Part No. 070-4474-02
Product Group 24

1730–SERIES
WAVEFORM MONITOR

Please Check for
CHANGE INFORMATION
at the Rear of This Manual

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Tektronix®
COMMITTED TO EXCELLENCE

OPERATOR'S SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

TERMS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property, including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

SYMBOLS

In This Manual


This symbol indicates where applicable cautionary or other information is to be found.

As Marked on Equipment


DANGER — High voltage.


Protective ground (earth) terminal.


ATTENTION — refer to manual.

Power Source

This product is intended to operate from a power module connected to a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Ground the Product

This product is grounded through the grounding conductor of the power module power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power module power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating, and current rating as specified in the parts list for your product.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Operate Without Covers

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

1730-Series Waveform Monitor.

SECTION 1
INTRODUCTION

The TEKTRONIX 1730–Series is an 8-1/2-inch wide by 5-1/4-inch high Waveform Monitor, weighing approximately 8 pounds. The 1730 (System M, NTSC) and the 1731 (System I, B, etc., PAL, PAL–M), and the 1735 (dual standard) versions can be powered from an ac source or, with the addition of a field upgrade kit (1700F10), 12 Vdc. The crt occupies approximately two-thirds of the front-panel area, with the control panel taking up the remainder of the space. Operation is controlled by a microprocessor that polls the front-panel switches and remote ground closures. Front-panel switches are of the momentary touch type with lighted functional indicators. Most of the switches are also used to select special functions, which are accessed by holding the switches in until the microprocessor recognizes the request.

The signal is displayed on a bright crt capable of displaying one line per frame. It is of the mesh type, for better geometry, and uses an internal graticule to reduce parallax. Variable graticule scale illumination provides even lighting, without hot spots or voids, over the usable graticule area to improve measurement accuracy and the quality of waveform pictures.

Composite video signals for the Channel A and B Inputs and the External Reference Signal Input are high impedance bridging loop-throughs, in order to protect the integrity of the signal paths. The input switching allows for the display of either Channel A or Channel B Input or both inputs. Synchronization can be either internal or external, with the further choice of using remote sync where the application warrants.

The 1730–Series offers a choice of three basic sweep rates: 2 Field, 2 Line, and 1 Line, each of which can be magnified to provide three additional sweep rates: 1 µs (2 Line), 0.2 µs (1 Line), and X25 (for the 2 Field) which provides for viewing the complete vertical interval. In addition, there is full frame line selection that can be displayed as 1 line, 2 lines or 15 lines. A bright-up pulse, for Picture Monitors, that corresponds to the intensified region on the crt display, is available through a rear-panel bnc connector.

The vertical signal processing provides a choice of dc restoration, fast or slow, or an unclamped display. The input signal can be unfiltered (Flat) or either Low Pass or Chrominance filtered. When Low Pass filtering is selected and either a 2 Line or 2 Field sweep rate is employed, the display consists of one line or field Low Pass filtered while the second is unfiltered. Vertical amplitudes can be displayed in a calibrated gain mode, which corresponds directly with the graticule vertical scales, magnified 5 times or can be set to a specific amplitude by using the Variable.

An RGB or YRGB Parade display, for camera setup, is accommodated with a shortened sweep. The input of the camera signal and an enable are through the rear-panel Remote jack. The choice of 3-step (RGB) or 4-step (YRGB) is made by changing the position of an internal plug-jumper.

The 1730–Series has a unique Store and Recall function built in that allows for the storing of up to four front-panel setups that can be recalled by pressing the appropriate recall button, or a ground closure through the rear-panel REMOTE connector. In addition, four factory-programmed measurement setups can be accessed, by external ground closures input through the REMOTE connector.

An auxiliary output, to control a companion 1720–Series Vectorscope, is provided through a rear-panel connector. The auxiliary output contains a bus for two-way communications between the Waveform Monitor and Vectorscope microprocessors and a strobe to provide line select unblanking for the Vectorscope.

TYPICAL CONFIGURATIONS

The 1730-Series Waveform Monitor is designed for operation either alone or with a 1720-Series Vectorscope. Line select and measurement recall for this waveform monitor are also used by the vectorscope. Because of these capabilities the 1730-Series Waveform Monitor is ideally suited to operate in a VCR bridge. With its factory-preset measurement routines, that can be accessed through the rear-panel REMOTE connector and the Store/Recall functions, it is possible to have one-button measurements of key parameters, including various vectorscope measurements.

In addition to the VCR bridge and the typical Master Control monitoring applications, this monitor can be used in camera chains. It has a choice of RGB or YRGB Parade display that can easily be selected by changing one internal plug-jumper setting. The Parade signal and enable are input through the rear-panel REMOTE connector.

A number of operating conditions can be altered by changing internal plug-jumpers, using some of the factory-preset combinations, or setting up and saving the front panel with the Store/Recall function. Using these methods most of the current 528A operational mods can be accommodated. There is a difference in how the remote control operates; the 1730-Series uses ground closures, not positive voltage as the 528A did.

OPTIONS

The only options currently available for the 1730-Series Waveform Monitor are the power plug options A1 through A3. All 1730 NTSC and 1731 PAL-M Waveform Monitors are shipped with a 115 Vac power plug and a captive cord.

CSA certification applies to the product with CSA-certified power cords. International power cords (Options A1, A2, and A3) which are approved for the country of use are not included.

All 1731 PAL and 1735 Waveform Monitors are shipped with one of the following power plug options.

Option A1 Universal Europe 220V/16A Power Plug.

Option A2 United Kingdom 240V/15A Power Plug.

Option A3 Australian 240V/10A Power Plug.

ACCESSORIES

Standard Accessories

The following accessories are shipped with the 1730-Series. See the Accessories illustration, at the rear of the manual, for part numbers.

1	1730-Series Instruction Manual
1	Power Cord, with the selected power plug option
1	Replacement Cartridge Fuse (correct rating for the power plug option)
1	Male, D-Type, Subminiature, 15-Pin plug (for use with the REMOTE input)
1	Plastic Housing Remote, Tektronix Part No. 200-1666-00

Optional Accessories

There are a number of accessories that can be used with a 1730-Series Waveform Monitor. The following is a list of the most common accessory items for this series of waveform monitors. 1700F items are Field Upgrade Kits that are installed by the customer; instructions are included in all Field Upgrade Kits.

Cameras, C5C (Option 02) or C7 (Option 03)

Viewing Hood (016-0475-00)

Front Panel Cover (200-1566-00)

1700F00, Plain Cabinet (painted silver-grey)

1700F02, Portable Cabinet (painted silver-grey)

1700F05, Side-by-Side Rack Adapter

1700F06, Blank Half-Rack Width Panel

1700F10, DC Power Converter

Safety Information

The 1730–Series is intended to operate from an ac power source that will not apply more than 250 V rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor is essential for safe operation (except for those instruments that are operated from a battery supply).

The 1730–Series was tested for compliance in a cabinet. To ensure continued compliance, the instrument will need to be enclosed in a cabinet that is equivalent to the Factory Upgrade Kits that are listed as Optional Accessories for the 1730–Series. A drawing of the 1700F00 plain cabinet is contained in the Installation Instructions (SECTION 3).

The 1730–Series is designed and tested in accordance with the following industry safety standards:

UL1244–1980 — "Standard for Electrical and Electronic Measuring and Testing Equipment."

FM. 3820 — "Approval Standard for Electrical Utilization Equipment, Class Number 3820."

ANSI C39.5 — "Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation, 1974."

CSA — Electrical Bulletin No. 556B.

IEC 348, Second Edition — "Safety Standard for Electronic Measuring Apparatus."

VDE 0871.5 (Class B) — "Radio Frequency Interference Suppression of Electrical Equipment and Systems."

ELECTRICAL SPECIFICATION

Table 1-1
Vertical Deflection System

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
Frequency Response 1 V Full Scale or in X5 Gain FLAT (X1)	50 kHz to 6 MHz within 2% of response at 50 kHz.	Specifications apply for full screen height video input signal, with variable GAIN off.	12
FLAT (X5)	50 kHz to 6 MHz within 5% of response at 50 kHz.		12
LOW PASS	At least 30 dB attenuation at 3.58 MHz-1730 (4.00 MHz-1735, 4.43 MHz-1731).	Response at 15 kHz does not vary between FLAT and LPASS by more than 1%.	15
CHROMA NTSC and PAL-M	Nominal Bandwidth 1 MHz. Attenuation at 7.2 MHz 20 dB or greater.	Upper and lower –3dB points are approximately ± 350 kHz from 3.579545 MHz.	16
	Response at 3.58 MHz does not vary between FLAT and CHROMA by more than 1%.		16
PAL	Nominal Bandwidth 1 MHz. Attenuation at 8.9 MHz 20 dB or greater.	Upper and lower –3dB points are approximately ± 350 kHz from 4.433619 MHz.	16
	Response at 4.43 MHz does not vary between FLAT and CHROMA by more than 1%.		16
Transient Response 1 V Full Scale or X5 Gain FLAT (using 2T pulse and 2T bar) Preshoot	1% or less.	Specifications apply for full screen height video input signal, with variable GAIN off.	14

Table 1-1 (cont.)

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
Pulse-to-Bar Ratio	X1: 0.99:1 to 1.01:1. X5: 0.98:1 to 1.02:1.		14
Overshoot	X1: 2% or less. X5: 4% or less.		14
Ringing	X1: 2% or less. X5: 4% or less.		14
Tilt Field Rate Square Wave or Vertical Window	1% or less.		14
25 µs Bar	1% or less.		14
Overscan	Less than 2% variation in baseline of 100 IRE (700 mV) 12.5T (20T) modulated pulse as it is positioned over the middle 80% of the screen.		14
Differential Gain	Displayed differential gain is 1% or less with 10% to 90% APL changes.	Chroma filter must be selected. Baseline at 50 IRE and displayed subcarrier adjusted to 100 IRE with VAR gain.	
Deflection Factor 1 V Full Scale	140 IRE (1.0 V) within 1% with 1 V input.	FLAT response selected.	8
X5	Gain Accuracy ±5%.	1 V input signal	8
Variable Gain Range	Input signals between 0.8 V and 2 V can be adjusted to 140 IRE (1.0 V) display. 160 mV and 400 mV for X5 Gain.		8
Position Range	1 V signal can be positioned so that peak white and sync tip can be placed at blanking level, with the DC RESTORER on, regardless of gain setting.	Applies to calibrated gain positions only.	8

Table 1-1 (cont.)

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
Maximum Absolute Input Level	±5 Vdc + peak ac.	Displays in excess of 200 IRE (1.428 V) may cause frequency response aberrations.	
DC Input Impedance (Unterminated)	Greater than 15 kΩ.		
Return Loss (75Ω) Video Inputs (CH-A, CH-B)	At least 40 dB from 50 kHz to 6 MHz.	A and B channels, loop-through terminated in 75Ω. Input in use or not in use, instrument power on or off, all deflection factor settings.	17
Crosstalk between Channels		Greater than 50 dB of isolation between channels. Measured at F_{sc} between Channel A, Channel B, and EXT REF.	
Loop-Through Isolation		Greater than 80 dB of isolation between loop-throughs. Measured at F_{sc} between Channel A, Channel B, and EXT REF.	
PIX MON Frequency Response	50 kHz to 6 MHz, within 3% of response at 50 kHz.	Terminated in 75 Ω.	13
Differential Gain (50% APL)	Within 1% with a 140 IRE (1.0 V) unit display.		
Differential Phase (50% APL)	Within 1° with a 140 IRE (1.0 V) unit display.		
Dc Level onOutput	0.5 V or less into 75 Ω load.	No input signal.	10
Intensification (Brightup)		During line select only. Active video of selected lines has a dc offset of approx. 180 mV.	
Output Impedance		75Ω (Nominal).	
Return Loss (75Ω)	At least 30 dB, 50 kHz to 6 MHz.	With instrument turned on.	17
Input to PIX MON Output Gain Ratio	1:1 ±5% at 15 kHz.		10

Table 1-2
DC Restoration

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
DC Restorer Clamp Time		Back Porch.	
Frequency Response at 60 Hz	SLOW — 20% or less. FAST — 90% or greater.	Attenuation of 60 Hz on input signal.	11
Blanking Level Shift with 10% to 90% APL Change	APL changes from 50% to either 10% or 90% will cause blanking level shift of 1 IRE unit (7.14 mV) or less.		11
Blanking Level Shift Due to Presence or Absence of Burst	1 IRE unit (7.14 mV) or less shift from no color burst to presence of color burst.		11

Table 1-3
Calibrator

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
Calibrator Signal Frequency	100 kHz, ±100 Hz. Synchronizes in 2H and 1H sweep.	Crystal controlled. Timing accuracy is 10 µs, ±0.01 µs. Can be used as 10 µs and 1 µs timing calibrator.	3
Amplitude	140 IRE (1 V) within 1%.		9
Position		Top of waveform must be between 80 IRE (0.86 V) and 120 IRE (1.14 V) on graticule when Back Porch is positioned to 0 IRE (0.300 V) line, with DC RESTORER on.	

