Aug. 10, 1943. J. O. CAMP 2,326,329

INTERNAL COMBUSTION ENGINE

Filed June 29, 1940 2 Sheets-Sheet 1

Fig. 1

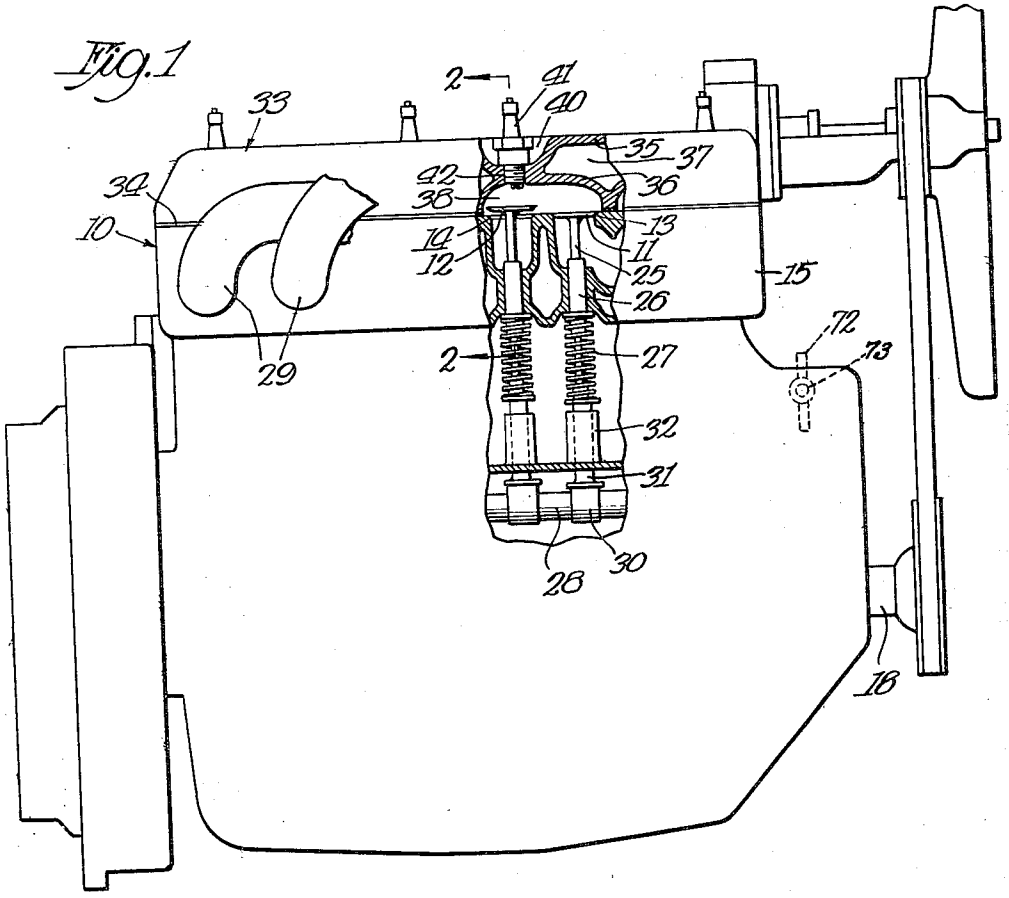


Fig. 2

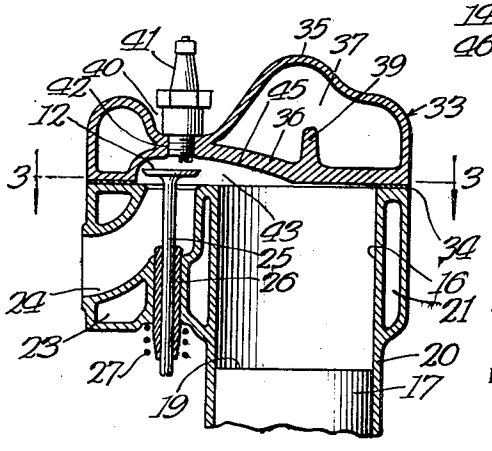
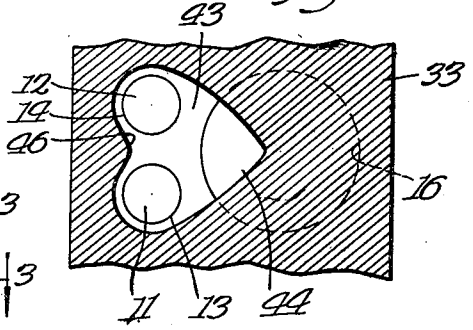


Fig. 3



INVENTOR.
Joseph O. Camp
BY
Mann Brownell Cox
ATTYS.

