July 17, 1956 E. R. WAGNER 2,755,413

GAS FILLED PROJECTOR TUBES FOR TELEVISION

Filed Feb. 23, 1951 2 Sheets-Sheet 1

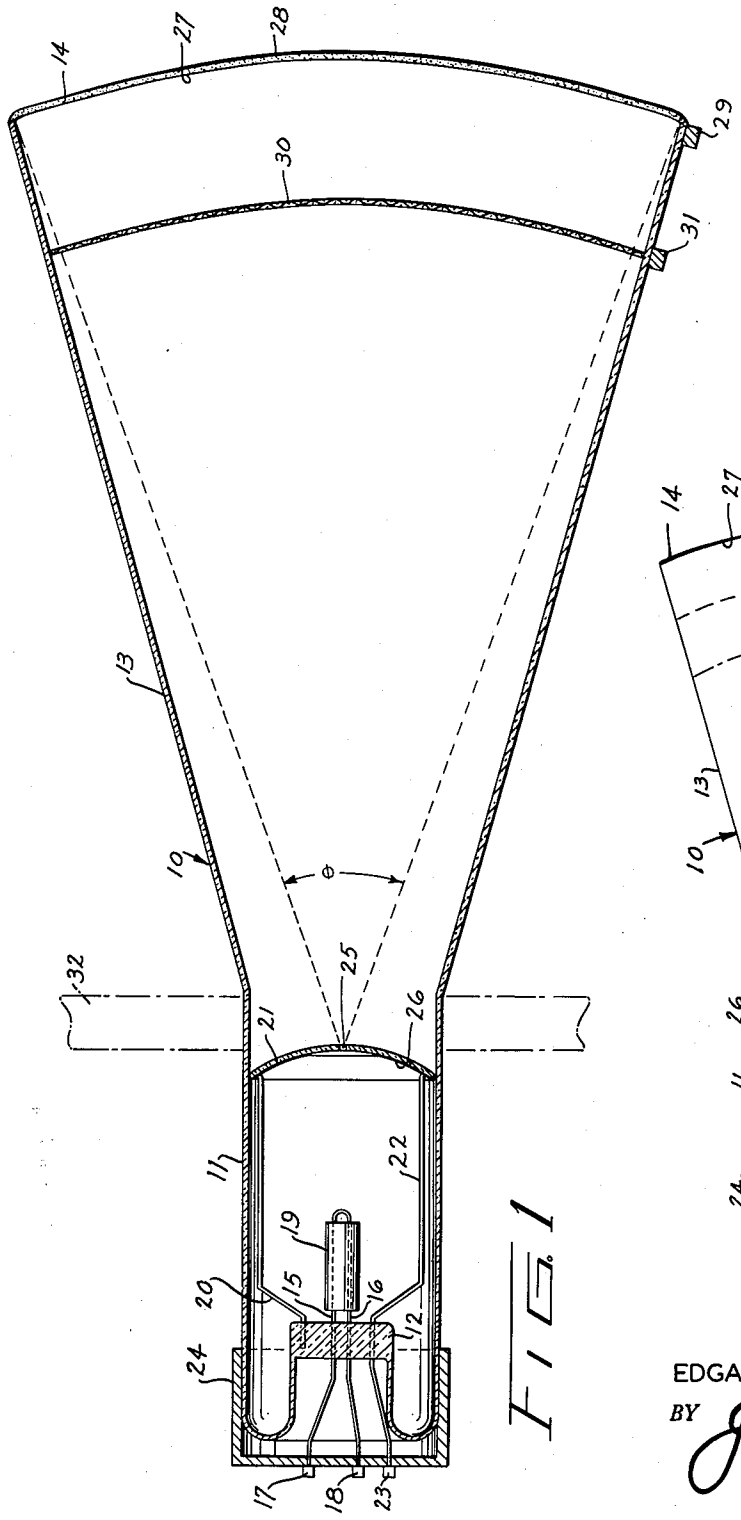

FIG. 1

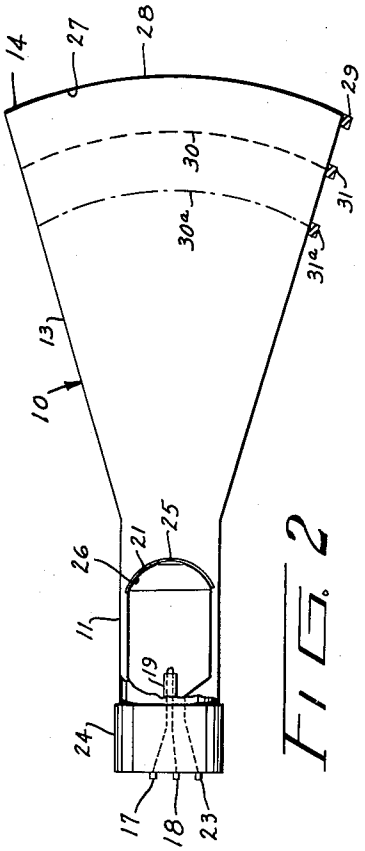

FIG. 2

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GAS FILLED PROJECTOR TUBES FOR TELEVISION

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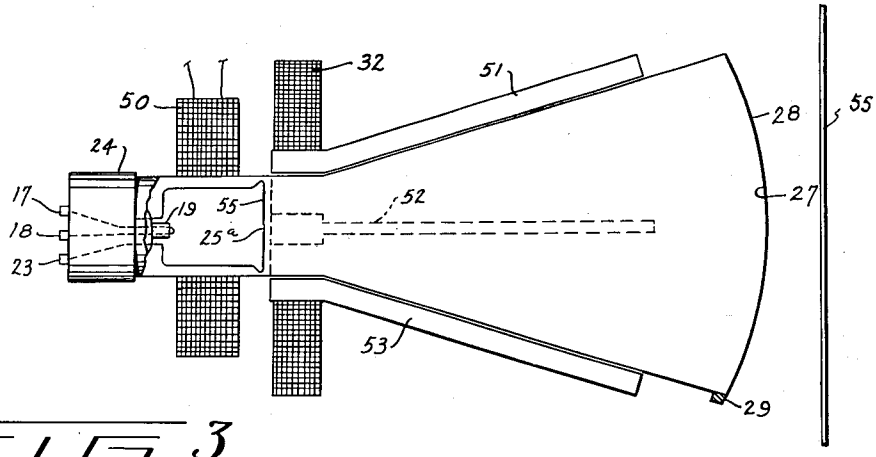

FIG. 3

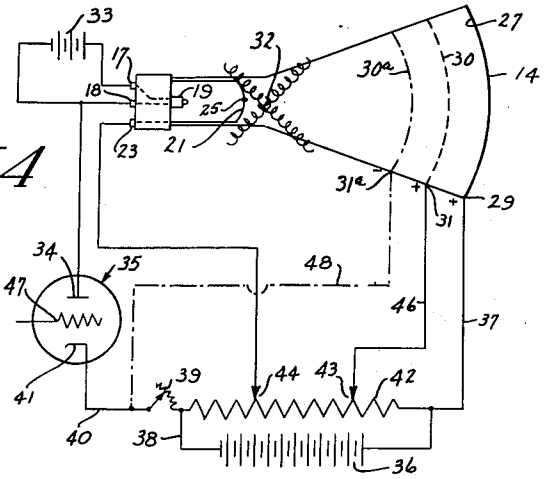

FIG. 4

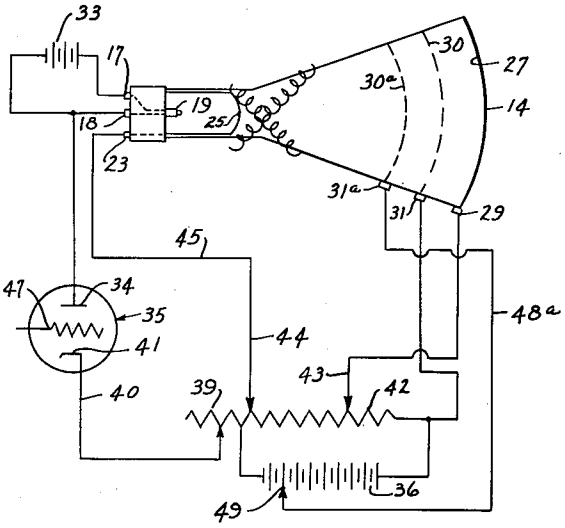

FIG. 5

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2,755,413

GAS FILLED PROJECTOR TUBES FOR TELEVISION

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Application February 23, 1951, Serial No. 212,220

5 Claims. (Cl. 315—17)

This invention relates to improvements in gas filled projector tubes for television and has for an object the provision, in a tube of this character, of a beam forming a light source, and means for both modulating and deflecting said beam.

