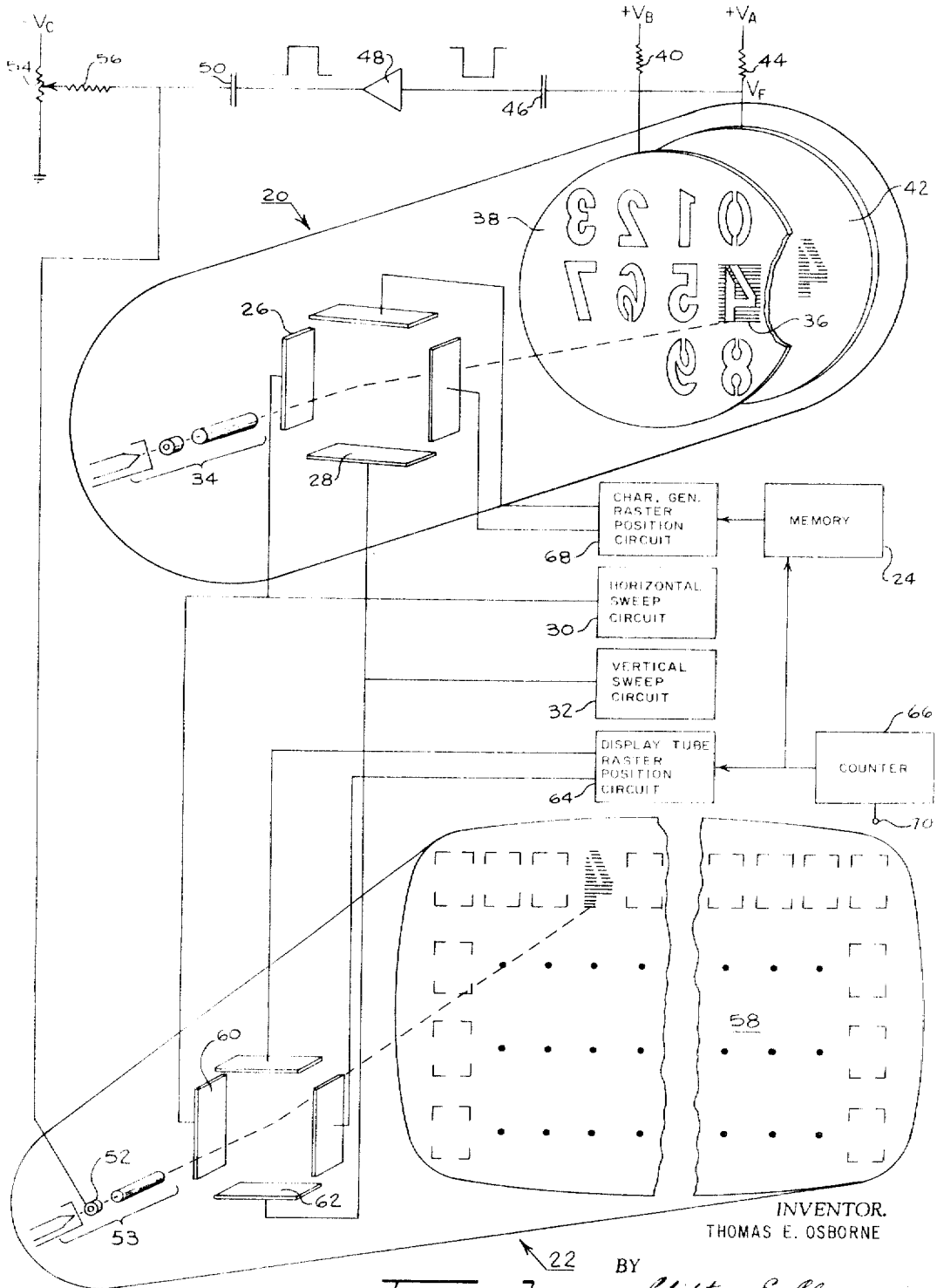
Aug. 15, 1967 T. E. OSBORNE 3,336,497

CATHODE RAY TUBE CHARACTER GENERATING AND DISPLAY SYSTEM

Filed March 20, 1964 4 Sheets-Sheet 1




Fig—1—

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CATHODE RAY TUBE CHARACTER GENERATING AND DISPLAY SYSTEM

Filed March 20, 1964 4 Sheets-Sheet 2

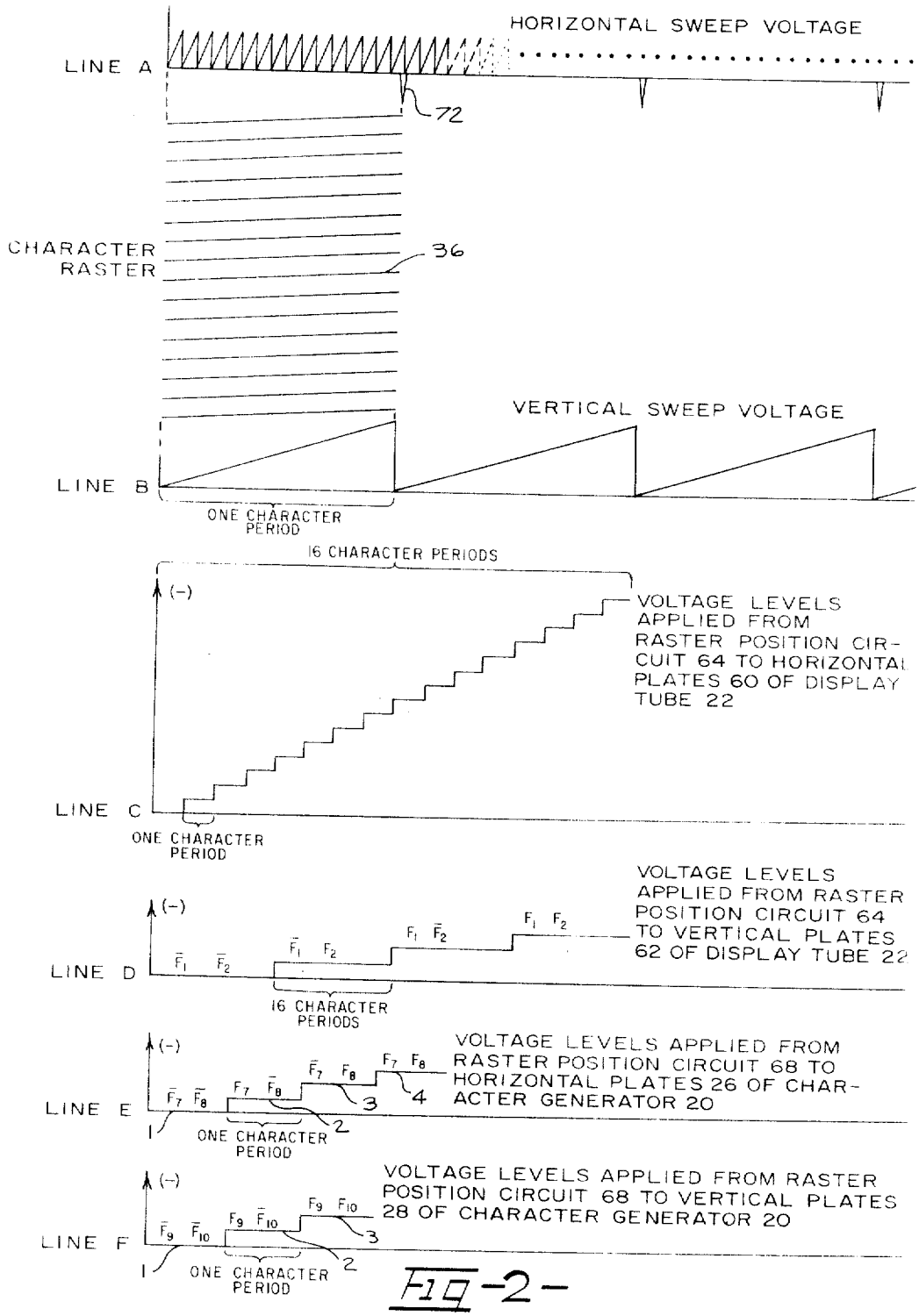



Fig -2-

CATHODE RAY TUBE CHARACTER GENERATING AND DISPLAY SYSTEM

Filed March 20, 1964 4 Sheets-Sheet 3

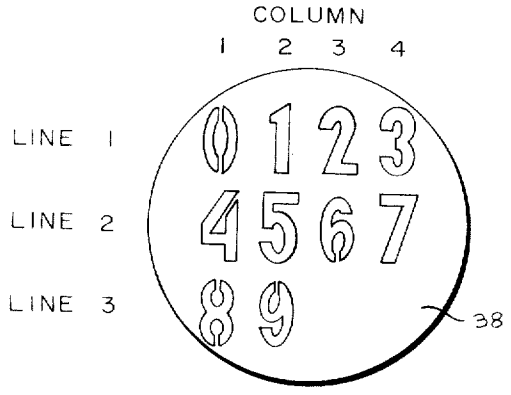



FIG-5-

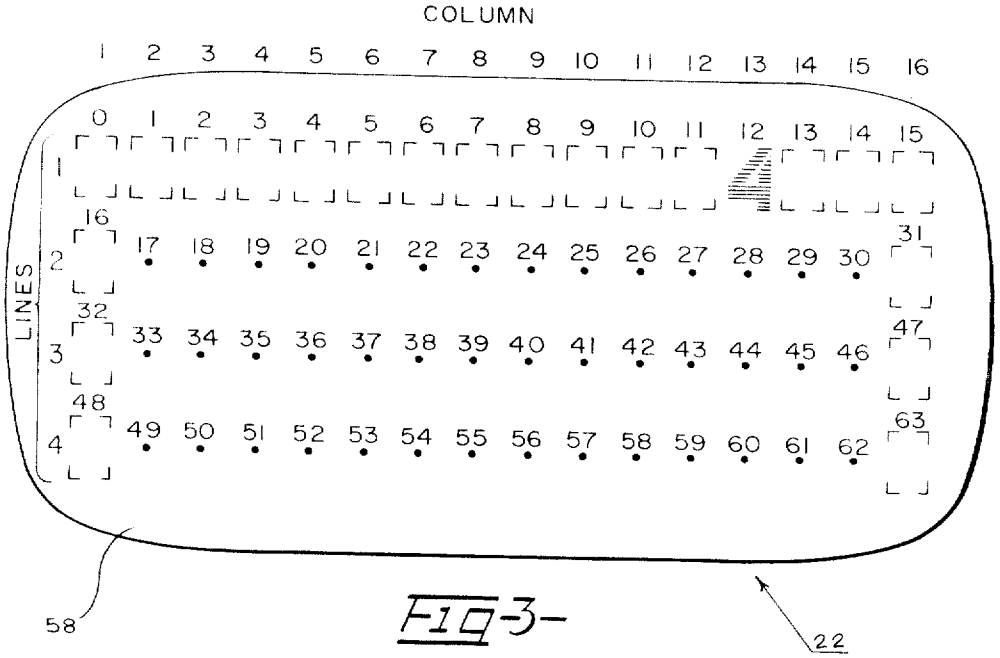



FIG-3-

CATHODE RAY TUBE CHARACTER GENERATING AND DISPLAY SYSTEM

Filed March 20, 1964 4 Sheets-Sheet 4

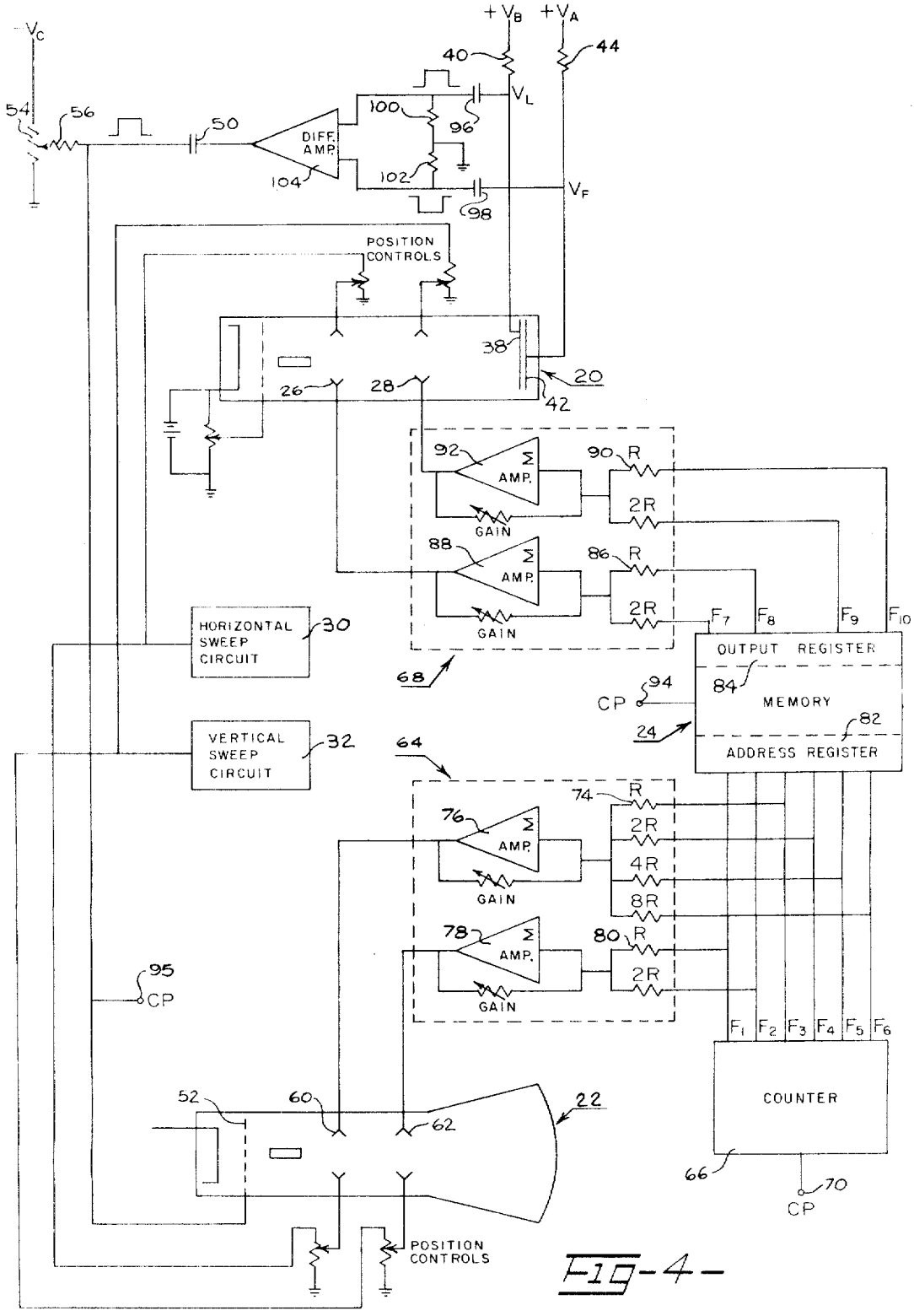



Fig-4-

United States Patent Office 3,336,497
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3,336,497

# CATHODE RAY TUBE CHARACTER GENERATING AND DISPLAY SYSTEM

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4 Claims. (Cl. 315—18)

The invention relates to improved cathode ray tube character generating and display systems and more particularly concerns a cathode ray character generating tube operable for generating characters in the form of a series of coded electrical impulses that may be applied to a conventional cathode ray tube for display of the characters.

According to the present invention, a character generating tube is provided for the generation of any character regardless of configuration, proportion or complexity of outline with the same ease with which the most simple character previously has been generated. This is accomplished by cutting holes in the form of characters in a conductive plate for use as first anode or character plate. The character plate