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Fig. 4

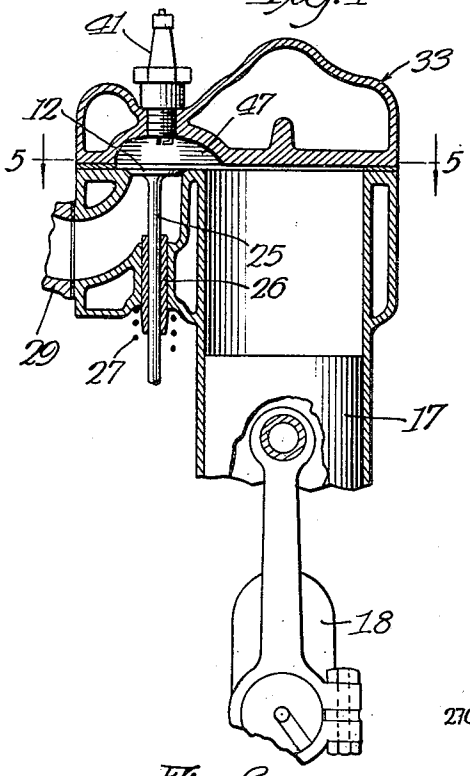


Fig. 5

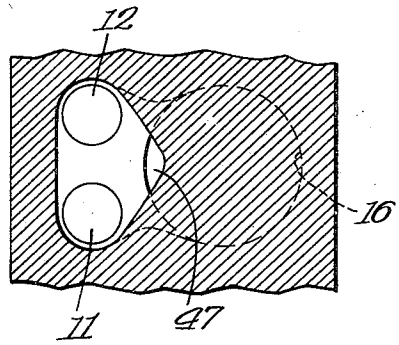


Fig. 6

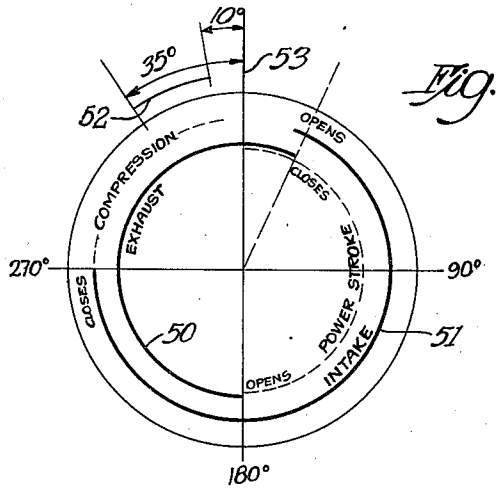


Fig. 8

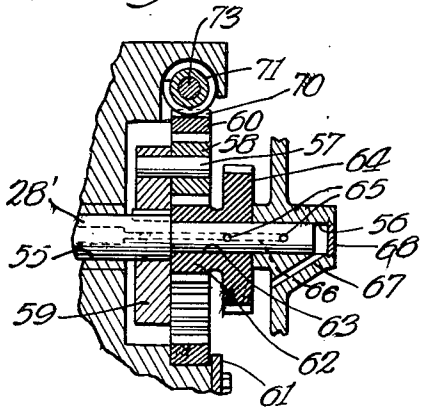
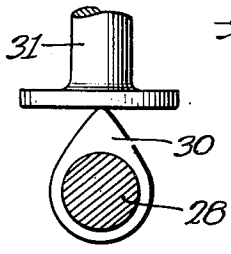


Fig. 7



INVENTOR.
Joseph O. Camp
BY
Mann Brownlee & Cox
ATTYS.

Patented Aug. 10, 1943

2,326,329

UNITED STATES PATENT OFFICE

2,326,329

INTERNAL COMBUSTION ENGINE

Joseph O. Camp, Oak Park, Ill.

Application June 29, 1940, Serial No. 343,087

15 Claims. (Cl. 123—105)

The present invention relates to improvements in internal combustion engines and also to certain improvements in the construction, arrangement and operation of parts thereof.

