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(54) Aging process for cathode ray tubes.

(57) An improved aging process for a cathode ray tube in which the main focusing grid (G3) is aged at a potential below that of the G2 grid, resulting in significantly reduced incidence of dark center cathode. In a typical example of the process the G3 grid is at a voltage of at least 100 volts, which voltage is at least 50 volts less than the G2 grid voltage.

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Improved aging process for cathode ray tubes.

This invention relates to the aging of cathode ray tubes, and more particularly relates to an improved aging process in which dark center cathodes caused by the aging of the focusing electrode are substantially reduced.

In the manufacture of cathode ray tubes for television and other display applications, various tube processing steps are carried out to ensure an acceptable life of reliable operation in the field. This processing begins after assembly of the tube components, and includes: exhausting and baking the tube to evacuate the envelope and outgas the tube components; flashing a getter onto the internal surfaces of the tube and components to provide continuous gettering of residual contaminants which are outgassed during tube operation; activating the cathodes of the electron gun by heating to promote the formation of low work function species in the emission layer; aging the cathode and lower grid elements of the gun to maintain cathode activation; and finally high voltage conditioning of the electron gun to remove particles and projections which could lead to interelectrode arcing.

The rate of outgassing is time and temperature dependent, and the throughput demands of the manufacturing process as well as the limited thermal stability of certain tube components make complete outgassing during exhausting and baking impractical. Thus, some residual gas and gas-producing contaminants, such as hydrocarbons, remain in the tube after sealing of the exhaust tubulation.

Getter flashing usually introduces additional hydrocarbon contaminants into the tube. These hydrocarbons cannot be effectively adsorbed by the non-bakable barium getters commonly employed in many types of colour television picture tubes. However, during subsequent aging, these hydrocarbons are dissociated into getterable components, resulting in the reduction of residual gas in the tube to acceptable levels.

Unfortunately, the aging process has also been found to result in a condition known as "dark center cathode", which by analysis has been found to be due to a carbon deposit in the center of the emissive layer of the cathode. Surprisingly, this deposit does not materially reduce cathode emission. However, it does restrict emission to the area of the perimeter of the emissive layer, resulting in a hollow beam which interferes with proper focusing and image resolution at the screen.

In U.S. Patent Specification 4,457,731, the dark center cathode problem is addressed for reprocessed cathode ray tubes. Tubes rejected for gun-related defects can be salvaged by "regunning", that is replacing the defective gun with a new one. Since this regunning operation necessarily reopens the envelope to the ambient, the tube must be reprocessed. This patent specification teaches that dark center cathodes can be substantially reduced by flashing the getter after aging, so-called "post-flashing". However, when post-flashing is practiced on virgin tubes, unacceptably high gas levels result.

An object of this invention is to reduce the incidence of dark center cathodes in a manner which does not result in unacceptably high gas levels.

Another object of this invention is to age a cathode ray tube after sealing and getter flashing without producing dark center cathodes, and simultaneously reduce residual gas to an acceptable level.

According to the present invention there is provided a process for aging a cathode ray tube after the tube has been evacuated, sealed and getter flashed, and the cathode has been activated; the process comprising applying predetermined voltages to the cathode heaters and G1 grid of the tube's electron gun, so as to result in the emission of electrons from the cathodes, and then sequentially adding predetermined voltages to the G2 and G3 grid electrodes of the gun, respectively, the G2 and G3 grid voltages being larger than the cathode and G1 grid voltages; characterized in that the G3 grid voltage is smaller than the G2 grid voltage.

In accordance with the invention, it has been discovered that the successively higher voltages impressed on the G1, G2 and G3 grids during aging results in the focusing of the electrons emitted from the cathodes into an electron beam which dissociates residual hydrocarbons present in the tube after exhausting, baking and getter flashing, and that such dissociation results in the formation of a beam of positive carbon ions which travel in the reverse direction from the electron beam and are deposited on the cathode.

It has further been discovered that reducing the potential of the G3 grid during aging to a critical level above a threshold needed for effective aging of this grid, but sufficiently below the potential of the G2 grid to create a potential barrier to prevent the positive beam from reaching the cathode, significantly reduces the incidence of dark center cathodes while substantially retaining the benefits of G3 aging.

