(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 178 857**
A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 85307284.1

(51) Int. Cl.[4]: **H 01 J 29/50**

(22) Date of filing: 11.10.85

(30) Priority: 19.10.84 US 662603

(43) Date of publication of application:
23.04.86 Bulletin 86/17

(84) Designated Contracting States:
DE FR GB IT

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(54) **Electron gun.**

(57) An inline electron gun (26:26') for a cathode-ray tube (8) includes an improved beam forming region comprising three cathodes (34), a control grid (36) and a novel screen grid electrode means (38, 38'), the latter comprising two spaced apart metal members (G2a, G2b;G2a',G2b'). In one embodiment (26), the first member (G2a) closest to the control grid is relatively thick and has three slots (52) formed in one surface thereof facing away from the control grid. Circular apertures (54) are formed within the slots and extend through the body of the first member. The second member (G2b) has three circular apertures (56) therethrough aligned with the circular apertures in the first member. When a dynamic signal is superimposed on the DC bias voltage and applied to the second member, the first member shields the control grid from the dynamic signal so that little or no brightness modulation occurs. In a second embodiment (26'), the first (G2a') and second (G2b') members of the screen grid (38') are structurally interchanged. In a third embodiment, the first (G2a) and the second (G2b) members have orthogonally disposed rectangular slots formed in facing surfaces.

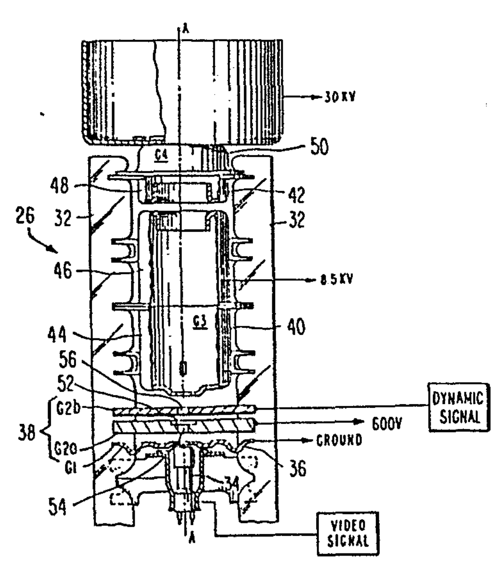

Fig.2

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ELECTRON GUN

The present invention relates to electron guns such as those used in color picture tubes.

There are several different types of electron guns used in color picture tubes. One type of gun presently in wide use is an inline electron gun. An inline electron gun is designed to generate at least two, and preferably three, electron beams in a common plane and to direct the beams along convergent paths to a small area spot on the screen.

There has been a general trend toward inline color picture tubes with greater deflection angles so as to provide shorter tubes. However, in tubes with 110° deflection, it has been found that the electron beams become excessively distorted as they are scanned toward the outer portions of the screen. Such distortions, commonly referred to as flare, appear on the screen of the tube as an undesirable low intensity tail or smear extending from a desirable intense core or spot. Such flare distortions are due, at least in part, to the effects of the fringe portions of the deflection fields of the tube deflection yoke on a beam as it passes through the electron gun, and to the nonuniformities in the yoke deflection fields themselves.

When the yoke's fringe fields extend into the region of the electron gun, as is usually the case, the beams may be deflected slightly off axis and into a more aberrated portion of an electron lens of the gun. The result is frequently a flare distortion of the electron beam spot which extends from the spot toward the center of the screen. This condition is particularly troublesome in tubes having self-converging yokes with a toroidal deflection coil, because of the relatively strong fringe fields of toroidal type coils.

Self-converging yokes are designed to have nonuniform fields in order to increasingly diverge the beams as the horizontal deflection angle increases. These nonuniform fields also cause vertical convergence of the electrons within each individual beam. Thus, the beam spots are vertically overconverged at points horizontally displaced from the center of the screen, causing a vertically extending flare both above and below the beam spot.

