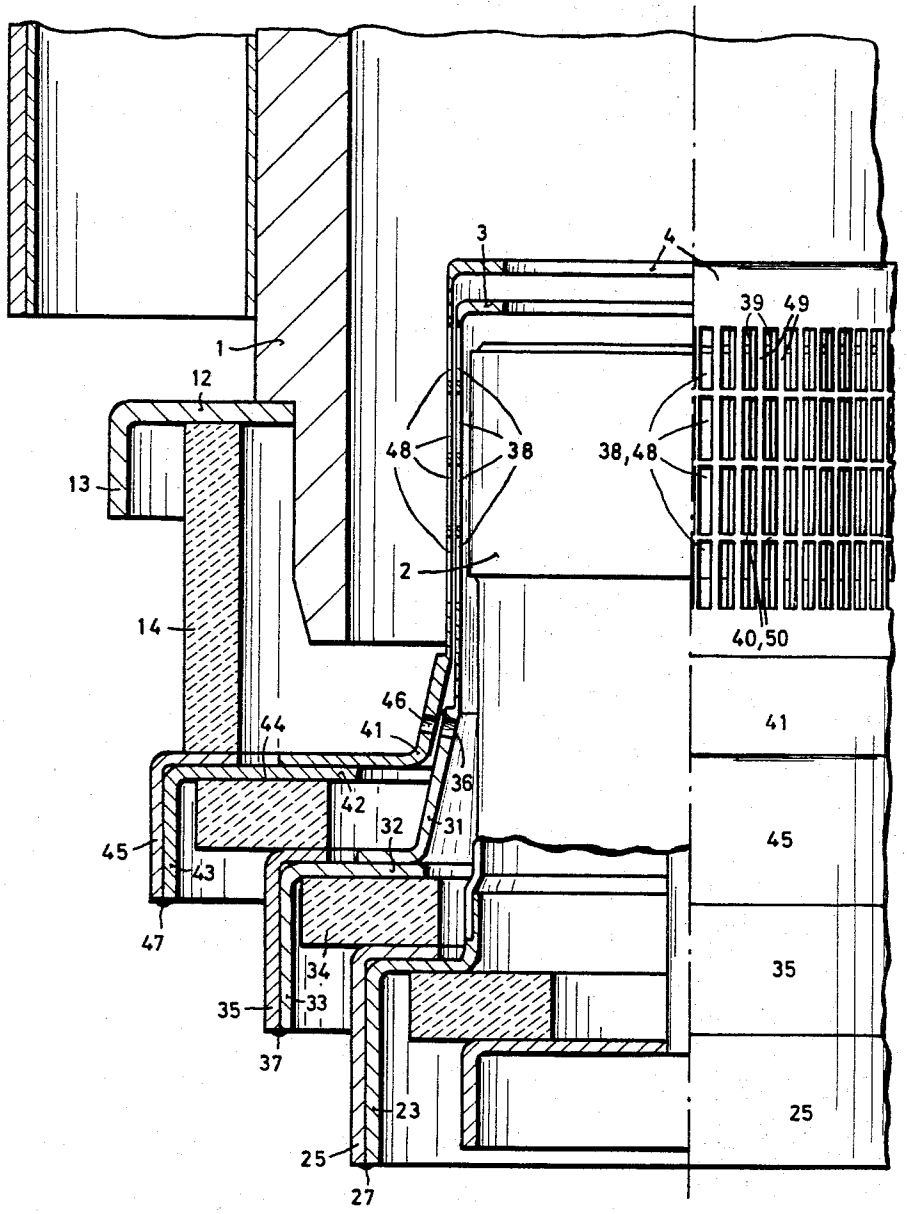
Aug. 29, 1967 W. SEIFFARTH ETAL 3,337,933