In an embodiment of the process in accordance with the present invention, the G3 grid electrode is at least 100 volts, and at least 50 volts less than the G2 grid electrode.

In another embodiment of the process in accordance with the present invention, the G2 and G3 grids are connected to the same potential source, and the lower G3 grid potential is achieved by inserting a resistor between these two electrodes.

The present invention will now be explained and described, by way of example, with reference to the accompanying drawings, wherein:

Fig. 1 is a partial cross-section view of a sealed and getter flashed cathode ray tube to be aged in accordance with the process of the invention;

Fig. 2 is a partial cross-section of the neck portions of the cathode ray tube of Fig. 1, showing the cathode and grid elements of a bipotential electron gun to be aged in accordance with the process of the invention;

Fig. 3 is a view similar to that of Fig. 2, showing the elements of a quadripotential electron gun to be aged in accordance with the process of the invention;

Fig. 4 is a graph of time in minutes versus potential in volts for a typical cathode activating and tube aging schedule of the prior art;

Fig. 5 is an enlarged plan view of a dark center cathode resulting from the prior art aging schedule of Fig. 4;

Fig. 6 is a graph of time in minutes versus potential in volts for a typical cathode activating and tube aging schedule of the invention;

Fig. 7 is a schematic diagram of a prior art arrangement for achieving the schedule of Fig. 4; and

Fig. 8 is a schematic diagram of an arrangement of the invention for achieving the schedule of Fig. 6.

With reference to the drawings, Fig. 1 is a sectioned view showing the essential elements of a plural beam in-line colour cathode ray tube 11 aged in accordance with the process of the present invention. Cathode ray tube 11 is oriented to have a central longitudinal axis 14 and X and Y axes normal to axis 14. The encompassing tube envelope is a glass structure comprised of a hermetically sealed integration of neck 13, funnel 15 and viewing panel 17 portions. Disposed on the interior surface of the viewing panel is a patterned cathodoluminescent screen 19 of stripes or dots of colour-emitting phosphor materials. A multi-opening structure 21, in this instance an apertured mask, is positioned within the viewing panel in spaced relationship to the patterned screen 19. Encompassed within the neck portion 13 of the envelope is a unitized plural-beam in-line electron gun assembly 23, from which emanate three electron beams, a center beam 25 and two side beams 27 and 29 in a common in-line plane. These beams are directed and focused to traverse the apertured mask 21 and converge at screen 19 to excite the colour-emitting phosphors.

The exterior surface of the tube has an electrically conductive coating 31, applied to the forward region of the funnel 15, and maintained at ground potential during tube usage.

The plural gun assembly 23 is positioned within the neck portion 13 in a manner whereby the three in-line beams 27, 25 and 29 are in a common horizontal "in-line" plane substantially coincident with the X axis of the tube. The gun assembly is a longitudinal construction of a plurality of spatially-related unitized in-line apertured electrode members. The electrodes are positioned in a spaced, sequential arrangement forward of individual electron emitting cathode elements to form, focus and accelerate each of the individual electron beams. The assembly is forwardly terminated by a convergence cup 39, and the whole structure is integrated by at least two oppositely disposed insulative multiform members, only one of which, 41, is shown. A getter container 35 is supported by a wand 37 attached to a convergence cup 39. A thin layer of getter material, not shown, was flashed from container 35 by induction heating, and covers portions of the inner surface of the envelope, mask and other tube components.

In Fig. 2, a unitized bi-potential electron gun assembly comprises a plurality of unitized in-line apertured electrode members sequentially positioned forward of individual cathode elements, K_1, K_2, K_3. The bi-potential electrode arrangement includes an initial beam forming grid G1, and initial beam accelerating grid G2, a main focusing grid G3 having a longitudinal dimension defined by rearward and forward apertured ends and a final accelerating grid G4.

