Feb. 24, 1970 C. A. WASHBURN 3,497,761

CATHODE-RAY TUBE APPARATUS

Filed March 11, 1968 4 Sheets-Sheet 1

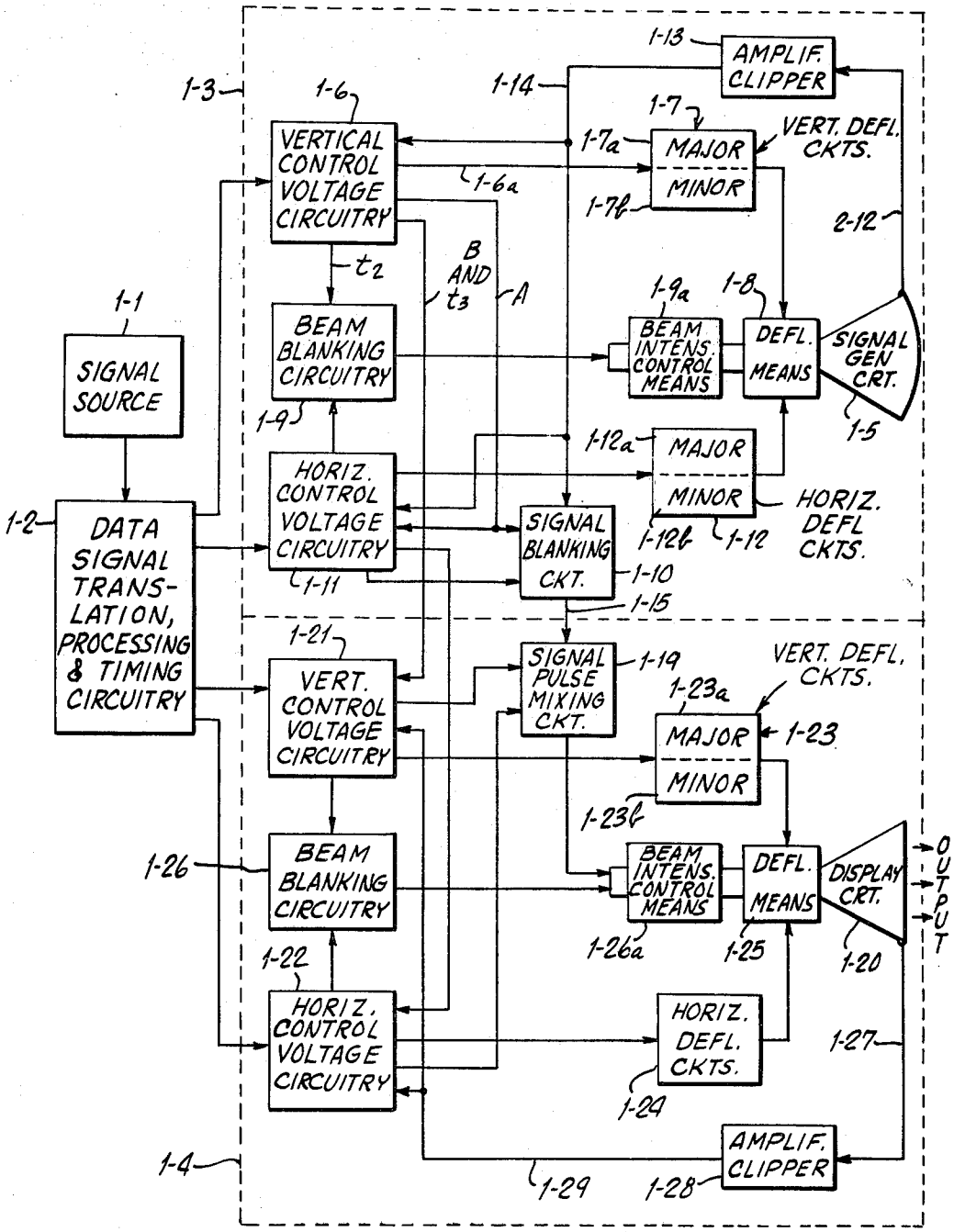


Fig. 1.

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CATHODE-RAY TUBE APPARATUS

Filed March 11, 1968 4 Sheets-Sheet 2

Fig. 2.

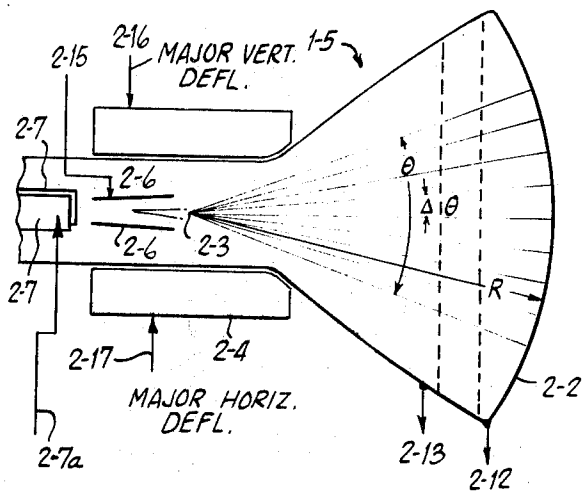


Fig. 2a.

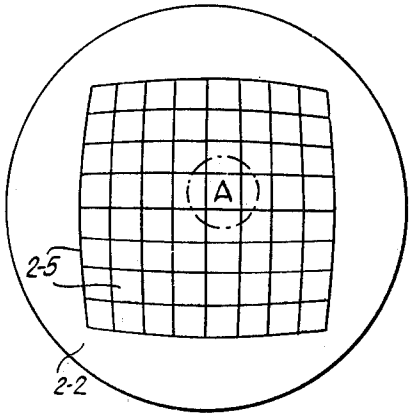


Fig. 2b.

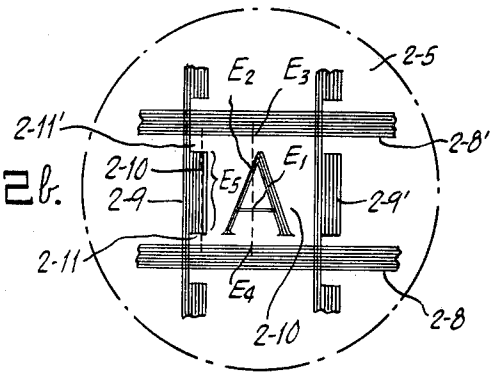
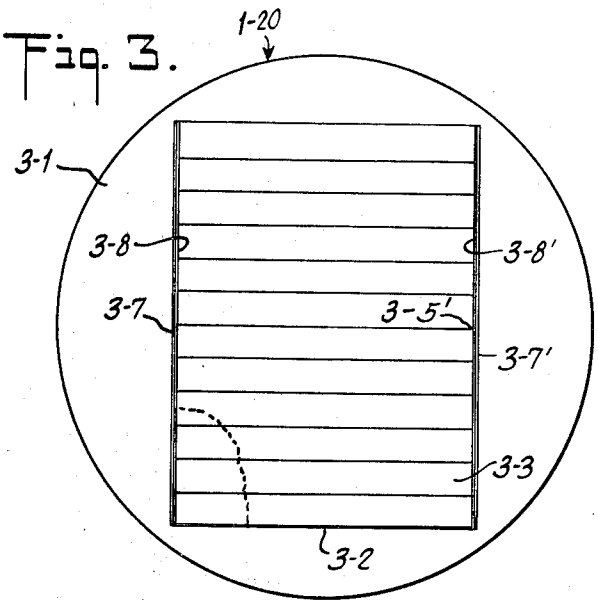


Fig. 3.



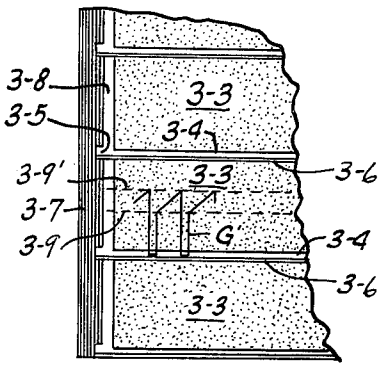


Fig. 3a.

CATHODE-RAY TUBE APPARATUS

Filed March 11, 1968 4 Sheets-Sheet 3

Fig. 4.