Another object of the invention is the provision of means, in a gas filled projector tube, for producing a beam having very low electron velocities.

A further object of the invention is the provision, in a tube of this character, of a cathode and an anode, said anode having a small orifice coinciding with the axis of the tube and through which the electrons pass, whereby said anode functions both as an anode and as a virtual cathode.

Yet another object of the invention is the provision, in a gas filled television tube, of a plurality of fields within a single envelope, at least one pair of said fields being separated by an electrode which functions as an anode to one field and as a cathode to the other, a cathode in said one field for delivering electrons thereto, which electrons have substantially low velocities, and means in combination with beams in said second field for increasing the excitation thereof, thereby producing high light intensities in the beams as seen endwise according to this invention.

Another object of the invention is the provision, in a gas filled television tube, of a plurality of fields within a single envelope, an anode forming a dividing line between one of said fields and another and functioning as a virtual cathode to the latter, metallic screen means between another of said fields and its neighboring field, a cathode in said first mentioned field delivering electrons whose velocities are maintained at relatively low velocities, and means in combination with electron beams in fields other than said first field for raising the energy level thereof and producing high light intensities in the beam as seen endwise.

A further object of the invention is the provision in a tube, of the character described, of a conductive end or window which, although conductive, is still of satisfactory transparency.

Another object of the invention is the provision, in a light source, of one or more metallic screens spanning the interior thereof and having external terminals, and means for generating a modulable, deflectable beam in the device for scanning the target end thereof. Such a screen should preferably have the openings therein correlated with the positionable axis of the beam as it scans the target end of the device.

A further object of the invention is the provision, in a gaseous discharge tube, of several stages of electron acceleration within a single envelope, a virtual cathode

between the first two stages having an orifice therein through which the electron beam passes, and the provision of focusing means in said first stage for compressing the beam that emerges from the orifice to a diameter that is substantially smaller than the size of the individual picture element or dot, thereby minimizing the tendency of the beam to spread.

Still another object of the invention is the provision in a gas filled television tube, of elongated poles extending along the surface of the tube toward the target end thereof and energized by the deflector coils, for the purpose of further reducing scattering effects by herding stray electrons into and along the path of the beam.

Yet another object of the invention is the provision in a gas filled light source, of a frosted external surface spanning the target end of the tube, for example by means of a comminuted solid having a low refractive index, for example between 1.1 and 1.75, to diminish the low intensity scattered light to a negligible value.

Another object of the invention is the provision, in a gas filled television tube, of a coating of fluorescent material on the outer surface of the viewing or target end of said tube.

Other objects and advantages of the invention will be apparent to those skilled in the art from a study of this specification and the accompanying drawings.

Referring to the drawings:

Figure 1 is a cross-section of one form of gas filled television tube according to the invention;

Figure 2 is a diagrammatic view similar to, and showing a modification of the arrangement shown in Figure 1;

Figure 3 is a diagrammatic view showing further modifications;

Figure 4 is a circuit diagram showing circuits for operating and for modulating the tube; and

Figure 5 is a circuit similar to Figure 4, showing some modifications.

Before describing the invention in detail I would like to point out that in the prior art many attempts to use gas focusing were abandoned because the image could not be made sharp. Extremely low gas pressures of the order of a few microns and electron velocities of several hundred volts were employed, and the targets were phosphors. The results were low intensity illumination of the phosphor, which restricted the applications of such tubes. Furthermore, such tubes were grid controlled, and if the pressures were increased, switch action was obtained.

Since I do not use a phosphor as a source of light, and since I do not have a control grid in my tube, such difficulties and limitations are not present. According to the present invention I am merely concerned with the proper narrowing of the entire beam as pointed out hereinafter.

