July 5, 1960 C. J. BUSSOM ET AL 2,943,904

CURRENT LIMITER

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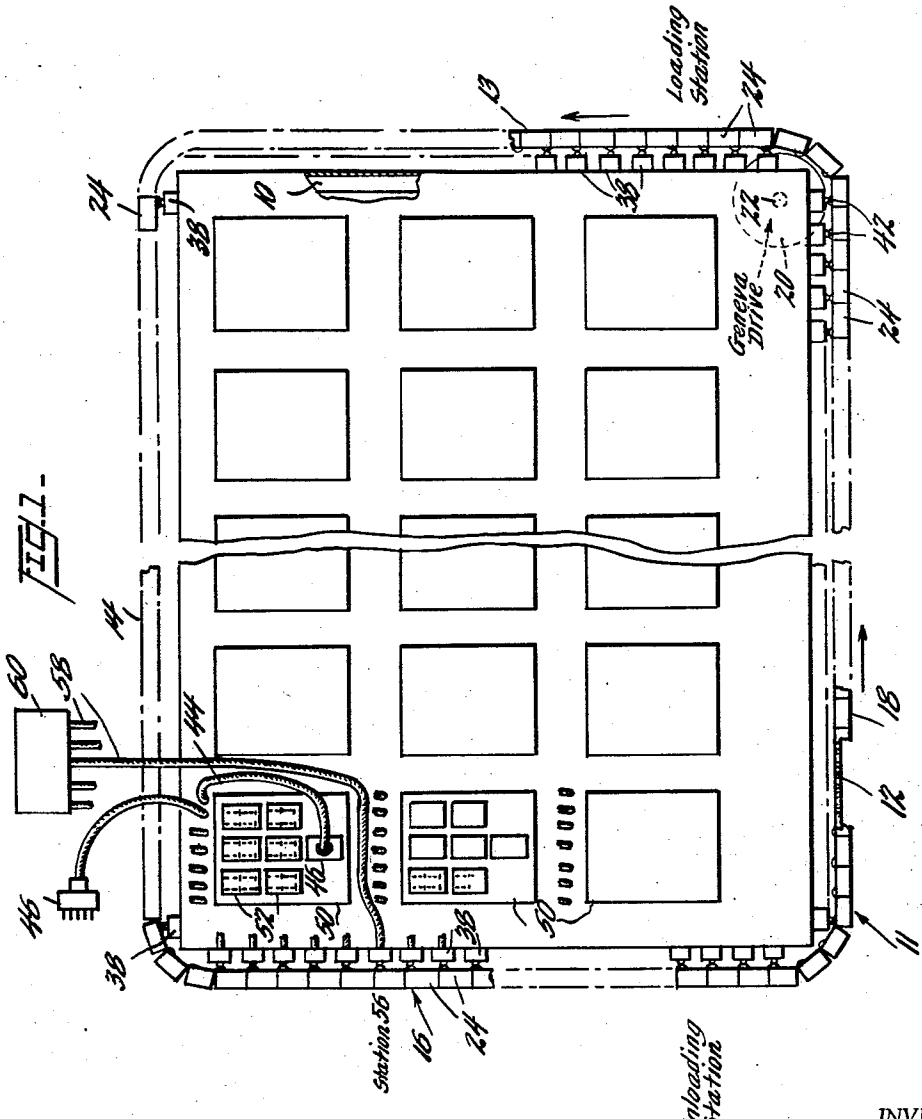


FIG. 1

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FIG. 2.

