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[54] **LIQUID COOLED RECIPROCABLE PISTON INTERNAL COMBUSTION ENGINE**

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[63] Continuation-in-part of Ser. No. 54,817, July 14, 1970, abandoned.

[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** **F02f 1/02,** F02f 1/04, F02f 1/10

[58] **Field of Search** ..... 123/41.28, 41.31, 123/41.54, 41.72, 41.74, 41.75, 41.82, 193 CH

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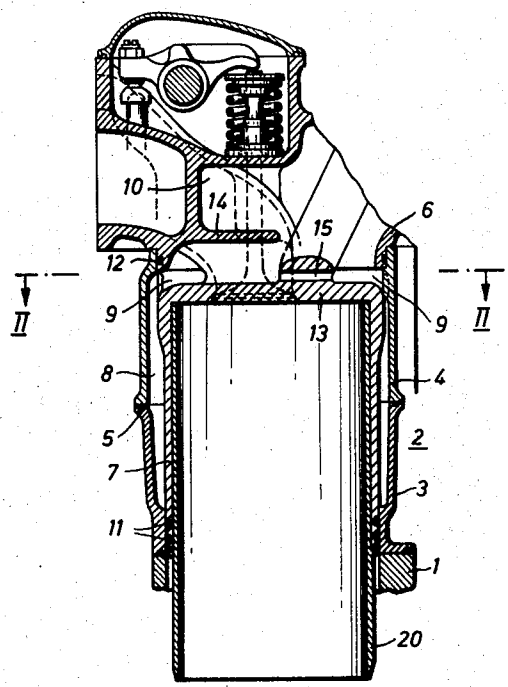
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[57] **ABSTRACT**

A liquid-cooled reciprocable piston internal combustion engine with a crank-case extending into the region of the foot portion of a cylinder while adjacent said crank-case there is provided a jacket surrounding said cylinder and forming therewith a first cooling fluid receiving chamber, while the cylinder head and said cylinder together form a structural unit which is inserted between and rests against the cylinder head and the crank-case, said first cooling fluid receiving chamber means communicating through passage means with second cooling fluid receiving chamber means in the cylinder head.

