March 6, 1951 H. R. FEICHTER 2,543,962

SPARK PLUG CONSTRUCTION

Original Filed Oct. 1, 1947 4 Sheets-Sheet 1

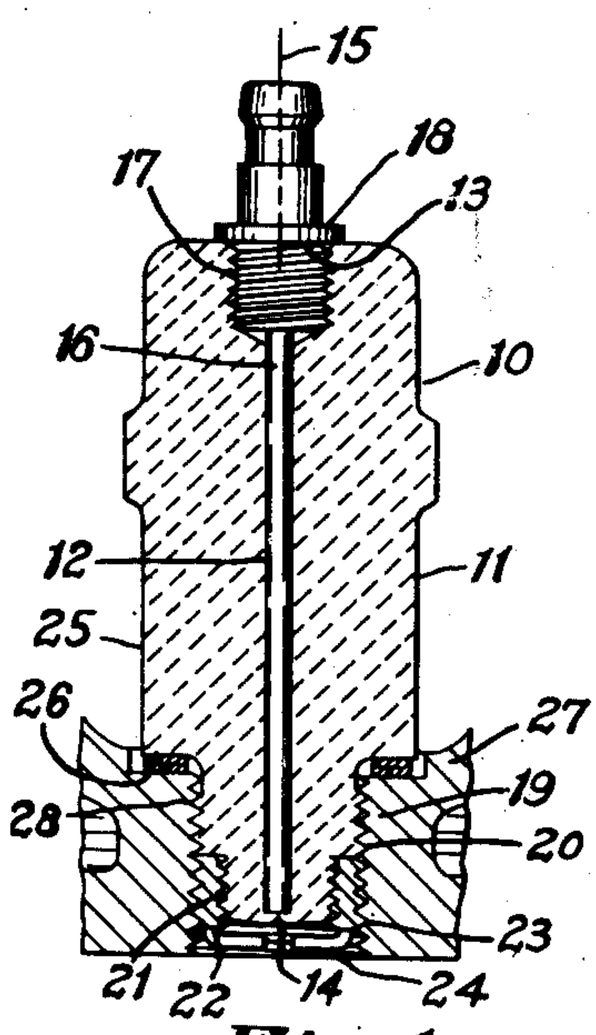

Fig. 1

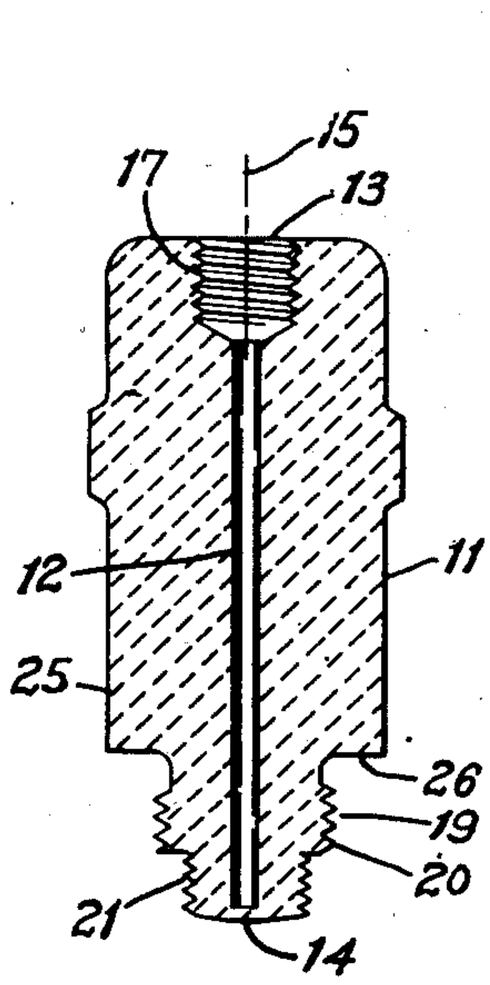

Fig. 1a

