Jan. 25, 1949. A. C. WALL 2,459,856

TRANSFORMER SPARK PLUG

Original Filed Aug. 12, 1944

Fig. 1

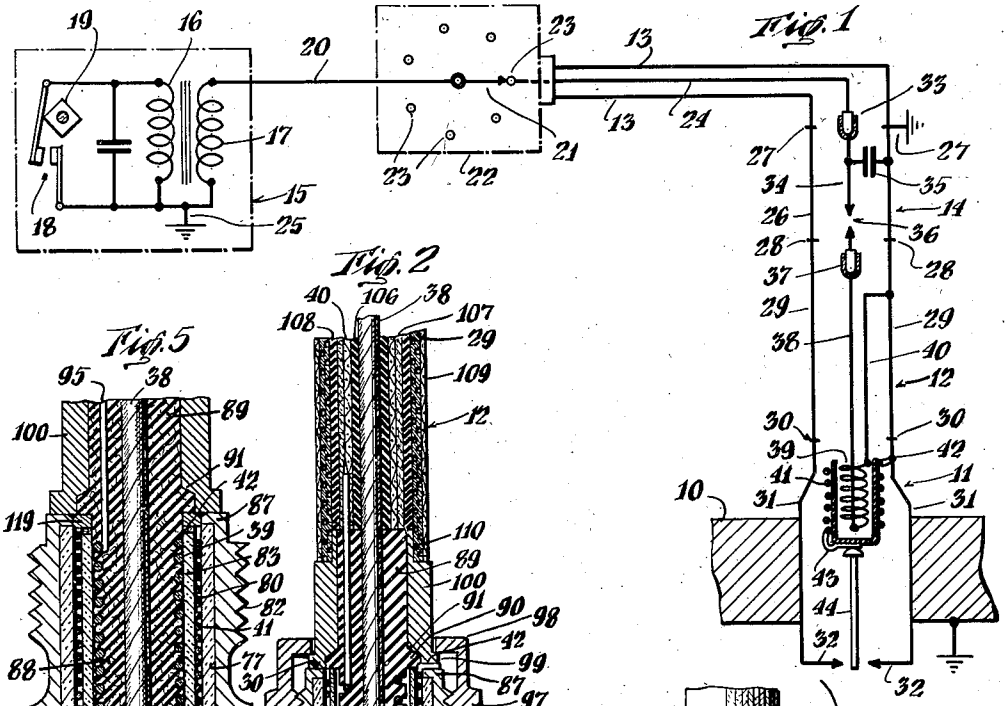


Fig. 2

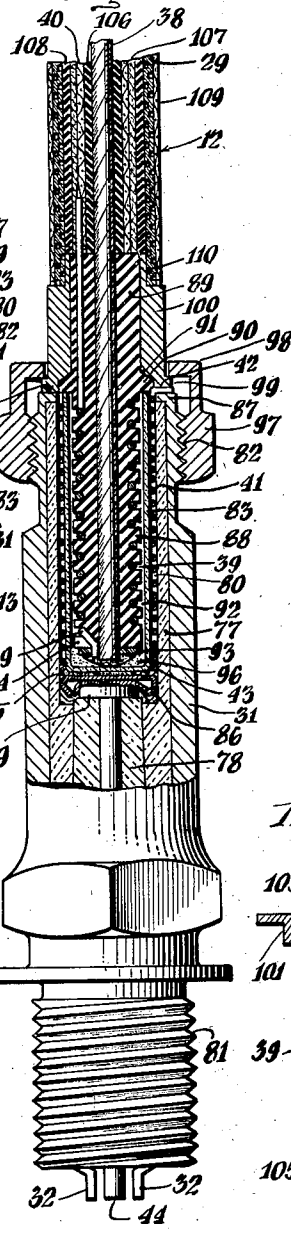


Fig. 5

Fig. 3

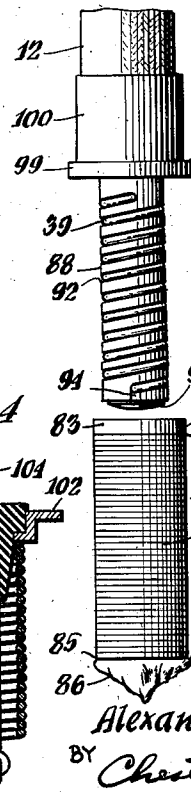


Fig. 4

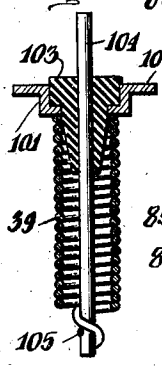
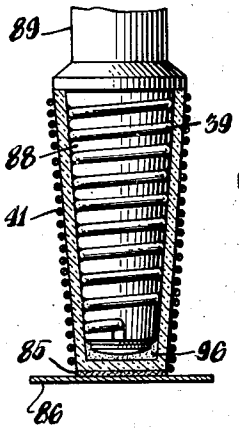