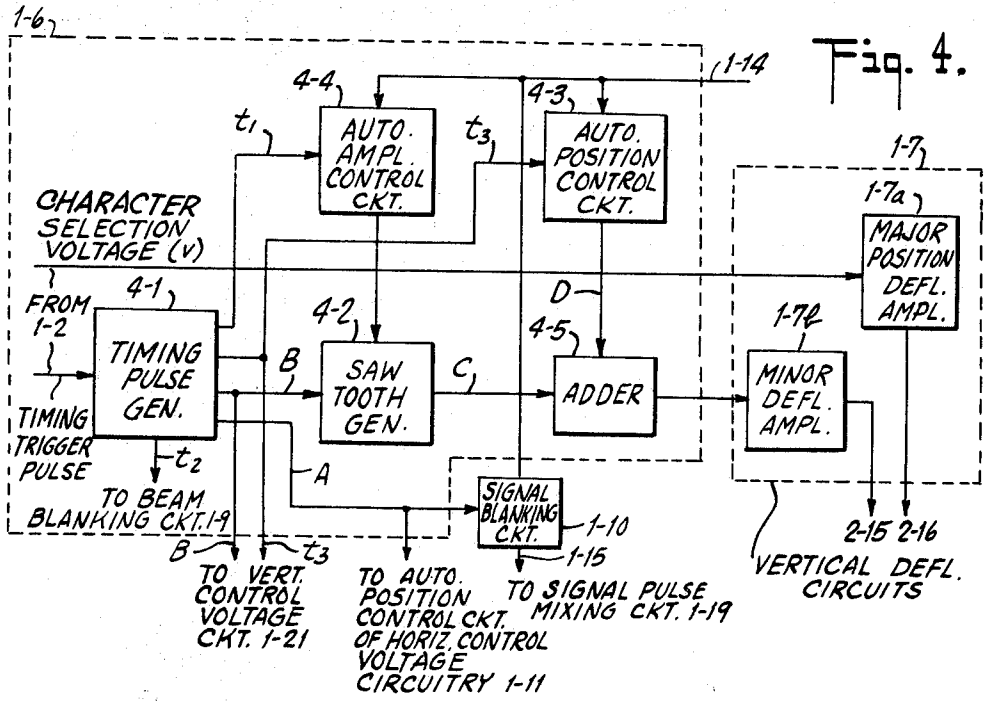
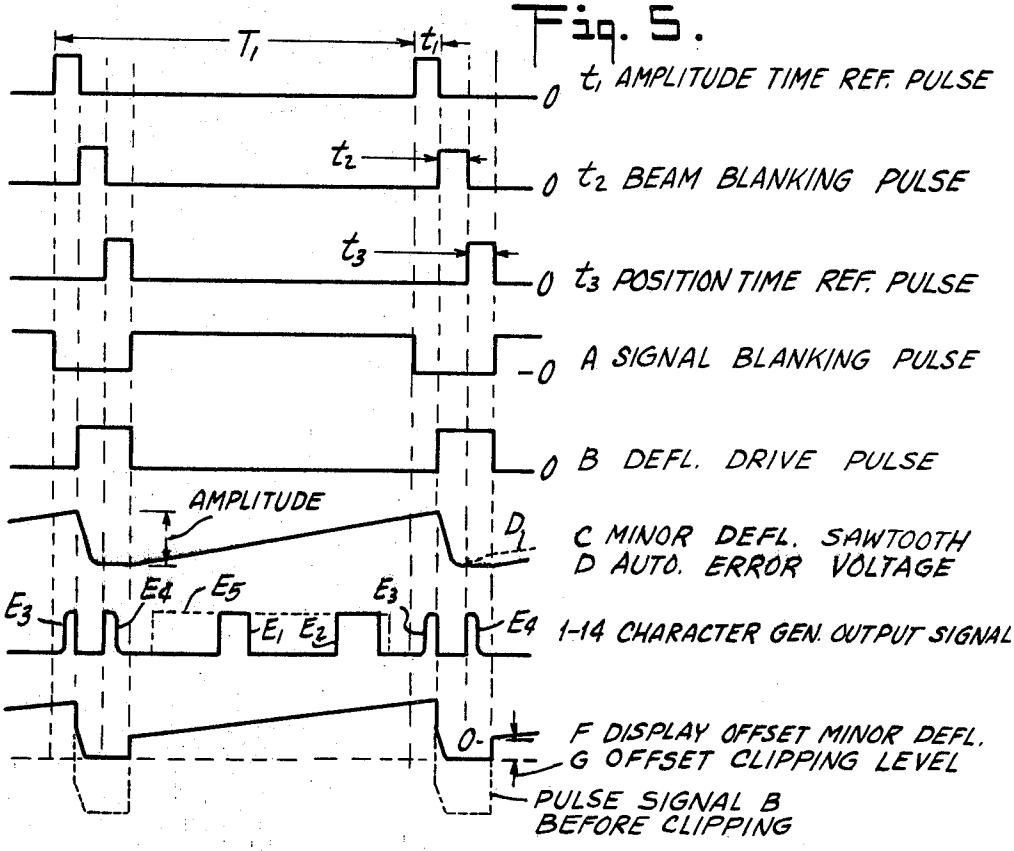


Fig. 5.



CATHODE-RAY TUBE APPARATUS

Filed March 11, 1968 4 Sheets-Sheet 4

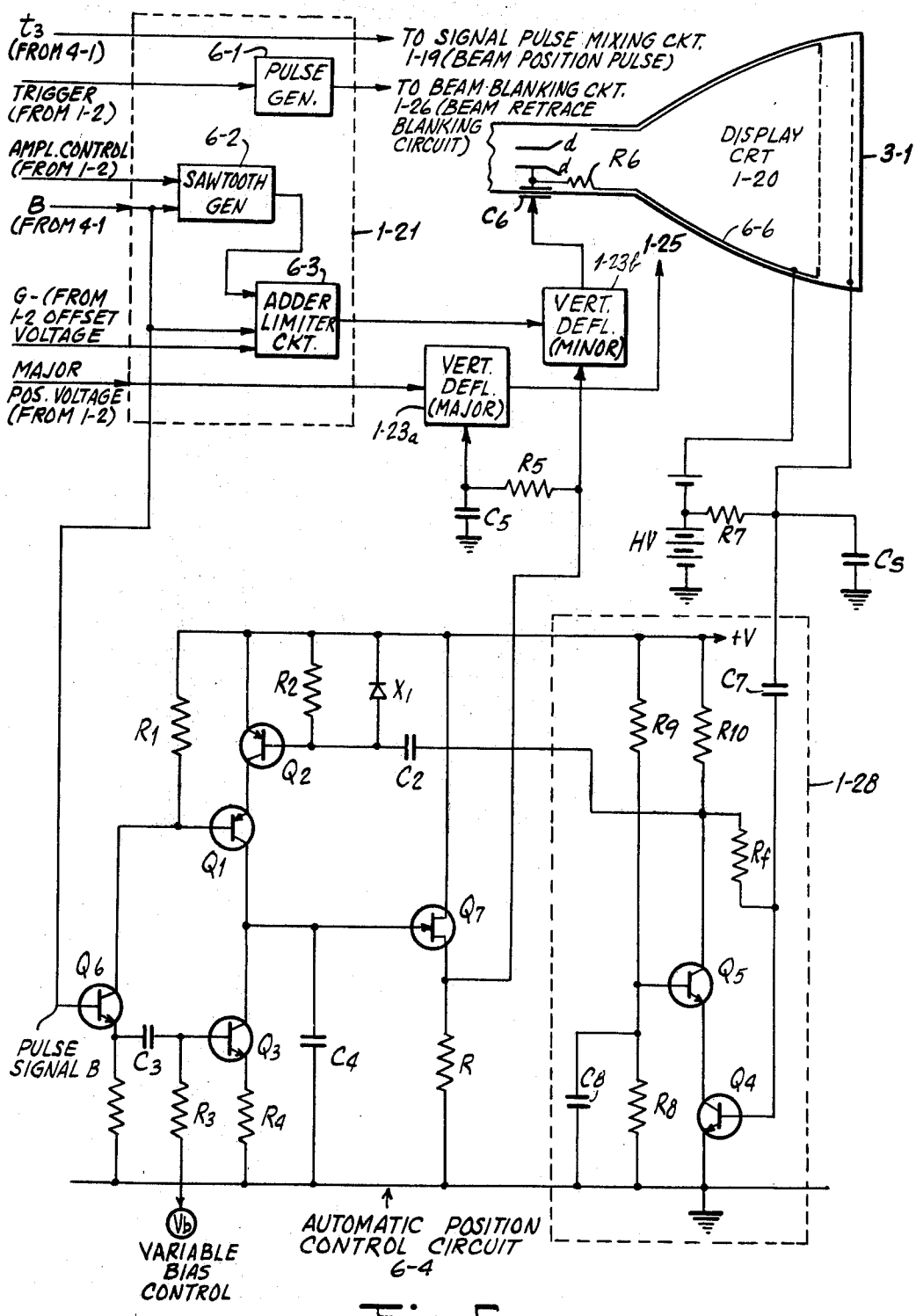


Fig. 6.

United States Patent Office 3,497,761
Patented Feb. 24, 1970

3,497,761

CATHODE-RAY TUBE APPARATUS

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Filed Mar. 11, 1968, Ser. No. 711,999
Int. Cl. H01j 29/70
U.S. Cl. 315—21 28 Claims

ABSTRACT OF THE DISCLOSURE

A cathode-ray tube is provided having a plurality of elemental areas which are bounded by signal generating material along selected sides of each area to provide registry of the cathode-ray tube beam with respect to each area. The boundary material is of stripes which may, for example, be secondarily emissive material along the sides of the area; one or more stripes may be partially cut away or serrated. In a signal generating tube, for example, the elemental areas may each include a character which is scanned by the electron beam. Detection of the secondary emission resulting from impingement of the beam on the character provides an output signal representative of that character and impingement on the boundary material is employed to position the start and termination of scans of the beam so that the scans are in registry with respect to the boundary. When the beam is deflected by major beam deflection means to the vicinity of a selected elemental area, the secondary emission from the beam impingement on the boundary material may be employed to control minor beam deflection means to initiate rapid trace scans with respect to an edge of one boundary region and to initiate a slower trace scan across the area with respect to the edge of another boundary region. The beam positioning control for each rapid trace scan takes place in the interval immediately prior to start of that scan, and the registry of the beam prior to slow trace scanning may take place during one or more of the rapid trace scans. Control of the scanning rate across the area for the rapid and slow trace scans may both be achieved by employing the secondary emission signal generated when the beam completes each trace scan and enters the boundary region to adjust the amplitude of the ramp signal that determines the extent of the trace scan. A beam control circuit is employed utilizing storage of the secondary emission signal, with transistor-controlled termination of the storage, to achieve beam control over long, indefinite and random intervals.

BRIEF DESCRIPTION OF THE INVENTION

This invention relates to cathode-ray tube structures, and more particularly to apparatus for controlling the electron beam in a cathode-ray tube (abbreviated herein as CRT). The invention finds particular application to image pickup, storage, scan conversion, signal generation and display, and has a number of applications, as for example, television, radar, graphic reproduction, traffic and similar control functions, computer readout and the like, although it is not limited to these particular applications. The invention also involves beam control techniques similar to those disclosed in my pending applications for Error Correction System for Cathode-Ray Tube Information Display, Ser. No. 592,625, filed Nov. 7, 1966, and Cathode-Ray Tube Structures, Ser. No. 613,830, filed Feb. 3, 1967.