8 Claims, 6 Drawing Figures



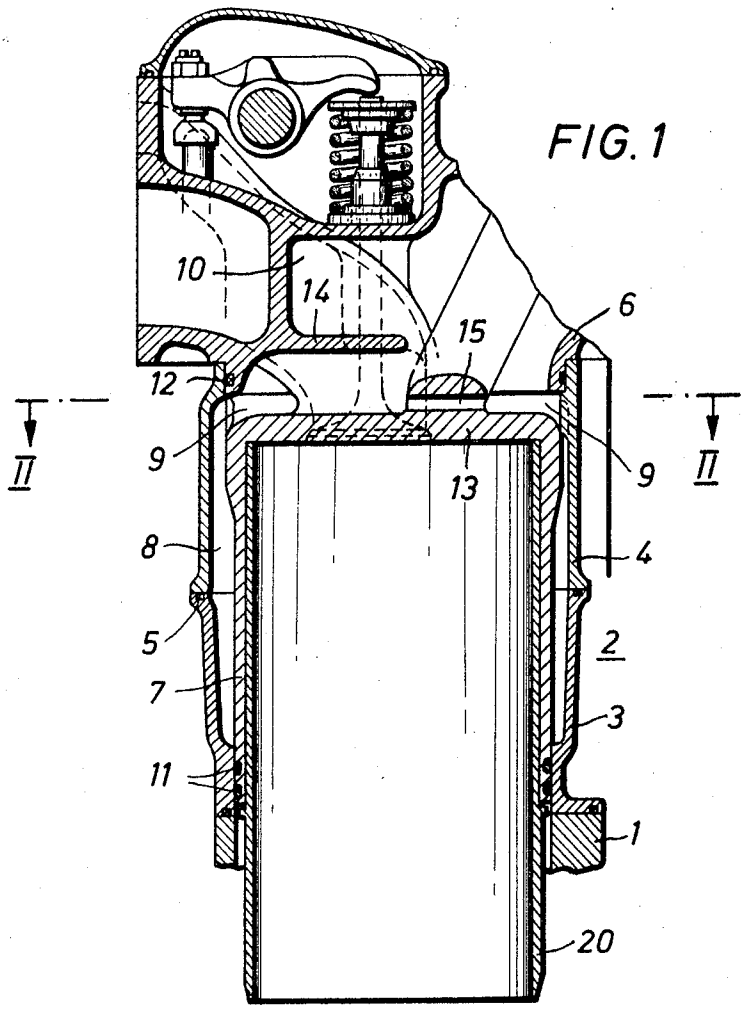


FIG. 1

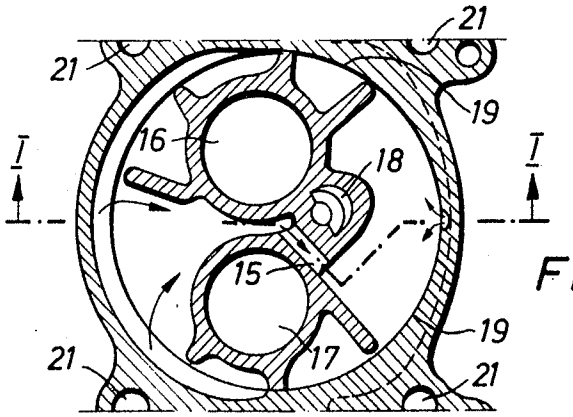


FIG. 2

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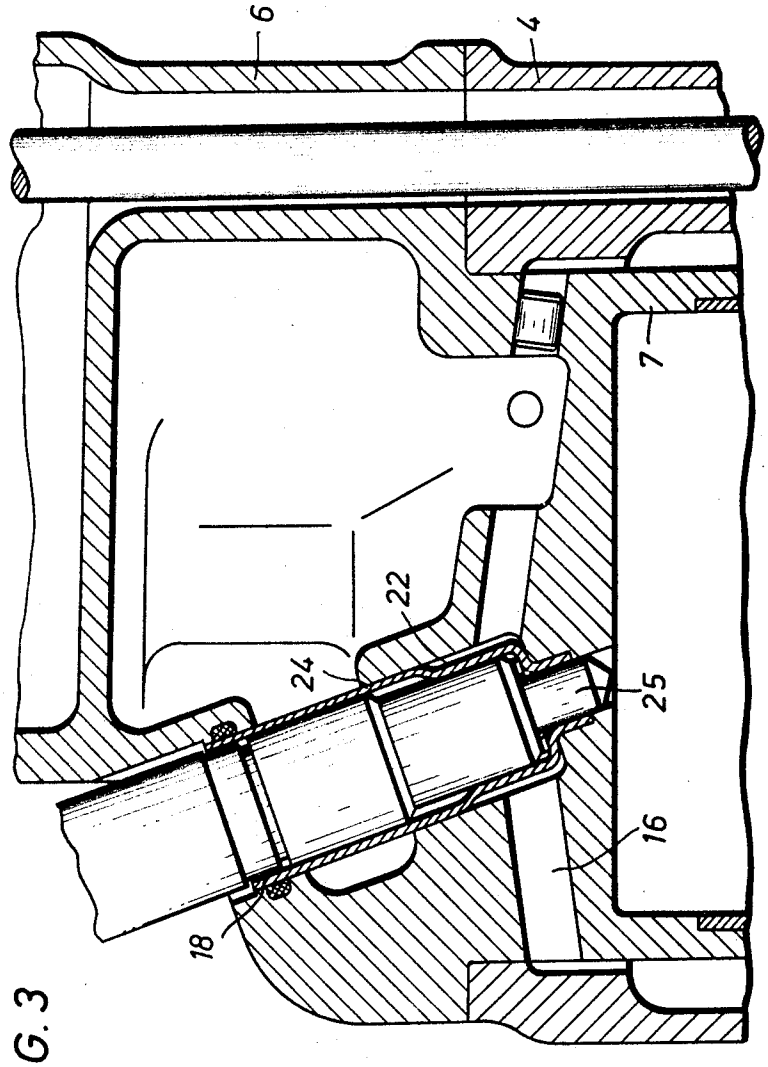


FIG. 3

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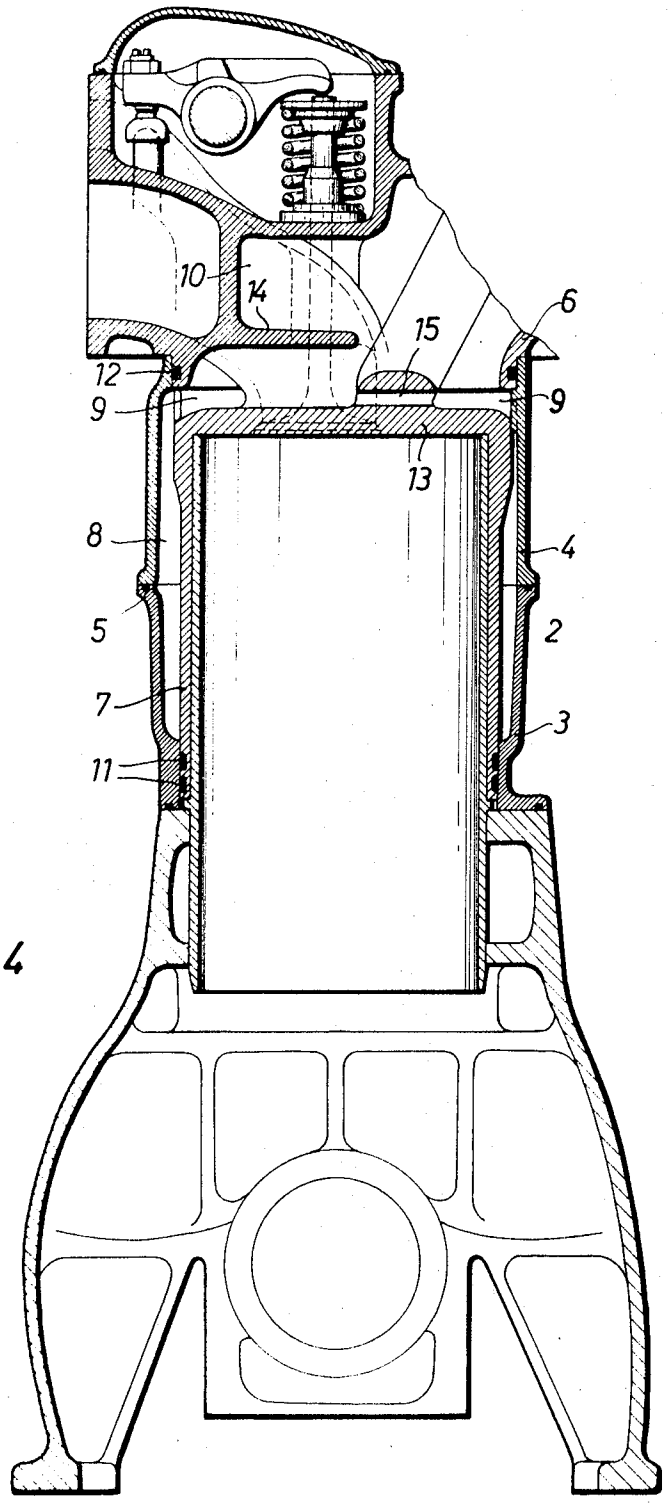


