May 26, 1936. F. LUKER 2,041,940

COMBUSTION CHAMBER CONSTRUCTION FOR INTERNAL COMBUSTION ENGINES

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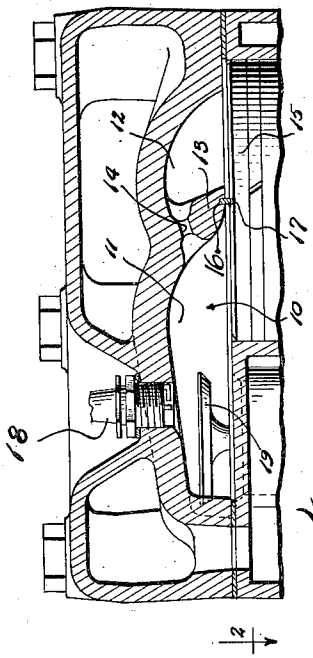


Fig. 2.

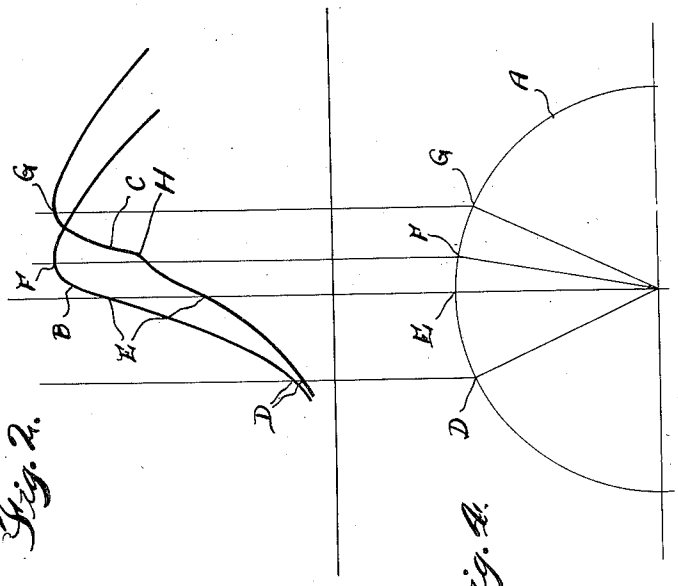


Fig. 4.

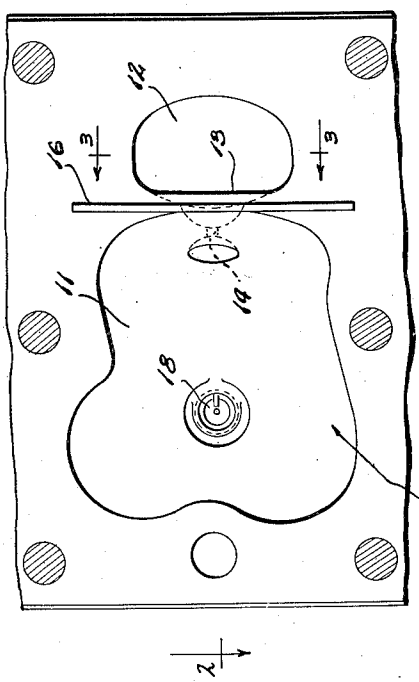


Fig. 1.

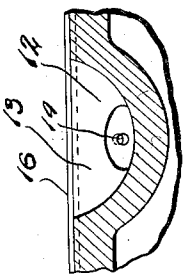


Fig. 3.

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COMBUSTION CHAMBER CONSTRUCTION FOR INTERNAL COMBUSTION ENGINES

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10 Claims. (Cl. 123—191)

This invention relates generally to internal combustion engines and refers more particularly to improvements in the combustion chambers of such engines.

With the steadily increasing demand for lighter and more powerful engines, considerable attention is being concentrated on combustion chamber design since raising the compression ratio of combustion chambers affords one means for increasing the power output of an engine without materially increasing the weight of the latter.

