March 11, 1969 D. G. GUMPERTZ 3,432,710

DISPLAY TUBE HAVING CHARACTER MASK WITH ELECTRON GUN INDIVIDUAL TO EACH CHARACTER

Filed June 8, 1967 Sheet 1 of 4

FIG. 1

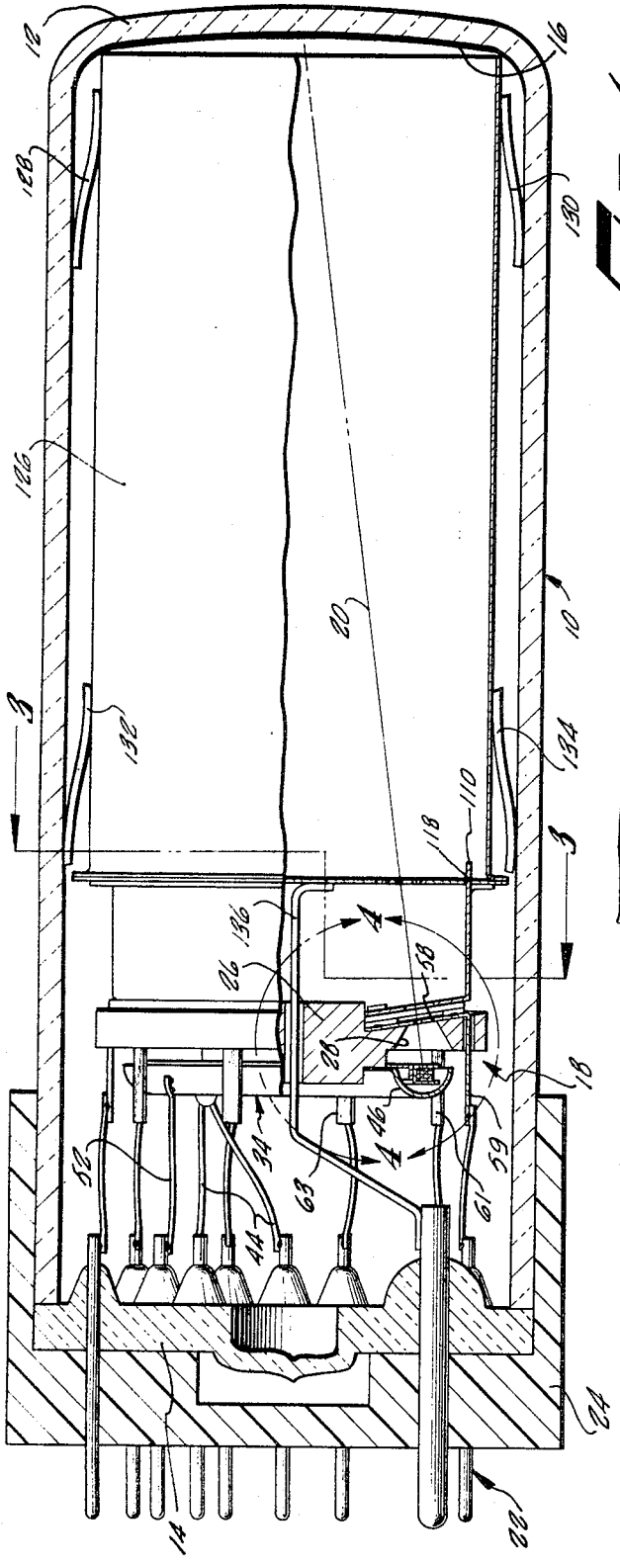
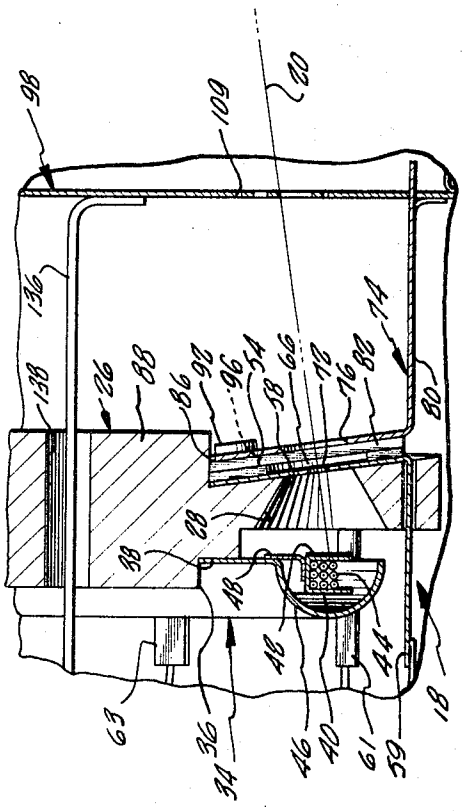


FIG. 4



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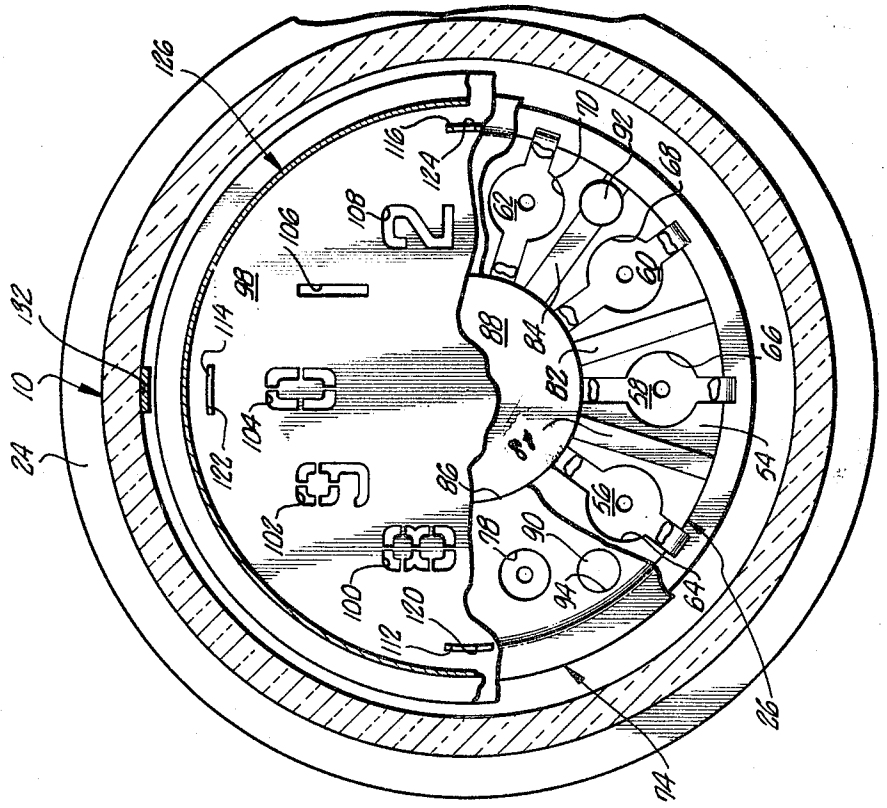

FIG. 3

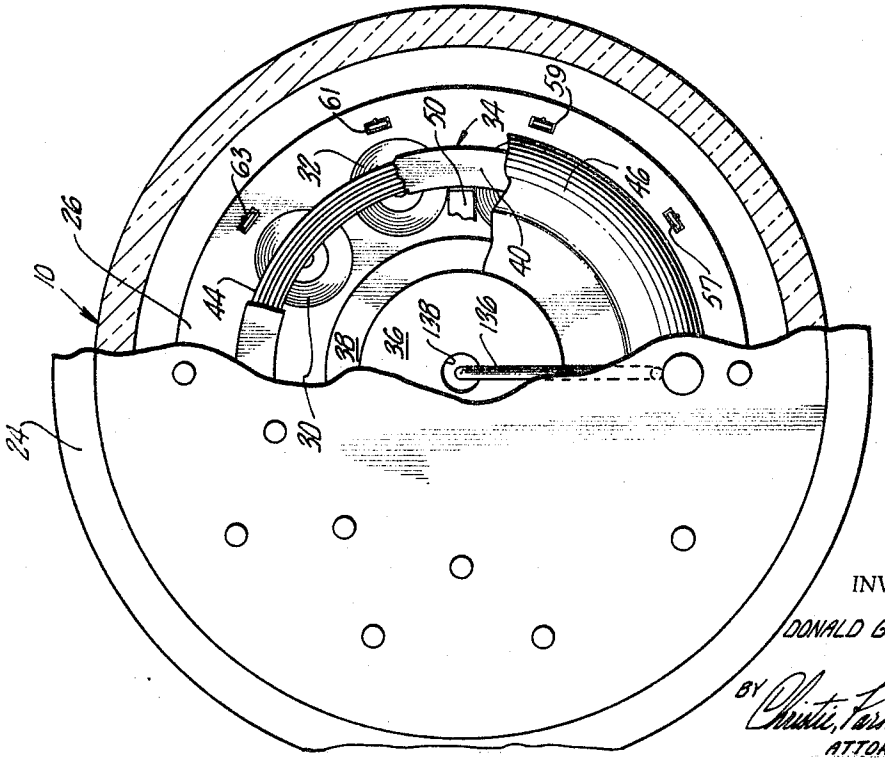

FIG. 2

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Filed June 8, 1967 Sheet 3 of 4

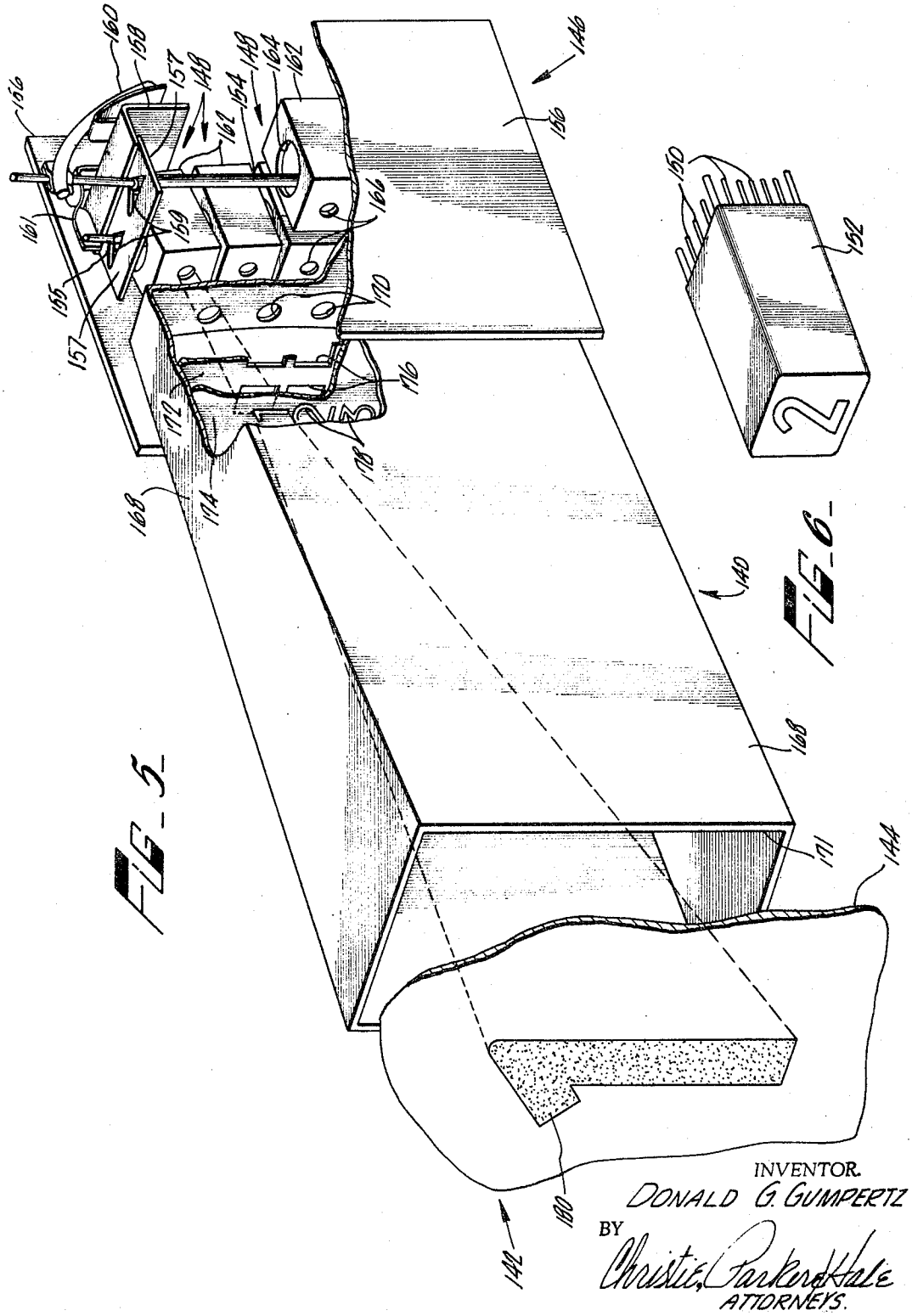

FIG. 5

FIG. 6

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DISPLAY TUBE HAVING CHARACTER MASK WITH ELECTRON GUN INDIVIDUAL TO EACH CHARACTER