In Fig. 3, a unitized quadri-potential in-line gun assembly has a plurality of electrodes positioned forward of individual cathode elements K_1, K_2, K_3, including an initial beam forming grid G1, an initial beam accelerating grid G2, a first high focusing grid G3, a low focusing grid G4 electrically connected to the G2 grid, a second high focusing grid G5 electrically connected to the G3 grid, and a final accelerating grid G6. Each of the G3, G4 and G5 grids has a longitudinal dimension defined by forward and rearward apertured ends.

It is a standard practice in the manufacture of cathode ray tubes to subject the cathodes and lower grid elements of the electron gun to an aging treatment subsequent to exhausting, baking, sealing and getter flashing the tube. Such aging takes place immediately after the cathodes are activated, and prior to high voltage conditioning. Aging has at least two objectives in addition to preparing the emission layer itself, both of which are directed to maintaining cathode activation and thereby insuring adequate electron emission from the cathodes.

The first object of aging is to "condition" the surfaces of the adjacent grid elements, that is, heat the grids to remove particles, adsorbed gases and other residue which are potential sources of cathode contamination.

The second object of aging is to convert residual gases, mainly hydro-carbons, into getterable species. This is done by selecting the voltages on the cathode and various grid elements so as to result in an electron beam of sufficient energy to dissociate these residual gas molecules into smaller components.

A typical prior art schedule for activating the cathodes and aging the tube for a 19V mini-neck colour picture tube having a quadripotential focus electron gun is illustrated graphically in Fig. 4. Heater filament and G1, G2 and G3 grid potentials, expressed in volts and designated E_F, EG1, EG2 and EG3, respectively, are plotted versus time in minutes. As can be seen from the graph, the heater filaments are initially subjected to a relatively low potential (E_F) of about 6.5 volts for about 1 minute to preheat the cathodes, and then the heater voltage is raised to about 9.5 volts for about 1 minute to activate the cathodes. Aging begins immediately after activation. A voltage of about 8.5 volts is maintained on the cathode heater filaments throughout the 33 minute aging cycle. At the start of aging, the G1 grid is subjected to a slightly lower potential of about 8 volts. After about 4 minutes, the G1 grid potential is increased to about 15 volts, and the G2 grid is subjected to a substantially higher potential of about 300 volts. After another 4.5 minutes the G2 potential is increased to 350 volts, and 11 minutes after the EG1 is reduced to 10 volts. At this time, about 19 minutes after the start of aging, the G3 grid is subjected to a potential of about 350 volts for about 13 minutes.

E_F is maintained for about 1 minute after EG1, EG2 and EG3 have been turned off, and is subsequently reapplied for an additional two minutes to insure against the formation of detrimental deposits on the cathodes from the grids, and to further reduce any contaminants on the cathode surface.

An arrangement for achieving the above activating and aging schedule is shown schematically in Fig. 7, wherein potential source E_F supplies the cathode heater filaments, source EG1 supplies the grid G1 and source EG2 supplies both the G2 and G3 grids. The actual potential values for each gun element being aged are controlled by the values of the resistors. Typical values for resistors RK1-3, for example, are 150 ohms each, for RG1, 100 ohms, and for RG2, 5000 ohms. Since there is no resistor between G2 and G3, these grids are subjected to the same potential.

As has already been explained, when the G3 grid is subjected to a potential similar to that of G2, the positively charged carbon particles resulting from the dissociation of residual hydrocarbons are formed into a beam and directed back onto the cathodes, forming dark center cathodes similar to that illustrated in Fig. 5, wherein cathode 90 includes carbon deposit 92 in the center of emissive layer 94. In order to avoid such detrimental deposits, the potential of the grid G3 must be lowered to create a barrier to the positively charged particle beam.

However, lowering the potential of the grid G3 too far can have at least two adverse effects. First, it reduces the effectiveness of gas dissociation, by reducing the energy of electron beam. Second, it reduces the effectiveness of G3 grid conditioning, by reducing the temperature produced by energy dissipation in the grid. Both residual gas and contaminants on the G3 grid can find their way to the cathodes during later tube operation, reducing emission and consequently shortening tube life.

