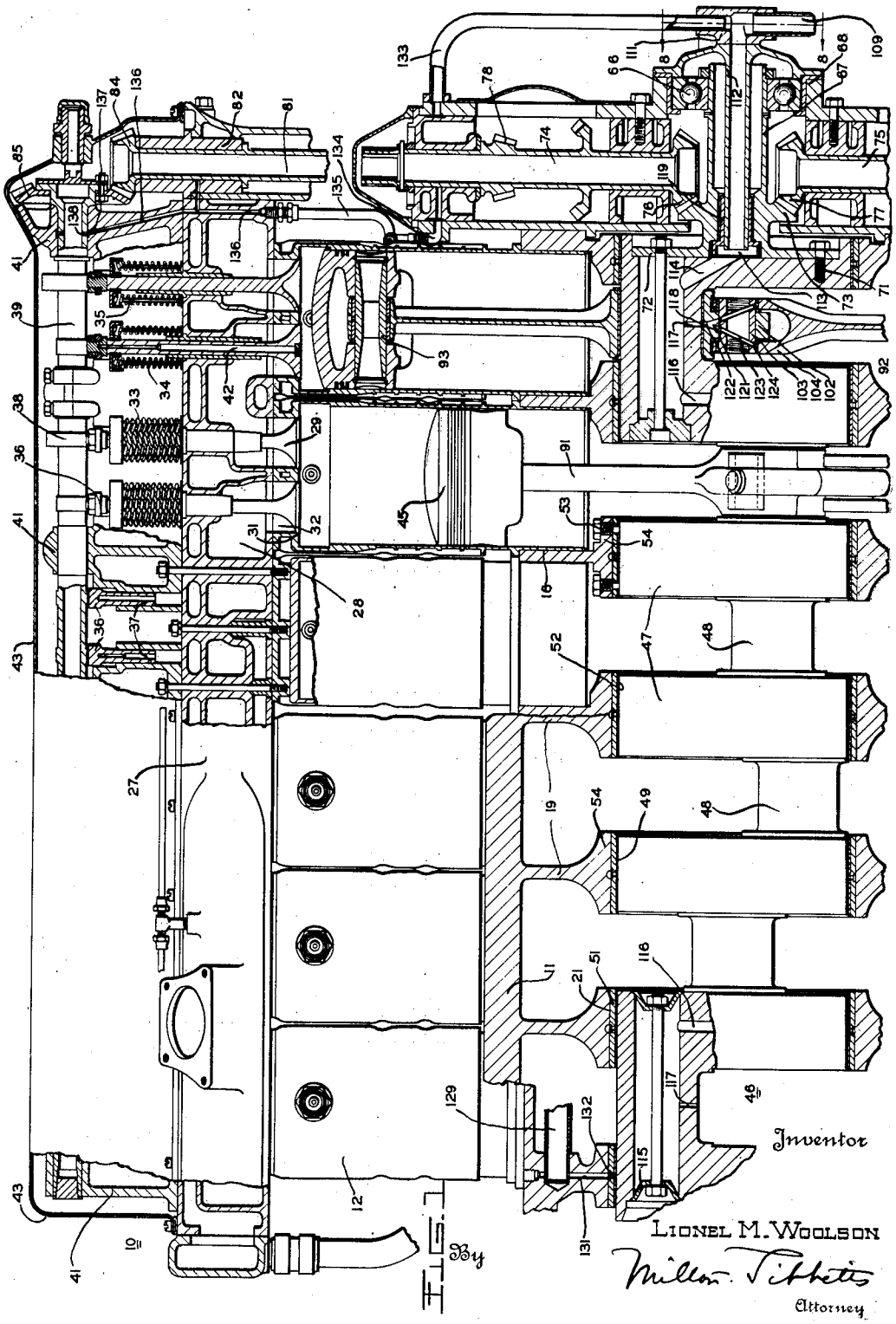
Nov. 29, 1932. L. M. WOOLSON 1,889,583

INTERNAL COMBUSTION ENGINE

Filed July 28, 1928 4 Sheets-Sheet 1



