July 15, 1958 J. A. CHASE ET AL 2,842,832

APPARATUS FOR AND METHOD OF AUTOMATIC ASSEMBLY OF ELECTRON TUBE PARTS TO FORM AN ELECTRODE CAGE

Filed April 2, 1951 7 Sheets-Sheet 1

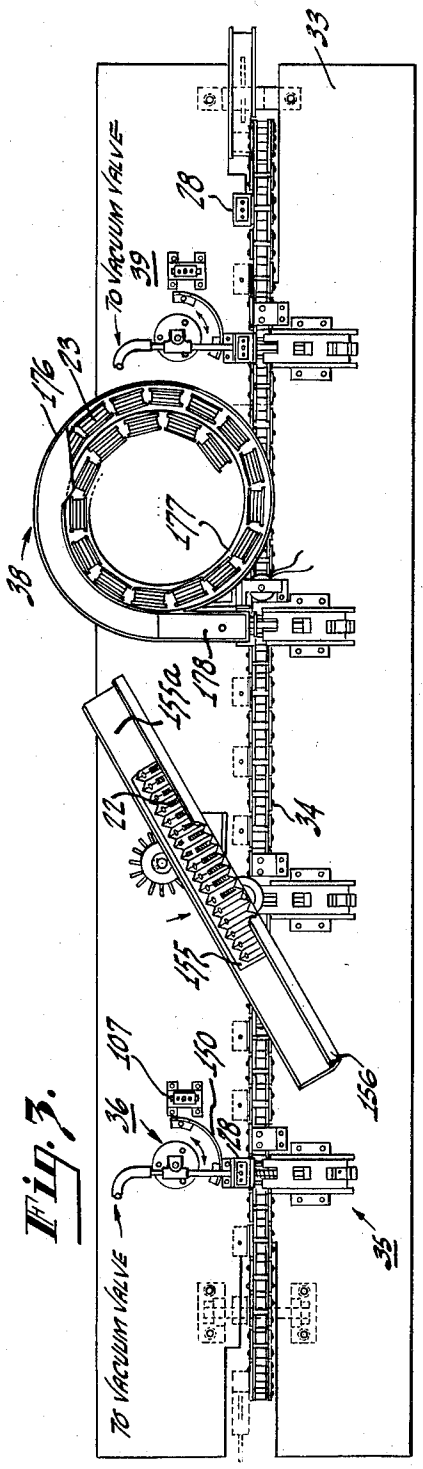

Fig. 3.

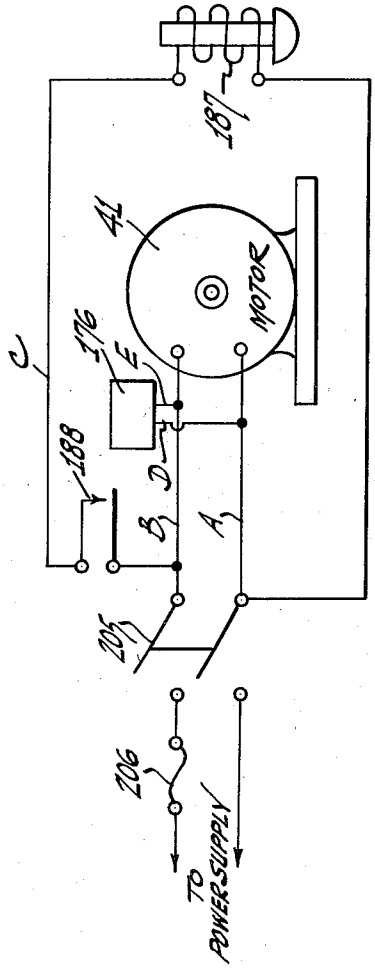

Fig. 11.

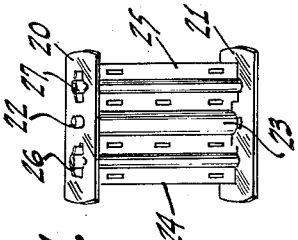

Fig. 1.

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APPARATUS FOR AND METHOD OF AUTOMATIC ASSEMBLY OF ELECTRON TUBE PARTS TO FORM AN ELECTRODE CAGE

Filed April 2, 1951 7 Sheets-Sheet 2

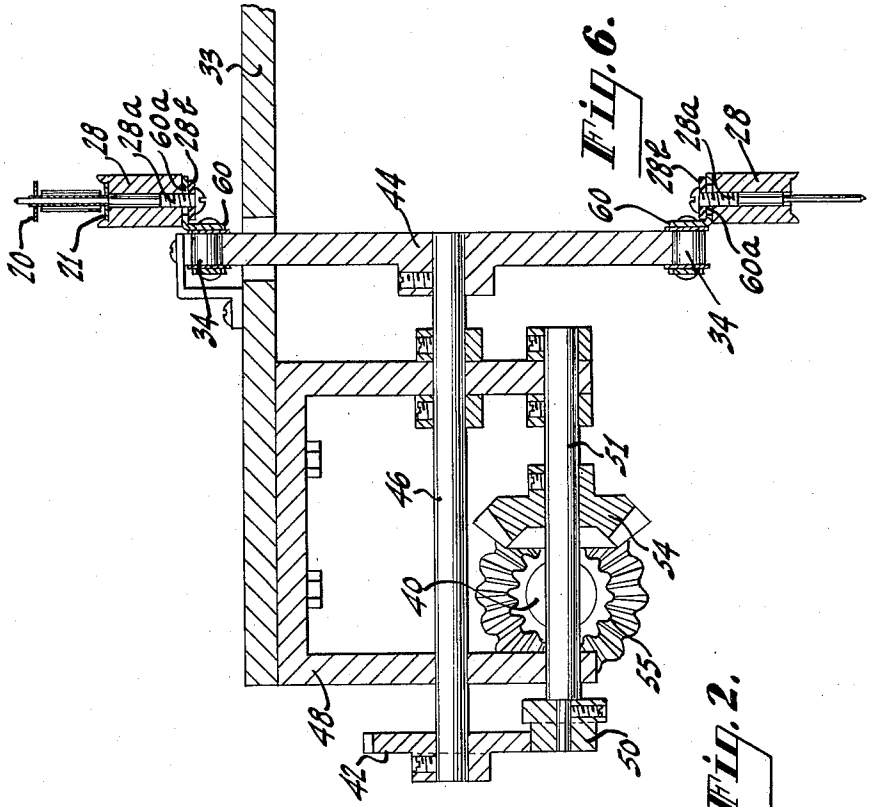

FIG. 6.

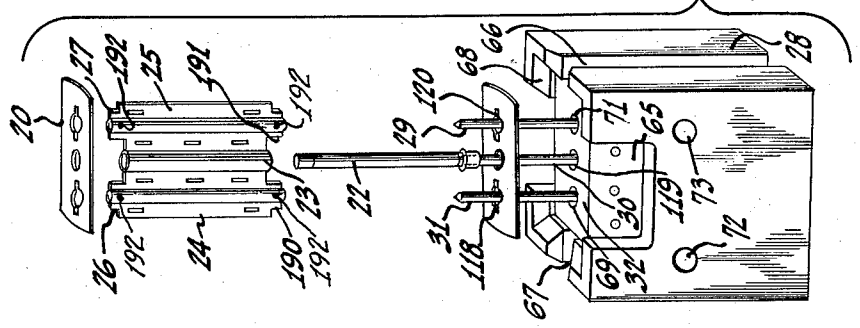

FIG. 2.

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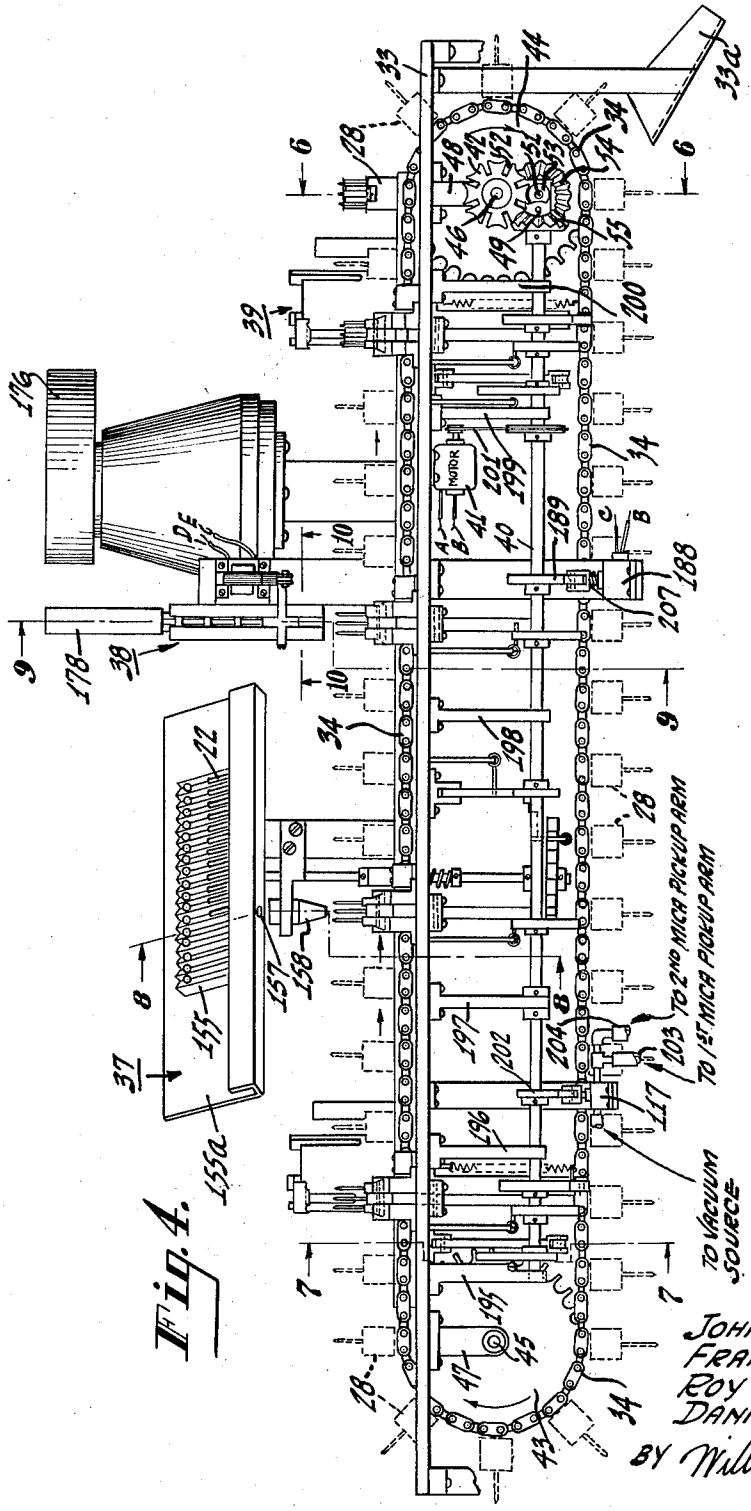

Fig. 4.