Referring to Figure 1 which shows a cross-section of a gas filled beam type light source for video reception and reproduction, the beam being adapted to be deflected and adapted to be modulated, the envelope **10** has a straight cylindrical wall portion **11**, one end of which joins a "press" **12**. The other end of the tubular portion **11** joins a conical wall portion **13** which carries on its outer end **14** a screen.

Leads **15** and **16** connected respectively to terminal pins **17** and **18** pass through the press **12** and support a cathode **19**. A support wire **20** has one end mounted in the press **12** and the other end is secured to an arcuate or cupped plate **21** in any suitable manner: for example,

by welding. A second support 22 has one end secured to the plate 21, and the other end passes through the press 12 and is connected to a pin 23 carried in the base 24.

The plate 21 has an aperture 25 formed therein, and the inner surface of the cupped plate 21 is oxidized or otherwise insulated at 26 to provide it with insulation so that the aperture forms the shortest path for the beam. The screen end 14 of the tube is formed of conductive glass which may be made in several ways, one example of which is by sputtering a film 27 of metal such as cobalt, nickel or the like onto it and fusing it into the surface thereby providing a conductive surface, and at the same time, keeping the film so thin that the transparency is not appreciably impaired. The end 14 has a radius of curvature equal to the length of travel, in a straight line of an electron from the anode, virtual cathode 21 to the center point of the end 14.

The outer surface 28 of the end 14 is frosted either by applying a coating of a white pigment with a refractive index of between 1.1 and 1.75; or by applying a fluorescent frosting material. (Boric oxide (B_2O_3) is one example of a suitable fluorescent frosting material.) This fluorescent material may be so chosen that the image is made to persist after the exciting light has moved on.

Within the tube and spaced apart from the end 14 is a metallic screen 30. This screen is preferably substantially parallel to the end 14 and has openings therethrough which are correlated with the positionable axis of the beam as it skims the surface 27 on the end 14 of the tube. The purpose of this screen, and multiple screens of this type, which are hereinafter described, will be explained in detail. The metallic screen 30 is provided with a terminal 31 external to the wall 13 of the tube. A terminal 29 also external to the wall of the tube is connected to the metallic film 27 on the end 14 of the tube. Deflecting means 32 embraces the straight portion 11 of the tube and is centered just forward of the aperture 25 and when the tube is in operation, deflects the beam in all directions.

The tube may be finished off in the usual manner and filled with gas at a predetermined pressure, of between .1 and 10.0 mm. for example, depending upon the gas or gases used. An example of gases used is helium, argon, neon, together with Krypton, xenon, and mercury.

Referring to Figure 4 which is a circuit diagram, the terminals 17 and 18 are connected to a source of heater current 33 and to the plate 34 of a vacuum tube 35. A source 36 of high potential direct current has one terminal 37 connected to the viewing screen terminal 29 and the other terminal is connected via a wire 38 to a variable resistor 39 and thence via a conductor 40 to the cathode 41 of the tube 35.

Bridging the D. C. source 36 is a resistor 42 which has slidable contacts 43 and 44 thereon. The contact 44 is connected via a conductor 45 to the plate and virtual cathode 21 and the contact 43 is connected via a conductor 46 to the terminal 31 of the metallic screen 30. The slidable contact 44 is adjusted to give a desired potential on the plate and virtual cathode 21, and the contact 43 is set to give a desired potential on the screen 30. The grid 47 may be connected to a source of modulation and the deflecting means 32 is connected to sources of horizontal and vertical sweeps.

Since the screen is viewed from the end 14 or since the image on the end 14 is projected, in cases where the tube is used for projection, the intensity of the beam is essentially the sum of all of the light emitted by the radiating molecules of gas along the path of said beam.

In view of the fact that each emitting light source radiates in all directions, a general glow will occur within the tube; however this glow is at a low level and it is very small as compared to the light along the length of the beam.

The beam is initiated in the field to the left of the anode 21 and passes via the aperture 25 into the field between the anode 21 and the film 27 on the end 14, the effect resembling in some respects the usual electron gun practice with several exceptions.

Since the tube is gas filled, no internal grid is employed in the tube. Modulation is effected by impressing modulating potentials on the grid 47 of the vacuum tube 35.

