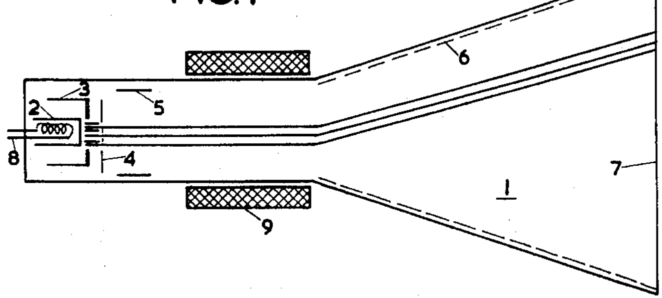
ELECTRIC DISCHARGE TUBES AND APPLICATIONS THEREOF

Filed April 24, 1961 2 Sheets-Sheet 1

FIG. 1



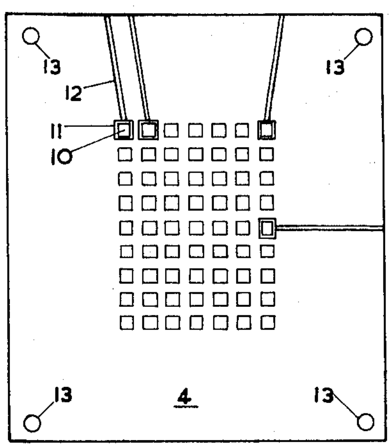


FIG. 2

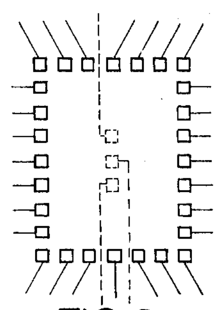


FIG. 3a

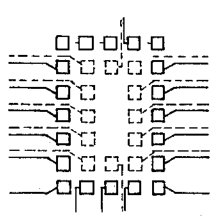


FIG. 3b

Aug. 3, 1965 A. T. STARR 3,198,976

ELECTRIC DISCHARGE TUBES AND APPLICATIONS THEREOF

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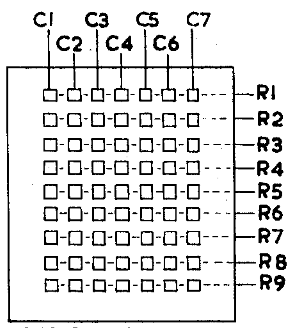


FIG. 4

FIG. 6

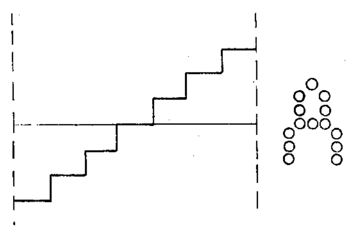


FIG. 8

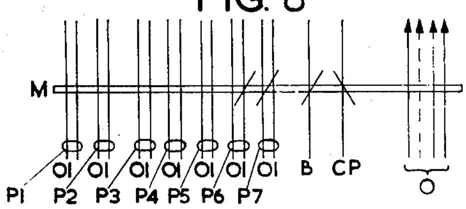


FIG. 5

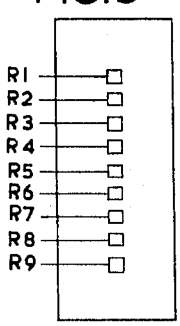
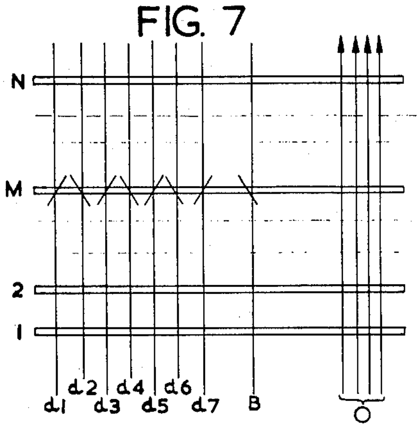


FIG. 7



United States Patent Office

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3,198,976

ELECTRIC DISCHARGE TUBES AND APPLICATIONS THEREOF

Arthur T. Starr, New Barnet, England, assignor to Rank Precision Industries Limited, London, England, a British company

Filed Apr. 24, 1961, Ser. No. 104,916
Claims priority, application Great Britain, Apr. 28, 1960, 14,874
15 Claims. (Cl. 313—86)

This invention relates to electric discharge tubes and, in particular, to cathode ray tubes including means for selectively switching elemental portions of an electron beam, and to systems incorporating said tubes.

