Sept. 2, 1952 H. H. ALBINSON 2,608,961

COOLING SYSTEM FOR INTERNAL-COMBUSTION ENGINES

Filed April 22, 1950 4 Sheets-Sheet 1

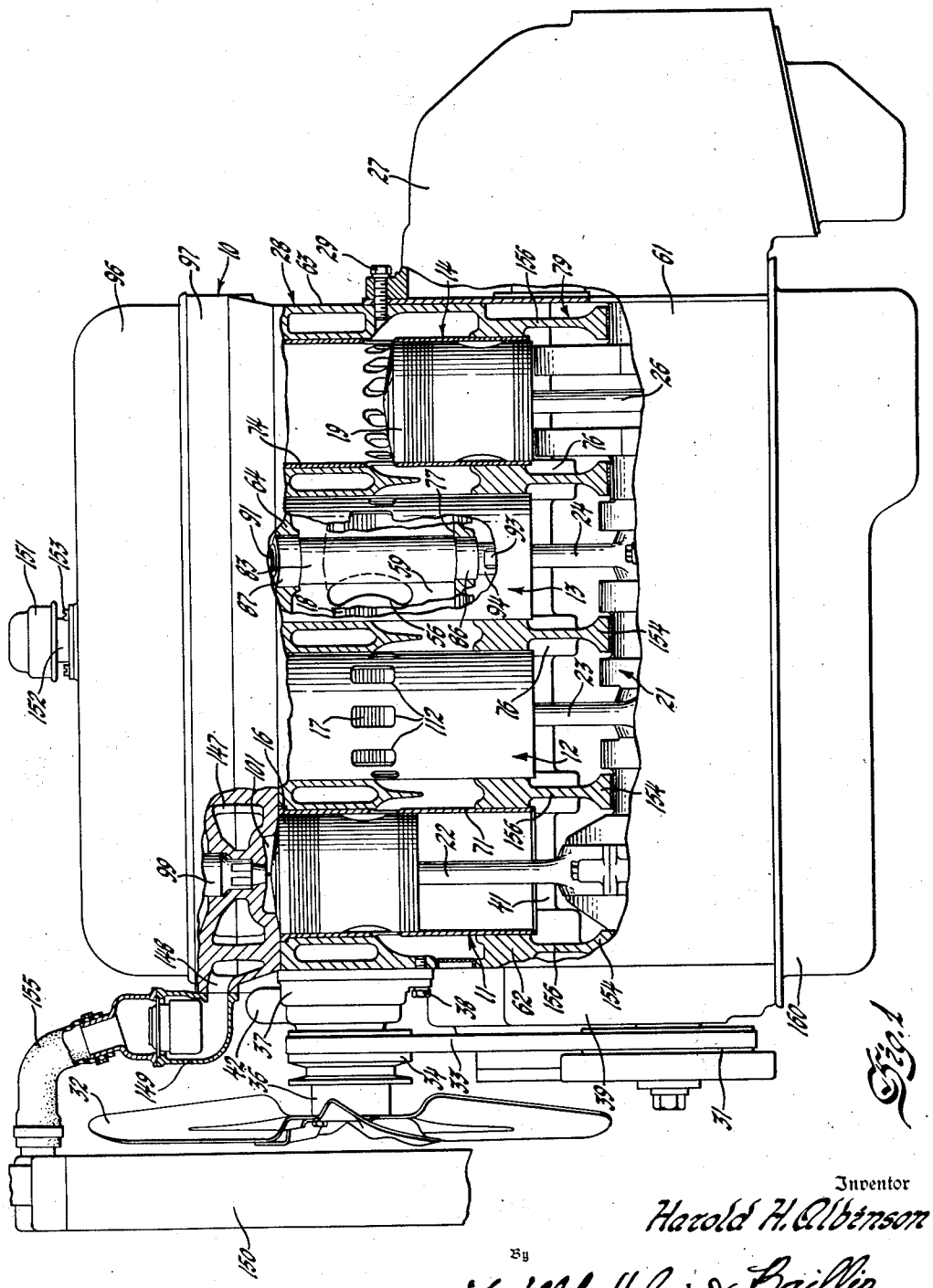


Fig. 1

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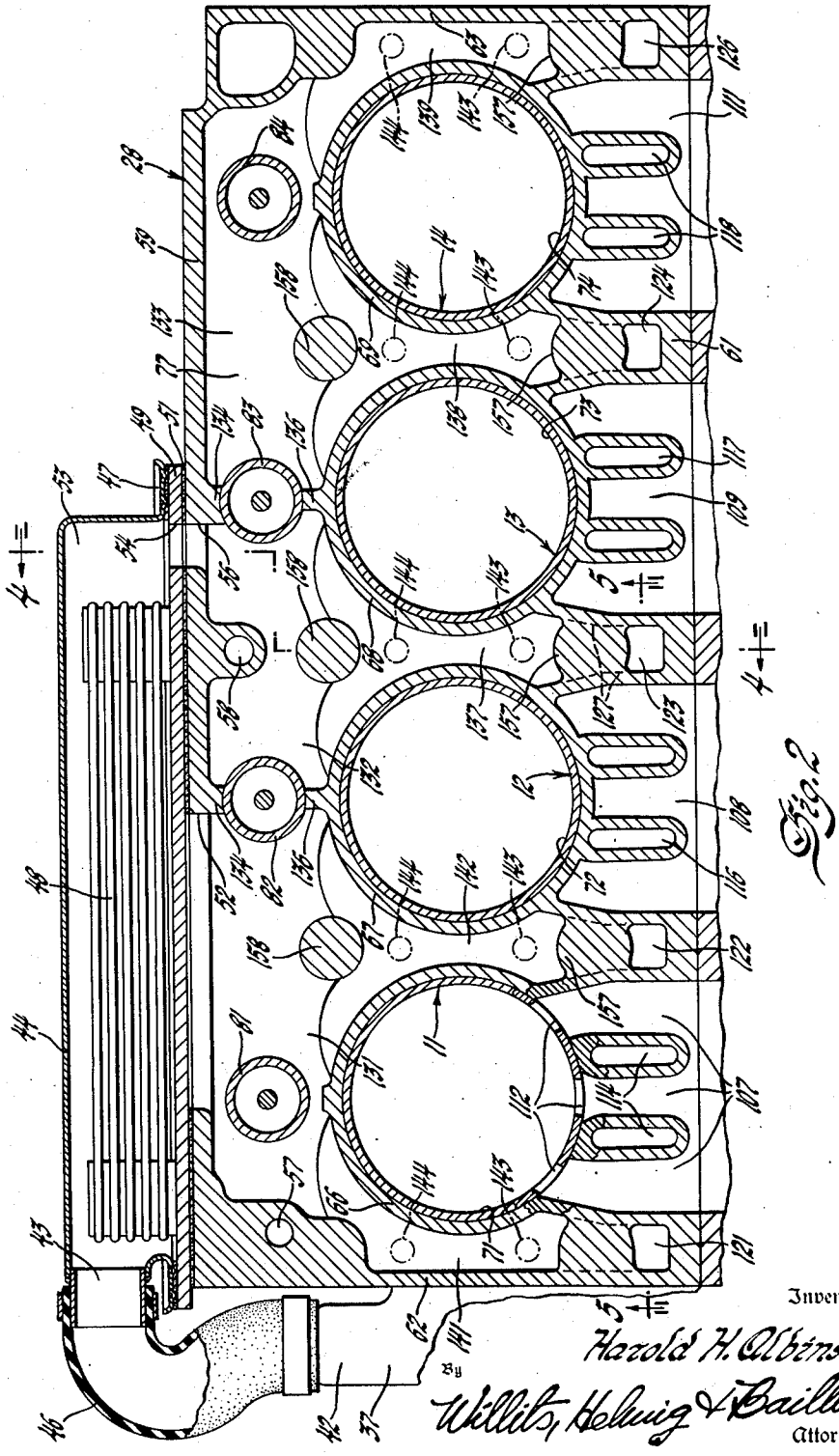


