April 27, 1937. F. LJUNGSTRÖM 2,078,499

COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINES

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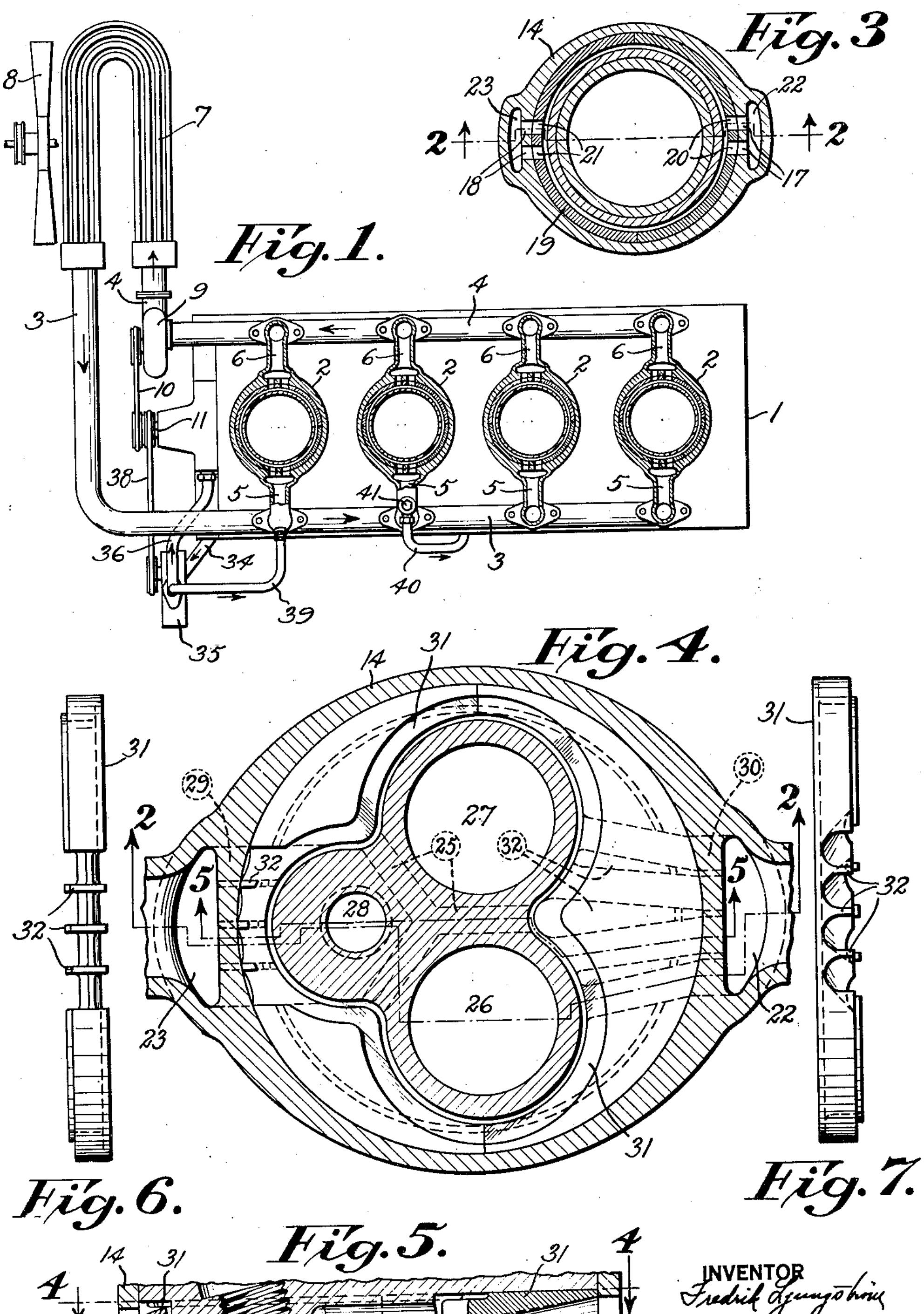