It has often been said that the way to higher engine efficiencies lies through higher compression ratios combined with manifold and valve designs that afford high volumetric efficiency so that a higher pressure results in the cylinder at the end of the compression stroke when ignition takes place.

However, higher compressions have functioned best only with high speed motors, such as in racing cars, and are not entirely acceptable in passenger vehicles where low and idling speed requirements are imposed upon the motor. At low speeds, unpleasant, uneven power impulses are noticeable, leakage of gas, frictional losses and, in some instances, heat losses are detriments accompanying higher compression ratios in motors for passenger vehicles.

Consequently, although theoretically, peak compression pressure in a cylinder, as distinguished somewhat from compression ratio, is to be desired, the maximum acceptable for commercial purposes is limited by the design of the motor that eliminates hot spots and other factors or results which are referred to generally as detonation.

It is one of the objects of the present invention to provide an improved design and operation of a motor vehicle engine, including or affording a higher compression pressure than heretofore used commercially in motor vehicles.

A further object is to provide a motor that features a very high compression pressure which runs smoothly at low speeds and can be accelerated to, and run at, high speeds without faltering even under heavy load rating conditions.

Moreover, I provide an internal combustion engine which develops an extreme high compression pressure under loads without detonation.

One of the objects of the invention is to provide an improved cylinder head construction and valve timing whereby improved turbulence and homogenization are accomplished for the mixing of the fuel and air forming the combustion mixture.

Another object is to provide certain timing characteristics for the valve action of an internal combustion engine which in combination with a high compression afford a longer and stronger power delivery for the pistons upon their power strokes and a smoother running motor.

Another object of the invention is to provide an improved cylinder and head construction wherein the exhaust gases are evacuated more completely from the compression chamber and dilution of the next charge by residual gases is correspondingly reduced, particularly at high speeds of engine operation.

Another feature of the invention is the provision of an engine construction wherein carbon deposits are practically eliminated from the piston head, the cylinder head and the compression chamber.

Another object of the invention is the provision of an improved combustion engine characterized by a high compression ratio as much as 12 to 1; by a piston subjected to the pressure of combustion throughout substantially its entire stroke; by substantial economies attained for unit of fuel consumption per horsepower; by greatly reduced pulsation vibration and, by an arrangement whereby the motor may be started with a minimum amount of effort.

Another object of the invention is to provide a cylinder head construction and a valve timing arrangement which may be employed to convert conventionally built engines to embody the improvements of the present invention with little change in construction and with a minimum amount of effort.

A further object of the invention is to provide a construction wherein an internal combustion engine is so constructed and arranged that adjustment of the valve timing may be had during operation of the motor, either to accommodate variations in atmospheric pressure, or other conditions to which the motor might be subjected in operation.

These being among the objects of the invention, other and further objects will become apparent from the drawings herein, the description relating thereto and the appended claims.

Referring now to the drawings:

Fig. 1 is a side elevation of a four cylinder motor, cut away in part to illustrate the head and valve construction as embodying one form of the invention;

Fig. 2 is a section taken on the line 2—2 in Fig. 1;

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

Fig. 4 is a view similar to Fig. 2 showing another form of the invention;

Fig. 5 is a section taken on the line 5—5 in Fig. 4;

Fig. 6 shows diagrammatically the preferred timing of the valve openings and closings;

Fig. 7 shows a valve cam and tappet which is employed in the valve train of the invention;

Fig. 8 is a section illustrating a construction whereby the setting of the valve timing may be changed while the engine is in operation.

Although, in some respects, it is not possible, at the present time to account fully for the improved results which are attained by the method, construction and arrangement provided for in this invention, it should be understood that any attempt herein to analyze theories that are believed to be responsible for these results is to be construed as not defining a mode of operation, but merely as a possible explanation of certain physical phenomena which has been observed.

The present invention may be used with engines having a single cylinder, but I prefer to show the invention as embodied in an engine having more than one cylinder, and the particular engine I have chosen is a four cylinder engine 10 of the L-head type wherein the inlet valve 11 and the outlet valve 12 and ports 13 and 14 therefore, respectively, are located in the block 15 to one side of the cylinder 16 (Fig. 2). A piston 17 is mounted for reciprocation in the cylinder in the usual manner by a crank shaft 18, and the head 19 of the piston is substantially level with the top of the cylinder at top dead center. The valve ports preferably have 30° angle seats and can be constructed with inserts if desired.

