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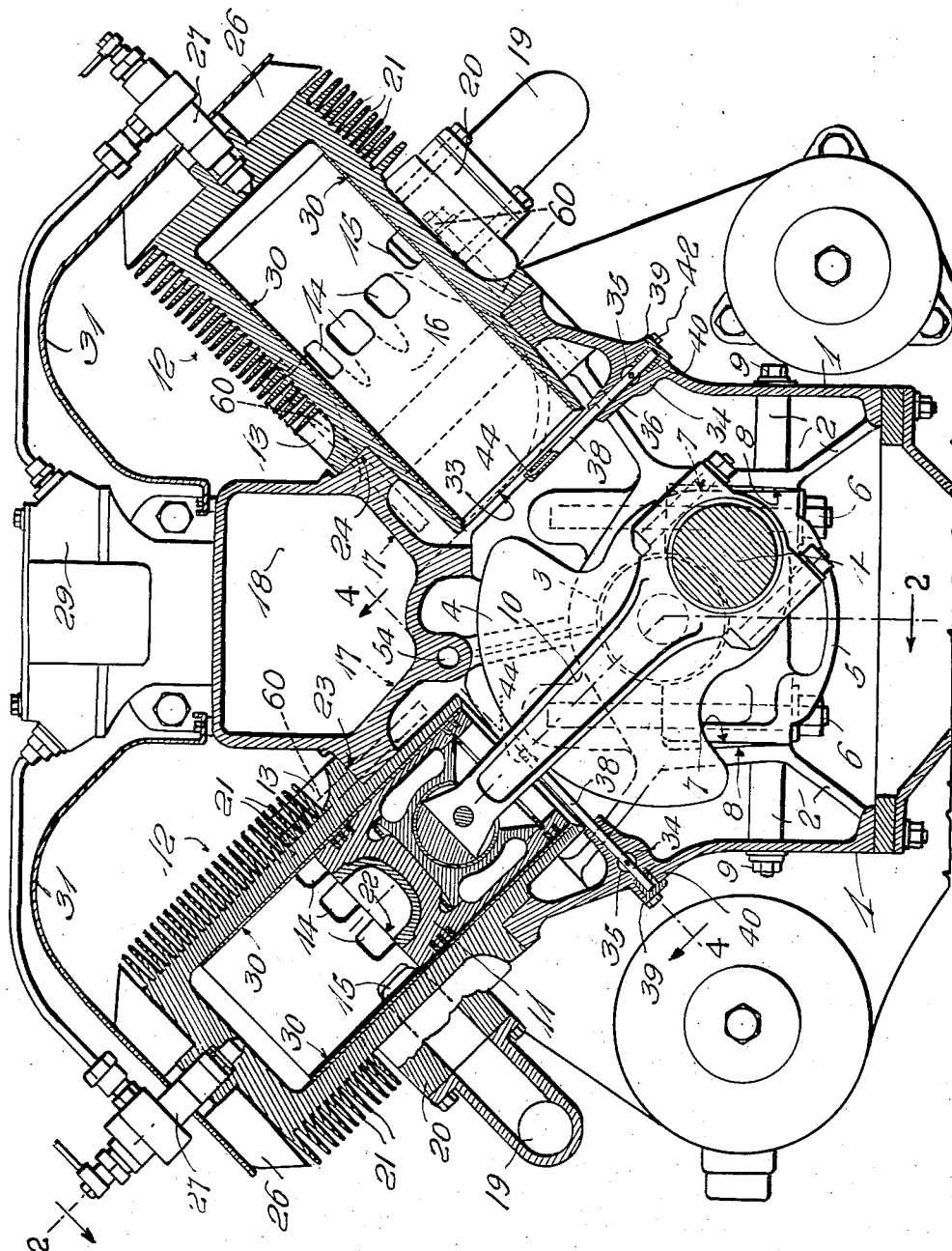
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2,966,146