In order to avoid these disadvantages, it is necessary to maintain the G3 potential within a critical range during aging, high enough to provide effective gas dissociation and conditioning, but low enough to provide a barrier to the deposition of carbon on the cathodes. In this regard, it has been determined that the G3 potential should be at least 100 volts, and at least 50 volts below the G2 potential, and preferably at least 150 volts and at least 100 volts below the G2 potential.

In order to demonstrate the advantages of the invention, an illustrative example is presented. Three sets of samples of 26V CFF colour picture tubes were divided into two groups. The first group was aged according to a prior art schedule similar to that described above for mini-neck tubes, and the second group was aged according to a schedule of the invention, depicted in Fig. 6. The samples were then compared for emission, dark center cathodes and emission slump.

Arrangements similar to those shown in Figs. 7 and 8 were used. In the prior art aging, (Fig. 7) the values of EG2 and RG2 were 600 volts and 5000 ohms, respectively, resulting in potentials of 515 volts at both the G2 and G3 grids. The currents flowing to the G2 and G3 grids were 0.8 and 17 milliamps, respectively.

In the aging schedule of the process in accordance with the invention, EG2 was reduced to 400 volts, and a 5000 ohm resistor (RG3 in Fig. 8) was inserted into the circuit between the grids G2 and G3, resulting in potentials of 325 and 255 volts at the grids G2 and G3, respectively. The currents flowing to the grids G2 and G3 were 0.5 and 15 milliamps, respectively.

Results are shown in the Table below.

TABLE

	Cathode Emission Electron Volts						Appearance of Cathode Centers	Emission Slump (Percent)		
	Red Gun		Green Gun		Blue Gun			Red	Green	Blue
	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s				
Set #1										
Group 1	3438	44	3482	29	3498	39	20 light deposits out of 30	----------		
Group II	3468	40	3453	36	3485	43	1 light deposit out of 36	----------		
Set #2										
Group 1	3391	-	3484	40	3490	35	7 light deposits	8	6	9
Group II	3436	40	3483	21	3471	34	0 out of 33	3	0	7
Set #3										
Group 1	3433	77	3443	73	3412	92	6 heavy deposits, 2 moderate deposits, 12 light deposits out of 33	4	8	8
Group II	3461	32	3462	28	3452	31	2 light deposits out of 33	4	2	2

Emission and emission slump are reported for each of the red, green and blue guns. Emission is reported in microamperes as an average ($\bar{X}$) of 10 to 12 samples, with standard deviations (s). Emission slump is reported as percent decrease in emission after 5 seconds at a filament potential of 5 volts and zero bias. Appearance of the cathodes after aging was visually rated as zero, light, moderate and heavy deposits, and reported without distinction between individual guns.

As can be seen from the results, the aging schedule of the process in accordance with the invention (Group II) resulted in good emission levels, significantly better stability as indicated by lower slump, and substantially reduced incidence of dark center cathodes.

Claims

1. A process for aging a cathode ray tube after the tube has been evacuated, sealed and getter flashed, and the cathode has been activated; the process comprising applying predetermined voltages to the cathode heaters and G1 grid of the tube's electron gun, so as to result in the emission of electrons from the cathodes, and then sequentially adding predetermined voltages to the G2 and G3 grid electrodes of the gun, respectively, the G2 and G3 grid voltages being larger than the cathode and G1 grid voltages; characterized in that the G3 grid voltage is smaller than the G2 grid voltage.

2. A process as claimed in Claim 1, characterized in that the G3 grid voltage is at least 100 volts.

3. A process as claimed in Claim 1 or 2, characterized in that the G3 grid voltage is at least 50 volts less than the G2 grid voltage.

4. A process as claimed in Claim 2, characterized in that the G3 grid electrode is at least 150 volts.

5. A process as claimed in Claim 3, characterized in that the G3 grid voltage is at least 100 volts less than the G2 grid voltage.

6. A process as claimed in Claim 1, characterized in that the heater voltage is within the range of from about 5 to 10 volts.

7. A process as claimed in Claim 1, characterized in that the G1 grid voltage is within the range of from about 5 to 20 volts.

8. A process as claimed in Claim 1, characterized in that the G2 grid voltage is within the range of from about 250 to 400 volts.