The block 15 is a single casting of a cast gray iron and nickel alloy, with separate cylinder barrels 20 surrounded by an integral water jacket 21. A gallery 23 is provided in the casing and has separate passageways 24 leading from a carburetor (not shown) or to an exhaust pipe (not shown) through separate manifolds 29 to the ports 13 and 14.

The passage of fuel and air from the carburetor to the ports is unrestricted, except for the conventional main throttle valve (not shown) of the carburetor, and both valves 11 and 12 are streamlined, poppet valves with their stems mounted in guides 26 that are disposed in the gallery 23 where compression springs 27 act upon the stem ends to seat the valves.

The valves are opened and are permitted to close by valve tappets 31 mounted for reciprocation in bosses 32 which are cast integral with the block 15 as driven by a cam shaft having cams 30 thereon which contact the bottoms of the tappets.

The engine head is indicated by the numeral 33 and is secured to the block, with a gasket 34 therebetween, by conventional stud and nut assemblies 34.

The head 33 comprises a construction of heat treated aluminum having an upper and lower wall 35 and 36, respectively, defining a water jacket 37 in which cooling fins 39, serving as reinforcing flanges, are disposed. Recesses 38 are provided in the lower wall which will be hereinafter referred to as the compression chambers, and depressions 40 are provided in the upper wall to receive spark plugs 41, preferably above the exhaust valves 12, where they are secured by threads in the openings 42.

Referring now to Figs. 2 and 4, two forms of combustion chambers are shown in sectional views that are taken transversely of the motor. In Fig. 2 the chamber 43 is very low and extends out over the cylinder a distance less than the radius thereof but, by way of comparative dimensions, is in total length approximately the diameter of the piston. The portion 44 extending over the cylinder is substantially V-shaped horizontally, as shown in Fig. 3, and the dome 45 of the combustion chamber over the valves is barely high enough to permit opening of the valves with a safe clearance. The volume of the combustion chamber is less than 10% of the displacement of the piston.

In order to attain this compression ratio, or one that is even higher, though below the compression-ignition point of the combustible mixture, I employ a streamlined boss 46 in the head to take up space otherwise present in the combustion chamber, wherever replacement heads, embodying characteristics of the invention, are supplied to convert conventionally constructed engines that permit or require it. The boss 46 and its size are limited by the spacing of the valves, but this is not a problem where the engine is originally constructed to embody the invention. In that instance, the head room is approximately slightly greater than the lift of the valve, otherwise being streamlined to assist in developing turbulence.

In this particular construction shown for purposes of example, the piston displacement is approximately 50 cubic inches, and the compression chamber is constructed with a volume as little as 4.5 cubic inches to provide upwards to approximately a 12 to 1 compression ratio rating for commercial engines. The invention is described in this relationship since as will be seen from Fig. 6 and described later, I provide a partial blow-back through the inlet valve, of mixtures drawn into the cylinder, and, in the embodiment shown in Fig. 8, the degree of the blow-back can be varied according to engine operating conditions.

In Fig. 4, I provide a combustion chamber which opens to a space over the cylinder a distance less than the radius of the valve and preferably only enough to provide for the flow of gas through the throat 47 thereof that is approximately equal to the gas flow volume available through the valves under vacuum factors imposed on the mixture by the action of the piston on the suction stroke.

In this particular embodiment, the turbulence is augmented and the volume of the combustion chamber is as little as 8% of the piston displacement. The chamber is more compactly arranged in a way providing minimum surface area for the volume thereof and also provides the shortest distance the flame front of ignition has to travel before all the gases are in flame.

Aside from the greater complicity of parts and constructions involved with valve-in-the head engines, the valve-in-the head type lends itself to the construction or adaptation of the invention because there the thin layers of compressed gas, trapped between the head and piston, can be greatly minimized as compared with the L-head motor. Moreover, no provision for a throat between the compression chamber and the cylinder need be made in the valve-in-the head motor since one side of the chamber can be the piston head itself, whereas with the L-type head the combustion chamber is located at one side of the chamber and requires a throat. On the other hand, turbulence is augmented in the L-head motor and the invention has been illustrated with this type of engine which presents the greatest number of problems that happens to be involved for the purposes at hand.