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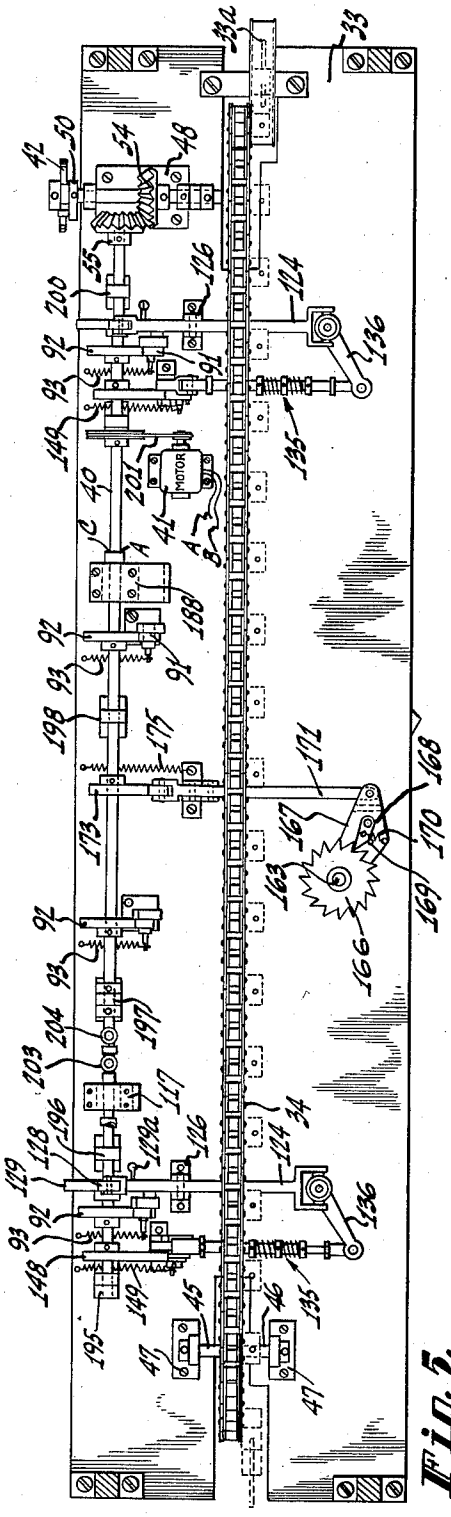

Fig. 5.

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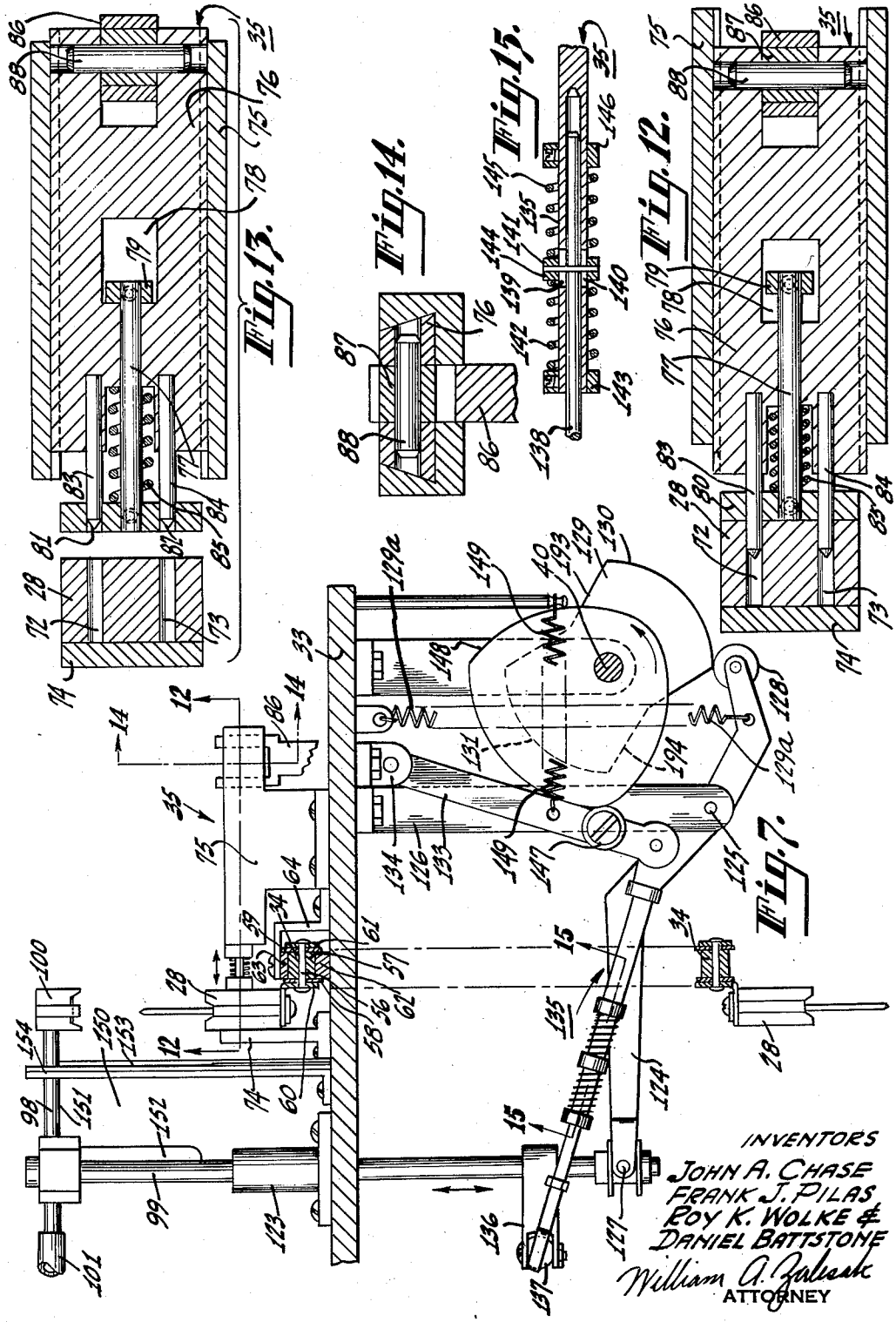

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 12.

Fig. 7.

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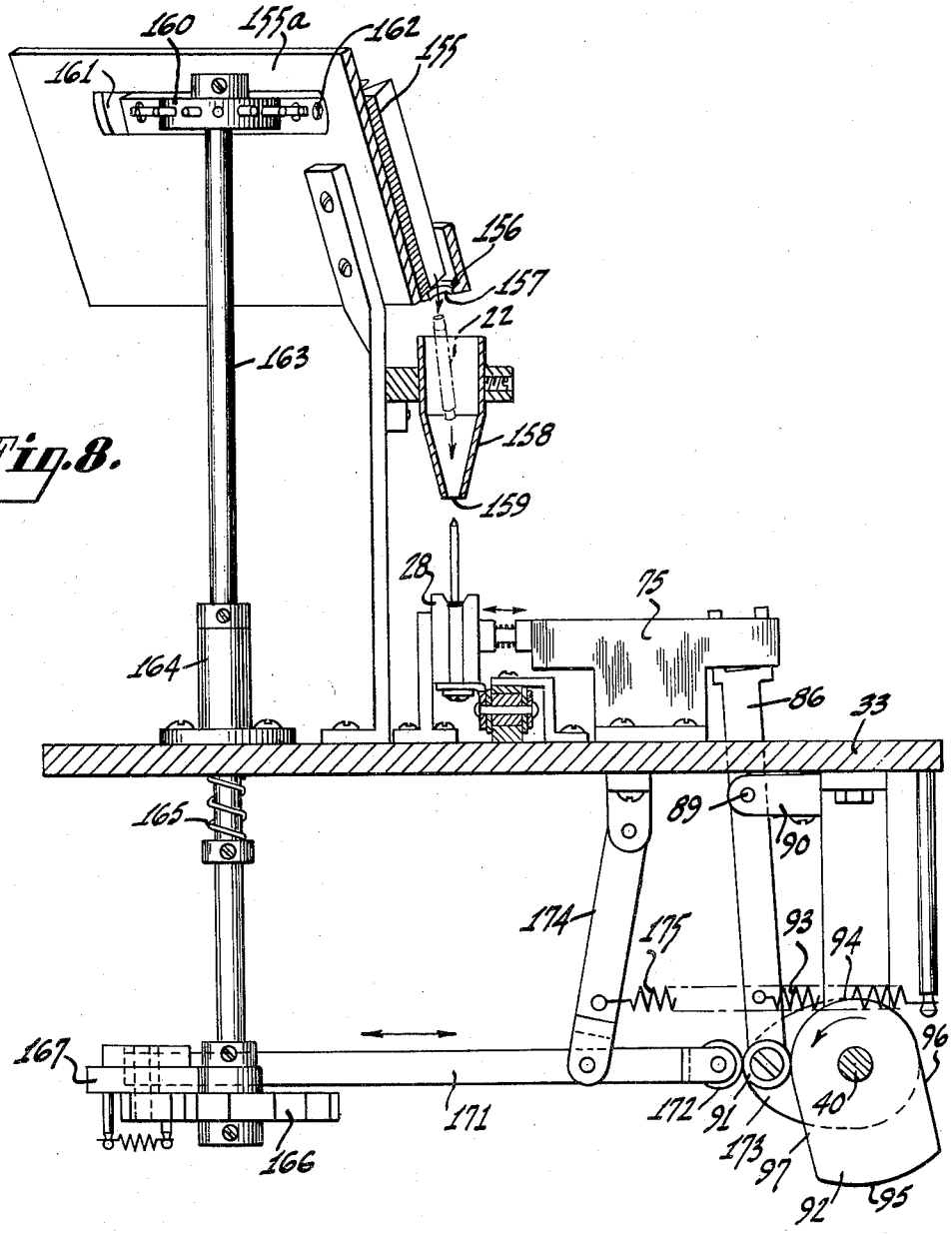

Fig. 8.

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APPARATUS FOR AND METHOD OF AUTOMATIC ASSEMBLY OF ELECTRON TUBE PARTS TO FORM AN ELECTRODE CAGE

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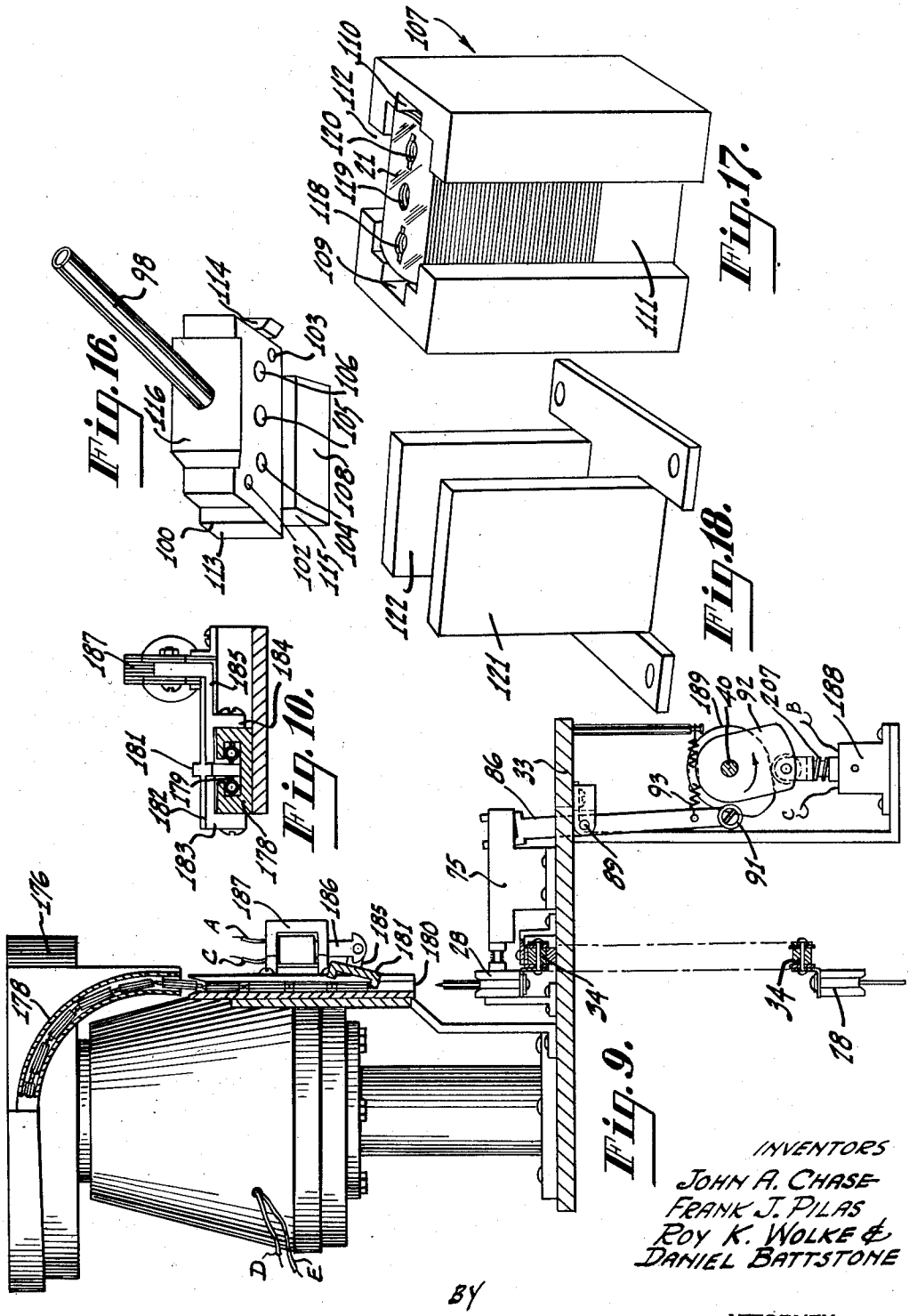

