Oct. 22, 1968 A. W. EVANS ET AL 3,406,667

IGNITION AMPLIFYING APPARATUS

Filed Sept. 29, 1966 2 Sheets-Sheet 1

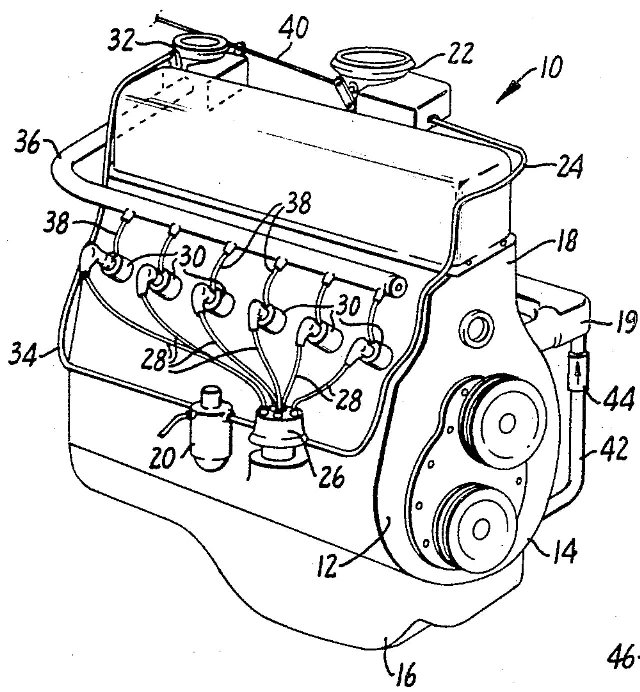

FIG. 1.

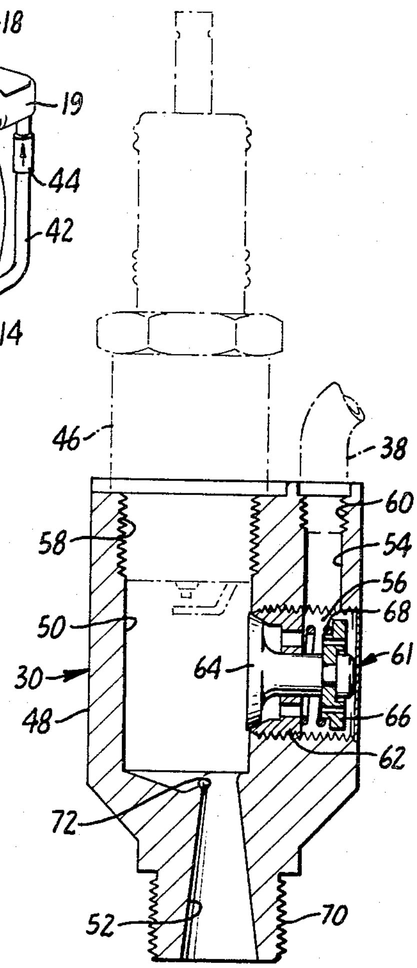

FIG. 2.

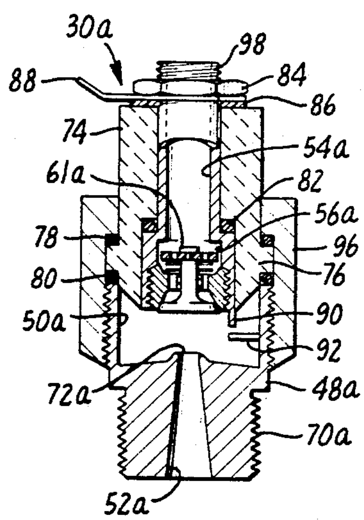

FIG. 3.

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Filed Sept. 29, 1966 2 Sheets-Sheet 2

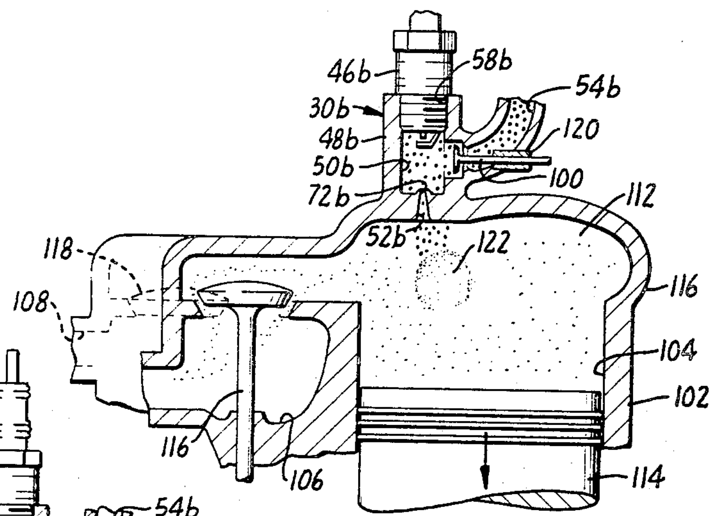

FIG.4.

