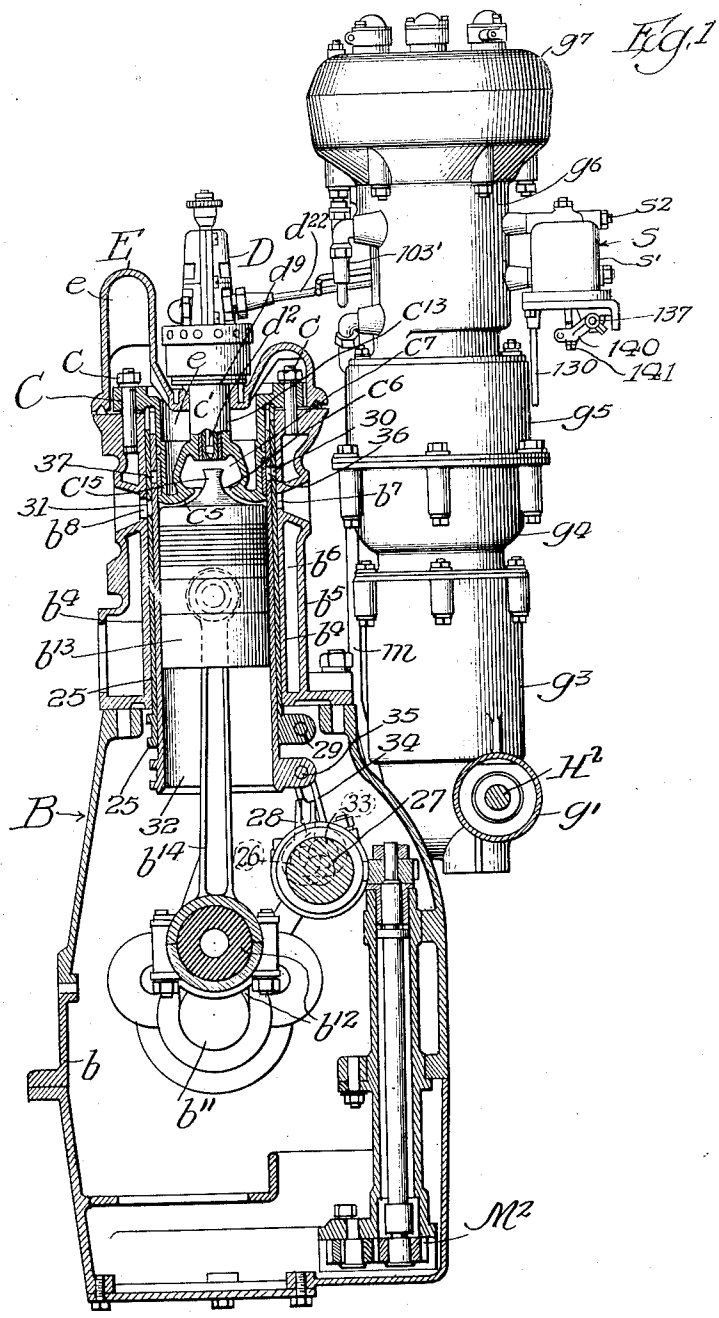
Nov. 13, 1928. 1,691,322

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LUBRICATING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed March 26, 1925 6 Sheets-Sheet 1



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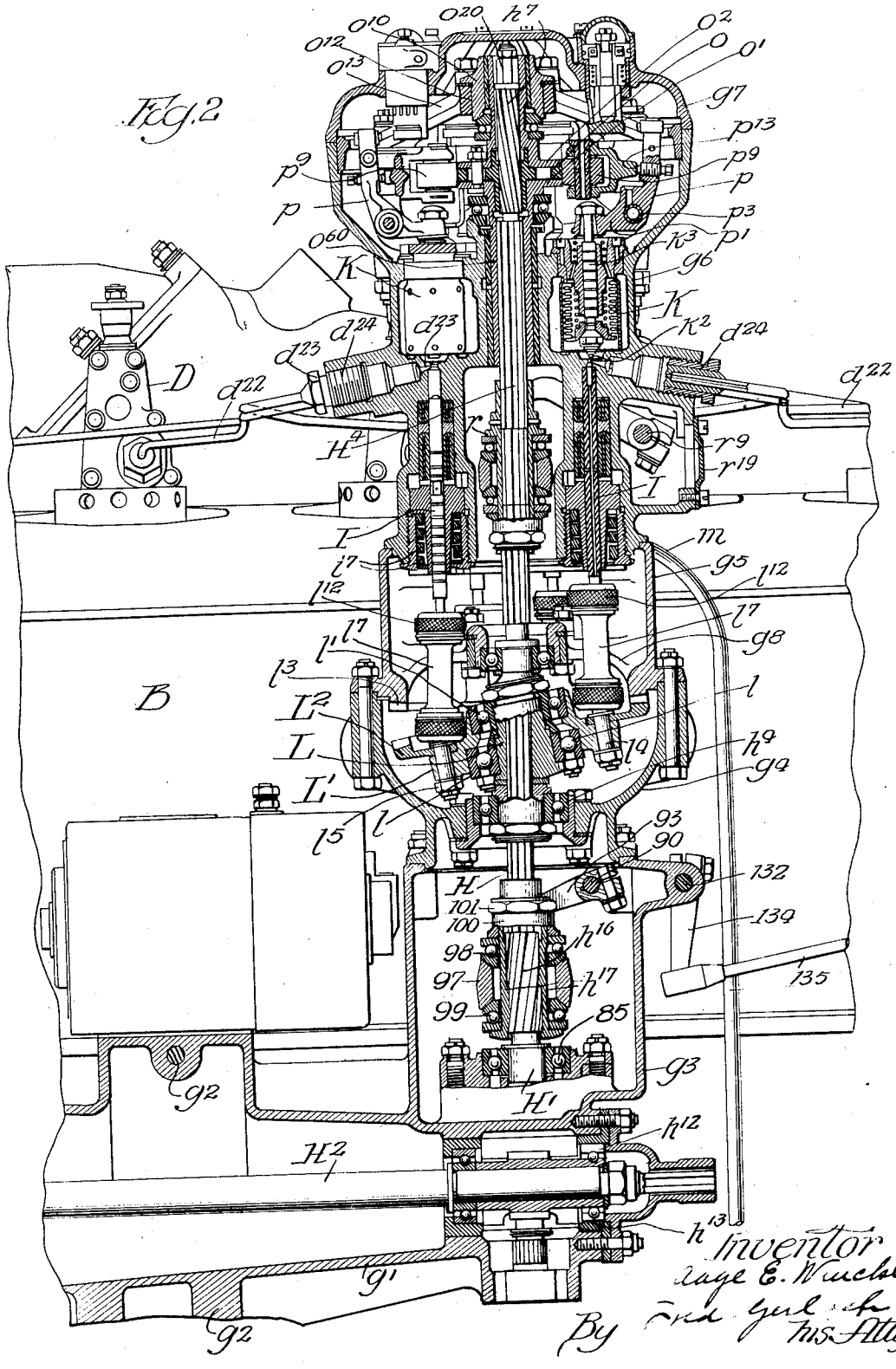
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LUBRICATING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed March 26, 1925 6 Sheets-Sheet 2