Table 1-4
Horizontal Deflection System

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
Sweep	Sweep will occur in all Horizontal mode settings with or without synchronization.		5
2 FLD Sweep Repetition Rate	Equal to frame rate of applied video or external sync.		
2 FLD Sweep Magnification		Approximately X25.	
1 LINE Sweep Repetition Rate	Equal to line rate of applied video or external sync.		
2 LINE Sweep Repetition Rate	Equal to half line rate of applied video or external sync.		
Sweep Length		2 LINE and 2 FLD sweep length is nominally 12.5 divisions.	
Timing Accuracy 1 µs/div. 0.2 µs/div.	 To within 2%. To within 3%.	All timing and linearity specifications exclude the first and last major divisions of the unmagnified display. Timing can be adjusted ±5% with front-panel H CAL.	 6 6
Linearity 1 µs/div. & 0.2 µs/div.	Within 2%.		6
Differential Linearity 1 µs/div. & 0.2 µs/div.	Within 2%.	0.1 div. or less compression or expansion of a center screen 5 div. signal, when positioned over the 10 center divisons.	6
Sweep Magnifier Registration		Magnification occurs about the center of the screen.	
HORIZONTAL Position	Any portion of a synchronized video sweep can be positioned on screen in all sweep modes.		

Table 1-4 (cont.)

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
LINE SELECT		Displays the selected line in 1 LINE. Displays the selected line first in 2 LINE. Intensifies selected line in 2 FLD. In 15 LINE, displays overlayed lines in 1 or 2 LINE, intensifies the selected 15 lines in 2 FLD. A small 15 is added to the bottom of the crt readout in 15 LINE mode.	
Read Out NTSC Field 1 Field 2 All		 Lines 1 to 263. Lines 1 to 262. Lines 1 to 262.	
PAL Field 1 Field 2 All		 Lines 1 to 313. Lines 314 to 625. Lines 1 to 312.	
PAL-M Field 1 Field 2 All		 Lines 1 to 263 Lines 264 to 525. Lines 1 to 262.	

Table 1-5
Synchronization

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
Input Requirements Internal Reference NTSC and PAL-M	Composite video or black burst with sync amplitudes 40 IRE ±6 dB.		4
PAL	Composite video or black burst with sync amplitudes 300 mV ±6 dB.		4
EXTernal REFerence	Sync amplitude between 143 mV and 4 V will synchronize sweeps.		4
EXT REF Input Dc Input Impedance (Unterminated)	Greater than 15 kΩ.		
Return Loss (75Ω)	At least 40 dB from 50 kHz to 6 MHz.	Loop-through terminated in 75 Ω, instrument power on or off.	17
Absolute Maximum Input Voltage		±12 Vdc plus peak ac.	
Remote Sync Amplitude	2.0 to 5.0 V square wave, or 4.0 V comp sync.	Input and enabled through rear-panel REMOTE connector. Input Impedance 1 MΩ. 30/60 Hz (25/50 Hz) square wave will sync 2 FLD Sweep. Remote sync bypasses the sync stripper and field ID circuits.	
Sweep Trigger Polarity		Internal jumper selects polarity. Normal: Negative-going edge line sync, positive edge of field sync. Inverted: Positive-going edge line sync, negative edge of field sync.	

Table 1-6
RGB/YRGB Mode

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
RGB/YRGB	Will display either a 3-step or 4-step RGB / YRGB parade or overlayed display.	Internal jumper is used to change from 3-step to 4-step capability. Factory set to 3-step.	7
Staircase Amplitude — RGB or YRGB	A 10 V input will result in a horizontal display of 9 divisions ±1.4 major divisions.	12 V p-p ac component. Signal voltage not to exceed ±12 Vdc plus peak ac. Internal adjustment offsets any incoming signal dc component between ±12 V. Input Impedance 1 MΩ shunted by approx. 3 pF.	7
Sweep Repetition Rate	Field or line rate of displayed video or external sync signal as selected by front-panel HORIZONTAL controls.	Field or line rate, if enabled from the REMOTE connector.	7
Control		RGB/YRGB mode and Parade / Overlay selected by applying ground (TTL low) at the RGB Enable pin on the rear-panel REMOTE connector. RGB components may be overlayed with normal sweep length by not activating RGB Enable.	
MAGnifier		Approx. X25 for 2 FLD, and X10 in 1 or 2 LINE.	
Sweep Length	3-step: 3.4 — 4.1 divs. 4-step: 2.5 — 3.1 divs.	Field or line rate sweeps. A 1 FLD sweep is selected by grounding the 1 FLD/1 LINE pin of the rear-panel Remote connector.	7

Table 1-7
CRT Display

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
CRT Viewing Area		80 X 100 mm. Horizontal = 12.5 div. Vertical = 170 IRE units (1.19 V).	
Accelerating Potential		Nominally 13.75 kV.	
Trace Rotation Range	Greater than ±1° from horizontal.	Total adjustment range is typically 8°.	
Graticule		Internal, variable illumination.	

Table 1-8
Power Source

CHARACTERISTIC	PERFORMANCE REQUIREMENTS	SUPPLEMENTAL INFORMATION	CHECK STEP
Mains Voltage Ranges 120 V 220 V	 90–132 V. 180–250 V.		2
Mains Frequency Range	48 Hz to 66 Hz.		
Power Consumption		35 Watts maximum.	
Optional Battery Operation		1700F10 Field Upgrade Kit can be installed for dc operation.	

Table 1-9
ENVIRONMENTAL CHARACTERISTICS

CHARACTERISTIC	SUPPLEMENTAL INFORMATION
Temperature Non-Operating Operating	 –55° C to +75° C. 0° C to +50° C.
Altitude Non-Operating Operating	 To 50,000 feet. To 15,000 feet.
Vibration — Operating	15 minutes each axis at 0.015 inch, frequency varied from 10–55–10 Hz in 1-minute cycles with instrument secured to vibration platform. Ten minutes each axis at any resonant point or at 55 Hz if no resonant point is found.
Shock — Non-Operating	30 g's, 1/2 sine, 11 ms duration, 3 shocks per surface (18 total).
Transportation	Qualified under NTSC Test Procedure 1A, Category II (24-inch drop).
Humidity	Will operate at 95% relative humidity for up to five days.

Table 1-10
CERTIFICATION

CHARACTERISTIC	SUPPLEMENTAL INFORMATION
Safety/EMI	Designed to meet or exceed: UL - 1244 Factory Mutual - 3820 CSA Bulletin 556B IEC 348 FCC EMI Compatibility (FCC Rules Part 15 Subpart J, Class A) VDE 0871.5 (Class B)

Table 1-11
PHYSICAL CHARACTERISTICS

CHARACTERISTIC	SUPPLEMENTAL INFORMATION
Dimensions Height Width Length	 5 1/4 inches (133.4 mm). 8 1/2 inches (215.9 mm). 18 1/8 inches (460.4 mm).
Weight	Approximately 8.5 lbs (approximately 3.8 kg).

SECTION 2
OPERATING INSTRUCTIONS

These instructions provide information about the front-panel controls, rear-panel connectors, graticules, and an Operator's Familiarization / Checkout Procedure, along with measurement discussions.

FRONT-PANEL CONTROLS AND INDICATORS

The front-panel controls and indicators consist of momentary contact push-button switches, variable controls, and backlit switch selections. See Fig. 2-1 (1730 and 1731) or Fig. 2-2 (1735) for control and indicator locations. When Line Select is being used, the field and line numbers are displayed on the crt for field rate sweeps; a strobe pulse is applied to displays of 2 field rate sweep to identify the selected line.

There are eight push-button switches that have functions that are accessed by holding the switch down for approximately one second. These functions are identified by a blue box surrounding the front-panel label. The DC Restorer switch toggles between FAST and SLOW when pushed and held. When exiting a held mode the selection reverts to the top of the list at the touch of the push button, with the exception of the REF switch, which returns to its previous setting.

INPUT

FILTER 1

Toggles through three positions, FLAT, LPASS, and CHROMA. In 2 Line or 2 Field Sweep a combination filtering routine, consisting of Low Pass and Flat for alternate lines or fields, can be accessed by holding the FILTER push button in. In the dual filter mode the low pass filtered line, or field, will always be on the left in 2 Line or 2 Field Sweeps. Lines are overlapped in 1 Line Sweep. The dual filter can not be accessed when 1730–Series is in AB switching or LINE SELECT mode. Filtering always returns to FLAT when coming out of the combination filtering routine. If AB switching or LINE SELECT is selected after the dual filter mode, filtering will be Low Pass.

REF 2

Toggles between internal and external reference. Calibrator is accessed by holding the REF switch. Instrument status is held in memory when CAL is selected and restored when the push button is again pushed. All front-panel lights, except SWEEP and MAG, go out and GAIN goes to X1, but X5 and VAR are usable with the CAL position. CAL cannot be STOREd or RECALLed. (Note that MAG and SWEEP are switchable in the Calibrator mode but revert to their previous setting when the mode is exited.)

CH–A–CH–B 3

Switch that toggles between Channel A and Channel B input. When held, the 1730–Series goes into an AB (BOTH) alternate mode, with the A input on the left and the B input on the right in 2 Line or 2 Field (overlapped in 1 Line). When in the AB switching mode the REF is forced to EXT, the FILTER is forced to LPASS (if it was in the LPASS-FLAT switching mode, if not the FILTER remains in the previous position), and the DC REST goes to SLOW; all three functions go back to their previous setting when input is switched out of AB. The DC Restorer can be changed after entering the AB mode. When leaving (BOTH), the INPUT always returns to CH–A.

VERTICAL

GAIN (Switch) 4

Toggles between VAR, X5, and off. A BOTH mode consisting of VAR and X5 is accessed by holding the push button until both LED indicators are lit.

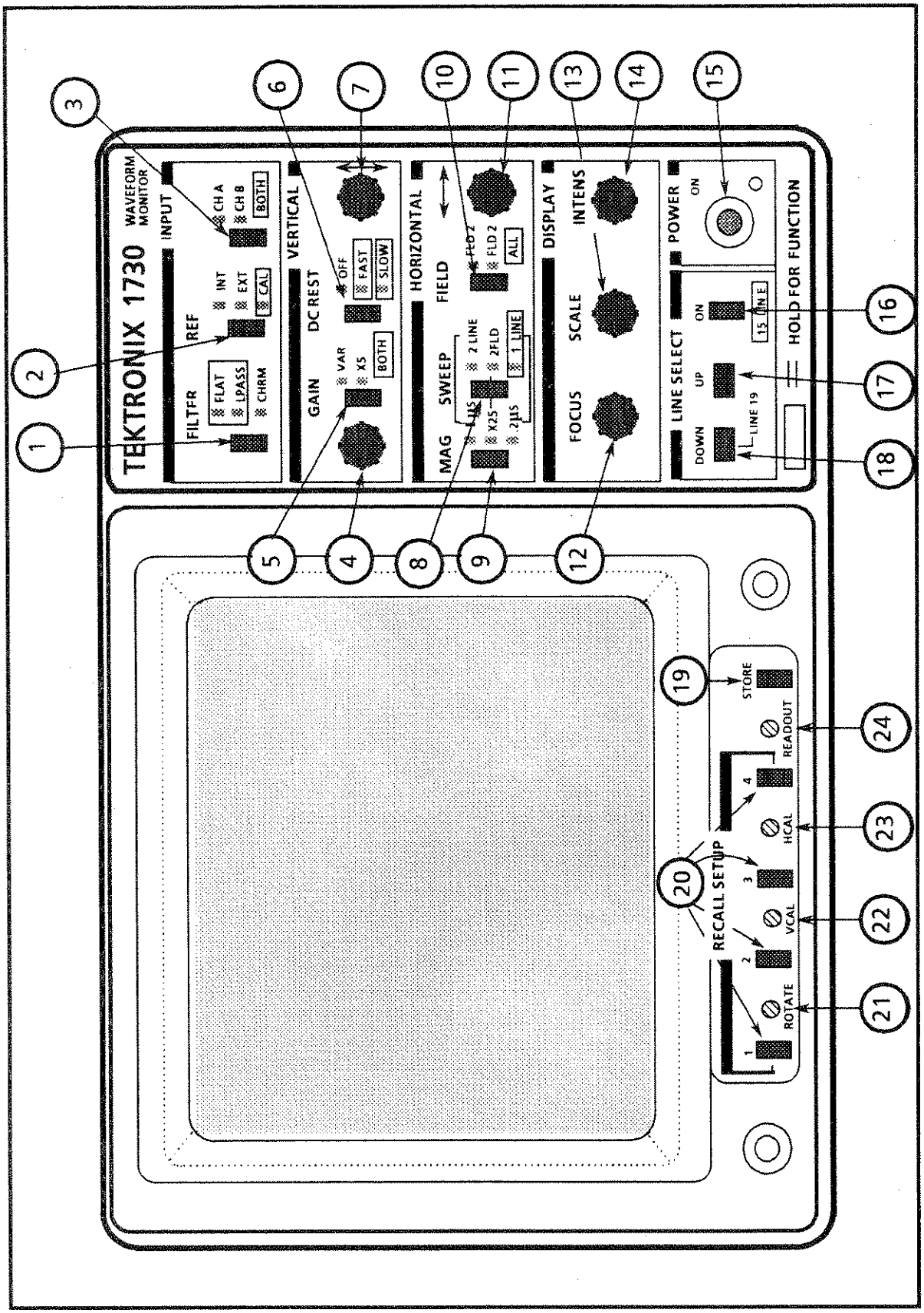

Fig. 2-1. 1730–Series front-panel control locations.

