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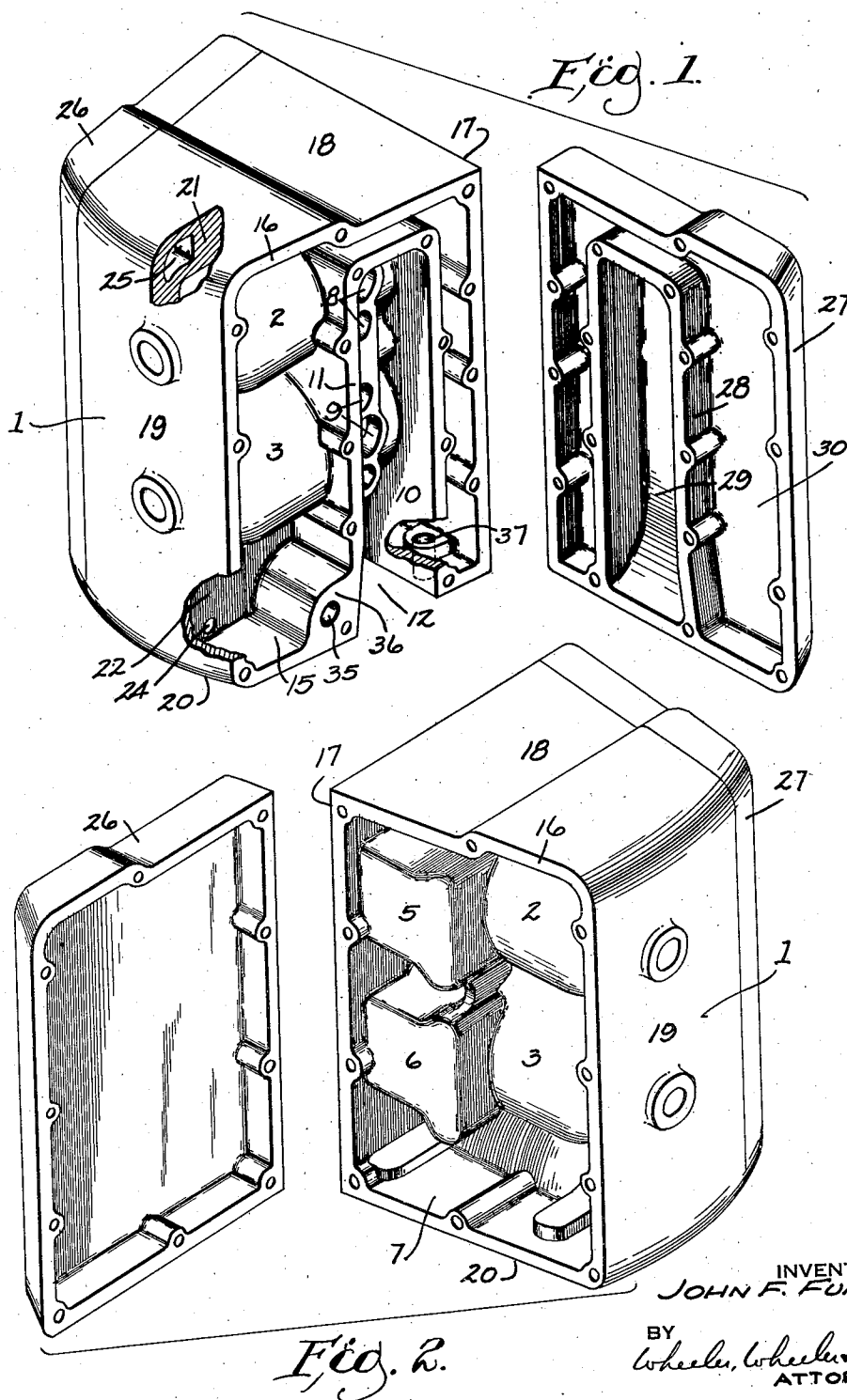
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2,408,386

