

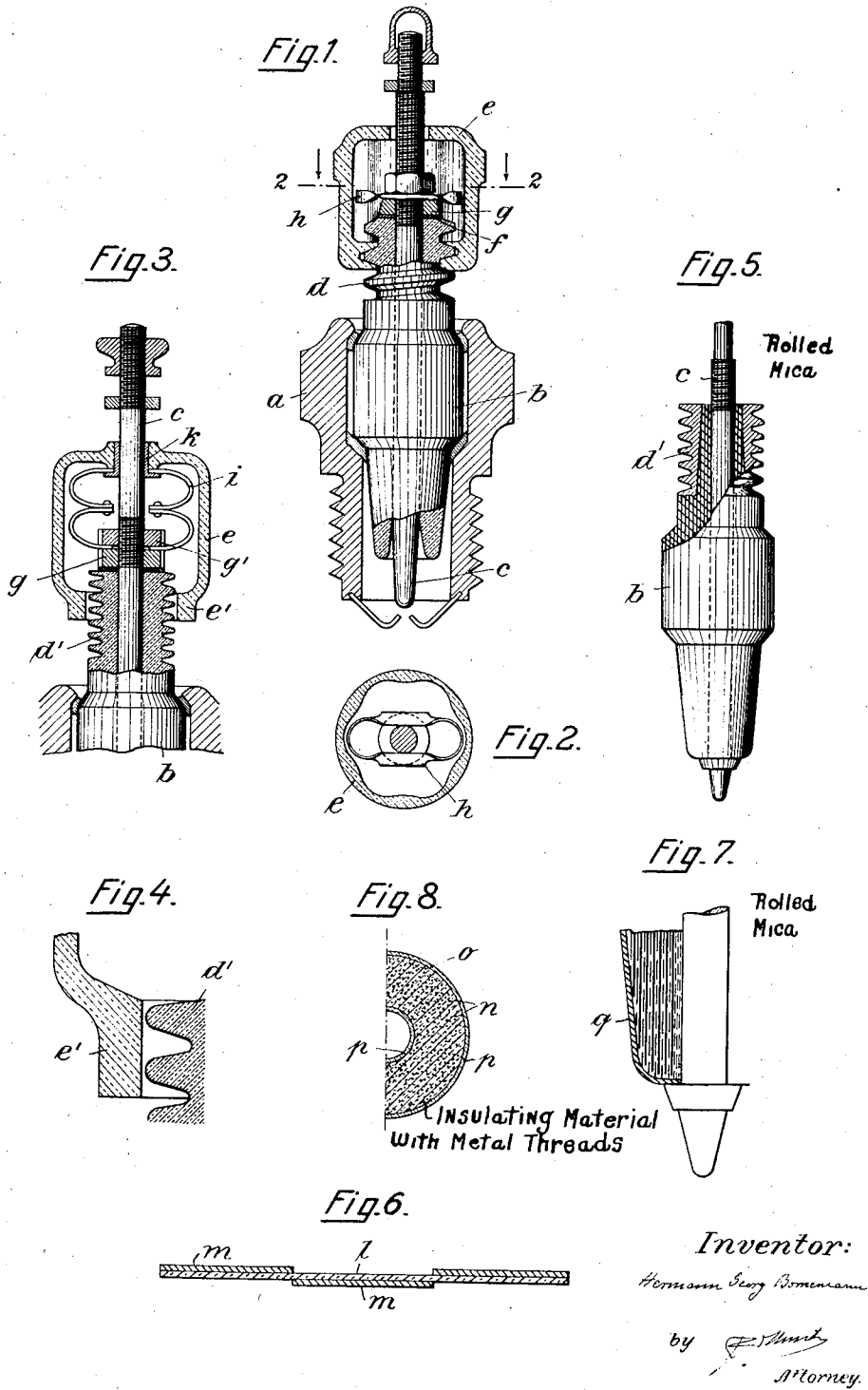
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ELECTRIC SPARK PLUG OR THE LIKE FOR INTERNAL COMBUSTION ENGINES

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ELECTRIC SPARK PLUG OR THE LIKE FOR
INTERNAL COMBUSTION ENGINESHermann Georg Bornemann, Zehlendorf-Klein
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This invention relates to an arrangement for regulating, in given cases automatically, the working temperature of electric spark plugs or electrically heated ignition tubes.

As is known, it is endeavoured to construct the electric spark plugs of internal combustion engines in such a manner that the insulating body does not exceed a certain temperature when the engine is running, because otherwise there is a danger of premature ignition. This danger will occur when the insulating body attains a temperature of approximately 600° C. On the other hand, the insulating body must not be cooled below a certain temperature because otherwise soot bridges are formed on this portion by deposits from the gases from combustion, on which bridges the voltage of the spark plug can pass from one pole to the other without attaining the object of the ignition. As a rule, it is endeavoured to maintain the insulating body at a medium temperature of 350 to 400° C. at which automatic cleaning—that is the prevention of the formation of soot bridges—is still to be expected.

The temperature of the insulating body is primarily influenced by the heat development of the engine, that is from its thermic properties and its manner of working; the tendency for the temperature to raise increases with the higher thermic properties of the engine and becomes greatest for example in the case when running under full load with supercharging. The temperature of the insulating body depends in the second place upon the construction of the spark plug, that is the possibility of absorbing heat on the one hand and giving up heat on the other hand. The lower the thermic value of the engine for which the spark plug is intended, the greater must be the heat absorbing surface (base surface) of the insulator, in order to reliably prevent jumping of the spark and to maintain the automatic cleaning temperature. If, however, the thermic value of the engine is particularly high, the foot of the insulator must be as small as possible in view of the danger of premature ignition. At the same time it is necessary to provide for an effective heat radiation in the event of increase of the influences tending to raise the temperature. This necessitates the provision of a relatively large surface on the head of the insulating body, and, in some instances, the employment of a good heat conductive material for this body. As a result, it is necessary to adapt the construction of the spark plug, especially of its insulating body, to the thermic properties of the internal combustion engine and to construct the plugs with numerous types of insulating bodies because the

spark plug of certain shape is restricted to a small range of thermic conditions. Although it is possible to meet the practical requirements of different engines in this manner by providing a sufficient number of different types of spark plugs, the known plugs are nevertheless always open to the objection that they can only approximately be chosen for a medium thermic value of the engine which, however, actually may vary within wide limits between no-load and full-load.

The object of the invention is to extend the thermic range of the spark plug so that a single type of plug can be employed for different kinds of engines. This is attained by means which enable the plug to be adjusted to the most favourable prescribed working temperature both for a high and low thermic value of the engine. Thus premature ignition by overheating in consequence of overloading of the engine and creeping caused by great drop of temperature when the engine is idling for a long time are prevented to a great extent. This effect can be improved according to a modification of the invention by an arrangement by means of which the plug is automatically adjusted to the most favourable working temperature in the event of changes in the heat conditions.

The thermic range can according to the invention be extended by making the insulating body of the spark plug of a material possessing a particularly great heat conductivity and providing its head or other radiating portion with an arrangement which enables the radiating surface to be more or less covered. The idea is that, if an insulating material is employed possessing a particularly high heat conductivity exceeding that of the known spark plugs, the heat passage to the surrounding metal mass and to the atmosphere will become so effective that the insulating body of the spark plug can be made with a relatively large base surface without its becoming too hot when fitted in a high power motor. The large insulating base also ensures a sufficient distance of insulation in the event of idle running. The large insulating base likewise reduces the danger of sooting or clogging especially when starting up. If the same plug is employed for an engine with a lower thermic value the size of the radiating surface is reduced by means of the adjustable cover, thus preventing the desired working temperature from being lowered. The head of the insulating body is preferably provided with cooling ribs of disk or helical form for the purpose of increasing the size of the radiating surface, whereas the size of this radiating surface can be varied in an

effective manner by slipping a cap more or less over the ribbed portion. In the case of automatic regulation this cap is automatically adjusted by a thermostatic element influenced by the actual heat of the insulating body.

In order to attain a particularly good heat conductivity of the insulating body it is proposed to make the same of alternate thin layers of a metal, such as aluminium, and an insulating material, such as mica, so that the heat can flow freely in the metal in the axial direction of the insulating body from the base to the radiating surface, whereas the voltage is prevented from passing from the middle electrode to the metal casing of the plug by the layers of insulating material. As the heat conductivity of aluminium is about ten times as great as that of the best ceramic material hitherto employed for insulating bodies, it is thus possible to effectively conduct the heat to the head or projecting portion of the insulator, so that by varying the radiating surface all occurring thermic conditions can be dealt with. The aluminium layers are preferably electrically oxidized on the surface, as a surface thus treated has a considerably greater ability for absorbing and radiating heat, whilst at the same time affording greater resistance against electrical piercing.

The invention also presents advantages in the case of ignition tubes for oil engines. The known tubes are generally hollow metal bodies with an insulated projecting heating coil which is maintained at glowing temperature by the heat from combustion but which must be brought to the necessary temperature by electric heating when starting up the engine. In this case the drawback also arises that one and the same plug is mostly not suitable for different thermic conditions. If the conditions for leading off the heat are such that the ignition takes place reliably at low external temperatures, there is a danger of the ignition body becoming overheated and the heating coil destroyed in the event of higher temperature conditions and when running for a long time under heavy load. This often occurs when the load is not even full-load. This drawback can likewise be overcome by providing the ignition tube with a radiating surface fitted outside the cylinder, the effect of which being adjustable by a movable cover. According to the invention a projecting head with cooling ribs of good insulating material, preferably aluminium, is provided on the plug and a cap of bad insulating material is adjustably supplied over this head, the adjustment being, if desired, effected automatically with the aid of a thermostatic member. The heat absorbing base of the ignition tube which accommodates the heating spiral may be made of pure aluminium, but it is advisable in this instance to electrically oxidize the surface to obtain a better heat absorption and chemical resistance.

Several embodiments of the invention are illustrated by way of example in the accompanying drawing in which:

Fig. 1 shows in longitudinal section a spark plug with hand adjustable cover cap,

Fig. 2 is a cross section through the upper end of the plug on line 2—2 of Fig. 1,

Fig. 3 is a part longitudinal section of a plug with automatic regulation,

Fig. 4 shows on a larger scale a portion of Fig. 3,

Fig. 5 is an elevation partly in longitudinal section of an insulating body,

Figs. 6 to 8 are details.

In the form of construction illustrated in Fig. 1 *a* designates the plug body, *b* the insulating body which may be made of ceramic material possessing a particularly high heat conductivity, and *c* the middle electrode which is cemented in the insulating body. The base and collar of the insulating body are of the usual construction, whereas the head *d* is provided with cooling ribs extending in the form of a screw thread. A cap *e* is screwed on to this screw thread and covers the head, this cap being made of material possessing a low heat conductivity such as asbestos slate, glass, porcelain or artificial resin. According to the position of the cap a greater or lesser portion of the head surface is prevented from radiating so that the heat radiation can be varied within wide limits and consequently the plug adapted to the actual thermic conditions of the engine. The middle electrode *c* is packed at its upper end against the insulating body preferably by means of a soft elastic disk *f*, for example of aluminium, which disk is held in position by a circular nut *g*. A spring *h* clamped on the nut *g* serves for securing the cap in its adjusted position. This spring consists for example of a resilient ring pressed in oval shape and bent over in its two middle portions. The loop shaped ends of this spring engage in recesses on the inner side of the cap (Fig. 2).

In the form of construction shown in Fig. 3 the head *d'* of the insulating body is provided with disk-shaped cooling ribs on which the cap *e* slides. The adjustment of the cap is effected in this instance automatically by means of a thermostatic element which regulates the working temperature of the spark plug to the prescribed value. This arrangement presents the advantage that the radiating surface is automatically varied in size when the heat conditions fluctuate. In the example illustrated in the drawing a pair of bi-metal springs is shown as regulating element. This element is secured in position on the insulating body at one end by nuts *g* and *g'*, whereas its other end is clamped to the cap *e* by means of the bent over edge of a small sleeve *k* which serves at the same time as guide for the cap. The outer edges of the cooling ribs are preferably rounded as shown in Fig. 4 so that the cap flange *e'*, bearing against at least two ribs, is guided at this point with very little friction.

In Fig. 5 an insulating body is illustrated which is made of a special material in a particular manner for increasing the heat conductivity. The main portion of the insulating body *b* is composed of alternate thin layers of a metal, preferably aluminium, and mica. The portion *d'* of the head carrying the cooling ribs is made of solid metal and slipped on to the inner portion in the manner illustrated in Fig. 5.

The layers may be produced in a simple manner by winding a mica band varying in width for the purpose of producing the final shape of the insulating body. A portion of such a band is illustrated on enlarged scale in longitudinal section in Fig. 6. The mica layers *l* may be about 1/16 mm. in thickness and on these layers aluminium strips *m* of about the same thickness are stuck or cemented transversely to the longitudinal direction of the band and mutually displaced on the two sides of the band. By this means the metal layers in the finished wound body extend continuously from one end to the other in longitudinal direction, whereas the metal

cores are interrupted and insulated from one another by the mica layers in the transverse direction. Fig. 7 shows diagrammatically a portion of the wound base of the insulating body, the mica layers being indicated by broken lines and the metal layers by full lines. The electrode pin is first surrounded by a casing composed of several mica layers. The band constructed in the manner illustrated in Fig. 6 is then wound about this casing, and the end of this band extends at an incline in order to produce the conical shape of the base portion. As can be seen from Fig. 7 the metal layers do not extend right down to the edge of the mica band in order to prevent the voltage from creeping over at this point. A further protection is effected by providing each aluminium layer with the above mentioned oxidized coating which possesses a good insulating property and at the same time improves the heat transmission. Finally the small gaps between the mica layers on the surface of the body thus wound are preferably filled with a strong insulating cement which smooths the surface. Pulverized asbestos mixed to a paste with water-glass which may also be employed for cementing the aluminium layers on the mica band has been found suitable for this purpose. If the whole mass after having been wound is heated to a temperature of 150 to 200° C. a body is formed possessing great mechanical strength and insulating properties and having an excellent heat conductivity.

The body produced in this manner is particularly suitable for the following reasons. Sintered corundum is known as the insulating material possessing the best heat conductivity. It possesses a heat conductive coefficient of about 16.8 (cals.×mtr./sq. mtr.×hr.×° C.), that is 14 times the conductive capacity of steatite. The corresponding coefficient for aluminium is 165, and for electrically oxidized aluminium slightly lower. Ignoring the relatively low conductivity of the mica which is 0.3, a heat conductive coefficient of about 80 can be reckoned for a mixed insulating material consisting approximately of 50% aluminium. This is about 5 times that of sintered corundum and 75 times that of steatite. The heat absorbed by the insulating body is therefore conducted in a very effective manner to the ribbed portion of the body, and the radiation from the surface of this portion can be increased by the above mentioned coating of electric oxide.

Fig. 8 shows a part cross section of a modified construction of the insulating body. In this instance the body is composed of fine threads *n* of metal wire embedded in an insulating material *o* such as pulverized mica mixed with a binding medium, the whole being moulded under pressure to the desired shape. The metal threads *n* may be in the form of a coiled wire netting or in the form of loose metal wool. In this latter instance the body must be inclosed on the inner and outer sides by a shell *p* of pulverized mica. It is evidently also possible to arrange a plurality of metal tubes of different diameters concentrically one within the other and to fill the gaps between these tubes with pulverized insulating material mixed with a binding medium.

In all instances it is essential that the metal inserts of the insulating body are in conductive connection with a large surface of good radiating material, for example in the form of a ribbed sleeve *d'* such as illustrated in Fig. 5.

The thin protecting layer *q* (Fig. 7) formed of the above mentioned cement like substance on

the surface of the base of the insulating body also has a particularly favourable effect. This layer formed for example of waterglass and asbestos powder possesses the property of good permeability for heat radiation, whereas it is a bad conductor of convective heat. As this thin layer is connected with good conductive metal veins uniformly distributed on its rear side the insulating body attains the necessary temperature very quickly when starting up because for this purpose only the accumulation of a relatively small quantity of heat in the coating layer is required. On the other hand the metal veins in a certain sense feel off the whole rear side of the thin layer and conduct the heat to the radiating surface at a speed increasing corresponding to the increase of temperature drop between the base and the head, and thus prevent the permissible temperature from being exceeded. This effect constitutes an extensive automatic regulation of the temperature conditions so that a relatively slight subsequent regulation by varying the radiating surface is sufficient, or this subsequent regulation may possibly even be entirely dispensed with if the thermic working range of the plug is not required to deal with all occurring working conditions.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from the said casing to form a radiating surface and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a material having high heat conductivity, and means on the projecting end of said insulating body for adjusting the exposed area of the radiating surface.

2. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from the said casing to form a radiating surface and having an axial bore, ribs on the projecting portion of said insulating body to increase the area of said radiating surface, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a material having high heat conductivity, and means on the ribbed end of said insulating body for adjusting the exposed area of the radiating surface.

3. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from the said casing to form a radiating surface and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a material having high heat conductivity, and a cap shiftable on the projecting end of said insulating body to adjust the exposed area of the radiating surface.

4. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from the said casing to form a radiating surface and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a material having high heat conductivity, means on the projecting end of said insulating body for adjusting the exposed area of the radiating surface, and a thermostatic member between the projecting end of said insulating body and said adjusting means adapted to automatically actuate said means.

5. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from the said casing to form a radiating surface and
 5 having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a material having high heat conductivity, a sleeve of a
 10 good radiating material slipped on to the projecting portion of said body, and means on said sleeve for adjusting the exposed area of the radiating surface.

6. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 15 the said casing to form a radiating surface and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a material having high heat conductivity, an aluminium sleeve having an electrically oxidized
 20 surface slipped on to the projecting portion of said body, and means on said sleeve for adjusting the exposed area of the radiating surface.

7. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from the
 25 said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of an electrically insulating mass with good conductors of heat extending therethrough and forming a continuous connection between the
 30 base and the projecting portion of the body, a large radiating surface surrounding the said projecting end and in contact with the said conductors, and means on the projecting end of said insulating body for adjusting the exposed
 35 area of the radiating surface.

8. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 40 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of metal threads embedded in a compressed substance composed of powdered insulating material
 45 with a binding medium, said metal threads forming a continuous connection between the base and the projecting portion of the body, and a large radiating surface surrounding the said
 50 projecting end and in contact with the said metal threads.

9. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 55 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of metal wool embedded in a compressed substance composed of powdered insulating material
 60 with a binding medium and being covered on its inner and outer sides by an insulating layer, said metal wool forming a continuous connection between the base and the projecting portion of the
 65 body, and a large radiating surface surrounding the said projecting end and in contact with the said metal wool.

10. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 70 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a plurality of concentrically arranged metal

inserts embedded in a compressed substance composed of powdered insulating material with a binding medium, said metal inserts forming a continuous connection between the base and the projecting portion of the body, and a metal sleeve
 5 with a ribbed surface slipped on to the said projecting portion and being in contact with the said metal inserts.

11. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 10 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of an electrically insulating mass with good conductors of heat extending therethrough and forming a continuous connection between the
 15 base and the projecting portion of the body, a large radiating surface surrounding the said projecting end and in contact with the said conductors, and a thin coating of a heat accumulating cement covering the outer surface of the base portion of the insulating body and being
 20 in contact with the said conductors of heat.

12. A spark plug, comprising in combination, a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 25 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a plurality of metal inserts embedded in a compressed substance composed of powdered insulating material with a binding medium, said
 30 metal inserts forming a continuous connection between the base and the projecting portion of the body, a metal sleeve slipped on to the said projecting portion and being in contact with the said metal inserts, and means surrounding the said metal sleeve for adjusting the exposed area
 35 of its radiating surface.

13. A spark plug, comprising in combination a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 40 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, a sleeve of a material of high heat conductivity slipped on to the projecting end and forming an enlarged radiating surface, said insulating body consisting of an electrically insulating mass with good conductors of heat extending
 45 therethrough, said conductors being separated both from the pin and from one another by the insulating mass and forming a continuous connection between the base and the said radiating sleeve.

14. A spark plug, comprising in combination a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 50 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, and an aluminium sleeve having an electrically oxidized surface slipped on to the projecting end and forming an enlarged radiating surface, said insulating body consisting of an electrically insulating mass with good conductors of heat extending
 55 therethrough, said conductors being separated both from the pin and from one another by the insulating mass and forming a continuous connection between the base and the said radiating sleeve.

15. A spark plug, comprising in combination a metal casing forming the outer electrode, an insulating body inserted in and projecting from
 60 the said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, said insulating body consisting of a plurality of concentrically arranged metal

inner electrode, a sleeve of a material of high heat conductivity slipped on to the projecting end and forming an enlarged radiating surface, said insulating body composed of a closely wound
5 band of mica having metal strips mutually displaced on its two sides, said strips being separated both from the pin and from one another by the band of mica and forming a continuous connection between the base and the said radiat-
10 ing sleeve.

16. A spark plug, comprising in combination a metal casing forming the outer electrode, an insulating body inserted in and projecting from

said casing and having an axial bore, a metal pin extending through said bore and forming the inner electrode, a sleeve of a material of high heat conductivity slipped on to the projecting end and forming an enlarged radiating surface, 5
said insulating body composed of a closely wound band of mica having aluminium strips with electrically oxidized surfaces, said strips being separated both from the pin and from one another by the band of mica and forming a continuous 10
connection between the base and the said radiating sleeve.

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