June 9, 1936. W. F. DAVIS 2,043,529

INTERNAL COMBUSTION ENGINE

Filed Dec. 19, 1931 6 Sheets-Sheet 1

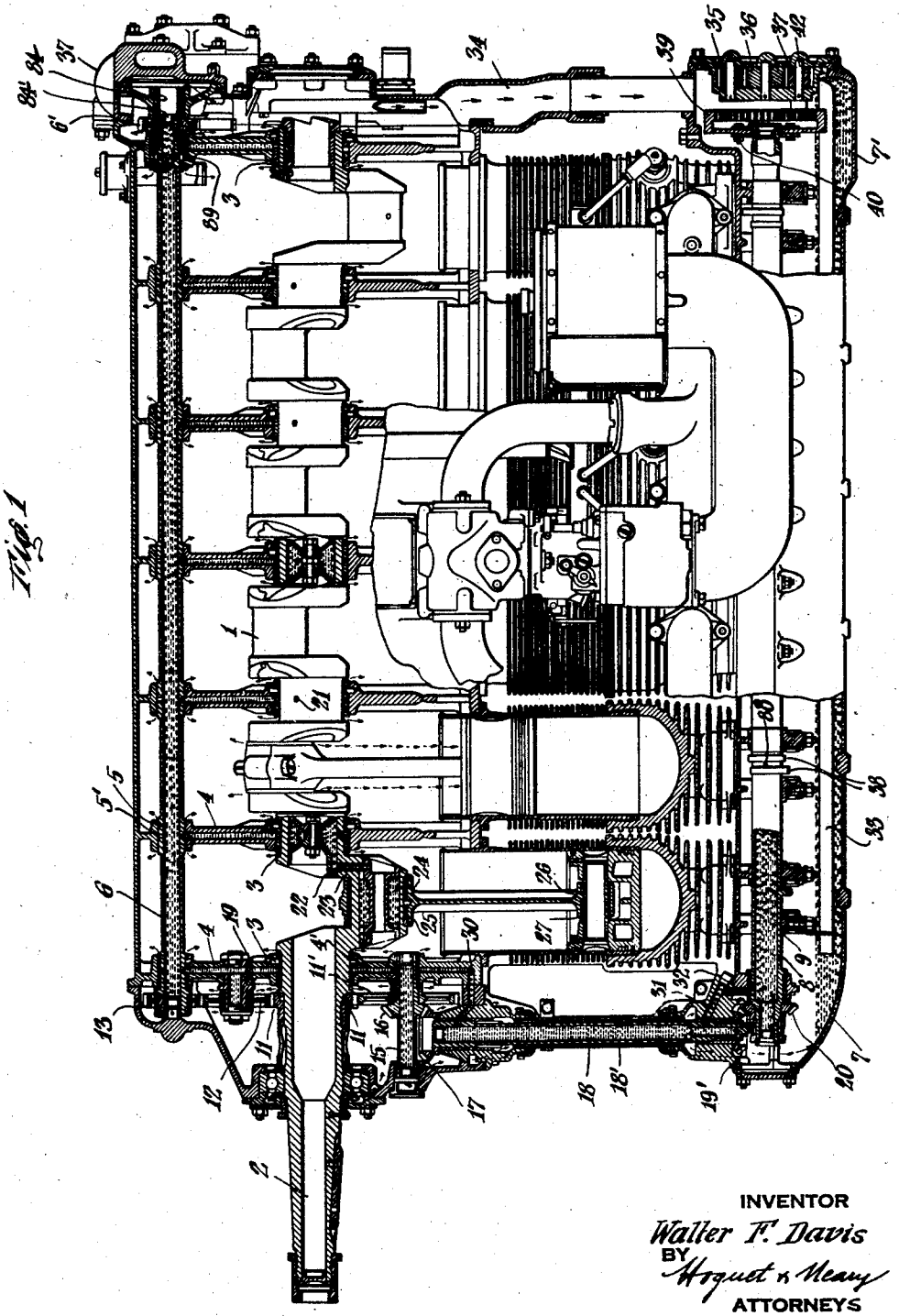


Fig. 1

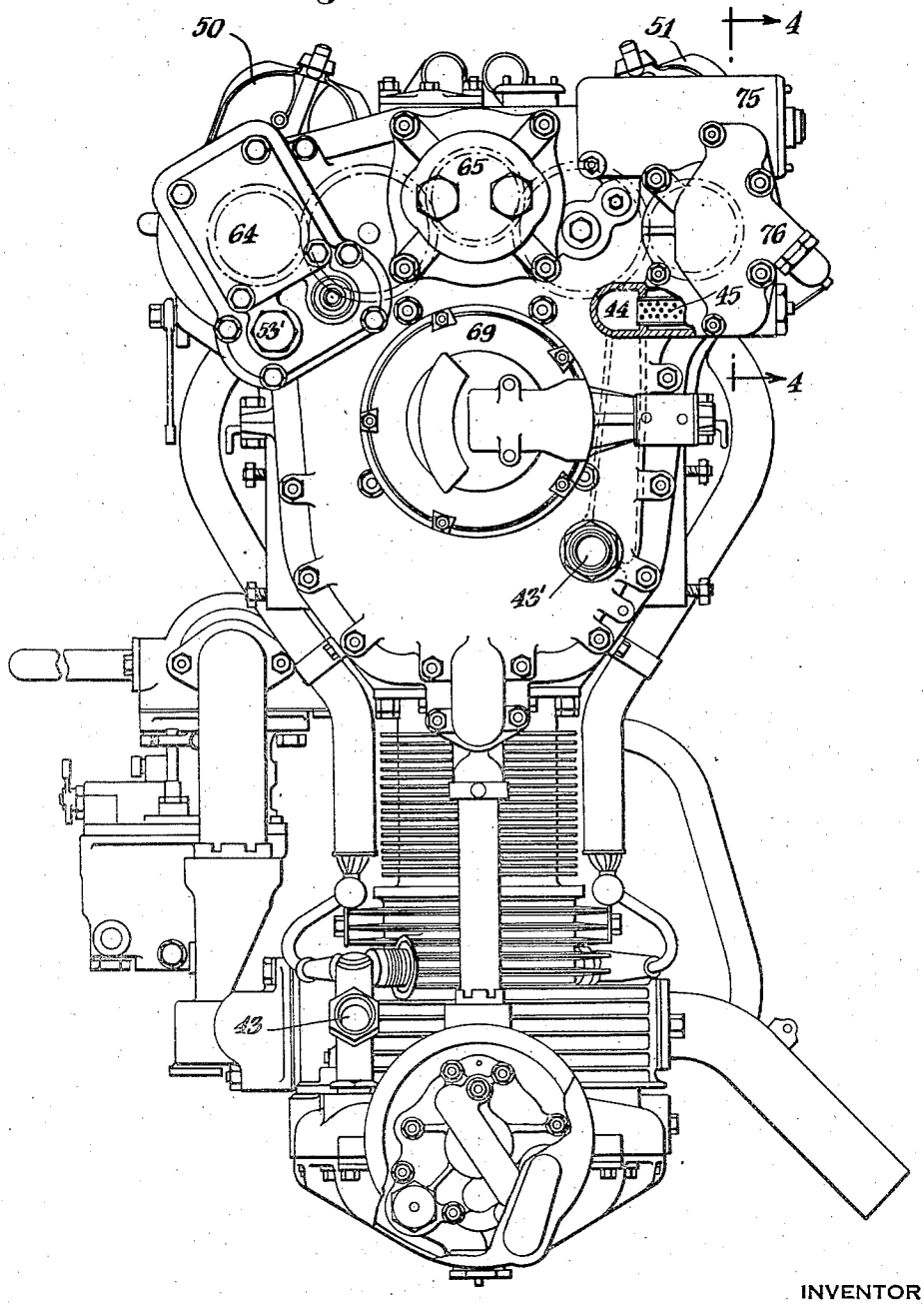