Filed June 8, 1967 Sheet 4 of 4

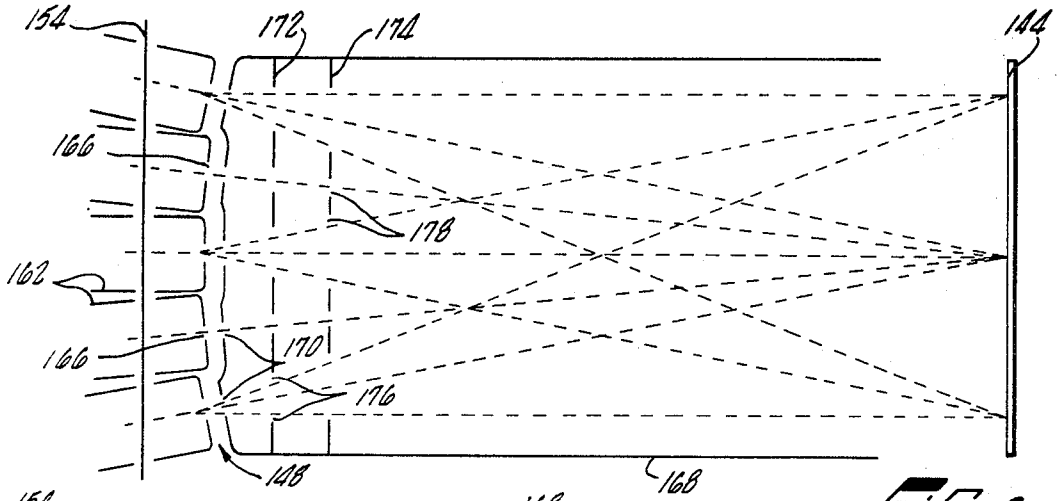

FIG. 8

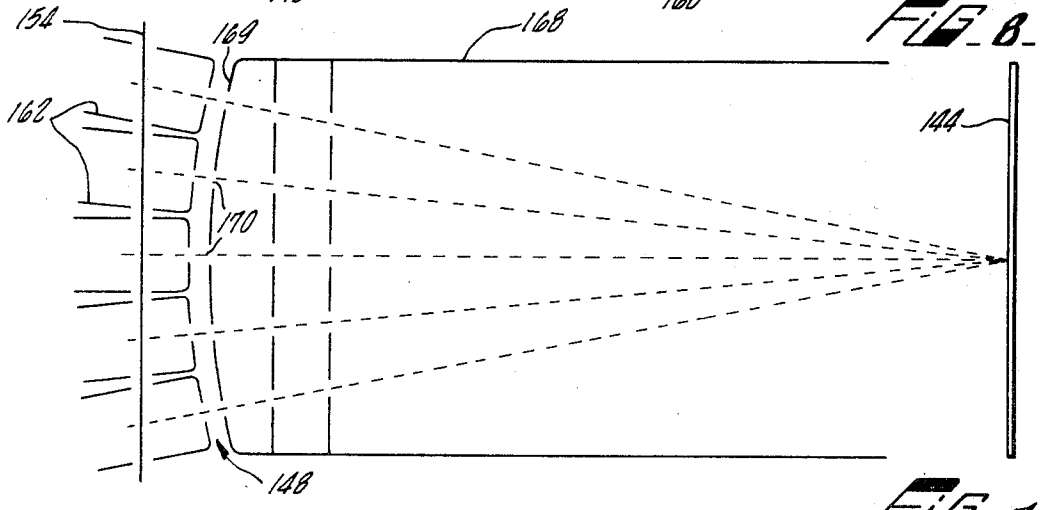

FIG. 7

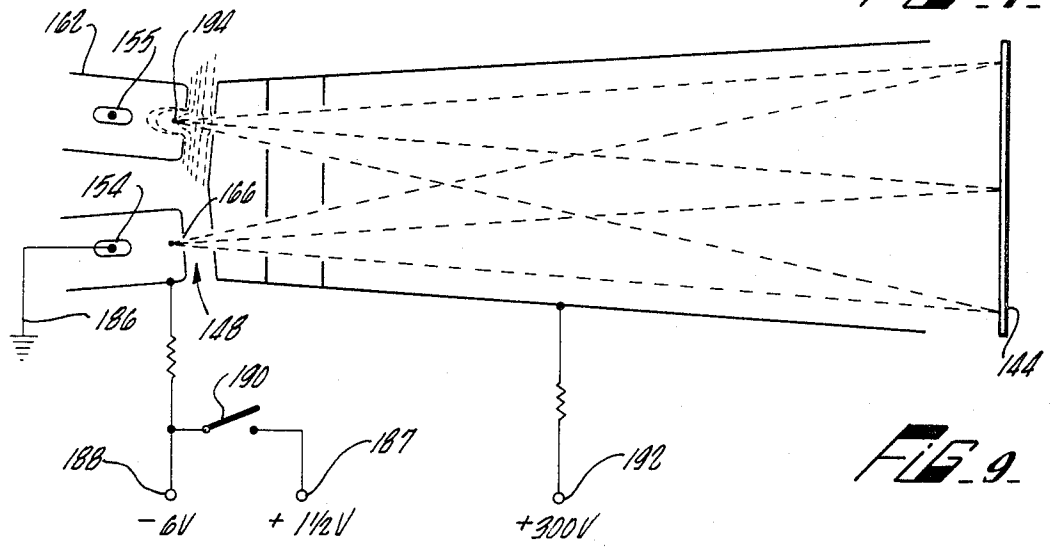

FIG. 9

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Patented Mar. 11, 1969

3,432,710

DISPLAY TUBE HAVING CHARACTER MASK WITH ELECTRON GUN INDIVIDUAL TO EACH CHARACTER

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Continuation-in-part of applications Ser. No. 182,455, Mar. 26, 1962, and Ser. No. 573,775, Aug. 8, 1966. This application June 8, 1967, Ser. No. 650,561
U.S. Cl. 313—69 11 Claims
Int. Cl. H01j 29/46, 31/16, 29/50

ABSTRACT OF THE DISCLOSURE

A character display device operating on the cathode ray tube principle. A plurality of individual electron guns are disposed at one end of a vacuum tube and each gun is aimed along an axis directed at the center of a fluorescent screen located at the opposite end of the tube. A mask having a plurality of character apertures is disposed between the ends of the tube with each of the character apertures being located on one of the electron gun axes. Selective control of the operation of each electron gun controls the particular character displayed by the device.

Cross-references to related applications

This is a continuation-in-part of application Ser. No. 182,455, filed Mar. 26, 1962, now abandoned, and application Ser. No. 573,775, filed Aug. 8, 1966, now abandoned.

Background of the invention

This invention relates to character display units for selectively displaying any of a plurality of different character forms, for example, the numbers 0 through 9, the letters of the alphabet, and miscellaneous symbols. More specifically, the invention relates to a cathode ray tube structure for performing this function.

Character display units are employed for conveniently converting information in the form of electrical signals to a visible, readable form. For example, such units may be employed to display the output of digital computing devices, electronic counters and registers; they may be used in large multiples to make up electrically controlled annunciator panels, flight arrival and departure tables, score boards, etc.

A compact, inexpensive unit providing a selective display of any of a large plurality of brilliant, high quality character images in one plane and capable of being controlled directly from transistorized circuits without buffering circuitry for power or voltage amplification, is a very rigid, albeit highly desirable, specification. Embodiments of the present invention will meet this specification.

The value of a single plane, high quality and brilliant image presentation lies in the provision of a display which is easily and clearly readable, even at an angle. Since character display units are frequently used in large multiples, disposed side by side in banks so that each one may display the separate digit of a long number or the separate letter of a word, unit cost becomes multiplied many times for given practical applications, and compactness becomes especially important in preserving conventional letter and digit spacing in words and multiple digit numbers. The capability of being controlled directly from electronic counters, registers and other electronic control circuitry, particularly transistorized circuits, relates mainly to the cost factor, since it results in the elimination of complex buffering circuits, otherwise necessary, which may cost as much or more than the display units themselves.

Summary of the invention

A character display unit constructed in accordance with the present invention includes an evacuated envelope having a display screen at one end thereof. The screen is provided with a fluorescent coating on its interior side. A plurality of separate electron flood guns are located within the envelope for creating a diverging stream of electrons from each of the guns. Means for aiming the diverging streams of electrons from each gun along an axis which converges toward the center of the screen are provided as well as electron stream shaping means interposed in the path between the electron guns and the screen. The stream shaping means define a series of characters corresponding to a selection of characters to be displayed, each of said characters being associated with a different one of the electron flood guns. The unit further includes means for selectively operating each of the electron guns to release a stream of electrons toward the stream shaping means and the screen and means for accelerating the electrons released by the selected gun through the stream shaping means to display a magnified image of the selected character on the screen.

Brief description of the drawings

The construction and operation of character display units embodying the invention will be better understood by reference to the following description of several embodiments thereof, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side elevation partly in section of one embodiment of a character display unit constructed in accordance with the invention;

FIG. 2 is a rear end elevation, partially cut away, of the display unit of FIG. 1;

FIG. 3 is a fragmentary sectional elevation taken along line 3—3 of FIG. 1;

FIG. 4 is an enlarged fragmentary view of area 4—4 in FIG. 1;

FIG. 5 is a perspective, elevational view in partial section of another embodiment of a character display unit in accordance with the present invention;

FIG. 6 is a perspective view of a display unit according to the present invention as it is ready for mounting;

FIG. 7 is a schematic side elevational view partly in section of the embodiment of FIG. 5;

FIG. 8 is a schematic side elevational view partly in section of a modified embodiment of the invention; and

FIG. 9 is a schematic top view of the embodiments of FIGS. 7 and 8 showing the associated electrical circuit.

Description of the preferred embodiments

Referring now to FIGS. 1, 2, 3 and 4, the character display unit includes an evacuated tubular glass envelope or tube **10** having front and rear ends **12**, **14**. A thin phosphor layer **16** on the interior of the front end of the glass tube forms a viewing screen, upon which images may be seen exteriorly of the tube.

As will be seen, a plurality of ten separate electron guns, as typified by one such electron gun **18** shown in detail, are mounted within the glass tube and aligned on axes, typically axis **20**, which converge toward the center of the screen **16**. Electrical connections to the electron guns exteriorly of the tube are made by means of a plurality of conductive pins **22**. These pins are sealed through the rear end **14** of the tube and protrude from a conventional insulative tube base **24** fixed over the rear end of the tube. The evacuating and sealing of the tube **10**, as well as the materials employed within the tube, is according to conventional vacuum tube construction practice.

The electron guns in this embodiment are mounted in a circular pattern on an insulative ceramic base or disc **26**, and arranged to selectively project different character forming electron beams onto the screen. The ceramic disc **26** is disposed in spaced and approximately parallel relationship with the viewing screen, and has ten gun apertures, typically at **28**, **30**, **32** formed therein at spaced locations around the perimeter thereof. These disc gun apertures are disposed in a circular pattern about the center of the disc and are respectively aligned on the converging gun axes. An annular cathode structure **34** is centered on a rear hub **36** of the disc and abuts a rear shoulder **38** formed on the disc adjacent the rear hub. The hub **36** and shoulder **38** locate the cathode structure in proper position and alignment. The cathode is connected to the ceramic disc by conventional means, such as by a suitable cement. The annular cathode extends over the disc apertures, and is intersected by the converging gun axes.

The cathode structure comprises an inner annular spool **40** having an emissive coating **42** on the front surface thereof, a ceramically insulated heater wire or element **44** wound about the spool within the confines thereof, and an annular conductive shield **46**. The spool **40** is physically and electrically connected to the shield **46** at locations remote from the heater wire **44** by means of a plurality of locating tabs, typically at **48**, **50**. The insulated heater wire **44** is wound by-filar on the spool so as not to create a magnetic field, and opposite ends of the wire are drawn rearwardly through openings (not shown) in the spool **40** and shield **46** and connected to two of the plurality of base pins **22**. The cathode is connected to one of the plurality of base pins by means of an insulated wire **52**.

The cathode shield **46** overlies the spool **40** in spaced relationship thereto. The shield is relatively cool and nonemissive, and serves to minimize leakage of electrons by deflecting them toward the disc gun openings and by shielding against any electrical potential gradients existing in the space adjacent the rear of the tube by virtue of the electrical connections there. Also, the shield increases efficiency by reflecting heat onto the cathode.

The front periphery of the ceramic disc **26** is a sloped annular surface **54** intersected by and disposed approximately normal to the converging gun axes. Ten separate control electrodes, typically at **56**, **58**, **60**, **62**, are cemented in accommodating depressions typically **64**, **66**, **68**, **70**, respectively, in the sloping annular surface **54** of the ceramic disc. The depressions overlie the respective disc gun apertures. Typical control electrodes **56**, **58**, **60**, **62**, each have a tang **57**, **59**, **61**, **63**, respectively, extending rearwardly through accommodating openings in the ceramic disc. Insulated wires extend from these tangs to different ones of the plurality of base pins **22**.