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INTERNAL COMBUSTION ENGINE

Filed July 28, 1928 4 Sheets-Sheet 2

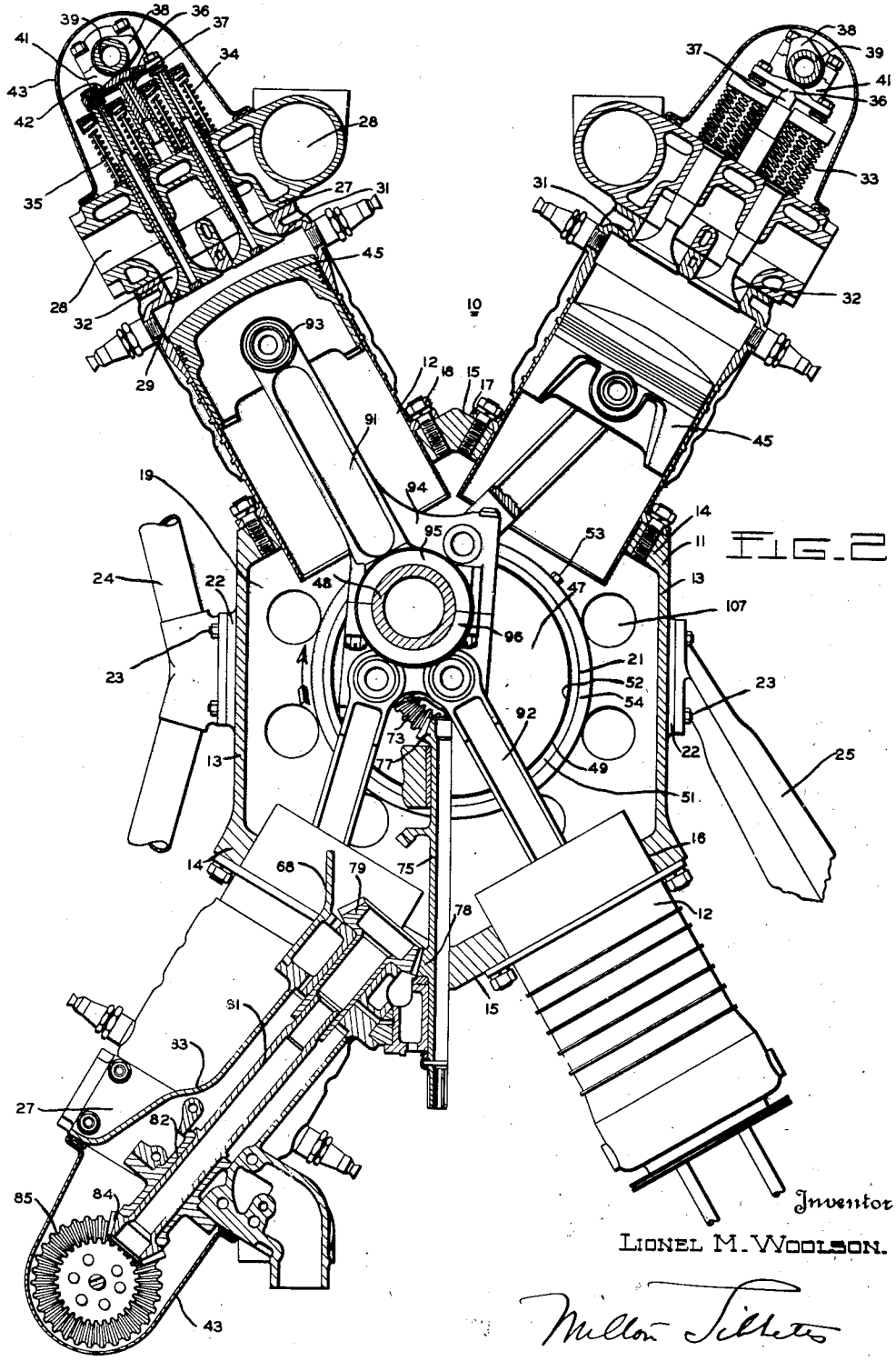

FIG. 2

