Jan. 30, 1940. E. G. FAHLMAN 2,188,876

METHOD OF COOLING INTERNAL COMBUSTION ENGINE AND CYLINDER HEAD FOR SAME

Filed Jan. 22, 1938 2 Sheets-Sheet 1

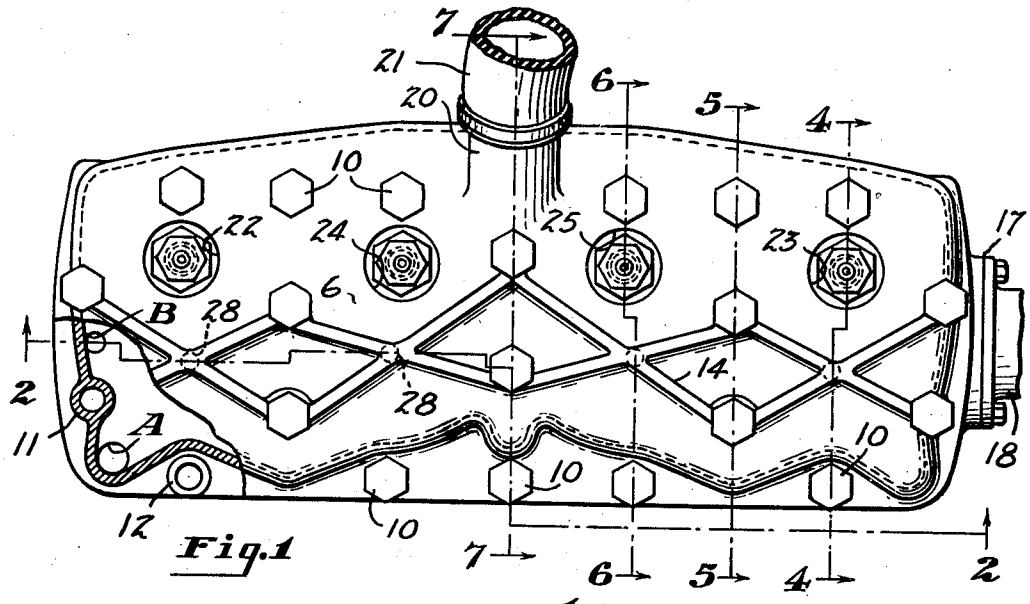


Fig. 1

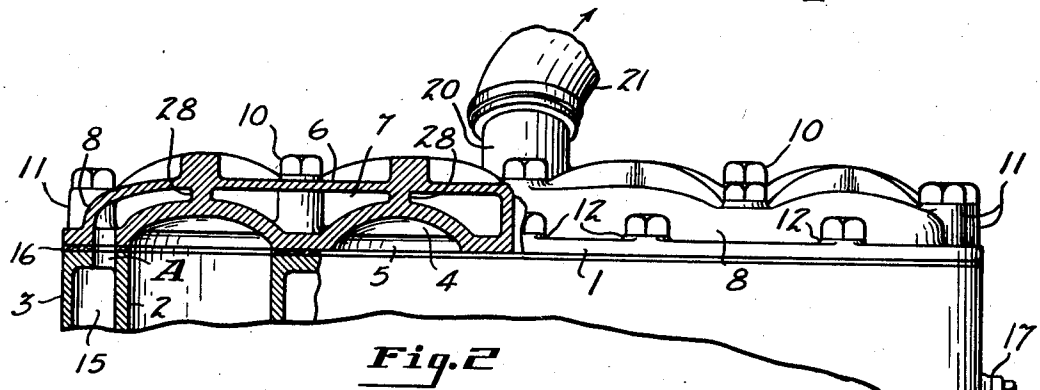


Fig. 2

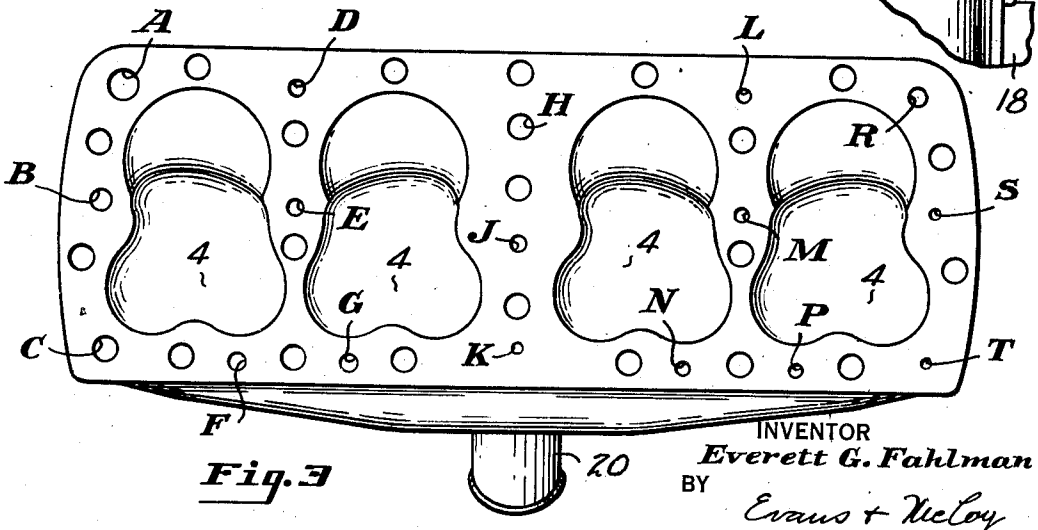


Fig. 3

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Filed Jan. 22, 1938 2 Sheets-Sheet 2

