

Jan. 9, 1940.

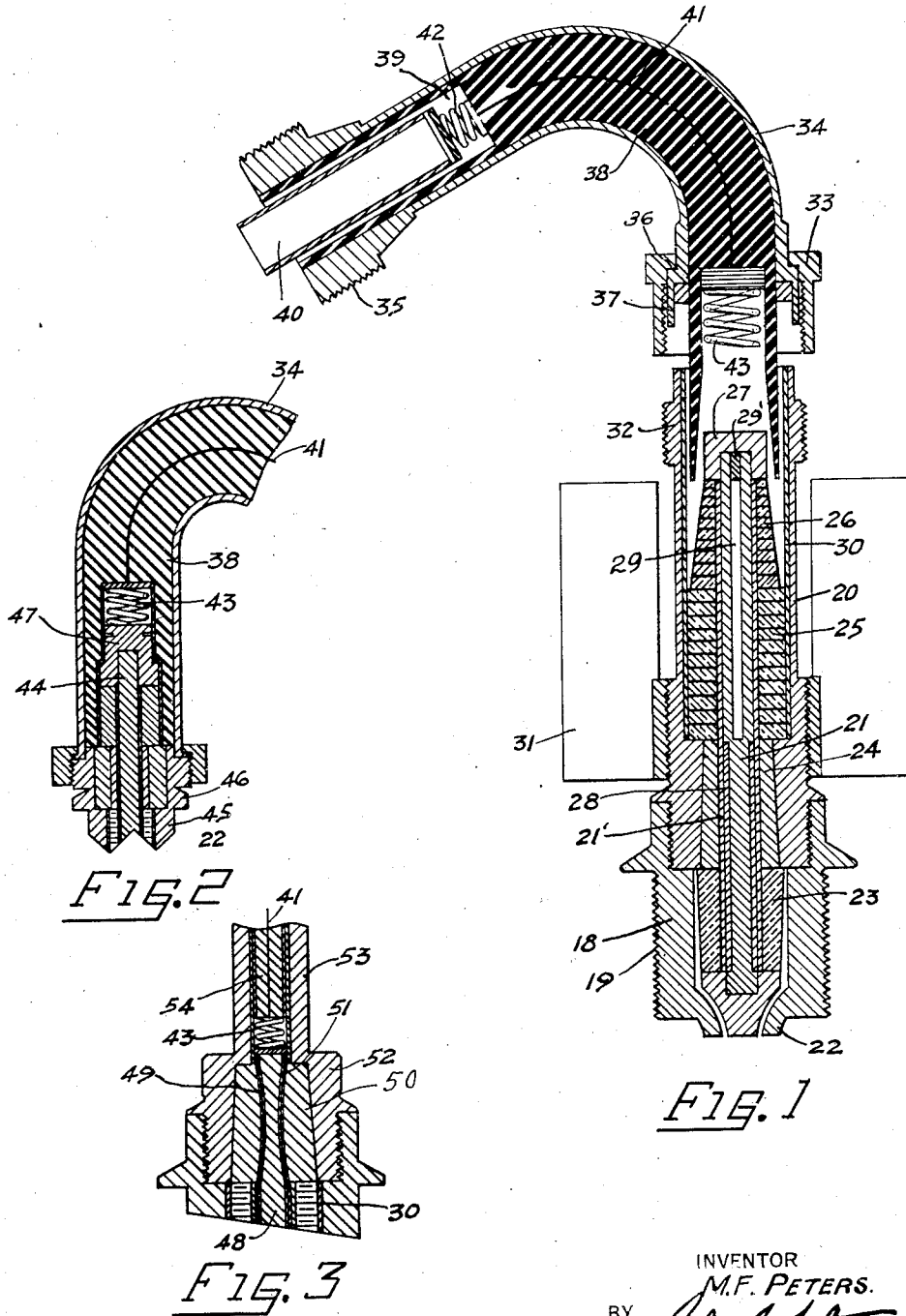
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2,186,038

THERMAL PROTECTION FOR SHIELDED IGNITION SYSTEMS

Filed Dec. 7, 1934

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

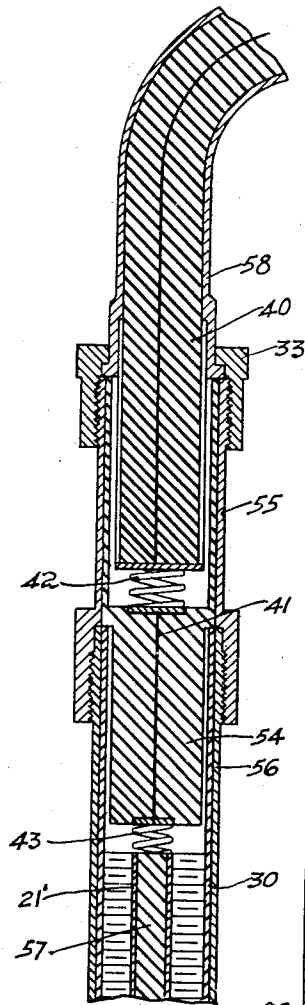


Fig. 4

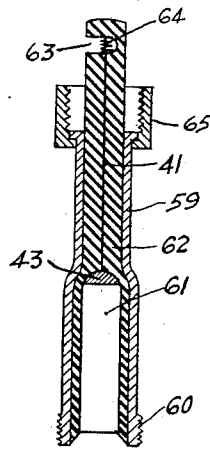


Fig. 5

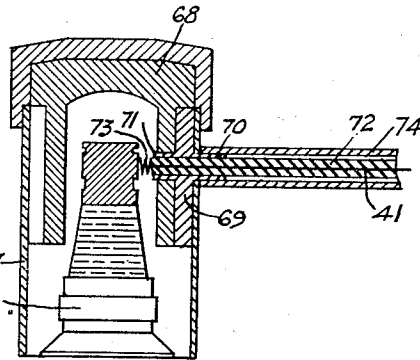


Fig. 6

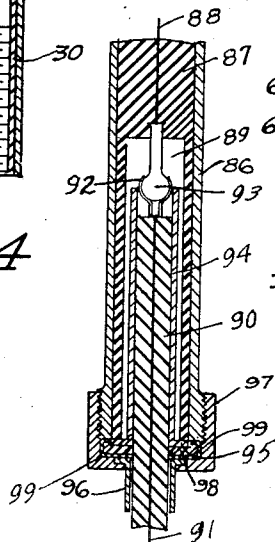


Fig. 13

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3 Sheets-Sheet 3

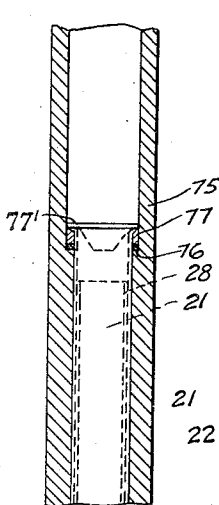


FIG. 9

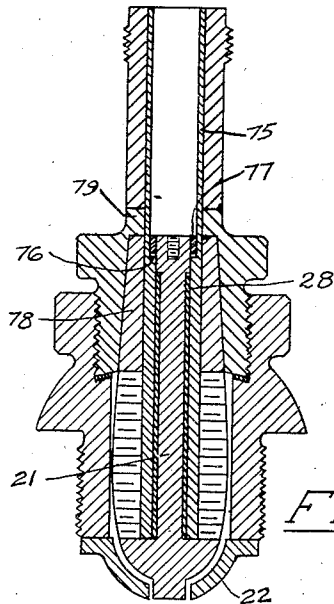


FIG. 7

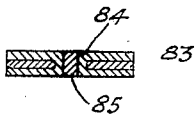


FIG. 10

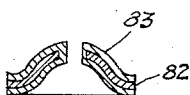


FIG. 11

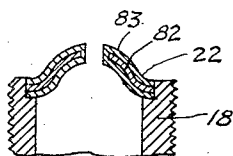


FIG. 12

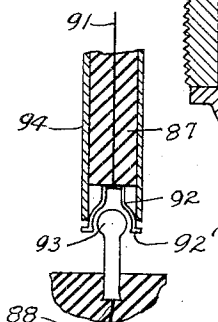


FIG. 14

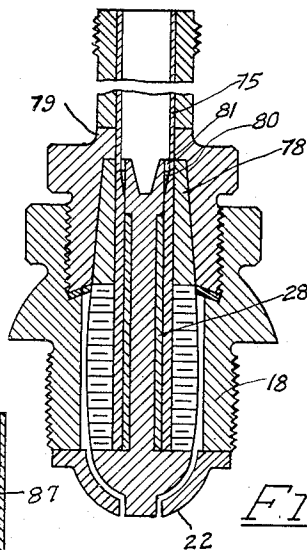


FIG. 8

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THERMAL PROTECTION FOR SHIELDED
IGNITION SYSTEMS

Melville F. Peters, Riverdale, Md.

Application December 7, 1934, Serial No. 756,431

62 Claims. (Cl. 123—169)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

This invention relates to spark plugs and has for its object the provision of means so to control the transmission and dissipation of heat from the plug to prevent the destructive heating of the insulation on the cable connected thereto and so to control the temperature of those portions of the center electrode and the insulating material thereon exposed to hot gases in the combustion chamber of an internal combustion engine as to prevent carbon fouling, preignition, and rapid wear of the sparking points of the plugs.

In the drawings:

Fig. 1 is a longitudinal section of a spark plug and means for restricting the flow of heat therefrom to the cable shielding harness, the plug being provided with cooling fins to dissipate heat;

Figs. 2, 4, 5, and 6 show different modifications of the means for preventing the transfer of excessive heat to the shielding harness of the cable;

Figs. 3, 7, and 8 illustrate certain new features in the construction of the spark plug;

Fig. 9 is an enlarged detailed view of the sealing means employed in the construction shown in Fig. 7;

Figs. 10, 11, and 12 illustrate my novel construction of the sparking points carried by the spark plug shell;

Figs. 13 and 14 illustrate devices for connecting two parts of an electrical circuit.

The use of radio on aircraft necessitates shielding the spark plugs and ignition cables of the engines of the craft to prevent the radiation of electrical disturbances that interfere with satisfactory operation of the radio. This has resulted in much difficulty from destruction of the insulation on the cables by the high temperature due to heat conducted from the spark plug by the metal shielding harness of the plug and the cable. The prevention of such destruction of the insulation is one of the principal features of my invention.

It is an elementary principle of heat conduction that if a poor thermal conductor be connected in heat transferring relation to a body having relatively high thermal conductivity, the end of the poor conductor remote from the good conductor will remain relatively cool with respect to the temperature of the good conductor. This phenomenon is the basis of some important aspects of the present invention.

Referring to Fig. 1, the shell 13 of the spark plug is externally threaded at 19 to engage the engine block and has a tubular member 20 engaged with its outer portion. It is to be understood that the terms "outer" and "inner" refer

to the parts of the spark plug with reference to their relative positions with respect to the combustion chamber of the engine. Center electrode 21 is carried by tubular member 20 and extends into the shell 13 to position its inner end in proper relation to the sparking points 22 on the shell. The so-called cigarette 21' is a mica sheath around electrode 21. Mica washers 23 are slipped over electrode 21 and are suitably held under compression by a brass ferrule 24 contracted upon the mica sheath 21' and pressed into the lower portion of tubular member 20. A second group of mica washers 25 is seated against the outer end of ferrule 24 and against these about the mica washers 26 that are tapered with outwardly diminishing cross section, the washers 25 and 26 being held under compression by a cap 27 fixed on the outer extremity of electrode 21. A sleeve 28 of copper, silver, or other metal which is a better conductor of heat than is center electrode 21, is fitted upon center electrode 21 and extends from a point adjacent the inner end of the electrode over a substantial portion of the length of the electrode, this sleeve being externally coated with chromium, nickel or other metal that is resistant to oxidation, it having been found that the leakage of gas from the combustion chamber along the electrode quickly oxidizes copper in this position unless protected as specified. If found preferable, a core of highly conductive metal may be used in the center electrode either instead of the sleeve 28 or in combination therewith. An axial bore 29 extends from the outer end of electrode 21 through a substantial portion of the length of the electrode, preferably to a point near the outer end of sleeve 28, the outer end of bore 29 being filled preferably as indicated at 29' to prevent collapse of hollow end. A cylindrical sleeve 30 of mica is placed within the tubular member 20.

Owing to the high thermal conductivity of the sleeve 28, the heat absorbed by the center electrode 21 is rapidly conducted outwardly to ferrule 24 and the lower portion of tubular member 20 whence it is transferred to the cooling fins 31 which dissipate it to the air. The diminished cross section of metal in the outer portion of the electrode, due to the bore 29, reduces the thermal conductivity of this part of the center electrode and tends to prevent conduction of large quantities of heat thereby.

It is well known that if that portion of the center electrode within the open portion of the shell, and hence exposed to the hot gases in the combustion chamber, is kept too cool, carbon

will quickly accumulate and short circuit the plug, thus preventing its proper functioning, whereas if these parts reach a temperature that is too high they will ignite the charge in the combustion chamber prematurely and cause pre-ignition. Heretofore it has been the dictum in this art that a short plug is a cool plug and a long plug is a hot plug, the length in question being that portion of the center electrode and its insulating material exposed to the hot gases as aforesaid and it has been the practice to use in engines operated at high temperatures spark plugs that are short and in engines operated at low temperatures plugs that are long, in order to secure suitable working temperatures of the center electrode. I have found that the length of the electrode within the open portion of the shell is not the sole controlling factor in this matter but that the thermal conductivity of the material used in constructing the center electrode must also be considered and that the correct relation of these factors may be expressed generally by the ratio

$$\frac{l}{\sqrt{k}}$$

wherein l is the length of the electrode and insulation exposed to the hot gases and k is the coefficient of thermal conductivity of the center electrode. Thus the length l may, within limits, be given any desired value provided k also has such value as to give their ratio the required magnitude.

It will be apparent that when the above described plug is used without shielding the poor thermal conductivity of the portion thereof beyond the shell will prevent excessive cooling of the portion exposed to the gases in the combustion chamber and thus greatly decrease the tendency to foul, while overheating of the inner portion of the center electrode is prevented by the conduction of heat to the outer end of the shell.

Connected to the threaded portion 32 adjacent the outer end of tubular member 20 by a union coupling 33 is a hollow member 34 of material that is electrically conducting but is a poor conductor of heat, which constitutes a unit in the electrical shielding, but cuts down greatly the transfer of heat to the cable shielding which is connected thereto by means of a member on the shielding harness that engages the threads 35. An example of a poor thermal conductor is nichrome but many other metals which are poor conductors and are easier to work are on the market. The union 33 seats against a shoulder 36 from which a cylindrical flange 37 extends outwardly, this flange being adapted to slip over the outer end of member 20 when in operative position. Member 34 is filled with insulating material 38 which is both electrically and thermally insulating and is formed to extend some distance beyond the end of member 34 into the member 20 around the outer end of the center electrode. In the other end of insulating material 38 is a recess or cavity 39 into which the cable 40 may be inserted. A wire 41 of nichrome or other electrically conducting material that is a poor conductor of heat, is connected to contact members 42 and 43, here shown in the form of springs, that make electrical connection with the cable 40 and the center electrode of the spark plug, respectively. It is to be understood that the configuration of member 34 may be changed to adapt it to the location in which it is to be used and it is not necessarily of the curved form shown in Fig. 1.

It may be seen that this construction embodies a portion having good heat conductivity connected in heat transferring relation to a member having poor heat conductivity and thus the shielding harness on cable 40 will receive relatively little heat from the spark plug and the insulation on the cable will be unimpaired regardless of the operating temperature of the spark plug. Actual test has proved the correctness of this. The extension of insulating material 34 into tubular member 20 very notably increases the flash over distance in this part of the assembly.

Fig. 2 shows the application of the present invention to one well known type of spark plug wherein the center electrode 44 extends beyond the tubular member 45. The member 34 is secured to the upper portion 46 of the tubular member 45 and the insulation 38 therein is recessed to receive the electrode 44 and the cap 47 thereon which contacts the member 43 that is connected to wire 41.

In Fig. 3 the center electrode 48 is reduced in cross section over a portion of its length near its outer end as shown at 49. Brass ferrule 50 is shrunk or pressed upon the electrode 48 and cigarette 51, around the said portion of reduced cross section, and thereby effects a gas-tight seal between the several parts, the ferrule being pressed into the enlarged portion 52 of hollow member 53, the cylindrical body 54 of heat and electrical insulating material being provided with a wire 41 that is connected to electrode 48 by a member 43.

In Fig. 4 the heat and electrical insulation 54 extends beyond the hollow member 55 of stainless steel or other material having like properties, into the tubular member 56 of the spark plug. Throughout the major portion of its length in the member 55 the insulating material 54 is hollowed to receive the insulated cable 40 which is connected to center electrode 57 by members 42 and 43 and the wire 41. The cable shielding harness 58 is connected to member 55 by a union 33. A form of heat insulating connection adapted for certain types of spark plugs is shown in Fig. 5 wherein the stainless steel member 59 is provided with external thread 60 to be engaged by a suitable coupling on the spark plug, the center electrode of the plug extending up into the cavity 61 in insulating material 62 to the contact member 43 which is connected to wire 41. The insulating material 62 extends beyond the outer end of member 59 and has in it a small recess 63 into which may be passed a connecting element to contact a suitable contact element 64. Coupling 65 serves to connect the assembly with the cable shielding harness.

Spark plug 66 in Fig. 6 is enclosed by an electrically conducting shield 67 in which is an electrical insulator member 68 that extends some distance inwardly past the outer end of plug 66, the member 68 and the shield 67 having aligned apertures through which the connecting element may be led to the spark plug 66. My improvement on this structure lies in placing between the shield and the insulation a member 69 that is a poor conductor of heat and is in the form of a disc with cylindrical flanges 70 and 71 projecting therefrom through the above-mentioned apertures in the insulation 68 and in the shield 67. Through the opening thus defined there is passed a cylindrical element 72 that is both thermally and electrically insulating and in which is a wire 41 of low thermal conductivity that is electrically connected to the spark plug 66 by the member 73, a hollow cylinder 74 of

stainless steel or the like being fitted over the member 72 and cylindrical flange 70.

Fig. 7 illustrates a novel method of sealing the spark plug against gas leakage. The mica cylinder 75 is so formed as to produce a shoulder 76 adjacent the outer end of center electrode 21 and the space outwardly from said shoulder, between the electrode and the mica cylinder 75, is filled with a metal that has considerable ductility when cold, such as a metal foil for which copper has been found suitable, this filling being indicated by reference character 77. The ferrule 78 is then contracted upon the mica cylinder and the electrode, either by shrinking or by pressing, and the sealing body 77 is firmly gripped and held in position. This construction is shown on a larger scale in Fig. 9. The ferrule 78 is thereafter pressed into the inner enlarged portion of tubular member 79. Another method of effecting a seal at the outer end of the center electrode is to force foil 80 between center electrode 21 and mica cylinder 75 or to impact copper therein, place a ring 81 around the outer end of the center electrode to seat against the sealing body 80 and then upset the outer end of the electrode to retain the ring and the sealing body in position, as shown at 77', Fig. 9.

Instead of pressing or shrinking a solid bushing 78 upon the center electrode and the mica cylinder therearound, it is perhaps preferable to assemble the cylinder in tubular member 79 and place a mandrel therein to hold the mica cylinder in shape, the space between the cylinder 75 and the lower portion of tubular member 79 being then filled with impacted granular metal or metal foil, while the metal or foil is either hot or cold. After the mandrel is withdrawn, center electrode 21 may be assembled therewith and fixed in position by upsetting the outer end thereof as above explained in connection with Fig. 8.

Long study has shown that the rate of wear of the sparking points 22 that are fixed to the shell 18, due to high temperature and electric discharge between these points and the center electrode, increases very rapidly as the temperature of the points rises. The life of these points 22 is greatly increased by making them with a core 82 of copper or other metal that is a good conductor of heat enclosed in a shell of the metal or alloy generally employed for such points, the copper serving to conduct the heat rapidly to shell 18 and the outer coating 83 of the more resistant material protecting the copper from excessive wear. Fig. 10 shows the preparation of the improved type of sparking points, the rod 84 of spark plug point material having the copper core 82 completely enclosed therein at each end with an intervening body 85 of the usual point material. This is then shaped as shown in Fig. 11 and cut through the portion 85, after which the points may be secured to the spark plug shell 18 in any suitable manner.

Heretofore some difficulty has been experienced in securing an efficient electrical connection between the several parts of the ignition circuit where springs such as 42 and 43, Fig. 1, or the like, have been employed. To eliminate this trouble I have devised a new means of making such connection. In Fig. 13 is shown a hollow member 86 of metal that is a poor thermal conductor having in it the heat and electrical insulation 87 with the wire 88 of low heat conductivity embedded therein, there being a recess 89 formed in the insulating material 87 to receive the cable 90. Fixed to the wire 91 in cable 90 are a plural-

ity of curved fingers 92 that are adapted to be spread apart when pushed against the bulbous terminal 93 on wire 88 to slip around and engage said terminal. To prevent casual separation of the fingers 92 from terminal 93 a sleeve 94 is slidably positioned on the cable 90 and after the fingers are engaged with the terminal this sleeve is pushed down to clamp the fingers against the terminal. At the outer end of sleeve 94 is a flange 95 that extends radially outwardly over the end of insulating material 87 and against which the shielding harness 96 is clamped by a union 97, a body 98 of asbestos, relatively soft rubber or the like, disposed in a thin metal retainer 99 being so positioned that when connection 97 is tightened down the rubber will be squeezed tightly around the cable 90 and against the adjacent end of sleeve 94 to form a tight seal and to form an electrically conducting connection, through retainer 99, between members 86 and 96. The flange 95 may be caught with the fingers or a screw driver to pull sleeve 94 outwardly when it is desired to disconnect the cable from the terminal 93. The sleeve 94 may be slit at its inner end or it may be inwardly bevelled or otherwise shaped to increase its effectiveness for the purpose stated. In Fig. 14 the fingers 92 are shown provided with outwardly turned portions 92' at their free ends. These outwardly turned portions contact the walls of recess 89 and so center the fingers 92 in proper position to engage the terminal 93.

The invention herein set forth may be made or used by or for the Government of the United States without payment of any royalties thereon or therefor.

I claim:

1. In combination, a spark plug, comprising a shell, a substantially tubular member engaged with the outer end of said shell, a center electrode mounted in said member to extend through said shell to the inner end thereof, said electrode having an external copper sleeve thereon extending from adjacent the inner end of the electrode to a point outwardly of said shell and an axial bore extending from adjacent the outer end of said sleeve to the outer end of the electrode, said sleeve being externally plated with chromium, and a member of low thermal conductivity having internal and external electrically conducting portions, said internal conducting portion being connectible to said electrode and to a cable and said external portion being connectible to said tubular member and to an electrical shielding harness on said cable.

2. In combination, a spark plug, comprising a shell, a substantially tubular member engaged with the outer end of said shell, a center electrode mounted in said member to extend through said shell to the inner end thereof, said electrode having an external sleeve of high thermal conductivity thereon extending from adjacent the inner end of the electrode and an axial bore extending from adjacent the outer end of said sleeve to the outer end of the electrode, said sleeve being of a length that is a substantial fraction of the length of said electrode and externally plated with a metal that is resistant to oxidation; and a member of low thermal conductivity having internal and external electrically conducting portions, said internal portion being connectible to said electrode and to a cable and said external portion being connectible to said tubular member and to an electrical shielding harness on said cable.

3. In combination, a spark plug, comprising a shell, a substantially tubular member engaged with the outer end of said shell, a center electrode mounted in said member to extend through said shell to the inner end thereof, said electrode having an external sleeve of high thermal conductivity thereon extending from adjacent the inner end of the electrode, said sleeve being of a length that is a substantial fraction of the length of said electrode and externally plated with a metal that is resistant to oxidation; and a member of low thermal conductivity having internal and external electrically conducting portions, said internal conducting portion being connectible to said electrode and to a cable and said external conducting portion being connectible to said tubular member and to an electrical shielding harness on a said cable.

4. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, a cylinder of mica interposed between said electrode and said member, said cylinder having a shoulder adjacent the outer end of said electrode, and a sealing body of metal that has a substantial degree of plasticity when cold forced in between said electrode and said cylinder against said shoulder, the outer end of said electrode being upset to retain said body in position.

5. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, an insulating member interposed between said electrode and said tubular member, said insulating member having a shoulder adjacent the outer end of said electrode, and a sealing body of metal that has a substantial degree of plasticity when cold forced in between said electrode and said insulating member against said shoulder, the outer end of the electrode being upset to retain said body in position.

6. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, an insulating member interposed between said electrode and said tubular member, said insulating member having a shoulder adjacent the outer end of said electrode, and a sealing body of metal, foil impacted between said electrode and said insulating member against said shoulder, the outer end of said electrode being upset to retain said body in position.

7. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, an insulating member interposed between said electrode and said tubular member, said insulating member having a shoulder adjacent the outer end of said electrode, and a sealing body of metal, foil impacted between said electrode and said insulating member against said shoulder.

8. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, an insulating member interposed between said electrode and said tubular member, said insulating member having a shoulder adjacent the outer end of said electrode, and a sealing body of copper impacted between said electrode and said insulating member against said shoulder, the outer end of said electrode being upset to retain said body in position.

9. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, an

insulating member interposed between said electrode and said tubular member, said insulating member having a shoulder adjacent the outer end of said electrode, and a sealing body of copper impacted between said electrode and said insulating member against said shoulder.

10. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, an insulating member interposed between said electrode and said tubular member, said insulating member having a shoulder adjacent the outer end of said electrode, and a sealing body between said electrode and said insulating member seated against said shoulder.

11. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, a sleeve of copper around said electrode extending over a substantial portion of the length of said electrode, said sleeve being externally coated with a metal that is resistant to oxidation, a cylinder of mica interposed between said electrode and said member, said cylinder having a shoulder adjacent the outer end of said electrode, and a sealing body of metal impacted between said electrode and said cylinder against said shoulder.

12. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, a sleeve of metal having a high heat conductivity around said electrode extending over a substantial portion of the length of said electrode, said sleeve being externally coated with a metal that is resistant to oxidation, a cylinder of mica interposed between said electrode and said member, said cylinder having a shoulder adjacent the outer end of said electrode, and a sealing body of metal impacted between said electrode and said cylinder against said shoulder.

13. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, a sleeve of metal having a high heat conductivity around said electrode extending over a substantial portion of the length of said electrode, said sleeve being externally coated with a metal that is resistant to oxidation, an insulating member interposed between said electrode and said tubular member, said insulating member having a shoulder adjacent the outer end of said electrode, and a sealing body of metal impacted between said electrode and said insulating member against said shoulder.

14. A spark plug, comprising a shell, a tubular member engaged with the outer end of said shell, a center electrode mounted in said member, a sleeve of metal having a high heat conductivity around said electrode extending over a substantial portion of the length of said electrode, said sleeve being externally coated with a metal that is resistant to oxidation, an insulating member interposed between said electrode and said tubular member, and sealing means between said electrode and said insulating member adjacent the outer end of said electrode.

15. A spark plug, comprising a shell, a center electrode mounted therein, said electrode being of diminished cross section over a portion of its length adjacent its outer end, a sheath of mica around said electrode, and a metal ferrule constricted upon said sheath and said electrode over the portion of reduced cross section.

16. A spark plug, comprising a shell, a center electrode mounted therein, a sheath of mica

around said electrode, and a metal ferrule constricted upon said sheath and said electrode over a portion of its length adjacent the outer end of the electrode.

17. A spark plug, comprising a shell, a center electrode mounted therein, said electrode being of diminished cross section over a portion of its length adjacent its outer end, a sheath of mica around said electrode, a body of insulating material around said sheath extending from the inner edge of said diminished portion to adjacent the inner end of said electrode, and a metal ferrule constricted upon said sheath and said electrode over the said portion to hold said insulating material under compression.

18. A spark plug, comprising a shell, a center electrode mounted therein, a sheath of mica around said electrode, a body of insulating material around said sheath extending from adjacent the inner end of the electrode over a substantial portion of the length of the electrode, and a metal ferrule constricted upon said sheath and said electrode adjacent the outer end of the electrode to hold said insulating material under compression.

19. A spark plug, comprising a shell, a center electrode mounted therein, a sleeve of metal having high heat conductivity around said electrode over a substantial portion of its length, said sleeve being externally coated with a metal that is resistant to oxidation, a sheath of insulating material around said electrode, said sheath having an internal shoulder adjacent the outer end of said electrode, a body of insulating material extending from adjacent the inner end of the electrode over a substantial portion of the length of the electrode, a ferrule of metal constricted upon said sheath and said electrode adjacent the outer end of the electrode and seated at one end against said body of insulating material, and a sealing element of impacted metal between said electrode and said sheath abutting against said shoulder.

20. A spark plug, comprising a shell, a center electrode mounted therein, a sheath of mica around said electrode, said sheath having an internal shoulder adjacent the outer end of said electrode, a sealing body of impacted metal between said electrode and said sheath abutting against said shoulder, and a metal ferrule constricted upon said sheath and said electrode adjacent the outer end of the latter.

21. In a spark plug, a center electrode whereof a substantial portion beginning adjacent the inner end thereof has a relatively high heat conductivity and the remainder has an abnormally low heat conductivity.

22. A spark plug, comprising a shell, a member engaged with the outer end of said shell and forming an extension thereof, a center electrode carried by said member and extending into said shell, said electrode having a portion of relatively high heat conductivity beginning adjacent the inner end of the electrode and extending well into said member and the remainder of the electrode having a very much lower capacity for heat conduction, and cooling fins carried by said member in a position to receive heat by conduction from the said high conductivity portion of the electrode.

23. A spark plug, comprising a shell, a member engaged therewith and forming an extension thereof, a center electrode carried by said member, and cooling fins lying in radial planes of said electrode carried by said member in a posi-

tion to receive heat by conduction from said electrode.

24. The combination with a spark plug, having a shell, a tubular member engaged with the outer end thereof, a center electrode carried by said member, and on said electrode adjacent its outer end a body of insulating material having an outwardly diminishing cross section, of a hollow member made of electrically conducting material of low heat conductivity, said hollow member being engageable at one end with said tubular member and at the other end with an electrical shielding harness on a cable, insulating material in said hollow member projecting from the first mentioned end thereof to extend into said tubular member around the insulating material on said electrode and at the other end provided with a cavity to receive the end of said cable, an electrically conducting wire of low heat conductivity extending longitudinally through said insulating material in the hollow member, and means at each end of said wire to form contacts with said cable and said electrode, respectively.

25. The combination with a spark plug having a shell, a tubular member engaged with said shell and having adjacent its outer end an externally threaded portion of greater diameter than adjacent parts of the member, and a center electrode assembly carried by said member that is at its outer end radially spaced from said member, of a hollow metal member of low thermal conductivity having at one end a radially extending shoulder and an outwardly extending cylindrical flange adapted to seat around the outer end of said tubular member, an internally threaded connecting element seated against said shoulder and engageable with the said threaded portion of the tubular member, electrically insulating material of low thermal conductivity in said hollow member projecting from the said one end of the hollow member to extend into said tubular member around a portion of said electrode assembly, there being in the other end of said insulating material a cavity for receiving the end of a cable, a wire of low thermal conductivity passing longitudinally through said insulating material, and means at each end of said wire to connect electrically said wire to said electrode and said cable, respectively.

26. An element of an electric circuit that includes a spark plug and an electrically shielded insulated cable, comprising an electrically conducting member of low heat conductivity securable at one end to the spark plug and at the other end to the cable shielding harness, insulating material of low heat conductivity in said member, an electrically conducting wire of low thermal conductivity enclosed in said insulating material, and means at the ends of the wire to make contacts with the center electrode of the plug and with the wire of said cable, respectively.

27. The combination with a spark plug having a tubular portion at its outer end and a center electrode extending into said tubular portion but terminating short of the outer end of said portion, of a hollow member of electrically conducting material of low thermal conductivity connectible to said portion as to the electrical shielding harness of a cable, insulating material of low thermal conductivity in said member projecting from the end of said member that is connectible to said tubular portion to extend into said tubular portion and having at its other end a cavity to receive the end of a cable, a wire of low thermal conductivity extending through

said insulating material, and means at the ends of said wire to form contacts with the wire of the said cable and with said electrode, respectively.

28. The combination with an electrically shielded spark plug and a shielded cable associated therewith, of an electrically conducting element of low thermal conductivity interposed between the shielding of the plug and the shielding of the cable, and connecting means between the center electrode of said plug and the wire of said cable, said means including a body of insulating material of low thermal conductivity and a wire passing through said insulating material, said wire being likewise of low thermal conductivity.

29. The combination with a spark plug having a center electrode, and a shielded cable associated therewith, of means having low thermal conductivity electrically connecting said plug to the shielding on the cable and means of low thermal conductivity connecting said electrode to the wire in said cable.

30. A spark plug, including a center electrode so designed and constructed that the ratio

$$\frac{l}{\sqrt{k}}$$

- has a predetermined and selected value, l being the length of the center electrode and insulating material thereon exposed to gases in the combustion chamber and k being the coefficient of thermal conductivity of the said electrode.

31. A spark plug, including a shell, and a center electrode whereof the material is so chosen and the length thereof within the open portion of the shell is so adjusted that the ratio

$$\frac{l}{\sqrt{k}}$$

- has a selected value, l being the said length of the electrode within the shell and k being the coefficient of thermal conductivity of the material of said electrode.

32. A spark plug, comprising a shell having transversely inwardly extending, heat dissipating electrode projections, each of said projections having a core of copper.

33. A spark plug, comprising a shell having transversely inwardly extending, heat dissipating electrode projections, each of said projections having a core of a substance of high thermal conductivity.

34. A spark plug, comprising a shell having transversely inwardly extending, heat dissipating electrode projections, each of said projections having an outer portion of material resistant to wear by heat and electric discharges and an inner portion of high thermal conductivity substantially coextensive in length therewith.

35. A spark plug, comprising a shell having a transversely inwardly extending, heat dissipating electrode projection, said projection having a core of material having a high thermal conductivity.

36. A spark plug, comprising a shell, having a portion engageable with an engine body, a center electrode carried thereby, the portion of said electrode within the shell having high thermal conductivity and the portion of the electrode beyond the outer end of said shell having an abnormally low thermal conductivity, and an element forming a path of high thermal conductivity from said electrode to the portion of said shell beyond said engaging portion.

37. In a spark plug, a center electrode whereof the longitudinally outer portion has a notably

lower thermal conductivity than does the inner portion thereof.

38. In a spark plug, a center electrode whereof substantially the longitudinally outer half has a notably lower thermal conductivity than does the remainder thereof.

39. In a spark plug, a center electrode whereof the outer portion in excess of one-fourth the length thereof and not substantially more than one-half said length has a notably lower thermal conductivity than does the remainder thereof.

40. The combination with a spark plug, of members having low thermal conductivity associated therewith to prevent radiation of electrical disturbances therefrom, and heat radiating fins carried by one of said members.

41. The combination with a spark plug, of members associated therewith to prevent radiation of electrical disturbances therefrom, and substantially plane heat radiating fins lying in radial planes of said spark plug carried by one of said members.

42. In a spark plug, a center electrode having an appreciably higher electrical conductivity in its inner portion than in the outer portion thereof.

43. In a spark plug, a center electrode having an appreciably higher thermal conductivity in its inner portion than in the outer portion thereof.

44. In combination with a cylinder head, a spark plug and a cable therefor, a chrome-nickel alloy shield to impede the transmission of heat from the cylinder head and the spark plug to the cable.

45. In combination with a spark plug and a cable therefor terminating at a point removed from the spark plug, an electrical conductor of low heat conductivity in electrical contact with the cable and partially bridging the distance between the spark plug and the cable and contact means to connect the spark plug and the conductor.

46. In combination with a cylinder head, a spark plug and a cable therefor, a shield of metal of low heat conductivity to impede the transmission of heat from the cylinder head and the spark plug to the cable.

47. In combination with a cylinder head, a spark plug and a cable therefor, a shield of metal of low heat conductivity disposed adjacent the spark plug to impede the transmission of heat from the cylinder head and spark plug to the cable.

48. A heat shield for spark plug cables comprising a sleeve of metal of low heat conductivity adapted to be disposed around a portion of a spark plug.

49. A spark plug radio shield having a section thereof formed of a metal of low heat conductivity to restrain the transmission of heat from the lower portion of the shield to the upper portion thereof.

50. In combination with a spark plug and a cable therefor terminating at a point removed from the spark plug, an electrical conductor of low heat conductivity connecting the spark plug and the cable.

51. In combination with a spark plug, a cable therefor and a shielding spark plug cap provided with an aperture which normally receives a cable, a rod of metal of low heat conductivity disposed in the aperture of the cap in contact with the spark plug and a cable holding means adjacent the aperture to maintain the cable in

spaced relation to the spark plug, said rod and cable being electrically connected.

52. In combination with a spark plug, a cable therefor and a shielding spark plug cap, a rod of metal of low heat conductivity disposed in the cap, a sleeve carried adjacent the cap, said sleeve being provided with a bore to receive the cable and spring means to maintain the spark plug, rod and cable in electrical contact.
53. In a spark plug shield including a dielectric cap disposed over a spark plug, a shield of metal of low heat conductivity to restrain the transmission of heat to the dielectric cap.
54. In a spark plug shield including a dielectric cap disposed over a spark plug, spark plug contact means carried by the cap, said contact means being made of metal of low heat conductivity.
55. In combination with a spark plug and a cable therefor terminating at a point removed from the spark plug, an electrical conductor of low heat conductivity in electrical contact with the cable and partially bridging the distance between the spark plug and the cable.
56. As a new article of manufacture a rod of metal of low heat conductivity and a covering of dielectric material on the rod, said rod being adapted to be disposed in the electrical circuit between a spark plug and a spark plug cable.
57. In combination with a radio shielded spark plug cable and a radio shielded spark plug cap which supports spark plug contact means, an adapter to connect the shielding of the cap and cable comprising a sleeve of dielectric material provided with a bore, a metallic coupling member on the outside of the sleeve in electrical contact with the shielding of both the cap and the cable and means to electrically connect the cable and the spark plug contact means in the cap.

58. In combination with a radio shielded spark plug cable and a radio shielded spark plug cap which supports spark plug contact means, an adapter to connect the shielding of the cap and cable comprising a sleeve of dielectric material provided with a bore, a metallic coupling member on the outside of the sleeve in electrical contact with the shielding of both the cap and the cable, and a metallic member of low heat conductivity connecting the cable and the spark plug contact means in the cap.

59. In a spark plug, a heat dissipating ground electrode consisting of a plurality of circular metallic members, the member on the inside of the assembly having higher heat conducting qualities than those on the outside.

60. In a spark plug, a heat dissipating ground electrode consisting of a laminated body circular in form and comprising a plurality of metal sheets in contact with one another, the center sheet being copper and the sheet on either side being nickel alloy.

61. A heat shield for spark plug cables comprising an electrical conductor of low heat conductivity and a covering of dielectric material on the conductor, said conductor being disposed in the electrical circuit between a spark plug and a spark plug cable.

62. A heat shield for spark plug cables comprising an electrical conductor of low heat conductivity, a covering of dielectric material on the conductor and radio shielding means surrounding the conductor and insulation, said conductor being disposed in the electrical circuit between a spark plug and a spark plug cable.

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