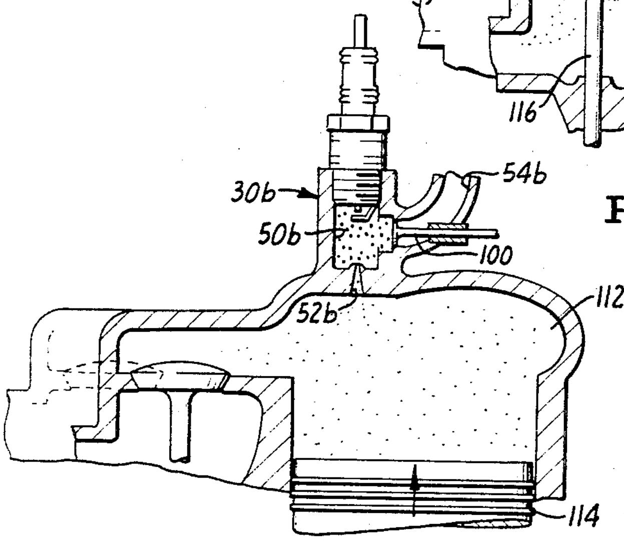

FIG.5.

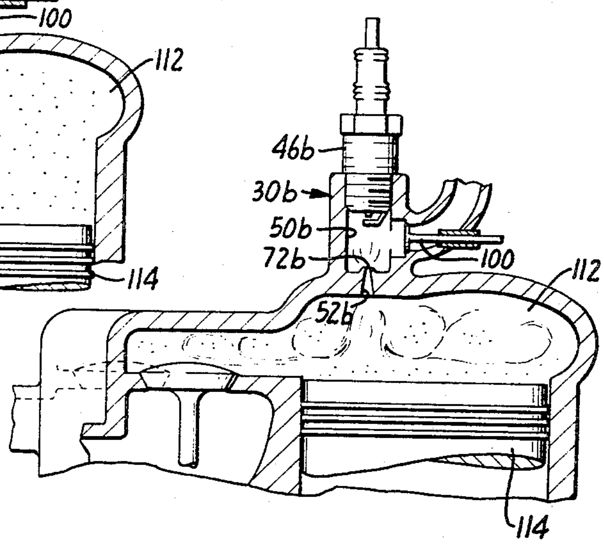

FIG.6.

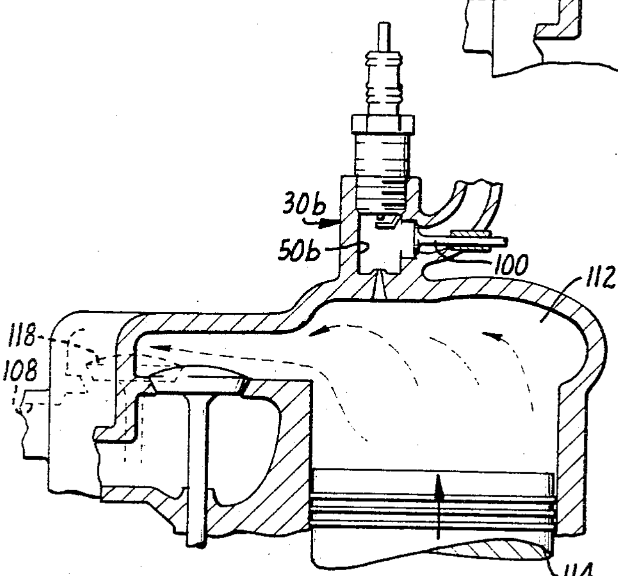

FIG.7.

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IGNITION AMPLIFYING APPARATUS

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8 Claims. (Cl. 123—32)

ABSTRACT OF THE DISCLOSURE

A stratified charge ignition system for a spark type internal combustion engine. The apparatus comprises; a precombustion chamber coupled in fluid communication with each primary combustion chamber of the engine in place of the spark plug normally coupled thereto; carburetion means to supply a relatively rich fuel-air mixture to each precombustion chamber; and, spark ignition means to effect the ignition of the fuel air mixture supplied to each of said chambers in timed sequence to the operation of the engine. Fluid communication between each precombustion chamber and the primary combustion chamber coupled thereto is provided by an orifice comprising a Borda mouthpiece opening into the precombustion to define an imperforate lip extending thereinto; and a nozzle of substantially truncated conical shape extending from the mouthpiece in diverging relationship relative thereto and opening into the primary combustion chamber.

The present invention relates to an improved ignition device for internal combustion engines and, more particularly, is directed to a smog control system adapted for use on Otto cycle engines. The invention is especially concerned with such a system facilitating the combustion of an air-fuel mixture having an excess proportion of air in the primary combustion chamber of an internal combustion engine.