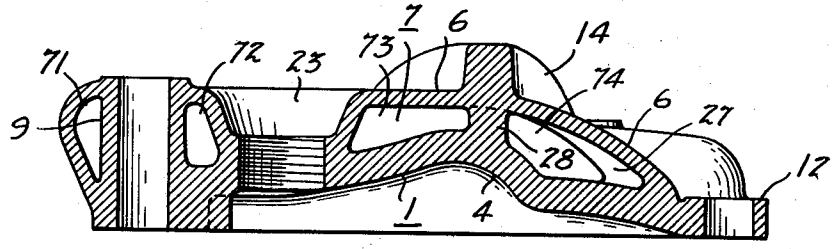


Fig. 4

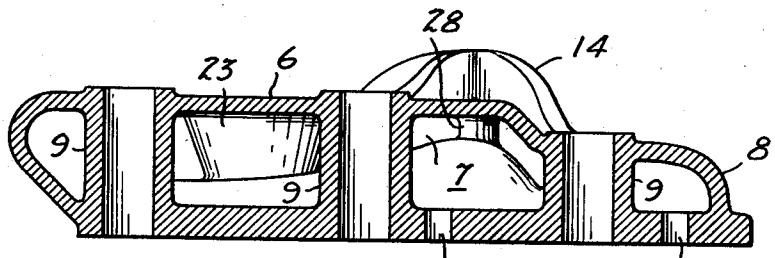


Fig. 5

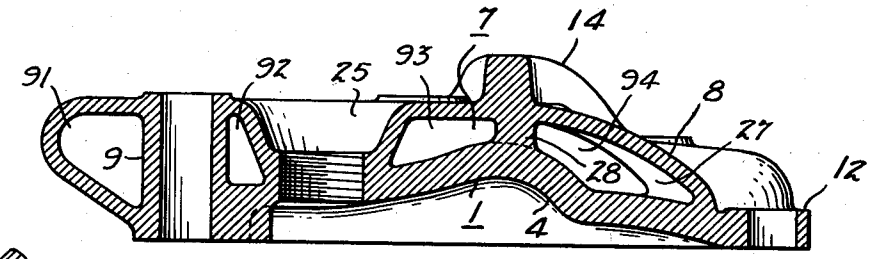


Fig. 6

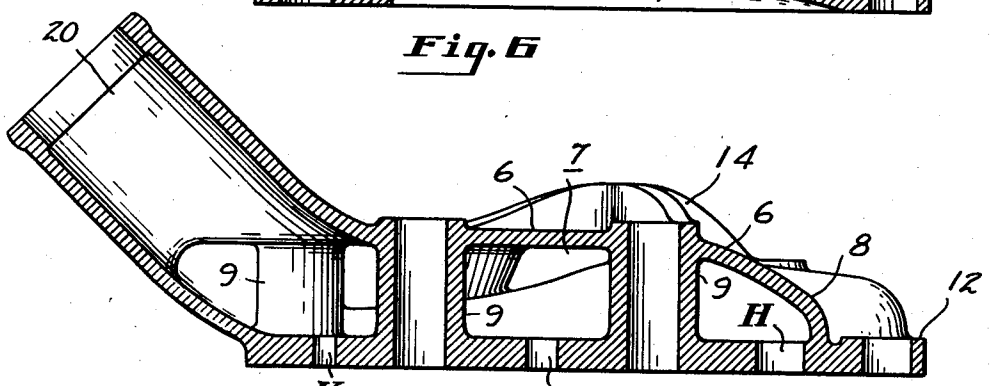


Fig. 7

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2,188,876

METHOD OF COOLING INTERNAL COMBUSTION ENGINE AND CYLINDER HEAD FOR SAME

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Application January 22, 1938, Serial No. 186,387

8 Claims. (Cl. 123—173)

This invention relates to a method and means for cooling internal combustion engines and more particularly to improved cylinder heads for such engines.

It is an object of the invention to provide a cylinder head for an engine having a cooling system employing forced circulation, which effectively maintains a substantially uniform temperature around the combustion chambers and in which overheating in one portion and excessive cooling in another portion of the head is avoided.

Another object is to provide a cylinder head having a chamber for the circulation therethrough of a coolant in communication with a cooling liquid jacket in the engine block by means of cooling liquid passages arranged to admit cooling liquid to the cylinder head chamber in proportion to the cooling capacity of the liquid and the cooling requirements of the cylinder head at various portions thereof.

Another object is to provide a cylinder head having a chamber through which liquid coolant flows from inlets to an outlet or outlets and which chamber has at spaced intervals a plurality of passageways extending across the cylinder head through which the cooling liquid flows and which are proportioned in cross-sectional area to direct the cooling liquid to flow over the portions of the combustion chamber wall which constitute zones of highest temperature.

Another object is to provide in combination in an internal combustion engine, a cooling liquid jacket surrounding portions of the cylinders, a pump for circulating cooling liquid, and an improved cylinder head of aluminum or its alloys, the head having a novel arrangement of cooling liquid inlet passages into the cooling liquid chamber of the head and openings in the cooling liquid chamber for the flow of cooling liquid through the head.

A further object is to provide a cylinder head for an internal combustion engine which is simple in design and construction and inexpensive to manufacture. Other objects and advantages will become apparent from the following detailed description of the invention.

In the usual construction of present-day internal combustion engines of the type employed in automotive vehicles, a number of cylinders are arranged in parallel relation and one behind another. Each cylinder receives a reciprocable piston and all of the pistons are arranged to actuate a common crankshaft. The cylinders are formed in an engine block having one or more cooling liquid jackets which surround the cylinders. A cylinder head is secured to the engine block and arranged to overlie one end of each of the cylinders to provide combustion chambers. A cooling liquid chamber is formed in the cylinder head and a number of passages afford communication between the cooling liquid jacket around the cylinders and the cooling liquid chamber in the cylinder head. The cooling liquid is circulated through the cylinder jacket, cylinder head chamber and then through a radiator which dissipates or withdraws from the cooling liquid the heat gained in passage through the engine block and cylinder head. This circulation is preferably accomplished by means of a pump which is usually positioned in the circulatory system between the cylinder head and radiator or between the radiator and cylinder jacket. The latter position is to be preferred because of a positive pressure above that of the atmosphere exerted on the cooling liquid in the cylinder jacket and cylinder head.