ENGINE AND ENGINE COOLING METHOD

Filed Nov. 4, 1944

2 Sheets-Sheet 1



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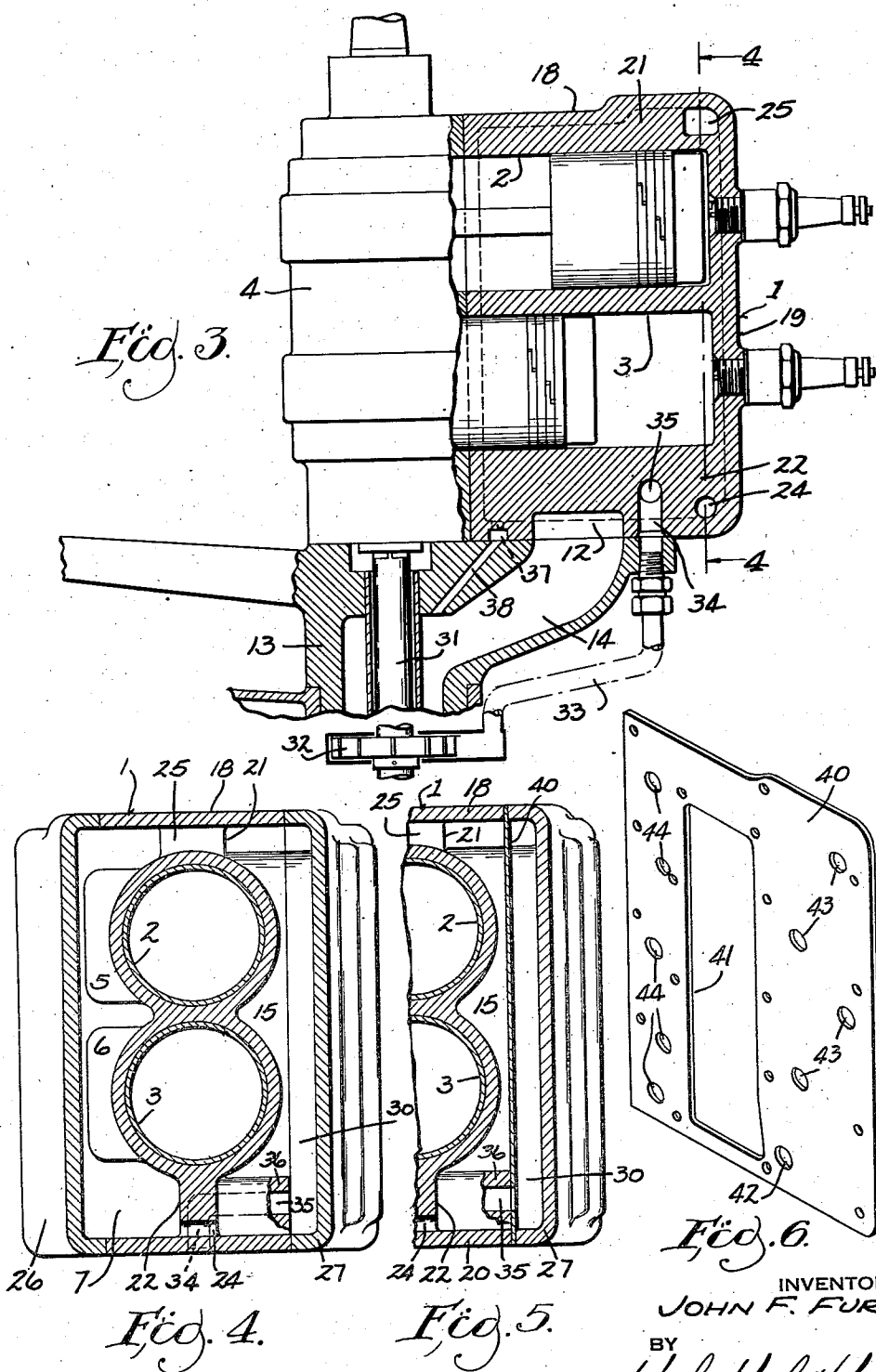
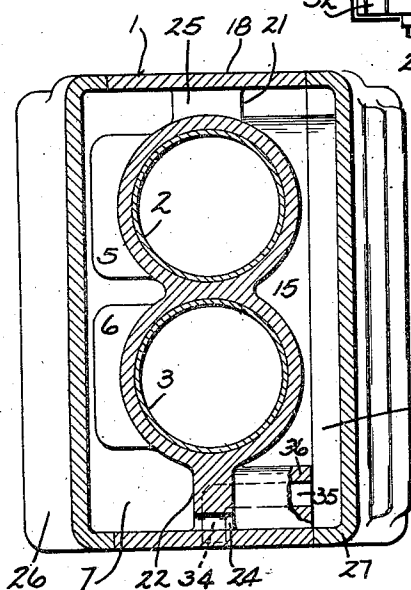
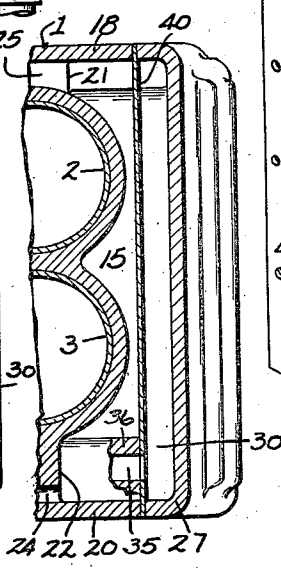
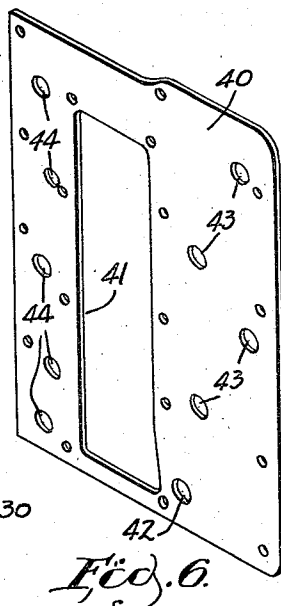
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2 Sheets-Sheet 2