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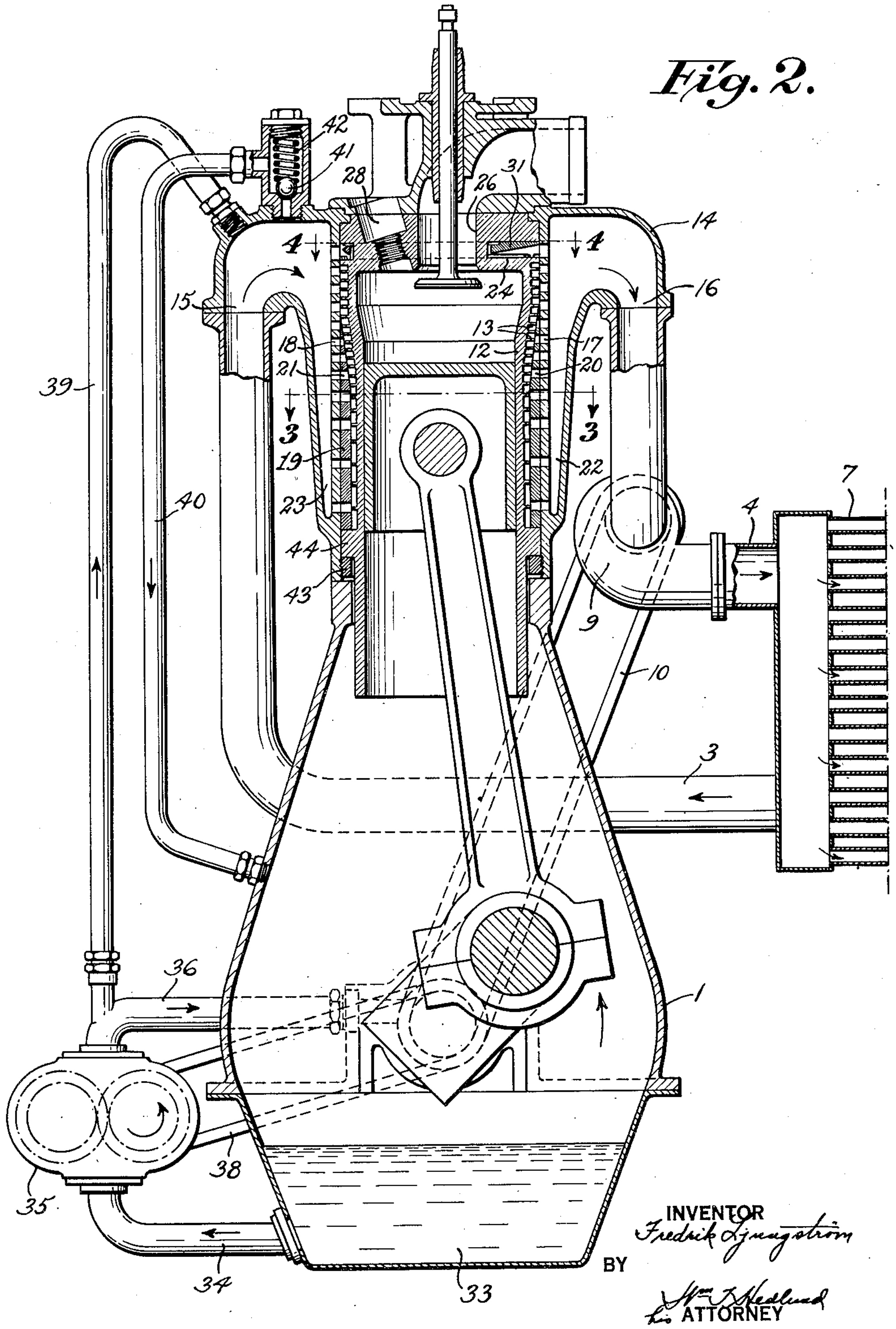
Fig. 2.