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INTERNAL COMBUSTION ENGINE

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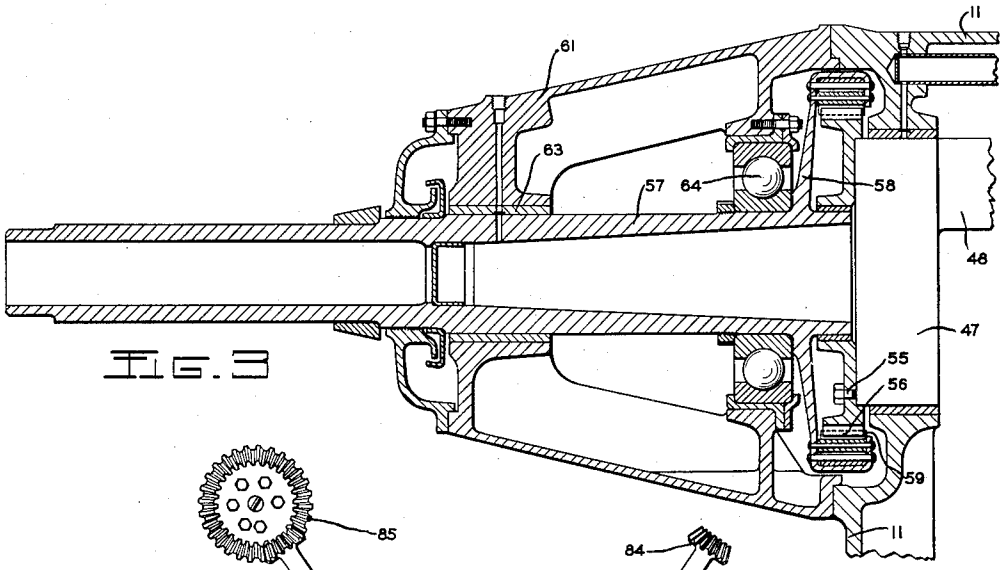