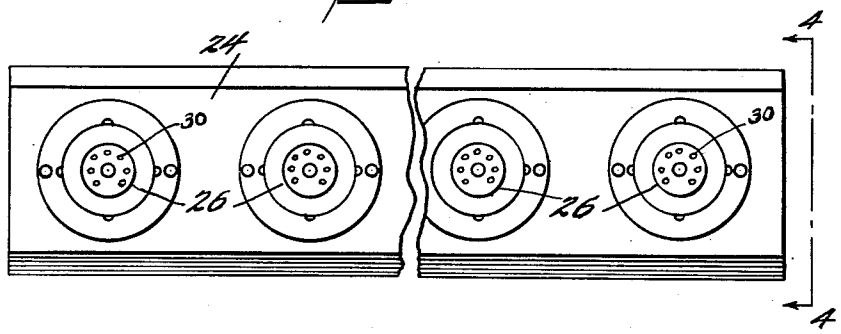
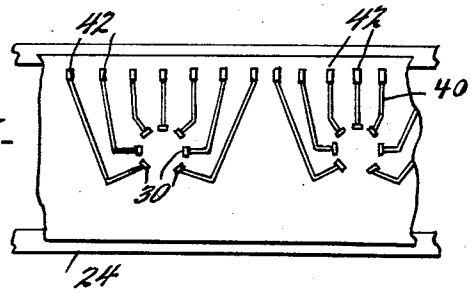


FIG. 3.



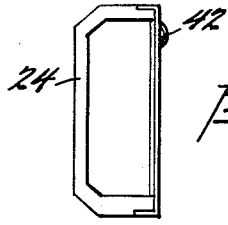


FIG. 4.

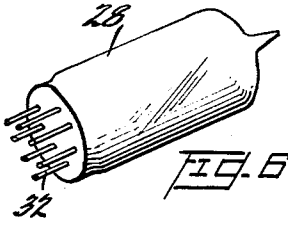


FIG. 6.

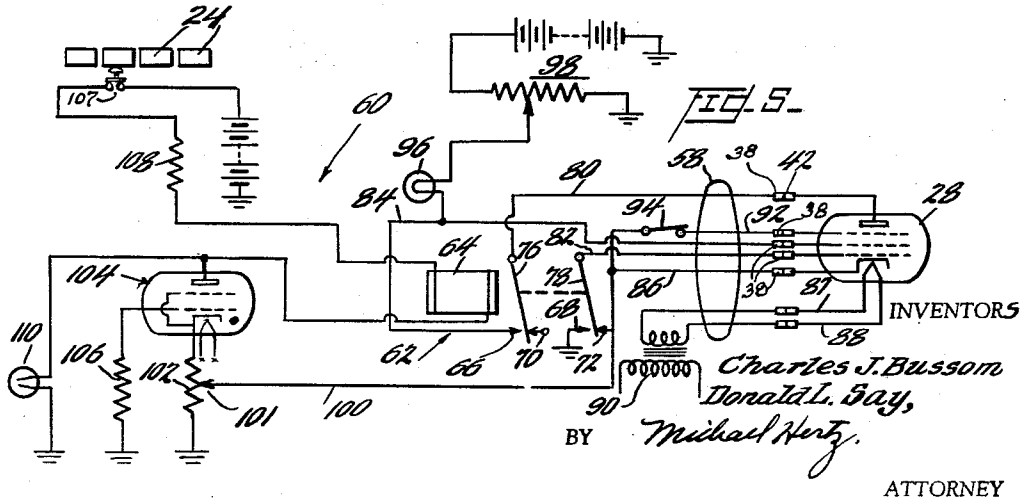


FIG. 5.

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7 Claims. (Cl. 316—27)

This invention relates to electron tube manufacturing and in particular to the aging of electron tubes.