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COOLING SYSTEM FOR INTERNAL COMBUSTION ENGINES

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In Sweden September 1, 1928

27 Claims. (Cl. 123—170)

This application is a continuation in part with respect to my copending application Serial No. 388,894, filed August 28, 1929, and is to be considered as relating back so far as subject matter herein continued for all dates and rights incident to the filing of said application.

The present invention relates to internal combustion engines, and particularly to cooling systems therefor in which a fluid cooling agent is circulated through a closed path of flow over the parts of the engine requiring cooling.

In one aspect my invention has for its general purpose the improvement of the method of cooling engine cylinders by the provision of improved means for distribution of the cooling fluid, and in another aspect the purpose of the invention is to provide improved cooling by the utilization in the cooling system of oil such as is used for purposes of lubricating the engine.

The more specific nature and advantages of the invention, together with the more detailed objects thereof, may best be understood from the following description of a preferred form of apparatus for carrying the invention into effect, which is illustrated in the accompanying drawings forming a part of this specification.

In the drawings:

Fig. 1 is a diagrammatic plan view, partly in section, of an engine embodying the invention;

Fig. 2 is a diagrammatic transverse section of the crank-case and one of the cylinders of the engine shown in Fig. 1 and includes a diagrammatic showing of the piping of the cooling system;

Fig. 3 is a section taken on the line 3—3 of Fig. 2;

Fig. 4 is a section taken on the line 4—4 of Fig. 2; and,

Figs. 5 to 7 inclusive show details of the structure illustrated in Fig. 4.

Turning now to Figs. 1 and 2 of the drawings, numeral 1 represents the crankcase of the engine, and the several cylinders of the engine are indicated generally at 2. A multi-cylinder engine is illustrated, but it is to be understood that the invention is equally applicable to single cylinder engines.

The cooling system for the cylinders comprises an inlet manifold 3 and an outlet manifold 4, the former delivering cooling fluid to the cylinders through branch pipes 5, and the latter collecting fluid from the cylinders through branch pipes 6. Manifold 4 delivers fluid to a radiator or cooler 7, which may be of any suitable form adapted to dissipate heat to the atmosphere. Cooling is preferably accelerated by means of the usual engine-driven fan shown at 8. The cooled fluid is withdrawn from the radiator through manifold 3, and pump 9, of the centrifugal or other non-positive delivery type, serves to provide circulation of the cooling fluid. This pump may advantageously be driven by means of belt 10 from the forward end of the engine crank shaft 11. The construction and arrangement of the radiator and fan for effecting cooling of the oil in the cooling system has been shown diagrammatically in Fig. 1 and forms per se no part of the present invention and is not claimed herein. Reference may be had to my copending application, Serial No. 661,251 filed March 17, 1933, in which application the subject matter relating to radiator and fan construction is disclosed and claimed, for description of preferred forms of this portion of an oil cooling system.

The cylinder comprises an integral inner cylindrical member 12 having a head and a barrel portion, the latter being provided with a plurality of circumferential flanges 13, these flanges being of different thicknesses and widths at different parts of the barrel. By reference to Fig. 2 it will be seen that the flanges are relatively thin and are closely spaced adjacent to the upper part or combustion chamber end of the cylinder where the amount of heat generated is greatest. Fitted over the inner cylinder member 12 is an outer cylinder casing or jacket 14 having oppositely disposed inlet and outlet connections 15 and 16 adapted to connect respectively with the inlet and outlet manifolds 3 and 4. The inner wall of jacket 14 is provided at one side with a series of openings or ports 17 and at the opposite side with a similar series of ports 18. These ports are spaced at different intervals along the vertical length of the cylinder. As will be noted from Fig. 2 the upper end of the inner cylinder member is tapered, and in order to provide ready assembly of the cylinder member and jacket a sleeve 19 is interposed between these two members. Sleeve 19 is provided with oppositely disposed ports 20 and 21, arranged in series and registering respectively with ports 17 and 18. These ports are also disposed so that they provide communication between the channels 22 and 23 in jacket 14 and the circumferential cooling channels around the cylinder formed between the flanges 13.

