Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

Filed Jan. 3, 1936 11 Sheets-Sheet 1

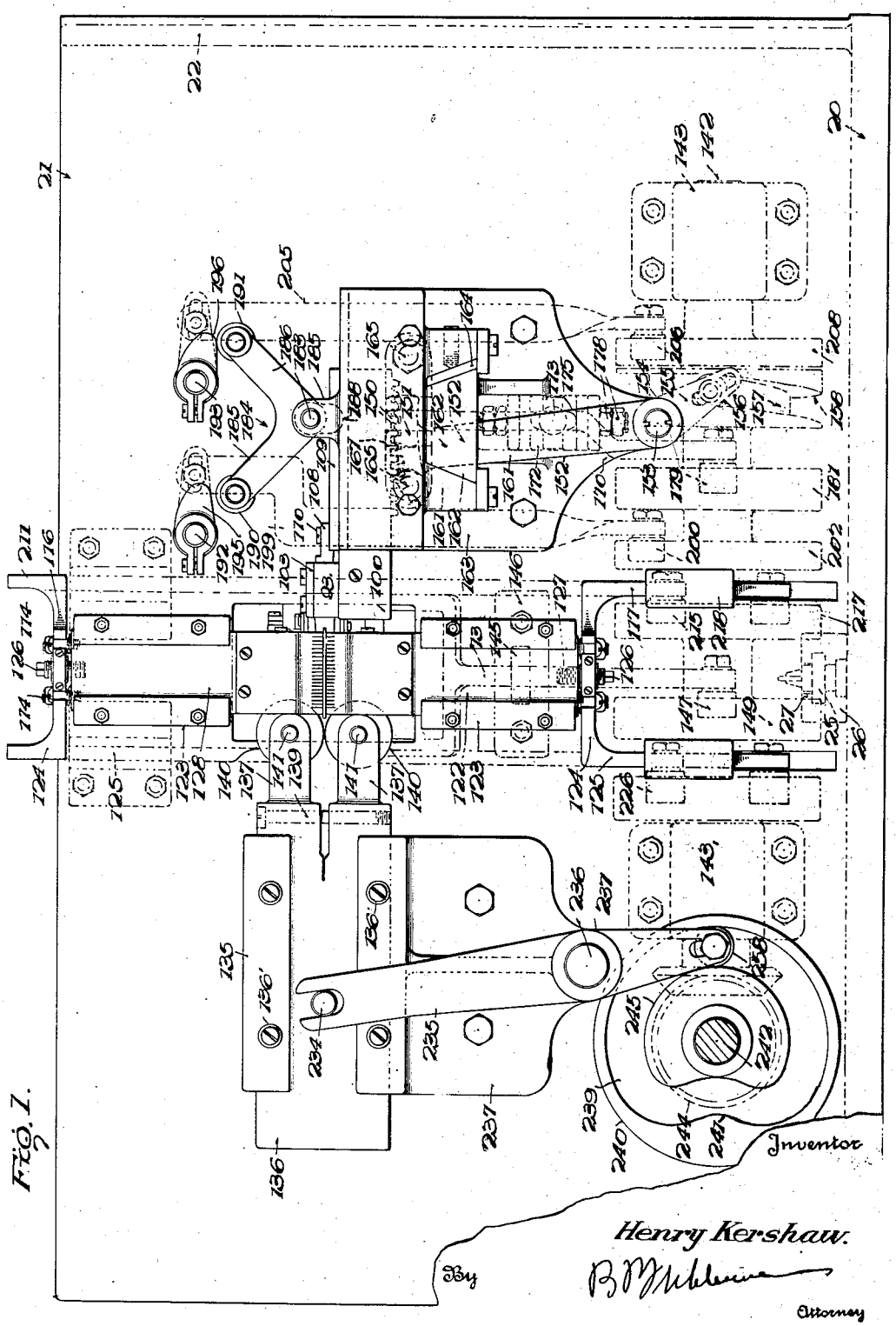


FIG. 1.

Inventor

Henry Kershaw.

By B. P. Mitchell

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

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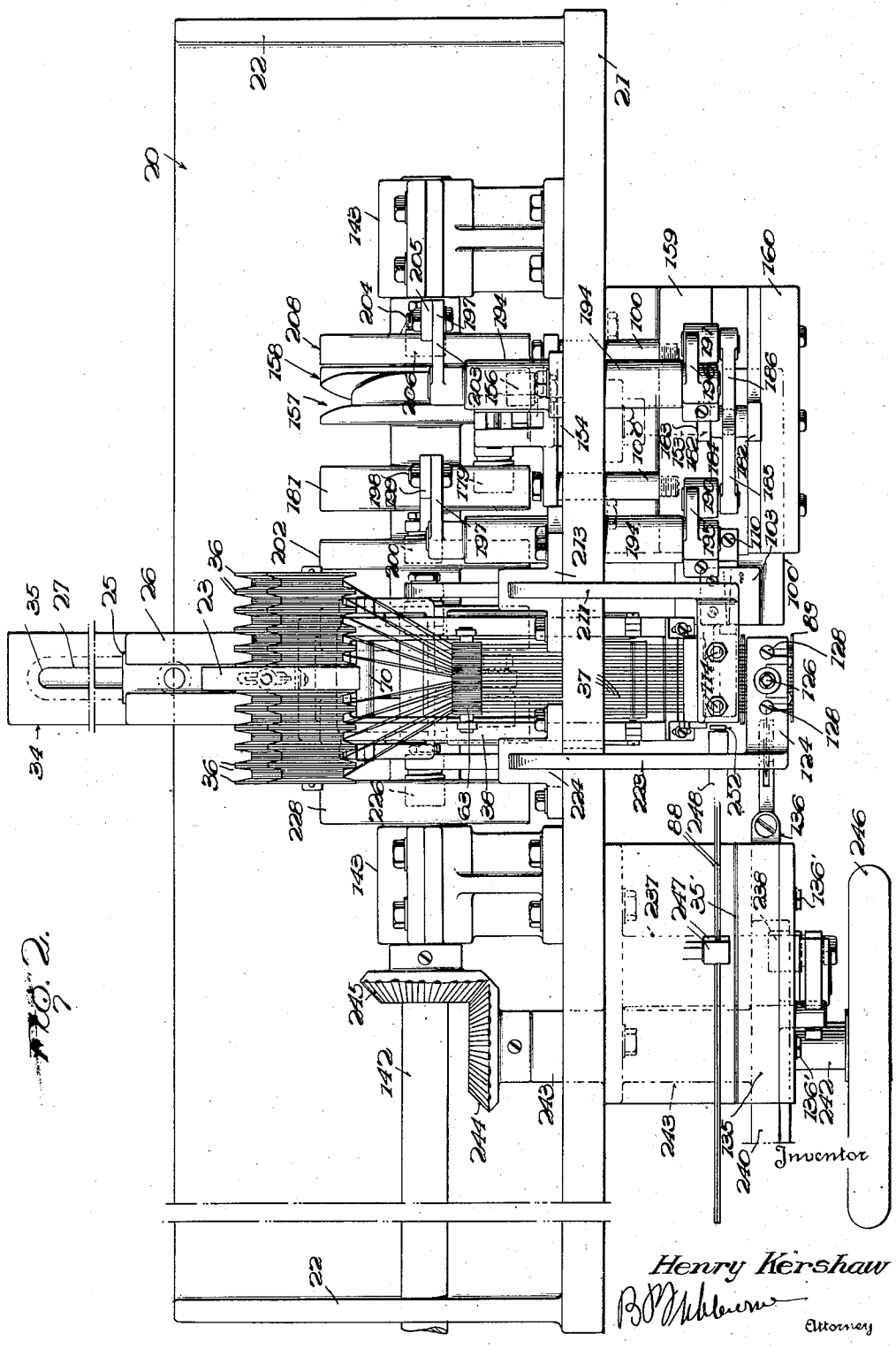


Fig. 2.

Inventor

Henry Kershaw

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Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

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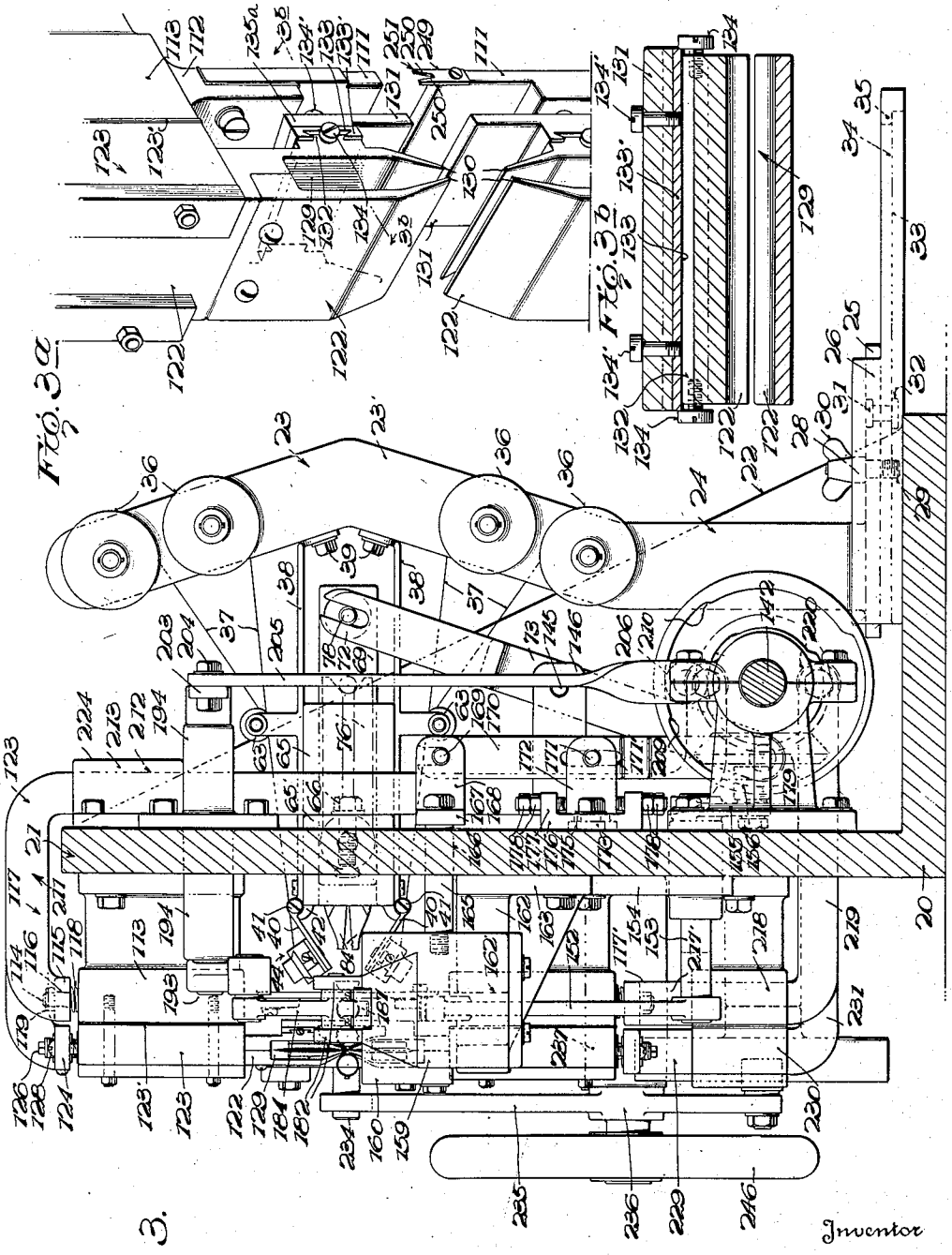


Fig. 3a

Fig. 3b

Fig. 3

Inventor

Henry Kershaw

By

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

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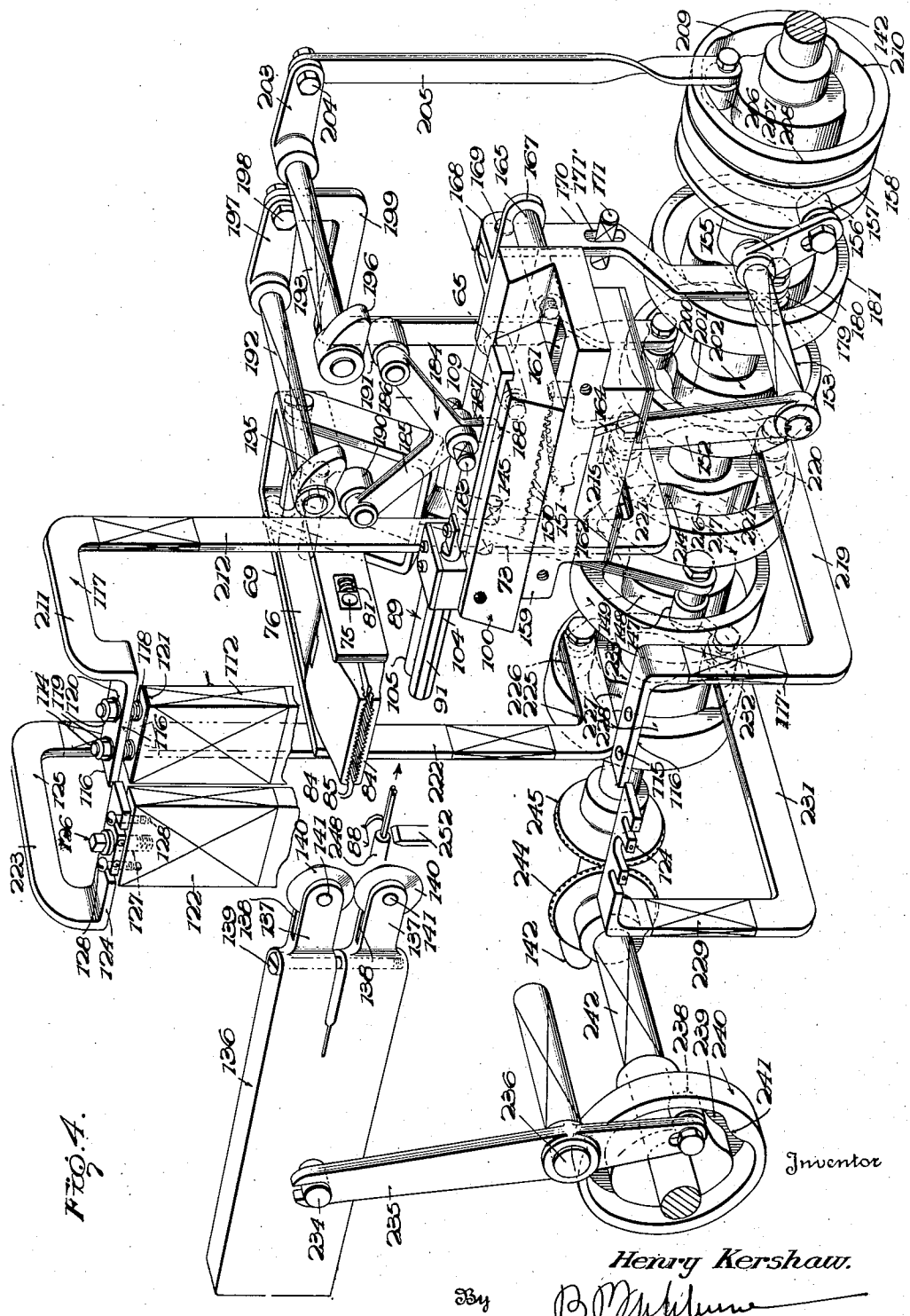


Fig. 4.

