USERS MANUAL

T4005 / 4201

GRAPHIC DISPLAY CONTROLLER

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070-1085-00

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Fig. 1-1. T4005 Graphic Display Controller.

SECTION 1
OPERATING INFORMATION

Introduction

This publication provides basic reference data for use in programming and operation of the Tektronix T4005 Graphic Display.

More technical information with regard to circuitry, calibration and maintenance is available in the maintenance series of manuals, one for each major functional component of the T4005 Graphic Display.

For those who wish to acquaint themselves more thoroughly with some of the basic concepts of data display, the following publication is recommended: "Information Display Concepts" published by Tektronix, Inc. Order Tektronix Part Number 062-1005-00.

PRELIMINARY INFORMATION

General

The Tektronix T4005 Graphic Display is an integrated, self-contained system designed for the rapid display of large drawings, graphics, or text on the slightly modified Type 611 Storage Display Unit contained within it. Selectable scaling allows the graphic information to be shown in its totality or any specific part to be magnified over a range of up to 32:1. Thus, any portion of a display may be inspected with an extremely high resolution. With the aid of appropriate parallel interfaces, the T4005 is able to call for, control, and accept graphic information from present day digital computers routinely used for generating drawings and graphics.

Interfaces for specific computers, provisions for three additional display drivers, and provisions for auxiliary functions add to the versatility of the T4005.

Features

1. Drive capability for four display devices (Storage Monitors, Oscilloscopes, X-Y Plotters, etc.). Devices individually selectable.

2. Detachable Control Panel for remote operation.

3. 8192 X 8192 Display Matrix capacity.

4. Display Scale selections: 8192, 4096, 2048, 1024, 512, and 256 points per axis selectable independently for each axis.

5. Magnification sufficient to resolve each plotted point. Aspect ratios from 32:1 to 1:32.

6. Offsetting anywhere within the 8K X 8K display matrix with 16 point resolution (512 offset levels per axis).

7. Framing to window on an area to be displayed next. Zooming capability allows framing in any display scale settings.

8. Retain/Recall for any particular scale and offset settings.

9. Positionable Locator to initialize plot origin.

10. Fast/Slow Switch. Fast allows rapid positioning of Frame or Locator. Slow Speed for accurate placement.

11. Auto and Manual Erase for selected display devices.

12. Eight selectable sense lines for software.

13. Eight software status lights.

14. Eight manual interrupts.

15. Real Time Clock.

16. Computer control of Front-Panel functions.

17. Interrupt structure can be disabled either manually or by computer control.

18. Ten auxiliary control lines.

19. Display devices may be remotely located.

20. Single button Homing of Frame or Locator to CRT origin.

21. Pushbutton initialization for first plot.

22. C.P.U. and interrupt status readout.

23. Hard copy compatible.

Component Description

Control Panel. The Control Panel is an inclined flat-front panel equipped with back-lighted, push on – push off, or mutually exclusive pushbuttons (see Fig. 1-2). It is the primary means of mode selection and control of the T4005 Graphic Display (the secondary means of control is through use of computer software). The pushbuttons allow selection of the following: scale and position of the display, display device(s) selection, T4005 display mode, and software control. Back-lit buttons indicate functional status of the T4005. An indicator window (top-right corner) gives the status of four computer/T4005 functions.

The operation of the Control Panel is entirely DC. It may be removed from its housing and remotely located to serve the user's convenience (accessory cables are available for this purpose).

Display Unit. The Display Unit is a very slightly modified (primary power and cosmetic features) Tektronix Type 611 Storage Display Unit. Its direct-view, bistable storage tube presents a large screen display of high-density complex graphics and/or alphanumerics without flicker or drift. Alphanumerics are produced by software character generators which give great flexibility for character style and size.

The Type 611 Display Unit may be used in the storage mode, non-store mode, or write-through mode. In the

