Sept. 16, 1952 E. E. BORLAND ET AL 2,610,387

METHOD OF MAKING GRID ASSEMBLIES

Filed March 22, 1945 2 SHEETS—SHEET 1

FIG. 1

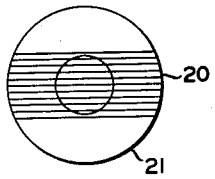


FIG. 2

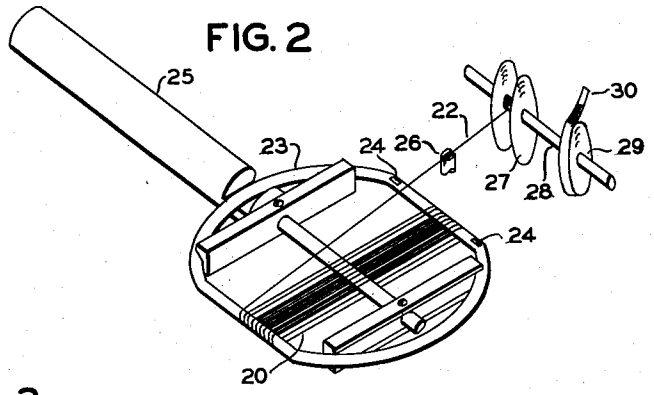


FIG. 3

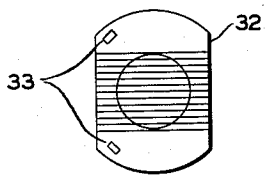


FIG. 6

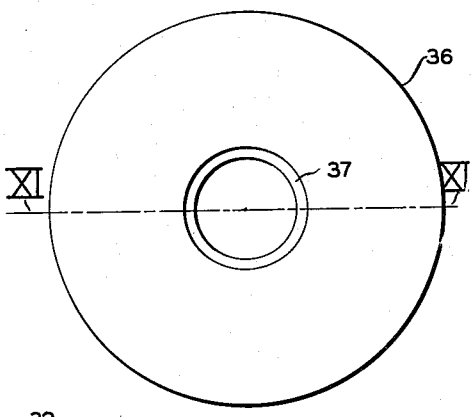


FIG. 4

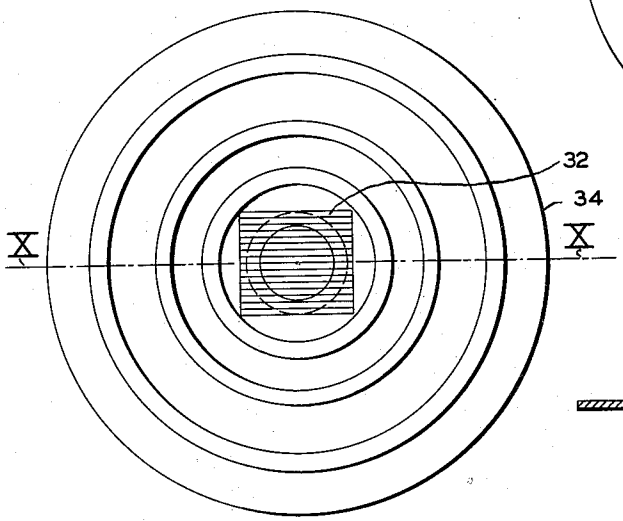


FIG. 7

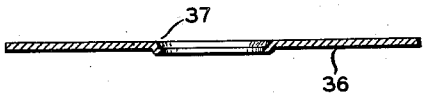
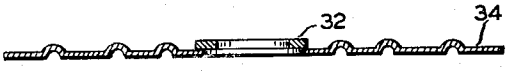


FIG. 5



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Filed March 22, 1945 2 SHEETS—SHEET 2