In determining the potential area of the throat

47, the space provided between the head and the top of the cylinder by the gasket thickness can be utilized also for the passage of gas. Although flow through this narrow space is retarded in proportion to the depth of the narrowness as the lines of the cylinder and head compartment contours diverge from the throat, the surge created that causes the flow of air through this space and the throat serves to produce a scouring effect that washes away the stagnant, slow-burning film which lies in contact with the walls of the combustion chamber. This film is generally the cause of carbon deposits and by breaking it up, each cycle of the engine, practically eliminates the deposit of carbon as part of the invention.

Referring now to Fig. 6, the preferred timing of the valves is shown. The period when the exhaust valve is open is indicated by the numeral 50. The timing of the inlet valve is shown by the numeral 51 and the time of "firing" by line 52 where top dead center of the piston is located at 53. Although I prefer to provide the cycles of the valve actions, as shown, conventionally constructed cam shafts, may be employed with my invention if they are retarded in their function by a resetting of the gear mesh timing so that they operate substantially as shown in relation to the piston movement. The results attained are comparable insofar as readapting old engines are concerned, although better results are attained where the engine is originally constructed according to the teachings of the invention.

The cams 30 are constructed at the nose to provide open periods indicated and preferably are of the quick opening type wherein the cam profile is of the mushroom type, wherein the cam faces are slightly convex.

In describing the operation of the invention as described thus far, it will be assumed that the crank shaft is in full motion and the crank for a particular cylinder is at top dead center 53. At this point the piston has done all it can to drive out the burnt gases. Residual gases which have not already escaped are subjected to a slight pressure, at this point, as somewhat induced by back pressure in the exhaust manifold, and if the exhaust valve is left open long enough, the inertia set up for the column of burnt gases throughout the exhaust passageway by the rapid rise of the piston, which effect may be referred to hereinafter as the inertial effect, will operate to evacuate the compression chamber. This inertial effect which is slight at low speed but increases considerably at high speed, serves to reduce the residual content of the combustion chamber beyond that capable by mere piston movement.

The time provided for the closing of the exhaust valve is at approximately 25° of top dead center. Thus, I maintain the open period of the valve slightly beyond the point where the inertial factor mentioned is exerting its greatest effect when the engine is operating at medium speed. This provides a margin of operation sufficient to cover the inertial function of the moving gas when the motor is being operated at high speeds.

Moreover, the piston does not move down far enough to start a substantial suction until after the exhaust valve has closed far enough that there is little danger of exhaust gases being drawn back into the compression chamber, and this avoids the effect experienced with conventional engines where the exhaust valve is almost, if not completely closed just as maximum inertial movement of the burnt gases is attained. In conventional engines, even with a so-called late closing valve, the maximum inertial factor works against a very narrow opening, a narrowness that retards the effect thereof at the expense of a better evacuation.

The point of exhaust valve closing is hastened in conventional engines so that emphasis can be put upon the earliest possible opening of the intake valve. In view of the fact, however, that with a smaller combustion chamber, less dilution will be present than with conventional chambers, the earliness of the intake valve opening may precede the closing of the exhaust valve slightly so that any vacuum beginning in the cylinder will soon be satisfied with the earlier state of a wider opening of intake valve at that instant. However, a slight overlap is desirable but not necessary for the correct functioning of the invention. Engine operating conditions, as thus designed, which tend to prevent the cylinder receiving a conventional charge are of slight consequence in the present invention when considered in relation to the point at which the intake valve closes in the present invention.

The vacuum created by the descending piston is augmented by the fact that the volume of residual burnt gases is much less than conventionally present because of the greater ratio existing between the size of the combustion chamber and the piston displacement. As a consequence, the vacuum is effective earlier and is greater. The results follow that the flow rate of incoming gas is augmented and the dilution is reduced by the construction shown.

In the manner similar to the inertia factor existing with the moving column of exhaust gases, the column of incoming fresh gas has an inertial factor which continues after bottom dead center is reached by the piston and after the vacuum has been relieved as much as permitted by the piston in its rapid return movement.