SCREEN GRID TUBE WITH COAXIAL TUBULAR MESH GRIDS

Filed Sept. 16, 1964 2 Sheets-Sheet 1

Fig.1



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SCREEN GRID TUBE WITH COAXIAL TUBULAR MESH GRIDS

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Fig.2

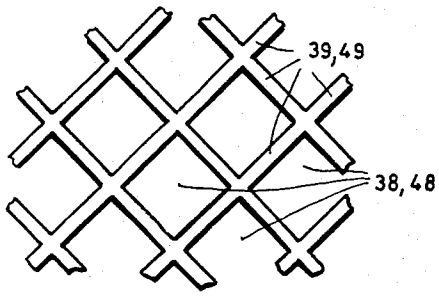


Fig.3

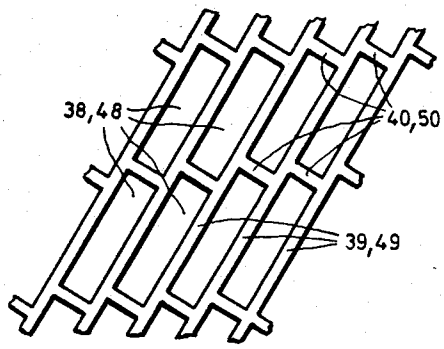


Fig.4

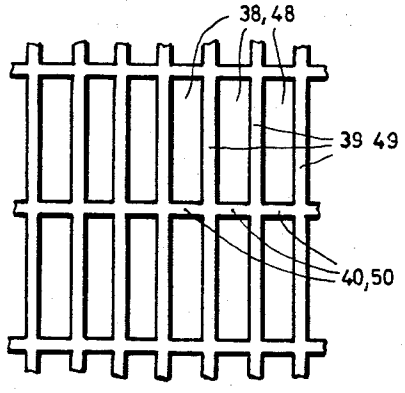
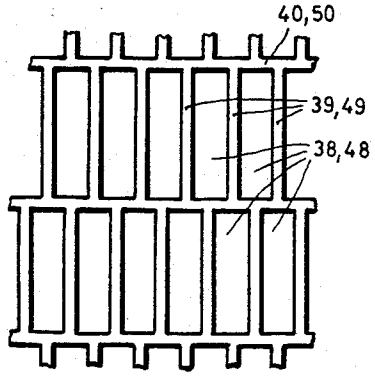


Fig.5



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3,337,933

SCREEN GRID TUBE WITH COAXIAL TUBULAR MESH GRIDS

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10 Claims. (Cl. 29—25.16)

The invention relates to a screened grid tube, especially a power tetrode, with cylindrical coaxial electrodes, in which the grid surfaces consist of tubular mesh grids with mesh openings so formed and arranged that the grid elements of control grid and screen grid cover each other and their current supply connections or terminals are connected thereto either by substantially tubular or disk-shaped structures.

Tubes of the type described are known, for example, as transmitting tubes, in which the tubular mesh grids consist of two layers of parallel wires of for example, tantalum, molybdenum or the like, which are so assembled that the wires of different layers cross each other and are welded or soldered at each of their crossing points. Especially unsuccessful have been mesh grids in which each wire layer consists of a large number of parallel wires extending at 45° to the long axis in such a way that the wires of different layers are oppositely wound. The main purpose thereof is that each grid element, that is, each self-supporting wire portion, has a mechanical bending pre-tension of such type that in operation, on thermal loading, a possible sagging or bulging can occur only in one direction, namely, outward. Thereby, possible contacts occurring in operation, both between control grid and cathode and also between control grid and screen grid, are very largely avoided. Such mesh grid electrodes are ordinarily employed with similarly constructed so-called mesh cathodes, as the mesh openings cannot fall below a certain size, while in a continuous surface cathode a certain troublesome island formation would occur. Although the mesh grids described have good stability, they have, for a number of purposes, certain drawbacks. Through the fact that the two wire layers are arranged one above the other, the control elements do not lie in a common plane, but, so to speak, in two spatially separated surfaces, whereby, for one thing, there results a considerable disadvantage with respect to the formation of the potential surfaces determinative for the control process and, for another thing, with respect to maintenance of small electrode spacings. In addition, as a result of the welding or soldering of the wires at the crossing points, uncontrollable voltages may arise in operation, for example, which may be released by thermal load and can lead to operational breakdowns.