Fig. 6



INVENTOR

Alexander C. Wall

BY Chester F. Carlson

ATTORNEY

Patented Jan. 25, 1949 2,459,856

UNITED STATES PATENT OFFICE

2,459,856

TRANSFORMER SPARK PLUG

Alexander C. Wall, Indianapolis, Ind., assignor to P. R. Mallory & Co., Inc., Indianapolis, Ind., a corporation of Delaware

Original application August 12, 1944, Serial No. 549,278. Divided and this application November 16, 1945, Serial No. 629,175

10 Claims. (Cl. 315—57)

1

The present invention relates to a combination transformer and spark plug unit and particularly to such a combination unit for use in a high frequency ignition system.

This application is a division of my copending application, Serial No. 549,278 entitled "Ignition system and apparatus thereof."

A general object of the present invention is the provision of such a device which is compact and self-contained, easily constructed, sturdy, readily replaceable, accurate and efficient in operation, moisture-proof, adapted for efficient operation under widely varying conditions of use, readily utilized in conventional structures with a minimum of alteration procedures, employable in a simple manner with associated structure to complete portions of circuits of an ignition system while effectively cooperating with said associated structure to provide complete and effective shielding thereby minimizing radiation of radio interference energy, and in which the parts are so arranged and assembled as to minimize energy losses.

A more specific object of the invention is the provision of a readily replaceable transformer-spark plug assembly which is adapted for a wide variety of circuit applications where ability to withstand mechanical vibrations, high voltage stresses and high temperatures is necessary or desirable.

A still more specific object of the invention is the provision of a transformer-spark plug assembly which assures freedom from flash-over, maximum coupling efficiency, minimization of corona effect and attendant energy loss, and immunity from danger of break-down under the high temperatures of engine operation.

Other objects of the invention will be apparent from the following description and accompanying drawings taken in connection with the appended claims.

The invention accordingly comprises the features of construction, combination of elements, arrangement of parts, and methods of manufacture referred to above or which will be brought out and exemplified in the disclosure hereinafter set forth, including the illustrations in the drawings, the scope of the invention being indicated in the appended claims.

In the drawings:

Figure 1 is a schematic diagram of a typical ignition circuit for use with the transformer-spark plug unit of the present invention;

Figure 2 is a sectional view, with parts broken away, of the novel transformer-spark plug assembly associated with a portion of a high frequency ignition system;

2

Figure 3 is a detail view, having parts broken away and omitted, of the unit shown in Figure 2 with the parts in disassembled relation;

Figure 4 is a longitudinal sectional view of a modified form of the primary winding structure shown in Figures 2 and 3;

Figure 5 is a view similar to Figure 2, but with additional parts broken away and omitted, of a modified form of the structure; and

Figure 6 is an elevational view, with parts broken away and omitted and with the secondary winding structure in longitudinal section, of a modification of the structure shown in Figure 5.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

In accordance with this invention, a combination spark plug-transformer unit is provided in which the transformer is seated in a chamber formed at the upper portion of the spark plug. The high tension end of the secondary winding is originally attached to a coned foil which is pressed and flattened against the contact for the central spark plug electrode during assembly of the unit while the low tension end of the secondary is positively grounded to the spark plug casing. The primary winding is preferably mounted upon a connecting cable of a high frequency ignition system, this cable being attached and sealed to the upper portion of the spark plug in a novel manner to secure the primary winding firmly in closely coupled relation to the secondary winding and to permit impregnation of the unit to exclude air or gases from the interior thereof whereby corona effect is eliminated or substantially minimized. A glass cup formed from a suitable insulating material may be interposed between the primary and secondary windings with the base of the cup adjacent the high tension end of the secondary winding. In this manner, arcing or flash-over difficulties due to the high voltage gradient at the high tension end are eliminated without the necessity of providing an extended insulating portion projecting a substantial distance beyond the end of the transformer.

