring units 110, 112, 114 and 116 which are located at 90° intervals around shaft 64 as shown in FIG. 5. These photoelectric measuring units are all the same, each consisting essentially of a small appropriately shielded light source such as 118 adjacent one side of the mask 104 and an appropriate photosensitive detector such as 120 on the opposite side of plate 104, the light source 118 and the detector 120 being at the same radial distance from the axis of shaft 64 as is the aperture 106 in mask 104, so that a pulse of current is produced by each of the photoelectric detectors such as 120 each time the aperture 106 is in angular coincidence therewith. Accordingly, four output pulses are produced for each complete cycle of rotation of the mask 104. Appropriate leads such as 124 pass from each of the photoelectric detectors into the circuitry housing 130 (FIG. 2), which contains appropriate electrical circuitry for processing signals produced by the photoelectric detectors and for distributing them by way of cable 132 to the injector-valve solenoid coils 36, 38, 40 and 42. It will be understood that the signals produced by the photoelectric detectors are supplied to corresponding different ones of the solenoid windings.

The speed-responsive advance-retard device 100 may be generally conventional in form. In this example it comprises the output member 102 rotatably mounted on shaft 64 by means of bearing sleeve 140. An externally-toothed spur gear 144 is mounted at the outer end of main support shaft 64 for rotation therewith, and to this end is provided with an internal key 146 mating with a keyway 148 at the outer end of shaft 64, the gear being retained by an appropriate spring washer 150. Accordingly, gear 144 rotates in fixed phase relation to the engine drive shaft 24, and its angular position is therefore fixed with respect to the engine operating cycle.

The output member 102 of advance-retard device 100 includes a pair of flyweights 160 and 162 pivotably mounted on respective pivots 164 and 166 located on diametrically opposite sides of the axis of main support shaft 64. Flyweights 160 and 162 are provided at their radially-inward sides with gear teeth 167 which mesh with the teeth 168 of spur gear 144 during rotation of either of the flyweights about its corresponding pivot. A coil spring 170 is secured at its opposite ends to pins 172 and 174 on flyweights 160 and 162 respectively, so as to urge them toward their radially most-inward position, which is shown in full line in FIG. 5. The center of gravity of the flyweights and their configuration is so selected that when main support shaft 64 is rotated clockwise as shown in FIG. 5 at a sufficiently high rate, the flyweights will move outward toward the corresponding positions shown in broken line, to an extend determined by the rotational speed existing at that time. Due to the interaction of the teeth of the gear 144 and those of the flyweights 160 and 162, such outward motion of the flyweights causes a relative clockwise advance of the flyweights and the associated output member 102 with respect to main support shaft 164. As described in more detail hereinafter, this advance will produce an advance in the timing of the electrical signals produced by the photoelectric system, in response to increases in rotational speed.

In the operation of the timing signal generator shown, when engine 12 is first started up from a very low speed the flyweights 160 and 162 will be in their radially-innermost position so as to produce substantially zero advance of timing. Similarly, since the fuel-quantity control pin 28 will be in its lowermost position as shown in FIG. 3, the photoelectric support 74 will be in its most clockwise position as shown in full line in FIG. 3; however, as fuel-quantity control pin 28 is moved upwardly in FIG. 3 to increase the quantity of fuel supplied to the engine, the photoelectric support 74 will be moved to the broken-line position shown in FIG. 3 by counterclockwise rotation thereof, thereby producing a controlled advance of timing as a function of fuel quantity. Accordingly, mask 104 is displaced angularly to produce timing advance in response to increasing speed by means of the advance-retard device **100**, while photoelectric support **74** is angularly displaced to produce timing advance in response to increasing fuel quantity by motion of linkage **82**.

