July 25, 1933. M. TIBBETTS 1,919,348

INTERNAL COMBUSTION ENGINE

Filed Nov. 24, 1930

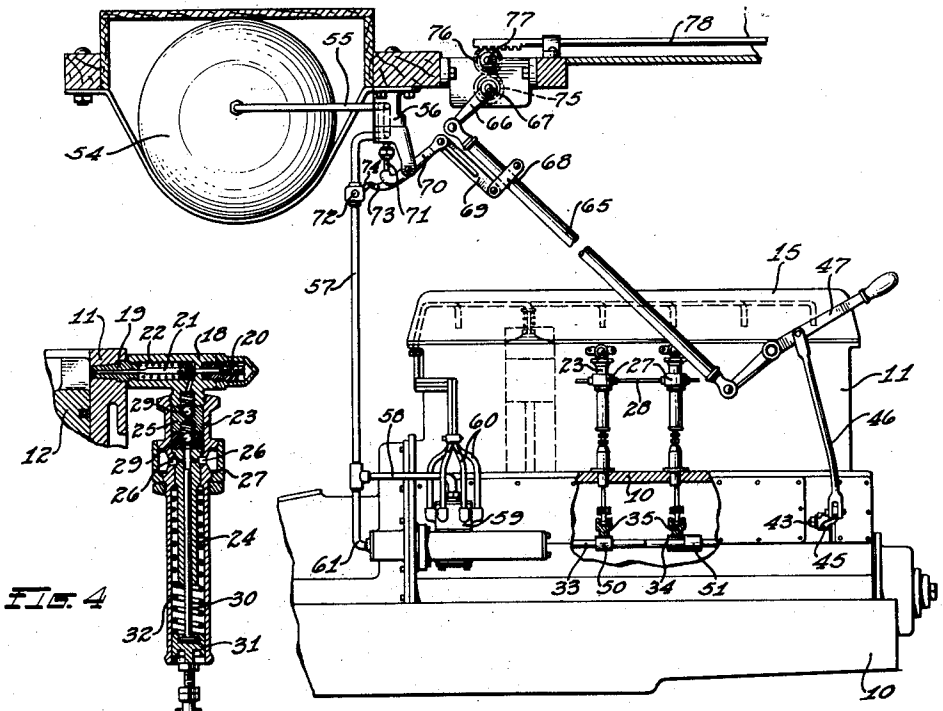

FIG. 1

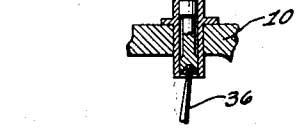

FIG. 4

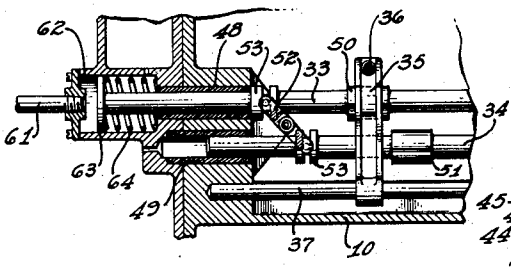

FIG. 3

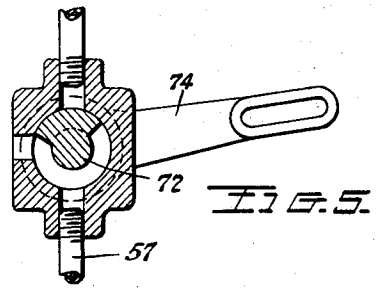

FIG. 5

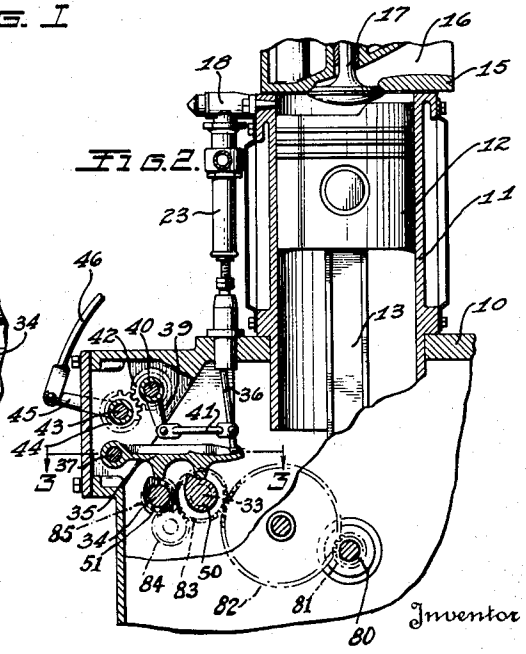

FIG. 2

Inventor

Milton Tibbetts

Patented July 25, 1933 1,919,348

UNITED STATES PATENT OFFICE

MILTON TIBBETTS, OF DETROIT, MICHIGAN, ASSIGNOR TO PACKARD MOTOR CAR COMPANY, OF DETROIT, MICHIGAN, A CORPORATION OF MICHIGAN

INTERNAL COMBUSTION ENGINE

Application filed November 24, 1930. Serial No. 497,644.

This invention relates to internal combustion engines and more particularly to engines of the fuel injection type in which ignition occurs through heat of compression.

In engines of the solid fuel injection type, air is compressed in the cylinders and atomized liquid fuel charges are injected into the air during the compression strokes of the engine pistons to form a mixture which ignites due to heat developed by the compression. Ordinarily the fuel is moved into the compressed air in the cylinders from injection devices which include pressure means operated by the engine. Such devices develop pressure in accordance with the engine speed and consequently, when starting the engine, the pressure developed behind the fuel is too low to secure the proper atomization and sufficient penetration thereof into the compressed air in the cylinders to form a mixture which will readily ignite under the heat of compression developed in the cylinders, and therefore, under such circumstances starting of the engine is difficult.

It is an object of my invention to provide a Diesel type of engine in which pressure developed behind the oil injections is caused through a rotating engine element having a selective two-speed actuating mechanism so that a higher fuel pressure will be developed when the engine is starting than would take place if the mechanism employed during regular operation were effective.

Another object of my invention is to provide an internal combustion engine of the Diesel type in which an air starter and selective speed fuel device actuating mechanism are simultaneously controlled by the operation of a single device.

A further object of my invention is to provide an internal combustion engine with two mechanisms driven at relatively different speeds for actuating a fuel injection device in which a pair of cam shafts are movable axially to allow one or the other mechanism to be placed in effective relation.

Still another object of my invention is to provide a fuel pump actuating mechanism for an injection device of an internal combustion engine which will develop a much greater pressure behind the fuel charges when starting the engine than would be developed by the mechanism which is effective during regular running operation of the engine.

Another object of the invention is to provide a fuel injection mechanism for internal combustion engines in which pressures are developed behind the fuel charges to provide for the proper commingling with the air charges at any speed at which the crank shaft may be turning.

These and other objects of the invention will appear from the following description taken in connection with the drawing, which forms a part of this specification, and in which:

Fig. 1 is a side elevation of a marine engine having my invention associated therewith;

Fig. 2 is a sectional view through the engine showing the cam shaft driving mechanism and the fuel injection actuating means;

Fig. 3 is a fragmentary horizontal sectional view taken on line 3—3 of Fig. 2 showing the cam shaft shifting mechanism in normal running position;

Fig. 4 is a fragmentary section of one of the fuel injection devices associated with a portion of the cylinder.

Fig. 5 is a sectional view of the air relief valve mechanism.

Referring now to the drawing by characters of reference, 10 indicates the crank case of a four cycle type internal combustion engine of the Diesel type upon which is mounted a cylinder block 11 forming a plurality of aligned cylinders. A piston, as indicated at 12, is arranged to reciprocate within each of the cylinders and is connected to a conventional form of crank shaft by rods, as indicated at 13. A head block 15 is secured upon the top of the cylinder block and is provided with separate exhaust and inlet passages for each cylinder, one of which is indicated at 16. A conventional valve mechanism, as indicated at 17, is associated with each of the inlet and outlet passages. The air inlet passage is preferably venturi in form and is arranged at an angle to the axis of the associated cylinder and tangential to the interior wall thereof so that

charges of air drawn into the cylinders will be caused to rotate.

With each cylinder I provide a separate fuel injection device, each of which is similar. Such a device consists of a nozzle section and a pump section and actuating mechanism for the pump section. The nozzle section includes a casing 18 formed with an end 19 which projects into an aperture in the cylinder and an adjustable stop member 20 for the valve 21 which extends through an axial chamber in the nozzle casing sections 18 and 19. The end of the valve is formed with a head and the stop member is adjusted so that this head will not quite touch the casing wall in its retracted position, and a coil spring 22 is arranged within the passage in the nozzle casing for normally urging the valve into retracted position.

A pump casing 23, carrying a barrel 24, is screwed upon the neck portion of the nozzle casing and a spacer 25 is interposed between the flanged upper end of the barrel and the neck of the nozzle casing. A passage extends through the spacer and the nozzle casing neck to establish communication between the nozzle chamber and the interior of the pump barrel. The pump barrel and casing are provided with a plurality of ports 26 and a casing 27 surrounds the ported portion of the pump casing and serves as a fuel oil inlet. Such inlets are connected by conduits 28 so that the oil can be supplied through means of a low pressure pump (not shown). The passage connecting the nozzle chamber and the barrel is provided with one-way valves 29 so that oil will not return from the nozzle section to the pump section. A plunger 30 is arranged to reciprocate within the barrel and is provided with a head portion 31 which is slidably mounted in the pump casing, there being a coil spring 32 arranged between the barrel and the casing and engaging the head 31 to normally urge and maintain the pump plunger in a position uncovering the ports 26.

It will be seen that the distance the plunger travels after closing the ports 26 will determine the quantity of fuel oil evacuated into the cylinders through the nozzle section, and the mechanism is so arranged that the effective oil injections will occur toward the end of the air compression strokes of the piston, preferably anywhere in a range extending between 35 to 5 degrees on the crank shaft angle before top center piston position.

Mechanism for causing injection strokes of the plungers is provided and consists of a pair of cam shafts 33 and 34, driven preferably from the crank shaft, a pivoted rock lever 35 associated with each device and an articulated push rod structure 36 which is interposed between the rock lever and the head 31 of the plunger. Such rock levers are mounted at one end upon a shaft 37 extending through the crank case and the free end of the rock levers is provided with a curved bearing face which is arranged so that adjustment of the push rod longitudinally thereof will cause plunger strokes of different lengths relative to the ports 26.

In order to adjust and position the push rod structures relative to the rock levers I provide an arm 39 which is mounted upon a shaft 40 and to the other end of which is pivotally mounted a link 41 which is also pivoted to the push rod structure. The shaft 40 has a gear 42 fixed thereto and carried upon a shaft 43 is a gear 44 which meshes with gear 42; this shaft 43 has a fixed arm 45 extending to the exterior of the crank case and is connected by a link 46 with a pivoted lever 47 which is adapted to be manually operated. Movement of the lever 47 will cause rotation of the shafts 43 and 40 with a consequent movement of the arm 39 and the link 41 to move and position the push rod structures upon the curved face of the rock levers. It will be understood that the fuel charge quantity can be regulated as desired through the mechanism described, and such mechanism can also be adjusted so that the stroke imparted to the plungers will not close the ports 26 so that the engine will not operate.

The two cam shafts for operating the rock levers 35 are suitably mounted in end bearings, as shown at 48 and 49, and mechanism is associated therewith so that either one or the other cam shaft is moved into a position so that the lobes 50 and 51, associated therewith respectively, are in a position to actuate the rock levers. In order that the cam shafts will be moved simultaneously so that the lobes of one will be effective and the lobes of the other ineffective, I provide a connection which consists of a pivotally mounted yoke arm 52 having a suitable projecting end for engaging collars 53 fixed to the cam shafts, and in this manner it is only necessary to apply mechanism to shift one of the shafts to place them both in desired relation relative to the rock levers.

In order to start the engine I provide a system through means of which compressed air is admitted to the cylinders. A compressed air tank 54 is conveniently arranged relative to the engine and has an outlet conduit 55 leading to a valve housing 56, and a conduit 57 leads from the valve housing. To this conduit 57 I conduct compressed air through a conduit 58 to a distributor 59 with which a plurality of conduits 60 are associated to deliver compressed air to the individual cylinders during the power strokes in a proper timed relation to move the pistons downward, and also associated with the conduit 57 is a conduit 61 which communicates with a chamber 62 formed in the crank case and in which the end of the cam

shaft 33 reciprocates. To end of this cam shaft is in the form of a head 63 and a spring 64 bears thereagainst to normally move the shaft axially so that the lobes 50 will be in effective position beneath the rock levers 35. When compressed air is admitted into the chamber 62 the cam shaft 33 will be moved axially so that the lobes thereon will move into a plane where they do not contact with the rock levers, and at the same time through the medium of the yoke arm 52 the cam shaft 34 is moved in an opposite direction such that the lobes 51 thereon will be moved into effective relation beneath the rock levers.

The cam shaft 34 is driven at a multiple speed relative to the cam shaft 33 and is employed when the engine is being started, but when the engine is running under its own power then the cam shaft 33 is moved into effective position. The cam shaft 33 is driven at one half the speed from the crank shaft 80 by means of gearing 81, 82 and 83, and such speed is not sufficient to operate the plunger fast enough to develop the desired pressure behind the oil injections when the engine is being turned slowly in starting. The cam shaft 34 is driven from the gear 83 by gearing 84 and 85 at crank shaft speed which will produce the desired pressure behind the oil charges, thus causing the oil charges, when the engine is starting, to penetrate and commingle with the compressed air charges to an extent such that a mixture is formed which will readily ignite after a very few revolutions of the crank shaft. The gears 85 and 83 are of sufficient length so that they can be shifted axially without becoming unmeshed from their associated gears 84 and 82. With the cam shaft 83 in effective position, there will be one fuel injection during each complete cycle of the engine operation which occurs late in the compression stroke of the pistons. With the cam shaft 34 in effective position, there will be a fuel injection stroke twice in each complete cycle of operation, one of these injections occurring late in the compression stroke of the piston. Of course, the extra injection in each complete cycle of operation wastes a small amount of fuel, but the normal operation of the four stroke cycle engine is in no way interfered with.

A link 65 is pivotally mounted at the lower end of the lever 47 and is pivotally mounted at its opposite end to an arm 66 which is mounted upon a shaft 67. A collar 68 is secured to the link 65 and has pivoted thereto a link 69 which is connected to the rock lever 70, such lever being pivoted to the valve housing 56. The free end of the lever 70 is arranged to actuate the valve stem 71 which projects into the valve casing and opens or closes the valve therein so that the passage of compressed air from the conduit 55 into the conduit 57 is thereby controlled.

In order that the air in the conduit 57 may escape when the starter has completed its usefulness, I provide a rotatable valve 72 which is controlled through means of an extension 73 on the lever 70 engaging the valve operating lever 74. As previously described, movement of the lever 47 will control the fuel charge quantity and it will be seen that movement of this lever will actuate the valve stem 71 through the connecting linkage 65, 69, 70 and the collar 68. When starting a Diesel engine in which the air charges remain constant it is desirable that the fuel charge be the maximum in order to have the maximum heat units therein as well as sufficient fuel to provide a readily ignitable mixture and, consequently, I have arranged the control mechanism so that the lever 47 must be moved slightly beyond a position giving maximum fuel injections, as shown in Fig. 1, before the compressed air conduit 57 is open to the tank and by this arrangement I can utilize a single control means for regulating the fuel quantities under any operating conditions and at the same time make the air starting system effective.

As an auxiliary means of controlling the fuel injection quantity and the air starting system I provide a gear 75 on the shaft 67 which meshes with a gear 76 on the shaft 77. The gear 76 is rotated by a rack formed on the end of a rod 78 which extends to or can be connected to be operated remotely from the engine.

While I have herein described in some detail a specific embodiment of my invention, which I deem to be new and advantageous and may specifically claim, I do not desire it to be understood that my invention is limited to the exact details of the construction, as it will be apparent that changes may be made therein without departing from the spirit or scope of my invention.

What I claim is:

1. In an internal combustion engine, a plurality of cylinders, a fuel injection device associated with each cylinder including a plunger, a pair of cam shafts driven at relatively different speeds for operating the plungers in sequence, a starter system for the engine, and means for shifting said cam shafts to place the faster cam shaft in plunger operating position when the starter system is applied to the engine.

2. In an internal combustion engine, a plurality of aligned cylinders, a fuel injection device associated with each cylinder including a plunger, a starter system for the engine, a pair of cam shafts driven at relatively different speeds for operating the plungers, means for adjusting one of the shafts to move it into or out of operative relation with the plungers, and a connection between the shafts causing their movement in opposite directions during operation of the adjusting means, the

faster cam shaft being moved into plunger operating position when the starter system is applied to the engine.

3. In an internal combustion engine, a plurality of cylinders, a fuel injection device associated with each cylinder including a plunger, a starter system for the engine, a pair of engine driven cam shafts operative one at a time for actuating the plungers to cause fuel injections, said shafts rotating at relatively different speeds, and means for shifting the shafts axially to place the desired one in operative relation with the plungers, the faster cam shaft being moved into plunger operating position when the starter system is applied to the engine.

4. In an internal combustion engine, a cylinder, a device for injecting fuel into the cylinder including a plunger, a pair of engine rotated cams for operating the plunger to cause injection strokes thereof, said cams rotating at relatively different speeds, a compressed air starter system for the engine, and shifting means for said cams actuated by the starter system, only one of the cams being in effective relation to operate the plunger at a time.

5. In an internal combustion engine, a cylinder, a device for injecting fuel into the cylinder including a plunger, a pair of engine driven cams effective one at a time to actuate the plunger, said cams being driven at relatively different speeds, a compressed air starter system, and means for applying the starter system to shift the cams so that the faster cam is effective during starting.

6. In an internal combustion engine, a plurality of cylinders, a fuel injection device associated with each cylinder including a plunger, means including adjustable mechanism for regulating the effective movement of the plungers to vary the charge delivered, a compressed air starter system for the engine controlled by the adjustable mechanism, cam mechanism for operating the plungers at different speeds relative to the engine speed, and means for utilizing the starter system to move the slower cams out of effective relation with the plungers and the faster cams into effective relation with the plungers while the starter system is effective.

7. In an internal combustion engine, a plurality of cylinders, a plunger fuel injection device associated with each cylinder, a pair of cam shafts driven at different relative speeds and adapted to operate the plungers one at a time, means normally maintaining the slower cam in operative relation with the plungers, a compressed air starting system for the engine, and a connection between the starting system and the cams simultaneously shifting the faster cam into effective position with the plungers when the system is applied to start the engine.

8. In an internal combustion engine, a plurality of cylinders, a plunger fuel injection device associated with each cylinder, a pair of cam shafts driven by the engine at relatively different speeds, said cam shaft cooperating to cause effective plunger strokes one at a time, means normally positioning the cam shafts with the slower one in plunger operating position, a starter system for the engine, and means actuated by the starter system while applied to position the faster cam shaft in operative relation with the plungers.

9. In an internal combustion engine, a plurality of cylinders, a fuel injection device including a plunger associated with each cylinder, a pair of engine rotated cam shafts adapted to be positioned in operative position with the injection devices one at a time, said shafts being operated at relatively different speeds, means normally placing the slower cam shaft in operative relation with the plungers of the fuel devices, and a manually controlled compressed air engine starter system for placing the faster cam shaft in operative relation with the plungers of the injection devices.

10. In an internal combustion engine having a plurality of cylinders, devices for injecting fuel charges into the cylinders, mechanism for adjusting the devices to regulate the quantity in the delivered fuel charges, a pair of cam shafts driven at relatively different speeds, means for shifting the cam shafts, a starting system for the engine, and a single control member for controlling the adjusting mechanism, the starter and the cam shaft shifting mechanism.

11. In an internal combustion engine of the Diesel type, a plurality of aligned cylinders, a fuel injection device associated with each cylinder including a plunger, plunger operating mechanisms including a rock lever, a pair of cam shafts effective one at a time to actuate the rock levers, said shafts being operated at relatively different speeds, a starter system for the engine, and means for shifting said cam shafts axially to place either in position to operate the rock levers in sequence.

MILTON TIBBETTS.