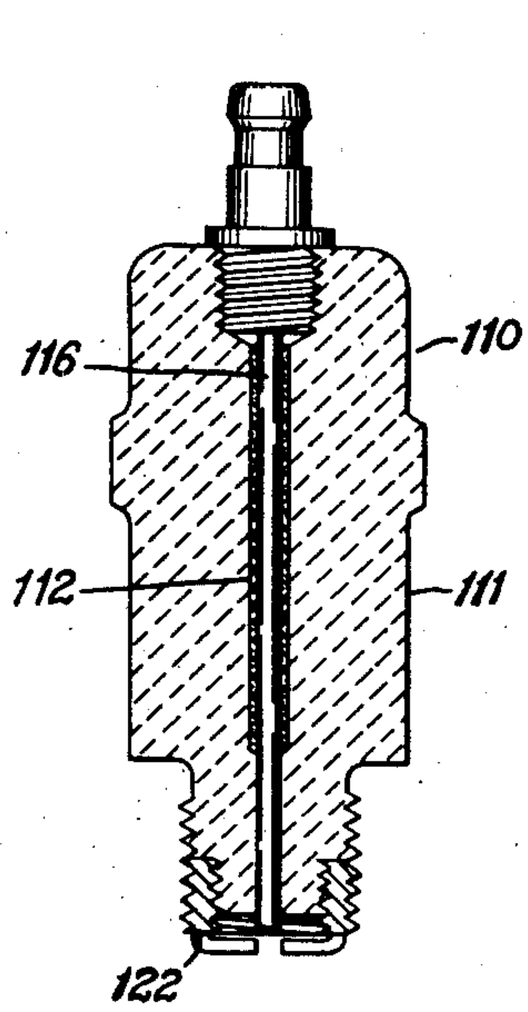

Fig. 2

Fig. 3

Fig. 4

Fig. 5

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SPARK PLUG CONSTRUCTION

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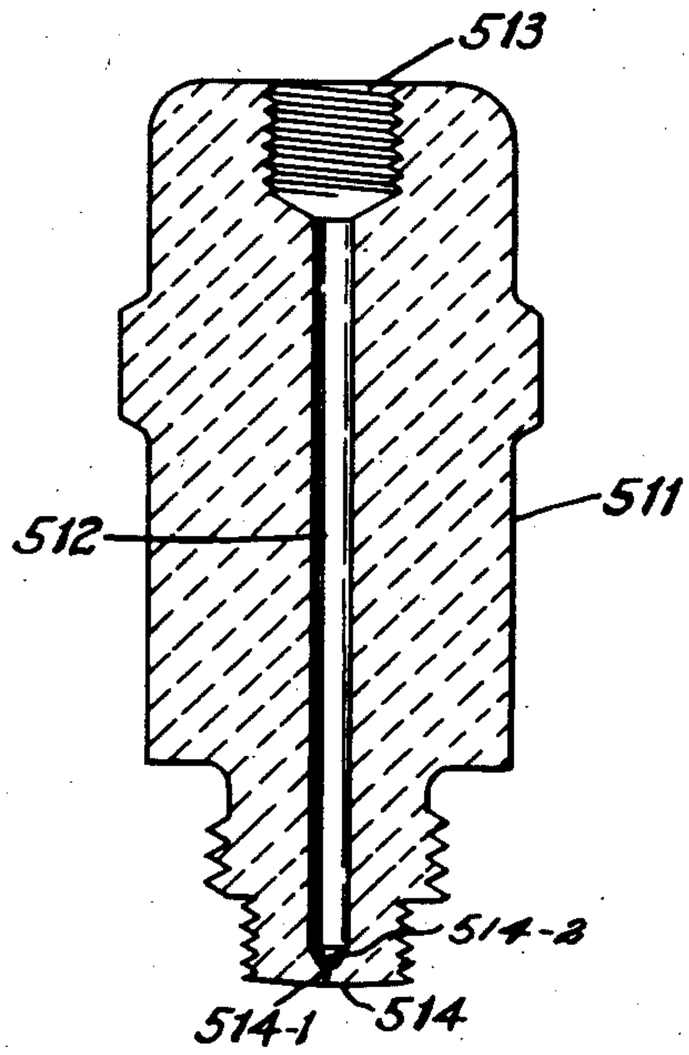

