June 26, 1956 W. E. GLENN ET AL 2,751,662

METHOD OF MAKING AN ELECTRONIC GRID

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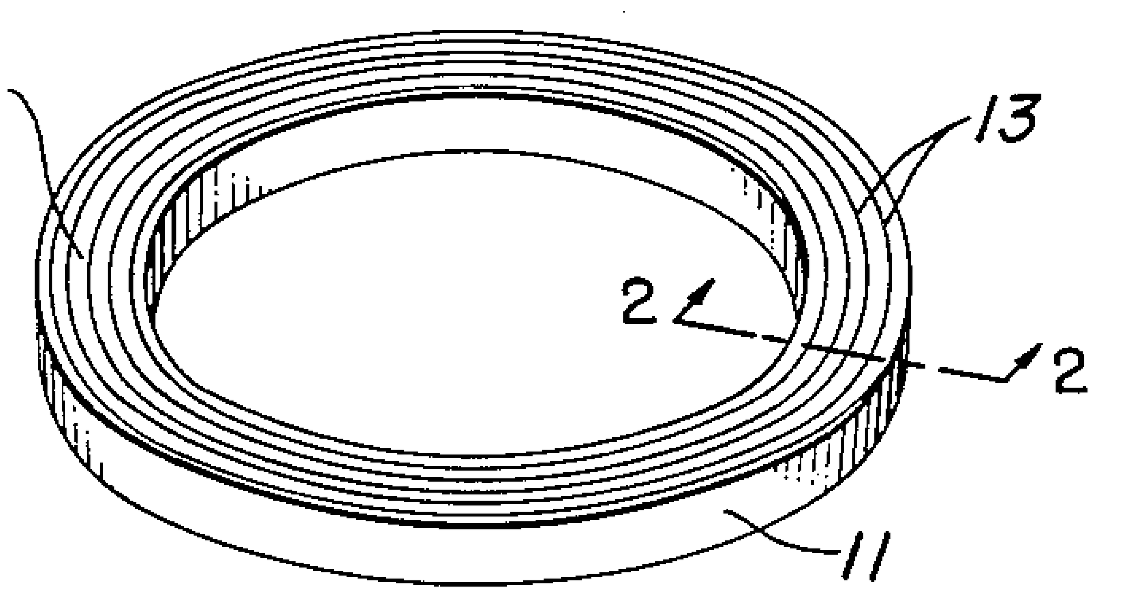