Conventional Otto cycle gasoline engines using spark igniters achieve best ignition with air-fuel mixtures containing fifteen to twenty percent excess fuel. Such conditions are required for reliable operation. Leaner mixtures are difficult to reliably ignite, while richer mixtures decrease flame propagation velocity.

Engines employing excess fuel mixtures, however, have the disadvantage that the exhaust gases emitted therefrom contain combustible products. These products are comprised, primarily, of incompletely combusted hydrocarbons. This effect is increased during acceleration, deceleration and all part-load conditions. Under cold starting conditions, choke devices further aggravate this effect by increasing the excess of fuel in the fuel mixtures supplied to such engines. The incompletely combusted hydrocarbons, together with the hydrocarbon fumes discharged from their crank cases, are transformed through a photochemical process into what is commonly called smog.

A reduction of the fuel content of the air-fuel mixture would eliminate the combustible products contained in the exhaust gases emitted from Otto cycle engines, but ignition and combustion propagation in the engines would then become slow and irregular. Under such conditions, the combustion would reach completion late in the expansion stroke. This would lead to hot exhaust gas and

the overheating of the engine because of lowering of the effective expansion ratio. Engine starting would also become more difficult, especially in cold weather, due to the further leaning of the air-fuel mixture through condensation of fuel in the intake manifold. For there reasons, conventional carburetors are adjusted to a fuel excess condition that produces the highest power output. As a result, the fuel consumption becomes higher and a source of smog is created.

With conventional spark ignition, the propagation of the combustion radially moves in an approximately spherical flame front from the ignition source through succeeding layers of the fuel-air mixture. By conduction, diffusion, radiation and convection, the succeeding layers are heated to the ignition point. In fuel-rich mixtures, with the higher turbulence associated with higher speeds, propagation velocity at top dead center is on the order of one hundred feet per second. This applies only for air to fuel ratios between 12.5 and 13.5. Because of the lower energy content of a lean mixture, propagation velocity is reduced to twenty feet per second for an air to fuel ratio of twenty. Lowering of the propagation velocity also occurs at fuel-rich mixtures because of reduced energy of reaction. For example, at an air to fuel ratio of 7, the propagation velocity is reduced to below twenty feet per second.

It has been recognized that a rich air-fuel mixture close to the spark plug and a lean fuel mixture in the remainder of the combustion chamber would improve the utilization of fuel and the thermochemical efficiency of Otto cycle engines. This stratified charge principle currently requires the use of a fuel injection system and is usually combined with intake swirl to produce stratification by centrifugal effect. With this principle, however, control and balance for uniform complete combustion has not been achieved over a normal operating range of conditions.

Prior art efforts to obtain a stratified charge in Otto cycle internal combustion engines have also suggested the employment of a small secondary chamber around the electrodes of the spark plug to contain a fuel-rich mixture for spark ignition. In such arrangements, an orifice establishes fluid communication between the primary combustion chamber and the secondary chamber and a fuel-lean mixture is supplied to the primary chamber while a fuel-rich mixture if supplied to the secondary chamber. Thus, in operation, the rich fuel mixture is readily ignited in the secondary chamber and a jet of hot gas is discharged through the orifice into the primary chamber. This jet was intended to thoroughly ignite the lean fuel mixture in the primary chamber.

Although the desirability of arrangements of the latter type has long been recognized, these arrangements have not proved successful in actual application. This is believed to have resulted because the inventors and developers of these arrangements did not appreciate the characteristics of flow required between the primary and secondary chambers for successful operation. In any event, even if these characteristics were appreciated, it does not appear that they were successfully provided in the prior art.

It is, accordingly, a principal object of the present invention to provide an arrangement of construction for a stratified charge engine employing primary and secondary chambers wherein flow conditions are established between the chambers for optimum engine operation.

Another object of the invention is to provide an arrangement of construction whereby a conventional Otto cycle engine may be converted to a stratified charge engine without major modifications of the engine structure. With respect to this object, it is another object of the invention to provide an ignition device for ready attachment to an engine to effect the conversion thereof to a stratified charge system.

Yet another object of the invention is to provide an ignition system for internal combustion engines wherein all unburned pockets of combustible fuel are burned to completion during the early phases of the power stroke and, thus, the necessity for anti-knock compounds is avoided. With respect to this object, it is another object of the invention to eliminate the poisonous exhaust products which result from the employment of lead-containing anti-knock compounds in the fuel for internal combustion engines.

Still another object of the invention is to provide an ignition system for an internal combustion engine that can be adjusted to assure free oxygen content in the combustion products of the engine over its entire operating range. Another and related object of the invention is to provide an engine wherein the exhausted combustion products may be employed to burn off the hydrocarbon fumes emitted from the engine crank case.

A further object of the invention is to provide an ignition system for an internal combustion engine which permits the use of an oxygen-rich air-fuel mixture for the primary combustion chamber and, thus, eliminates excess carbon residuals.

