United States Patent [19]

Rice

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[45] **Nov. 11, 1975**

[54] **APPARATUS AND METHOD OF IGNITION FOR COMBUSTIBLE GASES**

[75] Inventor: **Warren A. Rice,** Dexter, Mich.

[73] Assignee: **Chemotronics International, Inc.,** Ann Arbor, Mich.

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[52] **U.S. Cl.** ..... **431/6;** 123/169 C; 431/258; 317/82; 317/98

[51] **Int. Cl.²** **F23N 5/20;** F23N 5/22

[58] **Field of Search** ..... 431/6, 263, 258; 317/82, 317/98; 165/47; 123/169 C

[56] **References Cited**

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Primary Examiner—Charles J. Myhre
Assistant Examiner—William C. Anderson
Attorney, Agent, or Firm—Miller, Morriss, Pappas & McLeod

[57] **ABSTRACT**

A method and apparatus is described for igniting combustible gases by the zone heating of a pressure resistant, electrically conductive material with spaced apart electrical contacts on a surface of the material opposite the gases. After the ignition of the gases, the heated zone cools or is cooled and additional combustible gases can then be reintroduced for ignition by the same method. The material is preferably in the form of a small diameter metal tube with a portion of its length being electrically heated. The apparatus and method are particularly useful in the deburring of articles by controlling the ignition of the explosive gases in a rapidly and repetitively opened and sealed chamber for deburring articles by causing ignition of the gases in the sealed chamber at only that operator-selected portion of the cycle after maximum desired unexploded gas charge pressure has been obtained.

11 Claims, 4 Drawing Figures

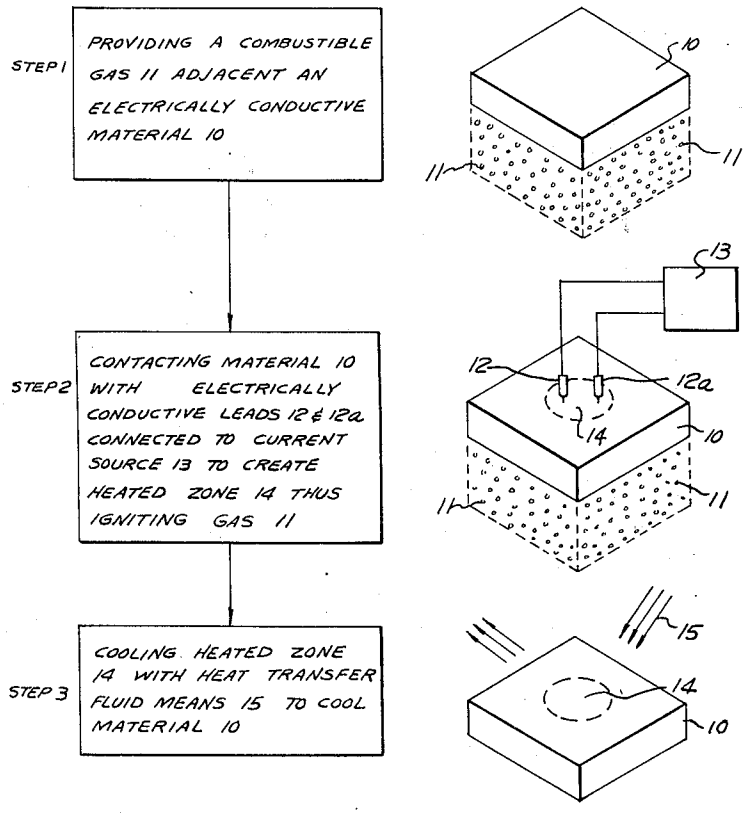
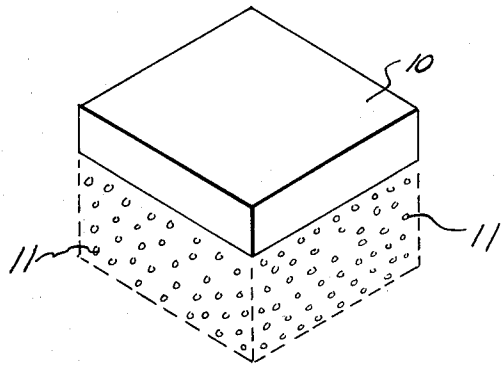


FIG. 1

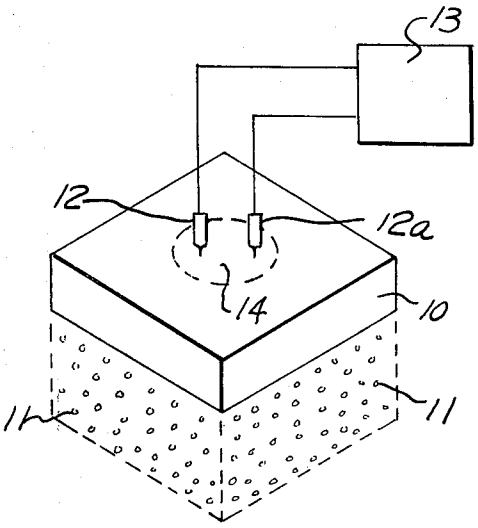
STEP 1

PROVIDING A COMBUSTIBLE GAS 11 ADJACENT AN ELECTRICALLY CONDUCTIVE MATERIAL 10



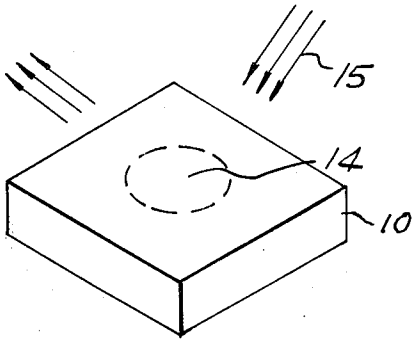
STEP 2

CONTACTING MATERIAL 10 WITH ELECTRICALLY CONDUCTIVE LEADS 12 & 12a CONNECTED TO CURRENT SOURCE 13 TO CREATE HEATED ZONE 14 THUS IGNITING GAS 11



STEP 3

COOLING HEATED ZONE 14 WITH HEAT TRANSFER FLUID MEANS 15 TO COOL MATERIAL 10



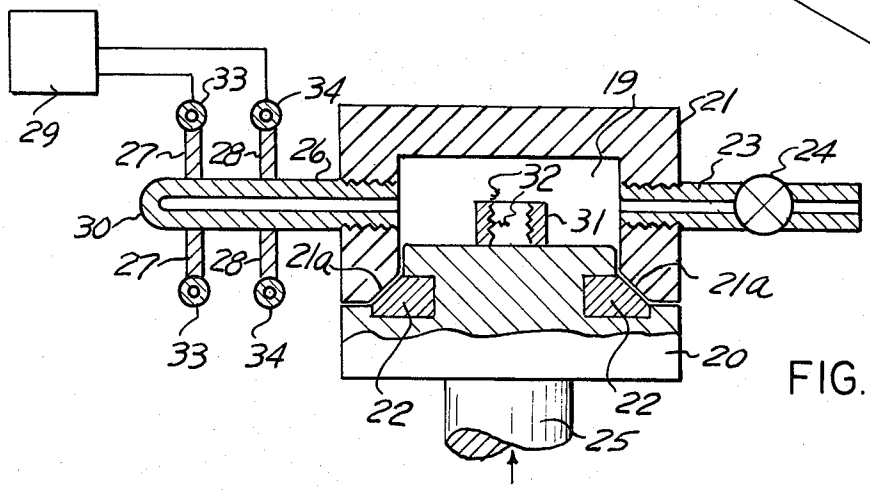


FIG. 2

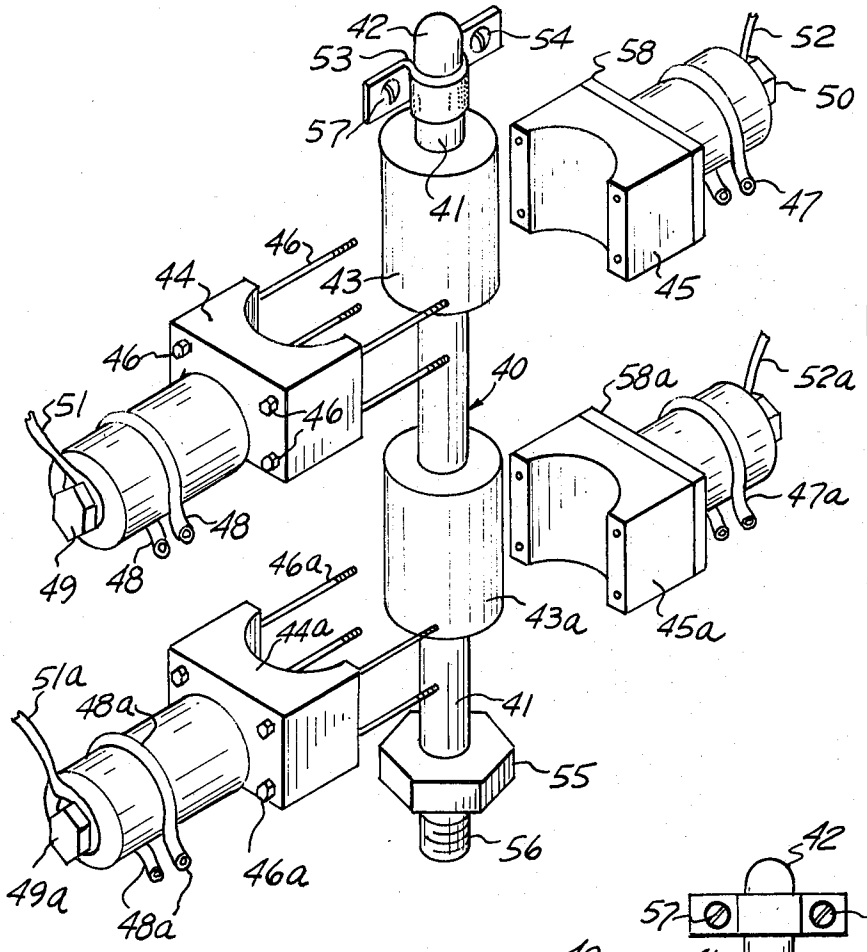

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FIG. 3

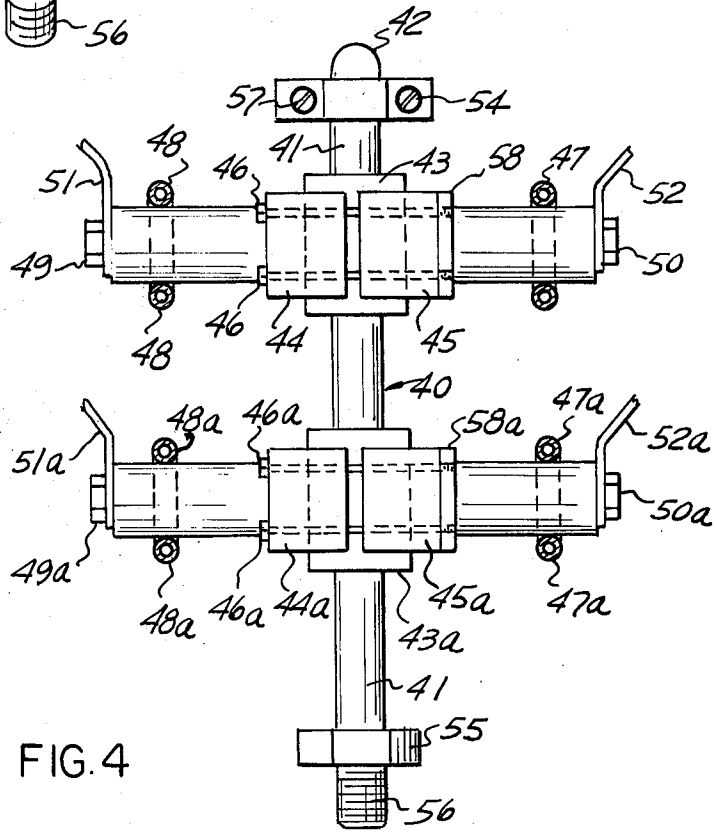

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FIG. 4

APPARATUS AND METHOD OF IGNITION FOR COMBUSTIBLE GASES

SUMMARY OF INVENTION

The present invention relates to an electrical apparatus for igniting combustible gases. In particular, the present invention relates to an apparatus with means which electrically heat a zone of a pressure resistant, electrically conductive material to a temperature adjacent to the gases sufficient for ignition. The pressure resistant material is preferably in the form of a metal tube connected with a sealed chamber such that the combustible gases inside the chamber can be ignited from inside the tube.

PRIOR ART

U. S. Pat. Nos. 3,475,229 and 3,666,252 show a method and various apparatus for thermally deburring articles by igniting a combustible gas in a sealed chamber. The chamber in the preferred equipment is opened for article removal and recycled rapidly on a continuous basis. Such chambers can have preignition combustible gas charge pressures of up to 2,000 pounds per square inch (141 kilogram per square centimeter) or more and generate large internally confined explosion pressures which can be on the order of 55 times the initial preignition charge pressure. Such conditions cause rapid deterioration and destruction of conventional igniter devices such as spark or glow plugs since they are designed to operate under much less severe ignition conditions.

The prior art has utilized heated tubes to ignite combustible gases usually in the operation of Otto or Diesel engines. In these devices, the igniter means is externally heated such as with a flame or electrically prior to the introduction of combustible gases to initially ignite the combustible gas as it is introduced into the chambers. Once the engine is running at a steady state the external heating source is removed and the igniter is maintained in a heated state at or above the combustible gas autoignition temperature by the repeated exposure to the periodically igniting gases. The patents to Nash (U.S. Pat. No. 563,051) and Vierling (U.S. Pat. No. 2,996,056) are illustrative.

In these prior art heated tube devices, provision to minimize external cooling of the igniter was made since this would stop the periodic ignition of the combustible gas. Further, in initiating the gas combustion in these devices, no attempt is made to selectively heat only a zone of the igniter, since it would ultimately be completely heated by the operation of the engine in any event. Thus, the prior art heated tube devices are heated to or above the combustible gas ignition temperature prior to the introduction of the combustible gas to the igniter.

It is therefore an object of the present invention to provide an igniter apparatus and method of ignition of combustible gases which allows for operator-selected control of the ignition of the combustible gases. Further, it is an object of the present invention to provide an igniter apparatus which can be rapidly cycled without concern about premature ignition of the combustible gases. It is further an object of the present invention to provide igniters which will withstand severe repetitive gas explosion conditions without failure. These and other objects will become increasingly apparent to those skilled in the art from the following description and by reference to the following drawings.

IN THE DRAWINGS:

FIG. I is a schematic illustration of the steps in the method of the present invention particularly showing the external heating of a zone of a material in contact with a combustible gas and also schematically showing a form of external cooling of the material using cooling gas or other fluid exposure, which can be forced air or liquid or which can be accomplished by other convective means.

FIG. II is a front cross sectional view of a thermal deburring chamber illustrating a tubular igniter apparatus connected to a current source with spaced apart cooled electrically conductive electrodes defining a heating zone of the tube.

FIG. III is a front exploded perspective view of the preferred igniter apparatus of the present invention.

FIG. IV is a front view of the preferred assembled igniter apparatus illustrated in FIG. III.

GENERAL DESCRIPTION

The present invention generally relates to the igniter apparatus adapted to be fitted to a combustible gas containing chamber to produce ignition of the gas with a consequent rapid thermal energy release and pressure rise which comprises: an integral heatable electrically conductive igniter material adapted to be fitted to the chamber and being of sufficient mechanical strength to be able to withstand a rapid thermal energy release and pressure rise in a gas on one side of the material; electrically conductive low resistance leads connected to the igniter material to form a conductive path between the leads such that a zone of the heatable igniter material is heated to produce ignition on the combustible gas side of the material when the leads are supplied from a current source; and heat transfer means in thermal contact with the heated zone of the igniter material for cooling the heated zone to below the ignition temperature of the combustible gas after the thermal energy release and pressure rise in the combustible gas in the chamber occurs by removing the heat. The present invention also relates to the method of igniting a combustible gas to produce a rapid thermal energy release and pressure rise which comprises: providing an ignitable gas adjacent to an electrically conductive igniter material having sufficient mechanical strength when heated to withstand a rapid thermal energy release and pressure rise in a gas adjacent to the igniter material; heating the igniter material by passing an electric current through a zone defined by spaced apart electrically conductive low resistance leads connected to a current source to ignite the combustible gas; and cooling the heated zone of the igniter material to below the ignition temperature after the combustible gas has ignited.

The igniter material of the present invention is conductive and is spot or zone heated electrically. This material can be in various forms but is preferably a tube. The igniter materials are preferably composed of high mechanical strength, and corrosion resistant metals such as the nickel-chrome alloys. Inconel is a particularly useful material since it is able to repetitively withstand the thermal cycling and the pressures generated by explosive gases when heated to the ignition temperature. The high tensile strength and high yield strength nickel-chrome alloys are suitable for this purpose. See

the *American Society for Metals Handbook* Vol. 1 (1961).

The gases which can be ignited by the method and apparatus of the present invention are combustible mixtures of an oxidizable material and an oxidizer material. Typical oxidizable gases are hydrogen, lower alkanes, alkenes and alkynes, such as those containing 1 to 4 carbon atoms, ammonia, hydrazine, hydrogen sulfide, carbon monoxide and various other rapidly oxidizable compounds.

Oxidizer compounds which can be used include air, oxygen, the halogens, such as fluorine and chlorine, ozone and various perchlorates and nitrogen oxides. Particularly preferred are the compositions shown in U.S. Pat. No. 3,475,229.

Referring to FIG. I, the steps in the method and igniter of the present invention are illustrated. In Step **1** an ignitable gas **11** is provided adjacent to an electrically conductive material **10.** In Step **2,** the material **10** is contacted with electrically conductive leads **12** and **12***a* connected to a current source **13.** The leads **12** and **12***a* heat the material **10** to the ignition temperature of the gas **11.** The distance is preferably between about 1 and 30 millimeters between the leads **12** and **12***a*. In Step **3,** fluid means **15,** such as air, is used to cool the material **10** to below the combustible gas **11** ignition temperature. The steps of the method can be performed by a specifically designed replaceable separate assembly.

Referring to FIG. II, a confined space **19** is formed by mating tooling **20** and chamber **21.** A pressure responsive seal **22** is mounted on the tooling **20** in contact with the lower lip **21***a* of the chamber **21.** Conduit **23** with valve means **24** are provided leading to the confined space **21** for gas inlet and outlet. The tooling **20** is mounted on ram means **25** for closure of the tooling **20** with the chamber **21.** The confined space **19** is provided with an ignition tube **26** mounted on the chamber **21** with the closed end **30** extending from the chamber **21.** The tube was about 300 millimeters long, 3 millimeters inside diameter and 6 millimeters outside diameter. Two spaced apart cooled electrodes **27** and **28** are mounted on the tube **26.** Cooling of the electrodes was provided by tubes **33** and **34** around the electrodes **27** and **28.** The electrodes **27** and **28** were spaced apart about 10 millimeters. The first electrode **28** was about 100 millimeters from the chamber end of the tube **26.** The tube **26** can be mounted on the tooling **20** or on the conduit **23** (not shown). The electrodes **27** and **28** are connected to a current source **29.**

In operation of the device of FIG. II, the ram **25** is pulled down and an article **31** with burrs **32** is mounted on the tooling **20.** The ram **25** is then moved upward so that the tooling **20** and seal **22** close the chamber **21** on the lip **21***a*. The valve **24** is opened to allow combustible gas to enter the confined space **19** and to fill the tube **26** and then closed. The current source **29** is then activated to ignite the gas by heating the tube **26** between the spaced apart electrodes **27** and **28.**

SPECIFIC DESCRIPTION

The preferred apparatus of the present invention is illustrated in FIGS. III and IV. The apparatus is similar in operation to that shown in FIG. II but modified to provide improved operating life. A heating zone **40** on a tube **41** with a closed end **42** is defined by copper bushings **43** and **43***a*, 19 millimeters in diameter, mounted on the tube **41** by silver soldering. This mating of the bushings **43** and **43***a* to the tube **41,** prevents corrosion at that interface. The bushings **43** and **43***a* are slightly oversize in inside diameter to permit silver soldering. The heating zone was **13** millimeters long. The tube **41** inside and outside diameters were 3.2 and 6.4 millimeters respectively. The further assemblies on bushings **43** and **43***a* are identical and only one set will be described. Clamped around bushing **43** are two opposing copper bus bars **44** and **45** secured together by bolts **46** and threaded retaining plate **58.** The copper to copper contact of the bus bars **44** and **45** and bushing **43** and **43***a* prevents corrosion, which would result from using dissimilar metals, and helps to uniformly distribute the current around and into the tube **41.** The extended portions of the bus bars **44** and **45** are provided with coiled cooling tubes **47** and **48** brazed to the bus bars **44** and **45.**

The ends of the bus bars **44** and **45** are provided with bolts **49** and **50** for mounting electrically conductive leads **51** and **52.** The closed end **42** of the tube **41** is provided with an insulating positioning bracket **53** secured by bolts **54** and **57** to a portion of the chamber or other fixed part of the equipment (not shown). The bracket **53** loosely surrounds the tube **41** to allow the tube **41** to elongate on heating without bending. The open end of the tube **41** is provided with a hexagonal fitting **55** with threads **56.**

In operation of the apparatus of FIGS. III and IV, fitted to a chamber, electrical leads **51** and **52** are connected to a current source (not shown) and water or other cooling fluid is supplied through the tubes **47** and **48** to cool the bus bars **44** and **45.** Current is supplied equally at the identical potential through leads **51** and **52** through zone **40** from the bus bars **44** and **45** and through bushings **43** to ring **43***a* from the current source (not shown). The zone **40** is thus heated to ignite the combustible gas provided inside the tube **41.**

It has been found that the device of FIGS. III and IV will function reliably for long periods of time and many firings without cracking of the tube **41,** particularly in the heating zone **40.** The reason for this is that there are relatively uniform mechanical and thermal stresses on the heated zone because of the construction and mounting of the apparatus. The electrical leads **51** and **52;** cooling tubes **47** and **48** and other tube **41** components are arranged to minimize mechanical stress on the zone **40.** Other bus bar means and cooling means providing this result will occur to those skilled in the art.

The heated tube is so designed and located so as to minimize the heat rise of the tube from the explosion in the chamber and is also designed to maximize the heat loss when the current is turned off after the explosion. This is necessary because the tube must be below the ignition temperature of the gas mixture between the selected ignition periods.

I claim:

1. The method of igniting a combustible gas to produce a rapid thermal energy release and pressure rise which comprises:

a. providing an ignitable gas adjacent to and on one side of an electrically conductive igniter material having sufficient mechanical strength when heated to withstand a rapid thermal energy release and pressure rise in the gas adjacent to the igniter mate-

rial and having sufficient surface on the side opposite the gas to permit cooling;

b. heating the igniter material by passing an electric current through the material such that a zone between spaced apart electrically conductive low resistance leads connected to a current source is heated to ignite the combustible gas; and

c. cooling the heated zone of the igniter material using a heat transfer means on the surface opposite the gas to below the ignition temperature after the combustible gas has ignited.

2. The method of claim **1** wherein the conductive leads are moved into and out of contact with the igniter material.

3. The method of claim **1** wherein the combustible gas is provided in contact with the igniter material inside a sealed chamber.

4. The method of claim **1** wherein heat transfer means is forced air in contact with the igniter material on the side opposite the gas side of the surface.

5. The igniter apparatus adapted to be fitted on a combustible gas containing chamber to produce ignition of the gas with a consequent rapid thermal energy release and pressure rise which comprises:

a. an integral heatable electrically conductive igniter material provided with means adapted to be fitted to a gas ignition chamber and being of sufficient mechanical strength to be able to withstand a rapid thermal energy release and pressure rise in a gas on one side of the material and with a surface permitting cooling heat transfer on the side opposite the combustible gas side of the material;

b. electrically conductive low resistance leads connected to the igniter material to form a conductive path between the leads through the material such that a zone of the heatable igniter material between the leads is heated to produce ignition on the combustible gas side of the material when the leads are supplied from a current source; and

c. heat transfer means mounted adjacent to the surface opposite the combustible gas side of the material and in thermal contact with the heated zone of the igniter material for cooling the heated zone to below the ignition temperature of the combustible gas by removing the heat after the thermal energy release and pressure rise in the combustible gas in the chamber occurs.

6. The apparatus of claim **5** wherein the igniter material is in the form of a tube with sides extending from the means adapted to be fitted to the chamber to a closed end and an open end at the end with the means adapted to be fitted to the chamber and wherein the leads are connected to the exterior sides of the tube opposite the gas combustion side of the igniter material to provide the heatable zones.

7. The apparatus of claim **5** wherein the heated zone of the igniter material is adapted to fit inside the chamber.

8. The apparatus of claim **5** wherein the electrically conductive leads are provided with fluid cooling.

9. The apparatus of claim **5** wherein the heat transfer means is air cooled surfaces mounted adjacent the heated zone.

10. The apparatus of claim **9** wherein the air cooled surfaces are electrically conductive and the leads are connected to the ignition means surface through the cooled surfaces.

11. The apparatus of claim **5** wherein a current source is connected to the leads and wherein the igniter material is fitted to the chamber.

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