In view thereof a process has become known in which the grid elements of a mesh grid are produced through electrolytic precipitation of, for example, nickel, on a corresponding prepared (perforated) matrix. The essential disadvantages of mesh grids produced in this way reside, above all, in the fact that high-melting metals of great strength, such as tantalum, molybdenum or the like cannot be utilized, and that moreover the strength of electrolytically precipitated grid elements is considerably lower than that of wires or bands produced by usual or special technological processes. Moreover, there is the disadvantage that the precision of the grid elements, especially of the edges of the mesh openings is not particularly good without further mechanical, especially expensive, processing. In view of the required stability, there can be produced by this process only grids with small mesh openings. However, with small mesh openings the covering ratio of

the mesh openings assumes an intolerable figure and, moreover, it is no longer possible to achieve the necessary geometrical exactness.

In another known production process these difficulties are avoided only in part by an arrangement wherein for the mesh grids, sheet metal cylinders are utilized into which, through erosion by means of ultravibration or electric sparks, the mesh openings involved are subsequently introduced. In order to achieve a reliable covering or superimposing of the grid elements in which the grid electrodes are arranged one behind the other, the metal shells are first brought into their final spatial system arrangement, and connected with the other parts, such as the appropriate current feed elements and the spacing rings, generally ceramic, forming a part of the vacuum vessel wall, in vacuum tight relation, and then subjected in common in suitable apparatus to the erosion process proper. A liquid medium of, for example, oil in the case of spark erosion, or of a suspended erosion agent in the case of ultravibration washes, in the erosion process, affects both the tool and the work piece, by serving as coupling medium. The advance of the erosion tool in question is accomplished in the axial direction of the system for the simultaneous production of continuous longitudinal slits or else in radial direction for the production of individual discontinuous slits. A very serious drawback of this known process lies in the fact that it is applicable only under great difficulties for high-melting metals of great strength, and, moreover, requires long processing times. Moreover, the system and wall parts, especially of ceramic material, are moistened with liquids which can be completely removed therefrom only with great difficulty, and whose possible residues in the discharge vessel can lead to operational difficulties. There also is the additional fact that the tool itself undergoes a considerable abrasion in the production process, so that a continuous change of contour occurs in the mesh openings, which cannot be disregarded, so that the tool has to be frequently renewed. Moreover, the tools necessary for this are technically extremely complicated and their manufacture is expensive. The edges of the mesh openings thus produced are throughout of little exactness, i.e. are ragged.

The invention, therefore, has as its problem to create a screen grid tube with tubular mesh grids, in which the grid electrodes have a very precise grid structure or division with very geometrically precise mesh openings, and whose grid elements are in exact alignment or superimposition without requiring special adjustments. The grid elements forming the mesh openings should have equal or smaller cross sections than those of corresponding thin-wire grids, so that their width facing the emission source (effective surface) is smaller than that of corresponding wire grids. Moreover, their stability, originating from the use of sheets of high-melting metal, for example, tantalum, molybdenum or the like, should be still higher and the effective surface, above all, more homogeneous than that of wire grids.

This is achieved in a screen grid tube of the type described, in particular a power tetrode with cylindrical coaxial electrodes, in which the grid surfaces are formed of tubular mesh grids, according to the invention, by the method that both mesh grids consist in each case of seamlessly formed foil cylinders, with reinforced flanged edges, produced by a common type drawing and pressure process, from high-melting metal, such as molybdenum or the like, into which in the formed state, there are created by stamping, in both the control and screen grids, openings of like number and division mesh in rectangular form, such that their otherwise equal dimensions, corresponding to the ratio of the corresponding grid-cylinder diameters are greater in the screen grid than

in the control grid, but width and thickness of the cross pieces between adjacent mesh openings are about equal, and of about 50μ in thickness or thicker, and that the unperforated or mesh-free parts, especially the edges of the grids, serving for the mounting thereof, have in each case recesses, holes, lugs, protrusions or the like as marking or reference points, always in a defined position with respect to the mesh structure, which serve either for the fastening or limiting, at least in the assembly of the individual grids in such a way that the grid structure (mesh division) of the control and screen grids cover, without special adjustment, to achieve an electron shadow.

