Sept. 7, 1937. H. V. HONN 2,091,987

INTERNAL COMBUSTION ENGINE

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Fig. 1

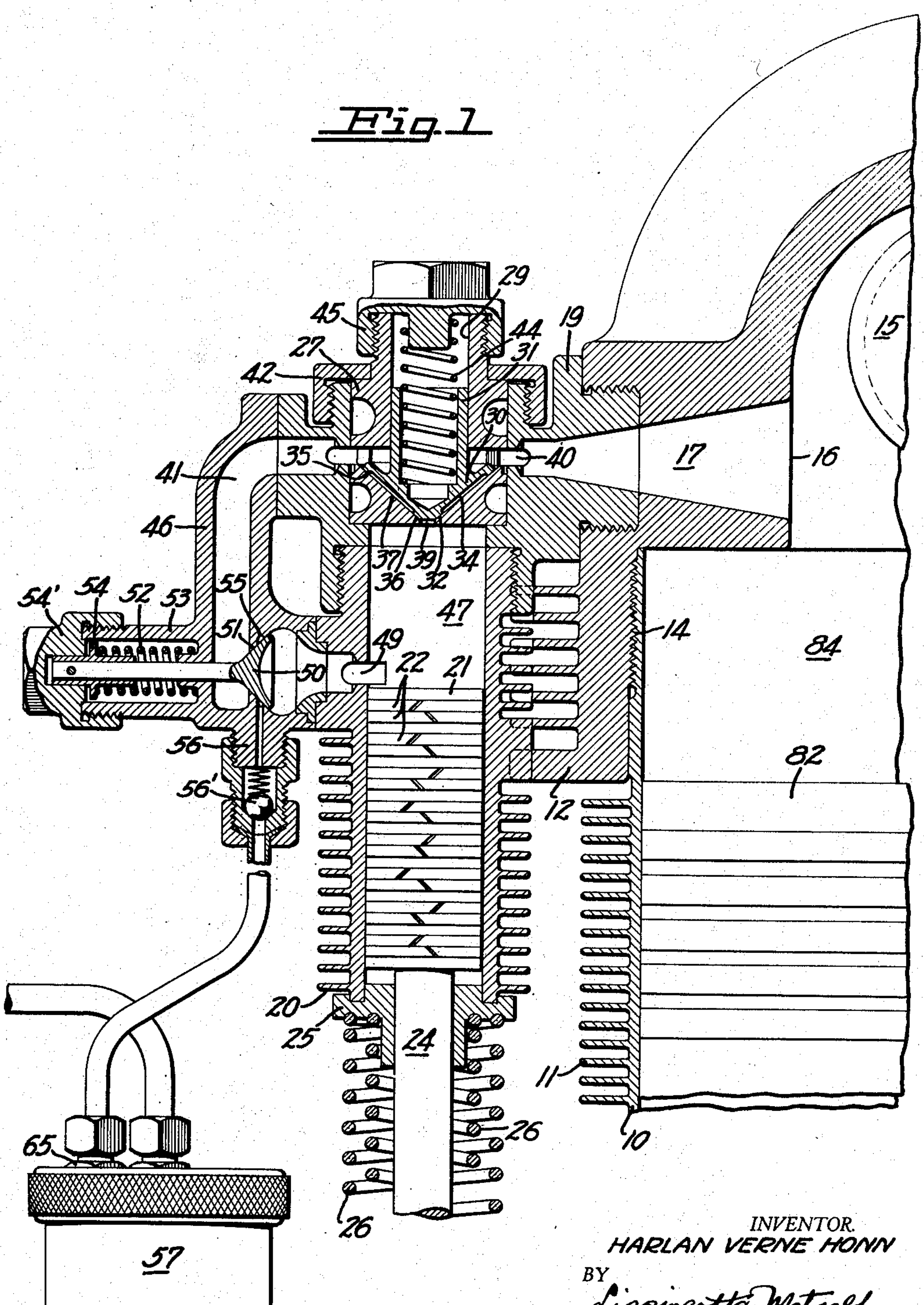


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Fig. 2

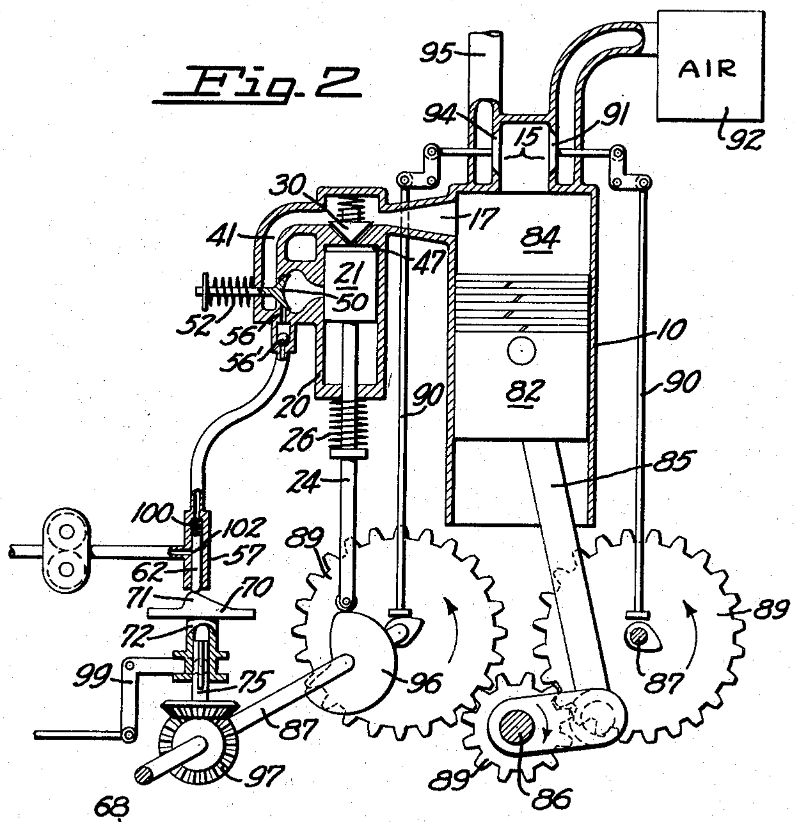
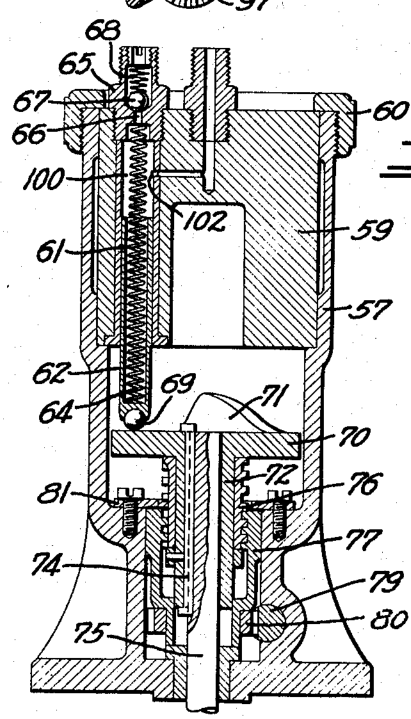



Fig. 3



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# UNITED STATES PATENT OFFICE

2,091,987

## INTERNAL COMBUSTION ENGINE

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Application September 26, 1934, Serial No. 745,573

7 Claims. (Cl. 123—33)

My invention relates to internal combustion engines, and particularly to engines adapted for burning the heavier grades of liquid fuel.