According to the present invention the cooling liquid passages extending between the chamber in the cylinder head and the water jacket in the engine block are positioned and proportioned with respect to one another to present different degrees of frictional resistance to the flow therethrough of the cooling liquid from the engine block into the cylinder head. For those passageways which are remote from the part of the engine block in which fresh cooling liquid from the radiator is first introduced, it is desirable to have a reduced frictional resistance to the flow of cooling liquid, while for those passages relatively close to the fresh cooling liquid inlet of the engine block it is preferred to have a relatively high frictional resistance to the flow of liquid. Such a system tends to equalize the relative heat absorbing capacities of the several portions of cooling liquid which flows into the cylinder head cooling chamber through the various passages. After being introduced into the chamber of the cylinder head the cooling liquid flows at a relatively high velocity over all portions of the bottom wall and in a general direction toward the cylinder head cooling liquid outlet. By providing a course for the flow of cooling liquid through the cylinder head which comprises a series of stages in which the cooling liquid flows through a plurality of openings of restricted cross-sectional area a relatively high velocity of flow is obtained which effectively cools the lower wall of the cylinder head and removes steam as rapidly as it is formed.

A proportional relationship is observed, as closely as possible considering the requirements of commercial manufacture, between the amount of water flowing through the cylinder head at one of the restricted area stages and the total cross-sectional area of such stage as well as a relationship between the cross-sectional area of the various stages and the cross-sectional area of the cooling liquid outlet from the cylinder head.

In the drawings, a cylinder head is shown which embodies the principles of this invention. Certain features of the cylinder head form the subject matter of my co-pending application Serial No. 185,881, filed January 20, 1938.

Figure 1 is a plan view partly in section and with parts removed of a cylinder head secured to a four-cylinder engine block;

Fig. 2 is a side elevational view partly in section and with parts removed of the cylinder head and engine block illustrated in Fig. 1;

Fig. 3 is a bottom view of the cylinder head shown in Figs. 1 and 2;

Figs. 4, 5, 6, and 7 are detail sectional views taken substantially on the lines 4—4, 5—5, 6—6, and 7—7, respectively, of Fig. 1 and enlarged with respect thereto.

Referring to the drawings by numerals of reference which are applied to like parts throughout the several figures, the cylinder head comprises a bottom or compression wall 1 which overlies a plurality of cylinders 2 formed in an engine block 3 and arranged in line with one another with their axes substantially parallel. Over each of the cylinders 2 the bottom wall 1 is formed into a dome 4 which provides a combustion chamber 5. An upper wall 6 is disposed over the compression wall 1 of the cylinder head and in spaced relation with respect thereto to provide a cooling liquid chamber 7. This cooling liquid chamber is continuous over substantially the entire area of the bottom compression wall 1 and overlies all of the domes 4 of the combustion chambers. The peripheral marginal portions of the upper wall 6 are curved into lateral walls 8 which join with the bottom compression wall 1 to enclose the cooling liquid chamber 7. A plurality of posts 9 extend through the cooling liquid chamber 7 and are integrally formed with the bottom wall 1 and top wall 6 of the cylinder head. These posts have longitudinal central apertures which receive stud bolts 10 for securing the cylinder head to the engine block. At each end of the cylinder head a pair of posts 11 are formed into the lateral walls 8 of the cylinder head and are also axially apertured to receive holding bolts. Additional stud bolts and nuts are secured in bosses 12 formed on a portion of the bottom or compression wall 1 of the cylinder head over which there is no cooling liquid chamber. Between the posts 9 and 11 extend reinforcing ribs 14.

The cooling liquid chamber 7 formed in the cylinder head communicates with a cooling liquid jacket or chamber 15 formed in the engine block through a plurality of cooling liquid passages, indicated by the alphabetical letters A, B, C, D, E, F, G, H, J, K, L, M, N, P, R, S and T, shown in Fig. 3 of the drawings. Between the cylinder head and engine block is a gasket 16 which affords a fluid-tight connection between the two and prevents loss of compression and escape of cooling liquid.

Fresh cooling liquid is introduced into the cooling liquid jacket 15 of the engine block through inlet 17 and is forced through the engine by means of a pump 18 which may be driven by the engine in any well known manner. The cooling liquid inlet passages A, B and C, seen at the left of Fig. 3, are a relatively great distance away from the inlet 17 and a suitable circulating pump, of conventional design, which may be secured to the engine block 3 at the inlet 17. The pump itself is not shown in the drawings, but the housing therefor is indicated at 18. Accordingly, the cooling liquid flowing into the cylinder head chamber 7 through these passages must first travel substantially the entire length of the engine block 3 through the cooling liquid jacket 15. Conversely, the cooling liquid inlets R, S and T, seen at the right of Fig. 3, are relatively close to the inlet 17 and pump 18, being located in the cylinder head at the forward end of the engine and communicating with the block jacket 15 directly above the inlet 17.

In flowing through the jacket 15 for substantially the entire length of the engine block the cooling liquid, entering the cooling liquid chamber 7 of the cylinder head through the cooling liquid passages A, B and C, loses considerable pressure because of the retarding or frictional effect of the walls of the cooling liquid jacket 15. The corresponding pressure losses on the cooling liquid entering the cooling chamber 7 through the inlet passages R, S, and T is relatively small since this cooling liquid flows substantially directly from the inlet 17 through the passages R, S, and T. For this reason it is desirable that the frictional resistance to the flow of cooling liquid into the chamber 7 from the jacket 15 be considerably less through the passages A, B, and C than through the passages R, S, and T, so that the quantity of liquid flowing through the latter passages in a unit length of time during normal operation of the engine will not be greatly in excess of that flowing through the former passages and preferably less in amount, as will presently appear.