It has, in itself, long been a known practice to produce grids for electric discharge vessels by the stamping thereof out of sheet metal. However, in the case of grids with non-planar grid surfaces, the plates stamped in planar form are shaped into the desired profile grids, for example, into tubular grids. Since such grids must be provided with at least one seam, such tubular grids must have in longitudinal direction relatively appreciable parts free of mesh openings, so that a cylindrically symmetrical discharge system is impossible. An accurate superimposition of the grid elements in a screen grid system produced in this way is technically impossible. There then is the added fact that the precision of the mesh openings deteriorates in the shaping operation and that, moreover, longitudinal seams, because of their variations during heat expansion in operation with respect to the remaining part, lead to deformation of the grid electrodes involved.

Further details of the invention will be explained with the aid of the drawings in which the figures have been kept purely schematic. In the figures, parts which do not necessarily contribute to the understanding of the invention are either omitted or remain undesignated.

FIG. 1 illustrates, partly in cross section, the entire structure of a screen grid tube constructed with ceramic material; and

FIGS. 2 to 5 illustrate portions of grid electrodes with mesh openings of various forms.

The system structure illustrated in cross section in FIG. 1 presents an example of construction utilizing ceramic elements according to the invention, in which the reference numeral **1** designates a pot-shaped anode, and **2** a cylindrical cathode, with **3** and **4** the tubular control and screen grids, respectively, which four electrodes comprises the electrode system. Each of these electrodes is mounted, for external contacting as well as for support in the system structure, to a respective approximately disk-shaped feed connection element. Between two adjacent feed-connecting disks there is inserted, in each case, a ceramic spacing ring which is connected in vacuum-tight relation with the adjacent lead-through disks, by hard soldering after suitable metalizing according to one of the usual processes, and thereby forms a part of the tube wall.

The grid electrodes consist of pot-shaped sheet metal cylinders produced according to a drawing or pressure process, into which, in the formed state, mesh openings are created by stamping and which are so arranged that the grid or mesh elements of the control grid and screen grid are in enact alignment with each other, without the necessity of extensive and difficult adjusting operations which have heretofore been common in the assembling of wire grids. This assumes, to be sure, that the individual grid units are very precisely finished, both with respect to their grid structure, that is, with respect to their mesh form and division, and also with respect to their other geometrical dimensions, so that in practice there is still necessary only an assembly of the parts with subsequent connection by a soldering process, especially by a rapid soldering operation. In accordance with this requirement, in an especially advantageous manner, the so-called grid blank in the form of a drawn pot-shaped sheet metal cylinder is first joined with the lead-through disk and

other adjacent system parts into an assemblage part and only later, after suitable mechanical tooling or finishing, the corresponding grid structure is created.

Thus, for example, for the screen grid **4** the drawn pot-like foil cylinder with its conical portion or skirt **41** is attached to the one side of the flat portion **42** of the corresponding lead-through disk consisting of such flat portion and the cylindrical edge portion **43** with the other side thereof attached to the ceramic spacing ring **44** and the later on its opposite side secured to the angle ring **35** carried by the disk lead-through for the control grid **3**, with such attachments being effected in one operation. The parts forming the inner and outer grid surfaces of the sheet metal cylinder, as well as the other seating and mating surfaces of the sub-assembly are tooled or finished to dimension by a shaving process. In the same manner the control grid **3** and approximately analogously the cathode **2** are prepared and in each case completed into a sub-assembly. Into the anode **1**, completed disk **12**, **13**, the ceramic spacing ring **14** and the angle ring **45** belonging to the screen grid lead-through disk are first attached, following which the corresponding sub-assemblies of screen grid, control grid and the cathode can be successively installed with their cylindrical mating surfaces in engagement. The final attachment or joining into a complete unit, that is, to the finished discharge vessel, takes place after the two grid electrodes have been precisely brought into superimposition, by soldering, especially by dip soldering, at the individual soldering edges **47**, **37** and **27**. The bringing into alignment or superimposition of the grid electrode is accomplished especially advantageously by means of the recesses, holes, studs, protrusions or the like arranged for this purpose on the grid electrodes, in the represented case by at least two corresponding holes **36** and **46** in conjunction with the concentric end openings in the grid **3** and **4**, or through, in each case, at least three openings through which, for example, a fitting pin is inserted at least up to the reciprocal adhension of the two grid electrode units. Thereby automatically there is achieved an accurate alignment of the grid structures of the two grids, because the holes in each case have a defined position with respect to the grid structure. In an especially advantageous manner this is achieved through the method that, for example, the holes concerned are introduced only in the stamping process of the mesh perforations, especially by punching. Obviously, they may also be previously made, that is, immediately after the drawing operation concerned for the sheet metal cylinder, so that they then serve as a marker or reference point for the stamping process and thereby provide an exact allocation of the marker and the grid structure.

Regardless of whether the markers are applied before or during the stamping process, the foil cylinder, for example, for the screen grid **4**, with its cylindrical edge, or instead thereof the corresponding subassembly part (**41**, **42**, **43**, **44** and **35**) with its finished cylinder is received in an annular lining of a partial head device in such a way that in the interior of the foil cylinder there is situated a hollow mandrel which has on its circumference a matrix corresponding to the particular mesh openings. Exteriorly there is arranged a mating cutting punch movably mounted with respect to the matrix. Through a suitable arrangement, for example, in the manner of a partial head, the foil cylinder is slidable both axially and also circumferentially over the matrix. The introduction of the holes **48**, **38** takes place in each case on a peripheral circuit by punching of hole beside hole and thereupon, in the manner on the adjacent circumference, possibly with a shifting in each case by a half division. The advance is executed so precisely that the small crosspiece width **39**, **49**, **40**, **50** of about 50 to 150μ always results in exactly the same manner. If need be, it is also possible to punch holes to be arranged one behind the

other in axial direction in each case directly in succession and, if need be, to use several matrics and cutting panels arranged in axial direction one after another. The necessary division or advancing operation can be mechanized correspondingly by known means.

Grids stamped in the manner described have a very precise grid structure and present no burr of any kind on the mesh openings. Their durability is considerably greater than that of grids wound from corresponding wire.

In accordance with mesh grids hitherto usual in transmitter tubes, there is so selected for the mesh openings, for example, a square or, in the case of the screen grid a rhomboid form that according to FIG. 2 the continuous cross-pieces **39, 49** cross an equatorial plane at less than 45°. This form has proved especially successful in the case of wire-wound grids for reasons of stability. The durability of the mesh grids described is considerably greater. A partial drawback of grids with square mesh form lies in the fact that with use of a surface oxide cathode the necessary fineness of the meshes for the avoidance of an island effect yields too unfavorable a covering ratio. With mesh openings that are not sufficiently small there occurs a troublesome island formation on the surface cathode arranged behind, for example, an oxide cathode. Grids of this type are used for this reason mainly with corresponding mesh cathodes. The advantage with respect to the stability through the fact that the two pairs of cross-pieces are curved can be utilized at least in part without it being necessary to accept the drawback of such island formation, if for the mesh form, longitudinally extending rectangles **38, 48** are chosen, which with their longitudinal cross-pieces **39, 49** have their longitudinal axis inclined by a small acute angle, as is illustrated in the embodiment of FIG. 3. Since the rigidity of the stamped grid is quite considerable, this oblique placement of the rectangles can be dispensed with and, in each case, permit the longitudinal edges to extend in axial direction. There, either the long cross-pieces **38, 49** of axially adjacent meshes can have a continuous course, as illustrated in the embodiment of FIG. 4, or the openings of successive peripheral rows can be offset with respect to one another by a half mesh width (½ step), as illustrated in FIG. 5, such mesh grids generally being termed staggered grids.

For the dimensioning of such rectangular meshes there is advantageously selected a side ratio of from 1:8 to 1:10. In the described and illustrated mesh grids with axially parallel course of the long edges it is possible fundamentally, as in all other cases, as, for example, in the case of axially running diagonals, to make the cross-piece width equal to the cross-piece thickness, so that the cross section can be smaller than in the case of a corresponding grid wound from wire. It is also possible, however, for the increase of the stability in the last described mesh grids with rectangular form and axially extending long edges in view of the fact that a very precise electron shadow can be achieved, to construct the short cross-piece running in circumferential direction wider than the long cross-pieces, without resulting drawbacks with respect to the functioning of the tube. It is, however, also possible without difficulty in view of the great stability of such grids, if need be to make the cross-pieces of the control grid wider than those of the screen grid, namely, when it is desirable to make the screen grid current extremely small.

