

May 27, 1941.

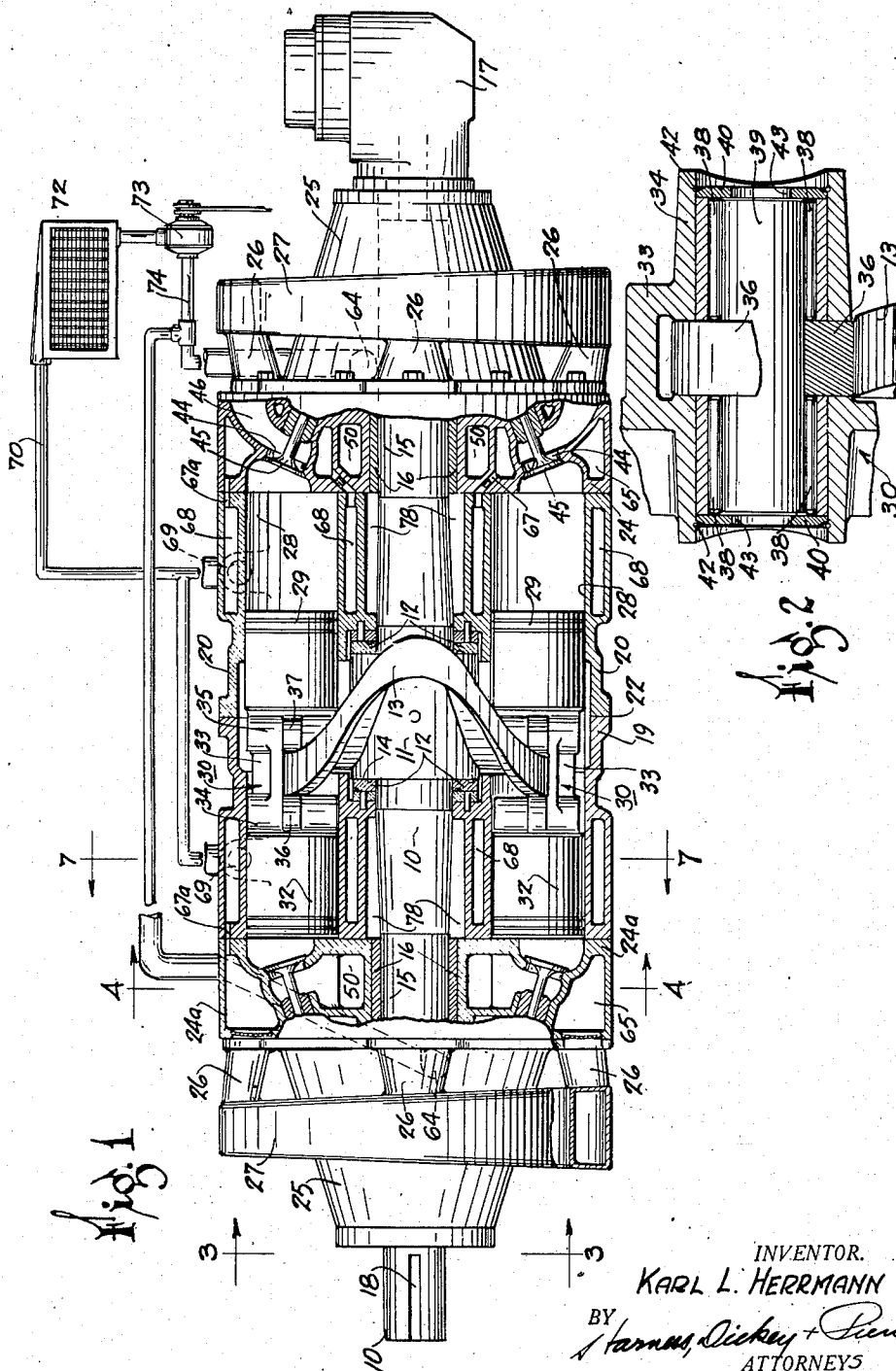
K. L. HERRMANN

2,243,818

INTERNAL COMBUSTION ENGINE

Original Filed May 14, 1937

5 Sheets-Sheet 1



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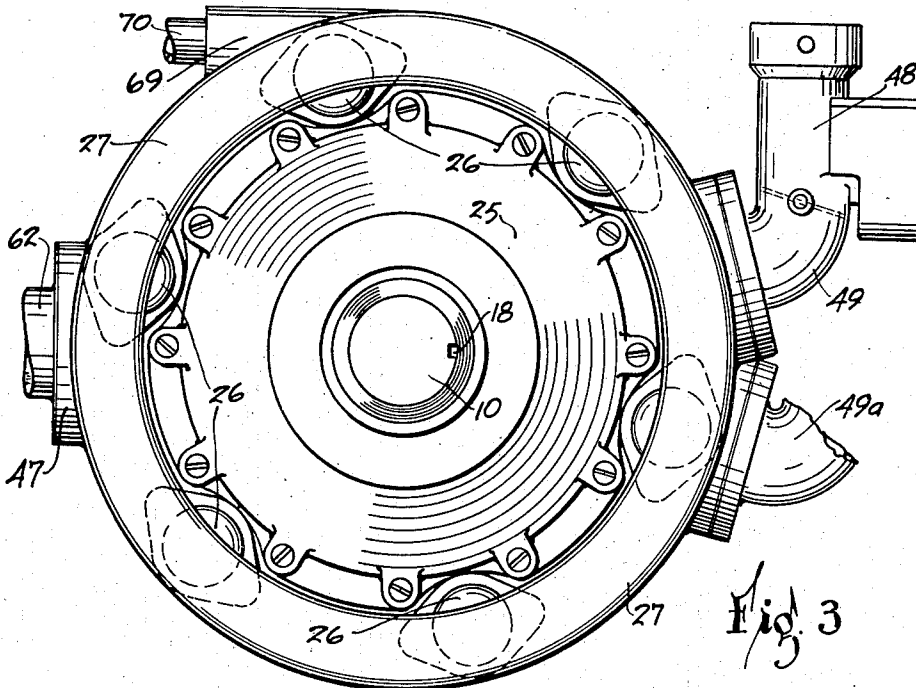
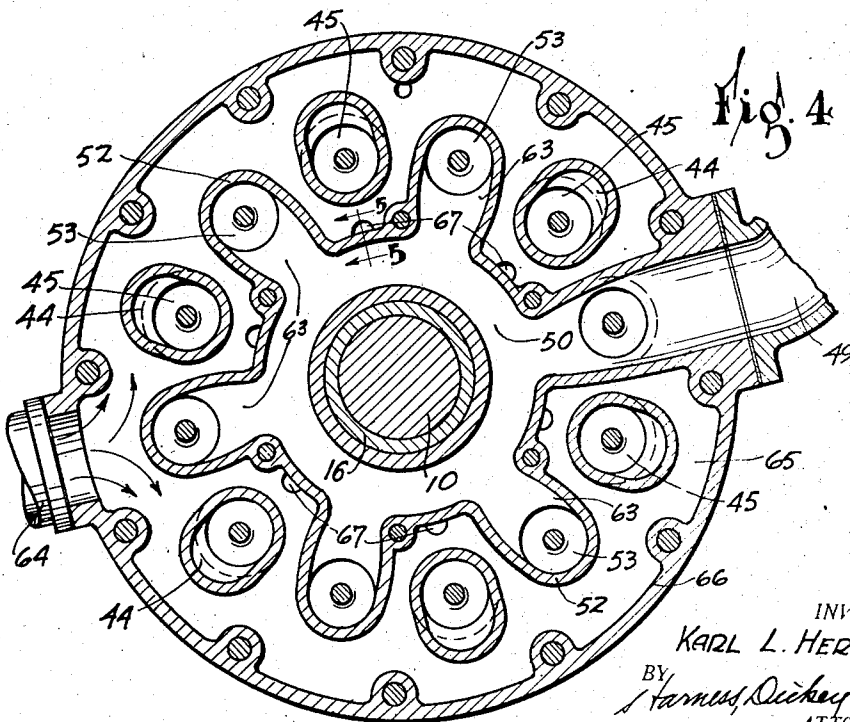
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INTERNAL COMBUSTION ENGINE