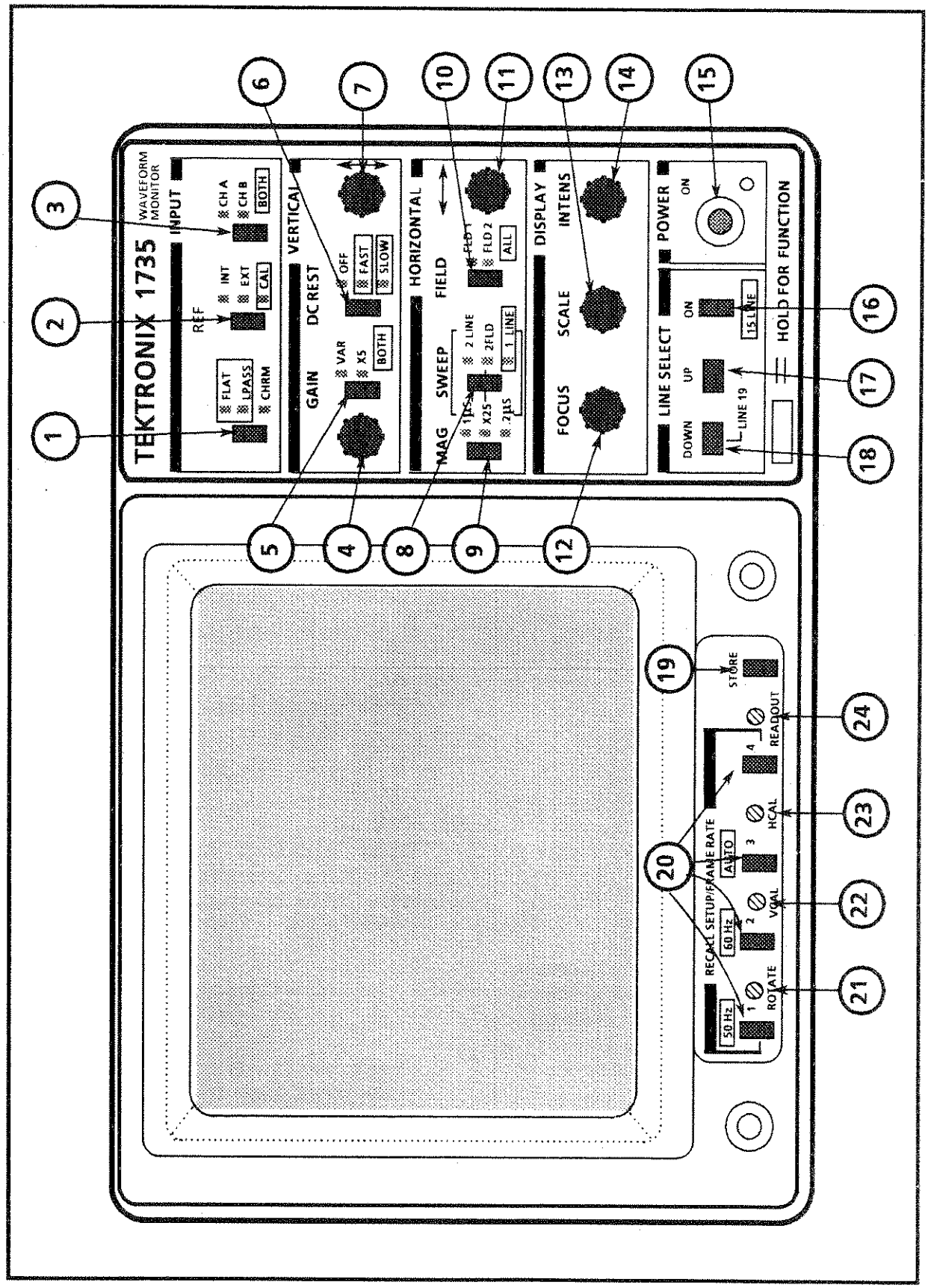

Fig. 2-2. 1735 front-panel control locations.

GAIN (control) 5
Enabled when the GAIN switch is in VAR. Adjusts amplifier input gain rate to make any input waveform signal, between 0.8 and 2.0 V peak-to-peak a full-scale display. Control has no detent.

DC REST 6
Toggles the DC Restorer on and off. When turned on the restorer comes up as previously selected, in either the slow or fast position. Pushing and holding the switch in toggles the restorer between FAST and SLOW. Once the restorer speed has been selected, pushing the DC REST button turns the DC Restorer on, at the selected speed, or off.

POSITION 7
Variable control that positions the waveform display vertically.

HORIZONTAL

SWEEP 8
Toggles between 2 LINE and 2 FLD sweep. 1 LINE sweep is accessed by holding the SWEEP push button in until recognition occurs. The MAG is automatically turned off if SWEEP is changed.

MAG 9
Toggles between on and off. Operates in conjunction with the SWEEP mode to provide usable sweep rates as follows:

2 LINE + MAG = 1 μs/div
2 FLD + MAG = 1 full vertical interval
1 LINE + MAG = 0.2 μs/div

The vertical interval displayed in 2 FLD MAG is the one following the selected field trigger; for example, if FLD 1 is selected as the trigger, the vertical interval displayed is the one between field 1 and field 2 (field 2 interval).

FIELD 10
Toggles between FLD 1 and FLD 2. The ALL mode is accessed, in the LINE SELECT mode, by holding the FIELD push button in until the word ALL appears on the CRT readout for 2 Line or 1 Line Sweep or a bright-up strobe appears in both fields for 2 Field Sweep.

This switch determines which field triggers the 2 FLD Sweep. The selected field trigger is the first (left) field displayed. For example, selecting Field 2 trigger places field 2 on the left, followed by field 1.

In LINE SELECT, the indicator lights go off but triggering of the 2 Field Sweep continues on the selected field. A line strobe identifies the selected line. In 1 LINE or 2 LINE, the FIELD button determines the field from which the selected line is displayed (field 1, field 2, or ALL fields). When exiting ALL fields, switching defaults to FLD 1.

POSITION 11
Variable control that positions the waveform display horizontally.

DISPLAY

FOCUS 12
Adjusts CRT beam for optimum definition.

SCALE 13
Controls the level of graticule illumination.

INTENSITY 14
Controls display brightness.

POWER

ON – OFF 15
Turns on and off external power to the 1730–Series. A mechanical indicator in the center of the switch shows the status of the POWER switch.

LINE SELECT

ON 16
Toggles between ON and OFF. Line and field number are displayed on the CRT in 1 Line or 2 Line Sweep rates with a colon as a delimiter, for example: F1:19 (field 1, line 19). In LINE SELECT mode, the selected line is displayed in 1 Line Sweep rate, the selected line is displayed first in the 2 Line Sweep rate, and a bright-up is provided to mark the selected line in 2 FLD Sweep rate. The field from which the line will

be displayed can be selected with the FIELD switch. For line numbering sequences, see Table 2-1 (1730 and 1731) or Table 2-2 (1735).

Table 2-1
Line and Field Select Sequence

Color Standard	Field 1 Lines	Field 2 Lines	All Lines
NTSC	1 - 263	1 - 262	1 - 262
PAL	1 - 313	314 - 625	1 - 312
PAL-M	1-263	264-525	1-263

15 LINE display is accessed by holding the LINE SELECT ON button until there is recognition. In 2 FLD, the 15 lines are intensified in the display. In 1 or 2 Line, the 15 lines are overlayed and the CRT readout is active, giving the field and line of the first displayed line plus a small 15 immediately below the colon in the readout.

Lines displayed in the LINE SELECT mode have their active video intensified on the PIX MON OUT signal.

UP 17

Increments the line count (when enabled). Holding the UP push button in increments faster.

DOWN 18

Decrements the line count (when enabled). Holding the DOWN push button in decrements faster.

Holding either button down until the count passes the beginning or end of field causes the count to shift to the other field.

Table 2-2
1735 NTSC/PAL Translations for Dual-Standard Switching

Color Standard Switched From:	Field 1 Lines	Field 2 Lines	All Field Lines	Color Standard Translated To:	Field 1 Lines	Field 2 Lines	All Field Lines
NTSC	1-263			PAL	1-263		
NTSC		1-50		PAL	264-314		
NTSC		51-262		PAL		315-525	
NTSC			1-262	PAL			1-262
PAL	1-263			NTSC	1-263		
PAL	264-313			NTSC		1-50	
PAL		314-525		NTSC		51-262	
PAL			1-262	NTSC			1-262
PAL			262-312	NTSC			19*
PAL		526-625		NTSC	19*		

***Where there is no corresponding line number associated with a standard change, line count is reset to line 19 (the reference position in the vertical interval).**

(When LINE SELECT is enabled, holding in both the UP and DOWN push buttons returns the line count to Field 1, Line 19.)

RECALL SETUP

STORE 19

Enables the storage of front-panel settings, including line number, in four different memory locations. To store a front-panel setup, the STORE switch is pushed and then one of the four RECALL SETUP switches is pushed. When STORE is pushed, all front-panel lights cycle off and on (approximately 15 times) to indicate that the front-panel, as it is currently set up, can be stored. If the current selection is not the desired setup, pushing any front-panel button, except a RECALL SETUP, will cancel the STORE mode. If one of the RECALL SETUP switches is pushed while STORE is active, the current front-panel setup will be stored in the selected RECALL position. CAL cannot be stored.

When a store operation is performed on the 1735, the selected standard (50 Hz, 60 Hz, or AUTO) is stored.

RECALL SETUP (1-2-3-4) 20

Recalls from memory, or causes the storage in memory of a (1-2-3-4) front-panel setting. Each of the four switches operates with a memory location and the STORE push-button switch.

A special feature in the 1735 allows the operator to use the STORE and RECALL function in the normal manner, or to select from three operating modes by holding the RECALL switches. The 50 Hz (PAL) standard of operation is selected by holding the Recall Setup 1 key and 60 Hz is selected with the Recall Setup 2 key. AUTO, which provides automatic switching between the two standards, is selected with the Recall Setup 3 key. In non-line select modes of operation, holding the Recall Setup 4 key will display the status of the current standard.

If 50 Hz or 60 Hz operation has been stored as a setup, it will be recalled by pushing a RECALL switch. If the AUTO mode of operation is recalled, and a change in input signal standard has occurred, the 1735 will recall the correct standard (after the slight delay associated with automatic determination of the reference standard).

MISCELLANEOUS

ROTATE 21

A 270° screwdriver adjustment that aligns the display with the graticule.

V CAL 22

A 270° screwdriver adjustment that sets the vertical amplifier gain. Is normally used with the CAL position of the REF switch.