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Filed Dec. 19, 1931 6 Sheets-Sheet 2

Fig. 2.



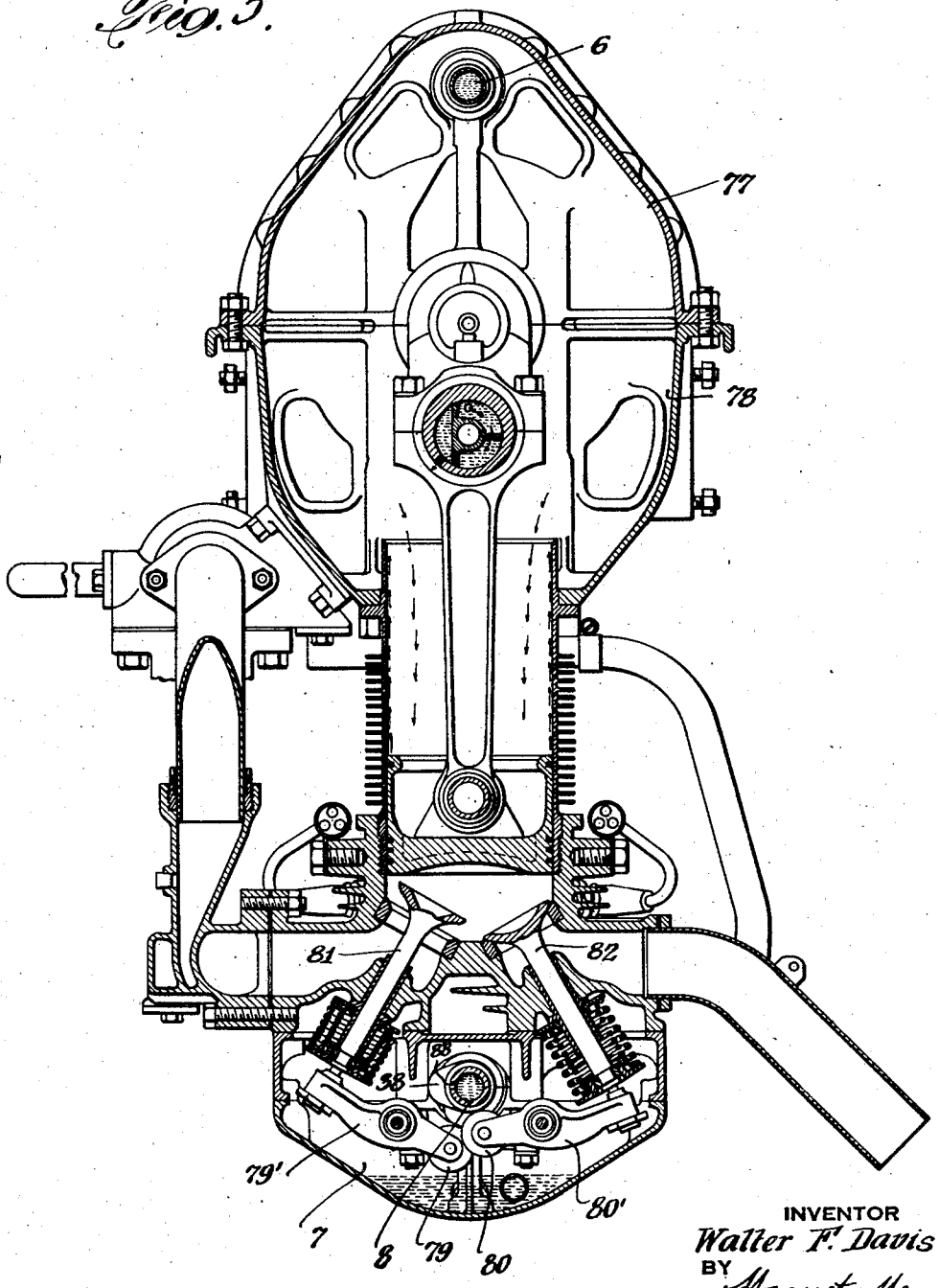
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Filed Dec. 19, 1931 6 Sheets-Sheet 3

Fig. 3.



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INTERNAL COMBUSTION ENGINE

Filed Dec. 19, 1931 6 Sheets-Sheet 4

Fig. 4

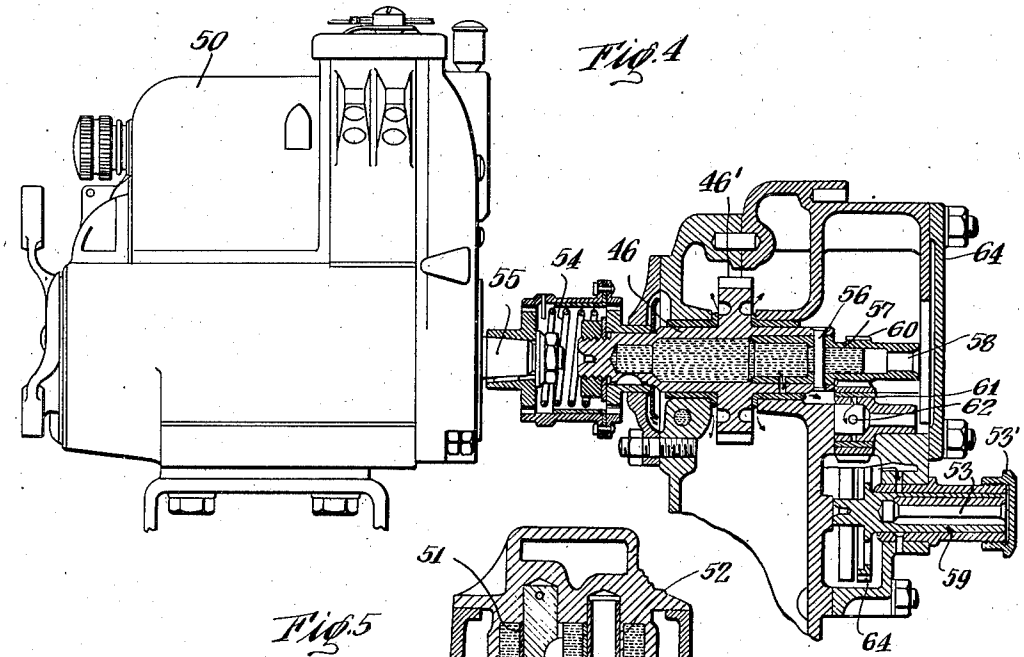


Fig. 5

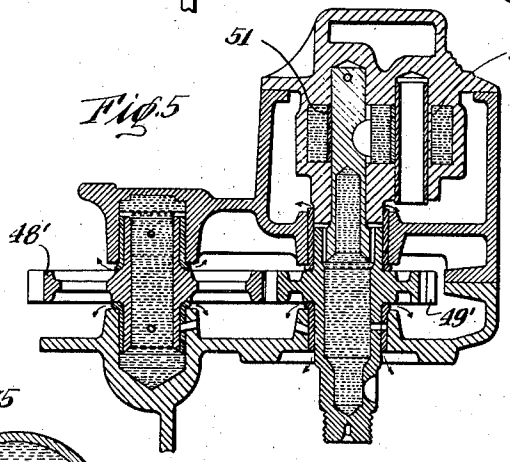
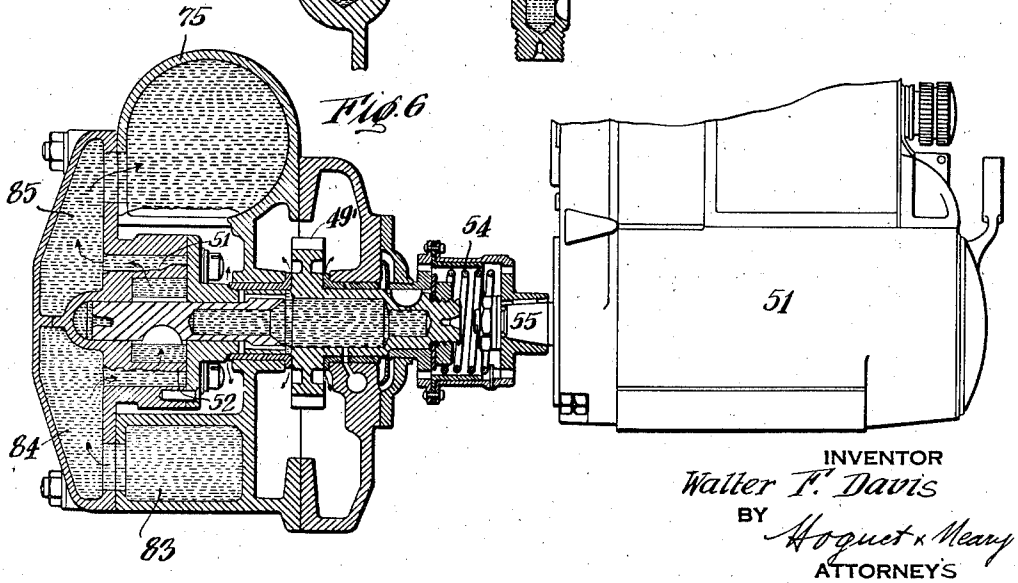


Fig. 6



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June 9, 1936. W. F. DAVIS 2,043,529

INTERNAL COMBUSTION ENGINE

Filed Dec. 19, 1931 6 Sheets-Sheet 5

Fig. 7.

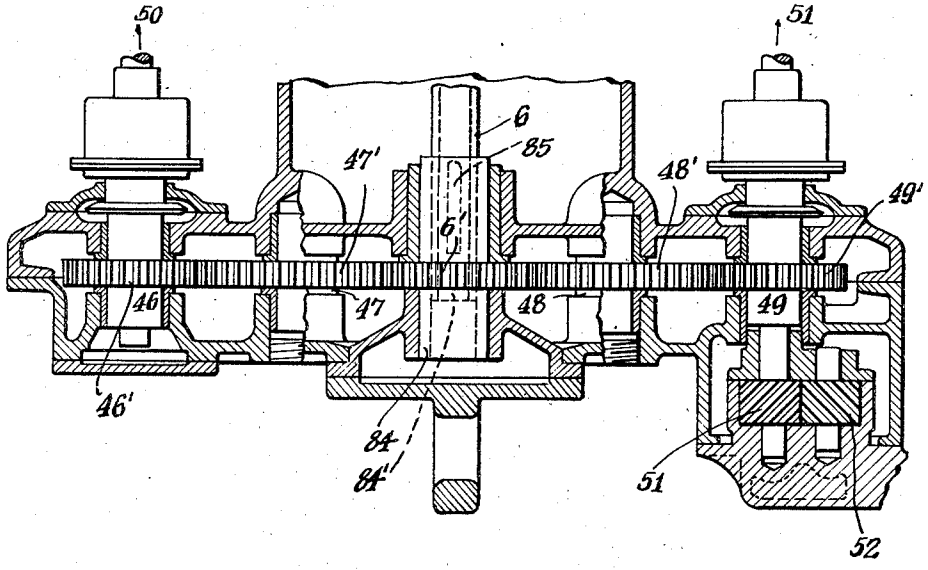
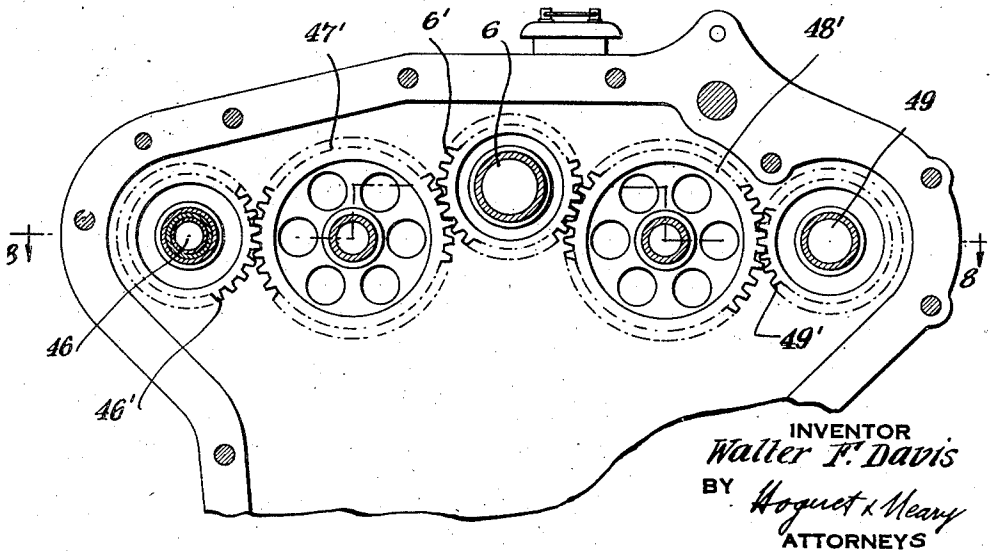


Fig. 8.



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June 9, 1936. W. F. DAVIS 2,043,529

INTERNAL COMBUSTION ENGINE

Filed Dec. 19, 1931 6 Sheets-Sheet 6

Fig. 9.

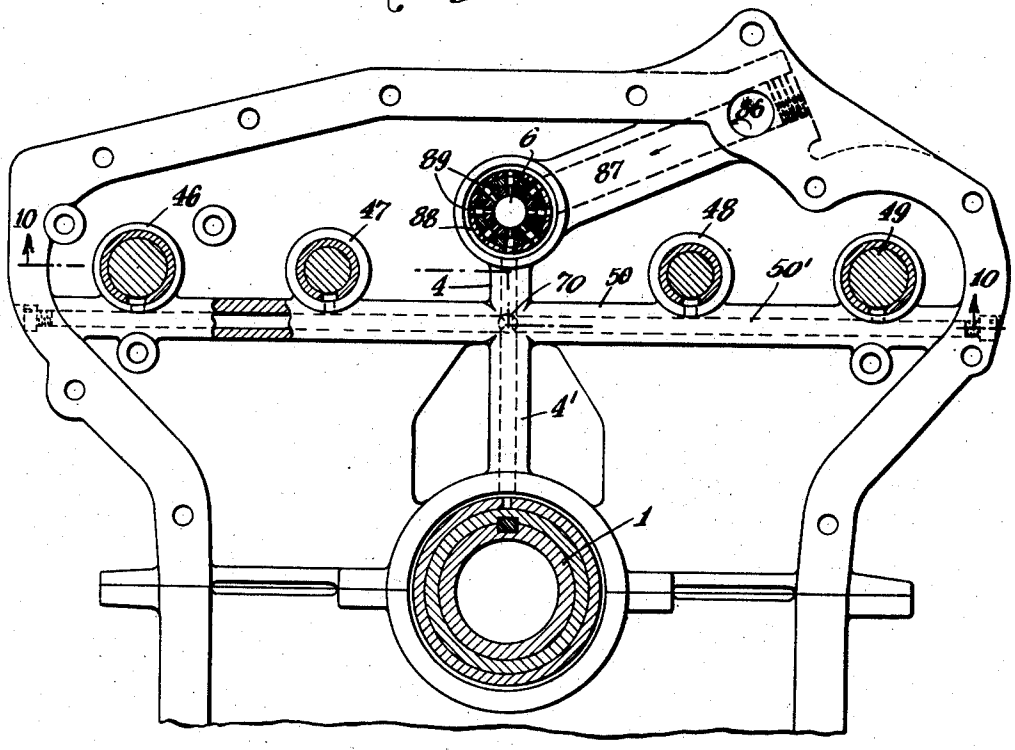
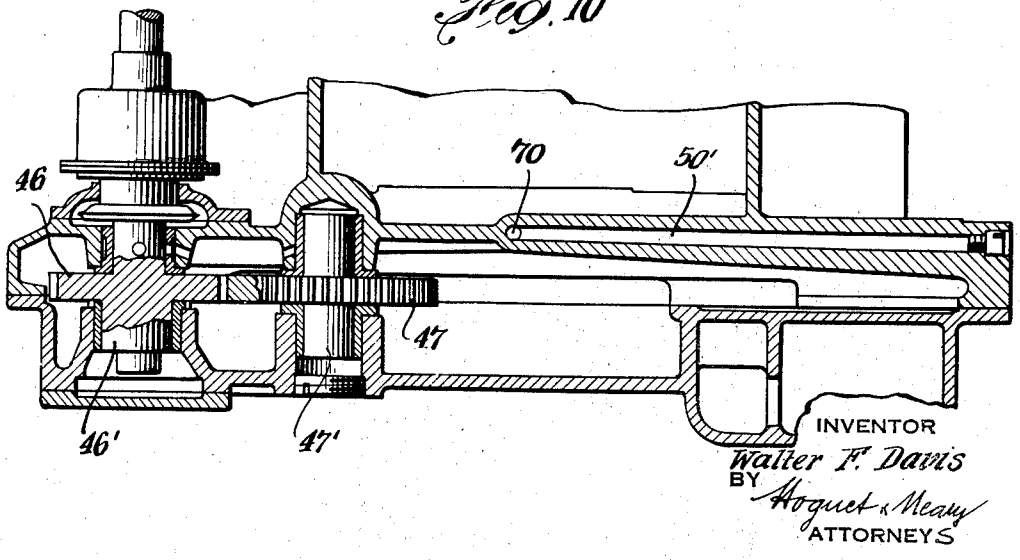


Fig. 10



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UNITED STATES PATENT OFFICE

2,043,529

INTERNAL COMBUSTION ENGINE

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Application December 19, 1931, Serial No. 582,085

12 Claims. (Cl. 184—6)

This invention relates in general to internal combustion engines and more particularly to improvements in the oiling system and in the means for driving the accessories of an engine of the multi-cylinder in-line, V or X type, wherein the crankshaft is comparatively long.

In these types of engines the crankshaft is subjected to an appreciable torsional vibration or oscillation due to periodically applied forces which result in changes in angular velocity, more particularly at the so-called critical or natural vibratory speeds of these shafts in the conventional internal combustion engine and flywheel, or in an aircraft engine where a propeller is provided on the end of the crankshaft where the engine power is absorbed. This large rotating mass runs at practically a constant angular velocity whereas the free end of the shaft is subject to the maximum torsional oscillation.

For reasons of simplicity, accessibility and compactness, and in an aircraft engine because of frontal area in streamlining, it is the usual practice to mount the accessories at the anti-flywheel or anti-propeller end. The accessory drive is then taken at the free end of the crankshaft where the maximum torsional oscillation takes place, thus subjecting the accessory drive gears and shafts and rotating masses of the accessory units to this rapid change in angular velocity with the resultant increased wear and decreased life of all of these parts.

The object of this invention is to provide a construction whereby the subjecting of the accessory units and their driving parts to torsional oscillation and consequent damage thereto may be substantially eliminated.

It is also an object of this invention to provide an inverted aircooled engine having a plurality of cylinders in line, in which engine the camshaft is located below the cylinders, and to provide a camshaft housing which will be adapted to act as an oil sump for the engine.

Another object of this invention is to provide means whereby the bottom covering of the camshaft housing may be detached whereby sumps of the wet and dry type may be interchangeable in the engine.

A further object of the invention is to provide suitable oil drains from the upper working parts of the engine into the sump wherein pump units are to be arranged for discharging from the sump the scavening oil and the oil in the hollow camshaft into an external oil tank.

A still further object of the invention is to arrange for the driving of the camshaft from the flywheel end of the crankshaft, and also for driving the accessories arranged at the anti-flywheel end of the engine through a shaft which takes its drive from the flywheel end of the crankshaft, and to provide an efficient lubrication system for all of these working parts, and to utilize the drive of the accessory drive shaft for operating a pressure oil pump for forcing the lubricant through said shaft and to the working parts of the engine.

Other general objects of the invention, particularly as far as its application to aeronautics is concerned, are to provide an aeronautical engine which is aircooled to reduce weight and which is arranged with its cylinders in line and thus cut down head resistance; to provide for full visibility for the airplane pilot; which will minimize vibration, exhaust noises, and strain on the engine and airplane parts; to provide a thoroughly reliable oiling system to the elimination of grease cups, such oiling system to include separate oil pressure and scavenging pumps; to provide for ready installation and inspection and repair or replacement of engine accessories without disturbing installation.

To this end, it is proposed to provide a flexible accessory drive shaft for driving the accessory units and to drive this shaft from the propeller or flywheel end, where the torsional oscillations are of low magnitude, and to carry the drive through this shaft to the anti-propeller end of the engine. The flexible drive shaft is thus able to absorb the remaining torsional oscillations of low magnitude imparted at the front end thereof so as to not be transmitted to the accessory units or their driving gears which are placed at the opposite end of the shaft. This provides for a very durable and superior arrangement, in that it has the advantages of lessening the shock on the gears and shafting when the throttle is suddenly opened or closed, with resultant acceleration or deceleration and high loading of the accessory driving members.

This type of drive has been found to be particularly desirable when the rotating masses in the accessory units have a fairly high inertia, as with magnetos and generators and high speed superchargers.

With the foregoing and other objects in view, the invention consists in the combination of parts and in the details of construction hereinafter set forth in the following specification and appended claims, certain embodiments thereof being illustrated in the accompanying drawings, in which:

Figure 1 is a longitudinal vertical section taken

through the engine and showing the arrangement of parts, and also showing the oil in dotted lines to represent the flow of oil in the lubricating system.

Figure 2 is a rear elevation of the engine, showing some of the accessories in rear elevation, and also a rear elevation of the cover plates for the attachment devices for other accessories.

Figure 3 is a view in vertical cross section of the engine, taken through one of the cylinders, showing the valve and valve operating mechanism.

Figure 4 is a view in side elevation of one of the magnetos, and also a view in longitudinal vertical section through the attachment and driving mechanism for a fuel pump and tachometer drive and of the lubricating system therefor.

Figure 5 is a view in section of the pressure oil pump, the idler gear, and the lubricating system therefor.

Figure 6 is a view in side elevation of one of the magnetos and a view in longitudinal vertical section of the pressure oil pump and drive therefor.

Figure 7 is a view in cross section of the rear end of the engine, showing the manner in which the accessories are driven.

Figure 8 is a view in vertical section near the rear end, showing in elevation the manner in which the magnetos are driven by the flexible accessory drive shaft.

Figure 9 is a view similar to Figure 8, showing the lubricating system.

Figure 10 is a view taken along lines 10—10 of Figure 9.

Referring more particularly to the drawings, Figure 1 shows the plurality of cylinders arranged in line and inverted position with the crankshaft 1 thereabove. The engine crank case is provided with a series of partitions 4 which provide the support for the crank shaft main bearings 3 and also a support for bearings 5 in which a flexible shaft 6 is rotatably mounted so as to be above and parallel with the crankshaft. This shaft 6 is for the purpose of driving the engine accessories which are arranged at the anti-flywheel or rear end of the engine. A camshaft 8 is arranged in parallelism with the crankshaft and accessory drive shaft and is carried in a housing 7, which also forms the oil sump of the engine. The flexible accessory drive shaft 6 and the camshaft are driven by the crankshaft and obtain their drive by means of intermediate shafts and gears, the driving force of the crankshaft being taken from the front main crankshaft bearing, at which point there is the minimum torsional oscillation.

The drive for the flexible accessory drive shaft is brought about by fitting a member 11 on the crankshaft so as to rotate a spur gear 12 mounted on a short shaft 19, which gear in turn rotates a gear 13 carried by the shaft 6. This shaft 6 extends rearwardly and forms the prime mover for all of the engine accessories, such as magnetos, generator, fuel pump, oil pressure pump, tachometers, etc.

The driving member 11 also rotates the ring gear 11' mounted on a short shaft 15, the latter also carrying a bevel gear 16 which engages a bevel gear 17 of a vertical shaft 18, causing the latter to be rotated. This vertical shaft 18 carries a gear 19' which meshes with a gear 20 carried by the camshaft, causing the rotation of the latter.

The flexible accessory drive shaft 6 has been referred to as a means for driving all of the engine accessories. This is true with the exception that the camshaft forms a means of driving a multiple oil gear pump 35, 36, 37 for forcing the scavenging oil from the sump into an external oil tank. The accessory drive shaft 6 is made flexible so as to eliminate the building up of a period of vibration or torsional oscillation. To carry out this general idea in connection with the camshaft, the latter is provided with a flywheel 39 at its rear or flywheel end, and the oil pump above referred to is driven by the camshaft through the meshing of the flywheel with the oil gear. This oil pump consists of the three gears 35, 36 and 37 which is driven by the meshing of the flywheel with the intermediate driving gear 41 carried by the short shaft 42.

In addition to the novel arrangement of parts for the purpose of producing a rugged design and the practical elimination of vibration and consequent wear on the engines' parts, the accessories and the mount for carrying the engine, the engine is also provided with a lubrication system which includes a full force feed system, a complete drainage and scavenging arrangement as well as a perfect circulation system to and through all of the wearing parts of the engine and the accessories carried thereby. This system is so arranged as to completely eliminate the necessity for any grease cups either in the engine or the accessories, or any parts thereof.