AIR-COOLED, PORT-SCAVENGED ENGINE

Filed Oct. 29, 1957

4 Sheets-Sheet 1



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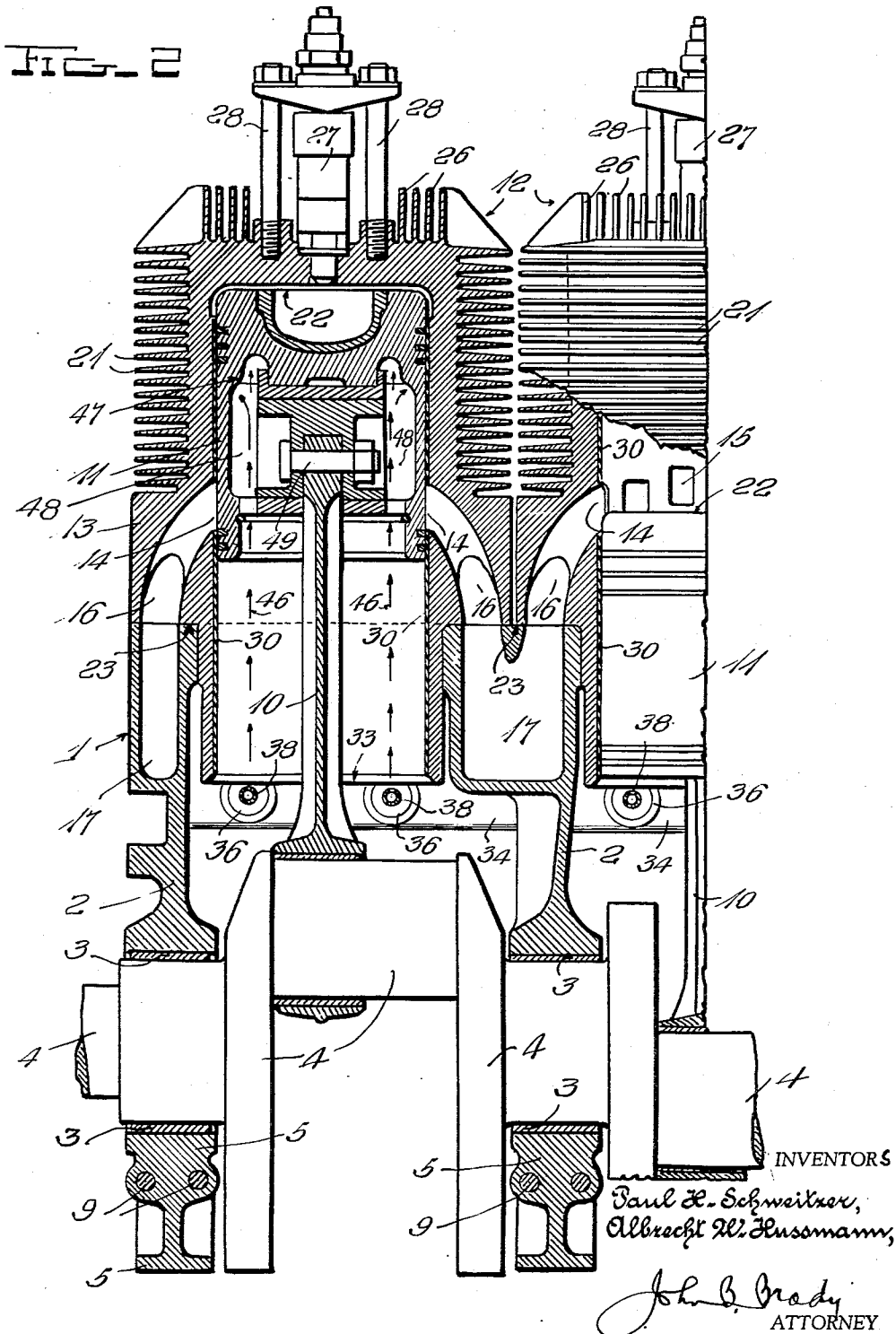
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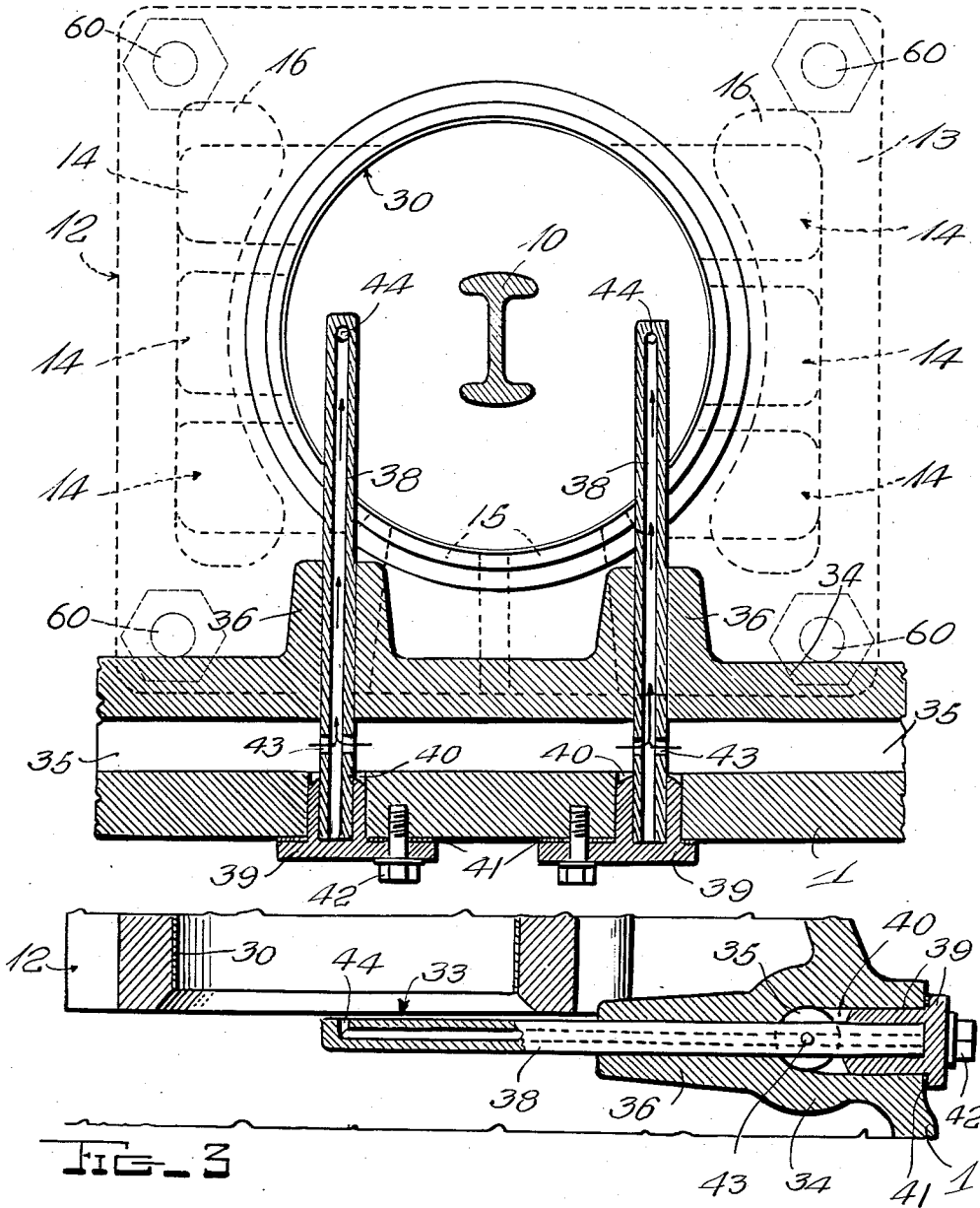
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FIG. 4



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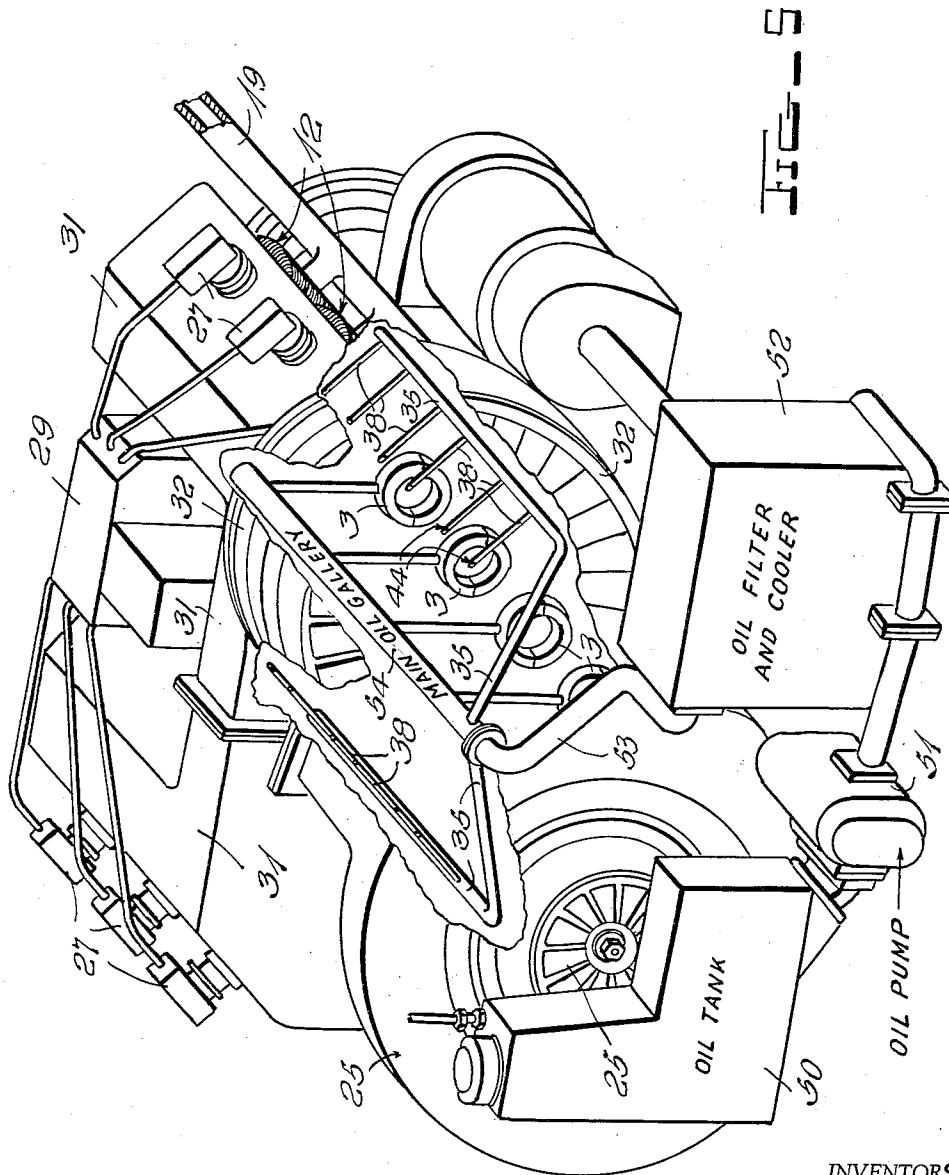
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2,966,146

AIR-COOLED, PORT-SCAVENGED ENGINE

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7 Claims. (Cl. 123—41.56)

Our invention relates broadly to engines and more particularly to an air-cooled, two-stroke cycle, loop-scamvenged engine with individual integral cylinder units.

One of the objects of our invention is to provide a construction of an air-cooled, two-stroke cycle, loop-scamvenged engine which is light in weight without sacrificing the qualities or rigidity, long life, and reliability.

Another object of our invention is to provide a construction of an air-cooled, two-stroke cycle, loop-scamvenged engine in which cylinder heads are eliminated by the integration of cylinder heads and cylinders into individual one-piece units for each cylinder in combination with forced-flow cylinder and piston lubrication and cooling means located in the crankcase below the integral cylinder units.

Another object of our invention is to provide a construction of an air-cooled, two-stroke cycle, loop-scamvenged engine with one or more stationary nozzles located beneath each piston, which emit jets of oil to cool the underside of said pistons and lubricate the cylinder bore associated with each of said pistons.

Still another object of our invention is to provide a construction of an air-cooled, two-stroke cycle, loop-scamvenged engine in which the number of parts, the number of heavy metal parts, and the number of moving parts have been reduced to a minimum to decrease engine cost and engine weight and to simplify engine maintenance.

Other and further objects of our invention are set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Fig. 1 is a vertical cross sectional view of an arrangement in V-form of the engine of our invention particularly showing the individual cylinders bolted on the crankcase and the crankcase air channels which conduct air from the air box to the matching air channels on the bottom of the cylinder flange;

Fig. 2 is a transverse sectional view taken substantially along line 2—2 of Fig. 1 and showing a fragmentary portion of the cylinder and associated crankcase and particularly showing the air intake channels in the crankcase and cylinder units, and the manner in which the jets of oil cool the inside of the pistons;

Fig. 3 is substantially an enlarged vertical view partly in elevation, of a fragmentary portion of Fig. 1, particularly showing the alignment of the oil nozzle with the center of the cylinder and the construction and arrangement of the oil tube and the oil manifold;

Fig. 4 is a transverse sectional view taken substantially along line 4—4 of Fig. 1 and particularly showing the construction of the oil tubes, their relation to the oil supply gallery and their symmetrical spatial relation with the piston rod and cylindrical unit; and

Fig. 5 is a perspective view of a particular arrangement of the air-cooled, two-stroke cycle, loop-scamvenged engine of our invention, partly cut away to schematically show the oil delivery system for the main bearings and the oil tubes.

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Our invention is directed to the construction of a lightweight, air-cooled, two-stroke cycle, loop-scamvenged engine. The engine is constructed entirely of aluminum or other light metal, except the crankshaft, connecting rods and some smaller parts, thus making its weight relatively light. Lightweight, compactness, and simplicity have been achieved by the omission of many components such as cylinder liners; cylinder heads; cylinder head covers; valves, valve springs, guides and seats; rocker arms, bearings and bushings; pushrods, tappets, cam rollers and bushings; camshafts and camshaft bearings; lubrication system for camshaft, tappets, rocker arms and valve guides; water jackets; water pump; and radiator which appear on conventional diesel engines. Because of the smaller number of parts the engine of our invention is economical to manufacture and to maintain.

The engine has only three principal moving parts: the pistons, crankshaft and connecting rods. A single integral piece constitutes the cylinder head, cylinder liner and cooling fins. This is possible since all valves and associated parts have been dispensed with and replaced with air intake ports and exhaust ports cast in the cylinders and controlled by the piston crown. An air box is cast into the top center of the crankcase and on either side an inclined plane accommodates circular holes into which the individual integral cylinder units are fastened. The air is supplied to the air box by a blower unit and conducted from there to openings on the cylinder seating planes which match openings in the cylinder unit flanges and from there through internal ducts to the air intake ports on the cylinder periphery.

The cylinder bore is plated with porous chromium and since the heat conductivity of the aluminum is several times greater than that of cast iron, and the heat dams at the surface joints between liner and cylinder, and between cylinder and cylinder head have been eliminated, the resulting unimpeded flow of heat from the cylinder to the cooling fins is a decisive factor in making the air-cooling of this engine possible.

Further cooling is provided by a pair of stationary oil tubes located directly beneath each integral cylinder unit and arranged to direct continuous jets of oil up into the cylinder bore and onto the under surfaces of the piston. The oil tubes for each cylinder are in the longitudinal plane of the cylinder axis and disposed equally on either side of the associated piston rod. They are mounted in a flange, protruding from the inner surface of the crankcase, which contains an oil manifold through which all the oil jet nozzles on one side of the crankcase pass. The oil tubes on the other side of the crankcase pass through an identical oil manifold and both oil manifolds are connected into the main lubrication system from which they receive their oil supply. An individual tube mounting flange protruding from the oil manifold flange is provided for each oil tube. The oil tubes are individually removable, for replacement or repair, from the outside of the engine crankcase.