Still a further object of the invention is to provide an internal combustion engine with an ignition system which, as compared to a conventional ignition system, results in complete combustion over a shorter period of time and the expansion of combustion products over a larger pressure ratio durring the power stroke. With respect to this object, it is another and related object to provide an ignition system for an internal combustion engine adapted to improve its thermal efficiency and lower the temperature of exhaust gas emitted therefrom.

In its broadest aspects, the present invention comprises a stratified charge ignition device and system which incorporates a secondary ignition chamber adapted to be coupled in fluid communication with the primary combustion chamber of an internal combustion engine through an orifice and control means operatively associated with said orifice to, upon operation with an engine:

(1) Effectively restrict the flow area of the orifice upon the ignition of an air-fuel mixture in the secondary chamber and establish a pressure differential between the primary and secondary chambers responsive to the ignition to support the supersonic discharge of gas through the orifice and into the primary chamber; and,

(2) Effectively open the area of the orifice upon the occurrence of a fluid pressure condition in the primary chamber exceeding that in the secondary chamber and permit the immediate and substantial dilution of gas in the secondary chamber by gas from the primary chamber responsive to the occurrence of such a condition.

As a result of this control means, upon ignition in the secondary chamber, a supersonic jet of hot gas is discharged into the primary chamber to effect complete combustion of the gas therein. Furthermore, during the compression and exhaust strokes of the primary chamber and the portion of the power stroke of the primary chamber after complete combustion therein, gas in the secondary chamber is readily diluted by that in the primary chamber. The latter characteristics have the advantage that gases from the primary chamber produce dilution and scavenging functions, respectively, upon compression and exhaust and backflow and reignition functions immediately after complete combustion during the power stroke.

The foregoing and other objects and the details of the invention will become more apparent when viewed in light of the following description and accompanying drawings wherein:

FIG. 1 is a perspective view illustrating an Otto-cycle engine of conventional character having the smog control system of the present invention applied thereto;

FIG. 2 is a sectional view illustrating one embodiment of the ignition device of the invention;

FIG. 3 is a sectional view illustrating a second embodiment of the ignition device of the invention; and,

FIGS. 4 to 7 are sectional views illustrating, sequentially, the operation of a third embodiment of the ignition device of the invention during the cycle of an Otto-cycle engine.

Referring now to FIG. 1, the exemplary engine therein is designated in its entirety by the numeral **10**. This engine is of the conventional six-cylinder overhead valve type and comprises, in part: a block **12**; crank case **14**; pan **16**; head **18**; exhaust manifold **19**; fuel pump **20**; primary carburetor **22**; primary fuel line **24** leading from the fuel pump **20** to the carburetor **22**; distributor **26**; six spark plug receiving openings (not illustrated); and, ignition wires **28** leading from the distributor **26** to close proximity with the spark plug openings.

The basic smog control system illustrated in FIG. 1 comprises six ignition devices **30** threadably received, respectively, in the spark plug openings of the engine **10**; a secondary carburetor **32**; a fuel line **34** leading from the pump **20** to the carburetor **32**; an intake manifold **36** leading from the carburetor **32** to close proximity with each of the devices **30**; and, a plurality of fluid conduits leading, respectively, from the manifold **36** to each of the devices **30**. The foregoing basic elements of the system are mounted on the engine in conventional manner by brackets and the like. In the illustrated embodiment, the smog control system also includes a link **40** coupling the primary carburetor **22** and secondary carburetor **32** for simultaneous operation and a breather pipe **42** connected in fluid communication between the breather of the crank case **14** and the exhaust manifold **19**. The breather pipe **42** is connected to the manifold **19** at a point wherein, during engine operation, the temperature of gas exhausted into the manifold exceeds the ignition temperature of hydrocarbon fumes in the engine crank case. The pipe **42** also has interposed therein a check valve **44** to prevent backflow therethrough from the exhaust conduit to the crank case.

The operation of the primary carburetion and electrical systems for the engine in FIG. 1 is conventional, with the exception that the primary carburetor **22** supplies an extraordinarily lean air-fuel mixture to the primary combustion chambers of the engine. This lean mixture is provided, for reasons which will become more apparent subsequently, to assure that the air content of the air-fuel mixture supplied to the primary combustion chambers will be in excess of that required to burn all of the fuel. The preferred air-fuel ratio of this mixture is approximately 16:1 to 20:1 and may be provided simply by reducing the area of the carburetor jets in the primary carburetor **22** by about twenty percent.

The secondary carburetor **32** and the intake manifold and fluid conduits cooperating therewith operate through pressure differentials created between the devices **30** and the atmosphere. The operation of the devices **30** will be developed in detail subsquently. Preferably, the secondary carburetor **32** provides an air-fuel ratio of from 4:1 to 6:1. In the preferred embodiment, the link **40** couples the carburetors **22** and **32** so that the volume of the fuel-air mixture supplied through the carburetor **32** is substantially directly proportional to that supplied through the carburetor **22** through the normal operating range of the engine.

