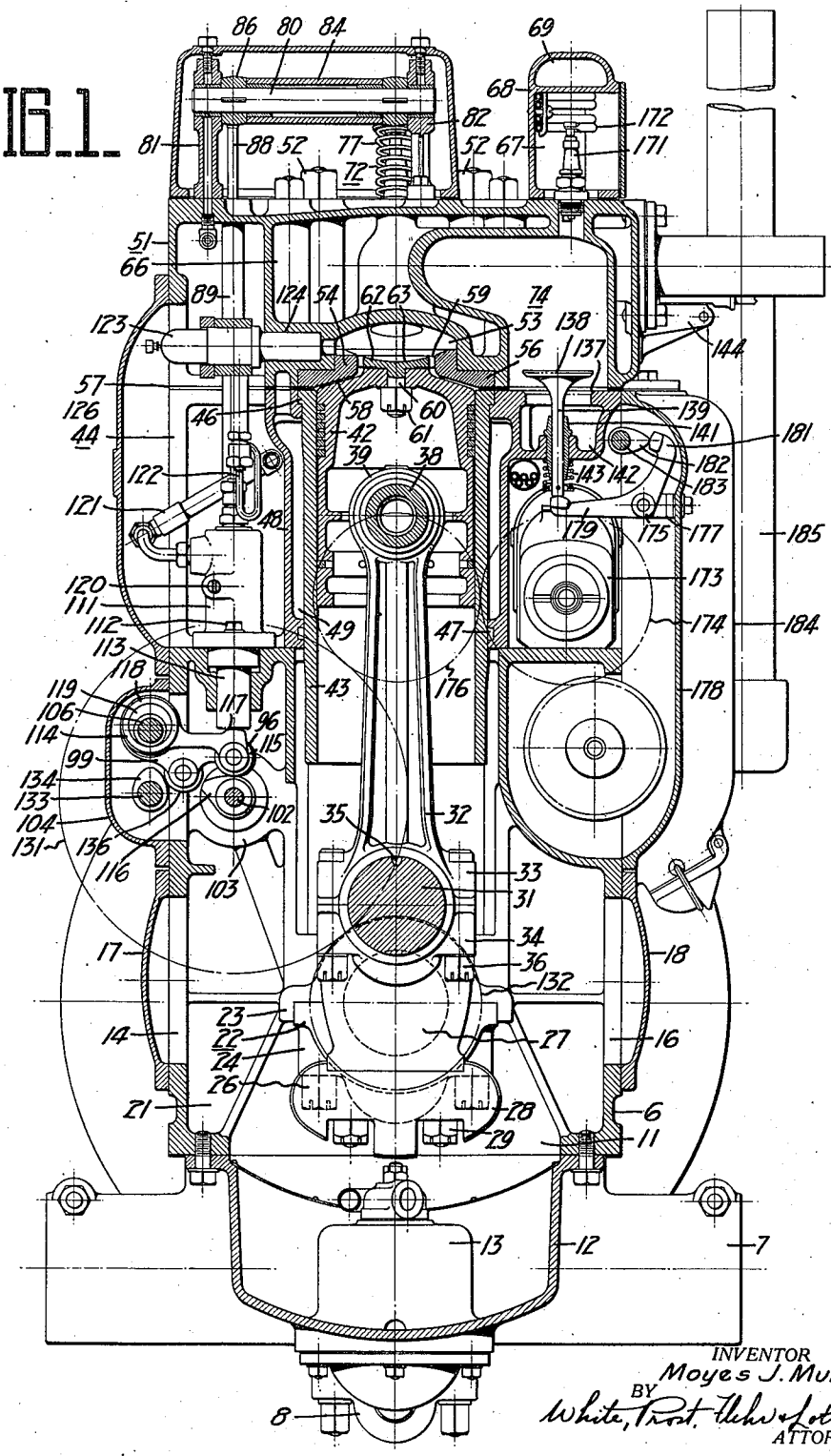
March 10, 1936. M. J. MURPHY 2,033,350

ENGINE

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FIG. 1.