9. A cathode ray tube aged by the process as claimed in any one of Claims 1 to 8.

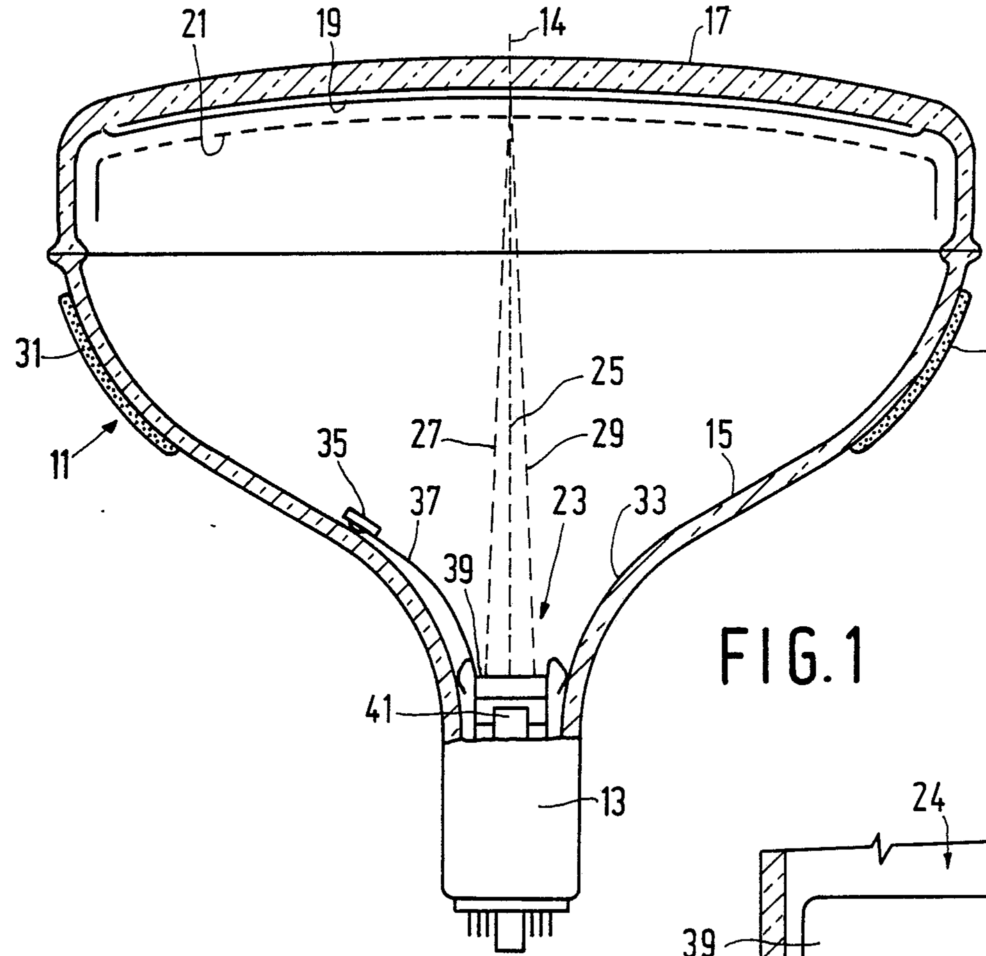

FIG.1

