Nov. 15, 1927.

1,649,700

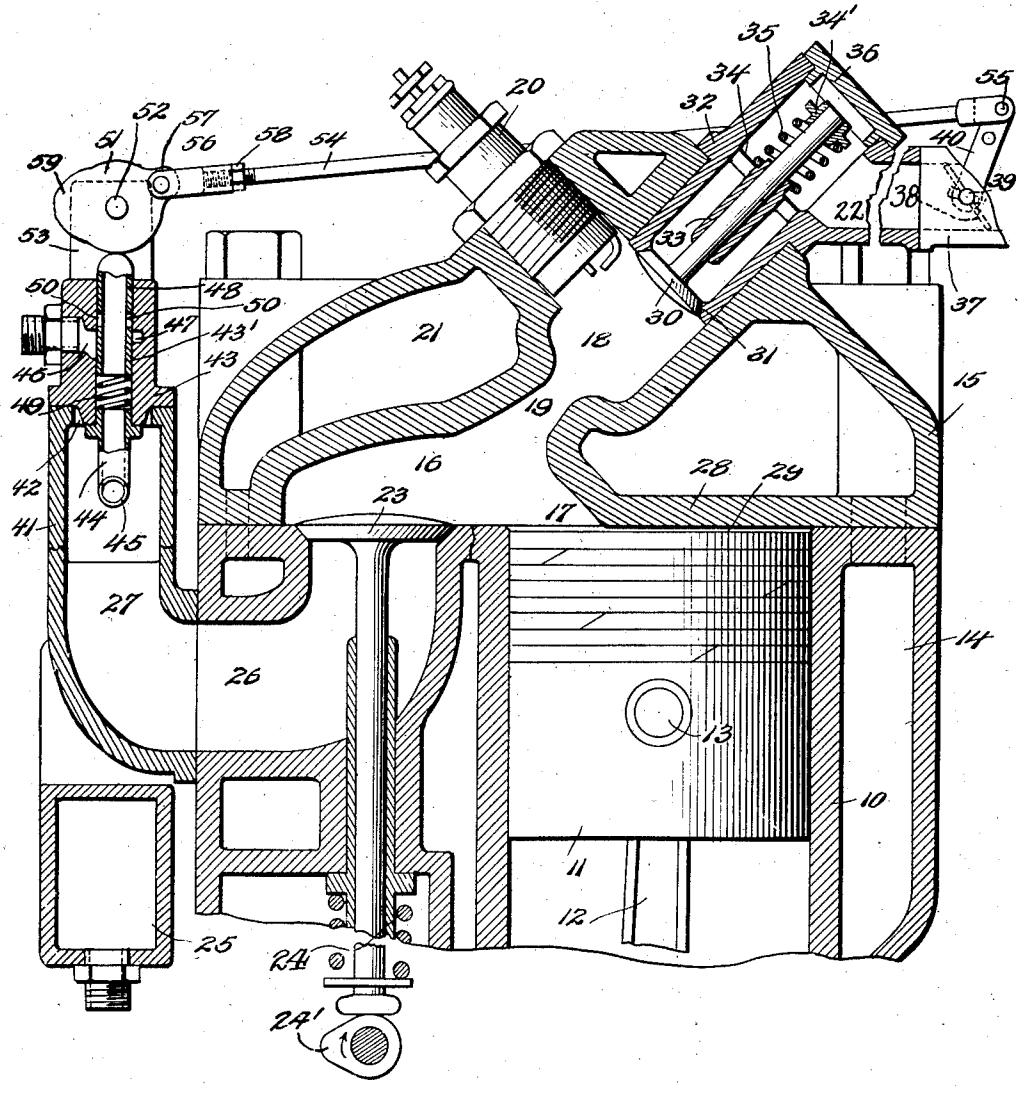
F. M. JOBES

INTERNAL COMBUSTION ENGINE

Filed April 23, 1924

3 Sheets-Sheet 1

FIG. 1.



Inventor

F. M. Jobes,

By Watson, Cole, Morse & Grindle.

Attorney

Nov. 15, 1927. 1,649,700

F. M. JOBES

INTERNAL COMBUSTION ENGINE

Filed April 23, 1924 3 Sheets-Sheet 2

FIG. 2.

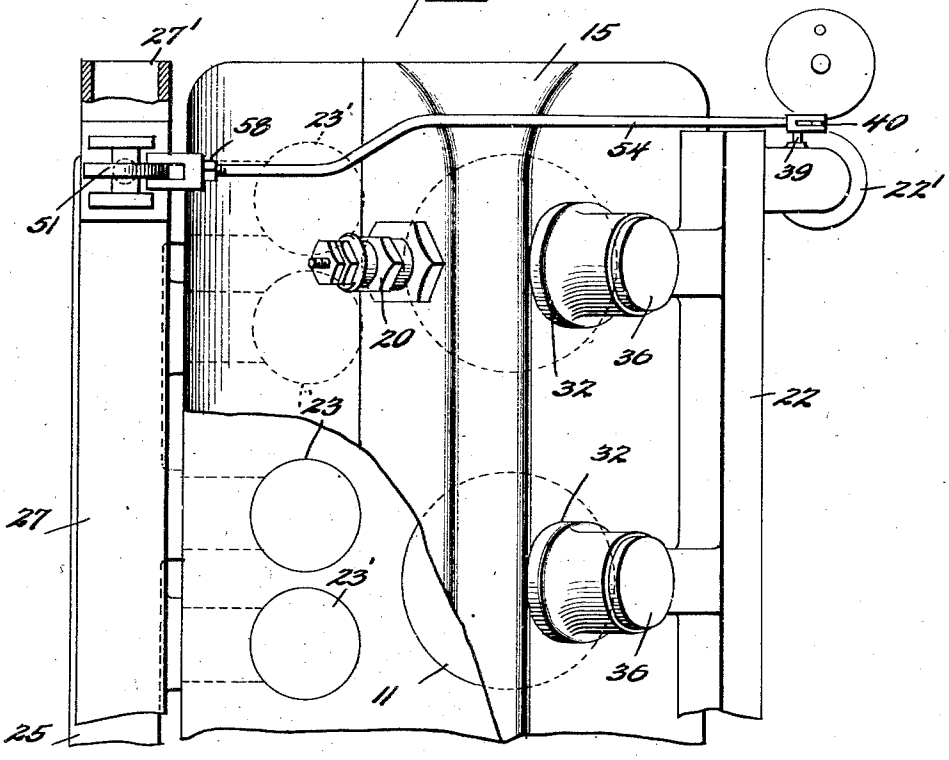
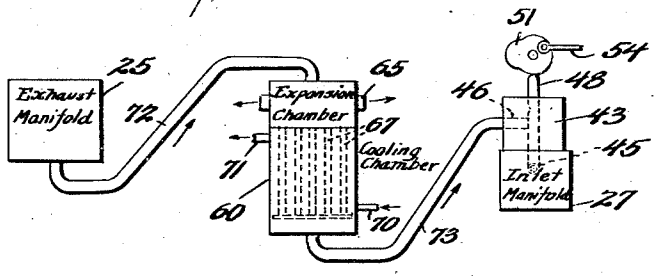