Inventor

Henry Kershaw.

By B. P. Mitchell

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

Filed Jan. 3, 1936 11 Sheets-Sheet 5

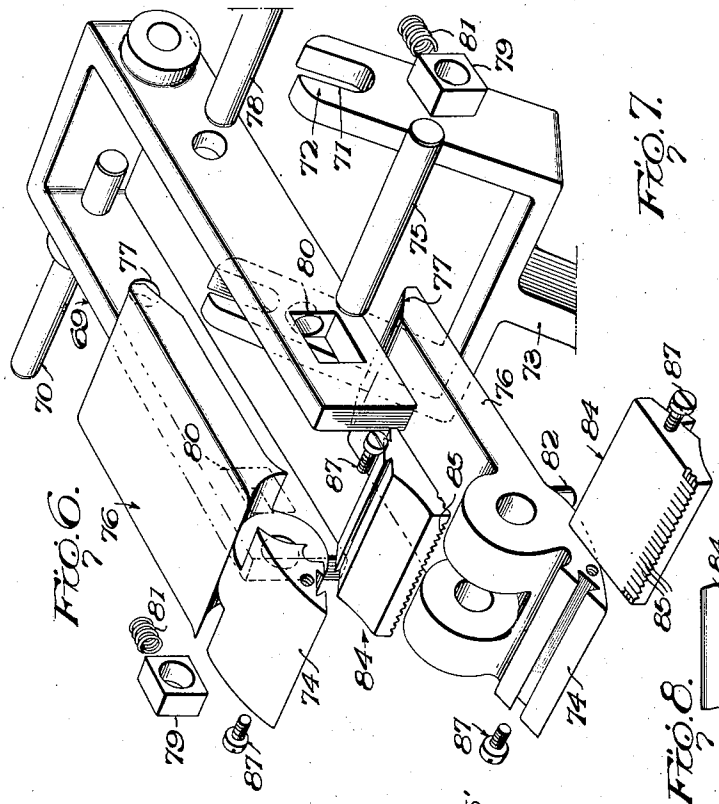


FIG. 6.

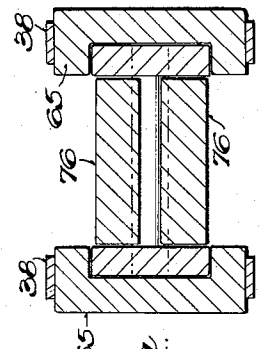


FIG. 7.

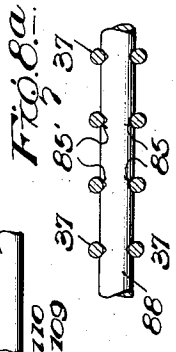


FIG. 8a.

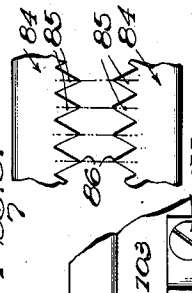


FIG. 8.

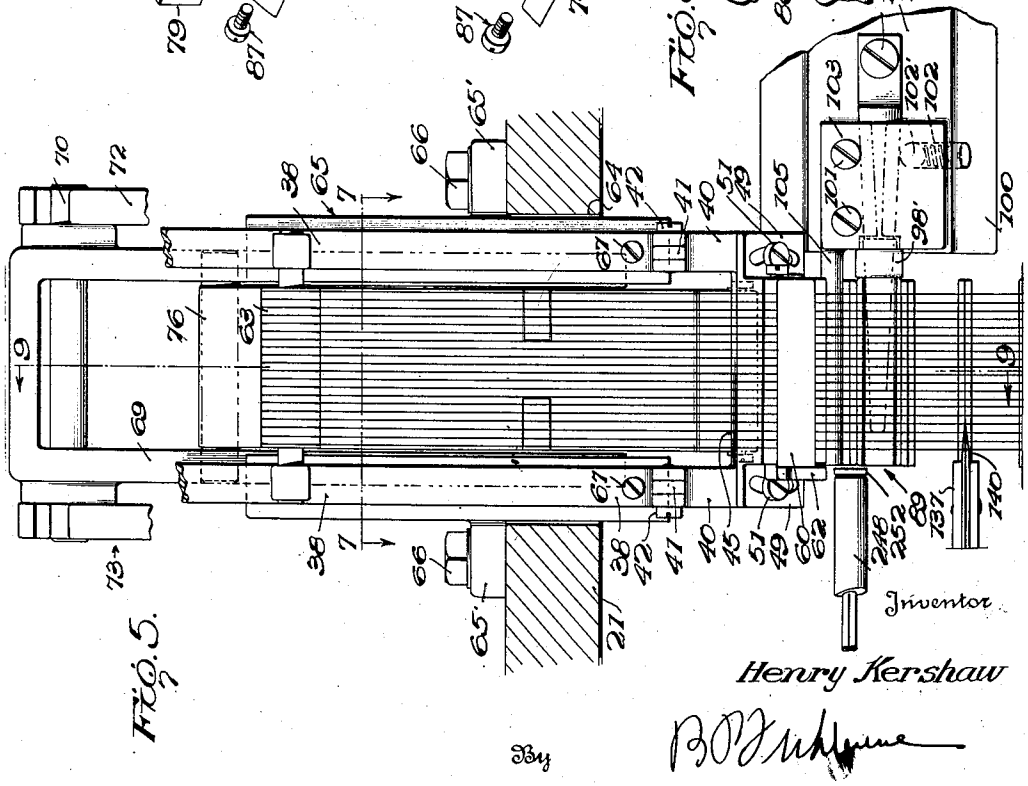


FIG. 5.

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By
Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

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FIG. 9.

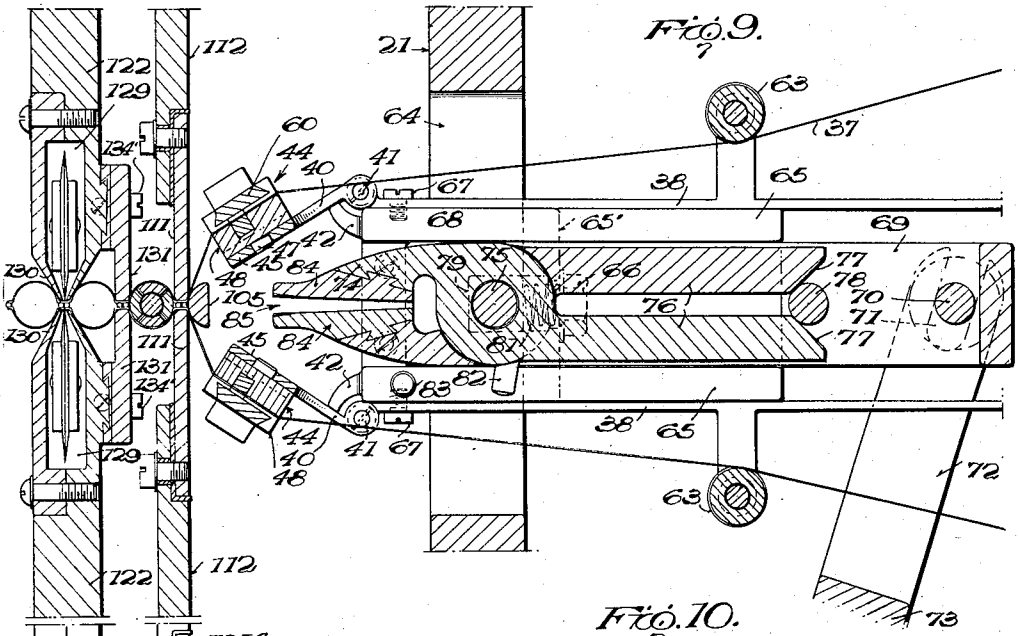


FIG. 10.

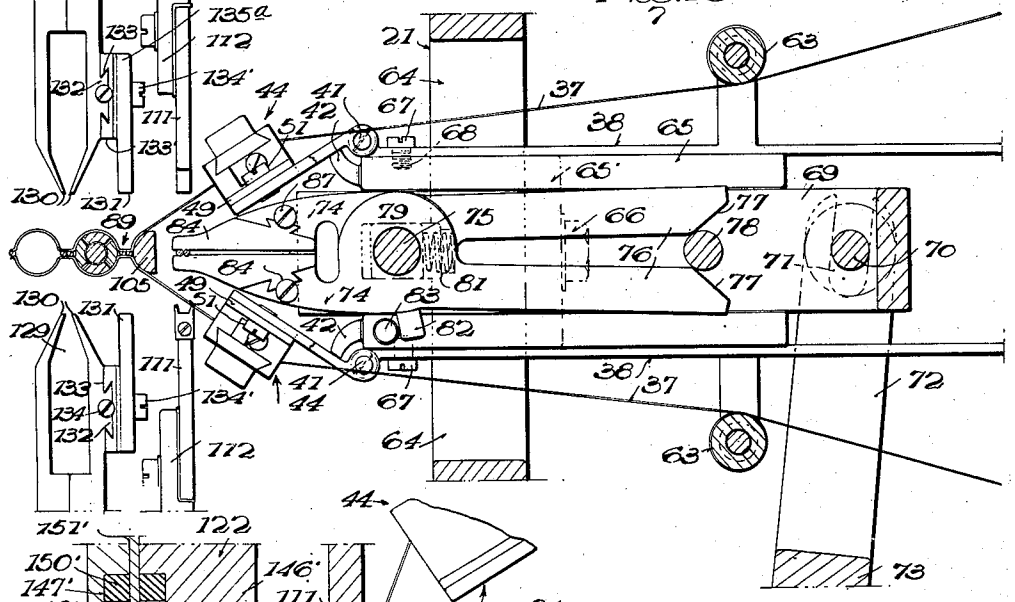
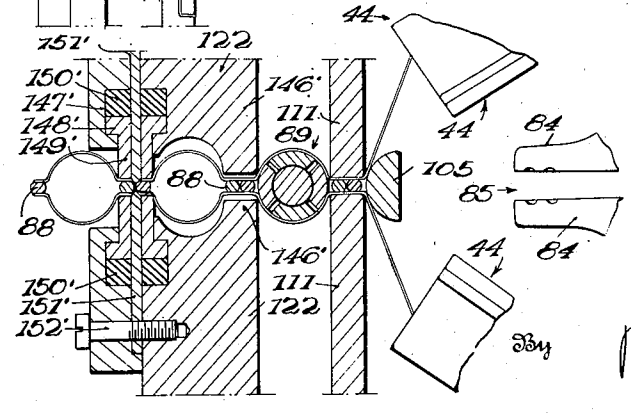


FIG. 11.



Inventor

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By B. P. Thalburn

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

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FIG. 12.

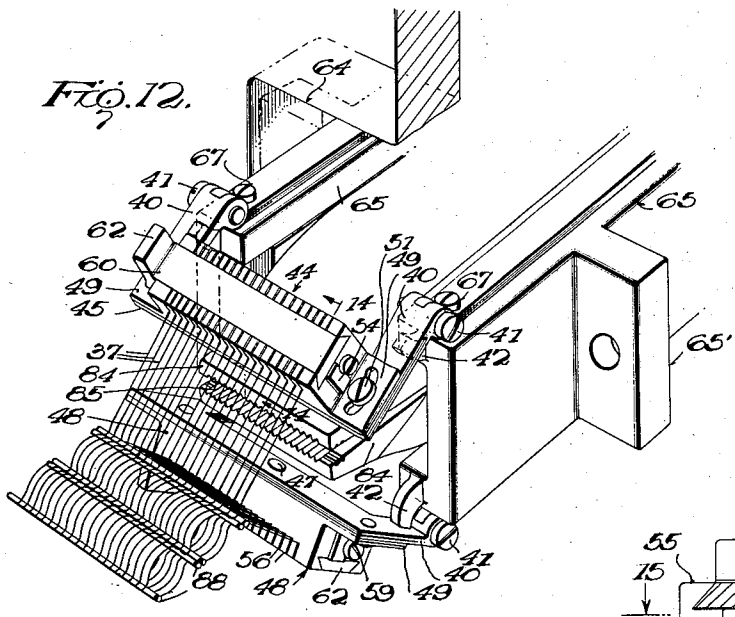


FIG. 14.

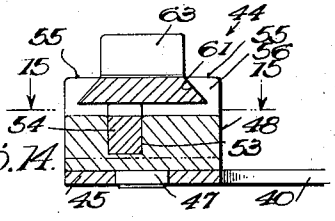


FIG. 13.

