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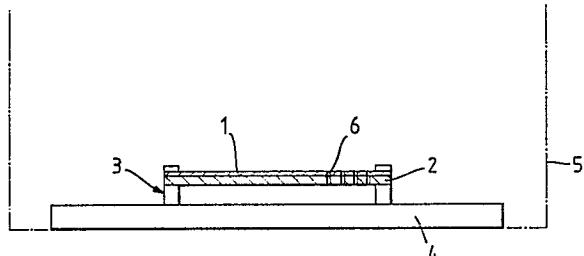
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⑯ Ion extraction grids.

⑰ A method of manufacturing a grid electrode comprising a lamina of refractory metal having an array of holes therein, wherein the holes are formed by a punching operation.

Fig. 1.



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Description**Ion Extraction Grids**

The present invention relates to the production of extractor grids for use in ion sources, ion engines and the like.

The manufacture of electrodes for the extraction and acceleration of ion beams from plasma ion sources presents a particularly difficult problem because of the high accuracy required in the finished products if they are to achieve the desired ion extraction efficiency, electrode lifetime and "optical" quality of the extracted ion beam. Because of the high temperatures at which they operate, the only suitable materials for the manufacture of the electrodes are refractory metals such as tungsten or molybdenum.

The electrodes take the form of a sheet of refractory metal with an array of holes formed in it. The holes have to be positioned very accurately relative to one another, parallel sided and without burrs or deformations at either end. The usual method of manufacturing such electrodes is by drilling the holes. However, this method of production is slow and expensive because of the difficulty of drilling holes in the refractory metals which are used to make the electrodes. Not only are drills blunted readily by the hardness of the metals, but they tend to wander off line. Also molybdenum in particular tends to suffer from brittle fracture or even, in rolled sheet form, to delaminate, so causing ragged edges to the holes where the drill emerges from the metal sheet. To some extent the problems of drill wander and ragged break-out can be lessened by clamping the sheet of refractory metal between two sheets of a softer metal such as mild steel, but this does not solve the problem of the blunting of the drills and makes the production process even slower as a much greater total amount of metal has to be drilled.

According to the present invention there is provided a method of manufacturing a grid electrode comprising a lamina of refractory metal having an array of holes therein, wherein the holes are formed by a punching operation.

The method of manufacture may also include the operations of forming the lamina into a non-planar shape and/or heating the lamina to relieve stresses set up in the lamina during earlier operations.

The process of the invention has a number of advantages compared with drilling and other hole-producing techniques such as laser drilling, spark erosion or photochemical etching. Not only does it produce accurately located holes of good quality with parallel sides and little or no burrs on the break-out side, but it is possible to produce holes of other than circular cross-section, such as hexagonal or square. Also, the process is much quicker and cheaper than the other processes previously referred to. Moreover, the hardness and brittleness of refractory metals and their tendency to delaminate when in rolled sheet form, which create problems with other hole-producing techniques, present no such problems to the process of the present

invention.

By way of example, the production by a method embodying the present invention of a screen grid for use in an ion engine will now be described with reference to the accompanying drawings in which:-

Figure 1 shows a lamina of molybdenum prepared for a first stage in the production of the screen grid

Figure 2 illustrates schematically a second stage in the production process

Figure 3 illustrates another stage in the production process, and

Figure 4 shows the finished article.

Referring to the drawings, a disk 1 of molybdenum in diameter and 0.25 mm thick was mounted on a rigid supporting backing piece 2. The assembly 3 was positioned on the table 4 of a CNC vertical machine, illustrated generally by the outline 5. An hexagonal array of holes 6 consisting of 9097 holes each of 1.75 mm diameter was formed by punching through the molybdenum disk 1 and the backing piece 2. The molybdenum disk 1 and the backing piece 2 were then separated and any minor burrs on the break-out edges of the holes 6 were removed by water blasting.

As it was desired that the completed grid should have a dished shape, a stiffening rim 21 was then formed as shown in Figure 2. After this had been done the grid was pressed to its approximate final shape. The pressing was carried out progressively at temperatures of up to 300°C with intervals for stress relieving. The partially formed grids were then finished to shape and simultaneously stress relieved by stretch forming against a die 31 at a temperature of 860°C for a period of ten hours.

Claims

1 A method of manufacturing a grid electrode comprising a lamina (1) of refractory metal having an array of holes (6) therein, wherein the holes (6) are formed by a punching operation.

2 A method according to claim 1 wherein there is included the operation of forming the lamina (1) into a non-planar shape.

3 A method according to claim 1 or claim 2 wherein there is included a stress-relieving operation subsequent to the formation of the holes (6) in the lamina (1).

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Fig. 1.

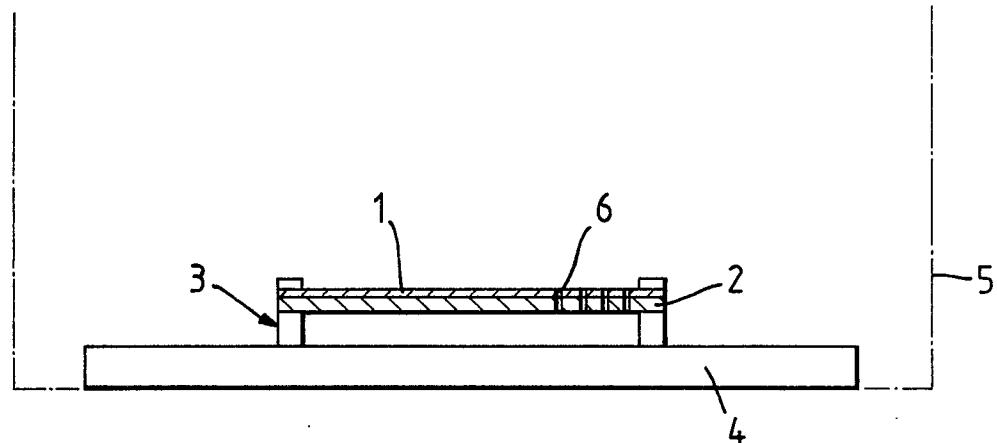


Fig. 2.

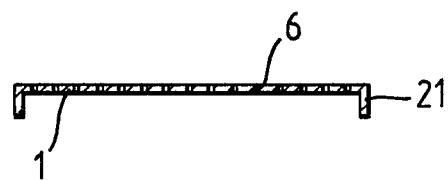


Fig. 3.

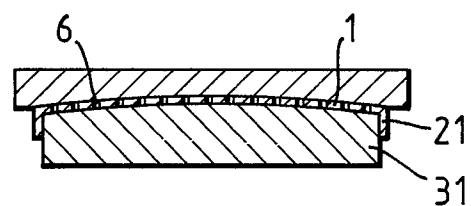


Fig. 4.





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	FR-A-2 530 378 (RCA CORP.) * Page 5, lines 8-31; claim 1; figure 1 * ---	1	H 01 J 27/02 F 03 H 1'00
A	FR-A-2 496 978 (K.P. TESLA) * Page 1, lines 29-38; claim 1; figure * ---	1,3	
A	US-A-4 447 773 (G. ASTON) * Column 1, lines 32-48; figures 1,2 * -----	1,2	
TECHNICAL FIELDS SEARCHED (Int. Cl.5)			
H 01 J F 03 H G 21 K			
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	28-11-1989	ERRANI C.	
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