

Oct. 5, 1965

W. JONES

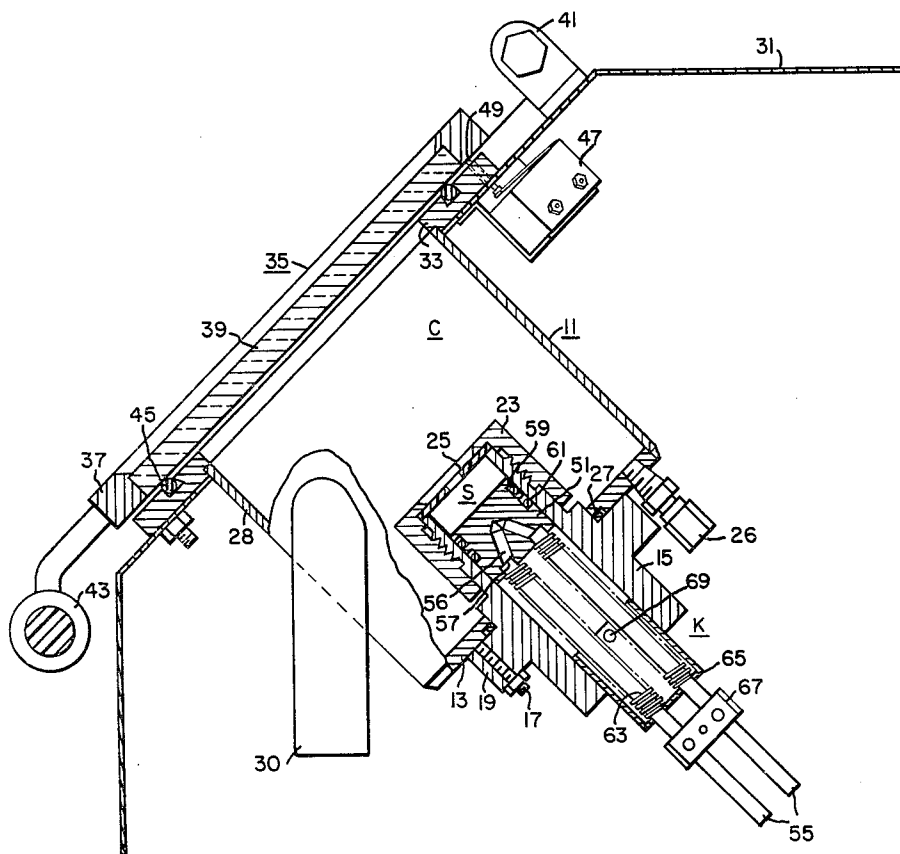
3,210,263

ELECTRIC DISCHARGE APPARATUS FOR ETCHING

Filed Jan. 11, 1962

2 Sheets-Sheet 1

FIG. 1



Oct. 5, 1965

W. JONES

3,210,263

ELECTRIC DISCHARGE APPARATUS FOR ETCHING

Filed Jan. 11, 1962

2 Sheets-Sheet 2

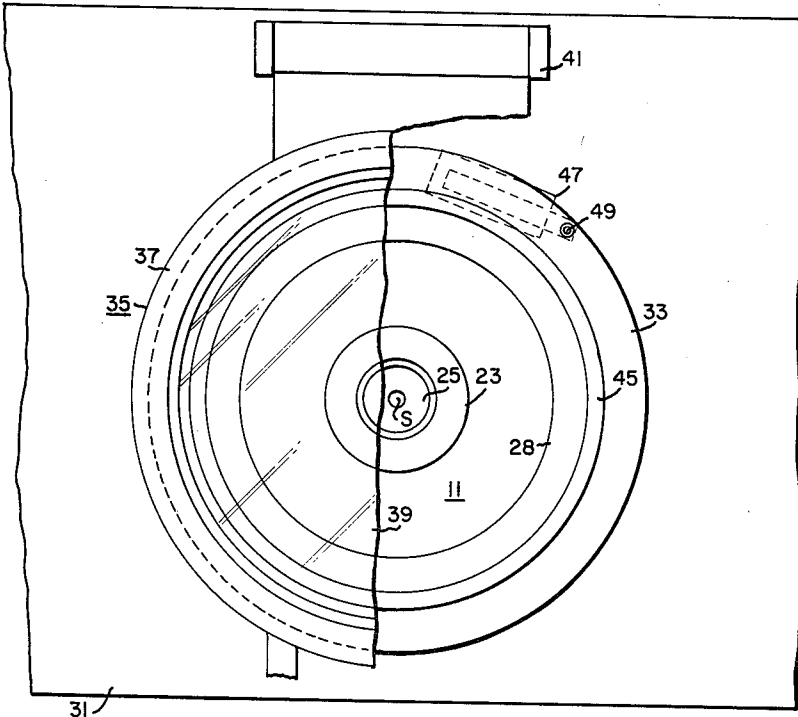


FIG. 2

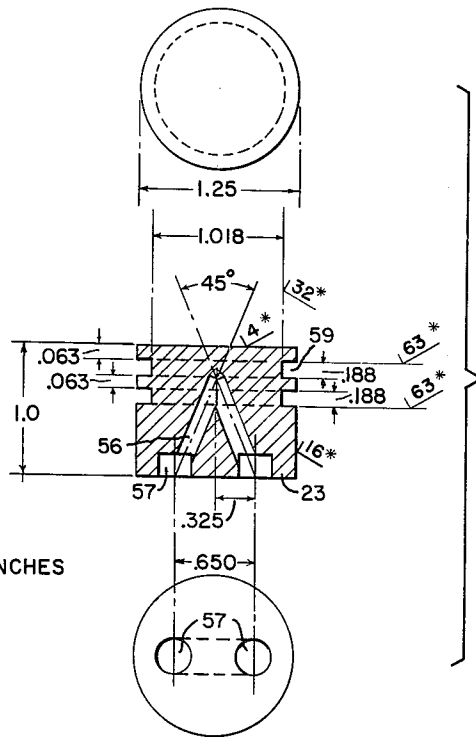


FIG. 3

* FINISH IN MICROINCHES

1

2

3,210,263 ELECTRIC DISCHARGE APPARATUS FOR ETCHING

Wallace Jones, Saltsburg, Pa., assignor to Nuclear Materials and Equipment Corporation, Apollo, Pa., a corporation of Pennsylvania

Filed Jan. 11, 1962, Ser. No. 165,628
5 Claims. (Cl. 204—298)

This invention relates to electric discharge apparatus and has particular relationship to cathodic vacuum etchers such as are disclosed in application 786,516, now Patent Number 3,097,154, filed January 13, 1959 to John E. Eck et al. for Apparatus and Method for Etching Objects and assigned to Nuclear Materials and Equipment Corporation. This Eck et al. application is incorporated herein by reference.

The Eck application discloses apparatus which has been used highly successfully for cathodic vacuum etching particularly of radioactive materials. In this apparatus a highly localized etching electric discharge is produced between the wall of a conducting chamber which serves as anode and a specimen which serves as cathode. The specimen is precisely seated on a support in firm thermal-interchange and electrical-conducting relationship with the support; the seating is effected by permitting the support to be urged into firm engagement with the specimen as the chamber is evacuated.

Because of the demand for the Eck etchers it has become desirable for economic reasons to simplify these etchers and also to improve the operation of these etchers and increase their reliability.

It is a principal object of this invention to achieve such simplification, improvement in operation and increase in reliability.

It is another object of the invention to provide relatively low-cost but highly reliable electric discharge apparatus for etching specimens.

An incidental object of this invention is to provide a novel cathode assembly which may be readily manipulated for a cathodic vacuum etcher particularly for use in etching radioactive specimens.

In accordance with this invention electric discharge apparatus for etching is provided which includes a cathode assembly that is readily manipulated as a unit. The assembly includes a block which serves for mounting the specimen and has a cooling cavity in communication with fluid-transfer conductors connected to the block. The block is mounted slideably in a wall of the container or chamber in which the etching discharge is produced and is resiliently urged into thermal-interchange and electrically-conducting relationship with the specimen by spring means supported on the fluid transfer conductors and, on evacuation of the chamber, by atmospheric pressure.

The sliding joint between the wall and the block must be vacuum tight and for this purpose an O-ring seal is provided. This seal includes grooves in the surface of the block contiguous to the wall of the chamber in each of which a resilient O-ring is compressed between the wall and the base of the groove. The block is urged into engagement with the specimen in part by the spring but predominately by the atmospheric pressure against the outside of the block when the vacuum is produced on the specimen side.

It is essential that the block move freely under the forces of the spring and the atmosphere and one of the important features of this invention arises from the discovery that binding between the O-rings and the wall must be avoided. This object is accomplished by dimensioning each groove so that the O-ring may roll freely in the groove as the block is moved inwardly to engage the specimen or outwardly.

Another important feature of this invention arises from the discovery that there is a definite limit to the excess in the dimension of the groove over the cross-sectional dimension of the O-ring. The relationship between the cross-sectional dimension of each groove and the cross-sectional dimension of the O-ring must be such that within the limits of voltage and pressure at which the apparatus operates a discharge in the space bounded by a groove the wall of the container and the O-ring is not produced. This condition is met by assuring that this space has substantially no dimension of length substantially greater than the mean-free-path of the ions of the gas which produce the etching at the operating voltages and pressures.

Typically the voltage of operation is about 5000, the gas is argon and the pressure range is from 10 to 2000 microns; the usual operating pressure is about 300 microns. From this data the mean-free-path may be calculated and the relative cross-sectional dimensions of the grooves and O-rings determined.

The novel features considered characteristic of this invention are disclosed generally above. For a better understanding of this invention both as to its organization and as to its method of operation the following description is presented of a specific embodiment taken in connection with the accompanying drawings, in which:

FIGURE 1 is a view partly in section and partly in side elevation of a preferred embodiment of this invention;

FIG. 2 is a view in top elevation showing a portion of this embodiment; and

FIG. 3 is an engineering drawing in section and top and bottom elevation of a specimen supporting block used in typical apparatus in accordance with this invention showing the dimensions of this block.

FIG. 3 is included for the purpose of aiding those skilled in the art in practicing this invention and not with any intention of restricting this invention in any way.

The apparatus shown in the drawings is a cathodic vacuum etcher including a chamber C in which the etching discharge is produced and a cathode assembly K with which a specimen S is subjected to ion bombardment. The specimen S may include a block of material to be etched embedded in a holder as disclosed in Cain et al. application Serial No. 125,442 filed July 20, 1961 and assigned to Nuclear Material and Equipment Corporation. When a specimen is so mounted one of its surfaces is adapted to be exposed to the discharge and the other surface adapted to be connected to a thermal sink and an electrical conductor.

The chamber C includes a cylindrical flanged pot 11 of conducting material having a central opening in its base 13 into which a cylindrical shouldered and flanged cathode holder 15 of an insulating material such as plexiglass extends. The holder 15 is secured to the base 13 by bolts 17 through its flange 19 and the junction between the holder 15 and the pot 11 is rendered vacuum tight by a compressed O-ring 21. The holder 15 is threaded near the top and a cap 23 of insulating material such as plexiglass may be screwed onto the thread. The cap 23 has a hole in its top and when screwed down secures the specimen S under a screen 25 of insulating material such as Teflon having a hole in its center through which the discharge impinges on the specimen.

The base 13 has another opening into which a fitting 26 for bleeding gas into the chamber extends gas-tight. The side wall 28 of the pot 11 has an exhaust tube 30 which may be connected to a vacuum system (not shown).

The pot 11 is suspended from the wall 31 of a cabinet (only wall 31 shown) with its flange 33 extending outside of the wall 31. The chamber C includes a composite top 35 for the pot 11. The top 35 includes a generally

3

circular frame 37 of aluminum or other material in which a plate 39 of glass or other suitable transparent material nests. The top 35 may be pivoted about a hinge 41 extending from the wall 31 by a knob 43 extending from the frame 37. When the top 35 is in the closed position the transparent plate 39 engages an O-ring 45 in a groove in the flange 33. When the chamber C is exhausted the atmospheric pressure on the plate compresses the O-ring 45 providing a vacuum seal between the plate 39 and the O-ring. The plate 39 is mounted in the frame 37 so that it is free to seat itself properly on the O-ring 45.

A micro-switch 47 is suspended from the wall 31 below the frame 35 near the hinge 41. The switch 47 is actuable by a pin 49 to close when the top 35 is in the closed position. The closing of the switch conditions the power circuit for the etcher to be closed so that the discharge voltage may be impressed between the specimen S and pot 11.

The cathode assembly K includes a block 51 of generally cylindrical form slideable in the holder 15. The block 51 is of a conducting material such as brass and has a V-shaped cavity 56 through which cooling water is transferred by conductors 55 which are brazed into grooves 57 (FIG. 3) in the block 51. The block 51 has grooves 59 in the surface contiguous to the wall of the holder 15. Within each groove 59 there is an O-ring 61. The O-rings are compressed by the wall of the holder 15 so that they vacuum seal the region inwardly from the grooves 59 from the region outwardly from the grooves.

The grooves 59 and O-rings 61 are so dimensioned that the O-rings can rotate or roll readily without binding as the block 51 slides in the holder 15. The cross section of the grooves 59 is thus appreciably greater than the cross section of the O-rings 61. The difference in cross section is limited to a magnitude such that with an O-ring 51 compressed in one corner of a groove 59 the distance, in a plane generally transverse to the groove and O-ring, between the outer surface of the O-ring and the remotest point of the groove from the surface is less than the mean-free-path of the ions in the chamber C. Under such circumstances there is no discharge in the groove when the electric potential is impressed between the pot 11 and the block 51. The dimensions of the grooves 59 of a typical block 51 are presented in FIG. 3. These grooves are dimensioned for O-rings each having an inside diameter of 1 inch, an outside diameter of 1½ inches and a ring diameter of ¾ inch, with the range of pressures for the chamber C between 10 microns and 2000 microns, the ionized gas argon and the ionizing potential about 5000 volts.

The specimen S is seated on the block 51 and is held between the screen 25 and the block 51. The block 51 is urged into engagement with the specimen S by compression springs 63 encircling the conductors 55 and compressed between the base of a cup 65 secured to the holder 15 and the block 51. The movement of the block 51 is limited by a stop 67 secured to the conductors 55 which when the block 51 is at its innermost position engages the cup 65. It is advisable to lubricate the grooves 59 with a suitable silicone grease.

In the use of the apparatus shown in the drawing the cap 23 is screwed onto the holder 15 holding the screen 25 against the upper rim of the holder. Preparatory to use the cap 23 is unscrewed from the holder 15, the screen 25 being removed with the cap 23. The top 35 is at this point removed from the pot 11 and the specimen S is set on the block 51 through the top of the pot by a remote manipulator or by hand, if permissible, and extends above holder 15. The cap 23 with screen 25 is then screwed into place compressing the specimen S under the screen 25. The springs 63 are compressed by the screwing down of the cap 23 so that the springs 63 urge the block 51 into engagement with the specimen S. The top 35 is then closed and the chamber C exhausted. The top 35 then compresses the O-ring 45, vacuum sealing

4

the container. The atmospheric pressure also urges the block 51 into firm thermal interchange and electrically-conducting contact with the specimen S. The pot 11 is grounded and the hot terminal of the supply is connected to the conductors 55 to establish an electrical discharge for etching.

While a preferred embodiment of this invention has been disclosed herein many modifications thereof are feasible. This invention then is not to be restricted except insofar as is necessitated by the spirit of the prior art.

I claim as my invention:

1. A cathodic vacuum etcher for etching a specimen including a chamber having an anode electrode for said etcher, means connected to said chamber for evacuating said chamber, and a readily manipulated cathode assembly for mounting said specimen in a position to be etched by a discharge in said chamber, said assembly including a block of thermally and electrically conducting material having a cavity therein, means for connecting said block thermally and electrically to said specimen, means for mounting said block so that said block supports said specimen in said chamber, said mounting means including a substantially vacuum tight joint permitting movement of said block, inlet and outlet conductors for a cooling fluid in communication with said cavity secured to said block, spring means encircling said conductors and in engagement with said block at the junctions between said conductors and block for exerting a force urging said block in said mounting means generally longitudinally of said conductors, and means connected to said block for impressing a cathode potential on said specimen with reference to said anode electrode.

2. Electric discharge apparatus for etching a specimen including a chamber having an anode electrode for said specimen, means connected to said chamber for evacuating said chamber, and a readily manipulated cathode assembly, said assembly including a block to engage said specimen in cooling and electrically conducting relationship, said block having a cavity therein, means for mounting said block so that said block supports said specimen in said chamber, said mounting means including a substantially vacuum tight joint permitting movement of said block, conductor means secured to said block in communication with said cavity for supplying cooling fluid to said cavity, and spring means encircling said conductor means and engaging said block for urging said block generally longitudinally of said conductor means into engagement with said specimen, and means connected to said block for impressing a cathode potential on said specimen with reference to said anode electrode.

3. Electric discharge apparatus for etching a specimen including a chamber having an anode electrode for said specimen, means connected to said chamber for evacuating said chamber, and a readily manipulated cathode assembly, said assembly including a block to engage said specimen in cooling and electrically conducting relationship, said block having a cavity therein, means for mounting said block so that said block supports said specimen in said chamber, conductor means secured to said block in communication with said cavity for supplying cooling fluid to said cavity, spring means encircling said conductor means and engaging said block for urging said block generally longitudinally of said conductor means into engagement with said specimen, said block also having at least one peripheral groove in an external surface thereof, said groove being generally transverse to the direction in which said spring means urges said block, a resilient O-ring in said groove cooperative with said mounting means to seal the joint between said mounting means and said block substantially vacuum-tight but permit movement of said block under the action of said spring means, and means connected to said block for impressing a cathode potential on said specimen with reference to said anode electrode.

4. Electric discharge apparatus for etching a specimen

5

including a chamber having an anode electrode for said specimen, means connected to said chamber for evacuating said chamber, and a readily manipulated cathode assembly, said assembly including a block to engage said specimen in cooling and electrically conducting relationship, said block having a cavity therein, means for mounting said block so that said block supports said specimen in said chamber, conductor means secured to said block in communication with said cavity for supplying cooling fluid to said cavity, spring means encircling said conductor means and engaging said block for urging said block generally longitudinally of said conductor means, said block also having at least one peripheral groove in an external surface thereof, said groove being generally transverse to the direction in which said spring means urges said block, a resilient O-ring in said groove, the cross-sectional dimensions of said O-ring and groove being so related that said O-ring is free to roll in said groove when subject to a force in a direction tangential to said O-ring and generally perpendicular to the plane of said O-ring, and means connected to said block for impressing a cathode potential on said specimen with reference to said anode electrode.

5. Electric discharge apparatus for etching a specimen including a chamber, having an anode electrode, means connected to said chamber for evacuating said chamber, said chamber having an opening for receiving a specimen, said opening having an extended wall, a block having an external surface of contour similar to said wall mounted slidably along said wall, said block having at least one groove in said external surface contiguous to said wall, a resilient O-ring in said groove compressed by said wall so as to provide a vacuum seal at the junction between

6

said wall and ring, means for mounting said specimen on said block, means connected to said block for urging said block into firm thermal and electrical engagement with said specimen by relative motion of said block and said wall, and means connected to said block for impressing a cathode potential on said specimen with reference to said anode electrode, the cross-sectional dimensions of said groove being sufficiently greater than the cross-sectional dimension of said ring to permit said ring to roll between said groove and said wall as said block is moved along said wall, but not so much greater that an electric discharge is produced in the free space between the boundary of said groove and said O-ring within the range of voltage and pressure at which said apparatus is operated.

References Cited by the Examiner

UNITED STATES PATENTS

2,206,020	7/40	Berghaus	204—298
2,219,611	10/40	Berghaus	204—298
2,314,683	3/43	Berry	277—177
2,521,248	9/50	Parker	277—177
2,614,793	10/52	Storm	277—168
2,647,810	8/53	McCuiston	277—177
2,768,036	10/56	Greenough	277—177

FOREIGN PATENTS

360,139	6/38	Italy.
372,480	6/39	Italy.

30 JOHN H. MACK, *Primary Examiner*.

JOHN R. SPECK, *Examiner*.