Fig. 6

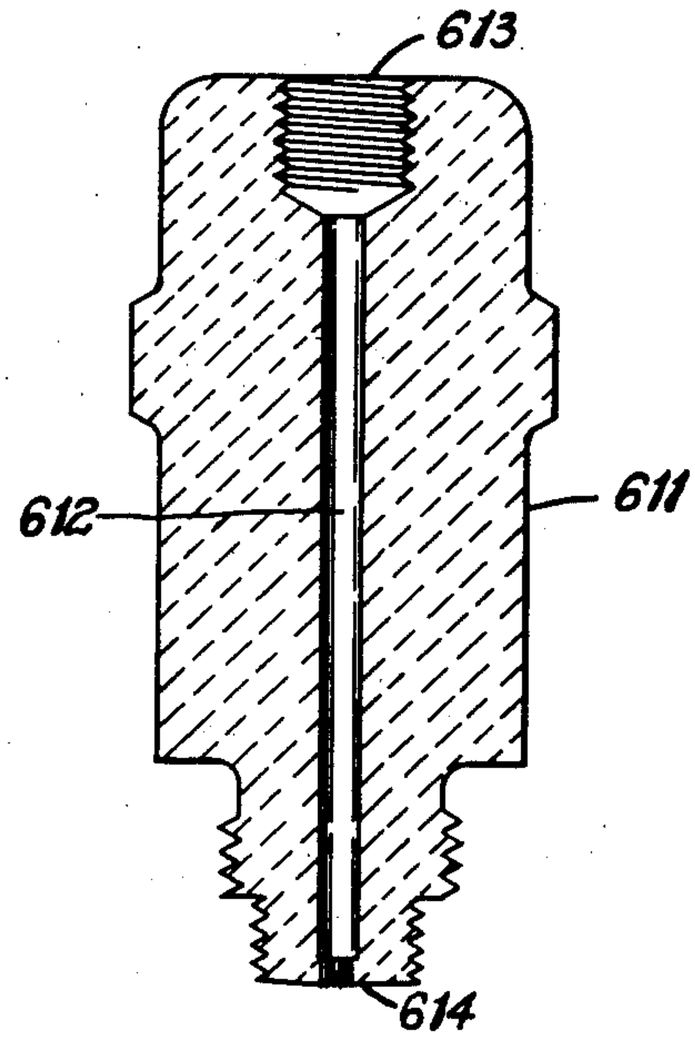

Fig. 7

Fig. 8

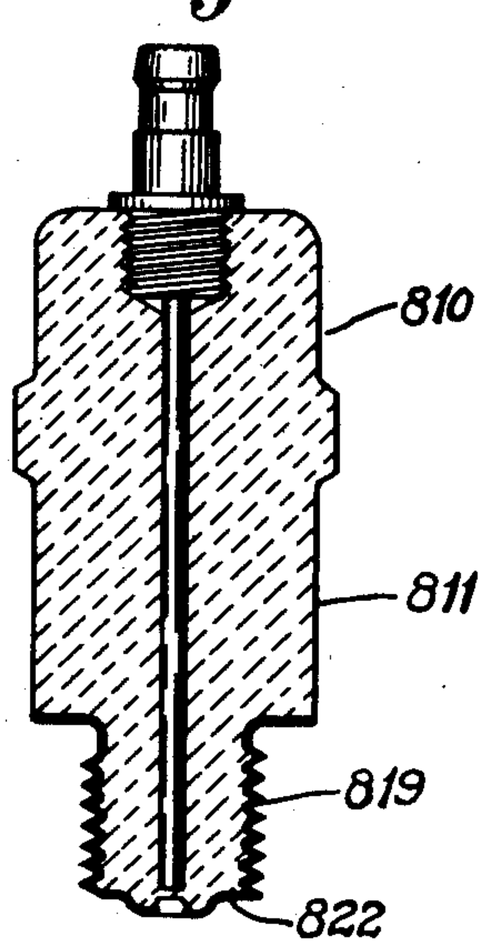

Fig. 9

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SPARK PLUG CONSTRUCTION

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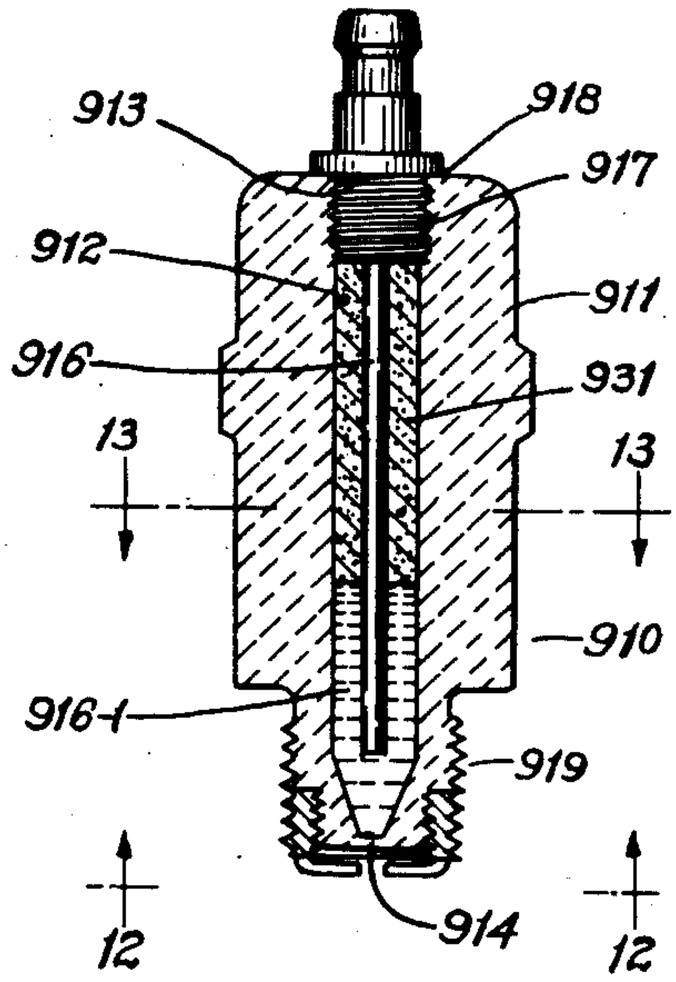

Fig.10

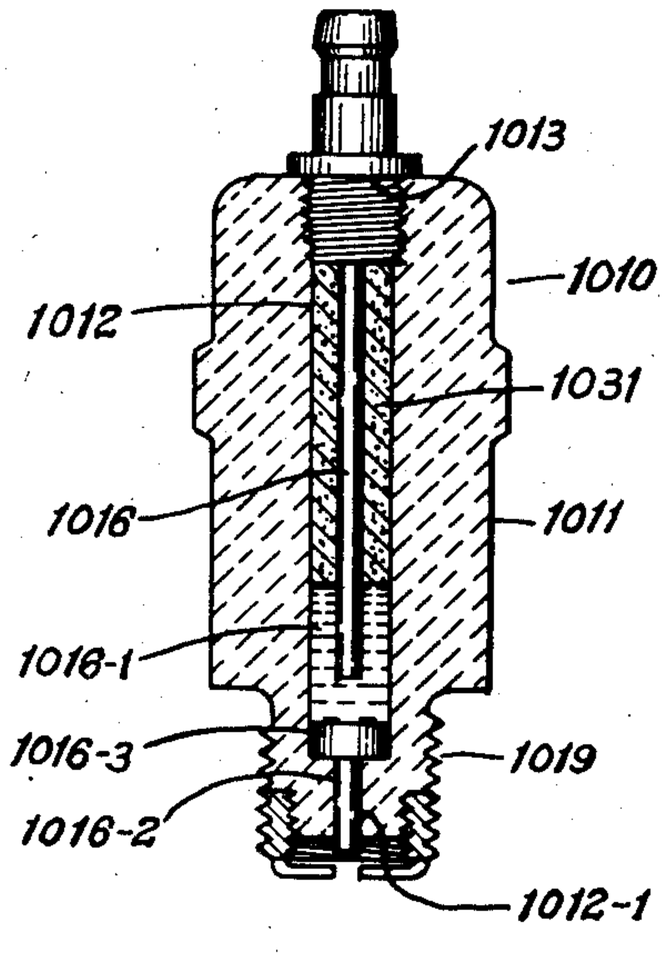

Fig.11

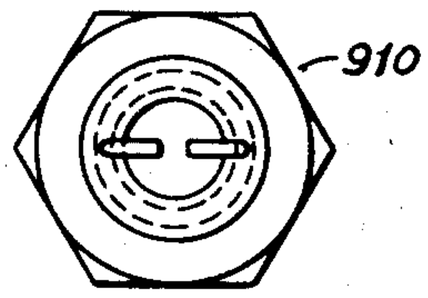

Fig.12

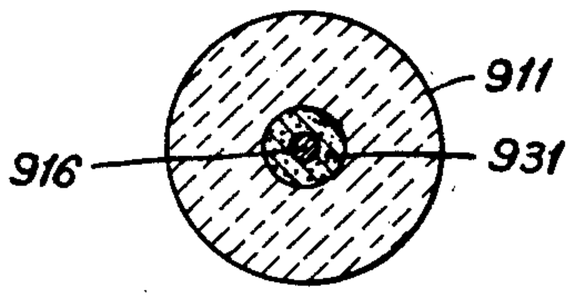

Fig.13

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SPARK PLUG CONSTRUCTION

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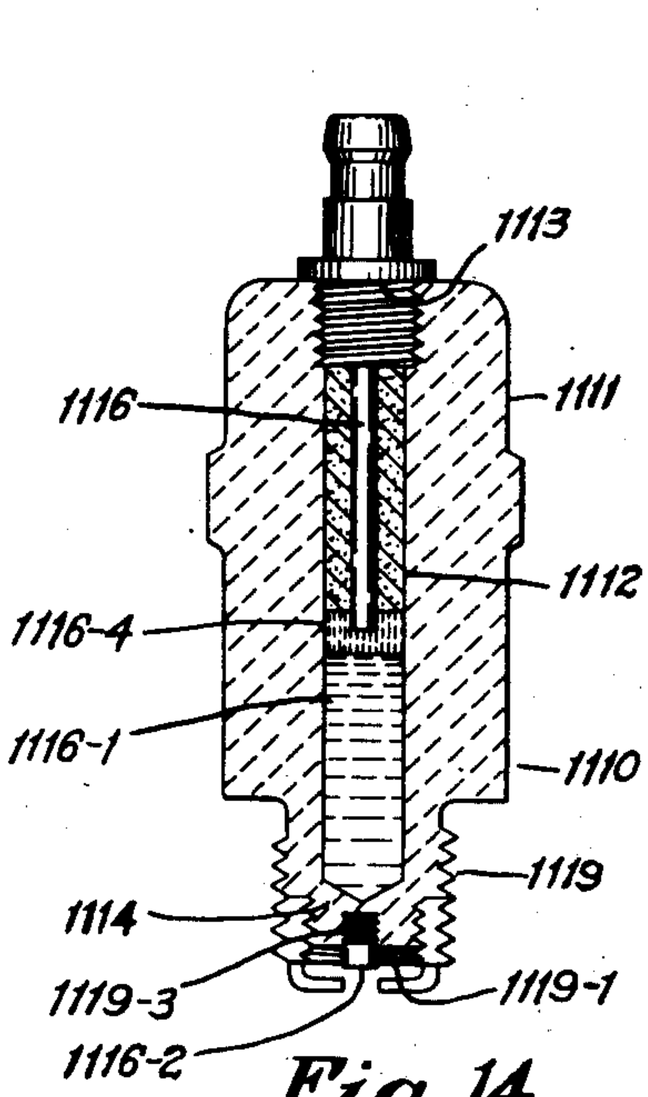