By maintaining a minimum potential drop between the cathode 19 and the anode 21, very low electron velocities are obtained, and the electrons which emerge through the orifice 25 in the anode 21 may be readily deflected magnetically. In the embodiments shown I prefer to deflect the beam magnetically. The few ions formed are discharged at the cathode 19. The anode 21 functions both as an anode, for the cathode 19, and as a cathode for the elements 27 and 30.

In the field between the anode-virtual cathode 21 and the film 27, the deflected electrons are subjected to a much higher potential drop than they are in the first field, thereby substantially increasing both the ionization and the excitation of the source of visible radiation, and since the path of travel is practically along a straight line, a pencil or fine beam of light results, and this beam when seen endwise has high intensity, but when viewed cross-wise or laterally is very faint by comparison.

The end 14 of the tube has a radius of curvature equal to the length of the path of travel along a straight line from the aperture 25 in the anode 21 to the center point of the film 27 on the end 14 of the tube, and all radial lines of travel between said aperture and the surface of the metallic film must have the same potential drop, whch is the potential drop between the anode 21 and the film 27, which is also an anode.

Now, since impact ionization causes secondary electrons to arise, some scattering along other said radial paths result, and the velocities of these secondary electrons depend upon the differences in potential between their respective points of origin and the metallic film 27 on the end of the tube. Obviously these potentials are lower than the full potential drop; therefore the velocities of these secondary electrons are lower than the velocities of electrons that originated farther back. Of those which scatter away from said path of travel, the light emitted from atoms that they excite will contribute to the low level glow referred to hereinabove. On the other hand, those that continue along the original path increase its light intensity.

The screen 30 which is positioned near the end of the tube may be formed of perforated metal, of a metallic mesh, or the equivalent, and preferably the openings therein should be correlated with the positionable axis of the beam as it scans the metallic film 27 on the screen end of the tube, and if the openings in the mesh or if the perforations are the same as the number of picture lines per inch, the beam is sharpened because the size of the beam passing through the mesh is the same as that of a picture element. By making the potential on the screen 30 higher than the potential on the metallic film 27, the electrons emerging from the mesh openings or perforations are decelerated and will have less tendency to recoil on impact with the surface of the film 27. Such recoil causes a diffuse light emission and corresponding reduction of sharpness.

Under some conditions the screen 30 may be negative with respect to the anode film 27 to slow up the electrons before they reach the latter. Under other conditions a second screen 30*a*, as shown in Figures 2 and 4 may be employed, and the screen 30*a* may have its terminal 31*a* connected via a conductor 48 to the potential of the cathode 41 of the tube 35, thereby making it negative with respect to the screen 30 to slow up the electrons before they reach the screen 30.

To insure minimum scattering, especially in gas pres-

sures in the higher ranges, where a visible glow appears, say at 10 to 12 mm., a focussing coil **50**, shown in Figure 3 is provided. This focussing coil embraces the first field, between the cathode **19** and the anode **21** and compresses the beam that emerges from the orifice **25** to a diameter which is substantially smaller than the diameter of the individual picture element.

The tube shown in Figure 3 is also provided with extended pole shoes **51**, **52**, **53**, and a fourth one, not shown, but which is disposed 90° apart from the shoes **51** and **53**. These shoes are influenced by the deflector coils in the unit **32**, and they extend along the outer surface of the tube towards the end **14** in the planes of the vertical and horizontal deflection. The resultant fields are co-extensive with these shoes and tend to herd stray electrons back into the correct path.

Each of the above methods used singly reduces scattering effects, and several or all of them in combination further reduce such effects.

The transparent end of the tube will pass the light from the entire length of the beam, and the projected image of the beam will vary from a dot at the axis to a line equal to the radius of the tube end, in length, which will cause grave image distortion. Fortunately the light that is normal to the end section comes from individual resonators that are aligned along the path.

By applying a frosting **28** on the end of the tube, this low intensity light is thereby so scattered that its luminosity is further reduced, and proper voltage regulation can bring it to a negligible value. On the other hand the light of the radial beam is merely scattered enough to render it visible endwise.

Where the frosting is a coating on the end of the tube comprised of a white pigment having a refractive index of about 1.3 to 1.5, the scattering is within desired limits.

