Sept. 1, 1936. L. M. WOOLSON 2,053,057

INTERNAL COMBUSTION ENGINE

Original Filed April 29, 1929 5 Sheets-Sheet 1

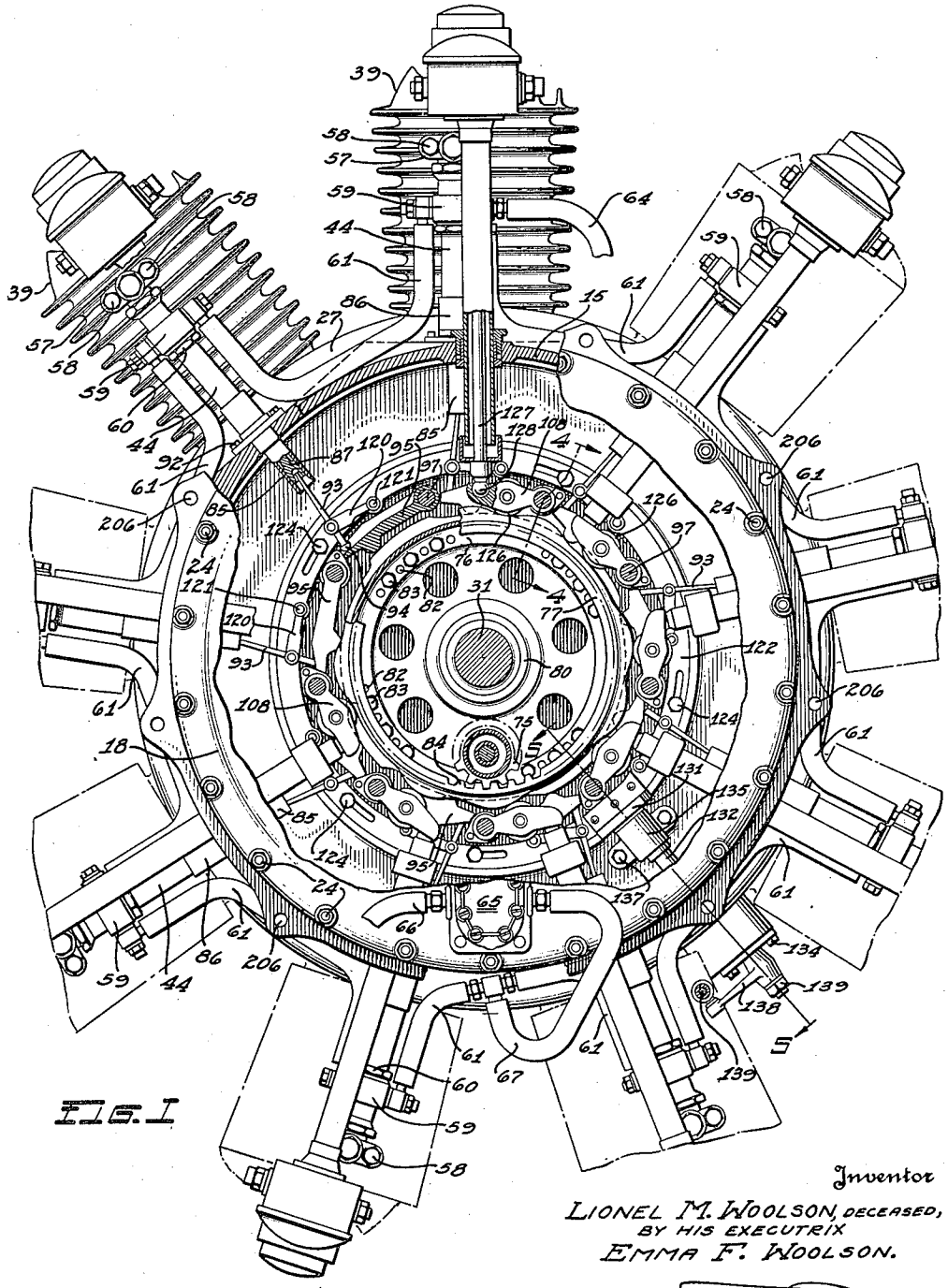


FIG. 1

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INTERNAL COMBUSTION ENGINE

Original Filed April 29, 1929 5 Sheets-Sheet 2

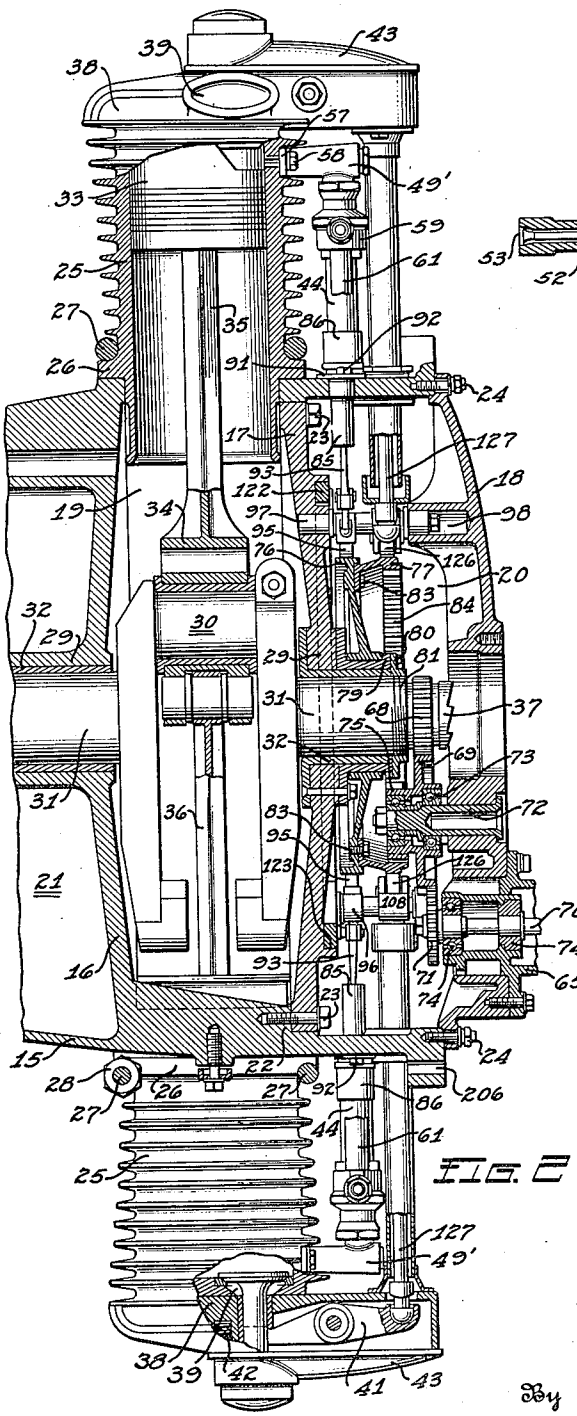


FIG. 2

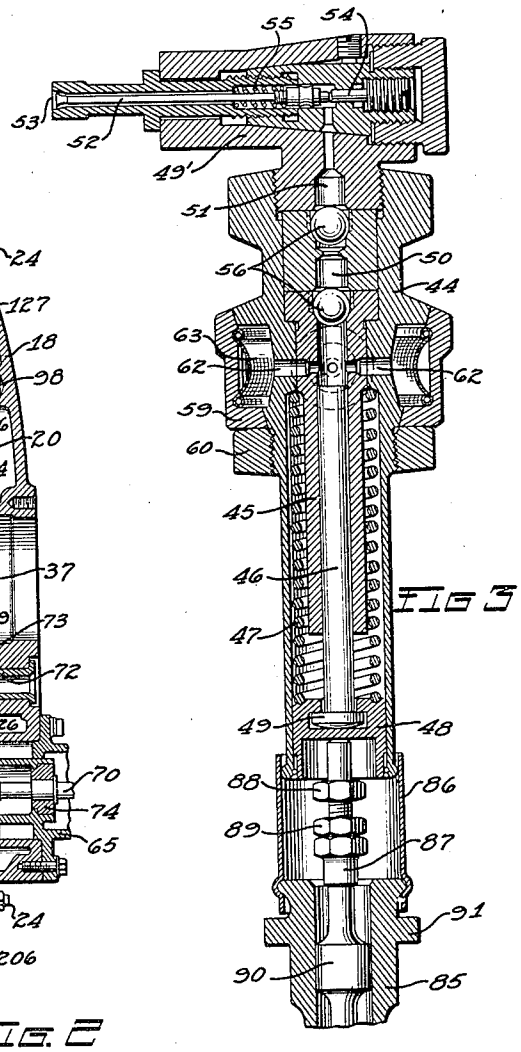


FIG 3

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INTERNAL COMBUSTION ENGINE

Original Filed April 29, 1929 5 Sheets-Sheet 3

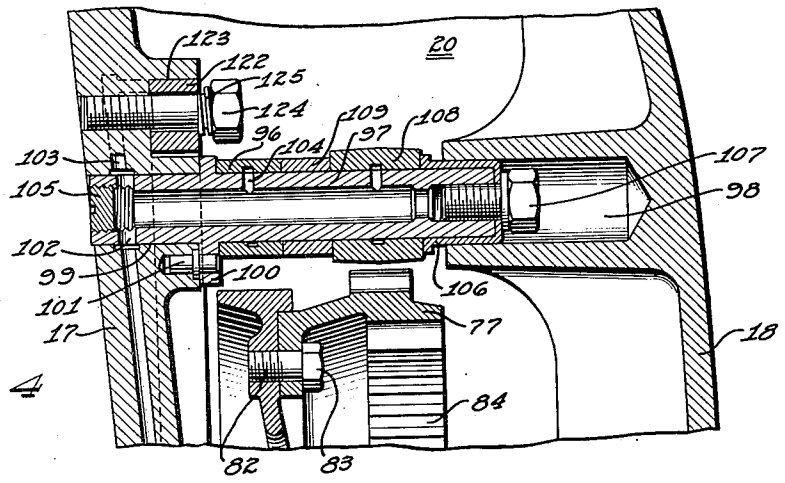


FIG. 4

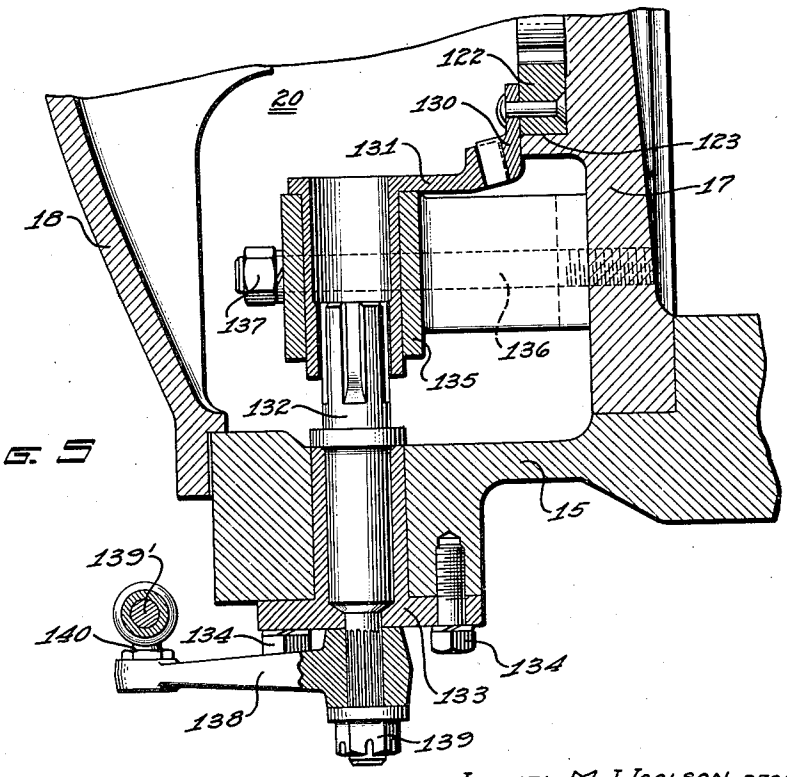


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INTERNAL COMBUSTION ENGINE

Original Filed April 29, 1929 5 Sheets-Sheet 4

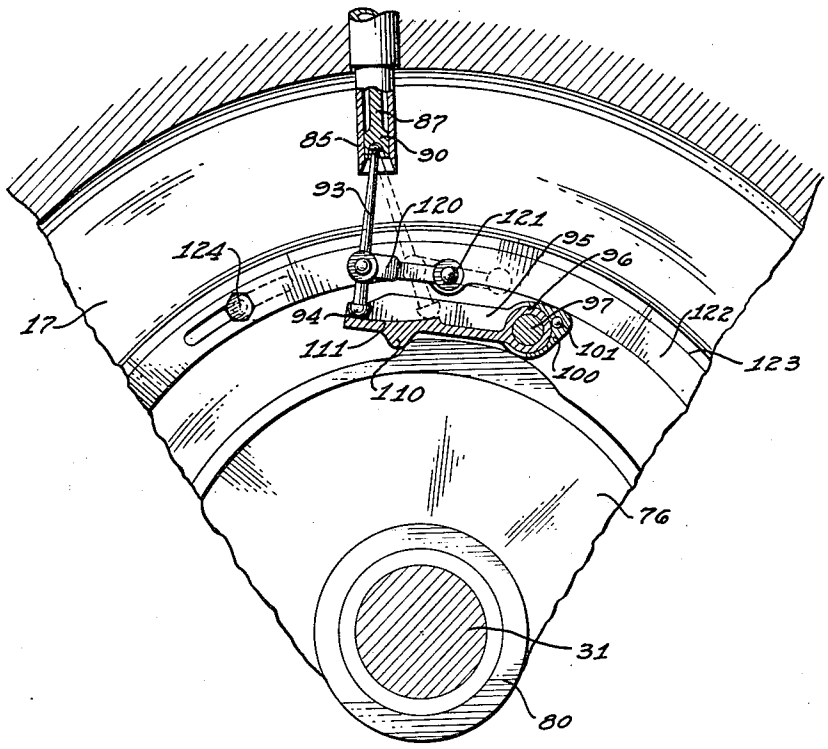


FIG. 6

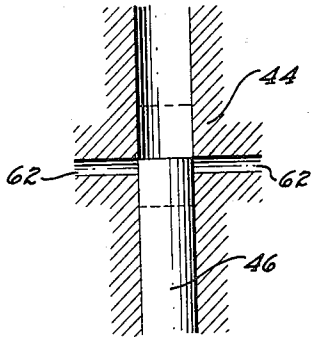


FIG. 7

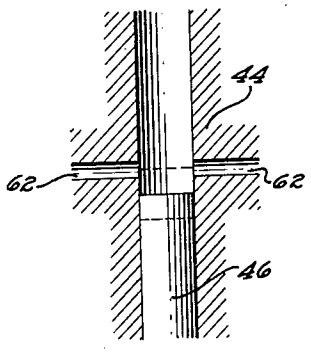


FIG. 8

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INTERNAL COMBUSTION ENGINE

Original Filed April 29, 1929 5 Sheets-Sheet 5

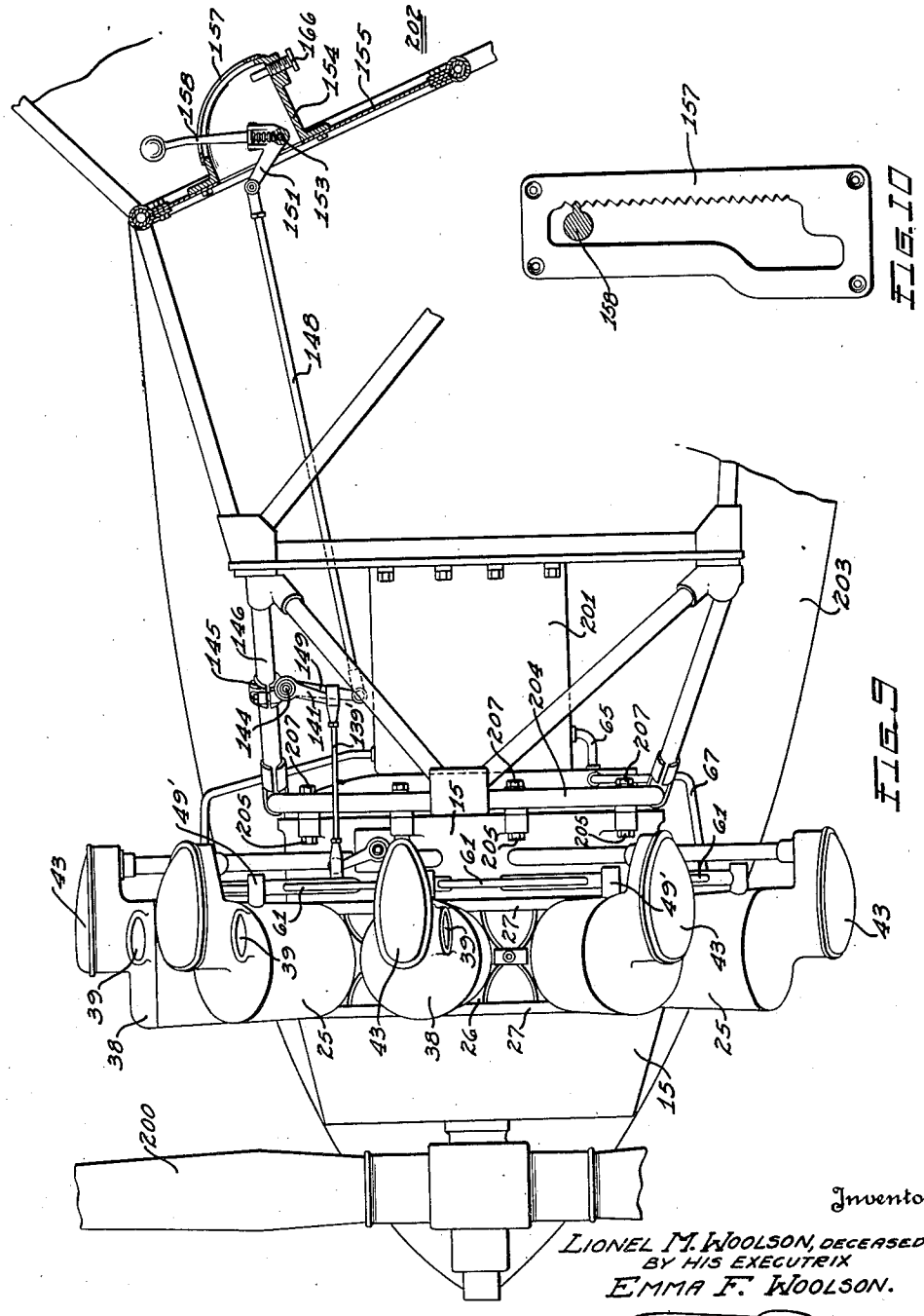


FIG. 10

FIG. 9

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Patented Sept. 1, 1936

2,053,057

UNITED STATES PATENT OFFICE

2,053,057

INTERNAL COMBUSTION ENGINE

Lionel M. Woolson, deceased, late of Detroit, Mich., by Emma F. Woolson, executrix, Bloomfield Village, Mich., assignor to Packard Motor Car Company, Detroit, Mich., a corporation of Michigan

Original application April 29, 1929, Serial No. 358,899. Patent No. 1,896,387, dated February 7, 1933. Divided and this application February 14, 1931, Serial No. 515,800

18 Claims. (Cl. 123—139)

This invention relates to internal combustion engines and more particularly to the type of engines in which combustion occurs through compression in the working cylinders, and is a division of Patent No. 1,896,387, dated February 7, 1933.