An object of the present invention is to provide an improved cathode-ray tube.

Another object of the invention is to provide beam control for a cathode-ray tube.

Another object is to provide for registry of scanning

of a beam over one or more selected areas of arbitrary shape of a CRT with respect to reference boundaries of those areas.

Still another object of the invention is to provide for the registry of a beam with respect to two or more directions of scanning across an elemental area on the face of a cathode-ray tube.

A further object of the invention is to provide for beam registry with respect to a beam indexing stripe which is parallel to, perpendicular to, or at another angle to a desired direction of scan.

It is a further object of the invention to control beam scanning across an elemental area so that scanning is initiated and/or terminated with respect to boundary regions.

Another object of the invention is to provide for the control of a cathode-ray tube beam with respect to an indexing stripe through the generation of a control signal which may be maintained over long, indefinite and random intervals.

The invention involves a cathode-ray tube having a plurality of elemental areas which are typically bounded by stripes which provide error control output signals due to interaction with the electron beam. In signal generation, for example, each area contains a character to be scanned by the beam for the generation of a signal to be used either for storage or for display purposes in another cathode-ray tube. The present invention provides for the registry of the beam during scanning across the area, particularly with respect to two or more directions of beam movement, one of the directions being for rapid trace and retrace scans and the other being for a slower trace scan so as to complete a typical raster scansion of the beam across the area. The error control signals which will be hereinafter described by way of example as secondary emission signals detected when the beam impinges on the boundary region of stripes surrounding the area are employed to provide proper registry of the beam. In particular, during the interval following rapid retrace of the beam across the area and prior to the next rapid trace scan, the secondary emission signal is used to deflect the beam with respect to an edge of a stripe so as to be in proper position for the next rapid trace scan. Additionally, before the initiation of a slow trace scan, the secondary emission signal developed by the beam moving back and forth in another boundary region of the area during rapid trace scans is employed to deflect the beam so that the rapid trace and retrace scans are along the edge of this boundary region. In this fashion the beam is properly registered so that the slow trace movement of the beam is initiated with respect to an edge of the correct boundary region.

In an application involving signal generation of selected alphanumeric characters, symbols, patterns, or other graphic information for concurent display, the display tube may employ the same type of beam positioning so that each character is accurately displayed on the tube in any desired preselected position. The display tube may include bands of phosphor (luminescent material) for the display of characters across the bands. Each band may include a stripe of secondarily emissive material along a longitudinal edge thereof to provide for proper positioning of the beam during the display of characters across the band. Rapid transverse trace scans of the beam as it traverses across the band are registered with respect to this stripe. A similar stripe of secondarily emissive material may be employed along an edge of the display tube face so that proper beam registry is achieved at the start of each slow trace scan across the face of the tube as characters are displayed in a band.

The invention also provides for the correct amplitude of

deflection of the beam across each elemental area. By detecting secondary emission developed when the beam completes a trace scan and enters a boundary region, such detected emission may be employed to generate a control signal which varies the amplitude of the ramp signal used to deflect the beam in its trace scan. In this manner the ramp signal is adjusted so that the trace scan properly terminates with respect to an edge of the boundary region.

As in my copending application Ser. No. 592,625, referred to above, the present invention may employ a circuit for detecting secondary emission utilizing the storage of the secondary emission signal for beam control purposes. In my copending application storage is by capacitor, with periodic charging to maintain the charge which is normally dissipated through a resistor. In the present invention capacitor storage is controlled by way of example by a transistor switch which, when properly energized, discharges the capacitor. In this fashion the charge on the capacitor may be maintained for long, indefinite and random intervals. Hence beam positioning in response to the stored signal may be maintained for as long a period as desired, with no drifting of the beam, until such time as it is desired to discharge the capacitor to initiate another cycle of control.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the invention will be more apparent upon consideration of the following detailed description which is to be read in conjunction with the drawings, in which:

FIG. 1 is a block diagram of a representative character signal generating and display system embodying the invention.

FIG. 2 is a diagrammatic view of a cathode-ray tube which may be employed as a character signal generating tube in the system of FIG. 1.

FIG. 2*a* is a view of the face of the cathode-ray tube of FIG. 2.

FIG. 2*b* is a view, to a enlarged scale, showing an elemental area of the face of the cathode-ray tube of FIG. 2*a*.

FIG. 3 is a view of the face of a cathode-ray tube suitable as a display tube in the system of FIG. 1.

FIG. 3*a* is a view, to an enlaged scale, of a portion of the cathode-ray tube face of FIG. 3.

FIG. 4 is a block diagram of beam control circuitry in accordance with the invention.

FIG. 5 contains waveform diagrams useful in understanding the invention.

FIG. 6 shows a cathode-ray tube and an associated circuit in the context of the display of information embodying beam control in accordance with the invention.

DETAILED DESCRIPTION.—FIG. 1

The system of FIG. 1 is a character signal generating and display system which embodies the invention. As indicated above, however, the invention is not limited to signal generation and display but is broadly directed to beam control for cathode-ray tubes.

In FIG. 1 a signal generating cathode-ray tube **1–5** contains a number of characters on the face thereof (one of which, the letter A, is shown in FIG. 2*a*). As used herein, the term "character" is intended to mean alphanumeric characters, numeric, punctuation, or specially devised symbols, and any other graphic information. By selective movement of the electron beam within the tube **1–5** to an area of the tube face containing a particular character, followed by a scanning of that area, a signal is developed which is ultimately applied to control the intensity of an electron beam in a display cathode-ray tube **1–20** which provides a visual or optical output of the character scanned in the signal generating tube **1–5**. By moving the beam from character to character within the signal generating cathode-ray tube **1–5**, a sequence of characters may be reproduced on the display cathode-ray tube **1–20**. U.S. Patent No. 3,281,822 to Evans describes a typical signal generating and display system employing scanning of characters in a signal generating cathode-ray tube and corresponding display in a display cathode-ray tube.

In the present invention scanning in both the signal generating and display cathode-ray tubes is controlled so that the beam movement including both starting poistion and amplitude or rate of deflection is properly registered with respect to reference locations representative of both coordinate directions of the area desired to be scanned.

In FIG. 1 a signal source **1—1** provides input signals to a data signal translation, processing and timing circuitry unit **1–2** which provides for signal storage and processing functions such as digital computations, digital to analog voltage conversion, and output signal timing control. Output signals are generated by the unit **1–2** which are applied to signal generating sub-system **1–3** and signal display sub-system **1–4**. In particular, the signals from the unit **1–2** are applied to vertical control voltage circuitry units **1–6** and **1–21** and horizontal control voltage circuitry units **1–11** and **1–22**. The signal source **1—1** and the translation, processing and timing circuitry unit **1–2** do not form a part of the present invention. Typically, the signal source **1—1** provides digital signals for control of the signal generating and signal display sub-systems, while the unit **1–2** provides a conversion of the digital information to output control signals in a form usable by these subsystems. Such signal translation, processing and timing are described, for example, in U.S. Patent No. 3,017,625 to Evans, U.S. Patent No. 2,875,951 to Schreiner, and U.S. Patent No. 3,267,454 to Schaaf.

Within the signal generating sub-system **1–3** of FIG. 1, the vertical control voltage circuitry unit **1–6** provides a number of timing control pulses, a ramp waveform signal to provide for cathode-ray tube beam deflection, signal blanking and beam positional control signals all in a manner to be subsequently described in detail. Generally, however, the vertical control voltage circuitry unit **1–6** generates signals applied via **1–6***a* to vertical deflection circuits **1–7**. These vertical deflection circuits may be comprised of major vertical deflection circuit **1–7***a* and minor vertical deflection circuit **1–7***b*. The major vertical deflection circuit **1–7***a* provides for the major movement of the cathode-ray tube beam to the edge of an elemental area in the signal generating cathode-ray tube **1–5**. The minor vertical deflection circuit **1–7***b* provides for the trace and retrace scans of the beam across the area in the vertical direction. In this regard, it is assumed that the beam within the signal generating cathode-ray tube **1–5** is deflected in rapid trace and retrace scans across the elemental area in a vertical direction, while the beam is moved relatively slowly in a trace scan in a horizontal direction across the elemental area under the action of horizontal deflection circuits **1–12**. Of course, it will be understood that the rapid trace and retrace scans could take place in the horizontal direction or in any direction, for that matter, and the slow trace scan in any other direction to provide for a typical raster scansion of the area containing the characters. in this fashion, major and minor beam deflection signals are developed within the vertical deflection circuit **1–7**, and signals are applied to a beam deflection means **1–8** which may comprise electrostatic deflection plates and/or magnetic deflection coils or any means for controlling movement of the beam within the cathode-ray tube.

A pulse signal t_2 is generated by the vertical control voltage circuitry unit **1–6** and is applied to a beam blanking circuitry unit **1–9**. In this connection, throughout this description, pulse signals and the lines in the drawing carrying such signals will be given the same designation in order to facilitate the description of the invention. For example, in FIG. 1 the line connecting together the units **1–6** and **1–9** is designated t_2; the pulse carried by the line is designated t_2 in FIG. 5.

The beam blanking pulse t_2 controls the beam blanking

signal applied from the unit 1–9 to a beam intensity control means 1–9*a* to blank (extinguish) the electron beam in the cathode-ray tube 1–5 during vertical retrace time intervals. Additionally, a blanking pulse A is generated by the vertical control voltage circuitry unit 1–6 which is applied to a signal blanking circuit 1–10 to provide for blanking of the main signal carrying information regarding the characters scanned within the signal generating cathode-ray tube 1–5. Signal blanking takes place during the vertical retrace intervals of the scanning beam as well as for short intervals immediately before and after each such interval when the beam is undergoing reference positioning. The pulse A is also applied to horizontal control voltage circuitry unit 1–11 for purposes (error control) subsequently to be described. The vertical control voltage circuitry unit 1–6 also applies pulse signals B and t_3 to the corresponding unit 1–21 in the display sub-system 1–4 to be used in the development of signals generated by that latter unit.