Fluorescent material may comprise, or may be included in, the frosting and the image is thus made to persist after the exciting light has moved on.

When the gases used in the tube are chosen to give a white light, the three primary colors are present. This occurs when a mixture of helium, argon and neon; together with krypton, xenon, and possibly mercury is used. If an external color screen **55** is placed at the end of the tube, it will filter out its complementary colors, and by using a fine screen printed in the three shades of blue-green, orange-yellow, and magenta or violet-red, the effect of color transmission results.

By forming the frostings of mixed fluorescent materials to give the three colors mentioned above, the ultra-violet radiation may be used to intensify the visible spectrum, and greater light efficiency is obtained with the color filter, or if a one color (white) luminophore is used, greater white illumination results.

Since ionization is an exponential and not a straight line phenomenon, good contrast between light and dark portions of the image result because the excited atoms that are the visible light emitters are generated by the same electrons that produce or result from ionization in still other atoms.

The circuit shown in Figure 5 is similar to that shown in Figure 4, except that the screen **30***a* is directly connected via the conductor **48***a* to the battery or source of current **36** to give the screen **30***a* negative bias.

In Figure 3, a flat anode-virtual cathode **55** is employed instead of the cupped one **21**, thereby making it unnecessary to insulate its surface, since the surface bordering the aperture **25***a* is nearest to the cathode.

Although this invention is described above as a television tube, it is in fact a source of high intensity illumination, whether used as a television tube or as any other light source. It is obvious that the electron beams may be deflected by means of the deflecting means in a circular or spiral path by means of a rotating field, or it may be deflected by means of combinations of rotating and crossed reciprocating fields to illuminate large areas at high intensities, but with low power consumption by using the persistence of vision to "carry over" the effect of illumination in areas which are no longer in direct line with the beam.

While one embodiment of the invention and modifications thereof have been herein shown and described, it will be understood that numerous variations in the arrangements may be altered or omitted without departing from the spirit of this invention as defined by the following claims.

I claim:

1. In a gas filled television tube, a window formed on one end of said tube, frosting means on the outer surface of said end, an electrode spaced apart from the other end of said tube and defining a field between itself and said first end, said electrode having a beam passage therethrough, a source of electrons in said field for directing an electron beam via said passage toward said window, means to supply a potential across said field to cause said beam to emerge from said passage at a comparatively low velocity, means to impress a higher potential upon said electrode to accelerate the velocity of said beam, means to deflect said beam to cause it to scan said window, means including magnetizable shoes extending lengthwise of the tube to minimize the scattering of light from the path of travel of said beam, and monatomic gas means in said tube at a pressure of between .1 mm. and 10.0 mm.

2. A gas filled television tube according to claim 1 wherein said tube carries adjacent to said means to deflect, means to compress the electron beam and further prevent scattering, due to collisions between the beam and molecules of said gas means.

3. In a gas filled television tube, monatomic gas means in said tube at a pressure of between .1 mm. and 10.0 mm., a viewing screen formed on one end of said tube, a source of electrons in a field at the other end of said tube, means cooperating with said source for directing an electron beam toward said screen, electromagnetic deflecting means external to the wall of said tube and having pole shoes extending toward said target along a greater portion of the length of travel of said beam for causing the latter to scan said screen and at the same time to reduce scattering effects due to collisions between said beam and molecules of said gas.

4. In a gas filled tube of the character described, an inert gaseous atmosphere in said tube at a pressure of between .1 mm. and 10.0 mm., an envelope having a window formed at one end thereof, a cathode in the other end of said tube, an anode between said ends and having an electron beam passage therethrough, said anode dividing the interior of said envelope into two fields, one of which embraces said cathode, means for supporting said anode in definite spaced relation to said cathode, said passage being provided as a channel through which electrons pass from one of said fields into the other, and a phosphor screen formed on the outer surface of the window end of said tube.

5. A gas filled tube according to claim 4 in which the inert gaseous atmosphere is comprised of a combination of gases capable of producing the three primary colors, and in which said phosphor screen formed on the outer surface of the window and of said tube is comprised of phosphors capable of converting the ultra-violet light of the beam into visible light, and comprising an external color screen.

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