The vertical flare due to both the effects of the yoke's fringe fields in the region of the gun and the nonuniform character of the yoke's fields is an undesirable condition which contributes to poor resolution of a displayed image on the screen.

It is known to utilize nonsymmetrical electron gun electrodes to provide an offsetting astigmatism in the electron optics of the gun, to compensate for the above-described flare astigmatism. See, for example, U.S. Patent No. 4,234,814, issued to Chen and Hughes on November 18, 1980, which describes a screen grid electrode having an aperture of rectangular cross-section facing backward toward the cathode and of circular cross-section facing forward toward the screen. This astigmatic screen grid is of one piece, electrically speaking, and is energized during tube operation with a fixed DC bias voltage. While this gun does reduce flare astigmatism to a degree sufficient for some tubes, still further correction is desirable for other tubes, particularly very wide angle deflection tubes, especially where they are to be used to display printed matter near the corners of the screen.

It also is known to provide a two-part screen grid electrode comprising a first apertured plate having an elongated aperture extending through the first plate and a second plate having a circular aperture therethrough. Such a structure is disclosed in U.S.

Patent No. 4,319,163, issued to Chen on March 9, 1982. In operating this gun, the second plate is energized with a DC bias voltage, and the first plate is energized with a DC bias voltage superimposed with a dynamic signal synchronized with the horizontal and/or vertical deflection signals. One drawback of this design is that, unless the modulation voltage is very small, the brightness of the tube also is modulated by the dynamic voltage applied.

U.S. Patent No. 4,443,736, issued to Chen on April 17, 1984, discloses a screen grid electrode structure including three stacked apertured metal plates separated from each other by two electrically insulating members. The two outside plates have three inline apertures and the center plate has at least one elongated aperture effectively extending at least to the outer edges of the two outer apertures of the outside plates. In this electron gun, the two outer plates are electrically connected to screen grid potential and a dynamic signal is superimposed on the DC voltage applied to it. The outside plate adjacent to the control grid electrode helps to minimize the brightness modulation of the tube; however, in the patented structure, a brightness variation within the range of 20 to 30 percent occurs. In order to reduce the brightness modulation further, it is necessary to apply counter-modulation to the cathode. The three plate structure also provides difficulty during the beading operation, because of the close spacing required between adjacent metal plates.

Accordingly, it is desirable to provide an electron gun that has a screen grid structure that is suitable for utilization with a dynamic voltage to reduce the problem of flare, and which is easier to fabricate but provides at least the same or better brightness modulation than prior art gun structures.

In accordance with the present invention, an inline electron gun for a cathode-ray tube includes an improved beam forming region and beam focusing electrodes. The improved beam forming region comprises a plurality of cathodes, a control grid and a novel screen grid electrode means spaced apart in the order named. The screen grid electrode means has two spaced apart metal members, at least one of which includes a plurality of elongated rectangular slots formed in one surface thereof. The slots have a depth less than the thickness of the member and face the other member. A plurality of circular apertures that communicate with the slots and extend through the member are formed therein.

In the drawings:

FIGURE 1 (SHEET 1) is a schematic elevation view, partially in axial section, of a cathode-ray tube embodying the novel electron gun.

FIGURE 2 (SHEET 1) is a longitudinal elevation, partially in section, of one embodiment of the novel electron gun of FIGURE 1.

FIGURE 3 (SHEET 3) is a plan view of one grid member of the screen grid electrode of the electron gun of FIGURE 2.

FIGURE 4 (SHEET 2) is a schematic illustrating one set of typical waveforms of signals used in operating the novel electron gun.

FIGURE 5 (SHEET 2) indicates the relative position on the screen of the tube for corresponding points in the signal waveform of FIGURE 4 applied to the screen grid electrode.

FIGURE 6 (SHEET 2) is a schematic illustrating another set of typical waveforms of signals used in operating the novel electron gun.