It has been proposed to interpose an array of horizontal electrically insulated wire electrodes superposed upon a similary array at right angles thereto in the path of the electron beam of a cathode ray tube, the cross-wire arrangement thus formed defining individually successively selectable "windows" which according to the polarity and value of potentials applied to said electrodes are either "open" or "closed" to elemental cross-sectional areas of the beam impinging thereon. The fact that the "windows" are, in the main, only successively selectable imposes a certain limitation where it is desired, for instance, to produce a shaped beam composed of simultaneously occurring elemental beams.

The object of the present invention is to provide an improved electric discharge tube of the type adapted to produce an electron beam and improved system incorporating said type of tube.

According to one aspect of the invention there is provided an electric discharge tube including beam switching means interposed in the path of the electron beam for selectively switching elemental cross-sections of said beam either simultaneously or consecutively whereby elemental beams may be caused to emerge from said switching means in a spatial arrangement or pattern determined by input signals.

The beam switching means is preferably in the form of an electron-impervious member provided with an array of apertures each ringed by a conductive annulus to which a connection may be made from without the tube.

According to another aspect of the invention, therefore, there is provided an electric discharge tube comprising means for producing an electron beam adapted to flood an array of apertures in an electron-impervious member interposed in the path of said beam, each of said apertures being ringed by a conductive annulus electrically insulated from said member, said annulus being associated with means for extending an electrical path thereto from without the tube.

The electron-impervious member preferably defines at least one matrix of apertures forming an array of rows and columns.

The matrix is preferably located near a virtual cathode of the electric discharge tube.

Each matrix may be formed by punching apertures in a plate of dielectric material, such as mica, and laying around each aperture, on either side of the plate, a conductive annulus provided with a lead by any convenient technique, such a metal evaporation under vacuum or printed circuit or photo-etching technique.

Where a high density of apertures is required for a betted defination of the pattern hereinbefore referred to, it may be desirable to superpose a plurality of identically perforated plates with the apertures in perfect register, the annulus associated with any one aperture being provided on any one plate, whereby some annuli and associated leads may be arranged on a plate and some on the remaining plates.

The apertures need not be circular; they may, for instance, be square with rounded corners.

The electric discharge tube is preferably provided with an anode for accelerating the emerging elemental beams and is operationally associated with focussing and deflecting means.

A post-deflection accelerator may be included.

The electric discharge tube hereinbefore outlined according to the present invention is intended for use in a system including means for controlling the operation of the tube and means for utilizing the selectively switched elemental beams.

According to a further aspect of the invention, therefore, there is provided a system comprising an electric discharge tube including beam switching means interposed in the path of the electron beam for selectively switching elemental cross-sections of said beam either simultaneously or consecutively in response to inupt signals whereby elemental beams are caused to emerge from said switching means in a spatial arrangement conforming to any desired pattern determined by said input signals, and means for utilizing the emerging elemental beams.

Said emerging beams may be utilized for selective switching purposes in connection with an array of target electrodes upon which the beams are accelerated.

A foremost application, however, is the visual display of graphical data upon a fluorescent screen in a cathode ray tube configuration, the data being, for instance, mined area of a fluorescent screen so as to excite therein a visual display of said selected character. The main disadvantage of this known scheme is its lack ofveralphanumeric characters, in which case the cathode ray tube and its associated controls may be conveniently referred to as a character generating and displaying system.

Generating and displaying systems including one or more cathode ray tubes have been proposed. One proposal includes a cathode ray tube having a character matrix therein in the fashion of a stencil. By suitable circuitry the electron beam is made to flood any one selected character and the emerging shaped beam is directed by electron-optics technique onto a predetersatility since the tube is only capable of displaying the range of symbols for which the matrix has been designed.

According to a still further aspect of the present invention there is provided a system for generating and displaying graphical data upon the screen of a cathode ray tube in response to input signals representative of said data comprising a cathode ray tube having beam switching means interposed in the path of the electron beam for selectively switching elemental cross-sections of said beam either simultaneously or consecutively whereby elemental beams are caused to emerge from said switching means in a spatial arrangement conforming to selected data, and means for directing the emerging beams so as to impinge upon a fluorescent coating provided on the screen of said tube and produce a visual display of the data in the desired area of the screen.