FIG. **6** illustrates, by way of example only, a circuit suitable for receiving the pulses produced by the photoelectric detectors such as **120** and for applying them to the corresponding solenoids of the injector valves. While only one such circuit is shown, it will be understood that in the present example there may be four such separate circuits, one for each of the photoelectric detectors and injection valves. In this example the photoelectric detector **120** comprises a phototransistor of the NPN type having its base open-circuited and its collector lead connected to a source of positive voltage designated as B+. The emitter of photoelectric detector **120** is connected by way of a resistor **200** to the base of an NPN transistor **202**, the emitter of which is connected to the negative supply terminal designated B–; the collector of transistor **202** is connected by way of resistor **203** to the base of a PNP transistor **204**, which base is supplied with operating bias from a source of positive supply potential designated B++ by way of a rectifier **210**, a series charging resistor **212** and a biasing resistor **214**. The emitter of transistor **204** is directly connected to the upper plate of a capacitor **216** and to the interconnection of resistors **212** and **214**. The lower terminal of capacitor **216** is connected to B–. The collector of transistor **204** is directly connected to the base of a further NPN transistor **220**, the collector of which is directly connected to the upper plate of capacitor **216** and the emitter of which is connected to one end of the solenoid **36** of injector valve **14**, for example. The other end of solenoid **36** is connected to the negative supply B–. Bias for the base of transistor **220** is supplied from the upper end of solenoid **36** by way of a biasing resistor **226**.

In the operation of the circuit of FIG. **6**, all of the transistors are nonconductive in the absence of illumination of the photoelectric detector **120**, and capacitor **216** is fully charged due to its connection between the B++ and B– supply terminals. When the aperture **106** in rotating mask **104** allows light to reach photoelectric detector **120**, the latter detector is rendered conductive and causes each of the other transistors in turn to become immediately conductive, whereupon capacitor **216** discharges rapidly through solenoid **36** to open solenoid valve **14**. After this initial rapid discharge, the current from capacitor **216** tapers off but, so long as photoelectric device **120** remains illuminated, sufficient current will flow through solenoid **36** to maintain the valve **14** open. When the mask **104** rotates sufficiently that photoelectric device **120** is no longer illuminated, all transistors resume their nonconductive state, current for solenoid **36** terminates, valve **14** closes, and capacitor **216** recharges in readiness for its next actuation.

It will be understood that any number of timing pulses per shaft revolution may be produced to accommodate any number of cylinders in an engine and that various forms may be utilized for the apertured mask **104**, such as cuplike or drumlike shapes, which in some cases may be multiply-apertured or translucent at different radial positions. Various other modifications of the photoelectric system suitable for producing the necessary angle of comparison will occur to one skilled in the art. The system is also applicable to systems other than diesel engine systems, in which electrical signals are to be used for timing purposes and in which automatic advance-retard is desirable.

Thus while the invention has been described in the interest of complete definiteness in connection with specific embodiments, it is understood that it may be embodied in any of the variety of forms diverse from those specifically described without departing from the scope of the invention as defined by the appended claims.

I claim:

1. In a diesel engine system comprising a diesel engine having at least one cylinder, electrically operable fuel-injecting means for each said cylinder, fuel pump means and adjustable fuel-metering means for delivering to each said fuel-injecting means a predetermined discrete quantity of fuel prior to each operation of said fuel-injecting means for injection by said fuel injecting means, said quantity of fuel delivered to said fuel-injecting means being determined by the adjustment of said fuel metering means, and a timing pulse generator for generating timing pulses and for applying them to said fuel-injecting means to cause said fuel-injecting means to inject said discrete quantity of fuel beginning at a time determined by the time of occurrence of each of said timing pulses, whereby the quantity of fuel injected is determined by the adjustment of said fuel metering means substantially independently of the duration of each injection period and the timing of injection is determined by the times of occurrence of said timing pulses, the improvement according to which:

said timing pulse generator comprises first means driven in rotation by said engine in predetermined angular phase relation to the phase of operation of said engine, second means rotated about a predetermined axis by said first means, advance-retard means for varying the angular relation of said second means to said first means as a function of the speed of said engine, third means mounted for limited angular displacement about said axis, means for producing a timing pulse each time said second and third means are in a predetermined angular relation to each other, and means responsive to adjustment of said fuel control means for changing the angular position of said third means about said axis thereby to shift the phases of said pulses with respect to the engine cycle.

2. The system of claim **1**, in which said means responsive to adjustment of said fuel control means comprises a linkage between said fuel control means and said third means connected to advance the phase of said timing pulses when said fuel control means is moved in the direction to increase said quantity of fuel.

3. The system of claim **2**, in which said means for producing a timing pulse comprises photosensitive detector means for optically sensing the relative angular positions of said second and third means.