It is common practice in the art, after the parts of a tube have been assembled and sealed within an air exhausted envelope, to transfer the tubes to an aging rack, usually in the form of a conveyor having bars with tube sockets thereon and wherein the tubes inserted in the sockets are heated by application of abnormally high voltages to the filamentary heater and other electrodes within the tube. The effect of this heating is to raise the temperature of the parts within the tube to higher than temperatures they would be subjected to in normal use, and, by controlling the heating, permanent changes are effected in the geometrical configuration in the electrodes within the tube. In the particular case of the second or screen grid, if the grid be elliptical, rectangular or of other shape displaying major and minor diameters with the minor diameter perpendicular to the active face of the cathode, the heating of the tube causes a permanent increase in the minor diameter of the grid, with a permanent increase of spacing between the screen grid and control grid. This increase in spacing reduces the anode current that would otherwise flow through the tube and correspondingly changes other characteristics of the tube, such as trans-conductance and screen grid current. The reduction in current flow is desirable, since the tubes, prior to aging, have widely different characteristics; but, by aging the tubes, the top level of anode current in all of them are reduced to a lower level, thereby reducing the spread above an arbitrarily designated lower level of current. Thus tubes with more uniform characteristics than prior to aging, are produced.

However, the prior art methods and machines lowered the current levels of all tubes alike, including those wherein current levels were initially too low, thereby failing to obtain tubes with as good uniform characteristics as could be obtained by means of the present invention.

It is an object of this invention to provide a system whereby, while all tubes are subjected to treatment which may bring about a lowering of the current level in the tube, the treatment is varied as required for each tube to bring about a fairly uniform characteristic of current flow through all of the tubes.

It is a more specific object of the invention to bring about an expansion of the screen grid of a tube, when required, to such a degree as to lower the cathode current to a predetermined value.

Another object of the invention is to provide a system whereby although a group of tubes is treated for lowering the cathode current therein, the treatment of each tube is individually controlled to bring about a substantially equal cathode current in each of the tubes.

Other objects of the invention will become apparent upon consideration of the following specification, when taken in conjunction with the accompanying drawings in which:

Fig. 1 is a diagrammatic vertical view of the aging rack employed in the invention, with a conveyor about the rack.

Fig. 2 is a fragmental plan view of one of the bars used on the conveyor.

Fig. 3 is a fragmentary portion of the underface of the bar.

Fig. 4 is an end view of the bar.

Fig. 5 is a wiring diagram of the circuitry involved in the invention and

Fig. 6 is a view of a type of tube which may be plugged into the sockets on the bars.

Referring to the drawings in greater detail, in Fig. 1 there is diagrammatically illustrated a conveyor frame **10**, around which travels a conveyor **11** of two spaced parallel chains **12** (only one chain being shown) running in the direction of the arrow and having a vertical ascending side **13**, an upper horizontal run **14**, a vertical descending side **16** and a lower horizontal run **18**. These chains are driven intermittently, for example one step every twenty five seconds, by a Geneva drive **20** whose drive shaft **22** may be variably driven, as through a Reeves transmission, not shown, to vary the timing of intermittent movement of the conveyor. Spanning the chains are bars **24**, each provided with a number of tube receiving sockets **26**. To simplify the description, but not as limitative of the invention, specific numbers of parts and a specific type of tube will be referred to although it will be obvious that other numbers of parts and other types of tubes may be selected. For an example, each bar, of which there may be one hundred and fourteen, is provided with nine sockets **26**, each adapted to receive a tube, as tube **28**, each socket being provided with seven contacts **30** to correspond with the pins **32** on the tube. Each of the ascending and descending sides of the conveyor may accommodate nineteen of the bars and the lower and horizontal runs may each accommodate thirty eight bars. The sockets are loaded with tubes to be aged at the loading station at the right of Fig. 1 at about the third indexed position of the bar from the bottom run, and the tubes are removed at the unloading station on the descending run of the conveyor at about the third bar above the bottom run. As a result, in this instance, the tubes can be aged through seventy-two indexes of the conveyor, for about twenty-five seconds at each index position. For each of the possible seventy-two aging positions of the bars there is a row of spring contacts **38** mounted on the frame of the conveyor, each row extending parallel to a bar and comprised of as many individual contacts in a row as there are sockets on the bar multiplied by the number of contacts in each socket; since seven contacts have been selected for each of nine sockets, there will be sixty three fixed contacts in a row. The socket contacts are brought to the lower faces of the bars **24** wherein printed circuitry **40**, similar for each socket, leads the contacts to a row of shoes **42** mounted on the bar to correspond with the lateral spacing of the fixed spring contacts. The nine wires leading to corresponding shoes on each socket, as for example, the anode connected shoes, are connected into a bundle **44**, each bundle leading to the terminals of a polarized plug **46**. The plugs from one bar all lead to a plug-in panel **50**. Each panel has seven plug sockets **52** to respectively receive the pins of the plugs. Each of the contacts of the plug-in sockets is fed with individually regulated current, at suitable voltages, so that each contact of the sockets on the bars can be fed with any desired voltage at any desired indexed position of the bars. This allows for extreme flexibility in aging of the tubes.

In accordance with applicant's invention, at one of the indexed positions of the bars, for example at the fifty sixth indexed position removed from the loading position, the wires from the spring contacts are differently bundled,

Here the seven wires originating from a socket are made into a group, as group **58**, and the nine groups of wires **58** from the nine sockets are fed to a relay box **60** within which are nine relays **62**, see Fig. 5, and associated equipment, as will be described. Each relay comprises an electromagnetic coil **64**, a pair of fixed back contacts **66**, **68**, a pair of fixed front contacts **70**, **72**, and an armature carrying a pair of tied together movable arms **76** and **78**, the arm **76** alternatively contacting contacts **66** and **70** and the arm **78** alternatively contacting contacts **68** and **72**.

A wire **80** connects movable arm **76** with the spring contact **38** leading to the anode of a tube. A wire **82** connects movable arm **78** with a spring contact **38** leading to the #1 or control grid of the same tube. A wire **84** connects #2 grid or screen grid spring contact **38** and relay contact **66**. A wire **86** connects cathode spring contact **38** and relay contact **72**. The heater wires **87**, **88** lead from spring contacts **38** to a variable transformer **90** so as to feed any desired voltage to the heater, and a suppressor grid spring contact connected wire **92** leads to one side of a closed switch **94** which switch is connected at its other side to the cathode lead **86**. The contact **68** is grounded while the contact **70** is open circuited. The contact **66** in addition to being connected to line **84** is connected via a load lamp **96** to a source **98** of D.C. potential which may be varied, at will. The contact **72** is connected via a lead **100** to the movable arm **101** of a potentiometer **102**, grounded at one end, and connected at its other end to the cathode of a self biased grid controlled gas filled tube **104**, as a type 2D21, whose grid is ground via a resistor **106**. By varying the position of the potentiometer arm **101**, the voltage required to fire the tube **104** may be varied at will. Current to the relay coil **64** is fed from a D.C. source, cut off with each index movement of the bars, as by a microswitch **107** opened with every index of the bars, via a current limiting resistor **108** and the anode of the gas filled tube, when the tube is fired. The state of tube **104** may be indicated by a high resistance indicating lamp as a neon lamp **110** in shunt with the tube **104** and its potentiometer **102**.

Each of the nine tubes on the bar at the fifty-sixth index position registers with an individual electrode switching circuit, exactly like the one described and illustrated in Fig. 5. If cathode current of a tube under test is sufficiently high to maintain over 2.0 volts bias (in the case of the 2D21 type tube) over the lower part of potentiometer **102**, the tube **104** will not fire and the circuit remains as shown in the said figure. In this position, the screen grid of the tube **28** under test is conducting current while the anode is not. Also the control grid is shorted to the cathode. Therefore, the current flow through the screen grid is high and the grid laterals of the screen grid become sufficiently hot to expand beyond their elastic limits. As the grid wires expand, they move farther from the control grid, whereupon the current flow via the screen grid and the potentiometer **102** diminishes. When low enough, the negative bias on the grid of the gas filled tube decreases and the tube fires and conducts until the next index of the bar. Firing of the tube **104** will cause current to flow through the relay coil **64** thereby throwing the movable arm **76** and **78** against the back fixed contacts **66** and **68** and the current flow through the tube **28** is directed via the anode and screen grid tied together as one unit. Also the control grid of the tube **28** is connected to the ground, imposing a negative bias on the grid of the tube under test via the lower part of potentiometer **102**, thereby limiting anode current through the tube. This controlled and lower value current is well below the current value which would cause further expansion of the screen grid and therefore no further permanent deformation of the grid will occur.