Another factor which is to be considered in determining the relative sizes of the cooling liquid passages is the temperature of the cooling liquid leaving the jacket 15. Since the engine block 3 and particularly the walls of the cylinders 2 are normally at relatively high temperatures during operation of the engine considerable heat is absorbed therefrom by the cooling liquid flowing through the jacket 15. Other factors being equal, the longer the cooling liquid remains in the jacket 15 the higher its temperature will become until it is substantially the same temperature as the portions of the engine block 3 which form the cooling liquid jacket 15. Of course, during normal operation of the engine with a force pump 18 the water circulates through the jacket 15 with sufficient rapidity so that a substantial temperature differential is maintained between the metal of the jacket and the cooling liquid. However, other factors being the same, that cooling liquid entering the cylinder head chamber 7 through the inlet passages A, B, and C has a greater opportunity to become elevated in temperature than the cooling liquid entering through the passages R, S, and T. Accordingly, the passages A, B, and C are substantially larger in cross-sectional area than the passages R, S, and T, so that the latter offers the greater resistance to the flow of cooling liquid from the jacket 15. In this manner the flow through passages R, S, and T is retarded to increase the relative period of time that cooling liquid entering the head chamber 7 through these passages remains in the

block jacket 15 to absorb heat, thus tending to equalize the temperatures and heat absorbing capacities of the cooling liquid entering the chamber 7 at opposite ends of the cylinder head. Another effect of increasing the flow resistance of the passages R, S, and T is that the cooling liquid, under the pressure of pump 18 seeks other outlets from the jacket 15 and flows through the jacket and out the passages more remote from the inlet, such as the passages A, B, and C. Proportionately as the cross-sectional area of the adjacent passages is decreased, the quantity of cooling liquid diverted from these passages to flow through more remote passages is increased.

The tendency for cooling liquid flowing in a general longitudinal direction through the engine block to become elevated in temperature is increased in engines of the V-type.

In such cases, engines of the V-type can be made to show greatly improved performance through use of the present invention, which aims to supply cooling liquid in sufficient quantity and at a suitable temperature to the several domes 4 of the compression wall 1 of the cylinder head so that substantially equal cooling capacity is supplied to each of the combustion chambers of the engine and the operating temperature of all the cylinders remains substantially uniform. In the cylinder head illustrated, the cooling liquid inlet passages into the cylinder head are in the form of round or cylindrical holes. By adding up the individual cross-sectional areas of all the passages, the total available cooling liquid inlet passage area is obtained. In the following table the relative sizes of the various passages are substantially indicated by expressing its area in percentage of the total area of the cooling liquid inlet passages between the jacket 15 and head chamber 7.

Remote inlet passages		Central passages		Adjacent passages	
Passage	Percent of total inlet area	Passage	Percent of total inlet area	Passage	Percent of total inlet area
A	17	H	11	L	4
B	9			M	4
C	11	J	4	N	3
	37			P	3
					14
D	5	K	2		
E	5			R	6
F	6		17	S	2
G	6			T	2
	22				10
	59				24

From the above table it appears that about 37% of the total passage area is furnished by the three remote inlets A, B and C, while only about 10% is furnished by the inlets R, S and T, which are adjacent the jacket inlet 17. The arrangement as to location and size of the cooling liquid passages is such with respect to the cooling liquid inlet into the cylinder jacket and the cooling liquid outlet from the cylinder head, that the flow of cooling liquid into and through the cylinder head is controlled to maintain uniform temperature. Substantially any performance of the cooling system that is desired may be obtained by variation of the design described in accordance with the principles of the invention. The sizes of the various cooling liquid inlets into the cylinder head are proportioned or adjusted with respect to one another so that the quantities of cooling liquid admitted to various portions of the cylinder head chamber have cooling capacities sufficient to maintain all analogous portions of the cylinder head, with respect to the various cylinders or combustion chambers, at substantially uniform temperatures. The adjustment or the proportioning of cooling liquid inlet size may be effected by coring the holes to proper dimensions when the cylinder head is cast, or by drilling the holes to the desired size. Another method is to make the holes through the head and engine block larger than required and to vary the size of the openings in the gasket 16 in order to give the desired cross sectional area to the passages. In thus adjusting the flow by regulation of inlet size, consideration must be given to the location of the cooling liquid circulating pump as will be later explained and the heating of the cooling liquid as it passes through the jacket 15. For a bank of cylinders as shown in the drawings, with the cooling liquid inlet into the jacket 15 at one end of the latter a satisfactory proportioning of the inlets into the cylinder head chamber has been found to be one wherein the available passageway area for the flow of cooling liquid into the cylinder head chamber 7 furnished by the remote inlets A, B, and C is nearly four times as great as that furnished by the adjacent inlets R, S, and T. The inlet passages between the adjacent passages and the remote passages vary in size substantially in accordance with their distance from the jacket inlet 17. For example, the intermediate remote passages D, E, F, and G have a combined cross-sectional area of about 22% of the total available inlet passage area. The intermediate adjacent passages L, M, N, and T have a combined cross-sectional area of about 14% of the total cooling liquid inlet passage area. Thus the seven remote passages, A through G, have a combined cross-sectional area of about 59% of the total inlet area while the seven adjacent passages, L through T, have a combined cross-sectional area of only about 24% of the total inlet area, which is about 40% of the area of the remote passages. The remaining 17% of the total passage area is furnished by the central passages H, J and K positioned in the central portion of the cylinder head substantially on the median line thereof.