Each control electrode follows the slope of the surface **54** and has a central aperture therein aligned on the corresponding gun axis. Typically, the control electrode **58** for the gun **18** has a central aperture **72** therein aligned on the gun axis **20**. The accommodating depression **66** in the sloped front annular surface **54** of the ceramic disc aligns the control electrode **58** in proper position.

An accelerator electrode in the form of conductive, cup-shaped plate **74** is cemented on the front side of the disc. The accelerator plate has a corresponding plurality of ten apertures, typically at **76**, **78**, formed in the bottom thereof each in alignment on one of the gun axes, and has a forwardly extending outer rim **80**. The bottom of the accelerator plate abuts a plurality of elevations, typically at **81**, **82**, **84** on the front sloping annular surface of the ceramic disc, and follows the slope of the annular surface. The accelerator plate and ceramic disc have interlocking surfaces for locating and aligning the plate on the disc. In this connection, the accelerator plate has a central opening **86** which fits a forward hub **88** of the disc, and is engaged over a plurality of ceramic posts, typically **90**, **92**, protruding from the elevations on the front surface of the disc and extending through and extending through mating openings **94**, **96**, respectively, in the bottom of the accelerator.

A character mask in the form of a conductive plate **98** is mounted across the forward edge of the outer rim **80** of the accelerator plate. The character plate **98** has a corresponding plurality of ten number-forming apertures therein, typically at **100**, **102**, **104**, **106**, **108**, **109**, respectively, aligned on the converging gun axes. The character plate and the outer rim of the accelerator plate have interlocking, mating surfaces in the form of a plurality of tabs **110**, **112**, **114**, **116** extending forwardly from the accelerator plate rim through accommodating openings **118**, **120**, **122**, **124** in the character plate. The character plate is spotwelded to the accelerator plate rim.

An elongated tubular conductive envelope **126** extends forward from the accelerator and character plate and terminates adjacent the viewing screen. The conductive envelope is slightly smaller in diameter than the glass tube and is open at both ends. It is electrically connected to the character plate and accelerator plate by spotwelding to the outer periphery of the character plate. A plurality of long spring fingers **128**, **130**, **132**, **134** are spaced around the periphery of two locations on the conductive envelope. The spring fingers extend outwardly and rearwardly from the conductive envelope to engage under spring tension the inner surface of the glass envelope, thereby aligning the conductive envelope coaxially with the glass tube. The connected assembly of the conductive envelope, character plate, and accelerator plate, is electrically connected to one of the plurality of base pins **22** by means of a heavy, insulated wire **136** extending from the character plate and through a central opening **138** in the ceramic disc.

The foregoing structure provides ten electron guns arranged in a ring and aligned on axes which converge toward the center of the screen for selectively projecting any one of the numerals 0 through 9. Each separate electron gun **18** is formed on one of the converging axes **20** by the aligned aperture **28** in the ceramic disc, the control electrode aperture **72**, the aligned aperture **76** in the accelerator plate, and the aligned character forming aperture **109** in the character plate, in association with the aligned portion of the cathode.

In the absence of the character plate, each electron gun is arranged to provide an electron beam which just slightly more than fills the viewing screen. The space forward of the bottom of the accelerator electrode to the screen is surrounded by conductive material at the same potential, including the character plate and the conductive envelope, so that no electric potential gradients exist. Hence, the electrons follow straight paths in this space so that an electron beam penetrating a character forming aperture in the character plate behaves like an analog of an optical shadowgraph having a point source of light.

A typical character display unit employs a glass envelope having a diameter of about 1⅛ inches with the ceramic disc disposed about 2¼ inches from the screen. The emissive surface of the cathode is disposed about $\frac{1}{10}$ inch along the gun axes from the control electrodes, which are in turn disposed about $\frac{2}{100}$ inch along the gun axes from the accelerator plate. The diameter of the gun aperture in each control electrode is about $\frac{2}{100}$ inch, and the diameter of each gun aperture in the accelerator plate is about $\frac{7}{100}$ inch. The distance along the gun axis between the gun openings in the accelerator plate and those in the character plate is about $\frac{5}{16}$ inch. The center of the gun openings in the ceramic disc are disposed about $\frac{3}{10}$ inch from the center of the disc, so that the converging gun axes each form an angle with the central axis of the tube of about 8°.

The various locating surfaces and interlocking mating surfaces between the cathode and disc, the control electrodes and disc, the accelerator plate and disc, the character plate and the accelerator plate and the character plate and the conductive envelope, together with the employment of a common annular cathode, a unitary ceramic disc, a unitary accelerator plate and a unitary character plate, all combine to simplify tolerance problems in constructing the unit, and substantially reduce the cost of the unit. The basic support and overall alignment for this interconnected structure is provided by the elongated conductive envelope fitting inside the slightly larger glass tube, supported by the long spring fingers which engage the interior of the glass tube. Furthermore, the disposition of the front end of the conductive envelope adjacent the screen provides a return path for the electron charge accumulating on the screen, thus doing away with any requirement for providing a conductive coating over the interior of the glass tube for this purpose. If an aluminized screen is employed, the conductive envelope should physically touch it, a matter which may be assured by employing a small leaf spring for this purpose. The longitudinal position of this interconnected electron gun structure is assured by means of the various wire connections to the conductive pins, the wires having a sufficient spring characteristic to keep the forward end of the conductive envelope pushed against the front end of the tube.

The tube may be powered from a conventional power supply, employing either direct current or alternating current. The tube is self-rectifying, and the persistence of the phosphor screen completely eliminates any 60-cycle flicker in the image projected on the screen.

Typically, the cathode heater operates on 60-cycle alternating current at 6.3 volts drawing about 2.5 watts power. The DC voltage of the cathode is maintained at ground level. The accelerating voltage is typically 2500 volts R.M.S. supplied at 60 cycles between the cathode and accelerator. With one electron gun on, the tube draws about 100 microamperes current at this voltage. Normally all electron guns, with the exception of one, are turned off by the application of −6 volts DC to their control electrodes. Any electron gun may be turned on by 0 volts or ground potential at its control electrode. The control electrodes draw only a few microwatts power, and this in conjunction with the low DC control voltage required, permits the display unit to be controlled directly from conventional transistor circuits, without buffering circuits to provide voltage or power amplification. The relatively large spacing between the control grid and the cathode facilitates the use of a relatively small control voltage.

The brightness of the image on the screen is controlled by varying the accelerating voltage with a potentiometer or the like. Substantial changes in accelerator voltage have only a small effect on the image size.