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ENGINE AND ENGINE COOLING METHOD

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19 Claims. (Cl. 123—173)

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This invention relates to improvements in engines and engine cooling methods.

The invention has particularly reference to a two-cycle engine with vertical drive shaft adapted for outboard motor use. It is a primary object of the invention to provide improved control of the cooling water in order to establish temperature differentials between various parts of the cylinder block in accordance with the varied requirements of different parts of the engine.

More specifically, it is my purpose to provide an internal combustion engine cylinder block, in which a combination of forced circulation and gravity circulation will properly cool different parts of the engine cylinders and exhaust to their respective required temperatures, regardless of the speed of operation of the engine and the pump which supplies its cooling water. Outboard motors in particular have to be adapted for a wide variation in the rate of water circulation due to the fact that these motors are sometimes run at top speed and at other times are idled over long periods. The pump is ordinarily driven from the crank shaft or propeller shaft at a rate proportioned to the rate of engine operation. In order to provide adequate cooling water during idling speeds of the engine, it is frequently necessary to provide an excess of cooling water at full engine speeds. There are some parts of the cylinder block to which the resulting excessive cooling is immaterial. Other parts of the engine cylinder block should be operated within a comparatively narrow range of temperatures. As will hereinafter be explained, I meet these requirements by a combination of forced circulation and gravity circulation, the latter being localized in the cylinder block.

It is a further object of the invention to achieve the foregoing objectives, while providing an engine cylinder block of smooth external outline and simplified design.

Still other objects will be apparent to those skilled in the art upon examination of the following disclosure of the invention.

In the drawings:

Fig. 1 is a view in perspective of the cylinder block casting with one of its removable face plates shown in a detached relationship, portions of the main casting being broken away to expose its interior construction.

Fig. 2 is a view in perspective showing the cylinder block casting with the other of its removable face plates shown in detached relationship.

Fig. 3 is a view partially in elevation and par-

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tially in longitudinal section through the cylinder block.

Fig. 4 is a detail view taken in cross section on the line 4—4 of Fig. 3.

Fig. 5 is a fragmentary view, similar to Fig. 4, showing a slightly modified construction.

Fig. 6 is a view in perspective showing the partition plate used in the embodiment shown in Fig. 5.