Referring now to FIG. 2, therein is illustrated one of the devices **30** with a spark plug **46** (illustrated in phantom) engaged therein. The device **30** is comprised, primarily, of a housing **48** having therein: a secondary combustion chamber **50**; an orifice **52** leading from the chamber **50** to the exterior of the housing; and, a conduit **54** leading into the chamber and comprised, in part, of a valve chamber **56**. The chamber **50** has formed in the upper portion thereof a threaded opening **58** adapted to receive the spark plug **46**. The conduit **54**, similarly, has formed in the upper portion thereof a threaded opening **60** adapted to receive one of the conduits **38**. The valve chamber **56** has received therein a pressure differential operated valve **61** of relatively conventional nature. This valve comprises: a seat element **62** threaded into the chamber **56**; a valve element **64** slidably received in the seat element **62** for sealed seating engagement therewith upon the occurrence of a pressure condition in the chamber **50** exceeding that in the conduit **54** and for opening upon a pressure condition in the conduit **54** exceeding that in the chamber **50**; a stop element **66** received on the valve element **64**; and, a compression coil spring **68** interposed between the elements **62** and **66**.

The orifice **52** is comprised of a nozzle section of generally truncated conical shape diverging from the chamber **50** to the exterior of the housing. As a result of this nozzle configuration, the gas jet which is discharged through the orifice **52** upon ignition of an air-fuel mixture in the chamber **50** is dispersed to a degree sufficient to avoid burning of the piston head within the primary cylinder cooperating with the device **30**. Control of the degree of dispersion effected in the orfice to satisfy the requirements of a particular engine may be accomplished by varying the length and degree of divergence of the nozzle section.

The elongated nozzle section of the orifice **52** extends longitudinally through an externally threaded section **70** provided on the lower portion of the housing **48**. This threaded section is designed for threaded engagement with the spark plug opening of a conventional engine, such as the engine **10**, so as to establish sealed communication through the orifice **52** between the primary combustion chamber of the engine and the secondary combustion chamber **50** of the device **30**. It is here noted that the elongated character of the orifice nozzle section and the mass of the housing therearound also facilitates the dissipation of heat away from the orifice.

The orifice **52** opens into the secondary chamber **50** through a mouthpiece **72** of Borda configuration. Although this mouthpiece is rounded slightly from true Borda configuration for heat dissipation purposes, it operates, essentially, in true Borda fashion. Specifically, the mouthpiece functions to restrict the effective flow area of the orifice **52** upon the outflow of gas therethrough from the secondary chamber **50** and to open the effective area of the orifice upon the inflow of gas therethrough into the secondary chamber. This change of effective area is aerodynamically generated and, where full Borda effect is accomplished, amounts to a change of two to one. From the subsequent description of the operation of the device **30** when attached to the primary combustion chamber of an internal combustion engine, it will be appreciated that this change in effective area causes a relatively low pressure differential during inflow into the secondary chamber from the primary chamber of the engine and a relatively high pressure differential during outflow from the secondary chamber into the primary chamber after ignition of an air-fuel mixture in the secondary chamber.

Referring now to FIG. 3, therein is illustrated an alternative embodiment of the device **30**, designated in its entirety by the numeral **30*a***. The device **30*a*** differs from the device **30**, in its basic aspects, primarily in that it incorporates, a self-contained spark plug unit. Thus, with the device **30*a***, it is not necessary to employ a spark plug, such as the plug **46** illustrated in FIG. 2.

The primary working elements of the device **30*a*** correspond to those of the device **30** in function and, accordingly, for the sake of simplicity will be designated by numbers differing from those used for the elements of the device **30** only by the subscript *a*. These elements are as follows: housing **48*a***; secondary chamber **50*a***; orifice **52*a***; conduit **54*a***; valve chamber **56*a***; valve **61*a***; threaded section **70*a***; and, mouthpiece **72*a***. In addition to these elements, the device **30*a*** comprises the following elements which make up the self-contained spark unit thereof: an annular insulator **74** received around the conduit **54*a*** and having extending radially therefrom a collar **76**; gaskets **78** and **80** received around the insulator **74** above and below, respectively, the collar **76**; a gasket **82** received around the conduit **54*a*** between the valve chamber portion thereof and the insulator **74**; a pair of nuts **84** and **86** threadably received on the upper end of the conduit **54*a*** above the insulator **74**; a lead connector **88** lockingly received between the nuts **84** and **86**; a central electrode **90** fixed in electrical contact with the conduit **54*a*** and depending downwardly therefrom into the chamber **50*a***; and, a ground electrode **92** fixed in electrical contact with the housing **48*a*** and extending therefrom into the chamber **50*a*** beneath the electrode **90**. The device **30*a*** also includes a sleeve **96** engaged over the gasket **78** and threadably received on the housing **48*a*** to maintain the insulator **74** in sealed, locked engagement with the housing. The conduit **54*a*** is provided with an outwardly extending threaded section **98** to which a fluid conduit, corresponding to the conduit **38**, may be connected.