Unfortunately, merely raising the compression ratio of an internal combustion engine does not necessarily result in an increase in power output of the engine especially when non-premium fuels, or fuels free from the so-called anti-knock ingredients, are employed in operating the latter, since the rate of burning of such fuels in a combustion chamber increases as the compression ratio increases. Increasing the rate of flame travel effects an increase in the rate of pressure rise per degree of crank travel with the result that peak pressure will be reached in the chamber when the crank is closer to its top dead center position and accordingly any increase in pressure resulting from raising the compression ratio, instead of actually raising the power output of the engine may be entirely sacrificed in supplying the additional torque required to compensate for loss in leverage resulting from applying maximum pressure to the crank when the latter is at a point relatively close to its top dead center position. Thus it must be admitted that combustion control is a definite restriction to the extent to which the compression ratio may be raised, and any attempt to increase this ratio above the limit established by the foregoing factors merely results in practically no gain in power output and excessive roughness in engine performance.

The present invention contemplates a chamber of such design as to permit accurately controlling the rate of pressure rise per degree of crank travel irrespective of the compression ratio, and thereby renders it possible to employ ratios considerably higher than heretofore thought commercially practical, without sacrificing the combustion control necessary in order that the increase in pressures resulting from higher compression ratios will be reflected in the power output of the engine free from combustion harshness or roughness instead of being lost in overcoming the less advantageous crank angle usually synonymous with higher compression ratios.

In accordance with this invention, the rate of pressure rise per degree of crank travel is definitely controlled by the provision of means in the chamber for effecting a lag in the rate of burning of the fuel so that the interval of time between ignition and peak pressure is delayed to such an extent as to permit the crank to assume an advantageous position past the top dead center position before maximum pressure is applied to the same.

More specifically, the present invention contemplates dividing the chamber into two parts; or, in other words, consists in separating the last portion of the charge to burn from the first portion of the charge to burn and establishing communication between said portions through the medium of an opening or port restricted to such an extent as to retard free transmission of the pressure built up by the burning charge in the first portion of the chamber to the second part of the chamber containing the last fuel mixture to burn. The result is that the pressure built up by the burning charge in the first part of the chamber is prevented from materially influencing the rate of pressure rise of the last fuel mixture to burn. This construction not only provides for reducing the rate of pressure rise per degree of crank travel, but also minimizes the tendency of the chamber to detonate since it is well established that detonation is initiated in a combustion chamber at the extreme end of the flame travel due to the compression of some relatively small portion of the unburned charge by the approaching flame.

In addition to the foregoing, this invention contemplates a combustion chamber of the type previously set forth so designed as to provide for completely filling the cylinders of the engine with fuel mixture and to otherwise improve the performance of same.

With the foregoing, as well as other objects in view, the invention resides in the peculiar construction of the combustion chamber which will be made more apparent as this description proceeds, especially when considered in connection with the accompanying drawing wherein:

Figure 1 is a fragmentary elevational view of the combustion chamber surface of a cylinder head;

Figure 2 is a cross-sectional view taken substantially on the line 2—2 of Figure 1;

Figure 3 is a sectional view taken on the plane indicated by the line 3—3 of Figure 1;

Figure 4 is a diagram to be more fully explained hereinafter.

Although it will be apparent as this description proceeds that the combustion chamber embodying the inventive principles involved herein may be advantageously employed in association with various types of cylinder heads, nevertheless, I have shown the same herein, for the purpose of illustration, as employed in connection with a water-cooled cylinder head of the L type. Before going into a detailed discussion of the combustion chamber, reference will be made to Figure 4 of the drawing in an effort to illustrate diagrammatically the effect that increasing the rate of flame travel by raising the compression rate has on the interval peak pressure is reached in relation to the degree of crank travel.

In Figure 4 of the drawing, I have illustrated two pressure rise curves of two combustion chambers in relation to the path of travel A of an engine crank. The curve designated by the character B indicates the pressure rise of a combustion chamber design considered commercially satisfactory by the trade and the curve "C" represents the pressure rise of a chamber designed in accordance with this invention. The points "D", "E", "F", and "G" on the above curves respectively represent the point at which ignition takes place; the pressure at the top dead center position of the crank; the point past dead center peak pressure is reached in a chamber having the curve "B" and the point past dead center peak pressure is reached in a chamber having the curve "C". Projecting the aforesaid points down upon the path of travel "A" of the crank reveals the fact that the point "G", or the point at which peak pressure is reached on the curve "C", is located at a greater angle past dead center than the corresponding point "F" on the curve "B", with the result that considerably greater effort would have to be exerted at the point "F" than at the point "G" in order to transmit the same torque to the crank. Consequently, even though the two aforesaid chambers have substantially the same compression ratio, the one having the curve "C" or the one embodying the principles of this invention will transmit an appreciably greater amount of torque to the crank due to the more advantageous leverage at which the maximum pressure is applied.

As a matter of fact, it is entirely possible to have a condition wherein a combustion chamber embodying the principles of this invention may have a lower compression ratio than the conventional chamber represented by the curve "B" and actually produce more useful work than the chamber of higher compression ratio, since the rate of flame travel in the former is less than the rate of flame travel in the latter, and accordingly peak pressure in the chamber of relatively low compression ratio is effected when the crank is at a greater distance past the top dead center position than the corresponding peak pressure of the higher compression chamber.

In view of the foregoing, the desirability of controlling combustion in such a manner that maximum pressure is applied to the crank at a greater angle past the top dead center position of the latter, is apparent since it offers the possibility of increasing the torque in an amount proportionate to the rise in the compression ratio.

In the present instance, the foregoing is accomplished by a combustion chamber so constructed as to virtually divide the last portion of the charge to be burned from the first portion of the charge in such a manner as to provide for igniting the former charge upon completion of the burning of the latter charge, and to prevent the burning charge from rapidly building up the pressure of the unburned charge. This arrangement not only provides for obtaining the desired combustion control, but in addition, minimizes the tendency for the chamber to detonate since the last portion of the fuel mixture to burn is not influenced by the burning charge to such an extent as to cause the former mixture to reach an abnormal pressure. This feature in itself permits obtaining higher compression ratios than heretofore thought commercially possible and, when combined with the arrangement for controlling combustion, provides for increasing the torque proportionately. In detail, the combustion chamber is designated in the several figures of the drawing by the reference character **10**, and comprises two distinct portions exemplified in Figure 2 by the reference characters **11** and **12**. The portion **11** establishes communication between the valve gallery of the internal combustion engine and the adjacent cylinder of the latter, while the portion **12** is of comparatively less volumetric capacity, and also communicates with the cylinder of the engine. The ratio of the volume of the portion **11** to the volume of the portion **12** will vary in dependence upon the compression ratio and the lag it is desired to effect in attaining maximum pressure. Consequently, it should be understood that, in the specific embodiment of the invention, the relative volumes of the two aforesaid portions of the chamber are especially calculated for one application only, and may be varied in accordance with the results desired.

The two portions **11** and **12** of the chamber **10** are separated by a partition **13** extending transversely of the chamber over the cylinder of the engine and establishing communication between the two portions of the chamber by means of a restricted port or opening **14**. Of course, the two aforesaid portions of the combustion chamber will also communicate with each other around the lower end of the partition **13**, but since the latter end of the partition is arranged flush with the bottom face of the head, it necessarily follows that only a very restricted opening will exist when the piston **15** in the cylinder is at its top dead center position as shown in Figure 2 of the drawing. However, in certain instances the area of this opening may prove detrimental, and in such cases, means may be provided for sealing the space between the lower end of the partition and piston when the latter is at its top dead center position. Although various types of seals may be employed for accomplishing this result, nevertheless, for the purpose of illustration, I have shown the same as comprising a strip **16** of relatively soft metal, such as copper, embedded within the lower end of the partition in such a manner as to project a sufficient distance below the partition to engage the piston in the uppermost position of the latter. The strip **16** extends for substantially the full width of the combustion chamber, and if desired, the piston may be slotted as at **17** to receive the projecting edge of the strip in the manner shown in Figure 2.