H CAL 23

A 270° screwdriver adjustment that sets the timebase. Can be used accurately with the CAL position of the REF switch in the 2H Sweep.

READOUT 24

A 270° screwdriver adjustment used to change the brightness of the readout portion of the CRT display, relative to the waveform intensity.

REAR-PANEL CONNECTORS

Signal input, power input, RGB input, Remote Sync Input, Picture Monitor Out, Auxiliary Control Output, and Remote Control are all located on the 1730–Series rear panel. Because of the similarity of the 1730– and 1720–Series rear panels, WAVEFORM MONITOR is printed on the 1730–Series rear panel. See Fig. 2-3 for the locations of the rear-panel connectors.

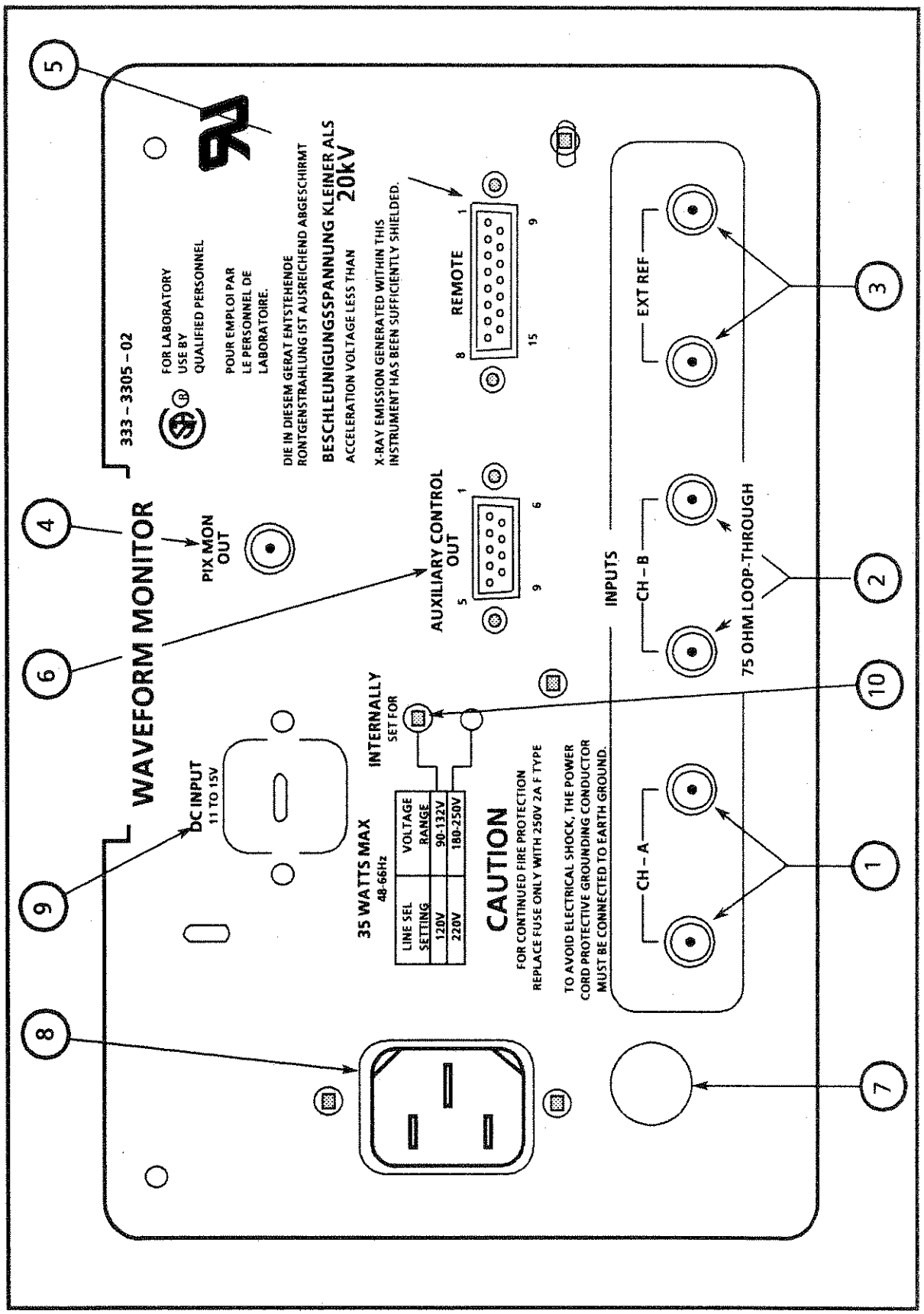

Fig. 2-3. 1730–Series rear panel.

BNC Connectors

CH–A 1

Bridging loop-through composite video input, compensated for 75 Ω. This input is selected for display by the front-panel INPUT switch.

CH–B 2

Bridging loop-through composite video input, compensated for 75 Ω. This input is selected for display by the front-panel INPUT switch.

EXT REF 3

Bridging loop-through synchronization input (compensated for 75 Ω), selected as the synchronizing source by the front-panel REF switch. The input signal may be composite sync, black burst, or composite video.

PIX MON 4

A 75 Ω output signal that corresponds to the front-panel selected display. This signal has bright-up, in the LINE SELECT mode, and is used to drive a picture monitor.

Multi-Pin Connectors

REMOTE 5

15-pin, D-type, female connector that provides limited remote control functions, such as four factory-preset front-panel setups, store disable, and the input connector and enable for the RGB/YRGB staircase.

Remote functions are activated by polled ground closure; only changes in remote input are responded to, allowing the front panel to be fully operational.

AUXILIARY 6

A 9-pin, D-type, female connector to interface with the 1720–Series. Auxiliary control consists of a signal line and an interface bus. The bus provides the 1730–Series with control of the status of the 1720–Series.

Power Input

AC FUSE 7

Holder for the instrument's mains fuse.

AC POWER 8

A standard ac plug receptacle for 120 or 240 Vac power mains. Plug is compatible with any of the three power cord options available for the 1730–Series Waveform Monitor.

DC INPUT 9

A knockout for installation of a 1700F10 Field Upgrade Kit dc power plug.

LINE SEL SETTING 10

A screw mounted to denote the placement of an internal, soldered-in strap.

OPERATOR'S CHECKOUT PROCEDURE

The following procedure is provided as an aid in obtaining a display on the 1730–Series Waveform Monitor (operator familiarization), and as a quick check of basic instrument operation. Only instrument functions, not measurement quantities or specifications, are checked in this procedure. Therefore, a minimum amount of test equipment is required. All checks are made with the cabinet on and all internal jumpers in the factory-set position. Display photographs shown in this procedure were taken with the 1730–Series.

If performing the Operator's Checkout Procedure reveals improper operation or instrument malfunction, first check the operation of associated equipment. If associated equipment is performing normally, refer the 1730–Series Waveform Monitor to qualified service personnel for repair or adjustment.

When a complete check of the instrument performance, to its specification, is desired, refer to the Performance Check (which should only be performed by qualified service personnel) in SECTION 5 of this manual.

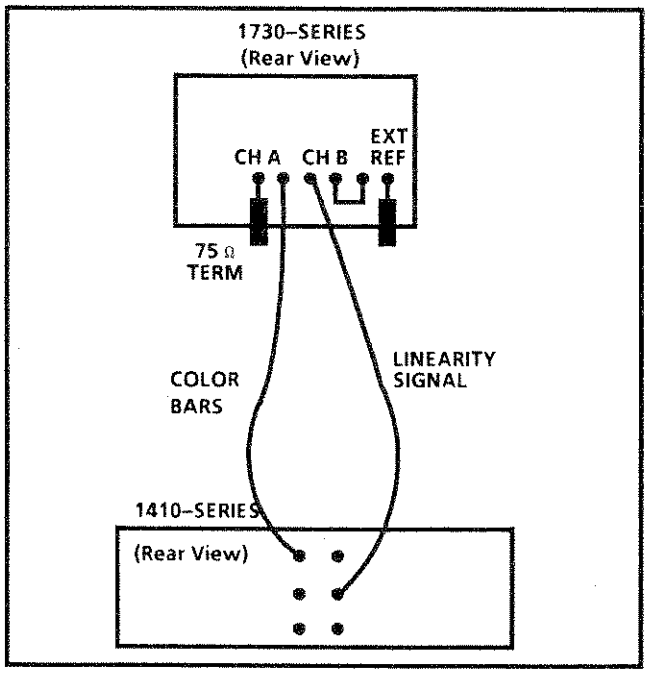

Fig. 2-4. Equipment connections for the 1730–Series Operator's Checkout Procedure.

This procedure requires a source of composite video. The TEKTRONIX 1410–Series Television Test Signal Generator (1410 for NTSC, 1411 for PAL or 1412 for PAL-M) with Sync, Color Bar, and Linearity modules was used in preparing this procedure.

Procedure

This procedure requires only one hook-up to perform. Fig. 2-4 shows the required connections. Once the signals are connected continue on to step 1 of the procedure.

1. Initial Generator Setup

Video Signal Generator

Test Signals
- Full Field Color Bars
- 75% Ampl. 7.5% Setup — NTSC and PAL-M
- 75% Ampl. 0% Setup — PAL

Modulated Staircase
(Flat Field, 5 Step)

2. Apply Power

Connect the instrument to a suitable ac power source and push the POWER button. A center dot should appear in the eye of the POWER switch to indicate that it is on.

NOTE

Do not set any of the front-panel screwdriver controls until after the instrument warms up (20 minutes minimum).

3. Initial Front-Panel Setup

1730–Series Monitor

FILTER	FLAT
REF	INT
INPUT	A
GAIN	Off (no indicators on)
VERTICAL POSITION	as is
DC REST	OFF
SWEEP	2 LINE
MAG	off (no indicators on)
FIELD	as is
HORIZONTAL POSITION	as is
FOCUS	as is
SCALE	as is
INTENS	as is
DOWN	as is
UP	as is
LINE SELECT	off (no line number readout on CRT)
RECALL SETUP	as is
ROTATE	as is
V CAL	as is
HCAL	as is
READOUT	as is
POWER	ON

4. Obtain Display

Adjust the INTENS and FOCUS controls for the desired brightness and a well-defined display. Adjust the multi-turn VERTICAL POSITION control to place the display blanking level on the graticule 0 IRE (NTSC and PAL-M) or 300 mV (PAL) line. Center the display with the HORIZONTAL POSITION. See Fig. 2-5.

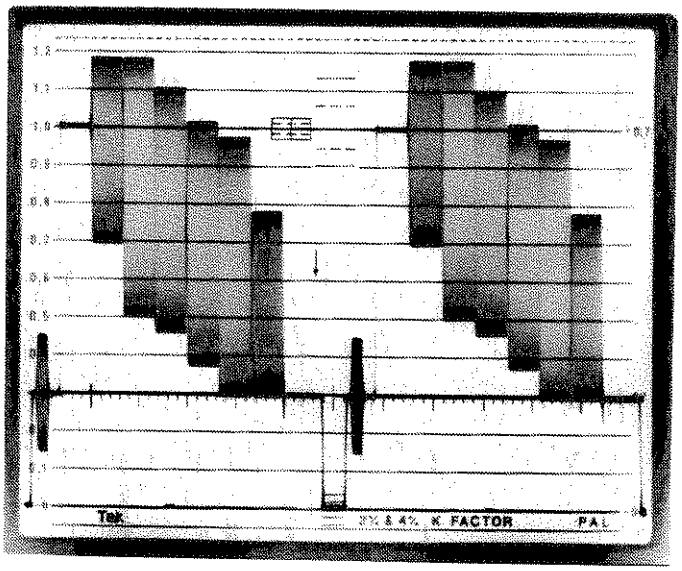

Fig. 2-5. 2 Line color bar display in FLAT filter mode.

Adjust the SCALE illumination control for the desired graticule scale brightness.

5. Check the Rotation of the Display

Variations in the earth's magnetic field may make adjustment of the ROTATE control necessary at installation time or whenever the instrument is moved.

Check that the display blanking level is parallel to the horizontal axis. If not, adjust the ROTATE screwdriver adjustment until the sweep is parallel to the horizontal axis.

6. Calibrate Display

The CAL mode on the REF switch enables the Waveform Monitor calibrator signal. Press and hold the REF button until the CAL indicator LED is lit. Adjust the VERTICAL and HORIZONTAL POSITION controls to obtain a display similar to that shown in Fig. 2-6. If necessary, adjust the V CAL screwdriver control for 1 V amplitude (140 IRE). Switch REF to INT mode. Turn CAL off by again pushing the REF button.