It is a feature of the invention that the casing of the spark plug effectively shields the transformer together with the associated leads and circuit components, the casing cooperating, in a novel manner, with the shielding cable and connection therefor to suppress radio noise disturbances resulting from the high frequency ignition circuits.

As pointed out in my copending application Serial No. 549,278, filed August 12, 1944, for "Ignition system and apparatus thereof," the transformer of the present invention is adapted for use in an ignition system for internal combustion engines which periodically generates pulses of electrical energy, distributes these pulses toward the spark plugs of the various cylinders, then converts the energy of the pulses to a high frequency current and finally steps up the voltage of said high frequency current for supply to the spark plug gaps thus overcoming firing difficulties caused by fouling of spark plug electrodes with carbon and oil.

Such apparatus may be incorporated in an ignition harness similar in many respects to those with which radial airplane engines are now equipped. Each engine cylinder, the wall of one of which is indicated at 10 in Figure 1, may be equipped for dual ignition and accordingly may have mounted in side walls thereof a pair of transformer spark plug units, one of which is diagrammatically indicated at 11, to each of which is connected a supply cable 12, in turn connected to an ignition manifold indicated at 13. The ignition manifold may be similar to that now used in ignition harnesses for other types of ignition systems and, as such, may be an encasing and shielding structure in which are located a plurality of supply conductors each of which is anchored to coupling means mounted on the manifold for connecting that conductor to the spark plug supply cable 12. The coupling means includes a converter unit which is diagrammatically indicated at 14 in Figure 1.

As shown in Figure 1, a typical circuit of an ignition system, in which the transformer of the present invention may be employed to advantage, may comprise a source 15 or means for generating pulses of electrical energy such, for example, as a standard magneto which may comprise a primary coil 16, a secondary coil 17 and breaker mechanism 18 including an operating cam 19. One side of the secondary coil 17 of the magneto 15 may, as shown, be connected by a conductor 20 to the rotary element 21 of a distributor unit 22, which rotary element is adapted successively to cooperate with a plurality of fixed distributor terminals 23—23. Each of a plurality of conductors 24 is connected to one of the distributor terminals 23 to form one side of a supply circuit to one of the transformer spark plug units 11. The other side of the supply circuit is provided by a grounding connection 25 for the secondary coil 17, such as through the case of the magneto 15 to the engine frame, and the manifold 13 is also grounded, preferably to the engine frame. The converter unit 14 comprises a metallic casing 26 connected to the manifold 13 at 27 and grounded thereby, the casing 26 in turn being connected at 28 to one end of a shielding sheath 29 provided for the cable 12. The other end of the shielding sheath 29 is connected at 30 to the shell or metallic casing 31 of the transformer spark plug unit 11 which is grounded to the cylinder wall 10 and, in a known manner, carries one or more spark plug electrodes 32—32.

The supply conductor 24 is connected at 33, as by a socket coupling, to a conductor 34 within the converter unit 14. A condenser 35 bridges the conductor 34 and the metallic casing 26. The conductor 34 is also connected to one electrode of spark gap means 36, the other electrode of which is connected to a circuit connector 37, which may also be a socket coupling. A cable conductor 38 is connected between the socket coupling 37 and one end of the primary winding 39 of the novel transformer, the other end of the primary being connected by a cable conductor 40 to the grounded side of the circuit, such as to the shielding sheath 29, preferably at or near the connection 28.

Corona effect tends to occur in gaseous media adjacent elements carrying current at high voltages and particularly at high altitudes where rarefaction becomes appreciable, resulting in serious power losses attended by decreased efficiency. In accordance with the present invention, this problem is efficiently overcome by excluding air or gases from the interior of the transformer-spark plug unit by saturation or impregnation with insulating compounds which will withstand the high temperatures adjacent the engine cylinders, such, for example, as a fluid polymerizing resin which will be transformed by heat into a heat-stable solid or semi-solid. Such material, if desired, may be filled with particles of refractory material such as ground glass, asbestos, mica, or the like. If the mechanical structure assures hermetic sealing of the parts within the encasing shell, heat-stable fluids known in the industry as "Dow-Corning Compound," "990-Resin," and "200 Fluid" are satisfactory for impregnating the interior of the spark plug unit.