In carrying out the present invention in connection with various designs of internal combustion engines the proportion between the cross-sectional area of the combined cooling liquid passages remote from the engine jacket inlet with respect to the combined area of the passages adjacent the inlet, is subject to considerable variation. A number of factors are to be considered in determining the relative proportion between the cross-sectional area of the remote and the adjacent passages. One such factor is the design and location of the force pump 18. If the pump is located at one end of the engine block, as shown in the drawings, a greater difference in cross-sectional area between the remote and adjacent passages is desirable than in the case where the pump is located so that the inlet 17 communicates with the jacket 15 midway between the ends of the engine block. Another factor is the resistance to the flow of cooling liquid offered by the jacket 15. If this jacket has relatively wide and open passageways the cooling liquid flows with considerable ease, whereas if the passageways are thin and narrow so that only restricted openings are present then the resistance to the flow of cooling liquid is increased and it is desirable that a proportionately larger differ-

ence be provided in the cross-sectional areas of the remote passages into the chamber 7 with respect to the passages which are adjacent the inlet 17. For an arrangement such as that illustrated in the drawings it has been found that a proportion of cooling liquid passage areas into the chamber 7 such that the combined cross-sectional areas of the adjacent passages is from 25 to 55% of the combined cross sectional areas of the remote passages is satisfactory. Preferably, the arrangement is such that the adjacent passages are about 40% of the area of the remote passages in accordance with the example described above.

After the cooling liquid has passed through the chamber 7 in the cylinder head it is carried off through outlet 20 and flows in a conduit 21 to the radiator previously mentioned through which the cooling liquid circulates before being returned to the engine block inlet 17. In the present instance the outlet 20 is disposed at a central portion of the cylinder head so that the cooling liquid flows through the chamber 7 from the ends of the cylinder head toward the central portion thereof. The location of the outlet 20 is another factor to be considered in determining the proportion between the cross-sectional areas of the remote cooling liquid passages and the cross-sectional areas of the adjacent cooling liquid passages which supply coolant to the chamber 7 in the head from the jacket 15 in the engine block. The ratio between the aggregate cross-sectional areas of the remote passages to the aggregate cross-sectional areas of the adjacent passages varies inversely with the distance between the inlet 17 into the cooling jacket 15 of the engine block and the outlet 20 from the cooling chamber 7 of the cylinder head. If the outlet 20 were to be moved to the right, as viewed in Figs. 1 and 2, so that it approaches the end of the engine at which the inlet 17 is disposed, then the relative areas of the adjacent passages L, M, N, P, R, S, and T would be decreased while the relative areas of the remote passages A, B, C, D, E, F, and G would be increased. Conversely, if the outlet 20 were moved to the left the adjacent passages would be increased in cross-sectional area while the remote passages would be decreased in relative cross-sectional area.

In differentiating between remote and adjacent cooling liquid passages into the cylinder head chamber 7 the central inlets H, J, K have been disregarded. This is for the reason that the cooling liquid entering the chamber through these inlets has a minimum flow in contact with the hot surfaces of the bottom compression wall 1 of the cylinder head. In constructions such as illustrated, where the inlet 17 is located at one end of the engine block the inlet passages such as H, J and K, which are located near the outlet 20 leading from the cylinder head chamber, must be considered. The cooling liquid which enters the cylinder head chamber 7 through the remote passages such as A, B, C, D, E, F, and G, must flow through the engine jacket 15 adjacent the inlets H, J and K. Accordingly, if these central passages are of excessive cross-sectional area they bleed off cooling liquid at this point in its travel so that it does not travel the full length of the jacket 15 and up into the cylinder head through the remote passages. Preferably the central inlets H, J and K are of relatively small size; less than the total cross-sectional area of the adjacent passages.

Although the regulation of the available cross-sectional areas of the cooling liquid passages communicating between the chamber 7 in the cylinder head and the cooling liquid jacket 15 in the engine block have been described with their cross-sectional areas controlled by the size of the opening through the bottom compression wall 1 of the cylinder head, substantially the same results may be accomplished by adjusting the sizes of the openings through the gasket 16 or through the top wall of the engine block 3.

Over portions of the bottom compression wall 1 forming the domes 4 of the combustion chambers 5 it is desirable to have a relatively high velocity flow of cooling liquid for a scouring action which entrains and scavenges therefrom any steam that may form. In the present instance this is accomplished by providing across the entire width of the cylinder head adjacent the domes 4 restrictions in the chamber 7 which are referred to as choke sections and illustrated in Figs. 4 and 6. The sectional view illustrated in Fig. 4 shows the choke areas through spark plug boss 23 at one end of the cylinder head, and the choke section illustrated in Fig. 6 corresponds to that through the spark plug boss 25 (see Fig. 1). Each of the choke sections has an available cross-sectional area of combined passageways for the flow of cooling liquid which is greater than the combined cross-sectional area of the passages from the jacket 15 which furnished the cooling liquid to flow through that particular choke section. For example, the choke section through spark plug boss 22 has a total area available for the flow of cooling liquid greater than the combined cross-sectional areas of the passages A, B, and C, and the choke section through spark plug boss 24 has an available area for the flow of cooling liquid greater than the combined cross-sectional areas of the passages A, B, C, D, E, F, and G. Thus, while it is desirable that the choke sections have restricted passages for the flow therethrough of the cooling liquid, they do not impede the flow sufficiently so that the cooling liquid backs up and interferes with the free entrance of fresh cooling liquid through the passages leading from the jacket 15 in the engine block.