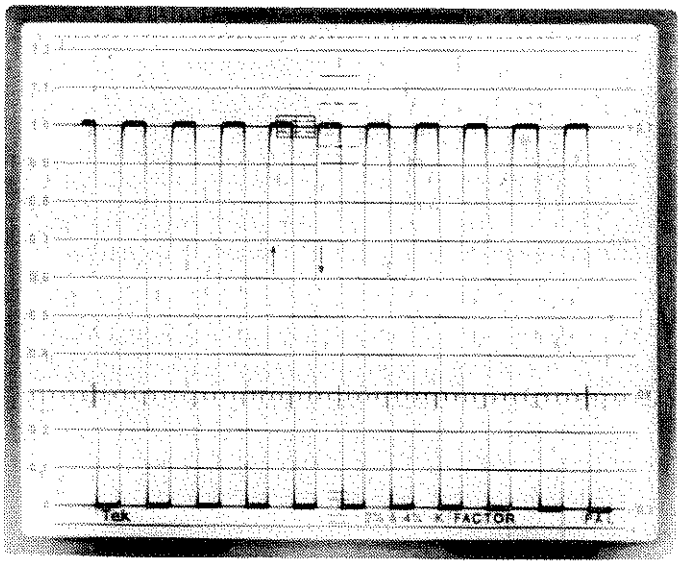

Fig. 2-6. Checking Vertical Gain Calibration with the 1730-Series internal CAL Reference

7. Select Input

The AB switch selects the rear-panel Channel A or Channel B inputs. Position the color bar waveform so that the blanking level is at the –40 IRE (0 V) graticule line and the sync pulses are at each end of the graticule.

Select the Channel B input. Note that the linearity waveform is displayed.

Push and hold the INPUT button until both the color bar and linearity waveforms are displayed. See Fig. 2-7. Check that both the CH–A and CH–B front-panel indicators are on.

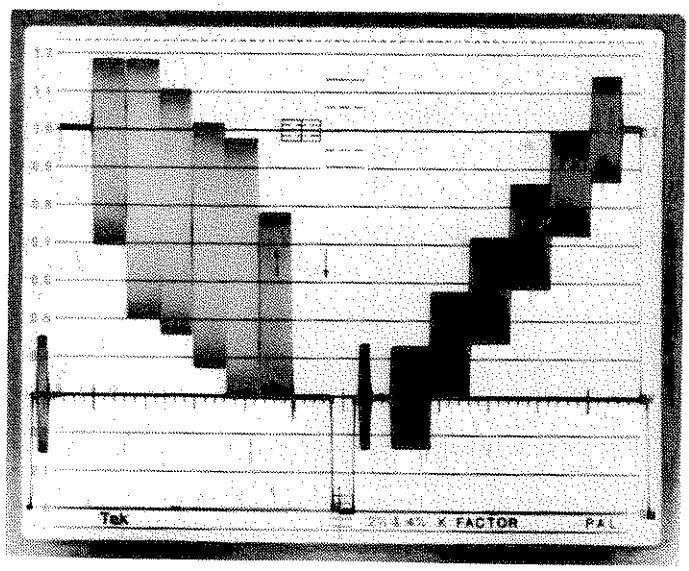

Fig. 2-7. Dual channel, 2 Line display of color bar and linearity signals.

Push the switch to return to the Channel A (color bar) display.

8. Select Timing Reference

Be sure that SWEEP is still 2 LINE. Hold the REF button until the CAL signal appears. Position it so the top of the display is on the 70 IRE (NTSC AND PAL-M) or 0.7 V (PAL). Horizontally position the display so the first transition is on the left side timing mark (the mark that goes completely through the blanking line. There are three on the graticule.) See Fig. 2-8a. Check that the falling transition of the 10th square wave passes directly through the right side timing mark. The H CAL can be adjusted if timing is off. Push the MAG button and check for one cycle of square wave over the 10 divisions of timing area. See Fig. 2-8b.

Hold the SWEEP button until the 1 LINE front-panel indicator lights. Check for five full cycles over the 10-division timing area. See Fig. 2-8c.

Push the Waveform Monitor REF switch and return to INT.

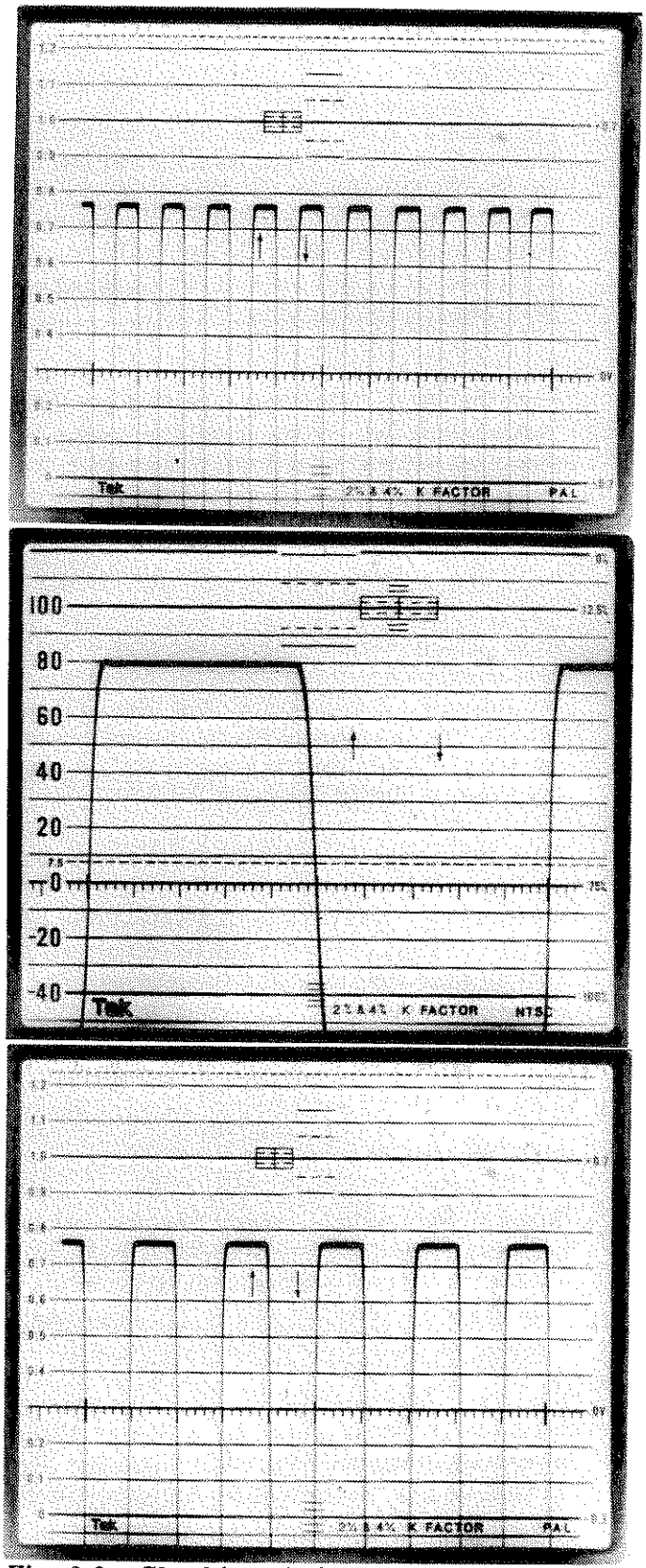

Fig. 2-8. Checking timing with the internal calibrator signal (a) 2 Line display, (b) 2 Line display magnified, (c) 1 Line display.

9. Gain Control

The normal GAIN setting (with the GAIN switch off) is 1 V full scale with neither the X5 nor the VAR indicator lit. The GAIN (VAR) control changes the amplifier gain so that signals greater or lesser in amplitude to the calibrated 1 volt full scale can be displayed as full scale.

Push the GAIN switch and note that the VAR indicator is lit. Also note the range of amplitude (signal amplitude greater than the scale at one extreme and considerably smaller at the other) that is obtained with the control.

Push the button and check that the X5 indicator lights. Check for a large increase in gain. (It can be determined that this is a X5 gain increase by setting the signal base line on the graticule 0 IRE (NTSC and PAL-M) or 300 mV (PAL) and checking that the maximum excursion of color burst is at approximately the 100 IRE or 1 V graticule line.)

Push the button in and hold it until both the VAR and X5 indicators are lit. Rotate the GAIN control and look for a greater than 5X amplitude display at one extreme and a nearly normal amplitude display at the other extreme.

Push the GAIN button once and notice that the display amplitude returns to 1 V Full Scale.

10. Filter Selection

The FILTER button selects the frequency response characteristic for the displayed signal. The FLAT response is used for normal applications. Fig. 2-5 shows the color bar signal with the FLAT response.

Press and hold the FILTER button to get the front-panel LPASS indicator to light. This provides the low-pass frequency response; the chrominance component of the signal has been removed. See Fig. 2-9.

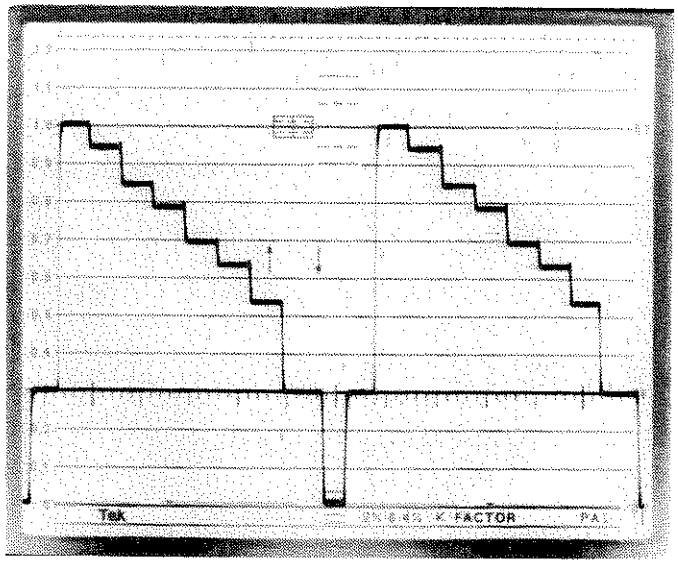

Fig. 2-9. 2 Line display of color bar signal with Low Pass filter on.

Press the FILTER button once more and look to see that the CHROMA indicator is lit. The signal is now displayed as chrominance only; the luminance component is removed. See Fig. 2-10.

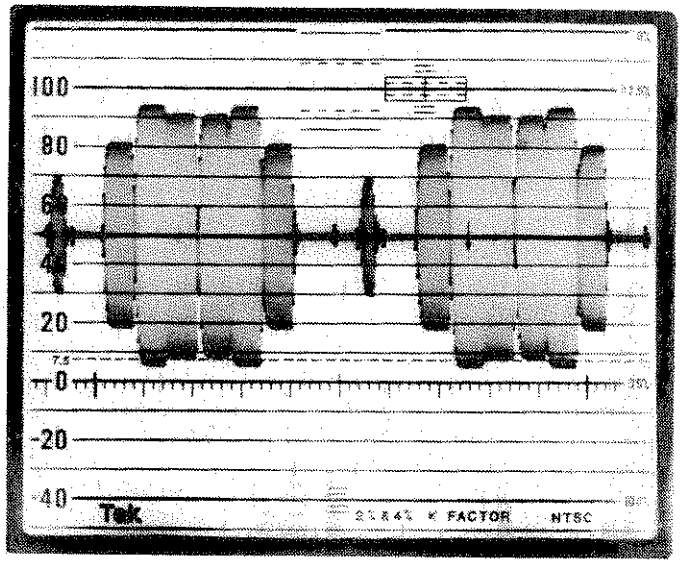

Fig. 2-10. 2 Line display of color bar signal with Chroma filter on.