FIG. 3.



Inventor

Frank M. Jobes,

By Watson, Coit, Moser & Grindle,

Attorney

Nov. 15, 1927. 1,649,700

F. M. JOBES

INTERNAL COMBUSTION ENGINE

Filed April 23, 1924 3 Sheets-Sheet 3

FIG. 4.

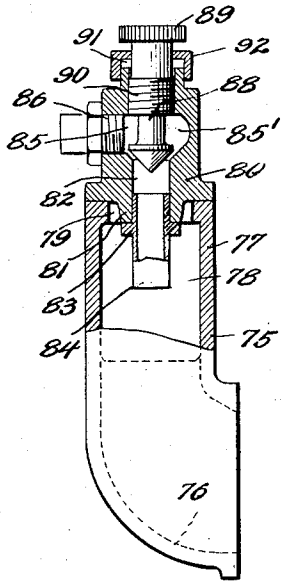
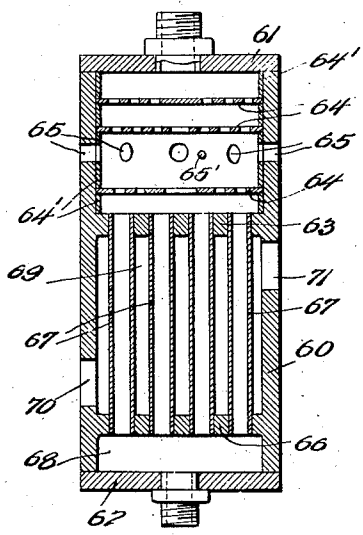


FIG. 5.



Inventor

F. M. Jobes,

By Watson, Cole, Grose & Grindle,

Attorney

Patented Nov. 15, 1927. 1,649,700

UNITED STATES PATENT OFFICE.

FRANK M. JOBES, OF ANN ARBOR, MICHIGAN.

INTERNAL-COMBUSTION ENGINE.

Application filed April 23, 1924. Serial No. 708,575.

This invention relates to internal combustion engines, and more particularly to internal combustion engines of the constant volume type adapted to be operated on gasoline or other light hydrocarbon fuels.

An object of this invention is to materially increase the thermal efficiency of such engines.

Another object of this invention is to maintain substantially the same efficiency throughout the full throttle range of an internal combustion engine.

A further object of this invention is to secure in a constant volume type of internal combustion engine a high maximum, mean effective pressure in the cylinder in order that the power output may be high in proportion to the piston displacement.

A still further object of this invention is to provide means to prevent detonation at all engine loads in an internal combustion engine having a higher than normal compression pressure.

It has long been known that the thermal efficiency of an internal combustion engine depends directly upon the expansion ratio, which is limited to a great extent, by the compression pressure of the engine. While this desirable theoretical condition of efficiency can be gained in practice to some degree, the expansion ratio is materially limited by the relatively low compression pressure under which the ordinary engine may work, for it has been determined that above the usual pressures, a peculiar condition of combustion develops especially when using an explosive mixture composed of light hydrocarbons or similar fuels mixed with air. When such a fuel is highly compressed and ignited a phenomenon known as detonation takes place in which the rate of combustion increases abnormally, making it substantially an instantaneous process, and producing a characteristic knock in the combustion chamber. Operation of a motor under these conditions results in rapid overheating to such an extent that it is impossible to operate it for any great length of time or with a high thermal efficiency. In order to secure a higher thermal efficiency, it becomes necessary to provide means for controlling this phenomenon, and much attention has been devoted in recent years to the solution of this problem, but in general the various solutions put forth have proved to be complicated or unreliable commercially.

Experimental work has demonstrated that the rate of combustion in the cylinder of an internal combustion engine may be materially decreased by adding to the combustible mixture a quantity of inert gases, an abundant supply of which is to be found in the products of combustion from such an engine. By providing means to properly proportion the diluent to the mixture, at the fuller throttle loads, it is possible to design an engine having a considerably higher compression ratio than is permissible when no detonation control is effected. The operation of such an engine is fully described in my copending application, Serial No. 669,173, filed Oct. 17, 1923.