In order that there is no backing up of the cooling liquid from the outlet 20, the latter is preferably substantially equal in cross-sectional area available for the flow of cooling liquid to the largest choke section over the combustion chambers. Because of the difference in frictional effect between a single large circular passage and a plurality of odd shaped passages of equal total area, it is satisfactory if the outlet 20 be slightly less in cross-sectional area than the total aggregate areas through the largest choke section. In the cylinder head illustrated, the outlet 20 has a cross-sectional area about 90% that of the total cross-sectional area of the passageways through the choke section illustrated in Fig. 6. Since there are two choke areas corresponding to Fig. 6, the available area of the outlet 20 is about 45% of the total passageway area through the next adjacent choke sections flowing cooling liquid thereto.

The individual passageways comprising the choke sections bear a relationship to one another. For example, the passages 71, 72, 73, and 74 through the sections at spark plug bosses 22 and 23 and illustrated in Fig. 4, have areas available for the flow of liquid of about 14%, 17%, 36%, and 32%, respectively, of the total area of the particular choke section. The areas of the choke section passageways 91, 92, 93 and 94

at the spark plug bosses 24 and 25, as illustrated in Fig. 6, have areas of 36%, 13%, 27% and 24%, respectively, of the total area through the particular choke section available for the flow of cooling liquid. Thus, the proportioning of the individual passageway areas through each of the choke sections, so that the greatest passage is not substantially more than three times the area of the smallest of that particular choke, assures a relatively high velocity of flow over the entire choke area, providing an efficient scavenging of steam therefrom and an effective cooling of the combustion chamber wall.

Fig. 5, which is a transverse section through the posts 9, which hold the cylinder head to the engine block, shows that a relative equality or uniformity in the cross-sectional areas of the various passages available for the flow of cooling liquid through the cylinder head is maintained.

In order that the proper relationship may be maintained between the various passageways through the choke sections, ribs 27 are formed on the under side of the upper wall 6 of the cylinder head. These ribs depend into the cooling liquid chamber 7 at the choke section and reduce the effective area of the passageways 74 and 94. This decrease in area of these passageways increases the resistance to the flow therethrough of cooling liquid, so that, in the case of the choke section illustrated in Fig. 4, a greater relative proportion of the cooling liquid flows through the passageways 71, 72 and 73, and in the choke section illustrated in Fig. 6 a greater proportion of the cooling liquid flows through the passageways 91, 92 and 93.

In carrying out the present invention there are various controlling factors which may be regulated to obtain the desired cooling of the cylinder head of any particular internal combustion engine. In the event that the position of the inlet 17, leading to the cooling liquid jacket 15 of the engine block, and the outlet passage 20, through which cooling liquid flows away from the cylinder head, are fixed by the design of the engine, the cooling characteristics of the system may be satisfactorily regulated by adjustment of the cross-sectional areas of the cooling liquid passages which control the flow of cooling liquid from the chamber 15 in the engine block to the chamber 7 in the cylinder head and the relative cross-sectional areas of each of the passageways through the several choke sections. For example, if one portion of the cylinder head normally operates at a temperature which is considered too low, one or more of the cooling liquid passages which supply cooling liquid to that portion have their cross-sectional areas reduced so that an increased resistance is offered to the flow of cooling liquid into that portion of the cylinder head. This results in cooling liquid having a decreased heat capacity, flowing over that portion of the cylinder head and diminished cooling results. Also a rib such as the rib 27 may be formed in the chamber 7 depending from the top wall 6 and transverse to the general direction of flow through the cylinder head. This rib increases the resistance to the flow of cooling liquid to that portion of the cylinder head and increases the relative operating temperature. It is to be noted that this increase in operating temperature occurs on both sides of the rib inasmuch as the rate of flow is generally decreased so that there is a backing up on one side of the rib and a failure to feed cooling liquid to the opposite side of the rib.

During operation of an internal combustion engine equipped with a cylinder head such as that illustrated in the drawings, and with the inlet passages arranged in accordance with the description above, an improved circulation of the cooling liquid is obtained which results in a more desirable cooling action. The resulting effect is not necessarily the removal of a greater quantity of heat from the combustion chamber but a mode of operation in which each of the combustion chambers has its upper walls maintained at substantially the same temperature as every other like wall of a combustion chamber. In this manner uniform operating conditions are obtained for all of the cylinders in the engine block which results in an improved burning of the fuel charge in each of the combustion chambers. Since all the combustion chambers are maintained at substantially the same temperature and the charges of fuel introduced into the chambers are substantially alike and uniform in composition, a smooth running engine is obtained which gives a substantially constant and uniform flow of power.

The cooling liquid flowing through the chamber 7 in the cylinder head proceeds in a general direction toward the outlet 20. Aside from the posts 9 which receive the hold-down studs and the spark plug bosses, the only obstruction to the flow of cooling liquid which extends through the chamber 7 are pillars 28 which extend between the upper wall 6 and bottom wall 1 of the cylinder head beneath the ribs 14 and serve to strengthen the domes 4. The pillars 28 and ribs 14 are more fully described in my copending application mentioned above. The cooling liquid flowing through the chamber 7 which is elevated to the highest temperature is that which flows through the passages 72 and 73, shown in the choke section of Fig. 4, and the passages 92 and 93, shown in the choke section of Fig. 6, particularly the passages 72 and 92. This high temperature cooling liquid is not directed over succeeding domes 4 overlying combustion chambers of the engine, but flows into the channel at one side of the head; that hot cooling liquid from passage 72 flowing largely through the passageway 91 of the choke section illustrated in Fig. 6 and through a portion of the chamber 7 removed from the domes 4 over combustion chambers. Accordingly, a flow of the coolant is obtained in which that coolant raised to the highest temperature is not directed over portions of the compression wall 1 of the cylinder head which overlie combustion chambers of the engine. Thus there is an avoidance of carrying of the high temperature coolant over relatively cooler portions of the cylinder head. Previous designs of cylinder heads have endeavored to equalize temperatures in various parts of the cylinder head, by conducting the fresh coolant first to the hottest portions of the cylinder head and then diverting it to the cooler portions to carry the heat from the hotter portions to the cooler portions. According to the present method, however, it is sought to withdraw the high temperature cooling liquid from the cylinder head cooling chamber as rapidly as possible and elevate the operating temperature of the portions of the combustion chamber formed by the bottom compression wall 1 of the cylinder head near the passageways 73 and 74 and 93 and 94 by choking the cross-sectional area of such passageways to retard the flow therethrough of the cooling liquid. Thus there is a quantity of cooling

