08-06-2002

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8.6.02

To the Honorable Commissioner of Patents and Trademarks: Please record the attached original documents or copy thereof.

1. Name of conveying party(ies): 8-6-02

Feuling Advanced Technologies, Inc.

Additional name(s) of conveying party(ies) attached? ☐ Yes ☑ No

3. Nature of conveyance:

☐ Assignment ☐ Merger
☐ Security Agreement ☐ Change of Name
☑ Other Reconveyance

Execution Date: May 15, 2000

2. Name and address of receiving party(ies)

Name: James J. Feuling

Internal Address:

Street Address: 1561 Pioneer Way

City: El Cajon State: CA Zip: 92020

Additional name(s) & address(es) attached? ☐ Yes ☑ No

4. Application number(s) or patent number(s):

If this document is being filed together with a new application, the execution date of the application is:

A. Patent Application No.(s)

B. Patent No.(s) 5,501,191; 5,638,787; 5,893,348; 5,313,921

Additional numbers attached? ☐ Yes ☑ No

5. Name and address of party to whom correspondence concerning document should be mailed:

Name: John L. Haller

Internal Address: Brown, Martin, Haller & McClain, LLP

Street Address: 1660 Union Street

City: San Diego State: CA Zip: 92101-2926

6. Total number of applications and patents involved: 4

7. Total fee (37 CFR 3.41).....$ 140.00

☑ Enclosed

☑ Authorized to be charged to deposit account

8. Deposit account number:

02-4070

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9. Signature.

To the best of my knowledge and belief, the foregoing information is true and correct and any attached copy is a true copy of the original document.

James J. Feuling
Name of Person Signing

Signature

7-29-02
Date

Total number of pages including cover sheet, attachments, and documents: 52

Mail documents to be recorded with required cover sheet information to:
Commissioner of Patents & Trademarks, Box Assignments
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FEULING ADVANCED TECHNOLOGIES, INC.

[a Nevada corporation]

RECONVEYANCE OF PATENT RIGHTS

AGREEMENT by and between FEULING ADVANCED TECHNOLOGIES, INC., a Nevada corporation [hereafter "ADVANCED"] and JAMES J. FEULING, an individual, [hereafter "FEULING"] on the date set forth below and upon the terms set forth as follows:

I. PREAMBLE

In December 1995, FEULING granted to ADVANCED rights of use to FEULING'S three valve combustion chamber system technology, including issued and pending patents. Said grant included the right of ADVANCED to enter into an exclusive license agreement with the Ford Motor Company, which license agreement [now a non-exclusive license agreement] is still in place.

Subsequently, additional patents on the three valve combustion chamber system technology issued from the United States Patent & Trademark Office. Said issued patents, were and are agreed to be part of the FEULING/ADVANCED agreement of December 1995. By March 1999, three three valve combustion chamber system patents had issued [See, EXHIBITS 1, 2, and 3; attached hereto and incorporated herein].

In March 1999, ADVANCED commenced suit for patent infringement on the issued U.S. Patents for three valve combustion chamber systems. In July 1999, said suit was amended to include a fourth three valve combustion chamber patent that had issued [EXHIBIT 4; attached hereto]. In May 2000, it was determined that the original documents to convey patent rights from FEULING to ADVANCED had not been completed, therefore ADVANCED did not have standing to maintain suit.

Based thereupon, FEULING and ADVANCED, on the terms and conditions set forth hereinbelow, amend and restate the agreement between them as to three valve combustion chamber technologies as represented by the four issued U.S. Patents.

II. RECONVEYANCE BY ADVANCED

ADVANCED hereby and herewith reconveys all right, title and interest, tangible or intangible, express or implied, oral or written, known or unknown in and to the subject matter three valve combustion chamber technologies, specifically including the four issued U.S. Letters Patent [EXHIBITS 1, 2, 3, and 4] to FEULING.

Said ADVANCED reconveyance to FEULING is expressly and materially subject to the concurrent grant by FEULING to ADVANCED of an exclusive license to said three valve combustion chamber system technologies, inclusive of the subject matter patents [EXHIBITS 1, 2, 3, and 4], as an express condition current to the above reconveyance. Both parties hereto expressly acknowledge and agree that nothing herein shall be deemed or construed to

interfere, in any way, with the rights granted Ford Motor Company by ADVANCED under the non-exclusive license agreement presently in force.

III. LICENSE BY FEULING

Pursuant to the terms and agreements as set forth under Article II, hereinabove, FEULING hereby grants to ADVANCED the exclusive license to use the three valve combustion chamber system technology under the terms and conditions as set forth in the Exclusive License Agreement as attached hereto as EXHIBIT 5. Amended 5/15/00

Nothing in this Article III, or this Agreement as a whole, shall be interpreted as, nor in any manner deemed as controlling over nor superior to, the terms and agreements set forth in the Exclusive License Agreement.

The parties expressly acknowledge and agree that the terms of the Exclusive License Agreement shall irrevocably govern the relationship between the parties with respect to the subject matter three valve combustion chamber system technologies.

EXECUTED in the City and County of San Diego, State of California on the 11th Day of May, 2000.

FEULING:

James J. Feuling,
an individual

ADVANCED:

By: James J. Feuling,
President

By: Gene Sheehan,
Acting Secretary

EXHIBIT 1

US005313921A

United States Patent [19]

Feuling

[11] Patent Number: 5,313,921

[45] Date of Patent: May 24, 1994

[54] HIGH EFFICIENCY COMBUSTION CHAMBER SYSTEM

[76] Inventor: James J. Feuling, 2521 Palma, Ventura, Calif. 93003

[21] Appl. No.: 995,785

[22] Filed: Dec. 23, 1992

[51] Int. Cl.[5] F02P 15/02

[52] U.S. Cl. 123/310

[58] Field of Search 123/310, 256, 279, 661

[56] References Cited

U.S. PATENT DOCUMENTS

2,111,601	3/1938	Rabezzana et al.	123/310
2,338,959	1/1944	Nallinger et al.	123/310
2,466,321	4/1949	Mackenzie	123/310
2,481,890	9/1949	Toews	123/310
4,116,179	9/1978	Nagumo et al.	123/310
4,116,180	9/1978	Hayashi et al.	123/310
4,421,081	12/1983	Nakamura et al.	123/310
4,452,198	6/1984	Berland	123/310
4,702,804	5/1988	Suzuki et al.	123/310

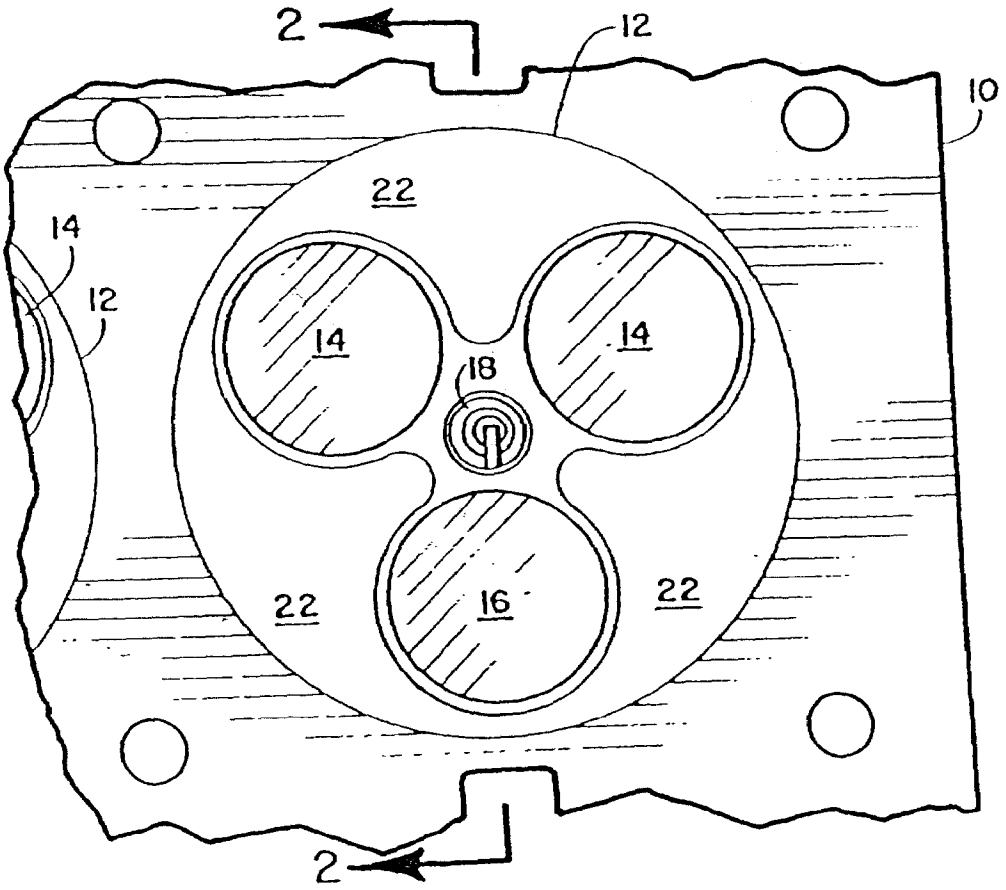
Primary Examiner—Raymond A. Nelli

Attorney, Agent, or Firm—Frank D. Gilliam

[57] ABSTRACT

An intake and exhaust system for use with internal combustion engines that uses two intake valves and one exhaust valve for each engine cylinder. The three valves are preferably round and spaced substantially uniformly in the cylinder head around the cylinder centerline. For best results, the two intake valves have substantially equal diameters, with the diameter of the exhaust valve having a ratio to the diameter of an intake valve of from about 1:1 to about 1:1.2. Preferably one axial, three peripheral or an axial and three peripheral spark plugs equally spaced around the cylinder axis each centrally located in one of the areas between adjacent valves and the edge of the cylinder. The head has three substantially hemispheric depressions each housing one of said valves. This invention provides a fast and uniform lean burn, permits use of a high compression ratio and lower octane, unleaded gasoline and provides improved thermal efficiency.

27 Claims, 2 Drawing Sheets



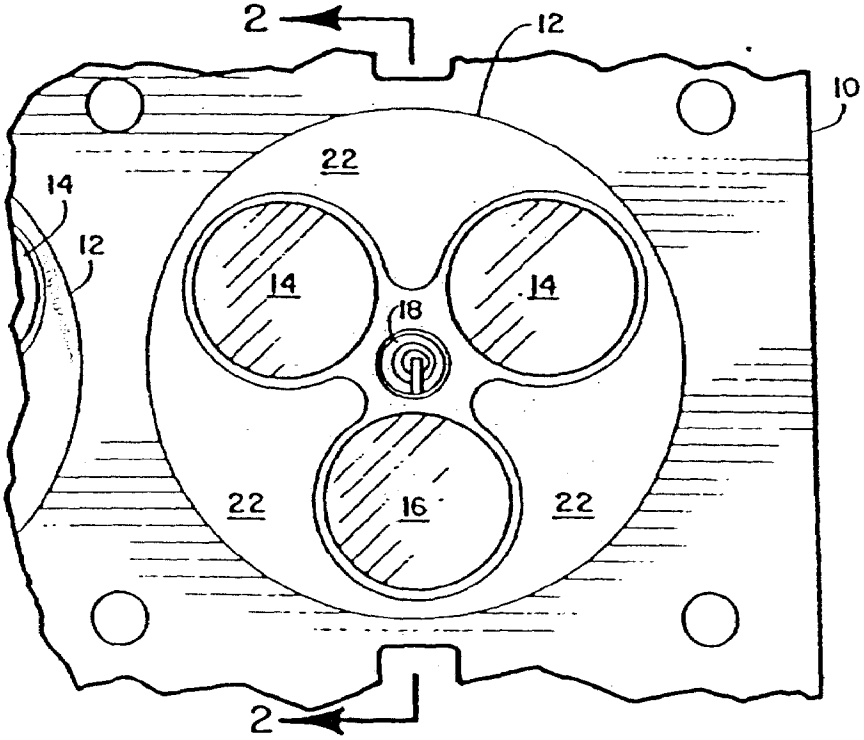


FIGURE 1

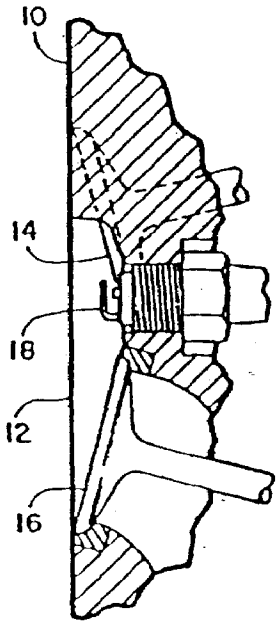


FIGURE 2

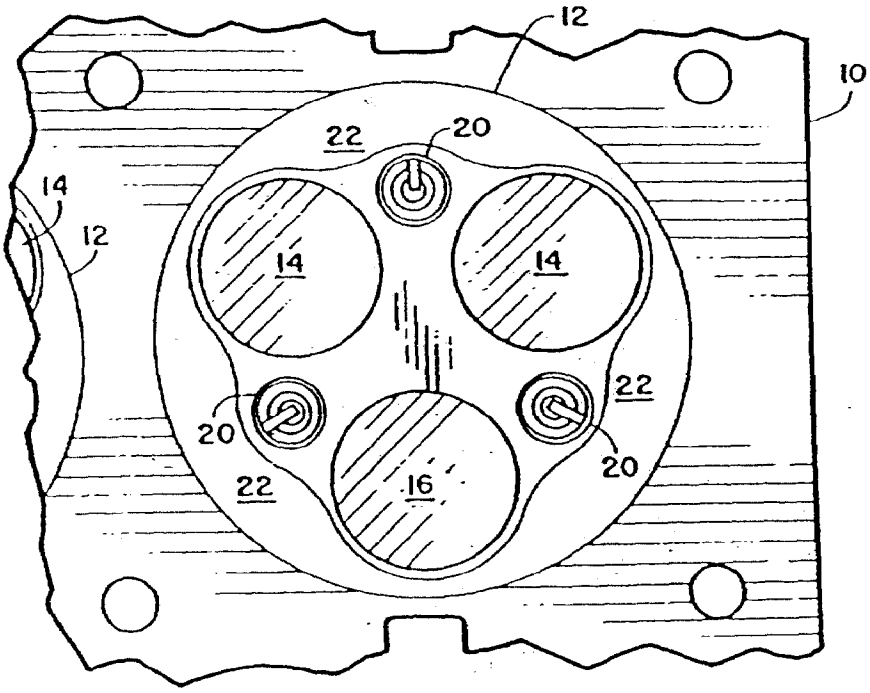


FIGURE 3

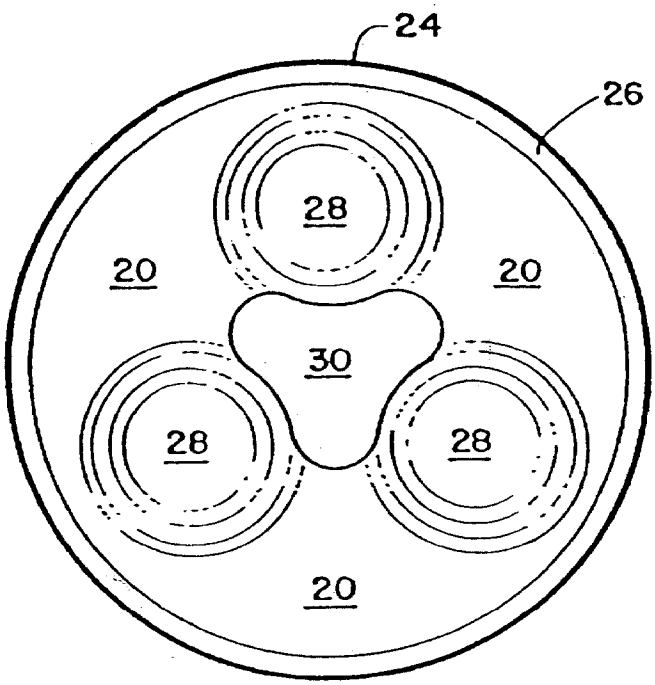


FIGURE 4

HIGH EFFICIENCY COMBUSTION CHAMBER SYSTEM

BACKGROUND OF THE INVENTION

This invention relates in general to improvements in internal combustion engines and, more specifically, to an improved cylinder head and piston arrangement with an improved valve and spark plug layout for use in those engines.

A great many different intake and exhaust valve arrangements have been developed over the years for use in internal combustion engines, in particular for use in automobiles. Most such engines use one intake valve and one exhaust valve at each cylinder with a single spark plug. The prior art arrangements utilize exhaust area/intake area in the range well above 65%. A great deal of effort has gone into optimizing the sizing and placement of the valves, the shape of the combustion chamber and the like. Since there is a great need for improvements in automobile fuel efficiency while maintaining or improving performance, a wide variety of different valve and spark plug configurations and arrangements have been designed and tested. In some of these, multiple valves and spark plugs have been used.

An arrangement of four valves per cylinder, two intake valves and two exhaust valves, has been disclosed, for example, by Akana in U.S. Pat. No. 3,411,490. Today, a number of high performance automobiles use four valve systems, with one or more spark plugs. In these high performance automobiles, several spark plugs may be provided around the periphery of the combustion chamber with an additional spark plug centrally located. Manufacture and operation of these four valve, multiple spark plug engines is complex and expensive and requires complex computer control for efficient operation.

Weslake in U.S. Pat. No. 2,652,039 describes a complex cylinder head arrangement for an internal combustion engine having a wedge-shaped combustion chamber adjacent to the cylinder feeding into a cylinder chamber above the piston. The combustion chamber has an intake valve, an exhaust valve and a single spark plug. A second intake valve is provided in the cylinder chamber. A weak mixture of air and fuel enters the combustion chamber, combustion begins and a rich mixture enters through the cylinder chamber and adds to the original combusting mixture. This very complex system appears to have been unsuccessful and to never have been brought into production.

Another three valve system is described by Von Segern et al in U.S. Pat. No. 3,443,552. Here, a basically conventional cylinder head having a single intake valve and a single exhaust valve with a primary, conventional, combustion chamber is provided. In addition, a centrally located auxiliary chamber is located on the cylinder axis away from the cylinder in gas flow communication with the primary combustion chamber. The auxiliary chamber has a single intake valve and a spark plug. Combustion begins in the auxiliary chamber, spreads to the main combustion chamber where added fuel mixture is introduced. Again, this is a complex and cumbersome system that appears to have been found to be impractical.

Thus, while a great number of different arrangements of multiple valves and/or multiple spark plugs have been designed, none have provided an optimum combination of structural simplicity, maximum fuel efficiency, low emissions and highest performance. Thus, despite the crowded nature of the automobile engine fuel and air introduction and exhaust removal art, there remains a continuing need for improvements providing greater overall efficiency at lowest cost.

It is, therefore, an object of this invention is to provide a simple, easily manufactured internal combustion engine combustion chamber system having increased operating efficiency. Another object is to provide such as system that provides both increased fuel efficiency, low emissions and higher performance. A further object is to provide such a system with high thermal efficiency. Yet another object is to provide a system capable of operating at high compression ratios with a variety of different fuels.

SUMMARY OF THE INVENTION

The above-noted objects, and others, are accomplished, basically, by a three valve combustion chamber system for use with internal combustion engine containing a piston and a cylinder head forming a combustion chamber therebetween. The system comprises three valves in the cylinder head, spaced substantially equally around the cylinder axis, two of the valves adapted to act as intake valves and the third as an exhaust valve. The two intake valves preferably have the same diameter and surface area, with the exhaust valve preferably having the same or slightly greater diameter. The ratio of total exhaust valve cross-sectional area/total intake valve cross-sectional area is ideally less than 65% and can be in the range of 50% to 65%.

In a first version, three peripheral spark plugs are substantially centrally located in the areas surrounded by adjacent valves and the edge of the combustion chamber. A central, fourth, spark plug may be located substantially on the cylinder axis, surrounded by the three valves. A second version has a single central spark plug located substantially on the cylinder axis, surrounded by the three valves. If desired, the system of this invention may be used in a diesel or other engine using an ignition system other than a spark plug.

The cylinder head surface forming one side of the combustion chamber has hemispheric depressions containing each of the valves, with the piston having approximately flat areas corresponding to the approximately flat areas on the cylinder head located between adjacent valves and the edge of the combustion chamber. These opposed flat areas are configured so that as the flat piston and head areas closely approach each other during engine operation a very efficient "squish" area is created. This arrangement substantially improves combustion and fuel efficiency.

BRIEF DESCRIPTION OF THE DRAWING

Details of the invention, and of certain preferred embodiments thereof, will be further understood upon reference to the drawing, wherein:

FIG. 1 is a plan view of the face of a cylinder head combustion chamber, showing a first embodiment of this invention;

FIG. 2 is a section view, taken substantially on line 2—2 in FIG. 1;

FIG. 3 is a plan view similar to FIG. 1 but showing a second embodiment of the invention; and

FIG. 4 is a plan view of a piston face configuration useful with this invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, there is seen a cylinder head 10 having a recessed combustion chamber 12. Head 10 has a number of conventional bolt holes, vents and the like for attachment of the head to the engine block (not shown) and other purposes. Two intake valves 14 open to allow entry of air or an air-fuel mixture into combustion chamber and closed during combustion. One exhaust valve 16 is closed during combustion and opens to allow egress of exhaust gases. Optimally, the faces of valves 14 and 16 are circular and the three valves are substantially uniformly arranged around the cylinder and combustion chamber axis. The shafts may be canted to the cylinder centerline or vertical; that is, parallel to the cylinder centerline, as desired.

The faces of intake valves 14 preferably have the same area so that identical open areas are provided when the valves open and gas flow therethrough is uniform in pattern and volume for optimum efficiency. Exhaust valve 16 ideally has a diameter equal to or slightly greater than that of an intake valve 14, preferably a diameter ratio of from about 1:1 to about 1:1.2. The ratio of total exhaust valve cross-sectional area/total intake valve cross-sectional area is ideally less than 65% and can be in the range of 50% to 65%.

The utilization of the small exhaust port cross-sectional area and valves provides high exhaust gas velocity, on the order of 450 ft/sec. Intake gas velocity, depending on mass, volume and/or the presence of fuel would be in the 225 to 300 ft/sec range. This configuration yields excellent operating characteristics, including throttle response, exhaust gas scavenging, charge purity and octane tolerance. Improved thermal efficiency equates to significantly reduced heat transfer.

In the embodiment of FIG. 1, one central spark plug 18. A central spark plug 18 is shown located substantially on the cylinder centerline and may extend above the surface of the combustion chamber 12, in the preferred arrangement, as shown or may be recessed slightly below the surface, if desired.

In the alternative embodiment shown in FIG. 3, three equidistantly spaced spark plugs 20 are used. While optimum efficiency may in some instances by the addition of a fourth spark plug centrally located in the FIG. 3 embodiment, the embodiment of FIG. 3 is less costly and in many cases provides more or at least sufficient efficiency.

If desired, only a single central spark plug 18 may be used.

FIG. 4 shows the face of a piston 24 optimized for use with the combustion chamber 12 arrangement shown in FIGS. 1-3. It should be understood that FIG. 4 could also pertain to the inner surface of the cylinder head equally as well. For optimum combustion a "squish" area is often desired between portions of the opposed faces of piston 24 and/or combustion chamber 12. In that case, the areas 22 are flat and slightly tapered away from piston toward the combustion chamber centerline and the corresponding areas 26 are similarly flat and slightly tapered so that those areas closely approach each other as piston 24 makes its closest approach to combustion chamber 12 during engine operation, squeezing the fuel/air mixture in those areas toward the center of combustion chamber 12. Areas 22 and 26 lie approximately perpendicular to the centerline of the combustion chamber and cylinder. This "squish" effect has been found to improve combustion efficiency. Recessed areas 28 are formed in the face of piston 24 around central pad 30 or cylinder head to provide the desired compression ratio in conjunction with the squish areas. Recessed areas 28 are sized to provide the desired compression ratio in conjunction with the squish areas.

Other applications, variations and ramifications of this invention will occur to those skilled in the art upon reading this disclosure. Those are intended to be included within the scope of this invention, as defined in the appended claims.

I claim:

1. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three valves in the head of the combustion chamber, the valves substantially uniformly arranged around the axis of the cylinder;

two of the valves having substantially equal areas and adapted to act as intake valves;

the third of the valves having an area substantially equal to, or slightly greater than, the area of one of the intake valves, the third valve being adapted to act as an exhaust valve;

said piston having a generally planar surface adjacent to said head forming one wall of the combustion chamber; and

at least one spark plug for igniting an air/fuel mixture in the combustion chamber said spark plug located entirely within said head without extending below the plane of the piston generally planar surface at any point during engine operation.

2. The system according to claim 1 wherein said ignition means comprises a single spark plug located in said head substantially on the cylinder axis.

3. The system according to claim 1 wherein said ignition means comprises three spark plugs each approximately centrally located in one of the three spaces bounded by two adjacent valves and the cylinder edge.

4. The system according to claim 3 further including a fourth spark plug located in the head substantially on the axis of the cylinder.

5. The system according to claim 1 wherein said ignition means comprises at least three spark plugs.

6. The system according to claim 1 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve being from about 1:1 to 1:1.2.

7. The system according to claim 1 wherein the head includes three hemispheric depressions each housing one of the valves.

8. The system according to claim 1 wherein the exhaust area/intake area ratio is less than 65%.

9. The system according to claim 1 wherein the exhaust area/intake area ratio is in the range of 50% to 65%.

10. The system according to claim 1 wherein said combustion chamber includes a squish area.

11. The system according to claim 1 wherein said cylinder head includes a squish area.

12. The system according to claim 1 wherein squish areas are formed at substantially equally spaced areas around the combustion chamber, each squish area located along the combustion chamber periphery between two adjacent valves.

13. An improved combustion chamber system for use with an internal combustion engine having at least one cylinder each having a piston and a cylinder head forming a combustion chamber therebetween, which comprises:

three valves in the head at each combustion chamber, the valves substantially uniformly arranged around the axis of the cylinder;

two of the valves having substantially equal areas and adapted to act as intake valves;

the third of the valves having an area substantially equal to, or slightly greater than, the area of one of the intake valves, the third valve being adapted to act as an exhaust valve; and

the head having three approximately hemispherical recesses, each of the recesses housing one of the valves.

14. The system according to claim 13 further including an ignition means comprising a single spark plug located in said head substantially on the cylinder axis.

15. The system according to claim 13 further including an ignition means comprising at least three spark plugs.

16. The system according to claim 13 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve is from about 1:1 to 1:1.2.

17. The system according to claim 13 wherein the exhaust area/intake area is less than 65%.

18. The system according to claim 13 wherein the exhaust area/intake area ratio is in the range of 50% to 65%.

19. The system according to claim 13 wherein squish areas are formed at substantially equally spaced areas around the combustion chamber, each squish area located along the combustion chamber periphery between two adjacent valves.

20. The system according to claim 13 further including an ignition means comprising three spark plugs each approximately centrally located in one of the three spaces bounded by two adjacent valves and the cylinder edge.

21. The system according to claim 20 further including a fourth spark plug located in the head substantially on the axis of the cylinder.

22. An improved combustion chamber system for use with internal combustion engine having at least one generally planar piston surface cooperating with a recessed combustion chamber in a generally planar cylinder head, which comprises:

three valves in the head at the combustion chamber, the valves substantially uniformly arranged around the axis of the cylinder;

two of the valves having substantially equal areas and adapted to act as intake valves;

the third of the valves having an area substantially equal to, or slightly greater than, the area of one of the intake valves, the third valve being adapted to act as an exhaust valve;

at least one spark plug for igniting an air/fuel mixture in the combustion chamber, said at least one spark plug located entirely within said cylinder head and combustion chamber without extending below the plane of the cylinder head; and

three squish areas formed at substantially equally spaced areas around the combustion chamber, each squish area located along the combustion chamber periphery between two adjacent valves.

23. The system according to claim 22 wherein said at least one spark plug is a single spark plug is located in said head substantially on the cylinder axis.

24. The system according to claim 22 wherein said at least one spark plug comprises three spark plugs each approximately centrally located in one of the three spaces bounded by two adjacent valves and the cylinder edge.

25. The system according to claim 24 further including a fourth spark plug located in the head substantially on the axis of the cylinder.

26. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three valves in the head at the combustion chamber, the valves substantially uniformly arranged around the axis of the cylinder;

two of the valves having substantially equal areas and adapted to act as intake valves;

the third of the valves having an area substantially equal to, or slightly greater than, the area of one of the intake valves, the third valve being adapted to act as an exhaust valve;

a single spark plug for igniting an air/fuel mixture in the combustion chamber;

said single spark plug located at substantially the center of said combustion chamber.

27. The system according to claim 26 wherein the combustion chamber in the cylinder head includes three hemispheric depressions each housing one of said valves.

* * * * *

EXHIBIT 2

US005501191A

United States Patent [19]

Feuling

[11] Patent Number: 5,501,191

[45] Date of Patent: Mar. 26, 1996

[54] COMBUSTION CHAMBER SYSTEM HAVING AN IMPROVED VALVE ARRANGEMENT

[76] Inventor: James J. Feuling, 2521 Palma, Ventura, Calif. 93003

[21] Appl. No.: 246,788

[22] Filed: May 19, 1994

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 995,785, Dec. 23, 1992, Pat. No. 5,313,921.

[51] Int. Cl.[6] F02P 15/02

[52] U.S. Cl. 123/310

[58] Field of Search 123/310, 256, 123/279, 661

[56] References Cited

U.S. PATENT DOCUMENTS

2,111,601	3/1938	Rabezzana et al.	123/310
2,338,959	1/1944	Nallinger et al.	123/310
4,702,804	5/1988	Suzuki et al.	123/310

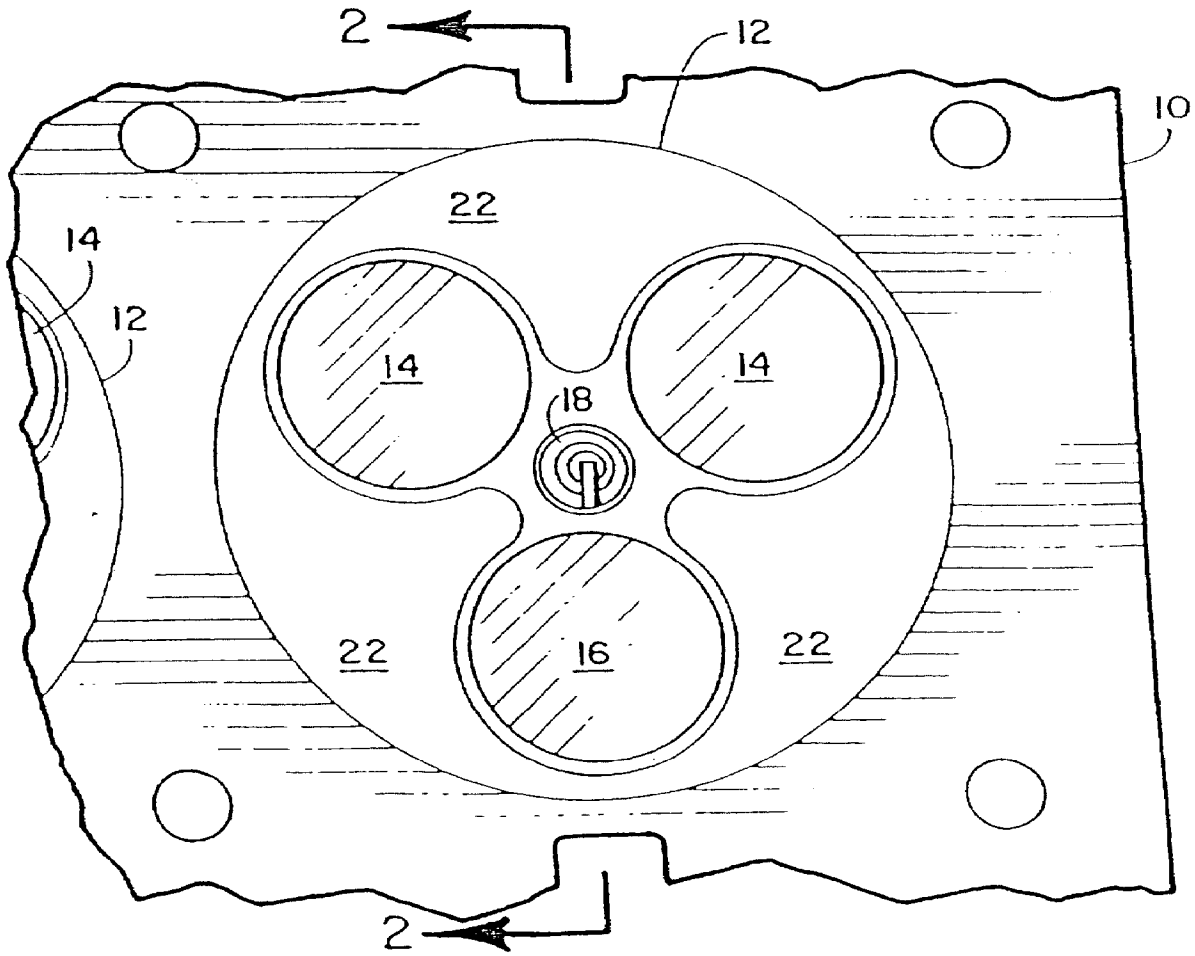
Primary Examiner—Raymond A. Nelli

Attorney, Agent, or Firm—John R. Duncan; Frank D. Gilliam

[57] ABSTRACT

An intake and exhaust system for use with internal combustion engines that uses two intake valves and one exhaust valve for each engine cylinder. The three valves are preferably round and spaced around the cylinder centerline in the cylinder head. The two intake valves may be spaced closer to the exhaust valve than to each other. The two intake valves may, alternatively, be spaced closer to each other than to the exhaust valve and two spark plugs may be provided, each lying between an intake valve and the exhaust valve. For best results, the two intake valves have substantially equal diameters, with the diameter of the exhaust valve having a ratio to the diameter of an intake valve of from about 1:1 to about 1:1.2. The head has three substantially hemispheric depressions each housing one of said valves. Squish areas are preferably provided between each pair of adjacent valves around the combustion chamber periphery. This invention provides a fast and uniform lean burn, permits use of a high compression ratio and lower octane, unleaded gasoline and provides improved thermal efficiency.

38 Claims, 3 Drawing Sheets



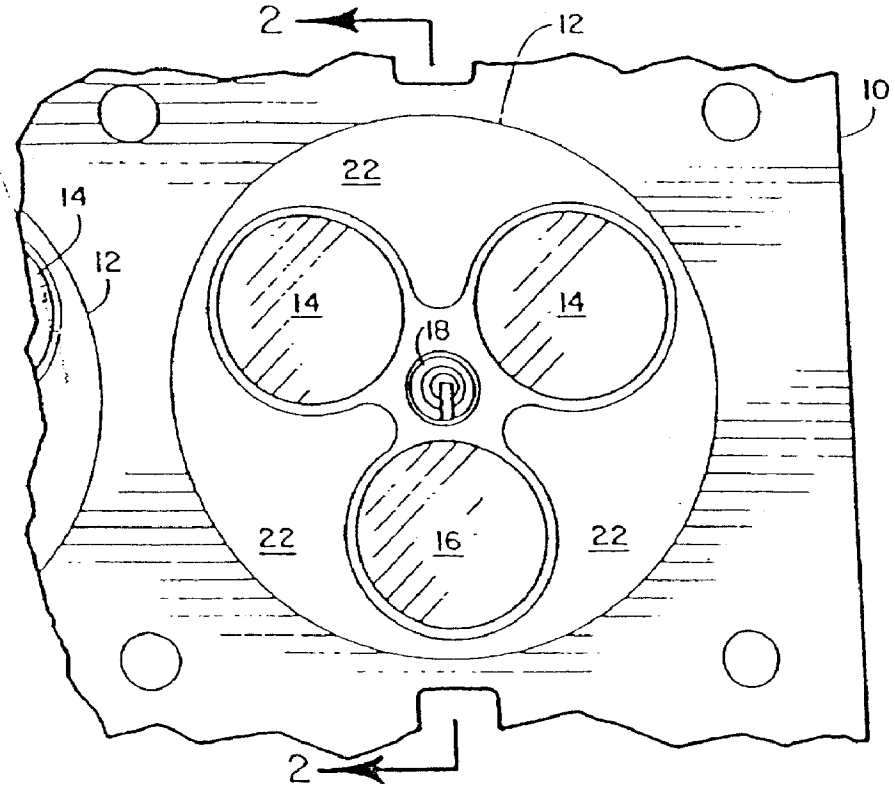


FIGURE 1

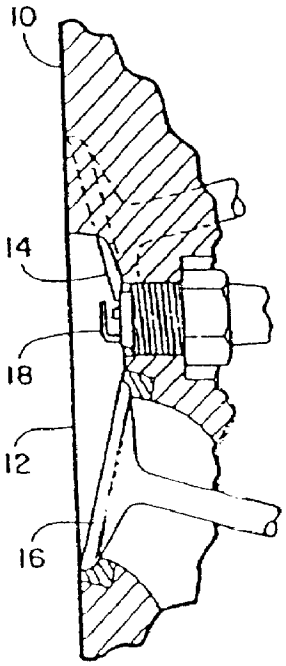


FIGURE 2

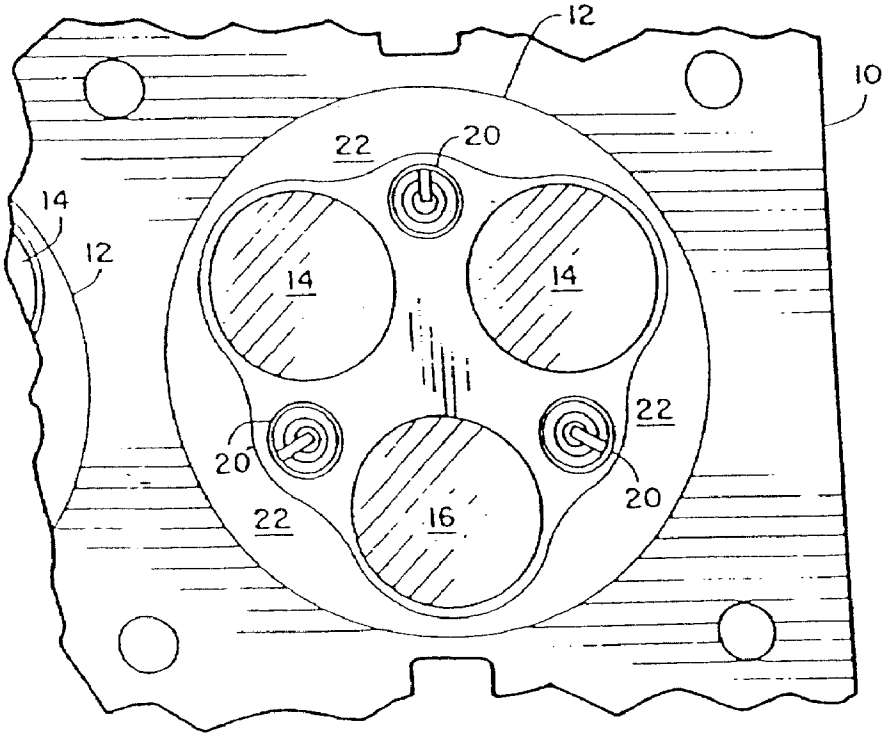


FIGURE 3

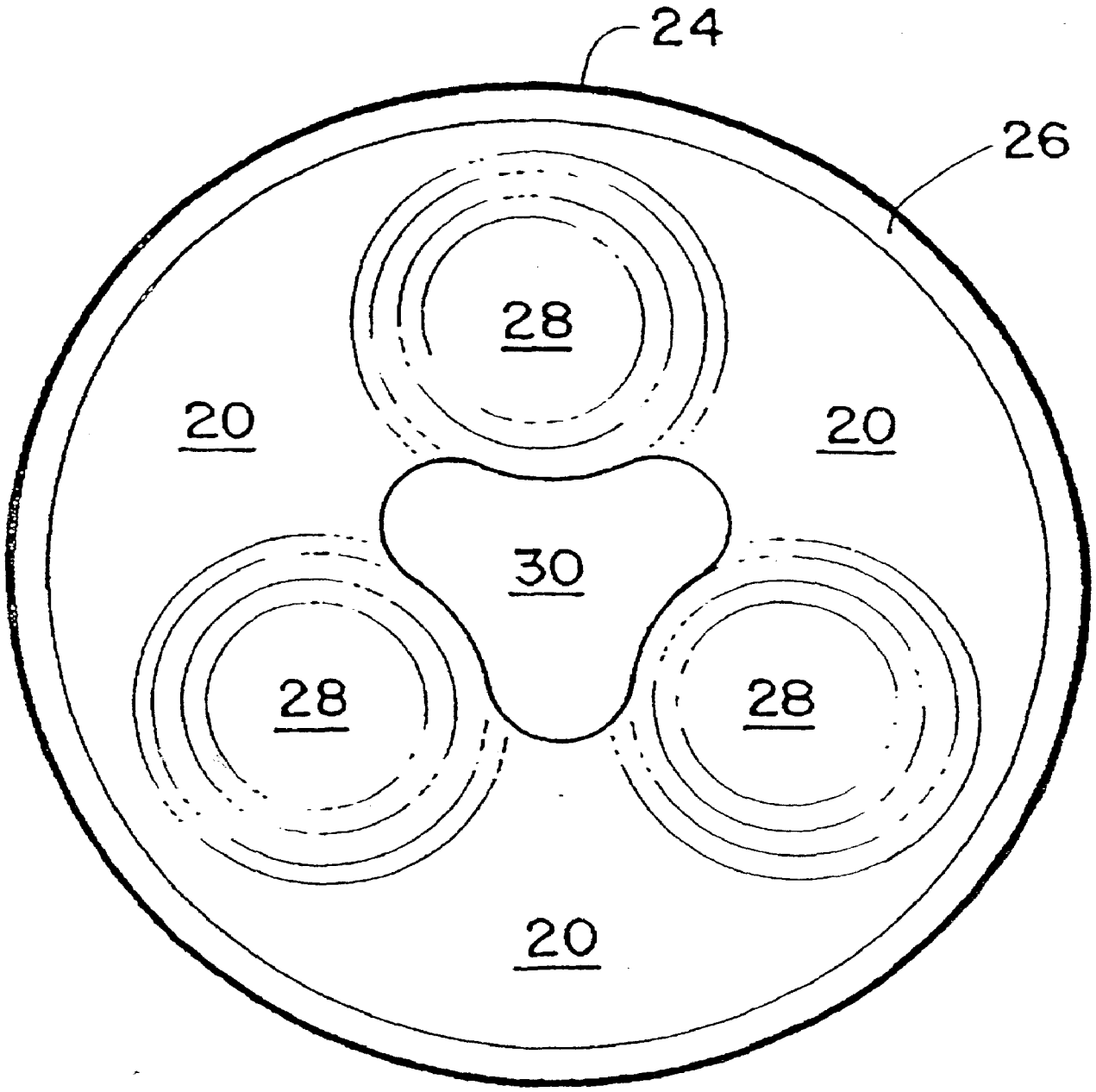


FIGURE 4

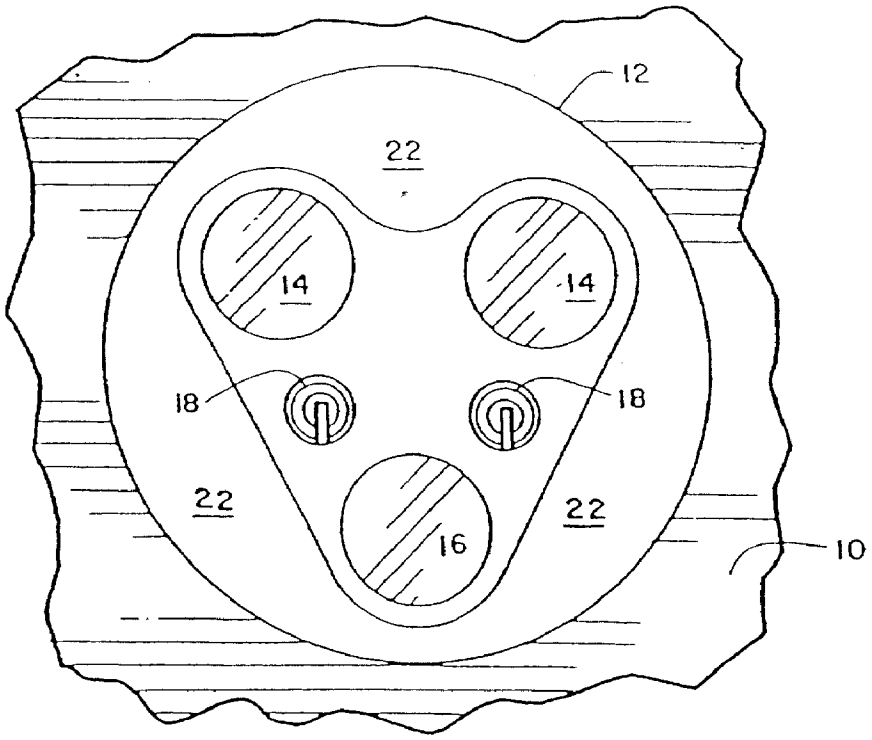


FIGURE 6

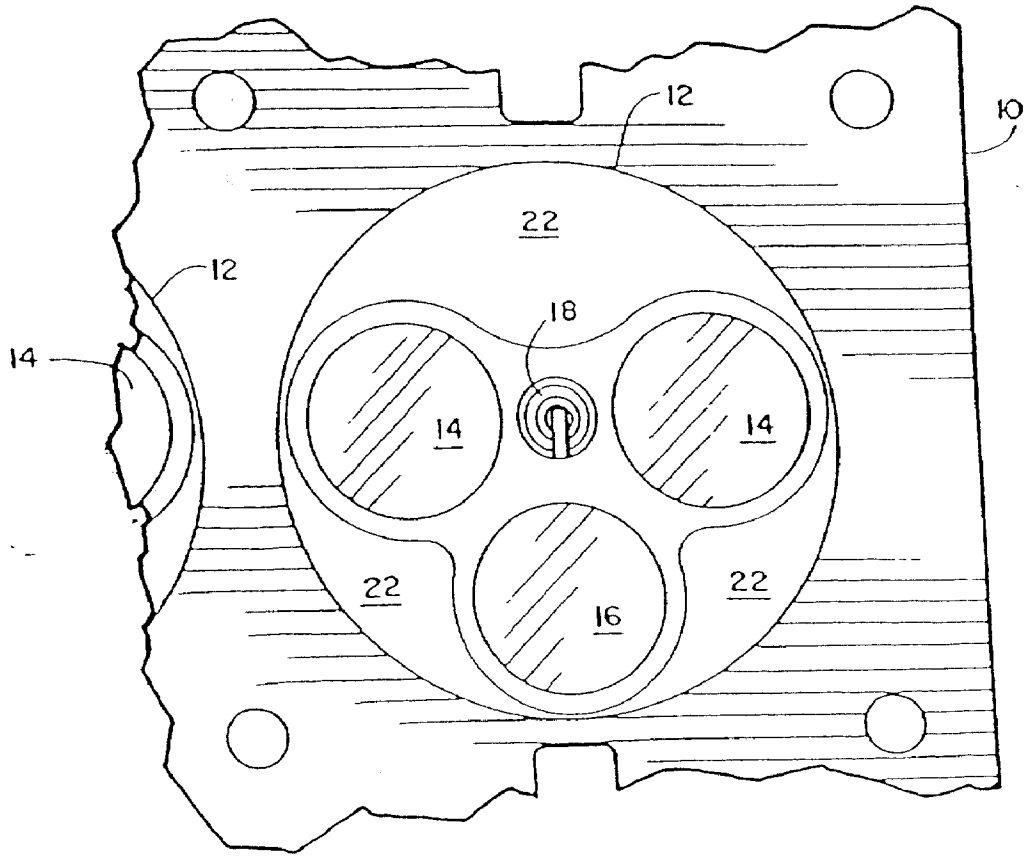


FIGURE 5

COMBUSTION CHAMBER SYSTEM HAVING AN IMPROVED VALVE ARRANGEMENT

This is a continuation-in-part of application Ser. No. 07/995,785 filed on Dec. 23, 1992, now U.S. Pat. No. 5,313,921.

BACKGROUND OF THE INVENTION

This invention relates in general to improvements in internal combustion engines and, more specifically, to an improved cylinder head and piston arrangement with an improved valve and spark plug layout for use in those engines.

A great many different intake and exhaust valve arrangements have been developed over the years for use in internal combustion engines, in particular for use in automobiles. Most such engines use one intake valve and one exhaust valve at each cylinder with a single spark plug. The prior art arrangements utilize exhaust area intake area in the range of over 65%. A great deal of effort has gone into optimizing the sizing and placement of the valves, the shape of the combustion chamber and the like. Since there is a great need for improvements in automobile fuel efficiency while maintaining or improving performance, a wide variety of different valve and spark plug configurations and arrangements have been designed and tested. In some of these, multiple valves and spark plugs have been used.

An arrangement of four valves per cylinder, two intake valves and two exhaust valves, has been disclosed, for example, by Akana in U.S. Pat. No. 3,411,490. Today, a number of high performance automobiles use four valve systems, with one or more spark plugs. In these high performance automobiles, several spark plugs may be provided around the periphery of the combustion chamber with an additional spark plug centrally located. Manufacture and operation of these four valve, multiple spark plug engines is complex and expensive and requires complex computer control for efficient operation.

Weslake in U.S. Pat. No. 2,652,039 describes a complex cylinder head arrangement for an internal combustion engine having a wedgeshaped combustion chamber adjacent to the cylinder feeding into a cylinder chamber above the piston. The combustion chamber has an intake valve, an exhaust valve and a single spark plug. A second intake valve is provided in the cylinder chamber. A weak mixture of air and fuel enters the combustion chamber, combustion begins and a rich mixture enters through the cylinder chamber and adds to the original combusting mixture. This very complex system appears to have been unsuccessful and to never have been brought into production.

Another three valve system is described by Von Segern et al in U.S. Pat. No. 3,443,552. Here, a basically conventional cylinder head having a single intake valve and a single exhaust valve with a primary, conventional, combustion chamber is provided. In addition, a centrally located auxiliary chamber is located on the cylinder axis away from the cylinder in gas flow communication with the primary combustion chamber. The auxiliary chamber has a single intake valve and a spark plug. Combustion begins in the auxiliary chamber, spreads to the main combustion chamber where added fuel mixture is introduced. Again, this is a complex and cumbersome system that appears to have been found to be impractical.

Thus, while a great number of different arrangements of multiple valves and/or multiple spark plugs have been designed, none have provided an optimum combination of structural simplicity, maximum fuel efficiency and highest performance. Thus, despite the crowded nature of the automobile engine fuel and air introduction and exhaust removal art, there remains a continuing need for improvements providing greater overall efficiency at lowest cost.

It is, therefore, an object of this invention is to provide a simple, easily manufactured internal combustion engine combustion chamber system having increased operating efficiency. Another object is to provide such as system that provides both increased fuel efficiency and higher performance. A further object is to provide such a system with high thermal efficiency. Yet another object is to provide a system capable of operating at high compression ratios with a variety of different fuels.

SUMMARY OF THE INVENTION

The above-noted objects, and others, are accomplished, basically, by a three valve combustion chamber system for use with internal combustion engine containing a piston and a cylinder head forming a combustion chamber therebetween. The system comprises three valves in the cylinder head, spaced around the cylinder axis, two of the valves adapted to act as intake valves and the third as an exhaust valve. The two intake valves preferably have the same diameter and surface area, with the exhaust valve preferably having the same or slightly greater diameter. The ratio of total exhaust valve cross-sectional area/total intake valve cross-sectional area is ideally less than 65% and can be in the range of 50% to 65%.

In a first version, three peripheral spark plugs are substantially centrally located in the areas surrounded by adjacent valves and the edge of the combustion chamber. A central, fourth, spark plug may be located substantially on the cylinder axis, surrounded by the three valves. A second version has a single central spark plug located substantially on the cylinder axis, surrounded by the three valves. If desired, the system of this invention may be used in a diesel or other engine using an ignition system other than a spark plug.

The cylinder head surface forming one side of the combustion chamber has hemispheric depressions containing each of the valves, with the piston having approximately flat areas corresponding to the approximately flat areas on the cylinder head located between adjacent valves and the edge of the combustion chamber. These opposed flat areas are configured so that as the flat piston and head areas closely approach each other during engine operation a very efficient "squish" area is created. This arrangement substantially improves combustion and fuel efficiency.

In a preferred embodiment, the three valves may be located towards one side of the combustion chamber with the space between each intake valve and the exhaust valve being less than the distance between the two intake valves. The single central spark plug (or other ignition device) is positioned approximately on the cylinder axis.

In another preferred embodiment, wo equally spaced intake valves are positioned to one side of the combustion chamber, with a single exhaust valves to the other side and two spark plugs, each positioned outwardly of a line between the center of the exhaust valve and the center of an intake valve. The intake valves and spark plugs are symmetrically located on the sides of a line drawn through the center of the exhaust valve and equally spaced between the intake valves. Squish areas are located along the edges of the

combustion chamber between each adjacent pair of valves. Optimally, the squish areas between the exhaust valve and each intake valve has a substantially straight edge, approximately parallel to a line drawn between the centers of the exhaust valve and the intake valve.

BRIEF DESCRIPTION OF THE DRAWING

Details of the invention, and of certain preferred embodiments thereof, will be further understood upon reference to the drawing, wherein:

FIG. 1 is a plan view of the face of a cylinder head combustion chamber, showing a first embodiment of this invention;

FIG. 2 is a section view, taken substantially on line 2—2 in FIG. 1;

FIG. 3 is a plan view similar to FIG. 1 but showing a second embodiment of the invention;

FIG. 4 is a plan view of a piston face configuration useful with this invention; and

FIG. 5 is a plan view similar to FIG. 1 but showing a third embodiment of the invention.

FIG. 6 is a plan view similar to FIG. 1 but showing a fourth embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, there is seen a cylinder head 10 having a recessed combustion chamber 12. Head 10 has a number of conventional bolt holes, vents and the like 11 for attachment of the head to the engine block (not shown) and other purposes. Two intake valves 14 open to allow entry of air or an air-fuel mixture into combustion chamber and closed during combustion. One exhaust valve 16 is closed during combustion and opens to allow egress of exhaust gases. Optimally, the faces of valves 14 and 16 are circular and the three valves are substantially uniformly arranged around the cylinder and combustion chamber axis. The shafts may be canted to the cylinder centerline or vertical; that is, parallel to the cylinder centerline, as desired.

The faces of intake valves 14 preferably have the same area so that identical open areas are provided when the valves open and gas flow therethrough is uniform in pattern and volume for optimum efficiency. Exhaust valve 16 ideally has a diameter equal to or slightly greater than that of an intake valve 14, preferably a diameter ratio of from about 1:1 to about 1:1.2. The ratio of total exhaust valve cross-sectional area/total intake valve cross-sectional area is ideally less than 65% and can be in the range of 50% to 65%.

The utilization of the small exhaust port cross-sectional area and valves provides high exhaust gas velocity, on the order of 450 ft/sec. Intake gas velocity, depending on mass, volume and/or the presence of fuel would be in the 225 to 300 ft/sec range. This configuration yields excellent operating characteristics, including throttle response, exhaust gas scavenging, charge purity and octane variation tolerance. Improved thermal efficiency allows for significantly reduced heat transfer.

In the embodiment of FIG. 1, one central spark plug 18. A central spark plug 18 is shown located substantially on the cylinder centerline and may extend above the surface of the combustion chamber 12, in the preferred arrangement, as shown or may be recessed slightly below the surface, if desired.

In the alternative embodiment shown in FIG. 3, three peripheral spark plugs 20 are used. While optimum efficiency may in some instances by the addition of a fourth spark plug centrally located in the FIG. 3 embodiment, the embodiment of FIG. 3 is less costly and in many cases provides more or at least sufficient efficiency.

If desired, only a single central spark plug 18 may be used.

FIG. 4 shows the face of a piston 24 optimized for use with the combustion chamber 12 arrangement shown in FIGS. 1–3. For optimum combustion a "squish" area is often desired between portions of the opposed faces of piston 24 and combustion chamber 12. In that case, the areas 22 are flat and slightly tapered away from piston toward the combustion chamber centerline and the corresponding areas 26 are similarly flat and slightly tapered so that those areas closely approach each other as piston 24 makes its closest approach to combustion chamber 12 during engine operation, squeezing the fuel/air mixture in those areas toward the center of combustion chamber 12. Areas 22 and 26 lie approximately perpendicular to the centerline of the combustion chamber and cylinder. This "squish" effect has been found to improve combustion efficiency. Recessed areas 28 are formed in the face of piston 24 around central pad 30 to provide the desired compression ratio in conjunction with the squish areas. Recessed areas 28 are sized to provide the desired compression ratio in conjunction with the squish areas.

FIG. 5 shows a plan view of another embodiment of the combustion chamber system. Here, the combustion chamber 12 in cylinder head 10 has a generally similar configuration to that shown in FIG. 1, but with a different valve arrangement. Intake valves 14 are positioned closer to exhaust valve 16 than to each other. The size relationship among the valves is the same as described above. Squish plates 22 of the sort described above are provided between adjacent valves, with the squish plate between the two intake valves 14 being larger in area than that between each intake valve 14 and the exhaust valve 16. The embodiment shown in FIG. 5 is particularly useful in permitting an offset pushrod arrangement for operating the valves. If desired, three spark plugs 18 could be used, spaced around the periphery between each adjacent pair of valves, as shown in FIG. 3. Or, three spark plugs oriented as shown in FIG. 3 plus a centrally located plug as seen in FIG. 1 could be used together.

FIG. 6 shows a plan view of another embodiment of the combustion chamber system. Here, the combustion chamber 12 in cylinder head 10 has a generally similar configuration to that shown in FIG. 1, but with a different valve arrangement. Two intake valves 14 are positioned to one side of chamber 12, with exhaust valve 16 to the other side. Two spark plus 18 are located between exhaust valve 16 and each intake valve 14. Each spark plug 18 is positioned outwardly of a line drawn between the center of exhaust valve 16 and each intake valve 14. A line of symmetry can be drawn from the center of exhaust valve between and equally spaced from intake valves 14. The combustion on one side of that line of symmetry is a mirror image of the other side. For optimum operation, squish areas 22 are provided between each adjacent pair of valves, with the edge of the squish areas between exhaust valve 16 and each intake valve 14 being a substantially straight line drawn approximately parallel to a line drawn through the centers of the exhaust valve 16 and an intake valve 14. While the arrangement shown with two spark plugs in FIG. 6 is preferred, if desired three peripheral plugs as shown in FIG. 3 and/or a central plug as shown in FIG. 1 could be used.

While certain preferred materials, dimensions and arrangements have been described in detail in conjunction with the above description of preferred embodiments, those can be varied, where suitable, with similar results. For example, in the embodiment shown in FIG. 6, a single spark plug could be used at the center of the cylinder (as shown in FIG. 5) instead of the two spark plugs shown. Other applications, variations and ramifications of this invention will occur to those skilled in the art upon reading this disclosure. Those are intended to be included within the scope of this invention, as defined in the appended claims.

I claim:

1. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three valves in the head at the combustion chamber, said valves being arranged around an axis of the cylinder;

two of the valves having substantially equal areas and adapted to act as intake valves;

the third of said valves having an area equal to, or slightly greater than, the area of one of the intake valves, the third valve being adapted to act as an exhaust valve;

said two intake valves being spaced a greater distance from each other than from said exhaust valve;

said piston having a generally planar surface adjacent to said head forming one wall of the combustion chamber; and

at least one ignition means for igniting an air/fuel mixture in the combustion chamber, said ignition means located entirely within said head without extending below the plane of said piston's generally planar surface at any point during engine operation.

2. The system according to claim 1 wherein said ignition means comprises a single spark plug located in said head approximately at said cylinder axis.

3. The system according to claim 1 wherein each of said valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve are from 1:1 to 1:1.2.

4. The system according to claim 1 wherein said head includes three hemispheric depressions each housing one of said valves.

5. The system according to claim 1 wherein the exhaust area/intake area ratio is less than approximately 65%.

6. The system according to claim 1 wherein the exhaust area/intake area ratio is from 50% to 65%.

7. The system according to claim 1 wherein squish areas are provided along the combustion chamber periphery between each pair of adjacent valves, a squish area between said intake valves having an area greater than a squish area between said exhaust valve and an adjacent intake valve.

8. The system according to claim 1 wherein said two intake valves have substantially equal areas.

9. The system according to claim 1 wherein said ignition means comprises a single spark plug located in said head substantially on said cylinder axis.

10. The system according to claim 1 wherein said ignition means comprises at least three spark plugs.

11. The system according to claim 10 further including a fourth spark plug located in said head substantially on said axis of said cylinder.

12. The system according to claim 1 wherein each of said valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve is approximately 1:1.

13. The system according to claim 1 wherein each of said valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve is approximately 1:1.2.

14. The system according to claim 1 wherein the exhaust area/intake area ratio is approximately 50%.

15. The system according to claim 1 wherein the exhaust area/intake area ratio is approximately 65%.

16. An improved combustion chamber system for use with internal combustion engine having at least one cylinder each having a piston and a cylinder head forming a combustion chamber therebetween, comprising:

three valves in the head at each combustion chamber, the valves being arranged around the axis of the cylinder;

two of said valves having substantially equal areas and adapted to act as intake valves;

the third of said three valves having an area substantially equal to, or slightly greater than, the area of one of the intake valves, the third valve being adapted to act as an exhaust valve;

said two intake valves positioned closer to each other than to said exhaust valve; and

said head having three approximately hemispherical recesses, each of the recesses housing one of the valves.

17. The system according to claim 16 further including an ignition means comprising a single spark plug located in said head approximately at the cylinder centerline.

18. The system according to claim 16 wherein said ignition means comprises at least three spark plugs.

19. The system according to claim 18 further including a fourth spark plug located in the head substantially on the central axis of said cylinder.

20. The system according to claim 16 further including squish areas are provided along the combustion chamber periphery between each pair of adjacent valves, the squish area between said intake valves having an area greater that the squish area between said exhaust valve and an adjacent intake valve.

21. The system according to claim 16 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve are from 1:1 to 1:1.2.

22. The system according to claim 16 wherein the head includes three hemispheric depressions each housing one of the valves.

23. The system according to claim 16 wherein the exhaust area/intake area ratio is from 50% to 65%.

24. The system according to claim 16 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve is approximately 1:1.

25. The system according to claim 16 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve is approximately 1:1.2.

26. The system according to claim 16 wherein the exhaust area/intake area ratio is approximately 50%.

27. The system according to claim 16 wherein the exhaust area/intake area ratio is approximately 65%.

28. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three valves in the head at the combustion chamber, said valves being arranged around the axis of the cylinder;

two of said valves having substantially equal areas and adapted to act as intake valves;

the third of the valves having an area substantially equal to, or slightly greater than, the area of one of the intake valves, the third valve being adapted to act as an exhaust valve;

said two intake valves being spaced a greater distance from said exhaust valve than from each other;

said piston having a generally planar surface adjacent to said head forming one wall of the combustion chamber; and

two spark plugs located between said exhaust valve and each of said intake valves, said spark plugs located outside of a line drawn between the center of said exhaust valve and the center of the corresponding intake valve.

29. The system according to claim 28 wherein squish areas are provided along the combustion chamber periphery between each pair of adjacent valves, the squish area between said intake valves being less than the squish area between said exhaust valve and an adjacent intake valve.

30. The system according to claim 29 wherein each squish area between said exhaust valve and an intake valve has a substantially straight edge portion, said straight edge portion being approximately parallel to a line drawn between the centers of said exhaust valve and an intake valve.

31. The system according to claim 28 wherein said intake valves and spark plugs are symmetrically located on the sides of a line drawn through the center of the exhaust valve and equally spaced between the intake valves.

32. The system according to claim 28 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve are from 1:1 to 1:1.2.

33. The system according to claim 28 wherein said head includes three hemispheric depressions each housing one of said valves.

34. The system according to claim 28 wherein the exhaust area/intake area ratio is from 50% to 65%.

35. The system according to claim 28 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve is approximately 1:1.

36. The system according to claim 28 wherein each of the valves is substantially circular and the ratio of diameters of the intake valves to the diameter of the exhaust valve is approximately 1:1.2.

37. The system according to claim 28 wherein the exhaust area/intake area ratio is approximately 50%.

38. The system according to claim 28 wherein the exhaust, area/intake area ratio is 65%.

* * * * *

EXHIBIT 3

US005638787A

United States Patent [19]

Feuling

[11] Patent Number: 5,638,787

[45] Date of Patent: *Jun. 17, 1997

[54] COMBUSTION CHAMBER SYSTEM HAVING AN IMPROVED VALVE ARRANGEMENT

[76] Inventor: **James J. Feuling**, 2521 Palma, Ventura, Calif. 93003

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,313,921.

[21] Appl. No.: **592,760**

[22] Filed: **Jan. 26, 1996**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 246,788, May 19, 1994, Pat. No. 5,501,191, which is a continuation-in-part of Ser. No. 995,785, Dec. 23, 1992, Pat. No. 5,313,921.

[51] **Int. Cl.**[6] **F02P 15/02**

[52] **U.S. Cl.** **123/310**

[58] **Field of Search** 123/310, 256, 123/279, 661

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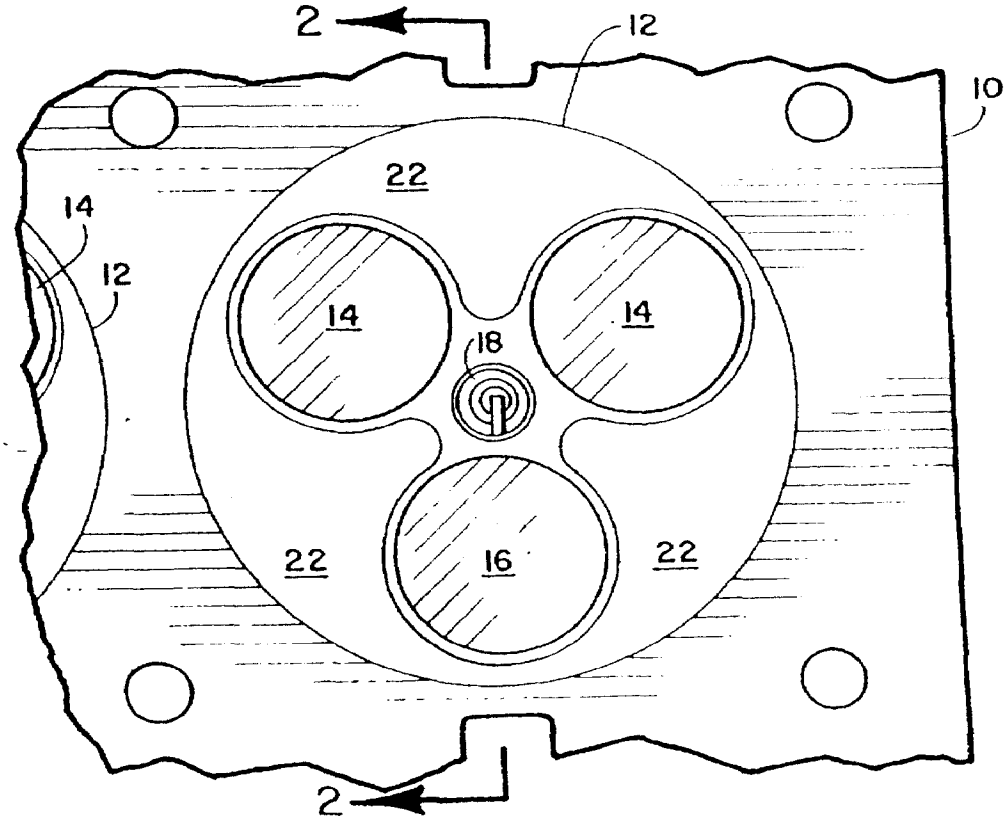
Primary Examiner—Raymond A. Nelli

Attorney, Agent, or Firm—Frank D. Gilliam; John R. Duncan

[57] **ABSTRACT**

An intake and exhaust system for use with internal combustion engines that uses two intake valves and one exhaust valve for each engine cylinder. Said three valves are preferably round and spaced around said cylinder centerline in said cylinder head. A spark plug is provided in said head on said cylinder centerline and/or between each pair of adjacent valves. For best results, said two intake valves have substantially equal diameters. Said ratio of said area of said exhaust valve to said total area of an intake valve of from about is about 45 to 65%. Said head has three substantially hemispheric depressions each housing one of said valves. Squish areas are preferably provided around said combustion chamber periphery. Said piston surface is at least partially planar and can have an angled or radiused periphery or may have a central recess corresponding generally to said valve region. This invention provides a fast and uniform lean burn, permits use of a high compression ratio and lower octane, unleaded gasoline and provides improved thermal efficiency.

19 Claims, 4 Drawing Sheets



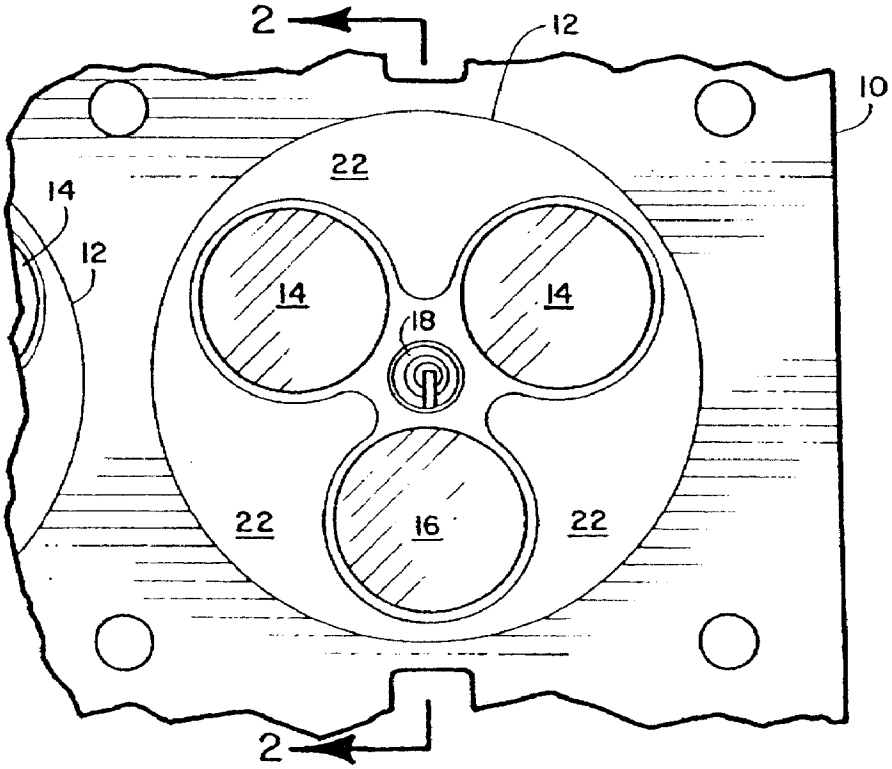


FIGURE 1

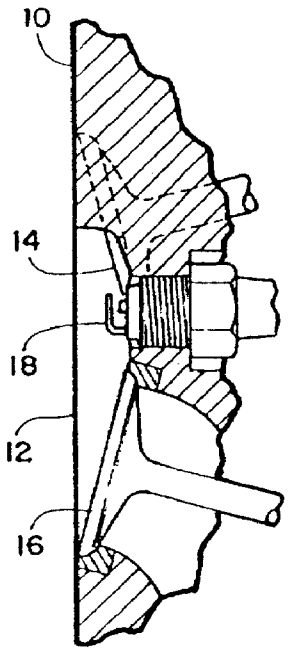


FIGURE 2

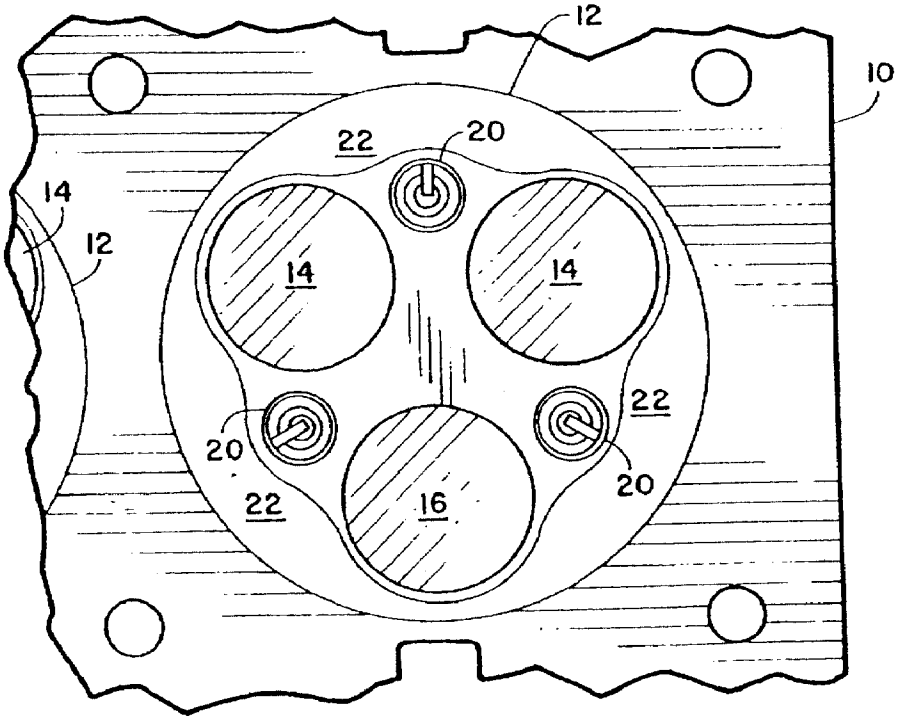


FIGURE 3

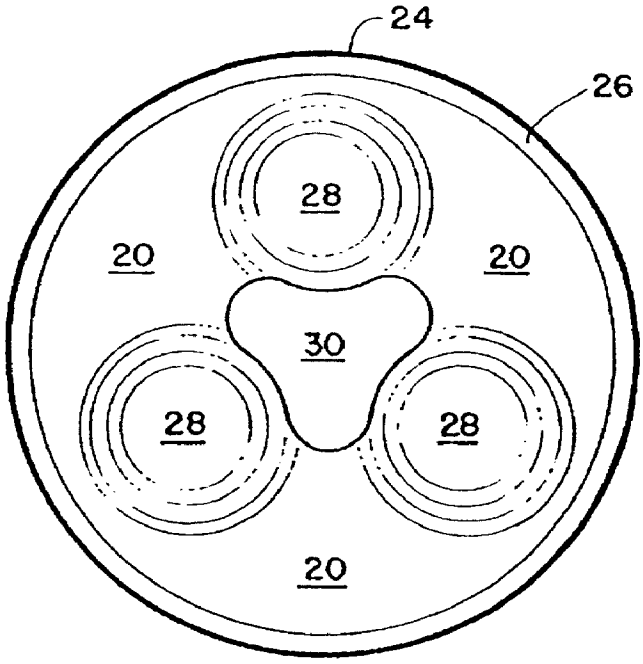


FIGURE 4

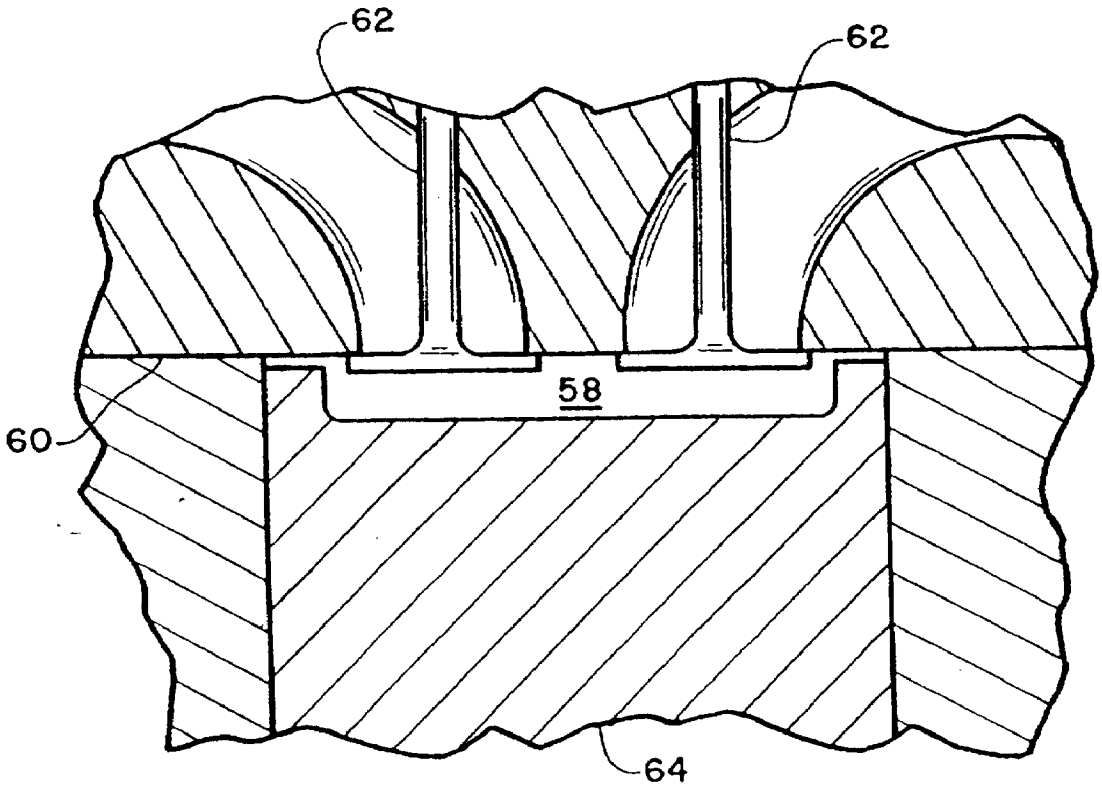


FIGURE 10

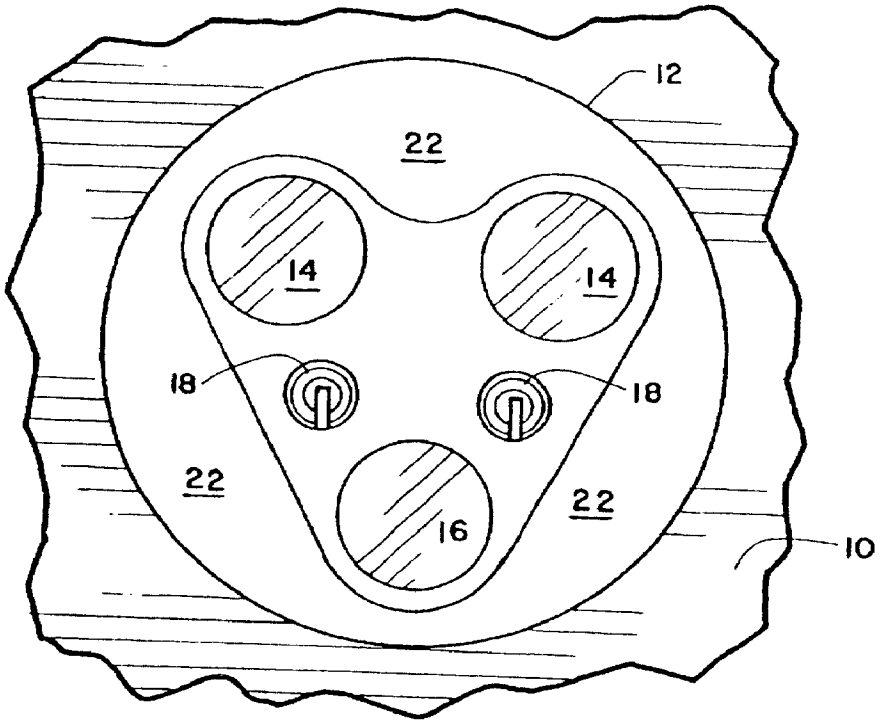


FIGURE 6

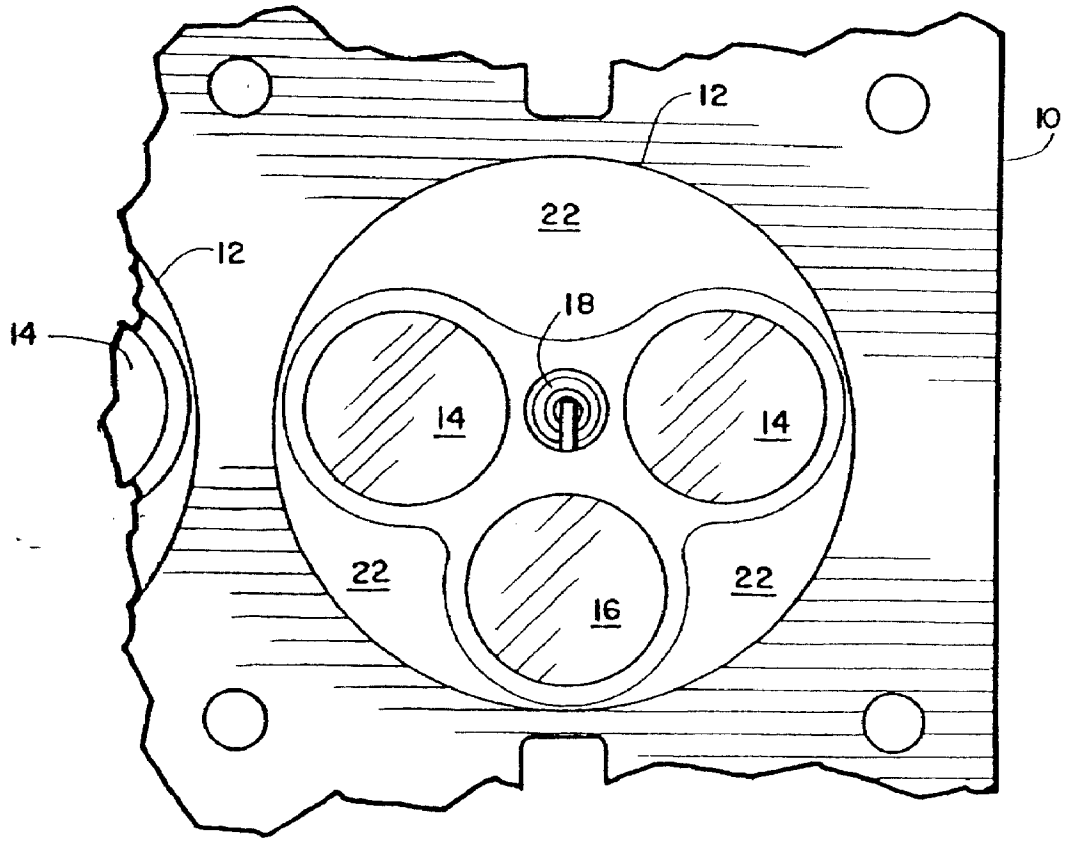


FIGURE 5

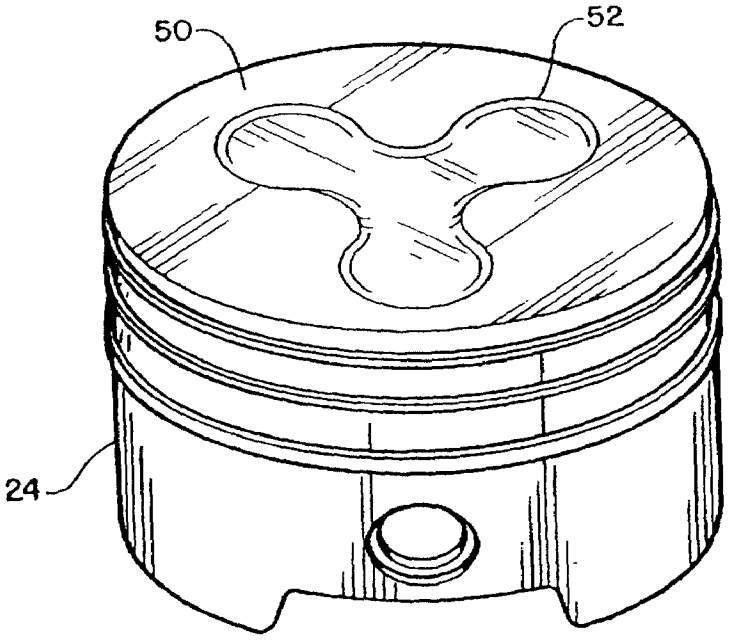


FIGURE 9

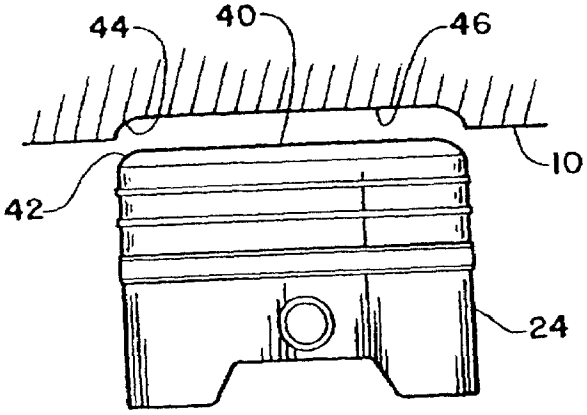


FIGURE 8

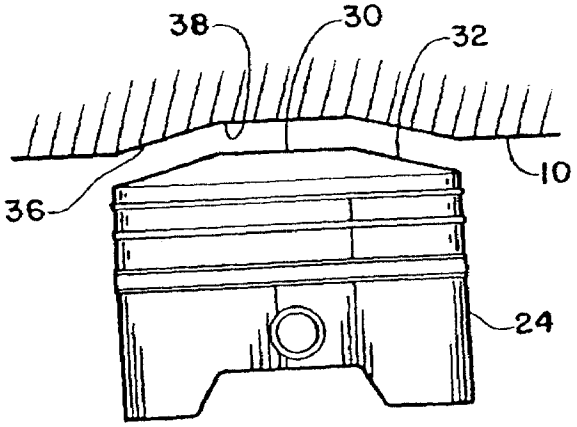


FIGURE 7

COMBUSTION CHAMBER SYSTEM HAVING AN IMPROVED VALVE ARRANGEMENT

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of patent application Ser. No. 08/246,788, filed May 19, 1994, now U.S. Pat. No. 5,501,191, which is a continuation-in-part of U.S. patent application Ser. No. 07/995,785, filed Dec. 23, 1992, now U.S. Pat. No. 5,313,921.

BACKGROUND OF THE INVENTION

This invention relates in general to improvements in internal combustion engines and, more specifically, to an improved cylinder head and piston arrangement with an improved valve and spark plug layout for use in those engines.

A great many different intake and exhaust valve arrangements have been developed over the years for use in internal combustion engines, in particular for use in automobiles. Most such engines use one intake valve and one exhaust valve at each cylinder with a single spark plug. The prior art arrangements utilize exhaust area/intake area in the range of over 65%. A great deal of effort has gone into optimizing the sizing and placement of the valves, the shape of the combustion chamber and the like. Since there is a great need for improvements in automobile fuel efficiency while maintaining or improving performance, a wide variety of different valve and spark plug configurations and arrangements have been designed and tested. In some of these, multiple valves and spark plugs have been used.

An arrangement of four valves per cylinder, two intake valves and two exhaust valves, has been disclosed, for example, by Akana in U.S. Pat. No. 3,411,490. Today, a number of high performance automobiles use four valve systems, with one or more spark plugs. In these high performance automobiles, several spark plugs may be provided around the periphery of the combustion chamber with an additional spark plug centrally located. Manufacture and operation of these four valve, multiple spark plug engines is complex and expensive and requires complex computer control for efficient operation.

Weslake in U.S. Pat. No. 2,652,039 describes a complex cylinder head arrangement for an internal combustion engine having a wedge-shaped combustion chamber adjacent to the cylinder feeding into a cylinder chamber above the piston. The combustion chamber has an intake valve, an exhaust valve and a single spark plug. A second intake valve is provided in the cylinder chamber. A weak mixture of air and fuel enters the combustion chamber, combustion begins and a rich mixture enters through the cylinder chamber and adds to the original combusting mixture. This very complex system appears to have been unsuccessful and to never have been brought into production.

Another three valve system is described by Von Segern et al in U.S. Pat. No. 3,443,552. Here, a basically conventional cylinder head having a single intake valve and a single exhaust valve with a primary, conventional, combustion chamber is provided. In addition, a centrally located auxiliary chamber is located on the cylinder axis away from the cylinder in gas flow communication with the primary combustion chamber. The auxiliary chamber has a single intake valve and a spark plug. Combustion begins in the auxiliary chamber, spreads to the main combustion chamber where added fuel mixture is introduced. Again, this is a complex and cumbersome system that appears to have been found to be impractical.

Suzuki et al. in U.S. Pat. No. 4,742,804 discloses a number of combustion chamber configurations, including some having two intake valves and a single exhaust valve. However, this arrangement requires that the exhaust valve be considerably larger than each intake valve and provides for a localized deep recess in the piston head to receive the spark plug. The combustion chamber is in the piston, rather than in a space between a generally planar piston face and the head.

Thus, while a great number of different arrangements of multiple valves and/or multiple spark plugs have been designed, none have provided an optimum combination of structural simplicity, maximum fuel efficiency and highest performance. Despite the crowded nature of the automobile engine fuel and air introduction and exhaust removal art, there remains a continuing need for improvements providing greater overall efficiency at lowest cost.

It is, therefore, an object of this invention is to provide a simple, easily manufactured internal combustion engine combustion chamber system having increased operating efficiency. Another object is to provide such as system that provides both increased fuel efficiency and higher performance. A further object is to provide such a system with high thermal efficiency. Yet another object is to provide a system capable of operating at high compression ratios with a variety of different fuels.

SUMMARY OF THE INVENTION

The above-noted objects, and others, are accomplished, basically, by a three valve combustion chamber system for use with internal combustion engine containing a piston and a cylinder head forming a combustion chamber therebetween. The system comprises three valves in the cylinder head, spaced around the cylinder axis, two of the valves adapted to act as intake valves and the third as an exhaust valve. For most effective operation, the ratio of total exhaust valve cross-sectional area/total intake valve cross-sectional area should in the range of 45% to 65%.

In a first version, three peripheral spark plugs are substantially centrally located in the areas surrounded by adjacent valves and the edge of the combustion chamber. A central, fourth, spark plug may be located substantially on the cylinder axis, surrounded by the three valves. A second version has a single central spark plug located substantially on the cylinder axis, surrounded by the three valves. If desired, the system of this invention may be used in a diesel or other engine using an ignition system other than a spark plug.

The cylinder head surface forming one side of the combustion chamber has hemispheric depressions containing each of the valves, with the piston having approximately areas corresponding to matching areas on the cylinder head located around the edge of the combustion chamber and extending inwardly somewhat between adjacent valves. These opposed matching areas are configured so that as the piston and head areas closely approach each other during engine operation a very efficient "squish" area is created. This arrangement substantially improves combustion and fuel efficiency.

In order to obtain this squish effect, the matching areas may be flat, may be radiused or angled. The piston face may be entirely flat or may have a shallow central recess (typically having a depth of from about 0.1 to 1 in.) corresponding generally to the pattern of valves in the head. For example, the piston face may have a generally planar domed central area and an angled edge portion extending

from the dome to the piston face edge, matching a similarly configured opposite area on the head. Alternatively, the edge portion may be radiused between a domed central flat area and the piston edge, with the edge portion of the head corresponding thereto.

In preferred embodiments, the three valves may be substantially equally spaced or may be located towards one side of the combustion chamber with the space between each intake valve and the exhaust valve being less than the distance between the two intake valves. The single central spark plug (or other ignition device) is positioned approximately on the cylinder axis.

In another preferred embodiment, two equally spaced intake valves are positioned to one side of the combustion chamber, with a single exhaust valve to the other side and two spark plugs, each positioned outwardly of a line between the center of the exhaust valve and the center of an intake valve. The intake valves and spark plugs are symmetrically located on the sides of a line drawn through the center of the exhaust valve and equally spaced between the intake valves. Squish areas are located along the edges of the combustion chamber and between each adjacent pair of valves.

BRIEF DESCRIPTION OF THE DRAWING

Details of the invention, and of certain preferred embodiments thereof, will be further understood upon reference to the drawing, wherein:

FIG. 1 is a plan view of the face of a cylinder head combustion chamber, showing a first embodiment of this invention;

FIG. 2 is a section view, taken substantially on line 2—2 in FIG. 1;

FIG. 3 is a plan view similar to FIG. 1 but showing a second embodiment of the invention;

FIG. 4 is a plan view of a piston face configuration useful with this invention;

FIG. 5 is a plan view similar to FIG. 1 but showing a third embodiment of the invention;

FIG. 6 is a plan view similar to FIG. 1 but showing a fourth embodiment of the invention;

FIG. 7 is a schematic elevation view of a piston having a domed face and angled edge, with a corresponding head shape;

FIG. 8 is a schematic elevation view of a piston having a domed face and radiused edge, with a corresponding head shape; and

FIG. 9 is a perspective view of a piston face with a shallow central recess configured to generally match the head valve configuration; and

FIG. 10 is a schematic axial section view through a cylinder with valves extending slightly into the combustion chamber.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, there is seen a cylinder head 10 having a recessed combustion chamber 12. Head 10 has a number of conventional bolt holes, vents and the like 11 for attachment of the head to the engine block (not shown) and other purposes. Two intake valves 14 open to allow entry of air or an air-fuel mixture into combustion chamber and close during combustion. One exhaust valve 16 is closed during combustion and opens to allow egress of exhaust gases. Optimally, the faces of valves 14 and 16 are circular and the three valves are substantially uniformly arranged around the cylinder and combustion chamber axis or the two intake valves 14 are evenly spaced from exhaust valve 16 bu at a different distance from each other. The shafts may be canted to the cylinder centerline or vertical (parallel to the cylinder centerline), as desired.

The faces of intake valves 14 preferably have the same area so that identical open areas are provided when the valves open and gas flow therethrough is uniform in pattern and volume for optimum efficiency. However, if desired, the two intake valves could have different areas, typically varying up to about 50% in area. Exhaust valve 16 ideally has an area from about 45 to 65 per cent of the total area of intake valves 14.

The utilization of the small exhaust port cross-sectional area and valves provides high exhaust gas velocity, on the order of 450 to 500 ft/sec. Intake gas velocity, depending on the type of fuel and/or the presence of fuel in the intake throat would be in the 225 to 300 ft/sec range. This configuration yields excellent operating characteristics, such as throttle response, exhaust gas scavenging, charge purity and volumetric efficiency. Smaller exhaust ports allow for significantly reduced heat transfer.

In the embodiment of FIG. 1, one central spark plug 18 is used. A central spark plug 18 is shown located substantially on the cylinder centerline and may extend above the surface of the combustion chamber 12, in the preferred arrangement, as shown or may be recessed slightly below the surface, if desired.

In the alternative embodiment shown in FIG. 3, three peripheral spark plugs 20 are used. While optimum efficiency may in some instances be improved by the addition of a fourth spark plug centrally located in the FIG. 3 embodiment, the embodiment of FIG. 3 is less costly and in many cases provides more or at least sufficient efficiency.

FIG. 4 shows the face of a piston 24 optimized for use with the combustion chamber 12 arrangement shown in FIGS. 1–3. For optimum combustion a "squish" area is often desired between portions of the opposed faces of piston 24 and combustion chamber 12. In that case, the areas 22 (as seen in FIG. 1 and 3) are flat and slightly tapered away from piston 24 toward the combustion chamber centerline and the corresponding areas 26 are similarly flat and slightly tapered so that those areas closely approach each other as piston 24 makes its closest approach to combustion chamber 12 during engine operation, squeezing the fuel/air mixture in those areas toward the center of combustion chamber 12. Areas 26 may extend inwardly from edge to at least partially match areas 22 between adjacent valves. Areas 22 and 26 lie approximately perpendicular to the centerline of the combustion chamber and cylinder. This "squish" effect has been found to improve combustion efficiency. Recessed areas 28 are formed in the face of piston 24 around central pad 30 to provide the desired compression ratio in conjunction with the squish areas. Recessed areas 28 are sized to provide the desired compression ratio in conjunction with the squish areas.

FIG. 5 shows a plan view of another embodiment of the combustion chamber system. Here, the combustion chamber 12 in cylinder head 10 has a generally similar configuration to that shown in FIG. 1, but with a different valve arrangement. Intake valves 14 are positioned closer to exhaust valve 16 than to each other. The size relationship among the valves is the same as described above. Squish plates 22 of the sort described above are provided between adjacent valves, with

the squish plate between the two intake valves **14** being larger in area than that between each intake valve **14** and the exhaust valve **16**. The cooperating piston face may have squish The embodiment shown in FIG. **5** is particularly useful in permitting an offset pushrod arrangement for operating the valves. If desired, three spark plugs **18** could be used, spaced around the periphery between each adjacent pair of valves, as shown in FIG. **3**. Or, three spark plugs oriented as shown in FIG. **3** plus a centrally located plug as seen in FIG. **1** could be used together.

FIG. **6** shows a plan view of another embodiment of the combustion chamber system. Here, the combustion chamber **12** in cylinder head **10** has a generally similar configuration to that shown in FIG. **1**, but with a different valve arrangement. Two intake valves **14** are positioned to one side of chamber **12**, with exhaust valve **16** to the other side. Two spark plus **18** are located between exhaust valve **16** and each intake valve **14**. Each spark plug **18** is positioned outwardly of a line drawn between the center of exhaust valve **16** and each intake valve **14**. A line of symmetry can be drawn from the center of exhaust valve between and equally spaced from intake valves **14**. The combustion on one side of that line of symmetry is a mirror image of the other side. For optimum operation, squish areas **22** are provided between each adjacent pair of valves, with the edge of the squish areas between exhaust valve **16** and each intake valve **14** being a substantially straight line drawn approximately parallel to a line drawn through the centers of the exhaust valve **16** and an intake valve **14**. While the arrangement shown with two spark plugs in FIG. **6** is preferred, if desired three peripheral plugs as shown in FIG. **3** and/or a central plug as shown in FIG. **1** could be used.

FIG. **7** shows in schematic elevation another embodiment in which piston **24** has a flat center face portion **30** lying substantially perpendicular to the piston centerline and an angled edge portion **32**. As schematically indicated by line **34**, the head **10** will include a matching angled portion **36** to form a squish area with piston angled area **32**. The central area **38** in head **10** will contain the valves and ignition means of the sort shown in FIG. **1** or others.

A further embodiment of the piston face configuration is schematically illustrated in FIG. **8**. Here piston **24** has a flat center face portion **40** generally perpendicular to the piston axis. The edge of the face of piston **28** has a radiused edge area **42**. Head **10** schematically shows a radiused edge portion **44** complementary with piston edge portion **42** to provide a radiused squish area and a central area **46** wherein the valves and ignition means of the sort shown in FIG. **1** et seq. could be located.

FIG. **9** illustrates an embodiment in which piston **24** has an approximately flat edge portion **50** and a shallow recessed central portion **52**. Edge portion **50** cooperates with a similar area in a head (not shown) of the sort shown in FIG. **1** to provide a squish action. Preferably, the two edge portions are arranged with a closer spacing at the piston edge opening slightly toward the center to "squish" the charge toward the center and ignition means. The size and shape of recessed area **52** corresponds to the general outer shape of the head squish pads, such as squish area **22** in FIG. **1**. While recess **52** can have any suitable depth, with most pistons a depth of from about 0.1 to 1 inch is preferred.

With the deeper piston recesses **58**, the cylinder head **60** may be only slightly recessed around the valves **62** or may be flat as shown in schematic approximately axial section view in FIG. **10**. The valves may be coplanar with the flat cylinder head or extend slightly into the cavities **58** in piston **64**, as desired. Preferably, the ignition means is recessed into the head and does not project into the piston recess.

While certain preferred materials, dimensions and arrangements have been described in detail in conjunction with the above description of preferred embodiments, those can be varied, where suitable, with similar results. For example, in the embodiment shown in FIG. **6**, a single spark plug could be used at the center of the cylinder (as shown in FIG. **5**) instead of the two spark plugs shown. Other applications, variations and ramifications of this invention will occur to those skilled in the art upon reading this disclosure. Those are intended to be included within the scope of this invention, as defined in the appended claims.

I claim:

1. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three valves in said head at said combustion chamber, said valves being arranged around an axis of said cylinder;

two of said valves adapted to act as intake valves;

said third valve being adapted to act as an exhaust valve;

total exhaust valve area being approximately 45% to 65% of total intake valve area;

said piston having an at least partially planar face adjacent to said head forming one wall of said combustion chamber; and

at least one ignition means for igniting an air/fuel mixture in said combustion chamber, said ignition means located entirely within said head without extending below said partially planar face at any point during engine operation.

2. The system according to claim **1** wherein said piston face has a substantially planar raised central area surrounded by an angled periphery and an angled squish area is provided along a combustion chamber periphery.

3. The system according to claim **1** wherein said piston face has a substantially planar raised central area surrounded by a radiused periphery and a squish area is provided along a combustion chamber periphery.

4. The system according to claim **1** wherein said piston has a substantially planar periphery and a recessed central area opposite said valves and a squish area is provided along a combustion chamber periphery.

5. The system according to claim **4** wherein said head is flat across said combustion chamber.

6. The system according to claim **1** wherein said ignition means comprises a single spark plug located in said head approximately at a cylinder axis.

7. The system according to claim **1** wherein said head includes three hemispheric depressions each housing one of said valves.

8. The system according to claim **1** wherein said two intake valves have substantially equal areas.

9. The system according to claim **1** wherein said ignition means comprises three ignition means each approximately centrally located in one of three spaces bounded by two adjacent valves and a cylinder edge.

10. The system according to claim **8** wherein said ignition means comprises at least three spark plugs.

11. The system according to claim **9** further including a fourth spark plug located in said head substantially on an axis of said cylinder.

12. An improved combustion chamber system for use with internal combustion engines having at least one cylinder, the engine having a piston and a cylinder head forming a combustion chamber therebetween, comprising:

said piston, cylinder head and combustion chamber each having a central axis and a common periphery;

three valves in said head at each combustion chamber, said valves being arranged around an axis of said cylinder;

two of said valves being adapted to act as intake valves;

the third of said three valves being adapted to act as an exhaust valve and having an area between approximately 45 to 65 per cent of total area of said intake valves;

a squish area along said combustion chamber periphery and extending at least partially between each adjacent pair of valves; and

said head having three recesses, each of said recesses housing one of said valves.

13. The system according to claim 12 wherein said piston has a face with a substantially planar raised central area surrounded by an angled periphery and an angled squish area is provided along said piston periphery.

14. The system according to claim 12 wherein the piston face has a substantially planar raised central area surrounded by a radiused periphery and a squish area is provided along said piston periphery.

15. The system according to claim 12 wherein said piston has a substantially planar periphery and a recessed central area opposite said valves and squish areas are provided around said recessed central area.

16. The system according to claim 12 further including an ignition means comprising a single spark plug located in said head approximately along said combustion chamber axis.

17. The system according to claim 12 further including an ignition means comprising three spark plugs each approximately centrally located in one of three spaces bounded by two adjacent valves and said combustion chamber periphery.

18. The system according to claim 17 further including a fourth spark plug located in said head substantially on said axis of said combustion chamber.

19. The system according to claim 18 wherein said three approximately hemispherical recesses are formed in a substantially flat head surface.

* * * * *

EXHIBIT 4

US005893348A

United States Patent [19]

Feuling

[11] Patent Number: 5,893,348

[45] Date of Patent: *Apr. 13, 1999

[54] **COMBUSTION CHAMBER SYSTEM HAVING AN IMPROVED VALVE ARRANGEMENT**

[76] Inventor: **James J. Feuling**, 2521 Palma, Ventura, Calif. 93003

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **08/827,722**

[22] Filed: **Apr. 8, 1997**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/592,760, Jan. 26, 1996, Pat. No. 5,638,787, which is a continuation-in-part of application No. 08/246,788, May 19, 1994, Pat. No. 5,501,191, which is a continuation-in-part of application No. 07/995,785, Dec. 23, 1992, Pat. No. 5,313,921.

[51] **Int. Cl.**[6] **F02P 15/02**

[52] **U.S. Cl.** **123/310**

[58] **Field of Search** 123/310, 256, 123/279, 661

[56] **References Cited**

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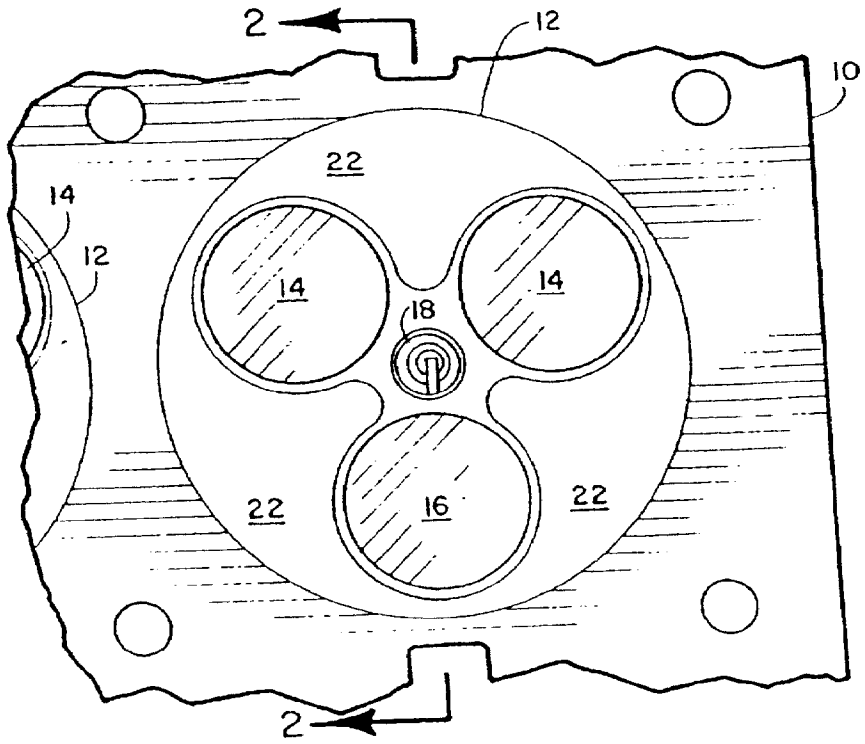
5,501,191	3/1996	Feuling	123/310
5,638,787	6/1997	Feuling	123/310

Primary Examiner—Willis R. Wolfe
Assistant Examiner—Hieu T. Vo
Attorney, Agent, or Firm—Frank D. Gilliam

[57] **ABSTRACT**

An intake and exhaust system for use with internal combustion engines that uses two intake valves and one exhaust valve for each engine cylinder. The three valves are preferably circular and spaced around the cylinder centerline in said cylinder head. One or more spark plugs (or other suitable ignition devices) are provided in the head on the cylinder centerline and/or between pairs of adjacent valves. For best results, the two intake valves have substantially equal diameters. Preferably, the ratio of exhaust valve diameter to intake valve diameter is from about 0.95:1 to 1:1.2. The head typically has three substantially hemispheric depressions each housing one of said valves. Squish areas are preferably provided around said combustion chamber periphery. The piston surface may be at least partially planar and may have an angled or radiused periphery or may have a central recess corresponding generally to the valve region. This invention provides a fast and uniform lean burn, permits use of a high compression ratio and lower octane unleaded gasoline and provides improved thermal efficiency. Other fuels and other fuel ignition systems also benefit, such as diesel engines.

26 Claims, 4 Drawing Sheets



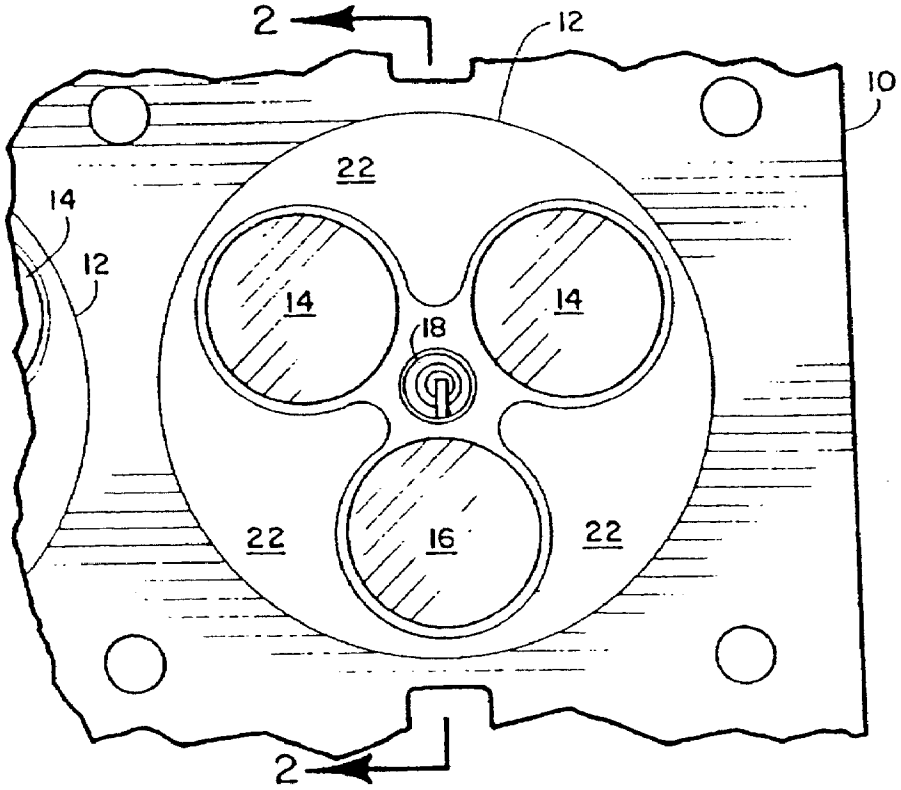


FIGURE 1

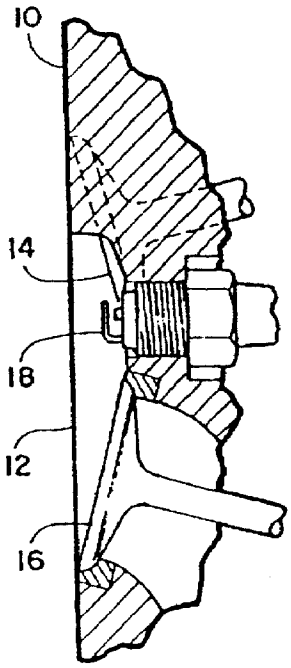


FIGURE 2

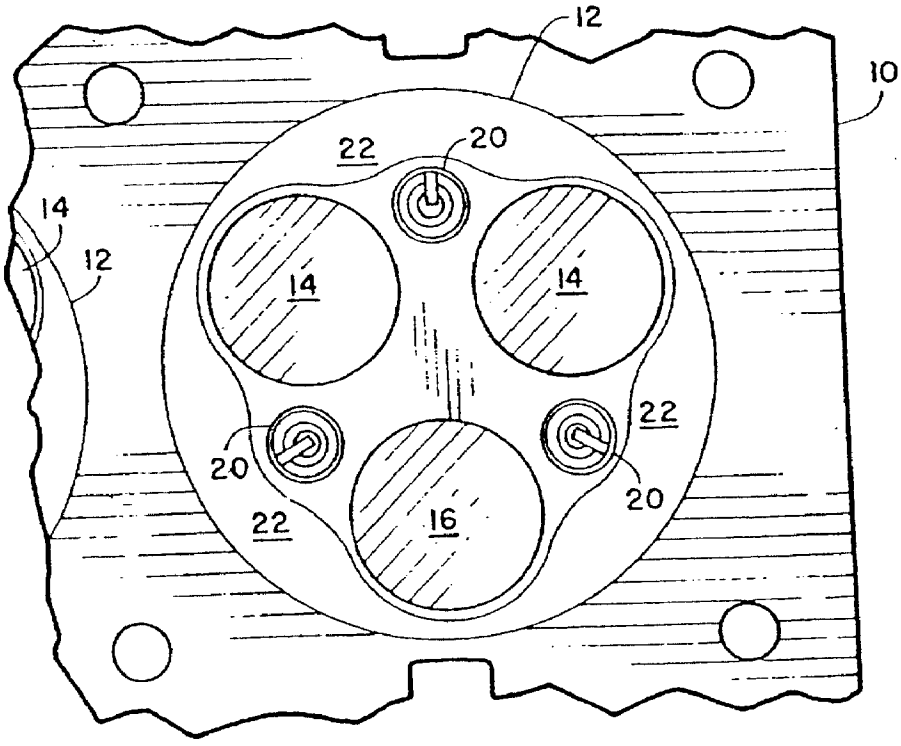


FIGURE 3

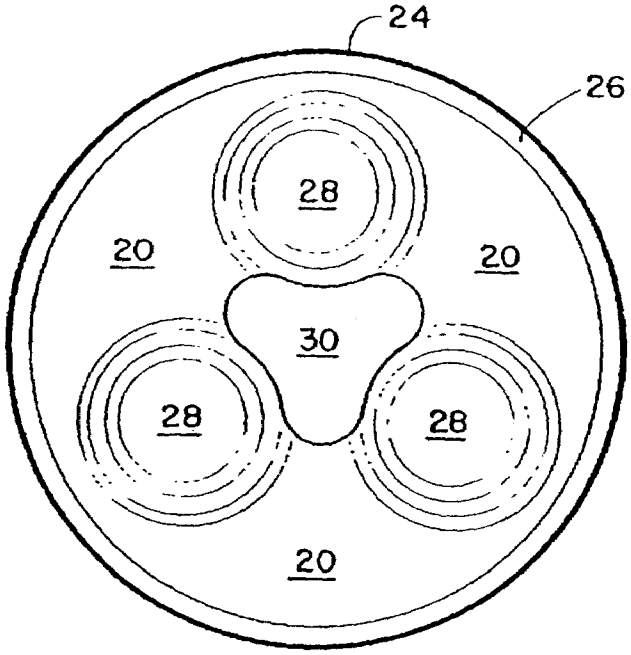


FIGURE 4

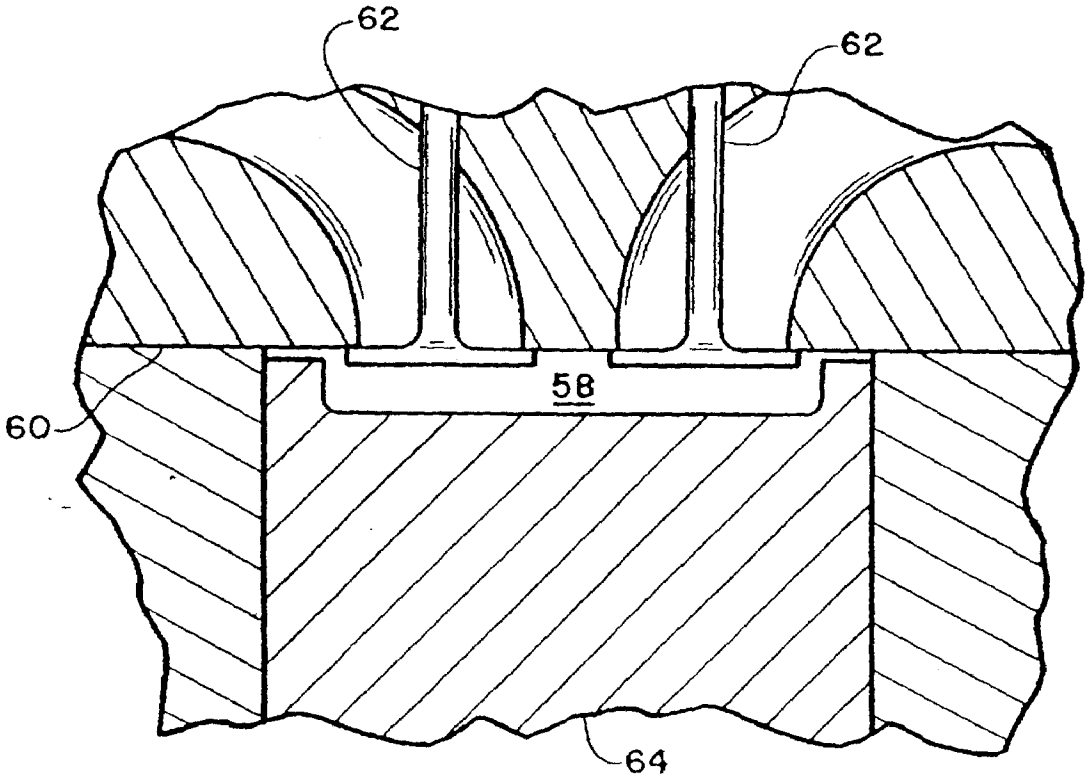


FIGURE 10

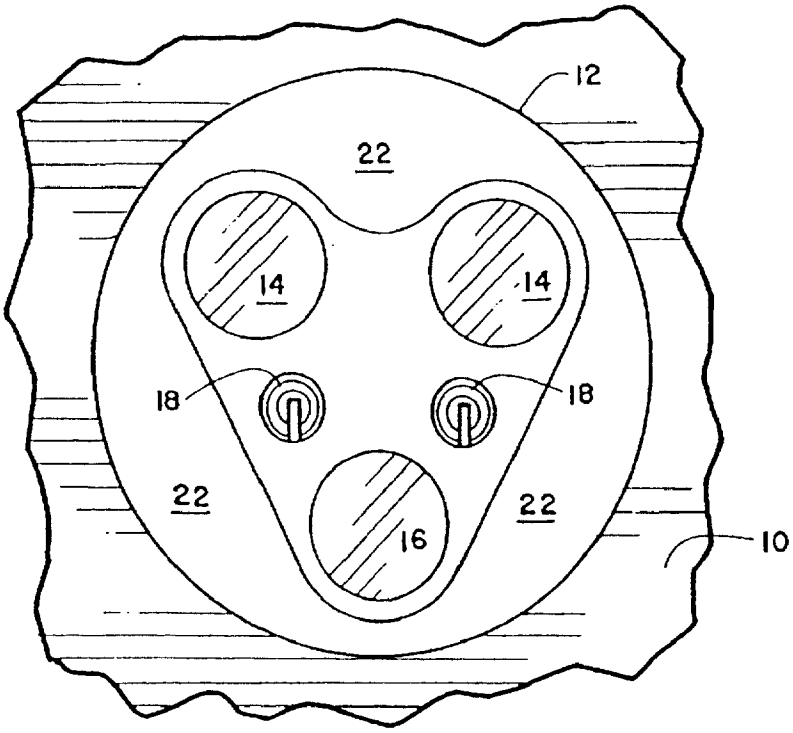


FIGURE 6

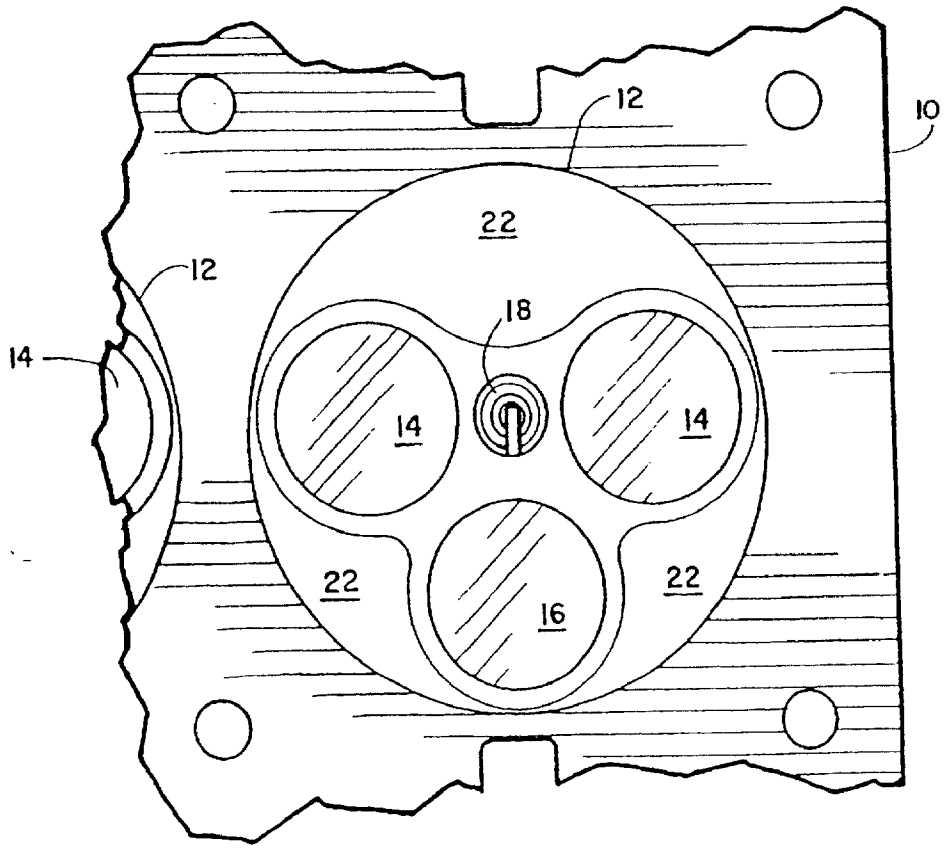


FIGURE 5

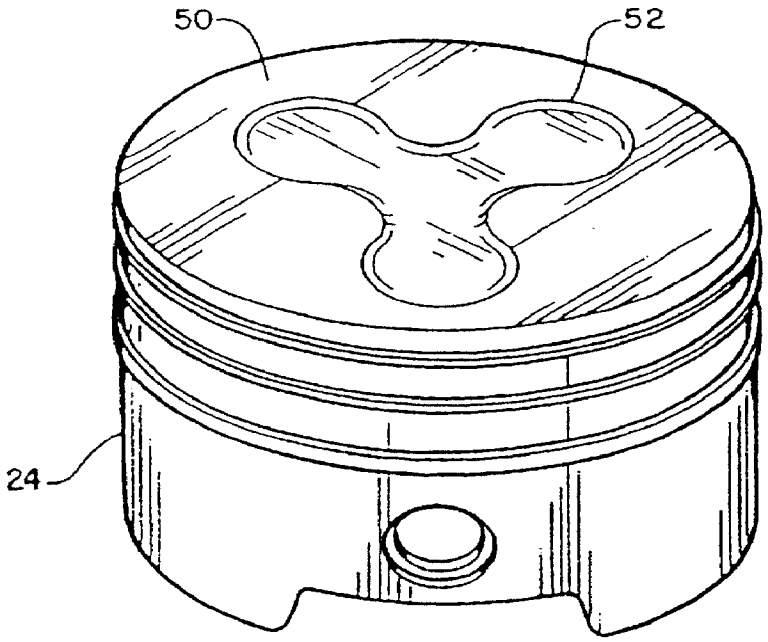


FIGURE 9

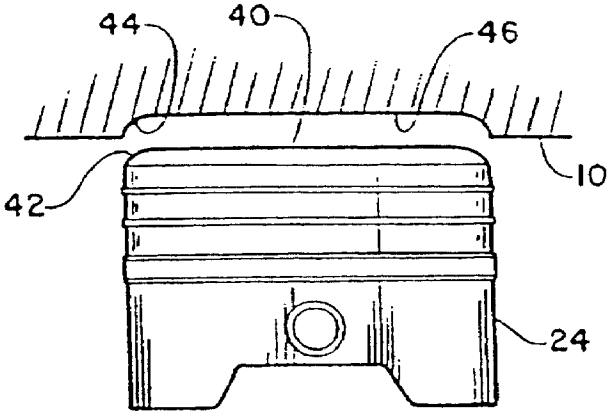


FIGURE 8

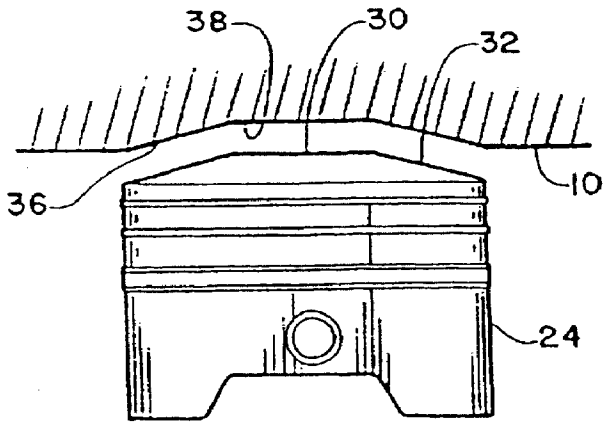


FIGURE 7

COMBUSTION CHAMBER SYSTEM HAVING AN IMPROVED VALVE ARRANGEMENT

This application is a continuation-in-part of application Ser. No. 08/592,760, filed Jan. 26, 1996, now U.S. Pat. No. 5,638,787 which is a continuation-in-part of application Ser. No. 08/246,788, filed May 19, 1994, now U.S. Pat. No. 5,501,191 which is a continuation-in-part of application Ser. No. 07/995,785, filed Dec. 23, 1992, now U.S. Pat. No. 5,313,921.

BACKGROUND OF THE INVENTION

This invention relates in general to improvements in internal combustion engines and, more specifically, to an improved cylinder head and piston arrangement with an improved valve and spark plug layout for use in those engines.

A great many different intake and exhaust valve arrangements have been developed over the years for use in internal combustion engines, in particular for use in automobiles. Most such engines use one intake valve and one exhaust valve at each cylinder with a single spark plug. The prior art arrangements utilize exhaust area/intake area in the range of over 65%. A great deal of effort has gone into optimizing the sizing and placement of the valves, the shape of the combustion chamber and the like. Since there is a great need for improvements in automobile fuel efficiency while maintaining or improving performance, a wide variety of different valve and spark plug configurations and arrangements have been designed and tested. In some of these, multiple valves and spark plugs have been used.

An arrangement of four valves per cylinder, two intake valves and two exhaust valves, has been disclosed, for example, by Akana in U.S. Pat. No. 3,411,490. Today, a number of high performance automobiles use four valve systems, with one or more spark plugs.

In these high performance automobiles, several spark plugs may be provided around the periphery of the combustion chamber with an additional spark plug centrally located. Manufacture and operation of these four valve, multiple spark plug engines is complex and expensive and requires complex computer control for efficient operation.

Weslake in U.S. Pat. No. 2,652,039 describes a complex cylinder head arrangement for an internal combustion engine having a wedge-shaped combustion chamber adjacent to the cylinder feeding into a cylinder chamber above the piston. The combustion chamber has an intake valve, an exhaust valve and a single spark plug. A second intake valve is provided in the cylinder chamber. A weak mixture of air and fuel enters the combustion chamber, combustion begins and a rich mixture enters through the cylinder chamber and adds to the original combusting mixture. This very complex system appears to have been unsuccessful and to never have been brought into production.

Another three valve system is described by Von Segern et al in U.S. Pat. No. 3,443,552. Here, a basically conventional cylinder head having a single intake valve and a single exhaust valve with a primary, conventional, combustion chamber is provided. In addition, a centrally located auxiliary chamber is located on the cylinder axis away from the cylinder in gas flow communication with the primary combustion chamber. The auxiliary chamber has a single intake valve and a spark plug. Combustion begins in the auxiliary chamber, spreads to the main combustion chamber where added fuel mixture is introduced. Again, this is a complex and cumbersome system that appears to have been found to be impractical.

Suzuki et al. in U.S. Pat. No. 4,742,804 discloses a number of combustion chamber configurations, including some having two intake valves and a single exhaust valve. However, this arrangement requires that the exhaust valve be considerably larger than each intake valve and provides for a localized deep recess in the piston head to receive the spark plug. The combustion chamber is in the piston, rather than in a space between a generally planar piston face and the head.

Thus, while a great number of different arrangements of multiple valves and/or multiple spark plugs have been designed, none have provided an optimum combination of structural simplicity, maximum fuel efficiency and highest performance. Despite the crowded nature of the automobile engine fuel and air introduction and exhaust removal art, there remains a continuing need for improvements providing greater overall efficiency at lowest cost.

It is, therefore, an object of this invention is to provide a simple, easily manufactured internal combustion engine combustion chamber system having increased operating efficiency. Another object is to provide such as system that provides both increased fuel efficiency and higher performance. A further object is to provide such a system with high thermal efficiency. Yet another object is to provide a system capable of operating at high compression ratios with a variety of different fuels.

SUMMARY OF THE INVENTION

The above-noted objects, and others, are accomplished, basically, by a three valve combustion chamber system for use with internal combustion engine containing a piston and a cylinder head forming a combustion chamber therebetween. The system comprises three valves in the cylinder head, spaced around the cylinder axis, two of the valves adapted to act as intake valves and the third as an exhaust valve. For most effective operation, the valves are generally round and have an exhaust valve to intake valve diameter ratio in the range of 0.95:1 to 1:1.2.

The system of this invention may use any suitable ignition means. Typically with a gasoline or natural gas powered vehicle spark plugs may be used. In a diesel engine, a glow plug or injection type igniter are typically used. One or more ignition means may be provide at each cylinder, at any suitable locations.

In a first version, three peripheral ignition means are substantially centrally located in the areas surrounded by adjacent valves and the edge of the combustion chamber. A central, fourth, ignition means may be located substantially on the cylinder axis, surrounded by the three valves. A second version has a single central ignition means located substantially on the cylinder axis, surrounded by the three valves. Other suitable positions of one or more ignition means may be used.

The cylinder head surface forming one side of the combustion chamber may have hemispheric depressions containing each of the valves, with the piston having approximately areas corresponding to matching areas on the cylinder head located around the edge of the combustion chamber and extending inwardly somewhat between adjacent valves. These opposed matching areas are configured so that as the piston and head areas closely approach each other during engine operation a very efficient "squish" area is created. This arrangement substantially improves combustion and fuel efficiency.

In order to obtain this squish effect, the matching areas may be flat, may be radiused or angled. The piston surface

making up one wall of the combustion chamber may be curved or flat, or any combination thereof. The piston face may typically be entirely flat or may have a shallow central recess (typically having a depth of from about 0.1 to 1 in.) corresponding generally to the pattern of valves in the head. For example, the piston face may have a generally planar domed central area and an angled edge portion extending from the dome to the piston face edge, matching a similarly configured opposite area on the head. Alternatively, the edge portion may be radiused between a domed central flat area and the piston edge, with the edge portion of the head corresponding thereto.

In preferred embodiments, the three valves may be substantially equally spaced or may be located towards one side of the combustion chamber with the space between each intake valve and the exhaust valve being less than the distance between the two intake valves. The single central spark plug (or other ignition device) may be positioned approximately on the cylinder axis. Basically, a single combustion chamber is formed. If desired, the piston surface can be formed with one recess, and the one or more ignition means can extend into that recess.

In another preferred embodiment, two equally spaced intake valves are positioned to one side of the combustion chamber, with a single exhaust valve to the other side and two spark plugs, each positioned outwardly of a line between the center of the exhaust valve and the center of an intake valve. The intake valves and spark plugs may be symmetrically located on the sides of a line drawn through the center of the exhaust valve and equally spaced between the intake valves. Squish areas may be located along the edges of the combustion chamber and between each adjacent pair of valves.

BRIEF DESCRIPTION OF THE DRAWING

Details of the invention, and of certain preferred embodiments thereof, will be further understood upon reference to the drawing, wherein:

FIG. **1** is a plan view of the face of a cylinder head combustion chamber, showing a first embodiment of this invention;

FIG. **2** is a section view, taken substantially on line **2**—**2** in FIG. **1**;

FIG. **3** is a plan view similar to FIG. **1** but showing a second embodiment of the invention;

FIG. **4** is a plan view of a piston face configuration useful with this invention;

FIG. **5** is a plan view similar to FIG. **1** but showing a third embodiment of the invention;

FIG. **6** is a plan view similar to FIG. **1** but showing a fourth embodiment of the invention;

FIG. **7** is a schematic elevation view of a piston having a domed face and angled edge, with a corresponding head shape;

FIG. **8** is a schematic elevation view of a piston having a domed face and radiused edge, with a corresponding head shape;

FIG. **9** is a perspective view of a piston face with a shallow central recess configured to generally match the head valve configuration; and

FIG. **10** is a generally axial section through a combustion chamber enclosed by a substantially flat head and a recessed piston.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. **1** and **2**, there is seen a cylinder head **10** having a recessed combustion chamber **12**. Head **10** has a number of conventional bolt holes, vents and the like **11** for attachment of the head to the engine block (not shown) and other purposes. Two intake valves **14** open to allow entry of air or an air-fuel mixture into combustion chamber and close during combustion. One exhaust valve **16** is closed during combustion and opens to allow egress of exhaust gases. Optimally, the faces of valves **14** and **16** are circular and the three valves are substantially uniformly arranged around the cylinder and combustion chamber axis or the two intake valves **14** are evenly spaced from exhaust valve **16** but at a different distance from each other. The shafts may be canted to the cylinder centerline or vertical (parallel to the cylinder centerline), as desired.

The faces of intake valves **14** preferably have the same area so that identical open areas are provided when the valves open and gas flow therethrough is uniform in pattern and volume for optimum efficiency. However, if desired, the two intake valves could have different areas, typically varying up to about 50% in area. Preferably, the valves have an exhaust valve to intake valve diameter ratio in the range of 0.95:1 to 1:1.2.

The utilization of the small exhaust port cross-sectional area and valves provides high exhaust gas velocity, on the order of 450 to 500 ft/sec. Intake gas velocity, depending on the type of fuel and/or the presence of fuel in the intake throat would be in the 225 to 300 ft/sec range. This configuration yields excellent operating characteristics, such as throttle response, exhaust gas scavenging, charge purity and volumetric efficiency. Smaller exhaust ports allow for significantly reduced heat transfer.

In the embodiment of FIG. **1**, one central spark plug **18** is used. While spark plugs will be referred to in this description of preferred embodiments, it should be remembered that any other suitable ignition means for fuel/air mixtures may be used as desired. A central spark plug **18** is shown located substantially on the cylinder centerline and may extend above the surface of the combustion chamber **12**, in the preferred arrangement, as shown or may be recessed slightly below the surface, if desired. If desired, the tip of spark lug **18** could extend below the surface of head **10**, into a single cavity **58** in piston **64** as seen in FIG. **10**.

In the alternative embodiment shown in FIG. **3**, three peripheral spark plugs **20** are used. While optimum efficiency may in some instances be improved by the addition of a fourth spark plug centrally located in the FIG. **3** embodiment, the embodiment of FIG. **3** is less costly and in many cases provides more or at least sufficient efficiency. If a recessed piston having a single large recess forming approximately half of a single combustion chamber as seen in FIG. **10** is used, tips of all of the ignition means **20** could extend slightly in that recess.

FIG. **4** shows the face of a piston **24** optimized for use with the combustion chamber **12** arrangement shown in FIGS. **1**–**3**. For optimum combustion a "squish" area is often desired between portions of the opposed faces of piston **24** and combustion chamber **12**. In that case, the areas **22** (as seen in FIGS. **1** and **3**) are flat and slightly tapered away from piston **24** toward the combustion chamber centerline and the corresponding areas **26** are similarly flat and slightly tapered so that those areas closely approach each other as piston **24** makes its closest approach to combustion chamber **12** during engine operation, squeezing the fuel/air mixture in those areas toward the center of combustion chamber **12**. Areas **26** may extend inwardly from edge to at least partially match areas **22** between adjacent valves. Areas **22** and **26** lie approximately perpendicular to the centerline of the com-

bustion chamber and cylinder. This "squish" effect has been found to improve combustion efficiency. Recessed areas **28** are formed in the face of piston **24** around central pad **30** to provide the desired compression ratio in conjunction with the squish areas. Recessed areas **28** are sized to provide the desired compression ratio in conjunction with the squish areas.

FIG. **5** shows a plan view of another embodiment of the combustion chamber system. Here, the combustion chamber **12** in cylinder head **10** has a generally similar configuration to that shown in FIG. **1**, but with a different valve arrangement. Intake valves **14** are positioned closer to exhaust valve **16** than to each other. The size relationship among the valves is the same as described above. Squish plates **22** of the sort described above are provided between adjacent valves, with the squish plate between the two intake valves **14** being larger in area than that between each intake valve **14** and the exhaust valve **16**. The cooperating piston face may have squish The embodiment shown in FIG. **5** is particularly useful in permitting an offset pushrod arrangement for operating the valves. If desired, three spark plugs **18** could be used, spaced around the periphery between each adjacent pair of valves, as shown in FIG. **3**. Or, three spark plugs oriented as shown in FIG. **3** plus a centrally located plug as seen in FIG. **1** could be used together.

FIG. **6** shows a plan view of another embodiment of the combustion chamber system. Here, the combustion chamber **12** in cylinder head **10** has a generally similar configuration to that shown in FIG. **1**, but with a different valve arrangement. Two intake valves **14** are positioned to one side of chamber **12**, with exhaust valve **16** to the other side. Two spark plus **18** are located between exhaust valve **16** and each intake valve **14**. Each spark plug **18** is positioned outwardly of a line drawn between the center of exhaust valve **16** and each intake valve **14**. A line of symmetry can be drawn from the center of exhaust valve between and equally spaced from intake valves **14**. The combustion on one side of that line of symmetry is a mirror image of the other side. For optimum operation, squish areas **22** are provided between each adjacent pair of valves, with the edge of the squish areas between exhaust valve **16** and each intake valve **14** being a substantially straight line drawn approximately parallel to a line drawn through the centers of the exhaust valve **16** and an intake valve **14**. While the arrangement shown with two spark plugs in FIG. **6** is preferred, if desired three peripheral plugs as shown in FIG. **3** and/or a central plug as shown in FIG. **1** could be used.

FIG. **7** shows in schematic elevation another embodiment in which piston **24** has a flat center face portion **30** lying substantially perpendicular to the piston centerline and an angled edge portion **32**. As schematically indicated by line **34**, the head **10** will include a matching angled portion **36** to form a squish area with piston angled area **32**. The central area **38** in head **10** will contain the valves and ignition means of the sort shown in FIG. **1** or others.

A further embodiment of the piston face configuration is schematically illustrated in FIG. **8**. Here piston **24** has a flat center face portion **40** generally perpendicular to the piston axis. The edge of the face of piston **28** has a radiused edge area **42**. Head **10** schematically shows a radiused edge portion **44** complementary with piston edge portion **42** to provide a radiused squish area and a central area **46** wherein the valves and ignition means of the sort shown in FIG. **1** et seq. could be located.

FIG. **9** illustrates an embodiment in which piston **24** has an approximately flat edge portion **50** and a shallow recessed central portion **52**. Edge portion **50** cooperates with a similar area in a head (not shown) of the sort shown in FIG. **1** to provide a squish action. Preferably, the two edge portions are arranged with a closer spacing at the piston edge opening slightly toward the center to "squish" the charge toward the center and ignition means. The size and shape of recessed area **52** corresponds to the general outer shape of the head squish pads, such as squish area **22** in FIG. **1**. While recess **52** can have any suitable depth, with most pistons a depth of from about 0.1 to 1 inch is preferred.

With the deeper piston recesses **58**, the cylinder head **60** may be only slightly recessed around the valves **62** or may be flat as shown in schematic approximately axial section view in FIG. **10**. The valves may be coplanar with the flat cylinder head or extend slightly into the cavities **58** in piston **64**, as desired.

while certain preferred materials, dimensions and arrangements have been described in detail in conjunction with the above description of preferred embodiments, those can be varied, where suitable, with similar results. For example, in the embodiment shown in FIG. **6**, a single spark plug could be used at the center of the cylinder (as shown in FIG. **5**) instead of the two spark plugs shown. Other applications, variations and ramifications of this invention will occur to those skilled in the art upon reading this disclosure. Those are intended to be included within the scope of this invention, as defined in the appended claims.

I claim:

1. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three generally circular valves in said head at said combustion chamber, said valves being arranged around an axis of said cylinder;

two of said valves adapted to act as intake valves;

said third valve being adapted to act as an exhaust valve;

said exhaust and intake valves having a ratio of exhaust valve diameter to intake valve diameter being from about 0.95:1 to 1:1.2;

said piston having an at least partially planar face adjacent to said head forming one wall of said combustion chamber; and

at least one ignition means for igniting an air/fuel mixture in said combustion chamber, said ignition means located entirely within said head without extending below said partially planar face at any point during engine operation.

2. The system according to claim **1** wherein said ignition means comprises a single spark plug located in said head approximately at a cylinder axis.

3. The system according to claim **1** wherein said head includes three hemispheric depressions each housing one of said valves.

4. The system according to claim **1** wherein said ignition means comprises three ignition means each approximately centrally located in one of three spaces bounded by two adjacent valves and a cylinder edge.

5. The system according to claim **4** further including a fourth spark plug located in said head substantially on an axis of said cylinder.

6. The system according to claim **1** wherein said piston face has a substantially planar raised central area surrounded by a radiused periphery and a squish area is provided along a combustion chamber periphery.

7. The system according to claim **1** wherein said piston has a substantially planar periphery and a recessed central

area opposite said valves and a squish area is provided along a combustion chamber periphery.

8. The system according to claim 7 wherein said head is flat across said combustion chamber.

9. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three valves in said head at said combustion chamber, said valves being arranged around an axis of said cylinder;

two of said valves adapted to act as intake valves;

said third valve being adapted to act as an exhaust valve;

said exhaust and intake valves having a ratio of exhaust valve diameter to intake valve diameter being from about 0.95:1 to 1:1.2;

said piston having a face adjacent to said head forming one wall of said combustion chamber; and

at least one ignition means for igniting an air/fuel mixture in said combustion chamber, said ignition means located entirely within said head without extending below said partially planar face at any point during engine operation.

10. The system according to claim 9 wherein said ignition means comprises a single spark plug located in said head approximately at a cylinder axis.

11. The system according to claim 9 wherein said head includes three hemispheric depressions each housing one of said valves.

12. The system according to claim 9 wherein said ignition means comprises three ignition means each approximately centrally located in one of three spaces bounded by two adjacent valves and a cylinder edge.

13. The system according to claim 12 further including a fourth spark plug located in said head substantially on an axis of said cylinder.

14. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a single combustion chamber therebetween, which comprises;

three valves in said head at said single combustion chamber, said valves being arranged around an axis of said cylinder;

two of said valves adapted to act as intake valves;

said third valve being adapted to act as an exhaust valve;

said exhaust and intake valves having a ratio of exhaust valve diameter to intake valve diameter being from about 0.95:1 to 1:1.2;

said piston having an at least partially planar face adjacent to said head forming one wall of said combustion chamber; and

at least one ignition means for igniting an air/fuel mixture in said combustion chamber.

15. The system according to claim 14 wherein said piston face has a substantially planar raised central area surrounded by an angled periphery and an angled squish area is provided along a combustion chamber periphery.

16. The system according to claim 14 wherein said piston face has a substantially planar raised central area surrounded by a radiused periphery and a squish area is provided along a combustion chamber periphery.

17. The system according to claim 14 wherein said piston has a substantially planar periphery and a recessed central area opposite said valves and a squish area is provided along a combustion chamber periphery.

18. The system according to claim 14 wherein said ignition means comprises a single spark plug located in said head approximately at a cylinder axis.

19. The system according to claim 14 wherein said head includes three hemispheric depressions each housing one of said valves.

20. The system according to claim 14 wherein said ignition means comprises three ignition means each approximately centrally located in one of three spaces bounded by two adjacent valves and a cylinder edge.

21. The system according to claim 20 further including a fourth spark plug located in said head substantially on an axis of said cylinder.

22. An improved combustion chamber system for use with internal combustion engine having at least one piston and a cooperating cylinder head forming a combustion chamber therebetween, which comprises:

three valves in said head at said combustion chamber, said valves being arranged around an axis of said cylinder;

two of said valves adapted to act as intake valves;

said third valve being adapted to act as an exhaust valve;

said exhaust and intake valves having a ratio of exhaust valve diameter to intake valve diameter being from about 0.95:1 to 1:1.2;

said piston having a face adjacent to said head forming one wall of said combustion chamber; and

at least one ignition means for igniting an air/fuel mixture in said combustion chamber.

23. The system according to claim 22 wherein said ignition means comprises a single spark plug located in said head approximately at a cylinder axis.

24. The system according to claim 22 wherein said head includes three hemispheric depressions each housing one of said valves.

25. The system according to claim 22 wherein said ignition means comprises three ignition means each approximately centrally located in one of three spaces bounded by two adjacent valves and a cylinder edge.

26. The system according to claim 25 further including a fourth spark plug located in said head substantially on an axis of said cylinder.

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EXHIBIT 5

LICENSE OF TECHNOLOGY AND TRADE SECRETS

Parties

This License Agreement is made by and between **JAMES J. FEULING** [hereafter "FEULING"] his successors and/or assigns, ["Licensor"], and, **FEULING ADVANCED TECHNOLOGIES, INC.**, a Nevada corporation [hereafter "ADVANCED"] ["Licensee"].

Recitals

The Licensor is the owner of the entire right in and to patent, and certain trade secret information concerning proprietary secret processes, techniques, tooling, customers, designs and proprietary know-how for the design and manufacture of three valve combustion chamber systems. Licensee desires to obtain a scope of use license, and the Licensor is willing to grant, subject to the terms and conditions set forth in this Agreement, the exclusive license from the Licensor, for the specific scope of use and in the designated territory, to use the Licensor's intellectual property in the manufacture and sale of three valve combustion chamber systems for combustion engines.

Terms of Agreement

Article I
Certain Definitions

Section 1.1 *Use Throughout.* Terms defined in this *Article I* and parenthetically elsewhere shall have the same meaning throughout this Agreement. Defined terms may be used in the singular or plural.

Section 1.2 *"Technology" means*:

1.2.1 The Licensor's secret processes, techniques, tooling designs, product designs and proprietary know-how and custom made proprietary machinery and tooling, plans, technology arising from and protected by U.S. Patents 5,313,921; 5,501,191; 5,638,787; and 5,893,348 owned by Licensor.

Section 1.3 "Developments" means any and all improvements and developments, whether or not patented, irrespective of the maker thereof, relating to or derived from the Technology or its use, including, without limitation, any process, method, technique or know-how.

Section 1.4 "Patents" means any patents which may issue in the Territory on the Technology described in *Section 1.2.1*, and all renewals of such patents, if any, including, but not limited to an foreign patent rights, if any, present or future.

Section 1.5 "Territory" means worldwide.

Section 1.6 "Advanced Use" means exclusive right to use, manufacture and sell 3 valve combustion engine systems, either in O.E.M. application or aftermarket application. This Agreement confirms the preexisting grant of rights between FEULING and Advanced with respect to Ford Motor Company in 1995. This exclusive license grant by Licensor is limited to, and solely for, automobile, truck and motorcycle application by Licensee. No other license, exclusive or non-exclusive, is granted hereby.

Section 1.7 "Revenue(s)" means the income generated by Licensee in a bona fide commercial transaction between unaffiliated parties, whether by royalty payments or sales.

Section 1.8 "Licensee" shall include companies which ADVANCED may associate or sub-license including, but not limited to, parent or subsidiary companies or any company wherein ADVANCED has voting rights and/or rights of corporate control, if any. ADVANCED shall be responsible for all royalties due on the activities of any person or entity which acts in concert with ADVANCED with respect to the subject matter of this Agreement. Licensor shall have the right to request identification of any person or entity acting in concert with ADVANCED with respect to the subject matter of this Agreement and Licensor shall retain all rights granted herein with respect to such persons or entities.

Article II

Grant of License; Disclosure of Developments

Section 2.1 ***Grant.*** Subject to this Agreement's terms and conditions, the Licensor hereby grants, to the extent that it lawfully may, to the Licensee, the right to use the Technology and the Developments disclosed under *Section 2.2*, for the use, manufacture and sale of 3 valve combustion chamber systems for combustion engines for use in automobile, truck and motorcycle engines in the designated Territory, during the License Term set forth in *Section 9.1*. The Licensor specifically reserves all rights in and to the Technology other than the rights granted Licensee herein.

2.1.1 ***Marking.*** Licensee agrees that all products sold pursuant to this license shall be clearly marked with the subject matter patent number(s).

Section 2.2 ***Sublicenses/Assignment***

2.2.1 The license granted to the Licensee under *Section 2.1* does include the right to sub-license the Technology and the Developments to others in the Territory with the express written permission of Licensor for such sub-license which may be granted or denied at the sole discretion of Licensor. Any such sub-license, if allowed, shall be upon the same terms and conditions granted Licensee herein. Licensor expressly acknowledges the existing license rights previously granted by Licensee to Ford, which license is agreed not to effect, in any way, the dealings between the parties hereto. Nothing in this Agreement shall be deemed to effect, in any manner, the existing agreements between ADVANCED and Ford, and said agreements are ratified by FEULING hereby.

2.2.2 The rights granted to Licensee hereunder are not assignable without the express, written consent of Licensor which may be granted or denied at the sole discretion of Licensor. Any such assignment, if allowed, shall be upon the same terms and conditions granted Licensee herein.

Section 2.3 ***Reservation of Rights.*** Subject to the Licensee's right to use the same pursuant to the terms of this Agreement, the Licensor reserves all proprietary rights in and to all discoveries, inventions, patent rights, trade secrets, know-how or other proprietary data embodied in the Technology or the Developments. The Licensee agrees to receive and use the Technology and the Developments for the term of the license granted under *Section 9.1* and subject to such reservation, and agrees to cease all use of Technology or Developments upon termination of such license. Licensee acknowledges that the Technology licensed herein is of a sensitive nature and is the trade secret and proprietary intellectual property of Licensor and hereby accepts Licensor's confidential disclosure to Licensee of the Technology pursuant to the terms of this contract.

Section 2.4 ***CARB or Federal Requirements.*** Licensee acknowledges that the California Air Resources Board and/or other state and/or federal agencies may require the Licensee and/or resellers of Licensee's products, to apply for and receive exemption status (50 state legal) allowing the products produced under license herein to be sold for OEM or aftermarket installation. Such requirements may change due to changes in the law from time to time. Licensee acknowledges that any and all such responsibility for any such approval is solely Licensee's and at the sole expense of Licensee.

Article III

Commencement of Disclosure

Section 3.1 ***Deliveries.*** Subject to the terms and conditions of this Agreement, the Licensor shall, within 30 days after the signing of this Agreement, commence any additional disclosure of the Technology and Developments to the Licensee, if any, by delivering to the Licensee copies of the Technology Documents and the drawings and other technical documentation in the Licensor's possession. Licensee acknowledges receipt of such delivery in 1995.

Article IV

Parties Independent

Section 4.1 ***Status of Parties.*** Nothing in this Agreement shall be construed to constitute the Licensee as the partner, employee or agent of the Licensor, not shall either party have any authority to bind the other in any respect, it being intended that each shall remain an independent party, responsible only for its own actions.

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Article V

Initials

Consideration

Section 5.1 ***Initial Royalty Pre-Payment.*** Licensor agrees to license the subject matter technology to Licensee for a royalty pre-payment acknowledged as paid in 1995, plus running royalties as stated hereinbelow, and Licensee agrees to license the subject matter technology, for said royalty pre-payment acknowledged as paid in 1995, plus running royalties as stated hereinbelow,

Section 5.2 ***Running Royalty.*** In consideration of Licensor's disclosure of the Technology, and, in consideration for the scope of use license granted by the Licensor for continued use of the Technology, and the performance of the Licensor's other obligations under this Agreement, the Licensee shall pay to the Licensor running royalties equal to ten percent [10%] of any and all gross revenue arising from the Technology, whether by royalty, sale or in any manner whatsoever, for the life of this License.

5.2.1 Quarterly running royalties payable under this License to be paid within 21 calendar days after the end of each such quarter by bank check or by wire transfer to Licensor's designated account.

5.2.2 The running royalty shall be paid based upon actual gross income until the expiration of the last of the patents to issue.

Section 5.3 ***Royalty Statements.*** All royalty payments shall be accompanied by royalty statements, certified by the Licensee's chief financial officer, setting forth the method in which the technology was used during the quarter by Licensee and the calculation of the amounts of royalty payable to the Licensor under this Agreement (including any currency conversion), all in such detail as the Licensor may reasonably request.

Section 5.4 ***Payment.*** All payments tendered to the Licensor by the Licensee under this Agreement shall be made in United States dollars, without any deductions. Payments shall be made at the Licensor's address for receipt of notices under *Section 11.2*, or at such other address or deposited in such bank account as the Licensor may from time to time designate by notice to the Licensee.

Section 5.5 ***Additional Consideration.*** Licensee agrees to sell products produced pursuant to this agreement to Licensor for the lowest price said products are offered to Licensee's best customers.

Section 5.6 ***Default Remedies.*** In the event of Licensee insolvency or any breach of the terms herein, specifically including, the timely making of all payments required hereunder, then shall this agreement terminate [except for the confidentiality provisions hereinbelow], and all rights shall immediately revest in Licensor. All payments made to date of termination shall be deemed non-refundable royalties. Licensee shall have rights to cure any default as follows:

[a] Any default of payment [initial royalty pre-payment or running royalty], including, but not limited to, failure to timely pay or insufficient funds, shall be curable by Licensor's receipt of full payment of the amount due within three days of FAX notice of such default;
[b] Any other default hereof shall be curable by Licensee by fully complying within thirty [30] days notice by Licensor. Notice of any default shall be reasonably identified,

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as shall requirements for cure. Default Notice may be by FAX.

Article VI

Confidentiality

Section 6.1 ***Nondisclosure of Confidential Information.*** The Licensee shall at all times during and after the term of this Agreement hold in the strictest confidence, and shall not directly or indirectly disclose to others, or use for any purpose other than as contemplated in this Agreement, any of the Technology or the Developments disclosed to the Licensee by the Licensor or as to the Developments of the Licensee. Notwithstanding the foregoing, the Licensee shall have the right to make disclosures of the Technology and such Developments on a strict "need-to-know" basis to the Licensee's employees, and, with the Licensor's prior approval, the Licensee's prospective suppliers and contractors, and to whom such disclosure is necessary for the performance of this Agreement; provided that the Licensee shall first obtain from each employee, supplier or contractor and their respective employees confidentiality agreements with respect to the Technology and such Developments in the form substantially similar to the requirements of this Agreement, and the Licensee shall promptly deliver copies of all such confidentiality agreements to the Licensor.

Section 6.2 ***Exceptions.*** The Licensee shall not be held to a duty of confidentiality for any of the Technology or any of the Developments which:

6.2.1 is, or becomes, generally known in the manufacturing industry by reason of a single integrated publication; or

6.2.2 after its disclosure to the Licensee, is received by the Licensee in an integrated form from an independent third party whose disclosure of such Technology or Developments shall not constitute a direct or indirect breach by that third party of any duty of confidentiality owed to the Licensee.

Section 6.3 ***Documents.*** Licensor may designate as confidential, by legending prominently as such, any drawings, charts, blueprints, specifications, magnetic cards, films or other documentary or physical manifestation or disclosure of any of the Technology or the Developments (collectively, the "Documents"). The Licensee shall legend prominently any Documents it may prepare which embody any Technology or Developments, to identify them as confidential trade secret proprietary information.

Section 6.4 ***Licensor Confidentiality Obligations.*** The Licensor shall comply with the provisions of confidentiality in *Sections 6.1* through *6.3* in connection with any disclosures of confidential information made to the Licensor.

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Section 6.5 ***Unique Character of Confidential Information.*** The Licensee acknowledges that the Technology and the Developments to be disclosed by the Licensor are of a special and unique character which gives them a peculiar value and that consequently any wrongful use or disclosure of the Technology

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or Developments will cause injury not readily measurable in monetary damages, and therefore irreparable. Accordingly, whether in court action or arbitration, the Licensor shall be entitled to the remedies of injunction, specific performance and other equitable relief to redress any such breach, and no proof of special damages shall be necessary for the enforcement of or for any action upon such obligations. Without limiting the generality of the foregoing, the Licensor shall have the right to require the surrender and return to the Licensor of all Technology and Developments disclosed by the Licensor, and all Documents and materials related hereto.

Section 6.6 ***Non Competition by Licensor.*** Licensor herein agrees that it will not compete with Licensee in the sales of 3 valve combustion chamber systems under the subject matter patents, in the Field of Use, and for the term, granted herein to Licensee, so long as Licensee shall not be in breach of any term hereof. Upon breach, as stated above, all rights revest in Licensor, this non-compete shall automatically terminate as to Licensor, and Licensee shall cease and desist from any and all use.

6.6.1 ***Licensor Shop Rights.*** Licensor shall have the right to utilize 3 valve combustion chamber systems coming within the scope of the subject matter patents in the following areas:

[a] For any non-licensed engine application, including, without limitation, aviation, marine, and stationary or static engine applications;

[b] Racing applications in any field, either by direct participation, or in conjunction with any company chosen by Licensor. It is the agreed intent of the parties that the technology not be disclosed to any competitor of Licensee; said racing application right includes the right to manufacture and sell limited edition [less than 300 per year] specialty models and/or engines in any field

Section 6.7 ***Survival.*** The obligations of the Licensee and the Licensor under this *Article VI* shall, except as otherwise expressly provided, survive termination of this Agreement.

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Article VII

The Licensee's Conduct of Business

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Section 7.1 *Compliance With Laws.* The Licensee represents and warrants to the Licensor that in the Licensee's performance of its obligations under this Agreement, the Licensee shall indemnify the Licensor against any loss which the Licensor may incur as a result of any claim or demand which may be made against the Licensor based upon the Licensee's failure to so comply.

Section 7.2 *Insurance.* As a material term, Licensee shall promptly [and prior to any sale of products using the Technology and/or taking possession of the inventory], or upon the demand of Licensor, cause its product liability, advertising claims and general liability insurance to be modified to name the Licensor as an additional insured. Licensee shall maintain such insurance in an aggregate amount sufficient to protect the interests of both Licensee and Licensor. Licensor shall have the right to demand that insurance be carried in an amount not less than one million dollars [U.S. $ 1,000,000] during the term of the license granted under *Section 2.1.* The Licensee shall promptly provide the Licensor with a certificate of insurance from Licensee's insurance company evidencing such coverage and the naming of Licensor as also insured upon demand. At all times relevant during the License Period, and after the License Period as to any product liability claim, Licensee shall indemnify and hold Licensor harmless from any claim or damage arising in whole or part from Licencee's use of the rights granted hereunder.

Section 7.3 *Indemnification/Hold Harmless.* As a material term, and notwithstanding any of the above, Licensee agrees to indemnify, defend and hold Licensor harmless from any claim arising from Licensee's use of the Technology, including, but not limited to, product liability. Licensor shall have the right to its own counsel, at the expense of Licensee.

ARTICLE VIII

Infringement

Section 8.1 *Notice of Infringement.*

8.1.1. The Licensee shall promptly notify the Licensor of any instance which comes to the Licensee's attention involving a possible misappropriation of any trade secret, or infringement of any Patent or other proprietary right of the Licensor, relating to the Licensed Technology or the Developments.

8.1.2. The Licensor shall make such inquiry as it deems appropriate. If, in its sole judgment, the Licensor elects to bring an infringement or misappropriation or other suit, the Licensee shall at the request of the Licensor, promptly lend all reasonable assistance to the Licensor, in the prosecution of such suit.

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Licensee, in the event of litigation to enforce intellectual property rights, shall bear the cost of prosecution. Licensor shall provide all reasonable assistance for such prosecution, and Licensor shall be compensated for such assistance at Licensor's normal consulting rate of $ 250.00 per hour, plus costs incurred; *i.e.*: without limitation, travel, telephone calls, copying and etcetera. Licensor agrees to voluntarily join any action for prosecution upon the reasonable request of Licensee.

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In the event of recovery under any intellectual property prosecution, whether by lawsuit, mediation, arbitration or private settlement, Licensor shall be entitled to ten percent [10%] of the gross recovery [excepting any portion of the recovery specifically awarded as additional relief in the form of attorneys' fees and costs] as and for Licensor's reasonable royalty. Said royalty shall be in addition to any compensation or reimbursement of cost due Licensor under this § 8.1.2.

8.1.3. Nothing contained in this Agreements shall be construed as an obligation of the Licensor or the Licensee, to bring or to prosecute any suit or other proceeding against any third party for misappropriation of trade secrets, or infringement of any patent or other intellectual property rights.

However, in the event that Licensee elects not to protect the subject matter intellectual property rights, then shall this License Agreement automatically terminate and all rights hereunder shall immediately revest in Licensor. Said reversion shall also apply to the Ford Non-Exclusive License with respect to receipt of payments and/or royalties thereunder. Licensee shall permit no act or omission that would interfere with the rights granted to Ford Motor Company

Section 8.2 ***Notice of Claims.***

8.2.1. The Licensee shall give prompt notice to the Licensor of any claim, action or proceeding pending or threatened against the Licensee, alleging misappropriation of trade secrets or infringement of any patent or other proprietary rights asserted by a third party, based on the use by the Licensee or its sub-licensees' use of the Technology or any Developments. If the Licensee's or any or its sub-licensees' use of the Technology and Developments is in accordance with the provisions of this Agreement, and if the Licensor shall so request, the Licensee shall make, and shall cause its sub-licensees to make, any practical modification of it's or their practice under the license or sub-license granted, amendment of this Agreement or other means (without the obligation of the Licensor or the Licensee to incur any material expense in respect thereof) in order to avoid suit or reduce the potential adverse effect of any such claim or action.

8.2.2. Licensor knows of no prior patents or prior art which would render the rights granted herein an infringement upon same. Nothing contained in this Agreement shall be construed as a warranty by the Licensor that the Technology or the Developments do not infringe the patent or other intellectual property rights of third parties, and the Licensor disclaims any such warranty.

8.2.3. Licensee is responsible for all costs related to or occurring from any returns of products produced by Licensee using the technology licensed herein whether returned for defective workmanship or part failures or defects covered by warrant or otherwise.

Article IX

Term; Termination

Section 9.1 ***License Term.*** The initial term of the License granted under *Section 2.1* shall commence on the date of this Agreement and shall continue in perpetuity so long as Licensee adheres to

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the terms and conditions of this license agreement.

Section 9.3 ***Termination.*** The License granted to the Licensee under Section 2.1 may be terminated upon notice as follows:

9.3.1 by either party, if the other party has materially breached or failed to punctually perform any of its duties or obligations under the Agreement and such breach remains uncured or such failure to perform continues for at least 30 days after the aggrieved party has given notice to the other party; or

9.3.2 by the Licensor, if the Licensee is insolvent or becomes the subject of a voluntary or involuntary petition in bankruptcy for its reorganization or liquidation, or makes any assignment for the benefit of its creditors, or if a trustee or receiver of its property is appointed, or if the Licensee takes or is subjected to any other similar action based upon its inability to meet its financial obligations; or

9.3.3 by the Licensor, if the Licensee assigns this Agreement or any of its rights under this Agreement without obtaining the Licensor's prior written consent; or

9.3.4 by the Licensor, if there is a sale of substantially all of the assets or a majority of the shares of the Licensee; or

9.3.5 by the Licensor, if the aggregate running royalties to be received by the Licensor under *Article V*, during any one year period, commencing for calendar year 1998, shall be less than one hundred thousand dollars [US $ 100,000] in total.

Section 9.4 ***Effects of Expiration or Termination.*** If the term of the License granted to the Licensee under *Section 2.1* or if the License is terminated, all rights of the Licensee under the License shall cease and the Licensee shall cease to use any part of the Technology or the Developments and shall immediately return and surrender to the Licensor all of the Technology, the custom-made machinery, the developments disclosed by the Licensor, any and all Documents and all other tangible disclosures of the Technology or Developments, which shall then vest solely in Licensor.

Section 9.5 ***Obligations Surrounding Termination.*** Not-with-standing any termination of the License granted to Licensee under *Section 2.1*, and any exercise by either party of any rights or remedies hereunder, the following rights and obligations shall survive any such termination or exercise of rights to the degree necessary to permit their complete fulfillment or discharge:

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9.5.1 the Licensor's right to receive or recover, and the Licensee's obligation to pay, the amount of all royalties and other sums payable under *Article V* which is vested in, accrued or accruable at the time of termination or exercise of such rights, and any adjustments in payments required thereafter as a result of any audits under *Section 11.7*; and

9.5.2 *Article VI,* and any subsequent undertaking or agreement, that may be in effect at

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the time of termination with respect to the maintenance of the confidentiality or secrecy of the Technology and or the Developments and covenant not to compete; and

9.5.3 any rights or remedies of either party under *Articles VIII* or *X* and any cause of action or claims of either party whether or not accrued at the time of termination, because of any breach of or failure to perform any obligation under this Agreement.

ARTICLE X

General Provisions

Section 11.1 ***Notices.*** All notices required or permitted under this Agreement shall be in writing and shall be effective upon personal delivery to or being sent by registered or certified mail, return receipt requested, postage fully prepaid and addressed to the respective parties at their addresses set forth below or to any other address designated by the parties at a later date.

Licensor: James J. Feuling
c/o Gilliam & Associates
4565 Ruffner Street, Suite 200
San Diego, California 92111

Licensee: Feuling Advanced Technologies, Inc.
c/o Gilliam & Associates
4565 Ruffner Street, Suite 200
San Diego, California 92111

Section 11.2 ***Binding Effect.*** This Agreement shall be binding upon and shall inure to the benefit of the Licensor and the Licensee and of their respective successors and permitted assigns.

Section 11.3 ***Waiver.***

[a] ***Requirement of Writing*** - No waiver of, acquiescence to, or consent to any breach of or default of any term or condition contained in this Agreement by Licensor shall be of any force or effect unless same is in writing, specifically identified, and signed by Licensor.

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[b] ***No Implied Waiver*** - No waiver of, acquiescence to, or consent to any breach of or default of any term or condition contained in this Agreement by Licensor pursuant to subparagraph [a], above, shall be deemed, express or implied, generally or specifically, to be a waiver, consent, or acquiescence to any other breach or default.

[c] No delay or omission in the exercise of any right or remedy by Licensor shall impair such right

or remedy or be construed as a waiver. A consent by Licensor to or approval of any act shall not be deemed to waive or render unnecessary consent to or approval of any other or subsequent act.

Section 11.4 ***Severability.*** If for any reason in any jurisdiction in which any provision of this Agreement is sought to be enforced, any one or more of the provisions of this Agreement shall be held to be invalid, illegal or unenforceable in any respect, such holding shall not affect any other provision of this Agreement and this Agreement shall be construed as if such invalid, illegal or unenforceable provision had never been contained herein.

Section 11.5 ***Governing Law.*** This Agreement shall be governed by and construed in accordance with the law of the State of California with all applicable contracts deemed made and to be performed wholly in that State. The federal law and public policy of the United States of America shall not govern this Agreement or a fact of its interpretation, save as to the operation of Licenses under U.S. Patents. The venue for the interpretation and or enforcement of any provision of this agreement is mutually agreed by the parties hereto to be the proper court of jurisdiction located in San Diego, California.

Section 11.6 ***Legal Fees and Costs.*** The prevailing party to any action to interpret and or enforce any provision of this Agreement shall be entitled to recover from the unsuccessful party(ies) to this Agreement, all costs, expenses and actual attorney's fees relating to the enforcement of, interpretation of, or any litigation, arbitration, mediation or private settlement, relating to this Agreement, in addition to any other relief that may be afforded.

Section 11.7 ***Accounting/Audit/Inspection.*** For the term of this License, Licensee shall maintain true, accurate and complete books and records of all transactions and uses of the Technology. Licensee shall make quarterly reports of gross revenues and costs, concurrently with the royalty statements.

Licensor shall have the right to inspect such books and records at any time, during normal business hours, with forty-eight hours notice to Licensee. Licensee hereby agrees that a court order for production of accounting, in the event of Licensee's failure to produce the records as required hereunder, may be granted. Licensor shall have the right to audit all books and records, not more than once per year. Such audit will be conducted by a representative of Licensor's sole choice, and will be paid for by Licensor, except in the event that such audit reveals an under-reporting of three percent [3%] or greater, in which event Licensee shall pay all costs of audit.

Licensee and Licensor shall promptly pay any adjustment required between them as a result of any such audit. True, accurate and complete books and records, as well as audit and inspection rights are a material provision of this License Agreement.

Section 11.8 ***Counterparts.*** This Agreement may be executed in several counterparts, each of which shall constitute an original, but all of which together shall constitute one and the same instrument. The headings contained in this Agreement have been inserted for convenience of reference only and shall not modify, define, expand or limit any of the provisions of this Agreement.

Section 11.9 ***Challenge***. A legal challenge to the validity of any patent or the other Technology licensed herein shall be a material breach of this agreement should such a challenge be unsuccessful and/or should Licensee not prevail in such an action.

Section 11.10 ***Drafting Ambiguities***. Each party to this Agreement and its counsel have reviewed and revised this Agreement or has had the opportunity to do so. The rule of construction that any ambiguities are to be resolved against the drafting party shall not be employed in the interpretation of this Agreement or of any amendments or exhibits to this Agreement.

Section 11.11 ***Entire Agreement***. This Agreement, which includes its Addendums, and Exhibits, constitutes the entire agreement of the parties relating to its subject matter, supersedes all prior oral or written understandings or agreements regarding that subject matter and may not be amended, modified or canceled except by a written instrument executed by both the Licensor and the Licensee.

IN WITNESS WHEREOF, LICENSOR and LICENSEE have executed this Agreement in duplicate as of the date hereinbelow. The signatories of the respective parties hereto, by affixing their signatures to this agreement, each individually warrant their ability to bind the party on whose behalf they are executing this agreement.

LICENSOR: *JAMES J. FEULING*

By: James J. Feuling

DATED: MAY 15, 2000

LICENSEE: *FEULING ADVANCED TECHNOLOGIES, INC.*

By: James J. Feuling, President

DATED: MAY 15, 2000

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