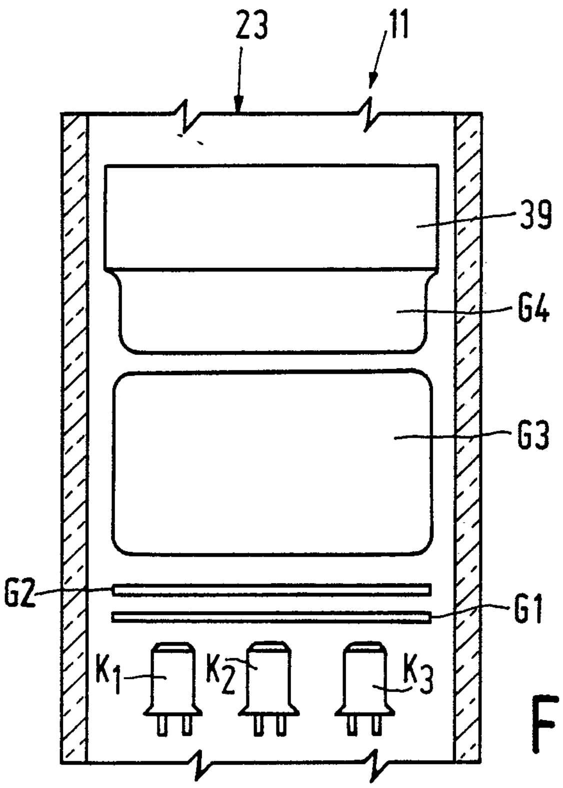

FIG.2

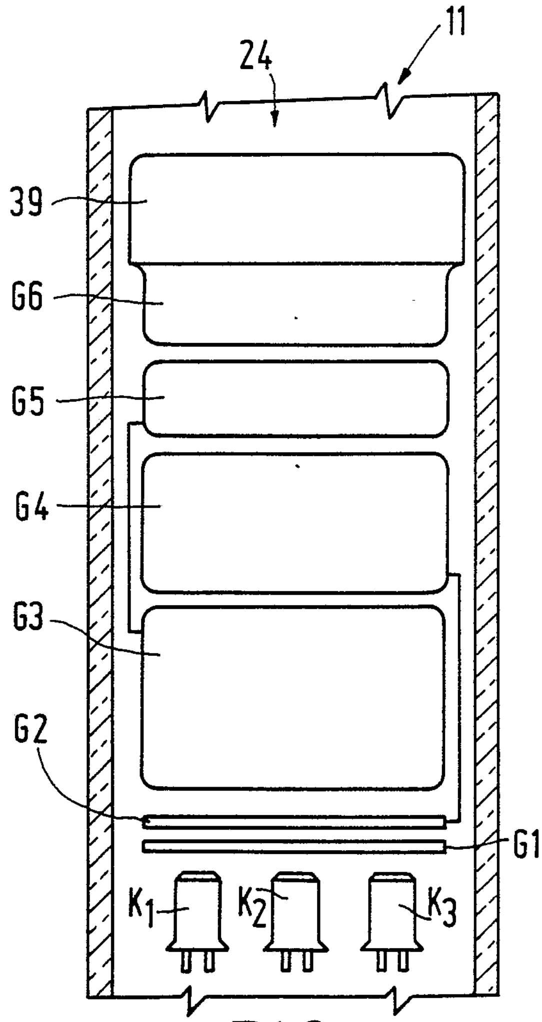

FIG.3

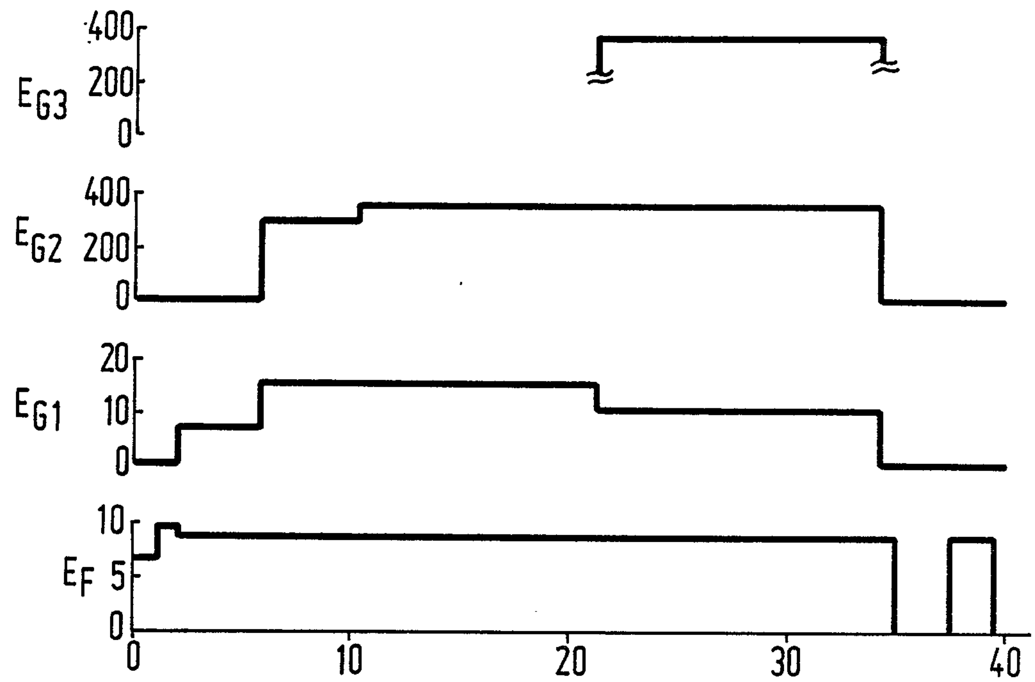

FIG.4