FIGURE 7 (SHEET 2) indicates the relative position on the screen of the tube for corresponding points in the signal waveform of FIGURE 6 applied to the screen grid electrode.

FIGURE 8 (SHEET 3) is a longitudinal elevation, partially in section, of a second embodiment of the novel electron gun of FIGURE 1.

FIGURE 9 (SHEET 3) is a plan view of the two superimposed grid members of the screen grid electrode, the grid members having orthogonally disposed slots.

FIGURE 1 shows a color picture tube 8 having a glass envelope 10, comprising a rectangular faceplate panel or cap 12 and a tubular neck 14 connected by a rectangular funnel 16. The panel 12 comprises a viewing faceplate 18 and a peripheral sidewall 20 which is sealed to the funnel 16. A mosaic three-color phosphor screen 22 is carried by the inner surface of the faceplate 18. The screen 22 is preferably a line screen with the phosphor lines extending substantially perpendicular to the high frequency raster line scan of the tube (i.e., normal to the plane of FIGURE 1). A multiapertured color selection electrode or shadow mask 24 is removably mounted, by known means, in predetemined spaced relation to the screen 22. An improved inline electron gun 26, shown schematically by dashed lines in FIGURE 1, is centrally mounted within the neck 14 to generate and direct three electron beams 28 along coplanar convergent paths through the mask 24 to the screen 22.

The tube of FIGURE 1 is designed to be used with an external magnetic deflection yoke, such as the yoke 30 schematically shown surrounding the neck 14 and funnel 16 in the neighborhood of their junction. When activated, the yoke 30 subjects the three beams 28 to vertical and horizontal magnetic fields which cause the beams to scan horizontally and vertically, respectively, in a rectangular raster over the screen 22. The initial plane of deflection (at zero deflection) is shown by the line P-P in FIGURE 1 at about the middle of the yoke 30. Because of fringe fields, the zone of deflection of the tube extends axially, from the yoke 30 into the region of the gun 26. For simplicity, the actual curvature of the deflected beam paths in the deflection zone is not shown in FIGURE 1. One example of a magnetic deflection yoke 30 is a saddle-toroid type (ST yoke), such as described in

U.S. Patent No. 4,143,345, issued to Barkow on March 6, 1979.

Except for the modifications described below, the electron gun 26 may be of the three beam inline type similar to those described in the above-cited U.S. Patent Nos. 4,234,814, 4,319,163 and 4,443,736, or to the inline, extended focus lens type described in U.S. Patent No. 4,370,592, issued to Hughes on January 25, 1983. These patents disclose modified versions of the electron gun described in U.S. Patent No. 3,772,554, issued to Hughes on November 13, 1973.

Details of the electron gun 26 are shown in FIGURES 2 and 3. The gun comprises two glass support rods 32 on which the various electrodes are mounted. These electrodes include three equally spaced inline cathodes 34 (one for each beam, but only one of which is shown), a control grid electrode 36 (G1), an improved screen grid electrode means 38 (G2a,G2b), a first main focus lens electrode 40 (G3), and a second main focus lens electrode 42 (G4), spaced along the glass rods 32 in the order named. Each of the G1, the G4 and both ends of the G3 electrodes has three inline apertures therein to permit passage of three coplanar electron beams 28. The construction of the screen grid electrode means 38 is described below. The main electrostatic focusing lens in the gun 26 is formed between the G3 electrode 40 and the G4 electrode 42. The G3 electrode 40 is formed with two cup-shaped elements 44 and 46, the open ends of which are attached to each other. Although the G3 electrode 40 is shown as a two-piece structure, it could be fabricated from any number of elements, including a single element of the same length. The G4 electrode 42 also is formed by two cup-shaped elements, 48 and 50, attached together at their open ends. Furthermore, although the main focus lens is shown as being formed by two electrodes, it could be formed by three, four or more electrodes (in which case the voltages applied would be different than shown).