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5 Sheets-Sheet 2



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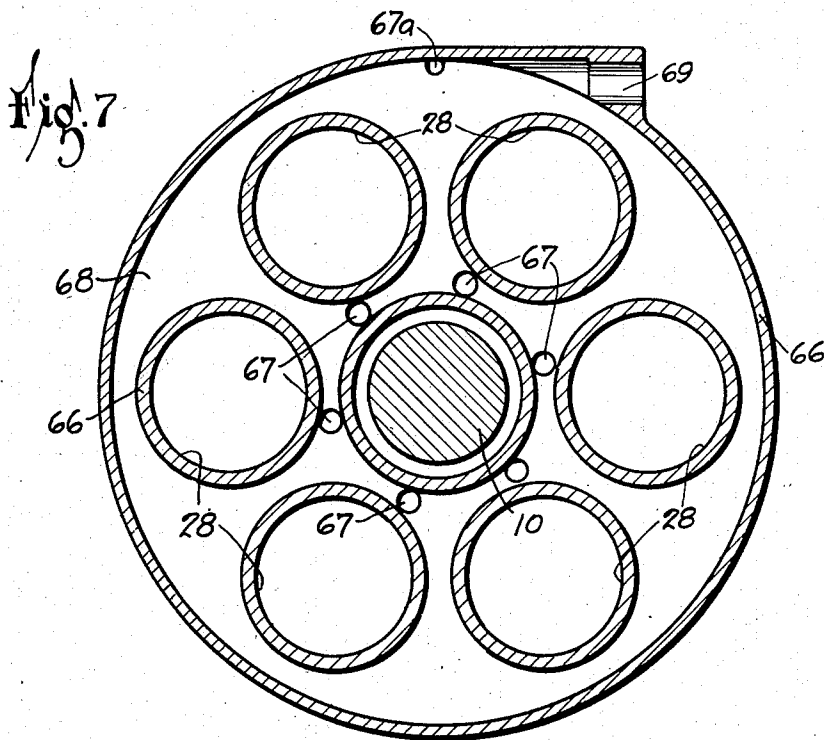
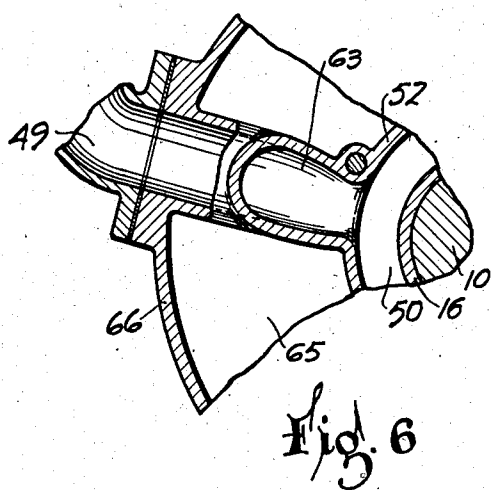
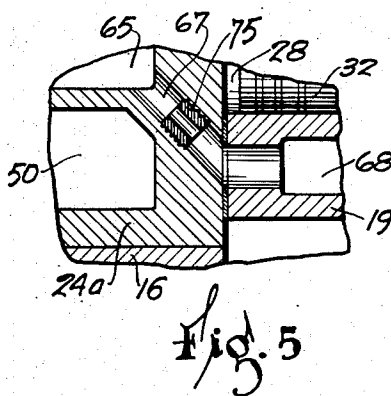
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INTERNAL COMBUSTION ENGINE

