United States Patent [19]

Lindsay

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[54] **BODY CONTROLLED HEAT RANGE AND EXTENDED GAP SPARK PLUG**

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[52] **U.S. Cl.** ..... **313/11.5,** 313/138, 313/143, 123/169 C

[51] **Int. Cl.** **H01t 13/16**

[58] **Field of Search**.... 313/143, 118, 140, 138–138, 313/11.5, 144; 123/169 C, 169 R, 169 EL

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[57] **ABSTRACT**

A spark plug for internal combustion engines wherein heat range is controlled by body configuration and the dissipation of heat through an extended nose portion of the body that extends beyond the "reach" to protectively enclose an extended insulator and center electrode, and that is exposed within the combustion chamber with the spark gap positioned at the "eye" of combustion and/or at an optimum ignition point. The heat range of the spark plug is efficiently controlled by means of the exposure and the fineness ratio of the extended nose portion of the spark plug body and heat transferred therefrom through threaded engagement that is of assured tightness adjacent the combustion chamber.

20 Claims, 11 Drawing Figures

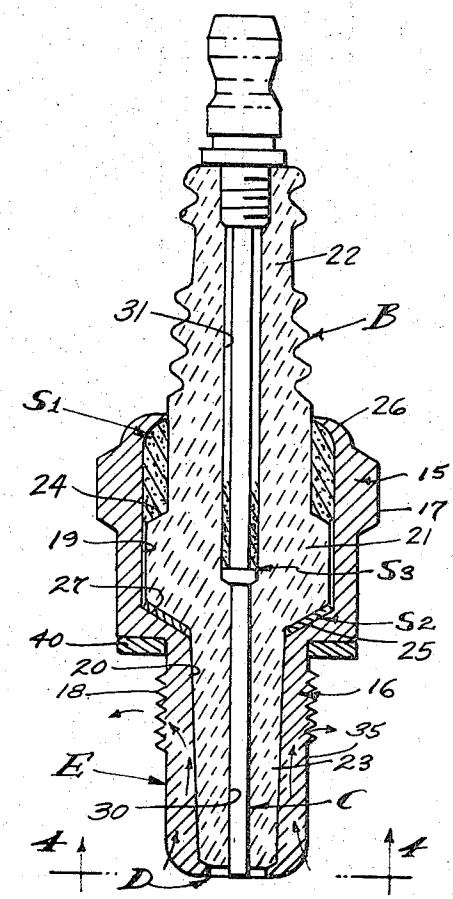


FIG. 1.

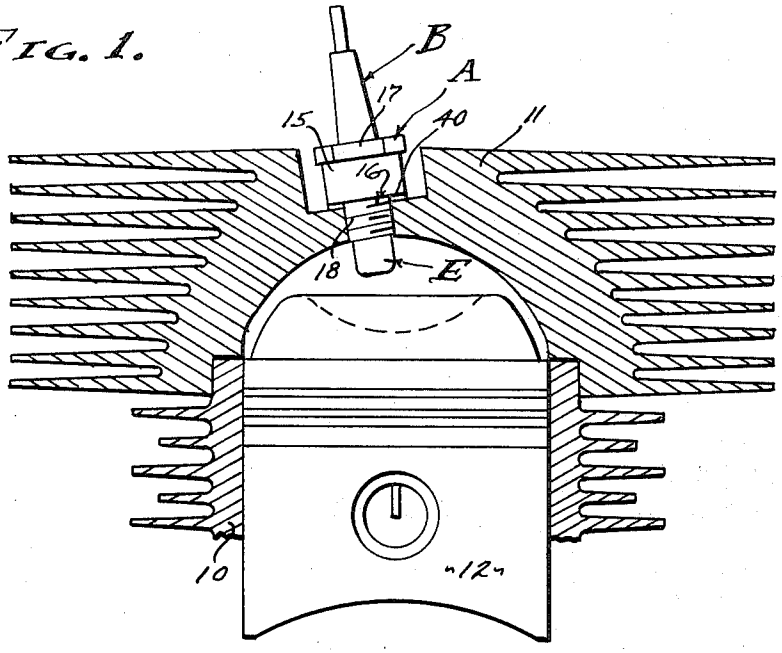


FIG. 3.

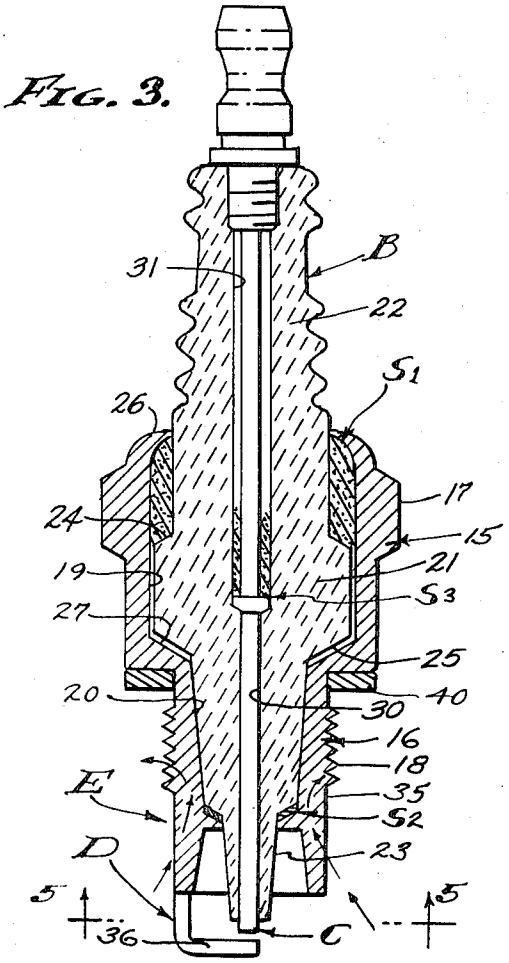


FIG. 2.

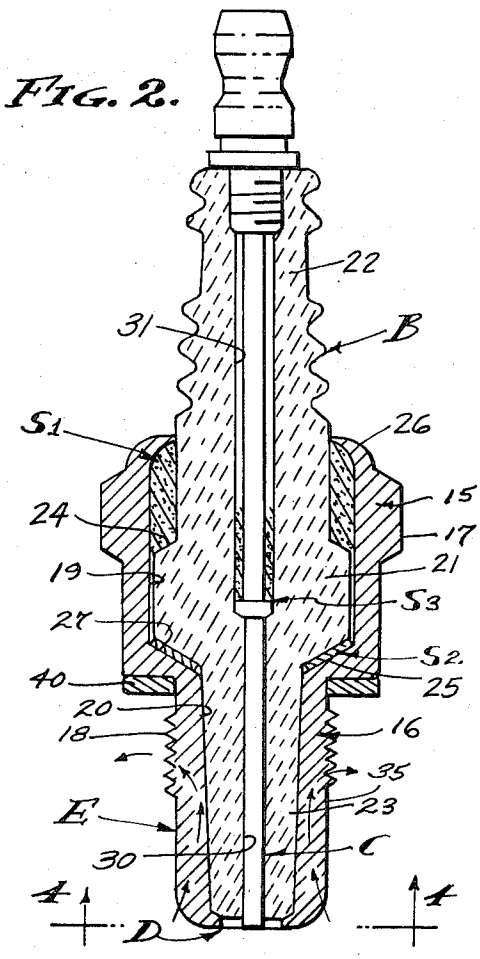


FIG. 1.

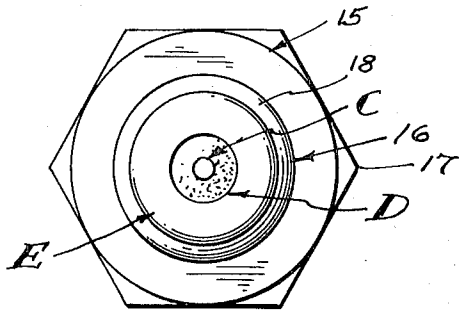


FIG. 5.

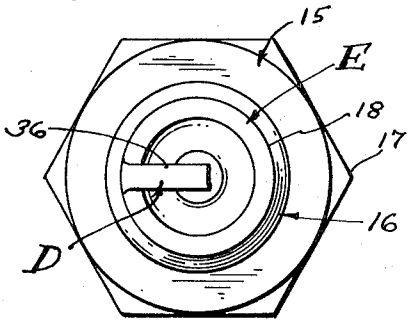


FIG. 6.

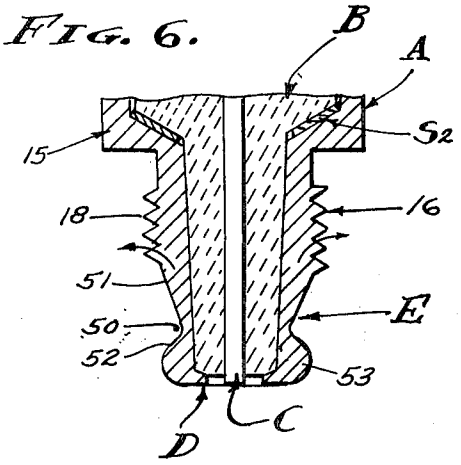


FIG. 7.

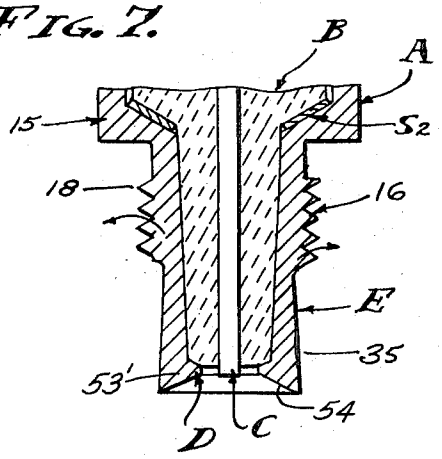


FIG. 8.

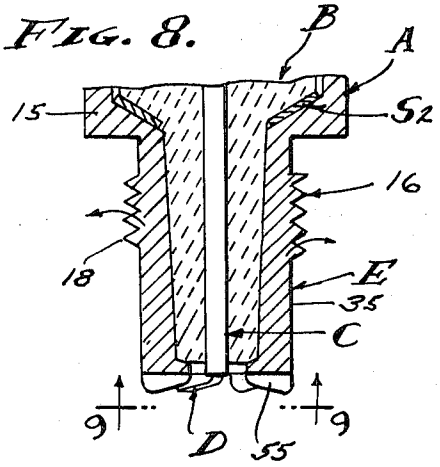


FIG. 9.

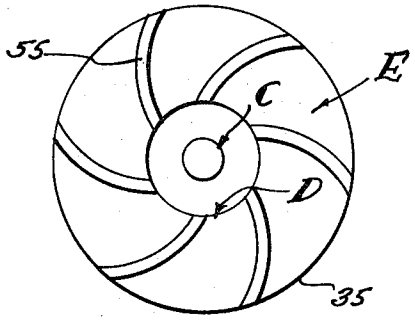


FIG. 10.

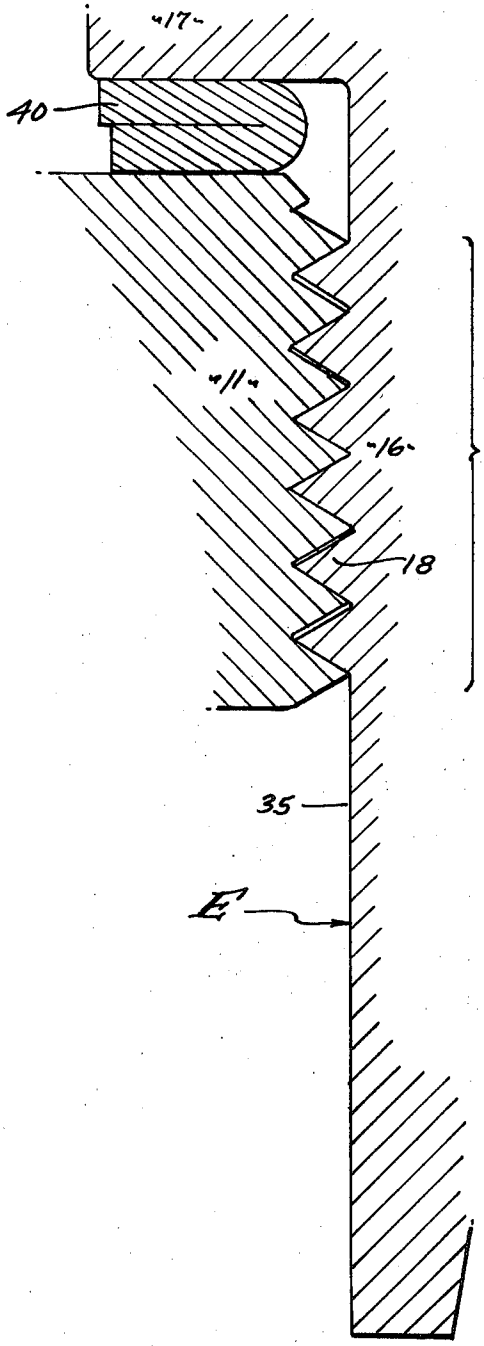
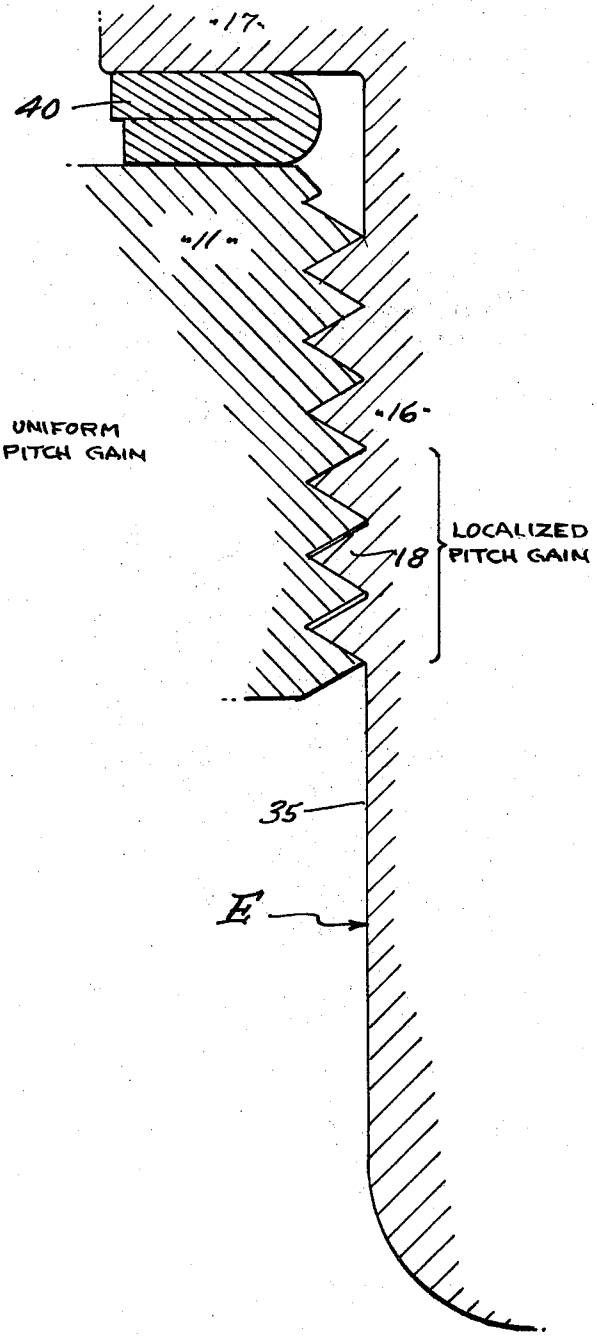

17
40
11
16
18
UNIFORM PITCH GAIN
35
E

FIG. 11.


17
40
11
16
18
LOCALIZED PITCH GAIN
35
E

BODY CONTROLLED HEAT RANGE AND EXTENDED GAP SPARK PLUG

BACKGROUND AND FIELD OF INVENTION

Efforts to provide clean running internal combustion engines, and particularly those using the Otto cycle, are met with problems related to and including combustion chamber design, valves and porting, and ignition. It is the latter which is most critical and usually accepted as being in a constant state of deterioration, due to normal operation and unpredictible variations in engine use.

Heretofore, spark plugs have been selected for their heat dissipating ability, with the expectation that they will burn "clean" without fouling. That is, the "heat range" is the controlling factor of virtually all spark plugs, and optimum engine operation is practically impossible to obtain with any one spark plug configuration. Although resort is sometimes made to increased electrical intensity and to spark plugs of radical design, those persons skilled in the art have relied exclusively upon the coil-breaker system and conventional spark plugs wherein the ceramic insulator is controlling in the determination of heat range.

The most common spark plug has a center electrode insulated from the spark plug body, and has an overlying grounded electrode. There are surface conductor spark plug designs, and it is the so-called "surface gap" spark plug which has concentric electrodes separated by an insulator. In all except the last mentioned surface gap spark plugs, the said "heat range" properties are of importance to proper engine operation, while in the latter it is definitely not. Another factor to consider is that surface gap spark plugs are recognized as useable only with the special high-voltage ignition systems and only in specified engines, and they are not used interchangeably with regular type spark plugs. Thus, the state of the art recognizes the affects of heat range and the requirements and inabilities of the wide variety of spark plug designs. And, despite the careful selection of a conventional spark plug, optimum ignition and flame propagation at all speeds is questionable.

Combustion chamber configuration is the result of head and piston design, and all of which is correlated to spark plug "reach." That is, the body of the plug which is threaded into the head is made so as to reach through the head and to position the spark gap within the combustion chamber. However, the body per se does not usually extend into the combustion chamber, and only in rare cases do the electrodes extend significantly into said chamber. For example, there are spark plugs known to have slightly extended bodies and insulator cores that project beyond the threads, but only as a convenience to project to a satisfactory ignition point at or near the head and not for the purpose of heat range control. In other words, the prior art places the spark gap near the cylinder head wall and utilizes the insulator design and/or configuration to control heat, and it is noteworthy that a ceramic insulator is a poor conductor of heat.

Same high performance, and "racing" spark plugs are made with exposed spark gaps projected somewhat into the cylinders, but nevertheless utilizing exposed ceramic insulators to control heat range, And even though the threaded bodies are sometimes extended to a slight degree, these bodies are not relied upon to control heat through the threaded connection into the heat. It is apparent that deepness of the spark gap and its projection into the cylinder is to be desired, but this advantage has been greatly restricted by the adversities encountered in dissipating heat through the ceramic insulator. In practice, over extension of the core nose in conventional spark plugs results in over heating and rapid deterioration thereof. An object of this invention is to provide for protection of the electrodes so that they can be projected to an optimum position deep within the cylinder and preferably at the "eye" of the explosive charge or at the optimum ignition point within the combustion chamber. With the present invention, it is to be understood that "reach" remains as it is in the prior art concerned with the length of the threaded portion of the body, while "extension" herein refers to the projection of the spark plug structure into the combustion chamber of the cylinder.

Heat conduction through a threaded joint is adversely affected by loose threads while it is enhanced by tight threads. It has been observed that the ordinary inner threads adjacent the combustion chamber acquire carbon deposits therebetween and which adversely affects heat transfer; while the outer threads remain clean and tight and which enhances heat transfer. Since it is a primary object of this invention to control heat range with the metallic body of the spark plug, it is also an object to provide tight threaded engagement at the innermost threads for increased effect in transferring heat away from the spark plug body. With the present invention, the leading thread convolutions are tight and preferably by means of a "pitch gain" thread localizing tightness around the body adjacent the combustion chamber.

Heretofore, the spark plug electrodes have been located at or close to the surface of the head structure and which requires a richer mixture for ignition and proper flame propagation as compared with the requirements of electrodes extended deeply into the combustion chamber. This is, extended electrodes are known to be beneficial but heretofore subject to damaging effects due to the inability of dissipating heat through the ceramic insulator. It is an object, therefore, to provide for heat controlled electrode extension and for the optimum placement thereof within the combustion chamber, and wherein the spark plug body is the instrument for dissipating heat. With the present invention, the metal of the body is selected and configured for efficient and direct heat transfer into the head structure of the engine.

Performance is of prime importance and it has been discovered that the spark plug of the present invention made in the variety of known electrode forms are most efficient. Not only are these spark plugs more responsive under prolonged pressure of strenuous engine operation but they do not tend to foul and remain clean under mild engine operations. The heat range is controlled by variations in the metal body shell whereby the electrode portions of the spark plug run sufficiently hot so as to be self-cleaning in the engine for which it has been designed and intended.

SUMMARY OF INVENTION

The spark plug herein disclosed involves, generally, the usual features which include a body or shell A and an insulator B with seals S1 and S2 therebetween. The usual center electrode C extends through the insulator with a seal S3 therebetween, and the ground electrode

D is carried by the body to oppose the electrode C. In accordance with this invention an extended nose E is provided to project from the threaded "reach" portion of the body A to expose the opposed electrodes deep within the combustion chamber, as shown. It is to be observed that the nose E is a non-threaded structural portion of the body that projects from the threaded reach portion thereof, regardless of the elongation of said reach portion; and in no case need the thread of said reach portion become exposed in the combustion chamber.

DRAWINGS

The various objects and features of this invention will be fully understood from the following detailed description of the typical preferred forms and applications thereof, throughout which description reference is made to the accompanying drawings, in which:

FIG. **1** is a sectional view through the head portion of an engine showing the installation of this spark plug. FIG. **2** is an enlarged vertical section of the spark plug shown in FIG. **1.** FIG. **3** is a view similar to FIG. **2** showing the preferred embodiment. FIGS. **4** and **5** are end views of the spark plugs as taken by lines **4—4** and **5—5** on FIGS. **2** and **3,** respectively. FIG. **6** is a fragmentary section showing a third form of invention. FIG. **7** is a fragmentary section of a fourth form of invention. FIG. **8** is a fragmentary section of a fifth form of invention. FIG. **9** is an end view taken as indicated by line **9—9** on FIG. **8.** FIGS. **10** and **11** are enlarged fragmentary sectional views of the spark plugs of FIGS. **3** and **2** respectively, showing the pitch gain threading for tightness.

PREFERRED EMBODIMENT

Referring now to the drawings, a typical combustion chamber is illustrated and which involves the cylinder **10,** head **11** and piston **12** of an engine. A refined configuration is shown wherein both the head and piston are hemispherical, and since they cooperate in opposition to each other, the chamber formed thereby is more or less spherical at maximum compression. This is but one engine configuration and is representative of the features involved in creating the "eye" of the combustible charge and/or in establishing an optimum ignition point, it being understood that the theoretical center or "eye" is not necessarily the optimum point for ignition. And, in accordance with this invention the extended nose E projects to what I term the "eye" of combustion and/or optimum ignition point, the geometric center from which flame propagation occurs.

The body or shell A is a metal structure suitably formed of material having the desired heat conductivity commensurate with the design which controls heat range. The body has three sections including a drive section **15,** a reach section **16,** and the extended nose E section. As shown, the three sections are integrally formed in the manner common to spark plug design; the drive section being cylindrical with a polygonal head **17** adapted to be turned by a wrench; the reach section **16** being of reduced diameter and externally threaded at **18** to be threadedly engaged in the head as hereinafter described; and the extended nose E section being projected from the aforementioned reach section **16** and characteristically devoid of the said threads at **18.** An upwardly disposed shoulder **27** defines the diameter reduction between the sections **15** and **16,** and in the case illustrated the body or shell A is characterized by an enlarged upper diameter body **19** and by a reduced lower diameter bore **20,** said bores **19** and **20** opening at the upper and lower extremities of the body respectively.

The insulator B is a ceramic element usually formed of aluminum-oxide having a cylindrical body **21** engaged in the bore **19** and with upwardly and downwardly projecting stem and nose portions **22** and **23.** The body **21** presents upwardly and downwardly faced shoulders **24** and **25** where the seals S1 and S2 capture and position the elements A and B relative to each other. The seal S1 is a sillment of powered material such as aluminum-silicate or sillimanite (fibrolite) that is compacted beneath an inturned flange **26** of the body A; while the seal S2 is a gasket ring supported upon shoulder **27** to engage the insulator body. The stem portion **22** projects from the bore **19** and well above the body A, while the nose portion **23** projects through the reach section **16** and into the extended nose E. An electrode bore **30** extends through the insulator B.

The center electrode C is a rod of electrically conductive material that extends through the bore **30** for exposure at the tip of the nose portion **23** and at the terminal end of stem portion **22.** The bore **30** is counterbored at **31** so as to receive and provide a shoulder to locate an enlargement positioning the said electrode.

The reach section **16** is coextensively threaded and surrounds both the insulator nose portion **23** and electrode C extending therethrough, and it carries the extended nose E which continues to surround both the insulator nose portion **23** and electrode C extending therethrough.

In accordance with the present invention, I provide the extended nose E for optimum placement of the electrodes C and D and for heat range control. The said nose is comprised of a tubular continuation of the spark plug body A and characterized by a right cylinder wall of predetermined fineness ratio. As shown, the bore **20** establishes the inner diameter wall thereof while the outer diameter wall **35** is smaller than the inner diameter of the threads at **18.** In practice, the nominal extension (longitudinal continuation) of the nose E can be equal to and in some instances greater than the longitudinal extent of the reach section **16,** thereby placing the spark gap between the electrodes at the "eye" or optimum point of ignition as circumstances require. As shown in FIG. **5,** the grounded electrode D is a finger **36** that projects outwardly and radially inward from the terminal end of nose E, to overlie the center electrode C with the spark gap exposure substantially as shown and as may be required. As shown in FIG. **4,** the grounded electrode D is the circular terminal end portion of the nose E per se, concentrically surrounding the center electrode C with the terminal end of the insulator nose **23** recessed slightly and in a normal plane extending radially therebetween.

The cylindrical wall of the extended nose E protectively encases the insulator nose **23** which electrically shields the outer electrode C except for the small normally exposed tip portion thereof. Precise positioning of the spark plug gap at the "eye" and/or optimum ignition point is determined by the longitudinal extension of the nose E beyond the reach section **16.** In practice, the longitudinal extension of nose E is provided in a series of uniform measured increments, and gaskets **40** of selectively varied thickness are employed to adjustably

position the spark gap as particular circumstances require.

In accordance with this invention, heat range is controlled by determined variation in thickness of the exposed metal of the tubular wall of nose E, by the configuration thereof, by the properties of the metals employed therein, and by the location of the contact area of the threads at **18** adjacent the combustion chamber. In carrying out this invention, it has been found to be most practical to construct ceramic insulators B of a given size, conventionally sealed at S2 as shown in a body-shell A of a given nominally thick wall in the extended nose E. The heat range is then controlled by increasing or reducing the wall thickness of the tubular nose E, so that the electrodes and immediate spark plug structure operate at the desired temperature in the engine for which it is intended.

Referring now to FIGS. **10** and **11**, and the aforesaid "pitch gain" thread, the lowermost thread convolutions at **18** and preferably two or three turns thereof next adjacent to the extended nose E are altered so as to tightly engage into the threaded bore in the engine head **11**. It is contemplated that the engine head threads remain uniform and that only the spark plug be modified in this respect, although either one or both threads can be so modified. Further, there are various ways in which to provide tight threads where specified it being preferred as shown in FIG. **11** that a localized gain in pitch be provided in the lowermost thread convolutions, or as shown in FIG. **10** that a uniform gain pitch be provided through the entire reach length. Thus, an unusually efficient and increased thread contact is provided and which assures a direct path for conducting heat into the head from the immediately dependent extended nose E of the spark plug.

Referring to the embodiment of FIG. **6**, retension of heat at the spark gap is provided for with a restriction of heat flow into and through the threaded reach portion. As shown, the lowermost end portion of the extended nose electrode is reduced at its outer diameter by means of an encompassing groove **50**, with an upwardly flared outer diameter wall **51** extending therefrom to the threaded reach portion, and with a downwardly flared outer diameter wall **52** extending therefrom to a terminal end enlargement **53**. This configuration provides for heat retension at the electrode and restricts the flow of heat as determined by the depth of the groove. Reference is made to FIG. **3** wherein heat flow is induced into the threaded reach section by means of an upwardly and inwardly tapered inner diameter wall leading to the reach section, and a continuing upwardly and outwardly tapered inner diameter wall leading therefrom to the drive section.

Referring to the embodiment of FIG. **7**, the control of flame propagation is in the shape of an electrode which is concaved at **54** for focusing the propagation of the flame front to a convergence. As shown, the uppermost end portion of the extended nose electrode is reduced in diameter where it joins to the threads **18** of the reach portion, and flares downwardly to a terminal end enlargement **53'**. It will be observed that the convex electrode of FIGS. **2** and **6** control a flame propagation that is divergent, in comparison; and it is to be understood that this spark plug can be constructed with any variation of convexity to concavity ranging between the two illustrations substantially as shown.

Referring now to the embodiment of FIGS. **8** and **9**, the control of flame propagation is in an electrode in which the flame front propagates from a ribbed surface preferably normal to the plug axis, as shown. In the broad sense, ribs **55** are extended as may be required to receive and direct the flow, the swirl, of gases. Therefore, and dependent upon combustion chamber design and characteristics, the ribs **55** are shaped to receive swirling gases and to advantageously govern the angular momentum thereof; and, for example, and as shown, by an involute curvature thereof which directs the gases into the gap (surface gap) area of the extended nose plug. FIG. **9** illustrates a typical rib configuration which has gas directing capability and heat collecting capability as well, and all of which is correlated to the heat dissipating capability of the extended nose E as hereinabove described.

From the foregoing it will be observed that the spark gap can be placed at the optimum position within the combustion chamber and provided with the desired heat range, by selecting the required nose extension and use of gaskets and by controlling the thickness and/or fineness ratio and/or configuration of the said extended nose. The extended nose of this spark plug gives up heat to the fuel droplets that impinge thereupon, converting them into vapor and further enhancing the combustibility of the fuel mixture. The ceramic insulator is no longer the determining factor for heat range, but is merely incidental in that the extended nose of the body is configured so as to run sufficiently hot so as to be self-cleaning and so as to convert the impinging fuel droplets into a true vapor. Thus, the ceramic insulator can be reduced in diameter so as to permit increased wall thickness in the extended nose which has for its primary purpose the transfer of heat into the head structure of the engine to be dissipated thereby. By providing a spark plug structure suitable for the extension of the electrodes to the "eye" or optimum ignition point, flame propagation is brought into corresponding control for providing clean running internal combustion engines.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any modifications or variations that may appear to those skilled in the art:

I claim:

1. A heat range controlling spark plug for extending the spark gap to an optimum ignition point away from the combustion chamber wall, and including; an integral heat conductive body comprised of an outer drive section and an intermediate reach section and an inner nose section, there being a bore extending through said body sections, an insulator comprised of a dielectric engageably carried in the bore with a stem portion projecting from the drive section of the body and with a nose portion projecting through the reach and nose sections of the body, there being a bore extending through said insulator body, and an electrode extending through the last mentioned bore and with an outermost terminal end exposed at the stem portion of the insulator and with another innermost end exposed at the terminal end of the nose portion of the insulator, the reach portion of the body having heat conductive threads for mounting engagement through a combustion chamber wall, and the nose section of the heat conductive body being of cylindrical tube form ex-

tended protectively over the insulator nose portion and with a predetermined fineness to length ratio determinative of heat transfer therethrough and dissipation thereof into the intermediate reach section and projecting into said combustion chamber with an electrode at its innermost terminal end opposed to the said other innermost end of the first mentioned electrode.

2. The heat range and extended gap spark plug as set forth in claim **1** wherein the cylindrical tube form of the nose section has a wall of tapered heat controlling configuration.

3. The heat range and extended gap spark plug as set forth in claim **1** wherein the nose section has a convexly shaped terminal end heat controlling configuration..

4. The heat range and extended gap spark plug as set forth in claim **1** wherein the nose section has a concavely shaped terminal end flame propagation configuration.

5. The heat range and extended gap spark plug as set forth in claim **1** wherein the diametral terminal end of the nose section is ribbed.

6. The heat range and extended gap spark plug as set forth in claim **1** wherein the nose section has radially disposed involutely curved ribs projecting from its terminal end.

7. The heat range and extended gap spark plug as set forth in claim **1** wherein the electrode at the innermost end of the inner nose section is comprised of a finger extending radially inward to oppose the said first mentioned electrode.

8. The heat range and extended gap spark plug as set forth in claim **1** wherein the electrode at the innermost end of the inner nose section is comprised of a bore therethrough spaced concentrically around the said first mentioned electrode forming an air gap therebetween.

9. The heat range and extended gap spark plug as set forth in claim **1** wherein the insulator is substantially longitudinally coextensive with the inner nose section of the heat conductive body.

10. The heat range and extended gap spark plug as set forth in claim **1** wherein the insulator is substantially longitudinally coextensive with the inner nose section of the heat conductive body, and wherein the electrode at the innermost end of the inner nose section is comprised of a finger extending radially inward to oppose the said first mentioned electrode.

11. The heat range and extended gap spark plug as set forth in claim **1** wherein the insulator is substantially longitudinally coextensive with the inner nose section of the heat conductive body, and wherein the electrode at the innermost end of the inner nose section is comprised of the bore therethrough spaced concentrically around the said first mentioned electrode.

12. A controlled heat range spark plug for extending the spark gap to an optimum ignition point away from the combustion chamber wall, and including; an integral heat conductive body comprised of an outer drive section and in intermediate reach section and an inner nose section, there being a bore extending through said body sections, an insulator comprised of a dielectric engageably carried in the bore with a stem portion projecting from the drive section of the body and with a nose portion projecting through the reach and nose sections of the body, there being a bore extending through said insulator body, and an electrode extending through the last mentioned bore and with an outermost terminal end exposed at the stem portion of the insulator and with another innermost end exposed at the terminal end of the nose portion of the insulator, the reach portion of the body having heat conductive threads for mounting engagement through a combustion chamber wall, and the nose sections of the heat conductive body being of cylindrical tube form having dimensionally predetermined inner and outer diameter walls commensurate with the fineness to length ratio determinative of heat transfer therethrough and dissipation thereof into the intermediate reach section and extended protectively over the insulator nose portion and projecting into said combustion chamber with an electrode at its innermost terminal end opposed to the said other innermost end of the first mentioned electrode.

13. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the said nose section of the heat conductive body is grooved intermediate its inner and outer extremities for restriction of heat flow.

14. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the said nose section of the heat conductive body is grooved spaced from its innermost end with a terminal end portion of the nose section remaining to retain heat and for restriction of heat flow into the said intermediate reach section.

15. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the convolutions of the heat conductive threads of the reach section and adjacent to the extended nose section of the heat conductive body are more tightly threaded through the combustion chamber wall than the remaining convolutions thereof.

16. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the convolutions of the heat conductive threads of the reach section and adjacent to the extended nose section of the heat conductive body are of greater ptich than the remaining convolutions thereof.

17. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the convolutions of the heat conductive threads of the reach section and adjacent to the extended nose section of the heat conductive body are of different pitch than the complementary threads through the combustion chamber wall.

18. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the nose section of cylindrical tube form is of enlarged configuration at its terminal end.

19. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the nose section of cylindrical tube form is of enlarged convex configuration at its terminal end.

20. The controlled heat range and extended gap spark plug as set forth in claim **12** wherein the nose section of cylindrical tube form is of enlarged concave configuration at its terminal end.

* * * * *