A permanent record of the visual display may be made by any convenient process including a photosensitive member. There may be employed, for instance, a process of xerography wherein the display is optically projected upon a rotating xerographic drum forming part of a continuous xerography printer. If the input signals giving rise to the pattern of elemental beams are in fact the output signals of a computer device, the above arrangement may be adapted to form an electron-optical output printer of the type for instance disclosed in a copending application Serial No. 803,210 filed March 31, 1959 in the name of Keith Gordon Hunley, now abandoned and which is assigned to the same assignee as is this application.

A further possible use of the cathode ray tube constructed according to the present disclosure is the storage of a charge pattern upon a dielectric screen in an electrostatic memory configuration.

A still further use is for the purpose of superposing alphanumeric and other symbols upon a P.P.I. radar display. In this particular application, only one aperture is left operative during a scan to produce a display in the conventional manner. Following the scan, the alphanumeric information is displayed by switching the elemental beams. The change over from one to the other is naturally so fast that the eye will perceive a composite picture.

In the applications outlined above the "closing" of any one aperture to impinging electrons is determined by whether the associated annulus is supplied with a sufficiently negative potential to repel the negatively charged electrons.

The switching of certain elements in an array of target electrodes or the formation of a symbol upon the fluorescent screen or the generation of a charge pattern upon a dielectric screen obviously calls for the application of certain potentials to at least some of the annuli to allow the electrons to pass only through certain apertures. The generation of the above potentials is perferably arranged in digital fashion whereby individual voltage levels are simultaneously or successively available at the beam switching matrix of the electric discharge tube through a translator device in response to a signal code, such as a binary code, representative of the pattern of elemental beams called for at any instant.

The invention will now be described by the way of example only with reference to the accompanying diagrammatic drawings, wherein:

FIG. 1 illustrates a cathode ray tube embodying a beam switching matrix according to the present invention.

FIG. 2 illustrates a beam switching matrix according to the present invention.

FIG. 3*a* and FIG. 3*b* illustrate different parts of a modification of FIG. 2.

FIG. 4 depicts a mode of operation of the matrix.

FIG. 5 depicts a further embodiment of the beam switching matrix.

FIG. 6 illustrates the operation of the embodiment of FIG. 5.

FIG. 7 illustrates a mode of generating the potentials for the activation of the beam switching matrix in response to a signal code.

FIG. 8 illustrates an alternative of FIG. 7.

Referring to FIG. 1, a cathode ray tube 1, embodying the present invention comprises, successively spaced, a cathode **2**, a control grid **3**, a beam switching matrix **4**, a first anode **5**, a post-deflection accelerator anode **6**, and a receiving means **7** for such of the elemental electron beams as are passed through the matrix **4**. Such receiving means may be an array of target electrodes or a dielectric member of an electrostatic storage device or a fluorescent screen. The cathode, which is heated by filament **8**, is adapted to produce a beam of electrons of adequate cross section to flood the operational area of the beam switching matrix **4**. Deflection and focussing coils **9** are located around the neck of the tube. Deflection plates within the tube could, naturally

tion plates within the tube could, naturally take the place of the deflection coils.

In FIG. 2 a beam switching matrix **4** according to the present invention comprises a plate of dielectric material, such as mica, having an operational area of, say, .3" x .4", provided with apertures, such as **10**, extending some .020" across and arranged in a rectangular array of nine rows and seven columns, each aperture being ringed by a conductive annulus, such as **11**, complete with lead **12** to which an electrical path is extended from without the cathode ray tube when the matrix is mounted therein.

The conductive annulus may be extended in depth to form a conductive lining of the aperture.

A number of duplicate plates may be superposed to form a composite matrix, in which case locating openings **13** may be included to ensure perfect register of the superposed apertures during both manufacture and assembly of the matrix.

A composite matrix greatly facilitates the laying of the annuli and leads, which may be arranged for instance in successive sets, from outermost to innermost, on successive plates. In this layout, the first set may comprise the peripheral elements; the next set, those adjacent thereto, and so on. Thus, the sixty three elements of the matrix depicted in FIG. 2 may be arranged as follows: twenty eight on plate one, twenty on plate two, twelve on plate three, and three on plate four. If both sides of a plate are used, only two plates are needed. In this case, the set of twenty eight is preferably paired up with that of three; and the set of twenty, with that of twelve. The arrangement is depicted in FIG. 3*a*, representing plate one, and FIG. 3*b*, representing plate two, wherein the elements drawn in dotted line are assumed to be located on the reverse side.

