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SPARK PLUG

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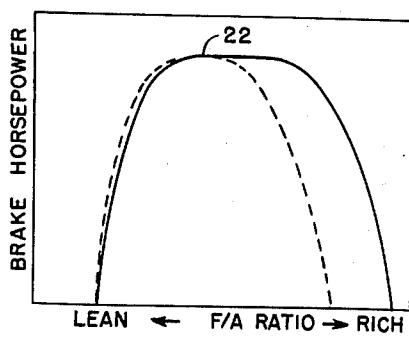
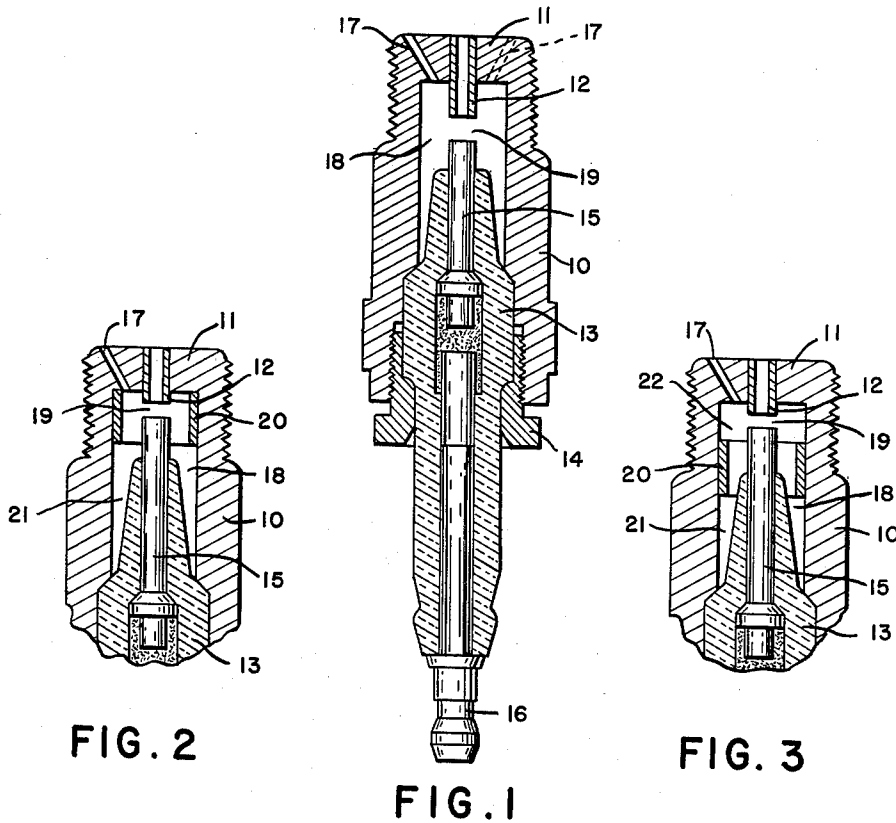


FIG. 4

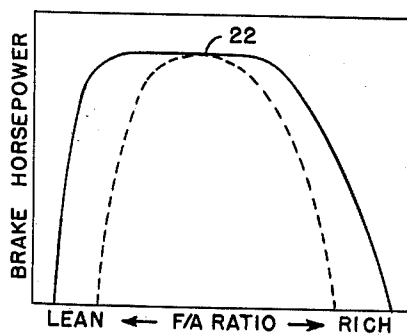


FIG. 5

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SPARK PLUG

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The present invention relates to spark plugs, and particularly to a new and improved spark plug that possesses a maximum brake horsepower characteristic over a relatively large but preselected range of varying fuel-air ratios.

Commonly known open-faced spark plugs possess a peaked curve brake horsepower characteristic when employed with varying fuel-air ratios. There is a single point throughout a range of fuel-air ratios at which maximum brake horsepower is available. Greater and lesser fuel-air ratios relative to this point are attended with a substantial decrease in available brake horsepower and, consequently, lower efficiencies of engine operation.

The tip of the insulation that supports the central terminal of such open-faced plugs is cyclically subjected to wide temperature variations, causing excessive fouling due to carbon deposits, pre-ignition, and lead deposits at the higher temperatures. Consequently, such plugs seldom operate within the most efficient operating temperature range.

In order to more clearly define the present invention, the following definitions are relied upon insofar as the present invention is concerned:

(1) The heat rating characteristic of a spark plug is the pounds per square inch of indicated mean effective pressure (I.M.E.P.) at which the spark plug will operate without pre-ignition occurring.

(2) The most efficient operating temperature or heat range through which the insulating tip should cycle means a range of temperatures wherein at temperatures below the low of the range, excessive fouling occurs due to carbon deposits on the tip; and wherein at temperatures above the high of the range, lead deposits and pre-ignition occur. It has been found that the most efficient temperature range is approximately from about 960° F. to approximately 1200° F.

(3) The mixture response of a spark plug means the fuel-air ratio in relation to the maximum brake horsepower that can be developed.

(4) A hot rated plug is one rated low on the I.M.E.P. scale and which can only operate at relatively low power output without pre-ignition occurring.

(5) A cold rated plug is one rated high on the I.M.E.P. scale and which can operate at high power output without pre-ignition.

Attempts have been made to produce spark plugs having a maximum brake horsepower over a relatively large range of varying fuel-air ratios, and these have for the purposes intended produced the results for which they were designed. Such a spark plug is shown, described and claimed in Patent No. 2,895,069, issued July 14, 1959, in the name of Putnam Davis. Spark plugs of this type usually include a body containing an ignition chamber within which spaced electrodes form a spark gap and ingress and egress of the fuel-air mixture as well as the burning gases after ignition occur through helical passages providing a swirling action to the fuel and gases. Such plugs, for the purpose of this application and to distinguish them from the open-faced plugs, will be referred to hereinafter as "chamber-type" plugs. These chamber-type plugs have a brake horsepower characteristic that essentially follows that of the commonly known open-faced plug to a point where maximum brake horsepower is produced with a given fuel-air mixture.

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As the fuel-air mixture is increased or becomes richer, the available brake horsepower of the open-faced plug rapidly decreases, whereas that of the chamber-type plug remains at a maximum for an extended range of fuel-air ratios.

It has become increasingly important to provide spark plugs capable of use under different conditions that will produce a maximum brake horsepower characteristic over a preselected range of fuel-air ratios. Thus, in aircraft and passenger automobile use, a relatively rich fuel-air mixture is desirable at take-off or start, and immediately upon moving, the aircraft and automobile preferably should operate on a much leaner mixture. Employing either the commonly known open-faced plug or the chamber-type having the characteristics above outlined causes power loss when the fuel-air ratio is varied toward a leaner condition.

The most efficient operating temperature range of a spark plug has become recognized as an important consideration in engine efficiency. In chamber-type plugs, this temperature range is controlled by the volume of the separate chamber within which ignition initially occurs, excluding the volume of the electrode supporting porcelain extending into said chamber. Accordingly, by varying this differential volume, a series of plugs can be designed having any desired heat rating characteristic.

The principal object of this invention is to provide a spark plug having a maximum horsepower characteristic over a relatively large preselected range of fuel-air ratios.

Another object of the invention is to provide a series of spark plugs having a predetermined heat rating and in addition a maximum brake horsepower characteristic over a relatively large preselected range of fuel-air ratios.

Another object of this invention is to provide a wide range of spark plugs covering a wide range of heat ratings as well as a wide range of mixture response, and wherein said plugs will possess the most efficient operating temperature range through which the insulating tip will cycle.

Another object of the invention is to provide a series of spark plugs having different heat ratings and which will operate to maintain in the vicinity of the spark gap, a fuel-air mixture of as near best power mixture as possible.

Another object of this invention is to provide a series of spark plugs having different heat ratings and which, when used with engines preferring a rich mixture during normal operation, will tend to automatically reduce the richness of the fuel-air mixture in the vicinity of the spark gap.

Another object of this invention is to provide a series of spark plugs having different heat ratings and which, when used with engines preferring a lean mixture during normal operation, will tend automatically to enrich the fuel-rich mixture in the vicinity of the spark gap.

In one aspect of this invention, the body of the spark plug may be provided with a chamber for receiving the usual electrode supporting porcelain. The chamber may be closed at its end that is adapted to extend into a cylinder of an internal combustion engine. Helical passages, or passages to produce a similar effect, may be provided between the interior of the chamber and the exterior of the closed end for imparting a swirling action to the gases that pass therethrough during the compression stroke of the engine, and to the burning gases after ignition takes place within the chamber.

In another aspect of the invention, means may be provided within the chamber for automatically controlling the fuel-air mixture adjacent the spark gap. In the embodiment disclosed, this means takes the form of an annular element which may be integrally fixed at different locations within the chamber. Since the most efficient operating temperature range of a plug is controlled by the volume of the chamber less the volume of the elec-

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trode supporting porcelain extending thereinto, this most efficient range may be provided by employing different length and/or different inside diameter annular elements, as well as by varying the capacity of the chamber farthest from the spark gap that is formed by the annular element. Once a design has been established with a given chamber size and annular element size, varying the location of the annular element within the chamber makes it possible to vary the fuel-air mixture response of the plug.

Accordingly, in another aspect of the invention the annular element may be fixed to the side wall of the chamber at different locations, providing separate compartments within said chamber which combine with the swirling action of the gases to vary the fuel-air mixture response of the plug.

The above, other objects and novel features of the invention will become apparent from the following specification and accompanying drawing which is merely exemplary.

In the drawing:

FIG. 1 is a sectional elevational view of a prior art chamber-type plug;

FIG. 2 is a sectional elevational view of a chamber-type plug for use with engines preferring a richer than best power fuel-air mixture for normal operation, and to which the principles of the invention have been applied;

FIG. 3 is a sectional elevational view of a plug similar to that of FIG. 2 but designed for use with engines preferring a leaner than best power fuel-air mixture for normal operation, and to which the principles of the invention have been applied;

FIG. 4 is a graph of the brake horsepower characteristics of the plugs of FIGS. 1 and 2 in relation to that of a conventional open-faced plug; and

FIG. 5 is a graph of the brake horsepower characteristics of the plug of FIG. 3 in relation to that of a conventional open-faced plug.

Referring to the drawing, and particularly to FIG. 1, a conventional chamber-type spark plug may comprise a substantially cylindrical metal body 10 having its end which is adapted to extend into a cylinder of an internal combustion engine closed by a plate element 11 which supports one electrode 12 of the igniter system. The usual insulator element 13 is mounted within the body 10 and is held therein by the usual nut 14. The insulator element 13 supports the other electrode 15 of the igniter system, to the outer end of which the usual terminal 16 is fixed.

Helical passages 17 may be provided in the body 10, providing communication between a chamber 18 surrounding the spark gap 19 and the interior of a cylinder with which the plug is employed.

It has been found that if a spark plug is caused to cycle throughout the most efficient operating temperature range, the insulator nose will be maintained free from conductive deposits which, due to their lower resistance than that of the normal air or spark gap, tend to flash over, causing loss of normal ignition.

Referring to FIG. 2, the principles of the present invention are shown in one form as applied to a plug similar to that shown in FIG. 1. In this disclosure, a plug of a desired heat rating has been designed for use with an engine which under normal operation prefers a fuel-air mixture that is richer than best power. Such engines are those for trucks, marine, industrial use and the like. The chamber 18 of the plug in FIG. 2 may include an annular element 20 that is shown as a sleeve that may permanently be fixed to the side wall of the chamber 18 in contact with the end plate 11. This element 20 may be provided in any one of several forms such as by boring and counter-boring the chamber 18, or forging the annular element at a predetermined location within chamber 18.

Tests have indicated that the portion of the insulator or ceramic nose which is positioned adjacent to the sleeve element 20 may be caused to cycle throughout the

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most desirable temperature range and prevent conductive deposits from forming thereon by virtue of the annular clearance between the sleeve 20 and the insulator nose. In fact, for a specific sleeve 20 having a specific annular nose clearance, the chamber construction to provide the most effective operating temperature range of the plug may be found by varying the volume of the chamber farthest from the spark gap. This may be accomplished by counterboring this chamber to increase its capacity, which causes a greater volume of high velocity gases to pass over the insulator nose without materially changing the basic heat rating characteristics of the complete plug. Accordingly, by the selection of correct dimensional sleeves 20 and chamber displacement combinations for a given heat rating, a maximum linear insulator nose cleaning effect may be obtained, thereby preventing conductive deposits from occurring on the insulator nose.

During the compression stroke of the engine, the fuel-air mixture, which is richer than best power and therefore contains a greater portion of fuel particles than a leaner mixture, is given a swirling or centrifugal action with a force component directed away from the spark gap 19 as it is forced under high pressure through the helical passages 11. Accordingly, the heavier fuel particles tend to be thrown away from the spark gap 19 into the portion 21 of the chamber 18, thereby providing a leaner fuel-air mixture in the vicinity of the spark gap 19. Accordingly, as the fuel-air mixture becomes richer and richer, the spark gap is surrounded by a fuel-air mixture that remains in the vicinity of the best power mixture, thus producing a relatively long range of maximum brake horsepower with increasing fuel-air ratios.

Referring to FIG. 4, the dotted line curve represents the brake horsepower characteristic of the conventional open-faced spark plug. This curve has a single point 22 of maximum brake horsepower. Variations of fuel-air ratio above and below this point are attended with rapid loss of brake horsepower and consequent inefficient engine operation. The solid line curve of FIG. 4 represents the brake horsepower characteristics of the chamber-type plug of FIGS. 1 and 2, and the increase in range of maximum brake horsepower is due, at least in part, to the previously described structure of the chamber-type plug. From a review of FIGS. 1, 2 and 4, it is evident that the prior known chamber-type plug has particular value when used with engines preferring, during normal operation, a fuel-air mixture richer than best power. However, if an engine prefers, during normal operation, a fuel-air mixture leaner than best power, the plugs of FIGS. 1 and 2 would produce a substantial fall in the available brake horsepower.

Referring to FIG. 3 wherein a chamber-type plug has been shown for use with an engine preferring a fuel-air mixture leaner than best power, the sleeve or annular element 20 has been relocated within the chamber 18 so as to provide not only a compartment 21 a substantial distance away from the spark gap 19, but also a compartment 22 surrounding the air gap. During the compression stroke of the engine, the leaner fuel-air mixture is again given a swirling centrifugal action, but in this case the heavier fuel particles are thrown outwardly by centrifugal force and tend to be trapped and to be built up in concentration within the compartment 22 while the lighter fuel particles pass outwardly into the compartment 21. In this way the fuel-air mixture in the vicinity of the air gap 19 tends to be nearer best power even though a leaner than best power mixture is being used.

Referring to FIG. 5, it is evident that the solid line curve representing the brake horsepower characteristic of the plug of FIG. 3 has shifted relatively to the dotted line curve from a longer range of maximum brake horsepower in a direction of increasing fuel-air ratios to a

longer range of such horsepower in a direction of decreasing fuel-air ratios.

Since the most efficient operating temperature range of a chamber-type plug is controlled by the free volume of chamber 18, and this free volume does not vary with varying positions of the annular element 20 within the chamber 18, it follows that the design of a chamber-type plug for a given heat rating can be made in which the annular element 20 is taken into consideration. Then, a set of plugs having a given, unvarying heat rating may be provided with varying fuel-air mixture response from a lean to a rich response with any number of desired intermediate response values therebetween and still all of the plugs will possess the same most efficient operating range throughout which the insulator nose will cycle without carbon fouling or lead deposit or pre-ignition occurring.

Although the various features of the new and improved spark plug have been described in detail to fully disclose one embodiment of the invention, it will be evident that numerous changes may be made in such details and certain features may be used without others without departing from the principles of the invention.

What is claimed is:

1. A spark plug comprising a hollow body having an internal space defining an ignition chamber, the free volume of which provides a predetermined heat range for said spark plug; a closure for said chamber at the end of said spark plug that communicates with the interior of an engine cylinder; spaced apart electrodes within said chamber forming a spark gap; means providing ingress and egress of gases from said engine cylinder to said chamber; and a member within said chamber forming a compartment of substantially constant cross section extending a substantial distance beyond said spark gap in each direction for maintaining the fuel-air mixture surrounding said spark gap at substantially best power mixture when said fuel-air mixture is different from best power mixture, said member within said chamber being adapted to be located in different positions within said chamber without materially affecting said heat range of said spark plug.

2. A spark plug comprising a hollow body having an internal space defining an ignition chamber, the free volume of which provides a predetermined heat range for said spark plug; a closure for said chamber at the end of said spark plug that communicates with the interior of an engine cylinder; spaced apart electrodes within said chamber forming a spark gap; means providing ingress and egress of gases from said engine cylinder to said chamber; and a member within said chamber forming an entrapping compartment of substantially constant cross section extending a substantial distance beyond said spark gap in each direction for maintaining the fuel-air mixture surrounding said spark gap at sub-

stantially best power mixture when said fuel-air mixture is richer than best power mixture, said member within said chamber being adapted to be located in different positions within said chamber without materially affecting said heat range of said spark plug.

3. A spark plug comprising a hollow body having an internal space defining an ignition chamber, the free volume of which provides a predetermined heat range for said spark plug; a closure for said chamber at the end of said spark plug that communicates with the interior of an engine cylinder; spaced apart electrodes within said chamber forming a spark gap; helical passages extending from the interior of said chamber to the exterior of said closure to provide ingress and egress of gases from said engine cylinder to said chamber; and a member within said chamber forming a compartment of substantially constant cross section extending a substantial distance beyond said spark gap in each direction for maintaining the fuel-air mixture surrounding said spark gap at substantially best power mixture when said fuel-air mixture is different from best power mixture, said means within said chamber being adapted to be located in different positions within said chamber without materially affecting said heat range of said spark plug.

4. A spark plug comprising a hollow body having an internal space defining an ignition chamber, the free volume of which provides a predetermined heat range for said spark plug; a closure for said chamber at the end of said spark plug that communicates with the interior of an engine cylinder; spaced apart electrodes within said chamber forming a spark gap; helical passages extending from the interior of said chamber to the exterior of said closure to provide ingress and egress of gases from said engine cylinder to said chamber; and a member within said chamber forming an entrapping compartment of substantially constant cross section extending a substantial distance beyond said spark gap in each direction for maintaining the fuel-air mixture surrounding said spark gap at substantially best power mixture when said fuel-air mixture is richer than best power mixture, said member within said chamber being adapted to be located in different positions within said chamber without materially affecting said heat range of said spark plug.

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