Among the objects of my invention are: to provide a means and method of eliminating ignition lag in heavy oil combustion engines; to provide a heavy oil engine having a relatively low maximum pressure; to provide a heavy oil engine suitable for aircraft propulsion; to provide an engine in which no electrical ignition is required; to provide a heavy oil engine requiring no carburetor; to provide accurate means for metering fuel charges for heavy oil engines; to provide variable means for metering fuel charges for heavy oil engines; to provide means for pre-igniting a heavy oil charge; to provide a means of controlling the speed of a heavy oil engine; to provide a heavy oil injector system for internal combustion engines in which the fuel lines are at relatively low pressure; and to provide a means and method, flexible as to adjustment and control, for operating an internal combustion engine on the heavier grades of fuel.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiments of the invention herein described, as various forms may be adopted within the scope of the claims.

In my prior Patent No. 1,896,174 issued February 7, 1933, I have described and claimed a means and method of operating an internal combustion engine by injecting a pre-ignited charge of frothed fuel into the combustion chamber of the engine. The instant application, while concerned with a pre-ignited charge, deals with a construction and method differing in many respects therefrom, as will be seen from the following disclosure.

In the drawings:

Figure 1 is a sectional view through a portion of an internal combustion engine cylinder and through a preferred fuel charging structure attached thereto.

Figure 2 is a diagram, reduced to lowest terms, showing the interrelation of parts in a complete single cylinder engine.

Figure 3 is a longitudinal section of a preferred type of fuel metering pump.

For purposes of simplicity I have chosen to describe my invention as applied to a single cylinder, as it will be obvious from the description that by multiplication of parts the invention may be applied to multicylinder engines. Actually, the parts shown in Figures 1 and 3 are component parts of an airplane radial cylinder power plant, to which my invention is ideally adapted.

The following description of parts which, when assembled form the preferred illustrative embodiment of my invention, will be made without reference to operational function, this being dealt with later.

Referring to the drawings, particularly to Figure 1 thereof, an engine cylinder 10 is provided with cooling fins 11 and a finned cylinder head 12 preferably attached by head threads 14. The head is supplied with the usual valve ports 15 shown more distinctly in Figure 2.

The head is provided with a fuel port 16 forming the opening of a fuel channel 17 of conical shape and which continues into a channel plug 19 screwed to the cylinder head.

Below, this plug supports a preheating cylinder 20, preferably finned in which an igniter piston 21 reciprocates, this piston being well supplied with igniter piston rings 22. An igniter piston rod 24 passes through a guide block 25 at the lower end of the preheating cylinder, and is preferably maintained at its lower limit of stroke by igniter piston springs 26.

Above, the channel plug supports an injector valve assembly comprising an injector valve cage 27 having an internal bore 29 in which is mounted an injector valve 30.

The injector valve comprises a stem 31 adapted to fit and slide in the internal bore 29, and a conical face 32 provided with a relief 34 giving upper 35 and lower 36 face rings, the latter bearing on a conical seat 37, part of the internal bore 29 of the cage 27. The apex of the seat is broken through to form an ignitor cylinder outlet port 39, preferably of relatively small dimensions.

The internal bore 29 communicates with the small end of the fuel channel 17 through a peripheral igniter port 40, which also communicates with an opposing air channel 41 in the channel plug 19.

The cage 27 is held in the plug 19 by a cage retaining nut 42, and the injector valve is seated by an injecter valve spring 44 positioned by an injector valve spring nut 45 screwed to the cage 27. For ease of assembly I prefer to split the cage 27 at the peripheral igniter port and parallel thereto, the parts being held together by friction caused by the pressure of the cage retaining nut 42.

The opposing air channel 41 continues into a fuel charging fitting 46, fastened at one end to the channel plug 19 and at the other to the preheating cylinder 20. The air channel 41 connects the peripheral igniter port 40 with the auxiliary combustion chamber 47 through a fuel port 49, but is normally closed by a fuel valve 50 opening toward the fuel port and seated against a fuel face 51 on the fuel charging fitting 46.

This valve is held against the seat by a fuel valve spring 52 contained in a spring extension 53 projecting from the fitting 46. The usual spring retainer 54 is attached to the valve stem, and a stem guide cap 54' provided.

