HIGH RESOLUTION IMAGE CATHODE RAY TUBE SYSTEM

Filed Jan. 3, 1956 2 Sheets-Sheet 1

FIG.4.

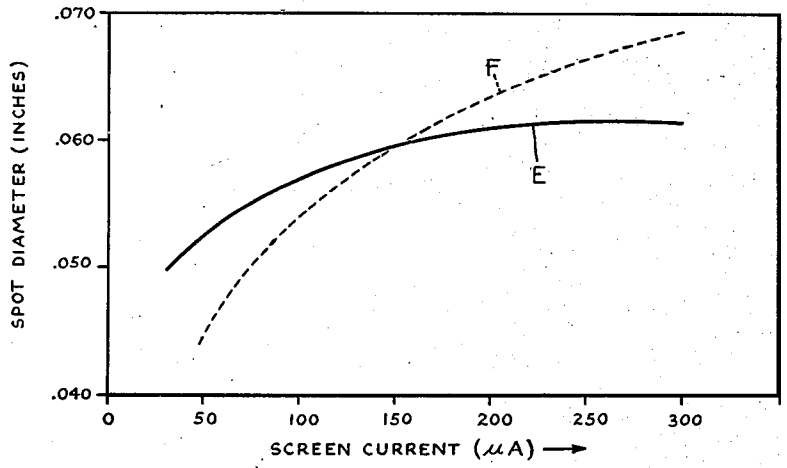


FIG.1.

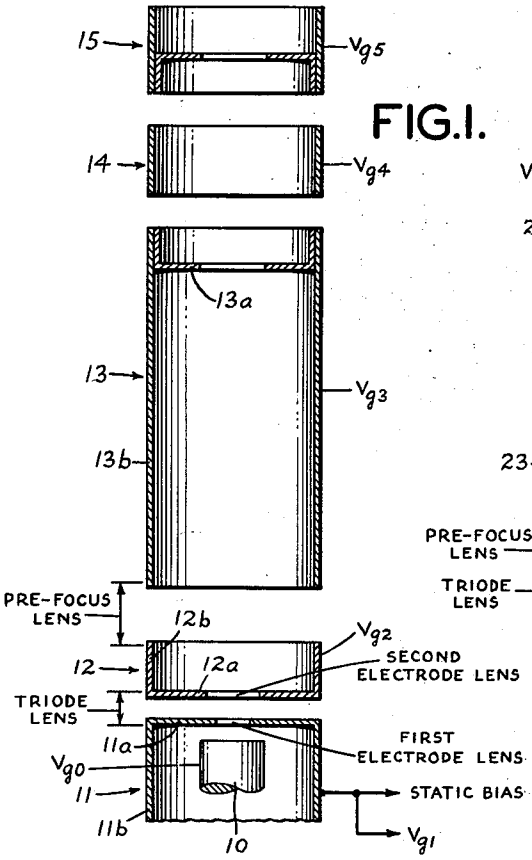
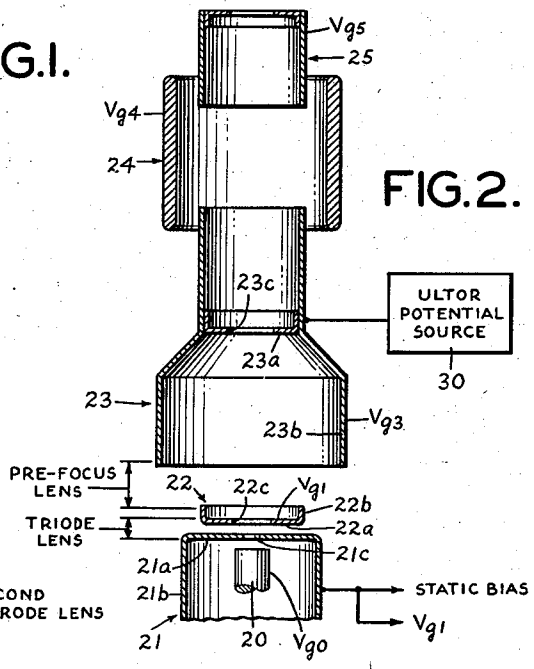


FIG.2.



INVENTOR
WILFRID F. NIKLAS
BY Campbell, Brumbaugh Tree and Graves
HIS ATTORNEYS

HIGH RESOLUTION IMAGE CATHODE RAY TUBE SYSTEM

Filed Jan. 3, 1956 2 Sheets-Sheet 2

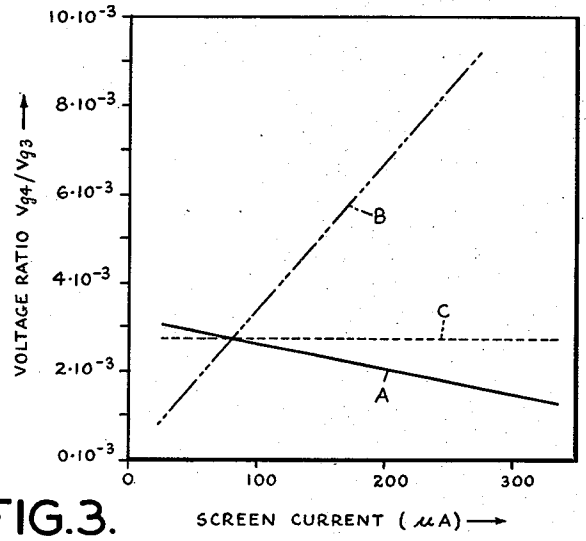


FIG.3.

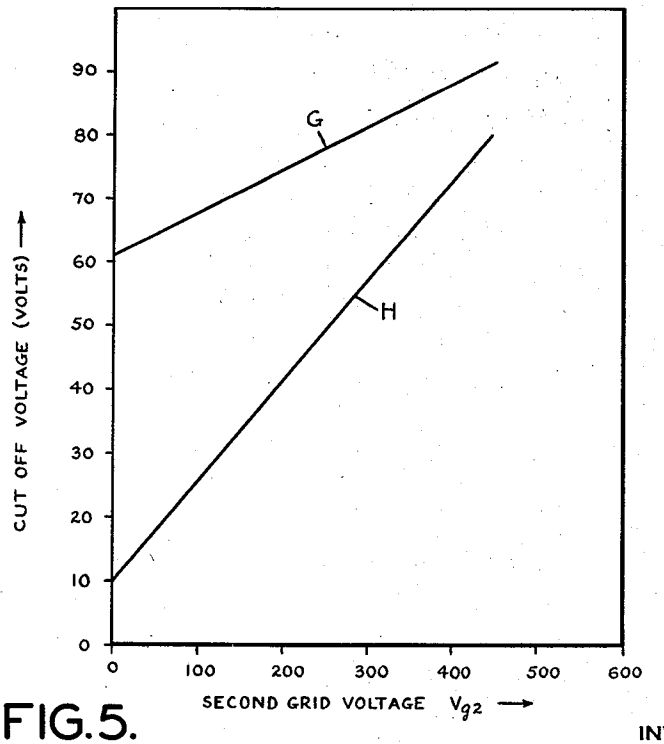


FIG.5.

INVENTOR
WILFRID F. NIKLAS
BY Campbell, Brumbaugh
Tree & Graves
HIS ATTORNEYS

United States Patent Office 2,839,703 Patented June 17, 1958

2,839,703

HIGH RESOLUTION IMAGE CATHODE RAY TUBE SYSTEM

Wilfrid F. Niklas, Flushing, N. Y., assignor to Columbia Broadcasting System, Inc., New York, N. Y., a corporation of New York

Application January 3, 1956, Serial No. 557,017

8 Claims. (Cl. 315—15)

This invention relates to a system for obtaining a high resolution image in a cathode ray tube and more particularly to a system of this nature which is adapted to substantially eliminate or substantially reduce one or more of the factors causing loss of resolution of the final image on the phosphor screen of the tube.

For a better understanding of the description to follow, reference is made to the accompanying drawings wherein:

Figure 1 is a view in cross-section of a conventionally used cathode ray tube electron gun and associated electrodes;

Figure 2 is a view in cross-section of one embodiment of a high-resolution image cathode ray tube system according to the invention;

Figure 3 is a graph representing a characteristic of the system of Figure 2; and

Figures 4 and 5 are graphs contrasting certain characteristics of the system of Figure 2 with the electron gun of Figure 1.

To understand the invention, it is desirable to describe how an electron beam is conventionally formed, shaped and modulated.

In modern television tubes, and particularly in television picture tubes, the electron gun used is mostly of the "tetrode" type. The construction of such a gun and associated electrodes is shown in Figure 1. Referring to this figure, the electron gun comprises; an electrode source **10** which may be an indirectly heated Ba-Sr-carbonate cathode, a first electrode **11** which is used for concentration and intensity modulation of the electron beam, a second electrode **12** used to extract electrons from the space charge cloud around the heated cathode **10**, and a third electrode **13** which accelerates the electrons to the final anode potential. Beyond the electron gun are located a fourth electrode **14** and a fifth electrode **15** which provide a main focus lens as later described.

The first electrode **11** comprises an annular disc **11***a*, coaxial with and located in front of the cathode **10**, and a cylindrical skirt **11***b* extending backward from the periphery of disc **11***a* to envelope the cathode **10**. The second electrode **12** is comprised of an annular disc **12***a*, coaxial with cathode **10** and located a small distance in front of disc **11***a*, and a short cylindrical skirt **12***b* extending forward from the periphery of disc **12***a*. The third electrode **13** comprises an annular disc **13***a*, coaxial with cathode **10** and located at some distance in front of electrode **12**, and a long cylindrical skirt **13***b* extending backward from the periphery of disc **13***a* part way to the skirt **12***b* of electrode **12**.

In discussing the operation of the Figure 1 electrode gun, the cathode potential (V_{g0}) will be used as zero reference potential. Assume that the second electrode **12** is supplied with a positive voltage (V_{g2}) of 300 volts, and that the third electrode **13** is supplied with potential (V_{g3}) of conventional value, and which, in the present instance, consists entirely of ultor potential impressed on electrode **13**. Assume, also, that the cut-off

potential (V_c) for the first electrode **11** is of minus 70 volts value, that the electrode **11** is statically biased to a value slightly above this cut-off potential, and that the first electrode has impressed thereon a dynamic potential (V_{g1}) which may vary from, say, cut-off potential to zero volts, and which may represent, for example, the varying amplitude of the signal which drives the picture tube of a television receiver.

When electrode **11** is adjusted, as assumed, to a value slightly above cut-off, the potential (V_{g2}) penetrates into the space between cathode **10** and electrode **11**, resulting in a positive potential gradient at the cathode surface. Under this condition, electrons leave the cathode surface in random directions. The most probable direction is normal to the cathode surface. Electrons leaving nearly normal form the "main rays" which collectively will be referred to hereinafter as the "electron beam." It will be understood that the terms "forward" and "backward" are used hereinafter to indicate directions which are, respectively, the same as and opposite to the direction of electron movement in the electron beam.

An electric field having a certain axial potential gradient exists between disc **11***a* and cathode **10**. An electric field having a different axial potential gardient exists between disc **11***a* and disc **12***a*. The disc **11***a* thus acts as a divider between two spaces possessing different axial potential gradient. It is well known, under these conditions, that the resultant electric field in the vicinity of the aperture of disc **11***a* will act as an electron lens (aperture lens) denoted herein the "first" lens. The difference in potential gradients on opposite sides of disc **11***a* is such that this first lens is a positive one and concentrates the main rays.

In a similar manner, the resultant electric field in the vicinity of the aperture of disc **12***a* forms another or "second" electron lens. With conventional operating potentials, and with the conventional electrode geometry shown in Figure 1, this second lens is a negative one in the sense that it diverges the electron beam. The absolute strength of this negative lens is smaller than the strength of the positive first lens formed in the vicinity of the aperture of disc **11***a*. The resulting strength of the first and second lens combination, denoted herein the "triode" lens, is, therefore, positive. The main rays are concentrated into a "beam waist" or "cross-over" in the neighborhood of the second electode.

A concentating lens of the accelerating type, denoted herein the "pre-focus" lens, is formed between the second electrode **12** and the third electrode **13**. The focal length of this lens is generally greater than the lens cross-over distance. The pre-focus lens thus forms behind the cathode **10** a virtual image of the electron beam at cross-over. The virtual intermediate image acts as an object for the main lens which in turn forms its image on the screen of the cathode ray tube in which the discussed electron gun is incorporated. The main lens is formed by the interaction of the fields provided by electrodes **13**, **14**, **15**. The field from electrode **14** is developed by a potential (V_{g4}) thereon of low value relative to the ultor potential. The field from electrode **15** is developed by a potential (V_{g5}) of the same order as the ultor potential.

The described electron gun is ordinarily operated in conjunction with a signal which varies the value of the potential (V_{g1}) impressed on electrode **11**. These variations change the magnitude of the positive potential gradient at the cathode surface and change, therefore, the amount of electrons which are permitted to leave the cathode. This result is, as desired, an intensity modulation of the electron beam.

Accompanying this desired intensity modulation are

certain phenomena which have hitherto limited the resolution obtainable in the final image cast on the phosphor screen of the cathode ray tube. Among these is the phenomenon that the strength of the triode lens weakens with the increasing beam current accompanying increasing V_{g1}, and the phenomenon that the "space charge factor" (defined herein as the ratio of the beam current to the 3/2 power of the local axial potential), increases with increasing beam current.

Both the weakening of the triode lens and the increase in value of the space charge factor produce (at constant ultor potential) a forwardly directed axial shift of the cross-over point or waist of the electron beam. The overall axial shift (i. e., axial cross-over variation) is a summation of these two effects. Additionally, the increase in value of the space charge factor produces an increase in the effective diameter of the beam waist (i. e., radial cross-over variation).

With respect to the axial cross-over variations, these variations are projected in magnified form by the prefocus lens into the space of the intermediate image. The magnified axial variations are acted on by a constant strength main lens to cause "current defocusing" of the electron beam. To elaborate on what is meant by "current defocusing," the optimum final image is obtained on the phosphor screen of the cathode ray tube when the "disc of least confusion" of the electron beam is located at the screen of the tube. With a constant strength main lens, the determinant of the axial location of the disc of least confusion is the value of beam current. This is so since the axial location of the disc of least confusion varies with the axial location of the beam waist, which in turn varies, as explained, as a function of beam current. Hence, as the beam current varies in the course of intensity modulation, the disc of least confusion also varies through an axial location range, there being only one point in this range at which the disc is on the screen of the tube to give the optimum final image.