The crankcase is a one-piece aluminum casting in which mounting webs are provided for the crankshaft bearings. Each main bearing has a bearing cap bolted to it which fits snugly in the recess of the crankcase. Under or through the bearing caps, anchor bolts draw the opposite crankcase walls rigidly together and to the bearing caps to form a stiff structure. The sides of the bearing caps are machined with a small angular difference of the order of one-half of one degree with respect to the matching surfaces of the crankcase. The pressure produced by the anchor bolts on the side surfaces of the bearing caps has a vertical upwardly directed component due to the angular difference between the surfaces and this tends to press the bearing caps onto their seats and discourages them from lifting from their seats during the

instants of peak pressures produced by firing, since at these times the bearing caps carry most of the cylinder gas pressures.

Referring to the drawings in more detail, reference character 1 designates the lightweight metal or aluminum crankcase carrying associated web members 2 which carry the main bearings 3 in which crankshaft 4 rotates. Main bearing caps 5 are bolted at 6 into snug fitting recesses in main bearing webs 2. Bearing cap sides 7 are machined with a slight taper progressing from bottom to top to present a small angular difference, of the order of approximately one-half of one degree, between the bearing cap sides 7 and the adjacent matching surfaces 8 of the bearing cap recesses in crankcase webs 2. Anchor bolts 9 passing through opposite walls of crankcase 1, crankcase web 2, and main bearing caps 5 after they are bolted in place, draw the opposite crankcase walls together and thus matching surfaces 8 and 7 of the crankcase web and main bearing caps, respectively. When thus drawn together, since there is a small angular difference between adjacent matching surfaces 8 and 7, the anchor bolts impart vertical upwardly directed force components to the bearing caps 5 which tend to press them against and hold them firmly in their seat on crankcase web 2. With this self-supporting type construction a stiff and more rigid structure is obtained and permits the use of lightweight metal in the construction of the engine crankcase and the main bearing caps without loss of rigidity. Two anchor bolts 9 are provided through each main bearing cap. Crankshaft 4 carries piston connecting rods 10 connected to piston 11.

As shown at 12 a single integral aluminum casting constitutes the cylinder, cylinder head, cylinder liner, mounting flange and cooling fins. The individual cylinder units are bolted as shown at 60 by means of their thick rectangular shaped mounting flange 13 to the upper surfaces 23 and 24 of crankcase 1 which, in the case of a V-arrangement with a 90° bank-angle, have a forty-five degree slope and contain holes to receive said cylinder units. When bolted in position the center lines of opposite cylinder units are normal to each other to form a ninety degree V-type engine of the type as shown in the example of Fig. 1. The integral cylinder unit contains air intake ports 14 and exhaust ports 15 of rounded rectangular shape cast into the cylinder wall. Two independent air channels 16 located on opposite sides of the cylinder unit, flanking the exhaust ports, and cast into the massive mounting flange 13, each join half of the air intake ports and when cylinder unit 12 is bolted in place by bolts 60 air channels 16 match with respective air channels 17 which are cast into crankcase 1 and connect with scavenging air box 18 cast into the upper portion of the crankcase. The high massive mounting flange 13 which contains the air ducts 16 contribute greatly to the cooling and equalization of temperatures in the cylinder by providing not only large cross sections of a highly heat conducting metal but also large areas for heat flow into the crankcase from the flange. In addition the air ducts 16 in the flange provide further effective cooling areas through heat flow from the metal to the scavenging air.

As shown in Fig. 1 the height of the massive flange 13 is substantially twice the height or twice the vertical dimension of the rounded rectangular shaped air intake ports 14. The flange is bolted to the crankcase as shown at 60 in substantially the four corners of the rectangular shape thereof to fasten the cylinder unit to the crankcase. The massiveness of the flange provides the necessary strength for transmitting explosive cylinder forces to the crankcase. Thus the cylinder unit by being bolted only at the flange to the crankcase allows free expansion of the upper part of the cylinder away from the crankcase, and of the lower part of the cylinder towards the crankcase, leaving the upper part of the cylinder and the cylinder head free of mechanical distortions. From the foregoing

it can be seen that the massive flange performs a three-fold purpose by cooling the cylinder port region, transmitting forces to the crankcase and by reinforcing the crankcase rigidity.

Exhaust ports 15 lead directly through the cylinder wall and into exhaust manifold 19 which is attached to mounting flange 20 provided at a break in the peripheral concentric cooling fins 21. The exhaust ports face toward the outside walls of the engine away from the air box 18. As piston 11 approaches the bottom of its travel, piston crown 22 first uncovers the exhaust ports 15 to enable the expanded hot gases to begin their exit before the air intake ports are uncovered.

Scavenging air is supplied to crankcase air box 18 by a blower unit, as shown at 25. The air from the air box passes through channels 17 to slots in the 45 degree cylinder unit mounting surfaces 23 and 24. Two slots, located laterally on the bottom of each cylinder unit mounting flange 13, match the slots in the crankcase surfaces 23 and 24 and convey air to inlet ports 14 through channels 16. Loop scavenging is used in which the inlet ports are located on the two sides of the exhaust ports and are directed to the cylinder wall opposite to the exhaust ports. The inlet ports are also directed upward at an angle of approximately 45 degrees. In this way the air is forced to rise along the inner cylinder wall, be deflected by the top of the integral cylinder unit, and flow down on the outer cylinder wall before it can escape through the exhaust ports.

The head of the integral cylinder unit 12 contains cooling fins 26 which are parallel to the transverse plane. A hole is provided in the center of the integral cylinder unit head, through cooling fins 26 and the cylinder head wall, to accommodate fuel injection nozzle 27 secured by mounting bolts 28. The fuel injection pump system is designated at 29 on top of crankcase air box 18.

To avoid heating and warping of the exhaust side of the cylinders and to discourage piston ring sticking and piston seizure the use of pistons of the class as set forth in co-pending application Serial No. 471,287, filed November 26, 1954, now Patent 2,815,993, dated December 10, 1957, by Paul H. Schweitzer, for "Piston and Connecting Rod Assembly for Internal Combustion Engines," is desirable. Under extensive tests we have found that use of oil jet-cooled rotating type pistons, in combination with the integral cylinder units, have successfully eliminated piston ring sticking which is a major problem to be overcome in the air-cooling of diesel engines.

The bore of the integral cylinder unit 12 is plated with porous chromium 30 to eliminate the necessity for a cylinder liner. The porous chromium plating on the aluminum cylinder bore gives very high wear resistance and still retains the excellent heat-conductivity of the aluminum. The greater heat conduction of the aluminum of the integral cylinder unit and the elimination of the heat dams at the surface joints between liner and cylinder, and between cylinder and cylinder head, improve the cylinder cooling to the extent that trouble-free air-cooling is attained.

The integral cylinder units 12 are partially enclosed in ducts 31 extending around the top of the engine and connected so as to receive air from cooling air blower 32. Cooling air from blower 32 is directed over cooling fins 26 and 21 of the integral cylinder units 12, by these air ducts.

Further cooling of the engine is accomplished by an oil jet nozzle system internally disposed within the crankcase. The side walls of crankcase 1, in the vicinity of the lower edges 33 of integral cylinder units 12, contain inwardly projecting protrusions shown at 34 in which oil manifolds 35 are located. One oil manifold 35 is provided for each side of the crankcase and they substantially traverse the length of the crankcase. Two extended flange protrusions 36, from protrusion 34, are provided beneath each cylinder unit 12 to support oil tubes 38.

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Oil tubes 38 pass through crankcase 1, oil manifold 35 and flange 36. Oil tubes 38 are individually and independently removable from the crankcase since each is brazed into an individual nipped mounting member 39, which is inserted in hole 40 and sealed and secured to crankcase 1 by gasket 41 and bolt 42, respectively. The oil tubes contain hole 43 through their diameter at the point where they pass through the center of oil manifold 35 and when secured in position the tubes are aligned so the center line of oil manifold 35 substantially passes through these holes. Holes 43 thus admit cooling oil from oil manifold 35 to the hollow centers of oil tubes 38. The ends of the oil tubes are provided with nozzle orifices 44 drilled approximately ninety degrees to the tube axis. The oil tubes are displaced in a plane parallel with the bottom edge of the cylinder unit so they are symmetrical with respect to the piston rod and the cylinder walls. Their locations and lengths are such that jets of oil 46, issuing from orifices 44 shoot straight up in the plane of the crankshaft and cylinder axis onto the underface 47 of the piston crown. Part of the cooling oil is caught in the piston cavities 48 and cavities in the wrist pin carrier and is sloshed up and down to increase its cooling effect. From the cavities the oil runs down to lubricate the piston wrist-pin 49 and the chromium plated cylinder bore 30, thus fulfilling both a lubrication and a cooling function.

Fig. 5 is a perspective view partly cut away to show the relation between the main bearing and the oil tube delivery systems. Oil tank 50 supplies oil to oil pump 51 which passes it to oil filter and cooler 52 from which it passes by way of delivery pipe 53 to main oil gallery 54 and oil manifolds 35. Main oil gallery 54 supplies oil to main bearings 3 while, as described earlier, oil manifolds 35 supply oil to oil tubes 38.

While we have described our invention in certain preferred embodiments we realize that modifications may be made and desire that it be understood that no limitations upon our invention are intended other than may be imposed by the scope of the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States is as follows:

1. An air-cooled, port-scavenged engine comprising a crankcase terminating in mounting surface having air channel openings therein, a scavenging air-box cast into the upper portion of said crankcase and substantially traversing the length of said crankcase, air-cooled lightweight metal integral cylinder units having massive mounting flanges, said massive mounting flanges having upper mounting surfaces thereon, means for securing said massive mounting flanges to the mounting surfaces of said crankcase, said mounting surfaces containing holes into which a portion of the lower extremity of said integral cylinder units extend, said integral cylinder units each comprising a single integral casting constituting the cylinder wall, cylinder head, cylinder liner, mounting flange and cooling fins exteriorly disposed about the periphery and the top wall thereof, and containing air intake and

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exhaust ports cast into the peripheral cylinder wall, said massive mounting flange having a seating surface and containing air channels connecting said air intake ports with openings in said seating surface which correspondingly match with respective air channel openings on said mounting surfaces of said crankcase which communicate with said scavenging air-box, said upper mounting surfaces of said flanges being disposed in substantially the same plane as the tops of said air intake ports, and said mounting flange air channels being disposed immediately beneath said upper mounting surface and pistons operating in said integral cylinder units under control of connecting rods carried by a crankshaft journaled with respect to said crankcase.

2. In an air-cooled port-scavenged piston engine, a crankcase, a cylinder comprising inlet and exhaust ports, a flange formed on said cylinder having air ducts therein connecting said inlet ports, said flange having a substantially rectangular contour and of a height substantially twice the vertical dimensions of said inlet ports and means rigidly connecting said flange to said crankcase for transmitting the forces between said cylinder and said crankcase, and air ducts in said crankcase mating with the air ducts in said flange.

3. An air-cooled, port scavenged piston engine as set forth in claim 2 in which said flange formed on said cylinder provides double walls on two of its sides.

4. An engine as set forth in claim 2, said cylinder being one integral part with its cylinderhead and said flange, said flange, said air ducts, said crankcase with its mating surfaces and air ducts, constituting part of the cooling system of said engine, whereby the width of said flange is such as to provide large contact surfaces for the flow of heat from said flange to said crankcase.

5. An engine as set forth in claim 2 in which said flange and said crankcase have relatively large contact surfaces located adjacent the exhaust ports.

6. An engine as set forth in claim 2 in which said flange, by said vertical dimension and said substantially rectangular contour provides means of improved heat flow from said exhaust ports to said inlet ports.

7. An engine as set forth in claim 2 in which the cooling system includes two means, one of said means consisting of a fin system, the other of said cooling means comprising the coating masses of said flange and said crankcase, said other cooling means coating to equalize the temperature of the region of said cylinder comprising said ports and reducing distortions to a minimum.

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