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Anthony et al.

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[54] **SPARK PLUG AND ROTOR ASSEMBLY FOR A ROTARY COMBUSTION ENGINE**

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[52] **U.S. Cl.**................ **123/8.01**, 123/8.09, 123/8.45

[51] **Int. Cl.** .. **F02b 53/00**, F02b 53/12, F02b 55/00

[58] **Field of Search**.................. 123/8.01, 8.45, 8.09

[56] **References Cited**

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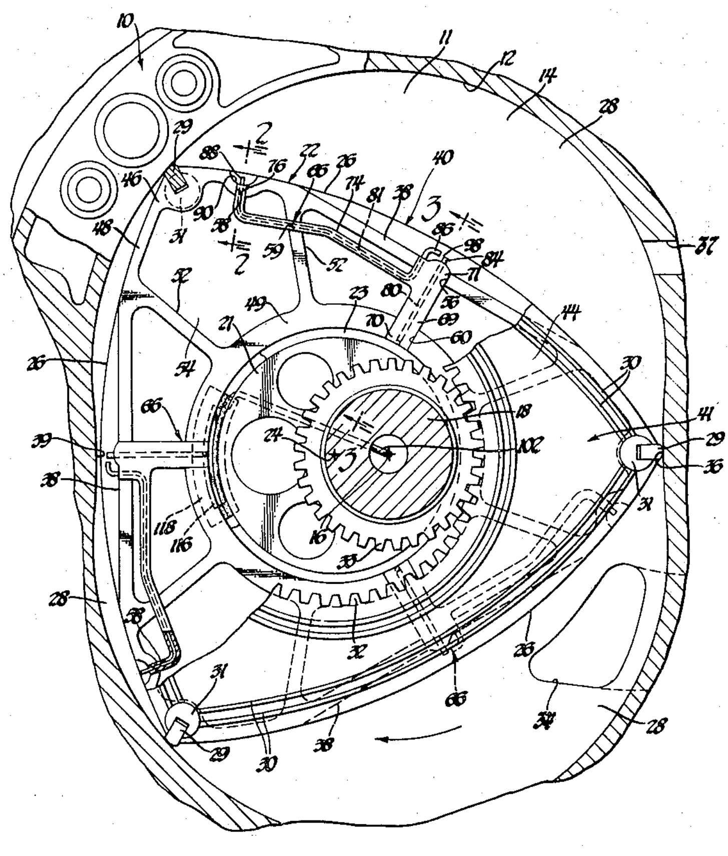
[57] **ABSTRACT**

A spark plug and rotor assembly for a rotary combustion engine having two rotor parts with mating interfaces with one rotor part having an integral phasing gear and the other rotor part being hollow and having an integral hub and an axially extending coolant passage therethrough and a spark plug for each chamber face of the rotor mounted in the interface of the hollow rotor part prior to joining this interface with the interface of the other rotor part.