The device **30*a*** is received in the spark plug opening of an engine through engagement of the threaded section **70*a*** with the threads of the opening. After the device is so received, its installation in a system as shown in FIG. 1 is completed by connecting one of the ignition wires **28** to the lead connector **88** and one of the conduits **38** to the threaded section **98**.

After installation on an engine, the devices **30** and **30*a*** operate in an identical manner. During this operation, an air-fuel mixture is introduced into the secondary combustion chamber of each device on the intake stroke of the combustion chamber of the engine communicating therewith. This function is permitted by the opening of the pressure differential operated valves **61** and **61*a*** responsive to each such stroke. These valves also function to close the secondary chambers to flow from the carburetor **32** when the primary combustion chambers communicating therewith are operating through their power, exhaust, and compression strokes. It is here noted that the walls of the conduit **54*a*** function as an electrical conductor for the central electrode **90** and that the flow of air-fuel mixture through the conduit **54*a*** functions to cool these walls and the valve **61*a***.

The embodiment of the inventive ignition device illustrated in FIGS. 4 to 7 is designated in its entirety by the numeral **30*b***. This embodiment differs from those illustrated in FIGS. 2 and 3 primarily in that it is fabricated as an integral part of the engine head cooperating therewith and that the intake valve, designated by the numeral **100**, for the secondary combustion chamber therein is operated by a timed mechanical operator (not illustrated) such as a solenoid or cam shaft. This operator is timed so that the valve **100** is open only upon the intake stroke of the primary combustion chamber communicating with the secondary combustion chamber of the device **30*b***. Thus, the valve **100** performs an operational function corresponding identically to that of the valves **61** and **61*a***.

For the sake of illustration, the embodiment of the ignition device **30*b*** in FIGS. 4 to 7 has been shown employed with an L-head engine, rather than a valve-in-head engine as shown in FIG. 1. This difference does not affect the operation of the device and, accordingly, all comments made herein relating to the operation of the invention on the engine shown in FIGS. 4 to 7 are considered applicable to the engine and system shown in FIG. 1, and vice versa.

The L-head engine shown in FIGS. 4 to 7 is of conventional nature and comprises, in part: a block **102** defining therein a cylinder **104**, intake manifold **106** and exhaust manifold **108**; a head **110** received on the block to define therewith a primary combustion chamber **112**; a piston **114** reciprocally received in the cylinder **104**; an intake valve **116** operatively associated with the manifold **106** and an exhaust valve **118** operatively associated with the manifold **108**.

The device **30*b*** is comprised of elements, in large part, which correspond operationally to the elements of the aforedescribed device **30**. Accordingly, for the sake of simplicity, these elements of the device **30*b*** are designated by numerals corresponding to those of the device **30**, followed by the subscript *b*, as follows: housing **48*b***; secondary combustion chamber **50*b***; orifice **52*b***; conduit **54*b***; threaded opening **58*b***; and mouthpiece **72*b***. The conduit **54*b*** receives therein through means of a valve guide **120** the aforedescribed intake valve **100**. The threaded opening **54*b*** receives therein a conventional spark plug **46*b*** corresponding to the plug **46** of the FIG. 2 embodiment. Although not illustrated, it is to be understood that the engine shown in FIGS. 4 to 7 would include carburetion and ignition components corresponding to those of the engine in FIG. 1 and that a fluid conduit, corresponding to the conduit **38**, would be connected in fluid communication with the conduit **54*b***. The spark plug **46*b*** would also have connected thereto an electrical ignition wire corresponding to the wire **28** and, preferably, the engine would be provided with a breather pipe and valve arrangement similar to the conduit **42** and valve **44**.

The operation of the inventive device system will now be described with reference to the embodiment thereof illustrated in FIGS. 4 to 7. It is to be understood, however, that this operation is substantially identical for all embodiments of the invention.

During the intake stroke of the engine, as illustrated in FIG. 4, the pressure within the secondary combustion chamber **50*b*** is reduced and the valve **100** is opened to admit a charge of rich air-fuel mixture to the chamber. This air-fuel mixture is provided by a carburetor corresponding to the carburetor **32** and, preferably, has a ratio of from 4:1 to 7:1. Some of this fuel-rich mixture, as is designated by the numeral **122** in FIG. 1, is drawn through the orifice **52*b*** and into the primary combustion chamber **112**. During this same intake stroke, the primary combustion chamber **112** is also filled with a lean air-fuel mixture through the intake manifold **106**. This mixture is provided by a carburetor corresponding to the aforedescribed carburetor **22** and, preferably, has a ratio of 16:1 to 20:1.