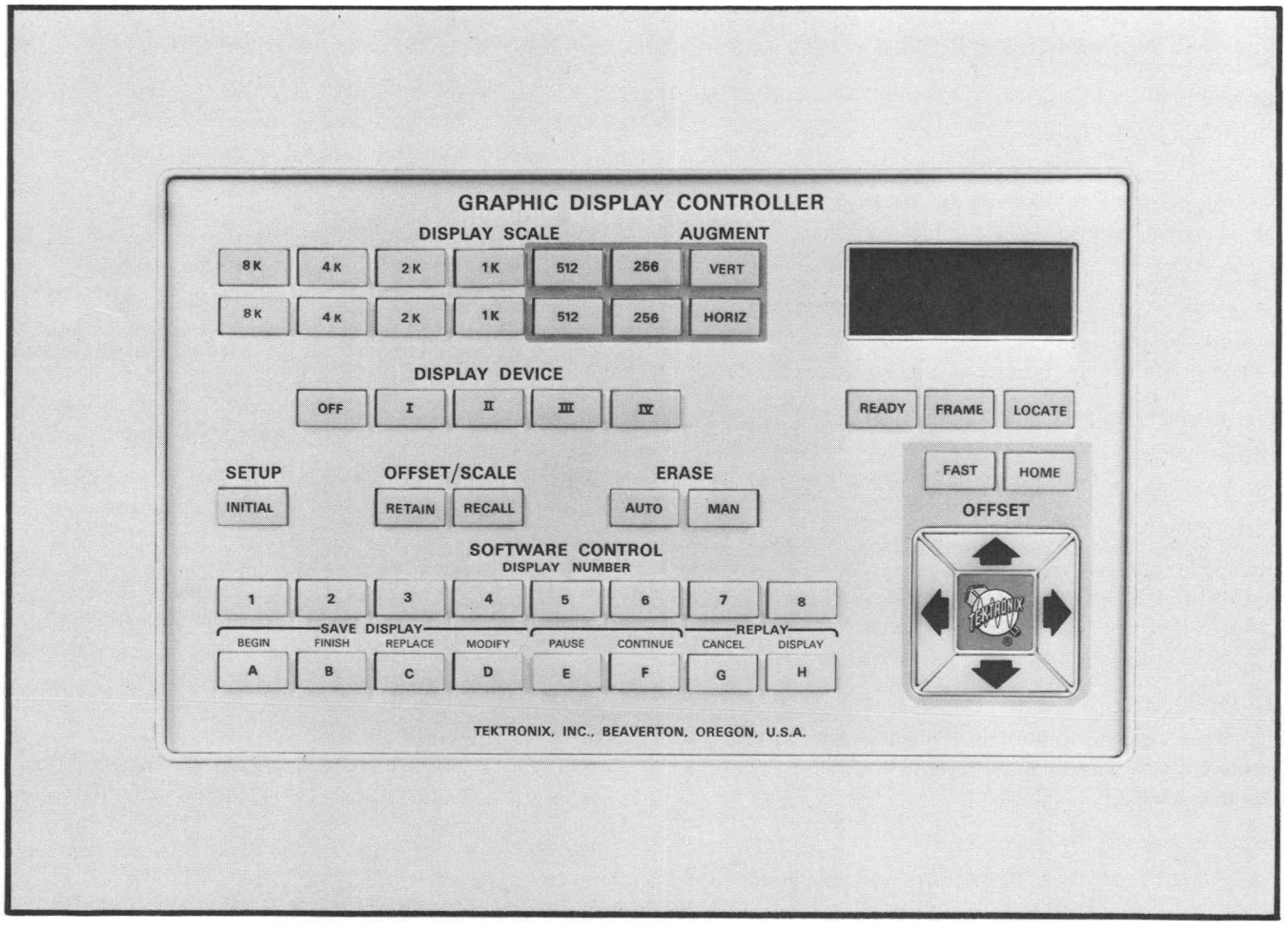

Fig. 1-2. Front Panel controls.

write-through mode, previously stored information remains on the screen but the spot itself does not leave a stored trail. The new figure remains on the screen only as long as it is refreshed. In the non-store mode nothing is retained.

Drawer Unit. The Drawer Unit is a graphic display controller with special data manipulation capabilities. The Drawer Unit consists of the following:

1. Display Driver area. This area has an output architecture capable of driving four display devices. The standard T4005 is supplied with one Display Driver card (611) installed in Display Device card position 1. Other displays, such as additional Type 611's, 601's, scan converters, oscilloscopes, and XY plotters can be driven by the addition of extra cost Display Driver cards.

2. Graphic Control area. Most of the digital processing of the computer graphic information (such as scaling, offset, Z-axis, etc.) is done in the Graphic Control area. This area contains eight dual-connector cards which perform the following functions:

Card GC-1	Mode Control and D/A Converter. Selection among the READY, FRAME and LOCATE modes, D/A (digital-to-analog) conversion for the X-axis, some housekeeping functions.
Card GC-2	Scale and Sector. Gating of the X position register into X-axis D/A converter, MSB (most significant bit) detection for sector control of the Z-axis, LSB (least significant bit) detection for Z-axis control when achieving a new D/A converter level.
Card GC-3	Position Register. The position register for accumulating X-axis input commands, X-axis augmenting circuitry, X-axis last scale latches.
Card GC-4	Offset Register and Loader. Both X and Y axis offset registers and the gating necessary to load their contents into the position registers, jam-transfer circuitry for loading the position registers.
Card GC-5	Position Register. The position register for accumulating Y-axis input commands, Y-axis augmenting circuitry, Y-axis last scale latches.
Card GC-6	Scale and Vector. Gating of the Y position register into the Y-axis D/A converter, MSB (most significant bit) detection for sector control of the Z-axis, LSB (least significant bit) detection for Z-axis control when achieving a new D/A converter level.
Card GC-7	Z-Axis Control and D/A Converter. Integration of write commands, augment feature, LSB detection for Z-axis control, D/A conversion for the Y-axis, and real time clock discussed under Software Circuitry.
Card GC-8	Frame/Locator Generator. The digital and analog circuitry necessary for the generator of a write-through frame or locator.

3. Software Circuitry. The Software Circuitry consists of an interrupt structure, status information and a real time clock.

The interrupt structure is a latch on Card A-4 which is set when any of the Control Panel pushbuttons A through H are pushed. The computer software must interrogate the T4005 to find out which button was pushed, and must reset the interrupt latch so that another button interrupt may take place. In addition to interrupt buttons A through H, the computer can also sense the state of Display Number buttons 1 through 8 (only one is selected and lit at any one time). Thus, 64 distinct interrupt states can be sent to the computer by the use of Display Number and Interrupt buttons.

Interrupt buttons are not automatically lit upon pushing a button. All of the interrupt button lights are under software control so that none, one, more than one, or all of the interrupt lights may be lit. The interrupt feature may be disconnected from the computer by use of an Interrupt Control switch that is provided as part of a specific computer interface. This switch is located at the rear of the T4005 on the cable mounting plate of the interface. The interrupt switch may be used to manually ENABLE or DISABLE the interrupt structure, or when set to the COMPUTER ENABLED position, it allows the software to enable or disable the interrupt structure. An internal jumper on an interface card causes the disabling to be either disarming (interrupt totally ineffective) or inhibiting (interrupt held pending until the interrupt structure is enabled).

Ninty-six bits of status information are gated to the computer by GDC (Graphic Display Controller) Status Gates A, B and C (Cards A-9, A-10, A-11). Depending upon

the computer interface installed, these information bits may be transferred to the computer as 8, 12, 16 or 24 bit words, as determined by Interface Card A-12.

A real time clock is located on Card GC-7 and is turned on and off by computer control commands. Normally the clock interrupts the computer at a 60 hertz rate (every 16.7 milliseconds), but provisions are made to allow the external application of other frequencies. The clock may be disabled from interrupting the computer by placing the INTERRUPT control switch (located on the rear panel) to the DISABLED position. The clock may be turned off by (a) momentarily going to the interrupt DISABLED position or (b) powering the T4005 down and then up again or (c) making use of a computer reset function if it exists, and if it is provided to the specific T4005 Interface utilized.

4. Power Supply. The primary power circuitry is arranged to tie the Type 611 Storage Display Unit and the Graphic Display Controller to one primary power switch and to one power cord. The line voltage input wiring insures that the two units will be powered by the same line voltage. For example: if the GDC line selector block is set to 115 V and the Type 611 line selector block is set to 230 V, no power will be applied to the Type 611. Both line selector blocks must be matched before primary power can be applied to the Type 611 (see Fig. 1-3).

5. Required and Optional Accessories.

a. Interfaces. Space and card guides are provided inside the T4005 Drawer Unit for interface electronics to a computer or communications equipment. The interface area provides space for six cards, an interconnect card, and a mounting plate to mechanically hold the computer cable in place. This mounting plate will normally carry the INTERRUPT control switch discussed previously. In addition, provision is made in the Auxiliary Area for Card A-12 (GDC Status Word Selector), which must be provided by a specific computer interface installation in order to determine the word length of the status information returned to the computer.

b. Display Drivers. In addition to the display driver necessary for the modified Type 611 installed in the T4005, there are provisions for three additional display controllers (II, III and IV) in the Auxiliary Area (Cards A-6, A-7 and A-8) which, if installed, can drive additional Type 611's, Type 601's, Scan Converters, etc.