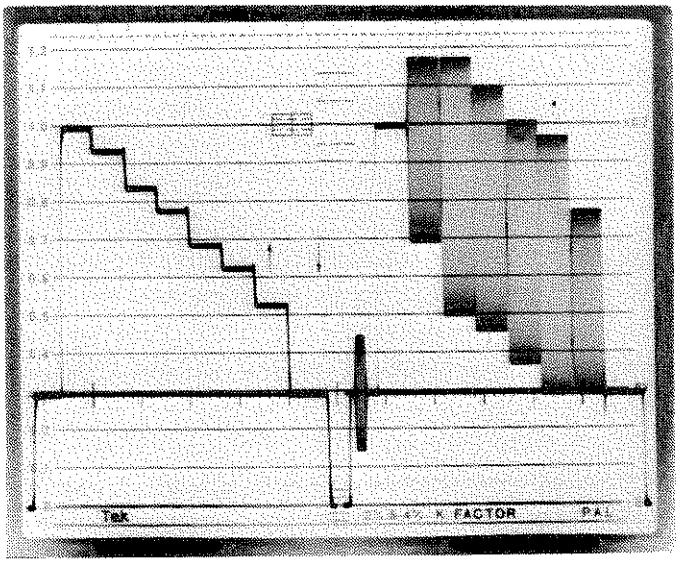

Fig. 2-11. Dual filter (Low Pass and Flat) display with a 2 Line Sweep.

Hold the FILTER button in until both the FLAT and LPASS front-panel indicators are lit. The display now consists of two lines, the first of which has the chrominance removed and the second is unfiltered. See Fig. 2-11.

Push the FILTER switch and return to FLAT.

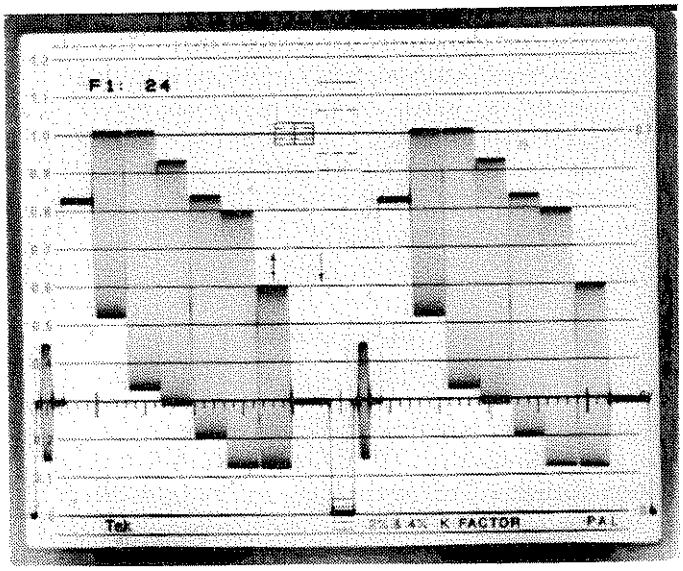

Fig. 2-12. 2 Line display with LINE SELECT on. Note readout in upper left corner of graticule.

11. Sweep Speeds and Line Select

Turn on LINE SELECT and push and hold both the UP and DOWN buttons until the readout indicates that line 19 of field 1 is being displayed. Use the LINE SELECT UP button or DOWN to display line 131. Holding in the UP or DOWN button causes the counter to move faster. See Fig. 2-12.

Push the sweep button and observe the 2 FLD Sweep with an intensified line at the mid point of one of the fields. See Fig. 2-13. Push and hold the LINE SELECT button until the intensified portion of the display increases in width; this is the 15 Line mode of LINE SELECT. See Fig. 2-14.

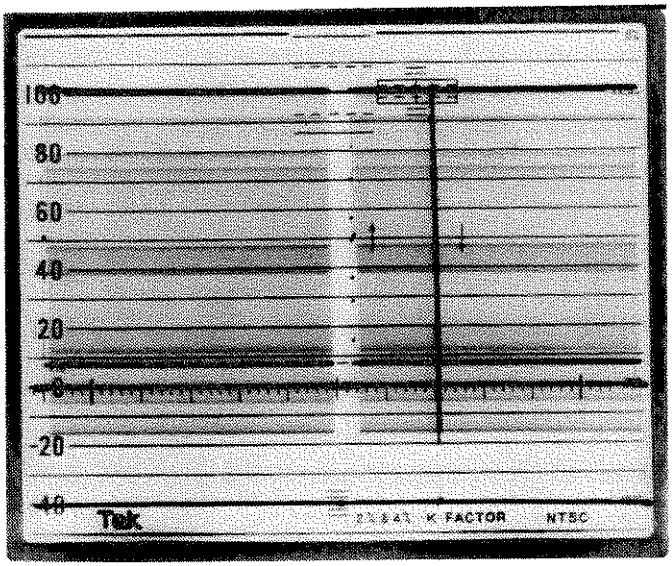

Fig. 2-13. 2 Field display with intensified line in the first displayed field.

Push and hold the SWEEP button until the front-panel 1 LINE indicator lights, look for a display of one line, with a line F1 or F2:131 over 15 readout. This is 15 continuous in field 1 or field 2 (as indicated by the readout). Change the field by pushing the FIELD button. See Fig. 2-15. Turn off the LINE SELECT.

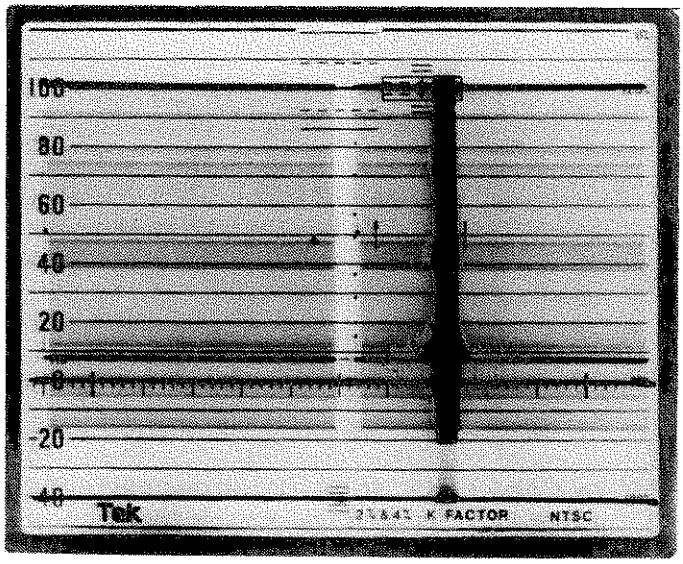

Fig. 2-14. 2 Field display with 15 Line mode of LINE SELECT on.

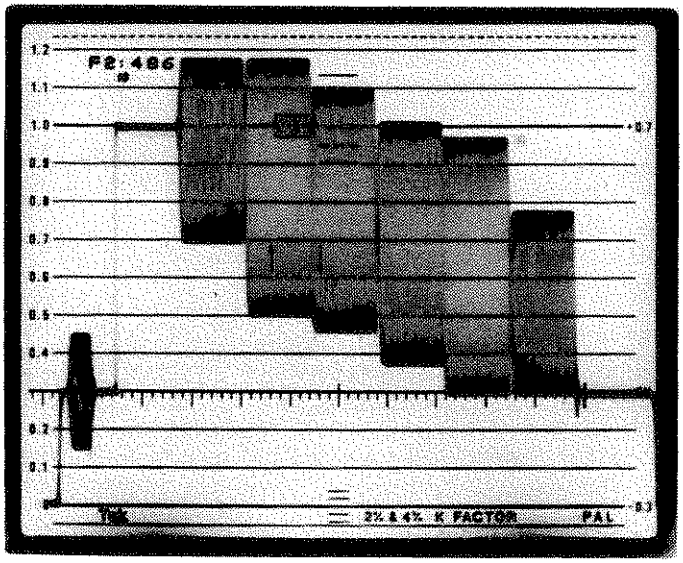

Fig. 2-15. A 1 Line Sweep rate with 15 continuous lines (from mid field) displayed using LINE SELECT.

12. Horizontal Magnifier

Select the 2H SWEEP and center the horizontal sync on the screen. Press the MAG button and note the magnification of the horizontal sync details. Push SWEEP for 2 FLD and MAG for X25 and note that the vertical interval is displayed. See Fig. 2-16.Note that the MAG button works with any SWEEP selection. Push the MAG button to turn off the MAG.

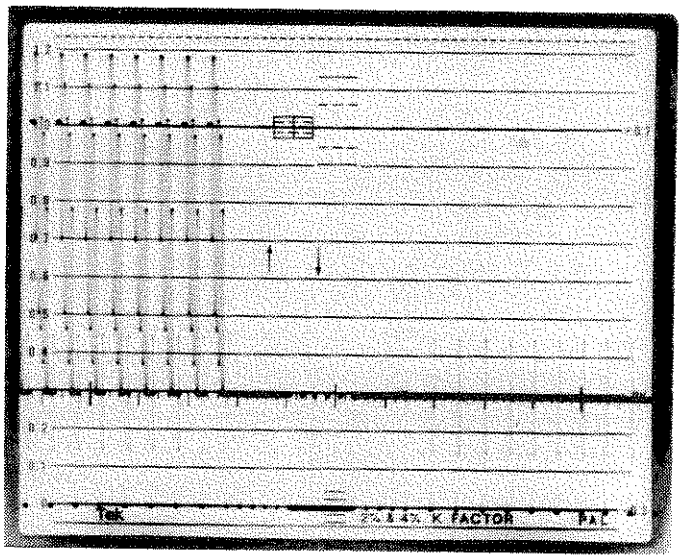

Fig. 2-16. Display of vertical interval with magnified 2 Field Sweep

13. Recall Setup

Set the 1730–Series for both CH–A and CH–B input, SWEEP to 1 LINE, MAG on, and VERTICAL GAIN to X5. Note front-panel indicators. Push the RECALL SETUP 1 button and note that the front-panel setup changes.

NOTE

The STORE function could also be checked; however, operating settings may be stored in the memory location, and they would be overwritten with the new front-panel information. For more information on how to use the STORE function, see CONTROLS and CONNECTORS in this section of the manual.

GRATICULES

There are three basic graticule patterns available for the 1730–Series. All three are internal with edge illumination. The graticule used by both the 1730 and the 1731 PAL-M is a 525 line/60 Hz NTSC Composite scale. The 1731 PAL has the CCIR 625 line/50 Hz graticule for the PAL color standard. The 1735 has a dual graticule which accomodates both NTSC and PAL scales.

Because the internal graticule is on the same plane as the CRT phosphor it eliminates viewing and photographic paralax errors. The graticule is illuminated, using a front-panel SCALE adjust control, so that the level of graticule brightness can be adjusted to optimum for viewing or photographing needs.

The major differences between the NTSC and PAL graticules are in the vertical scales. In the paragraphs that follow each of the vertical graticule scales will be discussed separately, while the horizontal scales are discussed together.

NTSC Composite Video Graticule Vertical Scales

The NTSC graticule has two main vertical scales to facilitate typical measurements. See Fig. 2-17. The left side scale is marked in IRE units and extends from –50 to +120 IRE in 10-IRE increments. An IRE unit is equal to 7.14 millivolts. Black level setup is denoted by a dashed line at 7.5 IRE.

There are ±2 IRE and ±4 IRE markings at the center of the –40 IRE line (sync tip) to assist in measuring sync amplitude. This scale is designed to be used with the 2 Line or 2 Field Sweep rates.

The scale on the right side of the graticule is for measuring depth of modulation. The scale extends from 0% at the 120 IRE line to 100% at sync tip (–40 IRE line).

The boxed area slightly to the right of center at the 100 IRE level is scaled in 2% and 4% increments for precise tilt measurements. This structure is designed to work with an 18 µs, half-amplitude duration (HAD) 2T Bar. The set of solid and short dashed lines to the left of the Bar tilt measurement structure is used to measure pulse-to-bar ratio; they are weighted to include K-Factor ratings of 2% and 4%.