FIG. 4

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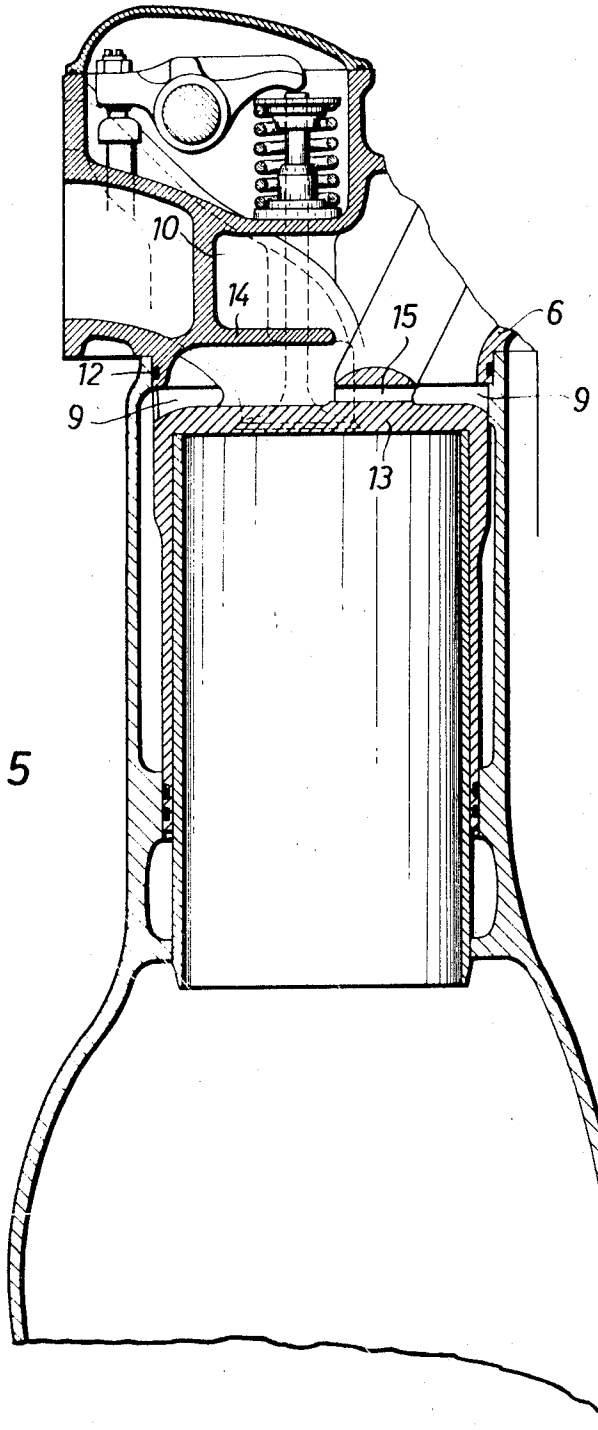


FIG.5

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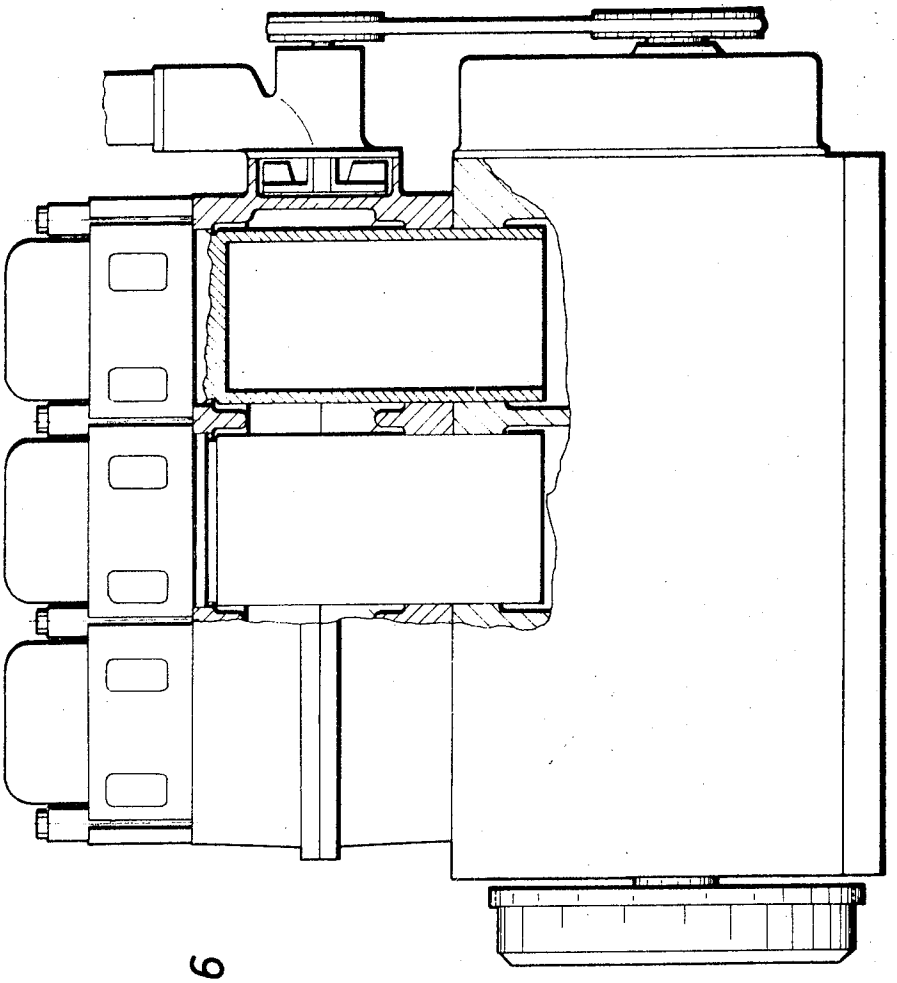


FIG.6

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LIQUID COOLED RECIPROCABLE PISTON INTERNAL COMBUSTION ENGINE

This is a continuation-in-part of co-pending application Ser. No. 54,817-Herschmann et al. filed July 14, 1970, now abandoned.

The present invention relates to a liquid-cooled reciprocable piston internal combustion engine which is provided with a crank-case extending into the range of the foot portion of a cylinder and being followed by a mantle surrounding the cylinder and forming therewith a cooling jacket.

With oil-cooled reciprocable piston internal combustion engines of the above mentioned type, it has become known to insert into the mantle from the side of the crank-case cylinder which cylinderwhich is closed at the cylinder head side. After this cylinder has been inserted up to a collar or abutment, it is connected to a cylinder head applied from the outside. When dissassembling the cylinder or a valve, it is necessary to disassemble the cooling mantle or cooling jacking and to disconnect the connecting lines for the admission of a cooling fluid. This requires considerable time and is particularly expensive when multicylinder engines are involved in which all cylinders are surrounded by a common mantle or jacket. Furthermore, with a reciprocable piston internal combistion engine of the above mentioned type, the cooling medium passes around the cylinder and the cylinder bottom in a direction transverse to the cylinder axis while no cooling chambers are provided in the cylinder head. Such an arrangement has the drawback that with internal combustion engines having a high specific output, a sufficient cooling of the cylinder head is not assured. Moreover, the separation of the cylinder head and the cylinder requires an additional seal or gasket between the chambers containing the cooling medium and the chambers containing gas, for instance, for air cooling.

According to another heretofore known reciprocable piston internal combustion engine, a cylinder closed at the side of the cylinder head is screwed to the cylinder head. In this instance, the cylinder head is provided with cooling chambers which, through bores in the cylinder bottom, communicate with a cooling chamber surrounding the cylinder. This last mentioned cooling chamber is surrounded by the outer wall of the cylinder and a water mantle or jacket which surrounds said cylinder and is welded to webs thereof. The foot portion of the cylinder has a flange by means of which the cylinder unit is connected to the crank-case. This arrangement has the drawback that the reaction forces resulting from the combustion are in axial direction conveyed to the cylinder wall which, therefore, have to be made correspondingly rigid and strong. Furthermore, it is not possible to surround a plurality of cylinders by a common mantle without creating the necessity that when disassembling one cylinder, also the other cylinders have to be disassembled. Furthermore, the short connecting screws between the cylinder and the crank-case represent a drawback for the obtainment of a good seal.