Engines of this character, commonly known as Diesel engines, have been in practical use chiefly with boats, for stationary work and other purposes where lightness, compactness and high speed are not essential requirements. Such engines therefore have had little use in the automobile industry, and, so far as is known, have never successfully propelled an aeroplane of the heavier than air type. With the engine illustrated in the drawings, many flights with a craft heavier than air have been made, and this application is directed more particularly to control mechanism employed therewith, it being understood however that the engine is equally adapted for purposes other than that of propelling aeroplanes.

An object of the invention is to provide an oil engine in which the quantity and the time of injection of fuel into a plurality of working cylinders can be simultaneously regulated through the manipulation of a common control mechanism.

Another object of the invention is to provide an engine in which the cylinder valves and fuel injection mechanisms are actuated in timed relation by an integral device which can be adjusted to vary the actuation of the mechanisms relatively.

Another object of the invention is to provide a radial internal combustion engine for aeroplanes in which a fuel feeding and injecting system is arranged in a plane directly behind the engine so that it offers no resistance to progress.

A further object of the invention is to provide an extended control device by means of which the operator of an aeroplane can readily manipulate mechanisms to regulate the quantity and timing of fuel delivered to the cylinders of an aeroplane engine of the self-igniting type.

Another object of the invention is to provide a single adjustable ring member for controlling the operation of a plurality of fuel injecting devices for the cylinders of a self-igniting radial engine.