Fig. 2

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COOLING SYSTEM FOR INTERNAL-COMBUSTION ENGINES

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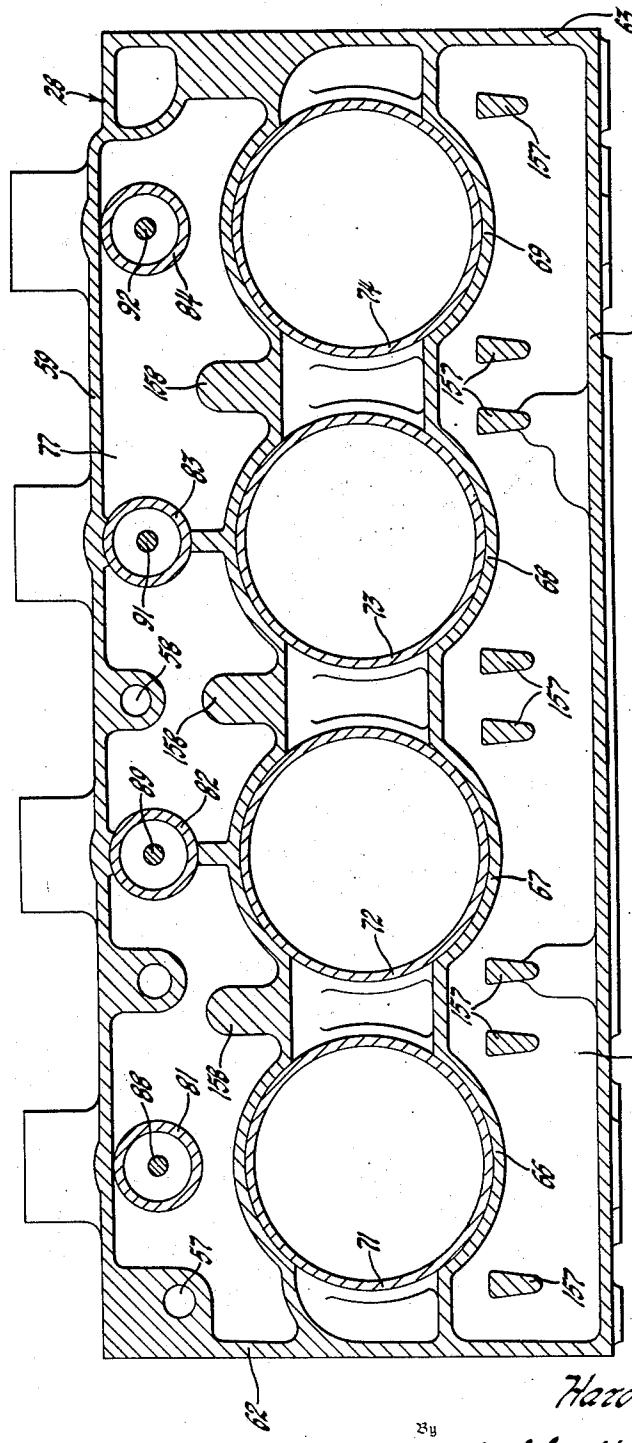


Fig. 3

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COOLING SYSTEM FOR INTERNAL-COMBUSTION ENGINES

Filed April 22, 1950 4 Sheets-Sheet 4

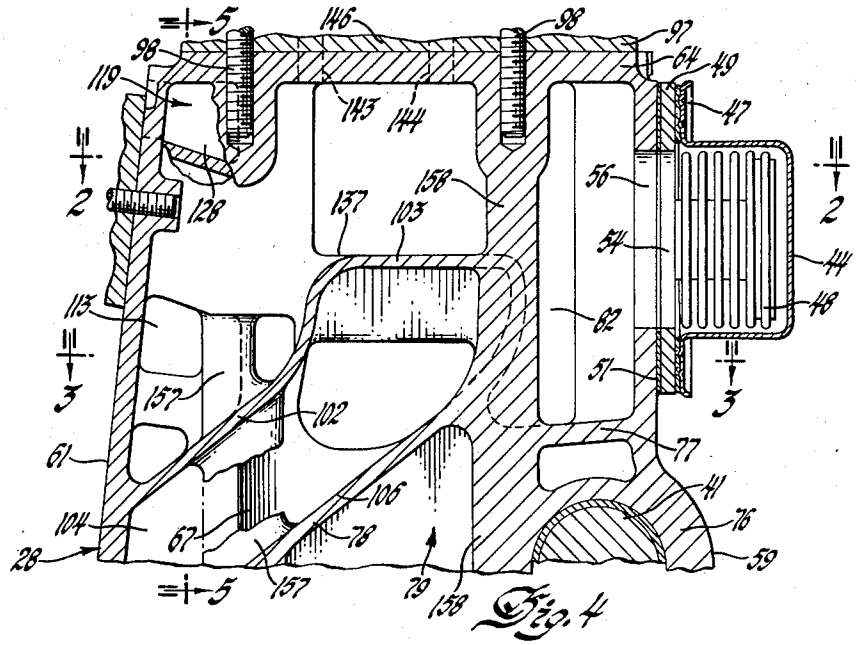


Fig. 4

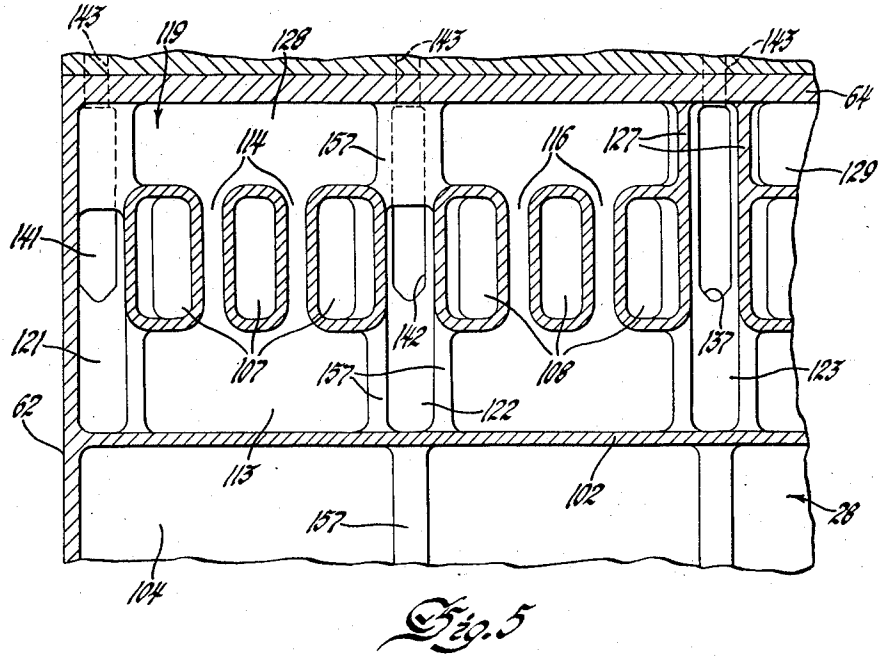


Fig. 5

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UNITED STATES PATENT OFFICE

2,608,961

COOLING SYSTEM FOR INTERNAL-COMBUSTION ENGINES

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Application April 22, 1950, Serial No. 157,585

44 Claims. (Cl. 123—41.28)

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This invention relates to internal combustion engines and has particular relation to cooling systems for two-stroke cycle compression ignition engines for use on trucks, busses, small boats, and other light weight load carrying vehicles, and on other devices or apparatus, where the space occupied by the engine and the weight and cost of the engine are important factors in the design of the engine.

An object of the invention is to provide a short, compact, inexpensive and light weight engine adapted to operate on inexpensive fuel and service and to employ such fuel in a two-stroke compression ignition cycle where relatively high temperatures will be developed in the operating parts of the engine, and, where an effective and efficient cooling system is required to prevent the cost, weight, and size of the engine from becoming excessive.

Another object of the invention is to provide an engine cooling system in which both pressure circulation and thermo-syphon circulation of cooling fluid are employed.

Another object of the invention is to provide an engine block having a cooling liquid circulating system formed therein, and in which circulating system the cooling liquid required to fill the cooling passages within the block and in the engine radiator, will be reduced to a minimum, and wherein such cooling liquid will be circulated at relatively high velocities over the parts of the engine requiring the greatest amount of cooling and at relatively lower velocities over parts that require less cooling.

Another object of the invention is to limit the application of cooling liquid to the hottest parts of the engine and to employ other cooling means for other parts of the engine where such liquid cooling may not be required.

Another object of the invention is to provide an engine cooling system in which the exhaust ports and passages for the engine will be cooled by all of the cooling liquid supplied to the engine and wherein the cooling liquid employed in cooling such ports and passages will then flow past the head end of the cylinders of the engine and then either into the engine head of the engine and to the radiator of the engine, or to other and cooler parts of said engine for cooling such parts and for the dissipation of excess heat therefrom.

Another object of the invention is to provide a cooling system for compression ignition engines which will require a quantity of water that will be smaller than the quantity of water that

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would be required to cool a conventional spark ignition engine of the same horsepower.