The composite matrix may be provided with an end plate of metal in which the apertures are duplicated and in register with those in the mica plates. The purpose of this is to prevent bombardment of the mica. The metal plate may be operationally adapted such as by suitably altering its potential to improve the incidence of the flooding beam of electrons.

An alternative to the mica plate is a glass plate wherein the apertures are generated by photo-form technique involving the use of a special kind of glass, which has projected thereon a pattern of ultra-violet light corresponding to the matrix of apertures prior to being immersed in an etching bath, the areas exposed being attacked in depth in preference to the unexposed areas.

The operation of the tube depicted in FIG. 1 is as follows:

A beam of electrons is caused to issue from cathode **2** so as to flood the operational area of matrix **4**, control grid **3** being kept at a suitable potential to enable this action. Assuming in the first instance that none of the conductive annuli are connected to a voltage source, the impinging electrons filter through the apertures and emerge in elemental beams which conform to the apertures both in number and spatial arrangement. The elemental beams are accelerated by the first anode **5** fed with a positive potential of conveniently high value, are prevented from spreading out by the focussing coil denoted at **9**, and are deflected in parallel formation onto a given area of the screen **7** in accordance with suitable X and Y deflection waveforms made available at the deflection coils also denoted at **9**. The elemental beams impinging upon the fluorescent screen **7** excite therein an array of light dots which is a replica of the array of apertures.

Assuming that at a given area on screen **7** it is desired to produce a display of the capital letter I as styled, the elements of the matrix are so biased that only the apertures along the longitudinal axis of the matrix and those immediately adjacent thereto at either longitudinal end allow the impinging beam to pass. The result of this is a dotted display of said letter. By suitable selection of the elements and the provision of suitable deflection waveforms a wide and variable range of graphical data may be selectively displayed upon the screen in any desired spatial interrelation in a manner which is clearly beyond the scope of known devices wherein only the range of symbols stencilled on a mask within the cathode ray tube may be displayed.

Where it is desired to produce the display of a character on a reduced scale compared with the scale determined by the size of the matrix, this can be accomplished by applying a sufficiently intense focussing field to produce two or more cross-overs, the deflection being applied at the cross-over nearest the matrix.

As to the selection of the matrix elements, two possible modes of operation shall be referred to hereinafter as the suppression and the non-suppression method respectively. In the former, all the elements are at zero potential initially thus enabling as many elemental beams to emerge. Selection is performed by applying a sufficiently high negative potential, say, minus 10 or more, to the elements where elemental beams must be suppressed. A display in the absence of graphical data signals is prevented by normally maintaining a beam cut-off potential on the control grid and supplying said grid with a positive pulse coincidently with data signals only. In the latter method, all the elements are initially biassed to inhibit the elemental beams and a positive potential in response to data signals is applied only to the elements required for producing the display selected through the input. This mode of operation may call for clamping means associated with each of the matrix elements to equalize voltage and current levels.

The suppression method requiring only one brightening up pulse, which ensures uniform flooding of the apertures provided the electron-optics is suitably designed, would appear more convenient in practice.

In the above methods the data selected, such as for instance alphanumeric characters, are displayed by simultaneous activation of the elemental beams required to define the character. A further alternative, which reduces the number of input wire required for a 7 x 9 matrix from sixty three to sixteen consists in connecting all the elements of one column to a column wire and all the elements of one row to a row wire, there being thus defined seven column wires and nine row wires. This means that each element is connected to one column wire and one row wire in a unique combination. The display of the character is effected in seven steps by activating the columns one at a time while inhibiting the remainder and supplying potentials through the row wires so as to enable access to the beam only through those elements of the activated column which are required for the formation of one out of seven possible vertical strips into which the character may be imagined to be included.

The matrix for the above step-wire operation is shown in FIG. 4 wherein C1, C2, C3, etc., represent the column wires, and R1, R2, R3, etc., the row wires, the latter being shown dotted since they are laid onto the reverse side of the matrix.

