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LB-973

TECHNIQUE FABRICATING SMALL CYLINDRICAL GRIDS OF NOVEL DESIGN FOR USE IN PENCIL TUBES

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Approved

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Introduction

When negative-grid tubes such as pencil-tube triodes are designed for use at ultra-high frequencies, the transit time of the electron stream becomes important. Better performance can be obtained in the UHF range when the control grid is positioned at a relatively short distance from the emissive surface of the cathode. Effective control can be maintained over the electron flow at close grid-cathode spacings only by the use of thinner and more closely spaced grid wires.

This bulletin describes two new techniques for the construction of grid structures used in pencil tubes. One is a technique for making a formed pencil-tube grid; the other, a technique for making a pencil-tube grid that has the grid lateral wires inside of the siderods.

Conventional Grid

Grids used in commercial pencil tubes consist of lateral wire wound at a relatively coarse pitch around many supporting siderods. The cross section of a typical pencil-tube triode shown in Fig. 1 illustrates the conventional coaxial cathode, grid, and plate elements. In the enlarged view of the grid positioned about the cathode, shown at the bottom of Fig. 1, the many siderods and the wrapping of lateral wire are shown in detail. The primary function of the lateral wire in this grid is to hold the siderods together. The siderod array, rather than the grid lateral wire, serves as the effective electron-control element.

The extent to which this type of structure can be used in high-frequency tubes is limited, however, because the minimum size of the siderods and the closest practical spacing between them depend on mechanical considerations and the need for thermal conduction of heat from the grid. The use of grids in which the siderods are the dominant control factor does not appear to be practicable for grid-cathode spacings smaller than about 0.002 inch.

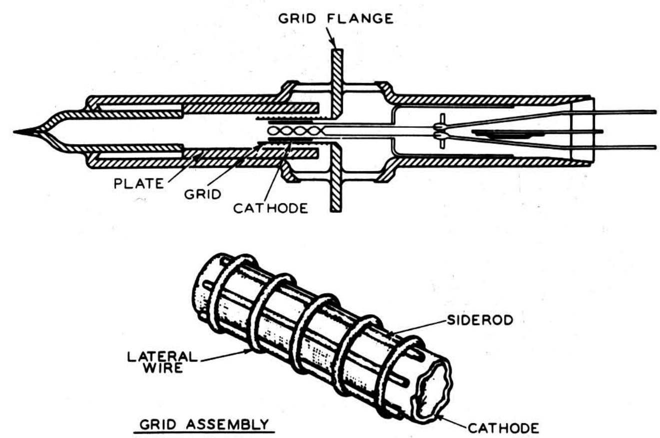

Fig. 1 - Cross section of typical pencil tube triode and enlarged view of conventional coaxial grid and cathode.

The practical limit for this type of structure is closely approached in a grid having an outside diameter of about 0.070 inch and consisting of 48 siderods of 0.001-inch-diameter wire around which 0.0008-inch-diameter lateral wire is wound at a pitch of 80 turns per inch. With this structure, lateral wire having a smaller diameter and wrapped at a relatively fine pitch can be made to serve as the dominant control element, but the minimum grid-cathode spacing will be limited by the diameter of the siderods interposed between the lateral wire and the cathode.

Two modifications of grid configuration which overcome the limitations described above and improve high-frequency performance are currently being employed in developmental pencil tubes. These modifications are called the "formed grid" and the "inside-out grid".

Formed Grid

In the formed grid structure, shown in Fig. 2, the lateral wire serves as the dominant control element. In this grid, the lateral wire is formed against an internal mandrel so that the inside diameter of the grid is substantially the same as the diameter of the mandrel.

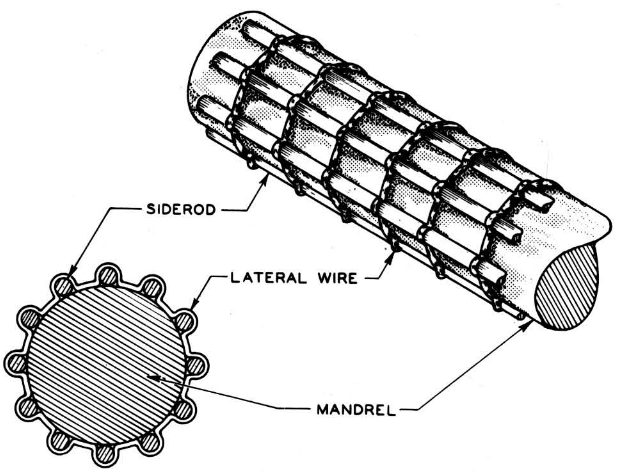

Fig. 2 - Formed grid showing lateral wire formed against internal mandrel.

Fig. 3 shows the apparatus on which conventional pencil-tube grids are made. The continuously moving mandrel comes out through a stationary nosepiece. As the head rotates, the lateral wire is drawn under tension from a spool through a guide and is wrapped around the siderods. The wound grid passes through a brazing chamber and the lateral wires are r-f brazed to the siderods in a hydrogen atmosphere.

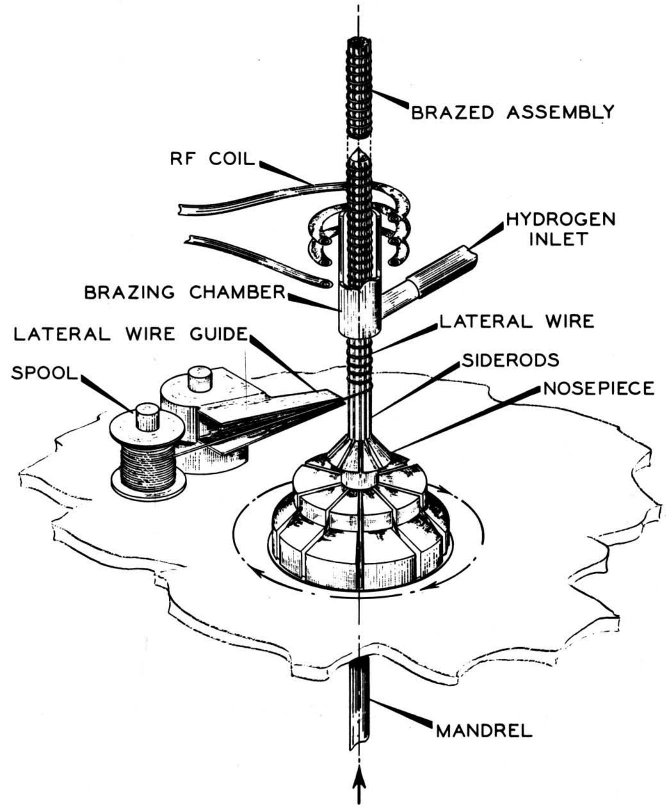

Fig. 3 - Apparatus used for fabrication of conventional pencil-tube grids.

A portion of the brazed assembly on the mandrel is shown at the top of Fig. 3.

In the fabrication of a formed pencil-tube grid, a conventional grid is first made on the equipment shown in Fig. 3 as follows: Eighteen nickel-clad copper siderods having a diameter of 0.002 inch are positioned around a mandrel of oxidized nickel-chrome alloy. The diameter of the mandrel is substantially equal to the desired internal diameter of the grid. A silver-plated nickel-cobalt alloy lateral wire having a diameter of 0.0005 inch is then wound under tension around the siderods at 400 turns per inch, which is suitable for effective control. The lateral wire is r-f brazed to the siderods in a hydrogen atmosphere at a mandrel temperature of about 1000 to 1050 degrees C in the coil region. The silver plating of the lateral wire serves as the brazing material so that a joint is obtained between the lateral wire and the siderods at each crossover point. The brazing operation is dependent upon the mandrel speed, the r-f field, and the hydrogen flow used.

Fig. 4 shows the apparatus used to form the grid. A mandrel-and-grid assembly is positioned on a rubber pad in the die and pressure is applied by the punch, which also contains an attached rubber pad. A ram force equal to 3000 pounds per square inch is applied to the rubber pads and transmitted to the lateral grid wire. This force is sufficient to exceed the elastic limit of the wire so that a plastic deformation is accomplished and the portions of the lateral wire between adjacent siderods are formed against the mandrel. Thus, this technique serves both a grid-sizing and a grid-forming function. After the grid is formed, the grid assembly on the mandrel appears as shown in Fig. 2.

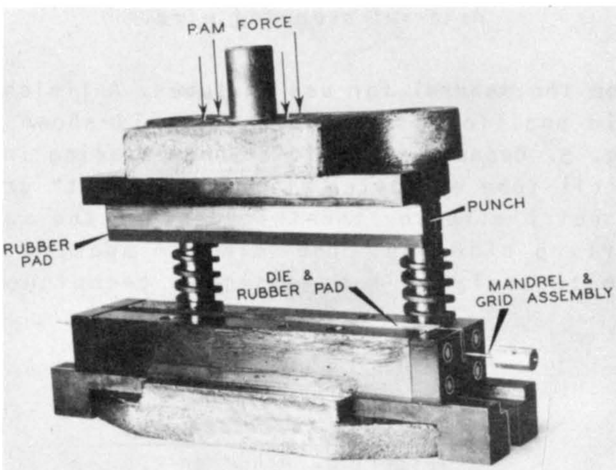

Fig. 4 - Grid-forming apparatus.

After the grid strip is formed, it is cut into grids of required length and these grids, still on the mandrel, are washed in a degreasing agent, rewashed in water, rinsed in methanol, and dried. The grids are then fired in a hydrogen atmosphere at a temperature of 600 degrees C for five minutes and removed from the mandrel for use in tubes. When these formed grids are used, the grid-cathode spacing in a pencil tube is not limited by the thickness of the supporting rods, but only by tube-assembly techniques.

"Inside-Out" Grid

Another grid structure used in developmental pencil tubes to improve UHF performance has the grid lateral wire fastened to the portion of the siderods nearest the cathode, as shown in Fig. 5. This construction variation has been called the "inside-out" grid. The apparatus on which this grid can be made, which is shown in Fig. 6, is similar to the equipment previously described. For the "inside-out" grid, however, the lateral wire is wound around the mandrel prior to insertion in the nose-piece, and a securing wire is used to hold the siderods in position against the lateral wire during grid winding.

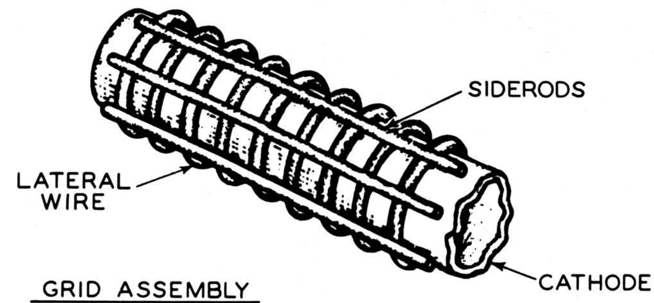

Fig. 5 - "Inside-out" grid with side rods outside the lateral wire.

A typical "inside-out" grid is made as follows: Silver-plated nickel-cobalt alloy or gold-plated tungsten lateral wire having a diameter of 0.0005 inch is wound under tension at the desired pitch around a nickel-chrome alloy mandrel having an oxidized surface. The mandrel then passes through a pencil-tube grid-winding machine, and 18 nickel-clad copper or silver-plated nickel-clad copper siderods are positioned around the helix parallel to the axis of the mandrel. The siderods are held in place around the outer surface of the helix by an external wrapping of oxidized stainless steel wire having a diameter of 0.0015 inch; the securing wire is wound at a coarser pitch than that used for the grid lateral wire. The grid strip is r-f brazed in a hydrogen atmosphere so that the grid lateral wire and the siderods are joined to each other at the points of contact. Because both the mandrel and the external securing wire have oxidized surfaces, they do not join with the materials of the lateral wire and the siderods during the brazing process. Fig. 7 shows a portion of the grid strip assembly consisting of the mandrel, the lateral wire, the siderods, and the external securing wire.

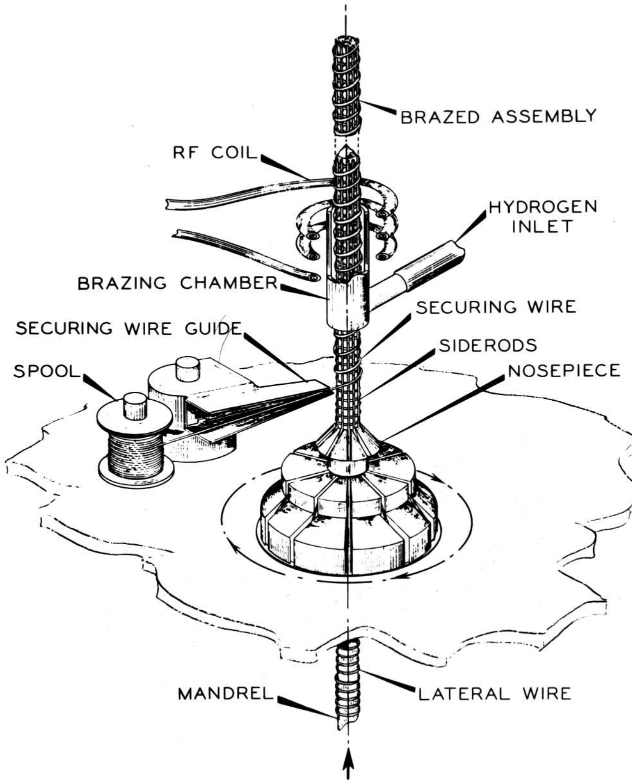

Fig. 6 - Apparatus used for fabrication of "inside-out" grid.

After the grid strip assembly is brazed, the external securing wire is removed and the strip is cut into grids of required length. The grids are then washed, fired and removed

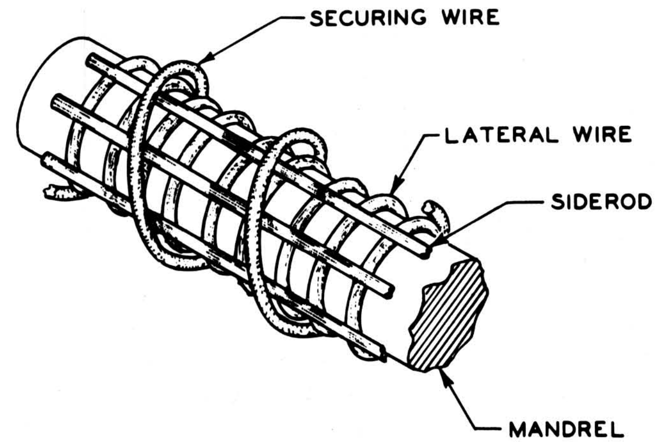

Fig. 7 - "Inside-out" grid strip assembly, showing mandrel, lateral wire, siderods, and external securing wire.

from the mandrel for use in tubes. A finished grid positioned about a cathode is shown in Fig. 5. Because the grid-cathode spacing in a pencil tube employing this "inside-out" grid is not limited by the thickness of the supporting siderods, the minimum spacing is limited only by tube-assembly techniques.

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