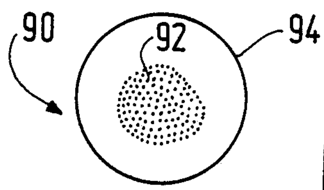

FIG.5

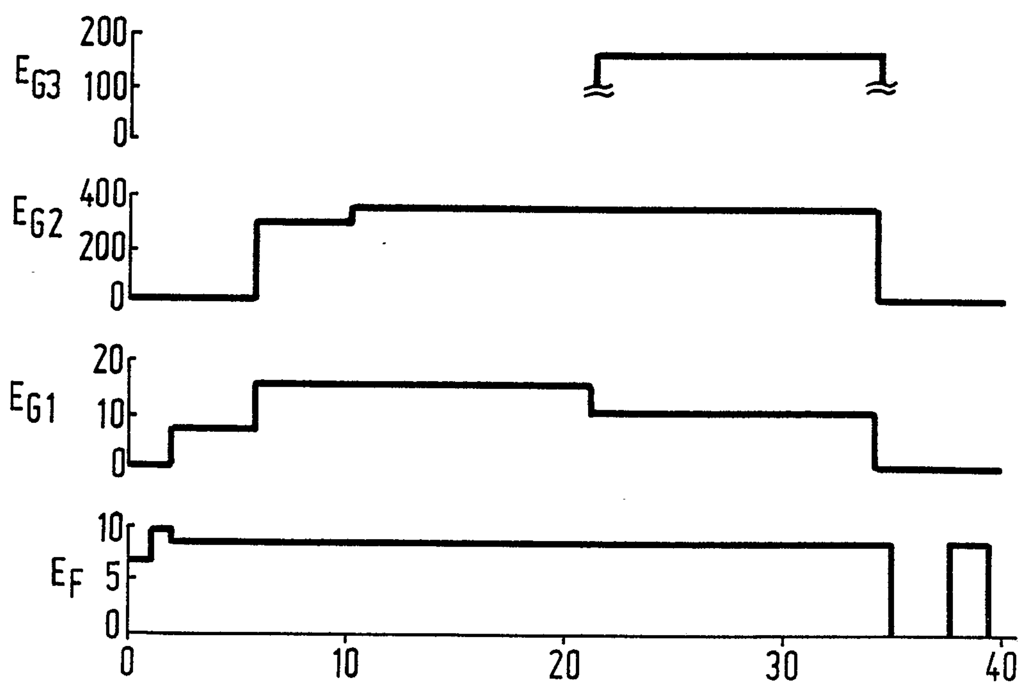

FIG.6

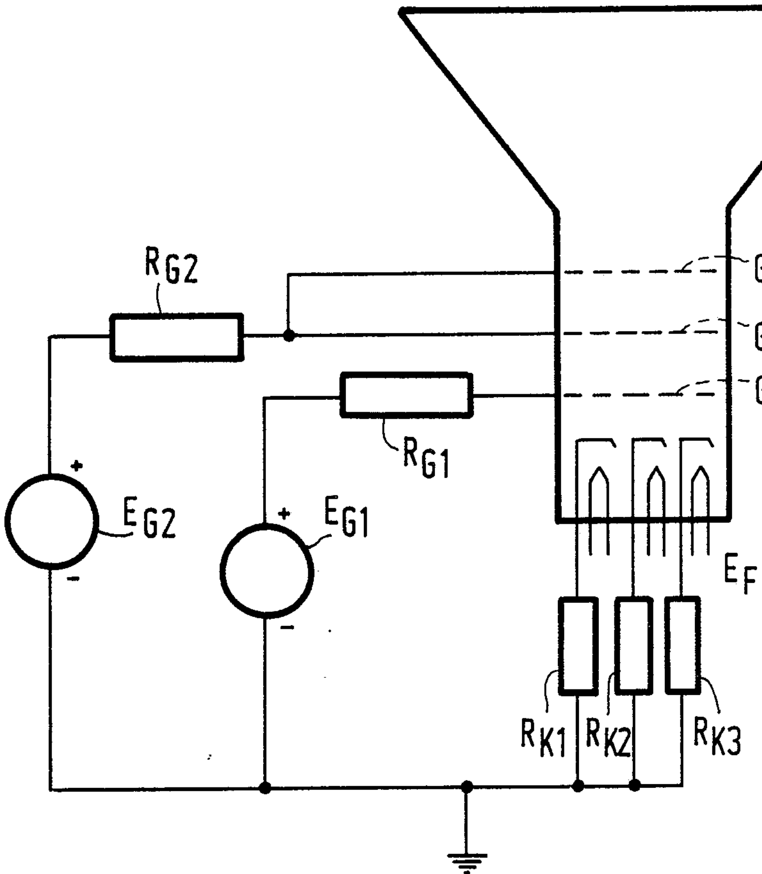