In the embodiment shown in FIG. 5, the unit **140** has a front end **142** at which is mounted a screen **144** having a thin phosphor layer which is excited when electrons impinge thereon. The rear end **146** of the unit houses a plurality of individual electron flood guns **148**. In the present embodiment the electron guns are arranged in two closely spaced groups of five guns each, the guns in each group being mounted in vertical alignment with one another. As in the preceding emobdiment, the electron guns are disposed and oriented such that each gun is mechanically aimed along axes which converge toward the center of screen **144**. A plurality of pins **150** such as those shown on the unit of FIG. 6 pass through an envelope **152** at the rear end thereof for providing means for connecting the various electrodes and elements within the display unit to sources of control voltages and electrical power for operating the unit.

The display unit of this embodiment comprises a pair of directly heated filaments **154** and **155** which are disposed in a parallel relationship between two vertical side supports **156** of mica or other insulating material. A metal plate **158** is mounted between and supported by vertical supports **156**. Attached to plate **158** is a mica plate **157** having triangular apertures **159**. Plate **158** provides means for suspending the filaments at one end thereof in the proper orientation within the unit. A similar plate (not shown) is provided at the opposite end of the filaments to provide a similar function at that point. The pair of filaments **154**, **155** extend through and are fitted into the apex of triangular apertures **159** in plate **158**. At their top end the filaments are attached to an electrically conductive wire **160** and strip **161** which provide mechanical support for the filaments and electrical continuity to the source of energization for the filaments. The point of attachment of the top end of filament **154** to support wire **160** is referred to as the suspended side or end of the filament. The top end of filament **155** and its point of attachment to its supporting wire **160** is referred to as the stationary side or end of the filament. The stationary side of filament **154** and the suspended side of filament **155** (not shown) are similar to those shown in FIG. 5.

In contrast with the indirectly heated cathode of the preceding embodiment, the electron source in the present embodiment is a pair of directly heated filaments of a material such as oxide coated tungsten or tungsten alloy.

A plurality of box-like enclosures or cups **162** are disposed about the filaments **154** and **155**. Each enclosure is provided with apertures in the top and bottom walls thereof through which the vertically oriented filaments are passed, but may be open at the back. Each of the enclosures **162** is attached to its adjacent side support **156** by means of tabs adapted to pass through slots in said support. Each enclosure is also provided with a third aperture **166** located in a side wall thereof, each individual enclosure being oriented such that aperture **166** is placed or mechanically aimed along an axis which extends from the filament toward the center of the screen **144**. Enclosures **162** serve as the control electrodes for the electron guns **148** of the display unit of this embodiment of the invention and as with the control electrodes in the previously described embodiment, the voltage level applied to each control electrode-enclosure controls the emission of electrons therefrom through aperture **166**.

To prevent emission by the electron flood guns, a negative voltage is applied to the control electrodes of each of the guns. By swinging the voltage applied to one of the electrodes to a more positive value, e.g., zero or some positive voltage, electrons are extracted from that gun and move in a direction along one of the gun axes which converge at the center of the screen. Due to the configuration of a high voltage field which is created between the control electrode-enclosures **162** and an accelerating electrode located between the enclosures and the display screen, the extracted electrons are accelerated in a diverging cone or stream toward an associated aperture in the accelerating electrode. As described in more detail below, each of the accelerating electrode apertures are located on one of the converging electron gun-screen axes. Each control electrode **162** is electrically connected to an associated external pin passing through the envelope of the unit to provide the electrical connections for supplying the desired voltage level to the control electrodes.

In comparison with standard electron guns, the filament-to-control grid spacing along the flood gun-screen axes in this embodiment of the invention is also relatively large, being on the order of .10 inch. Normally the control electrode to filament spacing in a cathode ray tube is .005 inch. The relatively large spacing between the filament and the aperture **166** in the control electrode and the use of box or cup-like configuration for the electrode enables the creation of an electron cloud within the enclosure such that when the proper voltage level is supplied to the electrode a stream of electrons having the configuration of a solid cone is passed through aperture **166** and directed toward the screen **144**.

Disposed between control enclosures **162** and screen **144** is an accelerating electrode enclosure **168** having a plurality of apertures **170** in the end thereof adjacent control electrodes **162**, each of said apertures being aligned with a corresponding aperture **166** in the control electrodes along one of the gun-screen axes. In the operation of the unit, a relatively high voltage is connected to accelerating electrode **168** to cause the electrons extracted from any one of the apertures **166** to be accelerated to a high velocity in their transit toward screen **144**. Accelerating electrode **168** is essentially a horn-like elongated enclosure which diverges from its narrow multi-apertured end to a large single opening **171** at the end thereof disposed adjacent screen **144**. By providing spring fingers extending from enclosure **168** as in the previous embodiment, the unit is easily aligned and positioned within the envelope.

Located within the accelerating enclosure are two masks **172** and **174**. Mask **172** is provided with a plurality of rectangular apertures **176** for shaping the cone of electrons entering the accelerating electrode enclosure through one of the apertures **170** into a stream or beam which is rectangular in cross-section. Because of the configuration of the apertures in mask **172**, this mask is normally referred to as the rectangular mask.

The primary function of the rectangular mask is to improve the definition of the image produced on the display screen of the unit. This is accomplished by positioning mask **172** at the point, or slightly in advance of the point, where the edge of the cone or stream of electrons from adjacent guns would intersect or begin to cross over were the two guns to be energized simultaneously, the crossover points defining a plane of intersection. By intercepting the stream at the crossover point and shaping it into a rectangular cross-section, it is possible to locate the mask having the character-shaped apertures at a point closer to the display screen rather than at the electron stream crossover point. Location of mask **174** closer to screen **144** permits the use of larger character-shaped apertures in the mask **174** thereby reducing the magnification required to fill the display screen. Reduced magnification provides a commensurate improvement in clarity and sharpness of the image displayed.

The second mask within the accelerating grid enclosure, mask **174**, is located adjacent rectangular mask **172** and on the side thereof nearest the open end **171** of accelerating electrode **168**. Mask **174** is a character mask for the display unit and contains apertures **178** having outlines corresponding to the selection of symbols or characters which can be displayed by this unit. Normally ten character apertures **178** are provided corresponding to the ten electron guns with which this embodiment is normally equipped. Depending on which of the ten guns is energized, the rectangular cone of electrons is directed through the character aperture corresponding to that gun where it is shaped into the form of the symbol to be displayed. The shaped electron beam or stream then proceeds from the mask in a diverging manner to impinge upon and substantially fill the screen **144** exciting the phosphor thereon and presenting the display such as the display **180** of the digit "1" shown in FIG. 5.