Finally, it is also known to case the cylinder head, cylinder and mantle in one piece. Such units require complicated molds and therefore are expensive to produce. Moreover, each motor type requires specific cast parts.

It is, therefore, an object of the present invention to provide a liquid-cooled reciprocable piston internal combustion engine which will overcome the above mentioned drawbacks and in which the cylinder and cylinder head units can be produced in a simple manner, can easily be exchanged and can be satisfactorily cooled.

It is another object of this invention to provide an internal combustion engine as set forth in the preceding paragraph in which the cylinder wall, at least to a major extent, be relieved in axial direction from forces exerted by the gas and from heat stresses.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 illustrates a longitudinal section through a portion of a cylinder and cylinder head unit of an internal combustion engine according to the invention, said section being taken along the lines I — I of FIG. 2.

FIG. 2 is a cross section along the line II — II of FIG. 1.

FIG. 3 represents a partial cross section through an embodiment of the cooling water feeding system within the range of the injection nozzle.

FIG. 4 is a longitudinal section similar to that of FIG. 1 showing the mantle or jacket as forming a separate part from the crank-case and being supported by the latter.

FIG. 5 likewise represents a section similar to that of FIG. 1, but showing the mantle or jacket forming one single integral piece with the crank-case.

FIG. 6 shows a side view of an engine unit according to the invention in which all cylinders are surrounded by a common mantle or jacket with individual units of cylinder and cylinder head inserted into said jacket while a cooling pump is connected to one end face of the jacket.

The liquid-cooled reciprocable piston engine according to the present invention is characterized primarily in that the cylinder head and the cylinder form a unit which is inserted into a mantle braced between the cylinder head and the crank-case while the cooling chamber which surrounds the cylinder communicates through passage means with cooling fluid chambers provided in the cylinder head through which the cooling fluid is discharged.

This design brings about that no seal is necessary between the cylinder head and the cylinder while, nevertheless, an easily obtainable cast structure is obtained in which the cylinder portion can be made with relatively thin walls while the mantle surrounding the same receives the axially directed forces caused by the combustion and conveys said forces to the machine frame. The cylinder part, which freely extends into the crank housing, is able to expand in axial direction so that no deformation of the cylinder running surfaces will occur as a result of heat stresses. By bracing the mantle between the cylinder head and the crank housing, it will be possible to insert the cylinder-cylinder head unit from the outside into the already assembled mantle. As a result thereof, a disassembly of individual cylinder unit is possible without difficulties. This is advantageous particularly when, in conformity with a further development of the invention, all cylinders of a multicylinder reciprocable piston are surrounded by a common mantle. In this connection, it may be mentioned

that it is principally possible to combine a plurality of cylinder-cylinder head units to a block. However, with regard to a better exchange possiblity, it appears advantageous according to a further development of the invention to insert individual units of cylinder heads and cylinders into the mantle.

The design according to the present invention has the further advantage that by simple means it is possible to convert an air-cooled internal combustion engine into a water-cooled internal combustion engine while the crank-case and the transmission parts for both types of machines remain the same. This permits a better economic exploitation of existing manufacturing facilities and allows a better adaptability of already built internal combustion engines to different purposes of employment.

According to a further development of the invention, it is suggested that the mantle extend beyond the bottom of the cylinder and that the passages for the cooling medium to the cylinder head are arranged substantially radially with regard to the cylinder axis. The supporting surface of the cylinder head is preferably located on the mantle and the centering is effected above the cylinder head bottom while the passages for the cooling medium to the cylinder head may extend over the entire circumference of the cylinder. Such a design affords a good support for the core and an easy removal of the core sand. Furthermore, the thermally highly stressed zones of the cylinders are particularly well cooled at the level of the cylinder head bottom.

For further improving the cooling and to realize a uniform temperature distribution in the cylinder head, it is suggested according to a further development of the invention to arrange the passages for the cooling medium primarily at a limited portion of the circumference of the cylinder. The intended intensive flow of the cooling medium in thermallyhihgly stressed thermally highly can advantageously be realized by designing the cylinder head open around its circumference within the opening in form of regions of the circumference will be covered by the centering of the mantle. In this connection, it is particularly advantageous when a cooling medium bore passes by the nozzle holder so that the cooling medium flows around the nozzle holder.

According to a further feature of the invention, a major portion of the cooling fluid flows around the nozzle holder which is sealed by a metal sheet spout and flows directly through a bore in a web into the chamber which contains the cooling fluid and pertains to the cylinder head.

For purposes of simplifying the manufacture of the mantle, it is suggested to divide the mantle in a plane transverse to the cylinder axis. Advantageously, the individual parts of the mantle may after being machined by connected to each other by cementing or the like. A further simplification can be realized by screwing a cooling water pump at the end face of the machine to the mantle while the spiral housing of the cooling water pump forms one part with the mantle.