The intake valve remains open to permit the continuing vacuum and the inertial flow to be effective for a short period of time. Thereafter, in conjunction with the length of time the inlet valve is open, the upward movement of the piston assists in relieving the vacuum and also creating an initial pressure on the compression stroke which blows a portion, if excess is present, of the gas back into the intake manifold before the intake valve closes. The closing of the intake valve is timed to take place about the middle of the compression stroke.

After the intake valve closes, compression takes place and the compressed mixture is ready for ignition. I locate the point at which ignition takes place where it insures that the gas is all in flame and develops maximum pressure in the cylinder by the time the piston is passing top dead center. In view of the fact that the mixture does not burn instantaneously but requires time for the flame front to penetrate the chamber complete, the timing of the ignition is ahead of top dead center.

In the invention, the ignition is timed as indicated by the numeral 52 (Fig. 6), to occur from 10° at slow speeds to 35° at high speeds in advance of top dead center. However, with the modification shown in Fig. 4, the spark advance need not be as much as 35° at high speeds since

the distance the flame front has to travel to complete combustion is less than that for the embodiment shown in Fig. 1.

The power stroke is then begun and I prefer to have it last for the full length of the stroke. In this connection, I find that where cams are constructed to hold the valve open for an arc of crank rotation in excess of 180°, it is more to be desired to have the open period of the exhaust valve timed to continue over top dead center, as shown in the invention than timed to open before bottom dead center is reached as conventionally provided. The benefits in the degree of evacuation derived at the critical point of top dead center of the piston where the residual contents are reduced to their smallest volume and therefore the effective evacuation pressure and inertia induced by the upward movement of the piston is the greatest, is of greater benefit than the advantage to be gained in opening the valve before the power stroke is completed and full effectiveness thereof attained. Moreover, by opening the exhaust valve at bottom dead center, it is opened against a pressure where that pressure is at its minimum.

I also find that this arrangement reduces pulsation vibration in the engine. From what I can discover, this is due to the long power stroke and confining the compression of fresh gases to the last quadrant of revolution before top dead center is reached by the piston where the crank angle factor diminishes as the compression induced increases. Limitation of compression to this last quadrant also minimizes leakage of compressed gases.

Moreover, substantial economies are attained since the blowback from one cylinder creates a turbulence in the intake manifold that is augmented by and assists in the intake of gases in the next opening cylinder on the suction stroke thereof already begun by that time. The blowback assists in homogenization of the fuel in the manifold with the speed of the motor varying the degree thereof in relation to the closing of the intake valve and the period of time permitted for the vacuum to be effective.

The higher compression of gases in a more closely confined space attendant with better homogenization and turbulence, practically eliminates carbon deposits in the engine. This increases the time between spark plug replacement and eliminates overhauls for the removal of carbon; moreover, enables savings in fuel due to reduction of the waste factor involved in setting all conventional carburetors to provide a safe fuel margin for operation. In fact, with the present invention even in cold weather I have found that one choking of the engine is enough to start it and no extra gas is needed thereafter during even the warm-up period.

Referring now to Fig. 8, I have illustrated how certain features of the invention can be adapted to work with conventional cylinder heads, or between certain limits, how an internal combustion engine embodying the invention may be employed to increase the relative volumetric intake as where the engine is used for aeroplane propulsion at high altitudes.

In Fig. 8, the cam is propelled by an epicyclic gear train in which the cam shaft carries the planet gears, the ring is stationary though adjustable, and the sun gear is driven from the crank shaft.

In the preferred construction shown, the end of the cam shaft 28' is journalled with respect to the block 15 in spaced bearings 55 and 56 between which the planet cage 59 is keyed to the shaft and carries studs 57 thereon which support planet gears 58. The planet gears run in mesh with the ring gear 60 that is journalled in the block as at 61, and with a sun gear 62 journalled upon the cam shaft as at 63. The sun gear 62 is a part of a pinion 64 which may have a sprocket for chain drive, or as shown, comprises a gear, driven from the crank shaft. The gear train illustrated, is designed to provide a 2 to 1 ratio between the crank shaft and the cam shaft.

Lubrication of the bearings is had under pressure through radial openings 65 from an oil line 66 in the cam shaft. A sump drain 67 is provided to relieve seepage pressure behind the Welch lug 68 which seals the opening of the bearing 56. Relative rotation of the ring gear by a worm 71 functions to vary the timing of the valves, and although I have shown, in Fig. 1, in broken lines, a manual means 72 for doing this, the adjustment may be accomplished automatically in relation to atmospheric pressure, torque load or speed.

