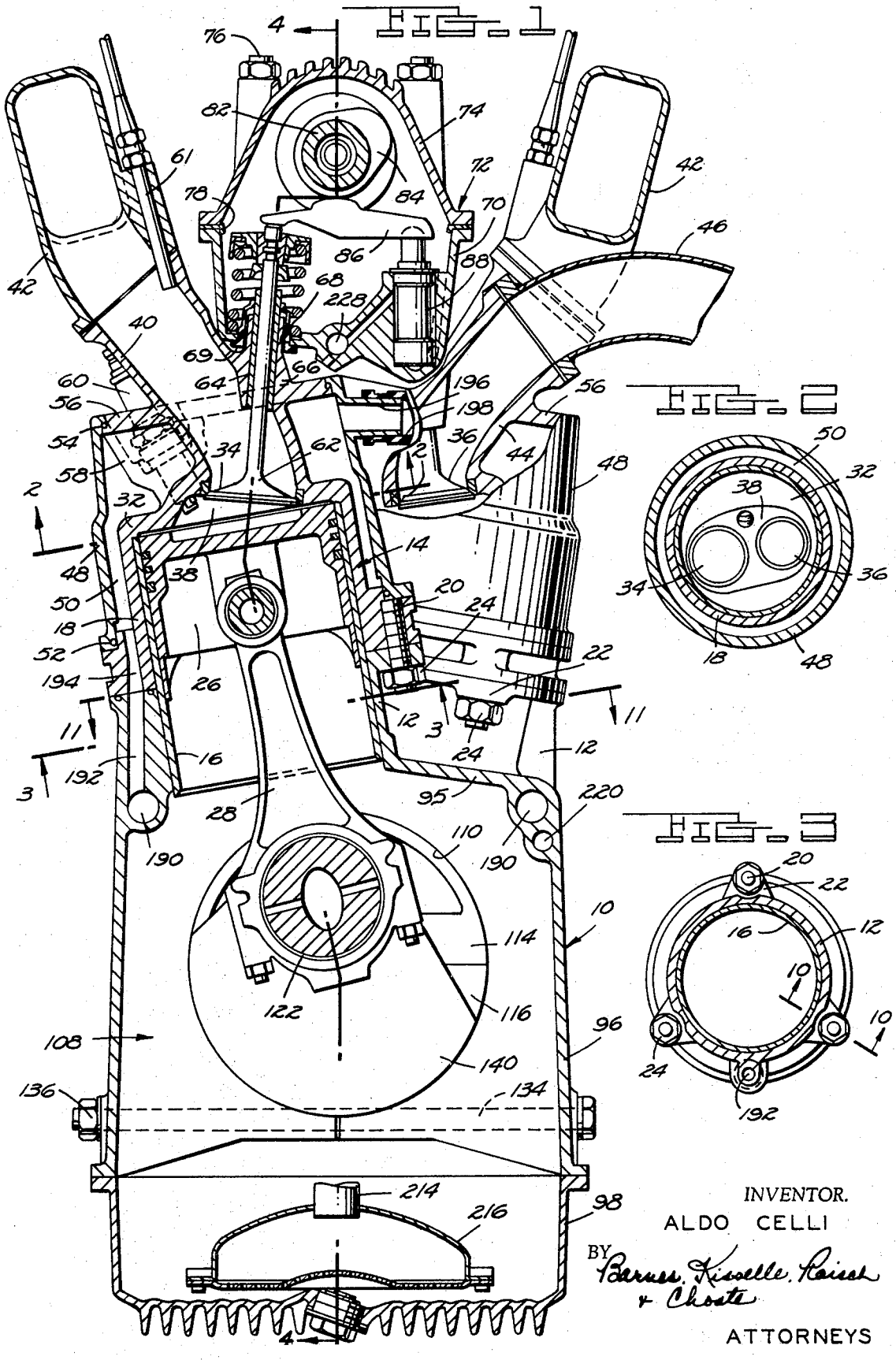
July 28, 1970 A. CELLI 3,521,613

ENGINE WITH DIE-CAST STATIC PARTS

Filed Sept. 17, 1968 6 Sheets-Sheet 1



July 28, 1970 A. CELLI 3,521,613

ENGINE WITH DIE-CAST STATIC PARTS