It has also been demonstrated experimentally that when a small localized charge of combustible mixture having access to a large volume of pure air or excessively lean mixture is burned under pressures which ordinarily cause detonation, the effects of such detonation are absent, and it is therefore permissible to use in engines operating in this manner, a considerably higher compression ratio than is otherwise found permissible. Engines of this type have been built, but it has been determined that the maximum power output is unusually low owing to the difficulty of rapidly and completely intermingling the localized charge with the large volume of air, during the small period devoted to combustion, as is necessary in order to secure the complete burning of a mean near normal mixture for the production of a high maximum power output at full throttle loads. The operation of such an engine is fully described in my copending application, Serial No. 696,878, filed Mar. 4, 1924.

This invention includes a combination of the two above mentioned means for controlling detonation, the use of inert gases mixed with the combustible mixture being restricted to the fuller throttle loads, while at the minimum and intermediate loads, a localized charge of rich combustion mixture is burned with access to a large volume of

pure air or lean mixture, with which it may intermingle during the process of combustion.

A highly satisfactory type of engine is provided by such a combination of control means, making it possible to design an engine having an unusually high compression ratio, which will operate without a trace of detonation, and in which there is also secured the valuable features of a constant compression ratio at all throttle loads, thus maintaining full efficiency throughout the throttle range. This latter feature is due to an arrangement which provides that only a small charge of combustible mixture is drawn into the compression chamber and retained in an isolated portion thereof, there being admitted a volume of pure air sufficient to fill the remainder of the compression chamber at substantially atmospheric pressure. Thus, even at reduced loads, the small combustible charge is compressed to the same pressure as the charge at full load, which pressure is materially higher than permissible in engines not including detonation control. There is also provided means for securing a high degree of turbulence of the pure air contained within the combustion chamber during the compression and expansion strokes, which is an effective solution of the problem of securing a high mean effective pressure in an engine which may be considered to belong to the partially localized charge type.

For a full understanding of this invention, reference should be had to the accompanying specification taken with the drawings, in which:

Figure 1 is a transverse section through the upper structure of one cylinder of an internal combustion engine, constructed according to this invention;

Figure 2 is a partial plan view of the engine with parts broken away;

Figure 3 is a schematic diagram showing the path of the inert gases;

Figure 4 is a side elevation partly in section of a modified form of device for regulating the flow of inert gases to the cylinder; and

Figure 5 is a longitudinal section through the combined expansion chamber and cooling device for the inert gases.

In Figure 1, the usual cylinder 10 is shown fitted with a piston 11 of well-known form and connected to a crank shaft (not shown) by means of a connecting rod 12 and wrist pin 13. The cylinder is surrounded by a water jacket 14 for cooling purposes. The upper end of the cylinder is closed by means of a cylinder head 15 which includes the dome-shaped combustion chamber 16, offset from, but communicating restrictedly with, the upper end of the cylinder through the passage 17; the pocket 18 communicating restrictedly with the combustion chamber through the passageway 19; the spark plug or ignition device 20; the water jacket 21 and the combustible mixture inlet manifold 22.

Arranged beside each cylinder in the manner common to the usual type of L-head motor, is the inlet valve 23 and the exhaust valve 23′. These valves are retained on their seats by the usual valve springs 24 and opened in the well-known manner by cams such as 24′ mounted on a cam shaft driven from the crank-shaft. These valves open into the combustion chamber 16, and the exhaust valve controls a passage leading to the usual exhaust manifold 25, while the inlet valve 23 controls a passage 26 leading to a manifold 27, which is open at one end to the atmosphere as shown at 27′.

The portion 28 of the cylinder head extending above the piston has merely sufficient clearance 29 at top dead center for safety, so that at the completion of a compression stroke, all the gas contained between the portion 28 and the piston head is violently projected into the combustion chamber 16 through the restricted opening 17, thereby causing a high degree of turbulence within the chamber.

The isolated pocket 18 is of comparatively small volume compared with the volume of the combustion chamber 16, and the passageway 19 is restricted, directed away from the piston and shaped somewhat as a Venturi tube in order that the products of combustion issuing therethrough may more readily intermingle with the air contained in the combustion chamber 16. The upper end of the pocket 18 is normally closed by a spring controlled valve 30 fitting upon a seat 31, which is integral with the valve cage 32. This cage is suitably inserted, preferably by threading, into the pocket 18 and contains a valve guide 33 mounted on the spider 34. Between it and the washer 34′, on the end of the valve stem, there is a spring 35 normally tending to retain the valve 30 against the seat 31. The upper end of the valve cage is closed by means of a cap 36, while the manifold 22 communicates with the interior of the cage. A carburetor, 22′ having an induction tube 37 is adapted to be attached to the manifold 22, and is provided with the usual butterfly throttle valve 38 mounted on a shaft 39 which is adapted to be rotated by means of the arm 40.

This carburetor may be of relatively small size compared with the size of the engine to which it is attached, and is normally adjusted to deliver an extremely rich combustible mixture to the pocket 18 of the engine.

In order to provide a supply of inert gases to the cylinder, there is provided means, attached to the air manifold 27 and

projecting therein near the air inlet, for the admission of such gases. The hollow casting 41 is adapted to be bolted to the intake manifold 27 and has in its upper end an aperture 42 through which a boss on the casting 43 is adapted to project. This casting 43 is rigidly secured to the part 41 and contains a vertical circular hole 43′ passing completely through it. Into the lower end of this hole is fitted the nipple 44 having the end bent at right angles so that it forms a horizontally projecting jet 45. A passage 46 extends transversely into the casting 43 and communicates by means of an enlarged circular recess 47 with the vertical bore 43′. To provide means to control the amount of gas flowing from the passage 46 to the bore 43′, there is provided a hollow tubular member 48 closed at its upper end and having a working fit in the bore. Arranged between the lower end of the tubular member 48 and the nipple 44 is a coiled spring 49 normally retaining the tubular valve member 48 in the position shown in Fig. 1, so that the holes 50 in the sides thereof do not register with the circular cavity 47.

The tubular valve member 48 is adapted to be depressed in order to allow communication between the passage 46 and the bore 43′ by means of a cam 51 rotatable about a pivot 52 supported in a pair of vertically extending arms 53 integral with the casting 43. This cam member is directly connected with the arm 40 on the throttle valve shaft, by means of adjustable link 54, pivoted at 55, to the arm 40 and at 56 to an extension 57 on the cam. The portion connected to the cam is tubular and internally threaded to fit corresponding external threads on the rod portion, so that the relative positions of the arm 40 and the cam may be adjusted by withdrawing the pivot 56 and screwing the tubular portion on or off of the rod, the lock nut 58 being provided to maintain the adjustment fixed. The cam 51 is substantially circular in form, concentrically mounted about the pivot 52, but has on the side opposite the extension 57 a lobe 59 which is so positioned as to contact with the rounded upper end of the tubular valve member 48 when the throttle valve 38 is opened to a position corresponding to considerably more than one half load of the engine, and from thereon the member 48 is progressively depressed as the throttle is opened to its maximum position.

In order to obtain a satisfactory quantity of inert gases under the proper conditions, it has been found desirable to withdraw an excess amount from the exhaust manifold and allow them to pass into an expansion chamber where the excess quantity is exhausted to the air, the remainder passing through a cooling device before being led into the passage 46. Such an expansion chamber and cooling device combined into a single unit is disclosed in Fig. 5 wherein a hollow tubular casing 60 is closed by heads 61 and 62, each provided with a nipple for the attachment of a pipe. This chamber is divided into two main portions by means of an integral wall 63, and the upper chamber formed thereby is divided into any suitable number of compartments, shown as four, by means of the perforated baffle-plates 64 spaced by spring collars 64′. The wall of the largest one of these compartments is provided with a series of exhaust ports 65 whereby the excess gas may be carried away to the atmosphere. The spacing collar is perforated to register with the ports 65 and is prevented from rotating by the pin 65′. The wall 63 and a similar wall 66 near the lower end of the casing are provided with perforations into which are tightly fitted a series of longitudinal tubes 67 connecting the upper compartment of the chamber with a small lower compartment 68 leading to the outlet thereof. Water is adapted to be circulated around the tubes 67 within the compartment 69, and there is shown at 70 an inlet and at 71 an outlet for such cooling water which may be conveniently taken from the radiator of the internal combustion engine.

Figure 3 shows the manner in which the expansion and cooling device is connected between the two manifolds, the path of the gases being indicated by the arrows. The gases from the exhaust manifold 25 pass through a pipe or tube 72, enter the upper end of the combined expansion and cooling device 60 where they are expanded in the upper compartment, the excess gases exhausting through the openings 65, and the remaining gases passing down through the tubes 67 which are surrounded by the cooling water, where they are cooled before passing out through the pipe 73 and entering the passage 46. When the tubular valve member 48 is depressed by the cam lobe 59, the openings 50 therein register with the cavity 47 connected to the passageway 46 and allow the cooled exhaust gases to pass within the tubular valve member and out through the jet 45 where they intermingle with the pure air taken in through the opening of the inlet manifold 27.

In Fig. 4, there is disclosed a modified form of device for regulating the amount of inert gases which are admixed with the pure air flowing in the inlet manifold. The casing 75 has a right angled elbow at the lower end, and is adapted to be bolted against the side of the cylinder so that its bore 76 communicates with the passage 26 leading to the inlet valve 23. The vertical tubular portion 77 is provided with an aperture 78 through which atmospheric air is taken. The bore 79 in the upper end of the member

75 is closed by means of a casting 80 having a boss 81 fitting into the opening and suitably attached to the member 75. This casting 80 has a vertical bore 82 passing completely therethrough into the lower end of which, is fitted a nipple 83 having attached thereto a tubular jet 84 concentric with the portion 75 of the casting. Entering the bore 82 transversely is the passage 85 having threaded therein the nipple 86 adapted to be attached to a pipe leading from the expansion and cooling device previously described. The junction of the passage 85 and the bore 82 is enlarged at 85′ and the upper end of the passage 82 is provided with a valve seat adapted to cooperate with the tapered point of a threaded valve plunger 88 having a knurled head 89 for ease in manual adjustment. The threaded portion 90 of this valve stem engages an internally threaded portion of the casting 80, and it is retained against movement and leakage by means of a packing 91 compressed and retained in position by the packing nut 92 having suitable threaded engagement with the reduced upper end of the casting 80.

While the method of operation of the modification shown in Fig. 4 is considerably different from that disclosed in connection with Fig. 1, yet the results obtained are substantially the same for the following reasons. In an engine of the constant compression localized charge type, the percentage of the products of combustion mixed with pure air in the exhaust is directly proportional to the engine load. Hence with a fixed setting of the valve 88 a substantially constant volume of exhaust gases enter through the jet 84 and mix with the pure air admitted to the cylinder through the mentioned intake valve but at extremely small engine loads the actual products of combustion mixed in these exhaust gases are very small due to the small amount of combustible mixture burned in the cylinder, with a large amount of air, but as the engine load increases the percentage of the products of combustion also increases so that at full engine load the gases admitted through the jet 84 are almost completely products of combustion and hence it may be considered that an automatic regulation of the percentage of the products of combustion admitted is effected in this type of engine. By means of manual regulation of the valve plunger 88 the amount of inert gases admitted can be regulated so that just the proper amount is obtained at maximum load to prevent detonation.

While it is most desirable to expand and cool the products of combustion before they are intermingled with the intake air, quite satisfactory operation can be obtained without this procedure although the volumetric efficiency of the engine will be somewhat lowered owing to the expansion of the intake air due to its being heated by the products of combustion resulting in a smaller actual quantity of air being taken in, which of course materially reduces the compression pressure within the cylinder resulting in a reduction in power.

Operation.

The operation of an engine constructed according to this invention may best be understood by tracing its cycle of operation at minor, intermediate and maximum engine loads. In each case it will be understood that the engine is considered to be ready to begin its intake stroke.

At minor engine loads, the carburetor throttle valve 38 will be in a closed or nearly closed position and as the piston moves down through the first fifteen to twenty per cent of the suction stroke the main inlet valve 23 and the exhaust valve 23′ previously mentioned remain closed under the action of the valve springs 24 so that a negative pressure is developed by the outmoving piston within the combustion chamber. Atmospheric air passing in through the carburetor forces the valve 30 from its seat against the action of the spring 35 and carrying with it its charge of hydrocarbon fuel picked up in the carburetor it enters the pocket 18. It will be understood that this charge of combustible mixture is exceptionally rich and is of a quantity insufficient to fill the pocket 18. Upon the completion of the mentioned interval of the intake stroke the air inlet valve 23 is opened under the action of its cam 24′, allowing, during the remainder of the intake stroke of the piston, a large volume of air to flow into the combustion chamber, the rich mixture receding into the pocket and allowing the valve 30 to close since the negative pressure is materially reduced by the opening of the large air passage to atmosphere through the valve 23. At the end of the intake stroke, the valve 23 is closed and the usual compression stroke follows immediately, the peculiar shape and offset position of the combustion chamber 16 causing a high degree of turbulence of the air which is rapidly transferred from the cylinder to the combustion chamber and at the same time causing considerable turbulence within the pocket 18 due to the restricted size and peculiar shape of the opening 19. It should be noted that at the completion of the compression stroke the air contained between the piston head and the overhanging portion of the cylinder head is violently projected through the opening 17 into the combustion space 16 in such a manner that it sweeps the walls of this space and causes a somewhat circular motion of the air within the chamber 16. Upon the completion of the compression stroke the charge

of combustible mixture within the pocket 18 is fired by the spark plug 20, and assisted by the high degree of turbulence within the pocket, the rate of flame propagation is very rapid and the heat liberated due to the combustion causes a rapid expansion of the gases resulting in the passage of a large part of them out of the pocket through the Venturi shaped opening 19 into the excess air filling the combustion space 16 where they are violently intermingled with the air. At this point it will be well to consider that all of the gases projected out through the opening 19 are not in a process of combustion, but some are rather unconsumed particles advancing before the expanding flaming mixture which is ignited near the rear portion of the pocket 18, and some of the projected flaming mixture is incompletely burned due to the richness of the mixture as admitted to the pocket 18. These unconsumed particles are swept away by the turbulent air in the combustion chamber and intermingled with it thereby forming an extremely lean mixture which is ignited by the high temperature and pressure of the projected flaming mixture resulting in complete combustion of said formed extremely lean mixture with no trace of detonation. Following this initial combustion the usual expansion stroke of the piston occurs, the first movement of the piston away from the wall 28 creating a vacuum into which the burning gases are immediately drawn, aiding in the turbulence and so promoting the rapid flame propagation. At any desired point in the expansion stroke the exhaust valve may be opened by its cam as is well known in the usual types of internal combustion engines, the exhaust valve opening occurring before the completion of the expansion stroke in order to reduce the pressure within the cylinder to atmospheric before the beginning of the exhaust stroke in order that there may be the least possible amount of back pressure.

It is essential to the satisfactory operation of an engine of the type disclosed that the charge of rich combustible mixture be maintained substantially isolated during the intake stroke, from the large volume of air admitted during the latter part of that stroke until the engine load increases to the point where the temperature and pressure of the combustion are sufficiently high to insure the complete combustion of any excessively lean mixture that might be formed by admixture of any part of the rich charge carried out of the pocket and intermingled with the air admitted during the intake stroke. The above results may be best obtained by using a small carburetor of the conventional type adjusted to give a mixture of the desired richness in combination with a pocket 18 large enough to hold the entire volume of mixture admitted up to the point of critical load, when it is permissible to form an excessively lean mixture by a commingling of fuel and air during the intake stroke. This results in a control whereby the power output is increased from minimum to a certain critical value by increasing the volume of mixture, maintaining it at a near constant strength and constructing the pocket 18 large enough to contain all of this mixture up to that critical load. Another possible method of control permits the use of a somewhat smaller pocket into which is admitted at below the critical engine load a constant volume of mixture just sufficient to fill the pocket, and in order to increase the engine power the richness of the charge is increased from minimum up to the point of critical load after which an increasing volume of nearly constant richness is admitted, an increasing volume of which is carried out of the pocket and mixed with the air until at full engine load a combustible mixture only slightly lean is built up in the combustion chamber. This latter condition is also duplicated in the first mentioned method of control.

The operation of the engine at intermediate loads above the critical point previously mentioned begins with substantially the same operation as previously described, but there is of course a larger volume of combustible mixture taken into the pocket 18 due to the wider opening of the throttle 38, and some of this mixture overflows into the combustion chamber 16 where it is quickly swept away from the mouth of the pocket by the turbulent air within this combustion chamber. This is again repeated at the completion of the compression stroke so that there is formed a very uniform lean mixture within the combustion chamber. These operations cause within the pocket 18 the turbulent condition previously mentioned so that upon ignition the previously described operations take place, the flaming mixture issuing through the passage 19 igniting the extremely lean mixture within the combustion chamber 16, but contrary to the usual practice, combustion of this lean mixture is very rapid and complete owing to the high degree of turbulence and high pressure maintained within the combustion chamber. The remaining operations are substantially identical with those previously described.

At full engine load the operation of the engine is quite similar to that taking place at intermediate engine loads, but a larger volume of the rich mixture issues from the port 19 and is commingled with the air in the combustion chamber 16 forming a mixture only slightly lean which is compressed with the usual turbulence in the combustion chamber as previously described. As the strength of the mixture thus formed ap-

proaches that of a normal mean mixture the conditions giving rise to detonation are present making it necessary to provide an additional means for controlling or preventing it, and by reference to Fig. 1 it will be noted that as the throttle reaches a position corresponding to that of approximately full load the link 54 rotates the cam 51 so that the lobe 59 contacts with and depresses the slidable valve member 48 to a position where the apertures 50 therein register with the circular enlargement 49 and allow the products of combustion to flow from the jet 45 and intermingle with the intake air in the correct proportion to prevent such detonation. Thus at the higher engine loads the mixture formed within the combustion chamber is diluted with the necessary inert gases i. e. the products of combustion, to control the increasing tendency to detonate. A similar result is attained by the use of the modification shown in Fig. 3 as previously explained. Upon conclusion of the intake stroke the charge is compressed into the combustion chamber and pocket 18 and fired as before. Since during the latter part of the intake stroke, air diluted with the products of combustion is being admitted, and since the air admitted earlier in the stroke has already swept away a large portion of the excessively rich mixture issuing from the port 19, then at the completion of the intake stroke there is a quantity of air outside of this port which at the beginning of the compression stroke is forced into the pocket 18 where it mixes with the excessively rich mixture already therein, forming a normal, slightly rich mixture which consequently burns very rapidly and is discharged out of the pocket to some extent during initial partial combustion. Due to the violent condition of turbulence in the combustion chamber 16, that part discharged out of the pocket is rapidly swept away from the mouth of the pocket, and is commingled with the normal slightly lean mixture in the main combustion chamber 16 so that the slight excess of oxygen present therein, and necessary to complete its combustion is provided. Owing to the high degree of turbulence set up through the early part of the expansion stroke by the rush of gas out of the chamber 16 to fill the space evacuated by the descending piston, a further discharge of the flaming mixture out of the pocket is induced by the decreasing pressure within the combustion chamber as the volume occupied by the gases is so enlarged. This condition favors the rapid commingling of the gases so that their further combustion progresses throughout the early part of the power stroke. At this point, it is well to note that the highest possible maximum power output from an engine of this type may be secured by adjusting the strength and volume of the rich mixture retained within the isolated pocket so that only a mean normal mixture is formed therein at the completion of compression and so that the commingling of the charge carried out of the pocket during the intake stroke with the air later admitted is such as to form a nearly mean normal mixture, diluted with the necessary products of combustion to prevent detonation when compressed into the combustion chamber 16.

Since this invention is mainly concerned with the power cycle of an internal combustion engine, there has not been shown nor described any of the means for operating the valves nor for driving the cam shaft or lubricating the engine, and it is to be understood that any suitable methods for obtaining the desired results along these lines may be used, and it is not desired to restrict the engine to any particular type of valves such as the poppet valves shown, for it may be readily seen that the same results may be obtained with rotary, piston, etc. type valves, and that the particular position of the valves is of little consequence, as it is evident that the exhaust valve may be arranged in the head directly over the inlet valve, and vice versa. It may sometimes be desirable, especially in high speed engines of this type, to provide mechanical means for opening the rich mixture intake valve 30, and in such cases it is evident that the air inlet valve 23 may be timed to open during the entire intake stroke and the timing of the mechanically operated valve 30 may be arranged to open said valve through a suitable fraction of the first part of the intake stroke sufficient to permit the flow of the rich charge to the pocket 18. It is also evident that when mechanical operation of the valve 30 is used that a carburetor having no throttle valve may be used and the engine throttled (its power output varied) by using means such as a longitudinally adjustable cam shaft having thereon conical tapered cams to operate valve 30, these cams in their various possible positions engaging to open the valve 30 for varying fractions of the intake stroke, so that the volume of charge admitted to the pocket may be varied from only sufficient for idling purposes to that excess over the capacity of the pocket necessary to form the previously explained admixture with the air admitted at full engine loads. In such a modification, there may be interlinkage between the means shifting the cam shaft longitudinally and the cam disc 51 so that the products of combustion may be added to the charge substantially as described for the illustrated modification. The engine would otherwise operate substantially as described for the present modification. It is also evident that the passage 19 may be formed from a suitably shaped bushing pressed into the cylinder head so that the Venturi shaped

passage passing centrally through the bushing may occupy the same relative position as illustrated. This passage 19 should also be as short as possible and yet secure the isolation of the charge contained within the pocket from the air admitted to the combustion chamber during the intake stroke. It is also evident that when this invention is adapted to a two cycle engine, means may be provided for pumping the charge into the pocket 18 and the air into the combustion chamber.

It is also to be understood that an engine operating substantially as explained in the previous part of this specification up to engine loads permitting the forming of an admixture of a part of the charge admitted to the pocket and the air admitted to the combustion chamber, but forming a lean mixture above such engine loads by mixing combustible mixture with the air outside of the combustion chamber in the air inductance passage shall constitute a modification of my invention. In such a modification as the admixture so formed approaches normal in strength, the charge would be diluted with products of combustion substantially as set forth for the present illustrated modification, but it is evident that if desired the engine could be modified further to permit the carburetor, supplying mixture to the pocket 18, to at near maximum loads supply a mixture decreasing in richness until at full load the mixture supplied would be normal in strength and to adjust the admixture of mixture and air in the inductance (air) passage so that at full engine load a normal completely combustible mixture would be so formed by admixture. Thus at full engine load a normal mixture diluted with the products of combustion necessary to prevent detonation would be burned. The modification of a carburetor to function as described could be very readily carried out on a number of conventional type carburetors, or if desired a new carburetor might be designed to so function.