A still further alternative enabling further simplifications consists in providing a matrix having a single column of apertures, say, nine apertures as depicted in FIG. 5. The formation of a graphical symbol is again performed in steps, each step corresponding to a vertical strip as before. The correct wires in the series R1 to R9 are selected in the first instance for the formation of the graphical content included in the first strip. Then the elemental beams are simultaneously subjected to a shift and the correct selection for the second strip is effected, and so on. The staircase deflection waveform for producing said shift is depicted in FIG. 6 next to the representation of the strip-wise formation of capital letter A.

The means for selectively activating the elements of a 7 x 9 matrix as shown in FIG. 2 in response to a binary signal code representing alphanumeric data shall now be described. It goes without saying that the above size of the matrix, nature of the code, and kind of data are given by way of example only and that departures therefrom may be made in practice within the scope of the invention.

With a sixty three-element matrix 2^{63} graphical combinations may be displayed including those calling for all and none of the elemental beams, respectively.

The range of alphanumeric symbols to be displayed naturally sets the number of digits in the code. For a range of, say, one hundred and twenty eight symbols seven digits are required. In the present example to each digit there corresponds a digit wire. Thus assuming that the incoming signal code on seven wires is 1010101, representing for instance character M, the odd-numbered wires would each be associated with an electrical level well distinguished from that of the even-numbered wires. It will be assumed here that digit "1" is represented by a positive pulse and digit "0" by a negative pulse. The selection of the matrix elements clearly calls for a system whereby a given signal combination on the seven digit wires activates the unique combination out of sixty three output lines extended to the matrix which will enable the elemental beams defining the character associated with said signal combination.

A system embodying a magnetic core translator is shown in FIG. 7 wherein D1, D2, D3, D4, D5, D6, D7 represent the seven digit wires, which are associated with as many magnetic cores **1**, **2** . . . M, N . . . as there are symbols to be displayed. Each magnetic core is threaded by the combination of output wires O which through the matrix will cause the display of the symbol associated with said core. Said combination is obviously effective when the appertaining core is activated by the input combination. It is clear, therefore, that for any one signal code on the seven wires only the core corresponding to the symbol selected must be switched.

Switching of the selected core is arranged by having a bias wire B providing, for instance, a bias of six units, arranging the digits wire to deliver plus one for a "1" and minus one for a "0," and by threading each digit wire through a core in a direction for digit "1" and in the opposite direction for digit "0," the actual direction being represented in FIG. 7 according to the mirror notation as for instance described in Digital Computer Components and Circuits, by R. K. Richards, published by Van Nostrand, page 196.

When the combination 1010101 for letter M is actually called, the M core is clearly the only one which has a drive of seven units to the right, i.e., all the digit wires cooperate in switching the core in the same direction thus overcoming the bias. All the other cores will have a drive varying between plus 5 and minus 7.

It should be observed here that although alternate positive and negative pulses are included in the above combination, the effect of a negative pulse in switching the core is identical to that of a positive pulse since it is fed through the core in the reverse direction to that in which the positive pulse is fed.

In the above arrangement the cores are threaded by all the digit wires and by some of the 63 output wires. It is clear that some output wires will thread more than one core, i.e. a number of the matrix elements will be required in the formation of more than one symbol.

A type of translator which allows wider tolerances in the digit pulse is shown in FIG. 8, wherein each digit is associated with a pair of wires as shown, one wire being the "1" wire and the other the "0" wire. In FIG. 8, P1, P2, P3, etc., denote successive pairs each comprising an "0" wire to the left of a "1" wire. If a "1" occurs, a positive pulse is applied through the "1" wire; if a "0" occurs, a positive pulse is again applied, this time through the "0" wire. When, for instance, 1010101 occurs for character M as before, only the M core receives no pulse; all the other cores are biased back by the digit pulses. Sometimes during the occurrence of the digit pulses a clock pulse is delivered on line CP which switches the M core. As to the output wires, the description with reference to FIG. 7 applies to FIG. 8 as well.

I claim:

1. An electric discharge tube comprising a two dimensional matrix of apertures in an electron-impervious member, electron-emitting means for generating an electron beam of adequate cross-sectional area to flood said matrix, an individual conductive annulus around each aperture and having an individual lead extending to the outside of the tube for the selective application thereto of a beam switching potential, a first anode for accelerating elemental electron beams defined through said apertures, and receiving means positioned to be impinged upon by the elemental electron beams.