A still further object of the invention is to provide a self-igniting engine of the radial type in which a compact and simple fuel and valve control mechanism is arranged.

Another object of the invention resides in providing an engine in which a low pressure fuel feeding pump is supported and driven in a novel manner.

Still another object of the invention is to provide a simple, compact and unexposed operating mechanism for the valves and fuel injecting devices in a radial engine in which explosion occurs through compression.

Another object of the invention is to provide a multi-cylinder engine of the self-igniting type in which the injection pumps, fuel feeding pump and cylinder valve operating mechanisms are all driven through a common transmission driven from the crank shaft.

Other objects of the invention will appear from the following description taken in connection with the drawings forming a part of this specification and in which:

Fig. 1 is a rear elevational view of a radial internal combustion engine, incorporating the invention, with a portion of the end wall broken away;

Fig. 2 is a vertical sectional view of the engine;

Fig. 3 is a vertical sectional view of the fuel injection device associated with each of the cylinders;

Fig. 4 is a fragmentary sectional view taken on line 4—4 of Fig. 1 illustrating the rocker arm mounting and the control ring and its securing means;

Fig. 5 is a fragmentary sectional view taken on line 5—5 of Fig. 1 illustrating a portion of the mechanism for adjusting the control ring for the fuel injecting devices;

Fig. 6 is a fragmentary vertical sectional view showing one of the mechanisms for actuating one of the fuel injecting devices;

Fig. 7 is a diagrammatic illustration of the stroke of the fuel injection pump when the operating mechanism is in the position shown in full lines in Fig. 6;