The fuel face 51 on the seat of the fuel valve is provided with an annular fuel chamber 55 which at some point on its circumference connects with a liquid fuel inlet 56 which in turn is supplied by a metering fuel pump assembly shown in detail in Figure 3, through an inlet check valve 56'.

Here a pump frame cylinder 57 is fitted at one end with a pump block 59 held in place by a lock nut 60. A single inserted pump sleeve 61 passes through the block if for use with a single cylinder engine, or a plurality of sleeves may be used if several cylinders are supplied.

A tubular fuel piston 62 slides in the sleeve 61, and is extended by a fuel piston spring 64 bearing against the lower end of the tube and against a check valve fitting 65 screwed in the top of the block. This check valve fitting is supplied with the usual outlet ports 66, ball valve 67 and ball spring 68.

The lower end of the tubular piston is provided with a ball bearing 69 rolling on the face of a rotating plate 70 which is provided with a peripheral cam 71 positioned and adapted to raise the piston 62 when rotated.

The rotating plate 70 has an extended stem 72 which, by means of an internal spline 74 slides freely on a fuel pump drive shaft 75. The rotating plate and extended stem are set in a screw threaded bearing 76 which is raised or lowered by rotating a bearing drive sleeve 77 by means of a rack 79 and pinion 80. Thrust is taken up by an apertured thrust plate 81 fastened to the pump frame cylinder 57 and bearing on the top of the drive sleeve 77.

Referring to Figure 2, the connection of the various moving parts is shown diagrammatically.

A piston 82 is mounted in the usual manner in the cylinder 10, thus providing a main combustion chamber 84. A connecting rod 85 drives the usual crank shaft 86 and cam shafts 87—87 through the customary gears 89—89 and the valves are lifted through any convenient operating mechanism 90.

The inlet valve 91 is connected to a source of air 92, and the exhaust valve 94 provided with an exhaust pipe 95.

One of the cam shafts, in this case the exhaust cam shaft, carries an igniter piston cam 96 and a bevel gear assembly 97 for driving the fuel pump drive shaft 75. In this diagram, for the sake of simplicity, I have shown a bell crank and sleeve assembly 99 for lifting the rotating plate 70.

Fuel, of the relatively heavy oil type may be supplied to the fuel pump chamber 100 under slight pressure from any convenient storage device, and as is clearly seen in both Figures 2 and 3, a fuel pump inlet 102 is provided slightly below the top of the pump chamber, and is not provided with any check valve.

I prefer to operate my engine on the four stroke cycle system, and as one complete up and down stroke of the piston is a scavenging movement, I prefer to start my operational description at the beginning of the charging stroke, after all scavenging has been completed.

At some time after the firing stroke, the time being at any portion of the complete cycle when the fuel valve 50 is closed and therefore not critical, a metered charge of fuel is deposited in the annular fuel chamber 55.

The metering is accomplished by regulating the distance the tubular fuel piston 62 travels past the fuel pump inlet 102. This regulation is accomplished by raising or lowering the rotating plate 70, and the raising mechanism may be said to constitute the throttle of the engine.

As there is no check valve in the fuel pump inlet, and as I adjust the pressure in the fuel supply pipe to be less than the pressure offered by the ball valve 67, all oil or fuel in the fuel pump chamber on the upstroke of the fuel pump piston will pass back into the fuel supply line up to the time that the piston covers the fuel pump inlet 102, but after the piston crosses the inlet the additional travel of the piston forces oil through liquid fuel inlet 56 into the annular fuel chamber 55, the amount depending on the extent of travel of the piston edge past the fuel pump inlet. The charge of liquid fuel in the annular chamber may thus be accurately regulated and metered, the ball valve 67 keeping it there until used.

As the piston 82 drops and starts to rise, air is admitted under relatively low pressure to the main combustion chamber, and on the upstroke is compressed, the pressure being communicated through the fuel channel 17, the peripheral igniter port 40, and the opposing air channel 41 to the back of the fuel valve 50 which will not open while the top of the igniter piston 21 is above the port 49.

Just as the piston 82 approaches top center, creating a head pressure of from 100–105 pounds per square inch, the igniter piston cam 96 allows the igniter piston to descend, creating a negative pressure in the auxiliary combustion chamber 47. As the fuel valve 50 then has the full head pressure on one side thereof and a negative pressure on the other, it snaps open and air rushes through the opening, carrying with it into the auxiliary combustion chamber, the fuel resting in the annular fuel chamber.

The igniter piston at once rises due to the cam contour, rising faster than the main piston and compresses the fuel charge in the auxiliary combustion chamber, the pressure rising until the charge ignites at about 3,500 pounds per square inch pressure according to the type of oil used. As soon as the igniter piston passes the fuel port 49 the fuel valve, having equal pressure on both faces, reseats under the action of the fuel valve spring 52, and the annular fuel chamber 55 is ready to receive the next charge of fuel.

With the fuel ignited in the auxiliary combustion chamber at 3,500 pounds per square inch pressure, the injector valve is subject to two gas pressures; one, on the lower or smaller face of 3,500 pounds per square inch, and the other of 350 pounds per square inch on the upper or larger face. I prefer to make the face relations such that the combined pressures, plus the minute action of the injector valve spring 44 will hold the injector valve closed until the pressure of the ignited charge reaches approximately 5,000 pounds per square inch whereupon the valve will open and the ignited charge at high pressure will rush into the main combustion chamber having air therein at approximately 350 pounds per square inch pressure. The ignited fuel combines with the air in the main combustion chamber, finishes its combustion and drives the piston down. It is obvious that the ignition in the auxiliary chamber and the subsequent injector valve opening can be timed to place the ignited fuel into the main combustion chamber at exactly the proper time for maximum effect on the piston 32, usually arriving three or four degrees before the piston starts down on the power stroke.

At the proper time in the power stroke the exhaust valve opens and the main combustion chamber is scavenged on the next two strokes as is usual in this type of engine, and the power stroke is repeated.

No special means are used to scavenge the fuel channel 17, the space above the igniter valve 30 or the opposing air channel 41 as the gases remaining therein do not affect the ignition of the fuel charge.

It should be noted that the ignited charge is extremely rich, and not until it reaches the main combustion chamber does it receive sufficient air to explode with proper air mixture. In the auxiliary chamber the fuel is merely ignited, only in the main combustion chamber is full power exerted.

My invention has numerous advantages. Pre-ignition of the fuel reduces ignition lag in the power cylinder practically to zero, and a predetermined cycle can be followed. The maximum speed available in the engine is much greater than that obtainable in the Diesel type of engine, and the whole cycle of the igniter assembly can be timed to any advance or retard in respect to the cycle taking place in the power cylinder.

Another important feature is that since the fuel enters the power cylinder above ignition temperatures, any compression ratio may be used in the power cylinder.

Other factors aid the efficient operation of the engine, as for example, in the case of idling. As the stroke of the igniter piston is constant, the fuel mixture in the auxiliary combustion chamber will be leanest when the engine is throttled and idling. This however leads to better ignition, the firing of the charges is still more certain, and the engine idles perfectly with minimum fuel consumption.

It will be at once apparent that the proper operation of the igniter valve can be controlled, for any relative pressure ratios, by regulating the size of the areas exposed to the head pressure and the pressure of the ignited gases, and this I believe to be well within the knowledge of those skilled in engine design. The igniter valve spring is substantially only a return spring, the relative pressures being the major forces controlling the action of the valve.

Incidentally, this valve is not, as might be supposed, subject to excessive temperatures. The gases are ignited, but the temperature has not had time to rise to the point where excessive pitting, erosion or wire drawing might occur. I have found that ordinary valve steels are perfectly satisfactory for use in valve and seat, and that the life of this valve is at least no less than other valves in the same engine.

While I have described my invention as applied to a four stroke cycle engine, its advantages will be equally apparent when applied to internal combustion engines operating with any of the known cycle relationships.

I claim:

1. In combination with an internal combustion engine having a combustion chamber and a compression therein insufficient to cause automatic ignition of heavy oils, a receptacle for liquid fuel, means for depositing a metered amount of fuel therein, means for charging said engine with air, means for mixing said fuel with a portion of said charge when compressed by the piston of said engine, means separate from said combustion chamber for compressing said fuel and air mixture to cause ignition thereof by heat of compression, and automatic means for releasing the ignited fuel into said combustion chamber.

2. In combination with an internal combustion engine having a combustion chamber and a compression therein insufficient to cause automatic ignition of heavy oils, a receptacle for liquid fuel, means for depositing a metered amount of fuel therein, means for charging said engine with air, means for mixing said fuel with a portion of said charge when compressed by the piston of said engine, means separate from said combustion chamber for compressing said fuel and air mixture to cause ignition thereof by heat of compression, and automatic means for releasing the ignited fuel into said combustion chamber when the pressure of the burning fuel reaches a predetermined figure.

3. In an internal combustion engine having a main combustion chamber containing a piston operating at a compression therein insufficient to cause automatic ignition of heavy oils, means for charging said chamber with air, an auxiliary combustion chamber, means for utilizing a portion of said air charge when compressed by said piston to blow liquid fuel into said auxiliary chamber, means timed with said piston for compressing said fuel and air mixture in the auxiliary combustion chamber to cause ignition thereof by heat of compression, and a valve between said auxiliary chamber and said main combustion chamber, said valve having a face exposed to each of said combustion chambers, each face differing in area in accordance with the working pressures directed thereagainst to control the opening thereof when the pressure of the ignited fuel reaches a predetermined figure.

4. In combination with an engine having a main combustion chamber and an auxiliary combustion chamber containing an inlet port, a poppet valve closing said port, an annular fuel recess in the seat of said valve and covered by said valve when closed, means for depositing liquid fuel in said fuel recess, and means for supplying air under pressure to said port from said main combustion chamber, said air carrying fuel from said fuel chamber into said auxiliary combustion chamber when said valve is opened.

5. In combination with an engine having a main combustion chamber and an auxiliary combustion chamber containing an inlet port, a poppet valve closing said port, an annular fuel recess in the seat of said valve and covered by said valve when closed, means for depositing liquid fuel in said fuel recess, resilient means for maintaining said valve in closed position, and conduit means connected with said main combustion chamber for supplying air therefrom under pressure sufficient to open said valve and sweep said fuel in said fuel recess into said auxiliary combustion chamber.

6. In combination with an engine having a main combustion chamber and an auxiliary combustion chamber containing an inlet port, a poppet valve closing said port, an annular fuel recess in the seat of said valve and covered by said

valve when closed, means for depositing liquid fuel in said fuel recess, resilient means for maintaining said valve in closed position, conduit means connected with said main combustion chamber for supplying air therefrom under pressure sufficient to open said valve and sweep said fuel in said fuel recess into said auxiliary combustion chamber, and means supplying sufficient pressure for the ignition of said fuel in said auxiliary combustion chamber.

7. In combination with an engine having a main combustion chamber and an auxiliary combustion chamber containing an inlet port, a poppet valve closing said port, an annular fuel recess in the seat of said valve and covered by said valve when closed, means for depositing liquid fuel in said fuel recess, resilient means for maintaining said valve in closed position, means for supplying air from said main combustion chamber under pressure sufficient to open said valve and sweep said fuel in said fuel recess into said auxiliary combustion chamber, means for igniting said fuel in said auxiliary combustion chamber, and means for releasing said ignited charge into said main combustion chamber at a predetermined combustion pressure.

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