

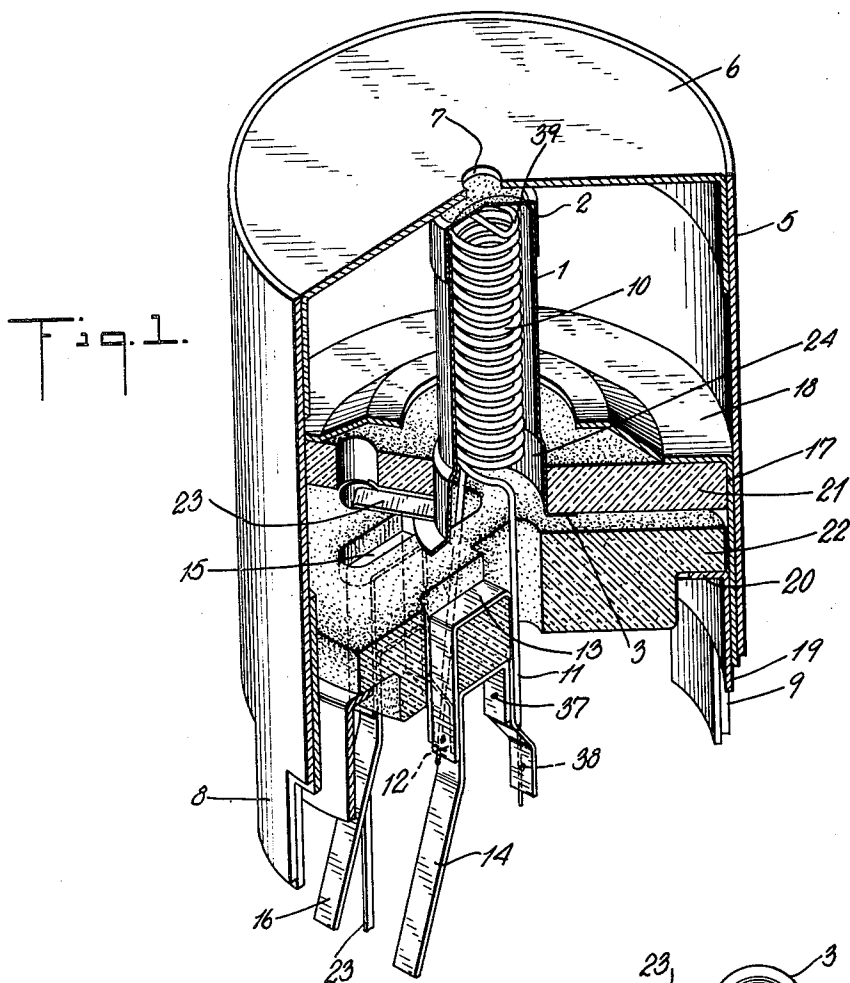
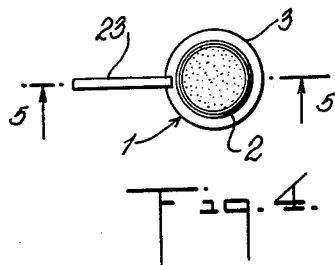
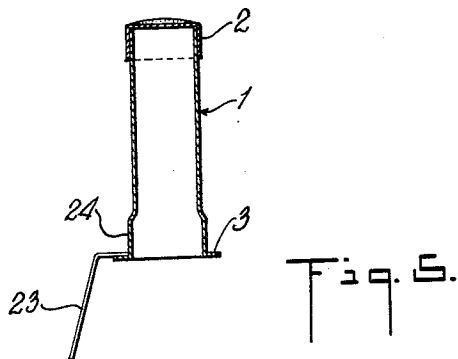
Oct. 16, 1945.

H. M. GAUN ET AL
ELECTRON GUN AND THE LIKE

2,386,790

Filed Nov. 29, 1944

4 Sheets-Sheet 1



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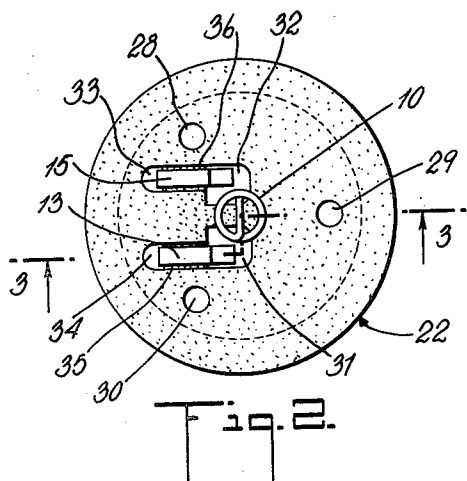
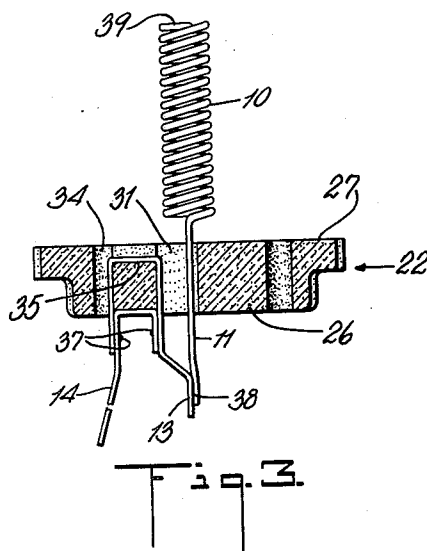
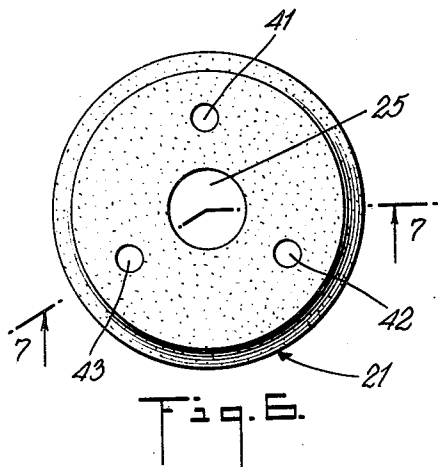
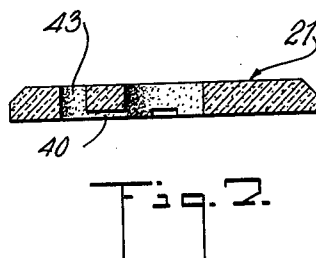
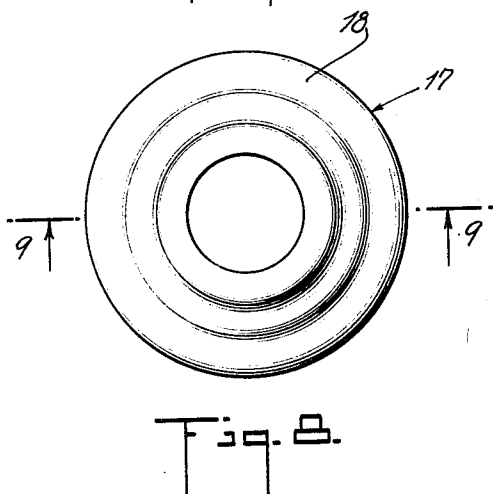
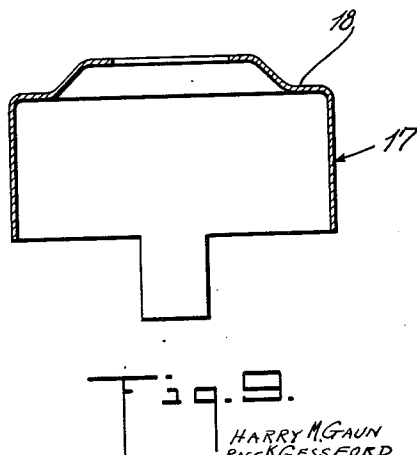
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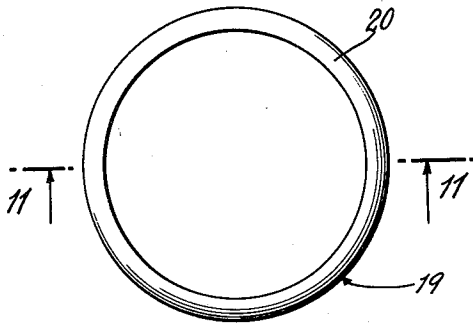


Fig. 10.

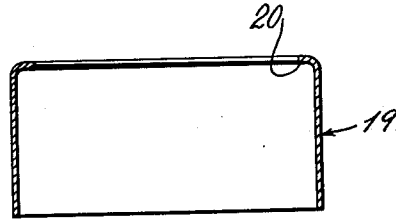


Fig. 11.

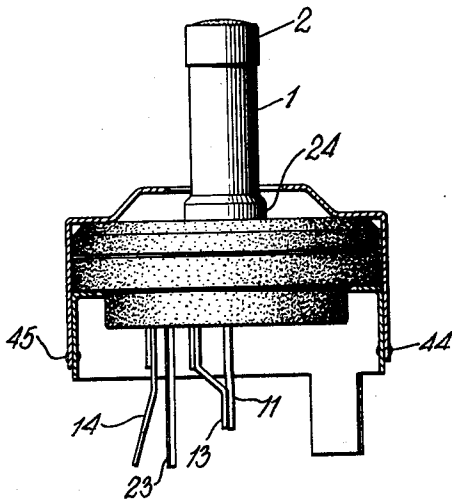


Fig. 13.

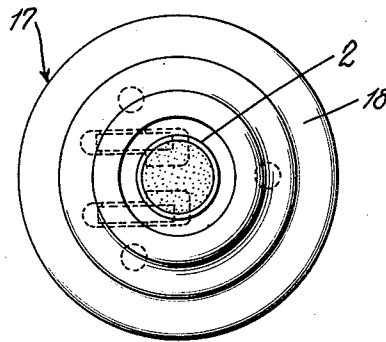


Fig. 12.

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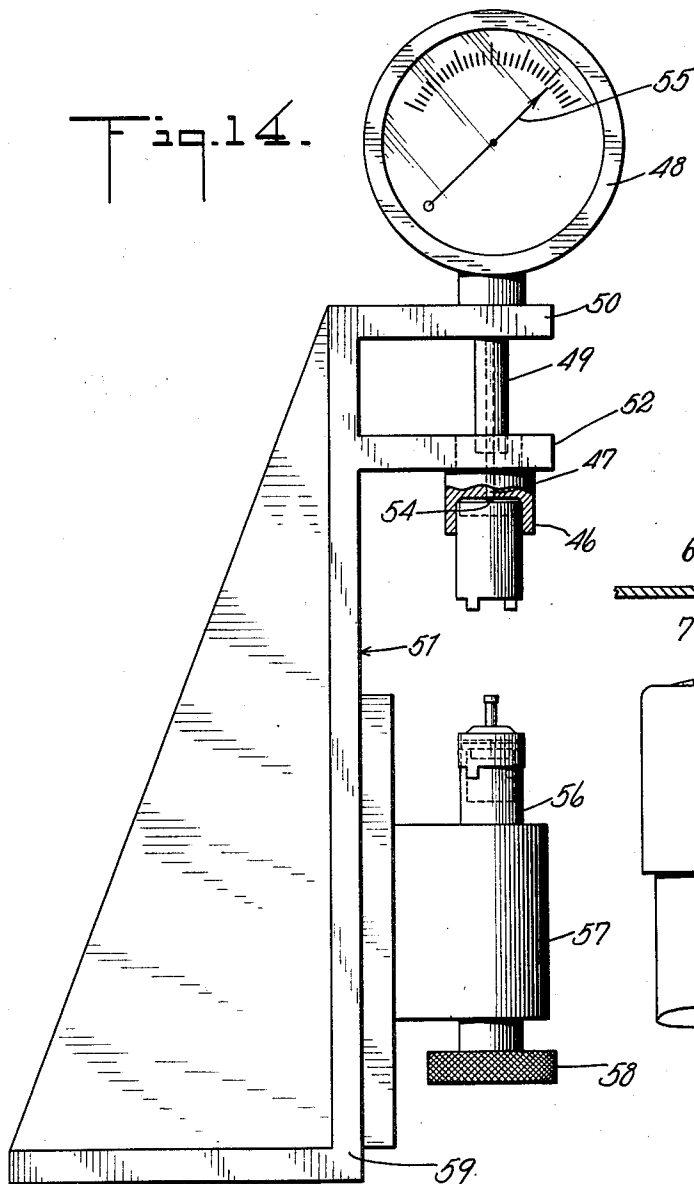
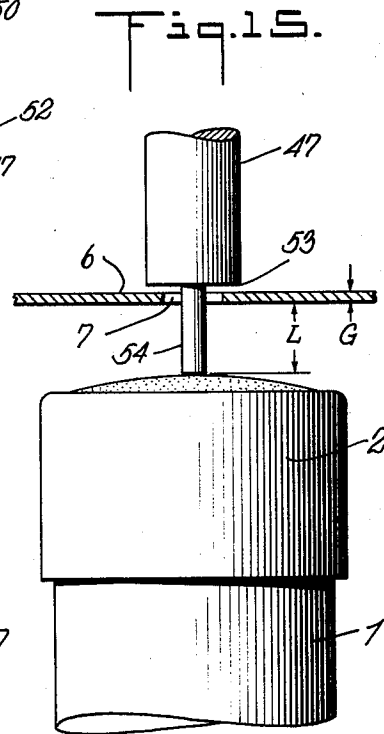
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UNITED STATES PATENT OFFICE

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ELECTRON GUN AND THE LIKE

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Application November 29, 1944, Serial No. 565,662

8 Claims. (Cl. 250—27.5)

This invention refers to electron guns as employed for the development and focusing of electron beams in cathode ray tubes and similar electron discharge devices, and more particularly to the cathode-grid unit of electron guns.

It is a principal object of the invention to provide an improved assembly unit consisting of cathode, grid, heater and co-ordinated auxiliary members which can be precisely and uniformly spaced and rigidly and permanently attached to each other by simple operations.

The type of electron gun with which this invention is concerned comprises a cylindrical cathode sleeve into which a heater coil is inserted from one end and which is closed at its other end by a flat metal cap covered with a thermionic electron emitting coating from which electrons are drawn in substantially axial direction by an axially symmetrical electric field which penetrates through a small central aperture in a disk shaped control electrode or grid mounted in axially spaced relation to the cathode cap and in close proximity to it. The grid or aperture disk forms the end surface of a cylindrical metal shell co-axially surrounding the cathode sleeve. The accelerating electrode or electrodes on the side of the grid remote from the cathode in axial direction may consist respectively of one or more apertured disks or cylindrical electrodes, properly aligned with cathode and grid, for focusing the electron beam at a desired axial distance. The invention is not concerned with the accelerating electrodes, which may be connected to the cathode-grid assembly in any known and convenient manner.

The exact spacing and permanent alignment of the apertured grid disk from the emitting flat cathode cap is very important because it determines the intensity control characteristic of the developed beam. This control characteristic must be uniform from tube to tube. The grid alignment and spacing must, furthermore, be accurate because it forms part of the first electron lens system by which the beam is focused and formed. Any deviation from perfect axial symmetry of the electric field near the cathode will cause considerable distortion of the axial symmetry of the developed electron beam, because the electron velocities are comparatively low in this part of the gun. Because of the required high precision of the spacing and alignment of cathode and grid, and of the required uniformity of the close spacing of these two electrodes from one unit to another in the mass production of tubes of the same type, the mechanical design of

this sub-assembly of an electron gun represents one of the fundamental problems in gun design.

The shape and mutual cooperation of the parts and their assembly is, in addition, determined by considerations of electrical insulation and conservation of the heat supplied to the cathode by the heater. The use of supporting or spacing members for the cathode near the emitting end surface must be avoided, in order to prevent excessive cooling of that part of the cathode. The exact location of the heater unit within the cathode cylinder, in particular the distance between the end of the heater unit in the cathode sleeve and the thermionically emitting cathode cap, must be carefully controlled. The heater unit must therefore be mechanically supported by and rigidly connected with a member carrying the cathode.

There are, generally, two methods for providing the spacing between cathode cap and grid disk. The first method depends on the difference of the axial dimensions of the parts forming the grid cathode assembly. In its simplest form, the known prior assembly consists of three parts: a ceramic disk with a central hole, through which the cathode cylinder is threaded. At its open end the cathode is provided with an annular flange which abuts with one side of the ceramic disk, and the cathode is firmly held in this position in the ceramic, frictionally engaging the wall of the hole and/or other supplementary locking means. The grid cylinder is concentrically telescoped over the cathode and its open end held in abutting relation to the other side of the insulating disk. The distance between the grid disk and the cathode cap is determined by the difference of the axial dimensions of cathode, grid, and the thickness of the insulator disk.

This prior known method relies on the accuracy of the fixed longitudinal dimensions of the three cooperating parts. While it is useful in small scale production, as for laboratory purposes, where the cost of extremely high precision of the parts is immaterial, its disadvantages for mass production of sub-assemblies having uniform spacing from one unit to the other are very considerable, if one considers the absolute dimensions of the spacing required for this assembly. This spacing is of the order of .020". A reasonable tolerance for the longitudinal dimensions of the component parts is of the order of .005", the greatest variation being usually in the thickness of the insulator disks. To secure reasonable uniformity in quantity production, the three parts for each unit must be carefully

matched, which is at least inconvenient, and in any event, not practical. After assembly, each unit must be inspected for spacing, e. g. by a micrometer depth gauge. During this inspection, many units are usually found which do not conform to the required spacing limits. It may be mentioned in passing that in this prior method, the heater unit is usually not inserted into the cathode sleeve before the grid-cathode assembly is mounted on a tube stem.

The other known method is positive, and uses a standard spacer gauge during mounting. In one known procedure of this type, slots are provided at the disk end of the grid cylinder, through which a standard spacer gauge is inserted. The cathode is telescoped concentrically into the grid cylinder, until it is stopped by the spacer gauge. The assembly is then locked together, as by welding, and the spacer gauge is withdrawn sideways from the gap between grid disk and cathode cap. That method has the disadvantage that, in withdrawing of the spacer gauge, emitter coating may be scratched off from the cathode cap. Furthermore, the exact location of the openings for introducing the spacer gauge very near to the grid disk is hard to keep within the close tolerances required for the purpose.

All these disadvantages are eliminated by the present invention, according to which the parts of the assembly are so formed and mutually related to each other, that the distance between the relevant electrode parts is continuously measurable during the telescoping of the two cylinders, by a micrometer dial gauge connected to a measuring rod passing axially through the grid aperture, the point of the measuring rod being pushed along by the cathode during the telescoping motion.

The invention further contemplates the provision of means for positively locking and locating the heater unit inside the cathode sleeve, and forming a rigid heater-cathode assembly which is telescoped into the grid cylinder as a whole.

It is, therefore, another principal object of the invention to provide a method of mounting a cathode-grid assembly in which the parts of the heater cathode section are first locked together and the cathode grid spacing is carried out subsequent to the heater-cathode assembly.

Another object of the invention is to provide means for rigidly locking the flange of the cathode sleeve between two disk shaped ceramic spacers by means of two auxiliary flanged metal cylinders.

A further object of the invention is to provide a separate heater supporting disk-shaped ceramic which is provided with holes separated by short bridge-like part of rectangular cross section, serving for rigidly supporting and locating pairs of metal straps to which the heater ends can be easily welded.

A feature of the invention refers to the shape of one of the auxiliary flanged metal cylinders used for clamping the two ceramic disks together, whereby the formation of a conducting layer on the surface of the insulator disk is prevented.

Another feature of the invention refers to the shape of one of the ceramic disks, which is provided with a central part of comparatively large thickness and a peripheral part of reduced thickness, whereby a correct seat for a centered telescoping tool during the assembly of cathode and grid is obtained.

It is another important feature of the inven-

tion to provide means connecting the heater straps to the heater unit in such a manner that the welding operation by which the heater straps are conductively connected to the lead-in wires in the stem of a tube does not affect the location of the heater unit in the cathode sleeve.

Referring to the drawings which show one preferred embodiment,

Fig. 1 is an isometric, partly sectionalized view of the finished assembly;

Fig. 2 is a top plan view of the lower ceramic disk with the heater sub-assembly;

Fig. 3 is a sectional view of Fig. 2 taken along the line 3—3 thereof;

Fig. 4 is a plan view of the cathode;

Fig. 5 is a sectional view of Fig. 4 taken along the line 5—5 thereof;

Fig. 6 is a top plan view of the upper ceramic disk;

Fig. 7 is a sectional view of Fig. 6 taken along the line 7—7 thereof;

Fig. 8 is a top plan view of one of the auxiliary cylinders for locking the cathode flange between the two ceramic disks;

Fig. 9 is a sectional view of Fig. 8 taken along the line 9—9 thereof;

Fig. 10 is a top plan view of the other auxiliary metal cylinder for locking the cathode flange;

Fig. 11 is a sectional view of Fig. 10 taken along the line 11—11 thereof;

Fig. 12 is a top plan view of the completed cathode-heater sub-assembly;

Fig. 13 is a side elevational view of Fig. 12, partly sectional;

Fig. 14 is an explanatory diagram of an assembly gauge according to the invention;

Fig. 15 is an enlarged view of part of Fig. 14.

As can be seen in Figs. 1, 3, 5 and 13, the assembly consists of cathode sleeve 1, closed at its upper end by top cap 2 and provided with a flange 3 at its open lower end; the grid cylinder 5 closed at its upper end by grid disk 6, having a central aperture 7 whose diameter is considerably smaller than that of cathode cap 2. The grid cylinder 5 carries, on its open lower end tabs 8 and 9 disposed diametrically opposite to each other. The assembly also includes heater coil 10 with terminal legs 11 and 12, attached to pairs of heater straps 13, 14 and 15, 16; shield cylinder 17 with upper annularly flanged shield 18; retainer ring 19 with flange 20; upper ceramic disk 21; lower ceramic disk 22; and cathode tab 23. The cathode tab 23 is welded to flange 3 of cathode 1.

Before describing the steps followed in the assembly of the parts, attention is called to some of the outstanding features of the unit. Cathode 1 is firmly locked in position with its slightly enlarged lower end 24 which fits tightly in hole 25 of upper ceramic 21, and by the position of flange 3 between upper ceramic 21 and lower ceramic 22. Upper ceramic 21 and lower ceramic 22 are clamped together tightly by the flange 18 of shield cylinder 17 and flange 20 of retainer ring 19. These two members 17 and 19 are welded together after the desired tight clamping of the two ceramic disks has been carried out. Heater coil 10 is supported by its legs 11 and 12, which are welded to the heater straps 13 and 16 respectively. The heater straps themselves are rigidly anchored in holes provided for this purpose in lower ceramic 22. It will be noted that the diameters of the two ceramic disks are equal, and that the shield cylinder 17 fits very tightly over the periphery of ceramic 21. A particular advantage in aligning grid cylinder 5 over shield cylinder 13

results from the fact that the axial length of the latter is nearly as great as the length of the cathode sleeve, and more than one third of the length of the grid cylinder, which in turn fits tightly over the shield cylinder 17. This construction reduces to a minimum any tilting between the axes of the cathode and the grid cylinder, when the heater-cathode assembly, clamped together by the two auxiliary cylinders 17 and 19, is telescoped upward into the grid cylinder. Grid cylinder 5 fits tightly over the external cylindrical surface of shield cylinder 13, whereby a rigid, coaxial mount unit is obtained.

In describing the steps comprising the method of assembling the unit, attention is first called to Figs. 2 and 3 which show top and side views of lower ceramic 22 having a thick central portion 28 and a thinner peripheral portion 27.

Lower ceramic 22 is provided with three circular holes 28, 29 and 30 arranged on a circle concentric with the external periphery of the disk-shaped ceramic, and four holes 31, 32, 33 and 34. The parts of the ceramic between holes 31 and 34, and between 32 and 33 are recessed and form solid bridge-like portions, and are shaped rectangularly, as shown in Figs. 2 and 3. These bridge-like portions are designated 35 and 36 respectively.

The first step in assembling the parts is to fit heater strap 13 through holes 31 and 34, and to fit heater strap 14 from below to portion 35 between holes 31 and 34. The straps 13 and 14 are then spot-welded together at points 37. The same operation is carried out with heater straps 15 and 16 around portion 36 between holes 32 and 33. The two legs 11 and 12 at the lower end of heater coil 10 are now inserted from above into holes 31 and 32, and the legs are welded to straps 13 and 15 at points 38. During welding of the heater legs, a length gauge or jig is preferably used to hold the heater coil in position so as to insure the desired height of the top 39 of coil 10 above the upper surface of ceramic 22.

The second step of mounting consists in threading cathode 1 from below through hole 25 of upper ceramic 21 until cathode flange 3 touches the lower surface of ceramic 21. Cathode 1 has a larger diameter at its lower end 24 which fits tightly into central hole 25 of top ceramic 21. Top cap 2 extends above the upper surface of ceramic 21, as determined by the thickness of the ceramic 21. Cathode 1 surrounded at its lower end 24 by ceramic 21 is now telescoped over the heater assembly shown in Figs. 2 and 3, until flange 3 of cathode 1 is sandwiched between ceramic 21 and ceramic 22.

In threading cathode 1 through hole 25, the cathode is axially oriented in such a position with respect to the ceramic 21 that cathode tab 23 fits into one of the three grooves 40 at the bottom surface of ceramic 21. At the end of grooves 40, holes 41, 42, and 43 are provided which can be brought to coincide with holes 28, 29 and 30 in ceramic 22. The loose end of cathode tab 23 is inserted into one of the holes, e. g. hole 28, in ceramic 22 when the cathode 1 with ceramic 21 is telescoped into position with the heater-ceramic assembly. All the holes 28-30 and 41-43 are thus in registry forming a continuous passage for air during exhaust.

The two ceramic disks, with attached heater and cathode electrodes are now locked together by slipping shield cylinder 17 from above over the two ceramics, and by telescoping retainer ring 19 from below into the open end of shield cylinder 17

as shown in Figs. 1 and 13. The two cylinders 17 and 19 are pushed together in axial direction as far as they will go to clamp the two ceramic disks rigidly together. When this position is reached, the two cylinders are welded together at points 44 and 45, and the finished sub-unit as shown in Fig. 13 is completed.

It will be noted that shield 17 forms a roof-like shield with a central opening, which protects the upper surface of ceramic disk 21 from particles which might tend to deposit on it, as by condensation of metal vapors developed by the cathode during its activation or during operation of the tube in which the assembly is finally mounted. Shield 17 prevents, therefore, the formation of a continuous conducting surface layer on ceramic disk 21 which would cause cathode-to-grid leakage.

Another source of leakage, caused by electron emission from the heater legs, is prevented by the comparatively large axial dimension of lower ceramic 22, at least in its central portion 28, through which the heater legs 11 and 12 pass. During operation, heater coil 10 is heated to a high temperature to obtain thermionic emission from the cathode. The legs 11 and 12 of heater 10 may become hot enough for thermionic emission, in particular near the lower end of the coiled heater. Any electrons emitted from the heater legs will be completely intercepted by the inner surface of the holes 31 and 32 in the lower ceramic 22, and are thus prevented from reaching any other electrodes or electrode leads attached to other co-operating electrodes of a completed electron gun mount of which the present assembly forms a part.

In order to complete the cathode-grid assembly, it is only necessary to telescope the sub-assembly unit of Fig. 13 into the sub-assembly unit consisting of grid cylinder 5 and apertured grid disk 6, as shown in Fig. 14. This operation is critical, because in the finished unit the distance of cathode cap 2 from the grid disk is required to be exact within less than one thousandth of an inch. The actual distance being of the order of 10 to 20 thousandths of an inch.

According to the invention the relative axial distance between cathode cap 2 and grid disk 6 is continuously supervised during the time the unit of Fig. 13 is approaching its desired location in the grid, starting about 10 to 20 thousandths of an inch, before the desired spacing is reached. The telescoping motion must therefore be carried out very slowly, so it can be stopped within about one thousandth of an inch. This can be carried out by controlling the relative motion of the two units with respect to each other with a micrometer screw if desired. A rigidly built fixture is preferably provided, as shown in Fig. 14, which is arranged to guide the two sub-assembly units into perfect axial alignment.

For this purpose, the grid unit is inserted into an appropriate grid holder 46 in which it is rigidly held, with the grid disk pointing upward. A fixed calibrated length of the gauge pin 47 of a micrometer dial gauge is inserted into the aperture 7 from above, so that the free lower end of the gauge pin extends a short known length below the level of grid disk 6, about double the desired final spacing of cap 2 to disk 6. The main body and barrel of the micrometer dial gauge 48 are rigidly supported above and axially spaced in fixed relation from the grid holder. A dial gauge reading is now taken. Preferably a gauge is used with an adjustable dial, so the dial read-

ing can be made zero with the position of the dial hand corresponding to the known length of the lower free end of the measuring rod extending below the grid disk in this initial position.

The sub-assembly unit of Fig. 13 is now inserted into the grid cylinder from below, and telescoped upward until cap 2 approaches very closely but does not touch the free lower end of the point of the measuring rod extending below the grid disk through aperture 7. The upward motion of the lower unit is now continued very slowly, preferably by means of a micrometer screw arrangement (not shown), and the hand of the dial gauge is carefully watched. Motion of the hand on the dial gauge begins at the instant cathode cap 2 touches the lower free end of the measuring rod 47, as, by the telescoping motion of the two units, cathode cap 2 pushes the lower end point of the measuring rod upward. Telescoping is continued, until the dial gauge indicates that the end of the measuring rod has traveled up to the position required for the specified cathode grid spacing. The two units are then welded together, and the completed assembly is removed from the grid holder.

Fig. 14 shows a typical guiding and spacing fixture for carrying out the described operation, and Fig. 15 illustrates a convenient method for establishing the proper reference level for the initial depth of the free end of the measuring rod below the grid disk.

As shown in Fig. 14, barrel 49 of the dial gauge is rigidly mounted on arm 50 of frame 51, above arm 52 which carries grid holder 46. When grid unit is inserted into holder 46 from below, and locked into position therein, a shoulder 53 of measuring rod 47 engages the annular region of grid disk 6 adjacent to aperture, as can be more clearly seen in Fig. 15. Measuring rod 47 terminates at its lower end in a thinner portion 54 of smaller diameter, adapted to pass through aperture 7 without friction. The length of this portion 54 is (L+G), as can be seen in Fig. 15. In order to insure a positive contact between shoulder 53 on grid disk 6 for the initial reading, the "free" position of the measuring rod must be so adjusted that the shoulder 53 is slightly pushed upward when the grid unit is inserted, so as to yield a readable motion of hand 55 on dial 48 in the initial position for obtaining a correct reference level reading.

The heater-cathode unit is seated in cup 56, which can be lifted in tail stock 57 by adjusting screw 58. Tail stock 57 is adapted to slide upward along main support 59 of frame 51 to a fixed first position into which it is locked. This fixed first position is so chosen that it telescopes the heater-cathode unit only partly into the grid unit, viz., up to a height at which cathode cap 2 does not yet touch the lower end of portion 54 of measuring rod 47. From then on, the telescoping motion is continued by slowly turning screw 58 until the desired dial reading indicates correct spacing.

The telescoping and adjusting device shown in Fig. 14 is merely illustrative, and the invention is, of course, in no way restricted to the application of this particular type of telescoping fixture. If desired, other gun electrodes may be mounted above and attached to grid unit, before the telescoping of the heater-cathode unit into the grid unit is carried out.

Various changes and modifications may be made in the disclosure without departing from the spirit and scope of the invention.

What is claimed is:

1. An assembly unit for electron tubes of the type described, comprising a pair of nested cylindrical electrodes, the inner electrode being closed at one end and in close proximity to the corresponding end of the outer electrode, said closed end of the inner electrode having a coating of electron-emissive material, and the adjacent end of the outer electrode having a small central opening concentric with the longitudinal axis of both said electrodes, a pair of rigid insulator members bridged across the interior of said outer electrode, said inner electrode having an outwardly extending annular flange at its open end the flange being sandwiched between said insulator members, and means to lock said insulator members, said flange and said outer electrode together as a unit.

2. An assembly unit according to claim 1 in which a heater wire is telescoped interiorly of said inner electrode and is spaced from the inner surface thereof, the free ends of said heater extending outwardly beyond the open end of said inner electrode, and means for anchoring said free ends to at least one of said insulator members to maintain said heater in symmetrical spaced position within said inner electrode.

3. An assembly unit for electron tubes of the type described, comprising a pair of nested cylindrical electrodes, each of said electrodes at the adjacent upper ends having substantially flat closure plates, the closure plate of the outer electrode having a central opening coaxial with the longitudinal axis of both electrodes, the closure plate for the inner electrode having a coating of electron-emissive material and being closely adjacent to said central opening, said inner electrode having a flange extending radially therefrom at its lower end, a pair of disk-like rigid insulators between which said flange is tightly sandwiched, a pair of cylindrical metal members having inwardly extending annular flanges between which said insulator disks are clamped, said inner electrode, said insulator members and said pair of cylindrical members forming a rigid unitary sub-assembly and with the cylindrical wall of at least one of said pair of cylindrical members rigidly fastened to said outer electrode.

4. An assembly unit according to claim 3 in which the upper one of said insulator disks has a central opening through which said inner electrode closely fits, and metallic strap means strapped around a section of the lower insulator and connected electrically to the free ends of the heater wire within said inner electrode.

5. An assembly unit according to claim 3 in which one of said pair of cylindrical metal members has an annular extension from its said annular flange which annular extension is spaced from the insulator disks and through which said inner electrode centrally passes in spaced relation.

6. An indirectly heated cathode unit for electron tubes comprising a tubular metal member having its upper end closed and exteriorly provided with electron-emissive material, the lower end of said tubular metal member being provided with a flat annular flange extending in a plane substantially perpendicular to the central longitudinal axis of the tubular member, a pair of disk-like ceramic members between which said annular flange is rigidly sandwiched, a metal member having a cylindrical portion closely fitting around said disk-like members and having a right-angle annular flange seated against the

upper face of one of said disks, the lower face of the other of said disks having an annular recess, and a retainer ring seated in said recess and rigidly fastened to the interior surface of said cylindrical portion of said last-mentioned metal member, a heater unit telescoped interiorly of said sleeve in spaced relation thereto, and means to anchor the free ends of said heater to said other ceramic disk whereby said heater is maintained in symmetrical axial relation within said tubular metal member.

7. A unitary electrode mount comprising a tubular cathode closed at one end by a flat thermionically emitting portion and provided at its open end with a flat annular flange; a heater unit enclosed by said cathode and held in spaced relation to said flat cathode portion; a cup-shaped grid electrode surrounding said cathode and having a flat apertured portion aligned with and held in axially spaced relation with respect to said flat cathode portion; spacing and supporting means including two axially aligned insulator disks between which said flat cathode flange is tightly held; retaining means clamping said insulator disks together comprising two flanged metal cylinders tightly fitting into each other and peripherally attached to said insulator disks; heater supporting means comprising pairs of metal straps attached to one of said insulator disks, and additional spacing and supporting means for the cathode consisting of a central opening in the other one of said insulator disks forming a tight fit around said tubular cathode.

8. The method of mounting an electrode assembly which comprises the steps of attaching pairs of metal straps to one of two apertured insulator disks, said disk having a thick central portion and a thin peripheral portion, introducing the free terminals of an elongated heater unit

through two of the apertures in said insulator disk, welding the heater terminals to the metal straps, threading a flanged cathode sleeve having a flat portion on one end through a central hole in a second insulator disk until the flange contacts one surface of said second insulator disk, telescoping the cathode sleeve with the second insulator disk attached to it over the elongated heater unit, locating the cathode flange closely between the two insulator disks, telescoping a first auxiliary flanged metal cylinder over the second insulator disk, bringing its flange in contact with the free surface of said second insulator disk, telescoping a second auxiliary flanged metal cylinder into the first auxiliary cylinder to engage with its flange the thin peripheral portion of the first named insulator disk, welding the two auxiliary flanged cylinders together to clamp the two insulator disks firmly to each other, thus forming a rigid heater cathode unit, inserting said heater cathode unit into the open end of a grid cylinder closed at its other end by an apertured disk portion, so that the tubular cathode sleeve is axially aligned with and concentrically surrounded by the grid cylinder, inserting a fixed length of the gauge pin of a micrometer dial gauge through the aperture of the grid disk, pushing the heater cathode unit further into the grid cylinder to engage the flat cathode end with the free end of the micrometer gauge pin, and continue pushing said heater-cathode assembly further into the grid cylinder until the micrometer dial indicates a desired depth of the gauge pin within the grid aperture, welding the grid cylinder to the first-named auxiliary cylinder, and removing the micrometer gauge from the grid aperture.

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