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APPARATUS FOR PRODUCING SMALL HOLES

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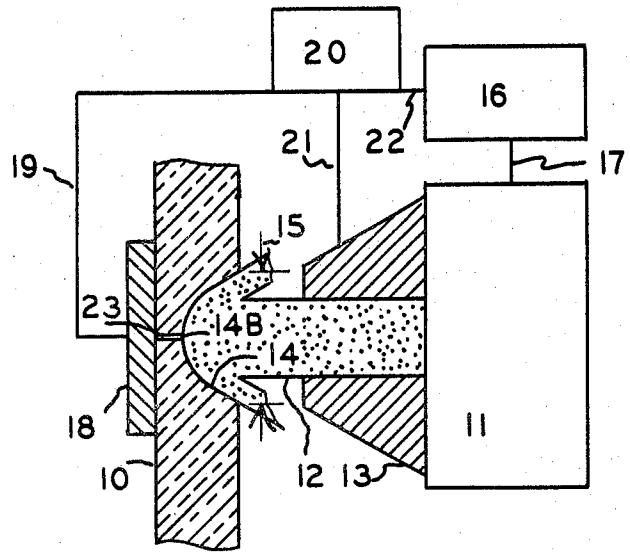


FIG. 1

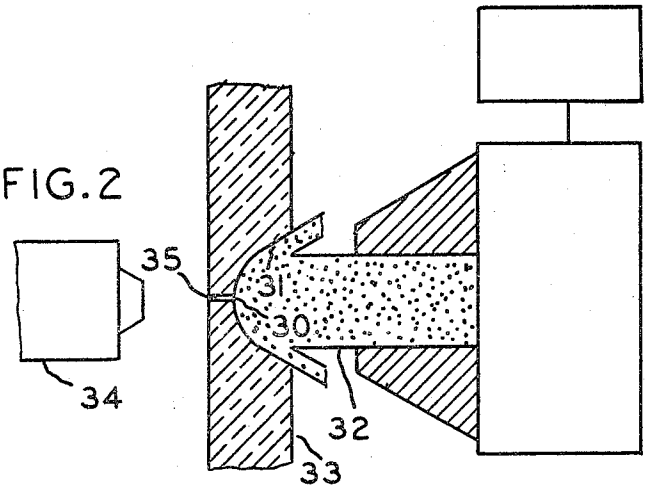


FIG. 2

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ABSTRACT OF THE DISCLOSURE

This device shows a unique and novel method for producing very small holes of predetermined size in materials such as glass by providing an abrasive stream for etching a portion of the glass and at the same time the stream provides one electrode of a pair of electrodes, the other of which is positioned on the other side of the glass so that when there is a predetermined thickness of glass electrical breakdown will occur therethrough.

This invention relates to a method of producing holes of extremely small diameters and more particularly to a method for drilling holes in glass and other substances in the 10 to 20 mircon range.

Modern technology has continued to expand and with it are the increased demands for improved measuring techniques. Many such techniques require extremely small holes in glass and other materials to perform such steps. For example, in the study of gaseous plasma phenomena it is necessary to use a mass spectrometer for identification of the various types of ions and/or gas atoms present in the plasma region. When the plasma is produced in gases at a pressure larger than about 10^{-4} torr, the plasma has to be separated from the mass spectrometer by a wall. The ions or gas particles are then either extracted or diffused through a hole in this wall by a high pressure region into the mass spectrometer. For gas pressures of the order of a few torr, this hole must have an extremely small diameter in order to be able to maintain a sufficiently low pressure inside the mass spectrometer without the use of elaborate pumping systems. Moreover, the length of the hole should be comparable to its diameter in order to reduce the possibility that ions are lost during passage by collision with the wall of the hole.

Several techniques have been devised to attempt to produce such small holes, one of which includes sealing a tungsten wire in the wall of glass tube to reduce the thickness of the glass tube to about the diameter of the wire and then etching the wire out of the wall.

It is an object of this invention to provide an improved method for producing holes in a walled member separating two defined volumes.

It is yet another object of this invention to provide a method of producing holes in a member having a known specific resistance comprising the steps of directing an abrasive stream of particles against the member at a point where a hole is desired, placing an electrode opposite said point, and providing a source of electrostatic potential coupled between said electrode and said stream of particles having a specific value such that when the desired thickness of glass is produced an electrical discharge will occur across the unabraded portion of glass.

Still a further object of this invention is to provide a device for making holes in a member, comprising: first means, including a nozzle, for directing an abrasive stream against the member; an electrode disposed opposite the nozzle, the member being positioned between the nozzle and the device; a source of electrostatic potential coupled between the nozzle and the electrode; control means responsive to a control signal coupled to the first means to control the stream; second means, coupled to the source and the control means to generate the control signal; and a third means, to control the source to preselect a given potential to cause electrical breakdown of the member at same thickness less than the initial thickness of the device.

Yet a further object of this invention is to provide a method of producing small holes in a member having first and second sides, comprising the steps of: directing an abrasive stream against the first side of the member in which a hole is to be produced, to produce an indentation; observing the second side of the member opposite the indentation with a microscope; stopping the stream when vibrations are observed; and applying an electrostatic potential across the member between the second side and the indentation to cause electrical breakdown of the remaining material of the member.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

FIGURE 1, in partial cross-section, shows one embodiment of the invention; and

FIGURE 2, in partial cross-section, shows a second embodiment of the invention.

FIGURE 1 shows a portion of a glass wall **10** wherein it is desired to drill a hole extending through the wall where said hole has a diameter in the **10** to **20** micron range. A first means including a device **11** is capable of generating a stream of abrasive or corrosive particles **12** and forcing it through a nozzle **13**. Such a particle stream will produce a concially shaped indentation **14** in wall **10** having first and second sides. This indentation has a diameter **15**. The abrasive stream will have a low specific resistance with respect to the specific resistance of the glass wall. A control circuit **16** coupled to device **11** is provided and is coupled to control the flow of stream **12** upon receipt of a signal through coupling **17**. An electrode **18** is positioned opposite the indentation **14** in juxtaposition with one side of wall **10** and is connected by lead **19** to a source of electrostatic potential **20** which in turn is coupled to nozzle **13** via electrical connection **21**. The value of potential of source **20** is sufficient to cause electrical breakdown between electrode **18** and the apex **14B** of indentation **14**, when the distance therebetween is reduced by the abrasive stream to approximately the diameter of the desired hole. Since the resistance per unit length of the material of wall **10** is known, and in this case is glass, it is a simple selection by one skilled in the art to select the voltage which will provide reproducible operation.

The breakdown of glass wall **10**, due to the electric discharge between stream **12** and electrode **18**, leaves a hole **23** which is in the range of 10 to 20 microns. When this occurs a signal is generated and connected to circuit **16** by lead **22** which turns off stream **12**.

FIGURE 2 shows a second embodiment of the invention wherein the depth between the apex **30** of an indentation **31**, produced by an abrasive or corrosive stream **32** in a glass wall **33**, is determined by observing through a microscope **34** the vibrations which occur when the indentation has reached a certain depth and at that time are readily apparent. When such vibrations are noted then the stream is stopped and an electrostatic potential is applied across the remainder of the wall material by means of a pair of electrodes and a final hole **35** is produced by electrical breakdown.

It should be noted that the method disclosed herein is particularly adapted for drilling holes in very complicated shapes of glassware and other materials. For example, should it be desirable to produce a small hole in a cy-

lindrical glass rod, it is very simple to shape an electrode such as to conform with the inner circumference of a rod and produce holes at any given spot opposite the electrode. Old techniques would not satisfactorily produce such holes wherein the invention as disclosed herein is particularly adapted to such use.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. A device for making holes in a member having a known specific resistance, comprising:

(a) first means, including a nozzle for directing an abrasive stream against said member;

(b) an electrode disposed opposite said nozzle, said member being positioned between said nozzle and said electrode;

(c) a source of electrostatic potential coupled between said nozzle and said electrode;

(d) control means responsive to a control signal coupled to said first means to control said stream;

(e) second means, coupled to said source and said control means to generate said control signal; and

(f) third means, to control said source to preselect a given potential to cause electrical breakdown of said member at some thickness less than the initial thickness of said member.

2. The device of claim 1 wherein said abrasive stream has a low specific resistance with respect to the specific resistance of said member.

3. The device of claim 2 wherein said electrode is disposed in a juxtaposition with said member and said abrasive stream is turned towards said member at a point opposite said electrode.

4. The device of claim 3 wherein said third means is adjusted to provide an electrostatic potential to cause electrical breakdown of said member when the thickness of the member between the apex of the hole and the electrode is approximately equal to the diameter of the desired hole.

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