FIG. 8

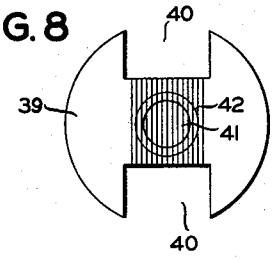


FIG. 9

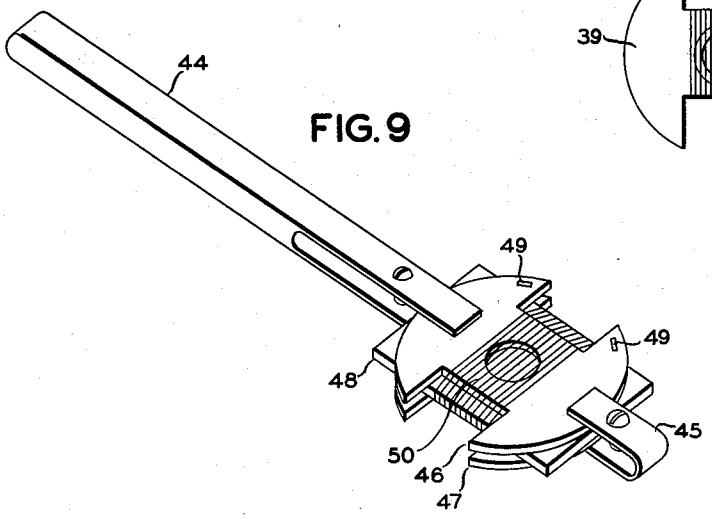
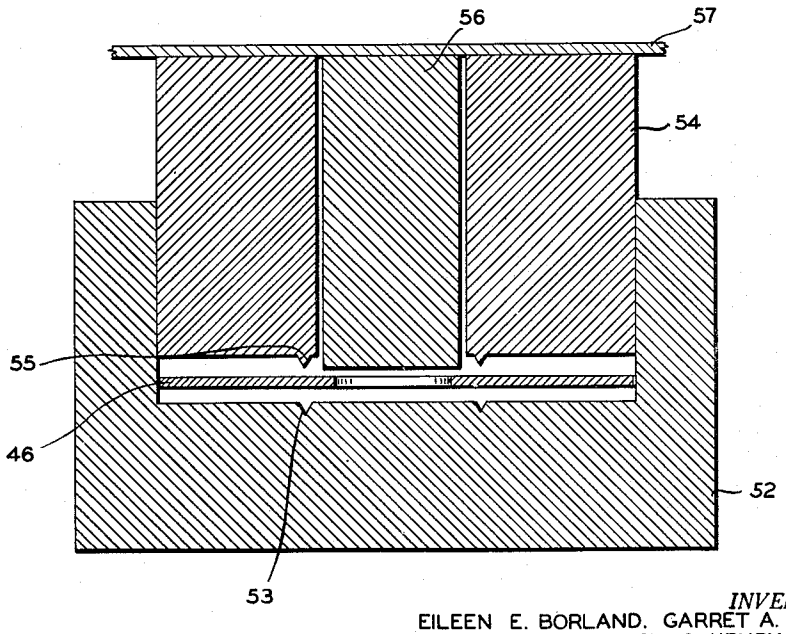


FIG. 10



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UNITED STATES PATENT OFFICE

2,610,387

METHOD OF MAKING GRID ASSEMBLIES

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Application March 22, 1945, Serial No. 584,225

3 Claims. (Cl. 29—25.17)

1

This invention relates generally to electrical apparatus and more particularly to fine wire grids for vacuum tubes and to methods for making such grids.

The use of ultra-high frequencies introduced the problem of designing vacuum tubes having transit times small compared to the period of oscillation. This problem resulted in the placing of the grid very close to the cathode. Such close spacing, if relatively large wires are used, causes variations in the transit times of emitted electrons.

The construction of fine wire grids presents various problems such as the accurate positioning of the fine wires on small grid supports. The problem of obtaining proper tension on these fine grid wires, along with proper spacing, is one which cannot be solved by previous methods. Because of the close inter-electrode spacing in tubes as well as because of the design of the tubes themselves, the thickness of material used in the grid supports and support holders is often limited.

One of the objects of this invention is to provide grids of accurately spaced fine wires to eliminate the above mentioned variations of transit times of emitted electrons. Another object of this invention is to provide methods of manufacturing such fine wire grids.

For a better understanding of the invention together with other objects and features thereof, reference is had to the following detailed description taken in connection with the accompanying drawings in which:

Fig. 1 is a plan view of a grid support with grid wires attached;

Fig. 2 is a perspective view of a grid winding holder with guide, feed spool and brake;

Fig. 3 is a plan view of a small grid support with grid wires attached;

Fig. 4 is a plan view of a convoluted grid support holder with a completed grid support inserted;

Fig. 5 is a cross sectional view of grid support in Fig. 4 shown through axis X—X;

Fig. 6 is a plan view of a grid support holder for holding single grid supports;

Fig. 7 is a cross sectional view through axis XI—XI of grid support holder shown in Fig. 6;

Fig. 8 is a plan view of a grid support with grid wires tightened by a convolute die method;

2

Fig. 9 is a perspective view of a grid winding holder used for winding single or double grids; and

Fig. 10 is a cross sectional view of a cylindrical die which is used to press convolutes in grid supports for tightening grid wires.

Referring now more particularly to Fig. 1, a fine wire grid construction is shown comprising grid wires **20** attached to and supported by grid support **21**.

One method of manufacturing the grid shown in Fig. 1 is shown in Fig. 2 in which grid wire **22** is wound on a ring **23** that is made of wire with two opposite sides flattened to provide straight sections on which the grid wire **22** is wound. Small nickel tabs **24** are spot welded to a straight section of ring **23** to provide a means for holding the wire to prevent unraveling. The ring **23** is clamped in a holder **25** which is rotated by a lathe. The ring **23** is stretched when clamped in the holder **25**, so that the distance between the straight portions of the ring **23** may be shortened by any desired amount which might be required to tighten the grid wires **20** after completing the winding. A slotted ruby **26**, mounted on the lathe carriage, is used as a guide for grid wire **22**. The grid wire **22** is fed from a spool **27** which is mounted on a shaft **28**. Also mounted on shaft **28** is a wheel **29** which is braked by a brush **30** to provide the necessary tension for winding the grid wire **22**.

Grid support **21**, shown in Fig. 1, is inserted between the two layers of grid wires **20** wound on ring **23**. The wires **20** are then gold soldered in a hydrogen atmosphere to the grid support **21**. The grid support **21** with attached wires **20** is then cut away from the winding ring **23** and the grid wires are cut off at the outside rim of the grid support.

In Fig. 3 the grid support **32** is made of tungsten and is of no larger size than is physically necessary for supporting the grid wire during manufacture and use. Nickel tabs **33** are spot welded to the support to hold the grid wire ends.

This grid may be produced by holding support **32** in a convenient clamp holder and winding it in the manner shown in Fig. 2. No method of tightening is used in making grids with tungsten discs with the grid wire wound directly thereon. The tungsten disc has the same expansion as the tungsten grid wires and the wind-

ing tension has to be relied upon to provide sufficient tension to hold the grid wires straight.

Fig. 4 shows a composite type of grid construction which has in combination a small double grid, such as shown in Fig. 3, soldered to a molybdenum convoluted support holder **34**. The convoluted support holder **34** is used where a rigid support is needed for small grids and where space will allow the use of convoluted construction. Fig. 5 shows a cross sectional view of Fig. 4 through axis X—X.

Fig. 6 shows a non-convoluted grid holder **36** which may be used where thickness is a limiting factor. Fig. 7 is a cross section view of Fig. 6 through axis XI—XI. It consists of a supporting ring which has a small offset **37** pressed near the inner rim. The offset **37** should be of such dimensions that the grid support will fit into it. The grid support should be soldered in and, if a thinner construction is desired, the lip formed by the offset may then be turned off in a lathe. In the event a double grid is used and a single grid is desired, one set of grid wires may then be removed from the grid support.

In Fig. 8 there is shown a preferred grid construction comprising support **39** having approximately the shape of a disc with two opposite peripheral notches **40** and a central aperture covered by grid wires **41**. A convolute **42** in support **39** and wires **41** surrounds the aperture.

Fig. 9 illustrates a preferred method of manufacturing grids.

Holder **44** clamps one end of the dumbbell type winding supports, and clamp **45** clamps the other end. The molybdenum grid supports **46** and **47** sandwich a separator **48** of any material, such as a ceramic or tungsten coated with graphite, that will not adhere to gold. Two nickel tabs **49** are spot welded to one of the forms for fastening the ends of grid wires **50**. The grid is wound in the same manner as was the ring **23** described in Fig. 2. The wound supports are then placed in a hydrogen atmosphere and the grid wires soldered to the modybdenum grid discs **46** and **47** with gold. The grid wires **50** may then be cut at the outer edges of the grid supports and the single grids **46** and **47** obtained.

Since it is often desirable to tighten grid wires to keep the wires straight and in position, a die shown in Fig. 10 may be used. The bottom die **52** has a circular well of size to accommodate a grid assembly **46**. A circular groove **53** is cut in the bottom with its inside diameter slightly larger than the grid aperture. Top die **54** fits into the base well and has a circular ridge **55** of the same diameter as groove **53**. A center plug **56** slightly longer than the top die, holds the grid flat while the top die presses a convolute on the grid **46**. A pad **57** of lead or other material is used to distribute the pressure from a press evenly to the die **54** and plunger **56**. The convolute thus made enlarges the grid aperture and thereby tightens the grid wires by an amount proportional to their lengths. By pressing a convolute in the grid, the grid may be wound with only sufficient tension to keep the wires straight and in position.

The size and depth of the convolute can be varied to produce the desired tightening of the grid wires. It is desirable to place the grid assembly **46** in well **52** with the grid wires down when making the convolute. Since the wires are of tungsten, they would rapidly dull the convolute ridge **55** on the die if they faced upwardly.

It is to be understood that the above described grids and grid supports may be made from materials other than described and used in combinations other than described. Different tube construction may require any combination of the above described grid structure and supports. It has been found that gold solder applied in a hydrogen atmosphere is a very satisfactory means of fastening grid wires to the grid discs and in fastening grid discs to supporting rings. The most satisfactory method of tightening grid wires has been by use of the stamped convolute near the aperture of the grid disc. The dumbbell type of grid disc is preferred since it conserves on grid wire. The method of feeding the wire while winding the discs is subject to many variations. When winding grids, a slotted ruby grid wire guide is preferred to other materials since it it has good wearing qualities.

While there has been described what is at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as set forth in the appended claims.

The invention claimed is:

1. The method of making a grid assembly comprising taking a support having a central aperture therein and placing a plurality of wires on said support, the wires overlying and extending beyond on each side of said aperture, permanently conductively bonding the ends of each wire to the support, and deforming simultaneously the support and wires intermediate the attached ends and the aperture to tension the wires.

2. The method of making a grid assembly comprising the steps of increasing the distance between the ends of a resilient winding frame to diminish the distance between its sides, winding wire substantially laterally about said frame to form a grid of a plurality of substantially parallel strands of wire spanning said sides, allowing the frame to resume its normal shape, thereby putting said strands of wire of said grid under tension, placing a support having a central aperture therein over said wires so that the wires lie across the aperture and extend beyond on each side of said aperture, permanently, conductively bonding the wire to the support near each edge, cutting away the wires extending beyond the edges of the support, and deforming simultaneously the support and wires intermediate the attached ends and the aperture to tension the wires.

3. The method of making a grid assembly comprising the following steps, clamping together two metallic grid supports having a central aperture in each support with a separator between the two supports, winding a wire about the clamped members to form a plurality of wires lying across and extending beyond the apertures on each side of each support, permanently, conductively bonding the wires to each support near each edge of each support, cutting away the wires extending beyond the edges of each support, and deforming simultaneously the support and wires intermediate the attached ends and the aperture to tension the wires.

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