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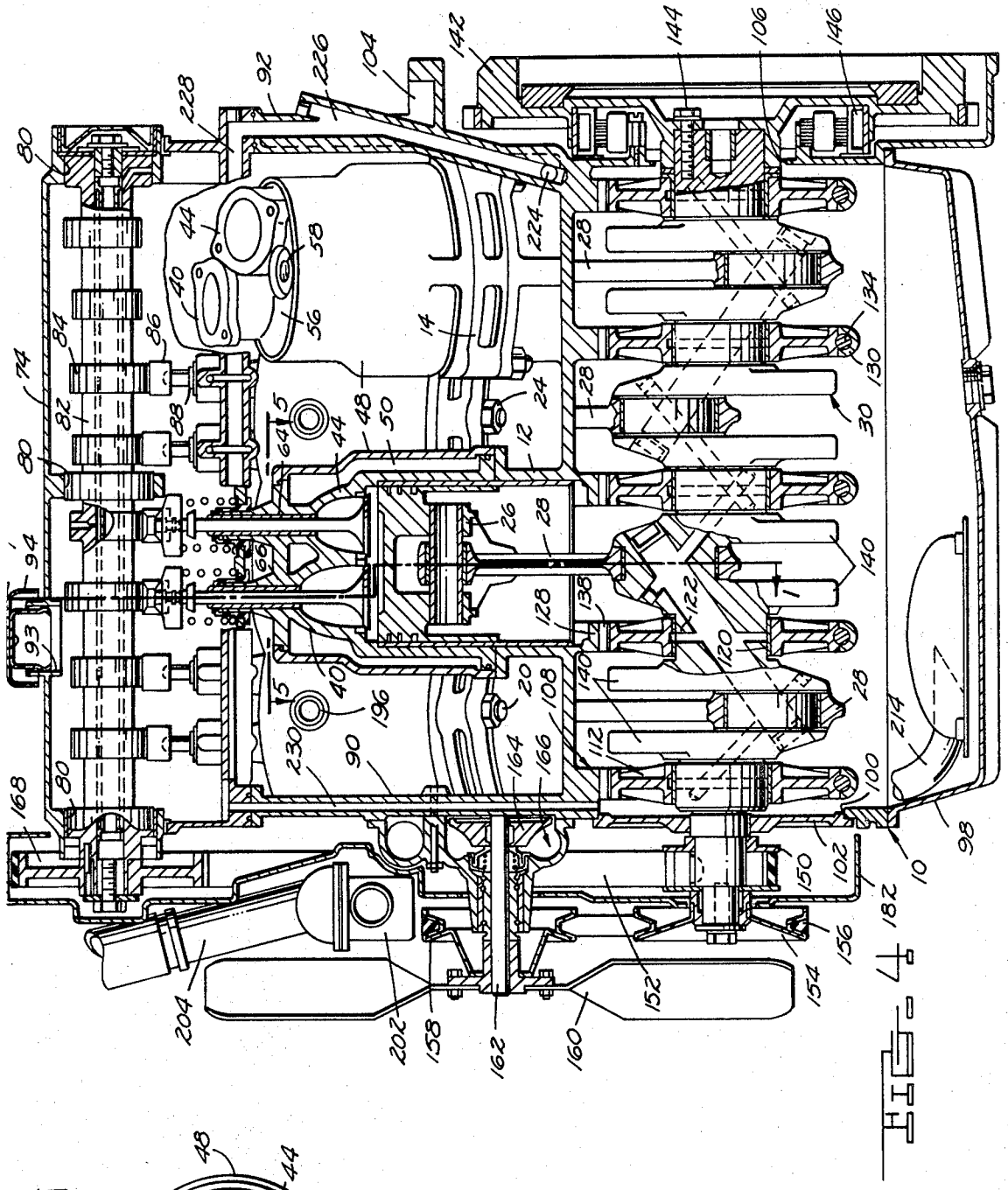

FIG. 4

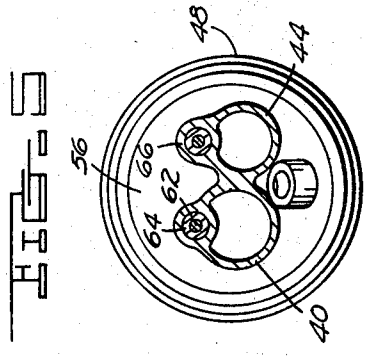

FIG. 5

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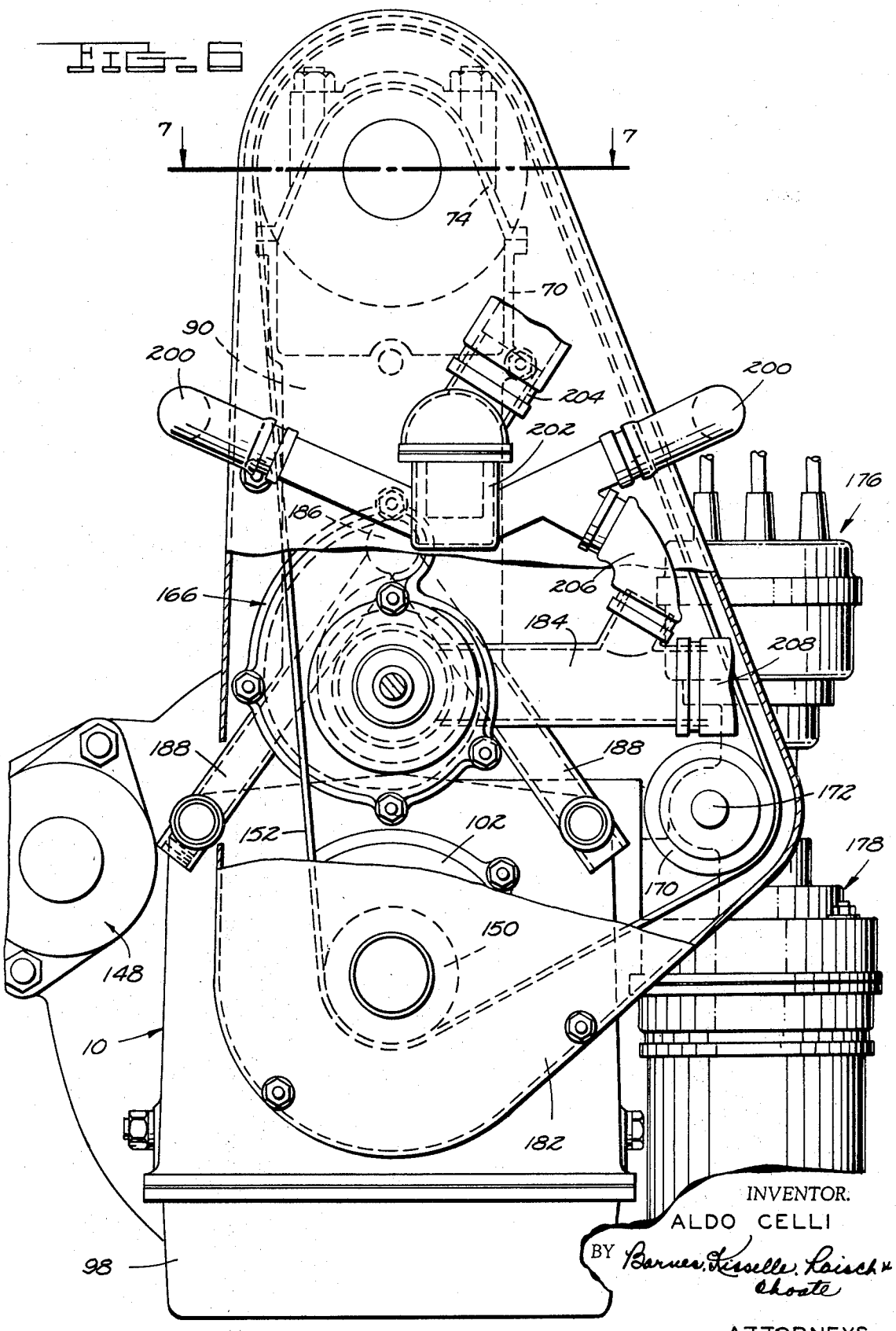
FIG. 6



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ENGINE WITH DIE-CAST STATIC PARTS

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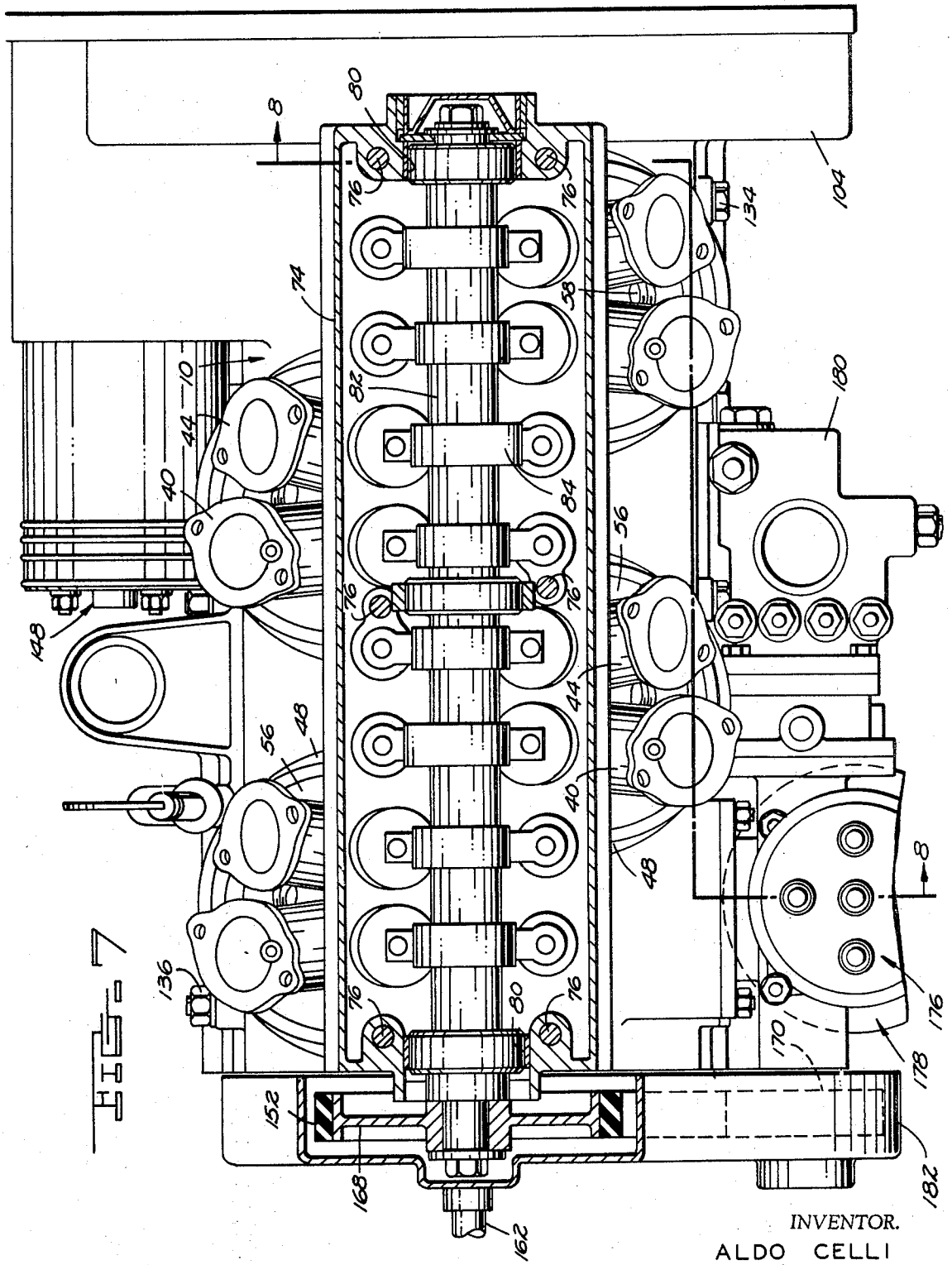

FIG. 7

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ENGINE WITH DIE-CAST STATIC PARTS