Fig. 2



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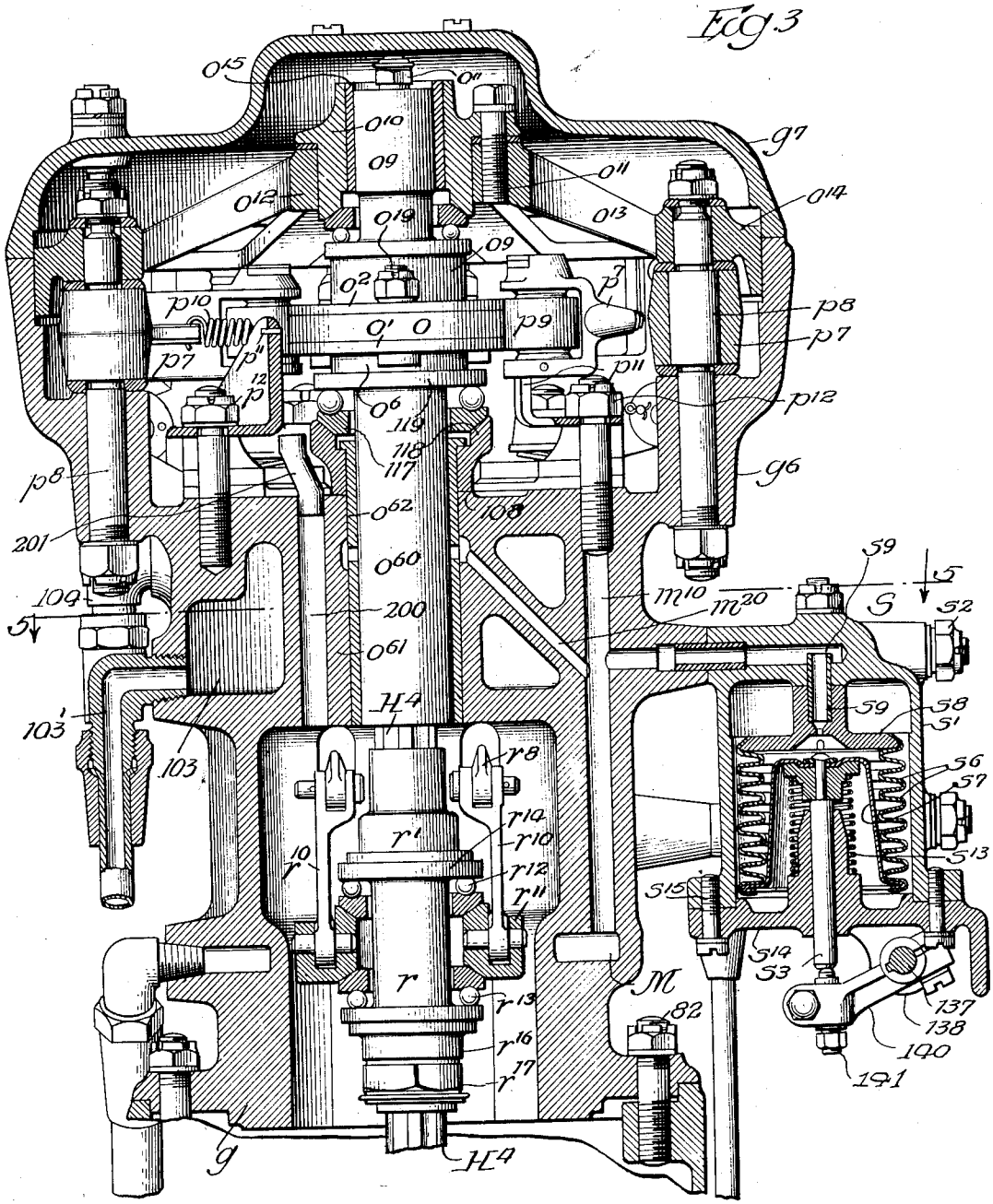
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LUBRICATING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed March 26, 1925 6 Sheets-Sheet 3

Fig 3



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LUBRICATING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed March 26, 1925 6 Sheets-Sheet 4

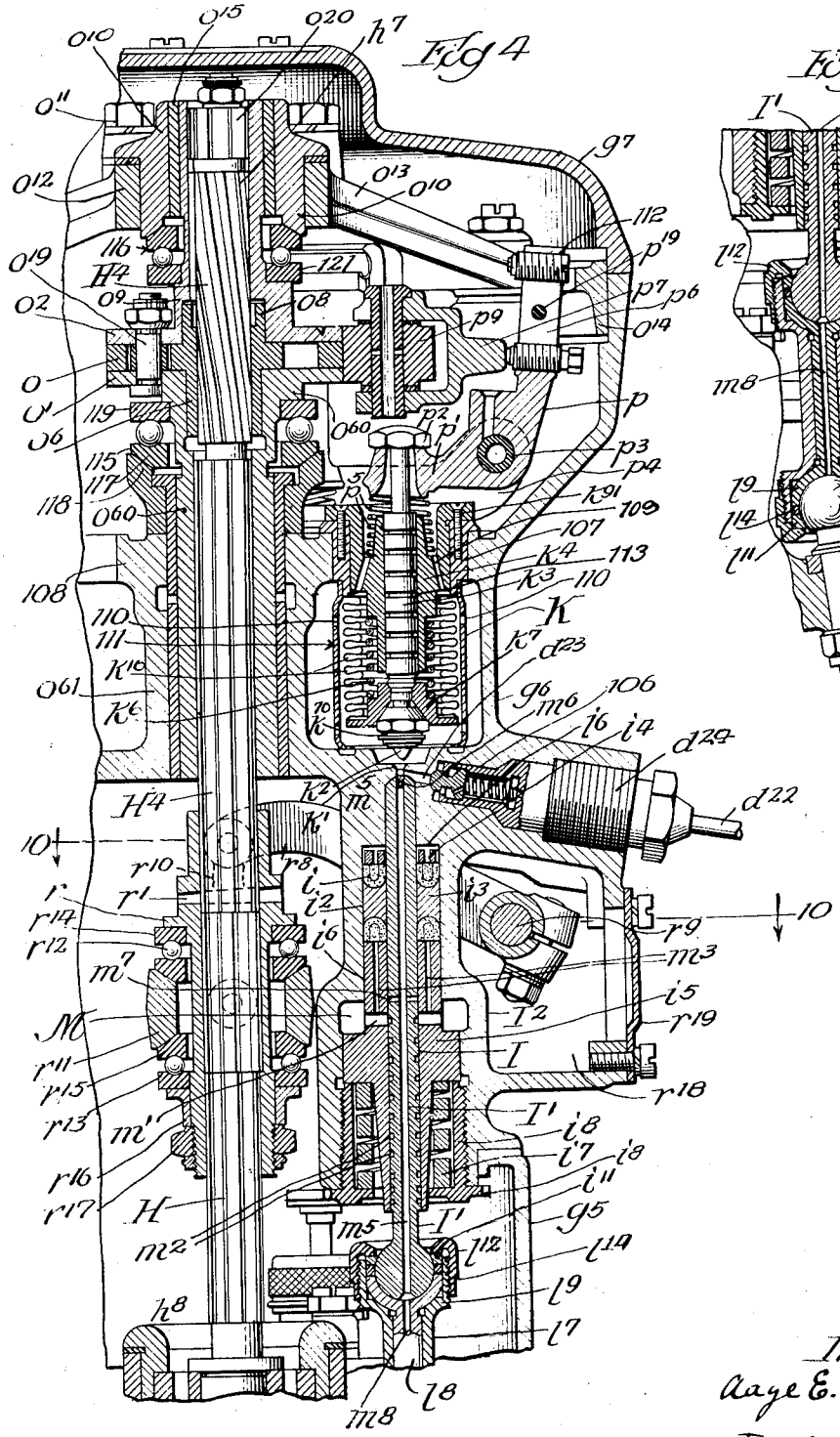


Fig 4

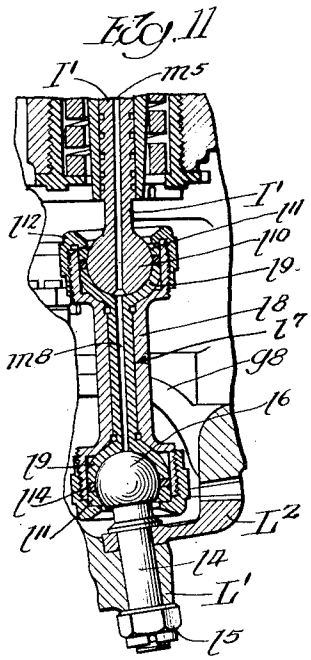


Fig. 11

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LUBRICATING SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed March 26, 1925 6 Sheets-Sheet 5