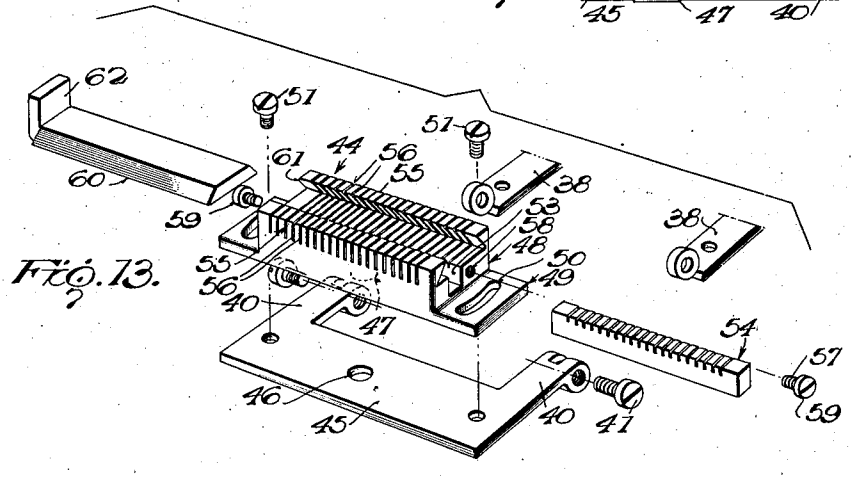
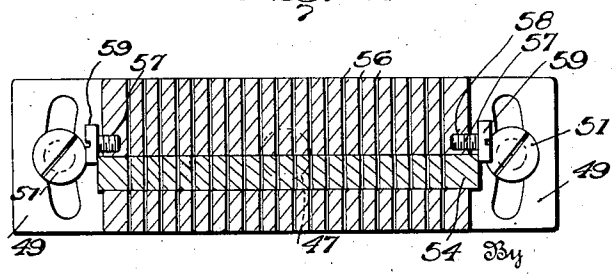


FIG. 15.



Inventor

Henry Kershaw.

By

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

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FIG. 16.

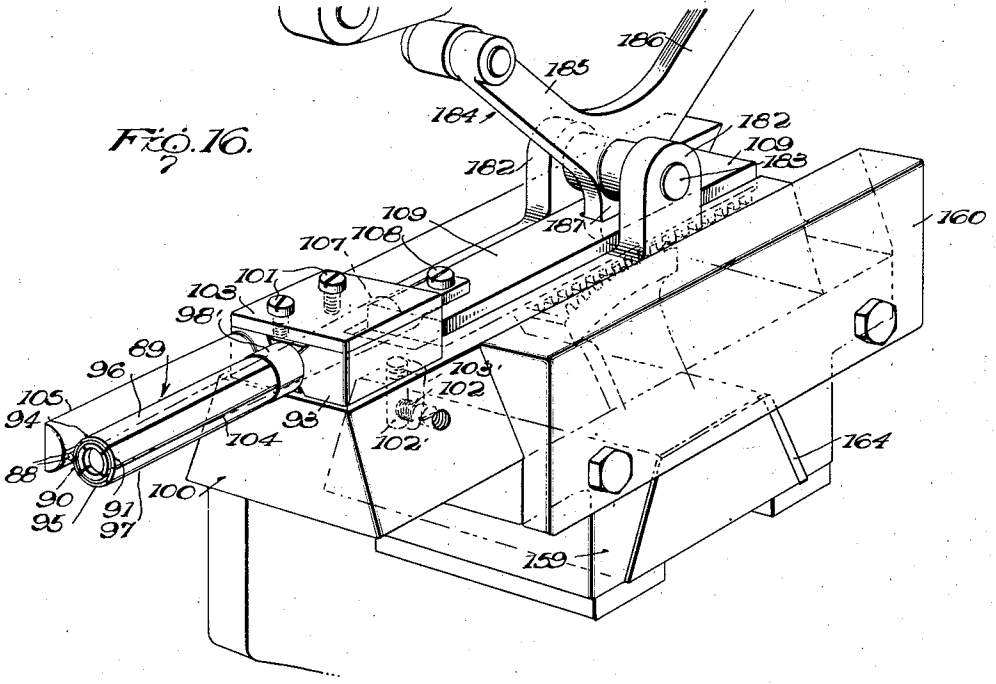


FIG. 17.

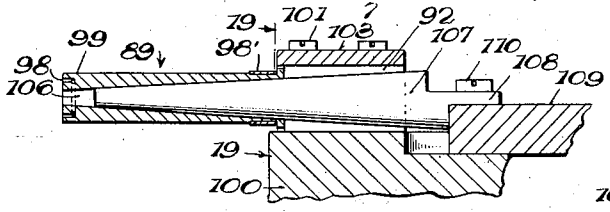


FIG. 18.

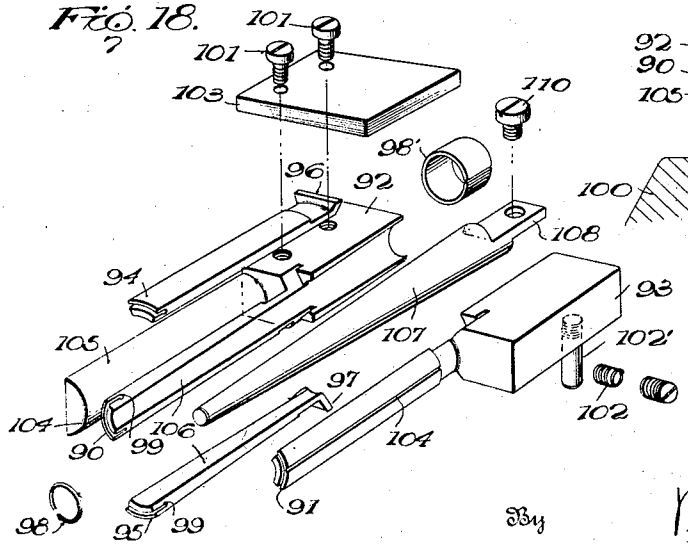
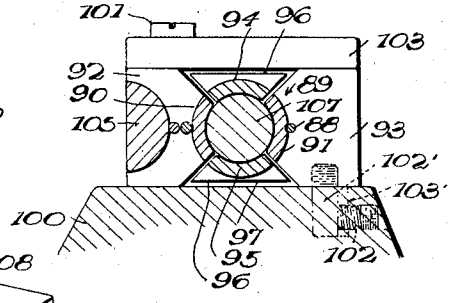


FIG. 19.



Inventor

Henry Kershaw

By B. P. Schlumm

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

Filed Jan. 3, 1936 11 Sheets-Sheet 9

FIG. 1a.

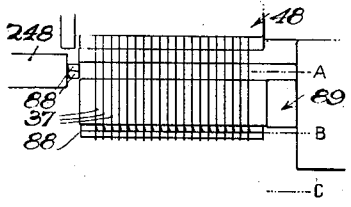


FIG. 1a'.

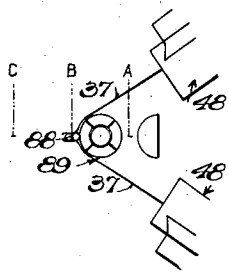


FIG. 1b.

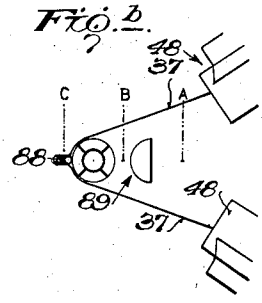


FIG. 1b'.

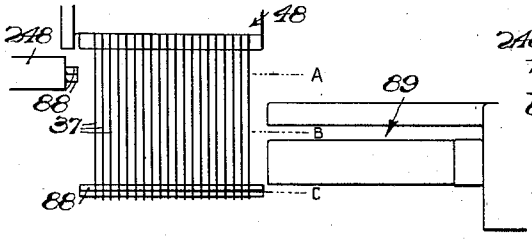


FIG. 1b".

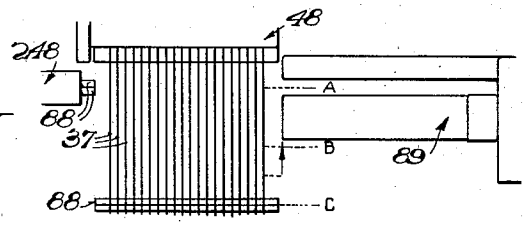


FIG. 1c.

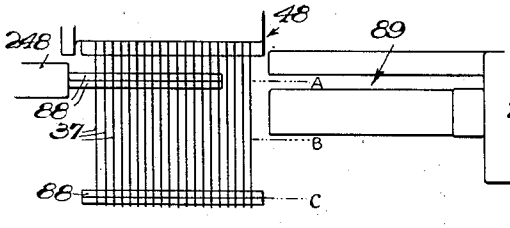


FIG. 1c'.

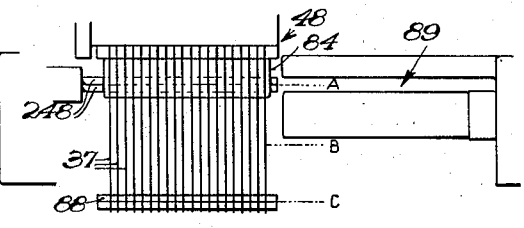
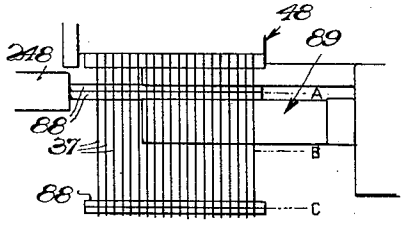


FIG. 1c".



Inventor

Henry Kershaw

By B. P. J. Mulvaney

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

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Fig. d.

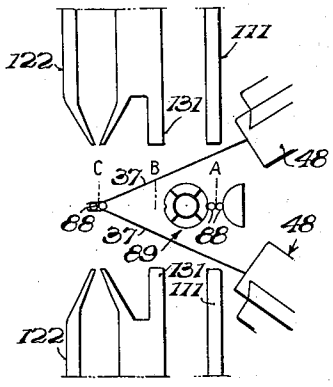


Fig. d'

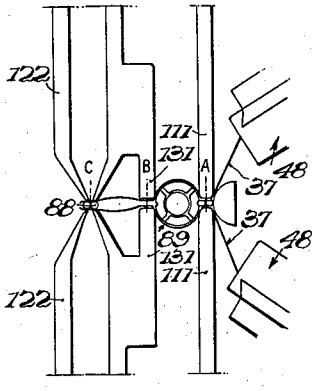


Fig. d''

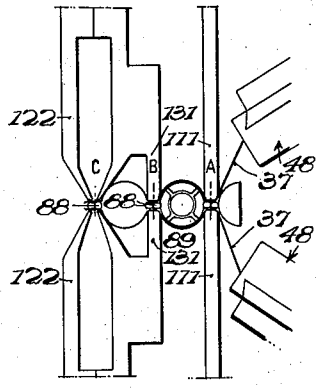


Fig. e

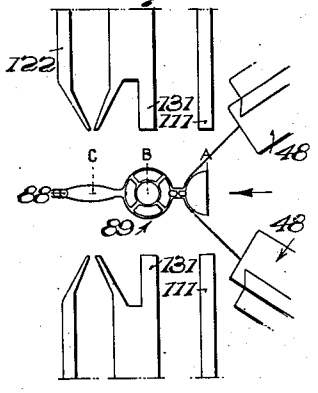


Fig. e'

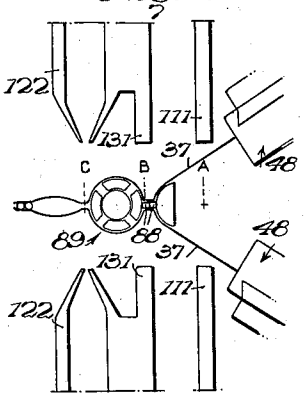


Fig. e''

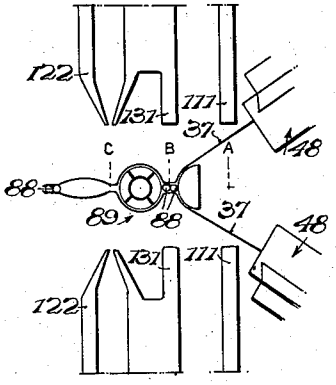


Fig. f.

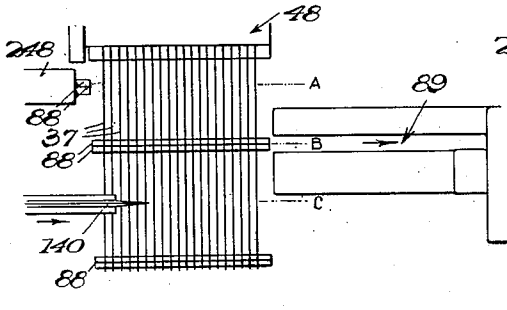
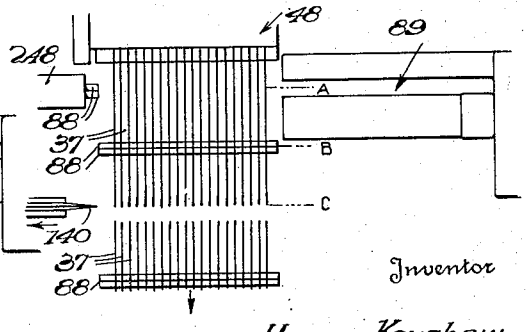


Fig. f'



Inventor

Henry Kershaw.

By B. P. Fahnestock

Attorney

Dec. 15, 1936. H. KERSHAW 2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

Filed Jan. 3, 1936 11 Sheets-Sheet 11

FIG. 20.

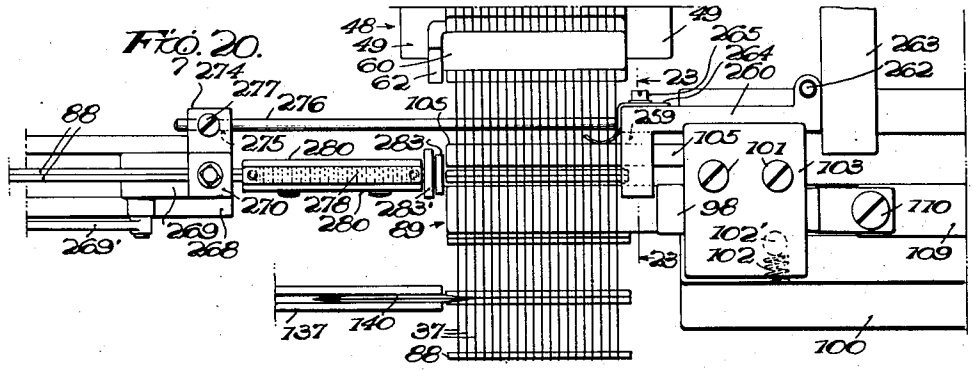


FIG. 21.

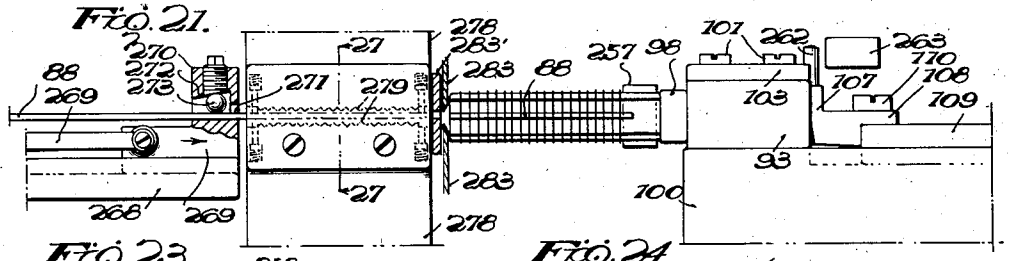


FIG. 23.

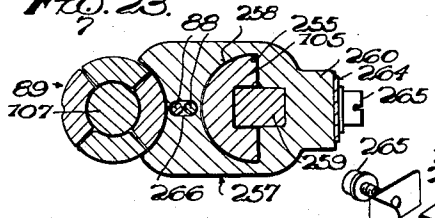


FIG. 24.

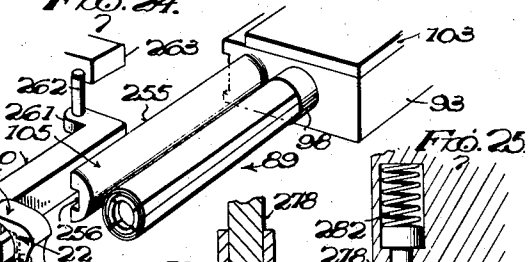


FIG. 25.

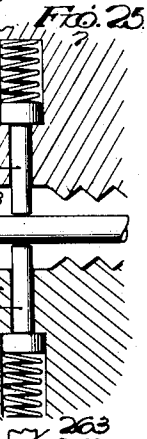


FIG. 22.

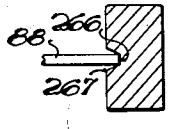


FIG. 27.

FIG. 28.

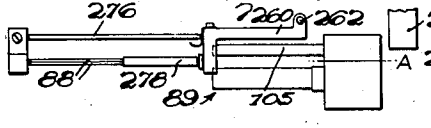


FIG. 26.

FIG. 29.

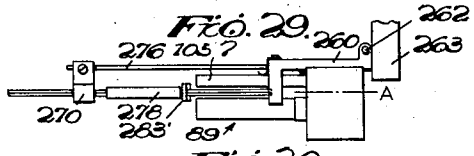


FIG. 30.

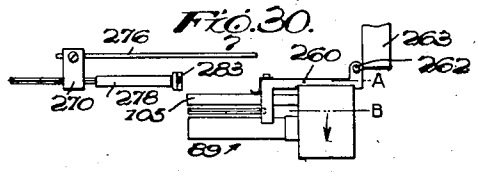
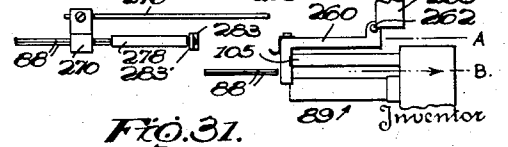


FIG. 31.



Inventor

Henry Kershaw.

By B. P. Whitmore

Attorney

Patented Dec. 15, 1936 2,064,169

UNITED STATES PATENT OFFICE

2,064,169

METHOD OF AND APPARATUS FOR PRODUCING RADIO TUBE GRIDS

Henry Kershaw, Newark, N. J., assignor to Sovereign Machinery Company, Newark, N. J., a corporation of New Jersey

Application January 3, 1936, Serial No. 57,444

60 Claims. (Cl. 140—71)

My invention relates to a method of and machine for producing radio tube grids.

An important object of the invention is to provide a method of the above mentioned character which will accurately space the grid wires upon the side rods.

A further object of the invention is to provide a method of the above mentioned character which will produce an initial stretching action upon the grid wires to take up slack, just prior to attaching the same to the side rods, and which will subsequently stretch or expand the grid to space the same, prior to the completion of the grid and its severance from the remaining grid or grids.

A further object of the invention is to provide a machine of the above mentioned character, which may be employed in the practice of the method shown in Letters Patent 2,004,246, granted to me under date of June 11, 1935, and in the practice of the improved method.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this application and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a front elevation of a machine embodying my invention,

Figure 2 is a plan view of the same,

Figure 3 is an end elevation, parts in section,

Figure 3*a* is a perspective view of the welding jaws and associated clamping jaws,

Figure 3*b* is a horizontal section taken on line 3*b*—3*b* of Figure 3*a*,

Figure 4 is a perspective view of the main cam shaft and associated elements driven thereby,

Figure 5 is an enlarged plan view of the means to form the spaced grooves upon the side rods, and associated elements,

Figure 6 is an exploded perspective view of the means to form the spaced grooves upon the side rods,

Figure 7 is a transverse section taken on line 7—7 of Figure 5,

Figure 8 is an enlarged fragmentary end elevation of the notching teeth of the groove forming means,

Figure 8*a* is an enlarged side elevation of one side rod,

Figure 9 is a longitudinal vertical section taken on line 9—9 of Figure 5, with the groove forming means retracted,

Figure 10 is a side elevation of the groove forming means, showing the same in the projected position and engaging the side rods,

Figure 11 is a vertical section through a modified form of side rod gripping and welding means, the same being a view similar to Figure 9,

Figure 12 is a perspective view of the comb devices and associated elements,

Figure 13 is an exploded perspective view of one of the comb devices,

Figure 14 is a transverse section taken on line 14—14 of Figure 12,

Figure 15 is a longitudinal section taken on line 15—15 of Figure 14,

Figure 16 is a perspective view of the mandrel and associated elements,

Figure 17 is a central vertical longitudinal section through the mandrel, parts in elevation,

Figure 18 is an exploded perspective view of the mandrel,

Figure 19 is a transverse section taken on line 19—19 of Figure 17,

Figures *a*, *a'*, *b*, *b'*, *b''*, *c*, *c'*, *c''*, *d*, *d'*, *d''*, *e*, *e'*, *e''*, *f*, *f'* are diagrammatic views illustrating the several steps of the operation of the machine and in the practice of the method,

Figure 20 is a plan view of a modified form of apparatus for producing the grids, the same being shown partly diagrammatic,

Figure 21 is a front elevation of the same, parts in section,

Figure 22 is a detailed section taken on line 22—22 of Figure 24,

Figure 23 is a transverse section taken on line 23—23 of Figure 20,

Figure 24 is a perspective view of the expansible mandrel and associated elements,

Figure 25 is a fragmentary section through the notching jaws, showing the ejector plungers,

Figure 26 is a plan view of one of the notching jaws, showing the ejector plungers,

Figure 27 is a transverse section taken on line 27—27 of Figure 21,

Figure 28 is a plan view, partly diagrammatic, of the expansible mandrel and associated elements, showing the side rod holding slide in the forward or projected position upon the mandrel element, upon the beginning of the feeding movement of the side rods, with the mandrel arranged at position A between the grid wires,

Figure 29 is a similar view with the side rods fed into the passage of the mandrel and the side rod holding slide in the retracted position,

Figure 30 is a similar view, showing the side rods cut and held within the passage of the mandrel and mandrel advanced to position B,

Figure 31 is a similar view showing the mandrel removed from between the grid wires and ready to be shifted rearwardly to position A.

In the drawings, wherein for the purpose of illustration is shown a preferred embodiment of my invention, a supporting structure is shown comprising a table or base 20 having a vertical plate or wall 21 rigidly secured thereto. The plate 21 and base 20 are further connected by webs 22, as shown.

Arranged upon one side of the plate 21 is an upstanding reel 23, Figure 3, carried by a vertical arm 24, in turn mounted upon a slide 25 arranged within a stationary guide 26, rigidly mounted upon the base 20. The slide 25 has a longitudinal slot 27, Figure 2, for receiving a clamping screw 28, engaging within a screw-threaded opening 29 formed in the stationary guide 26. Clamping bolt 28 carries a winged head 30 permanently secured thereto. By turning the winged head 30, the slide 25 may be longitudinally adjusted throughout the length of the slot 27 and clamped at selected adjusted positions. The slide 25 carries a guide pin 31, depending therefrom and rigidly secured thereto, and this pin is provided with a head 32, and is slidable within an elongated slot 33 formed in the extended bottom 34 of the guide 26. This extended bottom has a stop 35. It is thus seen that by removing the bolt 28 from within the screw-threaded opening 29, slide 25 may be moved longitudinally and outwardly to disengage the sides of the guide 26, while it remains upon the bottom extension 34, and is pivotally connected therewith by means of pin 31, so that the slide may be turned upon the bottom extension 34 to assume a position at about a right angle to the original position. The function of this construction is to provide means whereby access may be had to elements carried by the reel 23, as will be explained. The reel 23 pivotally supports a suitable number of spools 36, carrying the grid wires.

Rigidly attached to the sides 23' of the reel 23 are spaced superposed horizontal arms 38, Figure 3, the connection being effected by screws 39 or the like. The arms 38 in each pair are parallel and are preferably rigid. The numeral 40 designates pairs of leaves, hinged to the arms 38, at 41, Figure 9, to be swung to opened and closed positions, with relation thereto. When in the closed position, these arms converge forwardly, and engage stationary stops 42, rigidly secured to tracks 65, to be described. The leaves 40 are permanently pivotally connected with the arms 38, and are normally retained in the inner position in contact with the stops 42 by the pulling action of the grid wires, but these leaves are free to swing outwardly to clear the tracks 65, when the arms 38 are withdrawn, to afford access to the combs.

The leaves 40 carry combs 44, which are identical. Each pair of leaves 40 are included in a yoke comprising a bar 45, provided centrally thereof with an opening 46 to receive a pivot stud 47 of the comb housing 48. This comb housing is provided at its ends and at its bottom with ears 49 having curved slots 50, concentric with the pivot stud 47, and receiving clamping bolts 51 engaging the bar 45. It is thus seen that the comb housing may be turned or angularly adjusted upon the pivot stud 47 and locked in the selected adjusted position by manipulation of the clamping bolts 51. The comb housing is provided with a longitudinal groove 53 for slidably receiving a comb bar 54. The groove also forms outer stationary comb bars 55. The inner comb bar and outer stationary comb bars 55 are transversely milled to provide transverse slots 56, which are equi-distantly spaced and are the same width. These slots are wider than the diameter of the grid wire to be handled. The grid wires 37 pass through the slots of the outer stationary comb bars and the inner adjustable comb bar, and the inner comb bar is longitudinally adjusted with respect to the outer comb bars, until the grid wires are brought into sliding engagement with corresponding walls of the slots in the outer comb bars. The inner sliding comb bar is then locked in this adjusted position by means of screws 57, engaging within screw-threaded openings 58 in the comb housing, and having their heads 59 projecting laterally over the ends of the sliding comb bar, to engage therewith. In order that the grid wires may not move out of the transverse slots of the several comb bars, a sliding cover 60 is provided, the bevelled edges of which operate within under-cut grooves 61 formed upon the inner faces of the outer comb bars, the sliding cover preferably having an upstanding extension 62 to facilitate its adjustment. The sliding cover is removed when the grid wires are being positioned within the transverse slots of the comb bars. It is thus seen that the comb is adjustable so that wires in sets of varying diameters, are held accurately equi-distantly spaced, and the distance between the wires so held, may be varied by angularly adjusting the comb housing. The grid wires 37 pass from the spools 36 to the combs, as stated, and engage guide rollers 63.

The plate 21 is provided with an opening 64, through which the arms 38 project, and also stationary tracks or guides 65, which are rigidly secured to flanges 65', Figures 5 and 12, bolted to the plate 21, as shown at 66. The arms 38 preferably engage the outer edges of the stationary guides 65, and the arms 38 have screw-threaded openings formed in the same near their free ends for carrying locking bolts 67, adapted to engage within screw-threaded openings 68, formed in the guides or tracks 65, when the arms 38 have been shifted forwardly to the completely adjusted position, thus rigidly holding the forward end portions of the arms 38 against movement.

Means are provided to notch the side rods, for receiving the grid wires. This means comprises a sliding yoke-carriage 69, Figures 5, 6, 9, 10, operating within the tracks or guides 65. This yoke-carriage is provided near its rear end with a transverse pivot pin 70, operating within slots 71 formed in the forked end 72 of a lever 73, to be more fully described. The notching means further comprises a pair of opposed jaw heads 74 which are pivotally connected by means of a pin 75. The jaw heads 74 are rigidly connected with arms or levers 76. The jaw head and its corresponding arm are pivotally connected with the companion jaw head and its corresponding arm by means of pin 75, as stated, but these parts do not cross. When the rear ends of the arms 76 are spread, the forward ends of the jaw heads 74 will be moved together. At their rear ends, the arms 76 have bevelled faces 77, to be engaged by a pin or spreading element 78, extending across the yoke-carriage 69 and rigidly secured thereto. The jaw heads 74 are supported and guided during their longitudinal movement by the pin 75, journalled within blocks 79, which in turn are slidably mounted within elongated openings 80, formed in the sides of the yoke-carriage 69, with

compressible coil springs 81, arranged at the rear of the blocks 80, to oppose the forward longitudinal movement of the yoke-carriage 69 with respect to the blocks 80. The lower jaw head 74 is provided with a pin 82, rigidly secured thereto, and arranged to engage a stationary stop pin 83 rigidly attached to the guide or track 65. Jaws 84 are rigidly mounted upon the jaw heads 74, and preferably detachably connected therewith so that a different pair of jaws 84 may be employed, when desired, and each jaw has a set of preferably V-shaped teeth 85 extending longitudinally thereof. The apexes 86 of each set of teeth 85 are accurately equi-distantly spaced, and the apexes of one set of V-shaped teeth are arranged in alignment with the apexes 86 of the other set of V-shaped teeth, Figure 8, there being means to laterally adjust the jaws 84 upon the jaw-heads, in the form of screw 87 so that the sets of apexes 86 are brought into accurate alignment and maintained in such alignment. It might be stated at this point that the V-shaped teeth 85 form transverse V-shaped notches or grooves 85' in the opposite sides of each pair of side rods 88, Figure 8a. When the jaws 84 move inwardly to form these notches or grooves and while engaging with the pair of side rods, they do not partake of longitudinal movement with relation to the side rods, whereby there is no tendency to laterally displace the side rods. The V-shaped grooves 85', Figure 8a, are accurately equi-distantly spaced, and serve to hold the grid wires against lateral creeping when the welding jaws force them toward the side rods. These grooves also afford two welding contact points between the side rods and the grid wires.

The numeral 89 designates an expansible mandrel, Figures 1, 4, and 6 to 20, shown as cylindrical for the purpose of illustration, although it may be of a different shape. This expansible mandrel includes oppositely arranged rear and forward sections 90 and 91, rigidly attached to blocks 92 and 93, respectively. Arranged between the sections 90 and 91 are upper and lower sections 94 and 95, carried by bases 96 and 97, respectively, having outer straight edges, as shown. A split resilient ring 98' surrounds the inner ends of the mandrel sections, and a split resilient ring 98 engages within an annular groove 99 formed in the free end of the expansible mandrel. The function of these rings is to hold the mandrel sections together and to contract them after they are expanded and released. The block 92 is rigidly mounted upon a slide 100 by means of screws 101 or the like, while the block 93 is slidably mounted upon the slide 100 and is urged inwardly toward the block 92 by means of a compressible coil spring 102, engaging a pin 102', operating in an elongated slot 103' and rigidly secured to the block 93. A cap-plate 103 is arranged above the blocks 92 and 93 and is held in place by the screws 101. This cap-plate permits of the transverse sliding movement of the block 93 toward and from the block 92, but holds this block against any turning movement upon its longitudinal axis, and the slide 100 and the cap-plate 103 engage the straight edges of the bases 96 and 97, when the mandrel sections 94 and 95 approach the end of their expanded positions, and retain these mandrel sections in the normal position with respect to turning movement upon their longitudinal axes, if there has been any slight tendency for such displacement. The mandrel sections 90 and 91 are provided with shallow grooves or scores 104, which coact with the side rods, to properly center the side rods on the mandrel. Arranged near and spaced from the expansible mandrel 89 is a companion mandrel element 105, which is not expansible, and which is rigidly mounted upon the block 92. The side rods 88 are passed between the expansible mandrel 89 and the mandrel element 105, in a manner to be more fully described. The expansible mandrel is tubular and has a tapered bore 106 which is extended through the inner faces of the blocks 92 and 93, for the reception of a tapered expanding element or wedge 107, provided at its rear end with an apertured ear 108, connected with a slide 109, by means of a screw 110 or the like.

The numeral 111 designates a pair of vertical oppositely arranged welding jaws, Figures 3a, 9, and 10, which are rigidly attached to and insulated from vertical slides 112, operating in stationary guides 113, and these guides are rigidly attached to the upstanding plate 21. Each slide 112 is provided at its outer end with a pair of pins 114, rigidly secured thereto, and slidably operating within openings 115, formed in a head 116, rigidly secured to a lever 117. Compressible coil springs 118 surround the pins 114 beneath the head 116, and the pins 114 carry stop caps 119 at their outer ends, with washers 120. Any suitable number of shims 121 may be arranged between the top of the slide 112 and the springs 118. The welding jaws 111 are connected with the opposite sides of a transformer by a suitable circuit, and the circuit is closed for providing a current for the welding operation, for a short period, such as from one to two cycles. The welding jaws are sufficiently wide to extend across the pair of side rods 88 and properly force the grid wires into engagement therewith. The welding jaws are moved inwardly by the yielding action of the springs 118, and when the grid wires and the adjacent portions of the side rods fuse or become plastic, the springs 118 cause the welding jaws to follow these parts, thereby effecting a satisfactory weld.

Means are provided, Figures 1, 2, 3, 9, 10, to hold the adjacent pair of side rods, and cut the grid wires between them, in succession. This holding means comprises vertical slides 122, operating within stationary guides 123. The guides 123 are bolted to the guides 113, and in order that the guides 123 may be horizontally adjusted, I contemplate arranging shims 123' of different widths between the guides 123 and 113. Since the guides 123 control the plane in which the slides 122 of the side rod holding devices operate, and since the rotary cutters must operate within the recesses 129, I also provide means to horizontally adjust the slide 136, including a shim 135', the guide 135 being held in place by bolts 136'. It is thus seen that the side rod holding means and the grid wire cutting means are adjustable into proper alignment and are adjustable from the welding position, which is a fixed position. This adjustment is necessary as the size of the grid may be varied. The slides 122 are vertically movable toward and from each other and are shifted vertically by heads 124 carried by levers 125. A bolt 126 has a swivelled connection with the head 124, and its inner end has screw-threaded engagement with the slide 122, as shown at 127, whereby the slide may be adjusted toward and from the head 124, and the slide is locked in the adjusted position by locking screws 128. These locking screws have no screw-threaded engagement with the head 124

but have screw-threaded engagement with the slide 122, and are adapted to hold the slide in the adjusted position. Each slide is provided with a main recess 129, and a pair of depending holding or gripping jaws 130, the inner ends of which are slightly spaced, and the jaws 130 are adapted to engage with the pair of adjacent side rods 88. The jaws 130 preferably converge downwardly. Each slide 122 has a supplemental holding jaw 131 arranged upon one side thereof, to move therewith. The connection is preferably adjustable so that the supplemental holding jaw may be adjusted both vertically and horizontally with relation to the slide 122. To effect this, a dove tailed tongue 132 is provided, preferably integral with the slide 122, and this dove tailed tongue is vertically inclined, as shown in Figure 3a. The dove-tailed tongue operates within a dove-tailed groove 133, also horizontally inclined, and formed in an intermediate plate 133', which is rigidly and detachably secured to the supplemental jaw 131 by screw or screws 134', passing through a head 135a. The head 135a will vary in thickness depending upon the desired distance between the jaw 131 and the jaws 130, as may be required with a grid of a given width. When the distance is to be varied, the jaw 131 is removed and another jaw 131 placed upon the plate 133', and the head 135a of the desired thickness being thereby obtained. The jaw 131 is vertically adjusted by means of screws 134, engaging the slide 122, with their heads engaging the plate 133'. The supplemental jaws 131 are arranged between the welding jaws 111 and the pairs of holding jaws 130, and engage the pair of adjacent side rods next to the pair of side rods, then arranged at the point of cutting.

The cutting means, Figures 1, 2, and 4, comprises a stationary horizontal guide 135, rigidly supported from the plate 21 and this guide receives or holds a horizontal movable cutter carriage or slide 136. This carriage or slide is provided at its inner end with a pair of spaced arms 137, with a groove 138 between them, and the arms 137 are connected by a transverse adjusting screw 139, the purpose of which is to move the arms 137 slightly toward each other for effecting a slight adjustment between the cutting edges of the rotary cutters 140. These rotary cutters are mounted in the forked ends of arms 137 and are carried by pins 141. The rotary cutters are adapted to be shifted into the main recesses 129 so that the rotary cutters are moved longitudinally of the grid throughout substantially its entire length, and will cut the grid wires, between the adjacent side rods, in succession, both top and bottom. When this is done, the leading grid is completed and will drop from the presence of the holding jaws 130. These rotatable cutters not only cut the grid wires but serve to bend them inwardly and roll them about the sides of the side rods.

In Figure 11, I have shown a modified form of clamping jaws and supplemental clamping jaws, and a modified form of cutting means. The numeral 146' designates supplemental clamping jaws, suitably attached to the slides 122, and corresponding to the jaws 131. The slides 122 are provided with recesses 147', receiving the heads 148' of pairs of clamping jaws 149', which are longitudinally adjustable with relation to the slides 122, such adjustment being opposed by yielding means 150', such as rubber. Cutting blades 151' are arranged between the jaws 149', and are rigidly clamped to the slides 122, by screws 152' or the like. The jaws 149' normally project inwardly beyond the blades 151' and beyond the ends of the supplemental jaws 146'. When the slides 122 move inwardly, jaws 149' first engage the adjacent pair of side rods 88, and the rubber 150' will yield upon the further inward movement of the slides 122, permitting blades 151' to cut the grid wires between the side rods and jaws 146' to engage their adjacent side rods as soon as the grid wires have been cut.

The numeral 142 designates a main cam shaft, Figures 1, 2, 3, 4, journalled in bearings 143, and mounted upon the plate 21. This cam shaft is driven by any suitable means.

The lever 73 is pivoted at 145 to a stationary bracket 146, rigidly mounted upon the face plate 21, and this lever extends downwardly below the pivot 145 and carries a roller 147, operating within the cam groove 148 of a cam 149, which is rigidly mounted upon cam shaft 142 for rotation therewith.

The slide 100 is provided upon its lower face with gear teeth 150, engaged by a segmental rack 151 carried by lever 152. At its lower end, this lever 152 is splined upon a rock shaft 153, which is journalled in a stationary bearing 154. The lever 152 is therefore capable of sliding longitudinally upon the rock shaft 153 but positively turns with the rock shaft. At its opposite end, the rock shaft 153 has a crank 155 rigidly secured thereto, and this crank is provided at its free end with a roller 156, operating within a cam groove 157 of a cam 158. It is thus seen that means are provided to shift the slide 100 longitudinally in opposite directions and during this movement the slide 109 is stationary with relation to the slide 100, and the mandrel 89, as a whole, is shifted longitudinally, to bring the same into or out of the grid. During the operation of the machine, after the mandrel is expanded to shape or stretch the grid, it is shifted outwardly to withdraw the same from the grid, and must then be shifted rearwardly at a right angle to its withdrawing movement, after which it is again shifted into the next grid. In order that the mandrel may be shifted rearwardly at a right angle to its withdrawing movement, the slide 100 is mounted upon a lower slide 159, having a removable side 160. The lower slide 159 also has an upwardly flaring slot 161, for the reception of the upper end of lever 152 and the segmental rack 151. The lower slide 159 is in turn mounted upon a stationary track or guide 162, carried by a plate 163 bolted to the face plate 21. This track 162 has a recess 162' of sufficient length to permit of the proper movement of the lever 152, during its movement upon the rock shaft 153. A wear plate 164 is preferably provided between the slide 159 and the track or guide 162. The means to shift the lower slide 159, comprises a pair of pins 165, rigidly connected therewith, and slidable within openings 166, formed in the face plate 21, and the pins 165 are rigidly connected upon the opposite or rear side of the face plate with a plate 167, carrying knuckles 168, which are spaced, and carrying a pin 169, operating within the upper forked end of a lever 170. This lever is pivoted between its ends, as shown at 171, with a yoke 172, which is held stationary and is preferably vertically adjustable, to raise or lower the pivot 171, operating within the slot 171' in the lever 170. The function of vertically shifting the pivot 171 is to adjust the stroke of the upper end of the lever 170. The yoke 172 is provided at

its end with a headed stud 173, operating within slot 175 formed in a bracket 176, in turn rigidly mounted upon the face plate 21. This bracket has apertured ears 177, having screw-threaded engagement with adjusting screws 178, engaging above and below the yoke 172. It is thus seen that by manipulation of these adjusting screws, the yoke may be vertically adjusted and locked at a selected elevation. The lever 170 is provided at its lower end with a roller 179, operating within a cam groove 180 of a cam wheel 181 rigidly mounted upon the cam shaft 142.

Means are provided to move the slide 109, including upstanding apertured ears 182, rigidly mounted upon the slide 100, and these ears 182 carry a transverse horizontal pin 183, upon which is pivoted a bell crank lever 184, including upwardly diverging arms 185 and 186, and a short depending arm 187. The arm 187 has a rounded end 188, operating within a recess 189, formed in the slide 109. The arm 185 carries at its free end a roller 190, and the arm 186 carries at its free end a roller 191. It is thus seen that when the bell crank lever 184 is turned upon its pivot 183, the slide 109 will be moved longitudinally.

Arranged near and above the rollers 190 and 191 are horizontal rock shafts 192 and 193, respectively, journalled in elongated bearings 194, which are rigidly mounted upon the face plate 21. These rock shafts are free to turn but cannot partake of longitudinal movement. At their forward ends, rock shafts 192 and 193 are provided respectively with cams 195 and 196, rigidly secured thereto, and these cams are arranged to engage rollers 190 and 191, respectively. The rock shaft 192 is provided at its rear end with a crank 197, rigidly secured thereto, and this has pivotal connection at 198 with a link 199, extending downwardly and provided at its lower end with a roller 200, operating within the cam groove 201 of the cam wheel 202, in turn rigidly mounted upon the cam shaft 142 for rotation therewith. In a corresponding manner, the rock shaft 193 is provided at its rear end with a crank 203, rigidly secured thereto, and this crank is pivotally connected at 204 with a depending link 205, provided at its lower end with a roller 206, operating within the cam groove 207 of the cam wheel 208, in turn rigidly mounted upon the cam shaft 142, for rotation therewith. The cam wheel 202 serves to actuate the lever 184 to withdraw the expanding element 107, while the cam wheel 208 serves to operate the lever 184 for moving the expanding element 107 forwardly for expanding the expansible mandrel. The expanding element 107 partakes of two inward or expanding movements, the first to slightly expand or stretch the grid wires of the grid, before welding, and to again further expand or stretch the grid wires of the welded grid, to size the grid. Therefore, the cam groove 207 has an initial raised and expanding face 209 and a second or completing expanding face 210, such faces engaging the roller 206.

The upper head 116 of the upper welding jaw 111 is rigidly connected with the bar 117, including a horizontal portion 211 and a vertical portion 212, operating in a stationary guide 213, attached to the face plate 21. At its lower end, the vertical portion 212 of the slide bar is provided with a horizontal extension 214, carrying at its end a roller 215, operating in the cam groove 216 of a cam wheel 217, rigidly attached to the cam shaft 142. The lower welding jaw head 116 is rigidly attached to a vertical slide bar 117', operating in a stationary guide 218, and the slide bar 117' is provided at its lower end with a horizontal extension 219, carrying a roller 220 operating in the same cam groove 216. Particular attention is called to the fact that the rollers 215 and 220 are diametrically oppositely arranged in the cam groove 216, and will be simultaneously acted upon by the raised portions 221 so that they are moved simultaneously to the opened position and are also simultaneously moved to the closed position.