A horizontal control voltage circuitry unit 1–11 of the signal generating sub-system 1–3 receives input signals from the unit 1–2. These signals are processed in a manner similar to that of the unit 1–6, as described above, to provide for horizontal beam deflection within the cathode-ray tube 1–5. The signals from the unit 1–11 are applied to horizontal beam deflection circuits 1–12 which generate appropriate signals for horizontal beam deflection through beam deflection means 1–8. As noted above, in this embodiment of the invention a relatively slow trace scan in the horizontal direction across each elemental area in the signal generating cathode-ray tube is provided; slow trace scanning in a vertical or any other direction could also be employed. A major horizontal deflection circuit 1–12*a* provides for beam movement to an area containing a desired character, and a minor horizontal deflection circuit provides for beam movement across the area in a slow trace scan.

The horizontal control voltage circuitry unit 1–11 also provides for blanking of the cathode-ray tube beam during intervals when the beam is moving from one character area on the tube to another, by application of suitable blanking control signals to the beam blanking circuitry unit 1–9. Blanking control signals are also applied from the unit 1–11 to the signal blanking circuitry unit 1–10 during these intervals and during reference beam positioning time intervals, so as to blank all error control signals from the main signal carrying information regarding the character scanned within the signal generating tube 1–5. Finally, the unit 1–11 provides control signals to a corresponding horizontal control voltage circuitry unit 1–22 within the display system 1–4, to aid in developing signals generated by this latter unit for horizontal deflection of the cathode-ray tube beam in the display cathode-ray tube 1–20.

Output signals from the signal generating cathode-ray tube 1–5 are applied to an amplifier-clipper 1–13 which amplifies and clips the cathode-ray tube signal before that signal is applied to the vertical and horizontal control voltage circuitry units 1–6 and 1–11 as well as to the signal blanking circuit 1–10. The vertical and horizontal control voltage circuitry units employ parts of the signal for automatic positioning of the beam within the cathode-ray tube and control the scanning raster across each character area in accordance with the invention, as will be described in detail later. Briefly, however, parts of the input signal are attributable to the cathode-ray tube beam impinging on certain reference or boundary regions on the face of the cathode-ray tube. These parts of the signal are isolated and employed for movement of the beam to predetermined locations with respect to these reference regions to provide for proper scanning of each character within the cathode-ray tube.

The amplified and clipped cathode-ray tube signal, designated 1–14, is blanked within the signal blanking circuit 1–10 during those intervals as described above, namely when the beam is undergoing retrace, is moving from one character area on the tube face to another, and is undergoing reference positioning and amplitude control. In this fashion, the signal from the blanking circuit 1–10, which signal is designated 1–15, contains only information representative of the character scanned in the cathode-ray tube 1–5.

Within the display sub-system 1–4 of FIG. 1, the input signal from the blanking circuit 1–10 is applied to a signal pulse mixing circuit 1–19, which also receives signals from the vertical and horizontal control voltage circuitry units 1–21 and 1–22. The signal from the circuit 1–19 is applied to a beam intensity control means 1–26*a* of the display cathode-ray tube 1–20. The resultant beam current components reproduce the characters on the CRT face plate and provide pulse output signals for operation of automatic error control circuit portions of the control voltage circuits 1–21 and 1–22. As in the case of the signal generating sub-system 1–3, the display sub-system 1–4 receives control signals from the data signal translation, processing and timing circuitry unit 1–2. These control signals are applied to the vertical and horizontal control voltage circuitry units 1–21 and 1–22 which function the same as the same named units of the signal generating sub-system 1–3. Unit 1–21, responsible for vertical deflection of the beam, provides an output which is applied to vertical deflection circuits 1–23, consisting of major beam deflection circuit 1–23*a* and minor beam deflection circuit 1–23*b*. Signals from the vertical deflection circuits 1–23 applied to a beam deflecting means 1–25 provide for suitable deflection of the cathode-ray tube beam within the display tube in the vertical direction. The major vertical deflection circuit 1–23*a* provides for the movement of the beam to a selected position of the display tube format, while the minor vertical deflection circuit 1–23*b* provides for rapid vertical trace and retrace deflection of the beam across a selected area at that position. The horizontal deflection circuit 1–24 receives signals from the horizontal control voltage circuitry unit 1–22 and produces an output which is applied to the deflection means 1–25 to control the movement of the beam in the horizontal direction. Upon deflection to the above noted selected position, the horizontal beam trace movement is much slower than the vertical beam movement, the vertical and horizontal beam movements together providing a raster scansion of the selected area similar to that of the character generator thereby to reproduce the selected character at the selected format position. The beam is thus deflected within the cathode-ray tube 1–20 under the control of the units 1–21 and 1–22, so as to trace out raster scansions in any desired format of random or preselected scan patterns as determined by appropriate components of signals from the signal source 1–1. Typically, in the present exemplary system, the beam is made to scan horizontally across the face of the tube to write a line of characters.

The vertical and horizontal control voltage circuitry units 1–21 and 1–22 also supply signals for beam blanking to beam blanking circuitry unit 1–26. The unit 1–26 provides signals to the beam intensity control means 1–26*a* to blank the beam in the display cathode-ray tube during retrace intervals, and during movement of the beam from one selected format area to another. As will be described, although beam current is provided, it does not produce a visible signal during intervals when the beam is being registered with respect to reference or boundary regions.

As noted above, signals from the vertical and horizontal control voltage circuitry units 1–31 and 1–22 are applied to signal pulse mixing circuit 1–19. Such signals provide pulse components to the output signal from the mixing circuit 1–19 which provide for beam current at a preselected level during those times when the beam within the cathode-ray tube 1–20 is being positioned automatically with respect to reference or boundary regions. During such times output signal 1–27 developed by the cathode-ray tubes contains information representative of

the beam's location with respect to these reference regions. The signal is amplified and clipped within an amplifier-clipper unit **1–28** and applied to the horizontal and vertical control voltage circuitry units **1–22** and **1–21** to provide for automatic positioning of the beam with reference to the reference or boundary zones in a fashion similar to that employed in the signal generating sub-system **1–3**. In this manner the characters reproduced on the face of the display cathode-ray tube **1–20** are properly positioned.

FIG. 2

FIG. 2 shows some of the more important details of the cathode-ray tube **1–5** employed in the signal generating sub-system **1–3**. The tube has a curved face plate **2—2** of radius of curvature R. The center of curvature of the face plate is located on the cathode-ray tube axis substantially at the center of deflection **2–3** of a magnetic deflection yoke **2–4**. The magnetic deflection yoke forms a part of the deflecting means **1–8** of FIG. 1. The magnetic deflection yoke **2–4** is employed for major deflection of the cathode-ray tube beam to any one of an array **2–5** of elemental areas on the tube face shown in FIG. 2*a*. For example, the array of elemental areas on the face of the cathode-ray tube may consist of eight horizontal rows and eight vertical columns, or a total of sixty-four elemental areas. Each elemental area may contain a character therein. As an example, the character A is shown in one of the elemental areas of FIG. 2*a*. When the face plate is viewed from a position in front thereof, the array of elemental areas **2–5** appears to have "barrel distortion". However, when viewed from the center of deflection **2–3**, all areas displace equal angular increments $\Delta\theta$ of the total angular displacement θ for the array. In this case θ and $\Delta\theta$ refer to angular displacement in the vertical direction. The angular displacement is also equal for all elemental areas with respect to the horizontal direction, and accordingly the array of elemental areas appears from the center of curvature **2–3** to be a rectangular array of rows and columns in straight lines.

Deflection of the beam within the cathode-ray tube **1–5** is achieved by the magnetic deflection yoke **2–4** as well as by a first pair of electrostatic deflection plates **2–6** which provide for minor beam deflection in a vertical direction, and a second pair of electrostatic deflection plates **2–7** that provide for minor beam deflection in the horizontal direction. The magnetic deflection yoke receives signals providing for major vertical and horizontal deflection of the cathode-ray tube beam. Thus, referring to the circuit of FIG. 1, signals from the vertical and horizontal deflection circuits **1–7** and **1–12** are provided to the magnetic deflection yoke **2–4** to position the beam at one of the elemental areas on the face of the cathode-ray tube, e.g., at the area containing the character A which is to be scanned for reproduction. Because the angular beam deflection provided by a magnetic deflection yoke is essentially linearly proportional to the current in the yoke, the cathode-ray tube having a radius of curvature R for its face plate requires input signals to the yoke which are linearly proportional to the row and column positions of the selected character. Therefore, scanning of the curved face plate is linear and provides signals from the elemental areas which are not distorted during scanning. My copending application Ser. No. 613,830, referred to above, discloses a cathode-ray tube as just described.

After appropriate selection of an elemental area to be scanned, the cathode-ray tube beam is automatically correctly positioned on the area and scans across the area in an appropriate scanning pattern, as described in detail below. The scansion across the elemental area may be achieved either magnetically or electrostatically. In the embodiment shown in FIG. 2 electrostatic deflection is achieved through the deflection plates **2–6** and **2–7**. The vertical deflection plates **2–6** are shown energized by a signal **2–15**, provided by the circuit of FIG. 4 to be described below.