Heretofore it has been the practice to construct compression ignition engines in such a way as to weigh more pounds per horsepower, to occupy more space per horsepower, and to require more cooling liquid per horsepower than other engines of conventional design. The compression ratio is high in such engines and it has heretofore been considered necessary to employ an excessive number of pounds of iron to construct a block for such an engine, and, since the ignition temperature is also high, it was considered necessary simply to make the water circulating passages in such a block large enough so that in any event the engine would be cooled.

According to this invention, it is proposed to employ a relatively small light weight engine block in which the cylinders are placed about as close together and to the side walls of the block as they might be placed in any conventional spark ignition engine and to efficiently cool the parts of the engine that require excessive cooling by providing rapid circulation of cooling liquid over such parts and then to cool other parts of the engine not requiring excessive cooling means other than the direct circulation of cooling liquid thereover.

For a better understanding of the invention, reference may be had to the accompanying drawing forming a part of this specification, in which:

Figure 1 is a side elevational view of an engine embracing the principles of this invention and having certain parts thereof broken away to show the interior of the engine in vertical sectional view.

Figure 2 is a cross-sectional view of the engine taken substantially in the plane of line 2—2 on Figure 4.

Figure 3 is another cross-sectional view through the engine shown by Figure 1. Figure 3 is taken substantially in the plane of line 3—3 on Figure 4.

Figure 4 is a fragmentary transverse sectional view through the engine shown by Figure 1. Figure 4 is taken substantially in the plane of line 4—4 on Figure 2.

Figure 5 is a fragmentary vertical sectional view of the engine taken substantially in the plane of lines 5—5 on Figures 2 and 4.

Referring particularly to Figure 1, the invention comprises an engine 10 having cylinders 11, 12, 13, and 14, and containing pistons 16, 17, 18, and 19, for driving crankshaft 21 through connecting rods 22, 23, 24, and 26. The crankshaft

21 is adapted to drive a truck, bus, boat, or other vehicle or apparatus with which the engine may be employed, through a suitable and conventional clutch and transmission mechanism indicated at 27 and secured to the block 28 of engine 10 by bolts indicated at 29.

The front end of the crankshaft 21 terminates in a flywheel and drive pulley 31 which drives an engine fan 32 through a belt 33 and a pulley 34. The fan 32 and the pulley 34 are supported by a stub shaft 36 which projects from a housing of a pump 37, which is supported by the front end of the block 28 and is secured removably thereto as by cap screws indicated at 38.

The front end of the crankshaft 21 also projects through a gear housing indicated at 39 which is also secured to the front end of the block 28 by screws or other suitable means, not shown. The gear housing 39 contains suitable drive gear mechanism for driving a camshaft indicated in Figure 4 at 41.

The housing 39 also may contain and the drive gear mechanism therein may drive a suitable pump, not shown, for circulating lubricating oil throughout the lubricating system of the engine.

The water pump 37 is provided with an outlet connection 42 to which the inlet connection 43 of lubricating oil cooling jacket 44 is connected by a hose 46. Water from the lower part of the liquid cooling radiator, not shown, is supplied by the pump 37 to the water jacket 44 and at the pressure provided by the pump referred to.

The jacket 44 surrounds a multiple tubular plate lubricating oil cooler 48 and is secured to plate 49 supporting the cooler by an outwardly projecting flange 47. The plate 49 is secured by bolts or other suitable means, not shown, to one side of the block 48 along the upper edge of the block and with one end thereof adjacent the front of the block and the opposite end projecting toward the rear end thereof. A gasket 51 is employed between the plate 49 and the block 28 for preventing any leakage of fluid therebetween. The block 28 is provided with a core opening indicated at 52 and formed in one side thereof, the core opening 52 being covered by the plate 49 when the plate is secured to the block 28 upon the gasket 51.

Opposite the inlet 43 and beyond the cooler 48 the jacket 44 is provided with a discharge chamber indicated at 53 which communicates with registering openings 54 and 56 formed in the plate 49 and the block 28 respectively.

Cooling fluid supplied by the pump 37 is directed by the jacket 44 across the surface of the lubricant cooler 48, into the discharge passage 53 at the end of the cooler 48, and, into the block 28 through registering passages 54 and 56.

Lubricating oil to be cooled is supplied to the cooler 48 through a passage 57 which is formed in the block 28 and which communicates at the lower end thereof with the lubricating oil pump of the engine which was previously referred to as being contained within the housing 39. The lubricating oil so supplied to the cooler 48 is discharged from the opposite end of the cooler through an opening 58 which is also formed in the block 28 and which communicates at the lower extremity thereof with an oil cleaning and circulating device associated with a camshaft 41 which is mounted in the lower part of the block 28 and adjacent one side of the block 28.

It will be apparent that the lubricating oil cooler 48 will be cooled by the coldest cooling liquid which the liquid cooling system of the engine provides, this being the cooling liquid delivered directly from the radiator of the engine and by the pump 37.

The engine block 28 comprises a pair of oppositely disposed side walls 59 and 61, a pair of oppositely disposed front and rear end walls 62 and 63 respectively, and a top wall indicated at 64.

Cylinder shells 66, 67, 68 and 69 are disposed within the block 28 in spaced relation to one another and to the side walls 59 and 61 and to the end walls 62 and 63. The shells 66, 67, 68, and 69 are formed integrally within the block 28, and aligned with respect to one another and are disposed in parallel relation to the side walls 59 and 61.

Within the shells 66, 67, 68, and 69 are cylinder sleeves 71, 72, 73, and 74, the sleeves and shells respectively comprising the cylinders 11, 12, 13, and 14.

Camshaft 41 (see Figures 1 and 4) is mounted in bearings 76 which extend from the front to the rear of the block 28 and which are formed integrally with the side wall 59 and the lower extremities of the cylinder shells indicated at 66, 67, 68, and 69. Located above the bearings 76 is a partition wall 77 which also extends between the side wall 59 and the lower extremities of the cylinder shells 66, 67, 68, and 69. The partition 77 is connected between the cylinder shells 66, 67, 68, and 69 to the upward edge or extremity of a bottom wall 78 which slopes upwardly within the block 28 toward the cylinder shells 66, 67, 68, and 69 and from the lower edge of the side wall 61. The partition 77 and the inclined or sloping wall 78 provide a bottom wall for the space within the block 28 and surrounding the cylinder shells 66, 67, 68, and 69 and provide an upper wall for the crankcase of the engine and indicated at 79 in Figures 1 and 4.

Disposed between the side wall 59 and the cylinder shells 66, 67, 68, and 69 are tubular passage members 81, 82, 83, and 84 which are secured at opposite ends in openings formed in the top wall 64 and the partition wall 77 of the block 28. The passage members 81, 82, 83, and 84 each have reduced lower ends indicated at 86 and outwardly flanged upper ends indicated at 87 to permit the passage members to be removably inserted in the block 28 from outside the upper wall 64 of the block. Within the passage members 81, 82, 83, and 84 are push rods 88, 89, 91, and 92 respectively, each push rod being provided with a cam follower 93 which is secured between the bifurcated ends of a follower member 94. One of the follower members 94 is secured to the lower extremity of each of the push rods 88, 89, 91, and 92.

The followers 93 are adapted to be operated by the camshaft 41 for timing the injection of fuel to the cylinders 11, 12, 13, and 14.

The upper ends of the push rods 88, 89, 91, and 92 operate conventional arcuately moving rocker arms and a rocker shaft, not shown, but contained within a cover 96 that may be removably secured to the upper surface of an engine head 97, which in turn is removably secured to the block 28 by cap screws indicated at 98 in Figure 4. The rocker shafts referred to are adapted to time the operation of a plurality of fuel injection valves 99, one of which is provided for each of the cylinders indicated at 11, 12, 13, and 14. The injection valves 99 are secured in openings formed transversely across the head 97 which in turn open into compression spaces 101 provided in the lower surface of the head 97 and opposite each of the cylinders 11, 12, 13, and 14.

Disposed in parallel relation to the upwardly sloping wall 78 is another upwardly sloping wall which is indicated by the numeral 102. The wall 102 is disposed and spaced above the wall 78 and is formed integrally with the block 28 along the lower portion of the side wall 61. The walls 78 and 102 also are formed integrally with the lower parts of the cylinder shells 66, 67, 68, and 69 and project between such shells and there terminate in sections of an upper wall indicated at 103.