In the specific embodiment shown, the ports are disposed so that each port communicates with two adjacent cooling channels in the cylinder, but obviously this arrangement is subject to alteration.

The head of the cylinder member 12 is deeply grooved as at 24 (see also Fig. 5), directly above the top of the combustion chamber, and channels 25 are also provided through the center of the cylinder head between the valve openings 26 and 27 and the spark plug opening 28. The groove and channels provide a path for flow of cooling fluid across the cylinder head and around the valves from a series of inlet ports 29 to a series of outlet ports 30, these ports being formed in the inner wall of jacket 14 and communicating with channels 22 and 23.

In order to direct the flow of cooling fluid in the most efficient manner against the wall forming the head of the combustion chamber, an insert 31 is provided, said insert preferably having thereon a plurality of fins 32 for guiding flow of fluid across the cylinder head.

It will be seen that the cooling system is in the form of a closed circuit, in which the cooling fluid is circulated and re-circulated, with the several cylinders arranged in parallel and with the flow of cooling fluid past each cylinder subdivided into a number of relatively small streams arranged for parallel flow.

The lubricating system comprises the usual crankcase reservoir or sump 33 from which oil is withdrawn through pipe 34 by pump 35, which is preferably of the positive displacement type, and has been illustrated as of the ordinary gear type. Oil under pressure is discharged through pipe 36 to the main bearings and other parts of the engine, and after lubricating these bearings and other parts, returns to the reservoir 33. The specific details of the oiling system are not a part of the present invention and may vary considerably with different types of engines. In all cases, however, it will be evident that this circulating lubricating system effects cooling of the moving parts of the engine as well as lubrication thereof, since heat generated in the bearings is carried away by the lubricating oil and is dissipated by radiation from the crankcase or other member forming the oil reservoir. If desired, a special cooler for the oil in the reservoir may be employed, although cooling of this oil is usually accomplished by providing extended cooling surface in the form of fins on the portion of the crankcase forming the oil reservoir.

Pump 35 is, in the arrangement illustrated, driven by belt 38 from the forward end of crank shaft 11, and in this connection it is to be noted that while pumps 9 and 35 have been illustrated in the present case as independent pumps of different types, a single compound pump may be used instead, in which case suitable provision should be made, so that the part of the pump circulating oil in the lubricating system provides positive circulation, while that part effecting circulation in the cooling system does not provide a positive delivery.

The discharge side of pump 35 is connected by way of pipe 39 with the cooling system. This connecting pipe may conveniently be led upwardly from the discharge pipe 36 so as to deliver into one of the jackets 14 as shown in Fig. 2.

Relief against excess pressure within the cooling system is provided by means of the connection comprising pipe 40, which may advantageously connect one of the jackets 14 with the crankcase or other container forming the oil reservoir. An excess pressure valve 41, preferably of the ball type, is provided in this connection, the ball valve being held to its seat by the pressure of spring 42, the latter preferably being arranged so that the tension thereof can be adjusted.

From the foregoing it will be seen that the above described arrangement provides two independent oil circulating systems, one system being primarily for cooling purposes and the other primarily for lubricating purposes, although it effects, in addition, a certain amount of cooling. These systems are entirely independent except for the connection formed by pipe 39, whereby any leakage from the cooling system is automatically compensated for by supplying oil thereto from the lubricating pump, and a connection formed by the excess pressure valve 41 and pipe 40 for returning excess oil from the cooling system to the lubricating system.

By reference to Fig. 2 it will be seen that the cylinder members and jackets of the several cylinder assemblies are held together by means of threaded rings 43 adapted to engage retaining flanges 44 on the cylinder members 12.

A form of construction such as that illustrated, in which packing means is not employed and in which the joints need not be fluid tight, is possible with the present form of cooling system, since the fluid used in the cooling system is the same as that used in the lubricating system, and leakage from one system to the other is of no consequence.

The operation of the above described apparatus is as follows:

Oil for lubricating purposes is taken from the reservoir 33 by pump 35 and delivered under pressure to the bearings of the engine, from which it returns to the reservoir. Assuming the cooling system to be filled with oil, the operation of pump 9 circulates this oil through the cooling system, where it is alternately cooled in the radiator 7 and heated by passage over the heat delivering parts of the cylinders. The cooling of the cylinders is especially effective for the following reasons: Due to the relative spacing and size of the channels around the cylinders formed by flanges 13 and of the ports through which fluid is supplied to these channels, a differential flow is effected as between the channels surrounding the different parts of the cylinders, so that the flow of cooling fluid has greater cooling effect for those portions of the cylinders which must dissipate the greatest amount of heat. This differential flow is caused by the difference in resistance to flow of fluid through the numerous channels arranged in parallel around the cylinders.

It will be seen that the path of flow around the valve ports and the head of the cylinders is much shorter and freer than the path around other parts of the cylinders, thus inducing flow of a relatively large volume of the cooling fluid at this point, where the greatest cooling effect is needed. Also the relatively close spacing of the cooling fins or ribs 13 at the upper end of the cylinders provides a larger area of cooling surface per unit of cylinder area at the combustion chamber end of the cylinder than at the lower end thereof.

An important advantage is secured by utilizing the lubricating oil as the cooling medium in a cooling system of the type herein disclosed, since there is a material change in the viscosity of the oil with variations in its temperature. Because of this characteristic of the viscosity of oil, the relative rates of flow through the several cooling channels around the cylinder will be automatically adjusted, since the hotter parts of the cylinder, which require the greatest amount of cooling, will bring the temperature of the oil around said parts to the highest temperature and therefore to the lowest viscosity, from which it follows that the oil supplied to these parts will flow with greater rapidity than the more viscous oil flowing through the channels around the cooler parts of the cylinder. This feature is of particular advantage in cold weather operation, and it is because of this characteristic of oil as a cooling medium that a non-positive circulating pump for the cooling system is preferred. With such a pump, circulation of the oil through the cooling system may commence very slowly when the engine is started cold and the oil in the cooling system is relatively heavy and viscous. As the engine warms up the oil in the cooling system will automatically be rendered less viscous by the heat absorbed, and circulation due to the action of the pump will be started and accelerated only when and as such circulation is needed. This feature of the operation of the present cooling system eliminates, to a large extent, the necessity for providing any thermostatically operated device for controlling the rate of circulation within the cooling system.

A further advantage of the present arrangement is that, due to the fact that a small amount of leakage between the cooling and lubricating systems is permissible, each cylinder assembly may be made up of a number of parts which can be readily disassembled for purposes of cleaning the passages for cooling fluid, and thus maintaining the best efficiency of the cooling system. Furthermore, the present arrangement provides a system which requires substantially no care or attention from the operator, since the cooling system is maintained full of cooling fluid at all times from the reservoir of lubricating oil, and the importance of keeping this latter reservoir supplied with oil is so well known that it is seldom, if ever, neglected.

The valve **41** in the overflow connection **40** provides means for maintaining the cooling system under a pressure above atmospheric, which condition may be desirable under certain temperature conditions and in conjunction with the use of some cooling fluids, in order to prevent the formation of vapor pockets within the system or the possibility of failure to supply fluid to the suction side of pump **9**.

This valve, which can be unseated, further provides the necessary overflow from the cooling system, which is required due to expansion of the oil as the temperature of the system rises. Still another advantage of the apparatus disclosed lies in the fact that the two oil circulating systems can and do operate at different temperatures. In order to maintain the most efficient lubrication the oil in the lubricating system should be held at a relatively low temperature as compared with the temperature existing in the cooling system, the latter, under normal operating conditions, being maintained at a relatively high temperature in order to secure the efficiency of operation which accompanies high cylinder temperatures.

The invention is not to be considered as limited in its application to the form of apparatus herein disclosed, but is to be understood as embracing all such changes and modifications as may fall within the scope of the appended claims.