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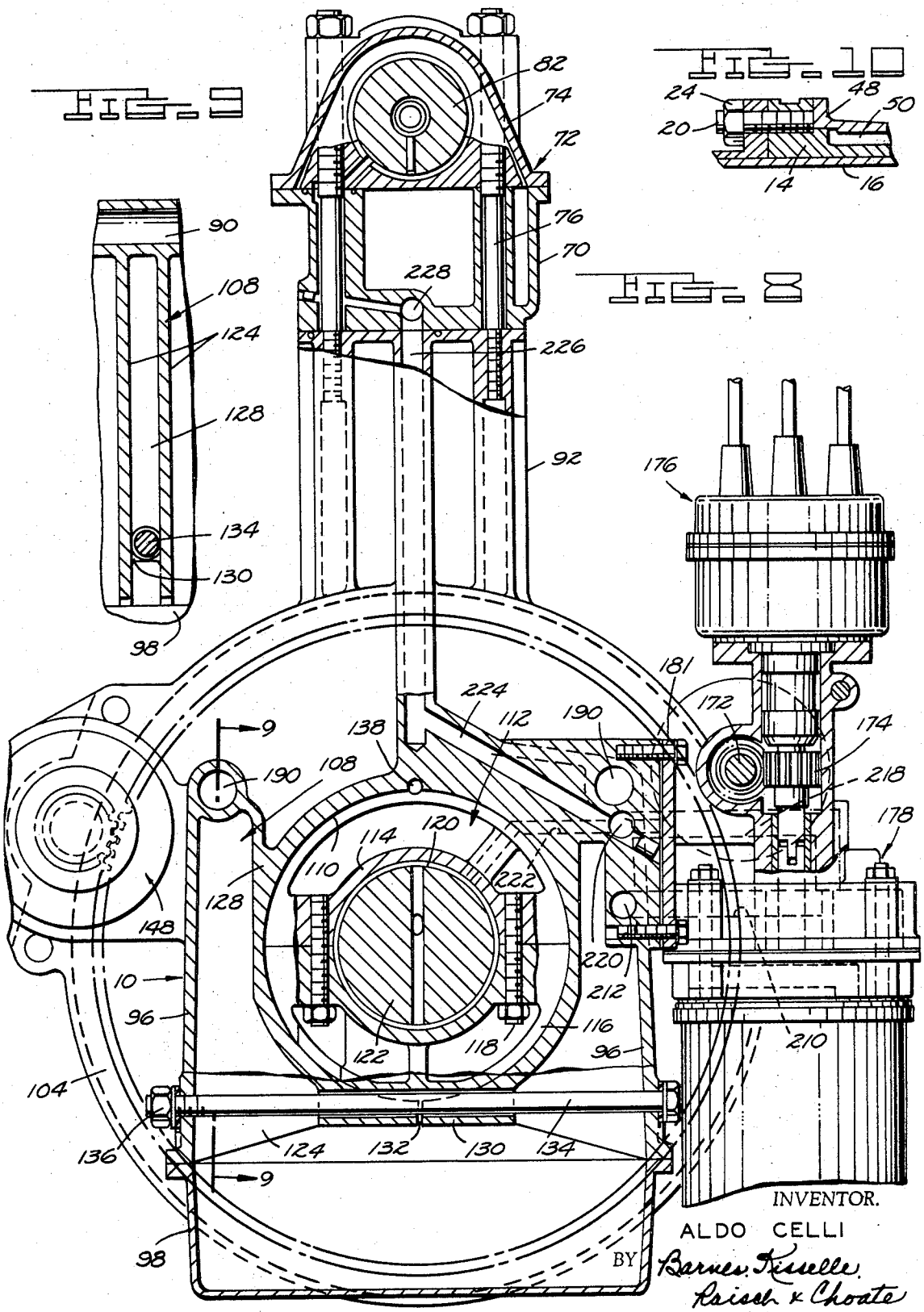

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ENGINE WITH DIE-CAST STATIC PARTS

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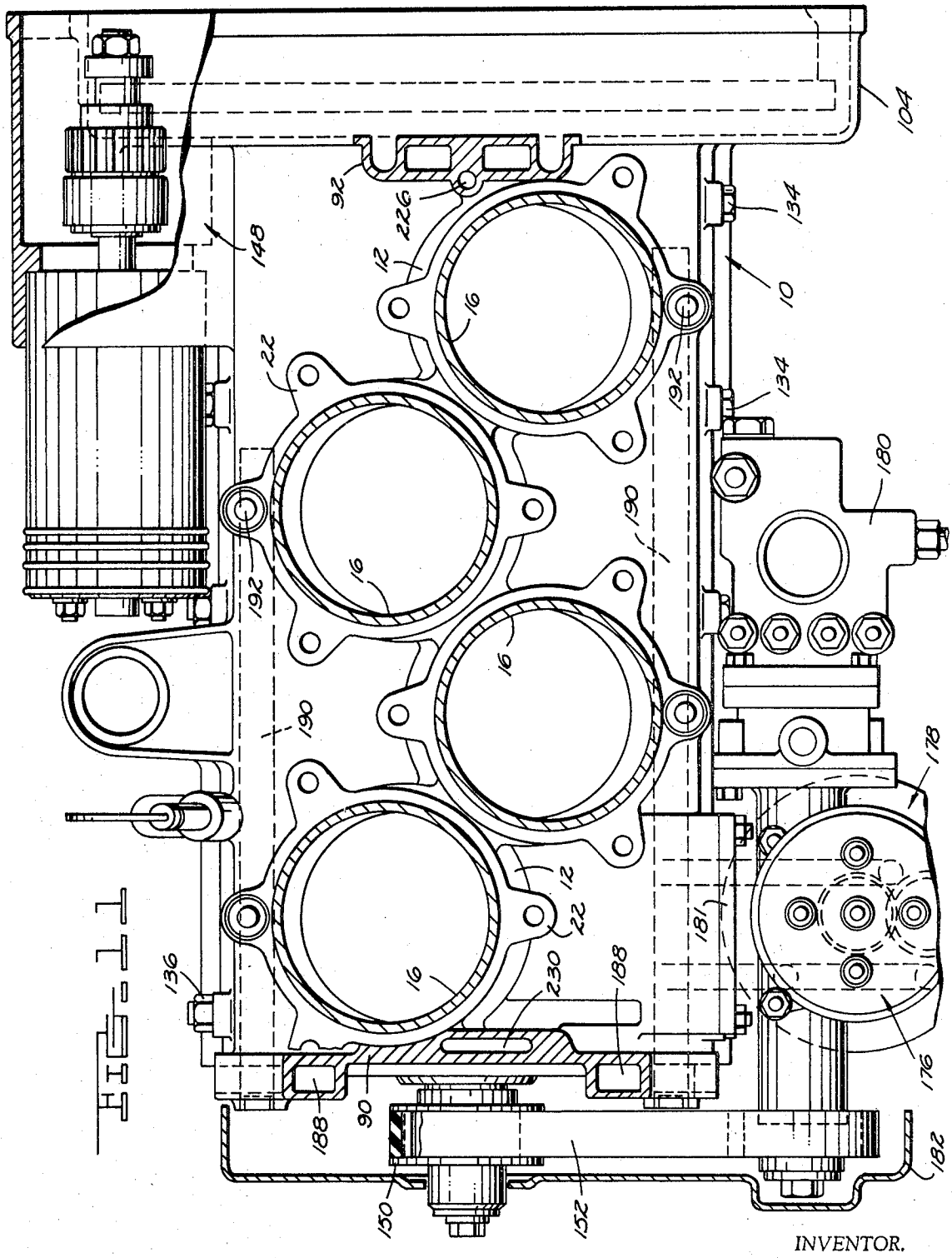

FIG. 11

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3,521,613

ENGINE WITH DIE-CAST STATIC PARTS

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Int. Cl. F02f 7/00; F01l 1/00
U.S. Cl. 123—195 20 Claims

ABSTRACT OF THE DISCLOSURE

An internal combustion engine of the liquid-cooled type wherein the static parts of the engine are designed to be made as die castings. The engine includes a crankcase with water jacketed cylinder castings individually mounted thereon. The valve timing mechanism is enclosed in a cast housing supported above the cylinders on a pair of brackets extending upwardly from the opposite ends of the crankcase. The interior of the crankcase is formed with a plurality of partition walls centrally apertured to receive bearing discs in which the crankshaft is journalled. The bearing discs are clamped in position in the partition walls by bolts extending transversely through the crankcase to impart rigidity to the entire crankcase assembly.

This invention relates to an internal combustion engine and more particularly to the design and arrangement of the static parts of a liquid-cooled, four-cycle, internal combustion engine.

Present day practice in the automotive industry in the manufacture of liquid-cooled, four-cycle engines involves the fabrication of many of the static parts of the engine as castings made from sand molds, shell molds or permanent molds. The use of such castings, particularly sand mold castings, results in an engine which is relatively heavy and which, because of the necessarily relatively slow production rate and the extensive machining required on such castings, renders such engines unnecessarily costly.

It has been recognized that such engines can be made lighter and less costly if the static parts can be die cast. Die-cast engine blocks have been produced with some degree of success but their use has not been widespread, particularly in the automotive industry, because, unless the industry can convert entirely to die casting of all the static parts of an engine, a partial conversion to die-cast parts for the engine is not economically justified.

It is an object of this invention to provide a liquid-cooled, four-cycle engine of light weight and which can be manufactured economically.

More specifically, the invention has for its object the provision of a liquid-cooled, four-cycle engine the static parts of which are designed and arranged so that they can be die cast.

Other features and objects of the present invention will become apparent from the following description and drawings in which:

FIG. 1 is a vertical sectional view of an engine according to the present invention taken generally along the line 1—1 in FIG. 4 and with parts broken away.

FIG. 2 is a sectional view along the line 2—2 in FIG. 1.

FIG. 3 is a sectional view along the line 3—3 in FIG. 1.

FIG. 4 is a longitudinal sectional view of the engine taken generally along the line 4—4 in FIG. 1.

FIG. 5 is a sectional view along the line 5—5 in FIG. 4.

FIG. 6 is a front end view of the engine with parts broken away.

FIG. 7 is a sectional view taken generally along the line 7—7 in FIG. 6.

FIG. 8 is a sectional view taken generally along the line 8—8 in FIG. 7.

FIG. 9 is a sectional view along the line 9—9 in FIG. 8.

FIG. 10 is a sectional view along the line 10—10 in FIG. 3.

FIG. 11 is a sectional view generally along the line 11—11 in FIG. 1.