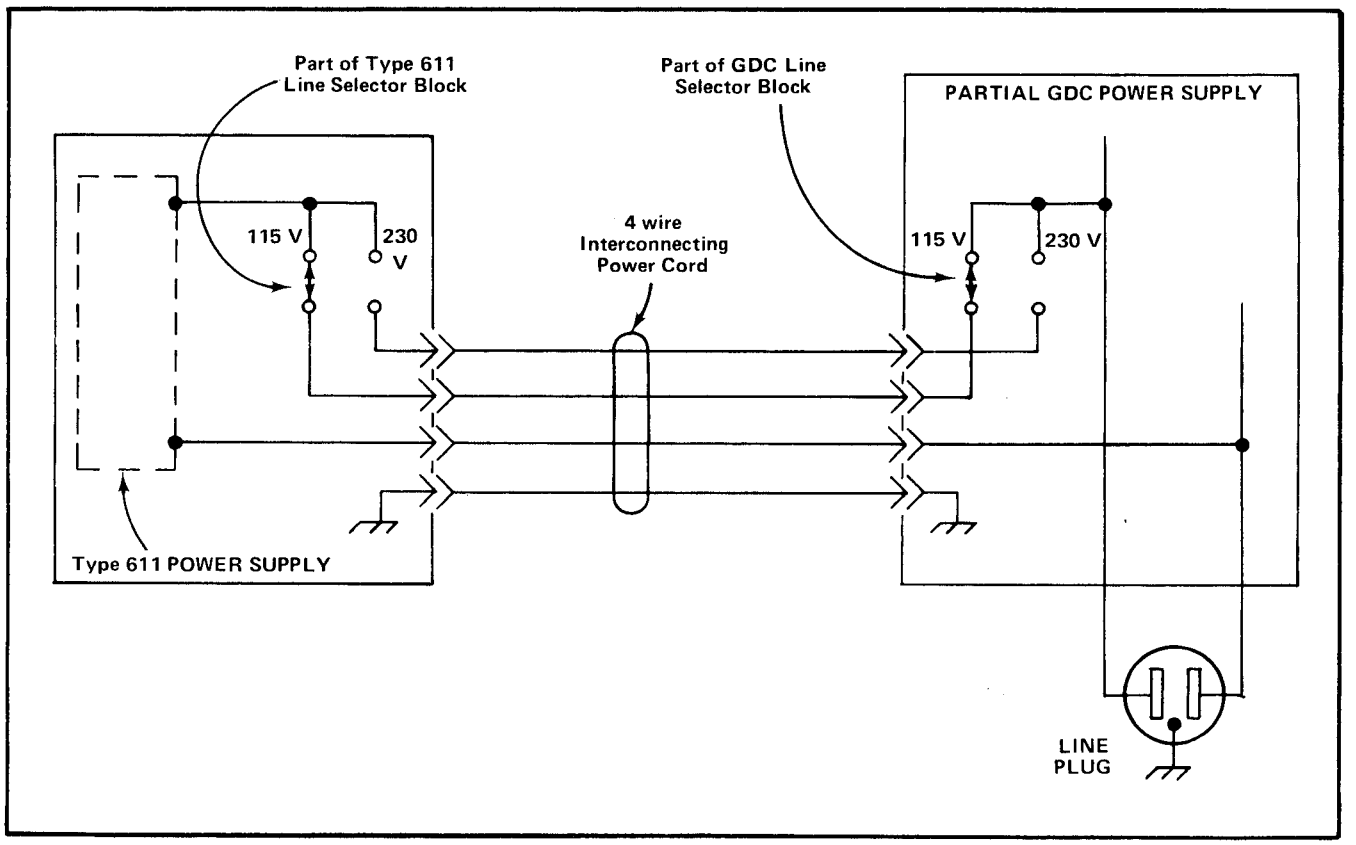

Fig. 1-3. Primary power interconnection between GDC and Type 611.

c. Auxiliary Functions. Three cards in the Auxiliary Area (Cards A-1, A-2 and A-3) are not dedicated to any specific function. Power, and a variety of signal and control functions are terminated in the vicinity of these card connectors. In addition there are provisions for two additional connectors on the rear panel of the T4005. These provisions provide the T4005 with a capability for future expansion by the addition of optional accessories and a versatility to satisfy unusual or special design requirements.

FRONT PANEL CONTROLS AND INDICATORS

DISPLAY SCALE Field

The DISPLAY SCALE consists of two rows of six mutually exclusive buttons labeled 8K (8192), 4K (4096), 2K (2048), 1K (1024), 512, and 256. In each row only one of the six buttons is lit. This indicates the DISPLAY SCALE currently selected for that axis. The buttons may be set manually by the operator, or remotely by the computer. The buttons labeled 8K, 4K, etc. refer to the number of computer steps required to travel along an axis. In the 8K through 1K scales, 1024 dots per axis are actually displayed. In the 512 and 256 scale, 512 and 256 computer steps are required for full axis travel, respectively. Since the dots are farther apart in the 512 and 256 scales, the display intensity is weakened. To overcome this loss of intensity, an AUGMENTing option is provided.

The top row of DISPLAY SCALE buttons controls the vertical steps/axis of the display. The lower row of buttons controls the horizontal steps/axis of the display.

AUGMENT Field

The two AUGMENT buttons labeled VERT and HORIZ are push on – push off types. The augment function may also be controlled by the computer. In the highest magnification (256 X 256), the dots are a quite noticeable distance apart. The display as a whole is much dimmer and harder to read. For this reason, the operator has the option of employing VERT and HORIZ AUGMENT. For example: in 256, with AUGMENT selected, a computer command for one visible step causes three additional dots to be written, for a total of four dots. This presents a solid line segment on the screen, rather than just the two written end points. AUGMENT provides clarity, continuity and brightness even with the highest magnification.

DISPLAY DEVICE Field

Five buttons labeled OFF, I, II, III and IV. If Display Device Cards are installed and the devices are connected and on, then buttons I through IV function as push on – push off types. If a device is not connected or is not turned on, then its display device light will not come on when the button is pressed. Pressing the OFF button will turn off all the display devices selected. If no device is selected, the OFF light is on and the GDC (Graphic Display Controller) is placed in the not ready state. Normally the computer's software will ascertain that the GDC is not ready, then it will do something else, such as plot on a mechanical plotter.