Formed between the lower parts of the inclined walls 78 and 102, the side wall 61 and the lower parts of the cylinder shells 66, 67, 68, and 69 is a charging and scavenging fluid inlet manifold indicated generally at 104 and supplied with such fluid by a blower, not shown. The spaces between the cylinder shells 66, 67, 68, and 69 and the upper parts of the walls 78 and 102 and below the wall 103 provide branch passages 106 for the manifold 104, such branch passages being adapted to supply such scavenging and charging fluid to the cylinders 11, 12, 13, and 14, through inlet ports 107 which are formed in the cylinder sleeves 71, 72, 73, and 74. One of the passages 106 extends between each of the cylinders 11, 12, 13, and 14 and one extends between the end wall 62 and the cylinder 11 and another between the end wall 63 and the cylinder 14.

Formed integrally with the block 28 and projecting across the block from the cylinder shells 66, 67, 68, and 69 to the side wall 61 is a plurality of groups of spaced exhaust passages indicated at 107, 108, 109, and 111, there being one group of passages for each of the cylinders respectively. Each of the groups of the exhaust passages comprises three exhaust passages which are disposed in spaced relation to one another and which extend between the exterior of the block 28 and a like number of exhaust ports 112 which are formed in each of the cylinder sleeves 71, 72, 73, and 74 in opposed relation to the passages of each group of passages indicated by the numerals 107, 108, 109, and 111. When the exhaust ports 112 are uncovered by pistons 16, 17, 18, and 19, the exhaust passages referred to provide communication between the interior of the cylinders 11, 12, 13, and 14 and the exterior of the block 28.

The passages 107, 108, 109, and 111 are aligned with respect to one another across the block 28, are relatively horizontally disposed within the block 28, and are spaced within the block above the inlet manifold 104, to provide a cooling liquid distribution passage, manifold or chamber indicated generally at 113.

Formed in the block 28 between the exhaust passages in the groups indicated at 107, 108, 109, and 111 are exhaust cooling passages indicated at 114, 116, 117, and 118. These passages each comprise a pair of passages extending between the exhaust passages of each group of passages indicated at 107, 108, 109, and 111. The lower extremities of the passages 114, 116, 117, and 118 each communicates with the liquid distribution chamber indicated at 113, while the upper extremities of said passages in turn communicate with a cooling liquid receiving passage 119 which is formed in the block 28 between the upper wall 64 and the groups of exhaust passages indicated at 107, 108, 109, and 111. The groups of exhaust passages indicated at 107, 108, 109, and 111 also are spaced from one another to provide a further series of passages indicated at 121, 122, 123, 124, and 126 and the lower ends of which passages also communicate with the cooling liquid distribution manifold indicated at 113. The

upper ends of the passages 121, 122, 124, and 126 likewise communicate with the liquid receiving chamber or passage 119 which is formed above the group of exhaust ports indicated at 107, 108, 109, and 111.

However, the passage 123 which is formed between the groups of exhaust passages indicated at 108 and 109 is provided with upwardly extending wall sections indicated at 127 which terminate in integral relation to the upper wall of the block 64. The passage 123 therefore divides the liquid receiving passage 119 into a pair of receiving passage sections indicated at 128 and 129. The wall sections 127 also extend from the side wall 61 to the cylinders 12 and 13 and therefore cut off all communication between the passage sections 128 and 129 and the space between the cylinders 12 and 13 and to the opposite side of the block. The space between the walls 127 and the space between the cylinders 12 and 13 does, however, communicate with the cooling liquid distribution manifold 113 through the space between the adjacent exhaust passages in the groups 108 and 109, thus providing a fluid supply passage for the distribution manifold 113 which leads from between the cylinders 12 and 13 and through the passage 123.

The space between side wall 59 and the opposite side of the cylinders 11, 12, 13, and 14, provides a plurality of cylinder cooling cavities indicated at 131, 132, and 133. These cavities extend around the tubular passage members 81, 82, 83, and 84 and hence cool these members throughout the entire length thereof. The cavities 131, 132, and 133 also extend from the top wall 64 of the block 28 downwardly on one side of and between the cylinders 11, 12, 13, and 14 to the partition wall 77, and around the curved upper ends of the divided parts of the inclined partition wall 78 to the spaces between the cylinders and above the upper wall 103.

The cavities 131, 132, and 133 are separated from one another by web walls 134 and 136, these walls being formed in the block 28 to project outwardly from the side wall 59 and from the cylinders 12 and 13 respectively. These outwardly projecting web walls are adapted to engage and to fit throughout the length thereof within the block 28, the oppositely disposed sides of the passage members 82 and 83.

The cooling cavity 132 therefore is limited in longitudinal extent by the passage members 82 and 83 and the web walls 134 and 136. Cooling cavity 131 likewise is limited in longitudinal extent by the end wall 62 and by the passage member 82 and the web walls 134 and 136 which the passage member engages. Cavity 133 likewise is limited in longitudinal extent by the end wall 63 and the passage member 83 and the web walls 134 and 136 with which the passage member 83 is likewise engaged.

The cavity 132 therefore extends from the side wall 59 and from between the passage members 82 and 83, upwardly around the curved end of one of the parts of the lower wall 78 which extends between the cylinders 12 and 13, over the top wall 103, between cylinders 12 and 13, and into the space between the cylinders 12 and 13 and providing the extension passage 137. Beyond extension passage 137 the cavity 132 is in open communication with the upper end and the side portion of passage 123 which at its lower end communicates with the central portion of distribution passage 113.

Cavity 133 likewise extends from tubular member 83 to end wall 63 and from side wall 59 up-

wardly and around the curved upper ends of two parts of the inclined wall 78 and of the top wall 103, these being the parts that project between the cylinders 13 and 14, to the spaces between the cylinders 13 and 14 and between the cylinder 14 and the end wall 63. The cavity 133 therefore has two extensions above the wall 103, which are indicated at 138 and 139, and, which project between the cylinders 13 and 14 and beyond the cylinders 13 and 14 into communication with the section or branch 129 of the liquid receiving passage 119.

Cavity 131 likewise extends from tubular member 82 to the end wall 62 and from side wall 59 upwardly around the curved ends of the parts of the wall 78 and above the wall 103 and into extension passages 142 and 141 which extend respectively between the end wall 62 and the cylinder 11 and between the cylinders 11 and 12 and above the wall 103. Cavity 131 therefore extends through extension passages 141 and 142 and into communication with the branch 128 of the receiving passage 119.

It will be apparent that cooling fluid which is introduced into cavity 132 through the registering openings 54 and 56 and from the jacket 44 will flow across the block 28 through extension passage 137, into the upper extremity of passage 123 between the walls 127, and downwardly through the passage 123 and into the central portion of the distribution manifold 113. From such central portion of the cooling liquid distribution manifold 113 the liquid will flow toward the front and rear ends of the block 28 between the upwardly sloping wall 102 and lower walls of the exhaust passages in the groups 107, 108, 109, and 111. The liquid thereafter may flow upwardly through the exhaust cooling passages indicated at 114, 116, 117, 118, 121, 122, 124, and 126. Since the upper ends of passages 114 and 116 communicate with the branch 128 of liquid receiving passage 119, and since the upper ends and side portions of the passages 121 and 122 also communicate with the branch 128 of the liquid receiving passage 119, the liquid which flows upwardly through all of the foregoing passages will be free to flow through the extension passages 141 and 142 and into the cylinder cooling cavity 131.

The exhaust cooling passages 117 and 118 and the passages 124 and 126 also similarly communicate with branch receiving passage 129, with the extension passages 138 and 139, and in turn with cylinder cooling cavity 133.

Directly above the extension passages 141, 142, 137, 138, and 139, are outlet passages indicated at 143 and 144, these passages being formed in and adapted to extend through the upper wall 64 of block 28. The passages 143 and 144 are arranged in pairs, there being one pair of these passages for each of the extension passages 141, 142, 137, 138, and 139. The passages 143 and 144 of each pair of passages are arranged on opposite sides of the center line through the axes of the cylinders 11, 12, 13, and 14 and inside of lines that might be drawn tangent to the cylinders at opposite sides of the cylinders.

The passages 143 and 144 which are formed in the top wall 64 of the block 28, are aligned with similar passages formed in lower wall 146 of the head 97. The openings in the lower wall 146 of the head 97 and referred to as being aligned with openings 143 and 144 also are indicated by numerals 143 and 144.

The head 97 is formed in such a way as to provide a relatively continuous cooling fluid cavity 147, the cavity 147 being formed in the head 97 around each of the injection valves 99 which project through the head to the combustion chambers 101 for each of the cylinders.

Cavity 147 communicates with each of the pairs of openings indicated at 143 and 144.

The front end of the block 97 is provided with an outlet opening 148 which communicates with the cavity 147 in the head 97 and is connected to an outlet fitting 149 which in turn is connected to the radiator 150 of an engine through a flexible conduit 155.

Lubricating oil for operating the engine is adapted to be supplied to the interior of the cover 96 by taking off the filler cap indicated at 151 which covers the inlet end of a flanged fitting 152, the latter being secured to the cover 96 by screws 153. A lubricant so introduced to the fitting 152 will flow within the cover 96 from one end to the other of the head 97 and thereafter will flow to the crankcase of the engine through the passage members indicated at 81, 82, 83, and 84.

The lower end of the crankcase 79 is covered by the usual crankcase pan or cover indicated by the numeral 160 thus retaining within the engine an oil supply from which the engine is lubricated.

The crankshaft 21 which is adapted to operate within the crankcase 79 is supported by bearings which are indicated generally at 154 and which are formed in block 28 between each of the cylinders 11, 12, 13, and 14. The bearings 154 are secured to the lower parts of each of the cylinder shells 66, 67, 68, and 69 by transverse walls indicated at 156. The opposite ends of each of the bearings are extended to provide rows of integral columns 157 and 158 which project upwardly within the block and in parallel relation to the axes of the cylinders 11, 12, 13 and 14 and between each of the cylinders and the side walls 59 and 61. The top or upper ends of the columns 157 and 158 are secured integrally to the top wall 64 of the block 28 and are likewise secured integrally to the walls of the various passages formed inside the block 28 and which walls all are secured directly or indirectly to the side walls 59 and 61 and to the cylinder shells 66, 67, 68, and 69.

The water or other cooling liquid supplied by the pump 37 will flow into the oil cooler jacket 44 through the coupling 46. The oil cooler jacket 44 is made to closely fit the oil cooler 47 contained within the jacket so that the velocity of flow of liquid over the cooler 48 will be about as high as the velocity of flow of liquid from the pump 37 and through the coupling 46. From the outlet chamber 53 the cooling liquid will flow into the cavity 132 through the registering openings 54 and 56. The openings 54 and 56 also are relatively limited in cross-sectional area so that the water from the chamber 53 is supplied to the cavity 132 at relatively high velocity and somewhat in the form of a high velocity jet. It will be apparent from observing the relation of the openings 54 and 56 leading to the cavity 132 and the extension passage 137 leading from the cavity 132 that this relatively high velocity jet of cooling liquid will tend to travel directly across the cavity 132 and through the extension passage 137 with little interference from the remaining quantity of liquid required to fill the cavity 132. From extension passage 137 a similar jet-like stream of water will flow downwardly through the passage 123 and into the central portion of the liquid distribution manifold 113. In the

manifold 113 such stream of water will spread out in both directions to the front and rear ends of the block 28 and will fill the passage or distribution manifold 113.

It will also be apparent from observing the cross-sectional area of the exhaust cooling passages indicated at 114, 116, 117, and 118 and of the passages 121, 122, 124, and 126 that the upwardly directed flow of fluid through the passages referred to and from the distribution manifold 113, and into the branches 128 and 129 of the receiving passage 119, also will be at a relatively great velocity.

It will likewise be apparent from observing the cross-sections of the extension passages 141, 142, and 138 and 139 that the velocity of the flow of the cooling liquid received from branches 128 and 129 of the receiving passage 119, will likewise be relatively great.

However, the opposite ends of the extension passages 141 and 142 communicate with cylinder cooling cavity 131 from which there is no liquid outlet, and, extension passages 138 and 139 likewise communicate with cylinder cooling cavity 133 from which there is no outlet.

It will therefore be apparent that the relatively high velocity streams of liquid in the extension passages 141, 142, 137, 138, and 139 will tend to flow upwardly and into the head 97 through the pairs of outlet passages 143 and 144 and one of which pairs of outlet passages is located opposite each of the extension passages 141, 142, 137, 138, and 139.

The liquid, therefore, will flow into the head 97 through passages 143 and 144 in a plurality of relatively high velocity streams.

The liquid capacity of the cavity 147 extending from one to the other of the head 97 is intended to be relatively small, and in such cavity these high velocity streams will tend to be deflected by upper wall of head 97, and will be compelled to flow rapidly through the head 97 and toward the outlet 148. From the outlet 148 the cooling liquid will be delivered to the radiator of the engine through the coupling 149.

From the foregoing and from observation of all of the figures of the drawing, it will be apparent that the cooling liquid in both the head and the block of the engine is forcibly directed at relatively high velocities only over the engine parts and surfaces which tend to operate at relatively high temepratures. The rest of the parts of the cylinders and particularly the lower parts of the cylinders are cooled by what might be called relatively stagnant bodies of cooling liquid. By this is meant cooling liquid that is not directly in the path of the high velocity streams of cooling liquid that are forced through the various passages of the engine block or that are caused to flow in limited areas throughout the engine block by pressure of the liquid and by the inertia of the particles of liquid in the liquid streams referred to.

For example, there will be little circulation of cooling fluid in the various cylinder cooling cavities indicated by numerals 131, 132, and 133, except for the stream of liquid that is impelled into and through the cavity 132 by the registering inlet openings 54 and 56. Except for this circulation and except for the forced circulation of cooling fluid in all of the extension passages 141, 142, 137, and 138 and 139, there will be little forced or pump impelled circulation of cooling fluid anywhere within the cavities 131, 132, and 133. Such circulation as may occur is these cavities will be caused by differences in temperature of the liquid which will differently affect the liquid in different parts of the cavities 131, 132, and 133.

Hence, practically all of the circulation of cooling liquid that occurs within the cavities 131, 132, and 133 will be thermo-syphon circulation of the cooling liquid. However, this circulation will occur to the greatest extent near the head end surfaces of the cylinder shells 66, 67, 68, and 69. Even such circulation will not occur to any great extent until the temperature of the water near the upper ends of the cylinder shells has increased to such an extent that the heated liquid will be able to overcome the velocity of the liquid in the extension passages 141, 142, 138, and 139 and tending to cause circulation of the liquid in the opposite direction. When the temperature of such liquid is high enough to overcome the tendency referred to, then such heated liquid either will flow out of the vicinity of the top of the shells 66, 67, 68, and 69 and into the head 97 through the openings 143 and 144, or will flow across the top wall 64 and downwardly along the side wall 59 where the heat will be transferred to the atmosphere through side walls 59. The remainder of the liquid in the cavities 131, 132, and 133 will tend to stratify at different levels and at different temperatures, and will tend to allow the tops of the cylinders to become relatively hot and the parts of the cylinders therebelow to be progressively cooler. This condition of differences in the temperatures of the tops and the bottoms of the cylinders 11, 12, 13, and 14 is approximately the same as that which will affect the opposite sides of the cylinders and where the exhaust passage portions of the cylinders will remain relatively hot while the lower parts of the cylinders affected by the distribution chamber 113 and the inlet manifold 104 will be progressively cooler.

It will be apparent, therefore, that the entire engine will be affected by two entirely different kinds of cooling; namely, by forced circulation of cooling fluid, and thermo-syphon circulation of cooling fluid.

By comparing the sizes of the various passages and cavities in the block 28, it will at once be apparent that the greater volume of cooling fluid in the block will be affected by thermo-syphon circulation and that the smaller volume will be affected by forced circulation.

For example, the cooling exhaust passages in the block, the upper extremities of the cylinder sleeves formed in the block, and the lower wall of the cylinder head 97 all will be affected by low volume, high velocity, pump impelled circulation of cooling fluid, whereas the larger volume of cooling fluid contained within the cavities 131, 132, and 133 will be almost entirely affected by thermo-syphon circulation of cooling fluid.

Under such conditions, it will be apparent that only a relatively small quantity of cooling fluid referred to will flow into the block through the inlet passages 54 and 56 and from the block and the head through outlet passage 148. The temperature of such small quantity of liquid, however, will be relatively high, inasmuch as this circulating liquid comes in contact only with the very hottest parts of the cylinder head and block. Consequently the liquid impelled from the outlet 148 might be said to consist of a relatively small quantity of cooling liquid having a relatively high temperature. It is therefore possible to employ a relatively small radiator for cooling the engine, because the amount of heat which may be dissipated by any radiator under any given set

of external conditions, will depend upon the temperature of the cooling liquid circulated throughout the interior thereof and the velocity of such liquid.

The cooling system for the engine therefore makes it possible to construct an engine block with a relatively small capacity for containing cooling liquid within the liquid circulating passages thereof, and makes it possible to provide a relatively small and inexpensive radiator for dissipating the heat rejected by the engine. Also the pump and water connections for the engine may be correspondingly small and inexpensive. The small quantity of water used also is an advantage from the standpoint that in cold weather only a relatively small quantity of anti-freeze solution will be required in order to maintain the cooling liquid in such condition that it will not freeze when the engine is not running and after it has been allowed to cool off.

In the claims:

1. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of liquid circulating cavities on opposite sides of a cylinder of an engine, providing extension passages between said cavities at the upper extremities of said cavities and surrounding the head end of said cylinder, and providing forced circulation of cooling liquid inwardly at the bottom of one of said cavities and outwardly of said cavity from said extension passages.

2. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of liquid circulating cavities on opposite sides of a cylinder of an engine, providing forced circulation of cooling liquid inwardly at the bottom of one of said cavities and outwardly of said cavity from the upper extremity of said cavity, and providing thermo-syphon circulation and cooling of cooling fluid within the other of said cavities.

3. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of liquid circulating cavities on opposite sides of a cylinder of an engine, providing extension passages between said cavities at the upper extremities of said cavities and surrounding the head end of said cylinder, providing forced circulation of cooling liquid inwardly at the bottom of one of said cavities and outwardly of said cavity from said extension passages, and providing thermo-syphon circulation of cooling fluid within the other of said cavities.

4. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of liquid circulating cavities on opposite sides of a cylinder of an engine, providing extension passages between said cavities at the upper extremities of said cavities and surrounding the head end of said cylinders, and providing forced circulation of cooling liquid to and from one of said cavities and thermo-syphon circulation of cooling fluid within the other of said cavities.

5. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of liquid circulating cavities on opposite sides and surrounding the head end of a cylinder of an engine, and providing forced circulation of cooling liquid to and from one of said cavities and providing thermo-syphon circulation of cooling fluid within the other of said cavities.

6. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of vertically disposed cooling cavities on opposite sides of a row of said cylinders, connecting said cavities at the tops of said cavities and between and around the head ends of each of said cylinders, pumping cooling liquid into the lower part of said cavity at one side of said cylinders, and distributing said liquid throughout the length of said cavity, conducting said cooling liquid upwardly in said cavity through a plurality of parallel passages extending from one end to another of said cavity, exhausting said cooling liquid from the upper part of said cavity, dissipating heat from said cooling liquid in a heat exchanger positioned remotely with respect to said cylinders, returning said liquid to said cavity by again pumping said liquid into said lower part of said cavity, and dissipating heat from the other of said cooling cavities by thermo-syphon circulation of cooling fluid within said cavity.

7. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of vertically disposed cooling cavities on opposite sides of a row of said cyliners, pumping cooling liquid into the lower part of one of said cavities and distributing said liquid throughout the length of said cavity, conducting said cooling liquid upwardly in said cavity through a plurality of parallel passages extending from one end to another of said cavity, exhausting said cooling liquid from the upper part of said cavity, dissipating heat from said cooling liquid in a heat exchanger positioned remotely with respect to said cylinders, returning said liquid to said cavity by again pumping said liquid into the lower part of said cavity, and dissipating heat from the other of said cooling cavities by thermo-syphon circulation of cooling fluid within said cavity.

8. A method of cooling the cylinders of an internal combustion engine which comprises, providing a pair of vertically disposed cooling cavities on opposite sides of a row of said cylinders, pumping cooling liquid into the bottom of one of said cavities and distributing said liquid throughout the length of said cavity, conducting said cooling liquid upwardly in said cavity throughout a plurality of parallel exhaust cooling passages extending from one end to another of said cylinders and said cavity, exhausting said cooling liquid from the upper parts of said cavity, dissipatinig heat from said cooling liquid in a heat exchanger positioned remotely with respect to said cylinders, returning said liquid to said cavity by again pumping said liquid into the bottom of said cavity, and dissipating heat from the other of said cooling cavities by thermo-syphon circulation of cooling fluid within said cavity.

9. A method of cooling the cylinders of internal combustion engines comprising, pumping cooling liquid at relatively high velocities upwardly and over the exhaust passages leading from said cylinders and around a portion of the heads of said cylinders and away from said cyliners for dissipating the heat absorbed by said cooling liquid in a heat exchange device located remotely from said cylinders, and cooling the remaining parts of said cylinders by thermo-syphon circulation of cooling liquid in a heat exchange device located adjacent said cylinders.

10. A method of cooling the cylinders of internal combustion engines comprising, pumping cooling liquid at relatively high velocities upwardly and over the exhaust passages of said

cylinders and away from said cylinders for dissipating the heat absorbed by said cooling liquid in a heat exchange device located remotely from said cylinders, and cooling other parts of said cylinders by thermo-syphon circulation of cooling liquid in a heat exchange device located adjacent said cylinders.

11. An internal combustion engine comprising an engine block having a row of engine cylinders formed in said block, said block also being formed to provide a plurality of cooling cavities for said cylinders, said cavities being located on different sides of said cylinders, means for pumping cooling liquid to and from one of said cavities and for dissipating heat from said cooling liquid in a heat exchanger located remotely from said cylinders, and means for dissipating heat from the other of said cavities by thermo-syphon circulation of liquid in said cavity.

12. An internal combustion engine comprising an engine block having a cylinder formed in said block, said block also being formed to provide a plurality of cooling cavities for said cylinder, means for pumping cooling liquid to and from one of said cavities and for dissipating heat from said cooling liquid in a heat exchanger located remotely from said cylinder, another of said cavities being formed to provide an exposed heat exchanging wall adjacent cylinder and to provide thermo-syphon circulation of cooling liquid between said cylinder and said wall.

13. An engine cooling system comprising a plurality of cylinders having cooling liquid circulating cavities formed on opposite sides of said cylinders, a wall formed adjacent said cylinders and on one side of said cylinders for dissipating heat absorbed by cooling liquid circulating by thermo-syphon circulation of said cooling liquid in one of said cavities and adjacent said wall, and means for circulating cooling liquid through a cavity on the other side of said cylinders and for dissipating the heat from said cooling liquid in a region remote from said cylinders.

14. An engine cooling system comprising a plurality of cylinders having cooling liquid circulating cavities formed on opposite sides of said cylinders, a wall formed adjacent said cylinders and on one side of said cylinders for dissipating the heat absorbed by cooling liquid circulating by thermo-syphon circulation of said cooling liquid in one of said cavities and adjacent said wall, and means for circulating cooling liquid through a cavity on the other side of said cylinders and for dissipating the heat from said cooling liquid in a heat exchange device located away from said cylinders and said block.

15. An engine cooling system comprising a water pump having an outlet, an engine block having a lubricant cooler secured thereto and a jacket surrounding said cooler and connected to said outlet, said engine block having a plurality of exhaust passages extending throughout the length of one side thereof for exhausting the cylinders of said engine, a cooling water distribution manifold formed in said block below said passages and extending from one end to the other of said block, a water supply conduit connected at one end with said lubricant cooler jacket beyond said lubricant cooler in said jacket and at the other end to the middle portion of said distribution manifold, a plurality of exhaust cooling passages formed in said block and communicating with said distribution manifold throughout the length of said distribution manifold and extending normally from said distribution manifold and upwardly in said block between said exhaust passages in said block, a plurality of cylinder cooling cavities formed in said block and communicating with the upper extremities of said exhaust cooling passages, said cavities being formed in said block around the head ends of said cylinders and being adapted to extend downwardly of said cylinders on the side of said block opposite said exhaust passages, and outlet means formed in the upper part of said block for exhausting said cooling water from the upper parts of said cylinder cooling cavities.

16. An engine cooling system comprising a cooling fluid circulating pump having an outlet, a lubricant cooling device having a jacket connected to said outlet and having a jacket outlet beyond said lubricant cooling device, an engine block having a plurality of aligned cylinders formed therein, said block being formed to provide a plurality of parallel and laterally disposed exhaust passages leading from said cylinders and communicating with the exterior of said block and extending throughout the length of said block, a cooling liquid distribution manifold communicating with said jacket outlet and formed in said block below said exhaust passages and being provided with branch passages extending throughout the length thereof and formed in said block between said exhaust passages, cylinder cooling cavity means formed on the side of said block opposite said exhaust passages and extending downwardly from adjacent the head end of said cylinders to portions of said cylinders below the level of said exhaust passages formed in said block, said cylinder cooling cavities being formed to provide extensions thereof projecting across the top of said block and between said cylinders and communicating with said branches above said exhaust cooling passages, and a plurality of outlets formed in said block and communicating with said extensions of said cylinder cooling cavities for exhausting said cooling liquid from said block.