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United States Patent Office 2,842,832 Patented July 15, 1958

2,842,832

APPARATUS FOR AND METHOD OF AUTOMATIC ASSEMBLY OF ELECTRON TUBE PARTS TO FORM AN ELECTRODE CAGE

John Anthony Chase, Nutley, Frank John Pilas, Kearny, Roy Karel Wolke, Maplewood, and Daniel Battstone, Newark, N. J., assignors to Radio Corporation of America, a corporation of Delaware

Application April 2, 1951, Serial No. 218,838

44 Claims. (Cl. 29—25.13)

The present invention relates to an apparatus for automatic assembly of electron tube parts, and more particularly to an apparatus for automatically mounting one or more electrodes on insulating spacer plates to form an electrode cage constituting a sub-assembly of an electron tube.

The fabrication of electron tubes usually involves first a preparation of sub-assemblies and then an arrangement of the sub-assemblies in predetermined relation and fixing the same to provide an electron tube. The sub-assemblies usually comprise an electrode cage, a stem including lead-in wires, and a bulb having an open end. The procedure in arranging these sub-assemblies to form an electron tube usually involves first fixing the electrode assembly to the lead-ins or other support parts on the stem to form a mount. The mount is then extended into the open end of the bulb until the stem thereof is adjacent said open end. The stem is then sealed across the open end of the bulb. An exhaust tubulation is provided either at the closed end of the bulb or in the stem, through which the interior of the enclosure formed by the bulb and stem is evacuated. After evacuation, the exhaust tubulation is pinched off to effectively seal the enclosure from the atmosphere. This completes the manufacture of an electron tube except for certain finishing operations, such as fixing a base to the stem required in some types of tubes, and aging and testing.

The sub-assembly comprising the electrode cage involves the handling of a relatively large number of parts. In some types of tubes these parts comprise two spaced insulating plates usually of mica, and electrodes including a cathode sleeve, an anode and in some cases, also one or more grids. The electrodes are mounted between the insulating plates and usually fixed thereto by snugly extending through apertures provided in the plates.

Heretofore, the parts forming the electrode cage have been assembled by hand. This practice is characterized by several serious disadvantages. One of these disadvantages is the relatively high labor cost involved. This cost has been estimated to be as high as 33% of the cost of manufacture of a completed tube. Another disadvantage of manual assembly of the electrode cage is the need to rely on operator skill. This skill is not always adequate in view of the critical nature of the assembly operation. For example, the cage assembly operation requires observance of relatively close tolerances to assure a desired tube characteristic. Also, uniformity in structure from cage to cage for a given tube type is important to assure uniformity in tube operation. Furthermore, some tube types such as the miniature and subminiature types have parts of such small dimensions that handling the parts is difficult and in some cases may require the use of a magnifying glass. All these factors point to the need for a high order of operator skill and the expenditure of a relatively long time for the completion of an electrode cage assembly.

Various attempts have been made heretofore to overcome the difficulties presented by a manual assembly of

an electrode cage. Jigs have been proposed for travel through a plurality of stations, at each of which an operator mounts on the jigs one part of an electrode cage. While such a proposal is an improvement, the most it does is to realize a splitting up of the mounting operation. While it enjoys some benefit from the division of labor involved, this benefit is largely lost as a consequence of the unavoidable increase in monotony on the part of an operator, that it involves.

However, to completely eliminate operators at the stations referred to has not been considered practicable. This is because no mechanism for feeding all the parts forming an electrode cage is known. The design of such mechanism has been discouraged, because not only would it be required to critically pick up and support a part to be fed, but it would require movement in a very sharply defined path to critically position and mount the part. And even though a suitable feeding mechanism should be designed, a suitable movable support for the mounted parts would be required that would be capable of assuming a predetermined exact position at each station, for receiving a part delivered by the exactly controlled feeding mechanism.

It is thus apparent that for a successful automatic mounting apparatus, the feeding mechanism and the movable support, or jig for receiving electrode cage parts, must be highly coordinated in their motions. This coordination requires a common actuating means for the two elements referred to. However, in view of the extremely critical nature of the cage assembly operation, it is desirable to supplement the action of the common actuating means so that preciseness in the positions of the feeding mechanism and the support or jig at each station is assured.

Accordingly, it is an important object of the invention to mechanize the assembly of electron tube parts to form an electrode cage.

A further object is to reduce the cost of assembling an electrode cage.

Another object is to assemble an electrode cage to higher precision standards than possible in manual operations.

A further object is to provide an improved apparatus for automatically mounting electron tube parts to form an electrode cage.

Another object is to provide an automatic mounting apparatus for tube parts to form an electrode cage wherein the movements of a feeding mechanism are accurately coordinated with the movements of a support or jig on which the parts are assembled.

A further object is to provide an automatic mounting apparatus wherein a movable support for receiving parts in mounted relation is disposed at a station in an exact predetermined position with respect to a mechanism for feeding one of said parts thereto.

Another object is to provide a mounting apparatus having feeding mechanisms at a plurality of stations, a plurality of supports movable successively to each of the stations for receiving parts fed to them by said mechanisms, a common actuating means for roughly assuring a predetermined position of the supports in relation to the feeding mechanisms, and a further actuating means for critically positioning the supports with respect to the feeding mechanisms, to assure a precision assembly of the parts on the supports.

According to one aspect of the mounting apparatus of the invention a plurality of supports or jigs are mounted on a conveyor such as an endless belt or chain for intermittent movement in a predetermined path. Adjacent the path of travel of the supports or jigs are a plurality of work stations each including a feeding mechanism for delivering electron tube parts to the supports or jigs. The intermittent movement of the belt or chain causes inter-

station travel of the supports and momentary stoppage thereof at the stations referred to.

According to a further feature of the invention the feeding mechanisms and the supports are actuated by a common power transfer means, so that the feeding mechanisms become operable to feed electrode cage parts to the supports when the supports are momentarily stationary.

A further aspect of the invention concerns a positive locking means for supplementing the action of the common power transfer means in precisely positioning and locking the supports in predetermined relation with respect to the feeding mechanisms during a feeding operation.

An embodiment of the invention includes an endless chain mounted on horizontally spaced sprocket wheels. The chain, therefore, includes vertically spaced portions lying in horizontal planes. At spaced portions of the chain are mounted supports or jigs for travel with the chain. One of the sprocket wheels is connected to a power source thru suitable means such as a Geneva gear, for intermittent movement.

In the path of travel of the upper portion of the endless chain are disposed a plurality of work stations which include mechanisms for feeding electron tube parts to the supports referred to. The stations are so disposed with respect to the intermittent travel of the endless chain and the supports thereon, that during stationary periods of said intermittent travel, one of said supports will be at each of said stations.

In one example of the invention, the work stations are four in number and include a first station for mounting an insulating spacer plate, such as a mica plate, on one of the supports, a second station for mounting a cathode sleeve on the support, a third station for mounting a tubular anode on the support, and a fourth station for mounting a second mica plate on the support. The support is designed to receive the parts in predetermined relation so that the parts referred to form an electrode cage of a diode type of electron tube.

A common power transfer means for each of the stations is connected to a power source. This common power transfer means may be a rotatable shaft extending parallel to the upper portion of the endless chain and having actuating means such as cams spaced longitudinally thereof and adjacent the stations referred for actuating the mechanisms at said stations. The cams are so mounted that they actuate the mechanisms referred to for a feeding operation only when the endless chain and the supports thereon are stationary during the interval between two intermittent movements.

For a successful practice of the invention, it is important that the jigs or supports be disposed at a very exact position at the work stations in relation to the feeding mechanisms at the stations. Furthermore, it is necessary that the supports or jigs be locked in position at the stations during a feeding operation to assure that no relative movement, of even a slight magnitude, occur between the supports and the fixed structures at the stations. Reliance only on the power transfer means and the chain itself for securing the desired exactness in positioning and a locking of the supports against movement, is not desirable. This is because the chain and power transfer means are subject to wear in use. Such wear may change, although very slightly, the position of the supports at the work stations. Furthermore, the chain and power transfer means control primarily, the position of the supports in one plane. A guide may be used to aid the control in a plane normal to the first mentioned plane. But the guide should not engage the chain with any appreciable pressure if it is to remain free from wear and retain its guiding function. According to the invention, therefore, a separate means is provided at each station for urging a support against the guide referred to and for positively locking the support against movement. This properly positions a support and fixes it against movement during a feeding operation.

Further objects and advantages of the invention will become manifest as a more detailed description thereof, taken in connection with the appended drawing, proceeds.

In the drawing:

Figure 1 (sheet 1) is a perspective view of an electron tube cage that the apparatus of the invention is adapted to assemble:

Figure 2, (sheet 2) is an exploded view of an electrode cage showing the parts of which the cage is comprised, as well as one form of support or jig that the apparatus of the invention may employ;

Figure 3, (sheet 1) is a plan view of the automatic mounting apparatus of the invention;

Figure 4, (sheet 3) is a side view of the apparatus shown in Figure 3;

Figure 5, (sheet 4) is a bottom view of the apparatus shown in Figure 3;

Figure 6, (sheet 2) is a sectional view along the line **6—6** of Figure 4 and shows the power transfer means for actuating the endless chain of the apparatus and the common actuating means for the several feeding mechanisms of the apparatus;

Figure 7, (sheet 5) shows a cross-sectional view along the line **7—7** of Figure 4 and depicts one of the feeding mechanisms for feeding insulating spacer plates to a support;

Figure 8, (sheet 6) shows a cross-sectional view along the line **8—8** of Figure 4, of another feeding mechanism of the apparatus of the invention, for feeding cathode sleeves to the supports or jigs of the apparatus;

Figure 9, (sheet 7) is a cross-sectional view along the line **9—9** of Figure 4, and shows the anode feeding mechanism of the apparatus of the invention;

Figure 10 (sheet 7) is a cross-section along the line **10—10** of Figure 4, and shows the mechanism for controlling the feed of anodes to the jig of the apparatus;

Figure 11, (sheet 1) is a schematic circuit diagram of circuit aspects of the apparatus of the invention;

Figure 12, (sheet 5) is a sectional view along the line **12—12** of Figure 7, and shows the mechanism for locking the supports or jigs in position during a feeding operation, the mechanism being shown in locked position;

Figure 13, (sheet 5) is similar to Figure 12, except the locking mechanism is shown in unlocked position;

Figure 14, (sheet 5) is a sectional view along the line **14—14** of Figure 7, and shows a feature of the locking mechanism;

Figure 15, (sheet 5) is a sectional view along the line **15—15** of Figure 7, and shows the resilient power transfer means employed in the mechanism for feeding an insulating spacer plate to a jig of the apparatus of the invention;

Figure 16 (sheet 7) is a perspective view of the plate engaging member of the mechanism for feeding insulating spacer plates according to the apparatus of the invention;

Figure 17, (sheet 7) is a perspective view of a magazine for holding insulating spacer plates to be fed by the apparatus; and

Figure 18, is a perspective view of a holder for the magazine shown in Figure 17.

Referring to the drawing in more detail, there is shown in Figure 1, an electron tube sub-assembly known as an electrode cage. The sub-assembly includes upper and lower insulating spacer plates such as mica discs **20**, **21**, between which are supported a group of electrodes comprising, for example, a cathode sleeve **22** and a tubular anode **23** having channelled side wings **24**, **25**. The mica discs are each provided with three apertures for receiving ears **26**, **27** extending from the side wings of the anode **23**, and an end portion of the cathode sleeve **22**.

According to the invention, an apparatus is provided for automatically mounting these parts. The apparatus

includes a plurality of supports or jigs **28**, one of which is shown in Figure 2. At a first feeding station, a spacer plate **21** is automatically loaded on the jig, with the mandrels **29**, **30**, **31** entering the three apertures in the plate. The plate falls onto the surface **32** of the jig. Thereafter, cathode sleeve **22** is automatically loaded on the jig by threading the sleeve on the mandrel **30**. The anode **23** is then automatically loaded on the jig, with mandrels **21**, **31** entering the channels in the wings **24**, **25**, and the anode proper telescoping around the cathode sleeve **22**. The other spacer plate **20** is finally automatically loaded on the jig with the apertures in the plate receiving the upper end portion of cathode sleeve **22** and the upper ears **26**, **27** of the anode. Pressure is then automatically applied to the upper plate **20** to cause the ears on the anode and the end portions of the cathode sleeve to enter the apertures in both plates **20**, **21**. The size of the apertures in the plate is such that the plates receive the cathode sleeve and the anode ears in relatively snug fits. Additional means, such as dimples on the electrode parts may be used to hold the parts together. The resultant electrode cage is therefore effectively held together as a unit.

General description of apparatus

Considering the automatic mounting apparatus of the invention in more detail, and referring first to Figures 3, 4 and 5, it includes an elongated support or table **33** for supporting a conveyor means such as an endless chain **34**. One path of travel in one direction of the endless chain referred to is adjacent the upper surface of table **33**. Another path of travel in an opposite direction of the endless chain lies below the table.

Fixed to the chain at spaced portions thereof and movable therewith is a plurality of supports or jigs **28** for receiving electrode parts to form an electrode cage.

Mounted on table **33** and spaced longitudinally thereof are a plurality of loading or feeding mechanisms for loading electrode cage parts on the supports or jigs **28**. Each of these mechanisms constitutes a feeding or loading station, past which the jigs **28** are successively and intermittently moved.

One of these feeding or loading mechanisms **36** is disposed at one end of table **33** from which the portion of the chain adjacent the upper surface of the table travels. The function of this mechanism in the example shown is to load a flat insulating spacer plate **21** on a jig **28**, held momentarily stationary adjacent the mechanism.

A succeeding loading mechanism **37** is spaced along the table **33**, for loading a cathode sleeve to the jig **28**, to which has been fed an insulating spacer plate by loading mechanism **36** as indicated above.

Spaced from the cathode sleeve loading mechanism **37** along the table **33** is an anode loading mechanism **38**, for feeding an anode to the jig **28**, to which, as described above, an insulating spacer plate and cathode sleeve have been fed.

A final loading mechanism, spaced along the table **33** from the anode loading mechanism **38**, is a mechanism **39** for loading another insulating spacer plate on the jig **28**, for completing an electrode cage including the cathode sleeve and anode referred to supported between the two insulating spacer plates mentioned.

Also, mounted on the table **33**, adjacent each of the stations or loading mechanisms referred to, is a locking mechanism **35** for accurately positioning and locking a jig against movement with respect to a particular loading mechanism, as shown in Figure 3.

A power transfer means, such as shaft **40** (Figure 5) is provided for actuating the endless chain **34** and the loading mechanisms referred to. This power transfer means is connected to a suitable power source, such as motor **41**. For imparting intermittent movements to the chain **34**, suitable means, such as a Geneva gear **42**, is provided in series with the shaft **40** and the chain.

For translating rotary movement of shaft **40** into desired movements for actuating the loading mechanisms of the apparatus, suitable means, such as cams and levers are provided, as will appear more clearly from the following. Some of the operations of the apparatus are actuated by an electrically controlled solenoid and by a pneumatic system also to be described more fully below.

A chute **33***a* is provided for receiving completed electrode cages.

From the foregoing, it will be apparent that the apparatus of the invention includes an intermittently movable conveyor; a plurality of jigs mounted on the conveyor for movement therewith; a plurality of locking mechanisms for accurately positioning the jigs and locking them against movement at loading stations; a first loading mechanism for loading an insulating spacer on a jig; a second loading mechanism for loading a cathode sleeve on the jig; a third loading mechanism for loading an anode on the jig; a fourth loading mechanism for loading a second insulating spacer on the jig; and a common actuating means for imparting intermittent movements to the conveyor, and energizing the loading mechanisms and locking mechanisms referred to. Each of these elements of the apparatus of the invention will be discussed in detail in the following.

The intermittently movable conveyor

The intermittently movable conveyor in the example shown is in the form of an endless chain **34** supported on sprocket wheels **43**, **44** (Figures 4 and 6). Sprocket wheels **43**, **44** are mounted on shafts **45**, **46** for rotation in a clockwise direction as viewed in Figure 4. The shafts referred to are supported on brackets **47**, **48**, in turn suitably fixed as by bolts, to the underside of table **33**. The chain **34** is so supported by the sprocket wheels **43**, **44**, that the upper portion of the chain is adjacent the upper surface of table **33**.

For rotating the chain intermittently there is mounted on shaft **45**, as shown in Figure 6, a Geneva gear **42**. Engaging the Geneva gear is a Geneva drive including a pin **49** (Figure 4) mounted on a rotatable support **50** fixed to shaft **51** (Figure 6) for rotation therewith. As the support **50** rotates, the pin **49** thereon enters successively the slots **52** in the Geneva gear for intermittently rotating the same. The Geneva drive also includes a cam **53** having a rounded surface for engaging the concave edge of a tooth of the Geneva gear, for holding the Geneva gear against rotation between intermittent rotary movements thereof. The cam **53** also includes a cutaway or concave edge portion which comes into registry with a Geneva gear tooth when the gear is engaged by the pin **49**, to permit rotation of the gear.

On shaft **51** supporting the Geneva drive referred to, is fixed a miter gear **54**. Miter gear **54** is meshed with a further miter gear **55**, the latter being fixed to the shaft **40** serving as the common actuating means of the apparatus and to be described more fully under a following heading.

The shafts **46**, **51** are mounted for rotation in suitable bearings as shown in Figure 6.

As shown in Figure 7, the chain **34** includes links comprising pins **56**, sleeves **57**, and side plates **58**, **59**, **60**, **61** through which the pins extends. The plates referred to are larger than the transverse area of the sleeves, so that a space is provided between plates **58** and **59** and above and below the sleeves referred to. For guiding the chain in its travel adjacent the upper surface of table **33**, a lower guide **62** fixed to the table is provided for extension into the lower space between plates **58** and **59**. An upper guide **63** fixed to the table by a bracket **64** is disposed to extend into the upper space between the plates **58**, **59**. The guides **62**, **63** bear slightly against the sleeves **57** and the inner walls of plates **58**, **59** to restrain the chain against movements

in vertical and horizontal directions other than its direction of travel. Some of the plates **60** are in the form of brackets, as shown in Figure 7, for supporting the jigs of the apparatus.

Jigs for receiving electrode cage elements

A plurality of jigs for receiving elements to build up an electrode cage are fixed to the chain **34**. A suitable jig **28** for use in the apparatus is shown in Figure 2. The jig comprises a block having sides cut away as at **65** and grooves **66, 67** for cooperating with a loading mechanism to be described. The upper portion of the jig includes a recess defined by bevelled walls **68** and having a bottom surface **32**. The bottom surface **32** is provided with recesses **69, 70, 71** from which three mandrels **29, 30, 31** extend upwardly. The recesses referred to as well as the bevelled walls **68**, are provided to facilitate a loading operation on the jig. The jig also has two openings **72, 73** in a side thereof adapted to receive portions of the locking mechanism to be described. As shown in Figure 7, the jigs **28** are supported on brackets **60** which are substituted for some of the plates forming the endless chain **34**.

The jigs are restrained in movement transversely of the path of travel of the chain **34** by means of a guide **74** shown in Figure 7. This guide also cooperates with the jig locking mechanism to be described, for correctly positioning a jig with respect to a loading mechanism of the apparatus.

An important feature of the invention is a resilient support for the jigs **28**. This is shown best in Figure 6. Each of the jigs is supported on bracket **60** by means of a screw **28***a* extending through oversize opening **60***a* in the bracket. A washer **28***b* made of resilient material, such as rubber is interposed between the head of screw **28***a* and the bracket **60**.

This resilient mounting of the jigs is advantageous in correctly positioning a jig in accurate registry with a loading mechanism. Thus when slight inaccuracies in the chain **34** dispose a jig out of registry with a loading mechanism, the jig is permitted relative movement with respect to the chain when acted on by the positioning and locking mechanisms to be described. This relative movement is important, since the chain may be incapable of movement during stationary portions of its cycles of operation, to permit correction by the positioning and locating mechanism of a faulty registry.

Jig locking mechanism

The jig locking mechanism **35**, as shown in Figures 7, 8, 12, 13 and 14 includes a housing **75** fixed to table **33** adjacent a loading mechanism. A locking mechanism is provided adjacent each of the loading mechanisms of the apparatus. Within the housing **75** is disposed a slide **76** having a passageway for receiving a rod **77**. The housing also includes a chamber **78** for receiving a nut **79** fixed to one end of rod **77**. The chamber is of sufficient length to permit clearance for the nut **79** during longitudinal movement of the rod **77** in the passageway referred to in the slide **76**.

At the other end of rod **77** is fixed a plate **80** having apertures **81, 82** through which pins **83, 84** fixed to slide **76** are adapted to extend. Embracing the rod **77** at a portion thereof intermediate the plate **80** and the slide **76**, is an urging means such as a coiled spring **85** for urging the plate **80** away from the slide with the remote face of the plate extending beyond the ends of the pins **83, 84**.

The pins **83, 84** are adapted to extend into the passageways **72, 73** in a jig, when the slide **76** is moved to the left as viewed in Figure 12, for locking the jig in a desired position with respect to a loading mechanism. Before the pins **83, 84** enter the passageways in the jig, the plate is first caused to bear against the jig as a result of the force of spring **85**, to cause the jig to abut against the guide **74**. After the pins have entered the passageways referred to, the plate **80** continues to urge the jig against the guide **74**, to contribute to an accurate positioning of the jig. During a disengaging movement of slide **76** to the right as viewed in Fig. 12, causing the pins **83, 84** to be pulled out of the passageways in the jig, the plate **80** continues to bear against the jig, to prevent the pins from pulling the jig with them. This opposing action of plate **80** with respect to the pins **83, 84**, is advantageous in that it avoids the application of a force to the jig in a direction in which no effective stop or guide such as guide **74** is provided. The chain guides **62, 63** (Figure 7) would be inadequate by themselves to support the jig against an appreciable force applied thereto, such as might be involved in retracting stuck pins from the passageways referred to.

Four causing sliding movement of slide **76** in housing **75**, a forked lever **86** (Figures 7, 12, 13 and 14) is provided actuated by a suitable power transfer means to be described, connected to the common actuating shaft **40**. Lever **86**, embraces a sleeve **87** around pin **88**. The pin **88** engages a bearing in slide **76**. Movement imparted to the pin **88** by lever **86**, is therefore transmitted to the slide. The slide **76** is dovetailed in a recess in housing **75** for fixed position therein.

As shown best in Figure 8, lever **86** is pivoted at **89** on a bracket **90** fixed to table **33**. At the lower end of the lever is a cam follower **91** urged against the surface of a cam **92** by a spring **93**. The cam **92** is fixed to shaft **40** for rotation therewith. The shaft **40** and cam **92** rotate in a counterclockwise direction as viewed in Figure 8. The cam includes a lower dwell **94**, an upper dwell **95** and risers **96, 97**. When the cam follower engages dwell **94**, the upper portion of lever **86** engaging the slide **76** urges the slide to the left as viewed in Figure 8, into locking position with respect to a jig **28**. The tension of spring **93** is sufficiently greater than the tension of spring **85** of the locking mechanism to cause the slide to move towards the jig against the force of spring **85**. As the cam continues to rotate counterclockwise, the riser **96** thereof engages the cam follower **91** causing the slide **76** to move away from the jig. Engagement between the cam follower and the dwell **95** of the cam causes the slide to remain out of engagement with the jig.

The first loading mechanism

The first loading mechanism **36** is shown at the extreme left of Figure 4. It is the first loading mechanism in the direction of travel of endless chain **34**, above table **33**. As shown more clearly in Figure 7, the first loading mechanism includes an arm **98** fixed adjacent one end to a standard **99**. At the other end of the arm referred to is mounted a pick-up member **100**. The arm **98** is a hollow tube connected to a hose **101** which in turn is connected to a vacuum source, not shown. The pick-up member **100** is provided with passageways **102, 103** communicating with the hollow interior of arm **98**, as shown in Figure 16. The pick-up member is also provided with apertures **104, 105, 106** for receiving mandrels **29, 30, 31** of a jig **28** during a loading operation.

The loading mechanism referred to is designed to pick up an insulating spacer plate **21**, which may be rectangular in shape, from a reservoir **107** shown in Figures 3 and 17. To this end the lower surface of the pick-up member is bounded by bevelled edges **108** which guide the pick-up member into suitable engagement with a spacer plate to be picked up.

To assure a registry relation between the pick-up member **100** and the reservoir **107** during a pick-up operation, the reservoir is provided with slots **109, 110** and cut-away sides **111** and **112** for receiving the side extensions **113, 114** and **115, 116** on the pick-up member.

While the stack of spacer plates shown in the reservoir **107** is compressible in response to pressure thereon by the

pick-up member **100** during a pick-up operation to thereby provide a stack accessible by the pick-up member during several pick-up operations, additional means, not shown, may be employed for raising the stack so that the upper spacer plate is in position for engagement by the pick-up member **100**, during a relatively large number of pick-up operations.

When the lower surface of the pick-up member **100** contacts the upper of a stack of spacer plates **21**, suitable means such as a valve **117** shown in Figure 4, serves to connect the hose **101** communicating with the passageways **102, 103** in said lower surface, with a suitable vacuum source, not shown, for causing the upper of the spacer plates to cling to the lower surface referred to of the pick-up member. It will be noted that the passageways **102, 103**, are offset with respect to the apertures **118, 119, 120** in the plate, so that the mouths of the passageways engage continuous material of the plate to provide a suction engagement between the pick-up member and the spacer plate.

The reservoir **107** is adapted to be supported in a frame shown in Figure 18, including uprights **121, 122** adapted to be received in the cut-away portions **111, 112** of the reservoir. The uprights **121, 122** extend only partways the height of the reservoir, so that an upper space is provided at each cut-away portion for receiving side extensions **115, 116** of the pick-up member for registering purposes. The reservoir **107** is easily removed from its supporting frame for replacement, when depleted, by a full reservoir.

In order to pick up a spacer plate from the reservoir and load it on a jig **28**, as viewed in Figures 3 and 7, it is necessary that the pick-up member **100** move in successive vertical and arcuate horizontal paths. To permit movement of the pick-up member in a vertical path, the standard **99** is movable vertically in a bearing **123**. To impart vertical movement to the standard referred to, a lever **124** is provided, pivoted at **125** on a bracket **126** fixed to the underside of table **33**. One end of lever **124** is connected to the lower end of standard **99** by a pivot yoke **127**. The other end of the lever is provided with a cam follower **128** adapted to follow a cam **129**, fixed on shaft **40** for rotation therewith. The lever is urged against the cam by a spring **129***a*. The cam **129** has dwell surfaces **130, 131** for holding the standard **99** and pick-up member **100** in raised position during rotary movements thereof for disposing the pick-up member in successive registry with the reservoir **107** of spacer plates and the jig **28**.

For imparting rotary movement to the pick-up member for travel between the reservoir and jig, a lever **133** is provided, pivoted at one end to a bracket **134** fixed to the underside of table **33**. At the other end of lever **133** is connected one end of a link **135**. The other end of the link is connected to an arm **136** through a universal joint **137**. The arm **136** is fixed to standard **99**. The link **135** as shown in Figure 15, includes a tubular member **135***a* and a rod **138** telescoped into the tubular member. The tubular member **135***a* is provided with opposite longitudinally extending slots **139, 140** for receiving a pin **141** fixed to rod **138**. The rod is thus permitted some longitudinal motion with respect to the tubular member. To restrain such motion in one direction a spring **142** is provided bearing against collar **143** fixed to the tubular member and collar **144** engaged by pin **141**. Movement in the other direction is restrained by spring **145** bearing against collar **144** and collar **146** fixed to the tubular member. While relative movement between the rod **138** and tubular member is thus restrained, it is permitted against the tension of either spring **142** or spring **145**. Any relative movement occurring is therefore resilient. This resilient control of the relative movement of the parts referred to is desirable in view of the different vertical positions assumed by the arm **136** during movements thereof. When the arm **136** is successively in lowered and raised position, the distance from the arm **136** to the free end of lever **133** is varied. If the length of the link **135** were fixed, it would impart a strain to the standard **99** when the standard is raised and lowered. However, due to the resilient power transfer effected by link **135**, in association with a guide to be described, the standard is free from strain during its vertical and horizontal movements.

For actuating the lever **133** to the left as viewed in Figure 7, a cam follower **147** is mounted on the lever and is urged against a cam **148**, by a spring **149**. Movement of the lever to the right is imparted by the tension of spring **149**. Cam **148** is fixed to shaft **40** for rotation therewith.

In view of the exact movements desired of the pick-up member **100**, its movements are further controlled by a guide **150** shown in Figures 3 and 7 having an upper guide edge **151**, and vertical slots **152, 153**. End portions of the guide, one of which is shown at **154** in Figure 7, rise above the edge **151**.

During rotation of the arm **98** from a pick-up position to a delivery position, the upper edge **151** engages the arm and supplements the action of lever **124** in determining the raised position of the arm and its pick-up member **100**. When the arm reaches the pick-up position, it is in registry wtih slot **152**. As the arm is lowered to permit the pick-up member **100** to engage a spacer plate, the action of lever **124** is further supplemented by engagement of the arm with the side edges of the slot, as a result of which the pick-up member is accurately guided. After the arm is raised in slot **152** and travels across the upper edge **151** of the guide, it comes in registry with slot **153**. This slot also supplements the control of the arm **98**, afforded by lever **124**, in its downward travel to dispose the pick-up member **100** in accurate registry with jig **28** during a loading operation. The end portions **154**, supplement the action of lever **133** and link **135** in determining the exact length of the arc through which the arm 98 is rotated.

The pick-up member **100** is therefore very accurately controlled in its vertical and horizontal movements in pick-up and loading operations, required for a precision assembly of electrode cage parts.

The second loading mechanism

The second loading mechanism **37** for loading a cathode sleeve **22** on mandrel **30** of the jig **28**, is shown in Figures 3, 4 and 8. The cathode sleeve loading mechanism includes a grooved tray **155**, supported for sliding movement on a holder **155***a*. The holder includes a back support lying in a plane inclined from the vertical, and a track **156** for supporting the tray **155**. The track is provided with an opening **157** with which cathode sleeves are successively brought into registry by movement of the tray across the holder. Such registry causes a sleeve to drop downwardly into funnel **158** having a restricted opening **159** with which the central mandrel **30** of the jig shown in Figure 2 is adapted to assure perfect registry by the means of the apparatus controlling the movements of the jigs. The cathode sleeve consequently falls onto the mandrel and is threaded thereon.

It will be noted from Figure 2, that the aperture **119** in the spacer plate and the recess **70** in the jig surface **32** are slightly larger than a cross-section of mandrel **30**. This permits the lower end of the cathode sleeve to enter the aperture **119** and to extend beyond the lower face of spacer **21** and into the recess **70** for snug engagement by the spacer plate. Adequate force for the attainment of this engagement is at least partly provided by the weight of the falling sleeve.

In order to provide for a registry of successive cathode sleeves with the opening **157** in the track **156**, for feeding cathode sleeves to successively registering jigs, means are

provided for intermittently moving the tray **155** on the track, for example, from right to left as viewed in Figure 4. The means referred to include a pinned wheel **160**, the pins of which are adapted to extend through a slot **161** provided in the holder **155***a* for engaging recesses **162** in the back side of the tray **155**, as shown in Figure 8.

The pinned wheel **160** is fixed to the upper end of shaft **163**, which is mounted for rotation in flanged bearing **164** fixed to table **33**. A spring **165** serves to resiliently support the shaft vertically.

At the lower end of shaft **163** is fixed a ratchet wheel **166** shown best in Figure 5. On shaft **163** is also pivotally mounted at one end thereof a support **167** for a paul **168** urged against a pin **169** by a spring **170**. The other end of support **167** is pivotally connected to one end of a lever **171**. The other end of the lever is provided with a cam follower **172** adapted to be engaged by a cam **173**. The lever **171** is swingingly supported at one end of an arm **174** pivotally supported from the underside of table **33**. A spring **175** connected to arm **174** serves to keep the cam follower **172** in engagement with the cam **173**. The cam **173** is fixed to shaft **40** for rotation therewith.

As the cam **173** rotates with the shaft **40**, it periodically pushes the lever **171** to the left as viewed in Figure 8. Return movement of the lever to the right is effected as a result of the tension on spring **175**. Movement to the left causes pawl **168** to jump a ratchet tooth on the ratchet wheel **166** under the restraint of spring **170**. Movement to the right causes the pawl to engage a ratchet wheel tooth and rotate the wheel in a counterclockwise direction as viewed in Figure 5. This causes shaft **163** and pinned wheel **160** shown in Figure 8 to rotate and move the tray **155** a step along the track **156**. The length of this step is equal to the spacing between adjacent sleeves on the tray, so that a succession of rotary movements of pinned wheel **160** disposes the cathode sleeves on the tray successively in registry with the opening **157** in the track of the tray holder.

The third loading mechanism

The third loading mechanism **38** is shown in Figures 3, 4, 9 and 10. It includes a vibrating pan **176**, supported on table **33** and having a spiral feed **177** for moving electrode elements, such as anodes **23**, from a random supply thereof at the center of the pan, to a chute **178**. The chute defines a passageway **179** rectangular in cross-section as shown in Figure 10. The passageway has a lower terminus **180** with which a jig **28** is adapted to be placed in registry by the apparatus.

To control the feed of anodes to assure a feed of only one anode to a jig, a control mechanism is provided. This control mechanism comprises U shaped member **181** supported on a further U shaped member **182** pivoted at its arms **183**, **184**. The U shaped member **182** has an arm **185** pivotally connected to plunger **186** of a solenoid **187**. Rotation of U shaped member **181** in a counterclockwise direction in response to an upward stroke of plunger **186**, as viewed in Figure 9, causes release of only one anode for loading on the jig **28**. Rotation of the member **181** in a clockwise direction in response to a downward stroke of plunger **186**, causes an anode to be engaged in readiness for release to a succeeding jig.

The solenoid is energized periodically by a switch **188** actuated by a cam **189** fixed to shaft **40** for rotation therewith, through conductors A, C. The energization is synchronized with the movements of jig **28** to assure registry of chute terminus **180** with a jig prior to release of an anode, as will appear more clearly in the following.

It will be noted from Figure 2, that the apertures **118**, **120** in the spacer plate **21**, and the recesses **69**, **71** in the jig surface **32** are larger than the mandrels **29**, **31**. Thus, when an anode **23** is released by the chute **178**, not only are the side wings **24**, **25** thereof threaded over the mandrels **29**, **31** by means of the channels therein, but the lower ears **190**, **191** of the anode enters the apertures **118**, **120** and the recesses **69**, **71**. This entry is effected, at least partly, as a result of the falling weight of the anode.

The fourth loading mechanism

The fourth loading mechanism **39** includes a structure similar to that of the first loading mechanism **36** and its function is to load a second spacer plate on a jig. While the magnitude of the vertical strokes of standard **99** may be the same in the two mechanisms, it is important that the length of the downward movement in the mechanism **39** should be sufficient to exert some pressure on the lastly loaded spacer plate, to snap the assembly together, if this has not already occurred as the result of the falling weight of the cathode sleeve and the anode.

It will be noted in Figure 2, that the anode ears **26**, **27**, **190**, **191** have dimples **192** thereon. These dimples cause the anode ears to have a slightly larger cross-section than the width of the apertures in the spacer plates. Some force is therefore necessary to cause extension of the ears with their dimples into the apertures. The falling weight of the anode may be inadequate to accomplish the penetration desired. To this end the loading mechanism **39** is so proportioned that pick-up member **100** when loading the final spacer plate, pushes down on the plate to force the upper ears of the anode through the apertures in the plate. This force is also transmitted to the anode so that the lower ears thereof are forced into the apertures in the spacer plate first loaded. When the anode ears are forced into the apertures, as indicated, the dimples are disposed against the outer surfaces of the plates and effectively serve to hold the resultant electrode cage together. Dimples may also be provided on the cathode sleeve for a similar purpose.

In order to assure the desired length of the downward stroke of the pick-up member **100**, the risers **193**, **194** on cam **129** may be modified to secure the required length of stroke, for fixing the electrode parts as indicated above.

The common actuating means

The common actuating means of the apparatus of the invention comprises shaft **40** supported in bearings **195** to **200** suitably suspended from the underside of table **33**. Mounted on one end of shaft **40** is miter gear **55** meshing with miter gear **54** for actuating Geneva gear **42**, through shaft **51** and Geneva drive **50**. The Geneva gear is in turn disposed in power transfer relation to sprocket wheel **44**, through shaft **46**, for imparting intermittent rotation to the sprocket wheel and intermittent movements to the chain **34** engaged by the wheel and to the jigs supported on the chain. The miter gears **54**, **55** have the same number of teeth, so that shaft **51** rotates at the same velocity as shaft **40**, in response to power provided by motor **41** through belt **201**. During one rotation of shafts **40** and **51**, the Geneva drive **50** goes through one cycle of operation. This cycle includes a portion during which the Geneva gear is held against movement, and another portion during which the Geneva gear is rotated through an arc having a length determined by the number of teeth on the Geneva gear. The arc, measured in degrees, will involve a value determined by dividing 360° by the number of teeth in the Geneva gear. By increasing or reducing the number of teeth in the Geneva gear, the lengths of the intermittent movements of the chain **34** may be decreased or increased.

In addition to driving chain **34** and the jig **28** thereon in intermittent movements of predetermined magnitude, the shaft **40** also actuates the loading mechanisms for causing them substantially simultaneously to perform their loading operations.

Some of the actuations of the shaft **40** are mechanically transmitted to parts of the loading mechanisms while other actuations are transmitted pneumatically and electrically. All of the actuations referred to, however, are controlled by cams fixed to shaft **40** for rotation there-

with. The cams are provided with surfaces having dwells and risers. The dwells serve to hold parts of the mechanisms in predetermined positions, and the risers serve to move the parts from one position to another. The dwells and risers of the cams are so disposed around shaft 40, that the dwells contact the mechanisms during intermittent movements of the chain 34 and the risers except those on cams 129, actuate the mechanisms only during periods between intermittent movements when the chain 34 and the jigs 28 thereon are stationary.

It will be noted from the foregoing, therefore, that the shaft 40 performs its function as a common actuating means, through the Geneva gear 42 for intermittently moving the jig 28 from one loading mechanism to another, and through the plurality of cams to be discussed in the following, for actuating the loading mechanisms during stationary periods of the jigs, and for suspending actuation of the mechanisms with the exception of the spacer plate loading mechanisms, during the intermittent movements of the jigs.

As has been indicated above, the function of some of the cams fixed to shaft 40 is to transmit a force mechanically to parts of the mechanisms to be actuated. The cams performing this mechanical power transfer are cams 129 and 148 at the first loading position and a similar set of cams at the fourth loading position. These cams, as has been explained before herein, serve to impart vertical and horizontal rotating movements to the pick-up member 100 at the first and fourth loading positions. These movements are transmitted through levers and links previously described. Other cams performing mechanical power transfer functions are cams 92 provided at each station for actuating the jig-locking mechanism 35 at each station. A final cam for mechanically actuating a part of a loading mechanism is cam 173. This cam controls the travel of the cathode sleeve tray 155 across the holder 155*a*.

One cam, 202, is provided on shaft 40 for controlling the pneumatic actuation of the first and fourth loading mechanisms. As shown in Figure 4, cam 202 is adapted to control pneumatic valve 117 to provide communication with a vacuum source, not shown, and each of the pick-up members 100 through conduits 203, 204. The pick-up members 100 at each of the first and fourth stations of the apparatus are therefore connected to the vacuum source simultaneously during the stationary portions of the cycles of intermittent movements of the chain 34 and the jig 28 thereon, to permit a suction pick-up of spacer plates at these stations.

A final cam 189 shown in Figure 9 fixed to shaft 40 is utilized for opening and closing an electric switch 188 for actuating solenoid 187. The electrical circuit controlling solenoid 187, as well as the motor 41, is shown schematically in Figure 11. This circuit includes a main switch 205 for connecting the circuit to suitable power supply through a fuse 206. Leads A, B from switch 205 are connected across the motor 41. A parallel circuit is provided by lead C connected to leads A and B through switch 188 and solenoid 187. A third parallel circuit is provided by leads D, E for energizing the vibrating pan 176. When the circuit C is closed by switch 188, current flows through the winding of solenoid 187 to cause the plunger 186 thereof to retract to feed one anode to a jig. The vibrating pan 176 is also energized to feed anodes to chute 178. The switch 188 is urged to open position by a spring 207.

Operation of the apparatus

A description of the operation of the apparatus will be facilitated by assuming the apparatus has been stopped and that the mechanisms thereof are in certain positions. For example, it is assumed the apparatus has been stopped during a portion of the cycle of operation at which the chain 34 is going through an intermittent movement. It is further assumed that the spacer plate reservoir 107 is full at the first and fourth loading stations, that at least some cathode sleeves remain on the tray 154, and that anodes are contained by the chute 178.

Under these conditions, the pick-up member 100 at the first and fourth loading stations will be in some positions other than a loading position. It may be assumed that the pick-up members are on their way to pick up spacer plates. The cathode sleeve tray 155 will have an empty groove in registry with opening 157 in the track 156 and a sleeve will occupy the adjacent grooves to the right as viewed in Figure 3. The feed member 181 at the third loading station will be in the position indicated in Figure 9.

Initiation of operation of the appparatus under these conditions, effected by closing main switch 205, will cause rotation of shaft 40 and completion of the interrupted intermittent movement of the chain 34 and the jigs 28 thereon. It will also cause the pick-up member 100 to complete a pick-up operation by the action of cams 129 and 148 causing mechanical movements, and the action of cam 202 in connecting the openings 102, 103 of the pick-up member to a vacuum source through valve 117. As soon as the interrupted intermittent movement of the chain 34 is completed the following operations of the loading mechanisms will take place.

The locking mechanisms 35, in response to cam 92 will lock a jig 28 in accurate registry with each of the loading mechanisms. Then simultaneously, the pick-up members will move into registry with the jigs thereunder and descend, under the influence of cams 129, 148. At this time, cam 202 closes valve 117, so that spacer plates engaged by the pick-up members are free to drop onto the jig 28 at the first and fourth stations and become threaded on the mandrels thereof.

Also, at this time, pinned wheel 160 rotates a predetermined distance in response to cam 173, to dispose a groove of tray 155 containing a cathode sleeve, against the aperture 157 in the track 156, causing the sleeve to drop through funnel 158 and onto a jig having a central mandrel in registry with the funnel at this station.

At the third or anode loading station, cam 189 closes switch 188 to actuate solenoid 187, resulting in a retraction of plunger 186. Such retraction causes rotation of feed member 181, to release one anode. The anode falls by gravity and is threaded on the three mandrels of a jig in registry with chute 178.

While the foregoing indicates the actions of the apparatus on resumption of operation thereof after a stoppage, and when the second to four stations thereof have jigs adjacent thereto that are partly loaded, these actions may also characterize an initial operation of the apparatus at the beginning of which all the jigs are empty. In this event the loading initially of jigs at the second to fourth loading positions is undesirable, and the parts loaded at these stations may be removed after a loading operation. After a second loading operation, the parts loaded on jigs at the third and fourth stations should be removed, and after the third loading operation, the part loaded on the jig at the fourth loading position should be removed. When the removal of the parts indicated, the apparatus will eject completed electrode cages to chute 33*a* after the fourth loading operation following the start of operation of the apparatus.

As an alternative, the loading mechanisms at the second to the fourth loading station may be rendered inactive, by suitable means not shown, in response to an empty jig. However, this problem is relatively minor, since initial operations of an apparatus having empty jigs occur very infrequently, the normal stoppage of the apparatus usually leaving the jigs partly loaded and in readiness for further loading.

It will be apparent from the foregoing that an advantageous apparatus is provided for automatically mounting electron tube parts to form an electrode cage. The

limitations of manual assembly of the parts are avoided, and an improved electrode cage results.

What is claimed is:

1. Apparatus for automatically mounting electron tube parts to provide an electron tube sub-assembly, comprising a jig for receiving said parts, a support resiliently engaging said jig, a loading mechanism, means for moving said support to dispose said jig in approximate vertical registry with respect to said mechanism, and means for moving said jig on said support into more accurate vertical registry with said mechanism, whereby one of said parts is adapted to fall into desired position on said jig when released by said mechanism.

2. Apparatus for processing electron tubes, comprising a jig for receiving electron tube parts, a loading mechanism for loading said parts on said jig, a resilient support for said jig, means for moving said support in steps in a path adjacent said loading mechanism for disposing said jig in a stationary position in approximate registry with said mechanism, means for moving said jig in relation to said support for more accurate registry between said jig and said mechanism, and means for actuating said mechanism for loading said jig while in said more accurate registry.

3. Apparatus for processing electron tubes, comprising a jig for receiving electron tube parts, a loading mechanism for loading one of said parts on said jig, a resilient support for said jig permitting relative movement of said support with respect to said jig in one plane only, means for moving said support to dispose said jig in approximate registry with said mechanism in said plane, and means for moving said jig in relation to said support and in said plane, for more accurately registering said jig with said mechanism whereby a loading of said jig by said mechanism is facilitated.

4. Apparatus for automatically mounting electron tube parts to form an electron tube sub-assembly, said apparatus including a loader, a jig for receiving a part from said loader, a conveyor for carrying said jig into relatively rough part-receiving registry with said loader, resilient means fixing said jig to said conveyor, and means operable to engage opposite sides of said jig for more accurately registering said jig with said loader and for locking said jig in its more accurately registered position, said last-named means including a fixed backing plate adjacent said conveyor and a movable member for urging said jig against said backing plate.

5. An apparatus for automatically assembling electron tube parts to form an electrode cage, including a movable flexible conveyor, a plurality of loaders disposed along said conveyor, a plurality of jigs mounted on said conveyor for movement therewith, means for intermittently moving said conveyor to dispose said jigs into approximate loading positions adjacent said loaders, means for more accurately disposing said jigs in said loading positions, said last-named means including relatively movable members on opposite sides of said jigs for moving the jigs with respect to said conveyor into said more accurate loading positions.