The portion of the electron gun 26 comprising the cathodes 34, the control grid electrode 36 and the screen grid electrode means 38 is known as the beam forming region of the gun. The beam forming region generates electrons and forms them into beams having crossovers in the vicinity of the screen grid electrode means 38. The main focus lens electrodes 40 and 42 comprise the beam focusing region of the gun. The beam focusing region establishes an electrostatic focusing field for focusing the electron beams to image the crossovers on the screen.

A first embodiment of the improved screen grid electrode means 38 includes two spaced apart metal members G2a and G2b. The first metal member G2a, located adjacent to the control grid 36 (G1), comprises a substantially flat plate having a thickness of about 0.51 mm (20 mils). As shown in FIGURE 3, three substantially identical horizontally disposed slots 52 are formed in one major surface of the first member G2a. The slots 52 are each about 0.71 mm (28 mils) high, 2.03 mm (80 mils) wide, and 0.25 mm (10 mils) deep. A circular aperture 54 is formed within each of the slots 52 and extends through the first member G2a in line with the apertures in the control grid 36 (G1). The three circular apertures 54 have a diameter of 0.635 mm (25 mils). The first member G2a is spaced about 0.229 mm (9 mils) from the control grid 36 (G1). The second metal member G2b has a thickness of about 0.13 mm (5 mils) and is spaced about 0.13 mm (5 mils) from the first member G2a. The second member G2b has three circular apertures 56 therethrough which have a diameter of 0.635 mm (25 mils) and are aligned with the circular apertures 54 in the first member G2a.

As shown in FIGURES 4 and 5, in the operation of the electron gun 26, the G2a first member has a DC bias voltage applied thereto to control beam cutoff. The G2b second member has a vertical and horizontal deflection related composite dynamic signal superimposed on a DC voltage applied to it. This dynamic signal modulates the beam cross sectional shape according to the deflection, thereby compensating for the above-mentioned flare. The dynamic signal applied to the G2b member, in combination with the horizontally disposed slots 52 in the G2a member, improve the corner brightness to compensate for the reduction in edge transmission loss caused by the shadow mask 24.

The dynamic modulation voltage electrically varies the asymmetric slot lens strength between the first member G2a and the second member G2b of the screen grid electrode means 38, and hence also improves corner resolution without reducing center resolution. The first member G2a, which has a thickness of about four times the second member G2b, shields the dynamic signal from the area of the control grid 36 (G1), so that brightness modulation or fluctuation is reduced to about 3 percent as compared with about 20 to 30 percent in the above-cited U.S. Patent No. 4,443,736. The low level of brightness modulation obtained in the present structure eliminates the need for counter-modulation of the cathode as required in some prior art electron guns utilizing a dynamic modulation voltage on the screen grid. The present structure is economical in that it is compatible with standard electron gun fabrication processes.

Alternatively, the slots in the G2a member can be vertically disposed, in which case waveforms such as those shown in FIGURE 6 can be applied to the G2b member. The corresponding points on the screen of the tube are shown in FIGURE 7.

A second embodiment of a novel electron gun 26' is shown in FIGURE 8. The gun 26' is similar to electron gun 26 described herein and differs only in that the locations of the screen grid elements are interchanged. In electron gun 26', the screen grid electrode means 38' includes a first metal member G2a' and a spaced apart second metal member G2b'. The first member G2a' is an essentially flat plate having a thickness of about 0.38 mm (15 mils) with three circular inline apertures 60 therethrough. Each of the apertures 60 has a diameter of 0.635 mm (25 mils) and is aligned with one of the apertures in the control grid 36 (G1). The second member G2b' has a thickness of about 0.30 mm (12 mils) and has three horizontally disposed slots 62 formed therein. The slots 62 are identical in dimensions to the slots 52 described above; however, in the gun 26', the slots 62 face the first member G2a' of the screen grid electrode means 38'. The circular apertures 64 are also 0.635 mm (25 mils) in diameter and are aligned with the apertures 60 in the first member G2a'.

As described above, the dynamic signal voltage is applied to the second member G2b'. With the relatively thin first member G2a', some brightness modulation, on the order of 20 to 30 percent, will occur. However, this can be compensated for by applying a counter-modulation to the cathode 34, or it can be minimized by incresing the thickness of the first member G2a' to shield the control grid 36.

It is also within the scope of this invention to slot both the first and second members of the screen grid electrode means 38. Such a structure is shown in FIGURE 9. The slots are formed in facing surfaces of the screen grid members G2a and G2b, and the slots, shown in phantom, are orthogonally disposed in the vertical and horizontal planes.

CLAIMS

1. An inline electron gun (26;26') for use in a cathode-ray tube (8), said gun including in spaced relation, in the order named, a plurality of cathodes (34), a control grid (36), screen grid electrode means (38;38'), and at least two main focus lens electrodes (40;42); characterized in that said screen grid electrode means includes two spaced apart metal members (G2a,G2b;G2a',G2b'), at least one of said members (G2a;G2b') having a plurality of elongated rectangular slots (52;62) formed in one surface thereof, said slots having a depth less than the thickness of said member and facing the other of said members (G2b;G2a'), and a plurality of circular apertures (54;64) that communicate with said slots and extend through said member.

2. The electron gun (26) of Claim 1, wherein said spaced apart members of said screen grid electrode means (38) include a first member (G2a) adjacent to said control grid (36) and a second member (G2b) located between said first member and said main focus lens electrodes (40,42), said first member having said elongated rectangular slots (52) facing said second member.

3. The electron gun (26') of Claim 1, wherein said spaced apart members of said screen grid electrode means (38') include a first member (G2a') adjacent to said control grid (36) and a second member (G2b') located between said first member and said main focus lens electrodes (40,42), said second member having said elongated rectangular slots (62) facing said first member.

4. The electron gun (26;26') of Claim 2 or 3, wherein said rectangular slots (52;62) are elongated in the inline direction of said gun.

5. The electron gun (26) of Claim 2, 3 or 4, wherein said first member (G2a) has a thickness greater than that of said second member (G2b).

6. The electron gun of Claim 5, wherein the said first member (G2a) has a thickness of about 4 times that of the second member (G2b).

7. The electron gun (26;26') of claim 2, 3, 4, 5 or 6 wherein a modulation voltage is applied to said screen grid second member (G2b;G2b').

8. A cathode raytube comprising an electron gun, according to Claim 6, for producing a plurality of electron beams, beam deflection means, and means for applying to the first member (G2a) a dynamic signal which modulates the cross-sectional shape of each electron beam passing through the first member according to the deflection of the beam in the cathode ray tube.

9. The electron gun of Claim 1; wherein each of said metal members (G2a,G2b) of said screen grid electrode means (38) has a plurality of elongated rectangular slots formed in one surface thereof, said slots having a depth less than the thickness of said members and facing the other of said members, and a plurality of circular aperatures (54) being formed in each of said members that communicate with said slots and extend through said members, said slots in one of said members being orthogonal to said slots in the other of said members.

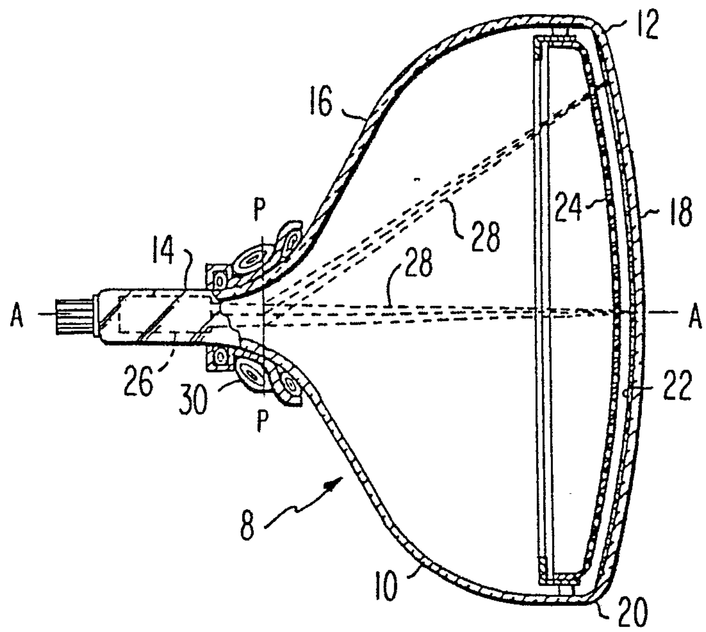
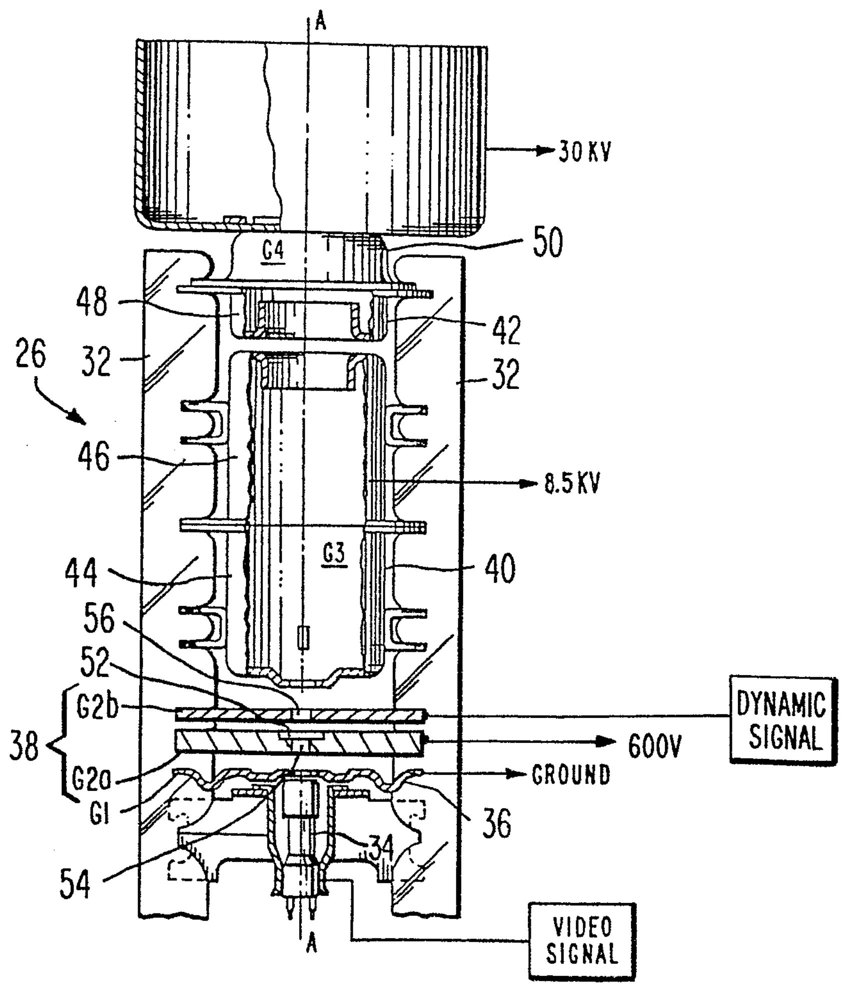

12
16
24
18
P
28
14
28
A
A
26
22
30
P
8
10
20

Fig.1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G4
50
48
42
26
32
32
46
8.5 KV
G3
44
40
56
52
G2b
DYNAMIC SIGNAL
38
600V
G2a
GROUND
G1
36
34
54
A
VIDEO SIGNAL