In moving the ring gear 60, by way of illustration, I provide the periphery of the ring gear 60 with worm teeth 70 to mesh with a worm gear 71 whose rotation adjusts the position of the ring gear. Rotation of the handle operates the worm gear 71 and moves the ring gear to vary the relative timing of the gears in the train, with respect to the rotation of the crank shaft, so that the timing of the valve is retarded or advanced as desired.

In event the installation of the cam adjustment is made with an engine having a conventional head, the advantages of a late closing exhaust valve and a blowback through the intake valve may be had.

In event the invention is used in motors for air craft, the valve timing can be advanced by the cam adjustment enough to reduce or eliminate blowback at higher altitudes, thereby increasing the relative volume of gas compressed in each cylinder well within the limits of the absolute compression determined for the head construction.

Throughout the specification and drawings, various constants have been set forth for purposes of illustration. These constants may be varied, especially if compensatory changes are made in other parts of the device and I therefore am not to be limited to the precise details set forth.

Consequently, although certain preferred embodiments of the present invention have been shown and described herein, it will be apparent to those skilled in the art that various uses, modifications and changes may be made without departing from the spirit and substance of the invention, the scope of which is commensurate with the appended claims.

What is claimed is:

1. In an internal combustion engine having a cylinder, a piston reciprocable therein, a means for igniting a charge of combustible gases and an inlet valve, the combination of a head for the cylinder having a combustion chamber less than one-tenth the piston displacement in communication with the cylinder, means for opening said inlet valve after the piston has passed top dead center and for closing the valve approximately in the middle of the compression stroke, and means for varying the relationship of said valve

closing means and the igniting means in relation to the speed of the piston.

2. In an internal combustion engine having a cylinder, a piston reciprocable therein and an inlet valve, the combination of a head for the cylinder having a high compression chamber in communication with the cylinder through a throat whose air flow characteristics are substantially equal to that of the valve, and means for opening said inlet valve after the piston has passed top dead center and for closing the valve approximately in the middle of the compression stroke.

3. In an internal combustion engine having a cylinder, a piston reciprocable therein, and an inlet valve, a head for the cylinder having a combustion chamber extending over the periphery of the cylinder to provide a connecting throat having an air flow capacity substantially that of said inlet valve during operation thereof, and means for closing the inlet valve in approximately the middle of the compression stroke of the piston, and means controlling the valve closing means for varying the relative time of said closing.

4. In an internal combustion engine having intake and exhaust valves, a cylinder and a piston, the combination of head means having a combustion chamber providing a compression ratio rating of approximately 12 to 1, a crank for reciprocating the piston, cam means driven by the crank and opening the exhaust valve at approximately bottom dead center of the piston and closing said intake at approximately the middle of the compression stroke of the piston.

5. In an internal combustion engine having intake and exhaust valves, a cylinder and a piston, the combination of head means having in conjunction with the intake valve and its time of closing a combustion chamber providing a compression ratio in excess of 10 to 1, a crank for reciprocating the piston, cam means driven by the crank and opening the exhaust valve approximately bottom dead center of the piston and closing said intake at approximately the middle of the compression stroke of the piston, and means for varying the timing of the cam means in relation to the piston movement.

6. In an internal combustion engine, the combination of a block having a cylinder therein, an inlet valve, an exhaust valve, a head, a combustion chamber opening into the cylinder through a throat having an air flow capacity substantially the same as the inlet valve, a piston reciprocating in the cylinder, cam means for opening and closing said valves, and means for timing the action of said cam means to open the inlet valve and close the exhaust valve after the piston has passed top dead center and to close the inlet valve approximately 245° of revolution of the crank thereafter, and to open the exhaust at approximately bottom dead center.

7. In an internal combustion engine, the combination of a block having a cylinder therein, an inlet valve, an exhaust valve, a head, a combustion chamber opening into the cylinder through a throat having an air flow capacity substantially the same as the inlet valve, a piston reciprocating in the cylinder, cam means for opening and closing said valves, means for timing the action of said cam, means to open the inlet valve and close the exhaust valve after the piston has passed top dead center and to close the inlet valve approximately 245° of revolution of the crank thereafter and to open the exhaust approximately 200° before the exhaust valve closes, and means controlling said timing means to vary the action of said timing means.