Obviously, in cases where the fuel mixture in the combustion chamber is ignited before the piston reaches top dead center position, a certain amount of pressure will be transmitted to the last fuel mixture to burn in the portion **12** of the chamber by the burning charge in the portion **11**, but this pressure does not become critical until the final burning of the fuel mixture in the latter portion of the chamber, and in view of the fact

that at this time the desired seal is effected between the partition and the piston, the restricted port 14 affords the only communication between the two portions of the chamber. Because of the fact that the port 14 forms the only communication between the portions of the chamber, the cross-sectional area, or diameter, of the latter is highly critical, and is so determined as to permit transferring the flame from the portion 11 to the portion 12, and to prevent free transfer of gases under pressure therethrough. In other words, the relatively small cross-sectional area of the port 14, together with the rapid rate of flame propagation, materially restricts the transfer of gases under pressure from the first portion of the fuel mixture to burn in the section 11 of the chamber to the last portion of the fuel mixture to burn in the section 12 of the chamber.

The fuel mixture in the portion 11 of the chamber is ignited on the compression stroke of the piston 15 in the usual manner by the means of a suitable spark plug 18, and the charge in this portion of the chamber is substantially completely burned before the flame ignites the fuel mixture in the portion 12 through the restricted port 14. As the fuel mixture in the portion 11 is burning, the pressure in this portion of the chamber becomes greater, but due to the restricted nature of the port 14 and the short time interval involved in burning, the rate at which the charge in the portion 12 of the chamber is compressed by the flame front is materially retarded with the result that maximum pressure is not attained until the piston begins its working stroke; or, in other words, until the crank assumes a substantial distance past the top dead center position thereof. This lag in the rate of pressure rise effected by the partition is clearly shown by the interruption of the curve "C" at the point "H". Inasmuch as the cross-sectional area of the port 14 controls, to a large extent, the influence of the burning charge in the portion 11 of the combustion chamber on the building up of the pressure in the portion 12, it will be apparent that varying the cross-sectional area of the port offers the possibility of varying the rate of pressure rise per degree of crank travel.

It will be observed that the foregoing construction provides for obtaining higher compression ratios, and at the same time permits controlling the rate of pressure rise per degree of crank travel so that substantially the entire force afforded by increased compression pressures will actually be employed to increase the efficiency or work output of the engine. In addition, to the foregoing, it is to be noted that the particular shape of the portion 11 of the combustion chamber shown in Figure 1 is such as to provide for uninterrupted flow of the fuel mixture from the intake valve 19 to the cylinder of the engine with the result that the filling characteristics of the latter are greatly increased.

What I claim as my invention is:

1. In an internal combustion engine, a cylinder head having a combustion chamber divided into two portions by a partition and communicating with each other through the medium of an opening through the partition of a size sufficient to permit the flame of the burning charge in one portion of the chamber to pass into the other portion to ignite the charge in the latter but to retard compression of the charge in said second named portion by the flame front in the first named portion of the chamber.

2. In an internal combustion engine, a cylinder head having a combustion chamber divided into two portions of predetermined volumetric capacity by a partition and communicating with each other through the medium of an opening through the partition of such a size as to materially retard the flow of burning fuel mixture under pressure from one portion of the chamber to the other but to permit the flame to pass readily from one portion of the chamber to the other.

3. In an internal combustion engine having a cylinder and having an intake port adjacent the cylinder, a piston in said cylinder, a cylinder head formed with a combustion space having two chambers both communicating with the cylinder, one of the chambers registering with the intake port and the other of said chambers being adapted to contain the last fuel mixture to burn and communicating with the first mentioned chamber through the medium of an opening restricted to retard the passage of fluid under pressure from the first to the second named chambers, and means cooperating with the piston in said cylinder to form a seal between said chambers.

4. In an internal combustion engine having a cylinder and having an intake port adjacent the cylinder, a piston reciprocally mounted in said cylinder, a cylinder head formed with a combustion space having two chambers both communicating with the cylinder of the engine, one of the chambers being adapted to register with the intake port and the other of said chambers being adapted to contain the last fuel mixture to burn, a partition separating the two aforesaid chambers and having an opening therethrough restricted to retard the rate of pressure rise per degree of engine crank travel, and means sealing the space between the end of the partition and head of the piston when the latter is in its uppermost position.