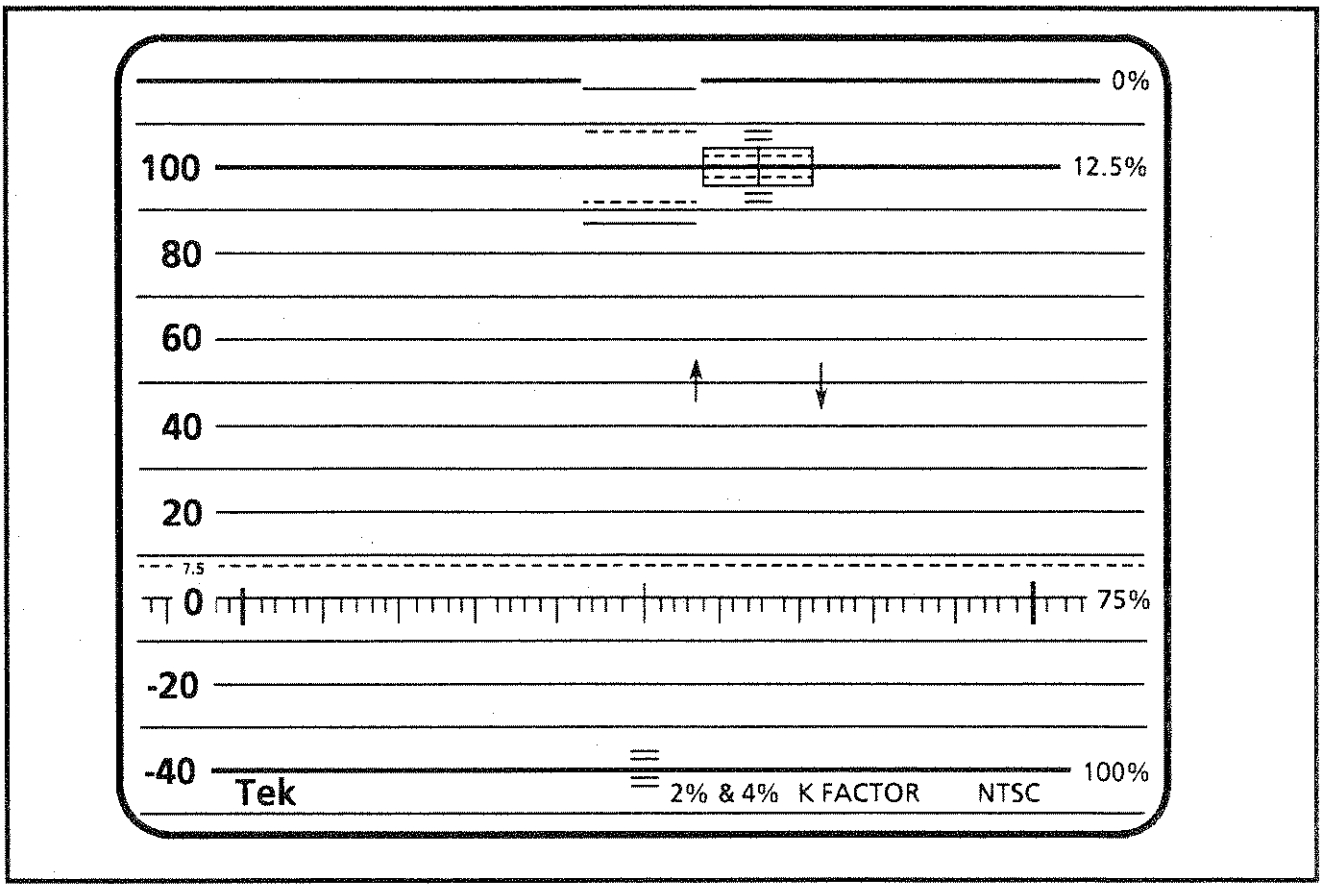

Fig. 2-17. NTSC graticule.

Making Measurements. To use the NTSC vertical scale to make line time distortion and pulse-to-bar ratio measurements, set the signal blanking level at the graticule blanking line (0 IRE) and position the leading edge of the Composite Test Signal bar to the ascending arrow (just right of graticule center). Check to see if insertion gain is unity. If it is not, adjust the 1730–Series VAR for exactly 100 IRE of signal amplitude from baseline to the middle of the white bar. Check to see that the negative-going bar transition passes through the descending arrow.

To measure the K-Factor line time distortion, measure the largest deviation of the bar top (tilt or rounding) within the structure. The structure is designed to ignore the first and last 1 µs of the bar where short-time distortions (ringing, overshoot, undershoot, etc.) occur. The solid outer box equals a 4% K-Factor, while the dashed line inner box equals a 2% K-Factor. (For signals with a bar half-amplitude duration that exceeds 18 µs, simply measure the bar top in increments by positioning the bar to the left or right from the leading or trailing edge. Note that when the leading or trailing edge is on the appropriate arrow, the first or last 1 µs is automatically excluded from the measurement.)

Pulse-to-bar K-Factor measurements are made using the solid and short dashed lines to the left of the line time distortion structure. These lines are scaled according to the following formulas:

$$\frac{1}{(1-4K)} \quad \text{and} \quad \frac{1}{(1+4K)}$$

Where: $K = 0.02$ for 2% K-Factor (dashed lines)
$K = 0.04$ for 4% K-Factor (dashed lines)

Calibrated 5X Gain increases resolution to 0.4% and 0.8%.

This scaling is described in detail in CCIR Standard Volume 5, 1966.

Make sure that the center of the bar is at 100 IRE when blanking level is at 0 IRE (use VAR to adjust gain, if necessary). If necessary, use the HORIZONTAL POSITION control to place the 2T Pulse over the measurement area and measure its amplitude. The top of the pulse falling within the dashed lines equals less than 2% K-Factor.

Horizontal Scales for NTSC and PAL Graticules

The Horizontal reference line is the baseline at 0 IRE (NTSC and PAL-M) or 0.3 V (PAL). This timing line is 12 divisions long on NTSC graticules (12.4 divisions for PAL), and takes on different timing intervals depending on the sweep rate selected. In 2 Line Sweep each major division is 10 µs, and when magnified (X10), each major division equals 1 µs. In 1 Line Sweep each major division is equal to 5 µs, and when magnified (X25), each major division equals 0.2 µs. In 2 Field Sweep the timing scale is of no real value, since this is a monitoring mode; however when 2 Field Sweep is magnified (X25), the entire vertical (field) interval can be displayed.

PAL Graticule Vertical Scales

The PAL graticule scales are from 0 to 1.2 V on the left side. See Fig. 2-18. The right side has markings at sync tip (–0.3 V), baseline (0 V), and peak white (+0.7 V). There are 2% and 4% markings at the horizontal center of the graticule on the 0 V line (sync tip level) to assist in measuring sync amplitude. The dashed horizontal line at the top of the graticule is equal to 1.234 V to indicate peak amplitude of 100% color bars.

The boxed area slightly to the left of center at the 1.0 V level is scaled for 2% and 4% K-Factor ratings for precise tilt measurements. This structure is designed to work with an 8 µs, half-amplitude duration (HAD) bar. The short dashed lines to the right of the Bar tilt measurement structure are used to measure pulse-to-bar ratio; they are weighted for 2% and 4% K-Factor ratings.

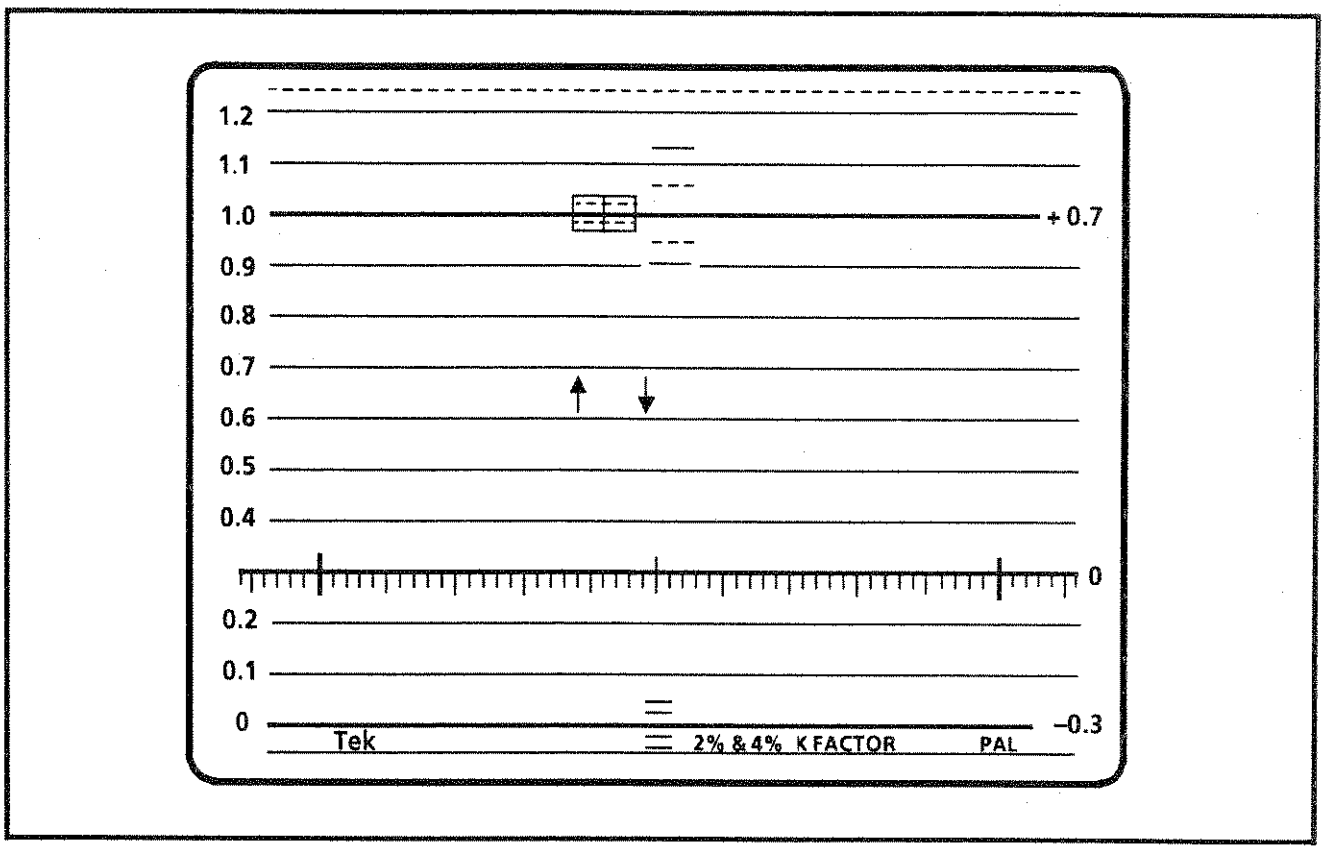

Fig. 2-18. PAL graticule.

Dual Graticule Vertical Scales

The PAL vertical scale, from 0V to 1.2V, is provided on the left side of the 1735 graticule. See Fig. 2-19. There are 2% and 4% markings near the horizontal center of the graticule on the 0V line (sync tip level) to assist in measuring sync amplitude. The dashed horizontal line at the top of the graticule is equal to 1.234V to indicate peak amplitude of 100% color bars. Between the 0.9V and 1.1V lines, there are markings at 20 mV intervals.

The NTSC vertical scale is provided on the right side of the 1735 graticule. It extends from –40 IRE to 120 IRE, in 10–IRE increments. Black level setup is denoted by a dashed line at 7.5 IRE. There are 2–IRE and 4–IRE markings near the horizontal center of the graticule, on the –40 IRE line (sync tip) to assist in measuring sync amplitude. This scale is designed to be used with the 2 Line or 2 Field Sweep rates.

Making Measurements. To use the PAL vertical scale for measuring the K-Factor for line time distortion and pulse-to-bar ratio measurements, set the signal blanking level at the graticule blanking line (0.3 V) and position the leading edge of the bar to the ascending arrow, just right of graticule center. Check to see if insertion gain is unity. If it is not, adjust the 1730–Series VAR for exactly 0.7 V of signal amplitude from baseline to middle of the white bar. Check to see that the negative-going bar transition passes through the descending arrow.

To measure the K-Factor for line time distortion, measure the largest deviation of the bar top (tilt or rounding) within the structure. The structure is designed to ignore the first and last 1 µs of the bar where short-time distortions (ringing, overshoot, undershoot, etc.) occur. The solid outer box equals a 4% K-Factor, while the dashed line inner box equals 2% line time K-Factor. (For signals with a bar half-amplitude duration (HAD) that exceeds 8 µs, simply measure the bar top in increments by positioning

the bar to the left or right from the leading or trailing edge. Note that when the leading and trailing edge is on the appropriate arrow, the first or last 1 µs is automatically excluded from the measurement.)