FIG. 2*b* shows in detail one of the elemental areas of the signal generating cathode-ray tube, specifically an area containing the alphabetic character A therein. The elemental area consists of secondarily emissive and non-secondarily emissive materials, or other materials which provide a change in energy level responsive to cathode-ray tube beam current, arranged in a pattern in which, e.g., the character and indexing signal generating elements are emissive and the other areas are substantially non-emissive. When the cathode-ray tube beam is scanned across an elemental area **2–5**, there is generated a signal due to the differences in response of the elements to the beam. An output signal is producd at an output terminal **2–12** of the cathode-ray tube (FIG. 2); the conventional beam accelerating high voltage potential is applied to terminal **2–13** (FIG. 2). As noted above, the cathode-ray tube is disclosed in my pending application Ser. No. 613,830, which gives a detailed description of the improved secondary emission structures, curved screen and signal coupling details applicable to the cathode-ray tube shown in FIG. 2. The present invention is concerned with arrangement of the indexing patterns to provide error control operation and accurate output signal generation.

In FIG. 2*b*, the character A is bounded by a boundary region consisting of stripes **2–8** and **2–8′**, located respectively below and above the character, and stripes **2–9** and **2–9′**, located respectively to the left and to the right of the character. The character is typically centered with respect to the boundary stripes. Additionally, the vertical stripes **2–9** and **2–9′** may be serrated or cut away in portions thereof, for example, adjacent to stripes **2–8** and **2–8′**, as at **2–11** and **2–11′**. The character, in this case the letter A, and the boundary regions are made of secondarily emissive material, and the other regions of the elemental area **2–5** are made of non-secondarily emissive material. Any arrangement of emissive and non-emissive materials may be employed, just so long as the boundary regions provide a characteristic response to the impingement of the electron beam thereon which is detectably different from the characteristic response to the beam of adjacent regions of the elemental area.

Signals produced by the impingement of the scanning beam on the character within the area, e.g., the character A, are used for reproduction of the character in the display cathode-ray tube **1–20** of FIGURE 1, while signals developed from impingement on the beam of the boundary regions or stripes **2–8**, **2–8′** and **2–9**, **2–9′** are employed to provide proper positioning of the scanning beam during a scansion of the beam across the elemental area. The purpose of the serrated pattern and the manner in which the signals therefrom are utilized will be described more fully below.

FIG. 3

FIG. 3 shows the face plate indexing features typically employed for error correction of the display cathode-ray tube **1–20** of FIG. 1. A corner portion of the face plate **3–1** is illustrated in FIG. 3*a*. Referring to both of these figures, the face plate is fabricated with a preselected number of phosphor areas. In the present example they comprise bands **3–3** extending across the tube face and positioned one above another over the format area. Below each band is a narrow non-emissive stripe **3–4**, which stripe is slightly wider than the beam width. Along the sides of the phosphor bands **3—3** are further stripes **3–8** and **3–8′** of non-emissive material (in FIG. 3*a* only the non-emissive stripe **3–8′** at the left-hand side of the face plate is shown). The non-emissive stripes **3–8** and **3–8′** may be wider than the stripes **3–4**. Beneath each non-emissive stripe **3–4** is a relatively thin stripe **3–6** of secondarily emissive material which is typically the same width as the non-emissive stripe **3–4**. Stripes of secondarily emissive material **3–7**

and 3–7′ are positioned at the right and left-hand margins respectively of the face plate of the display cathode-ray tube. These margin stripes may be relatively very wide with respect to beam width. Serrated or cut away portions 3–5 and 3–5′ which may be considerably wider than stripe 3–4 are included in the stripes 3–7 and 3–7′ at the corners of the phosphor bands as required. Since in the present example only vertical positioning is provided, they are required only at the corners adjacent to the stripes 3–6.

The stripes 3–6, 3–7 and 3–7′ provide signals upon impingement of the beam thereon which are the result of secondary emission, but they produce no light output. These stripes in conjunction with the non-emissive areas 3–4, 3–8, 3–8′, 3–5 and 3–5′ which also produce no light output are employed for proper positioning of the electron beam in the cathode-ray tube for scansion across the phosphor areas 3—3. Typically a rapid vertical trace and retrace scan may be employed with a relatively slow left-to-right trace scan of the beam across successive selected positions of the phosphor bands 3—3. As the beam scans rapidly back and forth vertically and relatively slowly horizontally, a series of characters are reproduced for visual display in the cathode-ray tube in accordance with signals generated by the signal generating tube 1–5. In practice, for many applications the display pattern can extend across the indexing or registration stripes 3–6 and 3–4 without significant optical disruption because these stripes are relatively narrow when compared with the height of the characters to be reproduced. In other applications only selected portions of the structure generally around the outside of the entire format or display area may be required or desired, e.g., in a very high resolution system where indexing stripes such as stripes 3–4 and 3–6 within the display area would be visible. However, where the format area is divided into bands or phosphor stripes for display purposes such as the bands 3—3 in the present display cathode-ray tube, indexing stripes along one longitudinal edge and along both side edges of each band area are normally employed for registration of the beam.

SIGNAL GENERATING.—FIGS. 4 AND 5

FIG. 4 is a detailed block diagram of the vertical control voltage circuitry unit 1–6 of FIG. 1. This unit provides for vertical registry of the cathode-ray tube beam scanning each of the elemental areas 2–5 of the signal generating cathode-ray tube 1–5. The circuit shown is generally duplicated in other parts of the system for beam registry.

A character selection voltage signal V from the unit 1–2 of FIG. 1 is supplied to the vertical deflection circuit unit 1–7, and particularly to the major position deflection amplifier 1–7*a*. The signal from the amplifier 1–7*a* is designated 2–16 and, as noted in FIG. 2, this signal is applied to the deflection yoke 2–4 as a major vertical deflection signal. This signal deflects the beam to the reference or boundary region 2–8 of the character selected, e.g., to the horizontal stripe 2–8 below the character A shown in FIG. 2*b*. A triggering pulse from the unit 1–2 of FIG. 1 is applied to a timing pulse generator 4–1 in FIG. 4. Since the circuit of FIG. 4 chosen for illustration provides the relatively high frequency trace and retrace vertical scans of the beam across the elemental area 2–5, its timing trigger pulse is the highest frequency applied to the entire system. Similar timing trigger pulses at lower frequencies are generated by the unit 1–2 in FIG. 1 to provide initiation of similar timing pulse generators for other functions. The timing pulse generator 4–1 provides a series of output pulses shown in FIG. 5, i.e., pulses t_1, t_2, t_3, A and B. The timing pulse generator may utilize any of conventional circuits employing well known techniques such as triggering, time delay, pulse clipping, inverting, addition, mixing and the like to generate the five output pulses just referred to from input timing trigger pulse. It will be noted from FIG. 5 that the pulse A is the equivalent of pulses t_1, t_2 and t_3 added together and inverted, and the pulse B is equivalent to the pulses t_2 and t_3 added together.

The output pulse B from the pulse generator 4–1 is applied to a ramp signal or sawtooth generator 4–2 which generates a minor deflection output sawtooth signal C, whose waveform is shown in FIG. 5. This is a typical sawtooth waveform and may be produced by any of conventional circuits. As shown in FIG. 5, the sawtooth waveform C has a retrace portion which is completed during the time interval corresponding to pulse t_2 and has a trace portion which commences after a pulse t_3 and terminates just after the following pulse t_1 The latter part of the trace portion of the sawtooth waveform C thus includes the interval of pulse t_1. The sawtooth waveform C also includes a flat or constant amplitude portion during the time of pulse t_3. This constant amplitude portion of the waveform C provides for the halting of the electron beam at an error correction indexing position corresponding to stripe 2–8.

The sawtooth waveform C is applied through an adder or summing circuit 4–5 which receives a signal D from an automatic position control circuit 4–3. The sawtooth signal and the signal D are added within the adder 4–5 to produce an output signal which is applied to the vertical deflection circuits 1–7, specifically to a minor deflection amplifier 1–7*b*. The output signal from the minor deflection amplifier 1–7*b* is designated 2–15, and, as shown in FIG. 2, is applied to the electrostatic deflection plates 2–6 causing minor electrostatic deflection of the cathode-ray tube beam in the vertical direction. As described above, this signal provides for the relatively high speed vertical scanning of one of the selected character areas 2–5 of FIG. 2*a*.

The timing pulse generator 4–1 generates a blanking pulse t_2 which is applied to beam blanking circuitry unit 1–9 of FIG. 1 which controls the signal generating cathode-ray tube 1–5 so that the beam is blocked or extinguished during the time of pulse t_2. Hence during the time of pulse t_2, which is the retrace portion of the sawtooth waveform C, no output signal can be developed from the cathode-ray tube. Whenever the beam is not blanked, however, secondary emission signal components can be developed at the output terminal 2–12 of the signal generating cathode-ray tube (see FIGS. 1 and 2). This output signal is amplified and clipped by the amplifier-clipper 1–13 of FIG. 1 resulting in an output signal 1–14. This output signal, as shown in FIG. 4, is applied to the automatic position control circuit 4–3 and to an automatic amplitude control circuit 4–4. The signal 1–14 will have a number of pulse components as shown in FIG. 5 which illustrate the signal 1–14 for a representative vertical scan of the character A. During the scan interval when the waveform C produces vertical deflection of the beam from the stripe 2–8 to the stripe 2–8′, pulses E_1 and E_2 are produced as the beam crosses the horizontal and upwardly sloping (to the right) portions of the character. A representative vertical scan is shown in FIG. 2*b* in dotted line, and the pulses E_1 and E_2 are noted in FIG. 2*b* on those portions of the character causing the pulses to be generated. Pulse E_3 shown in FIG. 5 is generated during the interval t_1 at the end of the trace portion of vertical scan, i.e., when the beam strikes and enters the top indexing or boundary stripe 2–8′. During vertical retrace of the beam the beam is blanked, as noted above, and hence no secondary emission signals are developed during t_2. Following retrace and during the interval t_3 prior to the next vertical trace scan, when the beam has halted on the bottom indexing or boundary stripe 2–8, the pulse E_4 is generated.

The pulses E_1 and E_2 represent the information part of the signal used for reproduction of the scanned character in the display cathode-ray tube 1–20 of FIG. 1.