17. An engine cooling system comprising an engine block having a plurality of spaced and aligned cylinders formed therein, said block being formed to provide a plurality of cylinder cooling cavities therein, said cavities being disposed on one side of said cylinders and extending throughout the length of said block, said cavities being formed in said block to provide a plurality of laterally disposed extensions projecting across the upper part of said block and between said cylinders, a plurality of exhaust passages formed in said block in parallel relation to one another and leading from said cylinders to the exterior of said block, said exhaust passages being formed in said block in spaced relation to one another to provide a plurality of exhaust cooling passages disposed in parallel relation to one another throughout the length of said block, said exhaust cooling passages and said cavity extensions being adapted to communicate with one another through a cooling fluid receiving passage formed in said block above said exhaust passages, and a distribution manifold formed in said block and extending throughout the length of said block and below said exhaust passages for circulating and distributing liquid through said exhaust cooling passages, said extension cavities and said cylinder cooling cavities.

18. An engine cooling system comprising a block having a plurality of aligned cylinders formed therein, a cam shaft mounted in said block and extending throughout the length thereof along the lower extremities of said cylinders, a plurality of engine cooling cavities

formed in said block and extending between said camshaft and the upper extremity of said block, and means for supplying cooling fluid to one of said cavities and for exhausting said fluid from the remaining cavities.

19. An engine cooling system comprising an engine block having a plurality of spaced and aligned cylinders formed therein, a plurality of cylinder cooling cavities formed in said block and on one side of said cylinders and being provided with extension passages for circulating cooling fluid between said cylinders and toward and from the other side of said block, and means for supplying cooling fluid to certain of said cavities and for exhausting said cooling fluid from the remainder of said cavities.

20. An engine cooling system comprising an engine block having a plurality of aligned cylinders formed therein, a cooling liquid distribution passage formed in said block on one side of said cylinders and adjacent the crank ends of said cylinders, a plurality of spaced and parallel cylinder exhaust passages extending throughout the length of said block and above said distribution passage, said exhaust passages being formed in said block to provide parallel exhaust cooling passages between said exhaust passages and communicating at one end with said distribution passage, a cooling fluid receiving passage formed in said block above said exhaust passages, said block between said cylinders being formed to provide a plurality of lateral communication passages communicating at one end with said receiving passage and said exhaust cooling passages and at the opposite ends thereof communicating with cylinder and camshaft cooling cavities extending throughout the length of said block.

21. An engine cooling system comprising an engine block having a plurality of aligned cylinders formed therein and a cooling liquid distribution passage disposed in parallel relation to said cylinders and adjacent the crank ends of said cylinders, a plurality of exhaust passages formed in said block and above said distribution passage and extending in spaced relation to one another from said cylinders through the exterior of said block, a cooling fluid receiving passage formed in said block above said exhaust passages and communicating with said distribution passage through the spaces between said exhaust passages, and a plurality of cylinder cooling cavities formed in said block and between said cylinders and extending around said cylinders and downwardly upon the opposite sides of said cylinders, certain of said cavities being supplied with cooling liquid from the cooling liquid circulating pump of said engine and other of said cavities being provided with outlet means for exhausting said cooling liquid from said cavities.

22. An engine cooling system comprising an engine block having a plurality of spaced and aligned cylinders formed therein, an engine inlet manifold formed in said block and along one side of said block and adjacent the lower extremities of said cylinders, an engine cooling water distribution manifold formed in said block above said inlet manifold and on the same side of said cylinders, a plurality of spaced and parallel exhaust passages formed in said block above said cooling fluid distribution manifold and on said side of said cylinders, means for supplying engine cooling fluid to said distribution manifold, and engine cylinder cooling cavity means formed in said block on the opposite side of said cylinders and communicating with said distribution manifold through said spaces between said cylinders and between said exhaust passages.

23. An engine cooling system comprising an engine block having a plurality of aligned cylinders formed therein, an upwardly and inwardly inclined wall formed in said block on one side of said cylinders and adjacent the crank ends of said cylinders, said wall being intersected by said crank ends of said cylinders, a cooling liquid distribution manifold formed in said block above said wall, a plurality of exhaust passages having spaces therebetween and being formed in said block above said distribution manifold and extending from said cylinders to the exterior of said block, a plurality of cylinder cooling cavities formed in said block on the opposite sides of said cylinders and extending downwardly of said cylinders and terminating in said block substantially opposite said inclined wall, said block being formed to provide laterally disposed passages formed across said block adjacent the upper extremities of said cylinders and providing for communication between said cavities and said spaces between said exhaust passages.

24. An engine cooling system comprising an engine block having a plurality of cylinders formed therein and having a camshaft mounted in said block in parallel relation to said cylinders and adjacent the lower extremities of said cylinders, a plurality of push rods actuated by said camshaft, said push rods being adapted to extend upwardly through said block substantially in parallel relation to said cylinders, a plurality of cylinder cooling cavities formed in said block and surrounding said push rods, passage means surrounding said push rods and extending from one extremity to the other of said cavities and providing oil conducting means through said cavities and around said push rods, certain of said passage means being disposed between said cavities for separating said cavities, and means for circulating cooling liquid to and from said block and throughout said cavities.

25. An engine cooling system comprising an engine block having a plurality of cylinders formed therein, said block being formed to provide cylinder cooling cavities adjacent said cylinders, for circulating cooling liquid about said cylinders for cooling said cylinders, passage means extending through said block for separating said cavities, and a push rod employed in operating said engine and disposed in each of said passage means.

26. An engine cooling system comprising an engine block having a plurality of cylinders formed therein and having a wall disposed in spaced relation to said cylinders, a tubular member disposed between each of said cylinders and said wall for dividing the interior of said block into a plurality of cooling liquid circulating cavities and a movable member in each of said tubular members and disposed in spaced relation to the inner walls of said tubular members for lateral and longitudinal movement within said tubular members.

27. An engine cooling system comprising an engine block having a plurality of aligned cylinders therein and a wall formed on one side of said cylinders and disposed in spaced relation to said cylinders, and a plurality of tubular inserts disposed between said wall and said cylinders and closing the space between said wall and cylinders for dividing the interior of said block into a plurality of engine cooling cavities.

28. An engine cooling system comprising an

engine block having a plurality of cylinder cooling cavities formed throughout the length thereof, a lubricant cooler secured on one side of said block and extending from the front end of said block beyond the first of said cavities, a liquid circulating pump operated by said engine and having a cooling fluid outlet connected to the front end of said lubricant cooler, and a duct formed between the opposite end of said lubricant cooler and an intermediate one of said cavities.

29. An engine cooling system comprising an engine block having a plurality of cylinders formed therein in spaced relation to one wall of said block, a plurality of cylinder cooling cavities formed in said block between said wall and said cylinder, said wall being formed to provide a plurality of openings therein communicating with the interior of certain of said cavities, a plate having a lubricant cooler secured thereto and having an opening therein adjacent one end thereof, said plate being secured to said block with said opening communicating with one of said cavities and with said plate covering said cavity openings, a jacket secured to said plate around said plate opening and said lubricant cooler, and a cooling liquid inlet formed on said jacket at the end of said jacket opposite said plate opening for circulating cooling liquid over said lubricant cooler and through said plate opening and into one of said cavities.

30. An engine cooling system comprising an engine block having a plurality of cylinders formed therein, said cylinders being disposed in spaced relation to one another to provide spaces for circulating cooling within said block between opposite sides of said cylinders, a plurality of passages formed in said block on one side of said cylinders and communicating with said spaces between said cylinders and means for circulating cooling fluid in one direction through certain of said spaces and in the opposite direction through other of said passages.

31. An engine cooling system comprising an engine block having a plurality of cylinders formed therein, a cylinder cooling cavity formed in said block between said cylinders and one wall of said block, a liquid distribution passage formed on the opposite side of said cylinders and communicating with said cylinder cooling cavity through spaces between and around said cylinders, a plurality of exhaust passages formed in said block above said distribution passage, said block being formed to provide exhaust cooling passages between said exhaust passages, and means for circulating cooling liquid within said block from said cylinder cooling cavity and in opposite directions through said distribution passage and from said exhaust cooling passages.

32. An engine cooling system comprising an engine block having a plurality of cylinders formed therein in spaced relation to one another and in spaced relation to a side wall of said block, a cylinder cooling cavity formed in said block between said wall and said cylinders and extending through the space between said cylinders to the opposite side of said block, said block being formed to provide a cooling liquid distribution passage extending downwardly on the opposite side of said block and communicating at the upper extremity thereof with said cylinder cooling cavity, a liquid distribution manifold formed in said block and extending along the lower parts of said cylinders and communicating with the lower extremity of said distribution passage, and a plurality of spaced and vertically disposed exhaust cooling passages formed in said block and between said cylinders and along an opposite side wall of said block, said exhaust cooling passages being formed to provide communication with said cooling liquid distribution manifold at the lower extremities of said exhaust cooling passages.

33. An engine cooling system comprising an engine block having a plurality of cylinders formed therein, said cylinders being disposed in spaced relation to one another and to the opposite side walls of said block, a cooling liquid distribution manifold formed between one of said side walls of said block and the lower extremities of said cylinders and extending transversely with respect to said cylinders, a plurality of exhaust passages leading from said cylinders to the exterior of said block, exhaust cooling passages disposed between said exhaust passages and communicating with said distribution manifold at the lower extremities thereof, a liquid distribution passage communicating with said distribution manifold at the lower extremity of said passage, a cylinder cooling cavity formed between said cylinders and an opposite side wall of said block, and a liquid receiving passage formed above said exhaust passages and said distribution passage and communicating with said cylinder cooling cavity through a space between said cylinders.

34. An engine cooling system comprising an engine block having a plurality of aligned cylinders therein, an engine inlet manifold formed between the lower extremities of said cylinders and a side wall of said block and having branch passages extending upwardly between said cylinders and around said cylinders for supplying scavenging and charging fluid to said cylinders and for cooling the lower parts of said cylinders, a cooling liquid distribution manifold formed in said block above said inlet manifold and having branch passages leading upwardly and laterally between said cylinders, cylinder cooling cavity means formed between said cylinders and around the opposite sides of said cylinders and downwardly within said block for cooling said cylinders on the side of said block opposite said inlet and said distribution manifolds, said block being formed to provide communication between said branch passages and said cavities, means for supplying cooling liquid to said distribution manifold and means for exhausting cooling liquid from said branch passages.

35. An engine cooling system comprising an engine block having a plurality of cylinders therein, said block being formed to provide a plurality of engine cooling cavities between said cylinders and on one side of said cylinders and between said cylinders and one wall of said block, an engine cooling liquid distribution manifold formed in said block on the opposite side of said cylinders and between said cylinders and the opposite wall of said block, fluid supply passage means connected to one of said cavities and extending between an adjacent pair of said cylinders and connected to the central part of said liquid distribution manifold, a plurality of exhaust passages formed in said block between said cylinders and the exterior of said block, said exhaust passages being disposed above said distribution passage and on opposite sides of said supply passage means and in spaced relation to one another to provide a plurality of branch passages between said exhaust passages and leading from said distribution manifold, said branch pas-

sages being adapted to communicate with the remainder of said cylinder cooling cavities.

36. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, an inlet manifold formed in said block and having branches thereof extending between said cylinders and at the ends of said cylinders, a plurality of exhaust passages formed in said block and above said manifold and leading from said cylinders to the exterior of said block, said block being formed between said inlet manifold and said exhaust passages to provide a cooling liquid distribution manifold formed in said block from one end to the other of said block, said exhaust passages being spaced from one another and formed in said block to provide exhaust cooling passages communicating at the lower extremities thereof with said cooling liquid distribution manifold, said block also being formed to provide a cooling liquid receiving passage below the upper wall of said block and communicating with said exhaust cooling passages, said upper wall of said block being formed to provide outlets from said liquid receiving passage.

37. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, an inlet manifold formed in said block and having branches thereof extending between said cylinders and at the ends of said cylinders, a plurality of exhaust passages formed in said block and above said manifold and leading from said cylinders to the exterior of said block, said block being formed between said inlet manifold and said exhaust passages to provide a cooling liquid distribution manifold formed in said block from one end to the other of said block, said exhaust passages being spaced from one another and formed in said block to provide exhaust cooling passages communicating at the lower extremities thereof with said cooling liquid distribution manifold, said block being formed to provide a cooling liquid receiving passage below the upper wall of said block and communicating with said exhaust cooling passages, said upper wall of said block being formed to provide outlets from said liquid receiving passage, said block also being formed to provide a supply passage for said liquid distribution manifold, said supply passage being adapted to intersect said liquid receiving passage and being disposed between and in parallel relation to certain of said exhaust cooling passages.

38. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, said block also being formed to provide cooling liquid circulating cavities on opposite sides of said cylinders and extending downwardly of said cylinders towards the crank ends of said cylinders, said block further being formed to separate said cavities at the lower extremities of said cavities and to provide communication between said cavities only between and around the upper extremities of said cylinders, said walls of said block being formed to provide a cooling liquid inlet to one of said cavities and an outlet from each of said cavities.

39. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, said block also being formed to provide cooling liquid circulating cavities on opposite sides of said cylinders and extending downwardly of said cylinders towards the crank ends of said cylinders, said block further being formed to separate said cavities at the lower extremities of said cavities and to provide communication between said cavities between and around the upper extremities of said cylinders, said walls of said block being formed to provide a cooling liquid inlet to the lower extremities of certain of said cavities on one side of said block and an outlet from said cavities from said communication between said cavities.

40. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, said block being formed to provide cooling liquid circulating cavities on opposite sides of said cylinders and extending downwardly of said cylinders towards the crank ends of said cylinders, said walls of said block being formed to provide a cooling liquid inlet to the lower extremity of one of said cavities and an outlet from the upper extremity of said cavity.

41. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, an inlet manifold formed in said block and having branches thereof extending between said cylinders and at the ends of said cylinders, a plurality of exhaust passages formed in said block and above said manifold and leading from said cylinders to the exterior of said block, said block being formed between said inlet manifold and said exhaust passages to provide a cooling liquid distribution manifold formed in said block from one end to the other of said block, said exhaust passages being spaced from one another and formed in said block to provide exhaust cooling passages communicating at the lower extremities thereof with said cooling liquid distribution manifold, said block being formed to provide a cooling liquid receiving passage below the upper wall of said block and communicating with said exhaust cooling passages, said upper wall of said block being formed to provide outlets from said liquid receiving passage, said block being formed to provide an inlet for said liquid distribution manifold, and said block being further formed to provide thermo-syphon circulation cooling cavity means on the side of said cylinder opposite said manifold.

42. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, an inlet manifold formed in said block and having branches thereof extending between said cylinders and at the ends of said cylinders, a plurality of exhaust passages formed in said block and above said manifold and leading from said cylinders to the exterior of said block, said block being formed between said inlet manifold and said exhaust passages to provide a cooling liquid distribution manifold formed in said block from one end to the other of said block, said exhaust

passages being spaced from one another and formed in said block to provide exhaust cooling passages communicating at the lower extremities thereof with said cooling liquid distribution manifold, said block being formed to provide a cooling liquid receiving passage below the upper wall of said block and communicating with said exhaust cooling passages, said upper wall of said block being formed to provide outlets from said liquid receiving passage, said block also being formed to provide an inlet for said liquid distribution manifold, said inlet being adapted to supply cooling liquid to said manifold for circulation upwardly through said exhaust cooling passages and outwardly through said outlets, and cooling cavity means formed in said block on the side of said cylinders opposite said receiving passage and communicating with said receiving passage through supply passages formed around the upper extremities of said cylinders.

43. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, an inlet manifold formed in said block and having branches thereof extending between said cylinders and at the ends of said cylinders, a plurality of exhaust passages formed in said block and above said manifold and leading from said cylinders to the exterior of said block, said block being formed between said inlet manifold and said exhaust passages to provide a cooling liquid distribution manifold formed in said block from one end to the other of said block, said exhaust passages being spaced from one another and formed in said block to provide exhaust cooling passages communicating at the lower extremities thereof with said cooling liquid distribution manifold, said block being formed to provide a cooling liquid receiving passage below the upper wall of said block and communicating with said exhaust cooling passages, cooling cavity means formed in said block on the side of said cylinders opposite said receiving passage and communicating with said receiving passage at the upper extremities of said cooling cavity means, said block being provided with connections for the forced circulation of cooling liquid into said distribution manifold and outwardly through openings formed in said upper wall of said block and communicating with said liquid receiving passage.

44. An engine block comprising an integrated metallic body having side walls, front and rear end walls, a top wall, and a plurality of aligned cylinders formed therein in spaced relation to said side and end walls and to one another, an inlet manifold formed in said block and having branches thereof extending between said cylinders and at the ends of said cylinders, a plurality of exhaust passages formed in said block and above said manifold and leading from said cylinders to the exterior of said block, said block being formed between said inlet manifold and said exhaust passages to provide a cooling liquid distribution manifold formed in said block from one end to the other of said block, said exhaust passages being spaced from one another and formed in said block to provide exhaust cooling passages communicating at the lower extremities thereof with said cooling liquid distribution manifold, said block being formed to provide a cooling liquid receiving passage below the upper wall of said block and communicating with said exhaust cooling passages, said block being formed to provide inlet connections for supplying cooling liquid to said liquid distribution manifold and outlet connections for exhausting said cooling liquid from said liquid receiving passage.

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