The cylinder block casting 1 includes cylinders 2 and 3 which, in accordance with conventional two-cycle engine practice, are supplied with combustible mixture from the crank case 4 through transfer manifolds 5 and 6 (Fig. 2). Surrounding the transfer manifolds 5 and 6 and the adjacent sides of cylinders 2 and 3, the block 1 provides a large cavity at 7 for cooling water.

At the opposite side of the block, the cylinders 2 and 3 have exhaust ports 8, 9, opening into a chamber 10 (Fig. 1) formed by an integral web 11. The chamber 10 opens downwardly at 12 and, when the engine is assembled on the shaft housing 13, the opening 12 communicates with the exhaust passage 14 which is provided in the shaft housing.

Surrounding the web and separated thereby from the exhaust manifold chamber 10 is a cavity 15 for cooling water, the sides of cylinders 2 and 3 on the exhaust side of the block being exposed in cavity 15.

Cast integrally with the cylinders 2 and 3 and the web is a jacket shell 16 finished at 17 to abut the crank case and having a top portion 18, an end portion 19 and a bottom portion 20. The inner or crank case end 17 of the shell is materially wider than its outer end 19, the shell being wedge-shaped in plane, as clearly appears in Figs. 1 and 2.

A partition web 21 connects the top 18 of the shell with cylinder 2. A similar web at 22 connects the bottom of the shell with the under surface of the cylinder 3. Each of the partition webs 21 and 22 extends longitudinally of the block in a central plane. Restricted communication between the cooling water cavity 15 at the exhaust side of the engine and the cooling cavity 7 at the intake side of the engine is provided by a bottom port 24 and a top port 25.

The cavity 7 is sealed by a removable closure 26 shown in perspective detail in Fig. 2. The cavity 15 is sealed by the removable closure 27 shown in perspective detail in Fig. 1. The closure 27 preferably has a web 28 which registers throughout with the web 11 to provide at 29 a cavity which serves to enlarge the capacity of

the exhaust chamber or manifold 10. Surrounding the web 28 is a water circulation cavity 30, which enlarges the capacity of the water circulation cavity 15. Due to the wedge-shape of the casting 1, the two closures 26 and 27 are convergent away from the crank case 4.

The outboard motor drive shaft 31 operates a pump of any desired type which is here illustrated, purely diagrammatically, as a centrifugal pump at 32, having a pressure pipe 33, communicating with duct 34 in the engine block casting 1. The duct 34 leads upwardly in partition 22 to a transverse bore at 35 which is preferably extended through an integral boss 36 to open into the cavity 30 within the closure 27. Since cavity 30 ordinarily communicates throughout its extent with cavity 15, the boss 36 may ordinarily be omitted if desired. It is useful primarily in connection with the modified embodiment shown in Figs. 5 and 6 hereinafter to be described.

The cooling water thus supplied under pressure from pump 32 passes upwardly through those portions of cavities 15 and 30 which are outside of the registering webs 11 and 28 and thence across above the tops of webs 11 and 28 into those portions of cavities 15 and 30 which lie near the crank case. The water will flow downwardly through these portions of the cavities to an outlet 37 communicating with a duct 38 in the lower unit, whereby the water is delivered into the exhaust manifold 14.

At the exhaust side of the engine it would be difficult to get excessive cooling. Most of the heat required to be removed during engine operation is developed at the exhaust side of the engine and even if all such heat could be removed, the resulting coolness of the engine at the exhaust side would not seriously impair combustion.

At the intake side of the engine, the requirements are different, since excessive cooling of the mixture supplied from the crank case 4 through the transfer manifolds 5 and 6 would impair combustion. On the other hand, excessive heating of the mixture in the transfer manifolds 5 and 6 would also impair combustion. Consequently, fairly close regulation of the temperatures on the intake side of the engine cylinders is required.