FIG_1_

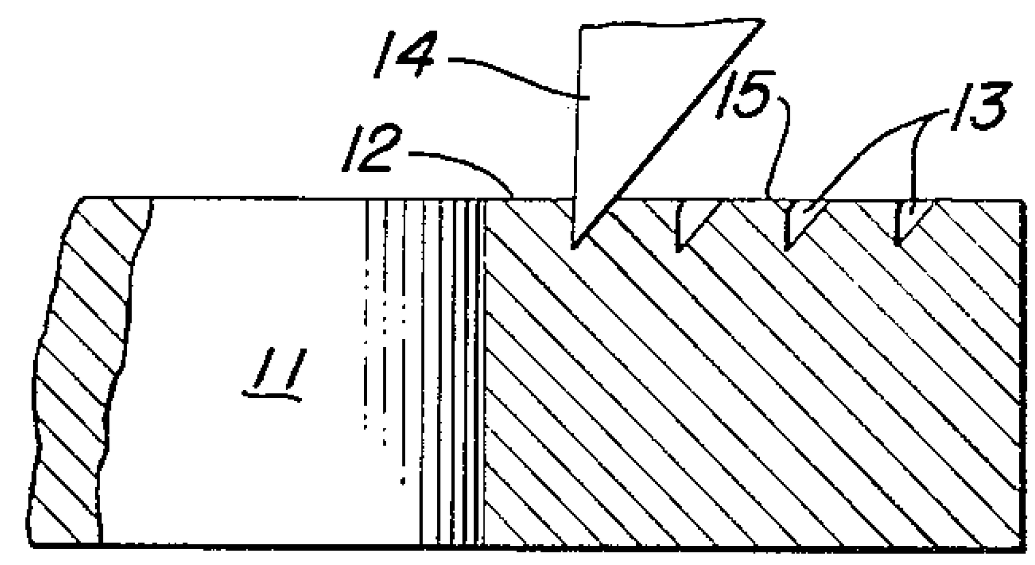

FIG_2_

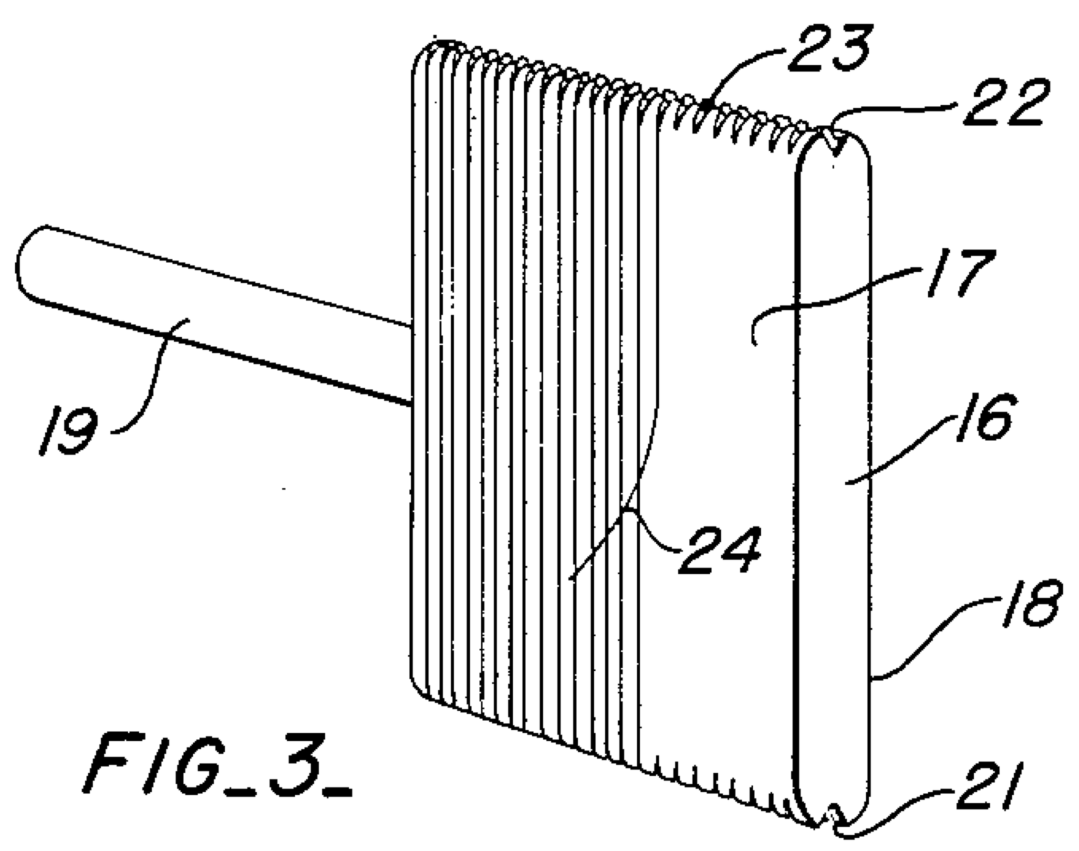

FIG_3_

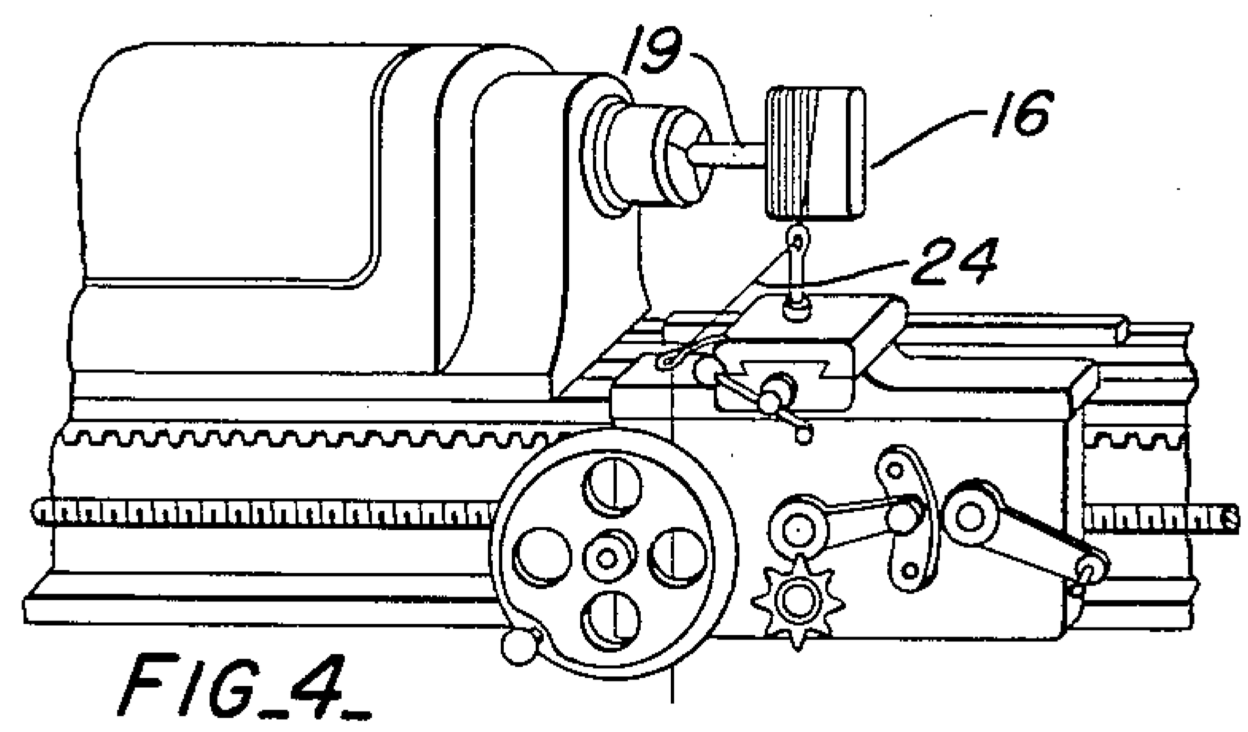

FIG_4_

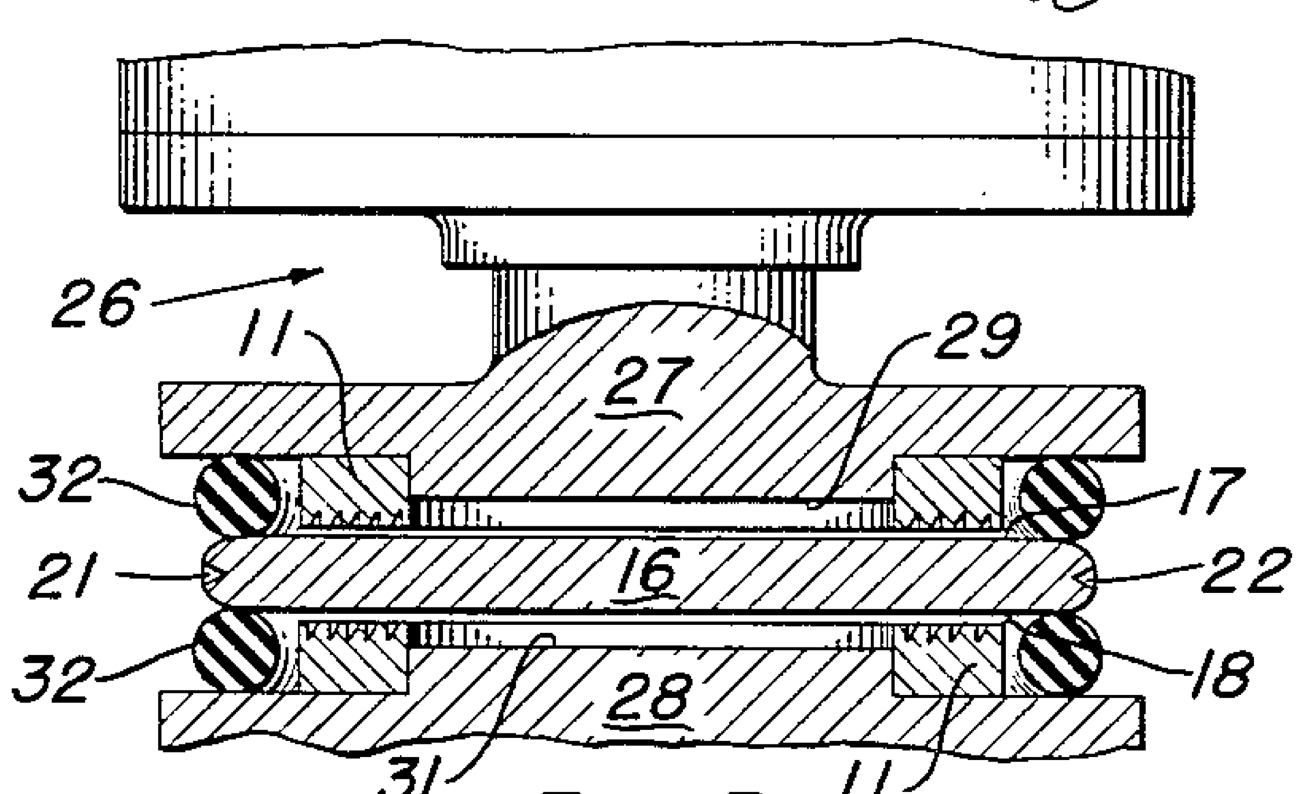

FIG_5_

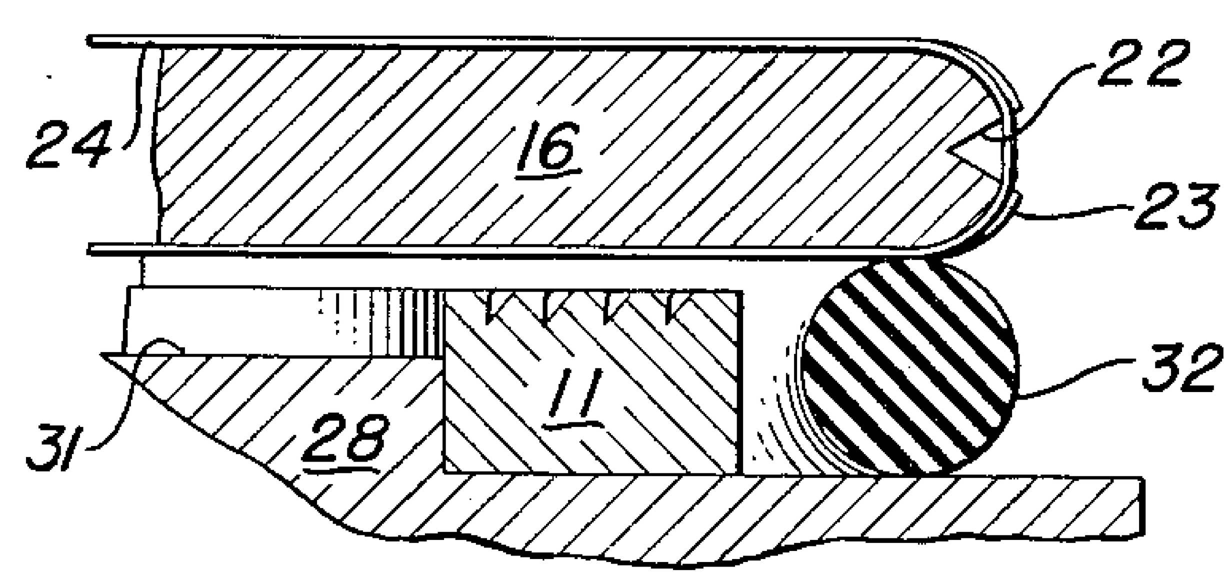

FIG_6_

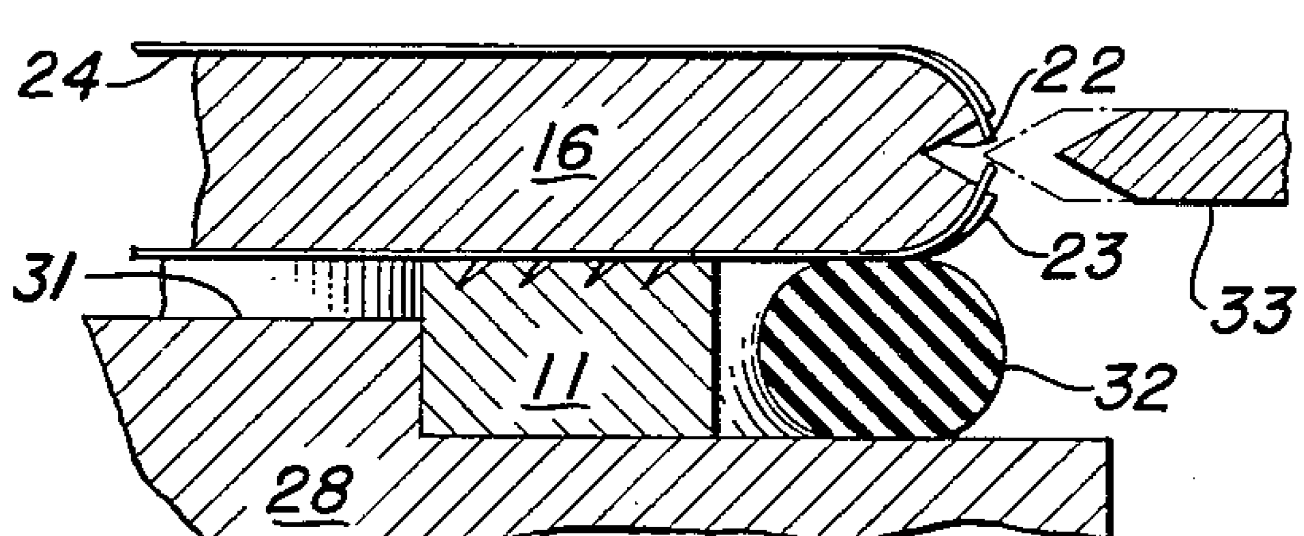

FIG_7_

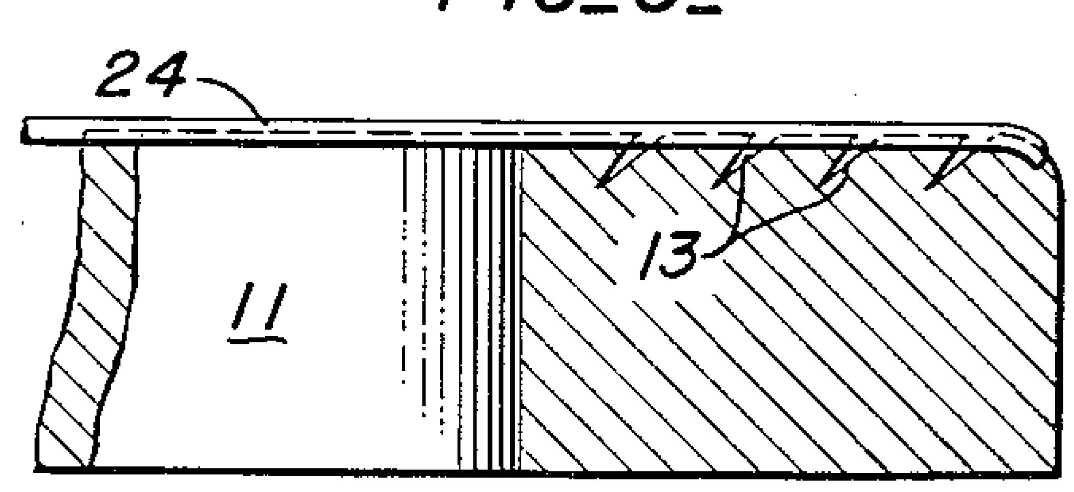

FIG_8_

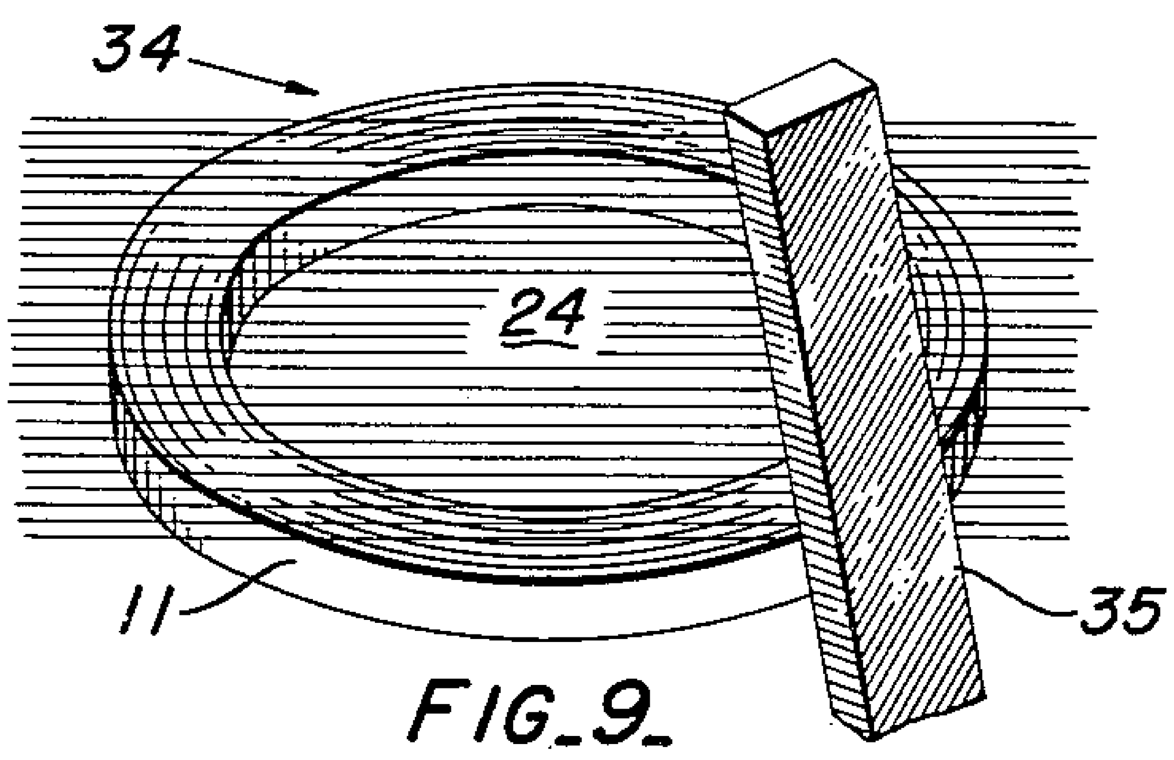

FIG_9_

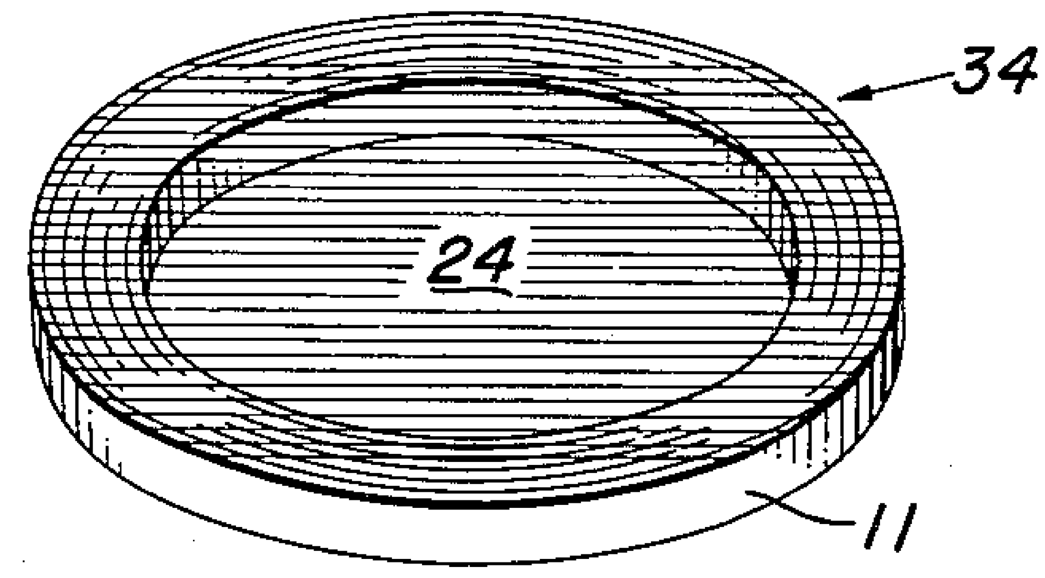

FIG_10_

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METHOD OF MAKING AN ELECTRONIC GRID

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4 Claims. (Cl. 29—25.17)

The present invention relates to an improved grid construction and method of making same and in particular to a grid for use in electronic equipment having parallel wires and maintaining such parallelism when in use in such as a klystron or the like.

Many of the new electronic vacuum tubes and even gas tubes employ flat parallel electrodes rather than cylindrical electrodes and the production of flat grid electrodes with parallel wires has proven quite difficult, particularly where large diameter grids are required. Conventionally flat grids are formed by gold soldering tungsten wires to a supporting ring; however, difficulty is experienced in holding the wires in parallel relationship during this process. Also heating and cooling of the wires and ring during soldering causes a warping of the ring and a certain amount of sag in the wires which is highly undesirable. Distortion of the ring after attachment of the wires, as by hammering, may be used to stretch the wires; however, this generally results in the individual wires lying in different planes and also results in a large percentage of breakage, often as high as 50%.

It is, of course, very important that electronic grids have their wires parallel and in a single plane, for otherwise the characteristics of the tube in which the grid is employed would depend upon the unpredictable grid configuration, and it is further important that the grid maintain its original dimensions and configuration during operation of the tube in which it is installed even though it is subjected to high temperatures and the like, for otherwise unpredictable variations of tube characteristics would result during operation thereof.

It is therefore an object of the present invention to provide a new and improved electronic grid and method of construction thereof.

It is another object of the present invention to provide a new and improved electronic grid having parallel wires under tension and lying in a single plane.

It is a further object of the present invention to provide a new and improved method of making an electronic grid without the application of heat thereto.

It is still another object of the present invention to provide an improved electronic grid structure of large diameter.

The present invention provides for imbedding fine wires in a support ring in such a manner that they are maintained in tension, and this is accomplished by preparing the surface of the supporting ring so that the same force which imbeds the wires therein also causes a radial shifting of the surface to stretch the imbedded wires.

Considering now the invention in some detail, reference is made to the accompanying drawings wherein:

Figure 1 is an isometric view of the grid support ring;

Fig. 2 is a cross section view of the support ring taken at 2—2 of Fig. 1 and showing the cutting tool used on the support ring;

Fig. 3 is an isometric view of the mandrel employed to contain the grid wires during the process of securing them to the support ring;

Fig. 4 shows the mandrel in place on a lathe employed to wind the wire on the mandrel;

Fig. 5 shows the mandrel and rings in place in a hydraulic press;

Figs. 6 and 7 are sectional views of the mandrel and support ring during the process of fixing the wires;

Fig. 8 is a sectional view of a portion of the support ring and attached wires;

Fig. 9 shows the grid structure after wire fixation; and

Fig. 10 shows the completed grid.

Proceeding now with a description of the improved method of grid manufacture, there is first formed an annular support ring **11** which may be cut from a tube of appropriate wall thickness upon a lathe for example. Ring **11** is preferably formed of a relatively soft or malleable metal, such as copper, and has at least one smooth face **12** which is accurately machined so that it lies in but a single plane. There is next formed upon the smooth face **12** of ring **11** a spiral cut **13** having a plurality of turns, and this may be best accomplished by placing ring **11** in a lathe chuck and driving a cutting tool **14** inwardly across ring face **12** at a constant speed while ring **11** is rotating in the lathe chuck. Cutting tool **14** has a specially ground sharp point and is set at an angle in the lathe tool mount so that one edge of tool **14** is slightly off perpendicular to the surface of ring face **12** and the cut therein slants away from the center of ring **11**. The turns of spiral cut **13** are made quite close together; for example, with a ring wall thickness of ⅛ to ¼ inch, five to ten turns may be made with a depth of cut of about .015 inch. Intermediate adjacent turns of spiral groove **13** there are formed lands **15** which extend over the perpendicular edge of the adjacent turn of the spiral groove **13** so that upon completion groove **13** is actually undercut. As cutting tool **14** passes over face **12** of ring **11** the heel of the tool deforms the adjacent land so that it is forced over the perpendicular edge of the adjacent turn of groove **13** and the perpendicularly cut edge of groove **13** is tipped to slant away from the center of ring **11** as shown in Fig. 2. By following the above-described steps of grooving the face of a malleable metal with a pointed cutting tool held at an angle to the face of the work the land deformation automatically results and the desired groove configuration is obtained.

At this point it should be noted that the configuration of support ring **11** is not limited to circular and square, octagonal or various other shapes may be used. Also, the cutting of groove **13** may be performed by other than a lathe, as for example by a shaper or milling machine and it is further possible to provide slanted lands by the use of a small grinding machine which cuts a sloping groove and in such case the lands would originally slant with deformation.

In the attachment of grid wires to support ring **11** there is employed a mandrel **16** as shown in Fig. 3. Mandrel **16** has two flat parallel faces **17** and **18** and may be formed in a plate shape with a shaft or handle **19** extending from one edge thereof parallel to faces **17** and **18**. Two opposite edges of mandrel **16** are rounded or curved and relief grooves **21** and **22** are formed therein and extending substantially parallel to faces **17** and **18** for the length thereof. There is also provided on opposite curved edges of mandrel **16** a plurality of small notches **23** which are spaced equidistant apart, a distance equal to the desired grid wire spacing. Upon mandrel **16** there is wound the grid wire **24** which is preferably tungsten or the like and winding of mandrel **16** may be accomplished by placing mandrel shaft **19** in the chuck of a lathe and threading wire from a spool over a pulley and through an eye as in the lathe tool holder onto mandrel **16**, as shown in Fig. 4. The lathe chuck is then rotated and the tool holder moved at a constant speed, which is related to the rotational speed of the lathe chuck and the spacing of notches **23** on mandrel **16** so that wire **24** is wound upon mandrel **16**. Wire **24** is secured at each end to mandrel **16** and the grid is then ready for wire fixation.

Attachment of grid wire **24** to support ring **11** is made by pressure as in a hydraulic press **26**, Fig. 5. There is provided on hydraulic press **26** a pair of opposing jaws or anvils **27** and **28** having opposite circular bosses **29** and **31**, respectively. The diameters of bosses **29** and **31** are equal to the inner diameter of grid support ring **11** and there is placed upon lower anvil **28** a support ring **11** which fits over boss **31** thereby restraining ring **11** from lateral movement. An annular squeeze ring **32** having a larger diameter than support ring **11** is placed on lower anvil **28** about ring **11**, and mandrel **16** is positioned above support ring **11**. Squeeze ring **32** has a greater axial depth than support ring **11** and thus mandrel **16** rests on squeeze ring **32** without touching support ring **11**; squeeze ring **32** being formed of rubber or the like so as to be readily deformable under pressure whereby mandrel **16** may be urged downward into contact with support ring **11**. A second support ring **11** is placed about boss **29** on upper anvil **27** and maintained thereon as by grease or other adhesive means and a second identical squeeze ring **32** is placed between mandrel **16** and upper anvil **27**. With this combination in place between anvils **27** and **28** of hydraulic press **26** the grids are ready for wire fixation. It is noted that in the above-noted combination, grid wire **24** is not in contact with support rings **11** and thus there is no possibility of displacing the turns of wire **24** on mandrel **16**.

In the process of connecting grid wires **24** to support rings **11**, hydraulic press **26** is operated to force anvils **27** and **28** together as shown in detail in Figs. 6 and 7. Squeeze rings **32** are deformed and flattened out by the pressure exerted on anvils **27** and **28** and mandrel **16** is urged into forceable contact with support rings **11**. The first consequence of the contact between mandrel **16** and support rings **11** is the forcing of hard grid wire **24** into the faces **12** of the fairly soft support rings **11**. Additional pressure exerted by press **26** causes mandrel **16** to bear directly upon surfaced faces **12** of support rings **11** and because of the configuration of the lands **15** they deform radially outward of ring **11** as shown in Figs. 7 and 8. Thus, the face **12** of support ring **11** effectively moves away from the center of ring **11** and as wire **24** is imbedded therein, this wire is put in tension and stretched.

While support rings **11** and mandrel **16** are in intimate contact and before the pressure exerted on the combination by press **26** is released, the wire **24** is relieved by cutting. This may best be accomplished by passing a sharp instrument **33** along the relief grooves **21** and **22** in two opposite sides of mandrel **16**. With wires **24** cut they are no longer attached to mandrel **16** and press **26** is then opened and mandrel **16**, squeeze rings **32** and support rings **11** and attached wires **24** removed.

It is desirable to finish the electronic grid **34** formed by the above method by cutting off the ends of wires **24** extending beyond the outer edge of support ring **11**. This may be accomplished by a hand file **35** or a grinding operation which not only severs the extraneous wire but also turns the ends of the wires downward and forces them into the edge of support ring **11** as shown in Fig. 8.

It will be appreciated that the foregoing process produces a grid structure having the wires thereof in strict parallelism and lying in a single plane. Also the grid wires **24** are in tension across support ring **11** and thus remain taut even though heated. It should be further noted that mandrel **16** is formed of a hard metal such as steel and thus is not affected or in any way deformed during the grid construction and may thus be used repeatedly.

It will be further appreciated that the configuration of electronic grid **34** may be varied merely by changing the shape of support ring **11** and, of course, various shapes of anvils **27** and **28** may be used to hold rings **11**. Also the spacing of grid wires **24** is dependent upon their disposition on mandrel **16** so that various mandrels with differently spaced notches **23** may be employed to form grids with desired wire separation.

While the present invention has been described with respect to a single embodiment and in terms of particular steps in the process, it will be apparent that numerous modifications and variations are possible within the spirit and scope of the invention and thus it is not intended to limit the invention except by the terms of the following claims.

What is claimed is:

1. A method of forming an electronic grid comprising the steps of cutting a flat end on an annular ring of relatively soft metal, cutting a spiral groove in the flat end of said ring with a sharply pointed cuting tool held at an angle to the cutting surface whereby the lands formed between adjacent turns of the spiral groove slope radially outward, winding a hard wire about a hard flat plate in parallel turns, forcing a face of said wire wound plate against the flat end of said annular ring whereby said wires are imbedded in the surface of said ring and the lands on the end thereof bend radially outward to place said wires in tension, cutting said wires free from said flat plate, and shearing off the loose ends of wire extending beyond said annular ring.

2. A method of forming an electronic grid having parallel grid wires lying in a single plane and comprising forming a support ring of a malleable material and having a flat end surface, cutting a spiral groove in the flat surface of said support ring with lands intermediate adjacent turns of said spiral slanting radially outward on said ring, winding a grid wire about a mandrel having a flat surface with the turns of said wire winding being separated and parallel, said mandrel and wires being formed of a material that is hard relative to the support ring, forcing the flat side of said mandrel against the flat end surface of said support ring whereby said wires are imbedded in the surface of said support ring, further urging said mandrel and support ring together to deform the lands on said support ring radially outward and place the grid wires in tension, cutting the grid wires loose from said mandrel and trimming the ends of said wires about said support ring.

3. A method of constructing a grid structure having parallel wires and comprising cutting an annular support ring from a tube having a small wall thickness, cutting a spiral groove upon one end of said support ring and having a plurality of turns defining lands therebetween, said groove being slanted from the surface radially inward of said ring whereby said lands slant radially outward, winding grid wire about a mandrel having a flat surface larger than the diameter of said support ring, said grid wire and mandrel being formed of a harder material than the material of said support ring, disposing said mandrel adjacent said support ring with the flat surface of said mandrel facing the grooved end of said support ring and said mandrel resting upon a readily deformable support, forcing said wire wound mandrel and support ring in contact and applying pressure thereto to imbed the grid wires in said support ring and deform the lands thereof radially outward whereby said grid wires are placed in tension, cutting said grid wires from said mandrel, releasing the pressure upon said mandrel-ring contact, and removing said mandrel from said support ring and attached grid wires.

4. A method of constructing an electronic grid comprising forming a flat surface on an apertured member to contain the grid, cutting a plurality of adjacent grooves on said flat surface with the lands between said grooves slanting away from the aperture, winding a grid wire on a mandrel to form a parallel wire formation on a flat face thereof, placing the flat face of said mandrel against the

flat surface of said apertured member and applying pressure thereto, said apertured member being formed of a softer material than said wire and mandrel whereby said wire is imbedded in the surface of said apertured member across the aperture therein and the lands on the flat surface are deformed in a direction away from the aperture to place the grid wire in tension, and releasing the grid wire from said mandrel whereby said apertured member contains a grid across the aperture therein formed of parallel wires in tension.

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