8. In an internal combustion engine, the combination of a block having a cylinder therein, an inlet valve, an exhaust valve, a head, a combustion chamber opening into the cylinder through a throat having an air flow capacity substantially the same as the inlet valve, a piston reciprocating in the cylinder cam, means for opening and closing said valves, and means for timing the action of said cam means to open the inlet valve and close the exhaust valve after the piston has passed top dead center and to close the inlet valve approximately 245° of revolution of the crank thereafter and to open the exhaust approximately 200° before the exhaust valve closes.

9. In an internal combustion engine having a casting with a cylinder, a crank, a piston reciprocable by the crank in the cylinder, and a head, said head and casting providing a combustion chamber above the piston, the combination of an intake valve for the combustion chamber, means for opening and closing the valve within approximately 245° of movement of said crank, and means for timing said first means to close the valve normally approximately in the middle of the compression stroke, and means controlling said timing means for varying the action of the first mentioned means.

10. In an internal combustion engine having a cylinder, a piston reciprocable therein, a head having a combustion chamber therein, an inlet valve, means for opening and closing said inlet valve, and means for timing the closing of said inlet valve, including an epicyclic gear train, the ring gear of which is marginally journalled in the engine block and movable to vary the action of the first mentioned means.

11. In an internal combustion engine having a cylinder, a piston reciprocable therein, a head having a high compression combustion chamber therein, an inlet valve, means for opening and closing said valve, means for driving the first means in timed relation to the piston movement including a ring gear, a planet gear and a sun gear, means for holding one of the gears in adjustably fixed relation and means for mounting one of the other two gears to drive said valve operating means and for mounting the other of the two gears to be driven in timed relation to the piston movement, said gearing receiving lubricant by direct pressure feed from the cam shaft.

12. In an internal combustion engine having a block provided with a cylinder, a piston reciprocable therein and an inlet valve, the combination of a head for the cylinder having a depression forming a combustion chamber of a maximum dimension less than the diameter of the cylinder and providing in combination with the piston a compression ratio in excess of 10 to 1, a crank for reciprocating the piston, cam means driven by the crank for opening said inlet valve after the piston has passed top dead center and for closing the inlet valve as the piston approaches the middle of the compression stroke, said combustion chamber including a throat connecting the cylinder and inlet valve of a sectional dimension from which the contours of the combustion chamber diverge to induce a scouring effect with the surge of gases through said throat that washes away the stagnant slow

burning film which lies in contact with the walls of the combustion chamber.

13. In an internal combustion engine having a cylinder, a piston, and inlet and outlet valves disposed at one side of the cylinder, the combination of a head having a depression therein forming a combustion chamber, a spark plug adjacent to the valves, said chamber extending from the spark plug to a point over the piston a distance less than the radius of the cylinder, to provide a minimum distance of flame travel from the spark plug to the remote points of the combustion chamber which are proximate the piston, said chamber providing in combination with the piston, a compression ratio in excess of 10 to 1, cam means synchronized with said piston for opening the exhaust valve at approximately the bottom of the power stroke and accomplishing closing of the intake valve as the piston approaches the middle of the compression stroke, and means for varying the relationship between the point of ignition and the closing of said intake valve.

14. In an internal combustion engine having a cylinder, a piston reciprocable therein, and a spark plug or the like, the combination of an inlet valve disposed at one side of the cylinder, a head for the cylinder having a combustion chamber less than one-tenth the piston displacement disposed over said valve and in communication with the cylinder, means for opening said inlet valve after the piston has passed top dead center and for closing the valve approximately in the middle of the compression stroke, and means for varying the timing of said valve opening means in relation to the speed of the engine.

15. In an internal combustion engine having a cylinder and a piston reciprocable therein, the combination of an inlet valve disposed at one side of the cylinder, a head for the cylinder having a combustion chamber providing a compression ratio rating in excess of 10 to 1 disposed over said inlet valve and in communication with the cylinder, a spark plug carried by the head and disposed proximate said inlet valve, means for operating the inlet valve in relationship to the piston movement for closing the inlet valve as the piston approaches the middle of the compression stroke, and means for automatically controlling said valve opening means to vary the point of said valve closing in relationship to the speed of the piston.

JOSEPH O. CAMP.