6. Apparatus for automatically mounting electron tube parts to form an electron tube sub-assembly, comprising a plurality of mechanisms spaced in one direction for loading said parts, a plurality of spaced and synchronously movable supports adapted to receive said parts, means adjacent said mechanisms for restraining said supports against movement in a direction normal to said one direction, means for moving said supports into parts receiving positions with respect to said mechanisms and adjacent said restraining means, and means engaging said supports and urging them in said normal direction and against said restraining means, for locking said supports in said parts receiving positions.

7. Apparatus for automatically mounting electron tube parts to form an electron tube sub-assembly, comprising a loading mechanism adapted to guide one of said parts in a predetermined path, a movable support adapted to receive said parts successively for build-up thereon of said sub-assembly, means for moving said support into a relatively rough orientation in said path, and means engaging opposite sides of said support for disposing said support in a predetermined critical position in said path, whereby said support is adapted to receive said one of said parts in a position thereon critically related to the position of another of said parts received by said support.

8. In electron tube processing apparatus including a loading mechanism and a movable jig to be brought into accurate registry therewith, the improvement comprising a movable support for said jig, a first means engaging said support for roughly registering said jig and mechanism, a second means engaging said jig for moving said jig with respect to said support for more accurately registering said jig and mechanism, and a third means mounted on said loading mechanism for still more accurately registering said support and mechanism, and a power transfer means connected to said first, second and third means, for sequentially actuating said first, second and third means, in the order named.

9. Apparatus for automatically mounting electron tube parts in a predetermined orientation, comprising a loading mechanism, a support, a movable jig mounted on said support for receiving one of said parts from said loading mechanism, means for moving said support in a rectilinear path to dispose said jig into part-receiving registry with said loading mechanism, means directly engaging said jig when in said registry for locking said jig in said part-receiving registry, said locking means being adjacent to said jig in said part-receiving registry, and means connected to said locking means and to said loading mechanism for first actuating said locking means to locking position and then actuating said loading mechanism for loading one of said parts on said jig while said jig is in locked position.

10. Apparatus for processing electron tubes, comprising a support for electron tube parts, said support comprising first and second relatively movable members, a plurality of spaced processing mechanisms for automatically and successively loading said parts on said second member, means for intermittently moving said members in a predetermined path including said mechanisms and for placing said second member successively in approximate registry with said mechanisms, means for locking said first member against movement when said second member is in said registry, and means adjacent each of said mechanisms for moving said second member into a more accurate registry successively with said mechanisms while said first member is locked against movement for facilitating the loading of said parts on said second member.

11. Apparatus for automatically mounting electron tube parts to form an electron tube sub-assembly, comprising a movable support, a jig resiliently mounted on said support for receiving said parts, a loading mechanism for loading one of said parts in said jig, common means for actuating said loading mechanism and for moving said support to dispose said jig into approximate registry with said loading mechanism, and combined positioning and locking means directly engaging said jig in said approximate registry for moving said jig into a more accurate registry with said loading mechanism and locking said jig against movement when in said more accurate registry, said positioning and locking means being adjacent to said jig when said jig is in said more accurate registry.

12. Apparatus for automatically mounting electron tube parts in a predetermined orientation, comprising a movable support, a jig movable on said support for receiving said parts, a loading mechanism for loading one of said parts on said jig, means engaging said support for moving said jig toward said loading mechanism, a positioning and locking mechanism for engaging and moving said jig into accurate registry with said loading mechanism and lock-

ing said jig in said registry, and a shaft connected to said support, said positioning and locking mechanism and said loading mechanism for actuating said support and mechanisms in a predetermined sequence, whereby said support and loading mechanisms are locked in registry prior to actuation of said loading mechanism.

13. Apparatus for automatically assembling electron tube parts in a predetermined orientation comprising an endless conveyor having a portion extending rectilinearly in a horizontal plane, a plurality of jigs supported on spaced portions of said conveyor, a loading mechanism, means for moving said conveyor to dispose one of said jigs in registry with said loading mechanism, means for locking said one of said jigs in the position of said registry, said last-named means including a fixed backing plate adjacent one side of said portion of the conveyor and a movable mechanism mounted adjacent the other side of said portion of the conveyor and opposite said plate, said mechanism being connected to said first-named means for movement towards said backing plate, whereby a jig disposed between said backing plate and mechanism is urged by said mechanism against said backing plate and means for actuating said loading mechanism to load one of said parts on said one of said jigs, said locking means holding said jig against said backing plate during a loading operation.

14. An electron tube processing apparatus comprising a movable support, a loading mechanism for loading said support, means for registering said support and mechanism in three steps of increasing accuracy of said registry, said means comprising a shaft, a power source for rotating said shaft, power transfer means connected to said shaft for moving said support into a relatively rough registry with said mechanism, a positioning and locking mechanism in power transfer relation to said shaft for moving said support into a more accurate registry with said mechanism, and a loading member on said mechanism connected in power transfer relation to said shaft for movement into telescoped relation with said support for substantially perfect registry of said support and said mechanism.

15. Apparatus for automatically mounting electron tube parts in predetermined orientation, comprising a plurality of movable supports mounted for intermittent movements in a predetermined path, a plurality of loading mechanisms having said parts and spaced along and above said path for vertical registry with at least some of said supports during terminal portions of said movements, means movable to directly engage said some of said supports for accomplishing said vertical registry, said means having members engaging said supports in transverse planes, and means for substantially simultaneously actuating said mechanisms for release of said parts therefrom, whereby said parts fall by gravity into predetermined positions on said supports.

16. Apparatus for automatically mounting electron tube parts to form an electron tube sub-assembly, said apparatus comprising a fixed loading mechanism, a movable conveyor spaced from said loading mechanism, a fixed support for said conveyor, a jig resiliently fixed to said conveyor, and having an axis for registration with said loading mechanism, means for moving said conveyor to dispose said axis in rough registry with said loading mechanism, and a positioning mechanism for disposing said jig axis in a more accurate registration with said loading mechanism, said last-named mechanism including a plate fixed to said fixed support in predetermined position and disposed to one side of said conveyor, a movable member mounted on said fixed support on the other side of said conveyor and opposite said fixed plate, and means for moving said movable member across said conveyor for engaging and urging said jig against said fixed plate.

17. Apparatus for processing parts to form an assembly thereof, comprising a processing mechanism, first and second members movable with respect to said mechanism, said second member being mounted on and movable in a plurality of directions with respect to said first member and adapted to receive said parts to form said assembly, means for moving said members in one of said directions to a position to dispose said second member in approximate registry with said mechanism, means for locking said first member in said position, means for moving said second member in at least one of said plurality of directions and into a more accurate registry with said mechanism while said first member is locked against motion and for locking said second member in said more accurate registry, and means for actuating said mechanism while said second member is locked in said more accurate registry.

18. Apparatus for automatically mounting electron tube parts, comprising a movable support, a member movable with respect to and mounted on said support, a loading mechanism for loading one of said parts on said member, and means for accurately registering said member with said loading mechanism, said means comprising a drive mechanism connected to said support for moving said support to dispose said member in a relatively rough registry with said loading mechanism, a positioning and locking mechanism for engaging and moving said member in at least one plane for accurately registering said member with said loading mechanism in said one plane, and a fixed locking plate extending normal to said one plane and adapted to engage said member when said member is moved by said positioning and locking mechanisms, for disposing said member in accurate registry with said loading mechanism in a plane normal to said one plane, said drive mechanism being connected to said loading mechanism for actuating said loading mechanism in a path parallel to and including the intersection of said planes.

19. Apparatus for processing electron tube parts, comprising a first member movable in a predetermined path, a second member mounted on said first member and movable with respect to said first member in a plurality of normal paths including said predetermined path, and adapted to receive said parts, a plurality of processing mechanisms spaced in said path, means for intermittently moving said members in said path, whereby said members are intermittently stopped in positions successively to dispose said second member in approximate registry with said mechanisms, means for locking said first member against movement when said second member is in said approximate registry with one of said mechanisms, and means adjacent said second member in said approximate registry for moving said second member with respect to said first member in at least one of said paths into a more accurate registry with said one of said mechanisms and for locking said second member in said more accurate registry for accurately loading said parts on said second member.

20. Apparatus for automatically mounting electron tube parts to form an electron tube sub-assembly, said apparatus comprising, a fixed support, a movable conveyor mounted for travel on said support, a jig, resilient means fixed to said conveyor for engaging one end of said jig for mounting said jig on said conveyor, said jig having a mandrel at the other end thereof, a loader mounted on said support and spaced from said conveyor in a plane parallel to the axis of said mandrel, means for moving said conveyor to dispose said jig in a position wherein said mandrel is in relatively rough axial registry with said loader, a positioning and locking mechanism between said loader and conveyor including two relatively movable members disposed on opposite sides of said conveyor and spaced from said conveyor for engaging opposite sides of said jig intermediate the ends of the jig, and means for moving one of said movable members to engage one side of said jig and for moving said jig on said resilient means into engagement with the other of said members for more accurately disposing said mandrel in a position of axial alignment with said loader, said mechanism having a finger for locking said jig in said position.

21. In an apparatus for automatically mounting elec-

tron tube parts to form an electrode cage, a loading mechanism movable in a predetermined path in a loading operation, a support adapted to receive one of said parts from said loading mechanism and having an opening therein, means spaced from said support for moving said support into at least a rough registry with said path, means adjacent to said support when said support is in said rough registry for moving said support into a more accurate registry with said path, said last named means including a finger movable in a path normal to said predetermined path for entering said opening, and a plate normal to and movable with said finger for engaging a surface of said support adjacent and normal to said opening, and means for urging said plate against said surface when said finger is retracted from said opening, whereby said support is preserved from displacement during the retraction of said finger.

22. In an apparatus for automatically mounting electron tube parts to form an electrode cage, a loading member movable in a predetermined path, a movable jig for receiving one of said parts from said member and having an opening and a flat surface normal and adjacent to said opening, and means for accurately moving said jig into said path, said means comprising a fixed stop adjacent to said path, a tapered finger movable on a fixed axis into said opening for moving said jig into a plane including said path, and a plate normal to and movable with said finger for engaging said flat surface for moving said jig in said plane into abutment with said stop, whereby said jig is accurately located in said path.

23. Apparatus for processing parts to form an assembly thereof, comprising a processing mechanism, first and second members movable with respect to said mechanism, said second member being mounted on and movable with respect to said first member and adapted to receive said parts to form said assembly, means for moving said members to a position to dispose said second member in approximate registry with said mechanism, means for locking said first member in said position, means for moving said second member into a more accurate registry with said mechanism while said first member is locked against motion, said second member having an opening therein, said last named means for moving comprising a device having a finger movable in a predetermined path to engage the walls of said opening for disposing said opening across said path, said second member being in said more accurate registry with said mechanism in one plane when said opening is across said path, said device including a plate movable with said finger for engaging a side of said second member, whereby said second member is adapted to be moved in said plane against a stop for more accurately registering said second member with said mechanism in a plane normal to said one plane.

24. An electron tube processing apparatus according to claim 14, and wherein said support is provided with a recess therein and said positioning and locking mechanism includes a finger in predetermined accurate registry with said loading mechanism and adapted to extend into said recess, said finger having a rounded leading end for moving said support laterally with respect to said finger when said finger and recess are out of registry in one plane, and a movable plate means on said positioning and locking mechanism for engaging said support for moving the same longitudinally of said finger in a plane normal to said one plane and into accurate registry with said loading mechanism.

25. Apparatus for automatically mounting electron tube parts, comprising a support for receiving said parts and having an opening in a side thereof, a loading mechanism for loading one of said parts on said support, means for moving said support into approximate registry with said loading mechanism, and means for moving said support into more accurate registry with said mechanism for facilitating the loading of said one of said parts in predetermined position on said support, said last named means including a finger adapted to extend into said opening, and a plate for engaging said side of the support during retraction of said finger from said opening for preventing displacement of said support.

26. Apparatus for automatically mounting electron tube parts, comprising a support for receiving said parts; a loading mechanism for loading one of said parts on said support; said loading mechanism including a pick-up member, means for moving said member in a predetermined path from a pick-up to a loading position, and a guide having an edge adjacent said path for guiding the movements of said member to dispose said member in a predetermined loading position; a positioning and locking mechanism having a tapered finger for moving said support into accurate registry with said loading position; and means for automatically releasing one of said parts picked up by said member for loading said support.

27. Apparatus for automatically mounting electron tube parts in predetermined orientation for providing an electron tube sub-assembly, comprising an endless conveyor disposed in a vertical plane, rotatable supports spaced horizontally for supporting said conveyor, a plurality of jigs each having an opening therein and mounted resiliently at uniformly spaced portions of said conveyor, means for moving said conveyor in steps having a length equal to the spacing between adjacent ones of said jigs, a plurality of loading mechanisms adjacent said conveyor spaced from each other by a multiple of said length, whereby said jigs are successively brought into at least a rough registry with each of said loading mechanisms, and a locating mechanism adjacent each of said loading mechanisms for moving said jigs into more accurate registry with said loading mechanisms, said locating mechanism including a tapered finger and a plate normal to said finger movable axially of said finger, said locating mechanism being operable to dispose said finger in said opening and urge said plate against a side of said jig.

28. An apparatus for automatically assembling electron tube parts to form an electrode cage, comprising a loading means, a jig for receiving a part from said loading means, a resilient support for said jig, means for moving said resilient support to dispose said jig adjacent said loading means and in a relatively rough part-receiving position with respect thereto, and means for moving said jig with respect to said support into a more accurate part-receiving position with respect to said loading means and locking the jig in said position, said jig having an opening therein, said last-named means comprising a tapered finger adapted to engage first an edge of said opening for moving said jig transversely of said finger and to extend fully into said opening for locking the jig against further movement transversely of the finger, and a plate movable to engage a side of said jig for moving said jig axially of said finger, and a fixed backing plate coextensive with said first-named plate for engaging the opposite side of said jig and limiting the movement thereof caused by said first-named plate.

29. Apparatus for automatically mounting in predetermined orientation electron tube parts comprising two insulating plates, a tubular cathode and a tubular anode, for providing an electrode cage for a diode type of electron tube, said apparatus comprising an endless conveyor disposed in a vertical plane, rotatable supports spaced horizontally for supporting said conveyor, a plurality of jigs each having an opening therein and mounted resiliently at uniformly spaced portions of said conveyor, means for moving said conveyor in steps having a length equal to the spacing between adjacent ones of said jigs, a first loading mechanism for loading one of said plates, a second loading mechanism for loading said cathode, a third loading mechanism for loading said anode, and a fourth loading mechanism for loading the other of said plates, said loading mechanisms being adjacent said conveyor and being spaced from each other in the order named by a multiple of said length, whereby said jigs are successively brought into at least a rough registry with each of said loading mecha-

nisms, and a locating mechanism adjacent each of said loading mechanisms for moving said jigs into more accurate registry with said loading mechanisms, said locating mechanism including a tapered finger and a plate normal to said finger movable axially of said finger, said locating mechanism being operable to dispose said finger in said opening and to urge said plate against a side of one of said jigs.

30. Apparatus for automatically assembling a first part having a tubular portion and a second part having an opening adapted to receive said tubular portion, said apparatus comprising a conveyor having a mandrel for snugly receiving said tubular portion, said mandrel having a free end portion and being substantially coextensive with said first part for supporting an end of said tubular portion adjacent to said free end in a predetermined position, a loading mechanism adjacent to said conveyor and adapted to carry said second part in a predetermined path, means for moving said conveyor to dispose said mandrel and said tubular portion longitudinally in said path, a first means for actuating said loading mechanism for carrying said second part to said path with said opening axially alined with said mandrel, and a second means for moving said loading mechanism in said path to cause said mandrel to enter said opening, whereby said opening is adapted to receive said tubular portion to form an assembly of said first and second parts.

31. In an apparatus for automatically assembling electron tube parts to form an electrode cage, wherein one of said parts comprises a flat insulating plate, a container adapted to support said plate in a predetermined plane and having a free recess, a jig spaced from said container and adapted to receive said plate, a loading mechanism having a member including a flat surface and a projection, said projection being adapted to enter said free recess snugly, for guiding said surface to said plate, said mechanism being movable from said container to said jig in a loading operation, said member having a passageway communicating with said surface, a conduit adapted to connect said passageway to a vacuum source, a valve across said conduit, means for opening said valve when said projection is received by said recess and said surface engages said plate for causing said plate to adhere to said surface during a loading operation, and means for closing said valve at the completion of a loading operation for causing said member to release said plate.

32. In an apparatus for automatically assembling electron tube parts, a loading mechanism for loading one of said parts, a container for a plurality of said parts, said container having a free recess, said mechanism comprising a pick-up head having a surface adapted to engage said one of said parts and having a projection adjacent to said surface, said projection having a dimension for snugly entering said free recess, for directing said surface into contact with one of said parts in said container, said loading mechanism having a passageway communicating with said surface, a valve adapted to connect said passageway with a vacuum source, and means for opening said valve when said projection is received in said free recess and said surface engages said one of said parts, whereby said head is guided by said projection to said one of said parts and said one of said parts adheres to said surface during a loading operation.

33. Apparatus for automatically assembling electron tube parts to form an electron tube sub-assembly, comprising a loading mechanism for picking up one of said parts from a reservoir and releasing said one of said parts at a loading location horizontally spaced from said reservoir, a first power transfer means connected to said loading mechanism for successively raising and lowering said loading mechanism, a second power transfer means connected to said loading mechanism for moving said mechanism in a horizontal plane, and a common power transfer means for actuating said first and second power transfer means, said second power transfer means being resilient for following said loading mechanism with reduced strain thereon during raising and lowering of said mechanism.

34. Apparatus for automatically mounting electron tube parts to form an electron tube sub-assembly, comprising a support movable in a predetermined path; a reservoir of parts to be loaded; a loading mechanism adjacent said path for loading one of said parts on said support; said loading mechanism including a pick-up member, means for moving said member successively in spaced parallel paths for picking up said one of said parts from said reservoir and for loading the same on said support, and resilient means for moving said member in a path normal to said parallel paths for disposing said member successively in registry with said reservoir and said support, whereby said resilient means is responsive to control the movements of said pick-up member in said parallel and said normal paths.

35. In an apparatus for assembling parts to form an electron tube sub-assembly, means adapted to hold a plurality of similar parts, said means comprising a fixed support and a member movable on said support, said member having recesses for retaining said parts, said support having an opening, said recesses being successively in registry with said opening when said member is moved in one direction on said support for loading said parts, a build-up fixture movable to a predetermined registry with said opening for receiving one of said parts, and common power transfer means connected to said fixture and to said movable member for first moving said fixture to said predetermined registry and then moving said movable member for disposing one of said recesses in registry with said opening for loading one of said parts on said fixture.

36. In an apparatus for assembling parts to form an electron tube sub-assembly, movable means adapted to hold a plurality of similar parts, a support for said movable means having an opening, a build-up fixture movable to a predetermined position for receiving one of said parts through said opening, a first power transfer means connected to said fixture for moving said fixture roughly into said position, a second power transfer means engaging said fixture, only after said fixture is disposed roughly in said position, for disposing said fixture more accurately in said position, and a third power transfer means connected to said movable means for moving the same only when said fixture is in said more accurate position for disposing said one of said parts in registry with said opening for loading said one of said parts on said fixture, said first, second and third power transfer means including a common power transfer shaft.

37. In an apparatus to form an electron tube sub-assembly, a movable build-up fixture, a first power transfer means connected to said fixture for moving the same intermittently, whereby said fixture is momentarily stationary in a position spaced from a predetermined accurate position, a second power transfer means movable to engage said fixture, only when the same is momentarily stationary for moving said fixture into said accurate position, means adapted to hold a plurality of similar parts, said means comprising a fixed support having an opening in registry with said accurate position and a member movable on said support and adapted to carry one of said parts to said opening, a third power transfer means connected to said movable member for intermittently moving the same only when said fixture is in said accurate position for loading said one of said parts on said fixture, said first, second and third power transfer means including a common power transfer shaft, and power transfer elements engaging said shaft and spaced angularly thereabout for sequentially actuating said second and third power transfer means in the order named between actuations of said first power transfer means.

38. Apparatus for automatically assembling two electron tube parts wherein said parts comprise a flat part and an elongated tubular part, to provide a predetermined

sub-assembly, said apparatus comprising a conveyor having a portion extending rectilinearly in a horizontal plane, two loading mechanisms adjacent to and spaced along said portion, one of said loading mechanisms including a chute in vertical registry with said conveyor portion and having a lower delivery end, said lower end having an opening for delivering said elongated part vertically only, the other of said loading mechanisms including a vertically movable member, a jig fixed to said conveyor portion and having a mandrel extending upwardly therefrom, said mandrel having a free upper end, said upper end terminating in a horizontal plane relatively close to a horizontal plane including said delivering end, means for moving said conveyor portion to dispose said mandrel in successive vertical registry with said chute end and said other of said loading mechanisms, means for actuating said one of said loading mechanisms for releasing said elongated tubular part through said opening when said mandrel is in said registry with said chute, whereby said mandrel receives said part with one end of said part engaging said jig and the other end engaging a free end portion of said mandrel for supporting said other end of said part in a predetermined position, and means for downwardly moving the other of said loading mechanisms when said mandrel is in vertical registry therewith, for loading said flat part forcefully against said other end of said elongated tubular part to form said sub-assembly.

39. Apparatus according to claim 38, and wherein the distance between said lower end of the chute and the upper end of said mandrel when said mandrel is in vertical registry with said lower end, is less than the length of said elongated tubular part, whereby the transit of said part from said chute to said mandrel is effectively controlled.

40. Method of mounting one electron tube part on another electron tube part to form an electrode cage, said method comprising moving said another electron tube part rectilinearly and roughly into a predetermined path, locking said another part against further rectilinear movement, angularly moving said another part into a more accurate position in said path, locking said another part against further angular movement, and moving said one part in said path and toward and into engagement with said another part for build-up of said cage.

41. Method of mounting electron tube parts on a support to form an electron tube sub-assembly, comprising the steps of first roughly orienting the support in a predetermined location, then moving said support first horizontally to a vertical plane including said predetermined location then in a horizontal direction in said vertical plane to a second vertical plane normal to said first-named vertical plane and including said predetermined location, and then in a vertical direction to said predetermined location, and then moving one of said parts in a vertical path including said predetermined location, for mounting said one of said parts on said support.

42. Method of assembling electron tube parts to form an electron tube sub-assembly, comprising collectively moving a group of said parts rectilinearly in a predetermined path and approximately into predetermined positions, then individually and rectilinearly moving said parts in said group in a plurality of paths including said predetermined path for disposing said last named parts more accurately in said predetermined positions, and then moving another group of parts accurately in paths terminating at said predetermined positions for loading said another group of parts on said first named group.

43. Method of locating a first part accurately in a loading position for build-up thereon of a second part to form a sub-assembly, said method comprising moving said first part rectilinearly in one direction and approximately into said loading position, then moving said first part in another direction normal to said one direction and into a plane including said loading position, then moving said first part in said plane and in a direction normal to said another direction and towards said loading position, and stopping said first part when accurately in said loading position.

44. Method of locating a first part accurately for build-up thereon of another part to form a sub-assembly, said method comprising moving said first part rectilinearly in a first path and into a position approximately in a second path extending angularly with respect to said first path, then moving said first part angularly in a plane parallel to said second path and to a position from which a projection perpendicular with respect to said plane includes said second path, and then moving said part along said projection and more accurately into said path, whereby said another part when moved in said second path towards said first part is adapted to engage accurately said first part for precision build-up of said sub-assembly.

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