FIG. 3

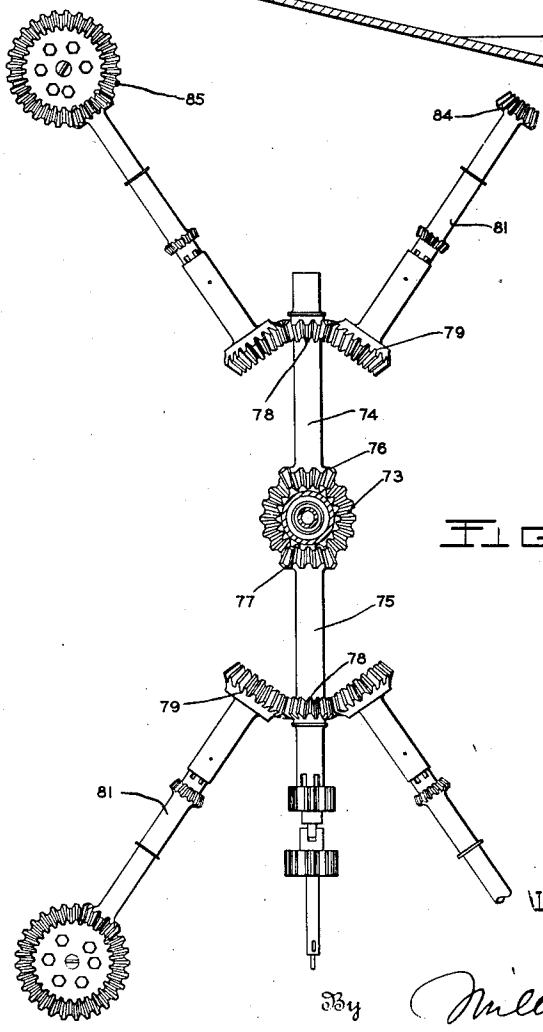

FIG. 10

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INTERNAL COMBUSTION ENGINE

Filed July 28, 1928 4 Sheets-Sheet 4

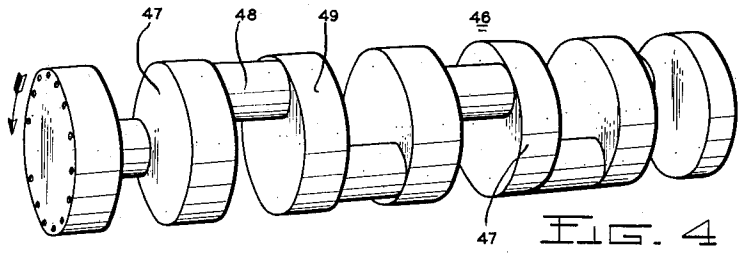

FIG. 4

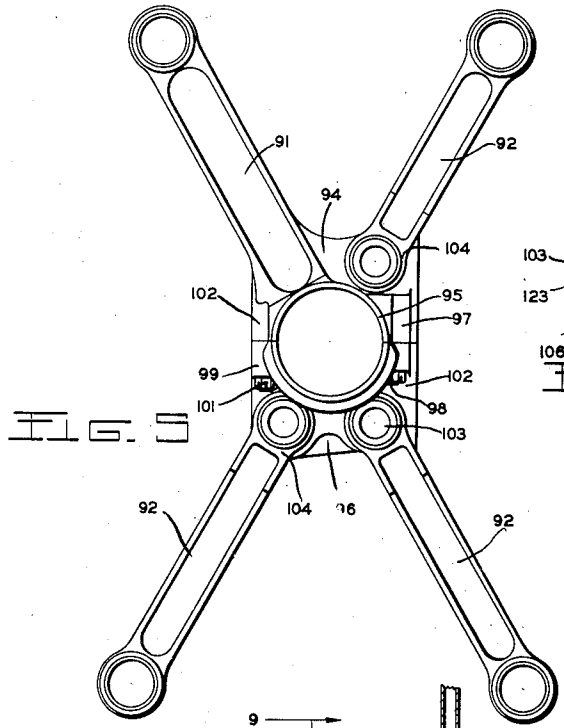

FIG. 5

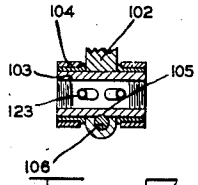

FIG. 7

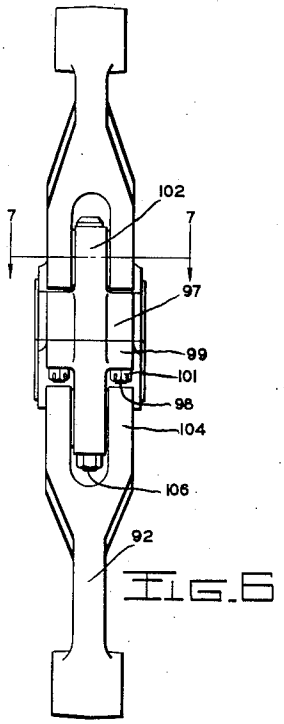

FIG. 6

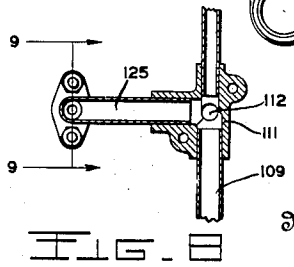

FIG. 8

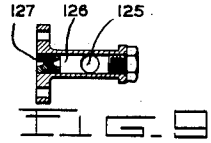

FIG. 9

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Patented Nov. 29, 1932 1,889,583

UNITED STATES PATENT OFFICE

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INTERNAL COMBUSTION ENGINE

Application filed July 28, 1928. Serial No. 295,937.

This invention relates to internal combustion engines and particularly to engines such as are used in the propulsion of aircraft.

It has for one of its objects to provide an engine of large power which shall be light and compact, and in which the frontal area shall be low relative to the power developed.

Another object of the invention is to provide an engine which shall have a high ratio of power developed to weight.

Another object of the invention is to provide an engine of large power without greatly increasing the total length thereof.

Another object of the invention is to provide an engine having a unitary crank case which shall be light and strong, adapted to rigidly support a large number of cylinders in a relatively small space.

Another object of the invention is to provide an engine having accessible and readily removable mounting means for the driven shaft thereof, which shall conform to the stream-lines of the engine and reduce its frontal resistance.

A further object of the invention is to provide an improved engine having a rigid crank case directly connected to and adapted to receive the stresses of the landing gear and the body members of the vehicle in which it is mounted.

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

Fig. 1 is a view, partially in side elevation, and partially in longitudinal section through an engine constructed in accordance with and embodying this invention;

Fig. 2 is a view, partially in rear elevation and partially in transverse section through the engine shown in Fig. 1, sections through different cylinders being taken in different planes to more clearly show the construction;

Fig. 3 is a view in longitudinal section through the forward end of the engine, showing the drive shaft and the connecting gearing;

Fig. 4 is a somewhat diagrammatic perspective view of the crank shaft preferably employed in the engine of this invention;

Figs. 5 and 6 are respectively end and side elevations showing the connecting rod assembly;

Fig. 7 is a detail section taken substantially on the line 7—7 of Figs. 5 and 6;

Fig. 8 is a detail section taken substantially on the line 8—8 of Fig. 1;

Fig. 9 is a detail section taken substantially on the line 9—9 of Fig. 8, and

Fig. 10 is a schematic view in elevation showing the cam shaft and accessory drive.

Referring to the drawings, at 10 is shown an internal combustion engine having a crank case 11 on which are mounted cylinders 12. The crank case is in the form of a hollow prismatic housing, preferably hexagonal in cross section, having parallel side walls 13 and upper and lower cylinder supporting walls 14, each presenting a pair of inclined faces 15. These walls 14 are provided with holes 16 through which the barrels of the cylinders 12 project, the barrels being provided with integral flanges 17 which contact the faces 15 and are secured to the walls 14 by bolts 18, in the well known manner. The interior of the crank case 11 is provided with transverse internal ribs or webs 19, preferably integral with the crank case and spaced longitudinally thereof between the cylinders 12, and each web 19 is provided at its central portion with a hole 21, which holes are in alignment axially of the crank case to receive the engine crank shaft, as will appear. The side walls 13 of the crank case are also provided with integral pads or lugs 22, having studs 23 by which the engine may be secured to the frame members 24 of the airplane or other motor vehicle in which it is mounted, and to the ground gear through the supporting members or landing struts 25 thereof, so that the crank case supports the vehicle and carries all the stresses usually taken by the engine bearers.

As will be readily seen from Figs. 1 and 2, this invention contemplates an engine having a plurality of the cylinders 12 arranged in inclined rows or banks in V-formation both above and below the crank case 11. In the

present embodiment there are four such banks of six cylinders each, arranged in two upright banks above, and two inverted banks below the crank case, in the general form of an X, but it is to be understood that the invention is not limited in its application to engines having such a number and arrangement of cylinders. This disposition of cylinders provides an engine having much greater power than a conventional engine of the same length and having a much lower ratio of frontal area to power developed, thus greatly reducing the parasitic resistance to flight.

The cylinder banks are each provided with a head member 27 in which are formed passages 28 for the intake and exhaust of each of the cylinders, these passages being controlled by valves as at 29, arranged in pairs across the head and having seats 31 formed at the ports 32 in the head. These valves are urged to closed position on their seats 31 by spring devices or units 33, each comprising a number of small helical springs 34 grouped about the valve stem. These springs operate between suitable abutment and are each provided with a guide pin 35.