I have found that such regulation can be achieved within the necessary limits entirely automatically by gravity circulation of cooling water between the cavity 15 on the exhaust side and the cavity 7 on the intake side of the engine. Some of the cooling water arriving through the ducts 34, 35, will flow through the orifice 24 in the lower partition 22 into cavity 7, displacing the water heated in cavity 7 to cause the hottest part of such water at the top of the cavity to escape through the orifice 25 back into the pressure circulated water in cavity 15. The warmer the water becomes in cavity 7, the more rapid will be its gravity circulation and the convection current thus established will tend to regulate the temperature in cavity 7 automatically, and entirely irrespective of the rate of circulation through the cavity 15, so long as the latter is adequate. In other words, all that is necessary is to maintain an excess of circulation of cooling water through cavity 15 to insure that there will always be ample coolant in that cavity. Thereupon, the convection currents will automatically insure proper temperatures at the intake side of the motor.

In actual practice, a still further segregation of temperatures may be desirable. While it is broadly true, as indicated above, that one cannot well cool the exhaust side of the engine excessively, the actual fact is that the temperature of the exhaust side of the engine should not be allowed to be reduced too low. In other words, the temperature is not nearly as critical on the exhaust side as on the intake side, but cooling can be overdone.

Where overcooling of the exhaust side is threatened, I may incorporate between the cylinder block casting 1 and the closure 27 a partition plate 40, which may be made of sheet metal, as indicated in Fig. 6, and inserted as a lamination between castings 1 and 27. The plate 40 has an opening 41 preferably registering with the exhaust manifold cavities 10 and 29 to afford full communication therebetween. The plate 40 has another opening at 42 registering with the duct 35 through which cooling water is supplied under pressure. The openings 43 and 44 are located at any levels where they are found desirable to direct the circulation between cavity 30 and cavity 15, these cavities now being partially separated from each other by the partition plate 40.

Where the modified embodiment shown in Figs. 5 and 6 is employed, the pressure circulation will be confined to cavities 30 and 15, originating in the former. The circulation between cavity 15 and cavity 7 will be more restricted by the fact that only two ports are provided at 24 and 25 between these cavities. With this arrangement, a very precise control of temperatures under all operating conditions may be achieved. Obviously, the number of vertical, longitudinal partitions may be multiplied to any extent desired to provide additional control. However, I have found the control afforded by the structures herein disclosed to be completely adequate for all practical purposes, it being understood, of course, that, according to variations in engine power and design, the size, number and dispositions of ports through which the convection circulation may occur will be changed as required.

It will be noted that all of the circulation is achieved and controlled within the cylinder block and its closures so that the external design is smooth and free of piping. The wedge shape provides an excess of cooling water at the crank case end of the block, thereby keeping the crank case cool as is desirable.

In all of the constructions herein disclosed, the controlling of the temperature at the intake, to prevent the intake from becoming overcooled, is also a matter of the greatest importance from the standpoint of controlling crank case temperature in a two-cycle engine. If the mixture in the crank case is unduly cooled, it condenses; if unduly hot, it expands too much with consequent loss of power. The control made possible by the present invention enables the regulation not only of the temperature in the cylinder block itself, but also the regulation of crank case temperatures, these latter being predetermined almost entirely by the extent to which heat developed in the cylinders is permitted to escape to the crank case.

In all embodiments of the invention it is preferred that all cavities of the water jacket's face be self-draining. This is particularly important in outboard motors and other engines which are exposed to sub-freezing temperatures. In the devices herein disclosed, the port 24 is located at the bottom of cavity 7, and the ports 35 and

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37 are located at or so close to the bottom of cavity 15 as to preclude any possibility of ice damage. Thus, whenever an outboard motor equipped with an engine cylinder block embodying this invention is not in use, its entire cooling system will be drained substantially completely.

While my improved method of cooling is believed to have been fully described in connection with the apparatus, it may be summarized by stating that I deliver coolant under pressure to the exhaust side of the cylinder block and divert a portion of the coolant to flow by gravity as a convection current for cooling the intake side of the cylinder block. As above described, I may subdivide the current into as many separate streams as may be desired, any number of which may be circulated under pressure, and any number of which may be circulated by convection, according to the cooling effect desired. It is important, however, that the convection currents are, in each instance, diverted from the pressure circulated currents so that no separate source is required.

I claim:

1. In an engine, the combination with an engine cylinder, of jacket means partitioned vertically into a plurality of compartments, said jacket means being ported to afford restricted communication between compartments at upper and lower levels, means for introducing coolant into one of said compartments and discharging coolant therefrom, at least one other compartment receiving coolant at least partially by convection.

2. The device of claim 1, in which the cylinder has intake and exhaust sides, and the partition means extends longitudinally of the cylinder between said sides, the compartment receiving coolant by convection being located at the intake side of the cylinder.

3. A cylinder block comprising at least one cylinder having an inlet side and an exhaust side, and a jacket providing cavities at the inlet and exhaust sides of said cylinder, said jacket being connected with the cylinder longitudinally thereof whereby to partition from each other the respective cavities at the intake and exhaust sides of the cylinder, and means for circulating coolant through the cavity at the exhaust side of the cylinder, said block being provided with convection circulation means affording communication between said cavities at vertically spaced points whereby a thermal convection current will circulate through the cavity at the intake side of the cylinder, a portion of the coolant circulated through the cavity at the exhaust side.

4. In an internal combustion engine cylinder block comprising a horizontal cylinder having an intake side and an exhaust side and provided with jacket means affording cavities at the respective sides of the cylinder, partition means between the cylinder and the jacket means longitudinally of the cylinder at the top thereof and provided with a port affording restricted communication between the respective cavities, means affording restricted communication between said cavities below the cylinder, and means for circulating coolant through the cavity at the exhaust side of the cylinder whereby primarily to cool the exhaust side of the cylinder, while affording means for the establishment of a convection current diverting a portion of the coolant from the cavity at the exhaust side of the cylinder through the cavity at the intake side of the cylinder for the regulated cooling thereof.

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5. An engine cylinder block comprising a pair of superimposed horizontal cylinders having intake manifold means at one side and exhaust means at the other, together with jacket means enclosing the cylinders and providing cavities at the intake and exhaust sides of the cylinders, said jacket means being connected to the top of the upper cylinder and the bottom of the lower cylinder whereby to measurably partition said cavities from each other, said cavities having restricted communication above and below the cylinders, and means for the pressure circulation of coolant through one of said cavities, the other cavity being adapted to receive coolant through the restricted communication means aforesaid.

6. In an engine, the combination with horizontal cylinder means provided with intake manifold means at one side and with exhaust means at the other side, of jacket means providing cavities respectively disposed at the intake and exhaust sides of the cylinder means, said jacket means being connected with the cylinder means longitudinally thereof above and below the cylinder means whereby substantially to partition the respective cavities from each other, the connection between the jacket means and the cylinder means providing upper and lower ports affording restricted communication between the respective cavities, means for supplying coolant under pressure to the cavity at the exhaust side of the cylinder means and for discharging such coolant from said last mentioned cavity, the cavity at the intake side of the cylinder means receiving coolant by convection circulation from the cavity to which coolant is supplied under pressure.

7. In an engine, the combination with a plurality of horizontal cylinders having intake manifold means at one side and exhaust means at the other, of a jacket faced to provide a crank case connection for said cylinders and extending above said cylinders and across their ends and beneath said cylinders back to said connection, partition webs connecting the jacket with the top of the upper cylinder and with the bottom of the lower cylinder, said partition webs being ported above and below the cylinders to afford restricted communication between jacket cavities at opposite sides thereof, a removable closure for a jacket cavity at the intake side of the cylinders, said closure embracing said manifolds, a jacket closure for the cavity at the exhaust side of said cylinders, and means for supplying coolant to the last mentioned cavity and discharging coolant therefrom.

8. The device of claim 7, in which said jacket is wedge shaped and the respective closures are convergent away from the crank case end of the jacket, whereby to afford additional cavity space at the crank case ends of said cylinders.

9. The device of claim 7, in which a web integral with the jacket encircles the exhaust means and partially subdivides the exhaust cavity, the closure for the jacket cavity having means engaging said web and constituting a closure therefor.