What I claim is:

1. In an internal combustion engine, means providing a plurality of separate circuits for flow of oil including a circuit for cooling stationary parts of the engine and a circuit for lubricating the working parts of the engine, means for circulating oil in the cooling circuit, means for circulating oil in the lubricating circuit at a pressure above that in the cooling circuit, and means for supplying oil to the cooling circuit from the lubricating circuit.

2. In an internal combustion engine, means providing a closed circuit for flow of oil to cool stationary parts of the engine, means providing a separate circuit for flow of oil under pressure to lubricate the working parts of the engine, and means for transmitting pressure from the lubricating circuit to the cooling circuit to maintain oil in the latter circuit under pressure.

3. In an internal combustion engine, means providing a closed circuit for flow of oil to cool stationary parts of the engine, means including an oil pump providing a separate circuit for flow of oil under pressure to lubricate the working parts of the engine, and means connecting said circuits in parallel, said means comprising a connection for supplying oil under pressure from the lubricating circuit to the cooling circuit and a relief connection for returning excess oil from the cooling circuit to the lubricating circuit on the suction side of said pump.

4. In an internal combustion engine having a cylinder, an oil cooling system for the cylinder comprising a closed circuit for circulation of oil over the cylinder, means for causing a different rate of flow of oil over different parts of the cylinder comprising a plurality of separate channels of fixed cross-sectional area and of different flow resistance in said circuit and in heat exchange relation with the cylinder, said channels being arranged for flow of oil in parallel therethrough, and means for circulating oil through said system.

5. An oil cooling system for internal combustion engines comprising conduit means forming a closed path for circulation of oil through the system, said means including a plurality of channels of fixed cross-sectional area arranged for flow of the oil in parallel in heat absorbing relation with the heat delivering parts of the engine, said channels offering different resistances to flow therethrough, and means for maintaining the oil under pressure in said closed path.

6. A cooling system for an internal combustion engine cylinder comprising conduit means forming a closed path for circulation of a cooling agent through the system, said means including a plurality of channels arranged in parallel and with the walls of the channels in heat conducting relation with said cylinder, and means for causing flow of a cooling agent through said system, said channels having different resistances to flow therethrough and the number of channels per unit area of the cylinder increasing toward the combustion chamber end of the cylinder.

7. In an internal combustion engine having a cylinder member, means forming a plurality of circumferential channels around said cylinder member for flow of cooling fluid, said channels being of different widths axially of the cylinder with the channels of lesser width located toward the combustion chamber end of the cylinder, means forming ports for introducing cooling fluid to and withdrawing it from said channels at peripherally spaced points on the cylinder and in parallel flowing streams, and conduits for conducting said fluid to and from said ports.

8. In an oil cooling system for an internal combustion engine cylinder having a barrel portion and a head, a plurality of channels for cooling oil extending circumferentially of the barrel portion and a separate channel for cooling oil in said head, said last named channel being arranged in parallel with said first named channels and formed to cause flow of cooling oil at high velocity in a thin film-like layer over said head, and means for circulating cooling oil through said channels.

9. In an internal combustion engine, a cylinder member comprising a barrel portion and a head, said head having valve openings therein, said member having a plurality of channels for flow of cooling fluid around the barrel portion and a channel for cooling fluid in said head, said last named channel being formed to cause flow of cooling fluid in a thin stream around said valve openings, and a cylinder jacket having ports therein for delivering separate streams of cooling fluid to the several channels.

10. In an internal combustion engine having a plurality of cylinders, an oil cooling system comprising means providing a circuit for flow of cooling oil over the cylinders, said means including conduits dividing a part of said circuit into a plurality of paths of flow of fixed cross-sectional area arranged in parallel, each of said paths of flow conducting cooling oil over a different cylinder and each of said paths of flow being arranged to conduct oil at different velocities over different portions of the same cylinder.

11. In an internal combustion engine having a plurality of cylinders, an oil cooling system comprising means providing a circuit for flow of cooling oil over the cylinders, said means including conduits dividing a part of said circuit into a plurality of paths of flow of fixed cross-sectional area arranged in parallel, each of said paths of flow conducting cooling oil over a different cylinder and each of said paths being arranged to cause oil to flow over different parts of the same cylinder at velocities dependent upon the rates of cooling required by the different parts of the same cylinder.

12. In an internal combustion engine having a cylinder, an oil cooling system comprising an inner cylinder member exposed to the heat of combustion gases, an outer cylinder casing separate from said inner cylinder member, a separate sleeve member around the inner cylinder member and between the inner cylinder member and the outer cylinder casing, said inner cylinder member and said sleeve providing between them inner space for flow of cooling oil over the inner cylinder member and there being outer space for cooling oil in said outer casing outside of said sleeve, and connections for supplying cooling oil to and withdrawing cooling oil from said outer space, said spaces being in communication to permit oil to flow from the inlet portion of the outer space through the inner space to the outlet portion of the outer space.

13. In an internal combustion engine having a cylinder, an oil cooling system comprising an inner cylinder member exposed to the heat of combustion gases, an outer cylinder casing separate from said inner cylinder member, a separate sleeve member around the inner cylinder member and between the inner cylinder member and the outer cylinder casing, said inner cylinder member and said sleeve providing between them inner space for flow of cooling oil over the inner cylinder member and there being outer space for cooling oil in said outer casing outside of said sleeve, and connections for supplying cooling oil to said outer space at one side of the cylinder and for withdrawing cooling oil from the outer space at the opposite side of the cylinder, said sleeve having a plurality of ports at opposite sides thereof for placing the inner and outer spaces in communication with each other on opposite sides of the cylinder.

14. In an internal combustion engine having a plurality of cylinders and a pressure lubricating system, a cooling system comprising means providing a closed circuit for flow of cooling oil over the cylinders, said means including conduits dividing a part of said circuit into a plurality of paths of flow arranged in parallel, each of said paths of flow being subdivided into a plurality of channels arranged for flow in parallel of cooling oil over a cylinder, means for circulating oil through said closed circuit and means providing a connection between the lubricating system and the cooling system to maintain the pressure therein above that required to effect circulation.

15. In an internal combustion engine having a plurality of cylinders and a pressure lubricating system, a cooling system comprising means providing a closed circuit for flow of cooling oil over the cylinders, said means including conduits dividing a part of said circuit into a plurality of paths of flow arranged in parallel, each of said paths being subdivided into a plurality of channels arranged for flow in parallel of cooling oil over a cylinder, a pump of the non-positive displacement type for circulating oil through said closed circuit, a connection placing said pressure lubricating system in communication with the cooling system whereby to maintain the cooling system under a pressure above that required to effect circulation, and a connection including a pressure relief valve for permitting return of excess oil from the cooling system to the lubricating system.

16. In an internal combustion engine having a plurality of cylinders and a pressure lubricating system, an oil cooling system comprising means providing a closed circuit for flow of oil over the cylinders, a part of said circuit being divided into a plurality of paths of flow arranged in parallel, each of said paths of flow conducting cooling oil over a different cylinder and each of said paths of flow being arranged to conduct oil at different velocities over different parts of the same cylinder, means for circulating oil in said cooling system, and means for supplying oil to said cooling system from said pressure lubricating system whereby to maintain the oil in the cooling system at a pressure above that required for circulation.

17. In an internal combustion engine having a plurality of cylinders and a pressure lubricating system, an oil cooling system comprising means providing a closed circuit for flow of cooling oil over the cylinders, a part of said circuit being divided into a plurality of paths of flow arranged in parallel, each of said paths of flow conducting cooling oil over a different cylinder and each of said paths being arranged to cause oil to flow over different parts of the same cylinder at velocities dependent upon the rates of cooling required by the different parts of the same cylinder, means for circulating oil in said cooling system, and means for supplying oil to

said cooling system from said pressure lubricating system whereby to maintain the oil in the cooling system at a pressure above that required for circulation.