5. In an internal combustion engine having a cylinder bore and having an intake port adjacent the bore for supplying fuel mixture thereto, a head provided with a combustion space establishing communication between the intake port and cylinder bore and composed of two chambers, one of the chambers being in direct communication with the intake port for receiving the fuel mixture and the other of the chambers being adapted to contain the last portion of the fuel mixture to burn in the combustion space, an ignition device associated with the first named chamber, and a partition separating the chambers having an opening therethrough of a size accurately predetermined to appreciably retard the rate of compression of the last fuel mixture to burn in the second named chamber by the flame front in the first named chamber and to permit the flame in the first chamber to pass through the partition into the second chamber for igniting the fuel mixture therein.

6. In an internal combustion engine having a cylinder bore and having an intake port adjacent the bore for supplying fuel mixture thereto, a head provided with a combustion space establishing communication between the intake port and cylinder bore and comprising two chambers, one of said chambers communicating with the intake port for receiving the fuel mixture therefrom and the other of the chambers being adapted to contain the last fuel mixture to burn, an ignition device associated with the first named chamber, and means in the combustion space separating the two chambers including a partition so disposed in the space that the chamber communicating with the intake port possesses a substantially greater volume than the other

chamber and having an opening therethrough of a cross sectional area predetermined to appreciably retard the rate of compression of the last fuel mixture to burn in the second named chamber by the flame front in the first named chamber and to permit the flame to pass readily from the first to the second chamber for igniting the fuel mixture in the latter.

7. In an internal combustion engine having a cylinder bore and having an intake port laterally offset from the cylinder bore, a piston mounted for reciprocation in the bore, a cylinder head having a combustion space therein establishing communication between the intake port and cylinder and consisting of two chambers, one of said chambers being arranged in direct communication with the intake port for receiving fuel mixture therefrom and having a portion overlying the cylinder bore and the other of said chambers also communicating with the cylinder bore and being adapted to contain the last fuel mixture to burn, an ignition device associated with the first named chamber, means in the combustion space cooperating with the piston in the top dead center position of the latter to separate said chambers including a partition formed with an opening therethrough having a cross sectional area predetermined to appreciably retard the rate of compression of the last fuel mixture to burn in the second named chamber by the flame front in the first chamber to effect a lag in the rate of pressure rise per degree of engine crank travel and also predetermined to permit the flame in the first chamber to pass readily into the second chamber for igniting the fuel mixture in the latter.

8. In an internal combustion engine, a cylinder head formed with a combustion chamber therein and having means for retarding the rate of pressure rise per degree of crank travel including a partition dividing a portion of the last fuel mixture to burn in the chamber from the first fuel mixture to burn and having an opening therethrough of a cross sectional area predetermined to retard the rate of compression of the last fuel mixture to burn by the first fuel mixture to burn and also predetermined to permit the flame to pass readily through the partition for igniting the last fuel mixture to burn.

9. In an internal combustion engine of the reciprocating piston type having a combustion chamber, means for igniting fuel mixture supplied to the chamber, and means in the chamber operable upon ignition of the fuel mixture therein to retard the rate of pressure rise per degree of piston travel including a partition in the chamber cooperating with the head of the piston in the top center position of the latter to divide the portion of the chamber adapted to contain the last fuel mixture to burn from the portion of the chamber adapted to contain the first fuel mixture to burn and having an opening therethrough establishing communication between the two aforesaid portions.

10. In an internal combustion engine having a cylinder and having intake and exhaust ports adjacent the cylinder, means establishing communication between the ports and interior of the cylinder bore including a combustion chamber having a portion overlying the ports and a part of the cylinder bore in direct communication with the latter and having another portion overlying the cylinder bore beyond the portion aforesaid also in direct communication with the bore, and means separating the portions aforesaid of the chamber including a partition extending transversely to the direction of flow of the fuel mixture from the intake port to the cylinder and having an opening therethrough restricted to retard the rate of pressure rise per degree of engine crank travel on ignition of the charge in one of the portions aforesaid of the chamber.

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