Fig. 14

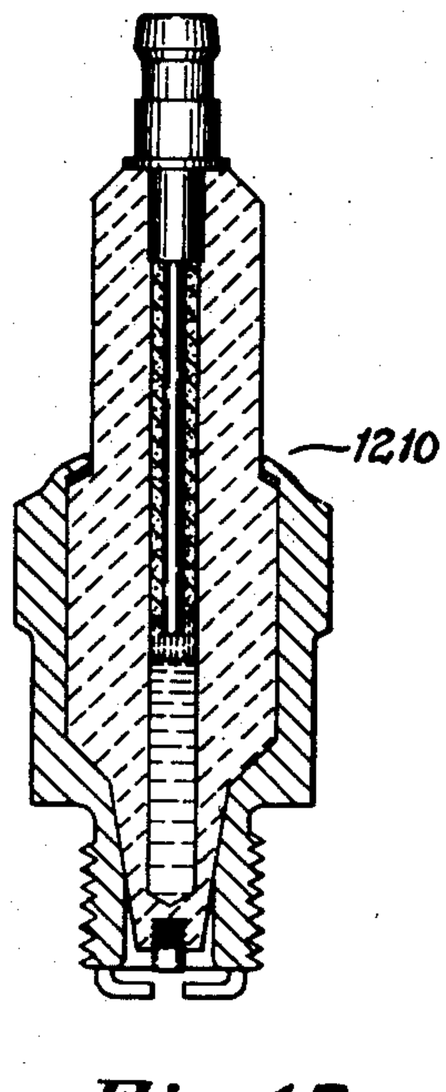

Fig. 15

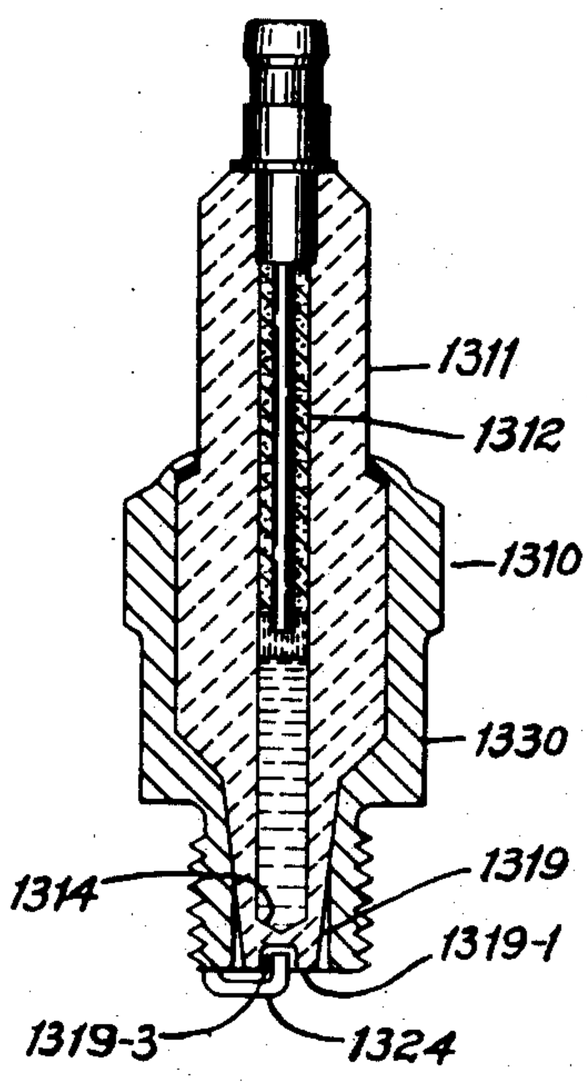

Fig. 16

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Patented Mar. 6, 1951

2,543,962

UNITED STATES PATENT OFFICE

2,543,962

SPARK PLUG CONSTRUCTION

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Original application October 1, 1947, Serial No. 777,350, now Patent No. 2,478,259, dated August 9, 1949. Divided and this application February 26, 1949, Serial No. 78,619

4 Claims. (Cl. 123—169)

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The invention relates to spark plug construction and to spark plugs for use in internal combustion engines for automobiles, aircraft, or wherever it is desired to ignite a combustible mixture, and this application is a division of my application, Serial No. 777,350, filed October 1, 1947, now U. S. Patent 2,478,259, granted August 9, 1949.

In a usual spark plug there are included a multiplicity of parts some of which are metal and which require a relatively large number of manufacturing operations for the production of the separate parts and their assembly.

In a usual spark plug there is included a metal ground shell in which a tubular insulator is inserted, and the tubular insulator has a bore extending entirely through the insulator, and a rod electrode is located in and extends through the bore of the insulator.

At the lower end of the metal ground shell there is welded or otherwise secured a ground electrode, and the lower end of the central rod electrode is spaced from the ground electrode. It is necessary to provide a gas sealing cement between the rod electrode and the bore of the insulator and it is also necessary to provide a gas tight seal between the insulator and the shell.

In other words a usual spark plug includes a multiplicity of parts which make the cost of production relatively expensive, the assembly of the parts being complicated and difficult to control to provide for a uniform finished product which does not deteriorate in use.

The objects of the present invention include the provision of an improved spark plug construction which is inherently adapted for a long period of use and which requires less metal than a usual spark plug construction, metal having become scarce as compared with ceramic material, and in which there is a reduction in the number of parts required to produce the improved spark plug on the one hand, and which provides the spark plug with substantially improved properties as compared with present spark plugs on the other hand. One of the more important of these improved properties is the minimizing of the necessity of replacing the spark plug at intervals as frequently as has been necessary prior to the present improvements.

The properties of the improved spark plugs of the present invention include freedom from gas leakage, freedom from rapid deterioration of the electrodes of the spark plug, convenient replaceability of the ground electrode, an arrangement of the reduced number of parts permitting broad scope in the design as to the size and shape of the parts of the spark plug, a relative arrangement of the size and shape of the parts of the spark plug whereby there may be a greatly increased length of the electrical leakage path between the central electrode of the plug and ground, without increasing the overall length of the plug as compared with conventional practice. A further property of one form of the improved spark plug of the present invention in addition to the foregoing is the maintaining of a constant position of the lower end of the central electrode, and the transfer of heat by convection through circulation of a conducting liquid as well as by its own conduction, from the tip of the insulator or electrode to other portions and surfaces of the insulator.

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The foregoing and other objects are attained by the spark plug construction, parts, combinations, and sub-combinations, which comprise the present invention, the nature of which is set forth in the following general statement, and preferred embodiments of which together with their mode of use are set forth by way of example in the following description, and which are particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

The nature of one preferred embodiment of the improved spark plug of the present invention may be stated in general terms as including an insulator body preferably of fired ceramic material, the insulator body having formed therein a well with an open upper end and the insulator body including a bottom wall extending across the lower end of the well. Electrode material is located in the well, and the insulator body includes a lower end having formed thereon external threads adapted for being screwed into an internally threaded opening in the wall of a combustion chamber such as the combustion chamber of an internal combustion engine. A replaceable metal ground electrode is provided on the lower end of the insulator body adjacent the bottom wall of the well.

By way of example, a number of embodiments of the improved spark plug construction of the present invention are illustrated in the accompanying drawings forming part hereof, in which

Figure 1 is a longitudinal axial sectional view of a first preferred embodiment of improved spark plug hereof;

Fig. 1*a* is a similar view of the insulator body shown in Fig. 1, before assembly in the complete spark plug;

Fig. 2 is a similar view of a second embodiment of the improved spark plug construction hereof;

Fig. 3 is a similar view of a third embodiment of the improved spark plug construction hereof;

Fig. 4 is a similar view of a fourth embodiment of the improved spark plug construction hereof;

Fig. 5 is a similar view of a fifth embodiment of the improved spark plug construction hereof;

Figs. 6, 7, and 8 are views similar to Fig. 1*a*, showing modified forms of insulator bodies for the improved spark plugs hereof;

Fig. 9 is a fragmentary view similar to Fig. 1, showing a modified form of ground electrode;

Fig. 10 is a view similar to Fig. 1 of a sixth embodiment of the improved spark plug construction hereof;

Fig. 11 is a view similar to Fig. 1 of a seventh embodiment of the improved spark plug construction hereof.

Fig. 12 is a bottom plan view of the spark plug construction of Fig. 10 looking in the direction of the arrows 12—12, Fig. 10;

Fig. 13 is a transverse cross section of the spark plug construction of Fig. 10 as on the line 13—13, Fig. 10;

Fig. 14 is a view similar to Fig. 1 of an eighth embodiment of the improved spark plug construction hereof;

Fig. 15 is a similar view of a ninth embodiment of the improved spark plug construction hereof; and

Fig. 16 is a similar view of a tenth embodiment of the improved spark plug construction hereof.

Similar numerals refer to similar parts throughout the several views.

The first preferred embodiment of the improved spark plug hereof is illustrated in Fig. 1 and is indicated generally by 10 and includes an insulator body 11 preferably made of fired ceramic material preferably having a high alumina content of upwards of 92 per cent, and also other ingredients, such as set forth in any of my U. S. Letters Patents No. 2,413,441, No. 2,414,367, No. 2,414,368, and No. 2,414,369.

The insulator body 11 is shown in Fig. 1*a* before assembly in the complete spark plug 10, and the insulator body 11 has formed therein a well 12 with an open upper end 13, and the insulator body 11 furthermore includes a bottom wall 14 extending across the lower end of the well 12. The insulator body 11 is elongated, and the well 12 extends longitudinally coaxially with the longitudinal axis 15 of the insulator body 11. Metal electrode material is located in the well 12 which may be as shown in Fig. 1 a rod 16 of metal such as steel. The upper end 17 of the well 12 may be enlarged and provided with internal threads, and the metal electrode rod 16 may have an enlarged head 18 which is externally threaded and screwed in the internally threaded enlarged upper end 17 of the well 12. The bottom wall 14 is preferably thinner than the surrounding walls of the insulator body, and in itself seals the lower end of the well 12, and covers the lower end of the electrode rod 16 therein. The bottom wall 14 preferably has a thickness between the limits of 5 thousandths and 125 thousandths of an inch. In addition, when desirable, the electrode rod 16 may be sealed in the well 12 in a usual manner as by ceramic cement.

The insulator body 11 has a reduced lower end indicated generally by 19 which includes an intermediate externally threaded portion 20 and a still smaller externally threaded extremity 21.

The spark plug 10 furthermore includes a replaceable ground electrode indicated generally by 22 which is made of metal such as steel or other hard metallic substance, and which includes an internally and externally threaded ferrule portion 23 whose internal threads are screwed on the externally threaded extremity 21 of the insulator body 11, and the external threads of the ferrule 23 match the externally threaded portion 20 of the insulator body 11. The replaceable ground electrode 22 furthermore includes one or more electrode tips or points 24 made of nickel or like material and extending inwardly from the ferrule portion 23. The insulator body 11 furthermore includes a larger upper portion 25 and an annular shoulder 26 between the inner end of the threaded portion 20 and the larger upper portions 25, which has a larger transverse cross section than the transverse cross section at any place of the reduced lower end 19.

A metal combustion chamber wall 27 which may be a wall of a combustion chamber of an internal combustion engine has formed therein an internally threaded opening 28 in which are screwed the externally threaded lower end portion 20 of the insulator body 11 and the externally threaded ferrule portion 23 of the replaceable ground electrode 22.

In using the spark plug 10 the central rod electrode 16 and the grounding metal combustion chamber wall 27 are connected in a usual ignition circuit which applies a potential to the central electrode rod 16, and from the lower end thereof contacting the well bottom wall 14 potential is applied to the bottom wall 14 until its charge is sufficient to cause a spark between the bottom wall 14 and the electrode tips 24.

In the improved spark plug 10 the upper portion 25 of the insulator body 11 may have any desired form and dimensions which are not subject to the form and dimensional limitations of a usual spark plug where the ground shell must be crimped over or otherwise fastened to an enlargement on the usual insulator body.

In the improved spark plug 10 there is freedom from gas leakage by reason of the location of the central electrode 16 in the well 12, the solid bottom wall 14 of insulating material extending across the lower end of the well 12. Thus protecting the central electrode 16 prevents rapid deterioration of the lower end of the electrode 16. When the electrode tips of the ground electrode 22 become burnt off too much, a replacement ground electrode 22 may be conveniently and easily applied to the insulator body 11. It is also to be noted that the length of the upper portion 25 of the insulator body 11 is substantial whereby there is a greatly increased length of the electrical leakage path between the upper head 18 of the central electrode 16 and the grounding combustion chamber wall 27, this increased length of the electrical leakage path being effected without increasing the overall length of the plug as compared with conventional practice in spark plug construction where ground shells are used which extend a considerable distance above the combustion chamber wall in which the spark plug is mounted.

In Fig. 2 there is shown a second embodiment of the improved spark plug hereof indicated generally by 110 and which is generally similar to the spark plug 10, but in the spark plug 110 the insulator body 111 has a bore 112 extending entirely through the body, and a center electrode 116 located in the bore 112 has its lower end protruding below the lower end of the insulator body 111. In the spark plug 110 there is also a replaceable ground electrode 122. The spark plug 110 has all the advantages of the spark plug 10 with the exception of lacking a central electrode in a well.

In Fig. 3 there is shown a generally conventional spark plug indicated generally by 210 including a ground shell 230 at the lower end of which there is screw connected a replaceable ground electrode 222 which constitutes one of the improvements of the present invention. The

ground shell 230 has mounted therein in a usual manner an insulator 211 in the central bore 212 of which there is sealed a central electrode 216 in the usual manner.

In Fig. 4 there is shown a spark plug indicated generally by 310 which is of generally conventional construction including a ground shell 330 mounting an insulator body 311 which is modified from conventional construction by including a well 312 having a bottom wall 314 extending across the lower end of the well 312, this being one of the improvements of the present invention. There is located in the well 312 a central electrode 316.

In Fig. 5 there is shown a spark plug indicated generally by 410 which is of modified conventional construction and includes a ground shell 430. One of the improved removable ground electrodes of the present invention indicated generally by 422 is screw connected to the lower end of the ground shell, and the ground shell mounts an insulator body 411 which is formed to include another of the improvements of the present invention, namely a central well 412 having a bottom wall 414 extending across its lower end. A central electrode 416 is located in the well 412.

In Fig. 6 there is shown a modified insulator body indicated generally by 511 which is generally similar to the insulator body 11, the insulator body 511 having formed therein a central well 512 having an open upper end 513 and a bottom wall 514 extending across the lower end of the well 512. Differing from the solid bottom wall 14 of the insulator body 11, the bottom wall 514 has a microscopic hole 514—1 formed therethrough by being punctured by a high tension electrical discharge passed therethrough by placing the wall 514 between electrodes of an electric circuit in which there is a sufficient potential difference between the electrodes to effect the puncturing. In Fig. 6, the microscopic hole 514—1 is necessarily magnified.

For properly locating the hole 514—1, the top face of the bottom wall 514 slopes to a central point 514—2 which insures that the puncturing high tension electrical discharge will pass through the wall 514 at the central point 514—2, the wall 514 being thinnest at that point.

In Fig. 7 there is shown another modified insulator body indicated generally by 611 which is also generally similar to the insulator body 11, the insulator body 611 having formed therein a central well 612 having an open upper end 613 and a bottom wall 614 extending across the lower end of the well 612. The bottom wall 14 of the insulator body 11 is formed entirely of insulation material, preferably fired ceramic material. The bottom wall 614 differs from this in that the bottom wall 614 has one or more fine metallic wires such as platinum extending therethrough, these wires being inserted in the bottom wall before the firing is effected, the firing serving to seal the wires in the bottom wall.

In Fig. 8 there is shown a modified insulator body indicated generally by 711 which is again generally similar to the insulator body 11, the insulator body 711 having formed therein a central well 712 having an open upper end 713 and a bottom wall 714 extending across the lower end of the well 712. Instead of being of insulation material as is the solid bottom wall 14 of the insulator 11, the bottom wall 714 includes a portion or is entirely made, as shown in the drawing, of conducting material, such as a combination of ceramic material and a metallic powder such as iron, nickel, chromium, or tungsten, sintered together.

The insulator bodies 511, 611, and 711 each includes a different means whereby a reduced potential difference is required to effect the passage of an electrical discharge or current through their respective bottom walls 514, 614, and 714, as compared with the potential difference required to effect the passage of a discharge through the solid bottom wall 14 of insulation material of the insulator body 11, where all of the bottom walls have the same thickness.

In Fig. 9 there is shown a spark plug indicated generally by 810 which is generally similar to the spark plug 10, but in the spark plug 810 the ground electrode 822 is formed by sprayed metal on the reduced lower end 819 of the insulator body 811.

It should also be noted that the replaceable ground electrode 22 on the insulator body 11 as shown preferably is screw connected with the insulator body 11. In addition to being merely screwed on the insulator body 11, the replaceable ground electrode 22 may be thermally sweated thereon.

In Figs. 10, 12, and 13 there is shown a spark plug indicated generally by 910 which is generally similar to the spark plug 10 with the exception of the construction and arrangement of the well and central electrode. The spark plug 910 includes an insulator body 911 having formed therein a central well 912 having an open upper end 913 and a bottom wall 914 extending across the lower end of the well 912. The well 912 has an increased diameter as compared with the diameter of the well 12 of the insulator body 11 of the spark plug 10.

In the lower end of the well 912 there is located a body of conducting liquid preferably liquid metal 916—1 which may be mercury or a lower melting alloy of bismuth, tin, lead, and antimony, or similar material. There is also located in the well 912 a metal electrode rod 916, the lower end of which extends into the body of liquid metal 916—1, and the metal electrode rod 916 has an enlarged head 918 which is externally threaded and screwed in the internally threaded enlarged upper end 917 of the well 912. A body of cement 931 seals the upper portions of the electrode rod 916 between the body of liquid metal 916—1 and the head 918.

In the spark plug 910 the lower body of liquid metal 916—1 and the electrode rod 916 whose lower end is immersed in the body of liquid metal 916—1 constitute a composite central electrode in which the lower end of the body of liquid metal 916—1 always rests upon the upper face of the well bottom wall 914. In other words the position of the lower end of the composite central electrode of the spark plug 910 always remains constant, where as disintegration of the lower tip of the central electrode rod 916 may take place if the lower tip of the central electrode rod 916 extends to the top surface of the well bottom wall 914, and no body of liquid metal 916—1 is used. The body of liquid metal 916—1 flows into any void produced in it on top of the well bottom wall 914.

Moreover, in the operation of an internal combustion engine, for example, in which the spark plug 910 is in use, the hot gases in the combustion chamber served by the spark plug 910 heats the lower end of the spark plug 910 and the body of liquid metal 916—1 therein causing circulation

of the liquid metal 916—1, whereby there is a transfer of heat from the lower end 919 of the insulator body 911 to upper portions and surfaces of the insulator body 911, this transfer of heat being effected by convection of the body of circulating liquid metal 916—1, as well as by its own conduction.

In Fig. 11 there is shown a spark plug indicated generally by 10—10 which is generally similar to the spark plug 910 and includes an insulator body 1011 having formed therein a central well 1012 having an open upper end 1013, and the insulator body 1011 has a lower end 1019 which has formed therein a bore 1012—1 which has a diameter reduced from that of the well 1012. An intermediate electrode shank 1016—2 is located and sealed in the bore 1012—1 and has on its upper end an enlarged head 1016—3 which fits and seals the lower end of the bore 1012. A body of conducting liquid 1016—1 is located in the lower end of the well 1012 and rests upon the top of the enlarged head 1016—3 on the intermediate electrode shank 1016—2. A metal electrode rod 1016 is located in the well 1012 and has its lower end immersed in the body of conducting liquid 1016—1, and a body of cement 1031 seals the upper portions of the electrode rod 1016.

In Fig. 14 there is shown a spark plug indicated generally by 1110 which is generally similar to the spark plug 910. The spark plug 1110 includes an insulator body 1111 having formed therein a central well 1112 having an open upper end 1113 and a bottom wall 1114 extending across the lower end of the well 1112. The insulator body 1111 has a reduced lower end 1119 having a bottom face 1119—1, and the well bottom wall 1114 is spaced above the bottom face 1119—1.

In the lower end 1119 of the insulator body 1111 there is formed an internally threaded socket 1119—3 in which is screwed an externally threaded intermediate electrode 1116—2. The wall 1114 may be provided, if desired, with one or more microscopic holes formed by puncture by an electrical discharge.

In the lower end of the well 1112 there is located a body of conducting liquid 1116—1 on top of which is a layer of powdered carbon 1116—4. There is also located in the well 1112 a metal electrode rod 1116, the lower end of which extends into the layer of powdered carbon 1116—4.

In Fig. 15 there is shown a spark plug indicated generally by 1210 which includes the improvements of the spark plug 1110 embodied in a construction which is otherwise conventional.

In Fig. 16 there is shown a spark plug indicated generally by 1310 which is generally similar to the spark plug 1210, with certain exceptions. The spark plug 1310 includes an insulator body 1311 with a bottom face 1319—1 and the insulator body 1311 has formed therein a well 1312 having a bottom wall 1314 extending across the lower end of the well 1312. The bottom wall 1314 is spaced above the bottom face 1319—1 of the insulator body 1311, and in the lower end 1319 of the insulator body 1311 there is formed a downwardly opening socket 1319—3.

The spark plug 1310 furthermore includes a metal ground shell 1330 on the lower end of which is a metal electrode tip 1324 whose outer end extends into the socket 1319—3.

The embodiments of the present invention illustrated and described herein are by way of example and the scope of the present invention is not limited to the same or to the particular details thereof but is commensurate with any and all novel subject matter contained herein which may at any time properly under the patent laws be set forth in the claims hereof or originating herein, and the elements of any such claims are intended to include their functional or structural equivalents.

I claim:

1. In spark plug construction, an insulator body having a bottom face and the insulator body having formed therein a well with an open upper end and the insulator body including a well bottom wall extending entirely across and closing the lower end of the well, the well bottom wall being spaced above the insulator body bottom face, a metal ground electrode adjacent the lower end of the insulator body, electrode material in the well, and the insulator body having formed therein a downwardly opening socket below the well bottom wall, and an intermediate electrode in the socket.

2. In spark plug construction, an insulator body having a bottom face and the insulator body having formed therein a well with an open upper end and the insulator body including a well bottom wall extending entirely across and closing the lower end of the well, the well bottom wall being spaced above the insulator body bottom face, a ground electrode adjacent the lower end of the insulator body, electrode material in the well, and the insulator body having formed therein a downwardly opening socket below the well bottom wall, and an intermediate electrode in the socket.

3. In spark plug construction, an insulator body having a bottom face and the insulator body having formed therein a well with an open upper end and the insulator body including a well bottom wall extending entirely across and closing the lower end of the well, the well bottom wall being spaced above the insulator body bottom face, a ground electrode adjacent the lower end of the insulator body, electrode material in the well, and the insulator body having formed therein a downwardly opening socket below the well bottom wall, and conducting material in the socket.

4. In spark plug construction, an insulator body having a bottom face and the insulator body having formed therein a well with an open upper end and the insulator body including a well bottom wall extending entirely across and closing the lower end of the well, the well bottom wall being spaced above the insulator body bottom face, a ground electrode adjacent the lower end of the insulator body, electrode material in the well, and the insulator body having formed therein an internally threaded downwardly opening socket below the well bottom wall, and an externally threaded intermediate electrode screwed in the socket.

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