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5 Sheets-Sheet 3



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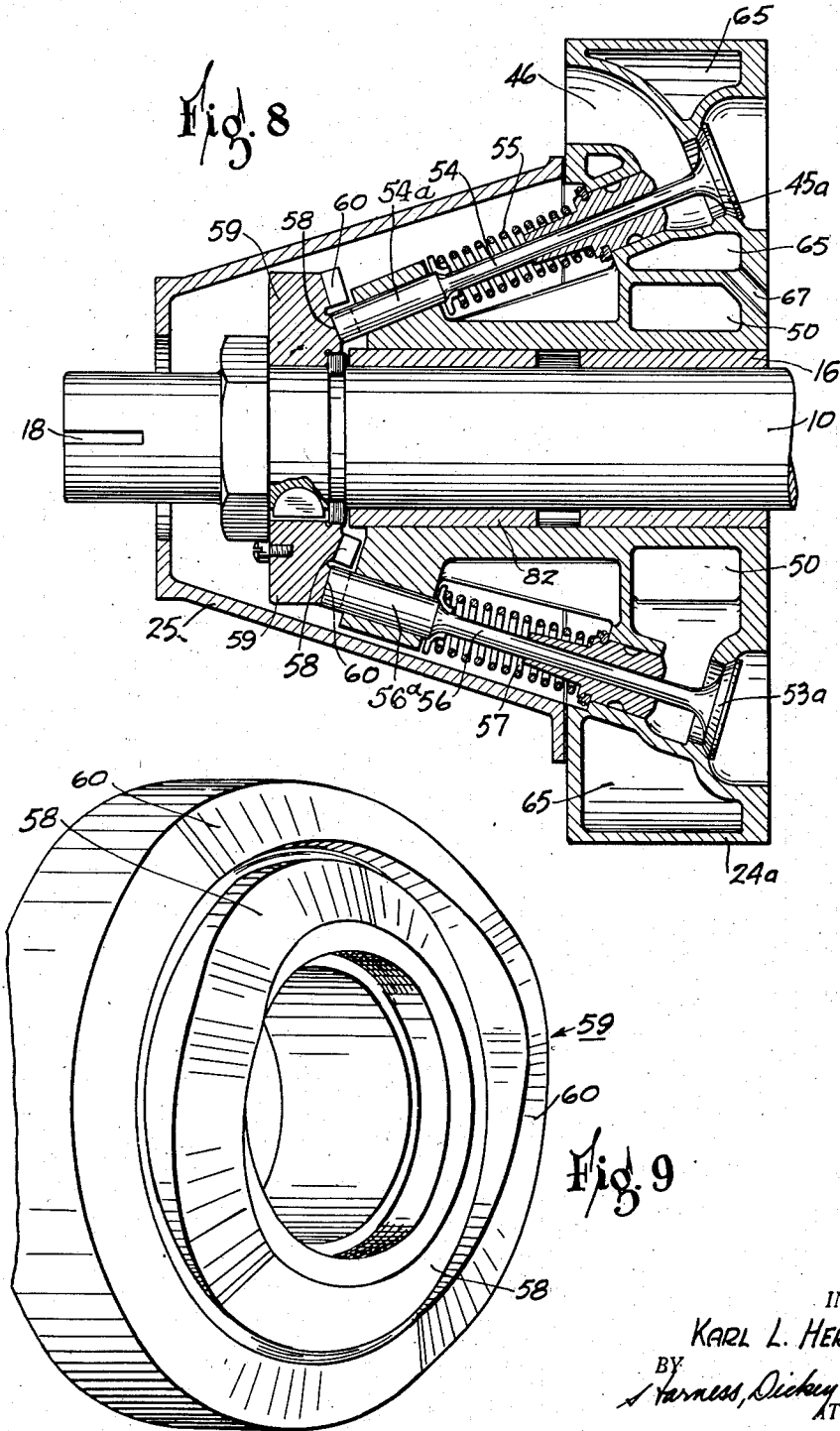
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INTERNAL COMBUSTION ENGINE

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May 27, 1941.