Referring first to FIG. 1, the engine includes a crankcase 10 formed as a die casting and having two rows of cylinder extensions 12 cast integrally with the top wall thereof. The two rows of extensions 12 are inclined at a narrow V and are staggered as shown in FIG. 11. On the upper face of each cylinder extension 12 there is secured a die-cast cylinder 14. Cylinders 14 have inner linings 16 cast bonded to the cylindrical wall 18 thereof. Each cylinder 14 is piloted in its respective cylinder extension 12 by the extended liner 16 and is mounted on the crankcase by studs 20 threaded into lugs 22 (FIG. 11) over the ends of which nuts 24 are threaded. Within the bore formed by each liner 16 there is arranged a piston 26 which is connected by a connecting rod 28 to a crankshaft 30 journalled in crankcase 10.

Each cylinder casting 14 is formed with a top wall or head 32 adjacent its upper end and each head 32 is formed with an inlet port 34, an outlet port 36 and a combustion chamber recess 38. Around each inlet port 34 there is integrally cast an inlet pipe 40 adapted for connection with an inlet manifold 42. Around each outlet port 36 there is integrally cast an outlet pipe 44 adapted for connection with an exhaust manifold 46. Each cylinder casting 14 is surrounded by a cap casting 48 which is spaced from the side wall 18 of cylinder 14 and forms a water jacket chamber 50 around each cylinder. Cap casting 48 is press fitted at its lower end over a shoulder 52 adjacent the lower end of casting 14 and is press fitted at its upper end over a shoulder 54 formed on a circular flange 56 cast integrally with cylinder 14 above the head 32. Suitable seals are provided for rendering these joints liquid tight. Each cylinder 14 is also formed with a recessed boss 58 adapted for reception of an ignition device such as a spark plug 60. Each inlet manifold 42 accommodates a fuel injector 61 for admitting fuel to the combustion chamber of each cylinder. In place of fuel injectors one or more carburetors may be employed.

Inlet and exhaust ports 34, 36, respectively, are controlled by valves 62 the stems of which extend upwardly through sleeves 64 press fitted into bosses 66 which are cast integrally with cylinder castings 14. The valve guide bosses 66 protrude upwardly from flange 56 and extend through openings 68 in the lower die-cast section 70 of a valve train housing 72. Oil leakage through openings 68 is prevented by rubber boots 69. Valve train housing 72 also has a die-cast upper section 74 which is secured to the lower section 70 by studs 76. A gasket 78 is provided between the adjoining faces of sections 70 and 74 of the valve train housing to prevent leakage of oil from the housing. Upper section 74 of housing 72 is formed with bearing sockets 80 at opposite ends and at the center thereof (FIG. 7) in which a camshaft 82 is journalled. In a more or less conventional manner the cam lobes 84 on camshaft 82 are adapted when rotated to engage rocker arms 86 to actuate valves 62. One end of each rocker arm 86 is engaged by a hydraulic backlash adjuster 88 which urges the rocker arm against the cam lobe 84.

Referring now to FIGS. 4, 8 and 11, crankcase 10 has upright brackets 90, 92 cast integrally therewith at the front and rear ends, respectively, thereof. Brackets 90, 92 extend upwardly to a level above top walls 56 of cylinders 14. The lower section 70 of valve train housing 72 is seated at its opposite ends on brackets 90, 92 and is secured thereto by the two pairs of studs 76 at the opposite ends of valve train housing 72. The pair of studs 76 at the central portion of housing 72 merely serve to secure the upper section 74 of housing 72 on the lower

section **70** whereas the studs **76** at the opposite ends of the housing (FIG. 7) serve to secure the housing as a whole on brackets **90**, **92** and to secure the upper section **74** on the lower section **70**. The upper section **74** of housing **72** is formed with flanged opening **93** for receiving a breather cap **94**.

Referring now to FIGS. 1, 4 and 8, crankcase **10** is generally rectangularly shaped and has a top wall **95** and side walls **96**. An oil pan **98** closes the bottom open side of crankcase **10**. The front end of crankcase **10** is fashioned with a circular opening **100** closed by a cover plate **102**. The rear end of crankcase **10** is formed with a circular flywheel housing **104** which is centrally apertured as at **106**. Internally crankcase **10** is formed with a plurality of transverse partitions **108** which are centrally apertured as at **110** to receive bearing discs **112**. Each bearing disc **112** comprises two half sections **114**, **116** which, when secured together as by studs **118**, form a main bearing **120** within which the bearing portions **122** of crankshaft **30** are seated. The disc sections **114**, **116** are arranged on the bearing portions **122** of crankcase **30** before the crankshaft is inserted in crankcase **10** through the opening **100** in the front wall thereof. Each partition **108** includes a pair of spaced side walls which extend transversely of the crankcase from the side walls **96** thereof to the annular boss **128** which defines the circular opening **110** in each partition. Boss **128** at the bottom side of opening **110** is formed as a sleeve **130** which is radially slotted as at **132**. A plurality of bolts **134** extend transversely through the side walls **96** of the crankcase between the walls **124** of each partition **108** and each sleeve **130**. When the nuts **136** on the ends of bolts **134** are tightened, each bearing disc **112** is firmly clamped within the circular boss **128** on partitions **108** and extreme rigidity is imparted to the crankcase as a whole. For the purpose of locating each bearing disc **112** in its proper rotative position within the apertures **110** dowel pins **138** are provided. Thus the crankshaft is solidly supported in crankcase **10** at each of its bearing portions **122** by the cross walls on partitions **108**. The spaces between partitions **108** accommodate the counterweights **140** on the crankshaft and the connecting rods **28**.

A flywheel **142** is secured to the rear end of crankshaft **30** as by screws **144**. The flywheel has a series of permanent magnets **146** mounted thereon to form an alternator. Starting of the engine is accomplished by means of a conventional starter **148** (FIGS. 7 and 11) which is mounted on crankcase **10** and flywheel housing **104**.