The means for raising and lowering the heads 124 are now to be described. Th upper head 124 is rigidly connected with a vertical slide bar 222, through the medium of a horizontal portion 223, and bar 222 operates within a stationary guide 224. At its lower end, bar 222 has a horizontal extension 225, carrying a roller 226 at its free end operating within a cam groove 227 of a cam wheel 228. The lower head 124 is rigidly connected with a vertical slide bar 229, operating within a stationary guide 230, and provided at its lower end with a horizontal extension 231, carrying the roller 232 at its free end, and this roller operates within the same cam groove 227. Particular attention is called to the fact that the rollers 226 and 232 are diametrically oppositely arranged and are therefore adapted to be simultaneously acted upon by the raised portions 233 of the cam groove, whereby the slides 122 are adapted to be simultaneously moved to the opened position and also simultaneously moved to the closed position.

Means are provided to move the slide 136 carrying the rotary cutters. Such means comprises a trunnion or pin 234, rigidly secured to the slide 136, and engaging within the forked end of a vertically swinging lever 235, pivotally supported at 236, upon a stationary bracket 237. At its lower end, lever 235 has a roller 238, operating within a cam groove 239 of a cam wheel 240. The cam groove is circular throughout substantially three-fourths of its circumference and also includes a shifting portion 241, extending throughout the remainder of its circumference. By this arrangement, the slide 136 will remain stationary in the outer position during substantially three-fourths of the revolution of cam shaft 142 and will then quickly move forwardly to the inner position and rearwardly to the outer position, during the remainder of the revolution of the cam shaft 142. The cam wheel 240 is rigidly mounted upon a transverse shaft 242, journalled at a stationary bearing 243 and this shaft carries a bevelled gear 244, rigidly secured thereto, and driven by a bevelled gear 245, rigidly mounted upon the cam shaft 142. The bevelled gears 244 and 245 are shown as of the same diameter, but the invention is not restricted to this ration as the same may be varied as found advantageous.

A hand wheel 246 is rigidly mounted upon the transverse shaft 242 and may be manually operated to turn the machine over, or to adjust the same for the starting operation.

The side rods 88 are normally in the form of continuous rods which are fed intermittently for a length depending upon the desired length of the side rods of the grid. Any suitable feeding means may be employed and for the purpose of illustration, I have shown the feeding means as including rotary feeding rollers 247, driven by any suitable means. The side rods 88 are fed through a stationary tubular guide 248, having a bore to snugly slidably receive the side rods and retain them in parallel relation and substantially contacting. Upon each feeding movement of the side rods, such side rods are projected forwardly upon the stationary guide 248 and a length of

the side rods is provided, as required for the grid. The projected portions of the side rods are unsupported except by the stationary guide 248, and there may be some tendency for the free ends of the side rods to slightly spread or separate. Means are provided to move such free ends inwardly into substantial contacting relation, when the welding jaws start upon the closing movement, Figure 3a, so that the side rods are in close or contacting relation before the welding jaws are completely closed. This means comprises a shifting element 249 rigidly attached to that end of the lower welding jaw 111 remote from the stationary guide 248. The shifting device 249 is laterally spaced from the upper welding jaw and will not contact therewith when the welding jaws approach each other. The shifting device includes sides 250, having slightly inclined faces 251, which converge slightly downwardly and serve to shift the side rods inwardly toward each other. After the welding operation has been completed, the side rods are cut by cutters 252, actuated by any suitable means.

The operation of the machine and the practice of the method in connection therewith is as follows:

Side rods 88 are arranged between the upper and lower sets of grid wires 37, Figure a, which pass through the upper and lower combs, and the machine is turned over so that such side rods are welded to the grid wires. The machine is now manipulated so that the welded and cut side rods 88 are arranged in advance of the expansible mandrel 89, Figures a'', 9, 10, which is now in the inner starting position. When the machine is set into operation, the mandrel now moves forwardly from position A to position B, Figure b, thereby advancing the sets of grid wires and the attached side rods into the next step position, and the mandrel now moves laterally from between the grid wires, Figure b', and then rearwardly of the grid wires, Figure b'', but is still arranged laterally outside of the grid wires. During this movement, the side rods 88 are again fed forwardly and are in alignment with the space between the expansible mandrel 89 and the auxiliary mandrel 105, Figure c. The side rods are now supported at the guide 248 with their forward ends free. With the expansible mandrel still arranged laterally exteriorly of the grid wires, the notching operation occurs, Figure c, which is effected by the upper end of the lever 73 moving forwardly for carrying the yoke-carriage 69 forwardly so that pin 82 engages stop pin 83, at which time jaws 84 will be arranged above and below the side rods. The longitudinal movement of the jaws 84 stops when pin 82 engages stop pin 83, but the yoke-carriage 69 continues to move forward slightly so that pin 78 engages bevelled faces 77, spreading the rear ends of levers 76, and closing the jaws 84 so that the teeth 85 produce the grooves or notches upon the opposite sides of the side rods. As soon as these notches are formed, the upper end of the lever 73 swings in an opposite direction, yoke-carriage 69 moves rearwardly, the expanding force is removed from the levers 76, and jaws 84 open and then move rearwardly and assume the position at the rear of the combs, as shown in Figure 9. After this notching operation has been completed and the jaws 84 have moved rearwardly out of the way, Figure c'', the expansible mandrel moves inwardly between the upper and lower sets of grid wires, and the side rods 88 are received in the space between the mandrel 89 and the auxiliary mandrel 105. The welding jaws 111, auxiliary clamping jaws 131, and clamping jaws 122, now move inwardly, Figure d, and the welding jaws force the grid wires toward the pair of side rods 88 so that such grid wires enter the grooves and are clamped to the side rods. Figure d' shows the three sets of clamping devices in the closed position, welding jaws 111 holding the pair of side rods 88, clamping jaws 122 holding the leading side rod, while there are no side rods between the auxiliary clamping jaws 131. In the beginning, the single side rod 88 was applied to the forward side of the expansible mandrel instead of at the rear of the expansible mandrel and between it and the mandrel element, and hence this single rod had already been advanced to the second or B position, and when the mandrel was advanced, as stated, the single rod was shifted to the third or C position, between jaws 122. After the first complete grid has been made, there will be no absence of side rods at position B, Figure d', as clearly shown in Figure d''. When the parts are in the positions stated, Figures d' and d'', the mandrel 89 is now first slightly expanded, to place the grid wires under suitable tension, and this first expansion is effected by the slide 109 moving toward the grid wires through the medium of the swinging movement of the lever 122, when roller 207 engages the smaller hump 209. The mandrel will be maintained in this first expanded position during the welding operation, which follows immediately after such initial expansion. As the lower welding jaw approaches the side rods, the shifting device 249 has its face 251 brought into engagement with the free ends of the side rods 88 and these side rods are accordingly shifted laterally toward each other and returned to the close or contacting position if there is any tendency for them to separate. When the welding jaws engage the grid wires, as stated, such grid wires are forced into the notches upon the side rods, and these notches accurately hold the grid wires against lateral displacement, so that there is no opportunity for the grid wires to creep laterally as the welding jaws force them into contact with the side rods. The welding is effected after the clamping of the grid wires and the initial expansion of the mandrel to place the grid wires under tension, and such welding is effected rapidly, ordinarily from one to two cycles. As explained, the welding jaws are moved inwardly by a yielding force and they will follow through when the grid wires and side rods yield, due to the heat treatment. The welding current remains on for from one to two cycles, and after the welding operation, the welding jaws 111, jaws 131 and 122 move outwardly to the open position, Figure e, so that the mandrel may be moved forwardly in a direction longitudinally of the sets of grid wires, whereby the pair of side rods welded to the grid wires will be shifted forwardly to the next step or position B. During this forward movement of the mandrel, the mandrel is expanded the second time, Figure e'', by the roller 206 engaging the larger cam projection 210 whereby the grid is stretched and sized, and as soon as the roller 206 moves off of the high portion of the cam 210, the mandrel is collapsed, Figure e'', so that it may be shifted laterally from between the sets of grid wires. The collapsing of the mandrel is effected while the roller 200, operating within the cam groove 201, whereby cam 195 shifts arm 185 of the bell crank lever 184 in an opposite direction, moving slide 109 in an opposite direction, to retract expanding element 107. The next step in the operation is the withdrawing

of the collapsed mandrel from between the grid, which is effected by the outward movement of the slide 100, as explained, and as the mandrel moves from within the grid, the slide 136 is shifted toward the sets of grid wires and the rotary cutters 140 move into the recesses 129 and cut the upper and lower sets of grid wires, Figure *f*, the grid wires in each set being cut in succession. During the cutting action, the jaws 122 are in the inner holding position and the cutters 140 move into and out of the recesses 129, before the jaws 122 begin to open. The expansible mandrel now moves rearwardly to assume the starting position, Figures *f* and *f'*, to be again shifted inwardly between the sets of grid wires, and to receive the next pair of side rods within the passage between the expansible mandrel and the mandrel element. The cycle of operation is repeated at this point, the welding jaws descending and welding the grid wires to the trailing pair of side rods, the expansible mandrel again moving forwardly a step to advance the grid wires, and the rotary cutters cutting off the leading completed grid, Figure *f'*. The action of the rotary cutters not only cuts the grid wires, but serves to bend the cut ends inwardly, and rolling the same downwardly about the side rods. The slide 136 carrying the rotary cutters, moves inwardly and outwardly of the recesses 29 in a substantially continuous manner, and this occurs at intervals, as explained. The holding jaws 122 and the auxiliary jaws 131 move together and these jaws move substantially simultaneously with the welding jaws 111 and in the same direction.

While it is preferred to operate the several units of the machine, such as the notch producing mechanism, the clamping and welding mechanism, and the cutting mechanism, by the cam operated means shown and described, yet the invention is not restricted to such form of operating means, as other means may be employed to actuate these units in proper timed order.

In the modified form of machine, Figures 20 to 30, the expansible mandrel 89 remains identical as shown and described in connection with Figures 16, 17, and 18 and the companion mandrel element 105 is also provided, arranged in the same relation to the mandrel 89. The same means is employed to expand the mandrel 89, and the mandrel unit is mounted upon the same slide 100, which partakes of the same movements, but in a different timed order, as will be explained.

The companion mandrel element 105 is provided upon its flat face 255 with a groove 256, extending longitudinally thereof. A sleeve or slide 257 is provided, having an opening 258 to slidably receive the companion mandrel element 105, and the sleeve 257 is provided upon the flat face of the opening 258 with a key or rib 259, rigidly secured thereto, and this key is slidable within the groove 256. It is thus seen that the sleeve or slide 257 cannot turn upon the companion mandrel element 105 by virtue of the key 259 and groove 256. The fit between the key and the groove is preferably extremely accurate, thus preventing any turning movement of the sleeve 257 upon the companion mandrel element 105. Rigidly connected with the sleeve or slide 257 is a horizontal arm 260, extending longitudinally of the companion mandrel element 105 and provided at its free end with a lateral extension 261, to which is rigidly secured a pin 262, to engage a stationary stop 263. In order that the sleeve or slide 257 may not move so freely upon the companion mandrel element 105 as to be accidentally displaced longitudinally thereon, I provide a leaf spring 264, attached to the arm 260 by a set screw 265 or the like, and this leaf spring is arranged to frictionally engage the companion mandrel element 105. The sleeve or slide 257 is provided upon its free or outer end with a recess 266 which is elliptical in horizontal cross-section, and has its longitudinal axis arranged horizontally. The recess has an outer flaring portion 267 increasing in size outwardly or forwardly. The pair of side rods 88, when fed forwardly, by means to be described, enter the flaring portion 267 and are guided thereby into the elliptical recess 266, so that the free ends of these side rods are held in the same horizontal plane, thereby overcoming any tendency for one rod to creep upon the top of the other, which might possibly occur, if they are not so held. The recess 266 also keeps the free ends of these rods from separating, and the side rods substantially contact throughout their length. The side rods, after being passed between the sets of grid wires and into the passage of the mandrel unit and before welding, are held at one end of the mandrel by a stationary guide 283' and at the opposite end of the mandrel by the slide 257, and the side rods therefore cannot be displaced. As a result of this construction the side rods may be spaced from the elements 89 and 105, when held in the passage of the mandrel unit. This will enable the welding jaws to effect the welding, without liability of contacting with elements 89 and 105.

The side rods 88 are fed in the form of continuous rods at the first position A. The side rod feeding means comprises a stationary guide 268, upon which is mounted a reciprocatory carriage 269, which is moved longitudinally in opposite directions for a distance corresponding to the selected length of the cut side rods. The carriage 269 may be moved by any suitable means, operating in proper timed order, which may include a link 269' connected therewith. Preferably formed integral with the carriage 269 is a head 270 included in a side rod gripping device. This head has an elliptical opening 271, having its longitudinal axis horizontally arranged in a manner corresponding to the recess 266, and of a size to snugly slidably receive the pair of side rods 88. Above the opening 271, the head 270 has a recess 272, tapering longitudinally and decreasing in width in a direction from the grid wires. A clutch cylinder or element 273 is rotatable within the tapered recess 272, and is arranged to engage with the upper surface of the side rods. When the head 270 is moved in the direction of its arrow, Figure 21, it is obvious that the element 272 will positively grip the side rods so that they will travel with the carriage, but when the carriage 269 is moved in an opposite direction, the element 273 will release the side rods so that they will remain stationary while the carriage is moved away from the grid wires. The carriage 269 also has an extension or lug 274, having an opening 275 formed therein, to adjustably receive a shifting rod 276, to be clamped to the lug by a set screw 277. This shifting rod extends forwardly beyond the head 270 and will engage the upper portion of the spring 264, and shift the slide 257 rearwardly upon the companion mandrel element 105. The side rods would shift the slide 257 rearwardly, in the absence of the shifting rod 276, but the purpose of the shifting rod is to shift the slide 257 and thereby take the strain off of the side rods, which might possibly be bent or distorted, to some extent, if they were employed to

shift the slide 257. Since the holding recess 266 has been provided, the attachment 249 having the tapered opening 250, Figure 3a, is not used.

In the modification shown in Figures 20 to 31, the notching device embodying the pivoted jaw heads 74, Figures 9 and 10, which operate upon the side rods after they have been positioned between the grid wires, is not employed, and opposed vertical reciprocatory notching jaws 278 are used. These vertical notching jaws 278 are reciprocated toward and from each other by any suitable means, in a manner similar to the reciprocation of the welding jaws 111. The reciprocating notching jaws 278 are provided upon their inner ends with equi-distantly spaced teeth 279, to form the grooves or notches 85' in the side rods 88, Figure 6a. In the present modification, the notching of the side rods is done before they are fed into position between the sets of grid wires 37, and to effect this operation, the notching jaws 278 are disposed upon one side of the sets of grid wires, between the sets of grid wires and the side rod feeding carriage 269. The reciprocating notching jaws 278 need have only a limited movement, sufficient to produce the notches or grooves 85', and then release the side rods so that they may be fed into place between the sets of grid wires 37. The lower notching jaw 278 is preferably provided with plates 280, rigidly attached thereto, and these plates slidably contact with the upper notching jaw 278. These plates serve as guide means for the side rods 88 as they are fed longitudinally with respect to the notching jaws. The notching jaws 278 are provided upon their ends and outwardly of the teeth 279 with spring-pressed ejectors 281, Figures 25 and 26, urged outwardly by springs 282. The function of these ejectors is to free the guide rods from the teeth 279, should there be any tendency for the side rods to stick to these teeth, after the completion of the notching process.

In this form of the invention, the means to cut the side rods after they have passed into position between the sets of grid wires 37, is illustrated as comprising a pair of reciprocatory blades 283, arranged between the notching jaws 278 and the sets of grid wires.

The same welding jaws 11, jaws 131, and holding jaws 122, Figure 3a, and means to support the sets of grid wires in spaced relation, are employed, with the same means to cut the grids after completion.

In the practice of the method by the operation of the form of apparatus shown in Figures 20 to 31, a first pair of side rods are welded to the sets of grid wires 37 and cut, and the machine is manipulated so that the side rods are placed in advance of and upon the expansible mandrel 89, as explained in connection with the first form of the invention. The machine is now adjusted so that the expansible mandrel 89 is at the side rod feeding position A, and has been shifted between the sets of grid wires 37, Figure 28. This has been done before the side rods 88 are fed into the position between the sets of grid wires, and this operation differs in this respect from the first form of the machine. By the time that the expansible mandrel 89 has reached the position shown in Figure 28, the notching jaws 278 are moved toward the side rods, producing the notches 85', and then separated, thus freeing the side rods. While the notching jaws 278 were engaging the side rods to produce the notches, the side rods 88 were of course held against longitudinal movement, and during this time the feed carriage 269 moved rearwardly to the end of its travel, and when the notching jaws 278 moved apart to release the side rods, carriage 269 moved forwardly to the end of its travel, thereby shifting the notched side rods forwardly into the passage between the expansible mandrel 89 and companion mandrel 105. Figure 28 shows the carriage 269 in the rear starting position, while Figure 29 shows the carriage 269 in the forward position. As soon as the side rods begin to move forwardly, their free ends enter the recess 266 and they are held against separation and also in the same horizontal plane. The side rods 88 project longitudinally beyond the shifting rod 276, for a short distance, so that the ends of the side rods 88 may enter the recess 266 before the shifting rod 276 starts to shift the slide 257, but the side rods 88 do not contact with the bottom wall of the recess 266. The rod 276 shifts the slide 257 forwardly upon the mandrel element 105, until it assumes the position shown in Figures 20 and 29, and in this position the pin 262 is spaced from the stop 263 a sufficient distance, so that the slide will first move with the mandrel element 105, to withdraw the ends of the side rods from within the recess 266, and this movement of the slide 257 is stopped when the pin 262 contacts with the stop 263. After the rods are shifted in place between the sets of grid wires and within the passage of the expansible mandrel 89, the forward ends of the side rods are being held within the recess 266, while the side rods are also being held by the stationary guide 263'. The welding jaws then move inwardly to engage the grid wires and force them into the notches 85 and weld the grid wires to the side rods. After this welding action, the welding jaws separate to release the side rods and the blades 283 are actuated to cut the side rods. The welding occurs in about two cycles, and the welding jaws may be still in engagement with the side rods, during the cutting action, if desired. After the cutting action and the movement of the welding jaws to the open position, the mandrel 89 is now shifted forwardly from position A, Figure 29, to position B, Figure 30, for effecting the step feeding of the grid wires. When the mandrel is shifted to this position, it is still between the sets of grid wires and the pin 262 is spaced from and has the stop 263 in its path of travel. When the mandrel 89 is shifted laterally with respect to the grid wires, Figure 31, the slide 257 first moving with the element 105 to release the side rods, and the pin 262 subsequently engaging the stop 263, holds the sleeve 257 against longitudinal movement while the companion mandrel element 105 is moved longitudinally outwardly, with the result that the sleeve 257 is again located at the forward end of the companion mandrel element 105. The mandrel 89 is again moved rearwardly to position A, travelling under stop 263, and will again be shifted at position A between the sets of grid wires, before the side rods are again fed into the position between the sets of grid wires. It is thus seen that in the modified form of the invention, the mandrel is first shifted to a position between the sets of grid wires, position A, and the side rods are subsequently fed between the sets of grid wires, at position A, which is just the opposite of the operation occurring in connection with the first form of the invention. The mandrel will partake of the same movements, but these movements and the feeding for the side rods would be differently timed, as is ob-

vious. After each grid is formed upon the expansible mandrel, and stretched or expanded thereon, as described in connection with the first form of the invention, the rotary cutters 140 cut the grid wires between the adjacent side rods 88 and the leading grid is thus cut from the next grid, and is completed.

It is to be understood that the forms of my invention herewith shown and described, are to be taken as preferred examples of the same and that various changes in the shape, size, and arrangement of parts may be resorted to without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. In the method of producing radio tube grids, the steps of supporting in spaced relation sets of spaced grid wires arranging and supporting side rods transversely of and between the sets of grid wires, forming sets of spaced grooves upon the opposite sides of each side rod and so arranging such grooves that they are in general alignment with the spaced grid wires, and moving the sets of grid wires toward the opposite sides of each side rod and causing the grid wires to enter the grooves, and attaching the grid wires while within the grooves to the side rods.

2. In the method of producing radio tube grids, the steps of supporting in spaced relation sets of spaced grid wires, arranging and supporting side rods transversely of and between the sets of grid wires, forming sets of accurately spaced grooves upon the opposite sides of each side rod, moving the sets of grid wires toward the opposite sides of each side rod and causing the grid wires to enter the grooves, and welding the grid wires while within the grooves to the sides of the rods.

3. In the method of producing radio tube grids, the steps of supporting in spaced relation sets of spaced grid wires, arranging and supporting side rods transversely of and between the sets of grid wires, moving the sets of grid wires toward the opposite sides of each side rod, holding the grid wires in each set in accurately equi-distantly spaced relation, and then attaching the grid wires to the opposite sides of each side rod.

4. In the method of producing radio tube grids, the steps of supporting side rods, forming accurately equi-distantly spaced grooves upon the opposite sides of each side rod, arranging sets of spaced grid wires upon opposite sides of the side rods and moving the grid wires into the grooves, and attaching the grid wires while within the grooves to the side rods.

5. In the method of producing radio tube grids, the steps of supporting a side rod having accurately equi-distantly spaced grooves upon one side thereof, arranging a set of spaced grid wires upon one side of the side rod and moving the grid wires into the grooves, and attaching the grid wires while within the grooves to the side rod.

6. In the method of producing radio tube grids, the steps of supporting a pair of side rods having accurately spaced grooves upon the corresponding sides thereof and holding the side rods in close relation, arranging a set of spaced grid wires upon one side of the side rods and moving the grid wires into the grooves, attaching the grid wires while within the grooves to the side rods, and then cutting the grid wires between the closely arranged side rods.

7. In the method of producing radio tube grids, the steps of supporting side rods, arranging sets of spaced grid wires upon the opposite sides of each side rod and attaching the grid wires to each side rod, and then cutting in succession the grid wires in each set of grid wires.

8. In the method of producing radio tube grids, the steps of supporting side rods, attaching a set of spaced grid wires to the side rods, and then cutting in succession the grid wires in the set.

9. In the method of producing radio tube grids, the steps of supporting side rods, arranging sets of spaced grid wires upon the opposite sides of the side rods, subjecting the sets of grid wires to a stretching action, attaching the sets of grid wires to the side rods, and again subjecting the sets of grid wires to a further stretching action to shape the grid.

10. In the method of producing radio tube grids, the steps of supporting sets of grid wires and imparting to said sets a step-by-step movement in a longitudinal direction, passing a pair of side rods transversely of and between the sets of grid wires between each step movement, subjecting the grid wires to a pulling action to place the same under tension, attaching the sets of grid wires to the opposite sides of the side rods for producing a partly formed grid, stretching the grid wires of the partly formed grid to impart to the same the desired size, and cutting the sets of grid wires between the side rods.

11. In the method of producing radio tube grids, the steps of supporting side rods, arranging a set of spaced grid wires upon one side of the side rods and pressing the set of grid wires into engagement with the side rods while holding them against lateral displacement at the points of engagement with the side rods, and welding the grid wires to the side rods.

12. In a machine for producing radio tube grids, means for supporting spaced sets of spaced grid wires, means for supporting side rods between the spaced sets of grid wires, means for forming spaced grooves upon the side rods while supported between the sets of grid wires, means to move the sets of grid wires toward the side rods and into the grooves and to attach the grid wires to the side rods while within the grooves.

13. In a machine for producing radio tube grids, means for supporting spaced sets of spaced grid wires, means for supporting side rods between the spaced sets of grid wires, means for forming spaced grooves upon the opposite sides of the side rods while they are supported between the sets of grid wires, and welding jaws to engage the sets of grid wires and move the same into the grooves and to weld the grid wires to the side rods.

14. In a machine for producing radio tube grids, means for supporting a side rod, a device to form spaced grooves upon the opposite sides of the side rod including a pair of movable jaws to receive the side rod between them and having teeth to form the grooves, means for supporting sets of spaced grid wires upon opposite sides of the side rod, and means to move the grid wires into the grooves and weld the same to the side rod.

15. In a machine for producing radio tube grids, means for supporting a side rod at a given position, a device movable to and from the given position and when shifted to the given position serving to form spaced grooves upon the opposite sides of the side rod, welding jaws operating near the given position and adapted to engage sets of spaced grid wires and move the same into

contact with the side rod, and means to guide the sets of grid wires in positions upon opposite sides of the side rod and in the path of travel of the welding jaws, and means to effect the longitudinal movement of the sets of grid wires.

16. In a machine for producing radio tube grids, means for guiding sets of spaced grid wires so that they may be moved longitudinally, a side rod guide means held at a given point near the guiding means and adapted to shift the side rod transversely of and between the sets of grid wires, welding jaws disposed outwardly of the sets of grid wires and movable toward the side rod to bring the grid wires into contact therewith, a device to provide grooves upon the opposite sides of the side rod and movable into and out of the path of travel of the welding jaws, and means to effect the longitudinal travel of the sets of grid wires.

17. In a machine for producing radio tube grids, means for guiding a set of spaced grid wires so that they may be moved longitudinally, means for holding a side rod upon one side of and transversely of the set of grid wires, a welding jaw arranged to move the set of grid wires into contact with the side rod, a device to produce spaced grooves upon one side of the side rod and movable into and out of the path of travel of the welding jaw, and means to effect the longitudinal travel of the set of grid wires.

18. In a machine for producing radio tube grids, means for supporting a side rod at a given position, means for engaging the side rod and simultaneously forming sets of spaced transverse grooves upon the opposite sides thereof, and means for introducing sets of spaced grid wires into the sets of grooves and attaching the same to the side rod.

19. In a machine for producing radio tube grids, means arranged at a given point for supporting a side rod, means for guiding sets of grid wires upon opposite sides of the side rod so that such sets may be moved longitudinally, a pair of welding jaws arranged outwardly of the sets of grid wires and movable toward the side rod for bringing the grid wires into contact with the side rod, a carriage movable toward the side rod, a device to produce spaced grooves upon the side rod and mounted upon the carriage, means to actuate the device, means to move the carriage, and means to effect the longitudinal movement of the sets of grid wires.

20. In a machine for producing radio tube grids, means arranged at a given point for supporting a side rod, means for guiding sets of grid wires upon opposite sides of the side rod so that such sets may be moved longitudinally, a pair of welding jaws to contact with the sets of grid wires and weld them to the side rod, a carriage movable toward the side rod, a device to produce spaced grooves upon the side rod and mounted upon the carriage to be shifted thereby, means to actuate the device upon the relative movement between the carriage and the device, means to move the carriage, and means to effect the longitudinal movement of the sets of grid wires.

21. In a machine for producing radio tube grids, means for supporting a side rod, guide means arranged near the side rod supporting means, a carriage to reciprocate upon the guide means, a device for forming spaced grooves upon the sides of the side rod mounted upon the carriage in a manner to partake of longitudinal movement with relation thereto, yielding means to oppose the relative longitudinal movement between the device and carriage, means to actuate the device upon the relative longitudinal movement between the device and carriage, means to guide sets of spaced grid wires upon opposite sides of the side rod, means to bring the sets of grid wires into contact with the side rod and weld the same to the side rod, and means to effect the longitudinal movement of the sets of grid wires.

22. In a machine for producing radio tube grids, means for supporting a side rod, guide means arranged near the side rod supporting means, a carriage engaging the side means to reciprocate toward and from the side rod, a supporting element mounted upon the carriage and movable in a direction longitudinally of the carriage, yielding means to oppose the relative movement between the supporting element and carriage, a pair of jaws pivoted upon the supporting element and having sets of teeth to engage the side rod and form sets of grooves therein, arms carried by the jaws to move them, a spreading element secured to the carriage for engaging the arms and moving them apart, a stop element connected with one jaw, a stationary stop element to engage the first named stop element, means to move the carriage, means to guide sets of spaced grid wires upon opposite sides of the side rod, means to weld the sets of grid wires to the opposite sides of the side rod, and means to effect the longitudinal travel of the sets of grid wires.

23. In a machine for producing radio tube grids, means for supporting a side rod, means for guiding sets of spaced grid wires, a pair of spaced combs arranged near the side rod supporting means and engaging the grid wires in the sets to retain them suitably spaced, a device to form spaced grooves upon the side rod and movable between the spaced combs, welding jaws operating near the spaced combs to weld the grid wires to the side rod, and means to effect the longitudinal movement of the sets of grid wires.

24. In a machine for producing radio tube grids, means for supporting a side rod, means for guiding sets of spaced grid wires, a pair of spaced comb devices arranged near the side rod supporting means and engaging the grid wires in the sets, each comb device including sets of teeth which are longitudinally adjustable with relation to each other so that the teeth will properly hold grid wires of different diameters, means to angularly adjust each comb device to vary the distance between the spaced grid wires in each set, means for attaching the sets of grid wires with the side rods, and means to move the sets of grid wires longitudinally.

25. In a machine for producing radio tube grids, means for supporting a side rod, means for guiding sets of spaced grid wires, a pair of comb devices arranged near the side rod supporting means and engaging the grid wires in the sets, each comb device including sets of teeth which are longitudinally adjustable with relation to each other, means for attaching the sets of grid wires with the side rods, and means to move the sets of grid wires longitudinally.

26. In a machine for producing radio tube grids, means for supporting a side rod, means for guiding sets of grid wires so that they may be arranged upon opposite sides of the side rod, a mandrel to be arranged between the sets of grid wires and about which the grid is formed, and means to shift the mandrel in a direction longi-

tudinally of the sets of grid wires to effect the longitudinal movement of such sets.

27. In a machine for producing radio tube grids, means for supporting a side rod, means for guiding sets of grid wires so that they may pass to the opposite sides of the side rod, means for attaching the sets of grid wires to the side rod, a mandrel to be arranged between the sets of grid wires in engagement with the side rod, means to move the mandrel longitudinally of the sets of grid wires to feed the same longitudinally, and means to move the mandrel transversely of such sets of grid wires.

28. In a machine for producing radio tube grids, means for supporting side rods at a given position, means for guiding sets of grid wires so that they may pass to the opposite sides of the side rods, welding jaws operating in proximity to the given position for welding the sets of grid wires to the opposite sides of the side rods, a mandrel upon which the grid is formed, means to shift the mandrel transversely of the sets of grid wires so that it assumes a position between such sets, and means to then shift the mandrel in a direction longitudinally of the sets of grid wires to effect their longitudinal movement.

29. In a machine for producing radio tube grids, means for feeding side rods into position at a given point, means for applying sets of spaced grid wires to the opposite sides of the side rods and securing the same to the side rods, a mandrel upon which the grid is formed, means to shift the mandrel in opposite directions transversely of and between the sets of grid wires, and means to shift the mandrel in opposite directions longitudinally of the sets of grid wires.

30. In a machine for producing radio tube grids, means for feeding a side rod into position, means for applying sets of spaced grid wires to the opposite sides of the side rod and securing the same thereto, an expansible mandrel upon which the grid is formed, means to shift the mandrel in opposite directions transversely of and between the sets of grid wires, means to shift the mandrel in opposite directions longitudinally of the sets of grid wires, and means to expand and contract the mandrel while it is arranged between the sets of grid wires.

31. In a machine for producing radio tube grids, means for supporting and guiding spaced sets of spaced grid wires so that they may be fed longitudinally, a carriage arranged near the guide means and shiftable longitudinally of the sets of grid wires, means to move the carriage, a second carriage mounted upon the first named carriage and shiftable with relation thereto in a direction transversely of the sets of grid wires, an expansible mandrel mounted upon the second carriage for movement between and outwardly beyond the sets of grid wires, an expanding element to control the action of the expansible mandrel, means mounted upon the second carriage to shift the expanding element in opposite directions, means to feed a side rod into position between the sets of grid wires, means to weld the grid wires to the side rod, and means to cut the grid wires.

32. In a machine for producing radio tube grids, a carriage movable in one direction, a second carriage mounted upon the first named carriage and movable with relation thereto at substantially a right angle to the direction of movement of the first named carriage, an expansible mandrel mounted upon the second carriage, an expanding element for controlling the action of the mandrel, an operating element pivoted upon the second carriage and serving to shift the expanding element in opposite directions, and cams engaging the pivoted operating element to move the same in opposite directions.

33. In a machine for producing radio tube grids, a laterally expansible and contractible mandrel, means for forming a radio tube grid upon the contracted mandrel, means timed in operation to expand the mandrel after the grid has been formed upon the contracted mandrel for stretching and sizing the grid, and subsequently contracting the mandrel, and means to withdraw the contracted mandrel from within the grid.

34. In a machine for producing radio tube grids, a laterally expansible and contractible mandrel, means for forming a radio tube grid upon the contracted mandrel, means to expand the mandrel for sizing the grid and subsequently contracting the mandrel, means for shifting the mandrel in one direction to advance the grid, and means to withdraw the contracted mandrel from within the grid.

35. In a machine for producing radio tube grids, a laterally expansible and contractible mandrel, means for forming a radio tube grid upon the contracted mandrel, and means timed in operation to expand the mandrel after the grid has been formed upon the contracted mandrel for sizing the grid and subsequently contracting the mandrel so that the grid may be separated from the mandrel.

36. In a machine for producing radio tube grids, means for supporting spaced sets of grid wires, means for supporting side rods in position between and transversely of the sets of grid wires, means for attaching the sets of grid wires to the side rods, and means to cut each set of grid wires including a rotary cutter to cut the grid wires in such set in succession.

37. In a machine for producing radio tube grids, means for supporting sets of grid wires, means for supporting side rods in position between and transversely of the sets of grid wires, means for attaching the sets of grid wires to the side rods, a member movable transversely of the sets of grid wires in a direction generally parallel with the plane of such set, and means carried by the member to cut in succession the grid wires of the sets.

38. In a machine for producing radio tube grids, means for supporting sets of grid wires, means for supporting a pair of side rods in close relation between the sets of grid wires, means for attaching the sets of grid wires to the side rods, means arranged upon opposite sides of the side rods for securely holding them against displacement, a carriage movable transversely of the sets of grid wires, and cutters mounted upon the carriage and disposed outwardly of and near the sets of grid wires, each cutter cutting in succession the grid wires in the corresponding set.

39. In a machine for producing radio tube grids, means for supporting sets of grid wires, means for supporting a pair of side rods in close relation between and transversely of the grid wires, means for attaching the sets of grid wires to the side rods, reciprocatory heads arranged near and upon opposite sides of the side rods, each head having a main passage and a pair of clamping jaws for holding action with the pair of side rods, a support movable transversely of the heads and including parts to enter the passages of the heads,

and rotary cutters carried by the parts of the heads.

40. In a machine for producing radio tube grids, means for supporting sets of grid wires, means for supporting a pair of side rods in close relation between and transversely of the grid wires, means for attaching the sets of grid wires to the side rods, reciprocatory heads arranged near and upon opposite sides of the side rods, each head having a main passage and a pair of clamping jaws for holding action with the pair of side rods, means to move the heads inwardly to a closed position and hold the same in the closed position for a selected interval, a reciprocatory carriage movable transversely of the heads and including parts to enter the passages of the head, rotary cutters carried by said parts to cut the grid wires in succession, and means to rapidly move the carriage toward and from the heads so that the carriage parts enter and are withdrawn from the passages of the heads while the heads are held stationary in the closed position.

41. In a machine for producing radio tube grids, means for supporting spaced sets of grid wires, means for feeding in succession at a given point a pair of side rods in close relation between and transversely of the sets of grid wires, a pair of opposed welding jaws to engage the sets of grid wires and attach them to the side rods, a pair of opposed heads spaced from and in advance of the welding jaws and movable toward and from each other, each head having a passage and a pair of spaced jaws for clamping action with the pair of side rods, a pair of opposed clamping jaws arranged between the welding jaws and heads and attached to the heads and adapted for clamping action with the pair of side rods, the last named clamping jaws being spaced from the welding jaws and from the said pairs of jaws, and a mandrel movable between the sets of grid wires and upon which the grid is formed, and means to move the mandrel in a direction to advance the sets of grid wires longitudinally, and rotary cutters for operation within the passages.

42. In a machine for producing radio tube grids, means for supporting sets of spaced grid wires in spaced relation, means for advancing the sets of grid wires longitudinally including a mandrel shiftable to a position between the sets of grids, means for feeding a pair of side rods in close relation between the sets of grid wires at a given point and adjacent to the mandrel, and means to attach the grid wires to the side rods.

43. In a machine for producing radio tube grids, means for supporting sets of spaced grid wires, means for arranging side rods between and transversely of the sets of spaced grid wires, means for attaching the grid wires to the side rods, and means for cutting the grid wires.

44. In a machine for producing radio tube grids, means for supporting sets of spaced grid wires, means arranged at a definite point for inserting side rods between the sets of spaced grid wires and in transverse relation thereto, means for attaching the grid wires to the side rods, a mandrel upon which the grid is formed, means to shift the mandrel between the sets of grid wires, means to move the mandrel in a direction to advance the grid wires longitudinally, and means to cut the grid wires between the side rods.

45. In a machine for producing radio tube grids, means for supporting sets of spaced grid wires, means arranged at a definite point for inserting a side rod between the sets of spaced grid wires and in transverse relation thereto, means for attaching the grid wires to the side rod, means to move the sets of grid wires longitudinally, and means to cut the grid wires.

46. In the method of producing radio tube grids, the steps of supporting in spaced relation sets of spaced grid wires, moving a mandrel in position between the sets of grid wires, feeding side rods between the spaced sets of grid wires and in close relation to the mandrel while holding the free ends of the side rods against lateral displacement, welding the sets of grid wires to the side rods, advancing the sets of grid wires longitudinally, and then cutting the grid wires between the side rods.

47. In the method of producing radio tube grids, the steps of supporting in spaced relation sets of spaced grid wires, moving a mandrel in position between the sets of grid wires, feeding side rods between the spaced sets of grid wires and in close relation to the mandrel, welding the sets of grid wires to the side rods, advancing the sets of grid wires longitudinally, and cutting the grid wires between the side rods.

48. In the method of producing radio tube grids, the steps of supporting in spaced relation sets of spaced grid wires, supporting side rods at one side of the sets of grid wires and forming spaced notches upon such side rods while arranged at the side of the sets of grid wires, moving the notched side rods between the sets of grid wires so that they extend transversely thereof, and welding the sets of grid wires to the notched side rods.

49. In the method of producing radio tube grids, the steps of supporting in spaced relation sets of spaced grid wires, supporting side rods at a fixed point of feeding and transversely of the sets of grid wires, notching the side rods while arranged exteriorly of the space between the sets of grid wires, feeding the side rods longitudinally to pass the same into the space between the sets of grid wires, moving the sets of grid wires into the notches and welding the same to the side rods, cutting the side rods, advancing the sets of grid wires longitudinally, and cutting the grid wires between the side rods.

50. In a machine for producing radio tube grids, a support, a mandrel secured to the support, a companion mandrel element secured to the support, and a device slidably mounted upon the companion mandrel element and having means to engage and hold the ends of side rods.

51. In a machine for producing radio tube grids, an elongated mandrel unit, and a device supported to move longitudinally of the elongated mandrel unit and having means for engaging with the end of a side rod.

52. In a machine for producing radio tube grids, an elongated mandrel unit, a device supported to move longitudinally of the elongated mandrel unit and having means for engaging with the end of a side rod, and means for effecting a relative longitudinal movement between the device and the elongated mandrel unit.

53. In a machine for producing radio tube grids, an elongated mandrel unit, a device supported to move longitudinally of the elongated mandrel unit and having means for engaging with the end of a side rod, means to move the mandrel unit longitudinally, and means for holding the device against longitudinal movement for effecting a relative movement between the device and the mandrel unit.

54. In a machine for producing radio tube grids, an elongated mandrel unit, a device sup-

ported to move longitudinally of the elongated mandrel unit and having means for engaging a side rod, means to shift the device longitudinally of the mandrel unit while the mandrel unit is held stationary, and means to hold the device against longitudinal movement and to shift the elongated mandrel longitudinally.

55. In a machine for producing radio tube grids, a support, a mandrel secured to the support, a companion mandrel element disposed near and upon one side of the mandrel and mounted upon the support, a slide mounted to move longitudinally upon the companion mandrel element and having means to engage with a side rod, an element connected with the slide, a stop arranged in the path of travel of the element, side rod feeding means, and an element connected with the side rod feeding means for shifting the slide in one direction.

56. In a machine for producing radio tube grids, a support, an elongated mandrel structure having a passage, a device mounted upon the elongated mandrel structure to move longitudinally thereof and having a part arranged within the passage and provided with means to hold the end of a side rod, side rod feeding means to advance the side rod so that the side rod engages with the holding means, and a relatively stationary guide for the side rod and arranged near one end of the mandrel structure when the mandrel structure is in the side rod feeding position.

57. In a machine for producing radio tube grids, a support, an elongated mandrel structure having a longitudinal passage, a device mounted upon the elongated mandrel structure to move from the forward end to the rear end thereof and having means for holding the end of a side rod, side rod feeding means to advance the side rods into engagement with the holding means, a relatively stationary side rod guide arranged near the forward end of the elongated mandrel when it is in the side rod feeding position, and side rod notching jaws arranged upon that side of the stationary guide remote from the mandrel.

58. In a machine for producing radio tube grids, means for supporting spaced sets of grid wires, a mandrel to be arranged transversely of and between the sets of grid wires and having a longitudinal passage, means for feeding a side rod into the longitudinal passage of the mandrel, movable jaws arranged upon opposite sides of the side rod at one side of the sets of grid wires for producing notches upon the side rod, and welding jaws to weld the grid wires to the side rod within the passage.

59. In a machine for producing radio tube grids, an elongated mandrel unit having a longitudinal passage, means to feed a side rod into the passage, a device engaging the free end of the side rod and moving with it toward the rear end of the mandrel unit, a relatively stationary guide for the side rod arranged near the forward end of the mandrel unit.

60. In a machine for producing radio tube grids, side rod feeding means, means to notch the side rod including a notching jaw having teeth, and spring pressed means carried by the notching jaw to free the side rod from the teeth after the notching action.

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