Dec. 12, 1961 A. G. FIELD 3,013,176

THERMIONIC VALVES

Filed Feb. 3, 1960

FIG. 1.

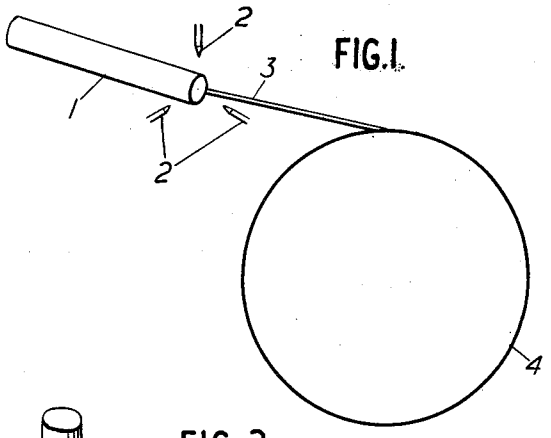


FIG. 2.

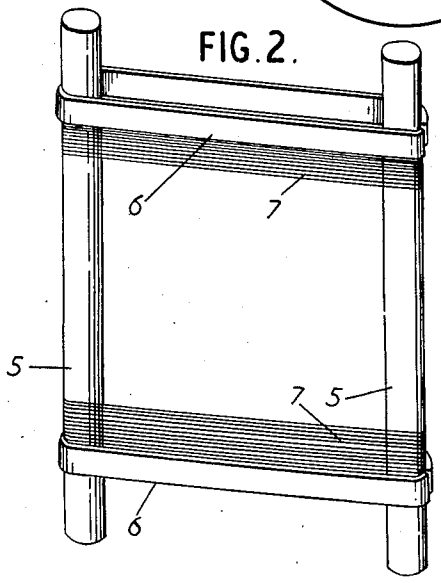


FIG. 3.

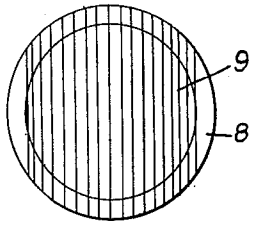
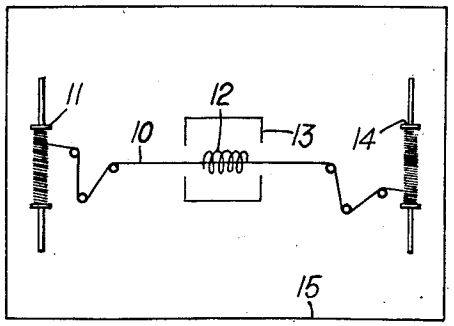


FIG. 4.



Inventor
A.G.FIELD
By W. W. Russo
Attorney

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THERMIONIC VALVES

Andrew George Field, London, England, assignor to International Standard Electric Corporation, New York, N.Y.

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The present invention relates to grids for thermionic valves.

The control grid—and also in some instances, other grids—of a thermionic valve is nowadays often formed of exceedingly fine tungsten wire. In what is known as a frame grid this wire is wound around a pair of side rods, spaced apart and held to make a rigid frame by a pair of straps between which the winding of fine wire is laid down. In other types of valve a planar grid is used in which the wire is stretched across one face of a rectangular or annular frame.

With a view to increasing, more and more, the ratio of mutual conductance to cathode-grid capacitance in a thermionic valve, the grid wire is made as fine as possible and wire between 5 and 10 microns in diameter has already been used (one micron—10^{-6} meter). Performance could be still further improved if yet finer wire could be used.

According to the present invention the grid-wire in a grid for a thermionic valve is provided by gold-coated quartz fibre. Such fibres can be produced in diameters of 2 to 3 microns and of adequate tensile strength.

The invention will be described with reference to the accompanying drawings in which:

FIG. 1 shows diagrammatically a preferred method of producing the required lengths of quartz fibre from a solid rock of quartz;

FIG. 2 illustrates a frame grid according to the invention on a much enlarged scale;

FIG. 3 illustrates a single-sided planar grid; and

FIG. 4 illustrates a preferred method of gold-coating the quartz fibre.

One known method of producing very fine quartz fibre, which has been in use now for many years, is to heat the end of a quartz rod to near its fusion point to draw off a fibre and attach it to the head of an arrow fitted in a cross-bow and to fire the bow, drawing off a length of fibre. In this way skilled technicians can obtain lengths of approximately 10 to 20 feet of fibre of the required 2 to 3 microns diameter; such lengths are of the order of that required for winding a frame grid. A preferred method of manufacture, however, is illustrated in FIG. 1 in which a rod of fused quartz **1** is driven slowly along its length through a set of oxy-gas jets **2**, which melt the end of the rod. A fibre **3** is drawn off from the molten end and passed round a revolving wheel **4** of large diameter. For the equilibrium condition in which the wheel **4** picks up just as much fibre in unit time as is being molten from the rod **1**, consideration of the volume of fibre being wound on the wheel per unit time with the corresponding volume of molten rod, shows that the diameter of the fibre can be controlled by adjustment of the relative speed of rotation of the wheel **4** with respect to the axial movement of the rod **1**. Thus, for a rod of 0.040" diameter a wheel 6 feet in diameter rotating at 200 revolutions per minute would draw off a fibre 2 microns in diameter when the rod is moved forward at 0.0175 inch per minute.