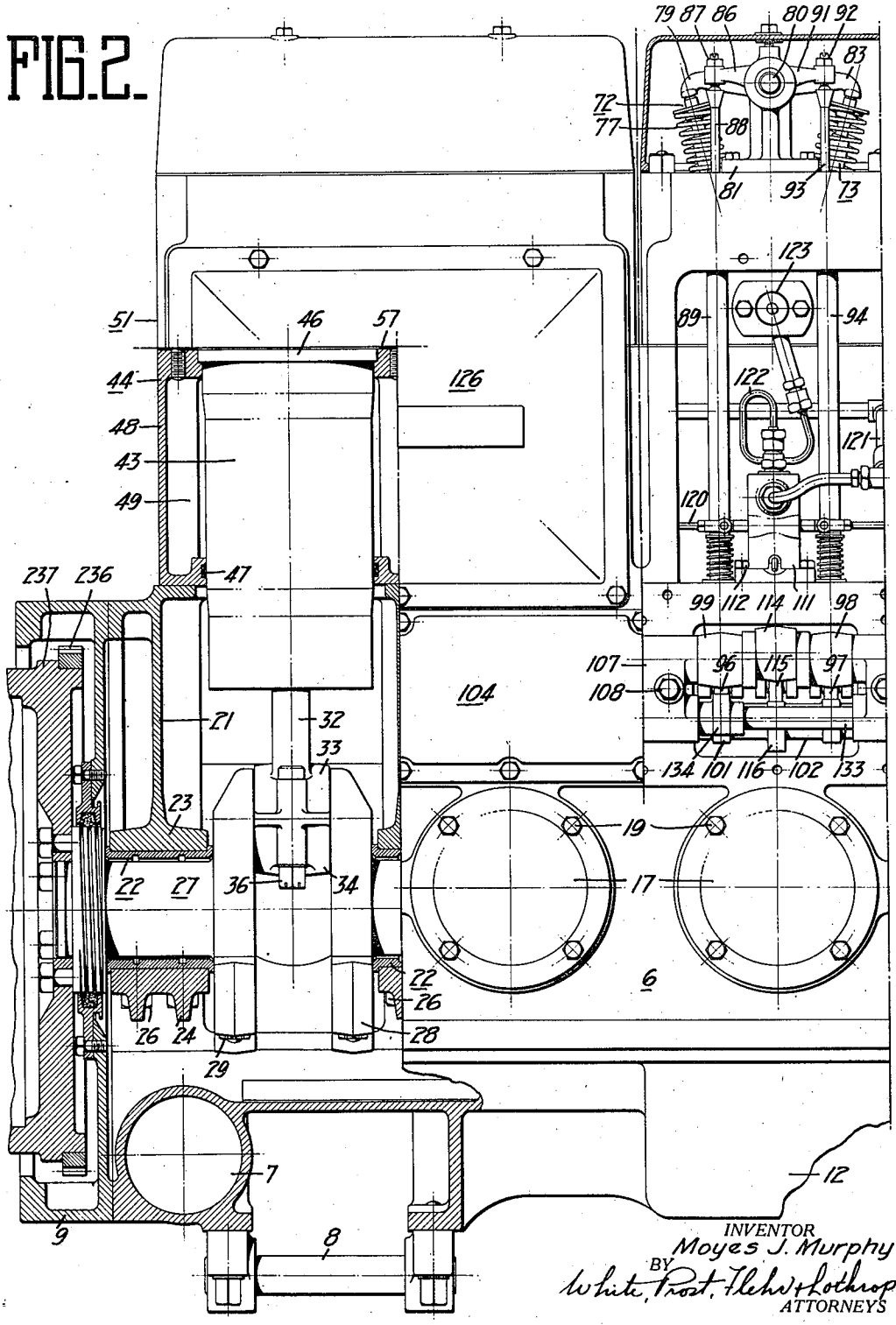
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ATTORNEYS

March 10, 1936. M. J. MURPHY 2,033,350

ENGINE

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FIG. 2.



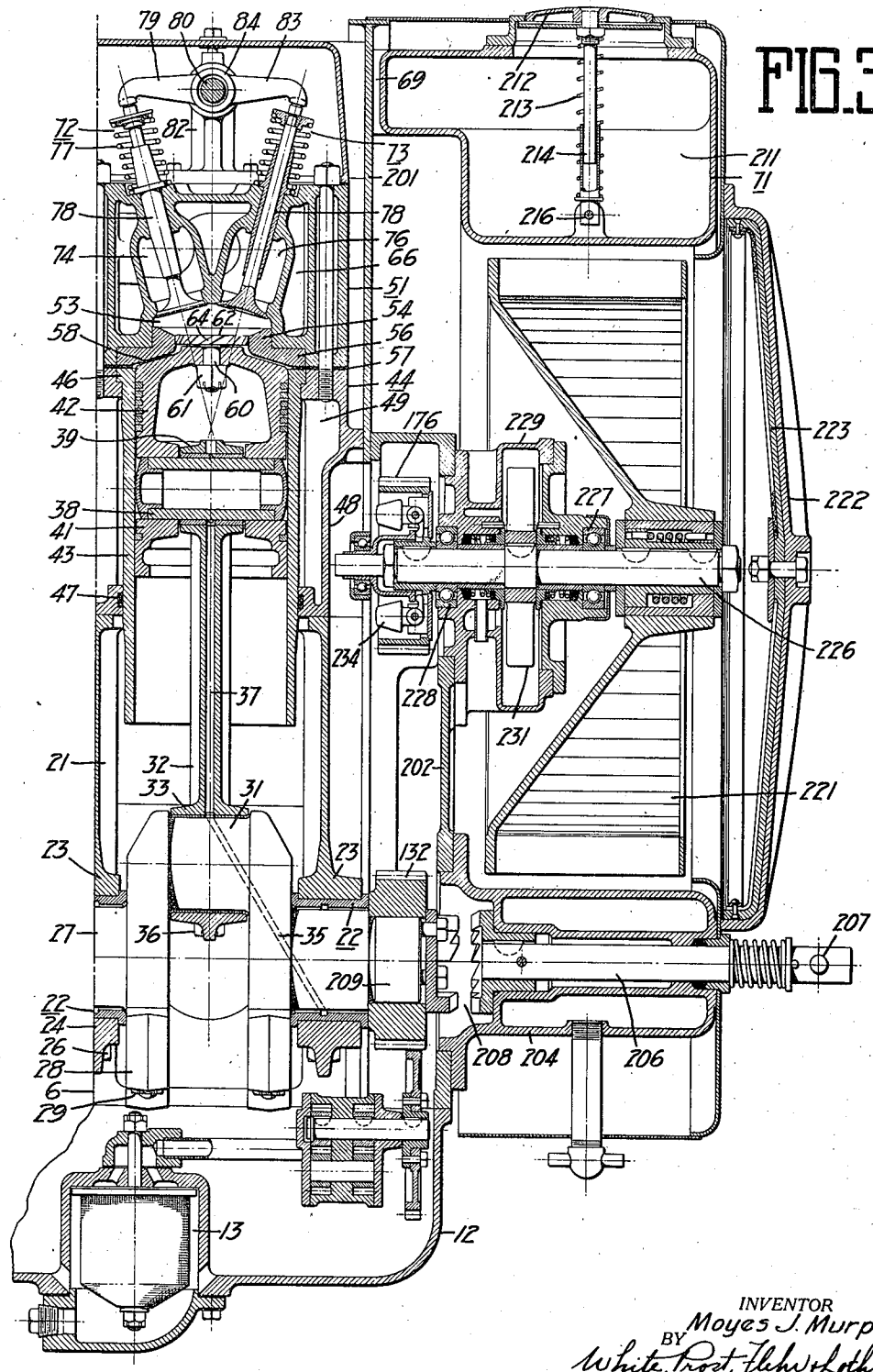
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FIG. 3.