18. An oil cooling system for internal combustion engines comprising conduit means forming a closed path for circulation of oil through the system, said means including a plurality of channels of fixed cross-sectional area having inlet and outlet ports and arranged for flow of the oil in parallel in heat absorbing relation with the heat delivering parts of the engine, said means offering different resistances to flow therethrough of the oil per unit length of the cylinder, and means for causing circulation of oil through said system.

19. An oil cooling system for internal combustion engines comprising conduit means forming a closed path for circulation of oil through the system, said means including a plurality of channels having inlet and outlet ports and arranged for flow of the oil in parallel in heat absorbing relation with the heat delivering parts of the engine, said means offering different resistances to flow therethrough of the oil per unit length of the cylinder, and means for maintaining the oil under pressure in said closed path.

20. A cooling system for an internal combustion engine cylinder comprising conduit means forming a closed path for circulation of a cooling agent through the system, said means including a plurality of channels arranged in parallel and with the walls of said channels in heat conducting relation with said cylinder, and means for causing flow of a cooling agent through said system, some of said channels offering different resistances to flow therethrough than other of said channels and the number of channels per unit length of the cylinder increasing toward the combustion chamber end of the cylinder.

21. In an internal combustion engine having a cylinder, means forming a plurality of circumferential channels around the cylinder for flow of cooling fluid, said channels being of different widths axially of the cylinder with the channels of lesser width located toward the combustion chamber end of the cylinder, means forming ports for introducing cooling fluid to and withdrawing it from said channels at peripherally spaced points on the cylinder and in parallel flowing streams, and conduits for conducting said fluid to and from said ports.

22. An oil cooling system for an internal combustion engine having a plurality of cylinders comprising conduits for conducting oil to and from each of said cylinders separately and in parallel, and a plurality of channels around said cylinder for conducting the oil in parallel flowing streams over each of said cylinders, the channels around each cylinder having different resistances to flow therethrough, and means for circulating oil through said conduits and channels.

23. In a cooling system for an internal combustion engine cylinder having a barrel portion and a head, a plurality of channels for cooling fluid arranged circumferentially of the barrel portion and a separate channel for cooling fluid in said head, said last named channel being arranged in parallel with said first named channels and formed to cause flow of cooling fluid in a thin layer over said head, and means for circulating cooling fluid through said channels.

24. In an internal combustion engine, a cylinder comprising a barrel portion and a head, said head having valve openings therein, said cylinder having a plurality of channels for flow of cooling fluid around the barrel portion and a channel for cooling fluid in said head, said last named channel being formed to cause flow of cooling fluid in a thin stream around said valve openings, and a cylinder jacket having ports therein for delivering separate streams of cooling fluid to the several channels.

25. An oil cooling system for multi-cylinder internal combustion engines comprising means forming a closed path for circulation of oil through the system, said means comprising conduits for distributing supplies of oil separately and in parallel to separate cylinders and channel means associated with each cylinder for dividing the separate supply of oil delivered to each cylinder into a plurality of separate streams in parallel flow relation and in heat transfer relation with the heat delivering parts of the cylinder.

26. An oil cooling system for multi-cylinder internal combustion engines comprising means forming a closed path for circulation of oil through the system, said means comprising conduits for distributing supplies of cooling agent separately and in parallel to separate cylinders and channel means associated with each cylinder for dividing the separate supply of oil delivered to each cylinder into a plurality of separate streams in parallel flow relation and in heat transfer relation with the heat delivering parts of the cylinder, said last named means being proportioned so as to provide greater flow of oil per unit length of cylinder at the combustion chamber end of the cylinder than at the opposite end of the cylinder.

27. In an internal combustion engine, means including an oil pump providing a first closed circuit for circulatory flow of oil to lubricate the working parts of the engine, means providing a second closed circuit for circulatory flow of a body of oil in a path of flow separate from said first circuit to cool stationary parts of the engine, and means connecting said first circuit on the pressure side of said pump with said second circuit for flow of oil from the first circuit to the second circuit to replace oil lost from the second circuit.

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