The pulse E_4 produced during the interval t_3 following retrace when the beam is on the bottom indexing stripe 2–8 is employed to position the beam at the upper edge of that stripe prior to the next vertical trace scan. This is accomplished by the automatic position control circuit 4–3 to which is applied the signal 1–14 from the signal generating cathode-ray tube. The pulse t_3 is also applied to the automatic position control circuit 4–3. A first section of circuit 4–3, as well as the other position and amplitude control circuits of the system, comprises a pulse comparator or, in computer terminology, an AND gate, which provides a unit output signal only during the portion of the t_3 interval when pulse E_4 is also present. Therefore, other secondary emission signal components of waveform 1–14, since they occur outside of the interval t_3, do not affect operation of circuit 4–3. The circuit 4–3 operates to integrate the pulse E_4 and to generate an output signal, designated D in FIG. 5 which is applied to the added 4–5. The signal D is added to the sawtooth signal C and is applied from the adder to the minor deflection amplifier 1–7*b* and thence to the vertical deflection plates 2–6 of FIG. 2. The signal component D deflects the beam upwardly. So long as the beam is on the stripe 2–8, the pulse E_4 persists, thereby producing a steadily increasing signal D, which causes the beam to move upwardly. As soon as the beam reaches and just moves off the upper edge of the stripe 2–8, the pulse signal E_4 drops to zero. The integrating of the signal 1–14 provided by the circuit 4–3 holds the value of the output signal D constant, thereby maintaining the beam in position just off the upper edge of the stripe 2–8. In this manner the "error" signal D is added to the sawtooth waveform C following the retrace interval and before the next trace interval so as to properly position the beam for vertical beam scanning. A circuit suitable for the automatic position control circuit 4–3 is shown in FIG. 6, to be described later. A circuit also suitable is described in my copending application Ser. No. 592,625, referred to above.

The integrating provided for by the automatic position control circuit 4–3 may be achieved through the use of a capacitor which is allowed to slowly discharge through a resistor throughout each cycle so that, by the time retrace is completed, the decrease in signal D tends to deflect the beam toward reference stripe 2–8. In this fashion, the automatic position control circuit may be made to be operative after each cycle of vertical deflection so as to properly position the beam at the upper edge of the indexing stripe 2–8 for the next cycle. The circuit of FIG. 4 thus may be made responsive to correct both positive and negative displacement errors which occur in the major deflection voltage for selection of characters or in the relative positioning of the characters on the CRT face plate.

The output signal 1–14 from the cathode-ray tube is also applied to an automatic amplitude control circuit 4–4 which controls the amplitude of the sawtooth waveform C. The control circuit 4–4 is supplied with the pulse t_1 from the timing pulse generator 4–1 so that all automatic amplitude control may take place only during the interval t_1, i.e., at the end of each vertical trace scan. The automatic control circuit 4–4 is thus only responsive to the secondary emission pulse E_3 occurring at the end of the vertical trace scan when the beam is deflected onto the upper indexing boundary stripe 2–8′ of FIG. 2*b*. If the amplitude of the sawtooth signal C is such as to deflect the beam substantially onto the stripe 2–8′, the pulse E_3 will be substantial and a substantial output signal will be generated by the automatic amplitude control circuit 4–4. This output signal is chosen to be of a polarity to reduce the amplitude of the sawtooth signal generated by the sawtooth generator 4–2, which amplitude is initially set larger than required to scan the area contained within the stripes 2–8 and 2–8′. The signal E_3 goes to zero when the sawtooth amplitude is sufficiently low so that the beam is not deflected onto the stripe 2–8′. The sawtooth generator 4–2 is controlled in any conventional fashion to reduce the amplitude of the sawtooth output signal. Typically, a control is achieved over a number of cycles so that the sawtooth generator 4–2 slowly reduces the amplitude of the sawtooth signal until the scanning beam just reaches the lower edge of the stripe 2–8′ after each vertical trace scan.

In this fashion, vertical scan amplitude is maintained at a reference height corresponding to the distance between the indexing or boundary stripes 2–8 and 2–8′, with the starting position of the scan maintained just at the upper edge of the lower stripe 2–8.

The pulse A generated by the timing pulse generator 4–1 is applied to an automatic position control circuit of the horizontal control voltage circuitry 1–11 (FIG. 1) for purposes to be described and to the signal blanking circuit 1–10 which is also supplied with the output signal 1–14 from the signal generating cathode-ray tube. The blanking circuit 1–10 blanks the output signal during the time of pulse A, which is when the error control pulses E_3 and E_4 are developed and during vertical retrace. Thus, as mentioned previously, the output signal 1–14 from the blanking circuit contains only signal pulse components occurring during the vertical trace scan interval. The pulse voltages t_3 and B are applied to the display vertical control voltage circuitry 1–21 as will be explained subsequently.

Operation of the character generator vertical control voltage circuitry 1–6 of FIG. 1 has been described in detail in connection with FIGS. 4 and 5. As previously noted, control voltage circuitry 1–11, 1–21 and 1–22 (FIG. 1) has also been provided for character generator horizontal deflection, display vertical deflection and display horizontal deflection, respectively. Each of these units may provide the identical or a similar arrangement of control functions (timing pulse generation, sawtooth signal generation, automatic position and amplitude control) and employ circuits which operate in a manner similar to those described in FIGS. 4 and 5. However it will be realized that the operating frequency or period of the functions will vary. Thus, horizontal character generator frequency will be reduced from the character generator vertical frequency by the number of vertical scans per character, display horizontal (line) frequency is further reduced by the number of characters per line, and display vertical frequency by the number of lines per selected area or total format. Each may add external sequential or random positioning voltages (which directs the beam to the vicinity of reference stripe zero positions of selected areas) to sawtooth waveforms which provide deflection components for scanning such areas and position and amplitude correction components which match the scans to the selected areas. For this purpose each of the above noted units may generate timing pulses for scan amplitude, positioning, beam retrace blanking, deflection drive and signal blanking or insertion control similar to and in the manner and for the purposes described in connection with FIGS. 4 and 5 or to be described. Each position and amplitude control pulse has associated with it a reference stripe position on the CRT format. As previously noted, for character generator vertical deflection, the reference stripes are 2–8 and 2–8′ (FIG. 2). For character generator horizontal deflection, the reference stripes are 2–9 and 2–9′. For display horizontal deflection, the reference stripes are 3–7 and 3–7′ (FIG. 3). For display vertical deflection similar format edges could be provided. However, as will be described, the stripes 3–6 in the present exemplary system provide only positional and not amplitude control. There are also differences and variations of the above described circuitry dependent on operating frequency and requirements for simultaneous horizontal and vertical error correction which will now be considered.

Simultaneous error correction

Simultaneous error correction (horizontal and vertical) will be described in connection with character generator horizontal deflection control circuitry **1–11** of FIG. 1. It may first be noted that normal operation of the vertical error circuits was described for a value of horizontal scan which provided a representative vertical scan located at an arbitrary position within the character elemental area. When the minor horizontal scan voltage is zero at the start of its position correction interval, which interval corresponds to t_3 of FIG. 5 but typically contains several vertical scans because of the lower horizontal frequency noted above, the vertical scan will be at a location on reference element **2–9** as shown by dashed line **2–10** of FIG. 2*b*. The corresponding output signal is designated E_5 in FIG. 5. The absence of any signal at the start and finish of vertical trace scan is due to the serrations **2–11** and **2–11′** which allow the vertical circuits to provide the error correction signals E_3 and E_4 in this region just as for the typical position in the character area previously described which led to the generation of signals E_1 to E_4. The serrations **3–5** in the display indexing format provide a similar function for vertical positioning. Without the serrations the vertical circuit would continue to develop error signals during the horizontal correction intervals which would result in serious displacement and amplitude errors at the start of horizontal scan. With the serrations, relatively large vertical errors can be corrected during the same time that the beam is being registered horizontally. However, the vertical correction signals are also introduced as false signals into the horizontal control voltage circuitry unit **1–11**, as noted from FIG. 1. These signals normally would affect the operation of the unit **1–11**. This difficulty is eliminated by blanking the horizontal error circuit during the vertical correction, that is, blanking the circuit during vertical error correction intervals just prior to and at the end of the vertical trace intervals. The horizontal error circuit then is free to operate only during vertical trace intervals when there will be no vertical error signals developed. It has been explained that the input to the error correction circuit is an AND or pulse coincidence circuit. This may have as many inputs as are essential to its control. In the present example the vertical signal blanking pulse A from timing pulse generator **4–1** is applied to one such input included in horizontal control voltage circuitry unit **1–11** (FIG. 1) to provide the above noted blanking so that only the signals E_5 (during vertical trace) are effective to operate the horizontal positioning circuit. These pulses are integrated and the resultant signal added to the horizontal deflection scan waveform in the same manner as has been described for the vertical circuit of FIG. 4 to position the beam at the right edge of stripe **2–9** at the start of horizontal scan. It will be obvious that serrations may be placed at the left side of the stripe **2–9′** etc. to achieve the same effect for amplitude control. However, in the present example the error introduced by not providing such serrations is negligible.

In the character generator just described employing horizontal scan amplitude control, the resultant amplitude for a given character is determined by the average width of one or more previous characters dependent on the response of the amplitude integrator.

The operation of the display horizontal correction circuit **1–22** is similar to the character generator horizontal circuit **1–11** just described. However, whereas the character generator beam current is normally on during operational cycles and can generate error control as well as output signals, the display CRT would be normally off except when character signals are received. It must therefor be selectively turned on to function during error correction intervals. For this purpose pulses are provided from the timing circuits of the circuitry units **1–21** and **1–22** to mixer **1–19** which adds them to the character signal thereby to provide current during intervals functionally corresponding to t_1 and t_3 when the beam is at corresponding error correction positions. Although this produces the necessary components of signal **1–27** for error correction, the reference stripes do not provide visible output as previously noted.