The essential advantages of the mesh grids described where utilized in corresponding multi-grid tubes are many. The stamped mesh grids described, as compared to the corresponding wire-wound grids, have, with the same cross piece cross section, a much greater stability. As viewed in the direction of electron flow, the stamped grids, with equal stability as compared to corresponding wire grids, have only about half the thickness of the grid elements concerned. Since all the grid elements lie

on one surface, the surfaces facing the adjacent electrodes are much more uniform than in the use of the wire mesh grids hitherto customary. Since through the uniform grid surface, simultaneously the potential surfaces forming in operation are uniform, in the end result the controllability of such tube is considerably improved. Moreover there is the advantage that the grids can vary much more easily and precisely be brought into coverage for the achievement of an electron shadow. This is possible, among other reasons, because not only the form of the meshes, but above all the corresponding mesh division, that is, the grid structure, can be very accurately produced by the stamping process.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent.

We claim:

1. A method for the production of a screen grid tube, such as a power tetrode having cylindrical coaxial grid electrodes with grid surfaces in the form of tubular mesh grids, the mesh openings of which are so formed and arranged that the grid elements of the grid electrodes are operatively aligned with one another, comprising the steps of forming from seamless tubular stock respective seamless thin-wall cylinders of a high-melting metal provided with reinforced edge portions, forming mesh openings in each of said formed cylinders, while in unassembled relation, in like number and arrangements, which are of quadrilateral shape, with the corresponding mesh dimensions in axial direction between the openings of respective grid electrodes being alike, and the corresponding circumferential dimensions thereof being greater in correspondence to the radial relationships involved, forming a respective marker element on a mesh-free portion of each grid electrode with each marker element being disposed in like relationship to the mesh openings in the associated grid electrode, and assembling said electrodes in operative relation, utilizing said marker elements to effect final operative alignment of corresponding mesh openings of the respective grid electrodes.

2. A method according to claim **1**, wherein said mesh openings are formed by stamping to produce connecting cross-members of the mesh of substantially uniform width and thickness and having a thickness of approximately 50 microns.

3. A method according to claim **1**, comprising the further steps, following a final tooling to measurement of the repective grid electrodes, of clamping the respective electrode in fixed relation for controlled stepwise movement both in axial and in circumferential directions on a hollow mandrel in which there is disposed at least one axially extending matrix which determines the location of the openings which are to form the mesh, and punching respective openings in accordance therewith in a predetermined axial and circumferential sequence.

4. A method according to claim **3**, wherein said matrix is constructed to provide an offset of one-half mesh division in desired direction.

5. A method according to claim **3**, wherein the openings are successively punched individually in circumferential direction.

6. A method according to claim **3**, wherein the openings are punched in a predetermined stepwise sequence in axial direction.

7. A method according to claim **3**, wherein the openings in the matrix are so arranged, and the punching so performed that the mesh openings extend diagonally with respect to the axis of the cylinder involved.

8. A method according to claim **3**, comprising the additional steps for each grid electrode of attaching respective lead-through disks to opposite ends of a ceramic insulating ring which is to form a part of the tube side wall, and attaching one of such disks to the associated grid electrode cylinder and the other of such disks to a cooperable disk of an adjacent electrode.

9. A method according to claim 3, comprising the additional steps of attaching, in a single operation, a lead-through disk to the cooperable cylinder, a ceramic insulating ring to said disk, and a second lead-through disk to said insulating ring in spaced relation to the first disk, to form an electrode subassembly, following which the cylinder surfaces for the grid element-forming surfaces, and surfaces to be mated in final assembly are trued to the desired measurements, and thereafter forming the mesh openings and marker element in such cylinder.

10. A method according to claim **9**, comprising assembling the respective grid electrode subassemblies, each comprising the cooperable cylinder, attached lead-through disk, ceramic insulating ring, and second lead-through disk, with the second lead-through disk mating with the first lead-through disk of the adjacent electrode, and soldering respective pairs of mated lead-through disks.

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