Fig.2

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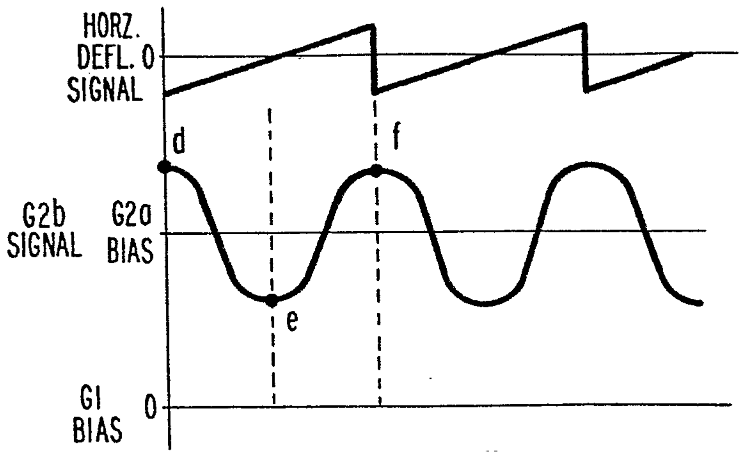

Fig.4

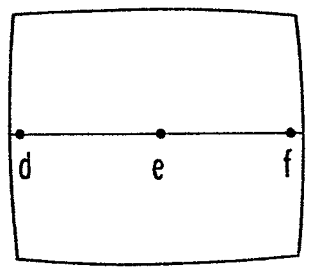

Fig.5

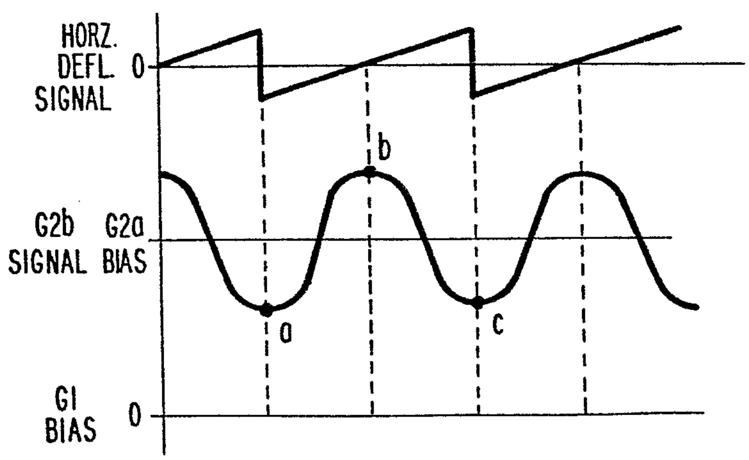