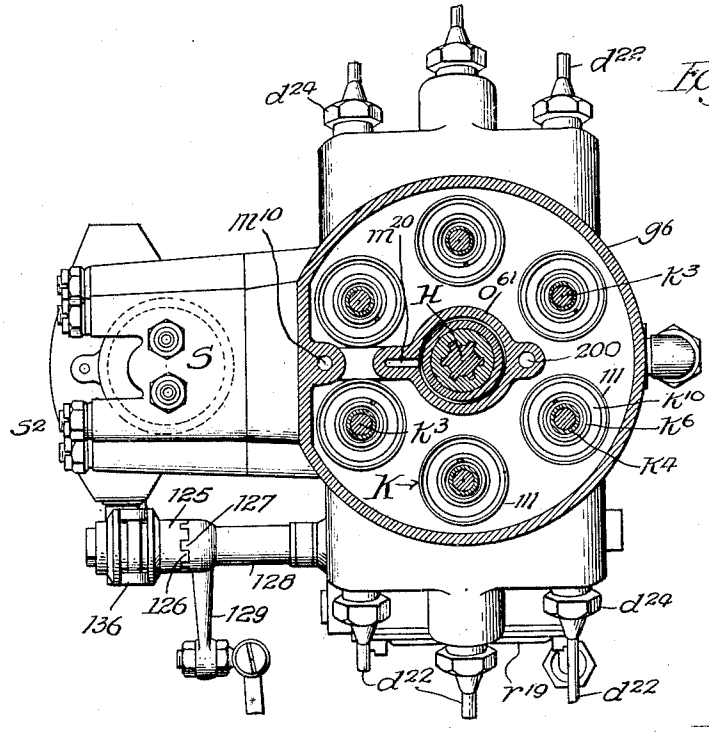


Fig. 5

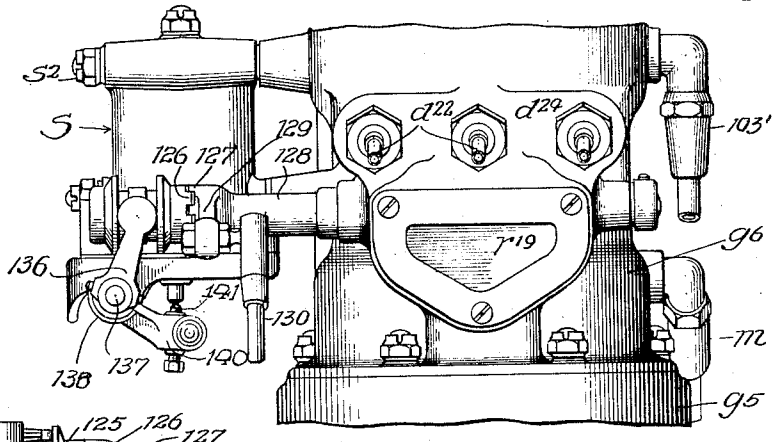


Fig. 6

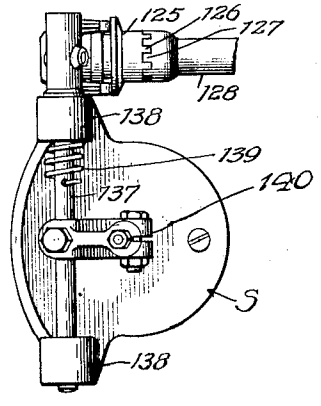


Fig. 7

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LUBRICATING SYSTEM FOR INTERNAL COMBUSTION ENGINES

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Fig. 8

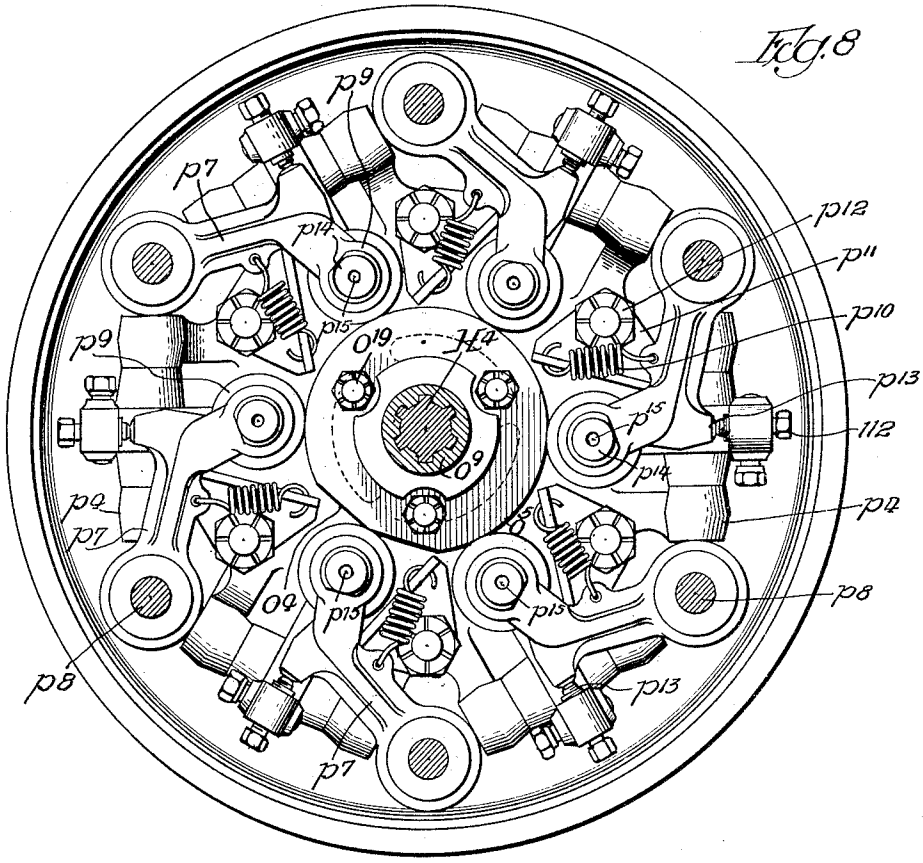


Fig. 9

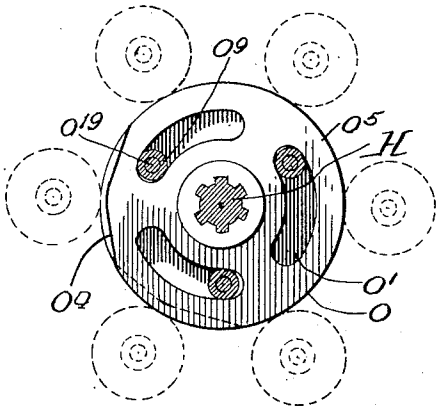
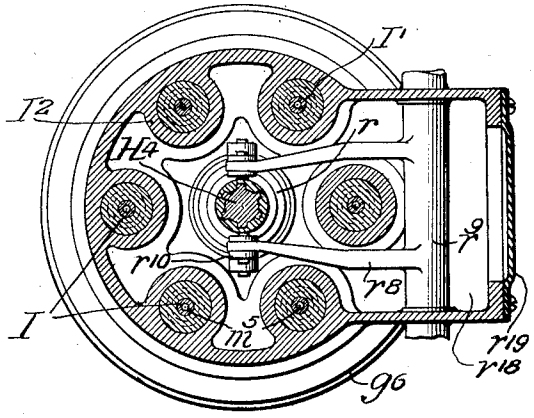


Fig. 10



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Patented Nov. 13, 1928. 1,691,322

UNITED STATES PATENT OFFICE.