Referring now to the drawings in detail, the arrangement shown therein comprises a crank-case **1** of a reciprocable piston internal combustion engine having arranged adjacent thereto a mantle **2** or jacket which surrounds the cylinder **7**. The said mantle **2** comprises two sections **3** and **4** which are connected along a common separating plane in a direction transverse to the cylinder axis. Provided at the separating surface of the mantle part **3** is an elastic seal **5** which seals the separating area toward the outside. Another type of connection may consist in that the parts **3** and **4** of the mantle **2** prior to the assembly are connected to each other by a suitable cement. By dividing the mantle, two cast parts are obtained which are simple to produce and which do not have any undercuts.

A cylinder-cylinder head unit comprising a cylinder head **6** and cylinder **7** forming a single cast piece is inserted into the mantle **2**. The cylinder **7** and the mantle **2** form a cooling medium-receiving chamber **8** which surrounds the cylinder **7** and is adapted to receive a cooling medium. The cooling medium-receiving chamber **8** communicates through cooling passages **9** with the cooling chambers **10** in the cylinder head for conveying the cooling medium. The cooling medium-receiving chamber **8** is, at the centering surfaces between the mantle **2** and the cylinder head-cylinder unit, sealed by means of annular seals **11** and **12**.

The mantle **2** extends beyond the cylinder head bottom **13** to such an extent that between said bottom **13** and the annular seal **12** there remains sufficient space to permit said passages being arranged substantially radially. In this way, in addition to the advantages concerning the simplified manufacturing process, it will be realized that the cylinder bottom **13** is passed around by the cooling fluid in a very satisfactory manner. This cooling may even be further improved by providing in the cylinder head **6** a guiding wall **14** and a cooling medium-conveying bore **15** between the passages **16** and **17** for the gas exchange and for a nozzle holder **18**.

According to a further development of the invention, a bore **23** may be provided similar to the bor **15** for the cooling fluid illustrated in FIG. **3**. Bore **23** leads to an annular chamber **22** which surrounds the nozzle holder **18** and from there leads to the remaining cooling chambers of the cylinder head **6**. The annular chamber **22** is formed by the nozzle holder **18** the diameter of which is somewhat reduced in this area, and is furthermore formed by the bore **24** for said nozzle holder. The forced flow around the nozzle holder **18** brings about an intensive cooling of the nozzle **25**.

In order to realize directed flow of the cooling medium on the cylinder head bottom **13**, the passages **9** for the cooling medium are arranged only at a limited portion of the circumference of the clyinder. The passages **9**, which are open in radial direction toward the circumference, are, within the regions **19** of the cylinder circumference, covered by the centering of the mantle part **4**. By a suitable adaptation of the covered portion of the passages **9** to the free portions of passages **9**, a substantially uniform temperature distribution over the cylinder head bottom **13** will be obtained.

The cylinder **7** may be so designed that its inner surface directly forms the running surface for the piston. According to the illustrated embodiment, however, a dry cylinder slleve **20** is inserted into the cylinder **7**.

The drawing shows a cylinder-head-cylinder unit of a multi-cylinder reciprocable piston internal combustion engine in which each two adjacent cylinder heads are connected by tie-rods common thereto. The recesses in the cylinder head for the passage of these tie-rods are shown in FIG. **2** and designated with the reference numberal **21**. By means of the tie-rods, not shown in detail, the mantle **2** will be braced between the cylinder **6** and the crank-case **1**.

The advantages inherent to the particular design of the cylinder head-cylinder unit according to the invention are also realized when the mantle **2** and the crank-case **1** form a single piece. In such an instance, however, it is not possible to employ the same crank-case for water cooled and air cooled inventions.

With the internal combustion engine according to the present invention there is a water mantle or jacket braced or held between the cylinder head of the crank-case housing. This occurs by way of clamping bolts or tightening screws which extend from the cylinder head as far as to the crank-case housing. So that the cylinder head respectively the water mantle or jacket under influence of gas forces does not lift from the crank-case housing, the clamping bolts must be tightened with a predetermined preload or force corresponding to the gas forces. There are two possibilities including, namely first that the stressing force is applied by way of the wall of the cooling water jacket or mantle on the crank-case housing or that secondly such stressing forces are applied by way of the cylinder sleeve on the crank-case housing. It is correct that the water mantle or jacket does not take up or receive directly the affected forces resulting axially from the combustion though indirectly there is loading thereof by way of the clamping bolts or tightening screws in a corresponding measure. If the water mantle or jacket were to be bolted or screwed into position with the end thereof directed toward the crank-case housing being screwed or tightened with the crank-case housing, so the gas forces would be effective directly upon the water mantle or jacket. The difference consists therein that in the first case the gas forces effecting unloading or lightening of the load relative to the water mantle or jacket while in the second case they draw upon the water mantle or jacket.

It is to be noted, however, that convertability of the internal combustion machines from water cooling to air cooling alone should not be considered alone but should be considered with other features of the present invention. Convertability by the water cooling and air cooling is basically made possible on the internal combustion machine in that the water mantle or jacket and crank-case housing are embodied separately from each other. In this case the water cooled cylinder and cylinder head can be replaced by way of an air cooled cylinder and cylinder head while the drive mechanism parts consisting of the piston, the connecting rods, the crank shaft, the crank shaft housing, and the control parts can be kept and maintained.

There is provided a liquid-cooled reciprocable piston internal combustion engine having a cylinder with a bottom at one end and open at the other end with a crank-case housing extending around the open end portion of the cylinder head. Jacket means mounted on the crankcase forms a first cooling chamber means surrounding the cylinder to receive and pass cooling fluid therethrough. The cylinder **7** and cylinder head **6** are structured in one piece and the jacket means **2** extends beyond the cylinder head bottom **13.** The cooling liquid overflow openings **9** included with conduit means establishing communication between the first cooling chamber means and the second cooling chamber means extend substantially in radial direction with regard to the axis of the cylinder.

The present invention strives to provide an internal combustion engine with which the crankcase housing and the drive mechanism parts are suitable both for water cooling and also for air cooling of an installation with cylinder means and cylinder head so cooled accordingly. With air-cooled internal combustion engines it is usual to place or set individual cylinder means with their cooling jacket means directly upon the crankcase housing which extends as far as to the cylinder bottom or foot portion. An important precondition for convertibility respectively utilization of the crank-case housing and the drive mechanism parts for both types of cooling accordingly requires that the crank-case housing extends only as far as into the range of the base or foot portion of a cylinder means.

In contrast to an air-cooled internal combustion machine or engine, the guidance or passage of cooling means and sealing as well as fabrication of the cylinder-cylinder head unit involves considerable difficulties with a version having water cooling. If the cylinder-cylinder head unit is embodied corresponding to the disclosure of prior art, then the gas forces are taken or received by the inner cylinder walls which for the purpose of good heat dissipation should be thinly structured and which now deforms under the influence of forces and heat stress. Furthermore the inner cylinder expands or deforms as a consequence of temperature differs in a manner differing from expansion or deforming relative to the outer cooling water jacket means so that for avoidance of deformation there must be provided additional complicated structural provisions or structural adaptations. Finally the sealing locations between the gas conducting passages or conduit means and the cooling water conveying parts of the machine must be sealed off under consideration of the difficulties which arise as a consequence of continuous temperature change. This is true especially for the spark plug passage and the gas interchange passage or conduit means.

A further point is the cooling of the cylinder and cylinder head in the range of the combustion chamber. With the conventional constructions the cooling water enters through smaller bores from the cooling water jacket means into the cylinder head. Particularly in the range of the combustion chamber and the cylinder head bottom plate there is insufficient provision for cooling means in the periphery of the cylinder. In contrast thereto with the present invention, the cooling medium along the periphery can reach as far as into the range of the bottom plate and streams over upon large parts of the periphery of the cylinder head. Moreover the cooling liquid overflow openings of the cooling liquid chamber surrounded by the cylinder means are to be arranged essentially radially with respect to the cylinder axis and relative to the cooling liquid chamber means in the cylinder head. A cooling water mantle means is provided surrounding the cylinder and which extends approximately into the height of the cylinder head. A subdivision of this mantle means is provided according to the present invention; a subdivision of a water mantle means is extended between the cylinder head and the crank-case housing. For simplification of fabrication and improvement of cooling water flow in the range of the pump, the housing of the cooling water pump formed as a single unit with the mantle means must be considered to be of decisive meaning.

There is to be developed and provided a water-cooled reciprocable piston internal combustion engine which can be changed into an air-cooled internal com-

bustion engine subject to utilization of the same or identical drive mechanism parts and the same or identical crankcase. It is necessary herefore that the cooling-water mantle or jacket surrounding the cylinder means can be removed and the cylinder can be replaced by way of air-cooled structure. With high capability machines however there exist still further requirements with respect to the cooling and loading of the cylinder sleeve or liner and the cylinder head as well as with respect to the fabrication or finishing thereof. Relative to the loading and deforming of the cylinder sleeve or liner is kept free of axially effective gas forces and heat stress. With previously known conventional constructions the engaging surface of the cylinder head lies in the range of the cylinder head bottom, whereby in this area there is required a material concentration or accumulation through which cooling-means bores pass directed essentially parallel to the cylinder axis and these bores interconnect the cooling middle space around the cylinder with the cooling-means chambers in the cylinder head. These in essence axially extending cooling means bores throttle the cooling-means stream or flow very strongly in the area or range of the combustion chamber so that the cooling effect is reduced particularly in the range of the greatest heat being encountered by the cylinder.

As set forth in the present description, the engaging surface of the inventive cylinder head lies upon the mantle above the cylinder head bottom so that the cooling means transfer passages to the cylinder head can extend over the entire cylinder periphery or circumference. There is achieved thereby aside from a good cooling also a uniform temperature distribution and deformation upon the cylinder periphery or circumference. Simultaneously by way of the radial arrangement of the cooling means transfer passages there is made possible a good core support and an easy removal of the core sand.

The designated problem of cooling-means guidance in the range of the cylinder head bottom arises only with internal combustion engines with which the gas forces respectively the forces of the cylinder head screws are introduced into the crank-case by way of the water mantle or jacket, including an engagement surface between the water mantle and cylinder head.

Cooling fluid transfer openings **9** are arranged essentially radially to the cylinder axis from the cooling fluid chamber **8** surrounded by the cylinder **7** to the cooling fluid chambers **10** in the cylinder head **6.** The engaging surface of the cylinder head upon the mantle and the centering lie above the cylinder head bottom.

A liquid cooled reciprocable piston internal combustion engine with a crankcase housing extending as far as into the range of the base or foot of a cylinder relative to which a jacket or mantle surrounding the cylinder and clamped between the cylinder head and crank-case is connected thereto and forms therewith a cooling liquid chamber. The foregoing is further characterized thereby that the cylinder **7** and the cylinder head **6** are constructed in one piece, that the mantle or jacket **2** extends as far as over the cylinder head bottom **13,** whereby the engaging surface and the centering of the cylinder head lie above the cylinder head bottom, and the cooling liquid transfer openings **9** of the cooling liquid chamber **8** surrounding the cylinder **7** to the cooling liquid chambers **10** in the cylinder head **6** are arranged essentially radially with respect to the cylinder axis.

The cooling means transfer conduit means **9** are arranged mainly over a limited portion of the circumference of the cylinder. Thereby a sought cooling water stream or flow is to be achieved and attained in the cylinder head. The cooling means transfer conduits also provide large cross sections in this case in comparison to the known cooling-means bores.

The radial opening of the cooling-means transfer conduits are to be covered in certain areas of the circumference by way of centering of the mantle or jacket means. Thereby the previously described purpose is achieved with straightforward means. The radial openings covered by way of the centering lie below the engaging surface and pertain to a particular direction of through passage flow with respect to the cylinder head.

In the area of the cooling means transfer passages the cylinder head is open along its circumference within the region of the conduit means so that a good core support is provided and the cooling means conduits in the cylinder head can be well cleaned and controlled as well as inspected. Further with the inventive construction of the cylinder head bottom upon a wide front there is streaming of the cooling flow around the same whereby an intensive cooling is achieved with respect to the parts thermally highly stressed. Finally, it is possible to influence the cooling means stream in a straightforward manner so that predetermined parts of the periphery are covered by way of the centering of the jacket or mantle; also it is possible by way of the peripheral opening parallel to the cylinder head bottom to provide cooling bores extending in the range of the passageway, bridge or flange area.

It is, of course, to be understood that the present invention is, by no means, limited to the particular construction shown but also comprises any modifications within the scope of the appended claims.

What we claim is:

1. A convertible gas-liquid-cooled reciprocable piston internal combustion engine, which includes in combination: a cylinder having a cylinder bottom at one end and being open at the other end, a crank-case extending around the open end portion of said cylinder, separable jacket means mounted on said crank-case and surrounding said cylinder so as to form therewith first cooling chamber means adapted to receive and pass cooling fluid therethrough, a cylinder head having second cooling chamber means therein for communication with a cooling circuit and being connected to that end of said cylinder which comprises said cylinder bottom, said cylinder head and siad cylinder forming a structural unit securely joined with respect to each other, and conduit means extending in radial direction with regard to the axis of the cylinder and thereby establishing communication between said first cooling chamber means and said second cooling chamber means, said jacket means resting both against said crank-case and said structural unit formed by said cylinder head and said cylinder, said jacket means and first cooling chamber means extending beyond the cylinder bottom, said jacket means being clamped axially between said cylinder head and said crank-case.

2. An internal combustion engine in combination according to claim **1,** in which said conduit means are arranged mainly over a limited portion of the circumference of said cylinder.

3. An internal combustion engine in combination according to claim 2, in which said cylinder head is open along its circumference within the region of said conduit means, and in which an open portion along the circumference of said cylinder head is over a section of said circumference covered above by said jacket means, said jacket means being centered by and above said cylinder head.

4. An internal combustion engine in combination according to claim 3, in which said cylinder head includes nozzle holder means and which comprises nozzle means mounted in said nozzle holder means, and passage means passing around said nozzle holder means and communicating with said first cooling chamber means for conveying cooling fluid uniformly distributed around said nozzle holder means.

5. An internal combustion engine in combination according to claim 4, in which said cylinder head is provided with web means having a passage therein communicating directly with said second cooling chamber means and the outer wall of said nozzle holder means.

6. An internal combustion engine in combination according to claim 4, in which said separable jacket means is divided along a plane transverse to the axis of the adjacent cylinder.

7. An internal combustion engine in combination according to claim 6, in which the sections of said jacket means are clamped securely to each other.

8. An internal combustion engine in combination according to claim 7, which includes cool water pump means threadedly connected to said jacket means at an end face of said engine, and in which the spiral housing of said cool water pump means together with said jacket means forms a single integral piece.

* * * * *