

Jan. 20, 1953

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SURFACE DISCHARGE SPARK PLUG FOR LOW VOLTAGES 2,625,922
AND CONDENSER DISCHARGE
Filed June 13, 1950

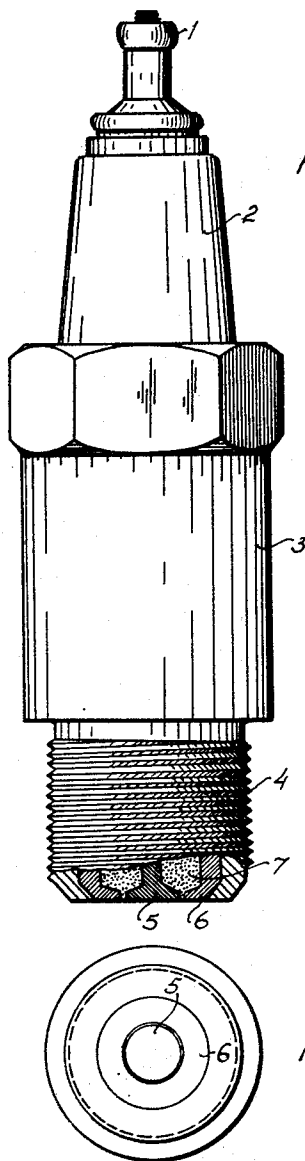


Fig. 1.

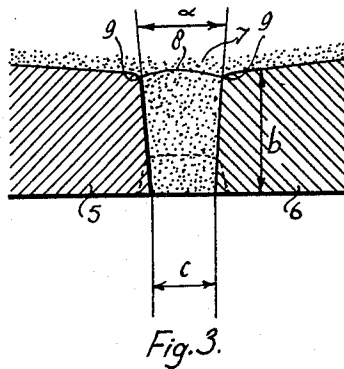


Fig. 3.

Fig. 2.

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UNITED STATES PATENT OFFICE

2,625,922

SURFACE DISCHARGE SPARK PLUG FOR
LOW VOLTAGES AND CONDENSER DIS-
CHARGEWytze Beye Smits, Voorburg, Netherlands, as-
signor to Smitsvank N. V., Rijswijk, Nether-
lands, a company of the NetherlandsApplication June 13, 1950, Serial No. 167,897
In the Netherlands June 17, 1949

5 Claims. (Cl. 123—169)

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The invention relates to a surface discharge spark plug for low voltages and condenser discharge, of the kind in which there is arranged, between the electrodes a separating body over the surface of which the spark sweeps.

Such plugs are known, for example, from the Netherlands patent specification No. 62,644. It is a well-known fact that in such plugs both the electrodes and the separating body are severely eroded by the ignition sparks, which have great current intensity. Owing to this erosion the distance between the electrodes will increase, so that the local sparking resistance will increase. The carbon deposited by the combustion-mixture, on the other hand, will often tend to reduce the said resistance.

It is thus a primary object of the invention to control these two factors, increase of resistance at a certain spot through continued increase of the gap between the electrodes and decrease of the resistance through agglomeration of deposits, and bring them into such mutual relation such that with continued wear of the plug and deterioration of the material at the sparking zone, the decrease of spark resistance through agglomeration of deposits is substantially compensated through the increasing width of the gap.

The invention thus refers to a spark plug whose electrodes are spaced apart from one another to leave a narrow gap therebetween, the width of the gap being determined dependent upon the characteristics of the spark operating condenser circuit and in accordance with the intended extension into the combustion space of the flame formed by the spark. An intermediate body of insulating or semi-insulating material separates the electrodes and reaches through the gap, its end face being flush with the sparking end faces of the electrodes, these faces together thus constituting the sparking surface of the plug.

In this spark plug, to the ends of the invention, the electrodes are shaped each at the gap with a rim, the rims projecting towards each other with their edges at a length apart from the body parts of the electrodes to hold deterioration of the electrode material through continued wear of the spark plug at a zone off the body parts of the electrodes. Towards the sparking surface, the edges of the rims converge forming between themselves a small angle, less than 15° down to 2°.

In this way, at a given spot, when the erosion continues, increasing width of the gap and thus

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increasing resistance and decreasing resistance through agglomeration of deposits compensate each other. In order to achieve uniform wear of the spark plug the edges of the rim abruptly recede at a certain distance from the sparking surface. When through deterioration of the intermediate material the depth of this distance is reached, the resistance will become too high and no sparking will occur at this spot, since the low voltage is then insufficient for the formation of a spark.

The depth where the edges of the rims abruptly recede is so chosen that the formation of a spark is prevented where at such depth the spark flame would no longer reach sufficiently into the combustion space to ignite properly the gas mixture.

Since one of the characteristics of the spark operating condenser circuit which determines the volume of the spark flame or the extent to which the spark flame reaches into the combustion space is the width of the spark gap, it results that there is a relationship between spark gap and depth where the rim edges recede such that by proper selection of this depth in proportion to the width of the gap the spark plug may be kept fully effective until full wear thereof to this depth along or around the sparking rims.