Fig. 8 is a diagrammatic illustration of the same when the operating mechanism is in the position shown in dotted lines in Fig. 6;

Fig. 9 is a side elevation, partly in section, of the forward end of an aeroplane having the invention associated therewith;

Fig. 10 is a plan view of the housing with which the hand lever control is associated, the control being shown in section.

Referring now to the drawings by characters of reference, the housing for the internal combustion engine includes a drum-shaped casing 15 having an integral transversely extending inte-

rior wall 16, a removable transversely extending interior wall 17 and a closure or end wall 18. The walls 16 and 17 extend entirely across the interior of the casing in parallel relation and define therebetween a compartment 19 in which the piston rods are contained. The partition 17 and the cover plate 18 define therebetween, within the drum casing, a closed compartment 20 in which mechanisms for operating the cylinder valves and fuel injection pumps are contained. The space 21 in the casing separated from the compartment 19 is utilized to contain the supply of oil used to lubricate the engine parts. The inner wall of the drum casing is formed with spaced bosses 22 to which the removable partition 17 is secured by the bolts 23, while the circular rear end wall of the drum casing defining the open rear end is provided with apertures to receive the bolts 24 for securing the closure plate 18 thereto. It will thus be seen that the drum casing and the associated walls provide three separate adjacent compartments which house the major operating mechanism of the engine in a compact and accessible manner so that the overall dimension of the engine will present a minimum resistance to progress when mounted upon the fuselage of an aeroplane or other rapidly driven devices.