The fibre taken off by the wheel **4** or obtained in other manner is wound on to small spools and is gold-

coated either before or after winding on the grid support.

For the gold-coating known sputtering techniques may be used or, as is at present preferred and illustrated in FIG. 4, where the coating is to be applied before winding, the fibre **10** is unwound from a small diameter spool **11** and run through a gold helix **12** heated in an oven **13** by means not shown, so that the gold is deposited evenly over the whole of the surface. The gold coated wire is rewound onto a second spool **14**. The whole is enclosed in a vacuum chamber **15**.

For a frame grid the gold-coated quartz fibre is wound on to a standard gold-plated grid frame with the normal manufacturing equipment. Thus the spools are rotated round the frame, their rotation being controlled either by a frictional pulley or by a torque motor. The torque produced must be adjusted to provide a tension in the fibre of less than 0.2 gramme. On completion of the winding, the grid is fired at 1150° C. in a reducing atmosphere to braze together the gold on the fibre to the gold on the frame; the grid is then ready for use. Alternatively the fibres can be adhered to the frame by using a glass frit and ovening at 800° C. in hydrogen.

A completed frame grid according to the invention is illustrated in FIG. 2, in which side rods are indicated at **5** spaced apart by straps **6**, welded to the side rods and the grid wire **7** is wound over the side rod **5** between the straps **6**. Typical dimensions for a grid are:

Diameter of side rods	.0345 inch.
Distance apart of side rods	.250 inch.
Width of straps **6**	.020 inch.
Thickness of straps **6**	.005 inch.
Distance apart between straps **6**	.250 inch.
Length of winding between straps	.250 inch i.e. space between straps completely wound.

A typical grid according to the invention uses 2 micron "wires" wound at 1000 turns per inch, which thus provides a very uniform electric field with a minimum interception factor for the electrons. The penetration of the field between the wires to the cathode surface is adequately controlled if the pitch is not greater than the distance from cathode to grid. With a finer wire the same shadowing effect takes place at a smaller pitch therefore regaining control over anode current at the same grid to cathode capacitance. Thus the ratio of material conductance to grid-cathode capacitance is improved.

In a normal frame grid the straps **6** are made of molybdenum and are welded to the molybdenum side rods. In the present invention, the straps **6** must be made of a material whose coefficient of thermal expansion is not too different from that of the quartz fibre e.g. it can be made of quartz strip which will unite readily to the molybdenum side rods and hold the frame sufficiently rigid to withstand the tension of the winding and maintain it in position during use. Alternatively, the whole of the frame may be made of quartz or of a refractory ceramic having a temperature coefficient of expansion approximating that of quartz in which case difficulties due to differential thermal expansion do not arise.

A planar grid is illustrated in FIG. 3. Here a ring of fused quartz **8** is used as a support and quartz fibres are stretched over the ring and secured thereto by means, for example, of a glass frit or the fusion of gold coatings applied before the winding operation. The grid, except that it is of quartz, which must, at some stage, be gold-

coated, is similar in construction and manufacture to known metal grids. In particular, if the support 8 is rectangular, the quartz fibre forming the grid "wire" could conveniently be wound over two ends of the support, as in the frame grid embodiment described above, and the winding cut away from one face after being secured to the support.

At the present time the material preferred for the non-metallic portions of FIG. 2 and the support 8 of FIG. 3 is quartz. Refractory ceramics of very low temperature cvoefficient of expansion are, however, becoming available and it is envisaged that it will soon be practical, and even preferable, to use such ceramics for the straps or support, respectively.

While the principles of the invention have been described above in connection with specific embodiments, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What is claimed is:

1. A grid for a thermionic valve in which the grid wires are of gold-plated quartz fibre.

2. A grid for a thermionic valve comprising a pair of side rods, a pair of transverse straps spaced apart and joining the side rods to form a rigid frame, and a winding, over the side rods and between the straps, of gold-coated quartz fibre.

3. A grid according to claim 2 in which the said frame is of quartz.

4. A grid according to claim 2 in which the said frame is of a refractory ceramic having a temperature coefficient of expansion approximating that of quartz.

5. A grid according to claim 2 in which the said side rods are metallic and the straps are of quartz strip united to the metal of the side rods.

6. A grid according to claim 2 in which the side rods are gold-plated and the winding is bonded to the side rods by the fusion of the gold on the quartz fibre and on the side rods.

7. A planar grid comprising a frame support of quartz to which are secured wires of gold-coated quartz fibre.

8. A planar grid comprising a frame support made of a refractory ceramic having a temperature coefficient of expansion approximating that of quartz, to which are secured wires of gold-coated quartz fibre.

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