As the character scanning speeds are reduced, as is the case particularly for the horizontal display, the desirability for separate deflection circuits, minor for fast small amplitude scans and major for large displacements, becomes obviated. Hence the external control positioning, sawtooth and error control deflection signal components described above may be added and all applied to the major deflection circuit involved. The minor deflection circuit in such a case may thereby be eliminated.

FIG. 6

Some of the above features as well as improvements and variations in application and operation of the error control circuit are illustrated by way of example in connection with the vertical deflection section of the display sub-system **1–4** which will now be described in connection with FIG. 6. A trigger signal from unit **1–2** is applied to pulse generator **6–1**. Its output is applied to beam blanking circuitry **1–26** to provide beam retrace blanking. The beam retrace interval is intended to comprise any non-operative interval after initiation of retrace and before the initiation of the trace interval of the succeeding scan. For example, on completion of generation of a character, an intermittent or indeterminate delay may take place before the generation of the next character.

In this arrangement a vertical major positioning voltage signal from unit **1–2** is applied via the vertical control voltage circuitry **1–21** to the major vertical deflection circuit **1–23***a* and serves to determine the approximate location of a line of characters to be displayed. As has been previously described, the characters are reproduced by scanning horizontally along the line with a succession of vertical strokes in synchronism with the vertical scan strokes of the character generator CRT **1–5**. For this purpose control pulse B from timing generator **4–1** is provided to a sawtooth generator **6–2** to determine the timing of the sawtooth signal. It will be apparent that the process could as well be reversed, whereby timing pulses are generated in unit **1–21** and then applied to unit **1–6**. The sawtooth generator **6–2** may be similar to generator **4–2**. However, the amplitude of the sawtooth signal is adjusted by a control voltage from unit **1–2** which determines the height of characters to be reproduced. The generated sawtooth signal is applied to an input of adder circuit **6–3**. Pulse B from timing pulse generator **4–1** and a minor position selection voltage G from unit **1–2** are also applied to adder **6–3**. The voltage G clips the amplitude of pulse B in direct relation to the amplitude value variation of G from a zero reference level corresponding to the amplitude of pulse B.

The clipped pulse B, whose amplitude is thereby adjusted by a preselected amount in proportion to the external DC control voltage G, is used to offset the line of characters being generated from a selected reference stripe (**3–6**) of the display CRT by a preselected amount in a manner to be explained. The clipped pulse B is then inverted and added to the sawtooth signal from generator **6–2** to produce the composite waveform F as shown by the solid line waveform of FIG. 5. The signal F is applied to the minor deflection circuit **1–23***b* where it is added to a position error correction component from the output of error correction circuit **6–4** to be described. The output of circuit **1–23***b* is AC coupled through capacitor C_6 to minor deflection plates *d* of display CRT **1–20**. The deflections just described position the beam on a selected format area or band **3—3** (FIG. 3) typically to produce vertical scan strokes of amplitude between dashed lines **3–9** and **3–9′** (FIG. 3*a*) corresponding to the sawtooth portion of waveform F. This deflection corresponding to waveform F is shown to a much expanded horizontal

scale in FIG. 3*a* for purposes of clarity. The beam offset displacement is shown as component G' corresponding to the clipped portion of waveform B.

The pulse component of signal F deflects the beam to the vicinity of a reference position **3–6** during error correction interval t_3. Pulse t_3 from timing pulse generator **4–1** is applied via vertical control voltage circuitry **1–21** to signal pulse mixing circuit **1–19** to provide beam current during error correction as previously described. Error correction circuit **6–4** adjusts the beam position during t_3 corresponding to the base of deflection waveform component G' from stripe **3–6** on the face of CRT **3–1** onto reference position **3–4** just above the edge of stripe **3–6**. At the end of t_3 the beam jumps to position **3–9**. The strokes are thereby offset or displaced from their selected reference position by the clipped amplitude of pulse B. The position of successive lines of characters is controlled by the relatively small offset voltage G to accurately locate them at selected positions in relationship to selected reference positions thereby compensating for errors in the major positioning voltage, for cathode-ray tube deflection distortions, circuit instability, etc. This is accomplished frequently at each of successive vertical scan strokes to make the horizontal lines of characters follow exactly the horizontal reference stripes selected thereby to eliminate the various geometrical distortions which are typically introduced by the deflection process and the CRT.

In the circuits described previously, the automatic position and amplitude control circuits such as circuits **4–3**, **4–4**, etc. and amplifier-clipper circuits **1–15**, **1–28**, etc., may utilize the circuit or equivalent shown in FIG. 5 of my application Ser. No. 592,625, referred to above. An alternative and improved circuit is shown in detail, section **6–4** of FIG. 6, in the present application. The circuit shown in FIG. 6 provides for the storage over long and random intervals of time of the automatic position control circuit signal to provide for proper beam positioning with respect to selected reference elements or stripes. It provides for high speed detection and amplification of the CRT error signals and for their application by the error control circuit simultaneously to major and minor deflection circuits to achieve both high speed and long term (DC) control of errors. The same circuit, of course, may be employed for horizontal control as well, and may be used in both the signal generating and display sub-systems **1–3** and **1–4**.

The secondary emission signal developed from the secondarily emissive areas of the screen **3–1** of the cathode-ray tube are coupled (FIG. 6) by means of a capacitor C, to the base of a transistor Q_4. The cathode-ray tube structures comprising screen **3–1**, gun (not shown) and deflection plates *d* with a capacitive coupling arrangement C_6 is the same as disclosed in my application Ser. No. 613,830, referred to above. The screen **3–1** has stray capacity to ground and to the high voltage anode structure; for AC purposes the anode structure may also be considered as connected to ground. This effective stray capacity of the screen to ground is represented by capacitor C_S in FIG. 6 which shunts the secondary emission signal. The transistors Q_4 and Q_5 in FIG. 6 along with the associated resistors R_f, R_8, R_9 and R_{10} and capacitor C_8 constitute the amplifier-clipper **1–28** shown in FIG. 1. The series cascade transistor Q_5 is provided to prevent capacitive coupling of the amplifier output at the junction of R_{10} and R_f back to the base if the transistor Q_4. The base of the transistor Q_5 is forwardly biased, e.g., by means of a by-pass capacitor C_8 and a divider constituted by resistors R_8 and R_9, to a suitable value (typically seven volts). Output to input feedback in the amplifier is provided by resistor R_f which serves to provide an effective low impedance input to the amplifier so that the loading effect of the shunt capacitance C_S does not appreciably slow down the amplifier response to the secondary emission indexing signal resulting from the impingement of the cathode-ray tube on one of the reference stripes.

The output of the amplifier **1–28** is applied by a capacitor C_2 to the base of a transistor Q_2. A pulse input signal to the amplifier **1–28** due to relatively high secondary emission from impingement of the beam on one of the secondarily emissive reference stripes provides a negative amplifier output signal which renders the base circuit of transistor Q_2 highly conductive. The resistor R_2 and diode X_1 connected to the base of the transistor Q_2 restore the base to a cutoff level during intervals when the output signal from the amplifier **1–28** is zero or of a negative polarity. The collector of the transistor Q_2 is connected to the emitter of another transistor Q_1. Pulse signal B is applied to the base of the transistor Q_6. It is inverted at the collector of Q_6 which is connected to the base of Q_1. Q_1 and Q_2 comprise an AND gate. When the pulse signal B is coincident with an indexing signal from the display cathode-ray tube, which may occur only during interval t_3 as described above when the beam is on the stripe **3–6**, the collectors of the transistors Q_1 and Q_2 become highly conductive thereby to place a charge on capacitor C_4. The voltage across the capacitor C_4 is raised, and this raised capacitive voltage is coupled by means of transistor Q_7 to the minor vertical electrostatic deflection plates *d* in the display cathode-ray tube. Q_7 may be of the field effect (FET) type which has very high input resistance. Specifically, the collector of the transistor Q_7 is coupled to the deflection plates through the minor vertical deflection amplifier **1–23***b* and through the capacitor coupling arrangement C_6. The raised electrostatic deflection plate voltage drives the beam in an upward direction with respect to one of the emissive stripes **3–6** until it just leaves the stripe. As soon as the beam leaves the stripe and enters into the non-emissive area **3–4**, secondary emission ceases and an input signal is no longer applied to the amplifier-clipper **1–28**.

The beam is therefore left at the upper edge of the stripe **3–6** in a proper reference position immediately following the interval of pulse t_3 (FIG. 5). The beam is then acted upon by the other circuit elements as described above in connection with FIG. 6, namely, so that it is offset to the selected line position to scan the area between **3–9** and **3–9'**.

During the vertical trace interval the signal across the minor electrostatic deflection plates *d* will decay by leakage off the capacitor C_6 through the resistor R_6 to the anode circuit **6—6**. Such signal decay would cause the beam to be deflected, losing the corrected shift provided for by the initial potential supplied to the electrostatic deflection plates. To compensate for such signal decay, the transistor Q_7 provides a counteracting signal. In particular, the transistor Q_7 drives a low-pass filter comprised of resistor R_5 and capacitor C_5 having the same time constant as the capacitor C_6 and associated resistor R_6. The signal from the low-pass filter is applied to an input of the major vertical deflection amplifier **1–23***a* so that it provides a deflection shift just equal and opposite to the decay across the capacitor C_6. Thus the net deflection of the beam is zero. The field effect transistor Q_7 has a very high input gate resistance, and thus there is no loading across the capacitor C_4. In this fashion, no discharge of the signal across the capacitor C_4 occurs. Hence the capacitor C_4 maintains the output signal of the transistor Q_1 thereon, representing the proper amount of shift of the beam so that it is correctly positioned with respect to the reference stripe **3–6**, until the capacitor is discharged under the action of transistor Q_3.

The base of transistor Q_3 is normally biased so that the transistor provides an open circuit across the capacitor C_4. At the end of a vertical trace interval and prior to the pulse t_3 the transistor Q_3 provides a discharge pulse to the capacitor C_4. Specifically the pulse B occurring during and after the vertical retrace interval is used to discharge the

capacitor C_4. The pulse B applied to the base of transistor Q_6 is transmitted via its emitter to capacitor C_3. The leading edge of the pulse B is differentiated by the capacitor C_3 and resistor R_3 to provide a positive input pulse to the base of transistor Q_3. An output pulse is thereby generated by the transistor Q_3 to discharge the capacitor C_4 only just prior to each new error control interval. This assures that the error signal is maintained over long periods of time such as during horizontal retrace or other interruptions in operation but is reduced before successive corrections sufficiently to assure that the beam is driven onto an error reference element each cycle. The resistor R_3 may be coupled to a bias source V_b which is variable in order to change the magnitude of the pulse signal applied to the base of transistor Q_3 so as to adjust the output pulse which discharges the capacitor C_4. In this fashion, the transistor Q_3 is controlled so as to assure correct operation of the error circuit, i.e., make the beam land on an error reference position at the start of each correction interval. Variation of V_b may be made of cyclical or random rates in accordance with known errors associated with the system operation thereby to reduce the range of control required of the error control system.

SUMMARY

A beam control system has been described involving novel cathode-ray tube indexing structure and beam control circuitry designed to position a scanning beam in a cathode-ray tube with respect to reference locations. Bidirectional indexing is achieved. The invention has been disclosed as embodying a signal generating a display system. However, this is representative only and constitutes one of a variety of applications of the invention.

It will be appreciated that numerous substitutions may be made in the embodiments disclosed. For example, electrostatic and magnetic beam deflection techniques have been employed; any suitable deflection technique may be employed to achieve the appropriate beam deflection for indexing.

Accordingly, the invention should be taken to be defined by the following claims:

1. A cathode-ray tube, in which the face of the tube includes one or more elemental information areas, each said area having a boundary region of a material which generates a signal response due to cathode-ray tube beam impingement on any portion thereof that is different from the signal response of immediately adjacent material within the area when the beam impinges on the adjacent material, the improvement in which said boundary region extends along at least two substantially non-parallel sides of the area so as to constitute two boundary region sides, and means including said boundary region sides for generating a single signal having individual components corresponding to beam impingement on the individual boundary region sides of the area.

2. A cathode-ray tube as defined in claim **1**, wherein the material in each boundary region comprises two intersecting stripes of material so as to permit registry of the beam with respect to beam movement in two directions.

3. A cathode-ray tube as defined in claim **2**, wherein one of the stripes is partially cut away in a region thereof adjacent to the other stripe.

4. Beam positioning means for a cathode-ray tube as defined in claim **1**, including circuit means for detecting said signal components and positioning said beam at reference locations with respect to two directions of beam scanning movement across each elemental area.

5. Beam scan control means for a cathode-ray tube as defined in claim **1**, including circuit means for detecting said signal components and controlling the beam so that it scans selected ones of said areas each as defined by said boundary region.

6. Beam scan control means as defined in claim **5**, wherein said circuit means includes means for storing one or more of selected signal components, means responsive to said stored signal components for effecting said beam scan control during a storage interval, and switch means for discharging said storage means in response to a control signal at the end of said storage interval.

7. In beam positioning means for a cathode-ray tube, said tube having a face comprising an information area bounded on one side by an indexing element stripe with a characteristic response to beam impingement thereon, the combination comprising beam scanning means for deflecting the beam over said area and onto said stripe, said deflection including a component having repetitive trace and relatively fast retrace portions normal to said indexing element, and circuit means for detecting the response of said stripe to the beam during an interval following a retrace scan of the beam across the area to move the beam to the edge of said stripe and hold it at said edge until the next trace scan of the beam across the area.

8. Beam positioning means as defined in claim **7**, including means for stepping said beam to an offset position with respect to the edge of said stripe so that the trace scan of the beam across the area commences with respect to said offset position.

9. Beam positioning means as defined in claim **7**, wherein the face includes a second stripe similar to said first named stripe but on an opposite side of said information area, and including signal input means for controlling the scan amplitude of said normal scan component, means for generating a time reference pulse signal just prior to a selected instant of trace termination, means responsive to said trace termination reference pulse and to the characteristic response of said stripes only during said termination pulse interval to detect the amplitude of said beam scan component relative to said second stripe and to generate a signal for control of said scan component amplitude.

10. A cathode-ray tube suitable as a signal generating tube, in which the face of the tube has a plurality of elemental areas each of which includes a character therein of a material which has a characteristic response when the cathode-ray tube beam impinges thereon that is different from the characteristic response of adjacent material within the area when the beam impinges on the adjacent material, each elemental area having a boundary region about all sides thereof which is of a material the same as that of the character within the area.

11. A cathode-ray tube as defined in claim **10**, in which the boundary region for each elemental area comprises four stripes of material substantially in the shape of a rectangle.

12. A cathode-ray tube as defined in claim **11**, wherein two opposite stripes are each partially cut away in regions thereof adjacent to the other stripes.

13. A cathode-ray tube suitable as a symbol display tube, in which the tube face has a plurality of elemental areas in the form of bands of light emissive material across the face of the tube, each band being bounded along a longitudinal and side edges thereof by stripes of secondarily emissive but non-light emissive material, the stripes of secondarily emissive but non-light emissive material bounding each band constituting a boundary region of a material which has a characteristic response when the cathode-ray tube beam impinges thereon that is different from the characteristic response of adjacent material.

14. A cathode-ray tube as defined in claim **13**, in which each band of light emissive material is spaced from its bounding secondarily emissive stripes by stripes of non-emissive material.

15. A cathode-ray tube as defined in claim **14**, in which one of the secondarily emissive stripes is cut away in a region thereof adjacent another secondarily emissive stripe.

16. A cathode-ray tube system, comprising a cathode-ray tube having beam generating means, a face plate having means associated therewith for defining boundaries

of one or more information areas by production of a single index signal when the beam impinges on any portion of said face plate corresponding to said boundaries, said single index signal having individual components corresponding to beam impingement on individual portions of the boundaries, beam deflection means for causing said beam to scan across said areas, said beam deflection means having a plurality of control inputs which control characteristics of said beam scan in response to signals applied thereto, means generating a plurality of reference time pulses, a plurality of detectors each responsive to one of said reference time pulses and to said index signal only during the interval of said one reference time pulse to separate from said index signal a component representative of beam position relative to a selected boundary portion and to generate therefrom a corresponding positional error signal, and means coupling each error signal to a corresponding control input of said beam deflection means so that said error signals control a plurality of characteristics of beam scan to provide a preselected relationship to said boundaries.

17. A cathode-ray tube system as defined in claim **16**, including circuit means responsive to corresponding ones of said error signals for positioning said beam so that the scanning movement thereof is adjusted in preselected relation to reference locations with respect to two directions of beam scanning movement across each information area.

18. A cathode-ray tube system as defined in claim **17**, including first beam deflecting means for deflecting said beam relatively rapidly back and forth across a selected information area in trace and retrace scans in a first direction, second beam deflecting means for deflecting the beam relatively slowly across said selected area in a trace scan in a second direction, and said circuit means includes means responsive to corresponding ones of said error signals for controlling the amplitude of one or more of said scans to maintain a preselected relation of scan amplitude with relation to corresponding boundary portions.

19. A cathode-ray tube system as defined in claim **18**, wherein said circuit means is responsive to an error signal during intervals occurring in one or more of the rapid trace scans of the beam across said selected area and before the slow trace scan of the beam across the area to position the beam at the edge of a corresponding boundary position in registry for the slow trace scan.

20. A cathode-ray tube system as defined in claim **16**, having a plurality of information areas, means for generating control signals for deflecting the beam sequentially to selected boundaries of corresponding information areas, and means operative at the end of each said beam area scan for signalling termination of scan and operative to control said control signal generating means to deflect the beam to the next said sequential area boundary.

21. A cathode-ray tube system as defined in claim **16**, wherein said beam deflection means causes said beam to scan across each information area with a relatively fast component of scan and a relatively slow component of scan, means responsive to one of said error signals for deflecting said beam so that said relatively fast scan component follows along the edge of a selected one of the boundaries, said relatively fast scan component taking place during traversal of the relatively slow scan component, said slow scan component proceeding in the general direction of said boundary edge.

22. A cathode-ray tube system as defined in claim **16**, including means operative to prevent components of said index signal corresponding to one of said error signals from interfering with correct utilization of other components of said index signal corresponding to the other error signals thereby to permit simultaneous control of said plurality of characteristics of beam scan.

23. A cathode-ray tube system as defined in claim **16**, including means for providing a value of beam current during the intervals of said reference time pulses.

24. A cathode-ray tube system as defined in claim **16**, in which said cathode-ray tube generates an output signal that includes components corresponding to said single index signal and information components corresponding to beam impingement on any portion of said face plate corresponding to said information areas, and means for removing from the output signal said index signal components.

25. A cathode-ray tube system as defined in claim **16**, including means for stepping said beam to an offset position with respect to the edge of one of said boundaries thereby to scan a selected portion of a corresponding information area removed from said boundary edge.

26. A cathode-ray tube system as defined in claim **16**, wherein the boundary of an information area includes individual portions extending in different directions, and including means for blanking components of the index signal corresponding to a boundary portion in one direction which interfere with components of the index signal corresponding to a boundary portion in another direction, thereby to provide simultaneous correction of beam deflection with respect to boundary portions extending in different directions.

27. A cathode-ray tube system as defined in claim **16**, including means for storing one or more of said error signals each for a preselected interval.

28. A cathode-ray tube system as defined in claim **27**, including means for discharge of one or more of said stored signals each at the end of said preselected interval.

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