A surface discharge plug of the said kind according to the invention is so designed that in cross-section through separating body and electrodes perpendicular to the surface, across which the spark "sweeps," the boundary lines between the separating body and the electrodes form an angle less than 15°, converging towards the active surface of the plug, and that the proportion of the thickness or the minimum thickness of the electrodes to the shortest distance between these electrodes is less than or equal to 5:1.

The achievement of the object is demonstrable by experiment. When such plugs are in use, the material of the separating body, and to some extent also the material of the electrodes, will be eroded in the place where the spark is formed. Through this erosion the distance between the electrodes at said place is slightly increased, so that the resistance increases. This effect is counteracted by the greater deposition of combustion residues, cracking products, and carbon particles in the place where the spark has burned a hole in the separating body, resulting in a reduction of the resistance.

When the separating body is eroded, the spark is formed further and further down between the electrodes, because the surface of the separating

body comes to lie at a deeper level owing to the erosion.

With this kind of spark plug for low voltages and condenser discharge, flame sparks are formed, which are not to be looked upon as mere discharges through highly concentrated electron paths, but as flame sparks which occupy a certain area and a certain volume beyond the surface of the separating body, for which reason they are called flame sparks. The size of this flame spark naturally depends on the condenser discharge. Upon the distance between the electrodes also depends the intensity of this discharge. The distance between the electrodes is, therefore, a visible feature of the plug, which is indicative of the intensity of the discharge and consequently of the size of the area occupied by the flame spark. When the separating body is eroded, the flame spark is naturally formed further and further down between the electrodes. Since through reduction of the resistance, owing to the deposition of particles as referred to above, the flame spark will tend to form invariably in the same place. Through proper choice of the depth or the distance from the sparking surface where the edges of the rims recede, the spark flame is prevented from forming too far beyond the electrodes, because otherwise, owing to the insufficient formation of ignition centres in the mixture to be ignited, ignition and combustion might not take place, so that the plug would become inactive. The plug would then be practically intact in other places and yet have reached the end of its life already. Dependent on the intensity of the condenser discharge, a measure of which is the shortest distance or the spark gap between the electrodes, the maximum depth, therefore, to which the separating body may be eroded in a given place may be predetermined in relation to the shortest distance between the electrodes, which distance is chosen in view of the intended intensity of the condenser discharge. When, therefore, the angle between the boundary lines of separating body and electrodes through the receding edges of the rims is too large, it results that owing to increased resistance at a given place, when the separating body is eroded, the flame spark will tend to form in another place, so that the erosion will be uniform. The life of the spark plug is terminated when the resistance will have become too great throughout for the production of an effective flame spark.

According to an embodiment of the invention, the angle in question formed by the said boundary lines between the separating body and the electrodes is between 2° and 8° . In this range the effectiveness and the progress of the erosion are found particularly favourable.

According to a further embodiment of the invention, the shortest distance between the electrodes is not more than 0.3 mm., while the thickness or the minimum thickness of the electrodes is not more than 0.5 mm. Thus a spark plug is obtained producing a spark which has a particularly favourable intensity and shape, and which always acts very effectively on the gas mixture.

The invention will now be explained more in detail with reference to the drawings.

Figure 1 is a front view, partly in cross-section, of a plug according to the invention.

Figure 2 is a bottom view of a plug according to Figure 1.

Figure 3 is a cross-section on a larger scale through the active part of the plug.

The plug according to Figure 1 is designed in the usual manner with a connecting terminal 1, an insulator body 2, and a casing 3, which can be screwed by means of a screw thread 4 into the cylinder head of an internal-combustion engine in which a gas mixture is burnt, an earth connection being established through the said screw thread 4 in the body of the plug. The connecting terminal 1 serves to fasten the connecting part of a lead, by means of which the said lead is conductively connected to an inner electrode 5 having an active circular edge. An outer electrode 6 is conductively connected to the plug body, surrounding the inner electrode like a sleeve, and also having on the inside an active circular edge.

Between the inner electrode 5 and the outer electrode 6 a separating body of insulating or semi-insulating material is disposed. This separating body fills up the whole space between the electrodes 5 and 6 up to the active surface of the plug.

The shape of the electrodes near their active edges is clearly visible in Figure 3. The angle formed in the cross-section through the separating body and electrodes by the boundary lines between the same is less than 15° and preferably varies between 2° and 8° , converging towards the active surface of the plug. Further, according to the invention, the proportion of the thickness or the minimum thickness of the electrodes to the shortest distance between these electrodes is less than or equal to 5:1. The minimum thickness of the electrodes is designated in Figure 3 by the distance b , while the shortest distance between these electrodes is designated in Figure 3 by c . The distance c is preferably less than or equal to 0.3 mm., while the distance b is less than or equal to 0.5 mm.

The spark plug operates as follows. By means of a condenser discharge, a low voltage ignition spark is generated on the boundary between one of the electrodes and the separating body, this spark sweeping as it were over the surface of the separating body towards the other electrode and having great current intensity. By this ignition spark the material of both the separating body and the electrodes is eroded, so that after some time the active edges of the electrodes will be shaped as indicated by dotted lines in Figure 3. The separating body will also be eroded approximately as far as the dotted line. Consequently, the sparks will now "sweep" approximately along the dotted line in the separating body. Owing to the increased distance to be bridged the resistance to the passage of a spark has slightly increased. This increases the tendency of the plug to form a spark at some other—less eroded—point, so that the erosion becomes as uniform as possible. The erosion continues until the separating body has worn down the distance b , so that the boundary of the separating body approximately coincides with the line 3 in Figure 3. When this limit has been reached, the plug continues to operate for some time, until the resistance has increased so much that the condenser discharges are no longer capable of forming a spark.

If the separating body is eroded as far as the line 3, the admissible erosion is limited fairly sharply, this limit being reached before the resistance has increased to such a value that the formation of a spark is no longer possible.

When the distance c is taken less than or equal to 0.3 mm. and the distance b less than or equal

to 0.5 mm., a particularly favourable embodiment is obtained, ensuring an effective action of the flame spark on the gas mixture to be ignited, even under unfavourable conditions with regard to mixture strength and turbulence in the combustion chamber.

The edges of the electrodes near the line 8 are preferably rounded at 9, to avoid the formation along these edges of cracks in the separating body, as a result of which the sparks might "slide" more readily in this place than on the free surface.

It is obvious that the invention could also be used if there were more than two active circular electrode edges, as is known, for example, from the Netherlands patent application No. 123,176, published on February 15, 1949, or if the electrode edges were other than circular in shape.

It will further be clear, that the drawing only relates to a preferred embodiment of the invention. The invention could also be applied in other types of spark plugs, e. g. in spark plugs in which the active surface of the separating body between the electrodes is cylindrical and situated on a part of the plug body, forming an extension of the screw-threaded part 4.

What I claim is:

1. A low voltage, condenser operated surface discharge spark plug including at least two electrodes spaced apart from one another to leave a narrow gap therebetween, the width of the gap being determined dependent upon the characteristics of the condenser circuit and in accordance with the intended extension of the spark flame into the combustion space; an intermediate body of none to semi-conductivity separating said electrodes and reaching through said gap, its end surface being flush with the sparking end faces of said electrodes to constitute therewith said sparking surface; said electrodes each shaped at said gap with a projecting rim, the rims projecting towards one another, with their edges at a length apart from the body parts of the electrodes to hold deterioration of the electrode material through continued wear of the plug at a zone off the body parts of the electrodes; the edges of said rims being further shaped to converge towards said sparking surface forming between themselves a small angle, less than 15° down to 2° , thereby, with continued wear of the plug and deterioration of the material at the sparking zone to compensate through the increasing width of the gap and thus its resistance the decrease of resistance through agglomeration of deposits; said edges abruptly receding at a short distance from the sparking surface, the proportion of the depths of said receding edges from the sparking surface to the width of the gap being at most five to one down to two to one, thereby, after wear of a spot to the depth of said distance, to prevent formation of a spark at said spot where at such depth the spark flame would not reach sufficiently into the combustion space to ignite the gas mixture, and, by proper selection of said depth in proportion to the width of the gap to keep said spark plug effective until full wear of the spark plug to said depth along said rim.

2. A spark plug as set forth in claim 1 where-

in said angle of convergence of the rim edges is between 8° and 2° .

3. A spark plug as set forth in claim 1 wherein the width of the gap at the sparking surface is of the order of 0.3 millimeter and less.

4. A spark plug as set forth in claim 1 wherein the depth of said receding edge from the sparking end surface is of the order of 0.5 millimeter and less.

5. A low voltage, condenser operated surface discharge spark plug including a center electrode and at least one tubular electrode surrounding the same and spaced apart therefrom to leave a narrow gap therebetween, the width of the gap being determined dependent upon the characteristics of the condenser circuit and in accordance with the intended extension of the spark flame into the combustion space; an intermediate tubular body of none to semi-conductivity separating said electrodes and reaching through said gap, the end surface of said intermediate body being flush with the sparking end faces of said electrodes to constitute therewith said sparking surface; said electrodes each shaped at said gap with a circular projecting rim, the rims projecting towards one another, with their edges at a length apart from the body parts of the electrodes to hold deterioration of the electrode material through wear of the plug at a zone off said body parts; the edges of said rims being further shaped to converge towards said sparking surface forming between themselves a small angle, less than 15° down to 2° , thereby, with continued wear of the plug and deterioration of the material at the sparking zone to compensate through the increasing width of the gap and thus its resistance the decrease of resistance through agglomeration of deposits; said edges abruptly receding at a short distance from the sparking surface, the proportion of the depths of said receding edges from the sparking surface to the width of the gap being at most five to one down to two to one, thereby, after wear of a spot to the depth of said distance, to prevent formation of a spark at said spot where at such depth the spark flame would not reach sufficiently into the combustion space to ignite the gas mixture, and, by proper selection of said depth in proportion to the width of the gap to keep said spark plug effective until full wear of the spark plug to said depth around said rim.

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