is placed in a cathode ray tube between an electron gun and a second anode. Electrons emitted from the electron gun may be directed to pass through the holes in the front anode and are collected on the second, or back, anode which normally is positively charged with respect to the front anode to eliminate any detrimental effects resulting from secondary emission. The output from either one or both of the anodes then is applied to a utilization device preferably a conventional cathode ray tube, for display or recording of the character selected. Identical deflection waveshapes, preferably sawtooth voltages, are applied synchronously to deflection plates of respective tubes to cause the tracing of a similar raster pattern in each tube in conventional manner.

The raster in the character generating tube is shifted to scan a selected character on the front or first anode by means of selection control voltages applied to the deflection plates, while the raster in the display tube is shifted to scan the position in which it is desired to display the character. Grid means in the display tube is responsive to coded electrical impulses from the character generating tube to permit only the portion of the raster that corresponds to the selected character to be developed. Characters in the character generating tube may be successively selected and displayed thereby on a fluorescent screen of the display tube, the persistence of the display being long enough to permit a series of character selections in the character generating tube to be displayed together.

The invention is particularly useful in the display of factors or results of a computation. For example, a number may be stored on the magnetic surface of a rotating drum or disc, in a matrix of electrical switches or magnetic cores, or in a delay line memory. In any event, conventional means may be provided to interrogate the sequential ordinal digits of the stored number, i.e. the digits are read out in serial fashion and converted into discrete voltage steps which are applied to the deflection plates of the character generating tube to cause the raster thereof to scan a selected number on the character plate corresponding to the stored value. The numbers are scanned in sequence and may be displayed in a row, for example, on the screen of the display tube by using stepping means for controlling voltage steps applied to the deflection plates of the display tube in such manner that the raster for the display tube is displaced one ordinal increment for each ordinal digit generated on the character generator tube. Thus, by repeatedly interrogating the stored numeral value, the same value appears to remain on the screen of the display tube.



Generally, in a cathode ray tube character generating and display system, there are certain features of the character generating tube that are especially desirable, as for example: the signals from the character generating tube should have sufficient current amplitude to reduce the stages of amplification; the signals should reproduce characters that are sharp and clear; the size of the character generating tube should be compact for usefulness in a wide range of applications; the character generating tube should be insentitive to stray fields in order to achieve compact packaging with a minimum of shielding; and the character generating tube should be simple in construction and reliable and durable in operation.

In one well known type of character generating and display system, a shaped beam cathode ray tube is used for generating coded electrical impulses or signals corresponding to stored characters, which signals are applied to a conventional cathode ray tube for visual display on the screen thereof. The shaped beam cathode ray tube comprises a cathode for generating a beam of electrons which are then caused to diverge into a wide beam which impinges upon a character plate in which a plurality of character-shaped apertures are cut. The apertures permit a portion of the wide beam to pass therethrough in the form of a plurality of character-shaped beams. The plurality of electron beams then are caused to converge by means of an electrostatic lens. Deflection plates at the point of conversion are under control of selection voltages applied thereto to select one of the plurality of beams and direct the beam through an aperture in a second plate which blocks the unselected beams. The selected beam, under control of scanning voltages applied to another set of deflection plates, causes scanning of the beam over a target anode which is a small wire-like element embedded in the end of the tube and is the single source of output signals. During the portion of each scansion that the shaped beam impinges on the target anode, a coded pulse is generated that is proportional in width to the period that the shaped beam scans the anode, i.e. proportional to the width of that portion of the character being scanned over the target anode. A series of time-coded signals are developed thereby. These coded signals are amplified and then applied to a grid control element of a conventional cathode ray display tube. In order to display the character, the scanning voltages used to scan the shaped beam over the target anode in the shaped beam cathode ray tube are applied also to deflection plates in the display tube for deflection of an electron stream therein to reproduce the character on a fluorescent screen of the display tube.

In a shaped beam character generating tube which scans a target anode, several disadvantages appear. First, the amplitude of the output signals is proportional to the diameter of the wire used for the target anode: the larger the diameter, the greater the signal amplitude; but a small diameter wire is required to provide output signals capable of reproducing clear sharp characters in the display tube. A wire of very small diameter, however, in addition to providing a weak signal, would be very delicate, requiring special handling in manufacturing as well as in use. Second, the sharpness and the clearness of the reproduced characters are a function also of the definition or shape of the beam of electrons when the beam impinges on the target anode. Since such beams are made up of negatively charged electrons, the electrons tend to mutually repel one another, causing the beam to spread, diffuse and distort. This distortion may be minimized by subjecting the electron beams to higher accelerating voltages. When higher accelerating voltages are used, however, it becomes necessary, if normal deflection poten-

tials are to be used, to increase the distance between the character plate and the cathode and therefore to increase the size of the tube in order to achieve divergence of the electron beam over the entire area of the character plate. Lower accelerating voltages on the other hand not only tend to diffuse but are more easily deflected by stray fields, thereby requiring careful shielding. Third, most of the wide beam of electrons propagated from the cathode of the character generating tube impinge on the solid portion of the character plate. The remainder of the original wide beam is formed into a plurality of character-shaped beams, only one of which is selected for display. Thus, the efficiency of the tube is very low since only a very small number of the electrons in the original wide beam is available for generating output signals.

In another well known type of character generating and display system, a monoscope type of video signal generator is provided wherein a stream of electrons from an electron gun are deflected in a raster pattern over one of a plurality of characters which are printed on a target plate. The target plate is of a material having high secondary electron emission qualities while the characters are of a material having relatively low secondary emission qualities. Thus, as the electron stream is deflected over a selected character in a raster pattern, many secondary electrons are emitted when the electron stream impinges on the target plate, while almost no secondary electrons are emitted when the electron stream impinges on a character. A secondary electron collector ring is positioned near the target plate to collect the secondary electrons. As a result of the secondary electrons, coded signals are transmitted from the collector, which is the sole source of output signals, to external circuits. Each signal is proportional in width to that part of the scansion which inpinges on the character being scanned. The coded signals from the monoscope are applied to a control grid in a conventional cathode ray display tube in which an electron stream is developed and then deflected in synchronism with the electron stream in the monoscope. Thus, only that part of the raster pattern corresponding to the numeral being scanned in the monoscope, is developed and displayed in the display tube.

The target anode in a character generating tube using secondary emission may be manufactured from a metal such as aluminum which has high secondary electron emission qualities. The material of low emissive quality used for numerals may be india ink or other material with a high graphite content. As presently advised, however, known low emissive materials tend not to stick to the high emissive material during manufacturing and thereafter may shake loose during use, this being especially true of complex configurations. It is found also that in tubes using secondary emission that the outline of the characters is not as sharp as desirable.

A main object of the invention is to provide an improved cathode ray character generating and display system.

Another object is to provide an improved character generating tube.

Another object is to place a conductive character plate having a plurality of apertures within a cathode ray tube and then develop and control a stream of electrons to scan a selected one of the apertures.

Another object of the invention is to direct a stream of electrons over selected areas of a character plate to trace a raster, a portion of the raster being traced on a second plate as the stream passes through an aperture in the selected area.

Another object is to provide improved means for generating characters in the form of coded electrical impulses.

Another object is to provide a character generating tube capable of producing coded output signals having a high output current.



Another object of the invention is to provide a character generating tube of high efficiency.

Another object is to provide a cathode ray character generating tube wherein substantially all of the electrons in the electron stream are available for generation of output signals.

Another object of the invention is to provide a character generating tube having a plurality of sources for output signals, which sources may be used individually or in combination.

Another object of the invention is to effectively couple a differential amplifier to a character generating tube.

Another object is to develop coded signals useful for developing sharp and clear reproductions of characters.

Another object of the invention is to develop coded signals in a cathode ray tube by means of scanning the ray over a plate with a character formed therein.

Another object is to provide a character generating tube having inherent qualities that enable the production of a compact tube.

Another object of the invention is to provide a character generating tube that is relatively insensitive to stray magnetic or electrostatic fields.

Another object is to provide a character generating tube having a minimum number of components which are simple to assemble.

Another object is to provide a character generating tube that is reliable and durable.

Another object is to provide a character generating tube that is easy to adjust and thereafter maintains adjustment.

Another object of the invention is to provide a simplified and dependable character generating tube.

Another object is to provide an improved character display system comprising a simplified character generating tube for controlling the intensity of a cathode ray.

Another object is to provide an economical and reliable readout means from conventional memories.

Other objects and advantages will be apparent from the following detailed description, when read in conjunction with the drawings, given by way of example only, in which:

FIG. 1 is a functional diagram of a cathode ray tube character generating and display system according to the invention;

FIG. 2 indicates various representative voltage levels and wave forms used for controlling the system and indicates the relative periods of the voltages;

FIG. 3 is a front view of the face of a cathode ray display tube with representative positions of display indicated;

FIG. 4 is a detailed functional diagram of a cathode ray tube character generating and display system; and

FIG. 5 is a front view of a character plate used in a cathode ray character generating tube.

The basic principles of the invention are embodied in the diagram of FIG. 1 wherein a circuit is shown which comprises two cathode ray tubes: a character generating tube **20** and a display tube **22**. The display tube **22** is of conventional design and is arranged in the circuit for simultaneous display of four lines of arithmetic information contained in an arithmetic memory **24**. The character generating tube **20** comprises a pair of horizontal deflection plates **26** and a pair of vertical deflection plates **28**. The plates **26** are connected to a horizontal sweep circuit **30** of conventional design, while the vertical deflection plates **28** are connected to a vertical sweep circuit **32** also of conventional design.

A horizontal sawtooth sweep voltage illustrated on line A of FIG. 2 is generated by the horizontal sweep circuit **30** and applied to the horizontal deflection plates **26**. A vertical sawtooth sweep voltage illustrated on line B (FIG. 2) is generated by the vertical sweep circuit **32** and applied to the vertical plates **28**. The combination of the horizontal and vertical sawtooth sweep voltages

applied to respective plates 26 and 28 serves to deflect a stream of electrons emitted from a conventional electron gun 34 to produce a character raster 36 (FIGS. 1 and 2) on a first anode or character plate 38. The character plate is formed of a conductive material with portions removed to provide apertures in the form of arabic numerals 0–9 therein. The plate 38 is connected to a positive voltage source $V_B$ through a resistor 40. A second anode or collector plate 42 is spaced from the character plate and is electrically isolated therefrom. The plate 42 may be a solid plate, a coating on the end of the tube 20, a screen or other suitable internal conducting means. In any case the plate 42 is connected through a resistor 44 to a positive voltage source $V_A$. The source $V_A$ is held at a slightly more positive voltage than the source $V_B$ in order to reduce the detrimental effects resulting from secondary emission from the plate 42. Normally, the entire electron stream is directed to strike the character plate 38 so that no electrons strike the plate 42 and no current flows through the resistor 44. Under this condition the voltage at an output terminal $V_F$ is at the level $V_A$. Whenever the electron stream is scanned over an aperture, substantially the entire stream is passed through a removed portion of the character plate 38. A pulse of a current, due to the electron stream striking the plate 42, is conducted thereby through the resistor 44, causing the voltage at $V_F$ to drop. A negative pulse proportional in width to the removed portion of the character plate is produced at $V_F$. Thus, as the raster 36 is developed, a series of negative control pulses is developed at $V_F$ which corresponds to the portion of the raster developed on the plate 42. The pulses are applied through an isolating capacitor 46 to a conventional inverting amplifier 48 which produces a series of corresponding positive pulses.

The series of positive pulses are applied through another insolating capacitor 50 to a control grid 52 of an electron gun 53 in the display tube 22. Normally, a negative voltage $V_C$ is applied to the grid 52 through resistors 54 and 56 to prevent the gun 53 from developing an electron stream, i.e. the electron stream in the display tube normally is maintained cutoff. Each positive pulse applied to the control grid 52 overrides the negative voltage to permit conduction of the electron stream to strike a target means in the form of a fluorescent screen 58 to trace out a pattern. The trace of the pattern is a function both of the pulses applied to the grid 52 and of raster voltages applied to a pair of horizontal and vertical deflection plates 60 and 62.

The horizontal sweep circuit 30 is connected to the horizontal plates 60 and the vertical sweep circuit 32 is connected to the vertical plates 62. Thus, the voltages shown on lines A and B of FIG. 2 are applied simultaneously and synchronously to horizontal and vertical deflection plates of both the character generating tube 20 and the display tube 22 to produce similar character rasters 36 in each tube. Normally, however, the electron stream from the gun 53 is cut off by the negative voltage applied to the control grid. During the periods that the electron stream in the character generating tube passes through a removed portion of the plate 38, control pulses are produced at $V_F$ and applied to the control grid 52 in the display tube. Each control pulse causes the electron stream in the display tube to conduct so that the part of the raster that passes through the removed portion of the character plate 38 is traced out on the screen 58. The character scanned in the tube 20 is displayed thereby on the fluorescent screen 58.

Alternatively, the control pulses applied to the grid 52 to obtain a character display may be taken at an output terminal across the resistor 40 instead of the resistor 44. In this case the amplifier 48 must be replaced by a noninverting amplifier since the pulses across the resistor 40 are positive. Experiments, however, indicate that pulses obtained across the resistor 44 provide a better character display. Still another alternative is to maintain the display tube normally conducting and then to provide negative signals to the grid 52 to stop conduction, thereby displaying characters in reverse contrast.

Circuitry, in addition to that discussed above, is included in FIG. 1 for display of several lines of plural order numbers simultaneously on the screen 58 of the tube 22. For example, the display tube 22 may be controlled to display up to four numbers, each having up to 16 orders, as indicated in a front view of the screen 58, shown in FIG. 3. The brackets and dots on the screen 58 indicate character positions in which an ordinal numeral may appear, the brackets showing the boundaries of the raster 36. The small numbers adjacent each position are positional numbers, designating the positions in which a numeral may appear. A raster position circuit 64 (FIG. 1) for control of the display tube 22 is connected to the horizontal and vertical deflection plates 60 and 62 of the display tube. Voltage levels applied from the circuit 64 to the deflection plates 60 and 62 cause the raster in the display tube to shift successively from position to position in each line and from line to line, thereby developing a raster in each possible raster position 0–63 (FIG. 3) of the display tube.

