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Burroughs

Application Notes

SINGLE-REGISTER SELF-SCAN® PANEL DISPLAY THEORY OF OPERATION

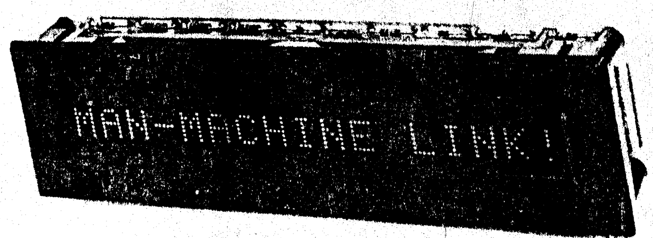

Figure 1. 16-DIGIT ALPHANUMERIC PANEL

INTRODUCTION

SELF-SCAN is a registered trademark of the Burroughs Corporation which identifies a family of panel displays capable of satisfying the display needs of systems requiring 16 to 256 or more character positions of information readout. These displays, such as the 16-character model shown in Figure 1, are capable of displaying numeric and alphanumeric information in a dot matrix format at low cost.

Experiments with matrix type gas discharge dates back to the early 1950's. None of these early displays achieved commercial success because they all required complex and expensive drive electronics. Burroughs, realizing the limitations of earlier attempts, has developed a unique new form of gas discharge display which eliminates as much as 90% of the addressing electronics by incorporating the X axis addressing function within the display panel geometry.

A variety of SELF-SCAN panel displays are currently available; however, because the theory of operation is basically the same for all of the units, this brochure is written around the 16-digit alphanumeric panel.

DESCRIPTION

The SELF-SCAN panel display discussed in this brochure is capable of displaying any intelligence adaptable to a dot matrix format. The panel consists of 112 columns with each column containing 7 glow cavities. One column is used for panel reset and is not visible from the display side of the panel. The display is 7 glow cavities (dots) high (1 column) by 111 columns long. This area is sufficient to display 22 characters in a 4 dot wide x 7 dot high matrix with one column of space between characters, 18 characters in 5 x 7 dot matrix with one column of dots between characters or 16 characters in a 5 x 7 dot matrix with 2 columns of space between characters. Figure 2 illustrates the letters B and R in each of these formats. The 5 x 7 dot matrix format appears most desirable for most applications because it gives full alphanumeric capability.

The panel shown in Figure 1, and described here, is designated the 16-character panel. The glow cavity or dot size is .036" in diameter and the dots are arranged on .060" centers (panels are also available on .030" and .040" centers).

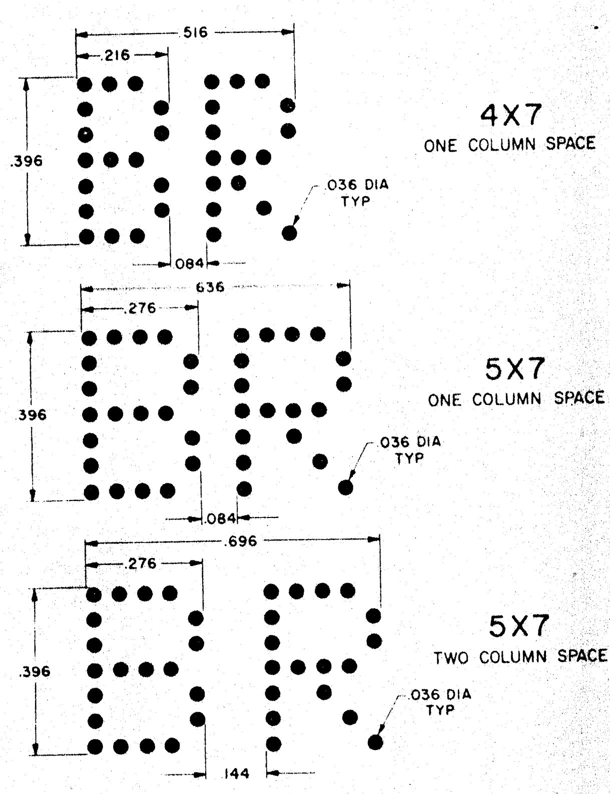

Figure 2. DOT MATRIX CHARACTER FORMATS

OPERATION

Figure 3 is an exploded view of the left hand section of a SELF-SCAN panel display. The panel can be thought of as having three basic sections: (1) The "glow scan" section which consists of the scan anodes and the rear side of the cathode strips, (2) The "glow priming" section which consists of tiny apertures in the cathode strips, and (3) The "glow display" section which consists of the display anodes, the center insulating sheet containing the display cavities and the front side of the cathode strips. This structure, with scan and display anode wires orthagonal to the cathodes, is hermetically sealed in a common envelope filled with a neon gas mixture similar to the gas used in NIXIE ® tubes.

Three basic glow discharge phenomena employed in this device are combined to produce the display. The first, glow scan, is the phenomenon where the glow is established at the back side of the reset cathode and is transferred sequentially

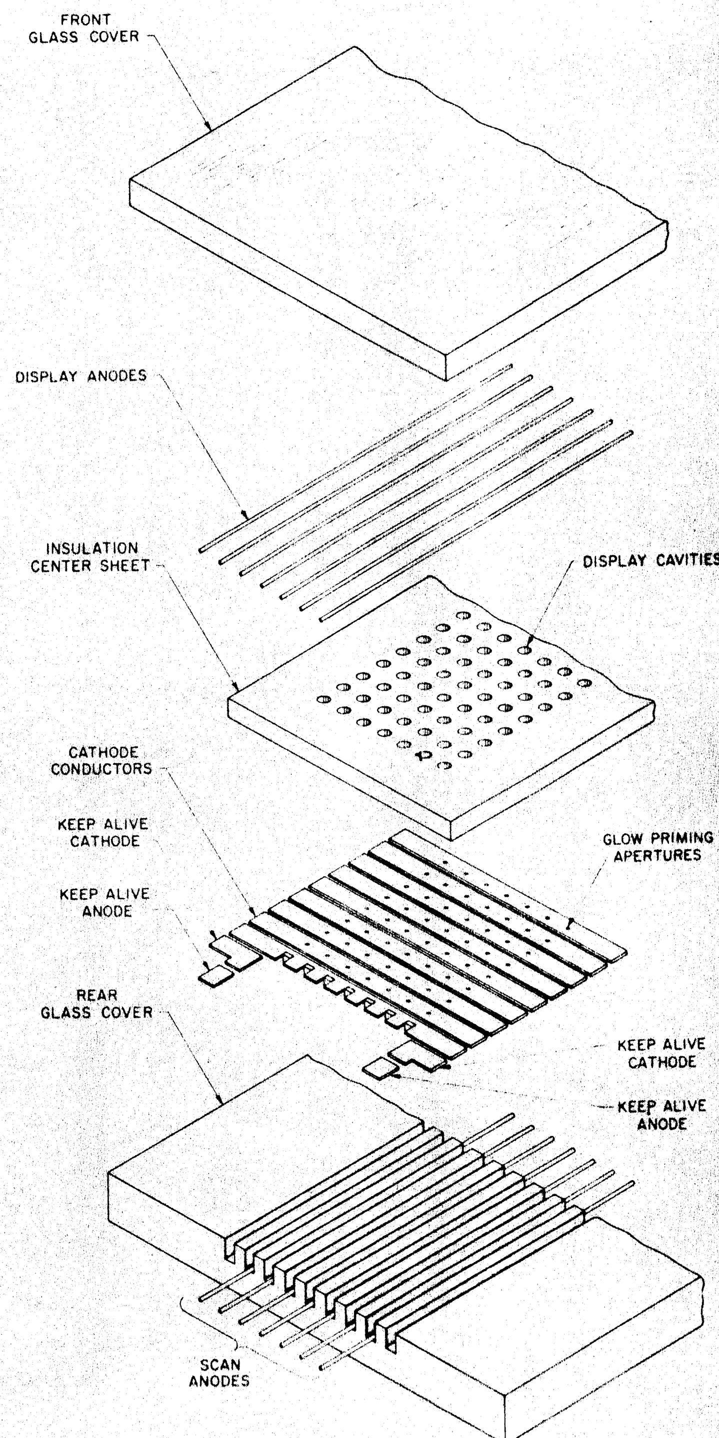

Figure 3. SELF-SCAN PANEL DISPLAY EXPLODED VIEW

down the entire length of the panel at the rear of each cathode at a rate of approximately 60 cycles per second. (This would be analogous to the scanning of a CRT if the entire face of the tube were scanned in one sweep.) This glow scan function occurs on the rear side of the panel and is not viewable from the viewing surface. The second phenomenon is glow priming which performs the function of allowing the glow to be drawn from the scan side of the panel to the viewing surface. A glow is established on the rear of the cathodes and transferred down the panel to produce a scanning effect (glow scan). As the glow occurs on the rear of each cathode, metastables[1] diffuse through the tiny glow priming apertures in the cathode and preionize the gas in the display cavity (glow priming). In synchronism with glow scan and glow priming, the third phenomenon, glow display is employed where front anodes are addressed as desired and a glow is established on the front side of the cathodes in the display cavities and is visible from the viewing surface. During one complete transfer of glow down the scan side of the panel, the glow scan phenomenon occurs and each dot in the desired message is illuminated on the display side of the panel. As the glow is scanned down the complete panel at a rate of approximately 60 cycles per second it follows that the dots drawn through to the viewing surface illuminate and extinguish at a rate which is above the flicker perceptability of the human eye. The result is a high-contrast, steady-state display.

Glow Transfer

As indicated earlier, glow scan is the preferential transfer of the glow discharge from one cathode electrode onto an adjacent cathode to achieve a glow scanning effect on the rear or scan side of the panel. Figure 4 is a combination isometric and schematic drawing, designed to show the scan or rear side of the panel pictorially and the drive electronics schematically. The glow scan function occurs as follows:

1. When the panel is energized current flows between the keep-alive anodes and cathodes and a glow discharge is established in the keep-alive grooves located in the rear plate.

2. In the vicinity of this glow discharge there is a heavy concentration of electrons, ions and metastables. The area around the keep-alive cathodes is open to allow the metastable and charged particles to diffuse into the area of the reset cathode. Two keep-alive cells, located as shown in Figure 4, are employed because the concentration of metastables decreases rapidly with distance. The construction of the reset cathode allows the metastable atoms from the two keep-alive cells to diffuse through the reset tabs into the scan groove area behind the reset cathode. (The glow transfer function occurs only on the rear side of the cathodes.)

3. A 3-phase clock with a reset phase is used to control the transfer of glow down the panel. To initiate a scan, the reset input is brought to ground potential which sets both Q outputs of the J-K flip-flops to the logical one state and turns on the reset transistor Q_R. To assure reliable resetting under minimum time conditions, the reset cathode is generally pulsed to a more negative voltage than the remaining cathode. The two resistor and capacitor combinations on the reset transistor causes the reset to the tube to be driven to approximately −70 volts when the reset phase is first turned on. During the reset period, this voltage exponentially increases toward ground potential.

4. The 7 scan anodes are connected through limiting resistors to the +250 volt power source. When the reset cathode is grounded, ionization occurs that covers the seven rectangular areas of this single cathode, defined by the intersection of the rear of the cathode strip and seven scan grooves in the rear plate. The glow occurs within a fraction of the 125 usec clock rate at this cathode because of the presence of the metastables which have diffused into the area from the keep-alive cells.

5. After ionization is achieved on the scan side of the reset cathode and the reset pulse is returned to the logic 1 state, the first negative transition of the clock pulse advances the J-K counter. (The timing diagram, Figure 5, shows the sequence of the reset pulse in relation to the clock pulses.) When the J-K counter advances, the transistor ($Q_{\emptyset 1}$) directly coupled to the phase 1 buss is turned on and the reset transistor is turned off. This means that all cathodes tied to the phase 1 buss (every third cathode) are brought to ground and the reset cathode is returned to + 82 volts.

6. During the ionization time of the reset cathode, metastable atoms diffused along the anode grooves to the adjacent (number 1) cathode. When the phase 1 cathode is brought to ground, ionization rapidly forms on the rear surface of cathode 1. At the same time ionization is no longer supported at the reset cathode since this electrode was returned to + 82 volts. The rapid transfer of the ionization glow from the reset cathode ØR to cathode Ø1 is attributed to the high concentration of priming particles near cathode Ø1. At the same time rapid decay of the particle concentration down the panel length (from previous scan cycle) is such that the glow will only transfer to the nearest or adjacent ground cathode (in this case Ø1) and once ionization occurs at this cathode the anode voltage drops, because of the current flow through the cell, to a level high enough to support ionization at the desired cathode but too low to cause ionization at any other grounded cathode, thus the

[1] Metastables are gas atoms that have been raised to an intermediate energy level from which they cannot return to the ground state without interacting with other particles. If this interaction takes place with an atom of lower ionization energy then the metastable causes this other atom to ionize. In the SELF-SCAN panel display the metastables of the neon ionize the atoms of an additive gas upon collision.

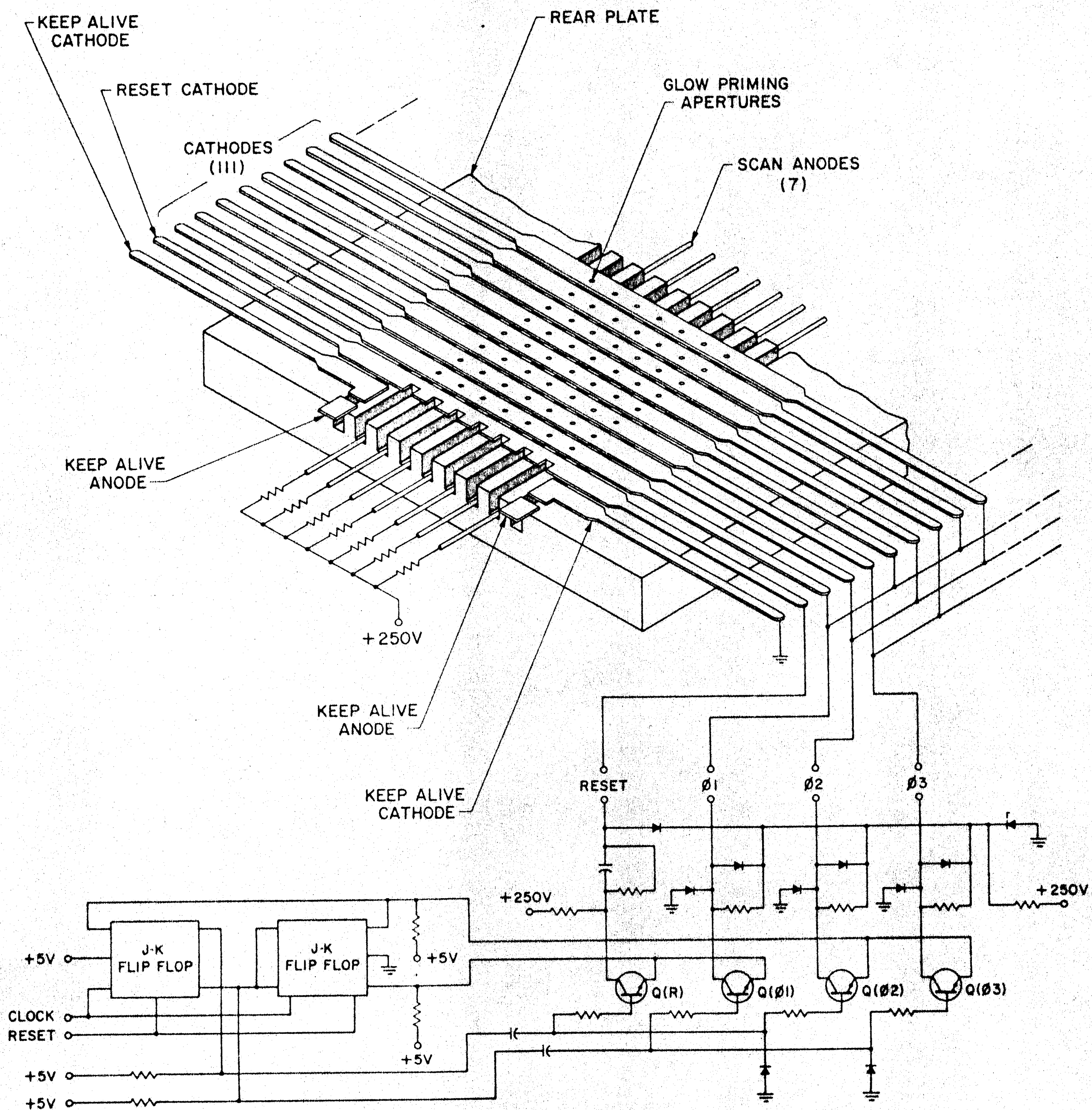

Figure 4. GLOW SCAN PORTION OF PANEL WITH ELECTRONICS

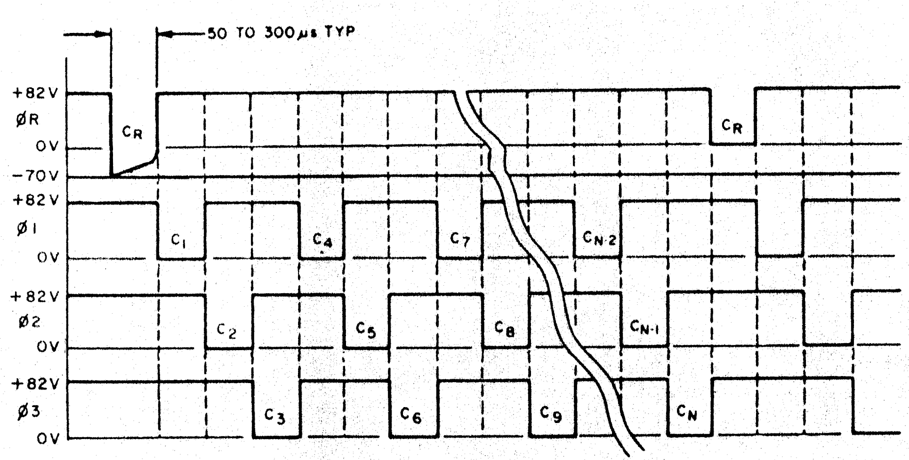

Figure 5. TIMING DIAGRAM

other grounded cathode in the buss will not support ionization. This concentration decay and anode voltage drop account for the smooth transfer of glow along the rear surface of the cathode.

7. The next clock pulse (Figure 5) advances the J-K counter, turns off the buss 1 transistor (QØ1) and turns on the buss 2 transistor (QØ2) which resets the Ø1 cathode to + 82 volts and grounds the Ø2 cathode (and all other cathodes connected to buss 2).

8. While ionization was present at the Ø1 cathode the concentration of charged particles was heaviest around the adjacent cathodes (ØR and Ø2). When the J-K counter advanced the Ø1 cathode was reset to + 82 volts and the Ø2 cathode was grounded. As the ØR cathode was still at + 82 volts ionization could not form on the reset cathode so the glow is formed or transferred to the scan side of the Ø2 cathode.

9. The next clock pulse turns off the buss 2 transistor and turns on the buss 3 transistor (QØ3). Cathode Ø2 is returned to + 82 volts and is no longer able to sustain the ionization which transfers to the preionized and now grounded, Ø3 cathode.

10. The timing signals continue to advance the J-K counter and the cathode busses are sequentially grounded, causing the glow to transfer down the panel. After the glow has transferred to the last cathode in the display the reset pulse again grounds the ØR cathode and scan cycle begins again.

11. The complete scan is accomplished at a rate in excess of 60 Hz to ensure a flicker-free display.

The 16-character alphanumeric panel has 112 columns. In order to maintain the 60 cycle refresh rate, it is necessary to accomplish one complete scan in 1/60 sec or 16.6ms. If each cathode is scanned within the 16.6ms limit then each cathode strip is "on" for a period of 16.6 ÷ 112 or approximately 150 usec. If it was desired to scan the panel in excess of 60 cycles, say at 70 cycles, then one complete scan would have to be completed at 1/70 sec or 14.2ms. This means the on time of each cathode (in the 112 cathode panel) would be 14.2 ÷ 112 or approximately 125 usec. There is a limit to the amount that frequency can be increased and this is determined by the off time of the cathodes. By referring to Figure 4 you see that Ø1 buss is connected to cathode number 1 and 4. When cathode 1 goes to ground so does 4, however, as described above the glow only appears at cathode 1. When cathode 1 is turned off the glow moves to cathode 2 and the ionization at cathode 1 starts to decay. When cathode 4 goes to ground (and cathode 1) it is imperative that ionization around cathode 1 has reduced below the point where a glow discharge will form again on this cathode or it would cause the scan to malfunction. To ensure a sufficient ionization decay a cathode must remain off for approximately two clock times (approximately 250 usec) before the buss connected to that cathode is grounded again. Increasing the length of the panel above 112 columns has the same effect as increasing the frequency because the larger number of cathodes must be scanned in the same time frame. The increased number of cathodes reduces the cathode on time (and also the off time). If a display much longer than the 16-character panel is required, then an adjustment must be made to increase the effective off time of each cathode. The obvious solution is to employ a 6Ø clock instead of the 3Ø clock shown here. In a 6Ø clock arrangement every sixth cathode is tied together instead of every third, which means the off time of the cathode is more than doubled and more cathodes can be added without exceeding the "off time" limit.

The cells on the scan side of the panel are designed to have a suitable differential between ionization and sustaining voltage. This margin when a cathode is activated, is necessary to assure that the potential of the scan anodes is reduced below the ionization potential of the remaining grounded cathodes along the display. Thus the display is statically stable and could be operated at nearly any scanning rate provided that power dissipation limits are observed.

Glow Priming

As the glow is scanned down the panel the second phenomenon, glow priming, occurs. It can be illustrated by Figure 6, a cut-away cross sectional view of a SELF-SCAN panel display. This cross sectional drawing depicts one cathode with a glow discharge on the scan side. The scan glow covers the rectangular portion on the scan side of the cathode located beneath each display cavity. Seven tiny glow priming apertures are located through the cathode strips directly behind each display cavity. These tiny, .003 inch, priming apertures are the only connection point between the scan side and the display side of the panel. Although the gas discharge which has transferred to this cathode covers the priming apertures their small size prohibits the glow from leaking through to the display side of the cathode. However metastables produced by this rear glow discharge diffuse through the priming aperture to the viewing cavity and establish a metastable concentration (glow priming) in the viewing cell. This condition exists for all 7 display cells in the column. (In the illustration metastables are represented by dots.) If the display anodes are held at +120 volts the display cells will not ionize and the primed cells will not look any different from unprimed cells. However, if any of the display anodes are connected to the +250 volts through an appropriate limiting resistor then the corresponding primed display cavity will ionize giving bright glow discharge. (This is the condition shown in Figure 6 of the second and fourth from the top, display cells.)

The display cells, much like the scan cells, are designed for a suitable margin between ionization potential and sustaining voltage. The ionization potential is typically close to 200 volts while the sustaining voltage is 150 volts. The internal cell impedance is on the order of 15K ohms. This wide margin between firing and sustaining voltages exists for all unprimed cells. When a display cell is primed its ionization potential is reduced nearly to the sustaining voltage. Therefore the primed display cell will begin to support a glow discharge once its anode is raised slightly above +130 volts (a primed display will ionize typically in approximately 2 usec). The current in a display cell can be increased to a point where the cell voltage drop approaches the ionization potential of unprimed cells.

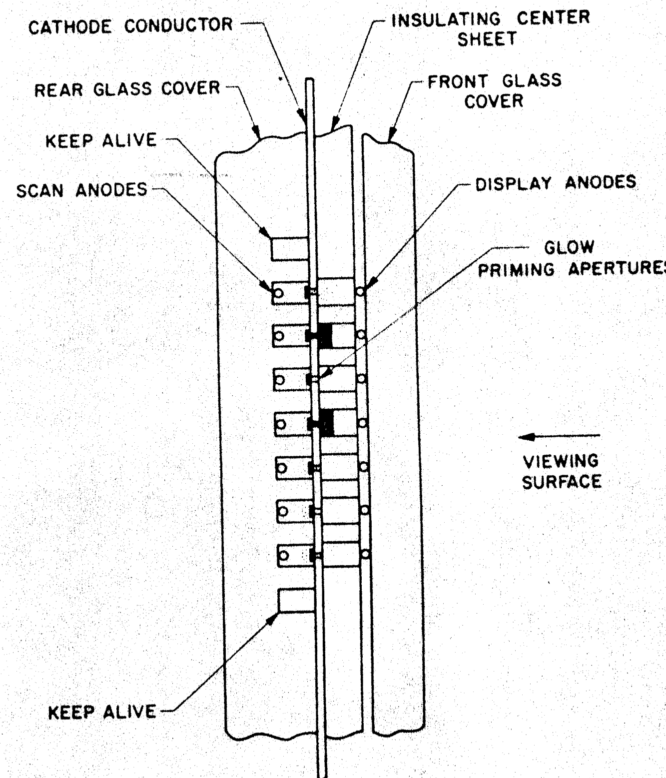

Figure 6. CROSS SECTIONAL VIEW

Glow Display

Characters are written on the viewing side of the panel by addressing the display anode wires in synchronism with the glow priming ionization present on the scan side of the cathode that intersects the point where the dot is to appear. When this condition exists and the display anode is brought up to +250 volts the metastables that have diffused to the front display cavity allow the gas between the display side of the cathode and the display anode to ionize. This glow display is the third phenomenon utilized in the SELF-SCAN panel display. To accomplish this timing the same clock pulse that controls the glow priming is connected to the character generator and controls the intelligence output of this device (refer to Figure 7, Block Diagram).

The display anodes (these are the anodes located on the front side of the panel, refer to Figure 3) are coupled to the character generator through a level shifting circuit consisting of a drive transistor, a resistor and two diodes. When the character generator indicates a dot is to be displayed, this circuit couples the display anode to the +250 volt power source through a limiting resistor. When the character generator indicates that

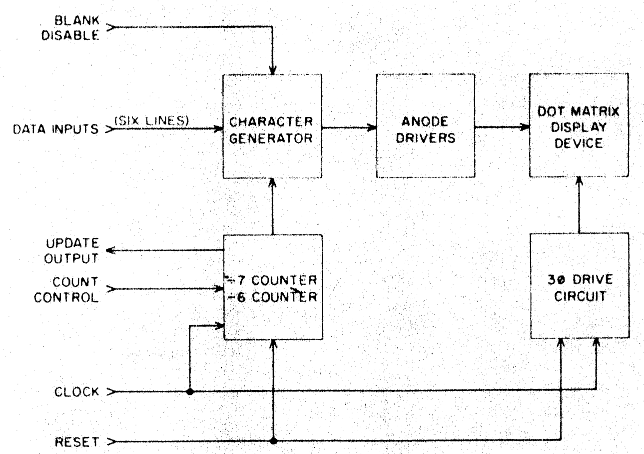

Figure 7. BLOCK DIAGRAM

a dot should not be displayed, the circuit clamps the display anode at +120 volts which is below the voltage necessary to either ionize or sustain ionization. When initiating a glow display dot it is necessary to delay the display anode energization until after the glow scan has been transferred to that cathode and the metastables have diffused from the scan surface of the cathode to the viewing cavity. This delay, of approximately 15 usec, is achieved by using a capacitively coupled one shot multivibrator to inhibit the anode drivers for this time period.

Character Generator

The character generator is a monolithic circuit which converts six bits of binary information and a clock pulse into a dot matrix character format made available column by column, seven bits in parallel. The circuit is divided into two functional blocks contained on the same chip: A counter section and a read only memory (ROM).

The ROM and counter are arranged in a 64 x 7 x 7 bit format (64 character) x (7 time positions) x (7 information or display anode outputs) with outputs available time sequentially column by column. The counter section is arranged in a divide by 7 counter configuration that resets to the 7th counter state when the panel reset input is applied. The circuit is designed to produce a logical 1 at all seven anode outputs for the 6th and 7th states of the counter, independent of the data input, which accommodates the two blank columns between characters. (This counter arrangement is for the "standard" alphanumeric panel using a 5 x 7 dot matrix format with 2 columns of space between characters. A divide by 6 counter or a divide by 5 counter is used when other character formats are required.)

Both the ROM and counter are static circuits. Protection is included against excessive charge accumulation and all inputs and outputs are DTL and T^2L compatible.

Before the first negative transition of the clock pulse after the reset pulse is returned to logic 1 level (the pulse that transfers the glow from the reset cathode to the first display cathode) the six binary inputs to the character generator must be in the quiescent state and correspond to the character to be displayed in the first character position at the left side of the panel. These inputs must remain in a quiescent state during the first five clock periods. As each clock pulse is applied a new set of data is generated at the outputs of the character generator. This data corresponds to appropriate bit patterns for the character corresponding to the code at the data inputs. The six binary input lines can be changed any time after the sixth pulse is applied. During these two 6th and 7th clock pulses the outputs of the character generator are automatically programmed to provide a blank in the display. The data inputs must be updated before the first clock pulse of the next character position.

Input Data Sources

The input data presented to the character generator must appear in a serial-by-word, parallel-by-bit format (see timing diagram). A typical data source with this format would be six 16-bit shift registers which operate in parallel, or the multiplexed outputs of a parallel type circuit.

ADVANTAGES

The SELF-SCAN panel displays provide a combination of the best advantages of many readouts without their drawbacks: The high contrast in-plane readout of gallium arsenide diodes without the fixed cost per digit, the large number of character positions and graphic capability of a CRT without the cumbersome bulk, and the slim shape of a plasma panel without the costly addressing electronics, are but a few of the advantages inherent to the SELF-SCAN panel display.