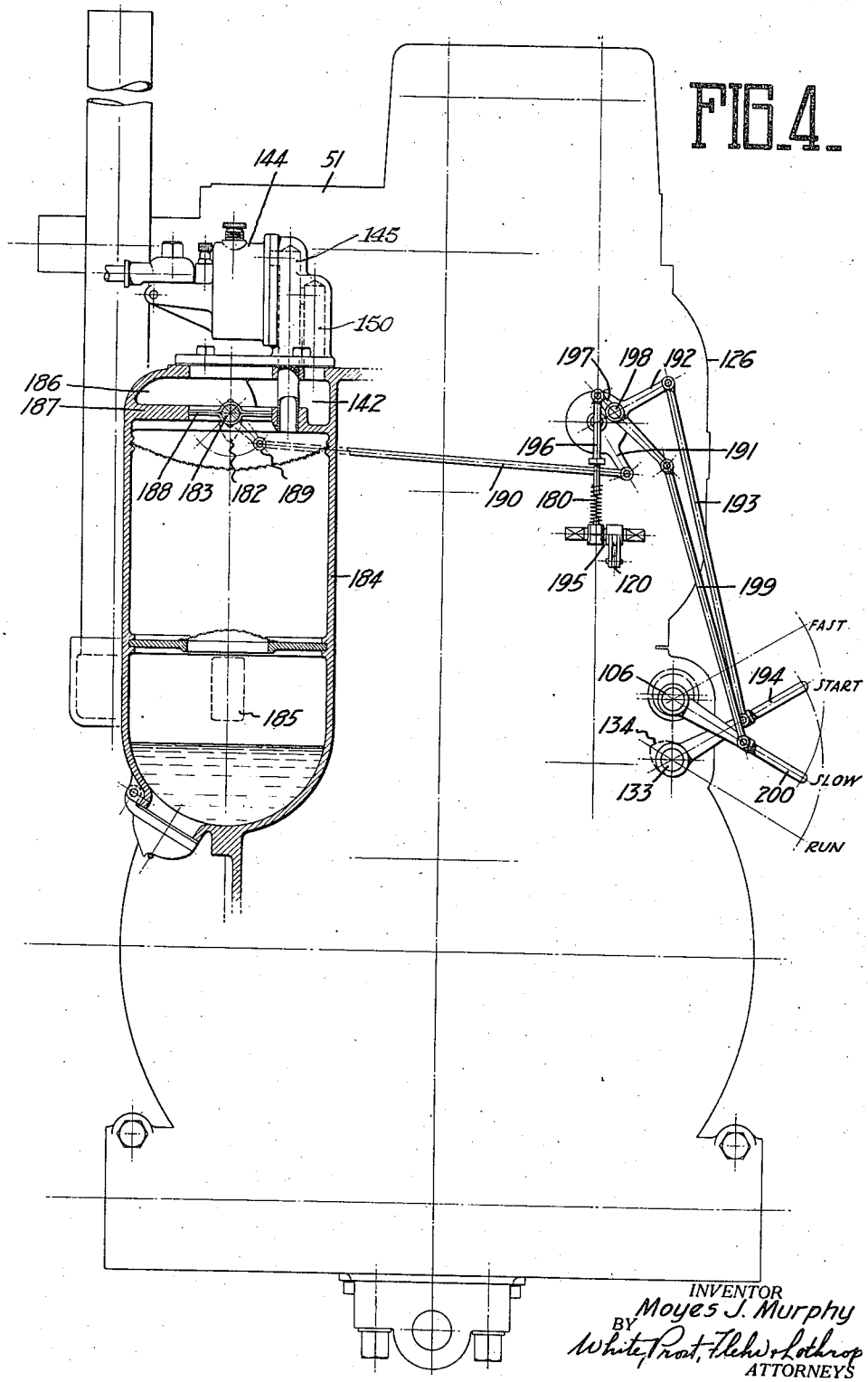
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March 10, 1936. M. J. MURPHY 2,033,350

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Filed Oct. 20, 1931 4 Sheets-Sheet 4

FIG. 4.



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Patented Mar. 10, 1936 2,033,350

UNITED STATES PATENT OFFICE

2,033,350

ENGINE

Moyes J. Murphy, San Leandro, Calif., assignor to Murphy Diesel Company, Ltd., Reno, Nev., a corporation of Nevada

Application October 20, 1931, Serial No. 569,907

6 Claims. (Cl. 123—21)

My invention relates to engines of the internal combustion type and particularly to engines designed to operate on relatively heavy fuels such as heavy hydrocarbon oils. Such engines are usually termed Diesel engines inasmuch as they operate in accordance with the cycle first proposed by Dr. Rudolph Diesel and my engine particularly relates to that type of engine which operates on the solid injection principle. The solid injection principle is distinguished from the air injection principle in that the fuel is injected directly into the cylinder by means of pressure upon the liquid fuel itself and without admixture of air and without depending upon compressed air for injection.