In modifications of this invention, it may be found that with engines designed for various duties (some requiring high speed operation, some low, and etc.) the most successful operation will require various timing of the valve mechanism controlling the admittance of the rich charge to the pocket 18, and it is therefore evident that it shall fall within the scope of this invention to vary such timing considerable from that specified in reference to the illustrated modification.

In withdrawing products of combustion from the exhaust manifold in any modification, it is preferable that they be withdrawn as remote from the exhaust port of the engine as is convenient so that their temperature be as moderate as possible.

It is also to be understood that the capacity of the passage 17 shall ordinarily be at least equivalent to that of the air passage 26 so that the volumetric efficiency may remain high.

While there has been shown but one modification, it is desired that the invention be not limited to this modification, for it is obvious that the same results may be obtained by various means, the preferred form of which has been disclosed, but it is to be understood that this invention shall be limited only by the appended claims.

Having thus described my invention what I claim as new and desire to be secured by Letters Patent is:

1. In a high compression internal combustion engine, a cylinder, a piston therein, a combustion chamber offset from, but communicating with said cylinder through a reduced passage, a pocket communicating with said combustion chamber through a restricted opening, means to supply a combustible mixture to said pocket, an ignition device in said pocket, an air intake valve communicating with said combustion chamber and means to supply a variable quantity of inert gases dependent upon engine throttle load, through said air valve.

2. In a high compression internal combustion engine, a cylinder, a piston therein, a combustion chamber offset from, but communicating through a reduced opening with said cylinder, the end of said cylinder being otherwise closed by a cylinder head substantially engaged by the piston at top dead center, a pocket communicating with said combustion chamber through a restricted passage, a carburetor connected to said pocket to supply combustible mixture thereto, an ignition device in said pocket, an exhaust valve in said combustion chamber, an inlet valve therein, means for operating said valves, a manifold leading to said inlet valve and open to the atmosphere, a jet in said manifold and means to supply inert gases to said jet in proportion to said engine throttle load.

3. In a high compression internal combustion engine, a cylinder, a piston therein, a combustion chamber offset from, but communicating through a reduced opening with said cylinder, the end of said cylinder being otherwise closed by a cylinder head substantially engaged by the piston at top dead center, a pocket communicating with said combustion chamber through a restricted passage, means for supplying an excessively rich combustible mixture to said pocket during the initial part of the intake stroke, an intake valve controlling a passage to a manifold open to the atmosphere, means to open said intake valve after the initial part of the intake stroke and means for supplying inert gases to said manifold in sufficient quantities to prevent detonation at all loads.

4. In a high compression internal combustion engine, a cylinder, a piston therein, a combustion chamber offset from, but communicating through a reduced opening with said cylinder, the end of said cylinder being otherwise closed by a cylinder head substantially engaged by the piston at top dead center, a pocket communicating with said combustion chamber through a restricted passage, means for supplying an excessively rich combustible mixture to said pocket during the initial part of the intake stroke in sufficient quantity to overflow said pocket at large engine throttle loads, means to complete the filling of the cylinder with air to mix with said overflow forming within the combustion chamber a substantially normal combustible mixture means to dilute said mixture with inert gas in proportions to just prevent detonation, an ignition device in said cylinder and an exhaust valve.

5. In an internal combustion engine having a compression pressure above that required to produce detonation, a cylinder, a combustion chamber, means to supply an excessively rich combustible mixture to said combustion chamber, means to supply air in a turbulent state to said combustion chamber, means regulating the admixture of said air and combustible mixture in accordance with engine throttle load, means to ignite said combustible mixture in an isolated portion of said combustion chamber, and means to prevent detonation at higher engine loads by proportionately diluting said air with products of combustion.

6. In a high compression, constant volume internal combustion engine, a cylinder, a piston therein, a combustion chamber offset from, but communicating with said cylinder through a reduced opening, the end of said cylinder being otherwise closed by a cylinder head substantially engaged by the piston at top dead center, an exhaust valve, an intake valve communicating with an intake manifold open to the air, a jet opening into said manifold, valve controlled means to supply cooled products of combustion to said manifold, a pocket communicating through a restricted opening with said combustion chamber, an ignition device in said pocket, a valved port opening into said pocket, means to supply an excessively rich mixture to said pocket in insufficient quantity to fill said pocket at engine throttle loads less than those giving sufficient temperature and pressure of combustion to insure a complete combustion of any excessively lean mixture formed by a part of the excessively rich combustible mixture charge and gases admitted through said intake valve to the combustion chamber, and in sufficient quantity to form by such admixture an only slightly lean mixture in the combustion chamber at maximum engine throttle loads, and means for simultaneously controlling the amount of charge and the proportion of products of combustion admitted.

7. In a high compression internal combustion engine, a cylinder, a piston therein, a combustion chamber offset from, but communicating thru a reduced opening with said cylinder, the end of said cylinder being otherwise closed by a cylinder head substantially engaged by the piston at top dead center, a pocket communicating with said combustion chamber thru a restricted passage, an ignition device in said pocket, means to supply said pocket with an excessively rich combustible mixture during the early part of the intake stroke, means supplying to the combustion chamber, during the remainder of the intake stroke, substantially pure air, means to retain the combustible mixture within the pocket until the engine throttle load is sufficient to insure complete combustion of any lean mixture formed in the combustion chamber due to the admixture of overflow combustible mixture and air, an exhaust manifold, means to cool and expand a portion of the products of combustion therefrom, means to conduct said products to the combustion chamber and means to regulate the quantity so admitted in proportion to the throttle position.