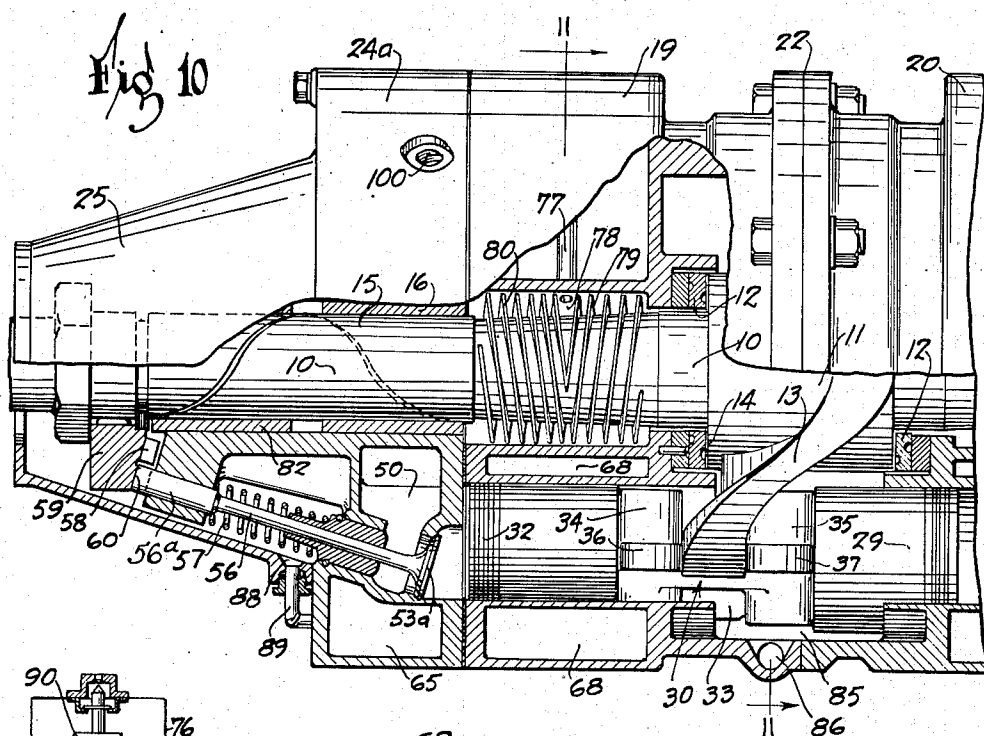
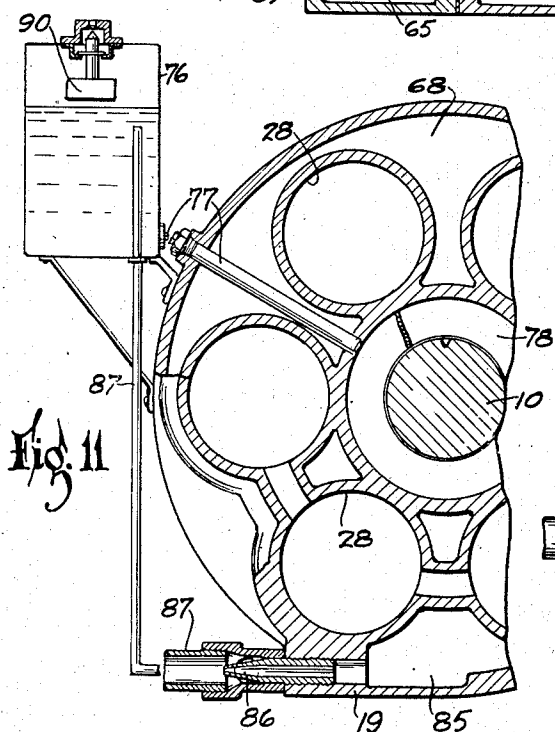
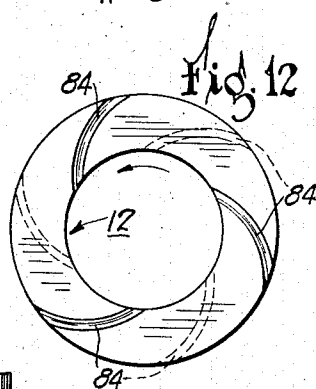
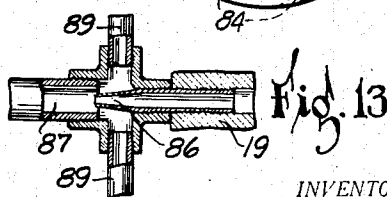
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INTERNAL COMBUSTION ENGINE

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,243,818

INTERNAL COMBUSTION ENGINE

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Original application May 14, 1937, Serial No. 142,653. Divided and this application May 6, 1940, Serial No. 333,517

12 Claims. (Cl. 123—173)

This invention relates to internal combustion engines and particularly to the cooling thereof, the principal object being the provision of a construction that will afford more efficient cooling of the engine and particularly certain portions thereof.

Objects of the invention include the provision of a new and novel cooling system for an internal combustion engine; the provision of a cooling system for an internal combustion engine so constructed and arranged as to increase the effectiveness of the cooling of the cylinder head of the engine; the provision of a cooling system for an internal combustion engine so constructed and arranged as to enhance the effect of the cooling medium particularly upon the seats for the exhaust valves thereof; the provision of a cooling system for an internal combustion engine so constructed and arranged as to provide for an even distribution of the cooling medium around the exhaust passages of the engine in the cylinder head thereof; the provision of a cooling system for an internal combustion engine in which the cooling medium is first introduced into the cylinder head of the engine and is then distributed therefrom to the water jacket for the cylinders thereof; and the provision of a construction as above described in which the flow of water from the cylinder head passes through a plurality of metered openings into the jacket for the cylinder block.

Other objects of the invention include the provision of a novel cooling system for a barrel type engine; the provision of a cooling system for a barrel type engine including an annular passageway in the cylinder head therefor arranged in novel manner with respect to the intake and exhaust passages in the cylinder head; the provision of a construction as above described in which pockets are formed in the annular passageway with the walls of each of the pockets in spaced relation with respect to an exhaust passage; the provision of a construction as above described in which each of the pockets is provided with a discharge port adjacent the bottom of the pocket whereby a cooling fluid medium introduced into the annular cooling chamber is discharged in a plurality of individual streams from the bottom of each of the pockets; the provision of a construction as above described in which an individual stream of water is caused to flow about each of the exhaust passages extending through the cylinder head; the provision of a construction as above described in which the discharge ports from each of the pockets serves to meter

and restrict the flow of cooling medium from the cylinder head to the jacket for the cylinder block, thereby maintaining a superior pressure of the cooling medium in the cylinder head as compared to the cylinder block; the provision of a construction as above described in which each of the ports in the aforementioned pockets is formed by a metering plug; and the provision of a construction as above described in which the cooling medium is first introduced into the cylinder head of the engine, then transferred to the cylinder block before being discharged from the engine.

The above being among the objects of the present invention, the same consists in certain novel features of construction and combinations of parts to be hereinafter described with reference to the accompanying drawings, and then claimed, having the above and other objects in view.

In the accompanying drawings which illustrate a suitable embodiment of the present invention and in which like numerals refer to like parts throughout the several different views,

Fig. 1 is a view showing parts in side elevation and other parts in vertical section and disclosed a barrel type of internal combustion engine constructed according to my invention;

Fig. 2 is a fragmentary sectional view, showing on an enlarged scale the construction of the thrust bearing and of the cam follower, which are carried in the connecting section of one of the double-ended pistons;

Fig. 3 is a view, in end elevation, taken in the direction of the arrows 3—3 of Fig. 2 and showing the exhaust manifold cover, carburetor and water outlet on an enlarged scale;

Fig. 4 is a sectional view, taken on the line 4—4 of Fig. 1, looking in the direction of the arrows 4—4 of that figure and showing on an enlarged scale the intake and exhaust valve pockets and also the passages from the carburetor to the respective intake valves and the passages through which the cooling fluid travels around the exhaust valves to the cylinder blocks;

Fig. 5 is a fragmentary sectional view on an enlarged scale, taken substantially on the line 5—5 of Fig. 4, showing a metering device which is located in one of the passages of the cooling system;

Fig. 6 is a fragmentary sectional view, taken on the line 4—4 of Fig. 1 but looking in the opposite direction of the arrows 4—4, showing a portion of the carburetor and the connecting passage for the intake manifold;

Fig. 7 is an enlarged sectional view, taken sub-

stantially on the line 7-7 of Fig. 1, showing the passages through which the cooling fluid travels within the cylinder block;

Fig. 8 is an enlarged sectional view, taken longitudinally through the cylinder head, having certain parts broken away and showing an intake valve, an exhaust valve and their related parts;

Fig. 9 is a perspective view of the valve operating cam, showing the cam surfaces for operating the intake and exhaust valves;

Fig. 10 is a fragmentary sectional view taken longitudinally of the engine and showing the supply and return of lubricant to and from the various moving parts of the engine;

Fig. 11 is a fragmentary cross-sectional view, taken substantially on the line 11-11 of Fig. 10, showing the method of supplying lubricant to the engine and also the arrangement for the return of lubricant to the reservoir;

Fig. 12 is a detailed view on an enlarged scale of one of the thrust bearings, showing the grooved surfaces for carrying and distributing the oil; and,

Fig. 13 is an enlarged fragmentary sectional view showing the venturi for returning oil to the reservoir.

The present invention is a division of my application for Letters Patent of the United States for Improvements in internal combustion engine, filed May 14, 1937, and serially numbered 142,653. Certain features of the present invention are applicable to internal combustion engines whether they are of the usual in-line type of construction, V-type of construction, or of the barrel type of construction, but inasmuch as all features of the invention are particularly adaptable for use in connection with barrel types of engines, the following description of the present invention will be limited to its application to barrel type engines only. From this description those skilled in the art will readily understand the manner in which the invention may be applied to internal combustion engines of other types without requiring specific mention thereof.

Referring to the drawings in which like numerals refer to like parts throughout the several views, there is shown an internal combustion engine of the barrel type having twelve cylinders in two groups of six each. As shown in Fig. 1, the engine is composed of two similar halves. The drive shaft 10 extends through both halves of the engine. The cylinders are equally spaced in a circle around the drive shaft. The drive shaft has mounted on it, or integral with it, an enlarged portion approximately midway between the ends of the shaft, the enlarged portion being positioned between thrust bearings 12. Supported on and carried by the enlarged portion 11 is a T-section driving cam 13, through which the drive shaft is driven from the pistons. Perpendicular surfaces 14 at opposite ends of the enlarged portion 11 provide thrust surfaces for the bearings 12. The shaft 10 extends the entire length of the engine and is provided with journal surfaces 15 arranged to rotate in bearings 16. One end of the drive shaft 10 is provided with an ignition distributor 17 and the other end is arranged as at 18 for connection to a coupling device. The cylinder block is formed in two sections 19 and 20, secured together as at 22. Adjacent the ends of the cylinder block sections 19 and 20 are cylinder heads 24 and 24a. The cylinder block sections are similar as are the cylinder heads, and the de-

scription of one in detail will serve to describe similar parts. On the head 24 there is secured a valve cover 25, and also thereon are six exhaust conduits, such as 26, all leading to the annular exhaust manifold 27 arranged concentrically with the axis of the engine. Each of the block halves is provided with six cylinder bores 28 equally angularly arranged about the axis thereof, and each cylinder bore has associated with it one piston, such as 29, of a double-ended piston, designated generally as 30.

Referring still to Fig. 1, the double-ended piston 30 may be seen to comprise a pair of pistons 29 and 32 connected by a connecting portion 33. The pistons 30 may be operatively connected to the cam 13 in the manner shown in my copending application for Letters Patent of the United States for Improvements in internal combustion engine, filed Oct. 29, 1938, the same being a continuation in part of my previously identified application of which the present application is a division, or may be connected as shown herein. In the particular construction shown the connecting portion has formed therein a pair of journals 34 and 35 within which there are mounted roller bearings and cam followers, such as 36 and 37, the cam followers contacting with the cam 13 and transforming the energy of the pistons into torque for rotating the cam 13.

The structure of the roller bearings, their journals and cam followers may be seen more clearly in Fig. 2, where there is shown the journal 34 within which there is mounted on needle or roller bearings, such as 38, a shaft 39. This shaft 39 carries the cam follower 36, which, as stated above, contacts with the cam 13. The shaft 39 and roller bearings 38 are retained in position by washers 40 and snap rings 42. Apertures, such as 43, are provided in the washers 40 to permit lubricant to contact the rollers 38. Having roller bearings on both sides of the cam follower 36 gives ample roller bearing surface.

After explosion, the burnt gases are exhausted from the cylinders by the following means. As may be seen in Fig. 1, each cylinder 28 is provided with an exhaust opening 44, which is usually closed by an exhaust valve 45, the exhaust valve opening at times to allow the burnt gases to pass into the exhaust passage 46. From each exhaust passage 46 the gases pass through the corresponding exhaust conduit 26 to the exhaust manifold 27 and escape therefrom through the exhaust opening 47. The exhaust manifold 27, the exhaust outlet 47, and the several exhaust conduits 26 are shown more clearly in Fig. 3.

Means are also provided for supplying fuel to the various cylinders. As may be seen in Fig. 3, I have provided a carburetor 48, which is connected to an intake conduit 49 (Figs. 3 and 4). This intake conduit 49 leads to an annular intake manifold 50 formed adjacent to the drive shaft and concentric therewith and provided with a casing 52, which is formed as a partition surrounding the inlet valves 53 but excluding the exhaust valves 45 and forming radially outwardly directed pockets or passages 63 each connecting the manifold 50 with one of the intake valves 53. One exhaust valve 45 and one inlet valve 53 is associated with each cylinder so as to allow the inlet of fuel and exhaust of burnt gases from each cylinder.

Means are provided for operating the exhaust and inlet valves, which means are shown the most clearly in Figs. 8 and 9. Referring thereto, it

may be seen that associated with the cylinder head 24a there is an exhaust valve 45a and an inlet valve 53a. The valve 45a has a valve stem 54, which is urged by a spring 55 to seat the valve 45a. The valve 53a has a valve stem 56, urged by a spring 57 to seat the valve 53a. The stem 54 acting through a conventional tappet 54a bears upon the inner face 58 of the valve cam 59, shown most clearly in Fig. 9, and the valve stem 56 acting through a tappet 56a bears on the outer face 60 of the cam 59. Similarly, all of the exhaust valves have stems bearing through tappets on the inner face, and all of the inlet valves have stems bearing through tappets on the outer face, and the cam thus operates both the exhaust and the inlet valves.

The axes of the intake valves, such as 53a, lie in the surface of a frustum of a cone, and the ends of the cooperating valve tappets are shaped to conform to the cam surface 58 of the cam 59. The exhaust valves corresponding to valve 45a and their valve stems and tappets are located so that their axes lie in the surface of a frustum of a cone with the ends of the cooperating valve tappets shaped to co-operate with the cam surface 60 of the cam 59. As shown in Fig. 9, the annular inclined cam surface 58 for the intake valves is combined with the concentric, annular, inclined cam surface 60 for the exhaust valves in a single unitary structure.

Referring again to Fig. 1, it may be seen that each exhaust manifold 27 is tapered to permit the continuous and uniform flow of exhaust gases into the exhaust pipe 62 (Fig. 3). The exhaust conduits 26 may be secured to the cylinder head 24 by means of bolts or studs.

In the operation of the valves, the cylinders fire in regular order in the direction of rotation. The intake valves open in the same order, and gases passing into the intake manifold 50, past the intake valves, are caused to whirl in a rotary swirling action in the short annular manifold, and thus the heavier vapor particles are prevented from settling, because they are thrown outward centrifugally into the valve pockets 63 (Fig. 4).

Means are also provided for cooling the engine and which means constitute the present invention. Referring especially to Fig. 4, there is shown a water or other cooling medium inlet 64, through which water is introduced into the annular compartment 65 formed between the partition 52 and the outer casing or wall 66 of the cylinder head 24. The water thus enters the cylinder head and forms a mass around and between the exhaust valves and travels toward the longitudinal center of the engine, passing through ports, such as the port 67. One of the ports 67 is shown more clearly in Fig. 5, wherein it may be seen that the port 67 connects the space 65 with a water-jacket 68 surrounding the cylinders 28. From the jacket 68 (Figs. 1 and 7), the water passes through an outlet 69 into a water conduit 70, leading back to the radiator 72. From the radiator 72, the water is pumped by the pump 73 through the water supply conduit 74 back to the water inlet 64. Thus it will be noted that contrary to conventional practice, in the present case the cooling medium or water is first introduced into the water jacket for the cylinder head, and is then discharged therefrom to the water jacket for the cylinder block.

In the passages 67 I insert removable ported metering plugs 75, as best shown in Fig. 5, which

permit the proper amount of water to flow around the exhaust valves and into the water jackets for the cylinders. By this arrangement the compartment 65 is maintained continuously filled with water and prevents the possibility of steam collecting in the exhaust cooling compartment. Also by making the passages in the plugs small enough, it is possible to maintain a positive pressure on the water in the jacket for the cylinder head, greater than the pressure on the water in the jacket for the cylinder block, and thus lessen the tendency of steam to form around the head, as well as to insure a proper flow of water around all of the exhaust passages 44 so as to maintain the seats for the exhaust valves properly cool and thus avoid warping of the same. By reason of the fact that the ports 67 are located in the pockets for the exhaust valves, the possibility of excessive hot water collecting in these pockets is eliminated, thus giving more desirable and efficient cooling of the engine. It is also understood that the ports in the plugs 75 may be varied in size so that a uniform temperature may be maintained throughout by increasing or decreasing the flow of the cooling medium. The fact also that the water heated by the exhaust surrounds the intake manifold 50 insures the maintenance of the fuel at a proper temperature. A steam relief port 67a, smaller than the metering ports 75, connects the compartment 65 in the head with the water-jacket 68 at their uppermost portions to permit any steam that might form in the head under unusual circumstances a ready escape to the outlet 69.

Means are provided for insuring the proper lubrication of all the moving parts of the engine and while any suitable means may be provided for this purpose, one suitable means is shown by way of illustration. Referring to Figs. 10, 11, 12 and 13, and especially to Fig. 11, it may be seen that there is provided an oil reservoir 76, from which oil may flow by a conduit 77 to a central chamber 78 formed in the engine block adjacent to the drive shaft 10. As may be seen more clearly in Fig. 10, the drive shaft 10, adjacent to the outlet from the conduit 77, may be but is not necessarily provided with a series of spiral baffles 79 and 80. As may be seen, with the drive shaft 10 rotating in a clockwise direction (as viewed from the left in Fig. 10), the spiral baffles will act to aid in forcing the lubricant in opposite directions from the conduit 77, forcing it to the bearings 15 and 82, and in the opposite direction to the thrust bearings 12. The thrust bearings 12 are shown on an enlarged scale in Fig. 12 and are each provided with a plurality of spiral grooves, such as 84, whereby the oil is thrown onto the enlarged portion 11 of the drive shaft 10 and outwardly therefrom to lubricate the cam followers 36, the roller bearings therefor, the cam 13 and the pistons, during their movement in the cylinders. The oil collects in the lower part of the crank case, as at 85 (Figs. 10 and 11), and is forced therefrom by pressure in the crank case developed from the blow-by past the pistons. The oil is forced, through a Venturi nozzle 86, as indicated in Fig. 13, into a return conduit 87, from which it flows back to the supply tank 76. In passing out of the Venturi nozzle 86 into the conduit 87, the flow of the oil creates a suction, which draws oil from the opposite ends of the engine through the conduits 89 leading thereto. Thus oil forced towards the ends of the engine by the baffles 80 or otherwise passes outwardly to lubricate the valve mechanism, and

eventually collects in pockets, such as 88, whence it passes through the conduits 89 to the outlet at the Venturi nozzle 86, and there by suction is pulled into the conduit 87 and thence forced by pressure to the reservoir. The reservoir 76 is provided with a float valve 90, used to close the vent opening of the reservoir in inverted flying. It is to be understood that oil passed through the journal 15 (Fig. 10) is discharged against the cam 59 and thrown centrifugally against the ends of the valve stems 54 and 56.

It is believed that the operation of the engine will be apparent from the above description. Fuel injected into the cylinders through the intake manifold 50 from the carburetor 48, at times permitted by the opening of the valves 53 as controlled by the cam 59, is exploded by the spark plugs, which may be inserted as at 100 (Fig. 10). The movement of the pistons outward reacts through the central beam, through the cam followers 36, upon the cam 13, and thus rotates the shaft 10. At this point the exhaust valves 45 are opened by the cam 59, and the exhaust gases escape through the exhaust manifold 27. The cam 59 is driven by the shaft 10 and, as stated, operates the exhaust and intake valves. The engine is cooled by the cooling system, previously described, and is lubricated by the lubricating system, also previously described.

It is to be understood that the above described embodiment of the invention is for the purpose of illustration only, and various changes may be made therein without departing from the spirit of the invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. In an internal combustion engine of the class wherein a cylinder block is provided with a cylinder head removably secured thereto, the cylinder head being provided with an inlet port and an outlet port for each of said cylinders and the cylinder block and the cylinder head being each provided with a water jacket, the combination with said cylinder head of an exhaust passage connected with each of said outlet ports, an intake manifold formed integrally with said head in communication with each of said inlet ports and having a wall arranged in spaced relation with respect to said exhaust passages and forming a pocket about each of said exhaust passages open to the cooling fluid within the water jacket for said head, and said engine being provided with a plurality of passages for the flow of cooling medium between said pockets and the water jacket for said cylinder block.

2. In an internal combustion engine of the class wherein a cylinder block is provided with a removable cylinder head, the cylinder head being provided with inlet and exhaust ports and each exhaust port being provided with an associated passage for the discharge of exhaust gases therethrough, the combination with said cylinder head of a water jacket for confining a flow of cooling medium in contact therewith, means for introducing a flow of cooling medium into said water jacket for the head, and means for discharging said cooling medium from said water jacket for the head in a plurality of separate streams, the cooling medium of each stream flowing around a corresponding one of said exhaust passages immediately prior to its discharge from said jacket for said head.

3. In an internal combustion engine of the class wherein a cylinder block is provided with

a removable cylinder head and said block and said head being each provided with a water jacket, the combination with said block and head of a plurality of passages connecting the water jacket for said head with the water jacket for said block, and a metering member removably received in each of said passages restricting the flow of water to flow therethrough.

4. The method of cooling an internal combustion engine having a water jacketed cylinder block and a water jacketed cylinder head having a plurality of exhaust passages arranged therein, comprising introducing a cooling medium into the water jacket for said head, causing said cooling medium in said water jacket for said head to flow in a plurality of individual streams into said water jacket for said block and with each of said streams flowing around a corresponding one of said exhaust passages, and then discharging said cooling medium from the water jacket for said block.

5. In an internal combustion engine of the barrel type wherein a plurality of cylinders are provided in a cylinder block and are arranged with their axes parallel to the axis of the engine drive shaft and grouped circularly thereabout, the cylinder block being provided with a water jacket, and the cylinder block being provided with a water jacketed cylinder head providing an inlet and exhaust port for each of said cylinders, the combination with said cylinder head of an annular intake manifold formed integrally therewith in surrounding relation with respect to the drive shaft, the radially outer wall of said intake manifold being formed to provide an outwardly directed pocket connecting each of said inlet ports with said intake manifold, said outer wall of said intake manifold forming between each adjacent pair of said pockets a radially outwardly opening pocket open to the interior of said water jacket for said cylinder head, and an exhaust passage formed integrally with said head in communication with each of said exhaust ports and projecting through each of the last mentioned pockets in spaced relation to the side walls thereof.

6. In an internal combustion engine of the barrel type wherein a plurality of cylinders are provided in a cylinder block and are arranged with their axes parallel to the axis of the engine drive shaft and grouped circularly thereabout, the cylinder block being provided with a water jacket, and the cylinder block being provided with a water jacketed cylinder head providing an inlet and exhaust port for each of said cylinders, the combination with said cylinder head of an annular intake manifold formed integrally therewith in surrounding relation with respect to the drive shaft, the radially outer wall of said intake manifold being formed to provide an outwardly directed pocket connecting each of said inlet ports with said intake manifold, said outer wall of said intake manifold forming between each adjacent pair of said pockets a radially outwardly opening pocket open to the interior of said water jacket for said cylinder head, an exhaust passage formed integrally with said head in communication with each of said exhaust ports and projecting through each of the last mentioned pockets in spaced relation to the side walls thereof, and said cylinder head having a passage therein adjacent the bottom of each of the last mentioned pockets affording a flow of cooling medium between the water jacket

for said cylinder head and the water jacket for said cylinder block.

7. In an internal combustion engine of the barrel type wherein a plurality of cylinders are provided in a cylinder block and are arranged with their axes parallel to the axis of the engine drive shaft and grouped circularly thereabout, the cylinder block being provided with a water jacket, and the cylinder block being provided with a water jacketed cylinder head providing an inlet and exhaust port for each of said cylinders, the combination with said cylinder head of an annular intake manifold formed integrally therewith in surrounding relation with respect to the drive shaft, the radially outer wall of said intake manifold being formed to provide an outwardly directed pocket connecting each of said inlet ports with said intake manifold, said outer wall of said intake manifold forming between each adjacent pair of said pockets a radially outwardly opening pocket open to the interior of said water jacket for said cylinder head, an exhaust passage formed integrally with said head in communication with each of said exhaust ports and projecting through each of the last mentioned pockets in spaced relation to the side walls thereof, said cylinder head having a passage therein adjacent the bottom of each of the last mentioned pockets affording a flow of cooling medium between the water jacket for said cylinder head and the water jacket for said cylinder block, and a metering plug in each of said passages.

8. In an internal combustion engine of the barrel type wherein a plurality of cylinders are provided in a cylinder block and are arranged with their axes parallel to the axis of the engine drive shaft and grouped circularly thereabout, the cylinder block being provided with a water jacket, and the cylinder block being provided with a water jacketed cylinder head providing an inlet and exhaust port for each of said cylinders, the combination with said cylinder head of an annular intake manifold formed integrally herewith in surrounding relation with respect to the drive shaft, the radially outer wall of said intake manifold being formed to provide an outwardly directed pocket connecting each of said inlet ports with said intake manifold, said outer wall of said intake manifold forming between each adjacent pair of said pockets a radially outwardly opening pocket open to the interior of said water jacket for said cylinder head, an exhaust passage formed integrally with said head in communication with each of said exhaust ports and projecting through each of the last mentioned pockets in spaced relation to the side walls thereof, means for introducing a cooling medium into the water jacket for said cylinder head, and means for discharging said cooling medium from the water jacket for said cylinder block.

9. In an internal combustion engine of the barrel type wherein a plurality of cylinders are provided in a cylinder block and are arranged with their axes parallel to the axis of the engine drive shaft and grouped circularly thereabout, the cylinder block being provided with a water jacket, and the cylinder block being provided with a water jacketed cylinder head providing an inlet and exhaust port for each of said cylinders, the combination with said cylinder head of an annular intake manifold formed integrally therewith in surrounding relation with respect to the drive shaft, the radially outer wall of said intake manifold being formed to provide an outwardly directed pocket connecting each of said inlet

ports with said intake manifold, said outer wall of said intake manifold forming between each adjacent pair of said pockets a radially outwardly opening pocket open to the interior of said water jacket for said cylinder head, an exhaust passage formed integrally with said head in communication with each of said exhaust ports and projecting through each of the last mentioned pockets in spaced relation to the side walls thereof, said cylinder head having a passage therein adjacent the bottom of each of the last mentioned pockets affording a flow of cooling medium between the water jacket for said cylinder head and the water jacket for said cylinder block, and an apertured plug removably received in each of said passages, said plugs being removable whereby to enable replacement of each thereof with a plug having a different sized aperture therein whereby to vary the distribution of flow of cooling medium from the water jacket for said cylinder head to the water jacket for said cylinder block.

10. In an internal combustion engine of the class having a rotatable shaft, a plurality of cylinders arranged with their axes parallel to said shaft and grouped around said shaft, pistons reciprocable in said cylinders, means interconnecting said pistons and said shaft for effecting rotation of said shaft upon reciprocation of said pistons in said cylinders, and cylinder heads for said cylinders, the combination with said engine of a water jacket for said cylinders, a water jacket for said cylinder heads having discharge openings leading into the water jacket for said cylinders, and means for circulating a cooling liquid through said jackets in the direction of toward said cylinder head jacket and from said cylinder jacket, said discharge openings being of such combined area as to cause a greater pressure on said liquid in said cylinder head jacket than in said cylinder jacket during operation of said engine.

11. In an internal combustion engine of the class having a rotatable shaft, a plurality of cylinders arranged with their axes parallel to said shaft and grouped around said shaft, pistons reciprocable in said cylinders, and means interconnecting said pistons and said shaft for effecting rotation of said shaft upon reciprocation of said pistons in said cylinders, the combination with said cylinders of a unitary cylinder head applicable to all of said cylinders, an annular fuel mixture intake passage formed integrally with said cylinder head, radially outwardly directed passages connected with said annular passage serving to connect said annular passage with each of said cylinders, said radial passages forming between them radially outwardly directed pockets, an exhaust passage for each of said cylinders connected thereto through said pockets and arranged in spaced relation to the walls of said pockets and extending outwardly therefrom, a water jacket for said cylinder head enclosing said intake and exhaust passages, a water jacket for said cylinders, means for introducing a cooling liquid to said jacket for said cylinder head, and conduits for the flow of cooling liquid from said head jacket to said cylinder jacket leading to said cylinder jacket from the bottom of said pockets.

12. In an internal combustion engine of the class having a rotatable shaft, a plurality of cylinders arranged with their axes parallel to said shaft and grouped around said shaft, pistons reciprocable in said cylinders, and means interconnecting said pistons and said shaft for ef-

fecting rotation of said shaft upon reciprocation of said pistons in said cylinders, the combination with said cylinders of a unitary cylinder head applicable to all of said cylinders, an annular fuel mixture intake passage formed integrally with said cylinder head, radially outwardly directed passages connected with said annular passages serving to connect said annular passage with each of said cylinders, said radial passages forming between them radially outwardly directed pockets, an exhaust passage for each of said cylinders connected thereto through said pockets and arranged in spaced relation to the walls of said pockets and extending outwardly therefrom, a

water jacket for said cylinder head enclosing said intake and exhaust passages, a water jacket for said cylinders, means for introducing a cooling liquid to said jacket for said cylinder head, and conduits for the flow of cooling liquid from said head jacket to said cylinder jacket leading to said cylinder jacket from the bottom of said pockets, the combined capacities of said conduits being less than the capacity of said liquid introducing means whereby to maintain a superior pressure on said liquid in said head jacket as compared to said cylinder jacket and during operation of said engine.

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