liquid of diminished heat capacity flowing over these portions of the combustion chamber and less heat is withdrawn and the average temperature of adjacent portions of the cylinder head and combustion chamber is raised. In addition to restricting the flow of cooling liquid by diminishing the cross-sectional area of the passageways 73 and 74 and 93 and 94 a similar result is accomplished by diminishing the relative cross-sectional area of the inlet pasages such as the passages D, E, L, and M.

In describing the control of the cooling liquid flow through the chamber 7 attention has been directed to the regulation of the rate and direction of flow by choke sections extending across the width of the head. Such choke sections are also provided across the length of the cylinder head, as appears in Fig. 2, both ends of the head being substantially symmetric about the transverse center line through the outlet 20. In the case of cylinder heads having a center outlet, like the embodiment illustrated, the control of the flow of cooling liquid transversely across the width of the cylinder head cooling chamber becomes of increased importance. However, the same principles described in connection with the control of the longitudinal flow apply and need not be repeated. Similarly, the relationship between the areas of the various inlets is regulated to obtain the desired rate and quantity of flow transversely across the cylinder head width. In this regulation the inlets A, D, H, L and R are the remote inlets, while the inlets C, F, G, K, N, P and T are the adjacent inlets, with respect to the cylinder head outlet 20. The principles governing the control of the flow by inlet size are the same for the transverse flow as for the longitudinal flow. In the embodiment illustrated this feature of the invention is shown in Fig. 3. Inlet or passage S adjacent the top side of the head, as viewed in that figure, is larger in area than the inlet or passage T adjacent the bottom side of the head. Also inlet or passage H adjacent the top side of the head is of greater area than the inlet or passage K adjacent the bottom side of the head. At the end of the cylinder head remote from the passages R and T the inlet or passage A adjacent the top side of the head, as viewed in Fig. 3, is of greater cross sectional area than the inlet or passage C adjacent the bottom side of the head. Each pair of passages mentioned are disposed substantially in line with one another across the width of the cylinder head and, accordingly, passages adjacent or along one side of the cylinder head may be said to be generally of greater cross sectional area than the passages along or adjacent the other side of the head.

While this invention has been described in connection with an internal combustion engine having an ignition device, it is to be understood that it may be applied advantageously to engines of the semi-Diesel or Diesel type. In a Diesel engine it is particularly desirable to have constant temperature at each cylinder and a substantially uniform temperature at all cylinders, since the cylinder temperature influences the time of ignition, which should occur regularly to obtain maximum performance and efficiency of the engine.

Although but a single embodiment of the invention has been illustrated, it is to be understood that various alterations and substitutions in the arrangement of the various parts is contemplated and intended to be practiced in carrying out the principles of the invention as described above.

What I claim is:

1. The method of cooling a multi-cylinder internal combustion engine, which comprises continuously flowing a liquid coolant over portions of the engine associated with the hot gases of combustion in a generally ascending direction from an inlet in the engine block to an outlet in the head, restricting the cross sectional area available for the flow at a plurality of successive stages in the path from the engine block inlet to the head outlet, regulating the relative total cross sectional area at each restricted stage to obtain a controlled flow of cooling liquid through all successive stages, and confining the cooling liquid between successive stages to regions under the influence of flow velocity from the preceding restricted stage, whereby all the cooling liquid is moved by the flow velocity developed at the restricted stages to eliminate pools of non-flowing cooling liquid.

2. For an internal combustion engine having a multiplicity of cylinders disposed in substantial alinement, a cooling liquid chamber extending substantially the entire length of the engine block in which the cylinders are formed, an inlet for receiving fresh cooling liquid, and means for forcing circulation of the cooling liquid, a cylinder head having top and bottom walls with a cooling liquid chamber between the walls, a plurality of combustion faces on the under side of the bottom wall, each overlying a combustion chamber of the engine associated with one of the cylinders, the head cooling liquid chamber being substantially continuous for the length of the engine block, a plurality of rows of post members extending through said head chamber between the top and bottom walls, and integrally formed therewith, said rows disposed transversely across the width of the cylinder head to provide a series of cooling liquid compartments, each extending across the width of the cooling liquid chamber, and the compartments being in intercommunication through passageways between posts of each row, said passageways in each row having cross sectional areas proportioned to direct the flow of cooling liquid over the hottest portions of the bottom wall in its course through the head chamber.

3. In an aluminum cylinder head having hot regions overlying combustion chambers and regions overlying combustion faces of the cylinder head of normally greater extent and cooler than the hot regions, a chamber for the circulation of cooling liquid, said chamber being continuous over a plurality of adjoining cylinders and having a plurality of liquid inlet openings adjacent each cylinder, a plurality of members extending through the chamber and forming with the walls of the chamber a plurality of passages for the flow of cooling liquid through the chamber, some of said members positioned adjacent hot regions and having sockets for ignition devices, a plurality of the passages lying in a cross section of the chamber through a hot regions and at right angles to the general flow of cooling liquid, each of said plurality of passages having an area proportioned to increase the flow of cooling liquid over the hot region and decrease the flow over cooler regions, and the portion of the chamber overlying said cooler regions being relatively shallow to increase the frictional resistance to flow of the cooling liquid

over such shallow portions relative to the resistance to flow over the hot regions.