AAGE E. WINCKLER, OF MILWAUKEE, WISCONSIN.

LUBRICATING SYSTEM FOR INTERNAL-COMBUSTION ENGINES.

Application filed March 26, 1925. Serial No. 18,383.

The invention relates to internal combustion engines of the injection type.

In the operation of internal combustion engines, particularly of the sleeve-valve type, it is important that the engine and feed mechanism should be properly lubricated. One object of the invention is to provide improved means whereby the pumping of fuel to the engine will be automatically stopped when the pressure in the lubricating system of the engine and the feed mechanism becomes deficient. Another object of the invention is to provide improved means for lubricating the working parts of the fuel feeding mechanism for the engine. Other objects will appear from the description.

The invention consists in the several novel features hereinafter set forth and more particularly defined by the claims at the conclusion hereof.

In the drawings: Fig. 1 is a transverse section of an engine embodying the invention, the fuel feed mechanism being shown in elevation. Fig. 2 is a vertical section through the fuel feed mechanism. Fig. 3 is a vertical longitudinal section of the mechanism for operating the metering valves. Fig. 4 is a longitudinal section of the fuel feed mechanism taken through one of the pumps and metering valves. Fig. 5 is a horizontal section taken on line 5—5 of Fig. 3. Fig. 6 is a side elevation of parts of the controlling mechanism actuated by the lubricating oil. Fig. 7 is an inverted plan of said parts. Fig. 8 is a plan view of the fuel feed mechanism, parts being omitted. Fig. 9 is a detail view of the cam structure for operating the metering valves. Fig. 10 is a section taken on line 10—10 of Fig. 4. Fig. 11 is a detail section of one of the pitmen for connecting the pump plunger to which it is attached to the wobble ring.

The invention is illustrated in connection with an engine B of the six cylinder type with cylinders vertically and longitudinally aligned, but one of which is shown. The engine casing comprises a crank-case b. Each cylinder comprises an inner wall b^4 and an outer wall b^5, which form a water-jacket b^6 around the cylinders. An air inlet port b^7 and an exhaust port b^8 are provided for each cylinder. A crank-shaft b^{11} is suitably journalled in the crank casing and provided with cranks b^{12} which are respectively connected by pitmen b^{14} to the working pistons b^{13} in the cylinders. The engine is of the fuel-injection type and the upper end of each cylinder is provided with a head C which is secured to the cylinder casting by bolts c. The engine is also of the four-cycle sleeve-valve type and each cylinder b^4 is provided with an outer cylindrical sleeve 25 which is operatively connected to an eccentric 26 on a valve-operating shaft 27 which is driven from the crank-shaft b^{11} in the ratio of 2 to 1. The eccentric 26 is provided with an arm 28 which is pivoted at 29 to a lug on the lower end of sleeve 25 and is adapted to reciprocate the sleeve-valve in the cylinder b^4. Each valve 25 is provided with a port 30 which is adapted to register with the air intake port b^7 and with a port 31 which is adapted to register with the exhaust port b^8 in the cylinder b^4. Each cylinder is also provided with an inner cylindrical sleeve valve 32 which is slidable in the sleeve valve 25 and is reciprocated by an eccentric 33 on the shaft 27 and an arm 34 which is fixed to said eccentric and is pivoted at 35 to a lug on the lower end of said sleeve valve 32. Each inner sleeve-valve is provided with an air port 36 which, when in registry with ports 30 and b^7, will admit air into the cylinder every fourth cycle. Each sleeve 32 is also provided with a port 37 which, during every fourth cycle of the piston, is adapted to register with the exhaust port 31 in the outer sleeve valve and an exhaust port b^8. Each cylinder head c comprises a cylindrical wall c' extending longitudinally of and into the working cylinder b^4 and the sleeve valves 25 and 32 slide between said wall and said cylinder. Each cylinder head comprises an inwardly extending wall c^5 which is inclined inwardly and upwardly and formed with an opening c^6. A combustion-chamber c^7 is formed in the opening c^6 and the wall around the chamber is extended upwardly to form a cylindrical portion c^{13}. The piston b^{13} has a tip c^{15} adapted to enter the combustion-chamber. The top closure for the water jacket b^6, which is common to all of the cylinders, is formed by a head E which is fitted to the top of the cylinder casting to form a water-space e around the cylinder-head and the combustion-chamber. The combustion-

chamber and cylinder head illustrated are more fully set forth in an application filed by me of even date herewith (Case B), Serial No. 18,381, to which reference may be had for a more detailed description.

An injector D is removably mounted in the cylindrical extension c^{13} of each cylinder head C. This injector comprises a valve d^2 which is adapted to be opened by the pressure of the fuel in the valve casing, acting against a diaphragm d^9 as more fully set forth in an application (Case A) filed by me March 26, 1925, Serial No. 18,381, to which reference may be had for a detailed description thereof. Fuel under pressure is delivered to each of the injectors from the feeding mechanism through pipes d^{22} which are connected to the injectors D.

The mechanism for feeding fuel under pressure to the cylinders of the engine constitutes a unit which is enclosed in a casing adapted to contain lubricant, so as to keep all of the working parts well lubricated and which may be connected as a unitary structure to the engine. This mechanism comprises a series of pumps and a series of metering valves, both annularly arranged around the axis of coaxial drive shafts, the pumps and metering valves operating longitudinally of the shaft or vertically, the several mechanisms being arranged in vertical series. The casing for enclosing the fuel feeding mechanism and the gearing for driving it comprises a horizontally extending hollow base-member g' which is bolted at g^2 to the crank-case of the engine and is provided with an upwardly extending integral cylindrical member g^3; a hemispherical section g^4, which is bolted to the top of member g^3 and in which the rotatable crank or wobble ring for operating the pumps is disposed; a cylindrical section g^5, in which the pitmen for operating the fuel pumps are contained, and which is bolted to the section g^4; a section g^6 in the lower portion of which the fuel pumps are disposed and which is bolted to the top of section g^5; and a cover g^7, which is removably secured on the top section g^6 to provide access to the mechanism for operating the metering valves which are disposed in the upper portion of section g^6.

A shaft H, centrally and vertically disposed in the casing members g^3 and g^4, is adapted to drive the fuel pumps. This shaft is journalled in a ball-bearing h^4 which is suitably mounted in the lower portion of the casing section g^4 and in a ball-bearing which is suitably mounted in the bottom wall g^8 of the casing section g^5.

The drive shaft H is connected to be driven by suitable gearing from the crank-shaft of the engine. Said gearing comprises a shaft H′ which is coaxial with and is disposed beneath the shaft H and is journalled in ball bearings 85 which are mounted in the casing member g^3; a horizontal shaft H^2 which is geared to the lower end of shaft H′; and suitable gearing between shaft H^2 and the cam shaft 27 of the engine, such, for example, as that described and illustrated in an application filed by me May 28, 1925, Serial No. 32,550. This gearing drives the shaft H′ in synchronism with the engine.

The driving connection between shafts H′ and H comprises a helically grooved portion h^{16} on shaft H′ and a correspondingly grooved or ribbed sleeve h^{17} interfitting with portion h^{16}. The upper end of sleeve h^{17} is slidably feathered to the lower end of shaft H. By adjusting the sleeve h^{17} axially, the relation between shafts H′ and H will be varied to correspondingly vary the timing of the fuel feeding mechanism as an entity with respect to the crank movements of the engine. Mechanism for controlling and shifting the sleeve h^{17} to vary the timing of the shaft H relatively to the shaft H′ comprises a rock-shaft 90 which is mounted in the casing section g^3 and is suitably connected to any conveniently accessible point for manipulation by the operator; and a forked arm 93, which is fixedly clamped to the shaft 90 and is suitably connected to raise and lower a collar 97 which extends loosely around the helically ribbed sleeve h^{17}. Ball bearings 98 and 99 are interposed between the non-rotatable collar 97 and the rotating sleeve h^{17} and are suitably held on said sleeve. By shifting arm 93, the driving sleeve h^{17} will be shifted longitudinally of the shafts H and H′ and the helical interfitting connection between the sleeve and shaft H′ will rotate the shaft H relatively to shaft H′ and correspondingly advance or retard the shaft H and the fuel feeding mechanism operated thereby relatively to the crank movements of the engine.

Fuel pumps I, one for each working cylinder of the engine are annularly arranged around the drive-shaft H. Each pump (Fig. 4) comprises a piston or plunger I′ fitting in a cylinder I^2 which is formed in the casing section g^6. Each plunger operates through packings i in a cylindrical recess i^2. A ring i^3 is interposed between these packing rings. A sleeve i^5 which extends around plunger I′ and fits in a cylindrical seat which is formed in the wall around the pump and is arranged concentrically with cylinder I^2, is forced upwardly to spread the packing rings and keep them pressed against the pump plunger. A spring i^7 is interposed between a shoulder on sleeve i^5 and an adjustable retaining ring i^8, which is screw-threaded to the casing member g^6 to force the sleeve i^5 upwardly to spread the packing rings. Sleeve i^5 is accurately confined against transverse displacement, so that the pump piston I′ will be truly and freely guided therein. A washer is disposed above the packing ring i and is per-

forated so that any fuel which may be forced around the plunger I′ will pass to the core of the upper packing ring *i* so as to assist in spreading the packing ring to keep it tight.

The mechanism for successively operating the fuel pumps comprises a hub L which is keyed to the shaft H and has its axis inclined relatively to the axis of said shaft to wobble the ring L′ in which the hub is rotatable. Ball bearings *l*, *l′* are provided between said hub and said ring. A gear L^2 which is fixed to ring L′, has teeth which mesh with teeth l^3 which are integrally formed on the lower end of casing section g^5 and are disposed inside of the casing-section g^4. The hub L during its rotation causes the gear L^2 to wobble and the rolling tooth connection between gear L^2 and teeth l^3 retains the ring against rotation, so that the pump-operating studs l^4, which are fixed in the ring, will be reciprocated in rotative succession. Each stud l^4 extends through gear L^2 and ring L′ and is secured therein by nuts l^5. At its upper end, each stud is provided with a ball l^6 which is adapted to operate a pitman l^7 which is connected to the lower end of one of the pump plungers I′. Each pitman is provided with a ball-socket at either end for connection to the balls on the pistons and plungers respectively. Each pitman comprises an inner bearing member l^8, which is provided at each end with an outwardly facing semi-spherical socket l^9, in which the balls l^6 and l^{10} are respectively seated and a coacting retaining ring l^{11} for holding each of said balls in its socket in the pitman. An adjusting sleeve l^{12} is threaded to the casing of each pitman to hold the bearing-members together and to retain the ball therein. Laminated washers l^{14} are interposed between bearing members l^8 and members l^{11} respectively to facilitate and aid in quick and accurate adjustment of the bearings. The outer ends of the pitmen are enlarged to enclose the bearing members for each ball.

In operation, the wobbling movement imparted to ring L′, while the shaft H is rotating, will operate the studs l^4 to reciprocate the pitmen l^7 in rotative and equally timed succession to reciprocate the pump pistons I′. The ball-and-socket joints between the pitmen and the pistons and the studs l^4 permit universal movement of the pitmen which is necessary for the free operation of the pump pistons by the studs on the wobble ring.

An annular lubricating oil chamber M is formed in the casing section g^6, to which oil under pressure is supplied by a pipe *m* from the customary engine-operated oil pump M^2 in the crank casing and which may be of any suitable construction as well understood in the art. Sleeves i^5 extend vertically through the chamber M and are provided with radial ducts *m′* to deliver oil from chamber M to the pump pistons I′. Annular grooves m^2 are formed in the peripheries of said pistons to feed oil longitudinally thereof to their bearings in sleeves i^5. Longitudinal ducts m^3 in sleeves i^5 deliver lubricating oil under pressure to the lower of each pair of packing rings *i* to aid in keeping them expanded. A port m^5 extends longitudinally through each pump piston I′ and has its upper end closed by a screw or other suitable closure m^6. A cross-duct m^7 delivers oil from port *m′* to the port m^5. The oil entering port m^5 is forced downwardly out of the lower end of ball l^{10} on the pump piston to deliver oil to the ball-bearing, of which the ball forms a part. A duct m^8 extends longitudinally through bearing member l^8 in each pitman l^7 to conduct oil from the upper ball-bearing to the lower bearing around ball l^6. This construction exemplifies one in which provision is made for efficiently lubricating the pump pistons and the mechanism for operating them.

A metering device K is associated with each fuel pump to control the volume and time of injection of the fuel charges into the combustion chamber. Each pump is provided with a discharge duct d^{23} which leads to a check-valve 106 in a plug d^{24}, to which is connected to a pipe d^{22} which is inclined downwardly and connected to one of the injectors which deliver the fuel into the combustion chambers. Each metering device controls the volume of the injected charge by the period during which it remains closed to render its associated fuel pump operating during its compression stroke to force fuel through the pipe d^{22} to one of the injectors. Each metering device comprises a valve k^2 adapted to fit and close a seat *k′* which is formed in the upper end of its associated pump cylinder; a stem k^3 for said valve; a sleeve and head k^4 in which the stem is slidably mounted; a ring 107 held in a cross-wall of the casing section g^6 and in which the head k^4 is removably secured by screws k^{91}; a head k^7 on the lower end of the valve stem; and a metallic bellows k^{10}, which has its ends respectively attached to head k^7 and ring 107. Head k^7 is clamped against a shoulder on the valve stem k^3 by a nut k^{70}. A spring k^6 is interposed between heads k^4 and k^7 to close the valve during the injection period. A sheath 111, the purpose of which is to limit the expansion of spring k^6 when the metering valve unit is removed so that undue expansion of the metallic bellows k^{10} is prevented, extends around the metallic bellows; is secured to the lower end of ring 107, extends to the lower end of the fuel supply chamber 103 and is provided with holes 110 to permit fuel to flow from the fuel reservoir or chamber 103 which is common to all of the metering devices. A pipe 103′ supplies fuel to the chamber 103. An overflow pipe 104 is connected to said chamber to return any excess above a

predetermined volume of fuel back to the supply reservoir. The injection of fuel occurs on the compression stroke of plunger I' and while the metering valve k^2 is momentarily closed and any excess fuel from the pumps is forced back into the chamber 103 while the valve is open, while on the other hand fuel is admitted to the pump cylinders through this valve during the suction stroke of the plunger I'.

The mechanism for operating the metering valves in rotative succession to control the volume of the fuel injections into the combustion chambers respectively comprises a three part cam, one part of which is rotatably adjustable relatively to the other two, to vary the duration of the closed periods of the valve and consequently the volume of fuel delivered to the injectors by the fuel pumps during each pressure stroke of the pump pistons. This mechanism is driven from a shaft H^4, which is coaxial with and driven by the shaft H, so that accurate synchronism is attained between the pumps and the metering devices. Normally, the cam mechanism is designed to keep open the metering valve k^2, so that the pumps will be inoperative to deliver fuel through pipes d^{22} to the injectors until the adjustable member of the cam has been shifted to cause the closing of the metering valves for sufficient periods to cause the pumps to force liquid fuel in substantially solid compression to the injectors.

This cam structure comprises a lower member o', an upper member o^2 and a central member o, which is rotatably adjustable relatively to members o', o^2. Each of these cams is provided with a concentric circular portion o^5 (Fig. 9) and a depression o^4, which, when they are longitudinally in registration, are congruent and will provide the maximum closure of the metering valves and cause the maximum volume to be delivered to the injectors. In its normal position, the central member o will be positioned to render the periphery of the cam structure circular, so that the metering valves will not be closed until the cam member o is rotatably adjusted. As said member o is rotatably adjusted relatively to members o' and o^2, the period during which the metering valves will remain closed will be lengthened. Cam member o' is formed with a longitudinally extending hub or sleeve o^{60} which extends downwardly and is journalled in a bushing o^{62} which is confined in a hub o^{61} integrally formed with the casing section g^6. Sleeve o^{60} is internally ribbed and grooved correspondingly to the shaft H^4 to form a feathered connection which permits said shaft to slide longitudinally in said sleeve which the shaft is rotating. Cam member o^2 is provided with an upwardly projecting hub o^9, which has its upper end journalled in a bushing o^{15} in a head o^{10} which is removably secured by bolts o^{11} to the hub o^{12} of a supporting spider which is composed of arms o^{13} and an outer ring o^{14} fitting in the upper portion of said casing section g^6. Hub o^9 of cam-member o^2 is ribbed and grooved to interfit with the upper end portion o^{20} of the shaft H^4. Cam members o' and o^2 are secured together by bolts o^{19}, which extend through arcuate slots in the cam member o, to permit the latter to be rotatively adjusted relatively to members o' and o^2.

Shaft H^4 is driven from shaft H by a sleeve r which is pinned at r' to the lower end of shaft H^4 and has a sliding rib and groove connection with the upper end of shaft H. The cam members are held against axial movement or longitudinally thrust by ball-bearings 115 and 116. Shaft H^4 is provided with a helically grooved and ribbed portion h^7 which interfits with corresponding ribs and grooves in the hub o^8 of cam o which is confined against longitudinal movement between the cam members o' and o^2. Axial movement of the shaft H^4 relatively to the cam members will effect a rotative adjustment of cam member o relatively to members o', o^2, thus shortening or lengthening the effective length of the depressions o^4 in the cam structure to correspondingly vary the duration of the period in which the metering valves will be closed.

The mechanism for shifting shaft H^4 longitudinally to adjust cam o relatively to cam members o', o^2, comprises a forked arm r^8 which straddles one of the fuel pumps and is fixed to a rock shaft r^9. Links r^{10} are pivoted to arm r^8 and to a collar r^{11}, which encircles the sleeve r and is adapted to shift the sleeve longitudinally on shaft H while the said shaft is in rotation. An upper thrust-bearing r^{12} and a lower thrust-bearing r^{13} are interposed between the sleeve r and collar r^{11} and are suitably mounted on the sleeve. A sleeve r^{16} is slidable on sleeve r to hold the bearing members in operative relation and a nut r^{17} is threaded to said sleeve to lock the sleeve r^{16} in its desired position. Rock shaft r^9 extends across a chamber r^{18} which is formed in the casing section g^6. The outer end of this chamber is enclosed by a removable head r^{19} to provide access to the shifting mechanism for the shaft H^4 when desired. Shaft r^9 is extended to the outside of the casing and a grooved collar 125 (Figs. 5 and 6) is slidably feathered to said shaft. The inner face of this collar is provided with teeth 126 which are adapted to engage teeth 127 on the hub 128, which is loosely mounted on said shaft and is integrally formed with an arm 129. The latter is connected by a rod 130 which is suitably connected to any convenient point within the reach of the operator. When collar 125 is coupled to the arm 129, the operation of rod 135 will cause shaft r^9 to be rocked to raise or lower the shaft H^4

to rotatably adjust the cam member o relatively to cam members o', o^2.

Shifting devices of like construction for actuating the metering valves respectively are arranged in annular series in the upper portion of the casing-section g^6. Each comprises a vertically swinging lever p which is pivoted on a pin p^3 which is supported in lugs p^4. The latter are formed on the head k^4 of the metering unit with which the lever p is associated. Lever p comprises a horizontally extending arm p' which encircles the stem of the metering valve and is adapted to engage a head or abutment p^2 on the upper end of the metering valve stem k^3. A spring p^5 which is disposed between lever arm p' and the head k^4 of the metering unit, presses said arm upwardly to hold it in engagement with the abutment p^2. Lever p also comprises an upwardly extending arm p^6 which carries an adjustable abutment-screw p^{60}. Each lever p is operated by a horizontally swinging arm p^7, which is pivoted on a pin p^8 adjacent the outer margin of casing-section g^6 and carries, at its distal end, a roller p^9, which is pulled into contact with the members of the cam structure by a spring p^{10} which has its inner end hooked to a lug p^{11}. The arm p^7 is provided with an abutment p^{13} which is adapted to engage the abutment-screw p^{60} to rock the lever p vertically to open the metering valve. Said spring serves to hold the arm p^7 so that its roller p^9 will remain in engagement with the cam structures o', o^2.

In operation, the rotation of said cam structure will operate the metering valves in rotative succession, according to the operative length of the depressions o^4, resulting from the adjustment of cam-member o relatively to the members o', o^2. The depression will permit the arms p^7 to be operated inwardly in rotative succession by springs p^{10} and k^6. The levers p will thereupon swing inwardly and downwardly and release the metering valve stems, so that the metering valves will be closed by their springs k^6. While the rollers p^9 are riding on the circular portion of the cam structure, lever arms p' will hold the metering valve stems raised, so that the valves will remain open to prevent the pumping of the fuel to the injectors, and to allow the fuel to flow into the pump cylinders during the suction stroke of the pump. The force of springs k^6 determines the pressure at which the fuel will be pumped to the injector.

The casing sections, containing the metering valve operating mechanism, are adapted to contain lubricant to keep all of the operating parts thoroughly lubricated. Lubricating oil is conducted from chamber M by ducts m^{10}, m^{20}, and the grooves in the bushing o^{62}, (Fig. 3) into the chamber containing the mechanism for operating the metering valves. Ducts 109 in the metering valve heads k^4 deliver oil from said chamber into the metallic bellows k^{10} to lubricate the stem k^3. Annular oil distributing grooves 113 are formed in the periphery of the valve-stems k^3. The pins p^{14}, on which rollers p^9 are journalled, are each provided with a vertical opening p^{15} extending therethrough and a cross-port p^{16} to lubricate the bearing for the roller. The duct m^{20} delivers oil from duct m^{10} to a channel m^{21} to lubricate the bearing between cam-sleeve o^{60} and the bushing o^{62}. A duct 200, in the upper end of which a tube 201 is secured, is adapted to drain the oil above the level of the tube from the chamber in the upper portion of casing section g^6 into the chambers in the lower portions of the casing to lubricate all other parts in the casing.

The invention contemplates rendering the engine inoperative when the pressure of lubricating oil, pumped by the engine, is less than a predetermined degree, to insure proper lubrication of the engine and fuel feeding mechanism. For this purpose, an automatic pressure control device is provided which is controlled by the pressure of oil in the lubricating system, by which collar 125 will be uncoupled from arm 129, so that it will be impossible for the operator to shift the shaft H^4 to adjust cam-member o into position to cause the metering valves to be closed. Arm 136 (Figs. 5 and 6) has its outer end confined in a groove in collar 125 which is slidably feathered to shaft r^9. A torsional spring 139 is applied to normally press arm 136 into position to disconnect collar 125 from arm 129. Arm 136 is fixed to a rock-shaft 137, which is journalled in lugs 138 and an arm 140 carrying an abutment-screw 141 is fixed to shaft 137.

The pressure control device s, which is controlled by the pressure of the lubricating oil, comprises a casing s' (Fig. 3) which is secured to the casing-section g^6 by bolts s^2; a stem s^3 which is adapted to engage the adjustable abutment 141 on the arm 140, which is fixed to shaft 137; a metallic bellows s^6, which is secured to a shell s^7 and to a head s^8 in the casing s'; and a duct s^9, by which oil under pressure will pass from duct m^{10} into the metallic bellows. Shell s^7 is secured to the upper end of stem s^3, so that when the oil pumped through annular chamber M in the feed mechanism casing and into the metallic bellows is of sufficient pressure it will force the stem s^3 downwardly against abutment 141, thereby turning arm 140, shaft 137 and arm 136 and coupling the collar 125 to the arm 129. A spring s^{13} is interposed between the shell s^7 and the casing to contract the metallic bellows when the pressure of the oil therein falls below a predetermined point. The casing s' comprises a head s^{14} which is removably secured in place so as to provide

access to the metallic bellows when desired. Bolts s^2 secure the casing s' to the casing section g^6.

Normally, when the collar 125 is uncoupled from arm 129, the cam-member o will be in its normal position so as to close the depression in the cam structure, so that the metering valves will all be kept open. If the pressure of the oil in the metallic bellows s^6 from the lubricating oil pumping system of the engine is sufficient to overcome the force of the spring s^{13}, it will operate the stem s^3 to rock arm 140, shaft 137 and arm 136 to shift collar 125 into coupled relation with the arm 129, so that the operator can then adjust the cam-member o, to cause the metering valves to be opened in rotative succession and in synchronism with the motor. If at any time the pressure in the lubricating system should fail, the spring s^{13} will lift stem s^3 the torsional spring 139 will turn shaft 137 and arm 136, thereby uncoupling the collar 125 from arm 129, so that the cam-member o will be free to return to its normal position and rendered non-adjustable by the operator.

The invention exemplifies improved fuel feed mechanism for engines of the fuel injection type in which provision is made for automatically rendering the engine inoperative if the pressure of the lubricating oil falls below a predetermined minimum; also one in which provision is made for lubricating all parts of the fuel feed mechanism including the pumps and the metering valves; also one in which provision is made for efficiently lubricating the mechanism for operating an annular series of fuel pumps.

The invention is not to be understood as restricted to the details set forth, since these may be modified within the scope of the appended claims, without departing from the spirit and scope of the invention.

Having thus described the invention, what I claim as new and desire to secure by Letters Patent, is:

1. The combination of an enclosing casing adapted to contain lubricant, fuel pumps in said casing, metering devices in said casing, mechanism for operating said devices in said casing, means for delivering lubricant under pressure to said casing to lubricate the parts therein, and means for rendering the pumps ineffective to deliver fuel when the pressure of the lubricant in the casing falls below a predetermined degree.

2. The combination of an enclosing casing adapted to contain lubricant, fuel pumps in said casing, mechanism for operating the pumps in said casing, metering devices in said casing, mechanism for operating said devices in said casing, means for delivering lubricant under pressure to said casing to lubricate the parts therein, and means for rendering the pumps ineffective to deliver fuel when the pressure of the lubricant in the casing falls below a predetermined degree.

3. The combination of an enclosing casing adapted to contain lubricant, fuel pumps in said casing, mechanism for operating the pumps in said casing, metering devices in said casing, means for delivering lubricant to said casing to lubricate the parts therein, and mechanism for operating said devices controlled by the pressure of the lubricant in the casing.

4. The combination with an engine of the fuel injection type, of a casing adapted to contain lubricant, mechanism in said casing for delivering fuel under pressure to the engine, comprising a pump, mechanism for supplying lubricant to said casing to lubricate the pump, and means to render the pump ineffective when the pressure of the lubricant falls below a predetermined degree.

5. The combination with an engine of the fuel injection type, of a casing adapted to contain lubricant, mechanism for delivering fuel under pressure to the engine comprising a pump and a metering device to render the pump effective to deliver fuel, mechanism for supplying lubricant to said casing, and means to keep the device open to render the pump ineffective when the pressure of the lubricant falls below a predetermined degree.

6. In mechanism for feeding fuel to a multi-cylinder engine, the combination of an enclosing and supporting casing adapted to contain lubricant, a drive-shaft longitudinally disposed therein, a series of fuel pumps annularly arranged around the axis of the shaft, mechanism for operating said fuel pumps, metering devices in the casing, mechanism driven by said shaft for operating the metering devices, means for delivering lubricant into the casing to lubricate the parts therein, and means operated by the lubricant for rendering the pumps ineffective to deliver fuel.

7. In mechanism for feeding fuel to a multi-cylinder engine, the combination of an enclosing and supporting casing adapted to contain lubricant, a drive shaft longitudinally disposed therein, fuel pumps annularly arranged around the axis of the shaft, mechanism for operating said fuel pumps, metering devices in the casing, mechanism driven by said shaft for operating the metering devices, means for delivering lubricant into the casing to lubricate the parts therein, and means operated by the pressure of the lubricant in the casing to automatically open the metering devices to prevent delivery of fuel.

8. In mechanism for feeding fuel to a multi-cylinder engine, the combination of an enclosing and supporting casing adapted to contain lubricant, a drive shaft longitudinally disposed therein, a series of fuel pumps annularly arranged around the axis of the shaft, mechanism for operating said fuel

pumps, timing mechanism through which said shaft is driven mounted in the casing, metering devices in the casing, mechanism driven by said shaft for operating the metering devices, means for delivering lubricant into the casing to lubricate the parts therein, and means operated by the lubricant for rendering the pumps ineffective to deliver fuel.

9. In mechanism for feeding fuel to a multi-cylinder engine, the combination of an enclosing and supporting casing adapted to contain lubricant, a drive shaft longitudinally disposed therein, a series of fuel pumps annularly arranged around the axis of the shaft, mechanism for operating said fuel pumps, timing mechanism through which said shaft is driven mounted in the casing, metering devices in the casing, mechanism driven by said shaft for operating the metering devices, means for delivering lubricant into the casing to lubricate the parts therein, and means operated by the lubricant for controlling the metering devices to render the pumps ineffective to deliver fuel.

10. In mechanism for feeding fuel to a multi-cylinder engine, the combination of an enclosing and supporting casing adapted to contain lubricant, a drive shaft longitudinally disposed therein, a series of fuel pumps annularly arranged around the axis of the shaft, mechanism in the casing and driven by the shaft for operating said fuel pumps, timing mechanism through which said shaft is driven mounted in the casing, metering devices in the casing, mechanism driven by said shaft for operating the metering devices, means for delivering lubricant into the casing to lubricate the parts therein, and means operated by the lubricant controlling the metering devices.

11. The combination of a casing adapted to contain lubricant, a pump for delivering fuel under pressure to the engine, a metering device for controlling the delivery of fuel to the engine, mechanism for controlling the metering device to vary the charges of fuel, means for supplying lubricant under pressure to the casing to lubricate the mechanisms therein, and means operable by the lubricant whereby the controlling mechanism will be rendered inoperative.

12. The combination of a casing adapted to contain lubricant, a pump for delivering fuel under pressure to the engine, a metering device for controlling the delivery of fuel to the engine, manually shiftable mechanism for controlling the metering device to vary the charges of fuel, means for supplying lubricant under pressure to the casing to lubricate the mechanisms therein, and means operable by the lubricant to render the control mechanism inoperative.

13. The combination of a casing adapted to contain lubricant, a pump for delivering fuel under pressure to the engine, a metering device for controlling the delivery of fuel to the engine, mechanism for controlling the metering device to vary the charges of fuel comprising a clutch, means for supplying lubricant under pressure to the casing to lubricate the mechanisms therein, and means operable by the lubricant for uncoupling the clutch.

14. The combination of a casing adapted to contain lubricant, a pump for delivering fuel under pressure to the engine, a metering device for controlling the delivery of fuel to the engine, mechanism comprising a cam for controlling the metering devices to vary the charges of fuel, means for supplying lubricant under pressure to the casing to lubricate the mechanism therein, and means operable by the lubricant for controlling the operation of the cam.

15. In mechanism for feeding fuel to a multi-cylinder engine of the injection type, the combination of a supporting casing adapted to contain lubricant, a drive shaft longitudinally disposed therein, a series of reciprocating pumps annularly arranged in the casing, mechanism enclosed in the casing for operating the pumps, metering devices in the casing, means driven by the shaft comprising a member coaxial therewith for operating the metering devices, a lubricant chamber in the casing, means for delivering lubricant under pressure to said chamber, means for delivering fuel from the chamber to the pumps, means for delivering lubricant from said chamber to the mechanism for operating the metering devices and to the mechanism for operating the pumps.

16. In mechanism for feeding fuel to a multi-cylinder engine of the injection type, the combination of a supporting casing adapted to contain lubricant, a drive shaft longitudinally disposed therein, a series of reciprocating pumps annularly arranged in the casing, mechanism enclosed in the casing for operating the pumps, metering devices in the casing, means driven by the shaft comprising a member coaxial therewith for operating the metering devices, a lubricant chamber in the casing, means for delivering lubricant under pressure to said chamber, means for delivering fuel from the chamber to the pumps, means for delivering lubricant from said chamber to the metering devices and the mechanism for operating them.

17. The combination of an enclosing casing adapted to contain lubricant, pumps in the casing for delivering fuel under pressure to the engine, mechanism in the casing for operating the pumps, metering devices in the casing, mechanism in the casing for operating the metering devices, means for manually controlling the operation of the metering devices by their operating mechanism, means for delivering lubricant under pressure to the casing, and means to render the

manual control ineffective when the pressure of the lubricant falls below a predetermined point.

18. The combination of an enclosing casing adapted to contain lubricant, pumps in the casing for delivering fuel under pressure to the engine, mechanism in the casing for operating the pumps, metering devices, mechanism in the casing for operating the metering devices comprising an adjustable cam, means for manually controlling the cam, means for delivering lubricant under pressure to the casing, and means to render the cam inoperative when the pressure of the lubricant falls below a predetermined point.

19. In mechanism for feeding fuel to engines, the combination of a casing adapted to contain lubricant, a reciprocating pump comprising a piston and cylinder, a lubricant chamber in said casing, the piston having a longitudinally extending port therein, a lubricant duct between said chamber and the port in said piston, and mechanism for operating the pump comprising a pitman connected to the piston, the longitudinal port being connected to deliver lubricant to the bearing between the pitman and the piston.

20. In mechanism for feeding fuel to engines, the combination of an enclosing and supporting casing adapted to contain lubricant, a drive shaft longitudinally disposed therein, a series of reciprocating pumps, each comprising a piston and cylinder, a lubricant chamber in said casing, each piston having a longitudinally extending port therein, lubricant ports between said chamber and the port in said pistons, and mechanism for operating the pumps comprising pitmen connected to the pistons, the longitudinal ports being connected to deliver lubricant to the bearings between the pitmen and the pistons respectively.

21. In mechanism for feeding fuel to engines, the combination of an enclosing and supporting casing adapted to contain lubricant, a reciprocating pump comprising a piston and cylinder, a lubricant chamber in said casing, the piston having a longitudinally extending port therein, a lubricant port between said chamber and said piston to deliver lubricant to the outside of the piston, a port in the piston to deliver lubricant into the longitudinal port, and mechanism for operating the pump comprising a pitman connected to the piston, the longitudinal port being connected to deliver lubricant to the bearing between the pitman and the piston.

22. In mechanism for feeding fuel to engines, the combination of an enclosing casing provided with a chamber adapted to contain lubricant, a reciprocating fuel pump comprising a piston and a cylinder, an oil port extending longitudinally of the piston, means to deliver oil from said chamber to said port, a pitman for operating the piston having a bearing therein to which said port leads, and an operating element connected to the other end of the pitman, the latter having a longitudinal port for delivering lubricant to the bearing between the operating element and the pitman.

23. In mechanism for feeding fuel to engines, the combination of an enclosing casing provided with a chamber adapted to contain lubricant, a reciprocating fuel pump comprising a piston and a cylinder, an oil port extending longitudinally of the piston, means to deliver oil from said chamber to said port, a pitman for operating the piston having a ball-bearing between one end of the pitman and the piston to which said port leads, an operating stud and a ball-bearing between the stud and the other end of the pitman, the latter having a port between the bearings to deliver lubricant to the bearing between the stud and the pitman.

24. In mechanism for feeding fuel to engines, the combination of an enclosing casing provided with a chamber adapted to contain lubricant, an annular series of fuel pumps each comprising a piston and a cylinder, each piston having longitudinal oil ports, means to deliver oil from said chamber to said ports, pitmen for operating the pistons each having a bearing therein to which one of the ports leads, operating studs connected to the other end of the pitmen respectively, and means for conducting oil from said ports to the bearings between the pistons and the pitmen and the bearings between the studs and the pitmen.

25. In mechanism for feeding fuel to engines, the combination of a casing provided with a chamber to contain lubricant, a reciprocating pump for delivering fuel to an engine comprising a piston and a cylinder, packing rings around the piston, a spring-pressed sleeve around the piston and for compressing the packing rings and means for delivering oil from the chamber through the sleeve to the packing rings.

26. In mechanism for feeding fuel to engines, the combination of a casing provided with a chamber to contain lubricant, a reciprocating pump for delivering fuel to an engine comprising a piston and a cylinder, packing rings around the piston, a spring-pressed sleeve around the piston and for compressing the packing rings, means for delivering oil from the chamber through the sleeve to the packing rings and to the piston, a pitman for operating the piston, and means to conduct oil through the piston to the connection between the pitman and the piston.

27. The combination with an engine of the fuel injection type, of a casing, mechanism for delivering fuel under pressure to the engine comprising a pump and a metering device associated with the pump and operable to control the delivery of the fuel pumped

thereby, mechanism for supplying lubricant under pressure to said casing, and means for stopping the operation of the metering device when the pressure of the lubricant falls below a predetermined degree.

28. The combination with an engine of the fuel injection type, of a casing, mechanism for delivering fuel under pressure to the engine comprising a pump and a metering device associated with the pump, mechanism for operating said device to control the delivery of fuel pumped, mechanism for supplying lubricant under pressure to said casing, and means for rendering said second mentioned mechanism inoperative when the pressure of the lubricant falls below a predetermined degree so as to stop the operation of the metering device.

29. The combination with an engine of the fuel injection type, of a casing, mechanism for delivering fuel under pressure to the engine comprising a pump and a metering device associated therewith and operable to control the delivery of the fuel pump thereby, mechanism for supplying lubricant under pressure to said casing, and means for stopping the operation of the metering device when the pressure of the lubricant falls below a predetermined degree comprising a bellows operated by the lubricant.

30. The combination with an engine of the fuel injection type, of a casing, mechanism for delivering fuel under pressure to the engine mounted in the casing and comprising a pump and a metering device associated with the pump and operable to control the delivery of fuel pumped thereby, mechanism for supplying lubricant under pressure to said casing to lubricate the fuel delivering mechanism, and means for stopping the operation of the metering device when the pressure of the lubricant falls below a predetermined degree.

Signed at Chicago, Illinois, this 24th day of March, 1925.

AAGE E. WINCKLER.