The voltage levels developed by the raster position circuit 64 and applied to the horizontal plates 60 of the display tube may be of the type shown on line C of FIG. 2 wherein each of sixteen negative-going voltage levels are maintained for one character period, i.e. long enough for one raster 36 to be developed. Other voltage levels developed by the raster position circuit 64 and applied to the vertical plates 62 of the display tube 22 may be of the type shown on line D of FIG. 2. Each of these levels are maintained for sixteen character periods, i. e. long enough for sixteen character rasters 36 to be developed. Thus, a raster 36 is sequentially developed in each of the character positions on line 1 of tube 22 (FIG. 3) and then successively on lines 2, 3 and 4. Then, the process is repeated. Preferably, the frequency at which the raster is developed and shifted is matched with the persistence of the fluorescent screen 58 so that a character developed in any position on the screen will glow long enough to permit all other positions to be scanned before dying out. Such a match eliminates flicker and yet is low enough for conventional amplifiers to handle easily. With a good match of scanning frequency and screen persistence, a character will appear to be displayed in each character position simultaneously.

An arithmetic memory such as the memory 24 (FIG. 1) may be provided with a capacity for storing sixty-four binary coded decimal digits simultaneously, a digit for each of the positions indicated on the screen of the display tube 22 (FIG. 3). The arithmetic memory 24 may be of a commonly available type wherein readout of data stored in the memory does not destroy the data. A counter 66 may be provided for selecting successive decimal digit positions of the memory for readout. A raster position circuit 68, under control of the memory 24, is provided for applying selection voltages to the horizontal and vertical deflection plates 26 and 28. These voltages cause the electron stream in the tube 20 to scan a location in the character plate 38 that corresponds to a digit selected in the memory 24. The raster position circuit 68 is operable in response to data read out of the memory 24 to selectively apply one of four voltage levels to the horizontal deflection plates 26 and one of three voltage levels to the vertical deflection plates 28. Possible patterns for these voltage levels are indicated on lines E and F (FIG. 2), respectively. The circuit 68 may be adjusted so that appropriate pairs of voltage levels are applied to the vertical and horizontal deflection plates in response to each decimal digit read out of the memory 24. Each pair of voltages will deflect the raster 36 on the plate 38 to a character position corresponding to the digit read out.

After raster **36** is developed in a character position, i.e. at the end of each character period, the counter **66** is advanced by means of a clock pulse **72** (line A, FIG. 2) applied from a conventional source to a terminal **70**. Such advancement controls the memory **24** to read out successive digit positions in the memory **24**. As the counter is advanced, the data in the next ordinal digit position in the arithmetic memory **24** is read out, causing corresponding raster position voltage levels to be generated by the circuit **68**. The raster **36** is positioned thereby to scan the character corresponding to the numeral selected from the arithmetic memory **24**. The counter **66** is operable also to control the raster position circuit **64** to selectively apply pairs of voltages (lines C and D, FIG. 2) to the horizontal and vertical deflection plates **60** and **62** to cause the appropriate ordinal raster position on the screen **58** to be scanned.

As discussed previously, the deflection plates of both the character generating tube **20** and the display tube **22** are connected together to the horizontal sweep circuit **30** and the vertical sweep circuit **32**. The respective electron streams are deflected thereby to produce the raster **36** simultaneously in each tube. That portion of the raster **36** which passes through the removed portion of the character plate **38** causes a positive pulse to be applied to the control grid **52** of the tube **22** to display a corresponding character on the screen of the tube. Thus, as successive corresponding ordinal positions of both the memory **24** and display tube **22** are simultaneously activated by the counter **66**, the numeral value found in the activated position of the memory causes the corresponding numeral to be selected in the character generating tube **20** for display in the corresponding ordinal position on the screen of the display tube.

A more specific circuit for controlling the character generating tube **20** and the display tube **22** to display the numbers stored in the memory **24** is shown in FIG. 4. The counter **66** may comprise six conventional flip-flop circuits with output leads designated $F_1$–$F_6$. These output leads are connected to both the raster position circuit **64** for the display tube and to the arithmetic memory **24**. The clock pulse **72** (line A, FIG. 2) is applied to the terminal **70** of the counter at the end of each character period to advance the counter one count each character period. A voltage level on an output lead of a counter flip-flop is designated as 1 and zero voltage is designated as 0 according to the binary code listed below in condensed form in Table I.

TABLE I

[Coded signals applied from counter 66 (FIG. 4) to raster position circuit 64 for control of display tube 22]

| Summing Amplifier 78 | | | Summing Amplifier 76 | | | | | |
|---|---|---|---|---|---|---|---|---|
| Coded Signals for control of Vertical Deflection Plates 62 | | Line of Face 58 | Coded Signals for Control of Horizontal Deflection Plates 60 | | | | Column of Face 58 | Ordinal Position on Face 58 |
| $F_1$ | $F_2$ | | $F_3$ | $F_4$ | $F_5$ | $F_6$ | | |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | | 0 | 0 | 0 | 1 | 2 | 1 |
| • | • | | • | • | • | • | • | • |
| 0 | 0 | | 1 | 1 | 1 | 0 | 15 | 14 |
| 0 | 0 | | 1 | 1 | 1 | 1 | 16 | 15 |
| 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 16 |
| 0 | 1 | | 0 | 0 | 0 | 1 | 2 | 17 |
| • | • | | • | • | • | • | • | • |
| 0 | 1 | | 1 | 1 | 1 | 0 | 15 | 30 |
| 0 | 1 | | 1 | 1 | 1 | 1 | 16 | 31 |
| 1 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 32 |
| 1 | 0 | | 0 | 0 | 0 | 1 | 2 | 33 |
| • | • | | • | • | • | • | • | • |
| 1 | 0 | | 1 | 1 | 1 | 0 | 15 | 46 |
| 1 | 0 | | 1 | 1 | 1 | 1 | 16 | 47 |
| 1 | 1 | 4 | 0 | 0 | 0 | 0 | 1 | 48 |
| 1 | 1 | | 0 | 0 | 0 | 1 | 2 | 49 |
| • | • | | • | • | • | • | • | • |
| 1 | 1 | | 1 | 1 | 1 | 0 | 15 | 62 |
| 1 | 1 | | 1 | 1 | 1 | 1 | 16 | 63 |

The raster position circuit **64** comprises four resistors **74** each having one end connected together to the input of a conventional summing amplifier **76** and the other end connected respectively to flip-flop output leads $F_3$–$F_6$. The output of the amplifier **76** is connected to the horizontal deflection plates **60** and may be adjusted to maintain the electron stream in the leftmost column of the screen **58** of the display tube as seen in FIG. 3 when all inputs $F_1$–$F_6$ are at zero. The value of each of the resistors **74** is weighted according to the coded output that appears on respective leads as listed in Table I. Since a clock pulse **72** is applied to the counter **66** at the end of each character period to advance the counter one count, successively larger inputs are applied to the summing amplifier to produce successively higher steps of voltage such as shown on line C (FIG. 2). The raster in the display tube is shifted rightward thereby as shown in FIG. 3 through sixteen horizontal ordinal positions.

A summing amplifier **78** is connected to the vertical deflection plates **62** and has two weighted resistors **80** connected to the input. The other ends of the resistors **80** are connected to respective flip-flop output leads $F_1$ and $F_2$. With no output voltages on leads $F_1$ and $F_2$, the summing amplifier **78** may be adjusted to a voltage level which maintains the electron stream on the level of line 1 (FIG. 3). As the count is advanced, corresponding outputs appear on lines $F_1$ and $F_2$, causing the summing amplifier **78** to produce successively different voltage levels on the plates **62** such as shown on line D, FIG. 2. The logical condition of the leads $F_1$ and $F_2$ necessary to produce the associated voltage at the output of amplifier **78** are indicated on each level of line D where the presence of a bar over a character indicates no output on that lead and corresponds to a binary 0 in Table I, and where the absence of a bar indicates the presence of an output voltage on that lead. Thus, as the count is advanced, according to Table I, the voltage applied to the vertical deflection plates **62** maintains the raster of the display tube on line 1 through sixteen counts and then successively on lines 2, 3 and 4 each through sixteen counts. The raster

thus is successively shifted, by means of pairs of the voltages applied to the deflection plates, from position 0 (FIG. 3) through position 63 and then returned to the zero position and the process repeated.

The leads $F_1$–$F_6$ are connected also to an address register **82** included in the memory **24**. The address register is responsive to outputs on the leads $F_1$–$F_6$ to activate an ordinal position in the memory for readout of the decimal digit therein, which position corresponds to the total count in the counter. The digit positions in the memory may be conveniently thought of as an array corresponding to the array of positions on the screen **58** (FIG. 3). The positions of both arrays are successively and simultaneously selected and the decimal digits in the memory displayed in corresponding positions in the display tube.

An output register **84** is included also in the memory **24** for receiving and storing successive decimal digits as they are read out of memory positions. The output register may comprise four flip-flops which produce coded output signals on leads $F_7$–$F_{10}$. The leads $F_7$–$F_{10}$ are connected to the raster position circuit **68** for control of the character generating tube **20**. The leads $F_7$ and $F_8$ are connected to a pair of resistors **86**, the other end of which resistors are connected to the horizontal deflection plates **26** of the character generating tube **20**. Another pair of resistors **90** are each connected with one end to respective output leads $F_9$ and $F_{10}$, the other ends being connected together to the input of a summing amplifier **92**. The output of the amplifier **92** is connected to the vertical deflection plates **28** of the character generating tube.

Information may be conveniently stored in the memory **24** in binary coded decimal form. Each clock pulse **72** (Line A, FIG. 2) is applied at the end of a character period to a terminal **94** of the memory, causing the decimal digit located by the address register **82** to be transferred to the output register **84**. Outputs are applied thereby to the leads $F_7$–$F_{10}$ and correspond to the binary-decimal code listed below in Table II.

TABLE II

[Coded signals applied from output register 84 (FIG. 4) to raster position circuit 68 for control of character generating tube 20]

| Decimal Equivalent in Character Plate 38 | Coded Signals for Control of Vertical Deflection Plates 28 | | Line | Coded Signals for Control of Horizontal Deflection Plates 26 | | Column |
|---|---|---|---|---|---|---|
| | $F_{10}$ | $F_9$ | | $F_8$ | $F_7$ | |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | | 0 | 1 | 2 |
| 2 | 0 | 0 | | 1 | 0 | 3 |
| 3 | 0 | 0 | | 1 | 1 | 4 |
| 4 | 0 | 1 | 2 | 0 | 0 | 1 |
| 5 | 0 | 1 | | 0 | 1 | 2 |
| 6 | 0 | 1 | | 1 | 0 | 3 |
| 7 | 0 | 1 | | 1 | 1 | 4 |
| 8 | 1 | 0 | 3 | 0 | 0 | 1 |
| 9 | 1 | 0 | | 0 | 1 | 2 |

The resistors **86** and **90** are weighted according to the binary code in Table II. The decimal numerals in character plate **38** that may be selected for display are listed in the first column of Table II while the corresponding binary equivalent that is represented in output register **84** is listed in the columns $F_7$–$F_{10}$, considering these columns together to represent each binary number. Output leads $F_7$ and $F_8$ are connected to weighted resistors **86** for application of voltages appearing thereon to the input of a summing amplifier **88**. Voltages are produced thereby at the output of amplifier **88** having a level that is proportional to the combination of input levels. These voltage levels are applied to the horizontal plates **26** of the character generating tube **20** and are shown on line E (FIG. 2). The logical conditions on the output leads $F_7$ and $F_8$ necessary to produce the associated voltage level are indicated on each level of line E in the manner discussed hereinbefore with respect to line D. The levels indicated on line D are applied to the horizontal plates **26** in the character generating tube **20** to position the electron stream horizontally. A front view of the character plate **38** is shown in FIG. 5 with lines and columns indicated for defining each character position. The voltage applied to the horizontal deflection plates determines in which of the columns the raster **36** is developed; while the voltage applied to the vertical plates determines the line on which the raster is developed and depends on the condition of the leads $F_9$ and $F_{10}$. For example, with either the binary equivalent of a decimal zero, four or eight in the register **84**, leads $F_7$ and $F_8$ have no output so that the amplifier **88** produces an output level designated $\overline{F}_7\overline{F}_8$ (line E) and does not deflect the electron stream horizontally from the normal position in the first column. In a like manner, the output voltages appearing on the leads $F_9$ and $F_{10}$ produce output voltage levels at the summing amplifier **92** as indicated on line F (FIG. 2) wherein the logical condition of the voltages on the leads $F_9$ and $F_{10}$ are indicated on adjacent corresponding levels. For example, with the binary equivalent of either four, five, six or seven in the register **84**, lead F has an output while lead $F_{10}$ does not so that the amplifier **92** produces an output level designated $F_9\overline{F}_{10}$ and deflects the electron stream so that the raster **36** may be developed in one of the positions on line 2 (FIG. 5). Thus, by means of pairs of voltage levels on leads $F_7$–$F_{10}$, the raster **36** is positioned to scan one of the ten positions on the character plate **38**.

In addition to applying clock pulses to the terminal **70** of the counter **66** and the terminal **94** of the memory **24**, clock pulses are applied also to a terminal **95** and thus to the control grid **52** of the display tube **22**. Since each pulse is negative, the electron stream in the display tube **22** is cut off or blanked thereby during the periods that the electron stream is swept from one raster position to another to prevent unwanted traces from appearing on the face of the tube.

In the circuit of FIG. 4, the signal applied from the tube **20** to the control grid **52** is derived from both the character plate **38** and the collector plate **42** instead of only from the collector plate as in the circuit of FIG. 1. Whenever the electron stream in the character generator **20** passes through an aperture in the plate **38**, a positive pulse is produced at a terminal $V_L$ while a negative pulse is produced at terminal $V_F$, the width of each pulse being proportional to the width of the removed portion. These pulses, therefore, occur simultaneously but are opposite in polarity. The pulses at $V_L$ and $V_F$ are coupled through capacitors **96** and **98** respectively; the pulses are then de-

veloped across resistors **100** and **102** and applied to the input of a conventional differential amplifier **104**. A resulting positive pulse output of the amplifier **104** is coupled through the capacitor **50** for application to the control grid **52** as discussed in regard to the circuit of FIG. 1.

The signal for the control grid **52** may be derived from both the plates **38** and **42** as a result of the side-by-side arrangement of the plates **38** and **42** within the tube **20**. Certain advantages are obtained by such an arrangement. First, since the signals at $V_F$ and $V_L$ are opposite in polarity, the difference between the two signals may be amplified to give a larger output signal than is possible for a signal only at $V_F$ or $V_L$ for a given power input to the amplifier. Second, since a larger signal is obtainable, the input resistance of the amplifier **104** may be made low so that the amplifier **104** will have a fast rise time, thereby improving the quality of the displayed character. Another well known advantage of a differential amplifier is the common mode noise rejection to extraneous noise appearing simultaneously at $V_L$ and $V_F$ (FIG. 4). The particular arrangement of plates **38** and **42** and the differential amplifier **104** provide, therefore, a signal for application to the control grid **52** that is sharp and of a relatively high amplitude.

The specific features of the invention that are disclosed but not claimed herein form the subject matter of a separate U.S. patent application Ser. No. 353,335, filed on even date herewith on Mar. 20, 1964.

The invention claimed is:

**1.** A character generating tube comprising:
(a) an electron gun for producing a stream of electrons;
(b) a front anode which stands in the path of said stream of electrons;
(c) a character-shaped aperture in said front anode;
(d) a back anode;
(e) means for directing said stream of electrons at said aperture for passage therethrough to said back anode, said back anode developing a signal of a first polarity upon impingement of the electron stream thereon and said front anode developing a signal of a second polarity upon passage of the electron stream through said aperture;
(f) a pair of output means; and
(g) means connecting said anodes to respective ones of said output means for simultaneous transmission thereto of a pair of signals representative of said character shaped aperture;
(h) means connected to said output means for determining the difference between said pair of signals.

**2.** A character generating tube comprising:
(a) a cathode for producing electrons;
(b) a back anode;
(c) a front anode which stands in substantial blocking relation to the back anode with respect to said electrons;
(d) a character-shaped aperture in said front anode;
(e) a plurality of output terminals; and
(f) respective connections from said front and back anodes to corresponding ones of said plurality of output terminals for transmission thereto of signals representative of said character-shaped aperture;
(g) means connected to said output terminals for combining said signals into a single signal.

**3.** A character readout system comprising:
(a) a cathode for producing electrons;
(b) a back anode;
(c) a front anode which stands in substantial blocking relation to the back anode with respect to electrons emitted by said cathode;
(d) a character-shaped aperture in said front anode to provide a path for said electrons to said back anode;
(e) a utilization device for readout of a character corresponding to said character-shaped aperture;
(f) a differential amplifier having an output connected to said utilization device; and
(g) a connection from each of said anodes to said amplifier, said amplifier being responsive to simultaneous pulses on said anodes to transmit a single pulse to said utilization device for control of said character readout.

**4.** A system for displaying a predetermined character, comprising:
(a) a character generating tube and a cathode ray tube, each having an electron gun and horizontal and vertical deflection means, the deflection means of said tubes being connected for synchronization of the horizontal and vertical sweep of streams of electrons emitted from said guns to describe a respective raster in each tube;
(b) two anodes in said character generating tube, the first one of which anodes has a character formed therein, said character being formed by the absence of anode material in the form of said character and over which said raster is developed, and the second of said anodes standing behind the first anode to receive the entire electron stream that passes through said aperture;
(c) target means in said cathode ray tube; and
(d) means responsive to simultaneous pulses on said first anode and said second anode for producing a single pulse to control passage of the stream of electrons in said display tube to the target means.

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