The spark plug 11, Figures 2 and 5, is partially of conventional construction and, prior to adaptation to the disclosed ignition system, may comprise a metallic casing or shell 31 lined with a sleeve 77 of suitable insulating material, such as a heat-stable ceramic or porcelain, which cooperates with an element 78 of similar material supporting the central electrode 44, the latter being exposed at the bottom of an interior chamber 80 of the spark plug. In the conventional construction, the chamber 80 is provided for reception of a circuit connector unit which, in accordance with the present invention, is replaced by a transformer. The metallic casing or shell 31 is threaded as at 81 for insertion into a passage formed in the wall 10 of an engine cylinder and the connecting cable 12 may be detachably secured to a threaded portion 82 of the casing.

The transformer secondary winding 41 is preferably wound about the exterior of a substantially cylindrical elongated cup or vial 83 of suitable insulating material, preferably glass, having the minimum wall thickness necessary for effective insulation of the transformer windings. In this manner, close coupling is afforded between the transformer windings while still obtaining adequate insulation. For efficient operation, the distance between the primary and secondary windings should be quite small compared to the distance between the secondary winding and the metallic casing 31 of the spark plug. The vial 83 preferably is made from Pyrex glass but other glass materials such as lead glass may be employed provided thin layers thereof are capable of withstanding the high temperatures and voltages to which they are subjected in operation of the system, in which voltage stresses of the order of 2,000 to 3,000 volts per mil are common and local-

ized stresses may at times be as high as about 10,000 volts per mil.

The secondary winding 41 is arranged upon the glass cup 83 with the low tension end 42 located adjacent the rim of the cup and the high tension end 43 located adjacent the bottom of the cup. Preferably, the low tension end is anchored directly to the rim of the cup by a body or smear 84 of metallic material, such as a silver compound, which may be adhered to the glass by firing and which is preferably tinned with solder to anchor the wire. The high tension end 43 is preferably anchored to the bottom of the cup 83 by another smear 85 of similar metallic material.

In accordance with one embodiment of the invention, a terminal 43 is provided for the high tension end by soldering a piece 86 of metallic foil to the smear 85. The foil, before soldering, may be a disc having a diameter approximately twice as great as that of the vial. After the foil is soldered, the disc is coned or drawn out to a peak as shown in Figure 3 so as to readily fit into the chamber 80 together with the secondary winding. When the secondary assembly is forced into chamber 80, the foil cone 86 is wadded against the electrode terminal 79 and adapts itself to the contour of the adjacent structure to assure good electrical connection and effective mechanical support. It is to be understood that other means may, if desired, be employed to afford a terminal for the secondary winding. For example, a small helical spring may be compressed between the smear 85 and the electrode terminal 79 to provide effective electrical connection and a resilient mechanical support.

When the transformer secondary assembly is mounted in the chamber 80, a low tension terminal or pigtail 42 may be held in contact with the edge 87 of casing 31 by the connecting cable 12. Alternatively, the transformer secondary assembly may be permanently mounted within the chamber 80 by a soldered connection between the low tension terminal at 42 and the edge 87, or by a body of solder bridging the spark plug casing and the smear 84, or by any other suitable anchoring means that may readily occur to one skilled in the art.

The primary winding 39 is adapted to be received in the glass cup 83 in closely coupled relation to the secondary winding 41. This primary winding may comprise an elongated substantially cylindrical sleeve or core 88, Figures 2 and 3, which has an axial bore for receiving an end of the conductor 38, together with a base portion 89, a flange 90 providing a shoulder 91, and a helical groove 92 in which the wire of the primary winding 39 is received and seated. Any insulating materials may be used for the core which will withstand the high temperatures encountered at the spark plugs without gassing, such, for example, glass, Micalex or Bakelite after treatment for about twenty-four hours at a temperature of about 150° C.

The conductor 38 may be anchored in the core 88 by an end plate or washer 93 and connected to the adjacent end of the primary winding 39. For this purpose, the end of the primary winding may be drawn through a slot 94 in the core 88 and soldered to conductor 38 at the time the washer 93 is soldered thereto for anchorage. The other end 95 of the primary 39 may extend through a passage in the base portion 89 to serve as a terminal for connection to the conductor 40.

As previously pointed out, the transformer structure is thoroughly impregnated, after assembly, with a suitable insulating compound to avoid corona effect and attendant energy loss. A body of such impregnating compound is indicated at 96. The transformer windings may be held within the chamber 80 in the spark plug casing 31 by an internally threaded sleeve nut 97 which engages the threaded portion 82. The nut 97 may have a flange 98 which is seated on a flange 99 formed on a sleeve 100, an internal shoulder in the sleeve 100 bearing against the core shoulder 91. The outer edge of the sleeve 100 is thus held in contact with the edge 87 of the spark plug casing 31 to clamp, if desired, the secondary terminal at 42 therebetween and to afford a good electrical connection between the casing and the sleeve as at 30.

From the foregoing description, it will be appreciated that a small compact transformer-spark plug unit is obtained which is effectively shielded by the casing 31 together with the shielded end portions of the cable 12 including the nut 97 and sleeve 100 whereby radio noise disturbances arising from the high frequency circuits are suppressed or eliminated. This mounting also eliminates long leads between the transformer secondary and the adjacent electrodes whereby energy losses are avoided. The transformer assembly of a typical embodiment of the invention is in overall dimensions about one inch long and about three-eighths of an inch in diameter and has a turn-ratio of the order of 15 to 20:1 with the secondary winding having about 400 turns of very fine wire. In conventional transformers where voltage stresses on the insulation separating the primary winding from the secondary winding run as high as 2,000 to 3,000 volts per mil, and may in the case of localized stresses run possibly as high as 10,000 volts per mil, there is a serious possibility of flash-over between the primary winding, which is substantially at ground potential, and the high tension end of the secondary winding if mere sleeve separating insulation is used. The use of the closed-bottom glass cup 83 in this invention avoids the necessity of providing a long flash-over path, as by extending a separating tube or sleeve far beyond the high tension end of the secondary winding. The relatively thin-walled glass cup or vial element of the novel transformer effectively eliminates flash-over while assuring a structure of minimum dimensions that is capable of efficiently standing up under such high voltage stresses and the relatively high heat of operation without an undue separation of the two windings, thereby assuring maximum operational efficiency.

In Figure 4 is shown an alternative construction which may be employed for the primary winding 39. This so-called "air-core" structure may comprise a cupped metallic member 101 having a peripheral flange 102. A plug 103 of suitable insulating material is molded into the cup 101 and extends through a passage in the bottom thereof, with an axially extending conductor or metallic rod 104 fixed therein. The primary winding 39 is disposed about the rod 104 with one end seated against the cup 101 and the other end preferably twisted about and soldered to the rod 104 at 105. In mounting this structure, the rod 104 and the flange 102 may be connected in any suitable manner, to the conductors 38 and 40 respectively.

In Figure 5 is shown a modified form of trans-

former construction and mounting thereof. The glass cup 83 with the secondary winding 41 mounted thereon is secured within the chamber 80 by a metallic ring 119 soldered to the casing within the end flange 87. The low tension end of the secondary 41 is also soldered to the ring 119. The core 88 is formed of suitable insulating material which is initially of such resiliency as to permit the wire of the primary to be embedded therein when wound. This primary construction preferably is of a diameter to permit snug socketing thereof into the glass cup 83 during assembly. The escape of excess impregnating compound 96 may be provided for during assembly of parts in any suitable manner, such as by longitudinally extending ways, to avoid difficulties which may arise as a result of piston action. Alternatively, piston action may be avoided by tapering both the glass cup 83 and the core 88 as suggested in Figure 6.

The operation of the device of the present invention will be more readily understood by reference to the circuit diagram shown in Figure 1. The magneto successively delivers pulses of current having a peak voltage of about 1,000 to 1,500 volts through the distributor to the various supply circuits 13—24, each of which includes, as a part of the converter unit 14, the condenser 35 which is thus charged. The condenser 35, spark gap 36 and transformer primary winding 39 are connected in series to provide a high frequency oscillatory circuit which is excited by the pulse impressed on condenser 35. The peak voltage of the high frequency oscillations is stepped up to in excess of 30,000 volts by the transformer with the result that high frequency sparks are created at the gaps between the spark plug electrodes 44 and 32, which efficiently fire charges of fuel even though the spark plug electrodes be fouled with carbon or oil.

It will thus be seen that the objects set forth above, among others, are efficiently attained and since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed as new and desired to be secured by Letters Patent is:

1. A transformer - spark plug comprising, in combination, a spark plug structure including a metallic casing having a chamber therein, a pair of electrodes mounted on the spark plug, a transformer secondary winding structure mounted in said chamber including a cup of insulating material and a secondary winding wound around the exterior of said cup, the ends of said winding being connected, respectively, to said electrodes, and a transformer primary winding mounted in said cup.