If a tube initially, with the circuit in the position shown in Fig. 5, should exhibit low screen grid current characteristics, the gas filled tube **104** will fire immediately and no permanent deformation of the screen grid will take place. Thus each tube **28** on a bar will be individually treated as the bars are indexed, to bring the conductivity of the individual tubes down to a substantially common level.

Although the invention has been illustrated as applied to the deformation of a screen grid, it is obvious that, instead, other electrodes may be deformed to secure the results desired. Also the current detecting means need not necessarily be a gas filled tube since contact making meters and other than gas filled grid controlled tubes can be used as well, as triodes with A.C. supply to the anode. Nor need the detecting mechanism be confined to the cathode circuit since it could be placed in any tube circuit where current flow varries with electrode deformation.

What is claimed as new is:

1. In a machine for aging electron tubes having a cathode, control grid, screen grid and anode, the combination comprising a conveyor frame, an indexible conveyor on the frame, bars carried by the conveyor and tube sockets for said tubes on each bar, contacts on each bar wired to individual contacts in the tube sockets, contacts mounted on the conveyor frame, one for each contact on the bars at each of a multiplicity of positions of the bars, said frame mounted contacts being connected individually to individual sources of voltage, the contacts on the frame at one position of the bars leading to relay mechanism, switching means forming part of said mechanism for normally establishing a current flow from screen grid to cathode within tubes in the sockets, said relay mechanism having a circuit element through which tube current flows and responsive to the magnitude of said current to switch the current so that it flows via the anode and screen grid to the cathode of the tube.

2. In a machine for aging electron tubes having a cathode, control grid, screen grid and anode, the combination comprising a conveyor frame, an indexible conveyor on said frame, bars carried by the conveyor and tube sockets for said tubes on each bar, contacts on each bar wired to individual contacts in the tube sockets, contacts mounted on the conveyor frame, one for each contact on the bars at each of a multiplicity of positions of the bars, said frame mounted contacts being connected individually to individual sources of voltage, the contacts on the frame at one position of the bars leading to relay mechanism, switching means forming part of said mechanism for normally establishing a current flow from screen grid to cathode within tubes in the sockets, said relay mechanism comprising a coil responsive to the magnitude of said current flow and operative upon an armature having contacts, said contacts in one position of the armature connecting the screen grid to an idle contact and in another position of the armature connecting the screen grid to the anode.

3. In a machine for aging electron tubes having a cathode, control grid, screen grid and anode, the combination comprising a conveyor frame, an indexible conveyor on said frame, bars carried by the conveyor and tube sockets for said tubes on each bar, contacts on each bar wired to individual contacts in the tube sockets, contacts mounted on the conveyor frame, one for each contact on the bars at each of a multiplicity of positions of the bars, said frame mounted contacts being connected individually to individual sources of voltage, the contacts on the frame at one position of the bars leading to relay mechanism, switching means forming part of said mechanism for normally establishing a current flow from screen grid to cathode within tubes in the sockets, said relay mechanism comprising a coil responsive to the magnitude of said current flow and op-

erative upon an armature having two contacts, one of said contacts in a first position of the armature connecting the screen grid to an idle contact and in a second position of the armature connecting the screen grid to the anode, the other of said contacts in said first position connecting the control grid to the cathode and in said second position connecting the control grid to a negative voltage with respect to the cathode.

4. In a machine for aging electron tubes having a cathode, control grid, screen grid and anode, the combination comprising a conveyor frame, an indexible conveyor on said frame, bars carried by the conveyor and tube sockets for said tubes on each bar, contacts on each bar wired to individual contacts in the tube sockets, contacts mounted on the conveyor frame, one for each contact on the bars at each of a multiplicity of positions of the bars, said frame mounted contacts being connected individually to individual sources of voltage, the contacts on the frame at one position of the bars leading to relay mechanism, switching means forming part of said mechanism for normally establishing a current flow from screen grid to cathode within tubes in the sockets, said relay mechanism comprising a coil in series with a self biasing grid controlled tube having a resistor in its grid circuit, an armature controlled by the coil, a contact movable with the armature in a first position to tie together the screen grid of the tube being aged and its associated anode and in a second position to disconnect the two, a second contact movable with the armature which in said first position connects the control grid of the tube being aged directly with its associated cathode and in the second position interposes at least a portion of the resistor into the said direct connection.

5. In a machine for aging electron tubes having a cathode, control grid, screen grid and anode, the combination comprising a conveyor frame, an indexible conveyor on said frame, bars carried by the conveyor and tube sockets for said tubes on each bar, contacts on each bar wired to individual contacts in the tube sockets, contacts mounted on the conveyor frame, one for each contact on the bars at each of a multiplicity of positions of the bars, said frame mounted contacts being connected individually to individual sources of voltage, the contacts on the frame at one position of the bars leading to relay mechanism, a coil and switching means forming part of said relay mechanism for normally establishing a current flow from screen grid to cathode within tubes in the sockets, said relay mechanism including a source of D.C. voltage, a relay having a first, idle, front contact and a second front contact connected to the cathode of the tube, a third, back contact connected to the source of D.C. voltage and to the screen grid, a fourth, back contact connected to ground and an armature having two poles a first one of which is movable between the first and third contacts and the second one of which is movable between the second and fourth contacts, said first pole

being connected to the anode and the second pole to the control grid, a grid controlled gas filled tube in series with the coil, means to break the current flow through the gas filled tube, said gas filled tube having a resistance in series with the cathode and ground and biasedly connected at a non cathode connected portion of the resistance with its control grid, and a connection between the resistance intermediate of its length and the second front contact.

6. In a machine for aging electron tubes having a cathode, control grid, screen grid and anode, the combination comprising a conveyor frame, an indexible conveyor on said frame, bars carried by the conveyor and tube sockets for said tubes on each bar, contacts on each bar wired to individual contacts in the tube sockets, contacts mounted on the conveyor frame, one for each contact on the bars at each of a multiplicity of positions of the bars, said frame mounted contacts being connected individually to individual sources of voltage, the contacts on the frame at one position of the bars leading to relay mechanism, switching means forming part of said mechanism for normally establishing a current flow from screen grid to cathode within tubes in the sockets, said relay mechanism comprising a coil responsive to the magnitude of said current flow and operative upon an armature having contacts, said contacts in one position of the armature connecting the screen grid to an idle contact and in another position of the armature connecting the screen grid to the anode, said screen grid, in both positions of the armature, being connected to a source of potential.

7. A system for controllably aging electron tubes having a cathode, a control grid, a screen grid and an anode, said system including a source of D.C. voltage, a relay having a coil, a first, idle, front contact and a second, front contact connected to the cathode of the tube, a third, back contact connected to the source of D.C. voltage and to the screen grid, a fourth, back contact connected to ground and an armature having two poles a first one of which is movable between the first and third contacts and the second one of which is movable between the second and fourth contacts, said first pole being connected to the anode and the second pole to the control grid, a grid controlled gas filled tube in series with the coil, means to break the current flow through the gas filled tube, said gas filled tube having a resistance in series with the cathode and ground and biasedly connected at a non cathode connected portion of the resistance with its control grid, and a connection between the resistance intermediate of its length and the second, front contact.

References Cited in the file of this patent

UNITED STATES PATENTS

2,435,475	Stromeyer	Feb. 3, 1948
2,773,731	Chick et al.	Dec. 11, 1956
2,804,365	Flowers	Aug. 27, 1957