On the front end of crankshaft **30** exteriorly of cover plate **102** there is keyed a pulley **150** engaged by a timing belt **152** and a second pulley **154** engaged by a belt **156**. Belt **156** is also trained around a pulley **158** mounted on a cooling fan **160**. The shaft **162** on which fan **160** is mounted also drives an impeller **164** of a water pump **166**. Timing belt **152** extends around a pulley **168** (FIGS. 4 and 7) at the front end of camshaft **82**. Timing belt **152** also extends around a third pulley **170** (FIG. 6) which drives a shaft **172**. Shaft **172** in turn drives suitable gearing **174** (FIG. 8) for providing a drive to distributor **176**, an oil pump **178** and a fuel injection pump **180** (FIGS. 7 and 8), all of which are supported on a side wall of crankcase **10** by a mounting plate **181**. The pulleys around which timing belt **152** is trained and water pump **166** are shielded by a cover **182**.

Water pump **166** has an inlet duct **184** and an outlet port **186**. A pair of branch conduits **188** formed in front bracket **90** extend from outlet port **186** downwardly toward each side of crankcase **10** as shown in FIG. 6 and communicate with cored passageways **190** extending along each side of crankcase **10**. As shown in FIG. 1, each cylinder extension **12** formed integrally with the top wall of crankcase **10** has a vertical passageway **192** therein which at its lower end communicates with passageway **194** at the lower end of cylinder casting **14**. Passageway **194** communicates with the water jacket chamber **50**. As the

water is directed upwardly between cylinder casting **14** and cylinder cap casting **48** the cylinder is cooled and the water is directed outwardly of water jacket chamber **50** through an outlet spout **196** formed integrally with cap casting **48**. The outlet spouts **196** are connected by hoses **198** to water manifold tubes **200** extending along each side of the engine (FIG. 6). The water manifold tubes **200** connect with a thermostat **202** at the front of the engine which directs the water either to a radiator (not shown) through an outlet **204** or back to the water pump through a bypass **206**. The outlet of the radiator is connected by a hose **208** with the inlet duct **184** of water pipe **166**.

Oil pump **178** has an inlet passageway **210** which communicates with a cored passageway **212** in crankcase **10**. A conduit **214** extends from screened intake member **216** in oil pan **98** to passageway **212** for supplying oil to the pump. The outlet passageway **218** of pump **178** extends to a cored passageway **220** extending longitudinally along one side of crankcase **10**. Branch passageways **222** are designed for supplying oil to bearing discs **112** which in turn, through suitable passageways in the crankshaft, direct oil to the bearings of the crankshaft. Another branch conduit **224** (FIG. 8) extends to a vertical passageway **226** formed in end brack **92** on which the rear end of the valve train housing **72** is supported. At its upper end passageway **226** registers with a longitudinally extending passageway **228** in the lower section **70** of housing **72**. Suitable branch passageways communicate with the longitudinally extending passageway **228** for supplying oil to the backlash adjusters **88** and the bearings of camshaft **82**. Oil is drained from housing **72** down to the crankcase through a discharge passageway **230** (FIGS. 4 and 11) which is formed in end bracket **90** on which the front end of valve train housing **72** is supported.

The advantages of the above described engine construction are apparent. It will be observed that all the static parts of the engine are ideally suited for die casting. These cast parts, particularly cylinder castings **14** which are the most intricate, are not formed with undercuts and, accordingly, permit straight withdrawal of the metallic cores of the dies. Since the parts can be die cast, the section thickness required to accommodate the stresses encountered are reduced, thus saving on metal costs and making the engine substantially lighter.

Further metal savings are obtained by staggering the cylinders in the two rows as illustrated in FIG. 11, thus shortening the camshaft and the crankshaft and as a result shortening the entire engine. The individual cylinder construction improves heat dissipation due to both liquid cooling of the cylinders and also heat dissipation by radiation from around the entire periphery of each cylinder. The individual cylinder construction minimizes the cost of casting and tooling and also the cost of rejections since only faulty casting represents only one cylinder as distinguished from a cylinder block containing six cylinders as in the case of a sand casting. The cost of machining the casting is also reduced because of the precision casting techniques involved in die casting and the resultant minimum stop removal required.

The lack of undercut surfaces and blind holes and bores in the castings has the further advantage of enabling impregnation and treatment for other types of surface protection easy to accomplish and to control.

The engine as described herein also has the advantage of eliminating the need for many closely controlled tolerances. Valve train housing **72** is completely isolated from the individual cylinders **14**. The manufacturing tolerances at the joint faces of brackets **90**, **92** and lower housing section **70** can be relatively large because this will not affect timing. Dimensional variations will be accomodated by the backlash hydraulic valve adjusters **88**. The crankshaft-camshaft center line distance is not critical because a slight variation in this distance results only in slightly different inclinations of the rocker arms **86** and this will

not affect timing of the engine. Timing of the engine is likewise not affected by a slight variation in the angular disposition of the cylinder axes because the lack of exact coincidence of valve stem center lines and the center of curvature of the rocker arm tips does not appreciably affect valve timing. At most this will cause only a slight variation in rocker arm lever ratios which might produce a slight difference in the valve opening but will not affect valve timing. Manufacturing tolerances of the cylinders, crankcase or the valve train will not affect valve timing because the holes in which the valve stem guides **64** are press fitted will be drilled and reamed in bosses **66** after temporary assembly of the cylinders on the crankcase and and temporary assembly of the valve train housing **72** on brackets **90**, **92**. This temporary assembly assures exact positioning of the valves relative to the tips of the rocker arms **86** in final assembly of the engine.

I claim:

1. A liquid-cooled internal combustion engine comprising a crankcase casting having a top wall, a plurality of individual cylinder-forming castings secured to said top wall, each cylinder casting having a generally cylindrical side wall and a top wall, said top wall having an intake port and an exhaust port therein, ducts extending upwardly from said intake and exhaust ports, said cylinder casting also having a wall-forming flange spaced above said top wall and connected to said top wall by said ducts and a cylinder cap casting surrounding said cylinder casting, said cylinder cap casting having a side wall spaced radially outwardly from the side wall of the cylinder casting and extending upwardly beyond the top wall of the cylinder casting, means forming a sealed connection between the lower end portion of the cap casting and the lower portion of the cylinder casting and means forming a sealed connection between the upper end portion of the cap casting and said wall-forming flange whereby to form a cooling chamber surrounding the side wall and top wall of each cylinder.

2. An engine as called for in claim **1** wherein said intake and exhaust ports extend upwardly beyond said wall-forming flange.

3. An engine as called for in claim **1** including a pair of hollow bosses formed on said wall-forming flange and aligned axially one with said intake port and the other with said exhaust port, valves controlling each of said ports and having stems projecting upwardly through and slideably guided in said hollow bosses.

4. An engine as called for in claim **1** wherein the top wall of said crankcase casting is formed with a plurality of cylindrical extensions projecting upwardly from said top wall, said cylinder castings being mounted on the upper ends of said extensions, a cylinder lining extending axially within each extension and its associated cylinder casting and a piston arranged for reciprocation in said liner.

5. An engine as called for in claim **1** including means forming a coolant passageway extending along each side of the crankcase, each of said cylinder castings having a passageway in the lower portion therein establishing communication between said coolant passageways and the coolant chambers surrounding each cylinder.

6. An engine as called for in claim **5** wherein each cylinder cap casting has a coolant outlet adjacent its upper end.

7. An engine as called for in claim **1** wherein said cylinder castings are arranged on the crankcase in two staggered rows with the axes of the cylinders in one row inclined to the axes of the cylinders in the other row to provide a V arrangement of cylinders.

8. An engine as called for in claim **7** wherein each of said cylinder and cap castings is spaced from the adjacent cylinder and cap castings so that the entire circumferential extent of each cylinder is exposed to the surrounding atmosphere to assist in heat dissipation.

9. An engine as called for in claim **1** including a valve train housing removably supported on said crankcase above said cylinders and independently of said cylinder and cylinder cap castings, valves controlling said intake and exhaust ports of each cylinder, said valves having stems projecting upwardly through said top wall and into said valve train housing, a camshaft journalled in said valve train housing and a rocker arm assembly in said valve train housing operatively interconnecting the stems of said valves and said camshaft.

10. An engine as called for in claim **9** including a pair of hollow bosses on said wall-forming flange of each cylinder casting and aligned axially one with the intake port and the other with the exhaust port, said valve stems being slideably guided for reciprocation in said bosses.

11. An engine as called for in claim **9** including a support bracket extending upwardly from each end of the crankcase, said valve train housing being mounted on the upper ends of said support brackets.

12. An engine as called for in claim **9** wherein said valve train housing comprises an upper section and a lower section which are separable, said upper section having a plurality of bearing sockets formed therein and spaced lengthwise thereof, said cam shaft being journalled in said bearing sockets.

13. A liquid-cooled internal combustion engine comprising a crankcase casting having side walls and a top wall, a plurality of individual cylinder-forming castings mounted on the top wall of the crankcase, each cylinder casting having an intake port and an exhaust port and conduits extending upwardly from said ports, a valve train housing supported on said crankcase independently of said cylinder castings, valves controlling said intake and exhaust ports, said valves having stems projecting upwardly from said cylinder castings and into said valve train housing and means within said valve train housing for operating said valves.

14. A liquid-cooled internal combustion engine comprising a crankcase casting having side walls and a top wall, said top wall having a plurality of openings therein, a plurality of individual cylinder-forming castings secured on said top wall one over each of said openings, said crankcase having a purality of transverse partition walls extending between the side walls thereof, each of said partition walls having a central opening therein, a split bearing disc removably retained in each of said central openings, a crankshaft having main bearing portions journalled in said bearing discs, said crankshafts having cranks thereon, a piston mounted in each cylinder casting for reciprocation and connecting rods connecting each piston with the cranks on the crankshaft.

15. An engine as called for in claim **14** wherein said crankshaft has counterweights thereon extending radially from the axis of rotation of the crankshaft, each of said central openings having a radius at least as large as the radial extent of said counterweights.

16. An engine as called for in claim **15** wherein the crankcase has an end wall provided with an opening sufficient in size to accommodate axial insertion of the crankshaft with the bearing discs mounted thereon.

17. An engine as called for in claim **15** wherein each partition wall has a slot therein extending from the lower edge portion of the wall to the periphery of the central opening therein and means for drawing the edges of said slots toward each other to clamp the bearing discs in said central openings.

18. An engine as called for in claim **17** wherein said last-mentioned means comprise bolts extending between the side walls of the crankcase at each of said partitions.

19. An engine as called for in claim **18** wherein each partition wall comprises a pair of spaced side walls extending inwardly from the side walls of the crankcase and connected by an annular boss extending around the periphery of said central opening.

20. An engine as called for in claim **19** wherein said

bolts are disposed between said spaced partition side walls.

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U.S. Cl. X.R.

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