Upon the compression stroke, as illustrated in FIG. 5, a portion of the lean air-fuel mixture in the primary combustion chamber **112** is forced through the orifice **52*b*** and into the secondary combustion chamber **50*b*** to effect the dilution of the rich air-fuel mixture therein. This dilution function is highly responsive and very immediate due to the unrestricted flow area of the orifice provided by the action of the mouthpiece **72*b***. At the end of the compression stroke, the dilution thus effected preferably increases the air-fuel ratio of the mixture in the secondary combustion chamber **50*b*** to from 12.5:1 to 14:1. This range of ratios is ideally suited for ready spark ignition. It is here noted that, during the aforedescribed compression stroke, the valve **100** is maintained closed and, thus, backflow through the conduit **54*b*** is prevented.

Upon commencement of the power stroke, as illustrated in FIG. 6, the valve **100** remains closed and the spark plug **46*b*** effects ignition of the air-fuel mixture within the secondary chamber **50*b***. On the latter occurrence, the effective flow area of the orifice **52*b*** is aerodynamically restricted by the mouthpiece **72*b*** and a high pressure differential is established across the orifice. The aerodynamic restriction of the orifice is sufficient so that gas discharged therethrough from the secondary combustion chamber **50*b*** assumes the form of a jet having supersonic velocity. This jet, upon entrance into the primary combustion chamber, creates great turbulence and ignites the lean mixture therein with an effective propagation velocity of several hundred feet per second. This high propogation velocity is also effected, in part, by a shock wave which travels through the orifice **72*b*** and into the primary combustion chamber immediately prior to the jet. The effectiveness of the jet in igniting gas within the primary combustion chamber is also enhanced by the relatively long jet duration provided by the restriction aerodynamically generated by the mouthpiece **72*b***.

As a result of the rapid propagation velocity provided by the ignition device, complete combustion within the primary chamber is effected at a crank angle of between 5° and 15° after top dead center. Immediately after combustion in the primary chamber **112** is thus completed, and during the remainder of the power stroke, the pressure condition within the primary chamber exceeds that within the secondary chamber **50*b***. At this point, due to the unrestricted area of the orifice **52*b*** provided by the mouthpiece **72*b***, backflow of hot gas into the secondary chamber from the primary chamber immediately occurs. Thus hot, air-rich gas is injected into the secondary chamber and any remaining combustible hydrocarbons therein are consumed. The latter characteristic is particularly advantageous, since it functions to clean the secondary combustion chamber and the spark plug.

During the exhaust stroke, as illustrated in FIG. 7, the engine operates in relatively conventional manner. The exhaust gases discharged therefrom, however, are oxygen-rich and relatively cool, as compared to those exhausted from conventional engines. The latter characteristics results because combustion in the primary combustion chamber is completed at a crank angle of between 5° and 15° after top center, as compared to 25° after top center for conventional spark ignition. Thus, a larger effective expansion ratio is provided and thermal efficiency of the engine is increased. It is here noted that during the exhaust stroke the value **100** is closed and that, due to the relatively unrestricted area of the orifice **52*b*** provided by the mouthpiece **72*b***, gas from the primary chamber may readily flow into the secondary chamber.

Although the present invention is concerned primarily with the provision of the aforementioned controlled flow charcteristics between the secondary and primary chambers of the ignition device, it has also been found that ideal operation of the ignition device occurs when the volume of the secondary chamber therein is equal to between .03 and 0.5 that of the primary chamber and, preferably, .04 that of the primary chamber. Thus, it should be appreciated that the relative proportions of the components of the ignition device and the overall system will vary, depending upon the physical characterics of the engine upon which they are employed.

In conclusion, it is noted that through the employement of a breather conduit, such as the conduit **42**, the oxygen-rich exhaust discharged from an engine employing the present invention may be utilized to burn hydrocarbon fumes from the crank case of the engine. Furthermore, the relatively low temperature of the exhaust gas discharged from engines employing the present invention results in the creation of less nitrogen-dioxide in the exhaust product than occurs with engines employing conventional ignition systems.

From the foregoing description, it is believed apparent that the present invention enables the attainment of the objects initially set forth herein. It is to be understood, however, that the invention is not intended to be limited to the details of the exemplary embodiments herein illustrated and described.

What is claimed is:

1. A device to effect the ignition of an air-fuel mixture within the primary combustion chamber of an internal combustion engine provided with a spark ignition system, said device comprising:

(a) a housing having:

(1) a secondary combustion chamber therein adapted to confine a spark ignitable air-fuel mixture;

(2) an orifice extending therethrough into communication with said secondary chamber; and ,

(3) securing means adapted to effect the attachment thereof to said engine so as to establish sealed fluid communication between said primary and secondary chambers through said orifice;

(b) conduit means communicating with said secondary chamber, said means being adapted to be connected in fluid communication with a supply of an air-fuel mixture to effect the introduction thereof into said chamber;

(c) valve means operatively associated with said conduit means to, upon attachment of said housing to said supply, selectively open said conduit means to fluid flow during the intake portion of the cycle of said primary chamber and close said conduit means during the remaining portion of the cycle of said primary chamber;

(d) component means adapted to cooperate with the spark ignition system of said engine to effect the spark ignition of an air-fuel mixture contained in said secondary chamber; and,

(e) a Borda mouthpiece for said orifice provided interiorly of said housing, said mouthpice defining a portion of said orifice and openings into said secondary chamber to define an imperforate lip extending thereinto; and,

(f) a nozzle of substantially truncated conical shape extending from said mouthpiece in diverging relationship relative thereto and through said housing, said nozzle defining the remaining portion of said orifice.