The lubricant is forced into the hollow accessory drive shaft 6 which also acts as a means of oil supply to all the main and connecting rod bearings. Oil flows through the ports 5' in the shaft 6 to the drive shaft bearings 5 and thence through each of the hollow partitions to each main bearing 3. The crankshaft is provided with inlet ports 1' for oil at each main bearing. Thus the oil flows from the hollow partition into the crankshaft which is hollow at 22, there being a passageway 23 to the hollow crank throw at 24 and from there to the connecting rod bearing 25. The oil overflowing through the connecting rod bearings follows down the sides of the connecting rod into the cylinder and through a port 26 reaches the wrist pin bearings 27.

The forward hollow partition 4 supporting the front main bearing 3 also supports a stationary shaft 19. The oil under pressure of a pump located near the top and rear of the engine is forced through the length of the shaft 6 and after part of the oil goes to each of the other main bearings passes through the stationary shaft 19 and lubricates the ring gear 12 before reaching the front main bearing. The oil then flows down through the lower hollow port 4' of the front partition and into the hollow shaft 15 to furnish lubrication therefor and thence through the passageway 30 in the stationary elements of the engine into the hollow vertical shaft 18 which being driven by the meshing of bevel gears 16 and 17 drives the camshaft through the meshing of the bevel gears 19' and 20. By-passes 31 and 32 carry the oil from the shaft 18 into the hollow camshaft 8, suitable ports being arranged therein to provide lubrication of each camshaft bearing 9. A port 88 is also arranged between each pair of cams to allow oil from the interior of the camshaft to spray over the valve stems and rocker arm assembly.

The oil seeping through the various bearings is collected in the camshaft housing 7 which forms an oil sump, the conduits 18' and 34 at each end of the engine being for the purpose of draining the oil from the crankcase of the engine. The scavenging oil collected in the cam box is pumped out by

means of a three gear pump 35, 36, 37 into an external oil tank T from which it is again drawn by an oil pressure pump, located near the top at the rear end of the engine and forced under pressure through the accessory drive shaft 6 forming the oil supply conduit. The three gear pump comprises gears 35, 36 and 37. The camshaft carries the usual type of valve operating cams 38. The camshaft has mounted at its rear end a flywheel 39 which may be secured in any suitable manner, such as by bolts and nuts 40. The flywheel has an internal gear to mesh with a gear 41 for driving the oil pump gear 37 through the shaft 42. An oil drainage pipe 33 is held near the bottom of the sump and communicates with the pump and has its open end near the front of the sump. The rear end of the sump may be slightly lowered as at 7' to provide a reservoir. The gears of the three gear pumps mesh and rotate to force the oil of the reservoir and drain pipe 33 through a suitable outlet pipe into an outside oil tank.

It has been found that the torsional oscillation of the crankshaft is of a very low magnitude at the point where the ring gear 11 is attached thereto, and is absorbed to a considerable extent through the meshing of the gears 12 and 13 necessary to impart rotary motion to the accessory drive shaft 6 and should there still be some oscillation present in the shaft 6, it will be additionally absorbed through the length of the shaft and virtually eliminated and certainly not added to at the opposite end of the shaft.

The drive shaft 6 is adapted to drive such accessories as the generator, magneto, oil pump, tachometer, and other accessories. A gear 6' is suitably secured to the shaft 6 and is adapted to mesh with the idler gears 47' and 48' mounted on shafts 47 and 48 and which mesh respectively with gears 46' and 49' mounted on shafts 46 and 49 for driving the two magnetos 51 and 51' through the magneto shafts 46 and 49 respectively. The shaft 49 has also a gear 91 secured thereto which coacts with a similar gear 52 to form an oil feed pump for drawing oil from either an external tank through the inlet 43' or from the sump.

The tachometer, not actually shown, may be driven by providing a socket 53 shown with its cover plate 53'. The gear 46' drives the shaft 46 and through a coupling including the spring 54 drives the magneto shaft 55 of the magneto 51. The shaft 46 is coupled at 56 to a hollow shaft 57 in the end of which is arranged a socket 58 to receive a fuel pressure pump. The drive of the hollow shaft 59, in which the tachometer drive socket 53 is arranged, is effected by a gear 60, driving an idler gear 61 mounted on a short shaft 62 and adapted to mesh with and drive the gear 63 carried by the shaft 59. The arrangement just described is shown in Figure 4 as covered by cover plates 53' and 64, the fuel pump and tachometer not being shown as they may be of any known construction, the drive for which will be adapted to fit the sockets provided therefor.

As shown in Figure 2, the generator pad 65 may be used to mount a generator (not shown) to be driven by the accessory drive shaft 6.

As shown in Figures 1 and 7 the gear 6' is carried by a short hollow shaft 84 which fits over and is suitably splined at 85 to shaft 6 beyond the end of which the shaft 84 extends. The end of shaft 6 is socketed at 84' to form a suitable means for connecting the intermediate drive for a generator.

Oil pressure pump 91—52 draws the oil from the exterior tank into the inlet 43'. The oil thus drawn passes into the reservoir 44, through the coarse strainer 45 into chamber 83 of the oil pump assembly (Figure 6). From here it passes into the direction indicated by the arrows into chamber 84, thence through oil gears 91—52, out into the chamber 85, and then into the reservoir 75.

Referring to Figure 9, the aperture 86 represents an oil passageway which communicates with the reservoir 75, and comprising a conduit 87 for conveying the oil to the annulus 88 surrounding the accessory drive shaft 6. Ports 89 provide a means for conveying the oil from the annulus to the interior of the hollow drive shaft 6 for conveying the oil to the working parts of the engine. The rear hollow partition 4 conveys the oil from the annulus 89 to a port 70 which communicates with the passageway 92' in the hollow lateral partition 92, a certain part of the oil also extending down through the lower portion 4' of the hollow vertical partition to communicate with and convey oil to the rear main bearing. The passageway 92' forms the conduit for oil to be supplied to various gears and working parts of the accessories mounted at the top rear end of the engine.

The accessories have no connection whatever to the anti-flywheel end of the crankshaft. The accessory drive shaft is flexible and of such proportions that it does not have any torsonal oscillations set up therein by its rotation. The imparting of any such oscillations from the crankshaft to the drive shaft is substantially eliminated by taking the drive from a point near the flywheel end of the crankshaft through ring gears in straight alignment at right angles to the two parallel shafts.

The crankcase is of split type comprising upper and lower parts 77 and 78, and each cylinder is built separately and provided with suitable cooling fins, cowling and air baffles. The valve operating means comprises the single underhead camshaft 8 with valve operating cams 38 which contact with the rollers 79 and 80 of the rocker arms 79' and 80' which through a suitable combination adjusting screw with a ball and socket joint or the like operate directly on the intake and exhaust valves 81 and 82 to the complete elimination of valve tappets or push rods.

What I claim is:

1. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, said upper shaft and said camshaft each being adapted to drive a separate oil pump.

2. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith and adapted to convey oil throughout the length of said engine, a housing for said camshaft, said housing also forming the oil sump for said engine, oil drains arranged at both ends of said crankcase leading into said housing.

3. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft

arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, a housing for said camshaft, said housing also forming the oil sump for said engine, oil drains arranged at both ends of said crankcase leading into said housing, said upper shaft and said camshaft each being adapted to drive a separate oil pump.

4. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, said upper shaft being driven from the flywheel end of said crankshaft and being adapted to drive at its other end an oil pump for forcing oil from an exterior source into said shaft, and passageways for oil from said shaft into said crankshaft.

5. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, said upper shaft being driven from the flywheel end of said crankshaft and being adapted to drive at its other end an oil pump for forcing oil from an exterior source into said shaft, passageways for oil from said shaft into said crankshaft, means for driving said camshaft from the flywheel end of said crankshaft, and oil passageways in said means for delivering oil into said camshaft.

6. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, said upper shaft being driven from the flywheel end of said crankshaft and being adapted to drive at its other end an oil pump for forcing oil from an exterior source into said shaft, passageways for oil from said shaft into said crankshaft, a housing for said camshaft, said housing also forming the oil sump for said engine.

7. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in prallelism therewith, means for driving said camshaft from the flywheel end of said crankshaft, oil passageways in said means for delivering oil into said camshaft, a housing for said camshaft, said housing also forming the oil sump for said engine, said camshaft driving an oil pump for forcing the oil in said camshaft into an exterior tank.

8. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, means for driving said camshaft from the flywheel end of said crankshaft, oil passageways in said means for delivering oil into said camshaft, a housing for said camshaft, said housing also forming the oil sump for said engine, oil drains from both ends of said crankcase for leading scavenging oil into said camshaft housing, said camshaft driving an oil pump for forcing said scavenging oils and the oil in said camshaft into an exterior tank.

9. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, means for driving said camshaft from the flywheel end of said crankshaft, oil passageways in said means for delivering oil into said camshaft, a housing for said camshaft, said housing also forming the oil sump for said engine, oil drains from both ends of said crankcase for leading scavenging oil into said camshaft housing, said camshaft driving an oil pump for forcing said scavenging oils and the oil in said camshaft into an exterior tank, said upper shaft driving a second oil pump for forcing oil from said tank into said shaft.

10. In an internal combustion engine, a plurality of cylinders inverted and in line, a crankcase, a hollow crankshaft therein, a hollow camshaft arranged beneath said crankcase, a straight, hollow shaft arranged above said crankshaft and in parallelism therewith, means for driving said camshaft from the flywheel end of said crankshaft, oil passageways in said means for delivering oil into said camshaft, a housing for said camshaft, said housing also forming the oil sump for said engine, oil drains from both ends of said crankcase for leading scavenging oil into said camshaft housing, said camshaft driving an oil pump for forcing said scavenging oils and the oil in said camshaft into an exterior tank, said upper shaft driving a second oil pump for forcing oil from said tank into said shaft, said shaft being driven from the flywheel end of said crankshaft, passageways leading from said upper shaft for passage of oil into said crankshaft.

11. In an internal combustion engine, a crankcase, a hollow camshaft therebeneath, a housing for said camshaft, said housing also forming an oil sump, drains from said crankcase leading into said housing, a flywheel mounted on said camshaft and an oil pump driven thereby for expelling the oil therein and in said housing to a point external of said engine.

12. In an internal combustion engine, a crankcase, a hollow crank shaft and a hollow drive shaft arranged thereabove and driven thereby, a hollow camshaft arranged below said crankcase, a housing for said camshaft, said housing also forming an oil sump, drains for oil from said crankcase to said camshaft housing, oil passageways from said upper drive shaft through said crankshaft into said camshaft, an oil pump driven by said camshaft for expelling oil from said camshaft and its housing, an oil pump driven by said upper drive shaft for forcing oil into said drive shaft and the remainder of said engine and its accessories.

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