SETUP Field

The SETUP field has one button labeled INITIAL. INITIAL resets many of the indicators and registers in the GDC to begin handling of a new plot. Since framed displays are inherently incompatible with locator displays, INITIAL resets registers used by the GDC in these modes so that a subsequent framing has appropriate offset (0,0) in the offset register. INITIAL, when pressed, preset the following:

DISPLAY SCALE	Preset value (usually 8K X 8K internally selectable)
Spot	to origin (0,0)
FAST	off
AUTO ERASE	off
VERT AUGMENT	on
HORIZ AUGMENT	on
Slant	off
Pending Interrupts	off
VIEW	holding
Write-Thru	store
OFFSET	(0,0)
Shift	off

OFFSET/SCALE Field

Two buttons labeled RETAIN and RECALL are in the OFFSET/SCALE Field. In the FRAME Mode, when a particular frame offset and display scale are found useful, the operator may push RETAIN to store those particular OFFSET/SCALE parameters in a special memory. Now, when RECALL is pushed, that particular OFFSET/SCALE will be brought from memory, a conditional erase will be issued, and a REPLAY interrupt will be initiated (unless internally disabled).

ERASE Field

Two buttons labeled AUTO and MANUAL. The MANUAL button (momentary and unlit) when pressed, erases the screen on all selected display devices. The AUTO button (push on – push off) when lit, allows automatic or conditional erasure of all selected devices. Automatic erasure occurs in these instances: (1) when RECALL is pushed, (2) when Software Interrupt Button H is pushed (unless the jumper option is removed), or (3) when the first Write command is received after a READY – FRAME – READY sequence. A conditional erase command, issued by the computer, causes the selected devices to be erased if AUTO Erase is on.

OFFSET Field

Five buttons labeled READY, FRAME, LOCATE, FAST, HOME and a four pushbutton control for positioning the Frame or Locator in the direction indicated by the four buttons. The control buttons are lit only in the Frame Mode when the lower lefthand corner of the Frame moves off-screen in the direction indicated by the button lit. READY, FRAME and LOCATE buttons are mutually exclusive, so that only one of the three is lit. HOME is a momentary closure and FAST is a push on – push off type.

READY is the mode in which the GDC is ready for computer write commands. If the READY Mode is reached from the FRAME Mode by pushing the READY button, the following actions take place before the GDC is fully ready:

1) Erasure, if in AUTO ERASE.

2) Storage of the current DISPLAY SCALES.

3) Transfer of the Offset Registers' content into the Main Position Registers.

4) Receipt of a computer command addressed to the GDC. FRAME places a write-thru Frame on those display devices currently selected by the GDC. If a display has just been output from the computer and no Display Scale change has been made, the Frame appears around the whole display. The Frame size may be reduced or enlarged (by use of the DISPLAY SCALE buttons) and moved to any area of the display (by use of the pushbutton control). Whatever is within the Frame would be displayed "full screen" if the display were replotted with the then-selected display scale and offset parameters. Normally this is done either directly by selecting READY Mode and then having the computer output the graphic display again, or indirectly (if the display has been saved) by pushing SOFTWARE Interrupt button H (DISPLAY). This forces the Ready Mode and causes the computer, via an interrupt, to output the display.

FAST is a push on – push off button that allows the OFFSET control to have two speeds. When the FAST button is lit, the Frame and Locator move quickly. When unlit, they move more slowly for accurate positioning.

HOME is a momentary button used to return the Frame or Locator to the lower lefthand corner of the screen. The HOME button is lit whenever the Frame or Locator is in the lower lefthand corner of the screen (home position). In the Ready Mode, it is lit whenever the spot is in the origin (0,0 of the 8K X 8K graphic matrix).

The pushbutton control is a group of four buttons used to position the Frame and Locator in the direction indicated on the buttons. If the lower lefthand corner of the Frame is moved off screen, the direction button is lit indicating the direction that it went off screen. If a Frame is selected which is larger than the display area, then the Frame surrounds the screen and all buttons are lit, indicating the loss of the Frame.

SOFTWARE CONTROL Field

Two rows of buttons. The top row selects a DISPLAY NUMBER and the bottom row selects an interrupt function.

DISPLAY NUMBER. These button-lights, numbered 1 through 8, are coded into 3 bits which can be interrogated by the computer. The computer receives the code of the button which is lit. The last button pushed stays lit. These buttons normally indicate the display number to which the operator refers when he requests some computer action via the INTERRUPT buttons. They can, of course, be used for any sensing function the computer's programmer chooses.

INTERRUPT Buttons. These button-lights labeled A through H, cause a coded interrupt on the level to which the GDC is connected. The GDC may be set (by means of jumpers) to several interrupt levels as determined by the specific computer and computer interface use. Provided that no button interrupts are pending at a given instant, each push of an interrupt button (A through H) causes an interrupt and causes 3 bits to be coded in the same fashion as the Display Number bits. These bits can also be interrogated by the computer to ascertain the specific button, and thus the cause, for the interrupt. The lights behind the interrupt buttons are completely under software control. Any number of them in any combination may be lit at one time. They generally indicate software acknowledgement of an operator request, error, warning, etc.

Status Indicators (unlabeled)

CONTROLLER ADDRESSED is lit whenever the computer sends any command or status request to the GDC. For example; if the computer receives an interrupt, it will interrogate the GDC for status, lighting the CONTROLLER ADDRESSED light. The light will remain on for about 500 milliseconds. It will also be lit for the duration of a plot.

INTERRUPT PENDING is lit whenever the computer fails to service a button interrupt, and will remain lit until the interrupt is cleared, either by the computer or by manual intervention.

PROCESSER RUNNING is lit whenever the computer is executing instructions.

INTERRUPT DISABLED is lit whenever button interrupts are disabled, either by computer command or by setting of the INTERRUPT DISABLE switch at the rear of the instrument (on the computer interface panel).

Primary POWER Switch

Provides AC power to the GDC electronic package and the Display Device(s) integrated into the system. The Display Devices retain their own standard power switches as well. Powering up the GDC causes it to go to the following preset condition:

1. DISPLAY SCALE(s) set to the scale predetermined by the user with the options on cards GC-2 and GC-6.

2. READY Mode.

3. DISPLAY DEVICE I through IV. All attached and powered up Display devices that are selected.

4. AUTO ERASE off.

5. SOFTWARE Interrupt lights cleared.

6. All registers are latches cleared.

7. FAST button off.

8. VERT and HORIZ AUGMENT on.

9. Computer Enabled Interrupt Latch disabled.

10. Real Time Clock off.

REAR PANEL CONTROL AND CONNECTORS

INTERRUPT Switch (Normally located on the Interface Panel)

ENABLE	In the ENABLE position, the computer may not disable button interrupts; however, clock interrupts may be disabled in the usual way.
COMPUTER	In the COMPUTER ENABLED position, the computer may disable ENABLED and enable button interrupts at any time.
DISABLED	In the DISABLED position, both clock and button interrupts are disabled.

Connectors

J101	Interfaces a Display Driver to DISPLAY DEVICE I.
J102	Interfaces a Display Driver to DISPLAY DEVICE II.
J103	Interfaces a Display Driver to DISPLAY DEVICE III.
J104	Interfaces a Display Driver to DISPLAY DEVICE IV.
J105	Interfaces to functions unassigned in the Auxiliary Area.
J106	Interfaces to functions unassigned in the Auxiliary Area.
J152	Provides interlocked AC power to the Type 611 Storage Display Unit contained within the T4005.
Line Voltage and Range Selector Block	Selects three voltage ranges (HI – MED – LO) for either 115 VAC or 230 VAC service.

NOTE

The T4005 Display Unit's Line Voltage and Range Selector, located on the rear of the Display Unit frame, performs the same function. It must match the Line Voltage Selector on the GDC before power can be applied to the Display Unit.

T4005 DISPLAY UNIT CONTROLS

(The Display Unit is a slightly modified Type 611 Storage Display Monitor)

VIEW

This pushbutton switch allows the operator to switch the instrument from a holding mode to a view mode during normal operation. The instrument will stay in the view mode for 60 to 90 seconds after the VIEW button has been pushed, or after the receipt of the last Z axis signal. After that period it will automatically return to the hold mode.

ERASE

This pushbutton switch provides a means of erasing any previously stored information on the CRT. The button is illuminated when the POWER switch is set to ON.

INTENSITY

Sets intensity level of writing beam when the Z axis is activated.

WRITE THRU

Sets the intensity, in the write-thru mode, to a non-store level.

FOCUS

Adjusts the writing beam focus.

OPERATING LEVEL

Sets the target backplate voltage to the proper level for storage operation. Refer to the Type 611 Calibration Procedure to set this adjustment.

TEST SPIRAL

Causes instrument to complete an erase cycle and store a single shot test pattern when pushed and held in. Releasing the switch after the test pattern is stored has no effect on the display. Pulling the TEST SPIRAL switch out puts the instrument in a non-store mode and the test pattern becomes repetitive for focusing and other tests.

POWER

Toggle switch to activate the Type 611.

Safety Considerations

The T4005 primary power circuitry ties two distinct units, the slightly modified Type 611 and the Type 4201 Graphic Display Controller, to one primary power switch and one power cord in an interlocked fashion. This allows the units to be protected simultaneously against application of the wrong line voltage, to be separated relatively easily, and allows the T4005 to meet UL specifications.

The T4005 is provided with a three-wire power cord with a three-terminal, polarized plug for connection to the power source. The grounding terminal of the plug is directly connected to the instrument frame as recommended by national and international safety codes. Color coding of cord conductors follows the National Electrical Code (ANSI C-1 1968) which specifies Line, black; Neutral, white; Safety Earth, or Ground, green with a yellow stripe (or solid green).

The T4005 is intended to be operated from a single-phase power source which has one of its current-carrying conductors (Neutral) at ground potential. Operation from other power sources where both current-carrying conductors are live with respect to ground (such as phase-to-phase on a multi-phase system, or across the legs of a 117-234 V single-phase three-wire system) is not recommended, as only the Line Conductor has over-current (fuse) protection within the instrument.

SECTION 2
PROGRAMMING
and
DATA TRANSMISSION

Basic Characteristics and Options

Several options are available on the T4005/4201 which increase its versatility as a graphic recording medium. In general, changes in these options are made by moving a switch or changing a strap on one of the circuit boards in the drawer unit. All of the options mentioned should be changed or activated only by a qualified service technician.

Strappable Options. The following list gives the Card location of various jumpers and a brief description of their functions.

1. Card GC-1

a. H Sw. input line. With jumper in and AUTO ERASE selected, pressing the Software H button will erase all selected display devices and place the GDC in the Ready Mode.

b. Input to U64B. With the jumper in, it insures that the locator will start at the origin when Locate Mode is selected. With the jumper removed, the locator will start at the current position of the Main Registers, which may be out of sector.

2. Card GC-2 and GC-6

a. Jumper selects which display scale is to be set at Power On Reset, Initial, or Software Initial.

3. Card A-4

a. With jumper in, pressing RECALL will generate an "H" interrupt.

4. Card A-5, A-6, A-7, A-8 (when controlling a Type 611)

a. Jumper in selects Shift Down (vertical format) or Shift Left (horizontal format).

5. Card A-12 (when interfacing GDC to IBM 1130)

a. Two jumpers, One jumper selects Button Interrupt Identification Bit and the other selects the Clock Interrupt Identification Bit.

NOTE

A differently configured Card A-12 may be used, depending upon the computer being interfaced.

The following options apply only to the 015-0180-00 IBM 1130 interface.

6. Card IF-1

a. Jumper from collector of Q29 selects level 2, 3, or 4 for Auxiliary Interrupt Request.

b. Jumper from collector of Q21 selects level 2, 3, or 4 for Button Interrupt request.

c. Jumper from collector of Q24 selects level 2, 3, or 4 for Clock Interrupt Request.

7. Card IF-2

a. Jumpers select Interrupt Level 2, 3, or 4 for the Clock, Button, and Aux (if used) interrupt levels.

8. Card IF-3

a. Jumpers select Area Code (address) for computer identification of station.

Device Status Words

The following list gives the Card Location, Activated Gate, Bit Number, Functional Name, and the DSW which will contain the function for any Word Size (8, 12, 16, or 24) with which the GDC is to be used.

Card	Gate	Bit	Name	WORD SIZE (bits) 8	12	16	24
Acc-11	A	8a-0	Ready Not Busy & Device Sel	DSW 0	DSW 0	DSW 0	DSW 0
		8a-1	Device Selected				
		8a-2	Button Interrupt Disabled				
		8a-3	Auto Erase On				
		8a-4	Horiz Augment On				
		8a-5	Vert Augment On				
		8a-6	Shifted				
		8a-7	Slanted				
		4a-0	Frame Generator On	DSW 1			
		4a-1	Locator Generator On				
		4a-2	Button Interrupt Number Bit 4				
		4a-3	Button Interrupt Number Bit 2				
		4'a-0	Button Interrupt Number Bit 1		DSW 1		
		4'a-1	Plot Number Bit 4				
		4'a-2	Plot Number Bit 2				
		4'a-3	Plot Number Bit 1				
		8b-0	Ready Mode	DSW 2		DSW 1	
		8b-1	Frame Mode				
		8b-2	Locate Mode				
		8b-3	Device 1 On				
		8b-4	Device 2 On				
		8b-5	Device 3 On				
		8b-6	Device 4 On				
		8b-7	X-Y Analog Recorder				
		4b-0	Storage Type 1	DSW 3	DSW 2 (1 of 2)		DSW 1
		4b-1	Storage Type 2				
		4b-2	Storage Type 3				
		4b-3	Storage Type 4				
		4'b-0	Non-Store Type 1				
		4'b-1	Non-Store Type 2				
		4'b-2	Non-Store Type 3				
		4'b-3	Non-Store Type 4				
Acc-10	B	8a-0	XP4 } Horizontal Present Scale Size	DSW 4	DSW 3	DSW 2	
		8a-1	XP2				
		8a-2	XP1				
		8a-3	XM12 } Horizontal Main Register Bits				
		8a-4	XM11				
		8a-5	XM10				
		8a-6	XM9				
		8a-7	XM8				
		4a-0	XM7	DSW 5			
		4a-1	XM6				
		4a-2	XM5				
		4a-3	XM4				
		4'a-0	XM3		DSW 5 (1 of 3)		
		4'a-1	XM2				
		4'a-2	XM1				
		4'a-3	XM0				

Card	Gate	Bit	Name	WORD SIZE (bits) 8	12	16	24
Acc-10	B	8b-0	YP4 — Vertical Present Scale Size	DSW 6	DSW 4	DSW 3	DSW 2
		8b-1	YP2 — Vertical Present Scale Size				
		8b-2	YP1 — Vertical Present Scale Size				
		8b-3	YM12 — Vertical Main Position Register Bits				
		8b-4	YM11 — Vertical Main Position Register Bits				
		8b-5	YM10 — Vertical Main Position Register Bits				
		8b-6	YM9 — Vertical Main Position Register Bits				
		8b-7	YM8 — Vertical Main Position Register Bits				
		4b-0	YM7 — Vertical Main Position Register Bits	DSW 7			
		4b-1	YM6 — Vertical Main Position Register Bits				
		4b-2	YM5 — Vertical Main Position Register Bits				
		4b-3	YM4 — Vertical Main Position Register Bits				
		4'b-0	YM3 — Vertical Main Position Register Bits		DSW 5 (2 of 3)		
		4'b-1	YM2 — Vertical Main Position Register Bits				
		4'b-2	YM1 — Vertical Main Position Register Bits				
		4'b-3	YM0 — Vertical Main Position Register Bits				
Acc-9	C	8a-0	XL4 — Horizontal Last Plot Scale	DSW 8	DSW 6	DSW 4	
		8a-1	XL2 — Horizontal Last Plot Scale				
		8a-2	XL1 — Horizontal Last Plot Scale				
		8a-3	X Offset 12 — Horizontal Offset Register				
		8a-4	X Offset 11 — Horizontal Offset Register				
		8a-5	X Offset 10 — Horizontal Offset Register				
		8a-6	X Offset 9 — Horizontal Offset Register				
		8a-7	X Offset 8 — Horizontal Offset Register				
		4a-0	X Offset 7 — Horizontal Offset Register	DSW 9			DSW 3
		4a-1	X Offset 6 — Horizontal Offset Register				
		4a-2	X Offset 5 — Horizontal Offset Register				
		4a-3	X Offset 4 — Horizontal Offset Register				
		4'a-0	SPARE		DSW 2 (2 of 2)		
		4'a-1	SPARE				
		4'a-2	SPARE				
		4'a-3	SPARE				
		8b-0	YL4 — Vertical Last Plot Scale	DSW 10	DSW 7	DSW 5	
		8b-1	YL2 — Vertical Last Plot Scale				
		8b-2	YL1 — Vertical Last Plot Scale				
		8b-3	Y Offset 12 — Vertical Offset Register Bits				
		8b-4	Y Offset 11 — Vertical Offset Register Bits				
		8b-5	Y Offset 10 — Vertical Offset Register Bits				
		8b-6	Y Offset 9 — Vertical Offset Register Bits				
		8b-7	Y Offset 8 — Vertical Offset Register Bits				
		4b-0	Y Offset 7 — Vertical Offset Register Bits	DSW 11			
		4b-1	Y Offset 6 — Vertical Offset Register Bits				
		4b-2	Y Offset 5 — Vertical Offset Register Bits				
		4b-3	Y Offset 4 — Vertical Offset Register Bits				
		4'b-0	SPARE		DSW 5 (3 of 3)		
		4'b-1	SPARE				
		4'b-2	SPARE				
		4'b-3	SPARE				

GENERAL CHARACTERISTICS

Introduction

The GDC (Graphic Display Controller) is a special purpose computer interface designed with data manipulation capabilities for a graphic record medium. It typically drives a Type 611 (part of the T4005 package), 601, 602, 4501, 564B, 549, 5031, or an analog ink pen plotter (chart plotter, chart recorder, X-Y recorder, etc.).

Type 611 Storage Display Unit

The Type 611 is built around a direct-view bistable storage tube. A storage tube has a viewing area much like the face of an oscilloscope on which the luminous spot can be turned on and off and be made to move around, with the important exception that with a storage tube, the spot leaves a permanent trail as bright as the spot itself. For example, if the spot were turned on, moved around in a circle once and turned off, a glowing circle would remain on the screen. This circle is very similar in appearance to the circle created by an oscilloscope on whose screen the spot is continuously circling, thereby refreshing the image.

In the Type 611 the tube may be used in the storage mode (described above), the non-store mode (like a conventional oscilloscope), or in the write-thru mode. In the write-thru mode previously stored information remains on the screen, but the spot itself does not leave a stored trail. New graphic information remains on the screen only as long as it is refreshed. In the non-store mode nothing is retained; only the information that is being continuously refreshed appears on the screen. When the GDC puts the Type 611 in the non-store mode and then switches back to the store mode, there is an automatic erasure of the screen.

Stored information on the Type 611 may be erased by pressing the MANUAL Erase button on the GDC or the ERASE button on the Type 611. No partial erasures are possible.

The direct-view, bistable storage tube presents a large screen display of high-density complex graphics and/or alphanumerics without flicker or drift. Alphanumerics are produced by software character generators which give great flexibility in character style and size. For example, using a 4 X 6 matrix and a two-dot character separation allows almost 30,000 very small characters to be stored within the 1024 by 1024 D/A levels presented on the Type 611 display (171 lines of 171 characters equals 29,241 characters).

The T4005 display screen is 21 cm X 16.2 cm. The GDC always uses a square section of this screen (16.2 X 16.2 cm). However, two methods are built in for utilizing the remainder of the screen. Refer to the discussion of Shift and Slant.

Graphic Display Controller

The GDC accepts computer graphic commands in the following forms: Move the spot in one of the eight directions (see Fig. 2-1) and either write or do not write a dot. The spot remains where it was last placed. When the GDC is initialized, the spot is at the lower lefthand corner (0,0) of the screen. The order to write or not write each dot is sent with each computer command. It is also possible to write many dots with a single computer command by including with the command a multiplier which will allow up to 15 iterations of the command. There are also commands to write without stepping (i.e., write in place, pen drop) and to skip ahead (without writing) 256 steps in any of the eight directions.

The graphics display may be considered to be formed on a square consisting of 8K (8192) dots to the side, with complete toroidal wrap-around. However, for viewing on the screen, the operator may select from 36 smaller squares or rectangles, adjusting the sides to be 8K, 4K, 2K, 1K, 512 or 256 dots in length. For example; after having made the 8K X 8K plot on the screen, the operator may select the FRAME Mode and form a small rectangle (i.e. 4K X 1K) which appears on screen one-half the screen height and one-eighth the screen width. Upon replotting with these scale settings, the new display will be just what was in the rectangle in the previous display, blown up to fill the whole

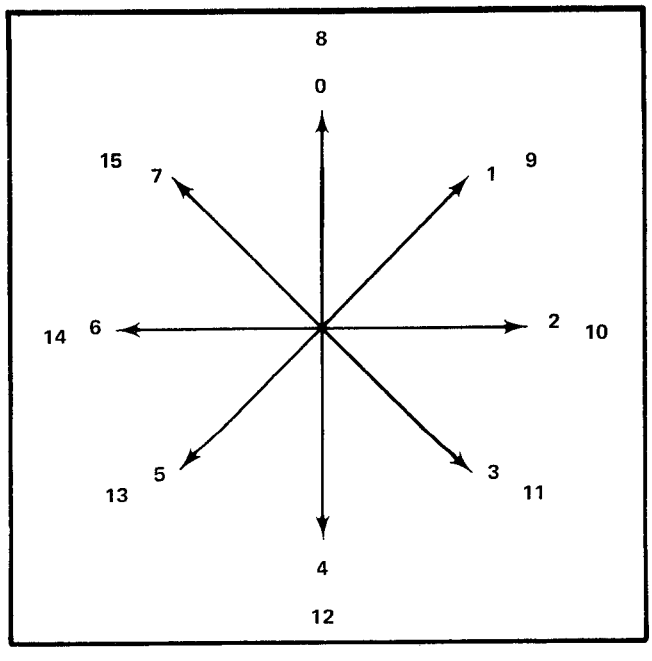

Fig. 2-1.

screen. The operator, by means of front-panel controls, can position the next Frame anywhere he likes upon the current display. In the FRAME Mode, the Frame is not stored and may be moved around without destroying any of the stored display. Therefore, after a plot, if the operator notices some detail he wishes to blow up and examine, he selects the FRAME Mode, adjusts the size and location of the Frame to surround the detail to be examined, returns to the READY Mode and replots the graphic display.

With the T4005 (611 DVBST) the highest magnification (256 X 256) of the GDC produces dots which are 0.6 millimeter apart (162 mm/256 = 0.6 mm). Since the Type 611 has an extremely fine spot size, this causes separation of contiguous dots and the display as a whole is much dimmer. For this reason, the operator has the option of employing HORIZONTAL and VERTICAL AUGMENT in the 256 and 512 display scales. In the 256 scale, when AUGMENT in the appropriate direction is selected, a computer command for one step actually causes four dots to be written, making a solid line segment appear on screen rather than just the two end points. In the 512 scale, a computer command for one step causes two dots to be written. AUGMENT provides clarity, continuity and brightness even at the highest magnification.

The operator may interrupt the computer at any time by any of eight coded interrupts (A through H) connected to one of several interrupt levels. The buttons provide for computer action upon operator requests, such as "replot the last plot", etc.

The GDC also contains, as a more or less separate device, a real-time clock which, when enabled by the computer, interrupts at the line frequency (usually 60 hertz) so that the computer can time out an interval. This can be useful in special applications. For example, periodically removing the Type 611 from the HOLD Mode and thus placing it in the VIEW Mode. Provision is made for user substitution of an oscillator at a different frequency.

OPERATION

Internal Registers

Besides the Recall Registers, there are only two pairs of important registers in the GDC. They are the Main Position Registers and the Offset Registers. The Main Registers hold the coordinates (X and Y) of the spot in the READY Mode, the origin of the Frame in the FRAME Mode, and the location of the Locator in the LOCATE Mode. The Offset Registers contain the accumulated offset from successive Frame relocations.

Mode Transistions

Suppose the operator wishes to see and examine a plot. He presses the INITIAL button which zeroes the Main and Offset Registers. The plot is drawn by adding and subtracting increments from the Main Registers, forcing the spot to move around. At the end of the plot, the Main Registers hold the coordinates of the spot's last position. The operator now sets the GDC to the FRAME Mode. The initial coordinates of the Frame (0,0 on the screen) are set into the Main Register. This destroys the contents of the Main Registers, but they are now connected to the Offset Registers, which hold the coordinate values of the lower left-hand corner of the screen. As the Frame is moved around, the Offset Registers are incremented in much the same way as are the Main Registers which are moving the Frame. If the plot has already been framed and offset before, then the contents of the Offset Registers reflect the current position of the Frame as offset is added to the initial offset. After the Frame has been positioned and the operator returns the GDC to the READY Mode (either manually or automatically via RECALL or REPLAY DISPLAY), but before the first plot command is executed, the GDC takes the contents of the Offset Registers (the coordinates of the Frame), complements them, and loads the results into the Main Registers. This preloads the Main Registers so that the area "Framed" is appropriately offset into the display area of the DVBST.

There is a sliding D/A Converter attached to the Main Register whose position is determined by the DISPLAY SCALE setting. It has 10 bit resolution, while the Main Register has 13 bits. The D/A Converter's high order bit may align with the Main Register highest order bit or in the next 5 lower bit positions (see Fig. 2-2). In the lowest position, the two low order bits of the D/A Converter hang off the end of the Main Register and are always considered zero. To keep the smaller display scales from wrapping spurious material around onto the screen, the Z-Axis controller examines all the high order bits of the Main Register which hang off the end of the D/A Converter. Only when all of these high order bits are zero is the Z-Axis allowed to come true and write plot material on the screen. With the DISPLAY SCALE set to 8K, there is no Z-Axis blanking, and all possible increments sent to the GDC may appear on the screen.

When the operator starts the new display, assuming a change in scale size and in offset, let us assume that the Frame is somewhere in the center of the plot so that the offset is middle-sized and positive. The number loaded into the Main Register is then negative, and at least one of the high order bits is one. For the plot to appear on screen, it must increment the Main Register sufficiently to clear the high order bits to zero so that the Z-Axis Controller will allow the dots to be written.

In successive Framings and enlargements of a plot, offset is accumulated in the Offset Registers and is negative-transferred to the Main Registers during each FRAME to READY mode transition.

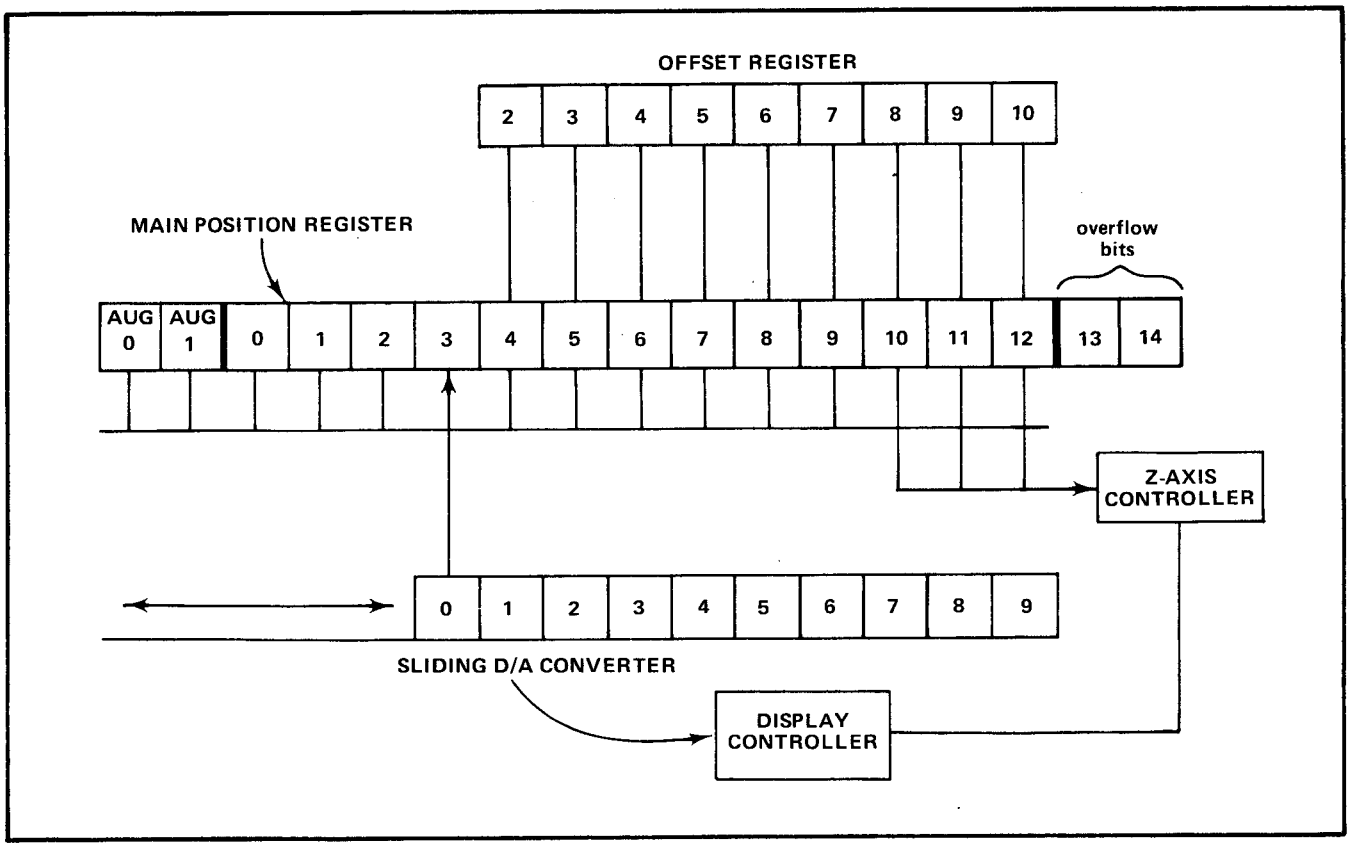

Fig. 2-2. Drawing shows the relationship between the Offset Register Bits, Main Register Bits, and D/A Converter. D/A Converter is shown with 8K DISPLAY SCALE selected.

In the READY to LOCATE mode transition, the Offset Registers are untouched and retain any stored information. The Main Register is not zeroed by this transition, but retains the X, Y coordinates it held in READY. Moving the Locator around increments the Main Registers so that they always contain the absolute coordinates of the Locator, relative to the origin of the 8192 X 8192 graphic matrix. If the contents of the Main X and Y Registers are outside the range of the current DISPLAY SCALE, the Locator may be brought on screen by pushing the HOME button which will set the Locator to 0,0.

When a LOCATE to READY mode transition is made, no registers are changed. The spot remains at the last position of the Locator and therefore the plot starts there. Effectively the Locator position becomes the new origin of the plot.

The Frame always appears with its lower left-hand corner at the lower left-hand side of the display. It does not stand for the graphic origin, but rather is referenced to the contents of the Offset Registers used in the previous display.

LOCATE to FRAME mode transition causes the Main Registers to be set to a preset value so that the Frame will appear in the Home position. It is assumed that the contents of the Offset Registers are significant and that they relate to the present on-screen plot (i.e. that no intervening Locator plot has been displayed). A Main to Offset Register linkage is established so that subsequent positioning of the Frame will adjust the Offset Register to reflect the absolute coordinates of the lower left-hand corner of the Frame.

FRAME to LOCATE mode transition automatically returns the Frame to its Home position (in registration with the lower left-hand corner of the screen) before the transition to the Locate Mode is made. That is, the Main Register and the Offset Register are counted down (decremented) until the Frame Home position is reached. At that time, full transition to the LOCATE Mode takes place. Therefore, if the LOCATE button is pushed by mistake, the FRAME Mode can be returned too, without losing registration between the write-thru Frame and the stored plot which appears behind it.

The position of the display is constant with respect to the Locator and no precautions need be taken to preserve

the last plot-to-Locator-to-next-plot relation as in the Frame case.

OPERATOR MAINTENANCE

Preventive maintenance performed on a regular basis may prevent instrument breakdown and will improve the reliability of the instrument. The severity of the environment to which the instrument is subjected should determine the frequency of maintenance. Certain kinds of exterior maintenance may be performed by the operator. All other maintenance work should be performed only by a qualified service technician.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

Exterior. Loose dust accumulated on the outside of the T4005 can be removed with a soft cloth or small paint brush. The paint bursh is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.