Of course, by adjusting the strength of the main lens, it is possible to place the disc of least confusion right on the screen for any one selected value of beam current in the range of variation thereof. If, however, the main lens strength is adjusted (by adjusting the value of the ratio V_{g4}/V_{g3}) to place the disc on the screen for a low beam current value, the final image for high beam current values will be "under-focus" in the sense that the disc is beyond the screen as seen in the direction of electron propagation. This under-focus condition results in an increase in spot size at the screen. On the other hand, if the main lens strength is adjusted to place the disc on the screen at a high beam current value (as is customary in cathode ray tube adjustments for television receivers), the final image for low beam current values will be in "over-focus" in the sense that the disc falls short of the screen with respect to the direction of electron propagation. This "over-focus" condition again results in an increase in the spot size on the screen. It will thus be seen that current defocusing occurs for either discussed adjustment, and, in fact, for any single value adjustment of the main lens strength in an electron gun having conventional electrode geometry and utilizing conventional operating potentials. It will also be seen in such gun that, as the beam current increases, the disc of least confusion shifts forwards. This last statement holds true whether the main focus lens is electrostatic or electromagnetic in nature.

When the main lens strength is adjusted, as just described, to give the best image at a high beam current value, there is present not only the current defocusing disadvantage just discussed, but another disadvantage as well. Due to space charge influences and aberrations, the current density distribution in any cross-section of the beam beyond the disc of smallest confusion departs more from the ideal Maxwellian distribution than in the cross-section of the beam which lies before the disc. With a high beam current adjustment for the main lens, the disc falls short of the cathode ray tube screen for most beam current values in the range of variation thereof. It follows, for this high beam current adjustment, that most of the time the cross-section of the beam which actually falls on the screen is the cross-section which, being beyond the disc, departs more from ideal characteristic than the cross-section before the disc. This greater departure of the beam cross-section from ideal characteristic is disadvantageous inasmuch as the greater departure introduces into the final image a correspondingly greater amount of an additional form of distortion, designated herein as "current aberration." Thus, for high beam current adjustment the final image suffers more from current aberration than for low beam current adjustment.

Attempts have been made in the past to counteract current defocusing and current aberration by modulating the strength of the main focus lens in phase with the intensity modulation so that the disc of least confusion stays on the screen of the tube. These methods of varying the main lens strength require, however, a high amplification of the modulating signal and are ordinarily, therefore, impractical.

Other expedients to combat current de-focusing and current aberration have also been attempted in the prior art. For example, it has been attempted to utilize a weaker prefocus lens, or to reduce the dimensions of the triode lens. These attempts have not been satisfactory inasmuch as, in the main, they create more disadvantages than they overcome.

With respect to radial cross-over variations, the changes in the effective diameter of the beam waist as a function of space charge factor are projected on to the screen and result in a variation of the size of the final image, the image increasing as the beam current increases. This disadvantageous phenomenon, known as "blooming" occurs whether or not the main lens strength is varied to counteract the current defocusing and current aberration effect caused by the axial cross-over variations.

It is an object of the invention, therefore to provide a cathode ray tube system which substantially eliminates or substantially reduces current defocusing of the electron beam.

Another object of the invention is to provide a cathode ray tube system which substantially eliminates or substantially reduces current aberration.

Another object of the invention, is to provide a cathode ray tube system which substantially reduces blooming.

A further object of the invention is to provide a cathode ray tube system characterized by more than one of the advantages noted above.

These and other objects are realized according to the invention, by providing a cathode ray tube system which takes the form of an electron gun of special geometry and source of high value ultor potential. The electron gun has a geometry for its component electrodes such that, with high value ultor potential values and with a constant strength main lens, the shift in axial position of the disc of least confusion may, by adjustment of the ultor potential, be substantilly eliminated, or at least changed in direction to move backwardly as the beam current increases. As later described in more detail, a system of this nature substantially eliminates or reduces one or more of the discussed disadvantages of current defocusing, current aberration and blooming.

Referring now to Figure 2, which discloses one embodiment of a cathode ray tube system according to the present invention, the electron gun of the system has an electron source or cathode **20**, a first electrode **21**, a second electrode **22**, and a third electrode **23**. Associated with the electron gun is, as before, a fourth electrode **24** and a fifth electrode **25**. The electric fields created by electrodes **23**, **24**, **25** form a main focus lens in the nature of an initially decelerating saddle field lens of the overlapping type.

The first, second and third electrodes of the gun of

Figure 2, are arranged and constructed as shown. Thus, electrode **21** is comprised of an annular disc **21***a*, a cylindrical skirt **21***b* and an aperture **21***c* in disc **21***a*; electrode **22** is comprised of an annular disc **22***a*, a cylindrical skirt **22***b* and an aperture **22***c* in disc **22***a*; and electrode **23** is comprised of an annular disc **23***a*, a cylindrical skirt **23***b*, and an aperture **23***c* in the disc **23***a*. These electrodes in the presence of suitable operating potentials thereon form in the Figure 2 gun a triode electron lens and a pre-focus electron lens at the same locations that these lenses occupied in the Figure 1 gun.

Various dimensions of the elements and spacings of these electrodes are given in the following table:

Table of dimensions

	Inches
(1) Diameter of aperture **21***c*	.031
(2) Diameter of aperture **22***c*	.060
(3) Diameter of skirt **22***b*	.375
(4) Length of skirt **22***b*	.050
(5) Axial distance between skirts **22***b* and **23***b*	.200
(6) Diameter of skirt **23***b* at lower end thereof	.650

The remaining part of the cathode ray tube system which is of particular interest is the source **30** of ultor potential. This source, which, in itself, may be a conventional voltage source, is adapted to provide an adjustable ultor potential in the range, say, of 20,000 to 30,000 volts.

As has been previously described, in a conventional cathode tube system, an increase in value of the intensity modulation produces an increase in beam current which, in turn, requires an increase of strength of the main focus lens if optimum focus is to be maintained. In such systems the mode of attaining an increase in main lens strength is to decrease the voltage ratio V_{g4}/V_{g3} by decreasing the potential (V_{g4}) applied to the fourth electrode. The potential (V_{g4}) is so varied by adding to the static potential on the fourth electrode a varying potential which reproduces in inverted amplified form the variations of the intensity modulation.

The cathode ray tube system of Figure 2 acts similarly to a conventional cathode ray tube system when the ultor potential applied to the third electrode is at the lower end of the range of ultro potentials available from source **30**. This conventional action is represented in Figure 3 by curve A which is taken for an ultor potential of 20,000 volts, and which represents the degree to which it is necessary to vary the ratio V_{g4}/V_{g3} to maintain continuous optimum focus in the presence of variation of the screen current derived from the electron beam.

When, however, the ultor potential applied to the third electrode is of a value which lies in the upper portion of the range of potentials available from source **30**, an effect exactly the reverse of the conventional effect is obtained in the operation of the tube. To specify this reverse effect, as the screen current increases, it is necessary, in order to maintain continuous optimum focus, to increase the value of the ratio V_{g4}/V_{g3}. This increase is attained by increasing the voltage (V_{g4}) which is applied to the fourth electrode. The described reverse effect is shown in Figure 3 by the curve B which is taken at 30,000 volts ultor potential, and which represents the manner in which the ratio V_{g4}/V_{g3} must be varied in the presence of changing screen current in order to maintain the constant optimum focus condition.

From Figure 3, it is seen that an increase in the value of ultor potential applied to the third electrode results in an increase of the slope of the curve plotting the voltage ratio V_{g4}/V_{g3} against screen current. For an ultor potential which gives a negative slope to this curve (e. g. 20,000 volts ultor potential), the lens which is formed at aperture **22***c* is a negative lens and the disc of least confusion of the electron beam will shift forward with increasing beam current when the potential (V_{g4}) remains constant. With an ultor potential which gives

a positive slope to the function line of Figure 3 (e. g., a 30,000 volt ultor potential), the lens formed at aperture **22***c* will be a positive lens, and the disc of least confusion of the electron beam will shift backward with increasing beam current when the potential (V_{g4}) remains constant.

From what has been said it will be seen that, within the range of potentials available from source **30**, there can be selected one particular value of ultor potential which, as shown by curve C in Figure 3, will impart a slope of zero value to the curve representing the plot of how V_{g4}/V_{g3} must be varied with screen current in order to continuously maintain the optimum focus condition. The significance of the zero slope of curve C is that it shows that, under the operating conditions represented thereby, it is not necessary to change the (V_{g4}) potential on the fourth electrode in order to maintain continuous optimum focus in the presence of changing values of screen current. In other words although the fourth electrode potential remains constant, the disc of least confusion of the electron beam will not undergo any substantial axial shift, but will, instead, stay located at or near to the phosphor screen of the cathode ray tube for all values of the changing screen current. This absence of substantial axial shifting of the disc of least confusion stands in contrast to the behavior of prior art cathode ray tube systems which utilize constant third electrode potentials, but in which the disc of least confusion inevitably shifts substantially forward in response to an increase in screen current.

While the zero slope condition is optimum, the operation of the Figure 2 gun is characterized by a substantial advantage when the ultor potential impressed on the third electrode is such as to give a positive slope to the plot of V_{g4}/V_{g3} against screen current. More specifically, the positive slope condition is indicative of the fact that, with increasing screen current, the disc of least confusion of the electron beam undergoes an axial shift directed backwardly rather than forwardly, as is characteristic of the shift of the disc in the operation of prior art cathode ray tubes. To make the converse statement, this positive slope condition indicates that the disc of least confusion will undergo a forward axial shift as the screen current decreases from a maximum value. As stated, it is customary to adjust cathode ray tubes to obtain best focus of the phosphor screen image at the maximum screen current value, the reason for such adjustment being that it is at high intensity values of the image that defects in the resolution thereof are most noticeable. If the tube is so adjusted to place the disc at the phosphor screen at maximum screen current value, and if the disc of least confusion shifts forwardly as the screen current decreases from maximum, the portion of the electron beam which falls on the phosphor screen for all other screen current values will be the portion of the beam which precedes the disc of least confusion. As stated heretofore, when this portion of the beam falls on the screen, the final image will suffer less from current aberration than when the beam portion beyond the disc falls on the screen. Accordingly, "current aberration" is substantially reduced for the whole range of screen current values, and, hence, for the whole range of values of the intensity modulating signal.

It will be understood that substantial operating advantages may be obtained with the Figure 2 electron gun by operating the gun with an ultor potential which does not give the optimum zero slope condition, but which does give an operational condition not far removed from the zero slope condition. This is so, since, the closer the operating condition approaches the zero slope condition, the smaller the distance the disc of least confusion shifts axially in response to a given change in screen current.

It will thus be evident that a cathode ray tube system in accordance with the present invention offers substan-

tial advantages as compared to the prior art in that it is possible to eliminate or substantially reduce the current defocusing effect and the current aberration effect which have hitherto caused loss of resolution in the image projected on the cathode ray tube screen.

At the same time the described cathode ray tube system decreases "blooming." This is shown in Figure 4 wherein the spot size D_s produced in the screen center of the cathode ray tube is plotted (vertical ordinate) as a function of the screen current (horizontal ordinate). Curve E shows the plot obtained with the electron gun of Figure 2. Curve F of the same figure is the plot obtained for a second electron gun which differs from the electron gun of Figure 2 in that it has a substantially longer skirt for the second electrode. It will be seen that the spot size derived from the electron gun of Figure 2 remains considerably more uniform in size with variations in screen current than does the spot size of the electron gun used for comparison purposes. Naturally, for better control of resolution of the image produced by the cathode ray tube, it is desirable that the spot size remain as close to constant value as possible.

The difference obtained between curves E and F of Figure 4 can be attributed to the fact that, due to its longer second electrode skirt, the electron gun used for comparison purposes has a considerably reduced ultor voltage penetration in respect to the electron gun of Figure 2. Evidence of this difference in ultor voltage penetration is given by curves E and F wherein curve E is substantially flatter than curve F.

Referring now to Figure 5, this figure evidences further that the advantageous results characterizing the instant invention of substantial elimination or reduction of current defocusing, and of substantial reduction of "blooming" can be attributed to a high degree of penetration of the ultor potential into the "triode" space, defined herein as the space between the second electrode and cathode which is bounded by the second electrode aperture, the first electrode aperture, and the emitting surface of the cathode. In Figure 5, the value of cut-off voltage (vertical ordinate) is plotted against the value of the voltage on the second electrode (horizontal ordinate). Curve G shows cut-off voltage as a function of second electrode voltage for the electron gun of Figure 2 when a high value of ultor potential (e. g., 30,000 volts) is applied to the third electrode of this gun. Curve H shows cut-off voltage as a function of second electrode voltage for an electron gun of conventional geometry which has the same value of ultor potential applied to the third electrode thereof. Comparison of curves G and H indicates that the cut-off voltage characteristic for the gun of Figure 2 is substantially flatter than the cut-off voltage characteristic for the electron gun of conventional geometry. This flatter cut-off voltage characteristic indicates that the electron gun of Figure 2 experiences a substantially higher penetration of ultor voltage into its triode space than does the electron gun of conventional geometry.

There remains the question as to how this substantially greater degree of ultor penetration into the triode space is achieved in a cathode ray tube system according to the present invention. It will be evident that this high degree of ultor penetration into the triode space is the direct result of the development from the ultor potential on the third electrode of a strong, axially directed, potential gradient at the center of the second electrode aperture. The development of this strong potential gradient depends, in turn, upon a number of factors as follows.

First, the strength of gradient developed varies as the third power of the diameter of the second electrode aperture. Accordingly, it is desirable that the second electrode aperture be of large size diameter, and preferably of larger size diameter than the first electrode aperture.

Second, in those electron gun constructions wherein the third electrode skirt is forward of the apertured disc member of the second electrode (as opposed to gun constructions where the third electrode skirt overlaps the second electrode), the skirt of the second electrode tends to shield the center of the second electrode aperture from the ultor potential of the third electrode to thus cut down on the strength of gradient which may be developed by the ultor potential at this center. This shielding effect can be obviated to the extent necessary by increasing, in effect, the apex angle of an envisagable geometric cone whose apex is at the center of the second electrode aperture, and whose base is defined by the peripheral circle of the free end of the second electrode skirt. It will be evident that by increasing the described apex angle in this manner, the ultor potential from the third electrode has a wider angle of access to the center of the second electrode aperture. It will also be evident that the described angle of access can be of wide nature either by having a large size diameter for the second electrode skirt, or by having a small length for the second electrode skirt, or both by having both of these dimensional characteristics.

In the case where the gun construction is such that the skirt of the third electrode overlaps the second electrode, the equivalent of a wide angle of access is obtained by providing for a close spacing between the inside cylindrical surface of the third electrode skirt and the outside cylindrical surface of the second electrode skirt.

Third, the strength of potential gradient produced by the influence of the ultor potential at the center of the second electrode aperture, will, to a reasonable approximation, vary in inverse relation to the square of the distance of this center from the portion of the third electrode skirt which is nearest to this center, and which is, thus, the nearest source of ultor potential. In the Figure 2 electron gun, for example, this shortest distance is the distance between the second electrode aperture center and the third electrode skirt. The mentioned shortest distance is, hence, equal to the square root of the sum of the squares of the radius of the third electrode skirt and of the axial distance of the nearest portion of the third electrode skirt to the mentioned center. Thus, to obtain the proper strength of gradient at this center, it is desirable, in a gun of the Figure 2 type of construction, to have relatively small dimensional values for the said radius or the said distance or both of these dimensions.

To summarize, the electron gun of a cathode ray tube system according to the invention is characterized by one or more of the features, in its geometry, of a large diameter aperture for the second electrode, a wide angle of access or its equivalent from the third electrode aperture, and relatively short distance between the center of the second electrode aperture and the nearest portion of the third electrode. At the same time these specialized features in the geometry of the gun are not exaggerated to the extent where, while appropriate to provide high ultor voltage penetration, they would not be appropriate to carry out the other operations which are required of the gun to produce an acceptable final image on the phosphor screen with the value of ultor potential impressed on the gun. For example, the second electrode aperture, although a large size aperture, is less than the size therefor at which impairment would begin in the ability of the aperture to form the second lens of the triode lens combination. Also, the angle of access, although wide, is less than the value therefor at which impairment begins in the formation of the pre-focusing lens. Likewise, in respect to the distance between the center of the second electrode aperture and the nearest portion of the third electrode skirt, this distance, although small, is greater than the value therefor at which impairment begins in the formation of the pre-focusing lens.

Fourth, even though an electron gun is characterized by a specialized geometry such as that the second electrode has an enlarged diameter for the second electrode aperture, the second electrode provides a wide angle of access for ultor potential, and a short distance is provided

between the center of the second electrode aperture and the nearest portion of the third electrode, it is not necessarily the case that a gun with this geometry will produce the desired ultor potential penetration in all instances. That this is so is shown in Figure 3 wherein curve A (which, as stated, is obtained for a 20,000 volt ultor potential on the third electrode) represents a mode of operation for the Figure 2 electron gun which is characterized by all of the disadvantages found in the conventional operation of conventional cathode ray tube systems. Thus, in order to obtain one or more of the advantages contemplated by the invention, it is necessary to provide (in association with an electron gun having the specialized geometry just described) a source of ultor potential which is adapted to supply to the third electrode of the gun an ultor potential of a value at least sufficient to give an operating condition not far removed on the low side from the zero slope condition shown by curve C in Figure 3. It has been found, with a gun whose geometry is characterized in effect by dimensional values whose relative proportions are on the same order as those characterizing the dimensional values of the Figure 3 gun, that to give this operating condition the ratio of ultor potential to second electrode potential should be on the order of 75:1.

It is understood that the above described embodiment is exemplary only, and that the present invention comprehends embodiments differing in form or detail from the presently described embodiment. Accordingly, the invention is not to be construed as limited save as is consonant with the scope of the following claims.

I claim:

1. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution final image on the screen thereof; said system comprising; an electron gun having a cathode, a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode having formed therein an aperture axially disposed forward of said first electrode aperture in coaxial relation therewith and of larger diameter than said first electrode aperture, said second electrode having a configuration which permits a potential gradient derived from ultor potential to form a positive electron lens in the vicinity of the center of said second electrode aperture, and a third electrode including a cylindrical skirt whose portion nearest to said center is in close spatial relation thereto; said system also comprising a potential source adapted to supply to said third electrode said ultor potential at a level which, in the presence of increasing screen current, imparts a backwardly directed axial shift to the disc of least confusion of the electron beam of the tube.

2. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution final image on the screen thereof; said system comprising; an electron gun having a cathode, a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode having formed therein an aperture axially disposed forward of said first electrode aperture in coaxial relation therewith and of larger diameter than said first electrode aperture, said second electrode having a configuration which permits a potential gradient derived from ultor potential to form a positive electron lens in the vicinity of the center of said second electrode aperture, and a third electrode including a cylindrical skirt whose portion nearest to said center is in close spatial relation thereto; said system also comprising a potential source adapted to supply to said third electrode said ultor potential at a level which, in the presence of increasing screen current, maintains the disc of least confusion of the electron beam of the tube in close proximity to the phosphor screen of the tube.

3. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution final image on the screen of the tube; said system comprising; an electron gun having a cathode, a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode having formed therein an aperture axially disposed forward of said first electrode aperture in coaxial relation therewith and of larger diameter than said first electrode aperture, said second electrode having a configuration which permits a potential gradient derived from ultor potential to penetrate through said second electrode aperture to the triode space of said gun, and a third electrode including a cylindrical skirt whose portion nearest said center is in close spatial relation thereto; said system also comprising a potential source adapted to supply to said third electrode said ultor potential at a level which, in the presence of increasing screen current, imparts a backwardly directed axial shift to the disc of least confusion of the electron beam of the tube.

4. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution final image on the screen of the tube; said system comprising; an electron gun having a cathode, a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode having formed therein an aperture axially disposed forward of said first electrode aperture in coaxial relation therewith and of larger diameter than said first electrode aperture, said second electrode having a configuration which permits a potential gradient derived from ultor potential to penetrate through said second electrode aperture to the triode space of said gun, and a third electrode including a cylindrical skirt whose portion nearest said center is in close spatial relation thereto; said system also comprising a potential source adapted to supply to said third electrode said ultor potential at a level which, in the presence of changing screen current, maintains the disc of least confusion of the electron beam of the tube in close proximity to the phosphor screen of the tube.

5. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution final image on the screen thereof; said system comprising; an electron gun having a cathode a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode including a forwardly extending cylindrical skirt coaxial with said beam and a disc member closing the rear end of said skirt, the disc member having formed therein an aperture of larger diameter than said first electrode aperture, said skirt being of a diameter and length to provide a wide access angle to the center of said second electrode aperture for ultor potential passing through said skirt, and a third electrode including a cylindrical skirt whose portion nearest to said center is closely spaced therefrom; said system also comprising a potential source adapted to supply to said third electrode said ultor potential at a level which, in the presence of increasing screen current, imparts a backwardly directed axial shift to the disc of least confusion of the electron beam of the tube.

6. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution final image on the screen thereof; said system comprising; an electron gun having a cathode, a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode including a forwardly extending cylindrical skirt coaxial with said beam and a disc member closing the rear end of said skirt, the disc member having formed therein an aperture of larger diameter than said first electrode aperture, said skirt being of a diameter and length to provide a wide access angle to the center of said second electrode aperture for ultor potential passing through said skirt, and a third electrode

including a cylindrical skirt whose portion nearest to said center is closely spaced therefrom; said system also comprising a potential source adapted to supply to said third electrode said ultor potential at a level which, in the presence of changing screen current, maintains the disc of least confusion of the electron beam of the tube in close proximity to the phosphor screen of the tube.

7. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution final image on the screen thereof; said system comprising; an electron gun having a cathode, a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode including a forwardly extending cylindrical skirt coaxial with said beam and a disc member closing the rear end of said skirt, the disc member having formed therein an aperture of larger diameter than said first electrode aperture, said skirt being of a diameter and length to provide a wide access angle to the center of said second electrode aperture for ultor potential passing through said skirt, the wide access angle characterizing said second electrode and the enlarged diameter of the aperture thereof permitting the potential gradient derived at said center from ultor potential to form a positive lens at said center and to pass therefrom into the triode space of said gun, and a third electrode including a cylindrical skirt whose portion nearest to said center is closely spaced therefrom; said cathode ray tube system also comprising a potential source adapted to supply to said third electrode said ultor potential at a level which, in the presence of increasing screen current, imparts a backwardly directed axial shift to the disc of least confusion of the electron beam of the tube.

8. A cathode ray tube system adapted by intensity modulation of the tube to produce a high resolution image on the screen thereof; said system comprising; an electron gun having a cathode, a first intensity modulating electrode having formed therein forward of said cathode an aperture centered on the axis of the electron beam, a second electrode including a forwardly extending cylindrical skirt coaxial with said beam and a disc member closing the rear end of said skirt, the disc member having formed theerin an aperture of larger diameter than said first electrode aperture, said skirt being of a diameter and length to provide a wide access angle to the center of said second electrode aperture for ultor potential passing through said skirt, the wide access angle characterizing said second electrode and the enlarged diameter of the aperture thereof permitting the potential gradient derived at said center from ultor potential to form a positive lens at said center and to pass therefrom into the triode space of said gun, and a third electrode including a cylindrical skirt whose portion nearest to said center is closely spaced therefrom, said cathode ray tube system also comprising a potential source adapted to supply to said third electrode an ultor potential at a level which in the presence of changing screen current maintains the disc of least confusion of the electron beam of the tube in close proximity to the phosphor screen of the tube.

References Cited in the file of this patent

UNITED STATES PATENTS

2,268,194	Glass	Dec. 30, 1941
2,268,196	Pierce	Dec. 30, 1941
2,302,876	Malling	Nov. 24, 1942
2,443,916	Kelar	June 22, 1948
2,484,721	Moss	Oct. 11, 1949
2,577,112	Duke	Dec. 4, 1951
2,818,519	Gundert	Dec. 31, 1957