4. In a multi-cylinder internal combustion engine having a cooling liquid jacket in an engine block, a chambered cylinder head overlying a plurality of cylinders and having top and bottom walls, and means for circulating a liquid coolant therethrough, the combination of a cooling liquid intake in the jacket of the block to receive fresh coolant, a cooling liquid outlet in the cylinder head, and inlet openings into the cylinder head chamber communicating with the cooling liquid jacket, said chamber overlying a plurality of combustion chambers and having a plurality of members extending therethrough between the top and bottom walls of the cylinder head, said bottom wall including a plurality of combustion faces, each overlying a combustion chamber and having a hot region of relatively small area and a relatively cool region of greater area than the hot region, sockets in some of the members for receiving ignition devices, each said socketed member positioned at a hot region, means associated with the portions of the cooling chamber overlying the relatively cool regions to restrict the relative flow of cooling liquid over such portions and increase the relative flow of cooling liquid over the hot region, said means comprising a top wall of the chamber positioned in relatively close proximity to the bottom wall of the chamber to provide a relatively shallow liquid passage having an increased frictional resistance to the flow of liquid coolant therethrough, inlet openings of relatively small area for admitting liquid coolant to the chamber to flow over cool regions and of relatively large area for admitting liquid coolant to the chamber to flow over hot regions, and the inlet remote from the intake of relatively larger area than those adjacent thereto.

5. The method of cooling a multi-cylinder internal combustion engine, which comprises continuously flowing a liquid coolant over portions of the engine associated with the hot gases of combustion in a generally ascending direction from an inlet in the engine block to an outlet in the head, restricting the cross sectional area available for the flow at a plurality of successive stages in the path from the engine block inlet to the head outlet, regulating the cross sectional area of the several passageways at each restricted stage with respect to one another to obtain a controlled velocity of flow through all of said passageways, and confining the cooling liquid between successive stages to regions under the influence of flow velocity from the preceding restricted stage, whereby all the cooling liquid is moved by the flow velocity developed at the restricted stages to eliminate pools of non-flowing cooling liquid.

6. The method of cooling a multi-cylinder internal combustion engine, which comprises continuously flowing a liquid coolant over portions of the engine associated with the hot gases of combustion in a generally ascending direction from an inlet in the engine block to an outlet in the head, restricting the cross sectional area available for the flow at a plurality of successive stages in the path from the engine block inlet to the head outlet, regulating the cross sectional area of the several passageways at each restricted stage with respect to one another to obtain a controlled velocity of flow through all of said passageways, regulating the relative total cross sectional area at each restricted stage to obtain a controlled flow of cooling liquid through all successive stages, and confining the cooling liquid between successive stages to regions under the influence of flow velocity from the preceding restricted stage, whereby all the cooling liquid is moved by the flow of velocity developed at the restricted stages to eliminate pools of non-flowing cooling liquid.

7. The method of cooling a multi-cylinder internal combustion engine having a jacketed cylinder block and a chambered cylinder head for the flow therethrough of a cooling liquid, with different portions of the head chamber overlying the several combustion chambers of the engine, which comprises continuously introducing cooling liquid into the jacket in the block, flowing the cooling liquid through the jacket in the block, simultaneously conducting the cooling liquid from the block jacket into the chamber in the head through a plurality of groups of individual courses, flowing the cooling liquid from all of the individual courses in the general direction of an outlet from the head chamber and in heat exchanging relation with portions of the cylinder head to be cooled, all of the cooling liquid flowing into the head chamber through all of said individual courses being moved substantially continuously solely in the general direction of the outlet substantially from the time it enters the cooling liquid chamber until it reaches the outlet, commingling the cooling liquid in the head chamber from a first group of the individual courses, simultaneously flowing different portions of the commingled cooling liquid in the general direction of the outlet from the head chamber and over a plurality of separate courses comprising a first control section in the head chamber, proportioning the relative cross-sectional areas of said separate courses with respect to one another to cause the several quantities of cooling liquid flowing thereover to be proportional to the quantities of heat to be removed from the portions of the cylinder head adjacent each of the courses, commingling the cooling liquid from the several courses of said first control section with cooling liquid introduced into the head chamber through a second group of the individual courses from the block jacket, simultaneously flowing different portions of the last named commingled cooling liquid in the general direction of the head outlet and over a plurality of separate courses comprising a second control section in the head chamber spaced from said first control section in the general direction of the head outlet, proportioning the relative cross-sectional areas of the separate courses of the second control section with respect to one another to cause the relative quantities of cooling liquid flowing thereover to be proportional to the quantities of heat to be removed from the portions of the cylinder head adjacent each of the courses, commingling the cooling liquid from courses of said second control section with cooling liquid introduced into the head chamber through a third group of individual courses from the block jacket, flowing the last named commingled cooling liquid in the general direction of the outlet and over portions of the cylinder head to be cooled, and conducting the last named commingled cooling liquid out of the head chamber.

8. In a multi-cylinder internal combustion engine, an engine block having sides and ends and a plurality of cylinders disposed in substantially side by side relation, a cooling liquid jacket in the block in heat exchanging relation with the

cylinders, a cylinder head overlying the cylinders and having ends and sides disposed adjacent the ends and sides respectively of the block, a cooling liquid chamber formed in the head and extending longitudinally of the engine and across the ends of the cylinders, an intake at one end of the block for admitting coolant to the jacket, an outlet at one side of the head for discharging liquid from the chamber, a multiplicity of distributed passages between the jacket and chamber, the passages adjacent the end of the jacket remote from the inlet being generally of greater cross sectional area than the passages adjacent the inlet, and the passages adjacent one side of the head being generally of greater cross sectional area than the passages adjacent the other side of the head, and pump means for circulating coolant through the jacket and chamber.

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