The valves are connected in pairs by a yoke or follower 36 having a guide stem 37, and operated from a cam 38 on a camshaft 39, supported in suitable bearings 41 on the head member 27. The valves 29 and their stems are preferably hollow and are adapted to receive cooling oil from the engine lubricating system through passages 42 in the cam follower 36. As mechanism of this type is well known in the art to which this invention relates, further description thereof is unnecessary.

The camshaft and the valve operating mechanism is enclosed in a housing or cover 43, which forms with the head member 27 an oil tight compartment to retain the lubricating and cooling oil supplied to the mechanism. In the lower banks of cylinders this cover 43 forms a sump to collect the oil, it being returned therefrom to the lubrication system by any suitable means (not shown).

Each of the cylinders 12 is provided with a piston 45 adapted to reciprocate therein in the usual manner, all these pistons being connected to and adapted to operate a common crank shaft 46. As clearly shown in Figs. 1 and 4, the crank shaft 46 is a six-throw shaft, there being four of the pistons 45 connected to each of the cranks in the present embodiment of this invention. It comprises spaced cylindrical crank arms or cheeks 47, connected by integral crank pins 48, preferably hollow as shown. The cheeks 47 provide bearing surfaces 49 which constitute the crank shaft journals and on which the crank shaft is rotatably mounted in aligned bearings 51 in the crank case 11. These bearings 51 are integral shells or rings of steel or other suitable material, lined, as shown at 52, with Babbitt metal or other bearing material. They are supported in the openings 21 in the crank case webs 19 and are held tightly therein preferably by inserting them in the crank case while it is heated, it being subsequently permitted to shrink over them. Set screws 53 are also threaded into peripheral flanges 54 on the webs 19, and engage the rings to further secure these in position. In this way large bearing surfaces are provided, well adapted to take the heavy loads imposed on this crank shaft without increasing the length of the bearings or of the shaft.

The crank pins 48 are preferably arranged in sets or groups of three, as clearly shown in Fig. 4, the three forward pins comprising one such group and the three rear pins another. In each set the pins are disposed at equal angles of 120°, as in the conventional six-throw shaft, but there is preferably a phase difference between the sets which may conveniently be a lead or lag equal to the number of degrees between successive cylinder explosions. Thus in the present embodiment the fourth crank pin has a lead of 30° over the third pin, the crank shaft rotating in a counter-clockwise direction viewed from the forward end, as indicated by the arrows in Figs. 2 and 4. In this way the power impulses of the pistons on the shaft are staggered so that the simultaneous firing of two cylinders on the same crank or on adjacent cranks is avoided, while a regular firing interval is maintained.

The front face of the first crank cheek 47 is adapted for connection, as by the bolts 55, to the gear 56 of a flexible coupling of known form, by which the crank shaft is connected to the drive or propeller shaft 57. This coupling comprises a spider 58, fixed to the rear end of the shaft 57 and carrying spring fingers 59 which engage the teeth of the gear 56 and are driven thereby. As coupling devices of this nature are well known in the art, further description thereof is unnecessary.

The shaft 57 is mounted independently of the crank shaft 46 in a removable housing or nose piece 61, secured to the end of the crank case 11 in any convenient way. This nose housing is preferably tapered, or of a general conical shape, well adapted to streamline the forward end of the engine. It provides a curved surface of proper streamline contour between the usual spinner, or rotating propeller nose (not shown) and the crank case, so that the head resistance of the engine is greatly decreased. This housing 61 also encloses the flexible coupling and provides a support for the propeller shaft 57. To this end it is formed with transverse webs adapted to support bearings 63 in which the shaft 57 is journaled, and a thrust bearing 64 adapted to transmit the propeller thrust

through the nose housing to the crank case 11.

The crank shaft 46 is maintained in correct axial position in the crank case by means of a thrust bearing 66, cooperating with a removable axial extension 67 at the rear end of the shaft. This bearing is mounted in a housing 68, removably secured to the rear end of the crank case 11, in which the timing gears of the engine are located.