2. A transformer - spark plug comprising, in combination, a spark plug structure including a metallic casing having a chamber therein, a pair of electrodes mounted on the spark plug, a transformer secondary winding structure mounted in said chamber including a cup of insulating material and a secondary winding wound around the exterior of said cup, the high tension end of said winding being connected to one of said electrodes, the low tension end of said winding being connected through the casing to the other of said electrodes, and a transformer primary winding mounted in said cup.

3. A transformer - spark plug comprising, in combination, a conventional spark plug structure including a metallic casing having a circuit connector chamber therein and a central electrode terminal exposed in the bottom of the chamber, a transformer secondary winding structure mounted in the chamber and including a cup of insulating material and a secondary winding wound about the exterior of said cup with the end of the winding adjacent the cup bottom being in electrical connection with said terminal and the other end being in electrical connection with said casing, and a transformer primary winding mounted in said cup.

4. A transformer - spark plug comprising, in combination, a spark plug structure including a metallic casing having a circuit connector chamber therein and a central electrode terminal exposed in the bottom of the chamber, a transformer secondary winding structure mounted in the chamber including a glass cup and a secondary winding wound about the exterior of said cup with the end of the winding adjacent the cup bottom being in electrical connection with said terminal and the other end being in electrical connection with said casing, and a transformer primary winding mounted in said cup.

5. A transformer - spark plug comprising, in combination, a spark plug structure including a metallic casing having a circuit connector chamber therein and a central electrode terminal exposed in the bottom of the chamber, a transformer secondary winding structure mounted in the chamber including a cup of insulating material and a secondary winding wound about the exterior of said cup with the end of the winding adjacent the cup bottom being in electrical connection with said terminal and the other end being in electrical connection with said casing, and a transformer primary winding removably socketed in said cup.

6. A transformer-spark plug comprising, in combination, a spark plug structure including a metallic casing having a circuit connector chamber therein and a central electrode terminal exposed in the bottom of the chamber, and a transformer secondary winding structure mounted in the chamber including a cup of insulating material and a secondary winding wound about the exterior of said cup with the end of the winding adjacent the cup bottom being in electrical connection with said terminal and the other end being in electrical connection with said casing.

7. A transformer-spark plug comprising, in combination, a spark plug structure including a metallic casing having a circuit connector chamber therein and a central electrode terminal exposed in the bottom of the chamber, and a transformer secondary winding structure mounted in the chamber including a cup of insulating material and a secondary winding wound about the exterior of said cup with the end of the winding adjacent the cup bottom being in electrical connection with said terminal and the other end being in electrical connection with said casing, the exterior of said casing being threaded for removable anchorage thereto of a connecting cable having a transformer

primary winding thereon adapted to be socketed in said cup.

8. A transformer-spark plug comprising, in combination, a spark plug structure including a metallic casing having a circuit connector chamber therein and a central electrode terminal exposed in the bottom of the chamber, and a transformer secondary winding structure mounted in the chamber including a glass cup and a secondary winding wound about the exterior of said cup with the end of the winding adjacent the cup bottom being in electrical connection with said terminal and the other end being in electrical connection with said casing.

9. A transformer-spark plug comprising, in combination, a spark plug structure including a metallic casing having a circuit connector chamber therein and a central electrode terminal exposed in the bottom of the chamber, a transformer secondary winding structure mounted in the chamber including a cup of insulating material and a secondary winding wound about the exterior of said cup with the end of the winding adjacent the cup bottom being in electrical connection with said terminal and the other end being in electrical connection with said casing, a transformer primary winding mounted in said cup, and bodies of a relatively heat-stable compound impregnating the interior of said cup.

10. A transformer-spark plug comprising, in combination, a spark plug structure including a metallic casing having a circuit connector chamber bounded by walls of insulating material and a central electrode terminal exposed in the bottom of the chamber, a transformer secondary winding structure mounted in the chamber including a glass cup and a secondary winding wound about the exterior of said cup, a wadded piece of metallic foil anchored to the bottom of said cup in electrical connection with the high tension end of said winding and in contact with said terminal, and means grounding the other end of said winding to said casing.

ALEXANDER C. WALL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,266,614	Robinson	Dec. 16, 1941
2,378,893	Berkey	June 26, 1945
2,392,171	Marsh	Jan. 1, 1946