3 Claims, 5 Drawing Figures



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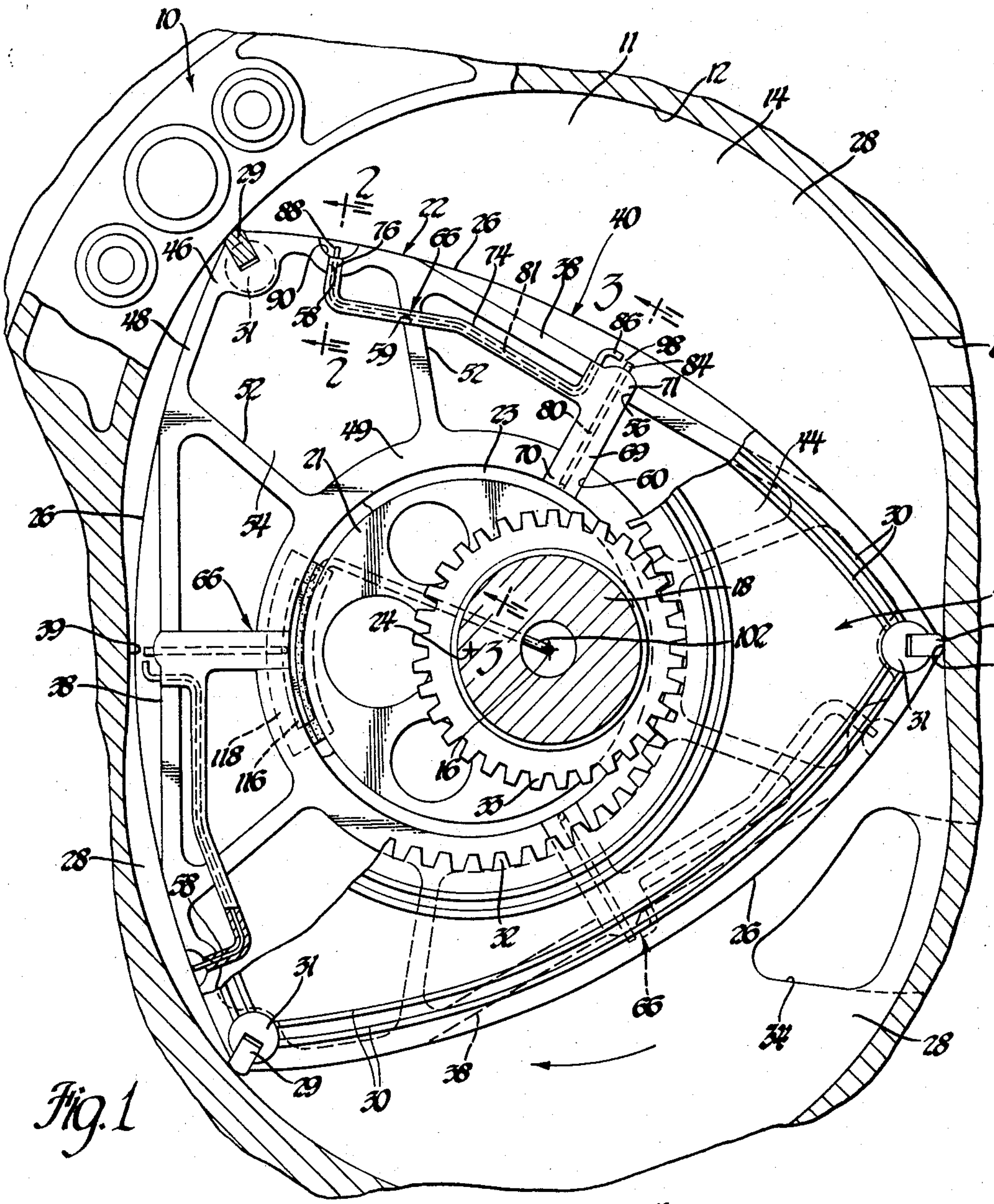

Fig. 1

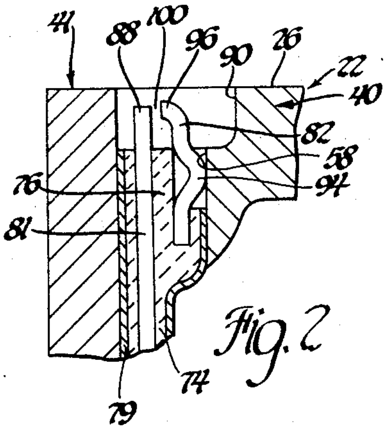

Fig. 2

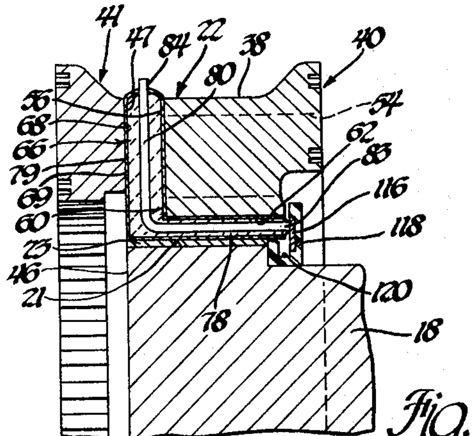

Fig. 3

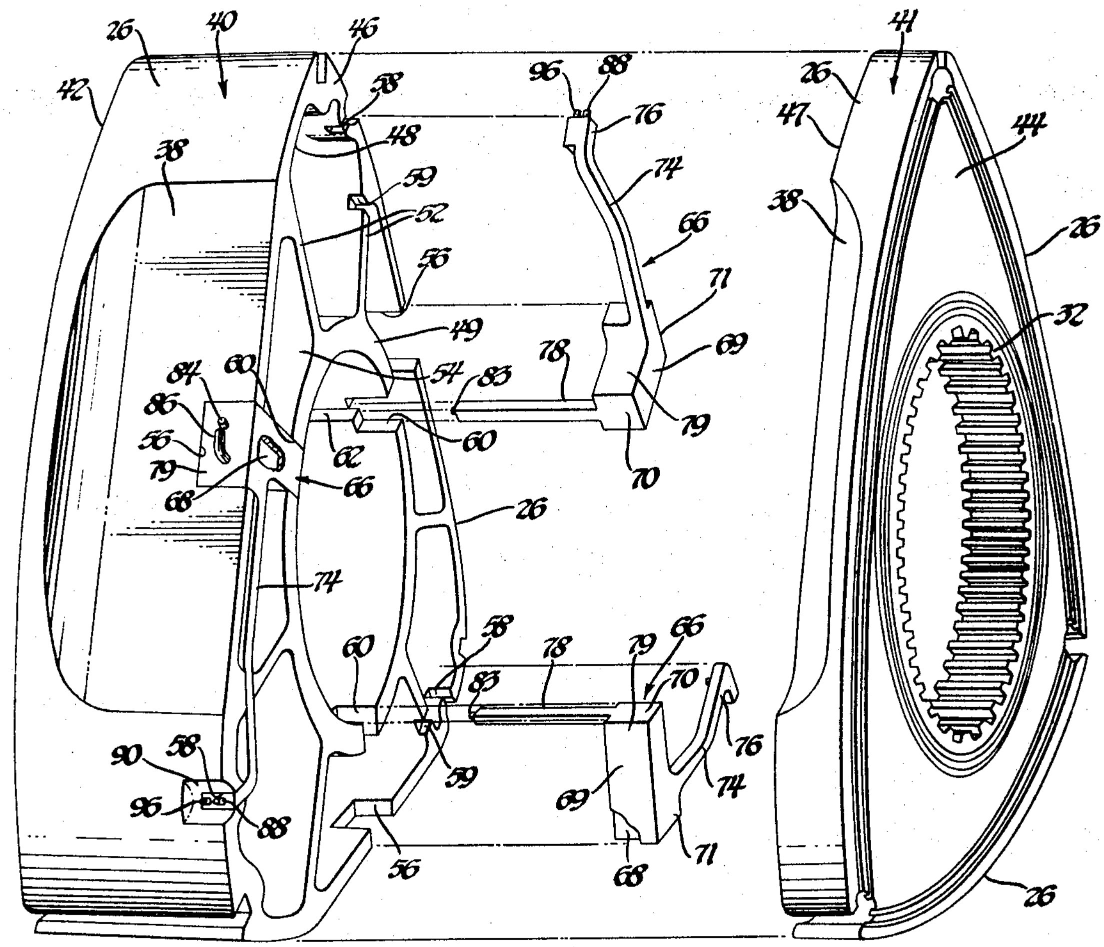

Fig. 4

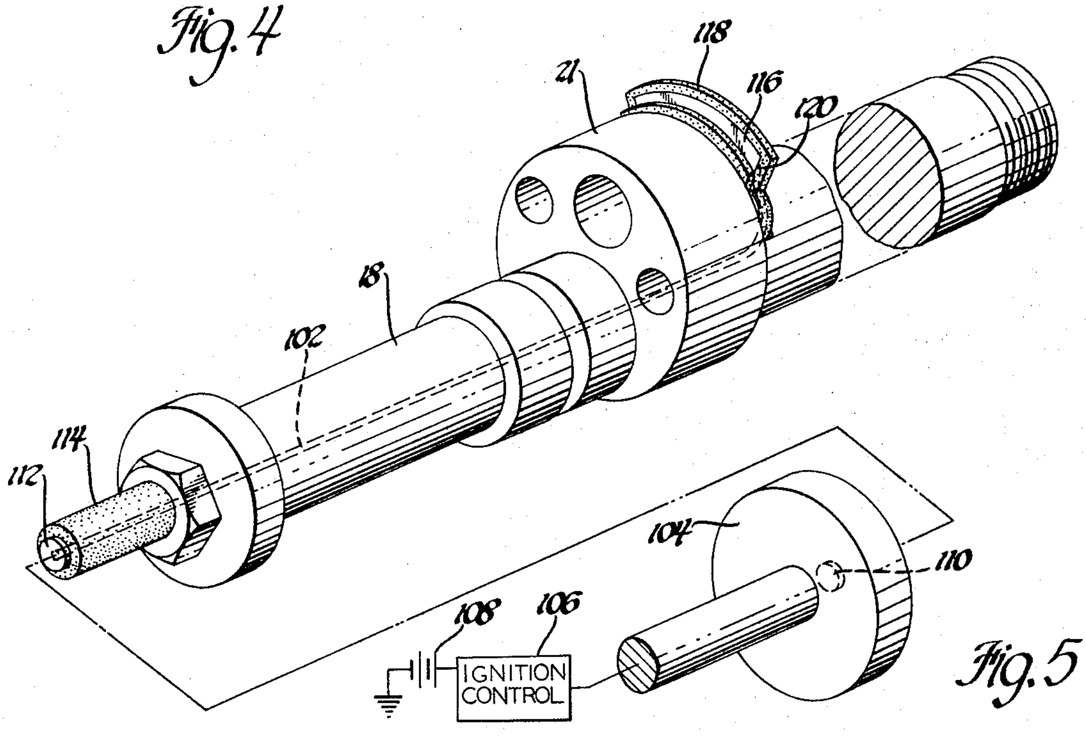

Fig. 5

SPARK PLUG AND ROTOR ASSEMBLY FOR A ROTARY COMBUSTION ENGINE

This invention relates to a spark plug and rotor assembly for a rotary combustion engine and more particularly to permanent integration of the spark plugs into a rotor.

In rotary combustion engines of the Wankel type, it is present commercial practice to have one or more conventional spark plugs mounted in the engine housing with each spark plug electrode exposed through a shooter hole to the rotor cavity to ignite fuel in the engine's working chambers that are spaced about and move with the engine's rotor. Where the rotor's apex seals traverse a spark plug shooter hole, there results a leak path for the compressed gases which lowers engine efficiency. Furthermore, when a spark plug is located in the rotor housing there is a loss of cooling and a resulting hot spot in this area due to the spark plug boss. One way of avoiding such gas leakage and also this hot spot in the housing is to mount spark plugs on the rotor wherein there is at least one spark plug for every rotor face or flank. However, in attempting to locate the spark plugs on the rotor, it has been found that conventional spark plugs with their attendant mounting bosses substantially complicate the construction of the rotor itself in addition to adding considerable mass that requires cooling and lowers the rotor speed limit.

The spark plug and rotor assembly according to the present invention comprises a pair of separately formed metal rotor parts having mating interfaces. One of these rotor parts has an integral hub portion determining an axis about which the rotor rotates with this hub portion and the peripheral face portions of this one rotor part having axially extending space therebetween for the passage of coolant through the rotor when the two rotor parts are mated. The other rotor part has an internal toothed gear concentric with the hub portion of the other rotor part to which it is later joined at the interfaces. The interface of the hollow rotor part has a spark plug recess for every face portion or flank that opens to one face portion and a spark plug is mounted in and fills each of these spark plug recesses in the interface of the hollow rotor part. Each spark plug comprises a high voltage wire or electrode which is encased in a ceramic body that is covered by a thin layer of metal with the electrode having a terminal end for receiving an electrical ignition pulse and a spark end projecting out through the opening past the rotor face portion and spaced a spark distance from a rotor grounded electrode. With these spark plugs in position in the recesses in the hollow rotor part, the two rotor parts are then mated and they and the spark plugs are brazed at their seams to provide an integral construction. Where more than one spark is desired for each working chamber, the ceramic body of each spark plug has a branch extending therefrom leading out another opening in the rotor face peripherally spaced from the other opening therethrough. In the multispark spark plug a second electrode extends through the branch with one spark end spaced a spark distance from the spark end of the first electrode and another spark end projecting out through the other opening past the rotor face portion spaced a spark distance from the grounded electrode. As compared with conventional spark plugs, this integration of the present spark plugs adds considerably less mass, yet the rotor is simple and easy to manufacture which contributes to reducing cost.

An object of the present invention is to provide a new and improved spark plug and rotor assembly for a rotary combustion engine.

Another object is to provide for a rotary combustion engine a two-piece rotor with an integral spark plug for each rotor face integrated with the rotor construction.

Another object is to provide a spark plug and multipiece rotor assembly for a rotary combustion engine which combines a spark plug at each rotor face during rotor fabrication wherein each spark plug comprises an electrode encased in a ceramic body which is covered by a layer of material that is bonded between the rotor parts.

Another object is to provide an integral spark plug and rotor construction wherein one of two rotor parts having mating interfaces has a spark plug recess in its interface receiving a spark plug for every rotor face which is joined to the rotor parts when they are joined.

These and other objects of the present invention will become more apparent from the following description and drawing in which:

FIG. 1 is a partial view of a rotary combustion engine having a spark plug and rotor assembly according to the present invention with parts broken away to show certain details of construction.

FIG. 2 is a partial view of the spark plug and rotor assembly along the line 2—2 in FIG. 1.

FIG. 3 is a partial view of the spark plug and rotor assembly along the line 3—3 in FIG. 1.

FIG. 4 is an exploded view of the spark plug and rotor assembly of FIG. 1.

FIG. 5 is a perspective view of the rotor's crankshaft in FIG. 1 with portions of the ignition system shown schematically.

Referring to FIG. 1, the spark plug and rotor assembly according to the present invention is illustrated for use in a rotary combustion engine of the Wankel type comprising a stationary outer body or housing **10.** The housing **10** has a cavity **11** that is defined by an inwardly facing peripheral wall **12** and a pair of axially spaced opposed end walls **14** of which only one is shown. The peripheral wall **12** is in the shape of a two-lobed epitrochoid or a curve parallel thereto whose center is indicated at **16.** A crankshaft **18** extends through the cavity **11** and is rotatably supported by the housing **10** in the end walls **14** so that the shaft axis is coincident with a line through the center **16** which is parallel to the peripheral wall **12.**

The crankshaft **18** is provided in the cavity **11** with an eccentric **21** on which a rotor **22** is mounted for rotation about the eccentric's center line **24** which is thus the rotor's axis, the rotor being provided with a sleeve bearing **23** for this mounting. The rotor **22** whose details of construction will be described in detail later has the general shape of a triangle with three flanks or faces **26** which are convex and face the peripheral wall **12** and cooperate therewith and with the end walls to define three variable volume working chambers **28.** An apex seal **29** is mounted at each apex or corner of rotor **22** and extends the width thereof and three pairs of side seals **30** are mounted in each rotor side and arranged to extend between the apex seals **29** with three corner seals **31** mounted in each rotor side providing sealing links between the ends of the side seals and the apex seals.

The apex seals **29** are urged by biasing means not shown to continuously engage the periperal wall **12** and both the side seals **30** and corner seals **31** are urged by biasing means not shown to continuously engage the end walls **14** with the complete seal arrangement acting to seal the chambers **28.** With the two-lobed peripheral wall **12** and the three-lobed rotor **22** there is made available the four phases of intake, compression, expansion and exhaust in each chamber for each rotor revolution in fixed relation to the housing by forcing the rotor to rotate at one-third the speed of the output shaft. This is accomplished by a gear train comprising an internally toothed gear **32** which is fixed to and concentric with the rotor **22.** The gear **32** meshes with an externally toothed annular gear **33** which is received about and is concentric with the crankshaft and is made stationary by being fixed to the engine housing **10** at one of the end walls **14.** The gear **32** has one and one-half times the number of teeth as the gear **33** to provide the required ratio of 3:1 between the crankshaft **18** and the rotor **22.** An air-fuel mixture from a suitable carburetor arrangement, not shown, is made available to each chamber **28** by an intake passage **34** that extends through the housing **10** and opens to the cavity **11** through the end walls **14** at axially opposite locations, this porting to the cavity being located to one side of the peripheral wall's cusp **36.** The exhaust products of combustion are delivered from each chamber **28** by an exhaust passage **37** which extends through the housing **10** and opens to the cavity **11** through the peripheral wall **12** on the other side of cusp **36.** A single channel or recess **38** is provided in the center of each chamber face **26** of the rotor **22** to provide for the transfer of working gases past the peripheral wall's other cusp **39** when a rotor face is at or near a top-dead-center position as shown in FIG. **1** so that a chamber is not divided by cusp **39** at the time when combustion is occurring therein.

The engine construction thus far described is conventional. Typically, such engines have each of the three working chambers undergoing intake, compression, expansion and exhaust with a single rotor arrangement as shown in FIG. **1** providing a power phase for each revolution of the crankshaft. As the rotor rotates in the direction of the arrow in FIG. **1,** the air-fuel mixture is periodically successively drawn into the working chambers **28** by the side seals **30** traversing the intake passage **34.** The fuel mixture is then trapped in each working chamber and compressed and when the rotor is in the vicinity of top-dead-center, this mixture is ignited. It is present commercial practice to have either one or two spark plugs located in the rotor housing **10** near the cusp **39** with their electrodes exposed in the cavity **11** to the passing working chambers for the ignition. Upon ignition of the mixture in the working chambers, the peripheral wall takes the reaction forcing the rotor to continue rotation while the gas is expanding. The leading apex seal of each of the working chambers successively traverse the exhaust passage **37** and the exhaust products are then expelled to the atmosphere to complete the cycle.

Describing now the spark plug and rotor construction according to the present invention with the attendant ignition circuit, the rotor **22** as shown in FIGS. **1, 2, 3** and **4,** has only two rotor parts **40** and **41** which are preferably made of powdered metal. The rotor parts **40** and **41** have outboard sides **42** and **44** and mating interfaces **46** and **47,** respectively, which are all perpendicular to the rotor's axis **24.** The interfaces **46** and **47** are split off-center width-wise of the rotor with the rotor part **40** being of generally hollow construction and constituting the larger part and the other rotor part **41** being of solid construction and constituting the small part. The hollow rotor part **40** has a peripheral wall **48** and a central hub portion **49** which receives the sleeve bearing **23** and is joined to the peripheral wall **48** by radially extending ribs **52** which leave axially extending spaces **54** between the hub portion **49** and the peripheral wall **48** for the passage of coolant in an axial direction through the rotor when the rotor parts are joined as shown in FIG. **3.** The solid rotor part **41** has an internal toothed gear **32** formed integral therewith concentric with the rotor axis **24.**

Describing now the spark plug construction and mounting in the rotor assembly, the interface **46** of the hollow rotor part **40** has in each angular segment between two rotor apexes a spark plug recess arrangement comprising a centrally located spark plug recess **56** in the peripheral wall **48** at the bottom of the channel **38** and another spark plug recess **58** in the peripheral wall intermediate the centrally located recess **56** and the trailing rotor apex with both these recesses opening through the associated rotor face portion. Furthermore, there is provided in the interface **46** a recess **59** in the rib **52** between the two recesses **56** and **58.** In addition, there is provided a recess **60** in one end of the hub portion **49** which is radially aligned with the recess **56** and opens to a recess **62** that is formed in the interior of the hub portion **49** and extends the width thereof parallel to the rotor axis **24.** The recesses **56, 58, 59, 60** and **62** in each of the angular segments cooperatively provide an accommodating recess for a spark plug **66.**

Each spark plug **66** comprises a ceramic body **68** which as best shown in FIGS. **1, 3** and **4** includes a trunk **69** with a base portion **70** which is received in one of the recesses **60** and a top portion **71** which is received in the radially outward leading recess **56.** The trunk **69** has a branch **74** extending from between the base portion **70** and the top portion **71** which is received at an intermediate area in the rib recess **59** and has a tip portion **76** that is received in the trailing recess **58.** In addition, the base portion **70** of the ceramic body has a root **78** that is received in the hub recess **62** and extends the length thereof. The ceramic body except for the trunk top, branch tip and root end and at least in those areas where it is received in the recesses in the interface **46** and is engaged by the opposite interface **47** of the other rotor part, is coated with a metal layer **79** that is bondable to the metal of the rotor parts with the dimensions of these metal coated spark plug portions received in the recesses in the interface being sized so that the accommodating recesses are completely filled and thus sealed by the bonding.

Three electrodes **80, 81** and **82** of high voltage wire are molded in place in each spark plug's ceramic body. As best shown in FIG. **3,** the electrode **80** extends through the trunk **69** and the root **78** with a terminal **83** projecting out through the root tip and a spark end **84** projecting out through the trunk top past the rotor face **26** into the channel **38.** The electrode **81** extends from the trunk **69** through the branch **74** and has one spark end **86** projecting out through the trunk top and spaced a spark distance from the spark end **84** of the electrode **80.** The electrode **81** has at its opposite end a spark end **88** projecting out through the branch tip into a cup-shaped depression **90** in the rotor face so that this spark end will not rub or spark against the peripheral wall **12.** The third electrode **82** as shown in FIG. 2 has a ground portion **94** extending out from the branch **74** grounded to the rotor in the recess **58** and a spark end **96** that is spaced a spark distance from the spark end **88** of the electrode **81.** This multielectrode arrangement having a leading spark gap **98** between the spark ends **84** and **86** and a trailing spark gap **100** between spark ends **88** and **96** is of the type disclosed in U.S. Pat. application Ser. No. 211,429 entitled "Rotary Combustion Engine Ignition" by Harvey A. Burley and assigned to the assignee of the present invention, which is hereby incorporated by reference. In such an arrangement with the capacitance across the leading gap considerably less than that across the trailing gap to ground, a greater percentage of the applied voltage appears across the leading gap to effect electrical breakdown and when this gap has been bridged all of the applied voltage except for the small amount in the plasma of the leading gap appears across the trailing gap and this gap also is quickly bridged with the double gap breakdown taking place almost simultaneously. Furthermore, with this location of the spark gaps the leading spark may be made to occur in the vicinity of top-dead-center at a mid point in the chamber and the trailing spark occurs near the trailing end of the chamber a very short time later. For a more detailed understanding of such a multispark electrode arrangement and the variations thereof, reference should be made to the Burley application. It will also be understood that the spark plugs may provide a single spark with only two electrodes wherein one of these is grounded to the rotor.

In assembling the rotor, the three spark plugs **66** are first mounted in their accommodating recesses in the interface **46** of the hollow rotor part **40.** With the spark plugs **66** in place, the solid rotor part **41** is then positioned in its mating relationship with the rotor part **40.** Then their mating interfaces **46** and **47** and also the mating surfaces of the spark plug's metal coatings and these rotor parts are brazed together with a suitable brazing material. The resulting spark plug and rotor structure has a gas tight seam in the rotor faces between the rotor parts and around the spark plugs where they project through the rotor faces.

Referring to FIG. **5,** voltage is provided to the spark plugs **66** by a high voltage insulated wire **102** which extends through an axial passage in the crankshaft **18** and out through a radial opening the side of eccentric **21** opposite where the gearing is located. A rotary disc **104** suitably mounted for rotation coaxial with the crankshaft **18** is connected to receive voltage from a suitable conventional ignition control **106** which is powered by a D. C. power source **108.** Disc **104** has a contact **110** from which electrical ignition pulses from the ignition control jump to a terminal **112** that is connected to wire **102,** the terminal **112** being mounted on the end of the crankshaft by a mount **114** of nonconducting material. The electrical ignition pulses are conducted by the wire **102** to an arcuate shaped metal conductor **116** which is mounted in one interior side of an arcuate channel member **118** of nonconducting material that is secured to the crankshaft so as to center the contact strip **116** with the top-dead-center position of the eccentric **21.** As shown in FIG. **3,** the terminal end **81** of each of the spark plugs **66** extends radially past the rotor body into the channel **120** so that it brushes the contact strip **116** as the crankshaft rotates when each rotor face is in the vicinity of top-dead-center. Thus, an electrical ignition pulse from the contact strip **116** is led to the appropriate spark plug **66,** the length of the contact strip being such that voltage then can be applied for sparking over a relatively large angle to provide for ignition timing changes.

The above described embodiment is illustrative of the invention which may be modified within the scope of the appended claims.

We claim:

1. A spark plug and rotor assembly for a rotary combustion engine comprising a pair of rotor parts having mating peripheral face portions that cooperate to define peripheral rotor faces and also having mating interfaces, one of said rotor parts having a hub portion determining an axis about which said rotor parts rotate, said interfaces transverse to said axis, the other of said rotor parts having an internal toothed gear concentric with said hub portion, the interface of said one rotor part having a spark plug recess for and open to every face portion of said one rotor part, spark plug means for each said rotor face, each said spark plug means comprising a metal coated ceramic body received in and having a shape to fill one spark plug recess, a first electrode in each said ceramic body having a terminal at one end for receiving an electrical ignition pulse and a spark end at the other end projecting out past the associated face portion, a second electrode in each said ceramic body operatively grounded to said rotor and having a spark end projecting out past the associated face portion and spaced a spark distance from said spark end of said first electrode, and means permanently joining said mating rotor parts and said spark plug means where they have metal-to-metal contact with said spark plug means mounted in the interface of said one rotor part.

2. A spark plug and rotor assembly for a rotary combustion engine comprising a pair of metal rotor parts having mating peripheral face portions that cooperate to define peripheral rotor faces and also having mating interfaces, one of said rotor parts having a hub portion determining an axis about which said rotor parts rotate, said interfaces perpendicular to said axis, said one rotor part having axially extending pasages therethrough for the passage of coolant when said rotor parts are joined, the other of said rotor parts having an internal toothed gear concentric with said hub portion, the interface of said one rotor part having a recess open to every face portion of said one rotor part, an opening through said hub portion for every face portion, spark plug means for each said rotor face, each said spark plug means comprising a metal coated ceramic body having a trunk with a base portion received in and having a shape that fills one of said openings in said hub portion and with a top portion received in and having a shape that fills one of said recesses open to one of said face portions, a first electrode in each said ceramic body extending through said trunk having a terminal for receiving an electrical ignition pulse and a spark end projecting out through said top portion, a second electrode in each said ceramic body operatively grounded to said rotor having a spark end projecting out through said top portion and spaced a spark distance from said spark end of said first electrode, and means permanently joining said mating rotor parts and said spark plug where they have metal-to-metal contact with said spark plug means mounted in the interface of said one rotor part.

3. A spark plug and rotor assembly for a rotary combustion engine comprising a pair of metal rotor parts having mating peripheral face portions that cooperate to define peripheral rotor faces and also having mating interfaces, one of said rotor parts having a hub portion determining an axis about which said rotor parts rotate, said interfaces perpendicular to said axis, said one rotor part having axially extending passages therethrough for the passage of coolant when said rotor parts are joined, the other of said rotor parts having an internal toothed gear concentric with said hub portion, the interface of said one rotor part having two recesses spaced angularly about said axis and open to every face portion of said one rotor part, an opening through said hub portion for every face portion, multielectrode spark plug means for each said rotor face, each said spark plug means comprising a metal coated ceramic body having a trunk with a base portion received in one of said openings in said hub portion and with a top portion received in and having a shape that fills one of said recesses open to one of said face portions, said trunk having a branch portion extending from between said base portion and said top portion with a tip portion received in and having a shape that fills another of said recesses open to said one face portion, a first electrode in each said ceramic body extending through said trunk having a terminal for receiving an electrical ignition pulse and a spark end projecting out through said top portion past the associated face portion, a second electrode in each said ceramic body extending from said trunk through said branch having one spark end projecting out through said top portion and spaced a spark distance from said spark end of said first electrode and having another spark end projecting out through said tip portion past the associated face portion, a third electrode in each said ceramic body having a ground portion extending out through said branch grounded to said rotor and a spark end projecting out through said tip portion and spaced a spark distance from said other spark end of said second electrode, and means permanently joining said mating rotor parts and said spark plug means where they have metal-to-metal contact with said spark plug means mounted in the interface of said one rotor part.

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