Such engines have been built in great quantities during past years but all of them have been faced with the difficult problem of starting. An engine operating in accordance with the Diesel cycle has a relatively high compression pressure and an engine of any size, particularly one designed for automotive work, has substantially been incapable of being rotated for starting purposes by an operator or by any of the usual electric or other common starting mechanisms. An air injection engine has available usually a relatively large supply of compressed air under a relatively high pressure so that a supplemental air engine serves admirably as an auxiliary starting device while with a solid injection engine such as the one described herein, there is not available any satisfactory auxiliary mechanism for starting nor is there any large supply of air under pressure which is available to operate such auxiliary devices.

It is considered advantageous to start such solid injection engines either by hand cranking or by means of a relatively small electric motor such as now commonly used for starting purposes in the automotive field.

It is therefore an object of my invention to provide an engine operating on the Diesel cycle and with solid fuel injection but which can easily be started by an operator or by the customary electrical or a similar starting device.

Another object of my invention is to provide means for facilitating the starting of a solid injection Diesel engine under cold conditions when the temperature of the engine is so low as to hamper the production of auto-ignition of the fuel despite the relatively high compression ordinarily utilized.

Another object of my invention is to provide a Diesel engine which is capable of operating quite slowly without fear of carbonization or fouling.

A further object of my invention is to provide a Diesel engine which is substantially no heavier than a comparable gasoline engine of similar horsepower and characteristics.

A further object of my invention is to provide a control mechanism for a Diesel engine which will permit not only of proper operation of the engine with heavy fuel on the Diesel cycle but also upon the Otto cycle using a light fuel such as gasoline.

A further object of my invention is to provide an engine capable of operating either on a light hydrocarbon such as gasoline upon the Otto cycle or on a relatively heavy fuel such as Diesel oil upon the Diesel cycle.

The foregoing and other objects are attained in the embodiment of the invention shown in the drawings, in which

Figure 1 is a cross-section on a vertical transverse plan through the first cylinder of an engine constructed in accordance with my invention.

Figure 2 and Figure 3 together show the engine of my invention in side elevation, certain portions being shown in cross-section on vertical planes.

Figure 4 is a rear elevation of an engine constructed in accordance with my invention, certain portions of the mechanism being disclosed diagrammatically and in cross-section.

In its preferred form the engine of my invention comprises an internal combustion mechanism designed to operate generally on the solid injection Diesel cycle and combined with means for permitting the operation of the engine, particularly for starting and slow running, on the customary Otto cycle using gasoline or comparable light hydrocarbon as a fuel, together with mechanism which precludes unwarranted or harmful operation of the engine upon a combined cycle.

Although the engine of my invention is susceptible to various different uses and is susceptible to modification for use in different environments, I have disclosed herein a typical form of engine primarily designed for use in a tractor as an illustrative arrangement. This engine comprises a crank case 6 which at its rearward end is indirectly carried by a support 7 for a cross shaft and a spring mounting 8 for attachment of the engine in a tractor in accordance with the customary scheme. The rearward end of the crank case is fitted to an intermediate casting 9 which forms a continuation of the crank case and it-

self is designed to be bolted or otherwise secured to the clutch housing and transmission case, not shown, of the tractor in accordance with customary fashion. The crank case is substantially a box rectangular in cross-section and is preferably machined on all four side faces to receive associated parts and closures for apertures formed in the crank case.

These apertures include a sump aperture 11 on the lower face of the crank case which is closed by a sump pan 12 usually of cast metal and extending to the rear of the crank case to carry the supports 7 and 8. The sump pan 12 provides an oil tight closure for the lower portion of the crank case and likewise forms a mounting for an oil strainer 13 in the customary fashion. The sides of the crank case 6 are provided with apertures 14 and 16, serving as hand holes, which are closed by cover plates 17 and 18, respectively, held in place by any suitable means such as bolts 19. Spanning the crank case 6 transversely at suitable intervals are webs 21 acting as mountings for the main bearings 22 of the engine. The main bearings are preferably formed with their upper caps 23 integral with the crank case webs 21 while the lower caps 24 are held in place by through bolts 26.

Rotatably mounted in the aligned main bearings 22 is a crank shaft 27 of the customary four throw five bearing type. The crank shaft is provided opposite each cheek with a detachable counter weight 28 held in place by suitable bolts and nuts 29 while between adjacent cheeks of the crank shaft connecting rod pins or crank pins 31 are provided. Since all of the cylinders of the engine are substantially identical with the possible exception of minor details the description of but one of them will suffice. Each of the crank pins 31 serves as the mounting for a connecting or pitman rod 32, at its lower end provided with an integral upper bearing cap 33 and a separable lower bearing cap 34 held to the upper cap by means of through bolts and nuts 36. Preferably the crank shaft 27 is drilled suitably to provide an oil passage 35 which communicates periodically during the rotation of the crank shaft with a drilled passage 37 extending thru a web of the connecting rod 32 from the crank pin 31 to a wrist pin 38 piercing a continuous band 39 forming an eye in the extremity of the connecting rod 32 and likewise mounted to rotate in the bosses 41 of a piston 42.

Upon rotation of the crank shaft 27 and through the medium of the connecting rod 32 the piston 42 is reciprocated within a removable liner 43 providing the cylinder bore of the engine. The liner is suitably pressed into and held by the cylinder block casting 44 mounted on the crank case 6 and located thereon by virtue of the fact that the through bolts 26 pass through suitable passages in the cylinder block 44. The sleeve or liner 43 at its upper end is externally flanged as at 46 to fit in a corresponding groove cut in the cylinder block 44 and between its ends abuts a rubber gasket 47 or any other suitable packing means for preventing leakage past the lower seat of the sleeve on the cylinder block 44. The cylinder block is preferably formed with a wall 48 which encompasses all of the cylinder liners 43 and is spaced therefrom to provide a water jacket 49 for cooling purposes.

Mounted on the cylinder block 44 is a cylinder head 51 which is a separate member through which the through bolts 26 pass and above which they terminate to receive fastening devices such as nuts 52 for clamping the cylinder block 44 between the cylinder head 51 and the crank case 6. The cylinder head 51 is formed to provide a combustion chamber 53 for each of the cylinders of the engine and the combustion chamber is preferably of a peculiar shape defined not only by the cylinder head 51 but also by a throat member 54 which is circumferentially flanged as at 56 and is fitted within the bore for the chamber 53 and clamped between the cylinder head 51 and the cylinder block 44, a gasket 57 extending between the cylinder block and the cylinder head serving as a seal to prevent leakage. The contour of the throat member 54 is such that the piston 42 at the upper point in its stroke approaches very closely to the surface of the member 54 and leaves but a slight compression space, such as 58, between the top of the piston and the lower surface on the throat member 54. Furthermore, the throat member is restricted in bore to a diameter substantially one half of the bore of the diameter of the engine cylinder but is again widened to meet the bore of the combustion chamber 53.

In order to facilitate the combustion in the engine, I take advantage of the tendency of the piston at the upper portion of its stroke to dislodge a very large volume of gas from the compression space 58 through the relatively narrow throat 59 of the throat member 54 into the combustion chamber 53. To this end the piston 42 is provided with an axial bore within which a stud 60 is seated and is held by a locking device such as a nut 61. The stud 60 at its upper end is flared to provide a disc 62, the upper surface 63 of which is concave to follow the general contour of the combustion chamber 53 which may be described as being of lens shape. The portion 64 on the periphery of the disc 62 is irregular or is serrated with the serrations lying in spaced helical paths after the fashion of a helical toothed gear, for the purpose of causing a helical swirl of the matter discharged from the interior of the cylinder by the piston in the upper portion of its stroke and for causing a whorl around the entire interior surface of the combustion chamber 53 during the completion of the compressor stroke.

The cylinder head 51 is provided with a water jacket space 66 suitably surrounding the combustion chamber 53 and communicating with the water jacket 49 in the cylinder block 44. Water from the jacket 66 is carried through a cored passage 67 in a housing 68 fitted on the cylinder head to a conduit 69 provided therein and leading to a radiator 71 presently to be described.

The combustion chamber 53 is placed in communication with the incoming gas and with outgoing gas at suitably timed intervals by means of an inlet valve 72 and an exhaust valve 73. The inlet valve 72 is of the customary poppet type and controls communication between the combustion chamber 53 and an inlet duct 74 while the exhaust valve 73 is of a similar poppet type and controls communication between the combustion chamber 53 and an exhaust duct 76. Each of these valves is maintained on its seat by a coil spring 77 surrounding a valve guide 78 pressed into the cylinder head 51. The inlet valve 72 is actuated by a rocker arm 79 projecting from a shaft 80 rotatable in pedestals 81 and 82 secured to the cylinder head 51. The exhaust valve is similarly actuated by means of a rocker arm 83 formed integrally with a sleeve 84 bearing upon the shaft 80.

The shaft 80 likewise carries a rocker arm 86 terminating in an adjusting mechanism 87 at the upper end of a push rod 88 passing through a guide 89 mounted in the cylinder head 51 and the crank case 6. The exhaust valve 73 is similarly actuated by a rocker arm 91 carrying an adjusting device 92 at its extremity which bears on the upper end of a push rod 93 extending through a guide 94 similarly held between the cylinder head 51 and the crank case 6. At their lower ends the push rods 88 and 93 terminate in rollers 96 and 97 respectively which bear on followers 98 and 99 respectively interposed between the rollers and cams 101 formed on a cam shaft 102 extending longitudinally through the crank case 6 and mounted in suitable bearings 103 therein. Access to the followers and to the cam shaft is through a cover plate 104 mounted on the machined side face of the crank case 6. The arrangement is such that the followers 98 and 99 are mounted concentrically on a through shaft 106 which extends longitudinally of the engine and is carried by bored clamps 107 fastened to the crank case 6 by bolts 108.

Mounted between the push rod housings 89 and 94 is a fuel pump 111 of any standard kind which is secured by studs 112 to the upper side of the crank case 6 and is provided with a depending plunger 113 adapted to contact a follower 114 carrying a roller 115 bearing on a cam 116 on the cam shaft 102. The follower 114 is preferably provided with a bearing lug 117 in contact with the plunger 113. The follower 114 is provided with an eccentric ring 118 which encompasses an eccentric 119 formed on the longitudinal shaft 106 so that upon rotation of the shaft 106 the followers 98 and 99 are not disturbed, but the follower 114 is moved transversely of the engine so that the cam 116 is effective upon the depending plunger 113 of the fuel pump 111 at different times during its cycle of rotation. In this fashion by suitably rotating the shaft 106 the time of operation of the fuel pump 111 is varied. The amount of fuel discharged by the pump is varied from zero to maximum by a rod 120 moving longitudinally of the engine.

The fuel pump receives the liquid fuel for the engine through a suitable arrangement of ducts 121 and discharges through a conduit 122 into a nozzle 123 or injector of any standard kind which is mounted in a suitable bore 124 in the cylinder head 51 so that the jet of liquid fuel issuing from the nozzle extends transversely of the combustion chamber 53 and is suitably merged with air compressed therein at the end of the compression stroke. Access to the fuel nozzle 123 and to the fuel pump 111 is obtained by removing a cover plate 126 which is fastened to the machined side of the cylinder block 44 and of the cylinder head 51.

The cam shaft 102 for actuating the push rods 88 and 93 and also for actuating the fuel pump 111 is driven through appropriate gearing. At its forward end the cam shaft carries a gear 131 which is twice the diameter of a crank shaft gear 132 with which it meshes. Due to the ratio of the diameters of these gears the speed of the cam shaft 102 is exactly half the speed of rotation of the crank shaft 27 which is proper for a four stroke cycle engine of the type described.

The cycle of the engine is in accordance with the usual Diesel cycle and with the parts so far described the engine is capable on the suction stroke of inducing air to flow in through the intake valve, of subsequently compressing the air taken in during which time the intake valve is closed, and, adjacent the upper portion of its stroke of receiving a charge of combustible fuel from the fuel nozzle 123, of subsequently moving on a downward stroke under the influence of the expanding products of combustion and finally discharging such products of combustion through the appropriately opened exhaust valve.

Although an engine operating in accordance with the described cycle is perfectly satisfactory for relatively heavy and medium duty it is very difficult to start manually and is not particularly susceptible to light load or slow running. In order to achieve the objects of my invention, I provide means for operating the engine upon a relatively light hydrocarbon fuel such as gasoline and not on the Diesel cycle but on another cycle, usually the Otto four stroke cycle. As is well know, the compression in accordance with the Diesel cycle is relatively high while the compression in accordance with the Otto cycle is relatively low and to afford a difference in clearance volume in the cylinder in order to provide for the necessary difference in compression pressures, I provide a means for augmenting the combustion chamber 53 when the engine is to be run in accordance with the Otto cycle.

To this end, the engine is built with a means for lifting the intake valve 72 and holding the intake valve 72 open during the operation of the engine in accordance with the Otto cycle. A longitudinal shaft 133 is held by the clamps 107 and is provided at spaced intervals along its length with cams 134. Each cam is designed when properly rotated, usually by hand, to abut a roller 136 on an extension of the cam follower 99 of the intake valve. When the shaft 133 is rotated clockwise, as viewed in Figure 1, the cam 134 abuts the roller 136 and causes the follower 99 to rotate about its concentric axis on the shaft 106 thereby lifting the cam follower 96 and the push rod 88 independently of the cam shaft 102 to hold the inlet valve 72 open thereby establishing continuous communication between the combustion chamber 53 and the intake duct 74.

In order that a proper amount of the inlet duct 74 will be utilized to augment the combustion chamber 53 and to provide an auxiliary combustion chamber for operation on the Otto cycle I preferably terminate the intake duct 74 adjacent the upper face of the cylinder block 44 by providing a valve seat 137. Adapted to operate on this seat is a poppet valve 138 provided with a stem 139 operating in a guide 141 secured in a pocket 142 formed in the cylinder block 44. The valve 138 is normally held on its seat by means of a relatively light coil spring 143 which however, is ineffective against vacuum existing in the inlet duct 74 on the suction or downstroke of the piston 42. In other words, the valve 138 is an automatic valve to the inlet duct 74 and is consequently capable of closing during the time any pressure approximating atmospheric pressure is present in the duct 74. The pocket 142 communicates with a carburetor 144 which is capable of providing a combustible mixture of air and light fuel such as gasoline to the pocket 142 from which the combustible mixture flows through the passage around the valve 138 to the inlet duct 74 and thence to the combustion chamber 53.

Under operation on the Otto cycle, the main intake valve 72 is open, the valve 138 serves as an automatic inlet valve for the engine and

the inlet duct 74 and the combustion chamber 53 are combined to present the proper volume so that the compression pressure effected by the piston is proper. Operation on the Otto cycle is at a compression pressure such that auxiliary ignition mechanism is necessary and for this reason I provide a standard spark plug 171 in the cylinder head 51, the spark plug being suitably energized in proper time relationship by means of a lead 172 extending to a magneto 173 of a standard kind mounted on the upper face of the crank case 6 and carrying a gear 174 which is driven from the cam shaft gear 131 by means of an intermediate gear 176.

During operation on the Otto cycle the spark plug 171 is suitably energized at proper intervals and produces combustion of the explosive mixture in the augmented combustion chamber 53 while during operation on the Diesel cycle the spark plug may or may not be energized depending upon the particular design of the mechanism and in any event, is not subjected in any way or manner to the excessive pressures and temperatures existing within the combustion chamber 53 during operation on the Diesel cycle since then only relatively cold air is present in the inlet duct 74. There is therefore no difficulty experienced in operation when a spark plug is positioned as indicated herein.

To control the position of the valve 138 which is operative during operation of the engine on the Otto cycle but is inoperative during the operation of the engine on the Diesel cycle I preferably mount a bell crank 175 on a pivot bracket 177 secured to a cover plate 178 fastened to the side of the crank case 6 and the cylinder block 44. The bell crank is provided with one arm 179 adapted to abut the end of the valve stem 139 and is likewise provided with another arm 181 adapted to be acted upon by a cam 182 fastened on a longitudinal shaft 183 passing along the side of the engine and held in place between the cylinder block 44 and the removable cover plate 178.

When the engine is to be operated on the Diesel cycle, the shaft 183 is rotated so that the cam 182 contacts the arm 181 of the bell crank lever and rotates it about its pivotal mounting on the bracket 177 so that the arm 179 contacts the valve stem 139 and against the urgency of the spring 143 holds the valve 138 off its seat so that fluid from the pocket 142 passes around the valve substantially unobstructedly and through the inlet duct 74 to the combustion chamber 53. Under operation on the Otto cycle however, the shaft 183 is rotated so that the cam 182 is out of contact with the arm 181, and the bell crank lever 175 under the urgency of gravity or a spring, not shown, swings out of the path of operation of the valve stem 139 and the valve 138 then responds to variations in pressure between the pocket 142 and the inlet duct 74 under the control of the spring 143.

In order that the various controlling shafts of the engine may be operated I provide a control linkage as shown in Figure 4. In this figure, the carburetor 144 is shown as mounted on an air cleaner 184 having an air inlet 185 and an air outlet 186 communicating with the pocket 142. A transverse wall 187 in the air cleaner prevents communication between the inlet 185 and the outlet 186 except through the carburetor 144 when a butterfly valve 188 is closed. Air from the interior of the air cleaner 184 flows into the carburetor 144 through an inlet tube 145, is carbureted, and flows through an outlet tube 150 into the pocket 142. Communication between the inlet 185 and the outlet 186 shunting the carburetor, is permitted when the valve 188 is open. The butterfly valve is mounted to turn with the shaft 183 and is arranged to be closed, thereby rendering the carburetor effective, when the shaft 183 is in a position to be ineffective on the valve 138. However, when the butterfly valve 188 is opened, thereby by passing or shunting the carburetor, as in operation on the Diesel cycle, the shaft 183 is effective to lift or to disable the valve 138.

The shaft 183 carries a lever 189 connected by a rod 190 to one arm 191 of a bell crank provided with an enlarged pivot boss preferably journaled in the rear face of the cylinder block.

The other arm 192 of the bell crank is connected by a rod 193 to a starting lever 194 preferably fixed on the extremity of the shaft 133. When the shaft 183 is in position for operation on the Otto cycle, the described linkage causes the shaft 133 to be in such a position that the cam 134 engages the roller 136 and holds the intake valve 72 off of its seat. This is the starting position. When, however, the starting lever 194 is moved to "run" position, as shown in Figure 4, the shaft 133 is rotated to remove the cam 134 from effect on the roller 136 and permits the valve 72 to be actuated solely in response to the cam shaft 102. The lever 194 when moved to "run" position forces the rod 193 to rotate the bell crank so that the rod 190, through the medium of the lever 189 rotates the shaft 183 to open the butterfly valve 188 and to disable the valve 138.

The rod 120 is moved axially to vary the injection of fuel as to amount by means of mechanism which is partially dependent on the position of the starting lever 194 so that in "start" position the injection of relatively heavy fuel is precluded. The fuel pump 111 is ordinarily responsive to a governor of any suitable kind which is effective to move the shaft 120. Also effective on the shaft 120 is a bell crank 195 mounted to pivot about a horizontal transverse axis and carrying a compression spring 180. Adapted to act on the spring 180 after overcoming considerable initial lost motion is a plunger 196 mounted pivotally on a lever 197. The lever is fulcrumed on a pin 198 projecting eccentrically from the enlarged central boss of the bell crank having the arms 191 and 192. The lever 197 is connected by a rod 199 to a speed regulating lever 200 fixed on the shaft 106.

When the lever 194 is in "run" or Diesel cycle position, the location of the bell crank is such that the plunger 196 contacts the compression spring 180. Subsequent movement of the lever 200 compresses and releases the spring 180 to vary the resistance which must be overcome by the governor in moving the shaft 120 to regulate the speed of the engine. Since the lever 200 is on the shaft 106, the time of injection of the fuel is varied in accordance with the amount of fuel injected. Thus, as the shaft 106 is rotated toward "fast" position, the follower 114 is projected to give an earlier actuation of the plunger 113 by the cam 101.

When the lever 194 is in "start" position, the pivot pin 198, being eccentrically mounted, is lifted, and the plunger 196 is raised from contact with the spring 180 a sufficient distance that no matter in what position the lever 200 is placed, the spring 180 is not compressed and

the shaft 120 must remain in position to prevent injection of fuel by the pump 111.

The engine is likewise provided with a suitable mechanism for circulating cooling water through the jackets 49 and 66 and likewise through the outlet duct 69. Mounted on the forward end of the crank case 6 is a plate 201 which not only forms a mounting for a timing gear cover 202 but likewise forms part of the support for the radiator 71 which additionally is mounted on an extension 204 secured to the crank case 6 at its forward end. The extension 204 forms the mounting for a shaft 206 at its forward end 207 designed to receive a hand crank and at its rearward end provided with a uni-directional clutch 208 for engagement with the forward end 209 of the crank shaft 27 for cranking the engine manually.

The radiator 71 which rests on the housing 204 and is additionally supported by the plate 201 comprises an upper tank 211 into which the water outlet 69 discharges. The upper tank is provided with a filler cap 212 which is in the nature of a poppet valve normally held closed by a spring 213 surrounding a telescopic stem 214 so that to fill the radiator, it is merely necessary to depress the cap 212 against the urgency of the spring 213 and to swing the telescopic mounting 214 about its point of pivotal attachment 216. Suitable tubes extend from the upper radiator head 211 to a lower radiator head, integral with the support 204, from whence the cooling water is returned to the engine. Interposed between the upper header and the lower header is a cooling fan 221 preferably of the sirocco type which induces an axial flow of air which is discharged tangentially over the cooling tubes of the radiator. Spanning the sirocco fan 221 between the upper tank 211 and the lower tank 204 is a spider 222 on which a rotatable shutter 223 is mounted. In one position of the shutter, the apertures, therein are in registration with the apertures in the spider and free air flow is permitted whereas, in a rotated position of the damper, its apertures are out of registration with the apertures in the spider and no air flow is permitted.

The sirocco fan 221 is mounted for torsional resiliency on the forward end of a fan shaft 226 carried in bearings 227 and 228 secured in a pump housing 229 fastened to the forward face of the timing gear cover 202. Between the bearings 227 and 228 is fastened the impeller 231 of a water pump which withdraws the cooling water from the lower tank 204 of the radiator and discharges the cooling water into the water jacket 49. Also mounted on the fan shaft 226 adjacent its rear end is a governor 234 of any suitable design which is effective to move the shaft 120 axially to regulate the volume of fuel pumped, as previously described.

In accordance with my invention, the engine is initially started by throwing the control lever 200 to "start" position and either utilizing a hand crank on the shaft 207 or an electric starter in engagement with teeth 236 on the fly wheel 237 of the engine at the end of the crank shaft to rotate the engine initially. Moving of the starting lever 194 to "start" position not only permits the valve 138 to act freely and closes the butterfly in the upper end of the air cleaner, but also causes the spark plug 171 to be periodically energized and lifts the main inlet valves 72 from their seats and moves the shaft 120 longitudinally so that the pumps 111 are incapable of discharging any fuel oil.

When the engine is started thus on the Otto cycle, using gasoline, it is relatively easily cranked and quickly comes up to a normal operating temperature under a relatively light load. As soon as the engine is operating satisfactorily the lever 194 is moved to "run" position which is effective to place the valve 138 in inoperative, open position, to de-energize the spark plug 171, to open the butterfly in the air cleaner, to translate the shaft 120 longitudinally so that the fuel pump 111 injects fuel oil into the combustion chamber 53 at the proper time, and likewise rotates the shaft 133 so that the main inlet valves 72 are solely under the control of the cam shaft 102 which operates them in proper sequence and in conjunction with the operation of the remainder of the engine. At any time during the operation of the engine the cycle can be changed from Diesel to Otto for light running and for idling thereby avoiding fouling and carbonization of the combustion chamber and valves and providing for a simple control under light load conditions. On the other hand, the engine can at any time be changed over to operation on the Diesel cycle which is suitable for heavy use and for continuous heavy load running.

It is to be understood that I do not limit myself to the form of the engine shown and described herein, as the invention, as set forth in the following claims may be embodied in a plurality of forms.

I claim:

1. A four-stroke cycle engine comprising a main chamber, an auxiliary chamber opening into said main chamber and opening to the atmosphere, a valve for controlling communication between said main chamber and said auxiliary chamber, an inlet valve for controlling communication between said auxiliary chamber and the atmosphere, and means for mechanically operating said valve in time with the operation of said engine while holding said inlet valve in open position and alternatively holding said valve in open position and releasing said inlet valve to operate in time with the operation of said engine.

2. A four-stroke cycle engine adapted to operate on the Otto cycle and on the Diesel cycle comprising a main chamber, an auxiliary chamber opening into said main chamber and to the atmosphere, valves for controlling communication between said auxiliary chamber and said chamber and between said auxiliary chamber and the atmosphere, respectively, and valve mechanism for operating said valves in time during the operation of said engine on both the Otto cycle and the Diesel cycle so that there is a flow of air from the atmosphere through said auxiliary chamber to said chamber for every fourth stroke of said engine.

3. A four-stroke cycle engine comprising a main chamber, an auxiliary chamber, a valve operating in time with said engine for controlling flow between said auxiliary chamber and said chamber, means for holding said valve in open position, an inlet valve between said auxiliary chamber and the atmosphere adapted to operate in time with said engine, and means for holding said inlet valve in open position.

4. A four-stroke cycle engine comprising a main chamber, an auxiliary chamber communicating therewith, a duct communicating with said auxiliary chamber and with the atmosphere,

a carburetor opening into said duct, means for selectively opening said duct to said carburetor or to the atmosphere, an inlet valve for closing communication between said duct and said auxiliary chamber periodically during the operation of said engine, means for disabling said inlet valve, a valve for closing communication between said auxiliary chamber and said chamber periodically during the operation of said engine and means for disabling said valve.

5. A four-stroke cycle engine comprising a main chamber, an auxiliary chamber communicating therewith, a duct communicating with said auxiliary chamber and with the atmosphere, a carburetor opening into said duct, means for selectively opening said duct to said carburetor or to the atmosphere, an inlet valve for closing communication between said duct and said auxiliary chamber periodically during the operation of said engine, a valve for closing communication between said auxiliary chamber and said chamber periodically during the operation of said engine, and means for alternatively disabling said valve and said inlet valve.

6. A four-stroke cycle engine adapted to operate on the Otto cycle and on the Diesel cycle, comprising a main chamber, an auxiliary chamber opening into said main chamber and to the atmosphere, a first valve for controlling communication between said chamber and said auxiliary chamber, an inlet valve for controlling communication between said auxiliary chamber and the atmosphere, and means for operating said valves so that said auxiliary chamber serves as the sole air inlet passage to said chamber during operation of said engine on the Diesel cycle and for holding said first valve open during operation of said engine on the Otto cycle so that said auxiliary chamber then serves as an additional combustion chamber.

MOYES J. MURPHY.