2. A device according to claim **1**, wherein:

(a) said securing means comprises a threaded section on said housing adapted to be received in a spark plug opening in said primary chamber forming part of the ignition system of said engine;

(b) said orifice extends longitudinally through said threaded section; and,

(c) said component means comprises a threaded spark plug opening extending through said housing and into communication with said secondary chamber, said opening being adapted to received a spark plug forming part of the ignition system of said engine.

3. A device according to claim **1**, wherein:

(a) said securing means comprises a threaded section on said housing adapted to be received in a spark plug opening in said primary chamber forming part of the ignition system of said engine;

(b) said orifice extends longitudinally through said threaded section;

(c) said component means comprises:

(1) a first electrode mounted on said housing so as to be grounded to said engine upon receipt of said threaded section in said spark plug opening; and,

(2) a second electrode mounted on said housing in electrically insulated relationship to said first electrode, said second electrode being adapted to be electrically connected to a spark plug wire forming part of the ignition system of said engine and defining, with said first electrode, a spark gap within said secondary chamber;

(d) said conduit means comprises a tubular passage extending through said second electrode; and,

(e) said valve means is disposed within said tubular passage.

4. In an Otto cycle internal combustion engine comprising at least one primary combustion chamber and a

spark ignition system therefor, a smog control system comprising:

(a) a housing having:

(1) a secondary combustion chamber therein adapted to confine a spark ignitable air-fuel mixture;

(2) an orifice extending therethrough into communication with said secondary chamber; and,

(3) means effecting the attachment thereof to said engine so as to establish sealed fluid communication between said primary and secondary chambers through said orifice;

(b) conduit means communicating with said secondary chamber through which an air-fuel mixture may be supplied thereto;

(c) primary carburetion means connected in fluid communication with said primary combustion chamber to supply an air-fuel mixture thereto having a ratio of from 16:1 to 20:1;

(d) secondary carburetion means connection in fluid communication with said conduit means to supply an air-fuel mixture to said secondary combustion chamber having a ratio of from 4:1 to 6:1;

(e) valve means operatively associated with said conduit means to selectively open said conduit means to fluid flow during the intake portion of the cycle of said primary chamber and close said conduit means means during the remaining portion of the cycle of said primary chamber;

(f) ignition means operatively associated with the spark ignition system of said engine to effect the spark ignition of an air-fuel mixture contained in said secondary chamber; and,

(g) a Borda mouthpiece for said orifice provided interiorly of said housing, said mouthpiece defining a portion of said orifice and opening into said secondary chamber to define an imperforate lip extending thereinto; and,

(h) a nozzle of substantially truncated conical shape extending from said mouthpiece in diverging relationship relative thereto and through said housing, said nozzle defining the remaining portion of said orifice.

5. In an Otto cycle engine according to claim **4**, further comprising:

(a) a crank case having a breather outlet; and,

(b) an exhaust conduit to receive gases exhausted from said primary chamber,

said smog control system further comprising:

(1) a breather conduit connecting said breather outlet in fluid communication with said exhaust conduit at a point wherein, during operation of said engine, the exhaust gases therein are at a temperature exceeding the ignition temperature of hydrocarbon fumes in said crank case; and,

(2) check valve means interposed in said breather conduit to prevent backflow therethrough from the exhaust conduit to the crank case.

6. In an Otto cycle engine according to claim **4**, said smog control system wherein said primary and secondary carburetion means are each selectively controllable to vary the volume of air-fuel mixture supplied therethrough and further comprising means to effect the control of said secondary carburetion means in substantially direct proportion to the control of said primary carburetion means.

7. In an Otto cycle engine according to claim **4**, said smog control system wherein the volume of said secondary chamber is less than .05 that of said primary chamber.

8. In an internal combustion engine:

(a) a cylinder having a combustion chamber;

(b) a cylinder head having a precombustion chamber; and,

(c) an orifice defining a throat section establishing communication between said chambers, said orifice comprising:

(1) a Borda mouthpiece opening into the pre-

combustion chamber to define an imperforate lip extending thereinto; and,

(2) a nozzle of diverging area extending from said mouthpiece in diverging relationship relative thereto and opening into said combustion chamber.

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CERTIFICATE OF CORRECTION

Patent No. 3,406,667 October 22, 1968

Alvin W. Evans et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 9, line 32, "openings" should read -- opening --.

Signed and sealed this 9th day of December 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents