March 20, 1951 B. C. FISHER 2,545,546

SPARK PLUG

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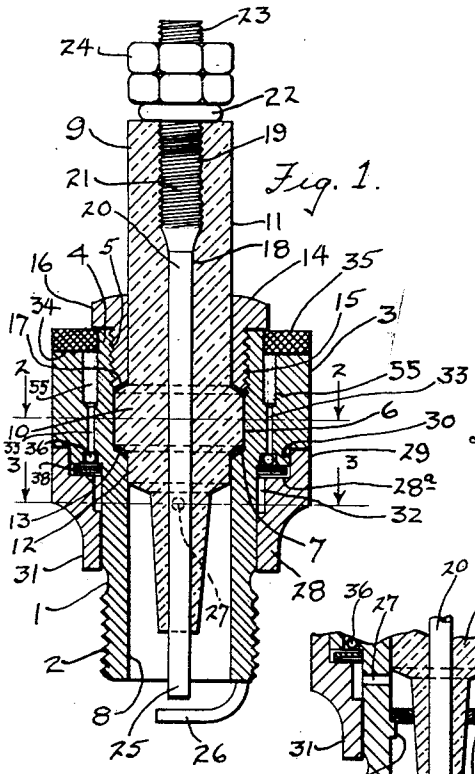


Fig. 1.

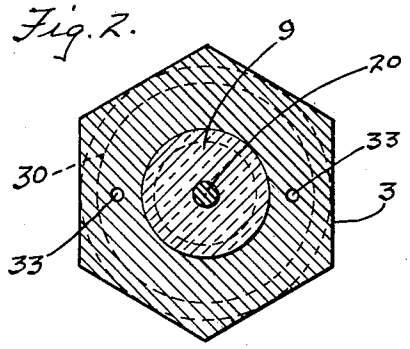


Fig. 2.

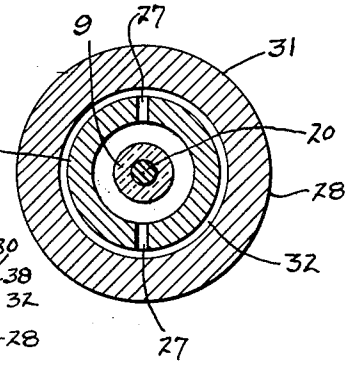


Fig. 3.

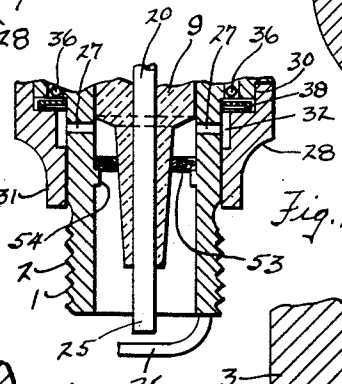


Fig. 7.

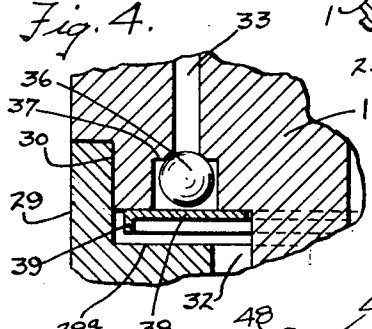


Fig. 4.

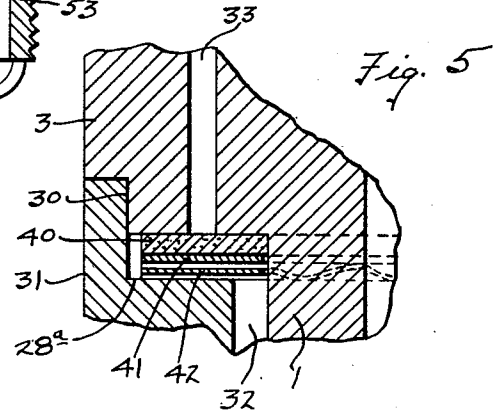


Fig. 5

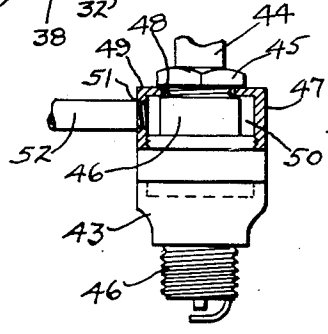


Fig. 6.

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## SPARK PLUG

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18 Claims. (Cl. 123—169)

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This invention relates to spark plugs for internal combustion engines.

One of the objects of the invention is to provide a spark plug which when used in an internal combustion engine will permit a higher compression ratio than has heretofore been possible, especially with ordinary fuels, and will produce rapid, substantially complete, and substantially instantaneous combustion of the fuel, at the same time minimizing, if not altogether eliminating, tendency for the engine to detonate or knock.

Another object of the invention is to provide a spark plug for an internal combustion engine by means of which the volumetric flow into the cylinder may be increased and a resulting increase in compression obtained over engines heretofore used in which the friction of the incoming air and fuel through the intake manifolds and associated parts provides a small charge at high speeds, thereby reducing the volume of gases to be compressed.

Still another object of the invention is to provide a spark plug which will have one setting of the electrodes for all engines and which when used will reduce missfiring and will reduce the necessity of frequent grinding of the valves.

Another object of the invention is to provide a spark plug for an internal combustion engine having means for producing a scavenging effect throughout the combustion chamber and especially adjacent the sparking electrodes, which minimizes injurious heating of the electrodes and materially increases the life of the spark plug.

Another object of the invention is to provide a spark plug which, because of the structure of the plug itself, will operate at a lower temperature than spark plugs heretofore known, operated in the same engine, with the result that there is less tendency for the electrodes to burn and get out of spacing adjustment.

Other objects will be apparent as the description of the invention proceeds.

The invention is illustrated in the accompanying drawings, in which:

Figure 1 is a sectional elevational view of one embodiment of my improved spark plug;

Figure 2 is a sectional plan view of the spark plug shown in Figure 1, taken on the line 2—2 of that figure;

Figure 3 is a sectional plan view of the spark plug shown in Figure 1, taken on the line 3—3 of that figure;

Figure 4 is an enlarged fragmentary sectional view of the valve mechanism of the plug shown in Figures 1 to 3;

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Figure 5 is a similar view showing a modified form of the valve;

Figure 6 is a fragmentary elevational view, partly in section, showing a modified form of the invention; and

Figure 7 is a sectional elevational view of a portion of a spark plug showing an additional air distributor.

Referring now more specifically to the drawing, a preferred form of the spark plug of the invention comprises a tubular member 1, provided with a threaded end 2, adapted to screw into the spark plug opening in the wall of an internal combustion engine and also with an enlarged section 3 at its other end having flattened sides to receive a wrench for screwing the plug into place.

The parts have been shown in the drawings in an upright position and will be described in reference to this position, although it will be understood that the plug may be operated in any position.

The tubular member has a bore therethrough of three different diameters. A portion 4 of the bore, at the upper end, is larger in diameter than the rest of the bore and is provided with internal threads 5. The central portion 6 of the bore is of slightly smaller diameter, forming a sloping shoulder 7 between the two sections, while the lower end portion 8 is still smaller in diameter. The member 1 may be made of any suitable metal, such as cold rolled steel or it may be a monel die casting.

An insulating member 9, preferably of porcelain or other suitable refractory material, is generally cylindrical in shape, having a central portion 10 of slightly smaller diameter than the mid-portion 6 of the tubular member 1 and adapted to fit into this portion of the tubular member. The upper portion 11 of the member 9 is smaller in diameter than the central portion 10 and is adapted to extend out of the end of the tubular member 1. The lower end of the member 9 has a straight portion 12, smaller in diameter than the central portion 10 and then tapers down within the lower portion 8 of the tubular member to a point just short of the lower end of the tubular member 1.

The member 9 is inserted in the tubular member 1 with the lower edge of the portion 10 seated against the shoulder 7 where a suitable gasket 13 may be provided to make a gas-tight joint. The member 9 is held in place by a sleeve 14 which is provided with outer threads 15 which screw into the internal threads 5 of the tubular member. The sleeve 14 has a suitable hexagonal flange 16,

so that a wrench may be fitted to it for turning it down against the member 9, a suitable gasket 17 being provided at the upper edge of the portion 16 to be engaged by the lower end of the sleeve 14.

The member 9 is provided with a cylindrical bore 18 having internal threads 19 at the upper end into which is threaded a central conductor member 20. This conductor may preferably be made of a metal, such as Nichrome, which will stand up under electric spark discharges, and has a slightly enlarged threaded portion 21 to screw into the internal threads 19 of the member 9. Above the threads 21 is preferably provided a flange 22 which seats upon the outer end of the member 9, and above the flange the member 20 has another threaded portion 23 upon which may be threaded a nut 24 to hold the wire for the external connection to the spark plug.

The lower end of the conductor 20 is slightly tapered, so as to be spaced slightly at the extreme end from the lower end of the member 9 from which it protrudes to form the electrode 25. This electrode extends somewhat below the tubular member 1 to one side of which may be welded another electrode 26 which may also be made of Nichrome. The spark occurs between these two electrodes.

In accordance with the usual practice, the conductor 20 may be cemented into the member 9 in addition to being held by the threaded connection therewith, suitable refractory cement being used for this purpose, and this cement is preferably applied for a portion of the entire length of the member 20 leaving about a third at the lower end free of cement. This is important, since I have found that where porcelain is used for the member 9, if the cement is carried too far down between the porcelain and the member 20, the porcelain will tend to crack from the heat of the engine.

The description of the spark plug of the invention thus far is similar to the construction of the type of spark plug now generally in use, and the novel features which produce the objects related above will now be described.

The wall of the tubular member 1 at the central portion 6 is provided with a plurality of passages or ducts 27 between the inner and outer surfaces thereof, two being shown, diametrically opposite each other, although it will be understood that more may be provided, if desired.

A sleeve 28 is provided around the tubular member 1 just below the enlarged portion 3. This sleeve is about one third as long as the member 1 and has a generally tapering configuration, getting smaller in diameter towards the lower end of the spark plug. The upper rim 29 of the sleeve 28 has an internal diameter such that it will have a drive fit over a short portion 30 of reduced diameter of the lowermost outer edge of the enlarged portion 3 of the member 1. The lower end 31 of this sleeve has an internal diameter such that it will have a press fit on the central portion of the tubular member 1 below the passages 27.

Between the upper and lower ends, 29 and 31, of the sleeve 28 the inner wall is stepped, forming when positioned on the tubular member 1, an annular cavity 32 into which the passages 27 open. The stepped inner wall of the sleeve provides a shoulder 28*a* the purpose of which will be described later. The dimensions of the sleeve 28 are such that the lower end 31 thereof comes just above the threaded lower end of the tubular member 1 and in such position that it will be



forced against the outer surface of the cylinder wall of the internal combustion engine when the plug is screwed into position and this, in addition to its press fit, holds the sleeve securely in position when the plug is in use.

The enlarged upper portion 3 of the tubular member 1 is provided with a plurality of passages or ducts 33 which lead from the cavity 32 to the outer atmosphere. The open ends of these passages may preferably be situated just below the hexagonal flange 16 of the sleeve 14 which holds the insulating member 9 in place. The top of the tubular member 1 below the flange 16 is cut away forming a shoulder 34 which provides a space between it and the flange 16 in which is fitted a ring 35 made of porous material. This ring acts as an air filter, preventing foreign matter from entering the passages 33 and the cavity 32.

In one instance I have obtained good results by making the ring 35 of a wire mesh sheet, rolled up into a cylinder and compressed, end to end, until a ring of the proper thickness is obtained. The interstices in this wire mesh ring are very fine but permit air to pass freely through it.

The openings of the passages 33 into the cavity 32 are provided with valves which open when the pressure in the cavity is less than atmospheric but close when the pressure in the cavity is greater than atmospheric, and I preferably use a double valve arrangement for this purpose. To this end the under surface of the portion 3 of the tubular member 1 may be flat and the passages 33 countersunk to receive balls 36 which seat upon shoulders 37 formed at the inner end of the countersunk portions. The countersunk portions are slightly deeper than the diameter of the balls, about one or two thousandths of an inch, so that when seated the balls just clear the flat under surface of the portion 3.

The balls are held in the countersunk portions of the passages 33 by a flat ring 38 preferably made of steel which fits in the cavity 32. This ring may be provided with a downwardly extending flange 39 around its outer periphery thereof to strengthen it and the flat upper surface not only holds the balls 36 in place but closes the passages 33 when the ring is pressed up against the surface of the portion 3.

The cavity 32 is made just a few thousandths of an inch deeper than the flange of the ring 38, hence the ring only has to move that distance towards and away from the flat under surface of the portion 3 in closing and opening the passages 33.

In Figure 5 is shown a modified form of the valve arrangement. Here the balls are omitted and the passages 33 closed by a ring 40 of asbestos, and in order to insure the proper seating thereof I may use a flat steel ring 41 under it with a corrugated steel spring 42 between the steel ring and the bottom of the cavity to urge both rings against the openings of the passages 33. The ring 40 may preferably have a close friction fit on the tubular member 1.

In some instances instead of making the valve ring 40 of asbestos I may use a ring made of several layers of fine wire mesh. When this ring is pressed hard enough against the under surface of the portion 3 of the tubular member 1 the individual wires press together making a complete seal. The steel ring 41 and spring 42 may be used with the wire mesh valve.

The operation of the spark plug will now be described. During the intake stroke, when the

pressure inside the combustion chamber of the engine falls below the atmospheric pressure, air is drawn through the passages 33 and into the cavity 32 and through the passages 27, around and along the surface of the straight portion 12 of the insulated member 9 and out of the lower end of the plug over the electrodes 25 and 26. At the end of the intake stroke, this region surrounding the electrodes and including the cavity 32 and passages 27 is full of fresh air.

During the compression stroke the pressure in the combustion chamber rises above atmospheric and the valves close and prevent the air from escaping, so that air is compressed in the cavity 32 and passages 27 and in the space in the immediate vicinity of the electrodes. This provides a lean mixture around the electrodes.

At the beginning of the explosion stroke the spark fires the mixture adjacent the electrodes and, because of the plentiful supply of oxygen present, the flame is forced towards the center of the combustion space like the flame of a blow torch. This flame fires the mixture in the main portion of the combustion chamber substantially instantaneously, the combustion being more complete than that which takes place in an engine using ordinary spark plugs.

When the explosion occurs and the pressure in the combustion chamber rises suddenly the balls 36 are held in their seats and the valve ring 38 is held against the openings of the passages 33, thus insuring the complete closure of these openings. Pressure then builds up in the cavity 32 and passages 27, but, since these spaces were filled with air at the end of the intake stroke there will still be air in them which will be compressed.

As soon as the exhaust valve opens the air compressed in the cavity 32 passes through the passages 27 and over the electrodes, flushing the burned gases away from this region and cooling the electrodes and adjacent parts and also flushing the entire cylinder.

The intake stroke draws fresh air into the passages again and the cycle is repeated.

When the air passes out of the restricted passages 33 into the cavity 32 it gives up heat to the surrounding metal. This heat flows through the metal of the tubular member 1 and the metal of the cylinder head to be dissipated by the cooling medium provided for the cylinder. Thus, at the beginning of each explosion stroke the cavity 32 is not only filled with fresh air, but that air is cooler than the hot gases adjacent the electrodes and cools the electrodes and adjacent parts when it rushes past them in the flushing process during the exhaust stroke.

I have found that the best results are obtained when the valves not only close completely during each compression and explosion stroke, but close and open very quickly. The double valve arrangement using the balls 36 and the ring 38 gives excellent results in this respect. The ring 38 is free to turn in the cavity 32 and does turn slightly with each movement against its cooperating surface, with the result that there is a lapping effect with that surface and the seating of the ring to close the passages 33 improves with use.

The spark plug of the invention may be used in many sinstances with the ducts or passages 33 opening into the atmosphere, as set forth in the description already given. However, there are times when it is desirable to introduce air under pressure into the passages 33, as, for instance, when the spark plug is used with an airplane engine. In Figure 6 is shown a modified form of the spark plug arranged for this purpose. The sleeve 43, insulating member 44, and associated conductor, and the sleeve 45, may be the same as the sleeve 28, the insulating member 9, the sleeve 14, previously described. The tubular member 46, corresponding to the tubular member 1, is extended up a little farther than the member 1 and is reduced in diameter above the hexagonal portion and threaded to receive a cap or housing 47. The housing 47 has an opening 48 in its upper end 49 to receive the insulating member 44 and the head on the sleeve 45 rests upon the top of the housing 47, thus completely closing it.

It will be seen that there is a space 50 within the housing 47 around the tubular member 46 into which the air passages open.

The housing 47 has an opening 51 which may be threaded to receive a suitable pipe connection 52 leading from a source of air under pressure. With such an arrangement air may be forced through the plug during the intake and exhaust strokes.

In some instances I may desire to diffuse or disperse the air coming through the passages 27 into the combustion space. In Figure 7 I have shown a modified form of the invention which accomplishes this result. The parts are the same as in the arrangement of Figure 1 except that a diffusing washer 53 is placed within the membeer 1 around the end of the insulator 9. This washer may be any suitable member having a large number of small openings therethrough, such as one formed of a roll of wire mesh flattened endwise to the desired thickness. As shown, it is held in place by a collar 54 formed on the inner surface of the member 1 and by the tapered portion of the insulator 9.

Air coming in through the passages 27 must pass through the openings in the washer which diffuses and distributes it about the region of the electrodes.

An important effect of cooling the parts adjacent the electrodes results in the cooling of the insulator 9. Keeping this vital part cool not only prevents it from breaking down and short circuiting the high tension current, but prevents it from breaking down under higher compression than is normally used in an internal combustion.

The sleeve 28 may be made of the same material as the other metal parts of the plug but, if desired, may be made of aluminum or an aluminum alloy, and when made of such material will help dissipate heat and will eliminate the necessity of a gasket when the plug is screwed into the enging casing, the material of the sleeve being soft enough to make a gas-tight seal.

With the spark plug of the invention I am able to produce a substantially instantaneous explosion in the engine cylinder with more complete combustion of the fuel than with spark plugs heretofore used. Also the compression is raised above that of the ordinary engine by increasing the volumetric flow into the cylinder. This increases the efficiency of the engine. The power of the engine is also increased because of the fact that the tendency to missfire causing detonation or knock is greatly reduced, owing to the presence of the leaner mixture adjacent the sparking electrodes and the fact that the parts adjacent thereto are maintained cool by the incoming air jet. There is no premature firing.

I have found that the gap between the electrodes may be set at .018 inch and that the same plug with that setting can be used in all types of engines, thus giving one heat range and eliminating the requirement of a variety of plugs for different engines. With the above mentioned setting I have found that the plug will fire satisfactorily at almost twice the regular plug pressure.

Optimum performance for a particular engine may be obtained by a particular size and arrangement of the air passages through the plug, this size and arrangement, for best results, depending on the standard mixture of fuel for the engine and the valve size and piston displacement. The best results may be determined experimentally by starting with small diameter passages 33 and then making these passages larger and larger and testing the engine each time. When there is no longer improvement in the operation of the engine the optimum diameter for the passages has been passed.

The velocity of the air into the cavity 32 may be increased by having the upper portions 55 of the passages 33 larger in diameter, as shown in Figure 1, the enlarged portion extending about half way through the portion 3 of the member 1. By adjusting the depth of the larger diameter portion 55 the velocity of the air into the cavity 32 may be adjusted for optimum operation. Plugs may thus be calibrated for volumetric flow for particular engines.

In general the passages 27 should be larger in diameter than the passages 33 to insure quick passage of air from the cavity 32 into the cylinder at the exhaust stroke.

In one instance a plug was used in which the diameter of the portion 55 of the two passages 33 was .081 inch, the diameter of the remainder of the passages 33 was .035 inch, and the diameter of the two passages 27 into the combustion chamber was .046 inch. The enlarged portions 55 of the passages 33 were about equal in length to the remainder of the passages.

The provision of a lean mixture adjacent the sparking electrodes at the beginning of each explosion stroke also insures easy starting in all kinds of weather and permits idling at much slower engine speeds than is possible with spark plugs now in general use.

The spark plug of the invention may be used in various types of engines and will permit the use of many fuels, such as kerosene and alcohol usually not considered suitable or possible for use in ordinary internal combustion engines.

Having thus described the invention, what I desire to secure by Letters Patent and claim is:

1. A spark plug comprising a main body member having a cavity therein, a conductor extending through said body, insulating means electrically separating said conductor from said body member, a relatively long duct of smaller cross section than said cavity leading from said cavity to the atmosphere when the plug is inserted in an engine cylinder, a duct leading through the wall of said body member from said cavity to a point adjacent the sparking end of said conductor, and means in said cavity for closing said first mentioned duct when the pressure within said cylinder exceeds a predetermined amount.

2. A spark plug, as defined in claim 1, in which filter means is provided at the outer end of the duct leading to the atmosphere.

3. A spark plug, as defined in claim 1, in which the cavity is annular and surrounds the conductor and there is provided a plurality of ducts leading from the cavity to the atmosphere and a plurality of ducts leading from the cavity to the inside of the cylinder, said ducts being distributed around the plug and the first mentioned ducts being staggered with respect to said last mentioned ducts.

4. A spark plug, as defined in claim 1, in which the means for closing the first mentioned duct is a ball positioned within an enlarged portion of said duct.

5. A spark plug, as defined in claim 1, in which there are a plurality of the first mentioned ducts distributed around said plug, and the means for closing said ducts comprises in each duct an enlargement of said duct where it opens into the cavity, a ball in said enlargement, the inner end of said enlargement forming a seat for said ball, and a plate in said cavity adapted to cover the enlargements of all of said ducts when pressure in said cavity rises above a predetermined amount, whereby said balls and plate form double valves for closing said ducts.

6. A spark plug, as defined in claim 1, in which the cavity is annular, extending around the axis of said plug, a plurality of said first mentioned ducts are provided distributed around said plug, and a flat ring is provided in said cavity adapted to close said ducts simultaneously when the pressure in said cavity rises above a predetermined amount.

7. A spark plug, as defined in claim 1, in which there are a plurality of the first mentioned ducts opening into said cavity in an annular flat wall thereof and the means for closing the ducts comprises a flat annular plate in said cavity adapted to fit against said wall to close said ducts.

8. A spark plug, as defined in claim 7, in which an additional valve is provided in each duct for closing said duct, said additional valve acting in the same direction as the plate.

9. A spark plug, as defined in claim 8, in which the additional valves are ball valves which are held adjacent their seats by the flat, annular plate.

10. A spark plug, as defined in claim 9, in which a filter is provided in each of said first mentioned ducts for filtering the air passing therethrough into said cavity.

11. A spark plug, as defined in claim 10, in which the filters for the ducts comprise a single annular member, provided with interstices and surrounding said plug and covering the openings into the atmosphere of said ducts, said filter member being formed of a cylindrical roll of wire mesh compressed endwise into a ring.

12. A spark plug comprising a tubular member having external threads at one end for screwing said member into the spark plug opening of an internal combustion engine, a conductor extending through said member and forming at one end one of the electrodes for said spark plug and at the other end the external electric connection for said plug, insulating means for insulating said conductor from said tubular member and for sealing the opening through said tubular member, a sleeve member surrounding a portion of said tubular member and cooperating therewith to form an annular cavity therebetween having a flat annular surface, a plurality of ducts in one of said members connecting said cavity with the atmosphere and entering said cavity through said flat surface, a plurality of ducts through the wall of said tubular member and connecting said cavity with the inside of the end of said tubular

member adjacent said electrode, and a flat annular plate within said cavity and surrounding said tubular member and adapted to close the openings of said first mentioned ducts in said flat surface when the pressure in said cavity rises above a predetermined value.

13. A spark plug, as defined in claim 12, in which the total resistance to the passage of fluid through said first and second mentioned ducts is substantially the same and said first and second mentioned ducts are distributed around said spark plug and are staggered with respect to each other.

14. A spark plug, as defined in claim 13, in which additional ball valves are provided in said first mentioned ducts acting to control the fluid passing therethrough in the same direction as said flat plate.

15. A spark plug, as defined in claim 14, in which an air filter is provided to filter the air passing through said first mentioned ducts.

16. A spark plug comprising a body member adapted to be secured in the spark plug opening of an internal combustion engine, a conductor extending through said member and at its end forming the sparking electrode for said plug, insulating means for insulating said conductor from said member, a cavity in said member, a duct connecting said cavity with the open end of said member adjacent said electrode, a housing attached to said member, a relatively long duct of smaller cross section than said cavity leading from said cavity to the interior of said housing, a valve in said last mentioned duct adapted to close when the pressure in said cavity exceeds the pressure in said housing by a predetermined amount, and means to connect said housing with a source of gas under pressure.



17. A spark plug comprising a main body member having a cavity therein, a duct leading from said cavity to the outer atmosphere, a duct leading from said cavity to the inside of the cylinder when the spark plug is in position in an engine cylinder, means for closing said first mentioned duct when the pressure in the engine cylinder exceeds a predetermined amount, and separate means for diffusing the air passing into the cylinder from the duct leading from the cavity.

18. A spark plug comprising a main body member having a cavity therein, a duct leading from said cavity to the outer atmosphere, said duct having a larger cross sectional area adjacent the opening to the atmosphere than adjacent the opening into the cavity, a duct leading from said cavity to the inside of the cylinder when the spark plug is in position in an engine cylinder, and means for closing said first mentioned duct when the pressure in the engine cylinder exceeds a predetermined amount.

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