8. In a high compression constant volume internal combustion engine, a cylinder, a piston in said cylinder, a combustion chamber offset from but communicating through a reduced passage with said cylinder, the end of said cylinder being otherwise closed by a cylinder head substantially engaged by the piston at top dead center, a pocket, communicating with said combustion chamber through a restricted opening, a spark plug in said pocket, a valve in said pocket, a carburetor connected to said pocket through said valve, a throttle valve between said carburetor and pocket, an intake manifold open to the atmosphere for said cylinder, an exhaust manifold for said cylinder, a valve between each manifold and the cylinder, a connection between said manifolds, and expansion and cooling device in said connection and means dependent on throttle position for regulating the flow of exhaust products through said connection.

9. The method of operating an internal combustion engine comprising, admitting to the combustion chamber during the intake stroke successively a volume of abnormally rich combustible mixture and a large volume of air, maintaining the mixture substantially isolated from the air during intake and compression at low engine loads, and at higher engine loads forming a readily ignitible admixture of part of the combustible mixture and the air, adding to this charge a determined quantity of expanded and cooled products of combustion to prevent detona-

tion, compressing the charge, igniting first the rich combustible mixture, expanding the products of combustion throughout the power stroke and exhausting said products during the exhaust stroke.

10. The method of operating an internal combustion engine comprising taking into the combustion chamber successively during the intake stroke a controlled quantity of excessively rich combustible mixture and a large volume of air at times diluted with cooled products of combustion, maintaining the charge of combustible mixture substantially isolated from the air during the intake and compression strokes at engine loads up to those insuring the complete combustion of a lean mixture formed by the admixture of the air and charge, diluting such a lean mixture with inert gases at the fuller engine loads to prevent detonation, controlling such dilution in proportion to throttle position, compressing the charge, igniting the rich mixture first, expanding the charge and exhausting it.

11. In a high compression internal combustion engine, a cylinder, a piston in the cylinder, a combustion chamber offset from, but communicating through a reduced opening with said cylinder, the end of said cylinder being otherwise closed by a head substantially engaged by the piston at top dead center, a pocket communicating with said combustion chamber through a restricted passage, an ignition device in said pocket, means supplying said pocket with a controlled volume of excessively rich mixture during the early part of the intake stroke, an inlet valve controlling a passage from said combustion chamber to the atmosphere, and adapted to positively open late during the usual intake stroke, means isolating the charge of rich mixture admitted to said pocket from the gases admitted to said combustion chamber by said inlet valve during the intake stroke at engine throttle loads below those giving temperature and pressure of combustion sufficient to insure the combustion of any lean mixture formed by admixture of a part of the rich charge carried out of the pocket and intermingled with gases admitted to the combustion chamber through said inlet valve, forming at engine loads insuring the combustion of a lean mixture formed by admixture of said rich mixture carried out of the pocket and the gases admitted to the combustion chamber through said inlet valve, a lean mixture increasing in richness until at full loads an only slightly lean mixture is so formed, an exhaust valve and passage opening into said combustion chamber, said exhaust valve being adapted to positively open said exhaust passage during the usual exhaust stroke, and means adapted to supply to said combustion chamber products of combustion sufficient to control detonation at near maximum engine loads.

12. The method of operating an internal combustion engine comprising taking into the combustion chamber during the intake stroke a large volume of air and a controlled volume of rich combustible mixture, the latter being admitted during the early part of the intake stroke, maintaining the charge of rich combustible mixture substantially isolated from the air admitted during the intake stroke at engine throttle loads up to that insuring the complete combustion of any lean mixture formed by admixture of a part of the charge of rich mixture and the large volume of air admitted to the compression chamber, forming during the intake and compression strokes, at engine loads above the critical mentioned, by admixture of a portion of said rich charge and the air admitted to the combustion chamber, a lean mixture increasing in richness until at full throttle loads an only slightly lean mixture is so formed, diluting the air admitted with products of combustion in quantities just sufficient to control detonation when the engine is heavily loaded, compressing the charge, igniting the rich charge when compressed, expanding the ignited charge and exhausting it.

13. In a high compression internal combustion engine the combination of a cylinder, a piston in the cylinder, a combustion chamber offset from, but communicating through a reduced passage with said cylinder, the end of said cylinder being otherwise closed by a cylinder head substantially engaged by the piston at top dead center, a pocket communicating with said combustion chamber through a restricted opening, an ignition device in the pocket, valved means supplying said pocket with rich combustible mixture in quantities insufficient to fill the pocket at low engine loads and in a large excess over the capacity of the pocket at full engine loads, an intake manifold open to the atmosphere, a valve between said cylinder and said manifold adapted to connect the two during the latter part of the usual intake stroke, an exhaust manifold for said cylinder, a valve between said manifold and said cylinder adapted to connect the two during the usual exhaust stroke, a connection between said manifolds, and means positively controlling the flow of products of combustion through said connection so as to supply to said intake manifold a quantity sufficient to control detonation only at near maximum engine throttle loads.

14. In a high compression internal combustion engine the combination of a cylinder, a piston therein, a combustion chamber offset from, but communicating through a reduced opening with said cylinder, a pocket communicating with said combustion cham-

ber through a restricted passage directed at an angle away from the piston and somewhat centrally into said combustion chamber, an ignition device within the pocket, means supplying said pocket with a rich combustible mixture during the early part of the intake stroke, means supplying to the combustion chamber during the intake stroke a mixture varying from substantially pure air at low engine throttle loads to an only slightly lean mixture at full engine throttle loads, means coordinating the means supplying the rich charge to the pocket with the means supplying the charge to the combustion chamber so that air only is supplied to the combustion chamber until the engine throttle load becomes great enough to insure complete combustion of any lean mixture supplied to the combustion chamber, means to allow the exhaust gases to pass from the combustion chamber during the usual exhaust stroke, means adding to the charge admitted to the combustion chamber sufficient products of combustion to control detonation only at near maximum engine throttle loads.

In testimony whereof I hereunto affix my signature.

FRANK M. JOBES.