2. An electric discharge tube as claimed in claim 1, wherein said receiving means is a fluorescent screen.

3. A cathode ray tube comprising a two dimensional matrix of apertures in an electron-impervious member, a cathode adapted to be heated by a filament for generating a uniform electron-beam of adequate cross-sectional area to flood said matrix, a control grid between said cathode and said matrix, a conductive annulus around each aperture and having an individual lead extending to the outside of the tube for the selective application of a beam-switching potential, a first anode for accelerating elemental electron beams defined through said apertures, a fluorescent screen positioned to be impinged upon by the elemental electron beams.

4. A cathode ray tube as claimed in claim 3, further comprising means for focussing and means for deflecting the elemental electron beams in parallel formation.

5. A cathode ray tube as claimed in claim 4, the deflection means being positioned at a cross-over point of the elemental electron beams nearest the matrix.

6. A cathode ray tube as claimed in claim 3, further comprising a post-deflection accelerator.

7. A cathode ray tube as claimed in claim 3, wherein the conductive annulus extends through said aperture to form a lining.

8. A cathode ray tube comprising a two dimensional matrix of apertures in an electron-impervious member, a cathode adapted to be heated by a filament for generating a uniform electron-beam of adequate cross-sectional area to flood said matrix, a control grid between said cathode and said matrix, a conductive annulus around each aperture and having an individual lead extending to the outside of the tube for the selective application of a beam-switching potential, a first anode for accelerating elemental electron beams established by passage through said apertures, means for deflecting the elemental electron beams in parallel formation, a fluorescent screen positioned to be impinged upon by the elemental electron beams, and a post-deflection accelerator anode.

9. A cathode ray tube as claimed in claim 8, further comprising focussing means.

10. A cathode ray tube as claimed in claim 8, further comprising focussing means and deflecting means for the electron beam, the deflection means being positioned at a beam cross-over point nearest the matrix.

11. An electric discharge tube comprising a plurality of superposed electron-impervious members each provided with a two dimensional matrix of apertures, all the matrices being in register, electron emitting means for generating an electron beam of adequate cross-sectional area to flood the matrix area, a control grid, a conductive trace round each of a number of apertures upon a member with an individual associated lead extending to the outside of the tube from each said trace, a conductive trace around each of a number of apertures upon another member with an individual associated lead extending to the outside of tube, from each said trace, the first mentioned number of apertures being apertures other than those in register with the second mentioned number of apertures, an anode for accelerating elemental electron beams defined through said apertures, and receiving means positioned to be impinged upon by the elemental electron beams.

12. An electric discharge tube as claimed in claim 11, wherein said tube further comprises a fluorescent screen.

13. An electric discharge tube comprising a two dimensional matrix of apertures in an electron-impervious member, electron emitting means for generating an electron beam of adequate cross sectional area to flood said matrix, an individual conductive beam switching electrode around each aperture and having an individual lead extending to the outside of the tube for the selective application thereto of a beam switching potential, and receiving means positioned to be impinged upon by the elemental electron beams.

14. A display system comprising a cathode ray tube having an electron beam a screen and a plurality of beam switching elements interposed in the path of the electron beam, said elements being disposed as a two dimensional array, each of said elements being individually switchable in response to an individual electrical voltage whereby elemental beams are caused to emerge from said switching means in a two dimensional spatial arrangement conforming to a selected character, and means to focus said elemental beams in said configuration on a selectable portion of said screen.

15. The system of claim 14 further including means connected with said tube to convert input signals representative of a particular character into a set of electrical voltages for simultaneous application to selected ones of said beam switching elements to form a representation of said character on said screen.

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GEORGE N. WESTBY, *Primary Examiner.*

ARTHUR GAUSS, *Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,198,976

August 3, 1965

Arthur T. Starr

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 17, for "similary" read -- similar --; line 30, for "system" read -- systems --; line 67, for "betted defination" read -- better definition --; column 2, lines 32 to 34, strike out "mined area of a fluorescent screen so as to excite therein a visual display of said selected character. The main disadvantage of this known scheme is its lack of ver-", and insert the same after "predeter-" in line 43, same column 2; line 66, for "xerography" read -- xerographic --; line 72, for "Hunley" read -- Huntley --; column 3, line 66, strike out "tion plates within the tube could, naturally"; column 5, line 47, for "step-wire" read -- step-wise --; line 50, for "onto" read -- on --; column 8, line 5, for "round" read -- around --.

Signed and sealed this 8th day of February 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents