

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11)

EP 1 060 546 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

10.11.2004 Bulletin 2004/46

(21) Application number: **99911035.6**

(22) Date of filing: **02.03.1999**

(51) Int Cl.7: **H01T 13/32**

(86) International application number:
PCT/US1999/004552

(87) International publication number:
WO 1999/045615 (10.09.1999 Gazette 1999/36)

(54) **SPARK PLUG PROVIDING IMPROVED OPERATING CHARACTERISTICS**

ZÜNDKERZE MIT VERBESSERTEN WIRKUNGSMERKMALEN

BOUGIE D'ALLUMAGE A CARACTERISTIQUES DE FONCTIONNEMENT AMELIOREES

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**

(30) Priority: **02.03.1998 US 76669 P**
16.06.1998 US 89458 P
16.06.1998 US 89491 P
16.06.1998 US 89499 P
31.12.1998 US 114439 P

(43) Date of publication of application:
20.12.2000 Bulletin 2000/51

(73) Proprietor: **Pyrotek Enterprises Inc.**
Altanta, GA 30308 (US)

(72) Inventor: **GARRETT, Norman, H., III**
Atlanta, GA 30327 (US)

(74) Representative: **Solf, Alexander, Dr.**
Patentanwälte
Dr. Solf & Zapf
Candidplatz 15
81543 München (DE)

(56) References cited:
DE-A- 3 935 165 DE-U- 9 403 943
US-A- 4 268 774 US-A- 5 264 754

- **PATENT ABSTRACTS OF JAPAN vol. 097, no. 008, 29 August 1997 & JP 09 092434 A (NAKANO TAMOTSU), 4 April 1997**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 060 546 B1

Description

Reference to Prior Applications

[0001] The present invention claims the priority of the following provisional US patent applications:

Serial No.60/076,669 Filed March 2, 1998.
Serial No. 60/089,491 Filed June 16, 1998.
Serial No. 60/089,499 Filed June 16, 1998.
Serial No.60/114,439 Filed December 31, 1998.

Technical Field

[0002] The present invention generally relates to spark plugs for igniting the fuel charge in an internal combustion engine, and is particularly concerned with an improved spark plug construction which improves combustion pressure, fuel mileage and diminishes exhaust pollution as compared with known prior art plugs.

Background of the Invention

[0003] Prior art spark plugs are well known. Such spark plugs typically include a center electrode and a ground electrode spaced apart from the center electrode. When a sufficient electrical potential is provided across the gap, a spark jumps across the gap. This spark can be used to ignite an air-fuel mixture within an internal combustion engine.

[0004] U. S. Patent No. 5,051,651 ("the '651 patent") which is considered to represent the closest prior art, details a "cylindrical hole" that is created around the center electrode by the shielding of the outer ground electrode. The '651 patent asserts that "ignition seeds" multiply inside of this cylindrical hole. The ground electrode, in all examples, has a "substantially concave inner surface complimenting the radial face of said center electrode" (Column 8, line 33). This creates a concentric curved surface that has an inner radius equal to "the sum of the radius of the center electrode and a spark gap can be nearly equal to the radius of the cylindrical hole" (Column 1, line 54).

[0005] As seen in Fig. 13 of the '651 patent, and in the language in independent claim 18, the invention relies specifically on spark strike areas wherein "at least a portion of each said inner orthogonal sides is provided with a concave surface having a curvature complimenting the axial face of the center electrode".

[0006] Since all sparks travel along the shortest path, center electrode to ground electrode, the effective surfaces of the '651 patent are similar to other concentric ring designs U. S. Patent Nos. 1,748,338; 1,942,242; 1,912,516; 5,430,346; 5,280,214) where the ground electrode is shaped in a complimenting radius centered on the same axis as the center electrode. The '651 patent at the functional core where the spark actually jumps, performs similarly to other concentric ring de-

signs.

[0007] However, it is believed by the applicant that concentric ring designs have shown no performance benefit over standard spark plug designs.

[0008] Reference is also made to U. S. Patent No. 5,612,586, in which particular importance is placed upon eliminating the 90 degree bend common to a standard spark plug.

[0009] The above prior art patents include some advantageous features. However, there is always a need for an improved plug design which provides improved fuel efficiency and reduced emissions.

[0010] From the JP-A-09092434 a spark plug is known which comprises a metal shell having a threaded portion fitting an engine, a center electrode protruding towards an engine combustion chamber from an insulator on an open end of said threaded portion; a ground electrode bending and extending to make a spark gap and having branches around the end portion, wherein each branch of the ground electrode has an inner corner of the end disposed at a position opposite to a peripheral edge of the center electrode end. With such a spark plug it is disadvantageous that due to corrosion and wear out the properties are influenced disadvantageous.

Summary of the Invention

[0011] The present invention relates to the use of a spark plug providing edge corners in a tangential relationship with the central electrode.

[0012] Therefore it is an object of the present invention to provide an improved spark plug.

[0013] It is a further object of the present invention to provide an improved spark plug ground electrode.

[0014] It is a further object of the present invention to provide an improved spark plug which exhibits improved fuel efficiency.

[0015] It is a further object of the present invention to provide an improved spark plug which exhibits improved combustion pressure.

[0016] It is a further object of the present invention to provide an improved spark plug which provides decreased pollution.

[0017] Other objects, features, and advantages of the present invention will become apparent upon reading the following detailed description of the preferred embodiment of the invention when taken in conjunction with the drawings and the appended claims.

[0018] The invention attains these objects with a spark plug according to claim 1. Advantageous embodiments of the invention are provided in the dependent claims.

Brief Description of the Drawings

[0019]

Fig. 1 is a top view of a portion of a first embodiment

of the present invention shown in overall view in Fig. 2.

Fig. 2 is a side plan view of the first embodiment shown in Fig. 1, being a spark plug 10.

Fig. 3 is a top view of two electrodes, a ground electrode 51 and a center electrode 20, used in a second embodiment of the present invention, which could be considered a "forked" configuration, with two tangential relationships and one vertex.

Fig. 4 is a top view of two electrodes, a ground electrode 52 and a center electrode 20, used in a third embodiment of the present invention, which includes three segments and three tangential relationships and two vertexes (a.k.a "vertices").

Fig. 5 is a top view of two electrodes, a ground electrode 53 and a center electrode 20, used in a fourth embodiment of the present invention, with six segments, up to five vertexes, and at least four tangential relationships.

Fig. 6 is a top view of two electrodes, a ground electrode 60 and a center electrode 20, used in a fifth embodiment of the present invention, with four segments, three vertexes, and four tangential relationships.

Fig. 7 is a top view of two electrodes, a ground electrode 70 and a center electrode 20, used in a sixth embodiment of the present invention, which could be considered a "closed box" configuration, with four tangential relationships and four vertexes.

Fig. 8 is a top view of two electrodes, a ground electrode 80 and a center electrode 20, used in a seventh embodiment of the present invention, which could be considered a "closed hex box" configuration, with six tangential relationships and six vertexes.

Fig. 9 is a top view of two electrodes, a ground electrode 90 and a center electrode 20, used in an eighth embodiment of the present invention, which could be considered a "single offset straight electrode" configuration, with one tangential relationship.

Fig. 10 is a top view of three electrodes, two ground electrodes 100, 101, and a center electrode 20, used in a ninth embodiment of the present invention, which could be considered a "double offset straight electrode" configuration, with two tangential relationships.

Fig. 11 is a top view of three electrodes, two ground electrodes 110, 111, and a center electrode 20 used in a tenth embodiment of the present invention, which could be considered a "double T electrode" configuration, with two tangential relationships.

Fig. 12 is a top view of three electrodes, two ground electrodes 120, 121, and a center electrode 20 used in an eleventh embodiment of the present invention, which could be considered an "offset double T electrode" configuration, with two tangential relationships.

Fig. 13 is a top view of four electrodes, three ground

electrodes 130, 131, and 132 and a center electrode 20 used in an eleventh embodiment of the present invention, which could be considered a "triangulated triple T electrode" configuration, with three tangential relationships.

Fig. 14 is a side elevational view of a typical center electrode 20, shown underneath a cross-sectional view of a portion of a ground electrode 140, including a lower corner edge directed towards the center electrode in a tangential relationship.

Fig. 15 shows a ground electrode 150 providing a simple convex curved edge presented to the center electrode 20, with one tangential edge relationship. The transverse cross-section of the ground electrode is rectangular.

Fig. 16 shows a simple straight edge presented to the center electrode. One tangential edge relationship is shown. The cross-section of the ground electrode is rectangular.

Fig. 17 shows the use of four ground electrodes 170, 171, 172 and 173, which combine to present multiple simple straight edges presented to the center electrode 20. No tangential edge relationships are shown in this figure, although four edges could be in the zone referenced in Fig. 26. The cross-section of each of the four ground electrodes is rectangular.

Fig. 18 shows a triangular-shaped ground electrode 180 presenting three edges and three vertexes to the center electrode 20. Three tangential edge relationships are shown. The transverse cross-section of each linear segment of the ground electrode is substantially rectangular.

Fig. 19 is similar to that shown in Fig. 11, and shows a triangular-shaped ground electrode 190, but with a triangular center electrode 195. Three tangential edge relationships and three vertexes are shown in this figure.

Fig. 20 is an open ended design including a ground electrode 200 presenting three curved edges and two vertexes to the center electrode 20. Three "curved" tangential edge relationships are provided under this configuration. Note that a tangential relationship can be a "straight" tangential relationship or can include a "curved" tangential relationship.

Fig. 21 is an open ended design including a ground electrode 210 presenting three straight edges and two vertexes to the center electrode 20. Three tangential edge relationships and two vertexes are shown in this figure.

Fig. 22 is an open ended design similar to that shown in Fig. 21, except with a center electrode 225 shape that substantially matches the ground electrode 220 geometry, which in this case is square. Three tangential relationships are shown.

Fig. 23 shows a "forked" design, in which two curved tangential edge relationships exist, with a single vertex therein. A ground electrode 220 and a center

electrode 230 are shown.

Fig. 24 shows two ground electrodes 240, 241 each having a "barb" at their end, which serve to substantially surround the projection of the center electrode 20. Four straight tangential relationships and two vertexes are shown in this figure.

Fig 25 shows a simple concave curved edge presented to the center electrode 20 by a ground electrode 250.

Fig. 26 is a side view illustrating various positions 1, 2, and 3 that a ground electrode 260 may be placed relative to the center electrode, with these three positions 1, 2 and 3 being within a "zone". The positions within the zone provide such that any of the positions expose the lower edge of the ground electrode to the center electrode's outer edge, which can create a "chimney" effect for the intake gases.

Fig. 27 is a side cross-sectional view of the embodiment shown in Fig. 1 (taken through the center longitudinal axis of the center electrode 20) with the lower edges of the ground electrode 270 presented above the center electrode in a substantially tangential relationship to the peripheral projection of the center electrode.

Fig. 28 is a view similar to Fig. 27, but the cross-section of the ground electrode 280 has been streamlined to offer less resistance to the flame front's propagation.

Fig. 29 is a view similar to that of Fig. 28, but the ground electrode 290 has been reduced to a single edge, and supported by an arc, as seen in electrode design shown in Fig. 25. Such a design could also apply to the view of Fig. 15. The cross-section could be of any shape other than that shown, that presents an edge (straight or otherwise) as the closest surface to the top edges of the center electrode 20.

Fig. 30 shows an embodiment including multiple ground electrodes 300, 301, and 302 (a fourth ground electrode, not shown, may also be used) which provides multiple straight edges presented to the center electrode's top via straight ground electrodes angled upwardly and inwardly. The angle is not believed to be as important as the final position of the edges of the tips of the elongate members.

Fig. 31 is a side cross-sectional view of a configuration generally similar to that shown in, for example, Fig. 1, except the cross-section of the ground electrode 310 has a "diamond" shape, presenting edges to the top circular edge of the center electrode 20. This design could promote better flow for the flame resulting from the spark ignition due to the chamfers above and below the ground electrode edges.

Fig. 32 is a modification of that shown in Fig. 1, except a simple chamfer is provided on the top surface of the ground electrode 320. This could gain some

of the benefits of the design shown in Fig. 31, but would appear to be easier to manufacture.

Fig. 33 is a view of an embodiment including a ground electrode which is similar to Fig. 1, except that a simple notch has been cut into the center electrode 335 to improve spark efficiency.

Fig. 34 is a side cross-sectional view of an embodiment similar to that of Fig. 1, including a ground electrode 340, except that a "necked-down" section is provided at the top of the center electrode 345, creating a "fine wire" discharge tip to the center electrode.

Fig. 35 shows an embodiment not according to the invention with a ground electrode 350 edge presented from above, through single (as shown) or multiple (not shown) stems that support the "important" edge. Also, the center electrode 355 has a chamfer at the tip.

Fig. 36 shows a top and side view configuration of another embodiment not according to the invention which includes "maximized edge-to-edge presentation" of two edges defined by the center and ground electrodes 365 and 360, respectively. While possibly more expensive to manufacture than other embodiments, this design presents a less shielded edge-to-edge spark to the combustion chamber. The small sizes of the electrodes are also believed to serve to reduce blockage to, the incoming fuel charge and the existing flame kernel.

Fig. 37 is a view of a spark having a ground electrode 370 similar to that of Figs. 1 and 2, except that a chisel point center electrode 375 is used.

Fig. 38 is a view of a spark plug having a single point center electrode 385, with a ground electrode 380 being similar to that shown in Figs. 1 and 2.

Fig. 39 is a view of a series of center electrode configurations which may be used with other ground electrodes within this description, including a chisel point 395A, pyramid point 395-B, a V-groove 395-C, a dimpled center 395-D, a polygon 395-E, a single point 395-F, multiple edges 395-G, a chamfer point 395-H, a hollow cylinder 395-I, a hollow polygon 395-J, and a necked down configuration 395-K.

Fig 40A and B are top and side plan views, respectively, of a configuration not according to the invention including a T-shaped center electrode 405 having T-shaped ends each defining an edge, and a pair of ground electrodes 400, 401 likewise each defining an edge. The edges of the center electrode are presented to the edges of the ground electrodes in a one-to-one relationship.

Figs 41A and 41B are top and side plan views, respectively, of a configuration including an L-shaped center electrode 415 and a ground electrode 410, with curved tangential edges. Note that two segments could be used such as in Figs. 40A and 40B, or more than two segments could be used, either with this configuration or the Figs. 40A/40B

configuration.

Figs. 42A/42B show a configuration which includes a center electrode 425 and a ground electrode 420, combining to form three tangential relationships.

Fig. 43 is a configuration which includes a center electrode 20 and a ground electrode 430, which provides vertical and horizontal spacing between the two points referenced as G1 and G2, respectively. Preferably G1 is greater than or equal to zero and G2 is greater than or equal to zero. As shown in the figures, specifically in Fig. 26, if G1 is zero, G2 must be greater than zero, and if G2 is zero, G1 must be greater than zero. This is another way to illustrate the "zone" concept of Fig. 26.

Fig. 44 is an illustrative top plan view of an exemplary center electrode 20 and two exemplary ground electrodes 440, 441, further illustrating the tangential relationship which is one feature of the present invention. As may be seen, a "tangential" relationship includes not only the "case 1" relationship of the elements 20, 440, but also the "case 2" relationship of the elements 20, 441.

Fig. 45 is an illustrative top plan view of an exemplary center electrode 20 and a two-pronged ground electrode 450, which is similar to that shown in Fig. 3 but has shorter prongs which provide two tangential relationships 453, 454, as shown in the case 2 example in Fig. 44. An intermediate vertex 455 is also shown.

Fig. 46 is a "wide-box" configuration which is similar to that of Fig. 1, except that instead of having four tangential relationships, the four edges of the ground electrode 460 are outside the projection of the center electrode, and in the "zone" of Fig. 26. In the inventor's opinion at the time of filing, this provides additional room under the "intake charge flow" concept illustrated in Fig. 26.

Fig. 47 is a "wide-fork" configuration which is similar to that of Fig. 3, except that instead of having two tangential relationships, the two edges of the ground electrode 470 are outside the projection of the exemplary center electrode 20, and in the "zone" of Fig. 26. In the inventor's opinion at the time of filing, this provides additional room under the "intake charge flow" concept illustrated in Fig. 26.

Fig. 48A and B illustrate a believed difference in concentric and nonconcentric electrode properties, showing a concentric ground electrode 480, an "open" ground electrode 481, each in association with a typical center electrode 20. As may be seen, open electrode surfaces are believed by the inventor to tend to encourage flame kernel propagation.

Detailed Description of the Preferred Embodiment

[0020] Generally described, the present invention is directed towards the use of a spark plug having a conventional center electrode and one or more ground elec-

trodes, each of which defines at least one lower corner edge which is substantially tangentially oriented relative to the periphery of the substantially round electrode below.

[0021] One configuration contemplated under the present invention can be referred to as a "box" plug, shown in Figs. 1 and 2. The "box" plug uses an electrode that is substantially in the shape of a square that appears to "encircle" the spark plug's center electrode, when viewed from above. However, in fact, as shown in Fig. 2, the box does not encircle the spark plug's center electrode, as there is a gap 0.635 mm (0.025 inches) in the case of one test) defined between the upper round end surface of the center electrode and the plane in which the downwardly-directed lower surfaces of the split prong members lie.

[0022] As may be seen, the electrode 30 includes two end prongs 32 which initially diverge but then eventually converge. The two end prongs 32 each include two segments 34 of substantially equal length. Two of these segments could be considered as the "diverging" segments 34, and the other two could be considered as the "converging" segments 34. This would mean that each prong includes one "diverging" segment and one "converging" segment.

[0023] An "Elbow" could be considered as connecting the diverging segment of a particular segment to its corresponding converging segment. Such elbows (two in the Fig. 1 version) are shown as being substantially in a vertical plane extending through the central longitudinal axis of the center prong.

[0024] The ground electrode could be considered to have three vertexes, a main vertex 40 and two elbow inner vertexes 41.

[0025] It may be understood that the transverse cross sections of the segments 34 are substantially rectangular, being in one configuration 1.27 mm (0.050 inches) wide and 1.27mm (0.050 inches) thick. Such a cross section provides four outwardly-directed, substantially linear (at least not near the bends) corner edges, (also shown in Fig. 14). It is believed that the relationship of at least the inner lower corner edges relative to the center electrode provides improved performance. Such a relationship will be referred to as a tangential relationship, with four tangential relationships provided in the Fig. 1 configuration, one for each segment 34.

[0026] It should be understood that the center electrode as shown in Fig. 2 shall be referenced in this application as an "upwardly"-extending center electrode. However, this is for reference purposes only and should not be understood as limiting. In operation such an electrode can be oriented in many different directions while in use.

Other Embodiments

[0027] Other ground electrode embodiments are contemplated under the present invention.

Fig. 3 is a top view of two electrodes, a ground electrode 51 and a center electrode 20, used in a second embodiment of the present invention, which could be considered a "forked" configuration, with two tangential relationships and one vertex.

Fig. 4 is a top view of two electrodes, a ground electrode 52 and a center electrode 20, used in a third embodiment of the present invention, which includes three segments and three tangential relationships and two vertexes (a.k.a "vertices").

Fig. 5 is a top view of two electrodes, a ground electrode 53 and a center electrode 20, used in a fourth embodiment of the present invention, with six segments, up to five vertexes, and at least four tangential relationships.

Fig. 6 is a top view of two electrodes, a ground electrode 60 and a center electrode 20, used in a fifth embodiment of the present invention, with four segments, three vertexes, and four tangential relationships.

Fig. 7 is a top view of two electrodes, a ground electrode 70 and a center electrode 20, used in a sixth embodiment of the present invention, which could be considered a "closed box" configuration, with four tangential relationships and four vertexes.

Fig. 8 is a top view of two electrodes, a ground electrode 80 and a center electrode 20, used in a seventh embodiment of the present invention, which could be considered a "closed hex box" configuration, with six tangential relationships and six vertexes.

Fig. 9 is a top view of two electrodes, a ground electrode 90 and a center electrode 20, used in an eighth embodiment of the present invention, which could be considered a "single offset straight electrode" configuration, with one tangential relationship.

Fig. 10 is a top view of three electrodes, two ground electrodes 100, 101, and a center electrode 20, used in a ninth embodiment of the present invention, which could be considered a "double offset straight electrode" configuration, with two tangential relationships.

Fig. 11 is a top view of three electrodes, two ground electrodes 110, 111, and a center electrode 20 used in a tenth embodiment of the present invention, which could be considered a "double T electrode" configuration, with two tangential relationships.

Fig. 12 is a top view of three electrodes, two ground electrodes 120, 121, and a center electrode 20 used in an eleventh embodiment of the present invention, which could be considered an "offset double T electrode" configuration, with two tangential relationships.

Fig. 13 is a top view of four electrodes, three ground electrodes 130, 131, and 132 and a center electrode 20 used in an eleventh embodiment of the present invention, which could be considered a "triangulated triple T electrode" configuration, with

three tangential relationships.

Fig. 14 is a side elevational view of a typical center electrode 20, shown underneath a cross-sectional view of a portion of a ground electrode 140, including a lower corner edge directed towards the center electrode in a tangential relationship.

Fig. 15 shows a ground electrode 150 providing a simple convex curved edge presented to the center electrode 20, with one tangential edge relationship. The transverse cross-section of the ground electrode is rectangular.

Fig. 16 shows a simple straight edge presented to the center electrode. One tangential edge relationship is shown. The cross-section of the ground electrode is rectangular.

Fig. 17 shows the use of four ground electrodes 170, 171, 172 and 173, which combine to present multiple simple straight edges presented to the center electrode 20. No tangential edge relationships are shown in this figure. The cross-section of each of the four ground electrodes is rectangular.

Fig. 18 shows a triangular-shaped ground electrode 180 presenting three edges and three vertexes to the center electrode 20. Three tangential edge relationships are shown. The transverse cross-section of each linear segment of the ground electrode is substantially rectangular.

Fig. 19 is similar to that shown in Fig. 18, and shows a triangular-shaped ground electrode 190, but with a triangular center electrode 195. Three tangential edge relationships and three vertexes are shown in this figure.

Fig. 20 is an open ended design including a ground electrode 200 presenting three curved edges and two vertexes to the center electrode 20. Three "curved" tangential edge relationships are provided under this configuration. Note that a tangential relationship can be a "straight" tangential relationship or can include a "curved" tangential relationship.

Fig. 21 is an open ended design including a ground electrode 210 presenting three straight edges and two vertexes to the center electrode 20. Three tangential edge relationships and two vertexes are shown in this figure.

Fig. 22. is an open ended design similar to that shown in Fig. 21, except with a center electrode 225 shape that substantially matches the ground electrode 220 geometry, which in this case is square. Three tangential relationships are shown.

Fig. 23 shows a "forked" design, in which two curved tangential edge relationships exist, with a single vertex therein. A ground electrode 220 and a center electrode 230 are shown.

Fig. 24 shows two ground electrodes 240, 241 each having a "barb" at their end, which serve to substantially surround the projection of the center electrode 20. Four straight tangential relationships and three vertexes are shown in this figure.

Fig 25 shows a simple curved edge presented to the center electrode 20 by a ground electrode 250. Fig. 26 is a side view illustrating various positions 1, 2, and 3 that a ground electrode 260 may be placed relative to the center electrode, with these three positions 1, 2 and 3 being within a "zone". The positions within the zone provide such that any of the positions expose the lower edge of the ground electrode to the center electrode's outer edge, which can create a "chimney" effect for the intake gases.

Fig. 27 is a side cross-sectional view of the embodiment shown in Fig. 1 (taken through the center longitudinal axis of the center electrode 20) with the lower edges of the ground electrode 270 presented above the center electrode in a substantially tangential relationship to the peripheral projection of the center electrode.

Fig. 28 is a view similar to Fig. 27. but the cross-section of the ground electrode 280 has been streamlined to offer less resistance to the flame front's propagation.

Fig. 29 is a view similar to that of Fig. 28, but the ground electrode 290 has been reduced to a single edge, and supported by an arc, as seen in electrode design shown in Fig. 25. Such a design could also apply to the view of Fig. 15. The cross-section could be of any shape other than that shown, that presents an edge (straight or otherwise) as the closest surface to the top edges of the center electrode 20.

Fig. 30 shows an embodiment including multiple ground electrodes 300, 301, and 302 (a fourth ground electrode, not shown, may also be used) which provides multiple straight edges presented to the center electrode's top via straight ground electrodes angled upwardly and inwardly. The angle is not believed to be as important as the final position of the edges of the tips of the elongate members.

Fig. 31 is a side cross-sectional view of a configuration generally similar to that shown in, for example, Fig. 1. except the cross-section of the ground electrode 310 has a "diamond" shape, presenting edges to the top circular edge of the center electrode 20. This design could promote better flow for the flame resulting from the spark ignition due to the chamfers above and below the ground electrode edges.

Fig. 32 is a modification of that shown in Fig. 1, except a simple chamfer is provided on the top surface of the ground electrode 320. This could gain some of the benefits of the design shown in Fig. 31. but would appear to be easier to manufacture.

Fig. 33 is a view of an embodiment including a ground electrode which is similar to Fig. 1, except that a simple notch has been cut into the center electrode 335 to improve spark efficiency.

Fig. 34 is a side cross-sectional view of an embod-

iment similar to that of Fig. 1. including a ground electrode 340, except that a "necked-down" section is provided at the top of the center electrode 345, creating a "fine wire" discharge tip to the center electrode.

Fig. 37 is a view of a spark plug having a ground electrode 370 similar to that of Figs. 1 and 2, except that a chisel point center electrode 375 is used.

Fig. 38 is a view of a spark plug having a single point center electrode 385, with a ground electrode 380 being similar to that shown in Figs. 1 and 2.

Fig. 39 is a view of a series of center electrode configurations which may be used with other ground electrodes within this description, including a chisel point 395A, pyramid point 395-B, a V-groove 395-C, a dimpled center 395-D, a polygon 395-E, a single point 395-F, multiple edges 395-G, a chamfer point 395-H, a hollow cylinder 395-I, a hollow polygon 395-J, and a necked down configuration 395-K.

Fig 40A and B are top and side plan views, respectively, of a configuration not according to the invention including a T-shaped center electrode 405 having T-shaped ends each defining an edge, and a pair of ground electrodes 400, 401 likewise each defining an edge. The edges of the center electrode are presented to the edges of the ground electrodes in a one-to-one relationship.

Figs 41A and 41B are top and side plan views, respectively, of a configuration including an L-shaped center electrode 415 and a ground electrode 410, with curved tangential edges. Note that two segments could be used such as in Figs. 40A and 40B, or more than two segments could be used, either with this configuration or the Figs. 40A/40B configuration.

Figs. 42A/42B show a configuration which includes a center electrode 425 and a ground electrode 420, combining to form three tangential relationships.

Fig. 43 is a configuration which includes a center electrode 20 and a ground electrode 430, which provides vertical and horizontal spacing between the two referenced as G1 and G2, respectively. Preferably G1 is greater than or equal to zero and G2 is greater than or equal to zero. This is another way to illustrate the "zone" concept of Fig. 26.

Fig. 44 is an illustrative top plan view of an exemplary center electrode 20 and two exemplary ground electrodes 440, 441, further illustrating the tangential relationship which is one feature of the present invention. As may be seen, a "tangential" relationship includes not only the "case 1" relationship of the elements 20, 440, but also the "case 2" relationship of the elements 20, 441.

Fig. 45 is an illustrative top plan view of an exemplary center electrode 20 and a two-pronged ground electrode 450, which is similar to that shown in Fig. 3 but has shorter prongs which provide two tangential relationships 453, 454, as shown in the case 2

example in Fig. 44. An intermediate vertex 455 is also shown.

Fig. 46 is a "wide-box" configuration which is similar to that of Fig. 1, except that instead of having four tangential relationships, the four edges of the ground electrode 460 are outside the projection of the center electrode, and in the "zone" of Fig. 26. Fig. 47 is a "wide-fork" configuration which is similar to that of Fig. 3, except that instead of having two tangential relationships, the two edges of the ground electrode 470 are outside the projection of the exemplary center electrode 20, and in the "zone" of Fig. 26. In the inventor's opinion at the time of filing, this provides additional room under the "intake charge flow" concept illustrated in Fig. 26.

The Tangential Relationship

[0028] As noted above, in some instances it is desired to have a one or more straight edges in a tangential relationship with the circular (a.k.a "round") upper edge of the ground electrode. This will be referred to as a "straight edge tangential relationship" in that the straight edge defined by the ground electrode presents one or more straight edges such that each edge is in a tangential relationship to the center electrode's circumferential projection. Such is shown in, for example only, Figs. 1, 3, 4, 9, and 10, although many others are shown).

[0029] However, it should also be understood that a "curved edge tangential relationship is also contemplated under one of the inventions disclosed herein, which is shown in, for example only, Figs. 15, 23, and 25.

[0030] The important point to note is that the spark will connect between the center electrode and the closest ground. The actual placement of the ground electrode's prongs may be anywhere adjacent to or outside the peripheral (which need not necessarily be round) projection of the center electrode, at a chosen height at or above the center electrode's tip.

[0031] It should be understood that certain aspects of the invention contemplate the use of some offset of the tangential relationship, such as shown in Figs 17 and 26.

The Straightness of the Edges

[0032] As noted above, in some instances it is desired to have a straight edge in a tangential relationship with the curved upper edge of the ground electrode. However, it should be understood that certain aspects of the invention contemplate the use of curved edges in such a tangential relationship.

The Zone Concept

[0033] Reference is made to Figs. 26 to illustrate the "Zone" concept, in which any of the positions shown expose the lower edge of the ground electrode to the center electrode's outer edge (a.k.a. its "upper peripheral

edge", which could be circular).

[0034] This is another related concept of the invention, in which the edges that are presented or exposed to each other are not necessarily tangential, but they do present themselves to each other such that the edges are the closest parts of the two electrodes to each other, or are at least as close as any other two parts of the electrodes, within the region of spark. It is believed that the "unshielding" of the top of the center electrode by placing the ground electrode outside the periphery is an advantageous concept above and separate from the tangential and/or vertex concepts. Again, it is believed that placing the lowest portion of the ground electrode's "active edge" at or above the center electrode allows the intake charge gases to flow more easily into the spark zone.

The Vertexes

[0035] It is believed at the time of filing that the combination of the tangential relationship and the vertexes, which is provided in some of the applicant's embodiments (for example those shown in Figs. 1, 3, 4, 5, 6, and others) provides a distinct improvement over the prior art. Some of such vertexes provide a vertical "opening" or a "chimney effect" which is believed to provide improved flame characteristics. Furthermore, it is believed at the time of filing that the combination of the "zone" relationship and the vertexes, which is provided in some of the applicant's embodiments, provides a distinct improvement over the prior art.

Processes Used

[0036] The simple shapes of the ground electrodes described in this application can be created by a secondary and subsequent operations on the standard wire-fed electrode currently in use in the industry. A mandrel of specific design can be used to form the various segments of each electrode. Alternately, a stamped electrode can be made using a die to create the specific configuration. The stamped electrode could then be welded to the spark plug base per usual practice. Instead of stamping, the electrode shape could be created by laser cutting, water jet cutting, chemical etching, forging, casting, powdered metal forming, etc. Any electrodes using these methods would then be welded to the spark plug base at the appropriate position.

[0037] With respect to the configurations shown in Figures 9 and 10, these electrode configurations can be created with little change to the current wire-feed arrangement. The offset with respect to the center electrode can be created in the basic wire feed machine set up, or by the use of a secondary operation that creates the specific alignment of the conventional sidewire.

Miscellaneous Comments

[0038] In, for example, Fig. 1, the thickness of the ground electrodes, including the end portions (including their segments), is as known in the art, or approximately 1.27 mm (0.050 inches), although the thickness can be 1.016-1.651 mm (0.040-0.065 inches), although it could be 0.254-3.81 mm (0.010-0.150 inches), or other similar dimensions. The width of the "stem" can be 1.905-3.175 mm (0.075-0.125 inches), although it could be 0.254-3.81 mm (0.010-0.150 inches), or other similar dimensions.

[0039] It is believed that the width of the prongs is not critical, but the sharpness of the edge(s) is important. However, in one preferred embodiment, the prongs are 1.27mm (0.050 inches) wide and 1.27mm (0.050 inches) thick, although each of these dimensions could be 0.254-1.27mm (0.010-0.150 inches), or other similar dimensions.

[0040] It should also be understood that it is not believed that the ground electrode be square or rectangular, as long as it includes a sharp corner which presents the lower corner edge to the center electrode as shown in Fig. 14 or 26.

[0041] The center electrode diameter can be 0.254-3.81 mm (0.010-0.150 inches). The thickness of the electrode "stem", where applicable, can be 1.016-1.651 mm (0.040-0.065 inches), although it could be 0.254-3.81 mm (0.010-0.150 inches), or other similar dimensions.

[0042] The materials used throughout are such as known in the art, including presently-used "premium" materials (e.g., platinum).

Comparison to the Prior Art

[0043] In contrast to the '651 patent, in the present invention, the striking surface for the spark on the ground electrode has been shaped in an open concave curve, a straight line, or even a convex curve in order to clear the way for the flame kernel to expand away from the sparking point. This occurs at a microscopic level such that any hint of a concentric radius on the striking surface has a negative effect on flame kernel growth. This discovery of the extreme sensitivity of the combustion process to this striking surface radius is an important aspect of the present invention.

[0044] It is believed that concentric ring designs, no matter how minimal the length of the concentrically curved section, perform no better in practice than conventional spark plug designs. This is the substantial difference between the present invention and that described in the '651 patent. The latter always relies on a "hollow cylindrical ground electrode ... by which combustion gas can gush out from..." (Column 2, line 59).

[0045] The ground electrode spacing in the '651 patent is always spaced away from the center electrode by a gap. In the present invention, tangential relationships

are useful due to the open nature of the striking surface. Any concentric radius imparted to the striking surface in a tangential relationship would severely constrain the flame kernel generation.

[0046] Finally, the '651 patent incorporates two mounting stems which have a certain amount of shielding effect on the flame kernel, particularly when compared to the single stem of the preferred embodiment of the present invention.

Conclusion

[0047] While this invention has been described in specific detail with reference to the disclosed embodiments, it will be understood that many variations and modifications may be effected, within the scope of the invention as described in the appended claims.

Claims

1. A spark plug (10) for providing a spark within a sparking region, said spark plug when in an upright position having an upwardly-extending center electrode (20) having a cross-sectional projection with a major dimension and a height, and a ground electrode (30), the spark plug **characterized by:**

the ground electrode defining an elongate edge, said elongate edge extending further than the major dimension of the center electrode (20), said elongate edge being positioned generally tangentially relative to said cross-sectional projection of said upwardly-extending center electrode (20), said elongate edge of said ground electrode (30) having its lowest portion at or higher than the highest portion of said center electrode.

2. The spark plug of Claim 1, **characterized in that** the ground electrode (30) defines two elongate edges (34,34) combining to form a vertex (40) outside the cross-sectional projection of the center electrode.
3. The spark plug of Claim 1, **characterized in that** said elongate edge (34,34) is one of two elongate edges of the ground electrode, combining to form a vertex (41) outside the cross-sectional projection of the center electrode
4. The spark plug of Claim 1, wherein said elongate edge is substantially straight.
5. The spark plug of Claim 1, wherein said center electrode (20) has a radius, and said elongate edge (150) of said ground electrode lies along a curved path having a radius greater than said center elec-

trode and having a center of radius dissimilar than that of said center electrode.

6. The spark plug of Claim 1, **characterized in that:**

the center electrode (20) defines a center electrode edge;
 said elongate edge comprises at least one substantially straight elongate edge extending further than the major dimension of the center electrode,
 said at least one substantially straight elongate edge is spaced apart from said center electrode edge,
 said at least one substantially straight elongate edge being positioned at or above a highest portion of said center electrode edge, and
 said at least one substantially straight elongate edge also being positioned at or outside a peripheral projection of said center electrode edge,
 such that said center electrode edge and said at least one substantially straight elongate edge are presented towards each other such that said center electrode edge and said at least one substantially straight elongate edge are closest portions of the center electrode and the ground electrode within the sparking region.

7. The spark plug of Claim 1, **characterized in that** said elongate edge comprises at least one elongate edge

said at least one elongate edge is spaced apart from said center electrode edge,

said at least one elongate edge being positioned only at or above a highest portion of said center electrode edge,

said at least one elongate edge also being positioned only at or outside a peripheral projection of said center electrode edge, and

said elongate edge having portions being non-concentric with said center electrode edge,

such that said center electrode edge and said at least one elongate edge are presented towards each other such that the edges are the closest portions of the center electrode and the ground electrode within the sparking region.

8. The spark plug of Claim 1, **characterized in that:**

the ground electrode (430) comprises at least one ground electrode defining an elongate edge, the elongate edge being non-concentric with the center electrode and extending further than the major dimension of the center electrode, said at least one elongate edge being outside the projection, and a lowest portion of the ground electrode being at or higher than the

highest portion of said center electrode, so that the center electrode edge and said at least one elongate edge are closest portions of the center electrode and the ground electrode within the sparking region.

9. The spark plug of Claim 8, wherein said upwardly-extending center electrode has a substantially circular transverse cross-section having a diameter, and a ground electrode (30) defining an elongate edge at least as long as said diameter and spaced above and outside said projection and having its lowest portion at or higher than the highest portion of said electrode.

10. The spark plug of Claim 1, **characterized in that** the elongate edge is one of two elongate edges each in a substantially tangential relationship relative to said cross-sectional projection of said upwardly-extending center electrode (20), said edges combining to form one intermediate vertex outside said projection.

11. The spark plug of Claim 1, **characterized in that:**

the ground electrode (30) is box shaped and includes an end portion diverging into two prongs (32), each of said prongs including a first length portion (34) and a second length portion (34), said first length portions diverging relative to each other, and said second length portions converging relative to each other and each having one free end, said two prongs combining to provide four tangential relationships relative to the cross-sectional projection and also providing three intermediate vertexes (40,41).

12. The spark plug of Claim 1, **characterized in that** the center electrode defines at least one substantially straight and non-circular elongate edge; and said center electrode (20) edge and said ground electrode edge are in a non-concentric relationship and are closest portions of the center electrode and the ground electrode to allow for sparking therebetween.

13. The spark plug of Claim 1, **characterized in that** the ground electrode includes a main portion extending above the center electrode and diverging into two prongs (32), said prongs forming a partial box shape, said box shape including four sections (34) oriented substantially tangential to a generally circular outline defined by a periphery of said center electrode (20).

14. The spark plug as claimed in Claim 13, wherein said ground electrode (30) includes a vertex portion (40) located outside of said periphery.

15. The spark plug as claimed in Claim 14, wherein said vertex (40) is at the point of divergence of said two prongs (32).

16. The spark plug as claimed in Claim 15, such that first and third portions (34,34) are substantially parallel.

17. The spark plug as claimed in Claim 16, such that second and fourth portions (34,34) are substantially parallel.

18. A spark plug as claimed in Claim 1, **characterized in that:**

the ground electrode (51) comprises a first edge and a second edge coupled together at a vertex;

wherein the first edge, the second edge, and the vertex of the ground electrode are positioned at or outside the projection of said center electrode edge such that the first edge or the second edge of the ground electrode is the closest portion of the ground electrode to the center electrode and an outside edge of the center electrode is the closest portion of the center electrode to the ground electrode, to allow for sparking to occur between the ground electrode and the center electrode.

19. A spark plug as claimed in Claim 1, **characterized in that:**

said elongate edge is substantially straight and is spaced apart from said center electrode edge in position only at or above a highest portion of an edge of said center electrode edge, and said at least one substantially straight elongate edge also being positioned only at or outside the cross-sectional projection of said center electrode edge, such that said center electrode edge and said substantially straight elongate edge are presented towards each other such that the edges are the closest portions of the center electrode and the ground electrode within the sparking region.

20. A spark plug for providing a spark within a sparking region, said spark plug when in an upright position having a center electrode (20) and a ground electrode (30,53,60,80) extending above the center electrode, **characterized by** said ground electrode defining at least three tangential relationships relative to a cross-sectional projection of the center electrode.

21. The spark plug as claimed in Claim 20, wherein said

ground electrode defining at least four tangential relationships.

22. The spark plug as claimed in Claim 20, wherein said ground electrode, (53,80) defines at least five tangential relationships.

Patentansprüche

1. Zündkerze (10) zum Erzeugen eines Zündfunken in einem Zündfunkenbereich, wobei die Zündkerze in aufrechter Position eine sich aufwärts erstreckende zentrale Elektrode (20) mit einem Querschnittsvorsprung mit einer Haupterstreckung und einer Höhe aufweist und eine Masseelektrode (30), wobei die Zündkerze **dadurch gekennzeichnet ist, dass:**

Die Masseelektrode einen länglichen Rand festlegt; wobei sich der längliche Rand weiter erstreckt als die Hauptabmessung der zentralen Elektrode (20), wobei der längliche Rand allgemein tangential relativ zum Querschnittsvorsprung der sich nach oben erstreckenden zentralen Elektrode zu liegen kommt, wobei der längliche Rand der Masseelektrode (30) mit ihrem am weitesten unten liegenden Teil am höchsten Teil der zentralen Elektrode bzw. in einer höheren Position als dieser zu liegen kommt.

2. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass** die Masseelektrode (30) zwei längliche Ränder (34, 34) festlegt, die in Kombination einen Scheitelpunkt (40) außerhalb des Querschnittsvorsprungs der zentralen Elektrode bilden.

3. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass** der längliche Rand (34, 34) einen der zwei länglichen Ränder der Masseelektrode bildet, die in Kombination einen Scheitelpunkt (41) außerhalb des Querschnittsvorsprungs der zentralen Elektrode bilden.

4. Zündkerze nach Anspruch 1, wobei der längliche Rand im Wesentlichen gerade verläuft.

5. Zündkerze nach Anspruch 1, wobei die zentrale Elektrode (20) einen Radius aufweist, und wobei der längliche Rand (150) der Masseelektrode entlang einem gekrümmten Pfad liegt, der einen Radius aufweist, der größer ist als derjenige der zentralen Elektrode, und der einen Ursprungspunkt des Radius aufweist, der von demjenigen der zentralen Elektrode abweicht.

6. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet,**

zeichnet, dass:

Die zentrale Elektrode (20) einen zentralen Elektrodenrand festlegt, wobei der längliche Rand zumindest einen im Wesentlichen geraden länglichen Rand aufweist, der sich weiter erstreckt als die Hauptabmessung der zentralen Elektrode, der zumindest eine im Wesentlichen gerade längliche Rand von dem zentralen Elektrodenrand beabstandet ist, der zumindest eine im Wesentlichen gerade längliche Rand am höchsten Teil des zentralen Elektrodenrandes bzw. oberhalb von diesem zu liegen kommt, und der zumindest eine im Wesentlichen gerade längliche Rand am oder außerhalb des peripheren Vorsprungs des zentralen Elektrodenrands zu liegen kommt, so dass der zentrale Elektrodenrand und der zumindest eine im Wesentlichen gerade längliche Rand derart aufeinander zu weisen, dass der zentrale Elektrodenrand und der zumindest eine im Wesentlichen gerade längliche Rand die am nächsten zueinander liegenden Teile der zentralen Elektrode und der Masseelektrode in dem Funkenbildungsbereich bilden.

7. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass** der längliche Rand zumindest einen länglichen Rand umfasst, der zumindest eine längliche Rand von dem zentralen Elektrodenrand beabstandet ist, der zumindest eine längliche Rand ausschließlich am oder über dem höchsten Teil des zentralen Elektrodenrands zu liegen kommt, der zumindest eine längliche Rand außerdem ausschließlich am oder außerhalb eines peripheren Vorsprungs des zentralen Elektrodenrands zu liegen kommt, und der längliche Rand Teile aufweist, die nicht konzentrisch zu dem zentralen Elektrodenrand verlaufen, so dass der zentrale Elektrodenrand und der zumindest eine längliche Rand derart aufeinander zu weisen, dass die Ränder der am nächsten zueinander liegenden Teile der zentralen Elektrode und der Masseelektrode in dem Funkenbildungsbereich bilden.

8. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass:**

Die Masseelektrode (430) zumindest eine Masseelektrode umfasst, die einen länglichen Rand festlegt, wobei der längliche Rand nicht konzentrisch zu der zentralen Elektrode verläuft und sich weiter erstreckt als die Hauptabmessung der zentralen Elektrode, wobei der

zumindest eine längliche Rand außerhalb des Vorsprungs zu liegen kommt, und wobei ein unterster Teil der Masseelektrode am höchsten Teil der zentralen Elektrode oder höher als dieser zu liegen kommt, so dass der zentrale Elektrodenrand und der zumindest eine längliche Rand die am nächsten liegenden Teile der zentralen Elektrode und der Masseelektrode innerhalb des Funkenbildungsbereichs bilden.

9. Zündkerze nach Anspruch 8, wobei die sich aufwärts erstreckende zentrale Elektrode einen im Wesentlichen kreisförmigen Querschnitt mit einem Durchmesser aufweist, und die Masseelektrode (30) einen länglichen Rand aufweist, der zumindest so lang ist wie der Durchmesser und beabstandet über sowie außerhalb des Vorsprungs liegt und der mit seinem untersten Teil am höchsten Teil der Elektrode oder höher als diese zu liegen kommt.

10. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass** der längliche Rand einer von zwei länglichen Rändern ist, die jeweils in einer im Wesentlichen tangentialen Beziehung zu dem Querschnittsvorsprung der sich aufwärts erstreckenden zentralen Elektrode (20) stehen, wobei die Ränder zur Bildung eines Zwischenscheitelpunkts außerhalb des Vorsprungs in Verbindung stehen.

11. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass:**

Die Masseelektrode (30) kastenförmig bzw. schraubenschlüsselförmig ist und einen Endabschnitt aufweist, der in zwei Zinken (32) auseinander läuft, wobei jeder der Zinken einen ersten Längenabschnitt (34) und einen zweiten Längenabschnitt (34) aufweist, wobei die ersten Längenabschnitte relativ zueinander auseinander laufen, und wobei die zweiten Längenabschnitte relativ zueinander aufeinander zu laufen und jeweils ein freies Ende aufweisen, wobei die zwei Zinken zur Bereitstellung von vier tangentialen Beziehungen relativ zu dem Querschnittsvorsprung miteinander in Verbindung stehen und außerdem drei Zwischenscheitelpunkte (40, 41) bereitstellen.

12. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass** die zentralen Elektrode einen zumindest im Wesentlichen geraden und nicht kreisförmigen länglichen Rand festlegen, und der zentrale Elektrodenrand (20) und der Masseelektrodenrand sich in einer nicht konzentrischen Beziehung befinden und die am nächsten liegenden Teile der zentralen Elektrode und der Masseelektrode bilden, um dazwischen Funkenbildung zu ermöglichen.

13. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass** die Masseelektrode einen Hauptabschnitt enthält, der sich über der zentralen Elektrode erstreckt und in zwei Zinken (32) auseinander läuft, wobei die Zinken eine Teilkastenform bzw. Teilschraubenschlüsselform bilden, wobei die Kastenform vier Abschnitte (34) umfasst, die im Wesentlichen tangential zu einem allgemein kreisförmigen Umriss ausgerichtet sind, der durch eine Peripherie der zentralen Elektrode (20) festgelegt ist.

14. Zündkerze nach Anspruch 13, wobei die Masseelektrode (30) einen außerhalb der Peripherie angeordneten Scheitelpunktabschnitt (40) aufweist.

15. Zündkerze nach Anspruch 14, wobei sich der Scheitelpunkt (40) in einem Auseinanderlaufpunkt der beiden Zinken (32) befindet.

16. Zündkerze nach Anspruch 15, wobei die ersten und dritten Abschnitte (34, 34) im Wesentlichen parallel verlaufen.

17. Zündkerze nach Anspruch 16, wobei die zweiten und vierten Abschnitte (34, 34) im Wesentlichen parallel verlaufen.

18. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass:**

Die Masseelektrode (51) einen ersten Rand und einen zweiten Rand umfasst, die in einem Scheitelpunkt miteinander verbunden sind,

wobei der erste Rand, der zweite Rand und der Scheitelpunkt der Masseelektrode am oder außerhalb des Vorsprungs des zentralen Elektrodenrands derart angeordnet sind, dass der erste Rand bzw. der zweite Rand der Masseelektrode der am nächsten liegende Teil der Masseelektrode zu der zentralen Elektrode ist und ein Außenrand der zentralen Elektrode den am nächsten liegenden Teil der zentralen Elektrode zu der Masseelektrode bildet, um eine Funkenbildung zwischen der Masseelektrode und der zentralen Elektrode zu ermöglichen.

19. Zündkerze nach Anspruch 1, **dadurch gekennzeichnet, dass:**

Der längliche Rand im Wesentlichen gerade verläuft und von dem zentralen Elektrodenrand in einer Position beabstandet ist, der sich am höchsten Teil oder über diesem eines Rands des zentralen Elektrodenrands befindet, und sich der zumindest eine im Wesentlichen gerade längliche Rand außerdem ausschließlich am oder außerhalb des Querschnittsvor-

sprungs des zentralen Elektrodenrands befindet,

so dass der zentrale Elektrodenrand und der im Wesentlichen gerade längliche Rand derart aufeinander zu weisen, dass die Ränder die am nächsten zueinander liegenden Teile der zentralen Elektrode und der Masseelektrode innerhalb des Funkenbildungsbereichs bilden.

20. Zündkerze zur Erzeugung eines Funkens in einem Funkenbildungsbereich, wobei die Zündkerze in aufrechter Stellung eine zentrale Elektrode (20) und eine Masseelektrode (30, 53, 60, 80) aufweist, die sich über der zentralen Elektrode erstreckt, **dadurch gekennzeichnet, dass** die Masseelektrode zumindest drei tangentielle Beziehungen relativ zu einem Querschnittsvorsprung der zentralen Elektrode festlegt.

21. Zündkerze nach Anspruch 20, wobei die Masseelektrode zumindest vier tangentielle Beziehungen festlegt.

22. Zündkerze nach Anspruch 20, wobei die Masseelektrode (53, 80) zumindest fünf tangentielle Beziehungen festlegt.

Revendications

1. Bougie d'allumage (10) destinée à fournir une étincelle au sein d'une zone d'étincelles, ladite bougie d'allumage ayant, en position verticale, une électrode centrale (20) s'étirant vers le haut et présentant en coupe droite une saillie dotée d'une dimension principale et d'une hauteur, ainsi qu'une électrode de masse (30), la bougie d'allumage **se caractérisant en ce que :**

l'électrode de masse définit une borne allongée qui s'étire au-delà de la dimension principale de l'électrode centrale (20), ladite borne allongée formant généralement une tangente par rapport à la saillie en coupe droite de ladite électrode centrale (20) s'étirant vers le haut, la partie la plus basse de ladite borne allongée de ladite électrode de masse (30) se trouvant au niveau ou au-dessus de la partie la plus haute de ladite électrode centrale.

2. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** l'électrode de masse (30) définit deux bornes allongées (34, 34) se combinant pour former un sommet (40) à l'extérieur de la saillie en coupe droite de l'électrode centrale.

3. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** ladite borne allongée (34, 34) est

l'une des deux bornes allongées de l'électrode de masse, se combinant pour former un sommet (41) à l'extérieur de la saillie en coupe droite de l'électrode centrale.

4. Bougie d'allumage selon la revendication 1, dans laquelle ladite borne allongée est sensiblement rectiligne.

5. Bougie d'allumage selon la revendication 1, dans laquelle ladite électrode centrale (20) possède un rayon, et ladite borne allongée (150) de ladite électrode de masse suit un trajet incurvé dont le rayon est plus grand que celui de ladite électrode centrale et dont le centre du rayon est différent de celui de ladite électrode centrale.

6. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** :

l'électrode centrale (20) définit une borne d'électrode centrale ;

ladite borne allongée comprend au moins une borne allongée sensiblement rectiligne s'étirant au-delà de la dimension principale de l'électrode centrale,

ladite au moins une borne allongée sensiblement rectiligne est écartée de ladite borne d'électrode centrale,

ladite au moins une borne allongée sensiblement rectiligne étant placée au niveau ou au-dessus de la partie la plus haute de ladite borne d'électrode centrale, et

ladite au moins une borne allongée sensiblement rectiligne étant également placée au niveau ou à l'extérieur d'une saillie périphérique de ladite borne d'électrode centrale, de sorte que ladite borne d'électrode centrale et ladite au moins une borne allongée sensiblement rectiligne se présentent en vis-à-vis, afin qu'ainsi ladite borne d'électrode centrale et ladite au moins une borne allongée sensiblement rectiligne constituent les parties les plus rapprochées de l'électrode centrale et de l'électrode de masse, au sein de la zone d'étincelles.

7. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** ladite borne allongée comprend au moins une borne allongée

ladite au moins une borne allongée est écartée de ladite borne d'électrode centrale,

ladite au moins une borne allongée étant placée uniquement au niveau ou au-dessus de la partie la plus haute de ladite borne d'électrode centrale,

ladite au moins une borne allongée étant aussi placée uniquement au niveau ou à l'extérieur d'une saillie périphérique de ladite borne d'électrode centrale, et

ladite borne allongée présentant des parties non concentriques par rapport à ladite borne d'électrode centrale,

de sorte que ladite borne d'électrode centrale et ladite au moins une borne allongée se présentent en vis-à-vis, afin qu'ainsi les bornes constituent les parties les plus rapprochées de l'électrode centrale et de l'électrode de masse, au sein de la zone d'étincelles.

8. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** :

l'électrode de masse (430) comprend au moins une électrode de masse définissant une borne allongée, cette dernière n'étant pas concentrique par rapport à l'électrode centrale et s'étirant au-delà de la dimension principale de l'électrode centrale, ladite au moins une borne allongée étant à l'extérieur de la saillie, et la partie la plus basse de l'électrode centrale se trouvant au niveau ou au-dessus de la partie la plus haute de ladite électrode centrale, de sorte que la borne d'électrode centrale et ladite au moins une borne allongée constituent les parties les plus rapprochées de l'électrode centrale et de l'électrode de masse, au sein de la zone d'étincelles.

9. Bougie d'allumage selon la revendication 8, dans laquelle l'électrode centrale s'étirant vers le haut présente une section transversale sensiblement circulaire ayant un diamètre, et une électrode de masse (30) définissant une borne allongée d'une longueur au moins égale audit diamètre, écartée au-dessus et à l'extérieur de ladite saillie et dont la partie la plus basse se trouve au niveau ou au-dessus de la partie la plus haute de ladite électrode.

10. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** la borne allongée est l'une des deux bornes allongées formant chacune sensiblement une tangente par rapport à ladite saillie en coupe droite de ladite électrode centrale s'étirant vers le haut (20), lesdites bornes se combinant pour former un sommet intermédiaire à l'extérieur de ladite saillie.

11. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** :

l'électrode de masse (30) est de forme rectangulaire et comprend une partie extrême se séparant en deux branches (32), chacune desdites branches comprenant une première longueur (34) et une seconde longueur (34), lesdites premières longueurs s'écartant l'une de l'autre, et lesdites secondes longueurs conver-

geant l'une vers l'autre et présentant chacune une extrémité libre, lesdites deux branches se combinant pour ménager quatre points de tangente par rapport à la saillie en coupe droite, et formant également trois sommets intermédiaires (40, 41).

12. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** l'électrode centrale définit au moins une borne allongée sensiblement rectiligne et non circulaire ; et

ladite borne d'électrode centrale (20) et ladite borne d'électrode de masse sont en relation non concentrique et constituent les parties les plus rapprochées de l'électrode centrale et de l'électrode de masse afin de permettre entre elles la production d'étincelles.

13. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** l'électrode de masse comprend une partie principale s'étirant au-dessus de l'électrode centrale et se séparant en deux branches (32), lesdites branches constituant une forme rectangulaire partielle, ladite forme rectangulaire comprenant quatre sections (34) orientées en formant sensiblement une tangente par rapport au pourtour généralement circulaire défini par la périphérie de ladite électrode centrale (20).

14. Bougie d'allumage selon la revendication 13, dans laquelle ladite électrode de masse (30) comprend une partie en sommet (40) située à l'extérieur de ladite périphérie.

15. Bougie d'allumage selon la revendication 14, dans laquelle ledit sommet (40) se trouve au point de divergence desdites deux branches (32).

16. Bougie d'allumage selon la revendication 15, conçue de sorte que la première et la troisième parties (34, 34) soient sensiblement parallèles.

17. Bougie d'allumage selon la revendication 16, conçue de sorte que la deuxième et la quatrième parties (34, 34) soient sensiblement parallèles.

18. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** :

l'électrode de masse (51) comprend une première borne et une seconde borne se rejoignant au niveau d'un sommet ;

dans laquelle la première borne, la seconde borne et le sommet de l'électrode de masse sont placés au niveau ou à l'extérieur de la saillie de ladite borne d'électrode centrale, de sorte que la première ou la seconde borne de l'électrode de masse

constitue la partie de l'électrode de masse la plus rapprochée de l'électrode centrale, et qu'une borne extérieure de l'électrode centrale constitue la partie de l'électrode centrale la plus rapprochée de l'électrode de masse, afin de permettre la production d'étincelles entre l'électrode de masse et l'électrode centrale.

19. Bougie d'allumage selon la revendication 1, **caractérisée en ce que** :

ladite borne allongée est sensiblement rectiligne et écartée de ladite borne d'électrode centrale en étant placée uniquement au niveau ou au-dessus de la partie la plus haute d'une borne de ladite borne d'électrode centrale, et ladite au moins une borne allongée sensiblement rectiligne étant aussi placée uniquement au niveau ou à l'extérieur de la saillie en coupe droite de ladite borne d'électrode centrale, de sorte que ladite borne d'électrode centrale et ladite borne allongée sensiblement rectiligne se présentent en vis-à-vis, afin qu'ainsi les bornes constituent les parties les plus rapprochées de l'électrode centrale et de l'électrode de masse, au sein de la zone d'étincelles.

20. Bougie d'allumage destinée à fournir une étincelle au sein d'une zone d'étincelles, ladite bougie d'allumage présentant, en position verticale, une électrode centrale (20) et une électrode de masse (30, 53, 60, 80) s'étirant au-dessus de l'électrode centrale, **caractérisée en ce que** ladite électrode de masse définit au moins trois points de tangente par rapport à la saillie en coupe droite de l'électrode centrale.

21. Bougie d'allumage selon la revendication 20, dans laquelle ladite électrode de masse définit au moins quatre points de tangente.

22. Bougie d'allumage selon la revendication 20, dans laquelle ladite électrode de masse (53, 80) définit au moins cinq points de tangente.

FIG. 1

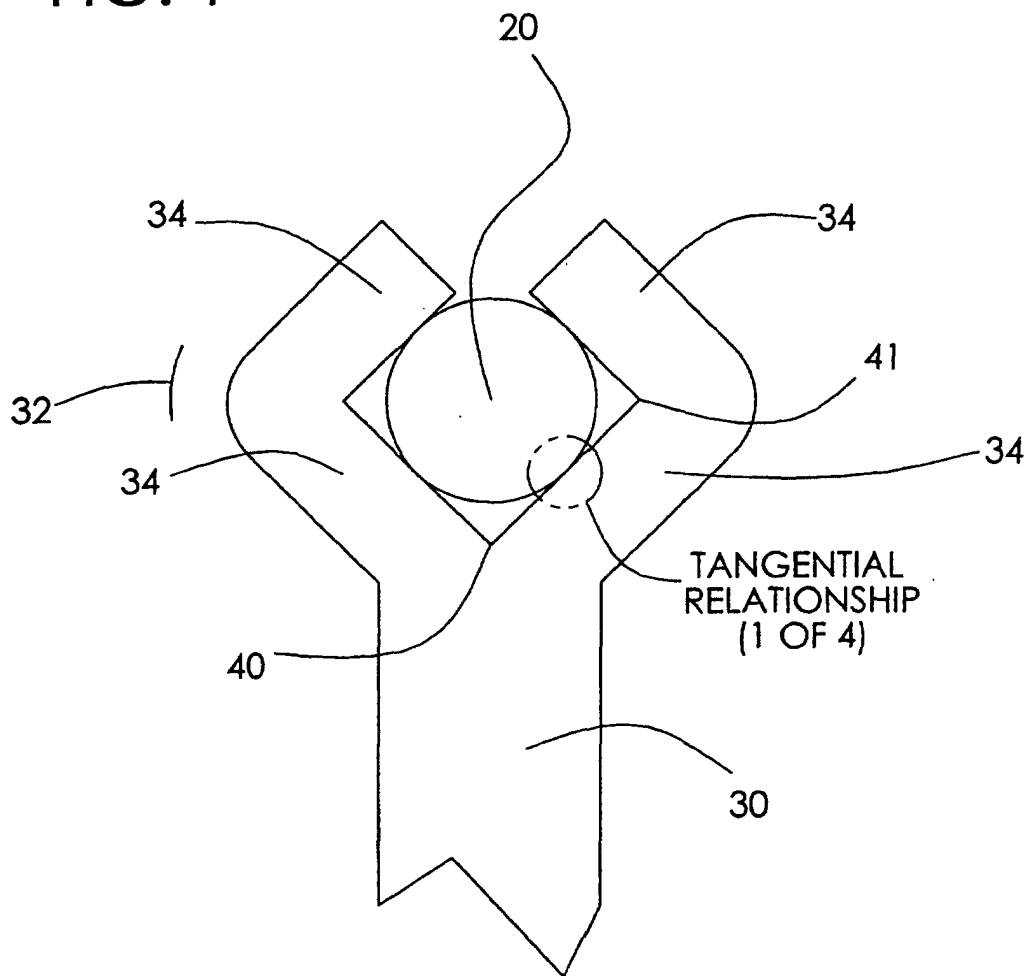


FIG. 2

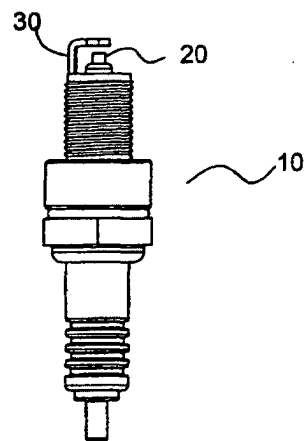


FIG. 3

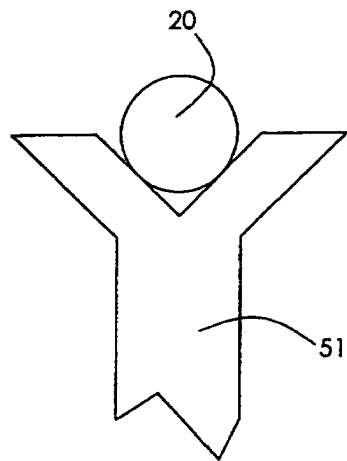


FIG. 4

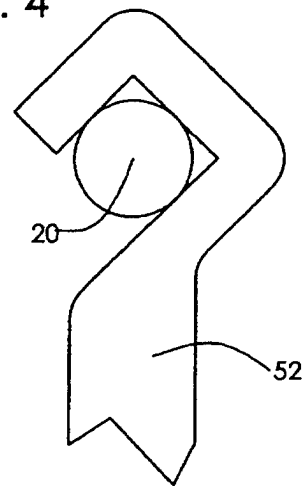


FIG. 5

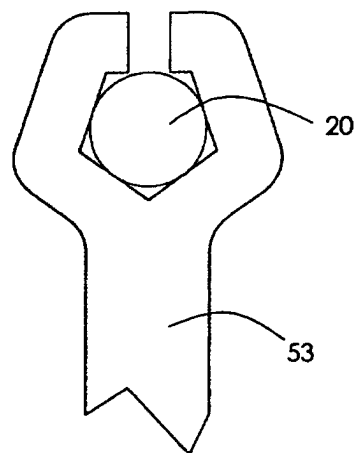


FIG. 6

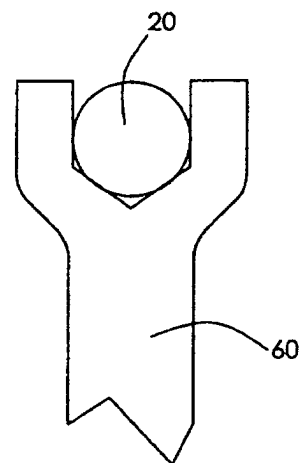


FIG. 7

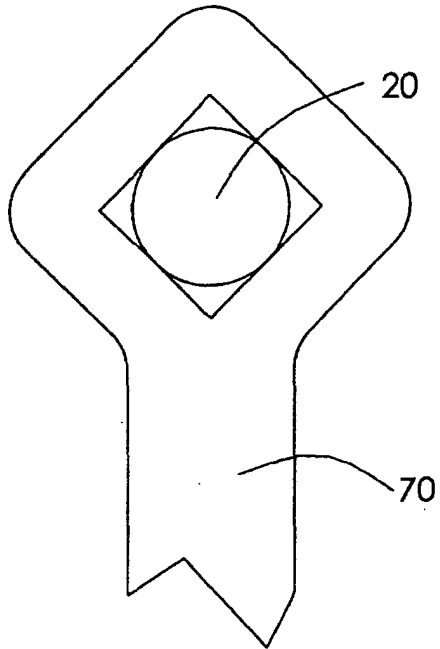


FIG. 8

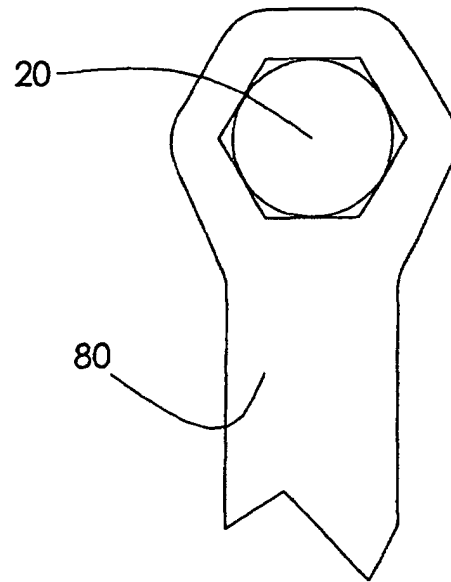


FIG. 9

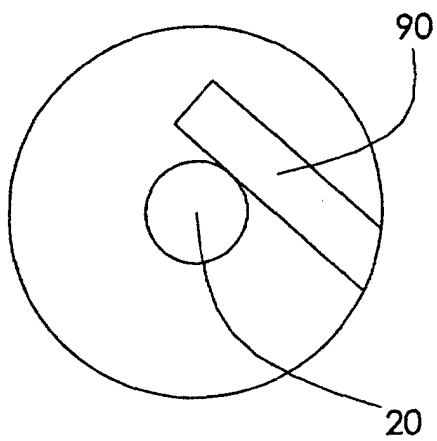


FIG. 10

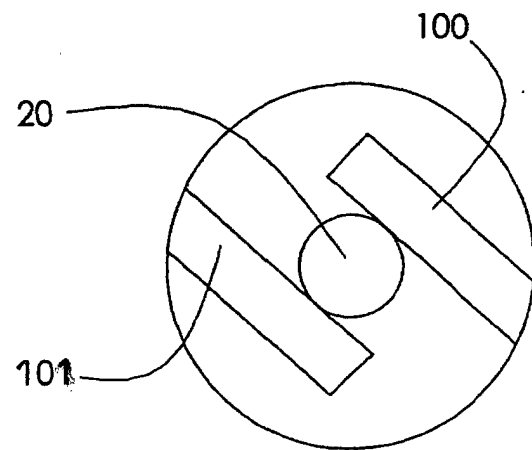


FIG. 11

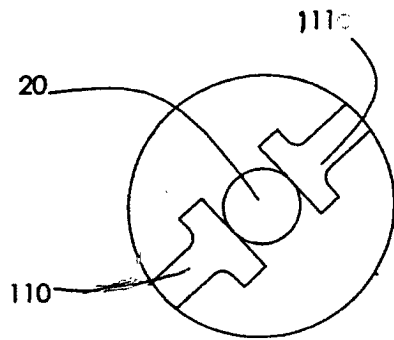


FIG. 12

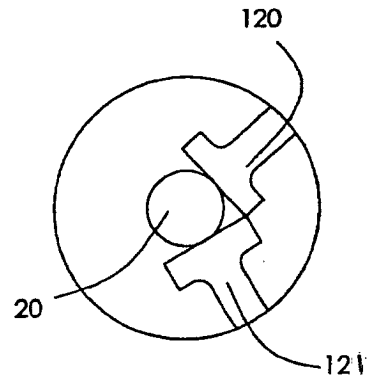


FIG. 13

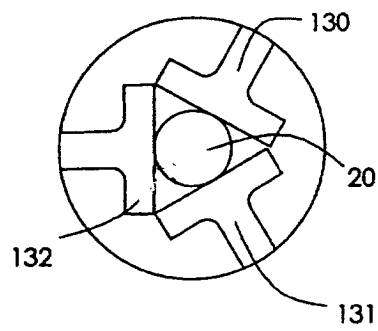


FIG. 14

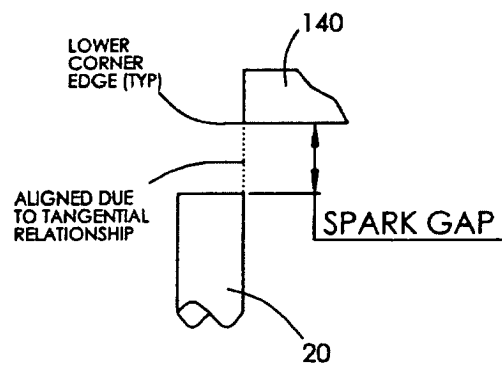


FIG. 15

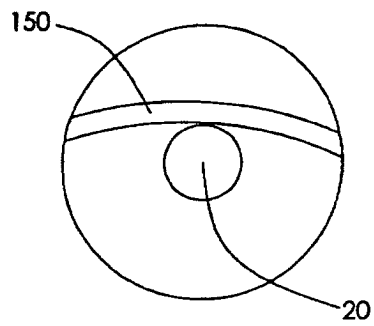


FIG. 16

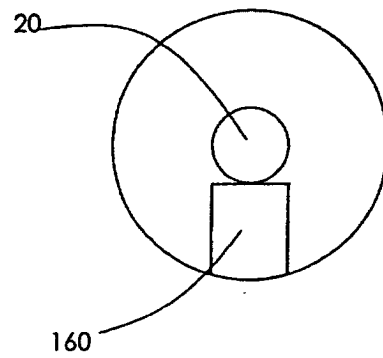


FIG. 17

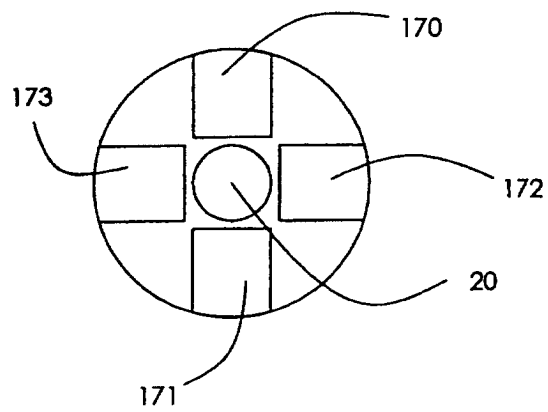


FIG. 18

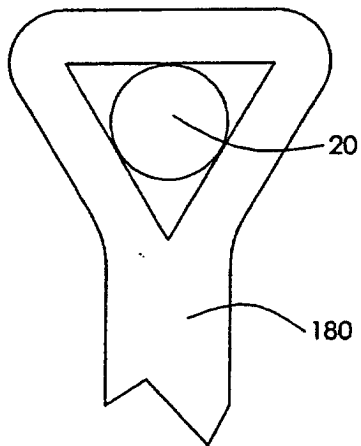


FIG. 19

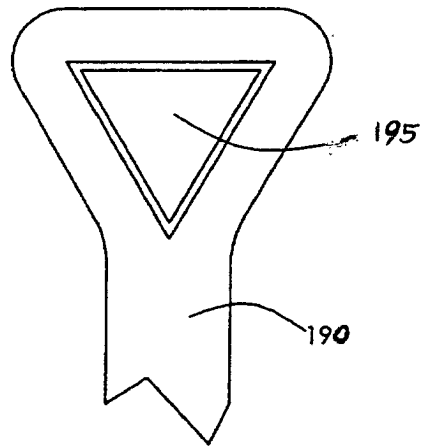


FIG. 20

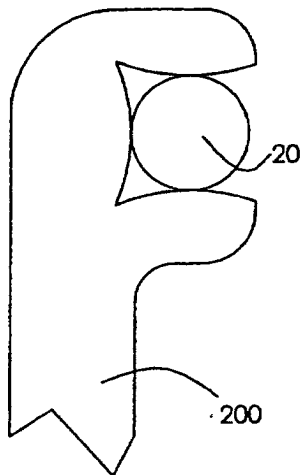


FIG. 21

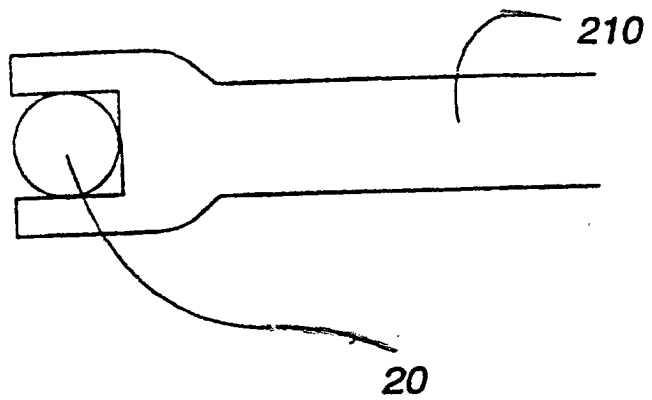


FIG. 22

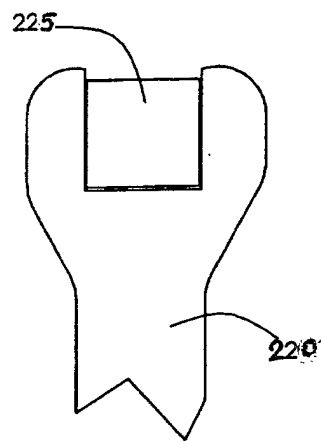


FIG. 23

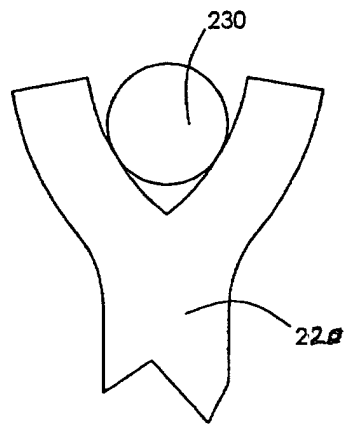


FIG. 24

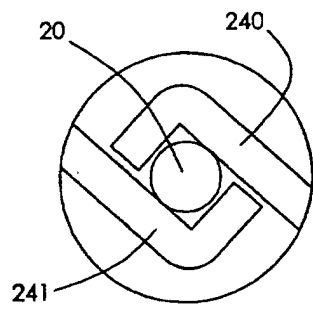


FIG. 25

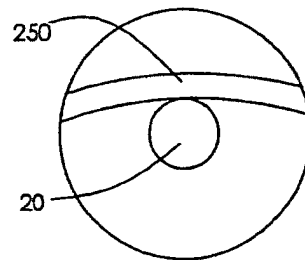


FIG. 26

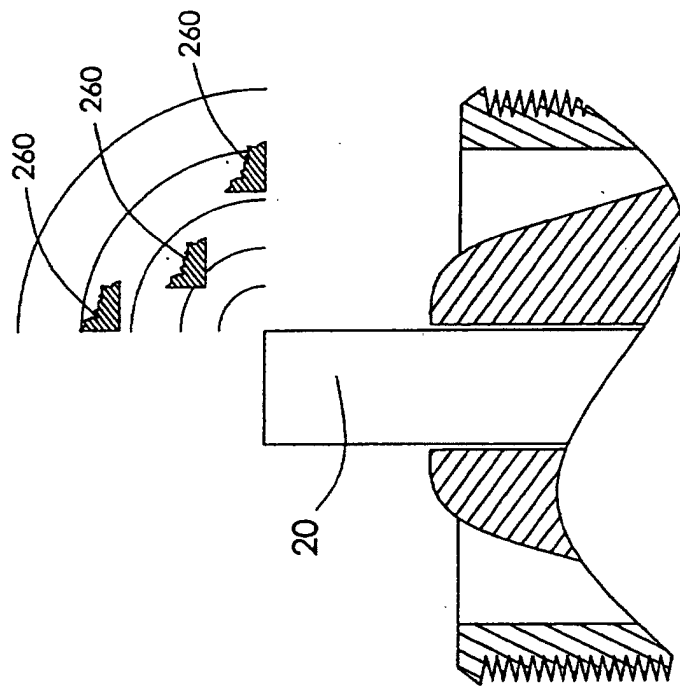


FIG. 27

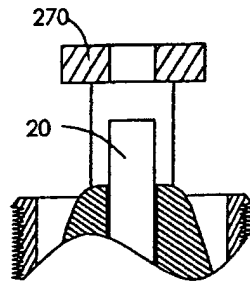


FIG. 28

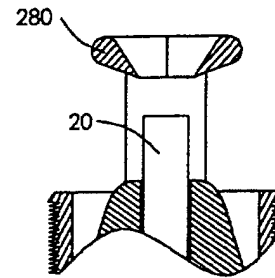


FIG. 29

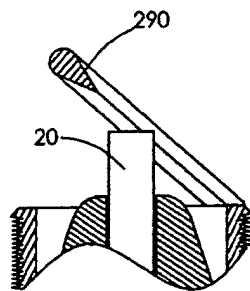


FIG. 30

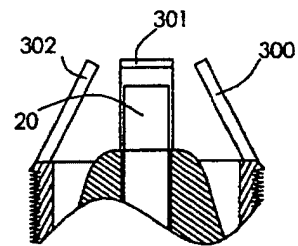


FIG. 31

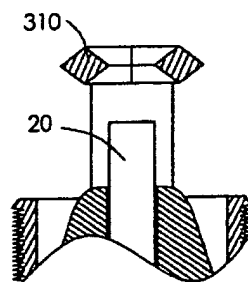


FIG. 32

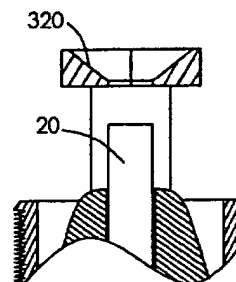


FIG. 33

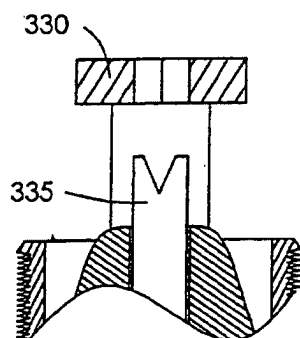


FIG. 34

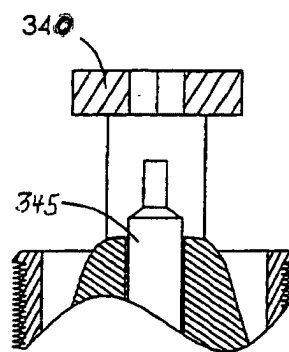
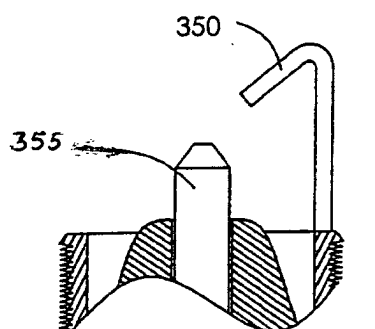
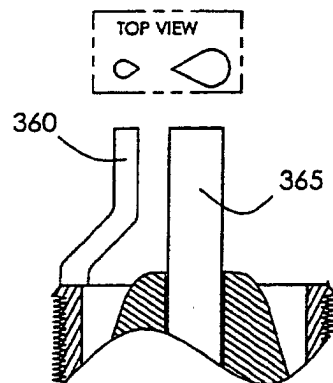


FIG. 35



not according to the invention

FIG. 36



not according to the invention

FIG. 37

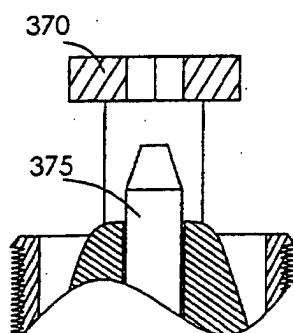


FIG. 38

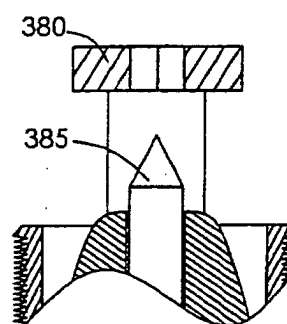


FIG. 39

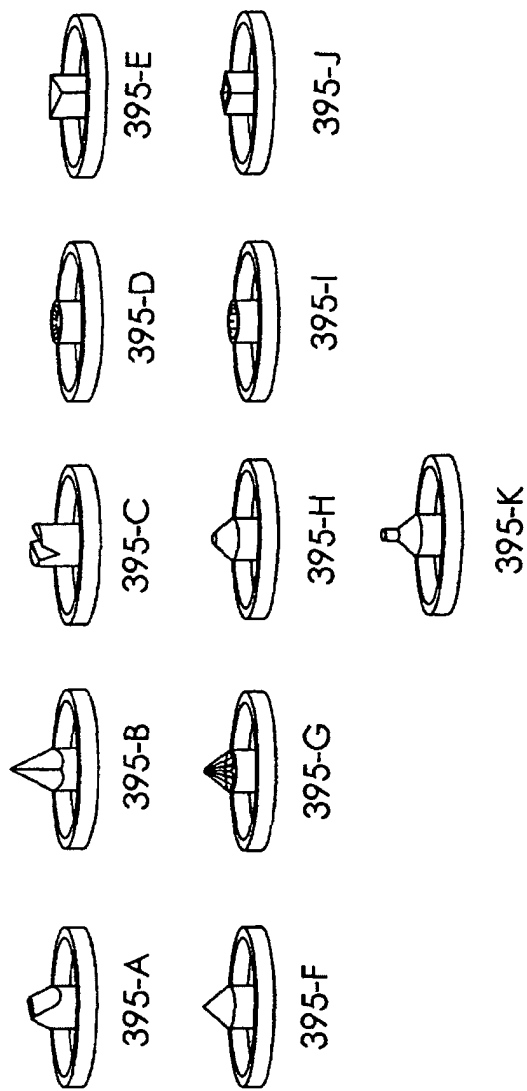


FIG. 41A

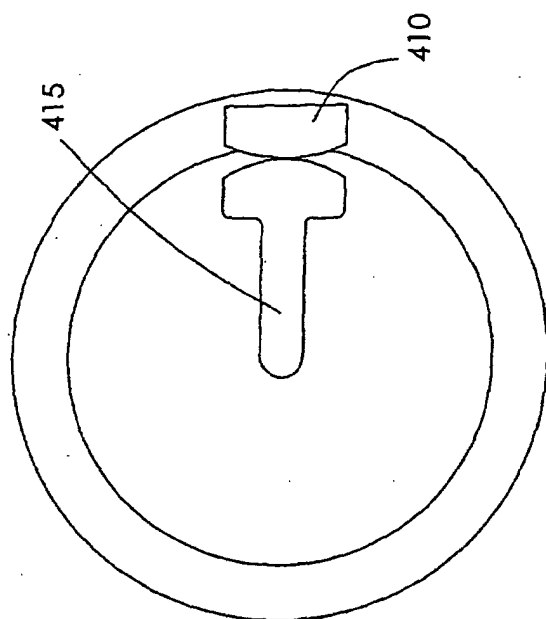


FIG. 41B

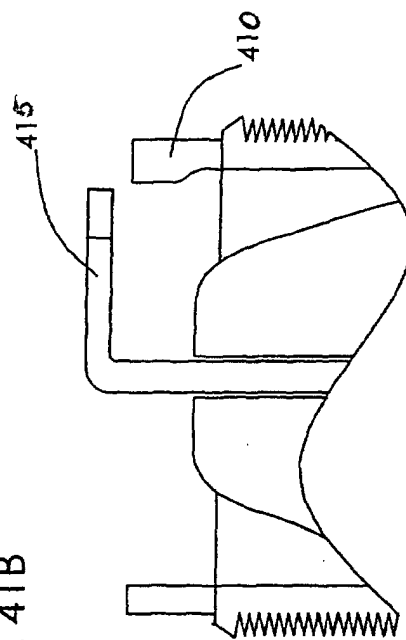
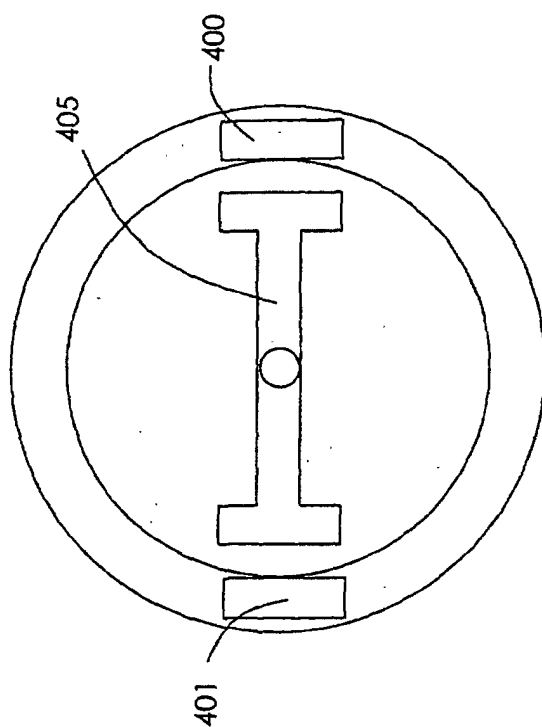
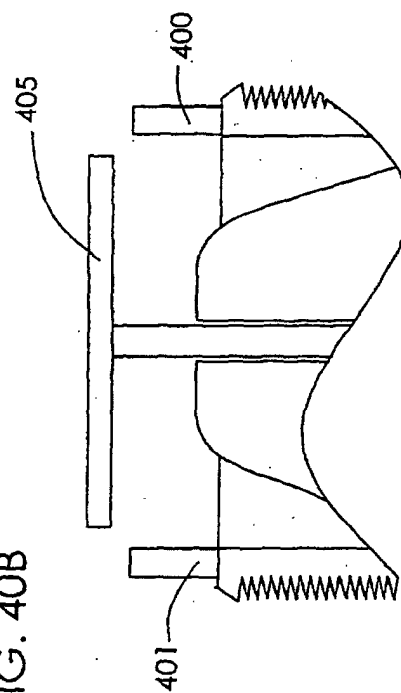


FIG. 40A



not according to the invention

FIG. 40B



not according to the invention

FIG. 42A

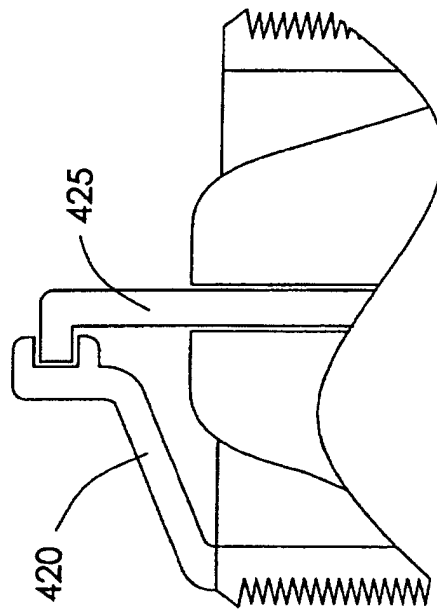


FIG. 42B

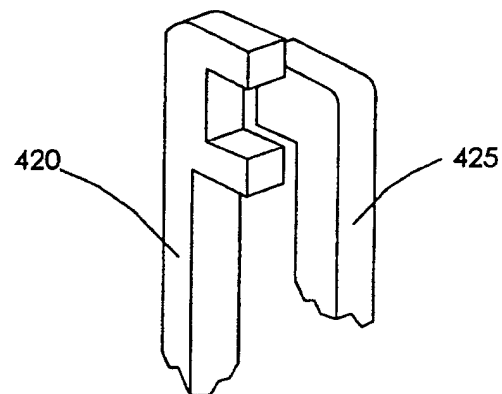


FIG. 43

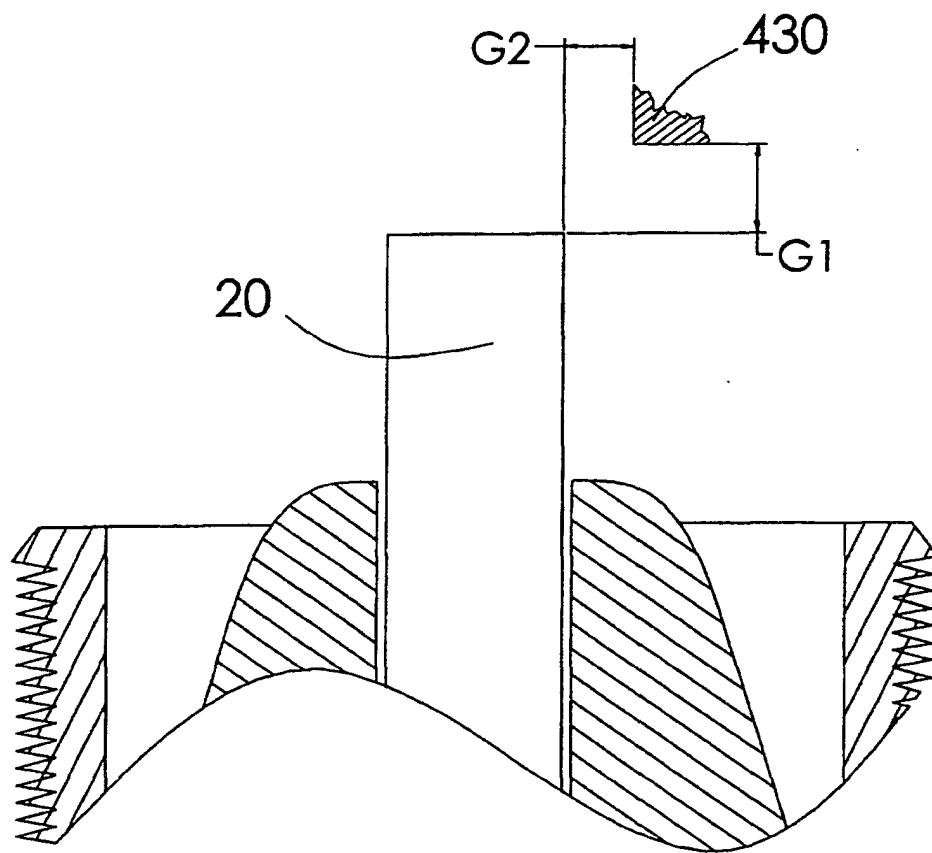


FIG. 44

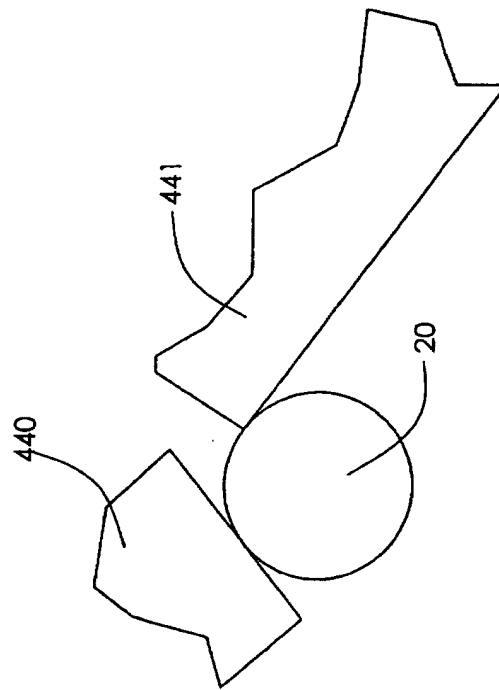


FIG 45

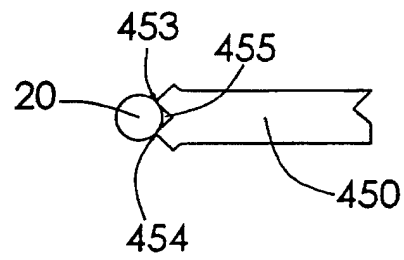


FIG. 46

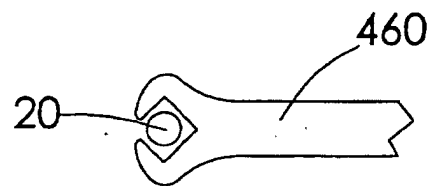


FIG. 47

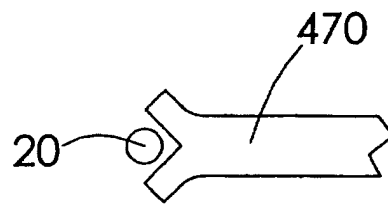


FIG. 48A

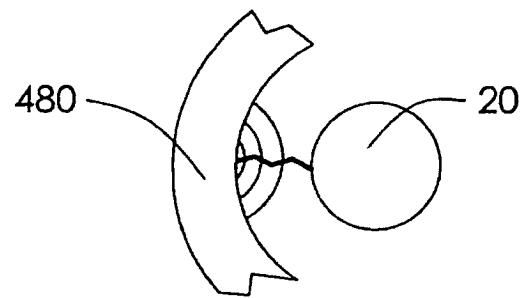


FIG. 48B