The construction of the crank shaft, the axial extension, the thrust bearing and the removable feature of the crank shaft and those bearings are particularly pointed out and claimed in my co-pending application, Serial No. 309,631 filed October 1, 1928.

The axial extension 67 may be conveniently secured to the rear face of the end crank cheek 47 by screws 71 passing through a flange portion 72, and this extension is provided with a gear 73 through which the timing gears are driven. This gearing comprises the vertical aligned shafts 74 and 75 extending above and below the crank shaft and provided with the integral gears 76 and 77 which mesh with and are driven from the gear 73, these gears being preferably bevel gears. The shafts 74 and 75 are provided near their ends with integral bevel gears 78, adapted to mesh with and drive gears 79 which are secured to inclined shafts 81, there being one of the shafts 81 for each of the banks of cylinders. These shafts 81 are journaled in bearings 82 in extensions 83 of the housing 68 and they are provided at their outer ends with gears 84 which mesh with and drive gears 85 connected to the ends of the respective cam shafts 39. In this way the four cam shafts are driven in synchronism from the crank shaft 46, the gear reduction being such as to secure the proper half speed for each of the cam shafts.

Each of the crank pins 48 is connected to four of the pistons 45, one in each of the cylinder banks, by a connecting rod assembly including a master rod 91, and link rods 92, each of these connecting rods being pivotally connected to its piston by a piston pin 93 in the usual way. The crank shaft end of the master rod 91 is provided with an enlarged portion 94 in which is formed half of the crank pin bearing 95, the remainder of this bearing being formed in a cap member 96. This cap member is removably secured to the portion 94, which is provided with integral lugs 97 in which four studs or bolts 98 are carried. These studs are arranged on each side of the bearing 95 and they are set in as close to the bearing as possible. They are adapted to pass through lugs 99 in the cap member 96 which corresponds to and cooperates with the lugs 97, and are provided with nuts 101 by which the cap member may be clamped to the portion 94, and the halves of the bearing 95 positioned upon the crank pin 48.

The portions 94 and 96 are also provided with integral flange members 102 disposed in the median plane of the bearing 95, which members support axially disposed tubular pins 103 adapted to pivotally engage the forked ends 104 of the link rods 92, these forked ends being adapted to straddle the flange members 102 as clearly shown in Figs. 1 and 6. The pins 103 are locked in position in the flange members 102 by notches 105, which are engaged by bolts 106, one on each side of the bearing 95, passing through the cooperating flange members 102 parallel to the studs 98, and spaced further from the bearing. These bolts assist the studs 98 to clamp the members 94 and 96 in operative position. The pins 103 are preferably threaded internally for engagement with the threaded end of a suitable bar by which they may be inserted or withdrawn through axially disposed holes 107 arranged in the crank case webs 19.

The lower end of the shaft 75 is connected to and drives the engine pump assembly, comprising pumps for the fuel, cooling and lubricating systems of the engine. As combined pump units of this nature are well known in the art the pumps have not been illustrated in the drawings, but it is to be understood that the water pumps are adapted to supply cooling water to the jackets of each of the four banks of cylinders, and that the lubricating pumps serve to scavenge or remove oil from the crank case and the camshaft housings as well as to supply oil under pressure for the various engine bearings.

The outlet of the oil pressure pump is connected to a conduit 109 through which it delivers oil under pressure to a fitting 111. From this fitting part of the oil passes to a tube or nozzle 112 which is supported on the housing 68 and projects through the hollow crank shaft extension 67 into a pressure chamber 113 in the inner end thereof. From this chamber a passage 114 leads to the inside of the rear crank pin 48. Each of the hollow crank pins is closed at the ends by suitable plugs 115, and the chambers thus formed are connected by passages 116, forming a continuous conduit through the crank shaft supplied with oil under pressure from the tube 112. A passage 117 is formed in each of the crank pins 48 which passage terminates at the bearing surface in a port 118, through which oil flows under pump pressure to the crank pin bearings, escaping at the ends thereof into the crank case in the usual way.