10. In an engine, the combination with a cylinder block unitarily providing at least one horizontal cylinder having an intake manifold and an exhaust port, and a web surrounding said port to provide an exhaust manifold, and a jacket extending above and below said cylinder and across the end thereof and to which said web is integrally connected, said jacket providing a cooling cavity at the intake side of the cylinder and a

cooling cavity at the exhaust side thereof, and said block being provided with ports affording limited communication between cavities above and below said cylinder, of closures removably connected with the jacket portions of said block to close the respective cavities, the closure connected with the block to seal the cavity at the exhaust side of the cylinder being provided with means engaging said web to constitute therewith an exhaust manifold about which said last mentioned cavity extends, and means for supplying and discharging coolant to and from the last mentioned cavity, the cavity at the intake side of the cylinder receiving coolant in restricted volume by convection currents through the upper and lower portions aforesaid.

11. The structure defined in claim 10, wherein the means for supplying and discharging coolant comprises bores in said block at opposite sides of said manifold.

12. The device of claim 10, in which the closure for the cavity at the exhaust side of the cylinder has a peripheral flange, and an inwardly spaced web complementary to the web of said block whereby to increase the capacity of said manifold and the capacity of said last mentioned cavity.

13. In an engine, the combination with cylinder means, of jacket means provided with a vertical partition extending longitudinally of the cylinder means, said jacket means providing cavities at opposite sides of the cylinder means, and the cylinder means having intake means extending through one of said cavities and exhaust means extending through the other, removable closures for the respective cavities in operative connection with said jacket means, the closure for the cavity through which the exhaust means extends being provided with a registering closure cavity, a partition plate between the closure cavity and the jacket cavity through which the exhaust means extends, said plate being ported to afford restricted communication between the closure cavity and the cavity last mentioned, and means for introducing coolant into the closure cavity and discharging coolant from one of the two cavities last mentioned, a portion of such coolant being diverted by convection through the cavity through which the intake means extends.

14. A method of controlling the intake temperature of a water cooled internal combustion engine cylinder having an intake side and an exhaust side, which method consists in the forced circulation of coolant about the exhaust side of said cylinder and the convection circulation of coolant about the intake side of said cylinder.

15. The method of controlling the intake temperatures of an internal combustion engine cylinder having an intake side and an exhaust

side, said method comprising circulating coolant under pressure about the exhaust side of said cylinder, diverting a portion of said coolant for the intake side of said cylinder and circulating the diverted portion of said coolant by convection, whereby an increase in temperature in the intake side of said cylinder will accelerate the flow of the diverted coolant.

16. A method of controlling the temperature of different portions of an internal combustion engine cylinder, which method consists in supplying coolant under pressure, diverting portions of said coolant and circulating said portions by pressure and gravity respectively about specific portions of said cylinder.

17. In an engine, the combination of a block providing a horizontal cylinder and jacket means for such cylinder partitioned vertically into a plurality of compartments, said block and jacket means being ported to afford restricted communication between such compartments above and below said cylinder, a coolant circulation inlet and a coolant circulation outlet for said cylinder jacket both connected to the same compartment, at least one other compartment receiving coolant through said ports by convection circulation from the coolant in the compartment with which such inlet and outlet communicate.

18. In an engine, the combination with an engine cylinder arranged to be disposed horizontally in operation and having an inlet port on one side and an exhaust port on the other, of jacket means enclosing said cylinder and partitioned vertically into a plurality of compartments, one of which is on the inlet port side and the other on the outlet port side of said cylinder, said jacket means being ported both above and below the cylinder to afford restricted communication between the compartments at upper and lower levels on the opposite sides of the cylinder, means for introducing coolant into the compartment on the exhaust port side of the cylinder and for discharging such coolant therefrom, the compartment on the inlet port side of the cylinder receiving coolant diverted from the coolant in the exhaust port compartment at least partially by convection.

19. A method of controlling the intake temperature of a water cooled internal combustion cylinder having an inlet side jacket compartment and an exhaust side jacket compartment, which method consists in mechanically circulating coolant through the exhaust side jacket compartment and diverting a limited quantity of coolant from the exhaust side jacket compartment and circulating the diverted quantity of coolant by convection about the intake side jacket compartment.

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