The periphery of the drum casing is provided with spaced radially disposed openings through which the cylinders 25 project, the cylinders being formed with laterally extending flanges 26 which bear against flat peripheral surfaces formed on the drum casing adjacent the openings. A pair of circular rings 27 are arranged adjacent two opposite sides of the cylinders in a relation to encircle the cylinder flanges, the ends of the rings being drawn together by turnbuckles, as shown at 28, to secure the cylinders to the casing and to create a high compression annularly against the drum casing. The partition walls 16 and 17 are provided with central hubs 29 which provide a support for a single throw crank shaft 30, the ends 31 of which extend through the partition hubs and the bearings 32. Rod connections are provided between the crank shaft and the several pistons 33, such connections including a master hub 34 from which extends an integral rod 35 and a plurality of pivoted link rods 36, the rods being pivoted with the pistons in a manner conventional with radial engines. The rear end of the crank shaft 37 is formed to receive a hand crank for starting the engine, while the front end of the shaft is adapted for driving an aeroplane propeller 200.

The engine illustrated is of the nine cylinder radial type, and the combustion takes place through the compression created in the cylinders by the pistons. The cylinder heads 38 are each formed with a Venturi passage 39 extending therethrough such passages being disposed angularly with respect to the axis of the cylinder and tangentially to the cylinder wall. The mouth of the passageways are arranged so that the air stream will move transversely thereacross when the engine is moving or when the propeller is in operation. A valve 40 is arranged to close each cylinder head passage 39 during the compression and explosion cycles of the engine, while during the inlet and exhaust cycles the valve is open, the passages thereby each serving as both the inlet and the exhaust. The engine illustrated is of the four cycle type and the valves 40 are directly actuated by rock arms 41 which are operated from the engine shaft to open the valves, springs 42 being associated with the valve for the purpose of normally closing the valves. A housing 43 is secured to each cylinder head for enclosing the valves and associated rocker arms.

Atomized liquid fuel is injected directly into the working cylinders, combustion taking place entirely through compression, an atomizing and injecting device being provided for each cylinder and preferably directly secured thereto. The injection devices are similar and each includes a barrel 44 having an interior sleeve 45 for the reception of a snugly fitting plunger 46. A coil spring 47 is arranged between the sleeve and the barrel, bearing at one end against adjacent shouldered portions of the sleeve and barrel and at the other end against a carrier 48 which is slotted to receive the enlarged end 49 of the plunger. The carrier is free to reciprocate in the barrel, the spring 47 normally moving the carrier and the plunger toward the inner end of the barrel, and mechanism hereinafter described, moving the plunger toward the outer end of the barrel. A nozzle casing 49' is screwed into the upper end of the barrel and a head portion extends at right angles to the barrel through an opening in the cylinder wall adjacent the cylinder head. The pump barrel is provided with a passage 50 leading therethrough and communicating with a passage 51 extending through the nozzle and directly associated with the combustion chamber. An atomizing member 52 extends through the end of the nozzle passage and is provided with a circular head 53 which is prevented from entirely seating by the adjustable stop member 54. A coil spring 55 is arranged within the nozzle to resist the outward opening of the valve under pressure of fuel thereagainst. Ball check valves 56 in the barrel passage prevent any return flow of fuel from the nozzle to the pump barrel proper. The nozzle 49' is provided with flanged portions 57 which abut the cylinder wall and are secured in leak proof relation thereto by bolts 58.

A low pressure fuel feeding system is associated with the several fuel injection devices. A substantially circular manifold connects the pump barrels and consists of housings 59, wedged upon the pump barrels by nuts 60, and conduits 61 extending intermediate the housings 59. The housings are provided with fittings to which the ends of the conduits are clamped and the conduits and housings are in communication so that liquid fuel will be conducted from a source of supply, such as the tank 201, into the passage in the pump barrels through passages 62 in the barrel wall. A suitable screen 63 is arranged in the housing so that foreign matter in the fuel oil will not pass into the injection device.

The fuel is moved through the manifold from the source of supply under low pressure and the excess fuel moved through the manifold returns to the source of supply through the conduit 64. A conventional gear pump (not shown) located in the housing 65 is utilized to move the fuel through the manifold and into the injection device, the pump being driven from the crank shaft and connected with the source of supply by the conduit 66 and with the manifold by the conduit 67. The pump driving mechanism consists of a gear 68, which is secured to the crank shaft and meshes with the gear 69 which drives the shaft 70 through the gear 71 secured thereon. The gear 69 is rotatably mounted on the pintle

72 secured to and supported solely by the cover 18, suitable bearings 73 being interposed between the gear and pintle, while the shaft 70 extends through an aperture in the cover 18 and is supported by suitable bearings 74. The pump driving mechanism is arranged within the compartment 20, and the shaft 70 extends into the pump housing 65, which is bolted to the cover 18 and encloses a pair of gears (not shown) or impellers, one of which is keyed to the shaft. It will be seen that the driving mechanism for the pump and the pump structure itself are carried entirely by the cover 18 and are readily accessible, and can be easily assembled or removed.

The pump and the manifold are of large capacity so that an excess volume of liquid fuel will be circulated through the manifold during operation of the engine, the ratio of fuel circulated being preferably six times the maximum quantity required by the injection devices. Circulation of this volume of fuel will move air in the manifold therewith, so that the major portion of air will be returned to the supply tank, which is vented, and there will be a very small amount of air moved into the fuel injector. The manifold is arranged at the rear of the engine with the conduits 61 arranged to lie within a plane behind the cylinders and the casing so that no resistance to air is presented to retard speed of an aeroplane or other high speed device propelled by the engine.

The liquid fuel injection devices and the valves controlling the combined inlet and exhaust passages are operated by mechanisms driven from the crank shaft, the major portion of which is housed within the compartment 20. A gear 75 is formed integrally with the driving gear 69 and is rotated through meshing of the gear 69 with the gear 68 keyed to the crank shaft. A pair of relatively adjustable rotatable cam members 76 and 77 are arranged in the compartment, the cam 76 actuating the mechanisms operating the fuel injection devices and the cam 77 actuating the mechanisms for opening the cylinder valves. The cam 76 has an integral hub portion 78 which loosely encircles the bearing 32 surrounding the crank shaft, and is held in desired relation axially upon the bearing by the spacer 79 and the retaining nut 80 which is screwed upon a threaded portion 81 of the crank shaft. The cams extend in similar spaced parallel planes and are provided with a plurality of similarly arranged apertures 82, and when desired apertures in the cams are arranged to register, screws 83 are inserted to maintain such relation. Thus, by rotating the cams relatively, the desired relation can be obtained between the fuel injections and the valve operations, so that the fuel will be injected in desired timed relation in the engine cycle. The interior of the cam rim 77 is provided with teeth 84 with which the gear 75 meshes to rotate the cams. It will be seen that the gear 69 serves to drive the low pressure fuel feeding pump, and also the two cams which actuate the valves and fuel injection devices.

The cam 76, as before stated, is rotatably mounted upon the crank shaft from which it is driven and is formed to alternately actuate mechanism for operating the several fuel injection devices. A fuel injection device is associated with each cylinder and an operating mechanism is connected with the plunger of each device and therefore a description of a single device will suffice for all the devices, however being arranged radially and in the same vertical plane in order to be actuated by the single rotating cam. A guide 85 extends through an aperture in the peripheral wall of the casing in axial alignment with the pump barrel 44, and a cylindrical shield 86 telescopes an enlarged end of the tube 85 to which it is secured, and the inlet end of the pump housing projects into the other end of the shield. A reciprocating rod 87 extends through the tube 85 and the shield 86 and is arranged with an adjustable end portion 88 which is screwed in desired adjusted relation axially of the rod by the nut 89. The adjustable end of the rod engages the carrier 48 of the fuel injection plunger and moves the plunger to close the inlet ports 62 and force fuel under high pressure from the nozzle into the engine cylinder in the quantity and at the time desired as determined by the stroke of the plunger beyond the ports 62. The actuator rod is provided with an enlarged portion 90 which slides snugly in the housing 85 for the purpose of substantially preventing lubricating oil from passing through the housing to the exterior of the casing. The tube 85 is provided with a flange 91 which is secured against the casing by bolts 92. One end of a link 93 pivotally engages the end of the rod 87 extending into the casing, while the other end 94 engages with a lever 95 which is pivotally secured to the casing and is rocked upon its pivot by the cam 76. The lever 95 is formed with a journal end 96 which rocks on the shaft 97, such shaft extending across the chamber 20 and extending into a recess 98 formed in the cover 18 and into an aperture 99 formed in the partition 17. The shaft is provided with a flange 100 which is adapted to abut the partition 17 and a pin 101 extends into the flange and partition to prevent rotation of the shaft. The shaft is hollow and has a port 102 therein, which registers with the passage 103 formed within the wall of the partition, which is connected with a pressure lubricant feeding system leading thereto through the crank shaft from the chamber 21, and a lubricant port 104 is formed in that portion of the shaft about which the journal 96 is mounted. A removable plug 105 closes the inner end of the hollow shaft 97, while a retainer 106 telescopes the outer end of the shaft and fits into the recess 98. A cap screw 107 is screwed into the end of the shaft through the end of the retainer cap, and the adjustment of the cap screw positions the lever 95 endwise upon the shaft. The shaft 97 also serves as the support for a rock lever 108, which is journaled thereon, and a spacer 109 is arranged on the shaft intermediate the rock levers. An oil passage is provided in the shaft for lubrication of the rock lever 108. The shaft and rock levers are removable from the casing, when the cover 18 is detached, and without disturbing the associated mechanism.

The free end of the rock lever 95 is provided on its bottom face with a depending projection 110 which is engaged by the cam 76 to move the actuator 93 in a direction resulting in an injection stroke of the fuel plunger. The upper face 111 of the free end of the rock lever 95 is in the form of a trough and the rounded end 94 of the lever 93 rides in the trough and is retained thereagainst by the coil spring 47 acting through the carrier 48 and the rod 87. It will thus be seen that the spring 47 will maintain the rock lever against the periphery of the cam 76, and when riding in the dwells of the cam the plunger will uncover the ports 62 in the pump

barrel, permiting oil under pressure in the manifold to flow into the barrel of the pump so that the injection device is automatically filled with fuel after each injection action.

The pump plungers are the only control for the quantity of fuel, delivered to the cylinders, and the time at which the injection occurs and a single means is provided for regulating the stroke of all of the pumps simultaneously. An arm 120 is pivotally attached at one end to each of the links 93 and is also pivoted at its other end to pins 121 secured to the ring member 122. The partition 17 is formed with an angular recess 123 for the reception of the control ring. Studs 124 extend through spaced arcuate slots in the ring member and are screwed into the partition to limit the adjusting movement and to assist in maintaining the ring in the recess, coil spring retainers 125 being utilized between the heads of the studs and the ring to press the ring into the recess and to prevent binding. The ring can be moved circularly in the recess 123 in order to change the position of the links 120 which will in turn change the position of the rods 93 laterally, in a range as shown in Fig. 10. The face 111 of the rock lever 95 against which the rounded end 94 of the lever 93 seats is formed as an arc which is struck from a point slightly off center from the axis of the rod 87, while the shaft 97 to which the rock lever is pivoted is arranged at one side of the pump so that the arcuate face will lie with its free end a little in advance of a line continued from axis of the rod 87. The rock levers 95 are not adjustable and therefore they are rocked in the same manner at all times, the pins 121, however, are secured to the adjustable ring and the circular adjustment of the ring will move the pins 121, the attached arms 120 and actuator links 93 laterally so that the relation of the free end 94 of the links can be shifted to be associated in a plurality of similar desired relations along the arcuate faces of the rock levers. When the links are placed adjacent the free end of the link faces, as shown in full lines in Fig. 6, the plungers will be given their longest stroke by the actuation of the rock levers by the cam, and when the levers are adjusted to engage the other end of the faces, as shown by dotted lines in Fig. 6, the actuators will be given their shortest stroke through rocking of the levers 95 by the cam. The links 93, it will be understood, can be adjusted so that the free ends 94 will be associated at any point between the positions shown at the ends of the arcuate face 111, in Fig. 6.

The fuel injection takes place in desired timed relation with the position of the pistons in the engine cylinders as determined by the position of the link members 93, which relation also varies the quantity of fuel delivered, hence adjustment of the links 93 through turning of the ring 122 will adjust the stroke of the plungers in all of the injection devices equally and simultaneously thereby regulating both the time and the quantity of fuel injected into the engine cylinders. Figs. 7 and 8 show diagrammatically the plunger positions when the actuating mechanisms are in the positions shown respectively by full and dotted lines in Fig. 6, and the dotted lines in Figs. 7 and 8, above and below the top of the fuel injection plunger, represent the bottom and top of the piston stroke when the mechanism is set as indicated in Fig. 6. It will be understood that there is no fuel injection, or plunger pressure exerted until the plunger covers the ports 62, and therefore the length of the plunger travel after closing the ports determines the fuel quantity injected and the timing is controlled by the time the plungers close the ports. With the mechanism illustrated, the timing and stroke are both controlled by adjustment of the ring 122 and the links 93, so that as the stroke and fuel quantity are increased the time of port closure is earlier than when the stroke is shorter and the fuel quantity delivered is less. When the piston stroke is adjusted as shown in dotted lines in Fig. 6, the fuel supply is cut off and the engine will stop, as the plunger does not close the ports 62, but when the stroke is adjusted so that the plunger will pass the ports 62, then the time of covering will be sooner as the plunger stroke is lengthened.

The mechanism which transmits motion from the cam 77 to the valve operating rock lever 41 will now be described. As heretofore described, the shafts 97 each support a fuel injection mechanism operating lever 95 and a valve mechanism operating lever 108 for each cylinder. The rock levers 108 each carry a roller 126 which is engaged by the cam 77 to actuate the rods 127, one end of the rods pivotally engaging the end of the arms 41 and the other end of the rods pivotally engaging the seat 128 formed in the rock levers 108. The springs 42 normally close the valves 40, so that, except during engagement of the lobe of the cam with the actuating rock lever the valves will be closed. Such mechanism is arranged so that the valve will be open during the intake and exhaust cycles of the engine cylinders and will be closed during the compression and working cycles. There is a valve operating mechanism for each cylinder and the links 127 extend radially so that they will be actuated by the centrally located rotated cam.

It will be observed that the relation between the valve and fuel injection actuation is determined by the cam relation which can be adjusted, but is fixed when operating. The amount of air therefore which enters the cylinders to be compressed is the same regardless of the fuel quantity adjustment and is uniformly sufficient to obtain complete combustion with the maximum fuel charge. With such arrangement of the valve and fuel control, the speed of an areoplane, driven by this type of engine, will automatically increase within certain elevation ranges when climbing without adjustment of the fuel control and when set at less than wide open position. As the engine ascends the air becomes more rare and the resistance to the propeller rotation and aeroplane progress decreases, and while the engine power will drop during ascension, the decrease is less in proportion than the resistance decrease resulting in acceleration of the speed of the aeroplane.

The timing of the cams is definitely set and therefore the valve cams and fuel cams rotate definitely relative to each other and to the crank shaft. The opening and closing of the valves is therefore constant after being adjusted while the fuel cam engages the pump actuating mechanism uniformly, the timing of the effective movement of the plungers to inject and control the fuel time and quantity can be regulated through moving the elements 93 laterally by turning the ring 122, but under all circumstances the cylinder will receive the same quantity of air.

In order to regulate the position of the ring 122,

there is provided a mechanism which extends to the cockpit 202, of an aeroplane 203, if the engine is used for this purpose, or to some point remote from the engine at which an operator is located. A gear segment 130 is secured to the ring 122 by riveting or otherwise, and a tooth segment 131 meshes therewith to rotate the ring. The tooth segment includes a hub portion, which is keyed to a shaft 132 carried by a bearing 133 extending through the wall of the housing 15 and secured in position by bolts 134. A bearing 135 is arranged within the compartment 20 for supporting the segment hub and is secured to the casing by studs 136 and nuts 137. Arm 138 is secured by the nut 139 to the end of the shaft 132 which protrudes from the casing wall and through the rotation of this arm the segment can be rocked to rotate the ring controlling the stroke of all the fuel pump plungers.

Extension operating mechanism is associated with the arm 138 and extends from the engine to the cockpit within easy reach for control by the operator. A link 139' is pivotally attached at its forward end to a pin 140 secured to the end of the arm 138, and this link is formed in telescoping sections screwed together to permit longitudinal adjustment. The rear end of the link is suspended from an arm 141 and is connected with a shaft 144 carried by clamps 145 which are secured to the engine mounting struts 146. Another link 148 is pivotally secured at its forward end to the depending end of the arm 149 by the pin 150, the upper end of the arm being secured to the shaft 146.

The rear end of the link 148 is pivotally secured to the rock arm 151 which is pivotally mounted to be rocked forward and rearward upon a shaft 153 carried by a housing 154 secured to the dash 155 in the cockpit. The housing is secured to the dash and is provided with a curved upper wall having a slot 157 therein through which the control hand lever 158 extends.

The rocking of the lever forward or rearward imparts a similar movement to the rock arm, the link and the arm 149, which rocks the shaft 146 to impart the lever movement to the arm 141, the link 139' and the arm 138, which in turn rotates the shaft 132 and the gear segment to turn the fuel control ring 122. When the hand lever is in the forward position the ring 122 adjusts the fuel pump actuating mechanism to inject the maximum quantity of fuel into the cylinders, while when moved rearward to the lower portion of the notched side of the plate the mechanism adjusts the ring 122 so that the pump mechanism will operate just sufficiently to inject the smallest quantity of fuel and still obtain a combustion of the fuel charge. The range, therefore, is indicated upon the plate as wide open, and idle, for the lever positions.

A ring supporting member 204 is arranged at the forward end of the strut structure in the fuselage, and bolts 205 extend through the supporting member and openings 206 in the flanged open end of the engine casing, nuts 207 being screwed upon the bolts to secure the motor to the frame. The aeroplane illustrated, with the exception of the engine and its controls, is of conventional form and a further description is therefore not thought to be necessary.

The engine herein described has been run at more than one thousand R. P. M. and weighs less than four pounds per developed horse power, and has propelled an aeroplane within the air for many flying hours. It is not believed that a self-igniting engine has ever before been built which has succcessfuly propelled a heavier than air plane. The engine control described herein is entirely effected through movement of the lever 158 which is an improvement over plural control mechanism heretofore employed with aeroplane engines.

Various changes can be made in the details of construction described without departing from the spirit of the invention and the scope of what is claimed.

What is claimed is:

1. In a radial engine, valve operating mechanism for each cylinder, a fuel injection pump mechanism for each cylinder, a cam structure including a pair of rotatable cams secured together and loosely encircling the crank shaft for operating said valve and pump mechanisms, and driving means intermediate the crank shaft and said cam structure.

2. In a radial engine, valve operating mechanism for each cylinder, a fuel injection pump mechanism for each cylinder, cam means loosely encircling said shaft for operating said valve and pump mechanisms, and cam means rotating mechanism driven by said shaft.

3. In a radial engine, a fuel injection device for each cylinder including plunger actuating mechanism, a rotating cam for actuating said mechanisms, and a rotatably mounted ring member connected with said mechanisms for simultaneously adjusting the same to control the effective fuel injection movement of the plungers.

4. In a radial engine having a fuel injection device associated with each cylinder, a casing, a transversely extending wall in said casing having a circular groove in one wall, an actuating mechanism for each fuel injection device extending into the casing adjacent the groove, a ring member in said groove connected similarly with each of said actuating mechanisms, spring means frictionally retaining the ring member against movement in the groove, and manually operable means extending to the exterior of the casing for rotating the ring member, the rotation of the ring member changing the movement of the actuating mechanism to regulate both the time and quantity of fuel delivered by the injection devices.

5. In a radial engine, an engine operated fuel injection device for each cylinder including plunger operating mechanism, a ring member in the engine casing attached to said mechanisms for simultaneously changing the operative effect thereof, a gear carried by the ring member, gear means supported in the engine casing for actuating the ring member gear, and manually operable means for the gear means extending exteriorly of the engine casing.

6. In a radial engine, a casing, an engine operated fuel injection device for each cylinder including plunger operating mechanism, a ring member in the engine casing, said ring member having arcuate slots therein, bolts extending through the slots in the ring member and attached to an interior casing wall, coil springs surrounding the bolts and compressed between the bolt heads and the ring member, said springs normally holding the ring stationary against the casing wall, means for rotating said ring, and connections between said ring and the plunger operating mechanisms for regulating the effective movement thereof in operating the plungers.

7. In a radial engine, a transverse interior casing wall, an end casing wall parallel with the

interior wall, said walls having aligned recesses on adjacent sides, a shaft extending across the chamber between said walls and having its ends extending into the aligned recesses therein, and a pair of rocker members carried by said shaft, one of said members actuating a cylinder valve operating mechanism.

8. In a radial engine, a casing having a pair of spaced walls, rock shafts carried by said walls, said shafts being each arranged rearwardly of and in a zone with an engine cylinder, a cam actuated rocker arm carried by said shaft, and mechanism operated by said rocker arm for operating the associated cylinder valve.

9. In a radial engine a casing having a pair of spaced walls, rock shafts extending between said walls and supported thereby one adjacent each engine cylinder, means securing said shafts against rotation, rock arms carried by said shafts for operating a plurality of engine mechanisms, and means for actuating said rock arms periodically.

10. In a radial engine, a casing having a pair of walls, rock shafts carried by said walls and travering the space therebetween, one of said shafts being located adjacent each engine cylinder, a pair of rock arms carried by each shaft, means retaining said arms in spaced relation and axially on said shaft, mechanisms associated with the cylinder operated by the rock arms, and means intermediate said walls for periodically actuating the rock arms.

11. In a radial engine, a casing having a pair of walls, one of said walls being removable, rock shafts held between said walls, and removable from the casing when the removable wall is detached, rock levers removably carried by said shafts for operating a plurality of mechanisms, and means in said casing for actuating said rock arms periodically.

12. In a radial internal combustion engine in which air and fuel are introduced separately into the cylinders and mixed therein to produce a fuel charge, means for introducing substantially constant quantities of air into the cylinders under all conditions, a plurality of injector means associated one with each cylinder to introduce fuel therein, and a ring control means for adjusting said injector means to thereby vary the quantity in the fuel charges introduced into all of the engine cylinders.

13. In an aeronautical motor of the radial type in which air and fuel are introduced separately into the cylinders and mixed therein to produce an explosion mixture, means for admitting substantially uniform supplies of air to the engine cylinders, liquid fuel injection devices associated one with each of the cylinders for introducing charges of liquid fuel thereto, and a member operable to simultaneously adjust said injection devices to control the quantity of fuel introduced and the time at which the fuel is injected into the cylinders.

14. In a radial engine, an injection device for each cylinder including a plunger for trapping and discharging fuel, mechanism for actuating each plunger in a predetermined order, a rotatably adjustable ring member connected to said mechanism for controlling the strokes of the plungers and thereby regulating the timing and the quantity of fuel injected by said device, and mechanism operable from the exterior of the engine for rotatably adjusting said ring member.

15. In a radial engine, a fuel injection device including plunger mechanism associated with each cylinder, a rotating cam for actuating said mechanisms, a rotable ring member extending adjacent said actuating mechanisms, and a connection between the actuating mechanisms and said ring member, a rotative adjustment of said ring moving said connections to determine the effective injection stroke of said plunger actuating mechanisms.

16. In a radial engine, a casing through which the crank shaft extends, cam means in the casing rotated by the shaft, a fuel injection mechanism for each cylinder including a plunger operated by said cam means, an adjustable member in each injection mechanism for varying the effective stroke of the plunger, a ring rotatably mounted in the housing adjacent the adjustable members and attached thereto, and a manually operable mechanism extending into the housing and connected to adjust the ring.

17. In a radial engine, an engine operated fuel injection device for each cylinder, including plunger operating mechanism, a rotatable ring member connected to adjust each operating mechanism and thereby regulate the time and quantity of fuel injected by said devices, and manually operated gear means for rotating said ring member.

18. In a radial engine, a valve operating mechanism for each cylinder, a fuel injection pump mechanism for each cylinder, an engine rotated cam for actuating said valve operating mechanisms, and a cam fixed to said engine rotated cam in a relation to operate said fuel injection pump mechanisms, said pump operating cam being adapted to be secured in variably adjusted positions angularly relative to the engine rotated cam.

EMMA F. WOOLSON,
Executrix of the Estate of Lionel M. Woolson, Deceased.