May 3, 1949. A. G. HERRESHOFF ET AL 2,468,976

INVERTED V-TYPE ENGINE

Filed June 11, 1942 5 Sheets-Sheet 1

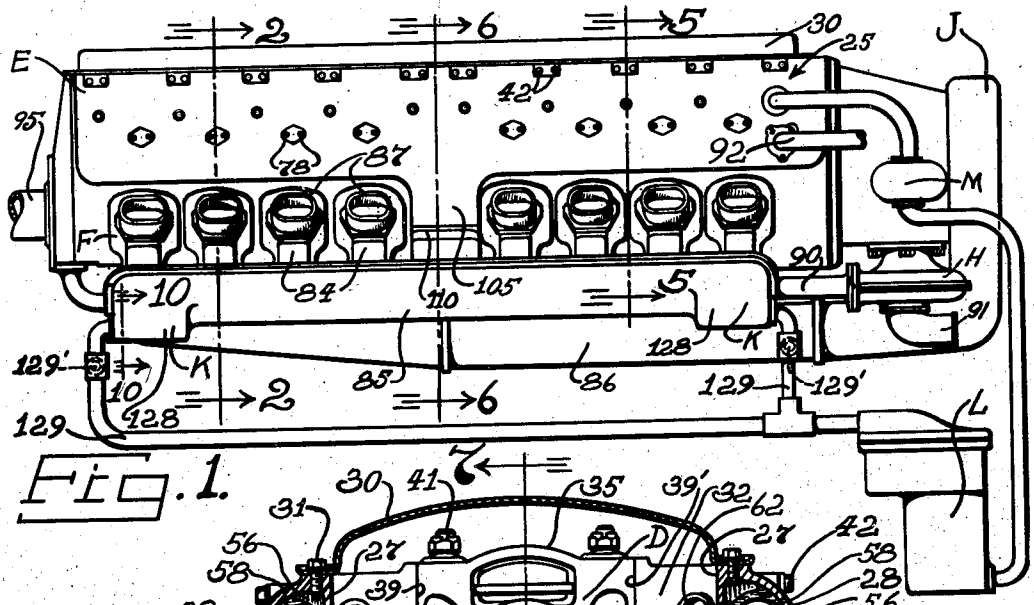

Fig. 1.

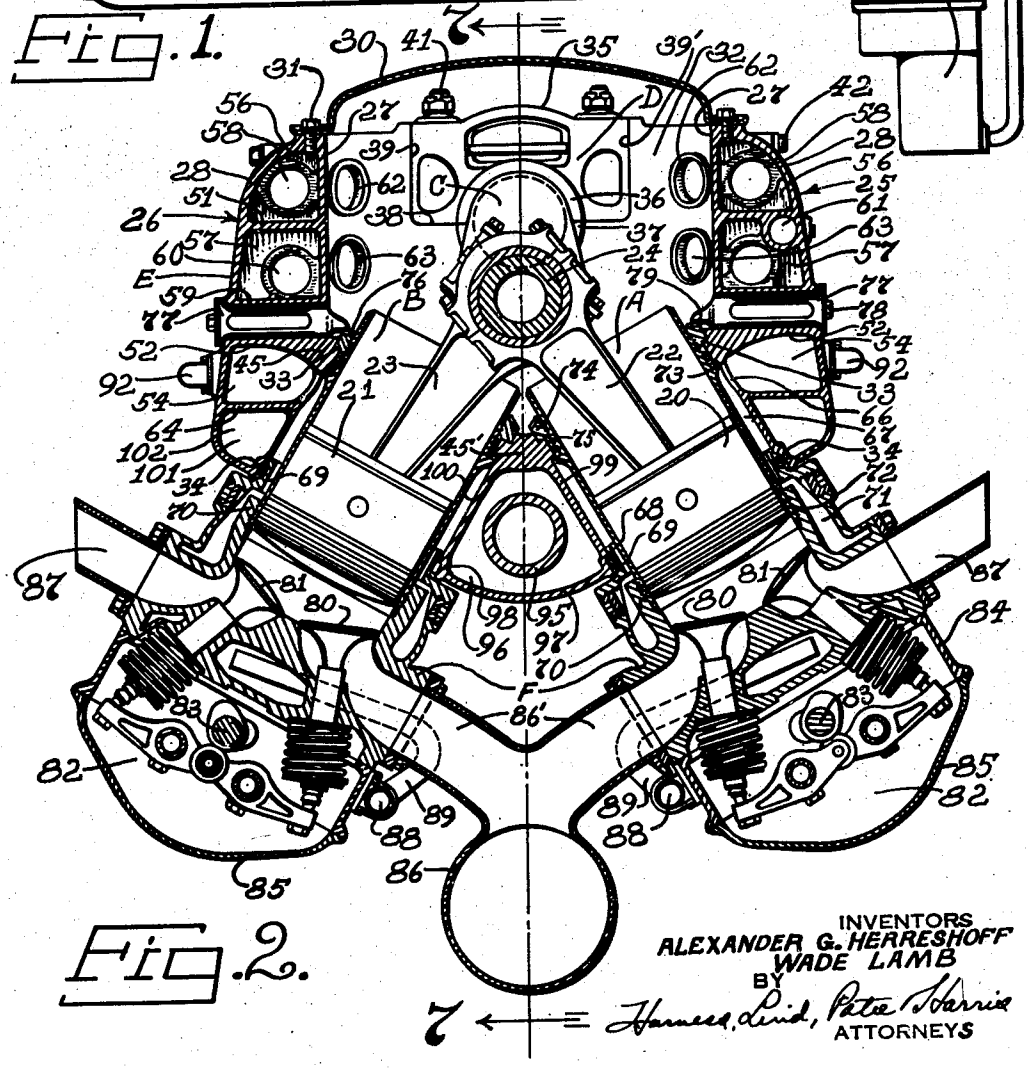

Fig. 2.

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INVERTED V-TYPE ENGINE

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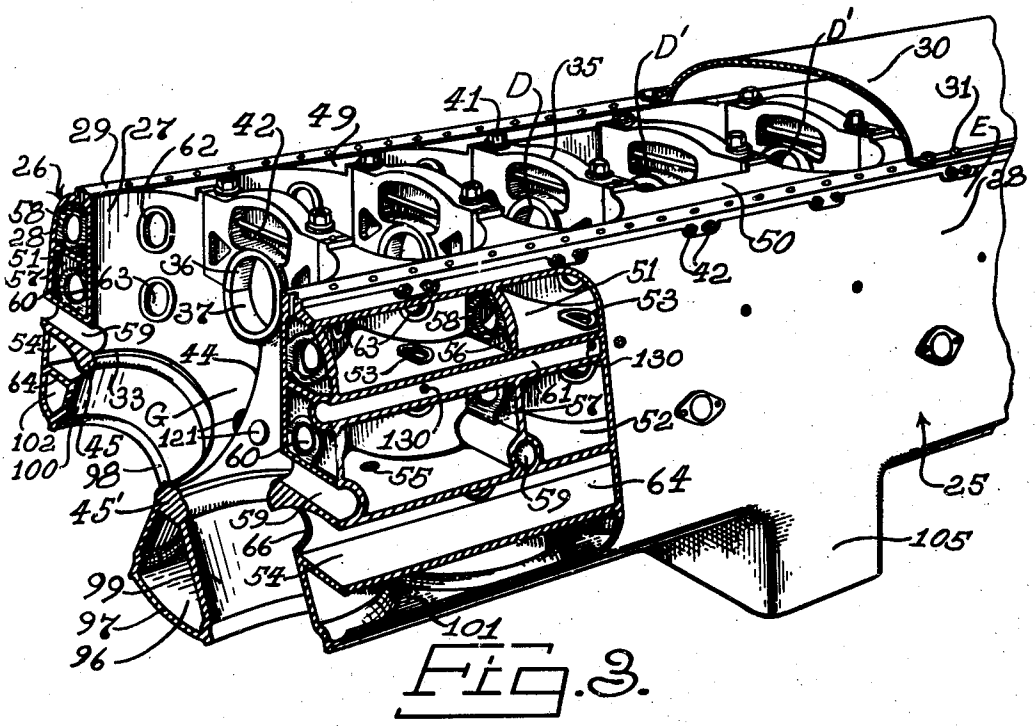

Fig. 3.

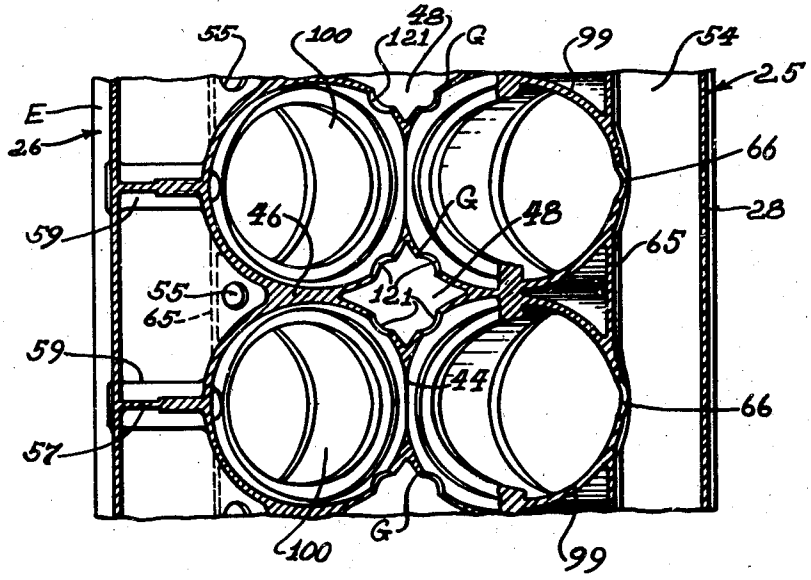

Fig. 4.

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INVERTED V-TYPE ENGINE

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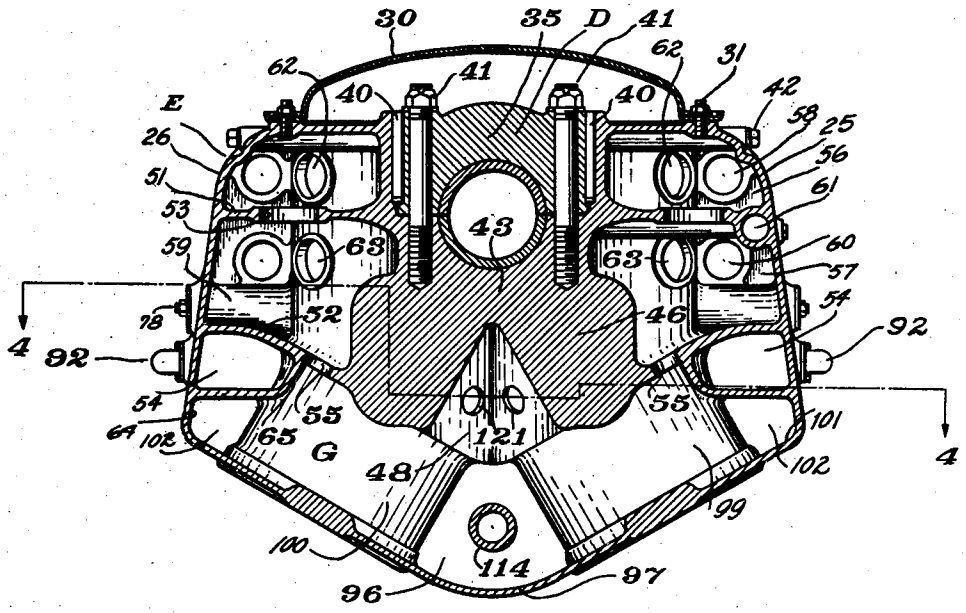

Fig. 5.

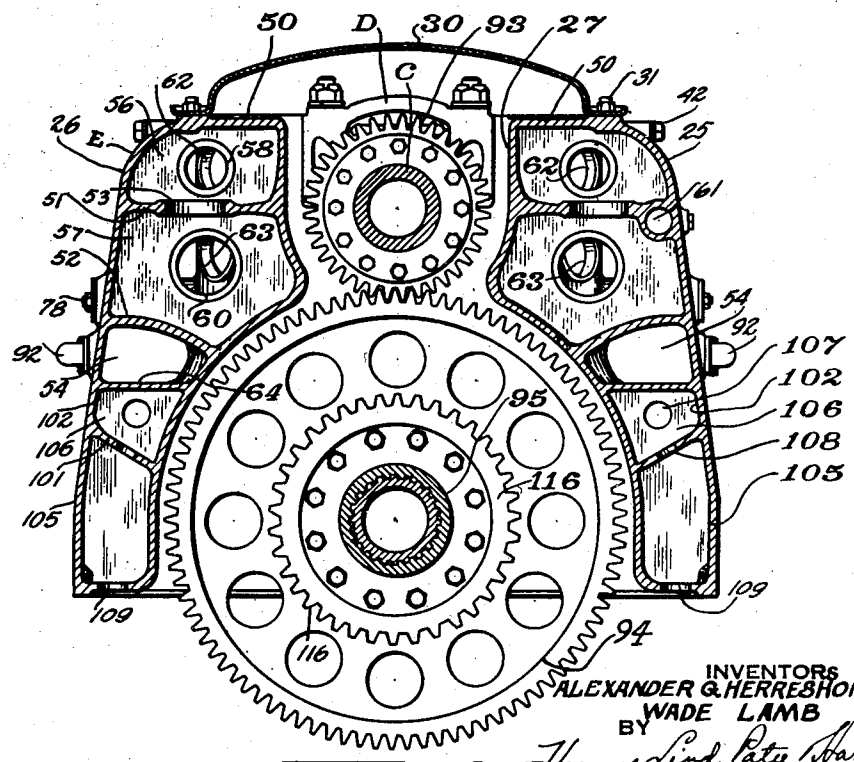

Fig. 6.

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INVERTED V-TYPE ENGINE

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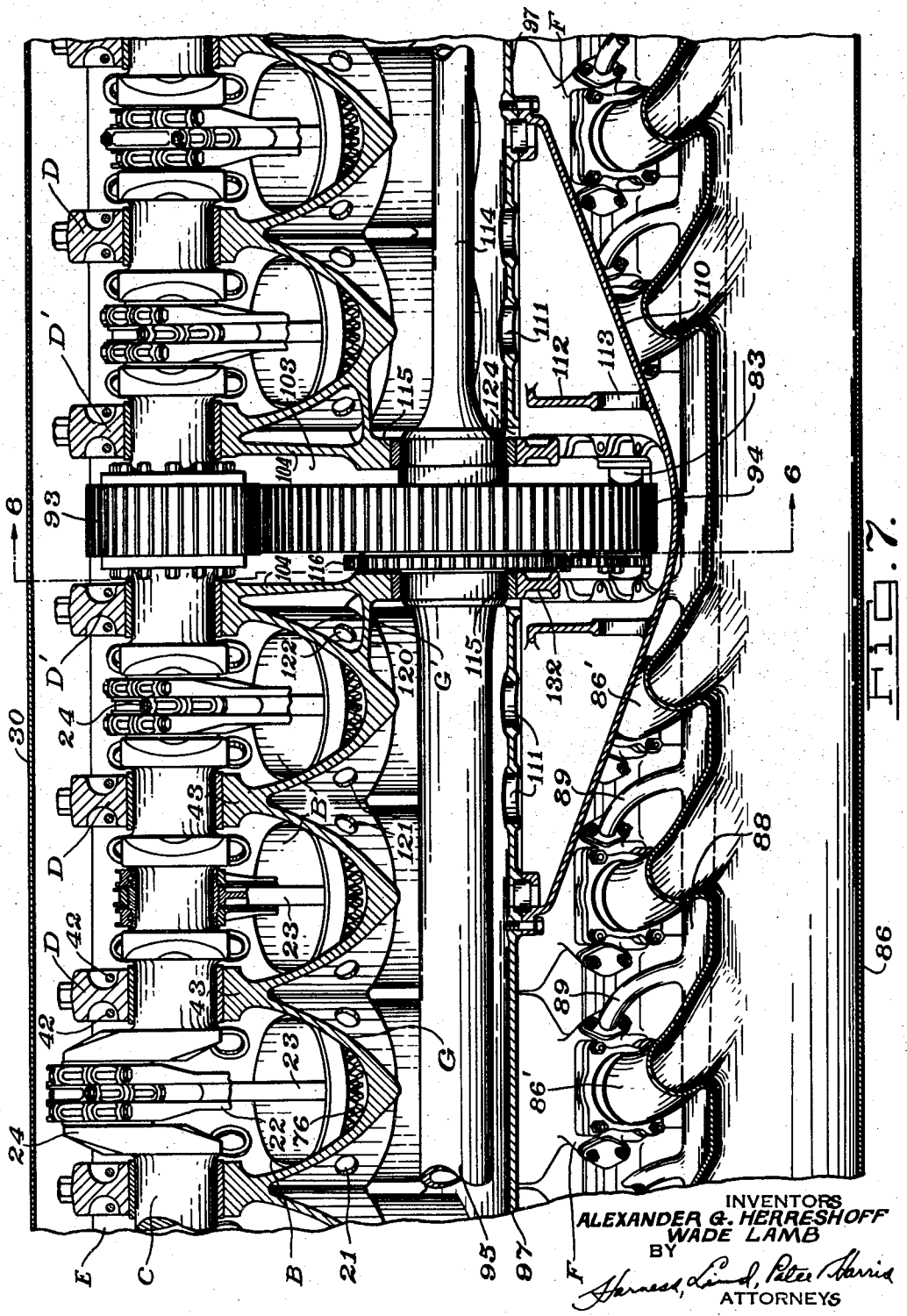

FIG. 7.

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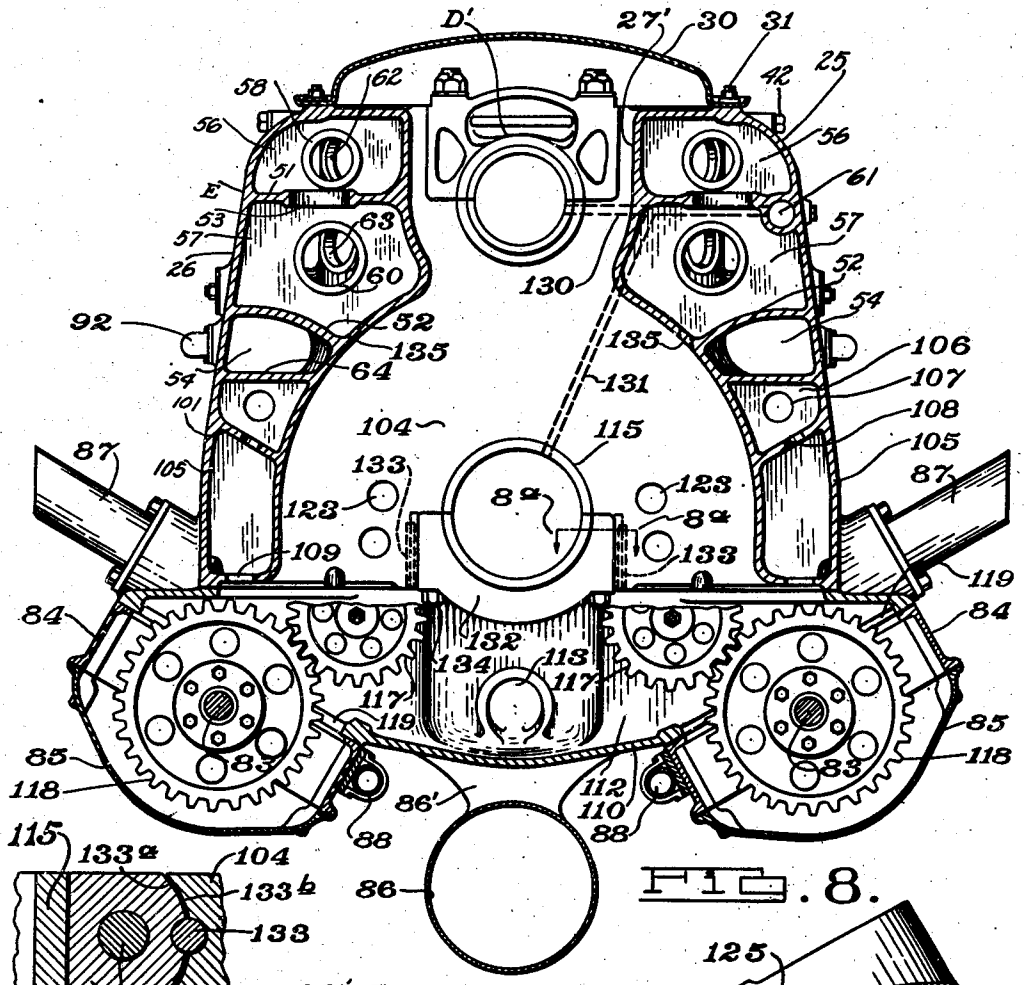

FIG. 8.

FIG. 8a.

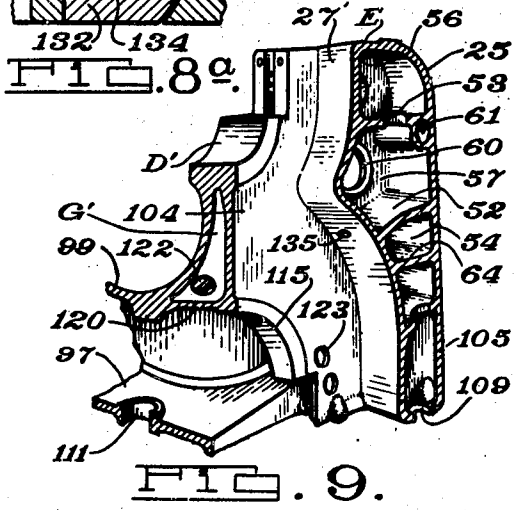

FIG. 9.

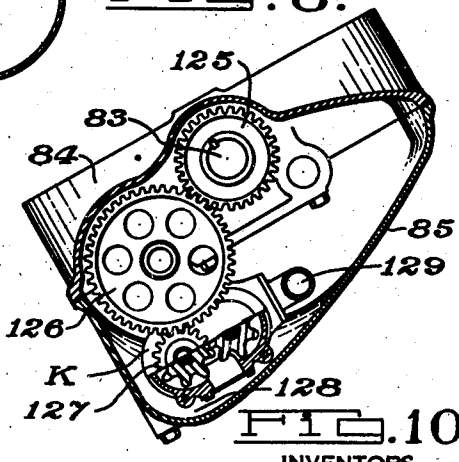

FIG. 10.

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Patented May 3, 1949

2,468,976

UNITED STATES PATENT OFFICE

2,468,976

INVERTED V-TYPE ENGINE

Alexander G. Herreshoff, Grosse Pointe, and Wade Lamb, Detroit, Mich., assignors to Chrysler Corporation, Highland Park, Mich., a corporation of Delaware

Application June 11, 1942, Serial No. 446,560

28 Claims. (Cl. 123—55)

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This invention relates to internal combustion engines and refers more particularly to improvements in aircraft engines although not necessarily limited thereto in its broader aspects.

One object of our invention is to provide an engine of the tandem cylinder liquid cooled type having improved power output per pound of weight accompanied by improved rigidity of the casing structure.

Heretofore, aircraft engines of the tandem cylinder type are known to have considerable flexing or distorting in the engine casing during normal engine operation. This flexing causes misalignment of the crankshaft bearings, introduces undesired load concentrations and failures at various regions in the casing and other engine parts, requires crankshaft counterweighting to an undesired and objectionable degree, gives rise to power losses within the engine, renders difficult the design of a properly functioning engine mounting system, and is otherwise objectionable.

Another object of our invention is to overcome the aforesaid defects and objections. Our invention is characterized by a casing structure of great rigidity, especially torsionally, and also transversely and longitudinally.

In carrying out our invention we have provided a crankcase casting of novel double wall rigid construction jacketed for cooling the cylinders so as to dispense with the conventional cylinder block. A further important characteristic resides in the provision of a novel construction of crankshaft main bearing pedestal of approximate pyramidal or X-brace construction serving to rigidly connect the main bearings with the double walls and with portions of the case which support the cylinders and which take the forces incident to combustion chamber pressure acting on the cylinder heads.

An additional object is to provide an improved aircraft engine of the so-called V-type preferably inverted such that the cylinders extend downwardly from the crankshaft.

A further object is to provide an improved aircraft engine of the tandem cylinder type having a casing of sufficient strength and rigidity such that the useful power output is delivered from the longitudinal mid-region of the crankshaft with many resulting advantages including engine balance and minimization of vibrations.

Another object is to provide a casing structure incorporating a novel system of lubricant and cooling medium distribution; also incorporating means for collecting oil particles and separating

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them from gases in the crankcase thereby preventing loss of oil through the crankcase breather system and facilitating the operation of the scavenging system.

Other objects are to provide simplified and improved construction and arrangement of valve gear and drive therefor especially adapted for engines of the V-type.

Further objects and advantages of our invention will be more apparent as this specification progresses, reference being made to the accompanying drawings which illustrate one embodiment of our invention and in which:

Fig. 1 is a side elevational view of our engine.

Fig. 2 is a typical sectional elevational view through the engine at a plane containing a pair of V-arranged cylinders, the view being taken as indicated by line 2—2 of Fig. 1.

Fig. 3 is a perspective view of a portion of the crankcase, parts being broken away.

Fig. 4 is a sectional plan view of the case structure taken approximately as indicated by line 4—4 of Fig. 5.

Fig. 5 is a sectional elevational view of the case structure taken through a typical main bearing of the crankshaft such as indicated by line 5—5 of Fig. 1.

Fig. 6 is a sectional elevational view of the case taken through the general mid-region of the engine as indicated by line 6—6 of Fig. 7, certain of the gears being omitted.

Fig. 7 is a sectional elevational view of a portion of the engine, the view being taken as indicated by line 7—7 of Fig. 2.

Fig. 8 is a sectional view generally similar to Fig. 6, omitting the Fig. 6 gearing but including the balance of the gearing at the mid-section of the engine.

Fig. 8A is a detail sectional plan view taken as indicated by line 8A—8A of Fig. 8.

Fig. 9 is a detail perspective view of a portion of the crankshaft main bearing support for the bearings adjacent the gearing shown in Fig. 7.

Fig. 10 is a sectional elevational view illustrating a typical drive for one of the scavenging oil pumps.

Referring to the drawings we have illustrated our invention in the form of an aircraft engine, the particular engine chosen for illustrative purposes having sixteen liquid-cooled cylinders arranged in two banks of eight cylinders, each bank having its cylinders disposed in-line or tandem. The cylinders of the banks are shown arranged as an inverted V with a 60° included angle. Many of the features of our invention may be employed

to advantage in an engine of the upright V-type or in engines having a single bank of cylinders-in-line.

The engine comprises eight pairs of transversely contiguous V-arranged cylinders A, B, the cylinders of each pair have their axes disposed in a plane perpendicular to the longitudinal vertical mid-plane of the engine and the cylinders of each of the two banks have their axes disposed in a common plane extending longitudinally of the engine. Each cylinder A or B slidably receives a working piston **20** or **21** respectively, the pistons of each contiguous pair of cylinders A, B operating through a connecting rod **22**, **23** bearing on the same throw or crank **24** of the eight-throw crankshaft C which is journalled adjacent each throw by a crankcase main bearing D, the two bearings immediately adjacent the gearing shown in Fig. 7 being designated as D'. One of the connecting rods of each pair, such as the connecting rods **22**, has its crankshaft-connected end forked to straddle the plain journalling end portion of the other connecting rod **23** associated therewith.

The crankcase or case E comprises a unitary casting of a light weight alloy such as the commercial alloys of aluminum or magnesium. This case has a pair of transversely spaced longitudinally extending hollow reinforcing side structures **25**, **26** each formed with a double wall comprising an upright outer wall **28**. These walls are merged together at the top of the case to form a seat **29** (Fig. 3) for receiving the pan **30** secured by fasteners **31** such that the pan provides a closure for the upwardly open case E.

Each of the hollow side structures **25**, **26** is formed with an upper transversely concave crankshaft-chamber-bounding hollow portion adjacent the crankshaft chamber **32** and a lower cylinder-bounding hollow portion adjacent the cylinders A and B respectively. These upper and lower hollow portions extend generally the length of the casting, portions of the inner walls of these hollow portions curving or sweeping inwardly toward each other as will presently be more apparent.

The upper portion of each hollow side structure **25**, **26** is defined by those portions which extend from the annular seats **33** to the pan seat **29** whereas the lower portion of each hollow side structure is defined by those portions which extend from the annular seats **33** to the plastic sealing rings **34** for the cylinder heads F. The outer wall **28** of each hollow side structure **25**, **26** slopes downwardly and outwardly from pan seat **29** to provide the outer boundary of the upper and lower hollow portions of such side structure, this outer wall being directed inwardly at the bottom to merge with the inner wall at the seal **34**. The inner walls **27** at the upper portions of the two hollow side structures **25**, **26** are so constructed and arranged as to directly tie together the two seats **33** of each transversely aligned pair of V-arranged cylinders A, B with those main bearings D which are disposed immediately adjacent such cylinders. Furthermore, the inner walls **27** at the upper portions of the two hollow side structures **25**, **26** directly tie together the four seats **33** of adjacent transversely aligned pairs of V-arranged cylinders A, B with that main bearing D which is disposed between such adjacent pairs of cylinders so as to form a hollow pyramidal pedestal or support G of X-brace effect between these cylinder loaded casing regions and

the main bearing. The latter is modified for adjacent pairs of V-arranged cylinders which are located at the longitudinal central region of the casing where, as illustrated, power takeoff gearing is disposed at this region. In this event each crankshaft bearing D' adjacent the gearing is directly connected with the cylinder seats of that pair of V-arranged cylinders which lies immediately adjacent such bearing D' by a pedestal support G' as will presently be more apparent.

Each main crankshaft bearing D comprises a bearing cap **35** of general rectangular formation formed with the downwardly open hemi-cylindrical bearing portion **36** complemental with the upwardly open bearing part **37** depending from the horizontal face **38** of the casing structure. The latter also has the side boundary faces **39**, **39'** which, along with face **38**, receive the cap **35** in the approximately rectangular trough thus formed by these faces. The bearing cap is located in position by dowels **40** (Fig. 5) and held securely in position by a pair of upright fasteners **41** which enter the casing adjacent bearing portion **37** and by a pair of transversely extending tension tie-rods **42** (Fig. 7) which extend between the hollow side structures **25**, **26** and which pass through cap **35**. These rods stress the side structures toward each other and are under initial tension. They also serve to reinforce the casing, add rigidity thereto, and divide portions of the bearing load between the side structures.

The faces **38**, **39**, **39'** are formed on a relatively heavy or thickened section of the casing **43** (Figs. 5 and 7) which extends around the bearing portion **37**. The inner walls **27**, adjacent a pair of the V-arranged cylinders A, B, are horizontally arched between the faces **39** of adjacent main bearings and between faces **39'**. These arched wall portions continue inwardly below face **38** and bearing portion **37** to intersect or merge at **44**. These arched wall portions also flare or sweep into the thickened annular casing portions **45** formed with shoulders **33**. The portions **45** merge at **45'** between the adjacent V-arranged cylinders at which region the intersecting portions **44** also merge into the upper face of the intermediate portion **45'** (Figs. 2, 3).

The desired hollow or double wall reinforcement is preserved along the hollow side structures **25**, **26** adjacent the crankshaft bearings by reason of the successive horizontally arched portions of the inner walls **27** merged at their adjacent ends between adjacent cylinders A and between adjacent cylinders B as at **46** (Figs. 4, 5). The oppositely disposed inner walls **27** are joined at **43** (Figs. 5, 7) at the apex of the pyramidal bearing support G immediately below each bearing portion **37** and then separate therebelow to provide the pyramidal support of hollow formation as at **48**.

The upper hollow portions of the side structures are further formed with horizontal walls **49** projecting as inner extensions of the pan seat **29** to the upright walls formed with faces **39**, **39'** respectively, the walls **49** merging with the upper ends of the horizontally arched portions of the inner walls **27**. At the mid-region corresponding horizontal walls **50** (Figs. 3, 6, 8) maintain their transverse width between the bearings D' as there is no crank throw at this region.

In order to reinforce the hollow side structures **25**, **26** the component walls **27** and **28** are integrally connected by a plurality of floors or horizontal walls. The upper portions of these side

structures are therefore formed with vertically spaced horizontal brace walls 51, 52.

The walls 51 join the successive horizontal arched portions of the inner walls 27 with the associated outer walls 28. At the sections containing the main bearings D (Fig. 5) the walls 51 laterally brace the hollow side structures 25, 26 in substantially a horizontal plane containing the axis of rotation of the crankshaft C. At these same sections the walls 51 have one or more openings 53.

The walls 52 join the outer walls 28 with the thickened annular casing portions 45, the walls 52 sloping inwardly and downwardly from the outer walls. These walls therefore assist in tieing the hollow side structures directly into the case regions which are loaded by the cylinders, these regions being tied into the pyramidal bearing supports G. Outer portions of the walls 52 also serve as top walls of coolant headers or galleries 54 respectively formed in the lower portions of the hollow side structures and inwardly of these galleries, at transverse sections containing the main bearings D (Fig. 5), each of the walls 52 has one or more openings 55 extending downwardly therethrough.

At the transverse engine sections containing the axes of each V-arranged pair of cylinders (Fig. 2), there is also provided vertical webs 56, 57 for each of the side structures 25, 26. The webs 56 rise from each floor 51 and join the upwardly converged walls 27, 28 of the associated side structure and are provided with one or more openings 58 longitudinally therethrough. The webs 57 depend from floor 51 to merge with floor 52 through the hollow bosses 59 which extend through the respective side structures 25, 26 in the transverse sections of which Fig. 2 is typical, the webs 57 also merging with the associated inner and outer walls 27, 28 and being provided with openings 60 similar to openings 58 for webs 56.

One or both of the hollow side structures 25, 26 is or are provided with a longitudinally extending lubricant feed gallery. In our present embodiment the side structure 25 is thus formed with lubricant feed gallery 61 formed as a hollow boss within this side structure merging with wall 28 and floor 51 and extending for the longitudinal length of the casing E.

The arching portions of each of the inner walls 27 between pairs of adjacent bearings D are each provided with two upper and lower pairs of openings 62 and 63 respectively. The inner walls 27, between each pair of adjacent bearings D, merge together at the bearing supports G and annular casing portions 45 so as to form a crankcase compartment for the associated crank throw and upwardly opening pair of associated cylinders A and B. Therefore there are successive crankcase compartments thus formed along the engine, these compartments being portions of the crankshaft chamber 32. The openings 62 extend obliquely of the casing E adjacent each bearing D so as to open each crankshaft chamber compartment with the uppermost hollow gallery of each side structure 25, 26, these galleries lying above floor 51. Adjacent compartments have the openings 62, which lie adjacent the common dividing bearing D, directed toward each other but not in axial alignment with each other. Such openings are preferably directed toward portions of wall 28 which bound the uppermost gallery at each side structure in the general region thereof containing the plane of an associated bearing D, such region lying between a pair of adjacent webs 56. The openings 63 are similarly arranged in association with the lower galleries lying between floors 51, 52 of each side structure 25, 26 and with portions of walls 28 which bound such galleries between adjacent webs 57.

By reason of the foregoing arrangement the pulsations in each of the crankcase chamber partitions, incident to the pairs of pistons 20, 21 alternately tending to compress and rarify the gases and oily vapors in these compartments, are relieved. Adjacent compartments are open to each other by reason of the openings 62, 63 and the galleries of the upper portion of each of the side structures 25, 26 so that the oily vapors and gases are free to surge back and forth between adjacent and other compartments as dictated by the pumping action of the various pistons, thereby relieving positive and negative pressure tendencies in the compartments. Furthermore, the oblique direction of openings 62, 63 is not only such as to expedite free surge between the compartments but causes the oily particles to separate from the gases due to the impingement on walls 28 and also by action of centrifugal force incident to the change in direction of the surge path in travelling between openings 62, 63 of different compartments. Such arrangement prevents objectionable loss of oil through the crankcase breathers of known construction (not shown) and also aids the oil scavenging system and general ventilating of the crankcase. The oil separated out at walls 28, and at walls 27, is collected in the galleries for drain back to the oil pumps, hereinafter referred to more specifically, by reason of the aforesaid openings 53 in floors 51 and openings 55 (Fig. 5) in floors 52. The openings 58, 60 in webs 56, 57 respectively, insure free surge of the vapors along the galleries which these webs respectively reinforce.

Referring now to the lower cylinder-bounding portions of the hollow side structures 25, 26, these portions are each likewise formed into a pair of vertically spaced galleries by reason of a floor 64 which joins the walls 27, 28 and which, between longitudinally adjacent cylinders, has an upstanding portion 65 (Figs. 4, 5) merging with floor 52 thereby closing the gallery 54 between floors 52, 64 from communicating with opening 55.

The gallery 54 of side structure 25 serves to return liquid coolant from cylinders A back to the cooling radiator (not shown) and is typical of the gallery 54 of side structure 26 associated with cylinders B. Each coolant return gallery 54 has an opening 66 (Fig. 2) in its wall 27 adjacent each shoulder 33 of the respective cylinders A and B thereby opening such gallery to the annular jacket space 67 surrounding each cylinder.

Each cylinder head F has an upwardly projecting outer cylindrical seating portion 68 spaced at 69 from its cylinder, and relatively outwardly disposed inner annular part 70 spaced within the external wall of the cylinder head to provide jacket 71. This latter part is internally threaded at 72 for connection with the outer or lower end of the cylinder. The jacket 71 is thus open at 69 with jacket 67 and thence by opening 66 to return gallery 54, the lower seal 34 preventing escape of the coolant.

At its upper or inner end each cylinder has a shoulder 73 seating on the annular portion 45. A ring 74 threadedly engages the cylinder at 75 and seats on a shoulder 33. Each ring 74 has gear teeth 76 formed thereon in position for engage-

ment by a suitable gear tool (not shown) applied through a boss 59 for rotating the ring so as to tightly pull the cylinder against seat 45, the ring 74 reacting at shoulder 33. After thus seating each cylinder and its associated cylinder head, the aforesaid gear tool is withdrawn and a lock member 77 fitted in sealing relation in each boss 59, the members 77 being held in place by fasteners 78 engaging a wall 28. Each member 77 has an inner finger 79 engaging a space between adjacent gear teeth 76 of an associated ring 74 thus locking the ring against accidental release.

Each cylinder head F is provided with an intake valve 80 and an exhaust valve 81 operated by valve gear 82 and camshaft 83 located in the valve-gear-housing 84 and cover 85. The intake valves control admission of air, in the case of a fuel injection type engine, or carbureted hydrocarbon fuel and air mixture, in the case of a carbureted engine, from intake manifold 86 and its branches 86' to the various combustion chambers from which the exhaust gases pass to exhaust pipes 87 under control of valve 81s. The manifold 86 is disposed between the banks of cylinders.

Attached to each valve gear housing 84 is a coolant supply header or pipe 88 running the length of the case E, these pipes 88 being disposed in the V-space between the banks of cylinders and adjacent opposite sides of manifold 86. Each pipe 88 has branch outlets 89 (Figs. 2, 7) for supplying coolant to the respective jackets 71 of cylinder heads F. The headers 88 merge at fitting 90 adjacent the rear of the engine (Fig. 1) for connection to the delivery of a coolant supply pump H having its intake 91 connected as customary to a cooling radiator or other supply of liquid coolant. Return coolant from the galleries 54 flows by return pipes 92 which extend from the rear of each gallery to the radiator.

Our engine is preferably of the type in which the power take-off from the crankshaft C occurs midway of the length of the crankshaft although in keeping with the broader aspects of our invention the power may be taken from one end of the crankshaft in more conventional manner.

The crankshaft is formed in two sections united to carry a gear 93 meshing with a larger gear 94 disposed directly below gear 93 so as to provide a torque-multiplying or reduction drive to the drive shaft 95 to which gear 94 is drivingly secured. This shaft extends forwardly of the engine to drive the aircraft propeller (not shown). The drive shaft 95 has its axis lying in the longitudinal vertical plane of the axis of crankshaft C and is disposed in a chamber 96 in the V-space. This chamber is formed by a bottom arched or trough-like lubricant-collecting wall 97 of the case E which joins the seal-seating enlarged ribbed annular end portions 98 of each V-arranged pair of cylinder-receiving tubular casing portions 99, 100 which depend from the annular seats 45 to receive cylinders A, B and form jackets 67.

The wall 97 is formed in two longitudinally extending portions owing to the interruption caused by the location of gear 94. However, each wall portion 97 extends around its associated seating portions 98 and outwardly at each side of the engine to provide bottom wall portions 101 which merge with the lower end portions of outer walls 26. These portions 101 therefore form the bottom wall of the cylinder-bounding lower portions of the hollow side structures 25, 26. The inner wall of each such lower portion is provided by the respective tubular portions 99, 100 each merging with an inner wall portion 27. This arrangement forms a hollow chamber 102 at the bottom of each side structure 25, 26, each of these chambers extending for the length of the casting. As seen in Fig. 5 the chambers 102 are open to each other at the transverse sections through the bearings D. At these sections the longitudinally adjacent tubular portions 99, 100 are spaced from each other so that chambers 102 are not only open to each other but also to the chamber 96.

At the longitudinal mid-region of the casting E, a transverse chamber 103 is provided for receiving the gears 93, 94, this chamber being formed by the transverse walls 104 (Fig. 7) and the longitudinally extending inner walls 27' (Figs. 6, 8) of the hollow side structures. These inner walls at this mid-region between bearings D' are shaped somewhat differently from the connected inner walls 27 at a section between bearings D in that they curve vertically around the adjacent peripheral portions of gears 93, 94, also in that they are of greater depth to provide the inner wall of an additional hollow chamber 105 integrally formed below chambers 102 at each of the hollow side structures 25, 26. This affords greater depth for the casing hollow side wall structures at the longitudinal mid-region which is stressed by the loads from gears 93, 94.

Each chamber 102 has transverse strengthening webs 106 in the planes of walls 104, these webs having an opening 107. The bottom wall portions 101 have openings 108 so that chambers 102 communicate with the additional chambers 105 which, in turn, open downwardly at 109 for drainage of oil from chambers 102 and 105 into a cast metal pan 110 which covers the bottom portions of the hollow side structures and gear 94 at the mid-region. The bottom wall portions 97 adjacent gear 94 are provided with openings 111 for drainage from chamber 96 into the pan 110. This pan has transverse reinforcing ribs 112 formed with a central bottom opening 113 for oil drainage from the ends of the pan toward the mid-region adjacent gear 94, the pan having its bottom sloping to expedite this oil drainage.

Shaft 95 together with its gear 94 and the rearward reduced accessory driving extension 114 of shaft 95 are journalled in a bearing 115 carried by each wall 104. The shaft 114 extends rearwardly for appropriate drive for the various accessories including supercharger J and water pump H. Gear 94 carries for rotation therewith a second gear 116 meshing with idler gears 117. Each idler meshes with a gear 118 mounted on one of the camshafts 83 for driving the same in timed relation with the crankshaft.

The pan 110 has openings 119 to receive the respective gears 118 and is formed with an inclined face bounding each of these openings. These inclined faces lie in the planes respectively of the lower faces of the cylinder heads F (Fig. 2) such that the housings 84 seat at the faces adjacent the pan openings 119 as well as at the bottom faces of the cylinder heads. Likewise a portion of cover 85 extends to house the lower portions of gears 118.

As hereinbefore stated, each bearing D' is provided with a hollow hemi-pyramidal pedestal or support G'. Each support G' comprises a transverse wall 104 which extends directly between a bearing 115 and a bearing D', and a curving or arching support wall similar to that hereinbefore described in connection with each of the supports G. A further wall or floor 120 joins the wall 104

with the arching support walls adjacent a bearing 115 (Figs. 7 and 9) thereby bracing each of the supports G'.

Each support G is provided with a plurality of holes 121 (Figs. 4, 5, 7) to accommodate drain of oil from around the upper ends of cylinders A and B downwardly through the pyramidal supports G to the floor 97. Each support G' also has corresponding drain holes 122 but in this instance the oil flows to each side along wall 120 and out from the hollow supports G' by way of the opening 122 (Figs. 8, 9) in each of the walls 104 whence the oil drains into pan 110. The oil collected on trough floor 97 flows from opposite ends of the engine toward gear 94 and drains into pan 110 by way of openings 111 and the space 124 between each floor 97 and wall 104 at a bearing 115. Also, the oil separated by the aforementioned surge between the crankcase chambers by way of openings 62, 63 drains downwardly in each of the hollow side structures 25, 26 through openings 53, 55 to the trough floors 97 and thence to pan 110.

At the lowest point in pan 110 which is adjacent the gearing 94, 116 the oil spills out laterally through openings 119 and downwardly into covers 85 for flow in opposite directions to the scavenging oil pumps K (Figs. 1, 10). There are four of these pumps, one at each end of each of the covers 85 driven from the adjacent end of one of the camshafts 83 as indicated in Fig. 10 for the pump K which is shown near the right-hand end of Fig. 1. Therefore regardless of the tilt of the engine one or more of the pumps will always deliver oil under pressure to the lubricating system of the engine.

In the typical drive shown in Fig. 10, a camshaft gear 125 drives through an idler gear 126 to a pump drive gear 127. The pump K is of any desired type such as the well known gear type pump for picking up the oil in the chambered end 128 of the cover 85 for delivery through pipe 129.

The delivery pipes 129 for each of the four scavenging pumps K are lead to an appropriate system of cooling and filtering the scavenged oil for redistribution under pressure to the engine parts which require lubrication. In Fig. 1 the delivery pipes 129, for the two scavenging pumps K shown on the illustrated left side of the engine, lead to a filter, cooler, and reservoir diagrammatically illustrated at L. Likewise the two pumps K on the right hand side of the engine have their delivery pipes 129 extending across the engine for juncture, as at 129', with the aforesaid delivery pipes leading to reservoir L.

An oil pump M draws the oil from reservoir L for pressure delivery to the lubricant gallery 61 whence the oil flows by appropriate passages to the various bearings and other parts requiring lubricating. In Fig. 8 we have illustrated passages 130 for lubricating one of the bearings D and a passage 131 for delivery of lubricant under pressure to a bearing 115 these passages being respectively formed in the floor 51 and walls 104.

Each bearing 115 has its cap 132 located in position with a pair of dowels 133 (Figs. 8, 8A) which take the lateral thrust due to the tangential loading of the gears 93, 94 and also serve to position the bearing caps laterally. In order to insure horizontal or lateral seating of each bearing cap 132 by means of the dowels 133, the sides of the cap 132 are formed convex as at 133a and the adjacent sides of wall 104 are formed concave as at 133b, there being a clearance between such sides. In this manner the dowels 133 must take the lateral loads from the gear thrusts. The bearing 115 is directly tied with bearings D' and the hollow side structures through supports G'. The bearing caps are fastened vertically into position by the usual fasteners 134.

It will be noted from Figs. 6 and 8 that the hollow side structures 25 and 26 are reinforced adjacent the gear compartment in a manner generally similar to the construction adjacent the various crankcase compartments. Thus, each of these side structures is provided with the aforesaid horizontal floor portions 51, 52, 64 and 101 forming hollow chambers in continuity with those illustrated in Fig. 2 for example. Furthermore, transverse webs 56 and 57 are provided in the general plane of each bearing D', these webs and floor 51 being apertured as indicated at 58, 60, and 53 in manner corresponding with the showing in Fig. 3 for example. The crankcase compartments adjacent each bearing D' are therefore open to each other through the hollow chambers above and below floor 51 at each hollow side structure 25 and 26 in conjunction with the aforesaid pairs of openings 62 and 63 for functioning as previously described. In order to drain the oil separated out of the gases surging through the uppermost pair of chambers in each of the hollow side structures 25, 26 between the crankcase compartments adjacent bearings D', the inner wall of each side structure is provided with a pair of openings 135 (Figs. 8 and 9). These openings lie adjacent the walls 104 out of the path of oil thrown by the gears 93, 94 and are located adjacent the inner ends of the floors 52 where oil would tend to accumulate. However any oil caught by the floors 52 at the Fig. 8 gear section, including that oil which drains down through openings 53 (Fig. 8) will drain through openings 135 and into pan 110 for passage to the scavenging pumps K as aforesaid.

We claim:

1. In an internal combustion engine of the V-type having longitudinally spaced pairs of V-arranged cylinders, a cylinder head carried by each of said cylinders and adapted to transmit thrust thereto as an incident to combustion in the cylinder head, a casing structure having longitudinally spaced pairs of V-arranged tubes respectively adapted to receive said pairs of V-arranged cylinders, each of said tubes having an annular thrust-receiving portion adjacent one end thereof for seating its associated cylinder thereby to take the aforesaid thrust of this cylinder, a crankshaft operably associated with said cylinders and having journal portions intermediate said pairs of V-arranged cylinders, said casing structure comprising bearing support portions for said crankshaft journal portions and a pair of side structures having curved wall portions thereof connecting adjacent bearing support portions and also extending between the annular cylinder seating portions of said pairs of V-arranged tubes and said bearing support portions.

2. In an internal combustion engine of the V-type having longitudinally spaced pairs of V-arranged cylinders, a cylinder head carried by each of said cylinders and adapted to transmit thrust thereto as an incident to combustion in the cylinder head, a casing structure having longitudinally spaced pairs of V-arranged tubes respectively adapted to receive said pairs of V-arranged cylinders, each of said tubes having an annular thrust-receiving portion adjacent one

end thereof for seating its associated cylinder thereby to take the aforesaid thrust of this cylinder, a crankshaft operably associated with said cylinders and having a journal portion intermediate said pairs of V-arranged cylinders, said casing structure also comprising a bearing support portion for said crankshaft journal portion and a pyramidal support extending from said bearing support portion to the annular seating portions of said pairs of V-arranged cylinders.

3. In an engine, a unitary crankcase casting comprising a pair of side structures each having a crankshaft-chamber-bounding wall, a pair of longitudinally spaced annular cylinder seats adjacent each side structure, crankshaft journalling means between adjacent cylinder seats, said walls having portions thereof transversely merged to provide a pyramidal pedestal adapted to connect, as a unitary structure, said seats and journalling means.

4. In an engine, a unitary crankcase casting comprising a pair of side structures each having a crankshaft-chamber-bounding wall, a plurality of longitudinally spaced pairs of V-arranged cylinder-receiving tubes each having an annular cylinder seat, crankshaft journalling means between said pairs of V-arranged cylinders, said walls having longitudinally extending portions thereof integrally connected with each other by said pairs of V-arranged tubes and other portions thereof transversely merged with each other to provide a hollow pyramidal pedestal adapted to connect, as a unitary structure, each of said journalling means with the seats of the adjacent pairs of V-arranged tubes.

5. A unitary crankcase for a multi-cylinder engine comprising, a plurality of pairs of cylinder-receiving tubes, crankshaft bearing portions interiorly of said crankcase and intermediate adjacent pairs of said tubes, said crankcase also having relatively spaced walls defining a hollow pyramidal structure integrally uniting two pairs of said tubes and a bearing portion.

6. A crankcase structure for an engine of the type having V-arranged banks of cylinders, comprising, transversely spaced side structures extending longitudinally of the engine, each of said side structures comprising inner and outer walls relatively spaced from each other, means comprising a plurality of pairs of transversely aligned V-arranged cylinder-receiving tubes connecting portions of the inner walls of said side structures, each of said tubes being arranged to receive a cylinder in jacketed relationship therewith for providing a coolant receiving space surrounding the cylinder, each of said side structures having a plurality of floors integrally connecting the inner and outer walls thereof and so constructed and arranged as to provide a coolant-receiving header between a pair of said floors communicating with the jackets of the cylinders of one of said banks.

7. A crankcase structure for an engine of the type having V-arranged banks of cylinders, comprising, transversely spaced side structures extending longitudinally of the engine, means comprising a plurality of pairs of transversely aliged V-arranged cylinder-receiving tubes connecting portions of said side structures, said tubes having bounding wall portions integrally connecting said tubes with each other as to provide a drive-shaft-receiving chamber extending longitudinally of the crankcase structures between said banks of cylinders, and said chamber having a concave lubricant collecting wall at the bottom thereof.

8. In an engine of the multi-cylinder type, a crankcase comprising a pair of transversely spaced longitudinally extending hollow side structures each having an outer wall and an inner wall, a crankshaft extending longitudinally between said side structures, bearings for said crankshaft, a pair of longitudinally spaced walls transversely joining the inner walls of said side structures intermediate the length thereof and forming therewith a gear-receiving compartment, a pair of said bearings being disposed respectively adjacent the opposite sides of said gear compartment for support by said compartment-forming transverse walls, a power take-off gear carried by said crankshaft in said compartment, said crankcase having a pair of annular cylinder seats longitudinally adjacent each of said compartment-forming transverse walls for respectively seating a pair of V-arranged transversely aligned cylinders, the inner walls of said side structures having arched portions thereof transversely merged with each other adjacent each of said compartment-forming transverse walls and so disposed as to connect one of said pairs of cylinder seats with one of said pairs of bearings.

9. In an engine of the multi-cylinder type, a crankcase comprising a pair of transversely spaced longitudinally extending side structures, a crankshaft, a power take-off gear carried by said crankshaft at a point intermediate the length thereof, a pair of crankshaft bearings disposed respectively adjacent the opposite sides of said gear, a second gear meshed with the first said gear, a gear-journalling bearing adjacent each of said crankshaft bearings for journalling said second gear respectively at opposite sides thereof, an annular cylinder seat adjacent each of said crankshaft bearings, and a pair of walls transversely connecting said side structures adjacent each side of said second gear, one of the walls of each of said pairs being curved and swept between one of said crankshaft bearings and the cylinder seat adjacent thereto, the other of the walls of each of said pairs being disposed between one of said crankshaft bearings and the gear-journalling bearing adjacent thereto.

10. In an engine of the multi-cylinder type, a crankcase comprising a pair of transversely spaced longitudinally extending side structures, a crankshaft, a power take-off gear carried by said crankshaft at a point intermediate the length thereof, a pair of crankshaft bearings disposed respectively adjacent the opposite sides of said gear, a pair of transversely disposed cylinder seats adjacent each of said crankshaft bearings, and a curved wall transversely connecting said side structures adjacent each of said crankshaft bearings, each of said walls being swept between one of said crankshaft bearings and the adjacent pair of cylinder seats so as to provide a pedestal bearing support of approximate hemi-pyramidal formation.

11. In an engine of the multi-cylinder V-type, a crankshaft having a power take-off driving gear carried thereby intermediate its length, a driven gear meshing with said driving gear, shaft means extending in opposite directions from said driven gear in parallel relationship with the axis of said crankshaft, a plurality of pairs of V-arranged cylinders at each side of said gears so arranged as to accommodate said shaft means in the V-space between said pairs of cylinders, a crankshaft bearing between adjacent pairs of said V-

arranged cylinders, a pair of cylinder seats respectively for each of said pairs of V-arranged cylinders, and a casing structure having a plurality of hollow pedestal supports of approximate pyramidal formation each of which comprises arched support walls swept between one of said crankshaft bearings and two adjacent pairs of the aforesaid cylinder seats.

12. In a multi-cylinder engine, a plurality of longitudinally spaced cylinders, a crankshaft, a plurality of longitudinally spaced crankshaft bearings, a casing structure mounting said cylinders and having a pair of longitudinally extending hollow side structures each of which comprises inner and outer walls, said inner walls having crankcase-forming arched portions thereof swept between adjacent crankshaft bearings and merged with each other adjacent said bearings thereby to provide a plurality of crankcase compartments, said arched inner wall portions having openings so disposed as to establish communication between adjacent compartments by way of said hollow side structures.

13. In an engine according to claim 12, said openings being so disposed in relation with each other and said outer walls that the oily vapors surging between adjacent compartments as an incident to operation of the engine are directed toward said outer walls.

14. In an engine of the inverted V-type having V-arranged banks of longitudinally aligned cylinders so disposed as to provide a plurality of longitudinally spaced pairs of transversely aligned V-arranged cylinders wherein the cylinders of each pair are diverged downwardly with respect to each other, a casing comprising a plurality of tubes respectively coaxially surrounding said cylinders thereby to provide transversely aligned V-arranged pairs of such tubes wherein the tubes of each pair are diverged downwardly with respect to each other, said casing having a lubricant-collecting wall extending between diverged portions of said V-arranged pairs of tubes, a crankshaft extending longitudinally of the engine above said cylinders, a plurality of longitudinally spaced bearings for said crankshaft disposed between adjacent pairs of said V-arranged tubes, said casing having crankshaft-chamber-forming walls including portions thereof swept from each of said bearings to the upper end portions of the pairs of V-arranged tubes which are disposed adjacent such bearings and so constructed and arranged as to provide a hollow pedestal of approximate pyramidal formation open downwardly toward said lubricant-collecting wall, each of said pedestals having an opening therethrough above said lubricant-collecting wall for draining lubricant collecting in said crankshaft-chamber downwardly through said pedestals and thence to said lubricant-collecting wall.

15. In an engine of the inverted V-type having V-arranged banks of longitudinally aligned cylinders so disposed as to provide a plurality of longitudinally spaced pairs of transversely aligned V-arranged cylinders wherein the cylinders of each pair are diverged downwardly with respect to each other, a casing comprising a plurality of tubes respectively coaxially surrounding said cylinders thereby to provide transversely aligned V-arranged pairs of such tubes wherein the tubes of each pair are diverged downwardly with respect to each other, said casing having a lubricant-collecting wall extending between diverged portions of said V-arranged pairs of tubes, said casing having a pair of longitudinally extending

hollow structures respectively defining the opposite sides thereof and each comprising an inner wall and an outer wall, the inner walls of said hollow side structures being transversely merged between adjacent pairs of said V-arranged tubes thereby defining a plurality of crankcase compartments, said inner walls having openings so arranged as to accommodate surge of the lubricant-containing vapors between adjacent compartments by way of said hollow side structures, and means for conducting lubricant tending to collect in said hollow side structures as an incident to said vapor surge downwardly to said lubricant-collecting wall.

16. In an engine of the inverted V-type, a crankcase having crankshaft-chamber-forming portions and an open bottom gear compartment, a plurality of longitudinally spaced transversely aligned pairs of V-arranged cylinder-receiving tubes disposed as a group at each side of said gear compartment, lubricant-collecting walls respectively extending between the tubes of each of said groups for collecting lubricant drained from said crankshaft-chamber, a pan adapted to receive lubricant from said lubricant-collecting walls, said pan underlying the bottom of said gear compartment and having a pair of lubricant discharge openings, a cylinder in each of said tubes and disposed in two longitudinally extending V-arranged banks, a cylinder head depending from the cylinder of each bank, a pair of valve-gear-housings extending longitudinally of the engine respectively adjacent its sides, each of said housings having portions respectively depending from the cylinder heads of one of said banks and an intermediate portion depending from said pan adjacent one of said lubricant discharge openings thereof so as to conduct lubricant downwardly therethrough from said pan, a cover for each of said valve-gear-housings adapted to receive said lubricant conducted through said intermediate portion.

17. In an engine of the inverted V-type, a crankcase having a gear compartment approximately mid-way of its length, a crankshaft in said crankcase, a gear mounted on said crankshaft and disposed in said gear compartment, a plurality of bearings for said crankshaft carried by said crankcase, means for conducting lubricant under pressure to said bearings, a plurality of pairs of V-arranged cylinders depending from said crankcase between said gear compartment and each end of said crankcase such that said cylinders form a pair of V-arranged banks extending longitudinally of the engine, means for conducting lubricant collected in said crankcase longitudinally inwardly from opposite end portions thereof to said gear compartment, means carried by each of said banks of cylinders for conducting lubricant from said gear compartment longitudinally outwardly therefrom to the opposite end portions of the engine for return to said pressure lubricant conducting means.

18. In an engine according to claim 17, and means for returning lubricant from said cylinder-bank-carried means to said pressure lubricant conducting means comprising a plurality of scavenging pumps respectively disposed at each side of said engine adjacent its said opposite end portions.

19. In an engine having a plurality of longitudinally aligned cylinders, a casing structure mounting said cylinders and having a crankcase portion subjected to lubricating oil drainage, a plurality of oil scavening pumps carried by the

engine, a pair of said pumps being disposed adjacent each end portion of the engine respectively at opposite sides thereof, and means accommodating oil passage from said crankcase portion to each of said scavenging pumps.

20. In an engine of the inverted V-type having a pair of downwardly diverged V-arranged banks of cylinders extending longitudinally of the engine, a pair of valve-operating shafts extending longitudinally of the engine respectively adjacent each of said banks of cylinders, a crankcase subjected to lubricant drain, a pair of scavenging pumps drivingly associated with each of said valve-operating shafts, the pumps of each pair being disposed respectively adjacent opposite end portions of said engine, and means accommodating passage of lubricant from said crankcase to each of said scavenging pumps.

21. In an engine of the V-type having a pair of V-arranged cylinder banks extending longitudinally of the engine, a casing for mounting said banks, said casing comprising a pair of hollow side structures including a lower portion defining elongated tubes for receiving the cylinders, said side structures each having an outer wall and an inner wall, and said inner wall extending around the cylinders and having portions forming an annular space with the cylinders providing coolant jackets for the cylinders of said banks, each of said side structures having a pair of vertically spaced walls transversely connecting the inner and outer walls thereof and extending lengthwise of the casing thereby forming a coolant-conducting header adapted to communicate with the jackets of the cylinders of one of said banks, groups of longitudinally spaced cylinder heads respectively associated with the cylinders of each of said banks, means for conducting coolant from the cylinder heads of each of said groups to the jackets of the cylinders respectively associated with such cylinder heads, and a pair of coolant supply pipes respectively associated with each of said groups of cylinder heads for coolant supply thereto.

22. A crankcase structure for an engine of the V-type comprising interconnected opposite sides and a bottom presenting a unitary casing of generally U shaped, elongated, trough-like appearance, a plurality of longitudinally spaced pairs of V arranged cylinder receiving openings in the bottom of said casing and a plurality of crankshaft bearing portions disposed within said casing between and above said pairs of V arranged openings; the opposite sides of said casing each consisting of spaced inner and outer walls defining a hollow side structure, said inner walls of said side structures being longitudinally arched between said bearing portions and each arranged to sweep inwardly of said casing to interconnect with the similarly arched inner wall of the opposite side structure and with said bearing portions to support the latter and convey inertia loads imparted to said bearings during operation of said engine to said structures.

23. A crankcase structure for an engine of the V-type comprising interconnected opposite sides and a bottom presenting a unitary casing of generally U shaped, elongated, trough-like appearance, a plurality of longitudinally spaced pairs of V arranged cylinder receiving openings in the bottom of said casing and a plurality of crankshaft bearing portions disposed within said casing between and above said pairs of V arranged openings; the opposite sides of said casing each consisting of spaced inner and outer walls defining a hollow side structure, said inner walls of said side structures being longitudinally arched between said bearing portions and each arranged to sweep inwardly of said casing to interconnect with the similarly arched inner wall of the opposite side structure and with said bearing portions to support the latter and convey inertia loads imparted to said bearings during operation of said engine to said structures, and a plurality of vertically spaced reinforcing and tube defining floors interconnecting said inner and outer walls of said side structures, one pair of floors defining a header for conducting coolant to adjacent the cylinder openings.

24. A crankcase structure for an engine of the V type comprising interconnecting opposite sides and a bottom presenting a unitary casing of generally U shaped, elongated, trough-like appearance, a plurality of longitudinally spaced pairs of V-arranged cylinder receiving openings in the bottom of said casing, a plurality of crankshaft bearing portions disposed within said casing between and above said pairs of V-arranged openings; the opposite sides of said casing each consisting of spaced inner and outer walls defining a hollow side structure, each of said inner walls having a plurality of concave portions adjacent said pairs of cylinder openings and so constructed and arranged so as to extend transversely to interconnect with the similar concave portions of the inner wall of the opposite side structure and with said bearing portions whereby inertia loads imparted to said bearings during operation of said engine may be transmitted to said side structures.

25. A crankcase structure for an engine of the V type comprising interconnecting opposite sides and a bottom presenting a unitary casing of generally U shaped, elongated, trough-like appearance, a plurality of longitudinally spaced pairs of V-arranged cylinder receiving openings in the bottom of said casing, each having a ring-like seat for taking the reaction of the cylinder combustion load, and a plurality of crankshaft bearing portions each disposed within said casing transversely between and juxtaposed a pair of said V-arranged openings, each of said bearing portions having curved wall portions sweeping down therefrom to interconnect with said bottom contiguous a quadrant of each of said pair of juxtaposed openings and to connect with concave wall portions of the casing sides in a substantially continuous curve.

26. A crankcase structure for an engine of the V type comprising interconnecting opposite sides and a bottom presenting a unitary casing of generally U shaped, elongated, trough-like appearance, a plurality of longitudinally spaced pairs of V-arranged cylinder receiving openings in the bottom of said casing each having a ring-like seat for taking the reaction of the cylinder combustion load, and a plurality of crankshaft bearing portions each disposed within said casing transversely between and juxtaposed a pair of said V-arranged openings, the opposite sides of said casing each consisting of spaced inner and outer walls defining a hollow side structure, said inner walls being longitudinally arched between said bearing portions and each arranged to sweep inwardly of said casing to interconnect with the similarly arched inner wall of the opposite side structure and with said bearing portions and said inner walls having curved portions continuous with said arched portions and that sweep down from said bearing portions to interconnect said

casing bottom contiguous the said ring-like seats of said juxtaposed openings.

27. A unitary crankcase structure for an engine of the V type comprising hollow side structures including an upper hollow portion defining a crankshaft chamber and a lower hollow portion defining a plurality of longitudinally spaced pairs of V arranged elongated tubes adapted to receive a cylinder in jacketed relationship therewith, and defining ring-like cylinder seating portions for taking the reaction of the cylinder combustion load, a plurality of crankshaft bearing portions in said crankshaft chamber above and intermediate said pairs of tubes; the said side structures having inner and outer walls, the inner walls of said upper hollow portion being longitudinally arched between and connecting with said bearing portions and having curved portions interconnecting said bearing portions with said cylinder seating portions and said lower hollow portion having a plurality of floors connecting the inner and outer walls thereof, a pair of said floors defining a coolant receiving header communicating with the jackets of said cylinders.

28. A crankcase structure for an engine of the V-type comprising interconnecting opposite sides and a bottom presenting a unitary casing of generally U-shaped, elongated, trough-like appearance, a plurality of longitudinally spaced pairs of V-arranged cylinder-receiving openings in the bottom of said casing, each having a ring-like seat for taking the reaction of the cylinder combustion load, and a plurality of crankshaft bearing portions each disposed within said casing transversely between and juxtaposed a pair of V-arranged openings, said casing having opposite wall portions longitudinally arched between said bearing portions and each arranged to sweep inwardly of said casing to interconnect with the similarly arched wall portion of the opposite side of the said casing and with said bearing portions,

and said wall portions having curved portions continuous with said arched portion and that sweep downwardly from said bearing portions to interconnect with said casing bottom contiguous the said ring-like seats of said juxtaposed openings.

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