Each gun is arranged to direct a diverging cone of electrons along an axis passing through the center of the screen. The first mask **172** restricts the outer limits of the conical electron beam to a rectangular area filling the screen in the absence of the second mask. The second mask further restricts the outer margin of the electron beam to the desired outline representing the character to be displayed. In order to achieve a sharply defined outline of each character at the screen, the electrons in each beam must all effectively emanate from a point source. The electrode structure and the accelerating potentials applied thereto combine to achieve an effective point source even though the actual source is an elongated heater wire and the electrons pass through a relatively large diameter opening at the control grid.

The effective point source and the direction of the axis of the diverging beam toward the center of the screen is achieved by the geometry of the electrodes, as best seen in FIG. 7. The control electrodes or grids **162** are cup-shaped and arranged with the front surfaces tangential to a single spherical surface generated by a radius about the center of the screen **144**. The end surface, indicated at **169**, of the accelerating anode **168** is also formed as a spherical surface whose center is the center of the display screen **144**. The aperture **166** in each control grid and the associated aperture **170** in the accelerating anode are centered along a common axis extending through the center of the screen. Thus the accelerating surface of the anode and control grid of each electron source are substantially parallel and equally spaced for all the guns.

As pointed out above, the minimum spacing between the heater-cathode and the apertured front of the control electrodes is relatively large as is the size of the aperture in the control electrodes in relation to the spacing between the front of the control electrodes and the anode. As a result, when a control electrode is raised to the same potential or a slightly positive potential with relation to the heater-cathode, the equipotential lines of the field between the control grid and anode dip in at the control grid aperture, drawing electrons from the cloud of electrons surrounding the heater. These lines are shown as broken lines in FIG. 9. The electrons are pinched by the field in passing through the aperture in the control grid and diverge as they are accelerated toward the anode.

The electrons passing through the aperture in the anode travel within a cone having its apex (the effective point source) slightly behind the aperture in the control grid. The geometry of the tube is arranged such that the cone of electrons would fully illuminate the full face of the tube in the absence of the masks **172** and **174**. Since each gun structure is symmetrical to and aligned with a radius or axis passing through the center of the screen, each of the guns when turned on illuminates in the absence of the masks **172** and **174** the same area of the screen. By interposing the character mask **174**, the screen is illuminated only by electrons passing through the cutout in the mask defining a particular character. Because the electrons effectively emanate from a point source, a sharp "shadow" of the mask is formed on the screen providing a clearly defined magnified visible character on the face of the screen. Thus no electron lenses or other focusing means are required to achieve a sharply defined magnified image of a selected character on the screen.

In the arrangement of FIG. 7, because the heater is a fine wire and held in a straight line under tension, the relative spacing between the apertured front of the control grids and the cathode varies from gun to gun, with the maximum spacing being in the four outermost guns. This spacing affects the anode current and therefore the brightness of the image. To achieve uniform brightness from gun to gun, the apertures in the outermost control grids are made slightly larger in diameter. Because the control grids are therefore not all identical, they must be made up in sets, adding to the cost of manufacture. This can be avoided by the arrangement of FIG. 8. Here the control grid cups are mounted so that the centers of the apertures of all the control grids are equally spaced from the cathode wires. However, each grid cup is tilted so that the front surface is normal to the axis passing through the center of the screen. The front surfaces of the control grids are therefore not tangential to a common spherical surface but are staggered with the outermost grids being farthest from the center of screen. The anode structure in turn is rippled or stepped to form a plurality of contiguous flat surfaces parallel and equally spaced from the front faces of the grid cups. The anode surface is analogous to a Fresnel lens, permitting the spherical surface to be broken up into segments that more nearly lie in a single plane.

Again each of the guns in the arrangement of FIG. 8 provides an effective point source of a diverging beam of

electrons that, in the absence of a character mask, floods the entire screen.

Because there are two rows of guns, as shown in FIG. 9, the anode end surface **169** is also formed to provide the flat surfaces at an angle to each other as viewed from the top. The cup-like control grids in each of the two rows are also tilted slightly as viewed from the top so that the front surfaces are normal to the same axes. This provides an aiming of each of the guns at a common point on the center of the screen.

By way of example only, the tube of FIG. 8 has grid apertures of .033 inch in diameter, anode apertures of .047 inch in diameter, with grid to anode spacing of .050 inch. The cathode wire is positioned between .075 and .125 inch behind the center of the aperture **166** in the control grid. The screen is spaced about 1.42 inches from the center of the apertures **170** in the anode surface **169**. Workable potentials are indicated in FIG. 9.

The operation of the unit of this embodiment can be illustrated in conjunction with the schematic diagram of FIG. 9 depicting the electrical circuitry and voltage levels associated with one of the electron flood guns of the unit of this invention. By virtue of using directly heated cathodes, power on the order of 100 milliwatts, supplied at a voltage level of 1 volt is sufficient to energize the filament and cause electrons to be thermionically emitted therefrom. The filament is also connected to a source of reference potential **186** such as ground for establishing its potential relative to the control electrodes **162**. Each control electrode **162** is connected by means of suitable circuitry to a source of negative voltage **188** and by a switching means **190** to the source of positive potential **187**. A typical voltage level for the source **188** is a negative six volts (−6 v.) relative to ground, and for the source **187** is a positive one and a half volts. During the time when −6 v. is connected to control electrode **162**, the electron gun is effectively turned "off" and no electrons are emitted from aperture **166**. By closing switch means **190**, thereby causing a six volt swing on control electrode **162** and raising the potential on this electrode to ground potential, the electrons in the cloud within the control electrode cup are permitted to pass through cup aperture **166** and are directed along an axis passing through aperture **170** in accelerating electrode **168**.

Typical voltage levels for accelerating electrode **168** are three to five thousand volts (3000–5000 v.) supplied from a high voltage source **192**. Electrons passing through aperture **170** are accelerated to a sufficiently high velocity to energize the fluorescent screen at the front end of the unit. Accelerating voltages on the order of 5000 volts are utilized when the phosphor layers used as the fluorescent material on the screen are aluminized for greater brightness. As discussed in conjunction with the description of FIG. 5, the accelerated electrons are directed through an aperture in mask **172** and the character aperture in mask **174** corresponding to the energized electron gun. In the operation of the embodiment just described, nine of the electron guns are deenergized by imposing a negative signal on the control grid. The remaining control grid corresponding to the character to be displayed is switched to ground to permit the egress of the electron stream therefrom. Upon emerging from the aperture in character mask **174**, the electron beam proceeds along a diverging path to impinge upon the screen **144** and present the desired image.

The unique construction of the cathode ray display device of this invention utilizes the principle of establishing a divergent beam of electrons shaped at high velocity in the form of a symbol which expands in transit to provide a display of suitable size at the screen. Electrons emerging from the apertures **166** in a typical control electrode are "pinched" without causing a crossover of electrons. The result is a stream of electrons emanating from an apparent point source or virtual cathode **194**, all of which proceed along uniformly diverging lines toward the phosphor screen. For the unit of this embodiment, the virtual cathode is located approximately .012 inch from aperture **166**. The construction of this device permits the shaping of a divergent beam and subsequent display of an image without a need for deflecting electrodes at any point along the path of the electron beam to change the direction or angle of the beam while at the same time permitting a sharply focused character to be displayed on the screen.

As shown in FIG. 6, the preferred configuration of the unit is rectangular for ease of mounting next to adjacent units and for economy of spacing. Other configurations, e.g., circular, can also be employed without departing from the scope of the invention.

In addition to the triode configuration described in conjunction with FIGS. 5, 7 and 8, it is also possible to provide a unit utilizing a tetrode configuration with the fourth electrode being located between the control and accelerating electrode. By imposing a relatively low voltage (on the order of 30 volts), it is possible to further reduce the voltage swing required on the electron gun control electrodes from approximately six volts to approximately two volts. Further, in addition to mechanically aiming the various guns of the unit along axes converging at the center, it is also possible, without departing from the scope of the invention, to provide aiming by means of a donut shaped magnet surrounding the unit or a disc shaped magnet located within the unit to urge the electrons toward the display screen along axes converging at the center of the screen.

Other advantages of the unit of this device are its low cost of manufacture and extreme simplicity of construction requiring relatively few parts to produce a device capable of displaying a plurality of symbols. The low voltage on the control electrodes means that a low voltage swing on these electrodes controls the operation of the device and results in a unit with extremely low power requirements. The low power requirement means that substantial economies can also be effected in the cost of the power supplied used to energize such units.

I claim:

1. A vacuum tube readout device comprising:

a vacuum tight enclosure having a transparent screen and coating of phosphor material on the inside surface of the screen;

a plurality of electron guns mounted within the enclosure, each gun including a cathode common to a plurality of the electron guns, a control electrode defining a partially enclosed region disposed about a portion of the common cathode for providing an electron chamber wherein an electron cloud individual to said chamber may be formed and an anode common to all said electron guns, each control electrode having an aperture and corresponding thereto an aperture in the common anode for the passage of electrons, the centers of the corresponding apertures being positioned along a line extending from the cathode to a point on the screen common to all the lines, the control electrode aperture being spaced from the cathode a distance sufficient to permit the drawing of a cone of electrons from an apparent point source of electrons in each of the electron chambers;

means for independently connecting each control electrode to a source of control voltage for selectively drawing said cone of electrons, the cones of electrons from adjacent chambers overlapping and illuminating the same area of the screen so as to define a plane of intersection intermediate the electron chambers and the screen; and

a mask located intermediate the plane of intersection and the chambers, the mask having a plurality of apertures corresponding to characters to be displayed, each aperture being associated with one of the plurality of electron chambers and interposed between the anode and the screen on the associated cathode-screen line at a distance from the anode such that

the cone of electrons illuminates only its associated aperture, the aperture in each anode being sufficiently large to permit said cone to pass therethrough and illuminate the mask aperture and a substantial portion of the full area of the screen.

2. A vacuum tube readout device comprising:

an evacuated envelope having a translucent screen and an electron excited, light emitting coating on the inside surface of the screen;

a plurality of electron guns mounted within the envelope, said guns comprising a cathode structure, a control electrode structure for each gun, each control electrode structure defining a partially enclosed region disposed about the cathode structure for providing an electron chamber wherein an electron cloud individual to said chamber may be formed, each control electrode having an aperture, and electrode means for providing an electron accelerating field comprising an anode section for each electron gun, each anode section having an aperture, the centers of each anode aperture and the aperture of the corresponding control electrode being positioned along a line extending from the corresponding cathode structure to a point on the screen common to all the lines, the control electrode aperture being spaced from the corresponding cathode structure a distance sufficient to permit the drawing of a cone of electrons by the corresponding anode section field from an apparent point source of electrons in each of the electron chambers;

means for independently connecting each control electrode structure to a source of control voltage for selectively drawing said cone of electrons, the cones of electrons from adjacent chambers overlapping and illuminating the same area of the screen so as to define a plane of intersection intermediate the electron chambers and the screen; and

a mask structure located intermediate the plane of intersection and the chambers, the mask structure having a plurality of apertures corresponding to characters to be displayed, each aperture being associated with one of the plurality of electron chambers and interposed between the anode sections and the screen on the associated cathode-screen line at a distance from the anode sections such that the cone of electrons illuminates only its associated aperture, the aperture in each anode section being sufficiently large to permit said cone to pass therethrough and illuminate the mask aperture and a substantial portion of the full area of the screen.

3. A vacuum tube readout device as defined in claim 2 wherein said anode sections are part of a common anode structure.

4. A vacuum tube readout device as defined in claim 2 wherein a plurality of cathode structures are part of an element common to a plurality of electron guns.

5. A vacuum tube readout device as defined in claim 4 wherein the common cathode element comprises a directly heated filament wire extending past the apertures of the control electrode structures.

6. A vacuum tube readout device as defined in claim 5 wherein the guns are aligned in at least one row.

7. A display device according to claim 2 including an additional mask located between the anode and said mask, said additional mask having a plurality of rectangular openings therein, each of said openings being aligned with a different one of said cathode-screen lines to limit the shape of the stream of electrons from each electron chamber to a rectangular outline.

8. Apparatus as defined in claim 2 wherein the accelerating anode sections of the guns are formed of a single conductive plate having a plurality of apertures, the plate being formed with a flat surface surrounding each section aperture, the flat surface being normal to an axis passing through the center of the aperture and through the center of the screen, the flat surface around each aperture being parallel to the adjacent control electrode structure.

9. Apparatus as defined in claim 5 further including means for applying a current through the filament wire to heat the filament wire, the filament wire being spaced on one side of each of the control electrode apertures a distance greater than the spacing between the control electrode aperture and the corresponding anode section.

10. Apparatus as defined in claim 2 wherein each of the control electrode structures is cup-shaped with a front portion parallel to the corresponding anode sections having said control electrode aperture therethrough and a tubular portion extending from the front portion, the tubular portion having at least one aperture therein through which the cathode structure extends.

11. Apparatus as defined in claim 2 wherein the anode sections of each gun are part of a single conductive plate, the anode plate being spherical in shape with the center of the sphere being at substantially the center of the screen, the control electrode sections each being spaced the same distance from the anode plate.

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