Fig.6

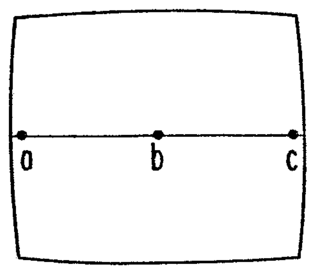

Fig.7

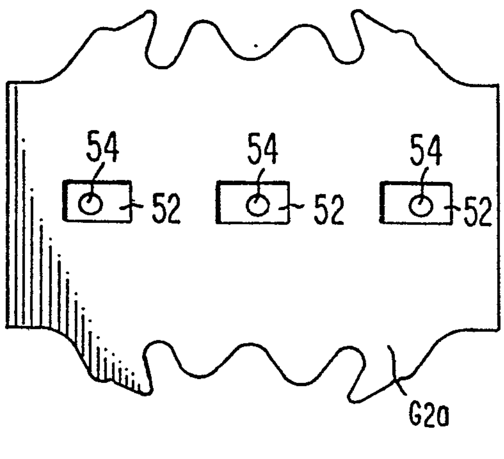

Fig. 3

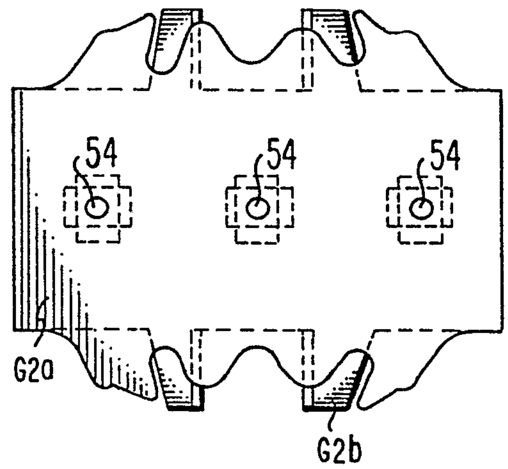

Fig. 9

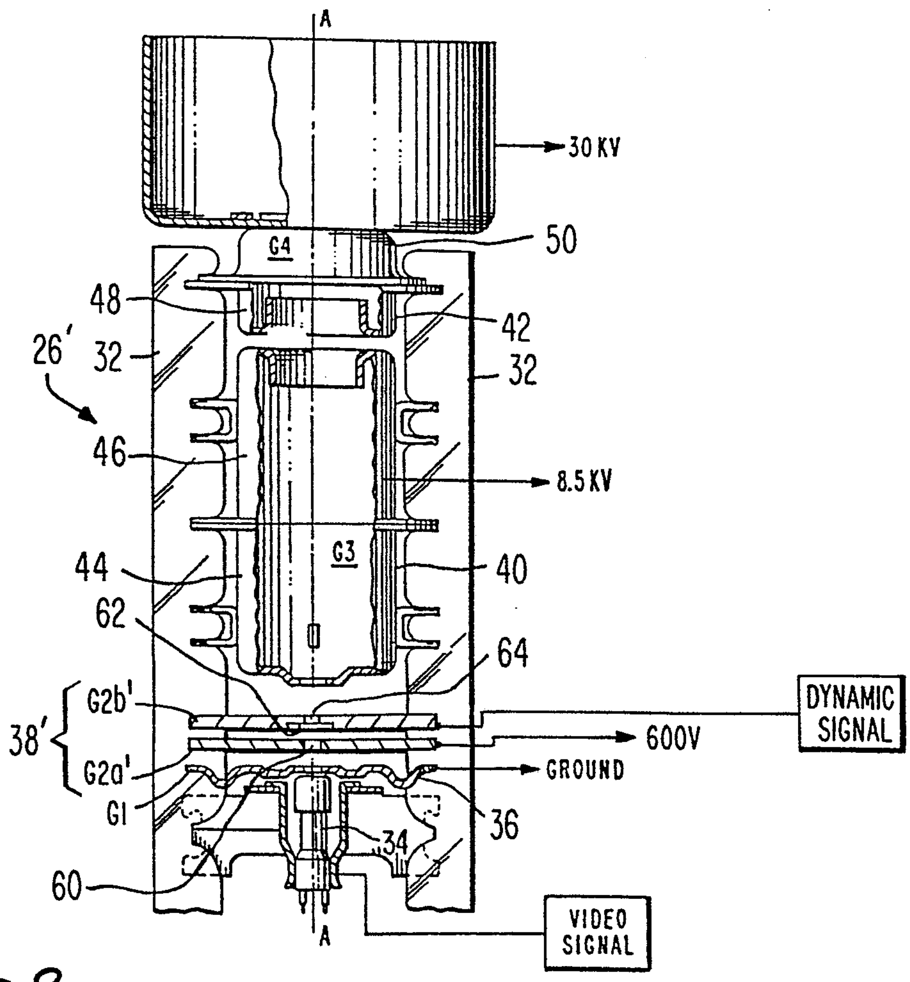

Fig. 8