RG2
G3
G2
G1
RG1
EG2
EG1
EF
RK1
RK2
RK3

FIG.7

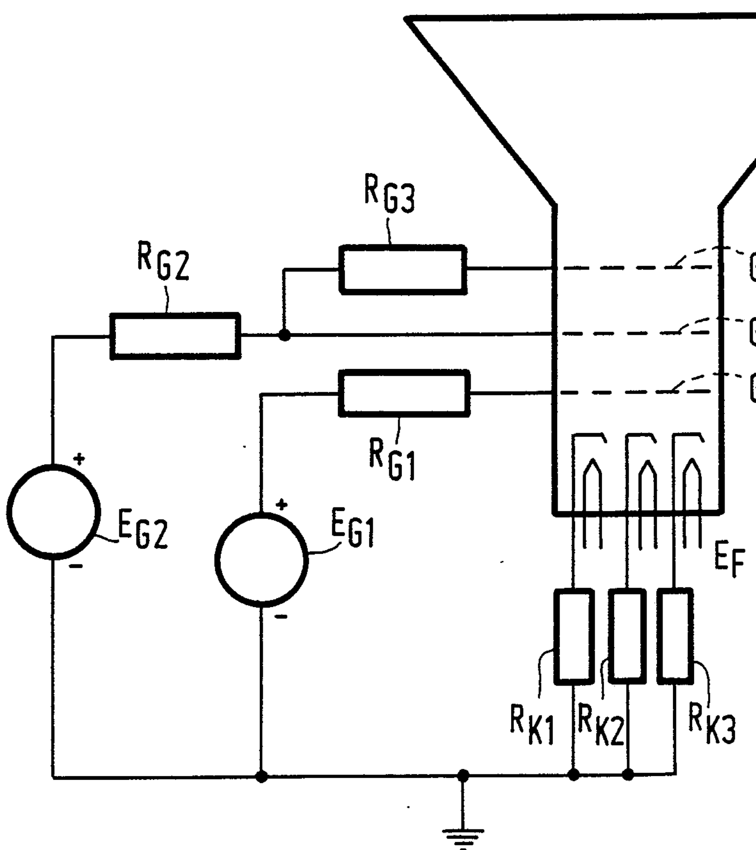
RG3
RG2
G3
G2
G1
RG1
EG2
EG1
EF
RK1
RK2
RK3

FIG.8