Loss of oil between the tube 112 and the crank shaft is prevented by a bushing 119, having a tight fit on the tube and a relatively loose fit in the crank shaft extension. This bushing has a flanged end located in and contacting the wall of the pressure chamber 113, in which position it is retained by the pres-

sure of the oil in the chamber, thus effectually sealing possible leakage at this point, and permitting slight variations in axial alignment between the tube and the shaft.

Passages 121 are also provided in each of the cap and the bearing portions of the master connecting rods, terminating in ports 122 at the bearing surface, which register once per engine revolution with the ports 118, receiving therefrom a measured charge of oil. This oil is conducted from passage 121 through branch passages 123 to the link pin bearings through ports 124, whereby these passages are lubricated.

The lubrication of the main bearings is preferably effected by a low pressure system connected to the fitting 111. It has been discovered that bearings which have a large diameter in proportion to their width, and a relatively large clearance, offer very little resistance to the flow of lubricating oil and in fact frequently have a pumping action which increases the flow of oil through them. For this reason the high pressure under which oil is fed to the connecting rod bearings is not desirable, since it causes the circulation of an unnecessarily large quantity of oil which must be removed by the scavenging pumps, and requires a large circulation pump to maintain the pressure. This invention provides for the circulation to the main bearings of oil under a lower pressure. To this end high pressure oil from the fitting 111 is conducted through a branch pipe 125 to a reducing chamber 126 having a pressure reducing passage 127. From this chamber oil at a reduced pressure is conducted through a suitable pipe (not shown) to a manifold 129 extending longitudinally of the crank case 11 and supported from the webs 19 thereof. A passage 131, formed in each of the webs 19, conducts the low pressure oil from the manifold 129 to an orifice 132 of the bearing surface, thus providing ample lubrication for these bearings without excessively reducing the pressure in the remainder of the lubricating system.

Oil from the fitting 111 is also supplied by a pipe 133 to the upper bearing of the shaft 74, and thence through a passage 134 to a branched pipe 135 which leads to each of the heads 27. These heads are provided with passages 136, communicating with the pipes 135, by which the oil is conducted to an annular groove 137 in the rear camshaft bearing 41, and thence through ports 138 to the interior of the hollow camshaft. From the camshaft the oil is distributed through suitable ports and passages (not shown) to the other bearings 41, the cams and cam followers, and to the valve cooling system, in the well known manner. Oil is supplied in a similar way to the camshafts of the lower cylinder banks through pipes (not shown) connecting with the pump conduit 109. The lubricating system just described forms the subject matter of my co-pending application, Serial No. 421,661 filed January 18, 1930.

Many of the constructional and operative advantages of the engine provided by this invention will be apparent from the foregoing description. The arrangement of the cylinders in the form of an X gives a minimum of frontal area, and the head resistance is further reduced by reason of the stream-line form of the crank case nose. Moreover, the cylinder arrangement permits a great increase in engine power without a corresponding increase in engine dimensions, the overall length and frontal area being comparable with previously constructed engines of other types which develop much less power.

The crank case is short and simple and because of its unitary construction is very strong, much stronger than the engine bearers usually employed to support the engine in the vehicle, and to connect it to the longérons or other frame members, and to the landing gears. By this invention the engine takes the place of such supporting members, assuming all the stresses usually carried thereby, so that the dead weight of the vehicle is greatly reduced and a stronger and stiffer mounting is provided.

While a specific embodiment of the invention has been herein described, which is deemed to be new and advantageous and may be specifically claimed, it is not to be understood that the 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 the invention.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In an aeroplane, an engine having a crank case, and landing gear struts secured rigidly and directly to the sides of the crank case.

2. In an aeroplane, an engine having a crank case, landing gear struts, and means securing the struts rigidly and directly to the sides of the crank case.

In testimony whereof I affix my signature.

LIONEL M. WOOLSON.