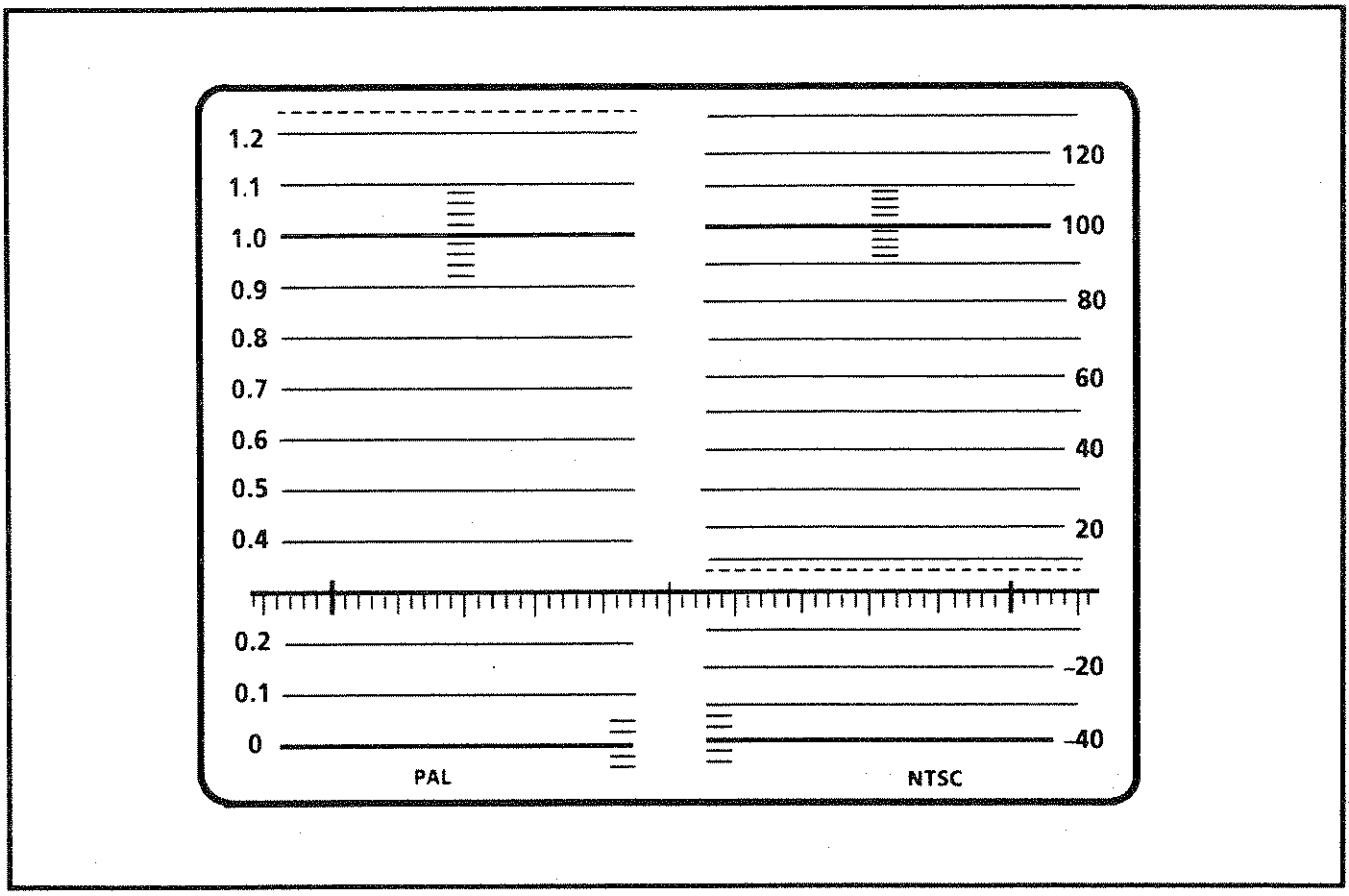

Fig. 2-19. Dual-standard graticule

Pulse-to-bar K-Factor measurements are made using the solid and short dashed lines to the right of the line time distortion structure. These lines are scaled to the following formulas:

$$\frac{1}{(1-4K)} \quad \text{and} \quad \frac{1}{(1+4K)}$$

Where: K = 0.02 for 2% K-Factor (dashed lines)
K = 0.04 for 4% K-Factor (dashed lines)

Calibrated 5X Gain increases resolution to 0.4% and 0.8%.

This scaling is described in detail in CCIR Standard Volume 5, 1966.

Make sure that the center of the bar is at 100 IRE when blanking level is at 0 IRE (use VAR to adjust gain, if necessary). If necessary, use the HORIZONTAL POSITION control to place the 2T Pulse over the measurement area and measure its amplitude. The top of the pulse falling within the dashed lines equals less than 2% K-Factor.

PRESET FRONT-PANEL MEASUREMENTS

The 1730–Series has four front-panel setups stored in internal memory. A TTL low (or ground closure) on one of the PRESET enables (pins 12 through 15 of the REMOTE connector) selects one of these pre-programmed, front-panel setups. Table 2-2 shows the preset front panels that are stored in memory.

When the 1730–Series is used as a direct replacement for the TEKTRONIX 528A Waveform Monitor (which used dc voltage levels as enables), it will be necessary to use a conversion circuit to change these positive voltage levels to apparent ground closures. See SECTION 3 for a simple conversion circuit.

RGB/YRGB DISPLAY

RGB staircase signals, either 3- or 4-step, are input to the 1730–Series through the rear-panel REMOTE connector. A 10 V input will provide a horizontal sweep length between 7.6 and 10.4 major graticule divisions. An adjustment on the Main Circuit Board (R856) can be used to adjust for offsets in various staircase signals. RGB sweep is enabled by a TTL low, which can be a ground closure applied to pin 2 of the rear-panel 15-pin connector. (There is a connector drawing in SECTION 3, INSTALLATION, of this manual.) The staircase signal is input through pin 1 of the connector.

Field and line rate displays, controlled by front-panel SWEEP settings, are available. These sweep rates can be magnified (2 LINE X10 and 2 FLD or 1 LINE X25). In addition, a low (ground closure) at pin 3, when 2 FLD SWEEP is selected, provides a 1 Field Sweep.

Remote Sync

Pin 10 of the REMOTE connector is a remote sync input. A 30 or 60 (25 or 50 Hz for PAL) square wave signal with an amplitude of 2 to 5 volts will trigger the 1730–Series 2 FLD Sweep. In addition, a 4 V composite sync signal can also be used as a remote sync signal. Pin 4, when pulled low (TTL low or ground) enables the Remote Sync triggering.

Table 2-3
Preset Front Panels

Front-Panel Control	Preset 1 (pin 13)	Preset 2 (pin 14)	Preset 3 (pin 15)	Preset 4 (pin 12)
INPUT Channel	A	A	A	A
REF	EXT	INT	INT	INT
FILTER	FLAT	FLAT	FLAT	FLAT
VERTICAL GAIN (VAR)	off	off	off	off
GAIN (X5)	off	off	off	off
DC REST	OFF	OFF	SLOW	SLOW
HORIZONTAL FIELD	FLD 1	FLD 1	ALL	FLD 1
SWEEP	2 FLD	2 LINE	1 LINE	2 LINE
MAG	off	off	off	off
LINE SELECT ON/15 LINE	off	15 LINE	ON	off
FIELD	1	ALL	ALL	1
LINE	19	—	19	19

PART II
SERVICE INFORMATION

SECTION 3
INSTALLATION

Packaging

The shipping carton and pads provide protection for the instrument during transit, they should be retained in case subsequent shipment becomes necessary. Repackaging instructions can be found in SECTION 6 (MAINTENANCE) of this manual.

ELECTRICAL INSTALLATION

Power Source

This instrument is intended to operate from a single-phase power source having one of its current-carrying conductors at or near earth-ground (the neutral conductor). Only the Line conductor is fused for over-current protection. Systems that have both current-carrying conductors live with respect to ground (such as phase-to-phase in multiphase systems) are not recommended as power sources.

Mains Frequency and Voltage Ranges

1700–Series instruments operate over a frequency range of 48 to 66 Hz, and at a nominal mains voltages of 120 Vac or 220 Vac. The instrument is shipped from the factory set up for either 120 V or 220 V operation; be sure that it is operated with the selected mains voltage. The rear panel of the instrument is marked, by placement of a screw, to identify the correct operating mains voltage. See Fig. 3-1.

Changing The Mains Voltage

Mains voltage is set for 120 Vac by the presence of a wire strap on the Power Supply (Assembly A1) etched circuit board. See Fig. 3-2. If there is no strap in the 120 V position, the mains voltage is set for 220 Vac. To convert from 120 to 220 simply remove the strap. To convert from 220 to 120, solder in a wire strap across the 120 Vac circuit board pads. (There are two sets of pads, either the inner or outer set of pads can be used.)

Operating Options

Not all installations are identical. In order to make operation of the 1730–Series Waveform Monitor as flexible as possible there are internal jumpers that can be changed to provide operating options. For example, it is possible to select either the 3-step or 4-step parade to accommodate RGB or YRGB displays. With the exception of the 50–60 Hz jumper, the factory preset position is indicated by a box printed on the etched circuit board. Table 3-1 details these internal jumper selections. Be sure that all operators are aware of changes, to prevent unnecessary trouble reports, if any of these jumpers are placed in the optional position. See Fig. 3-3 for location of the internal plug jumpers.

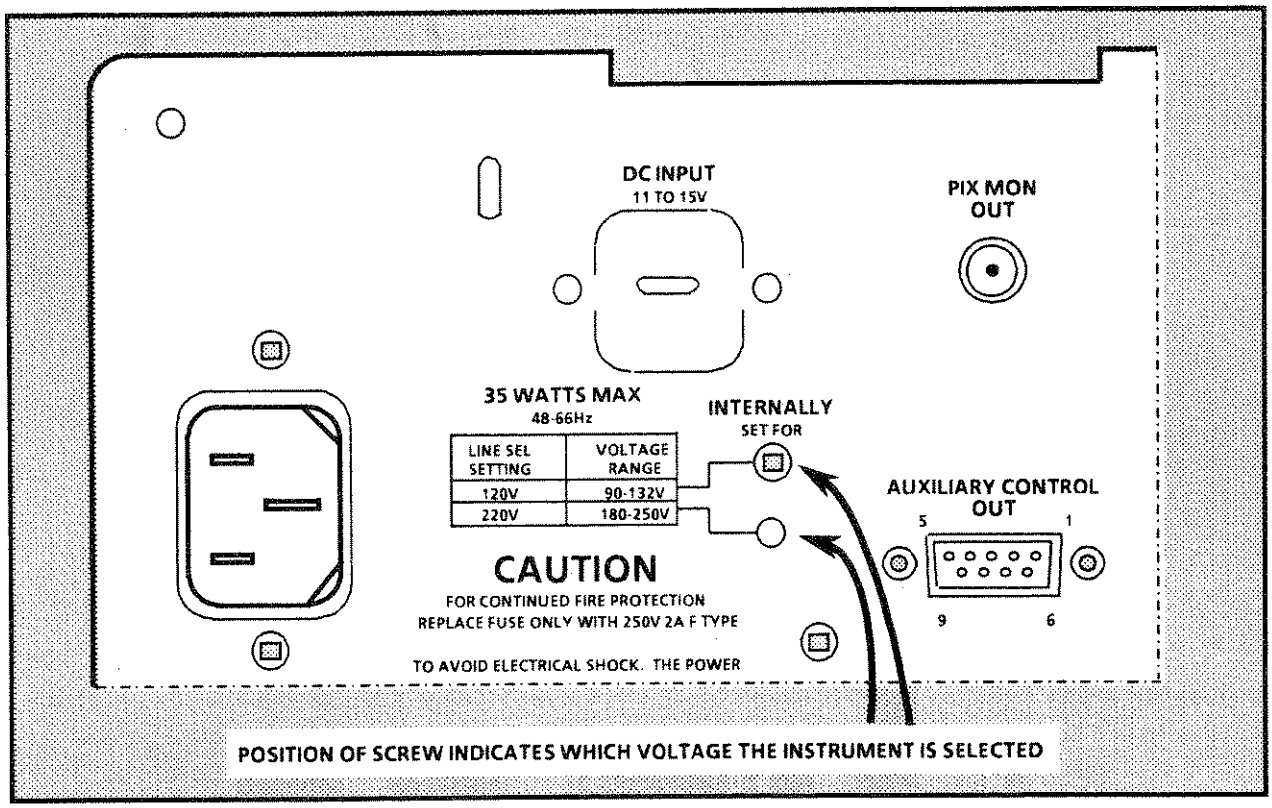

Fig. 3-1. Rear-panel line selector indicating instrument is set for 120 V mains.

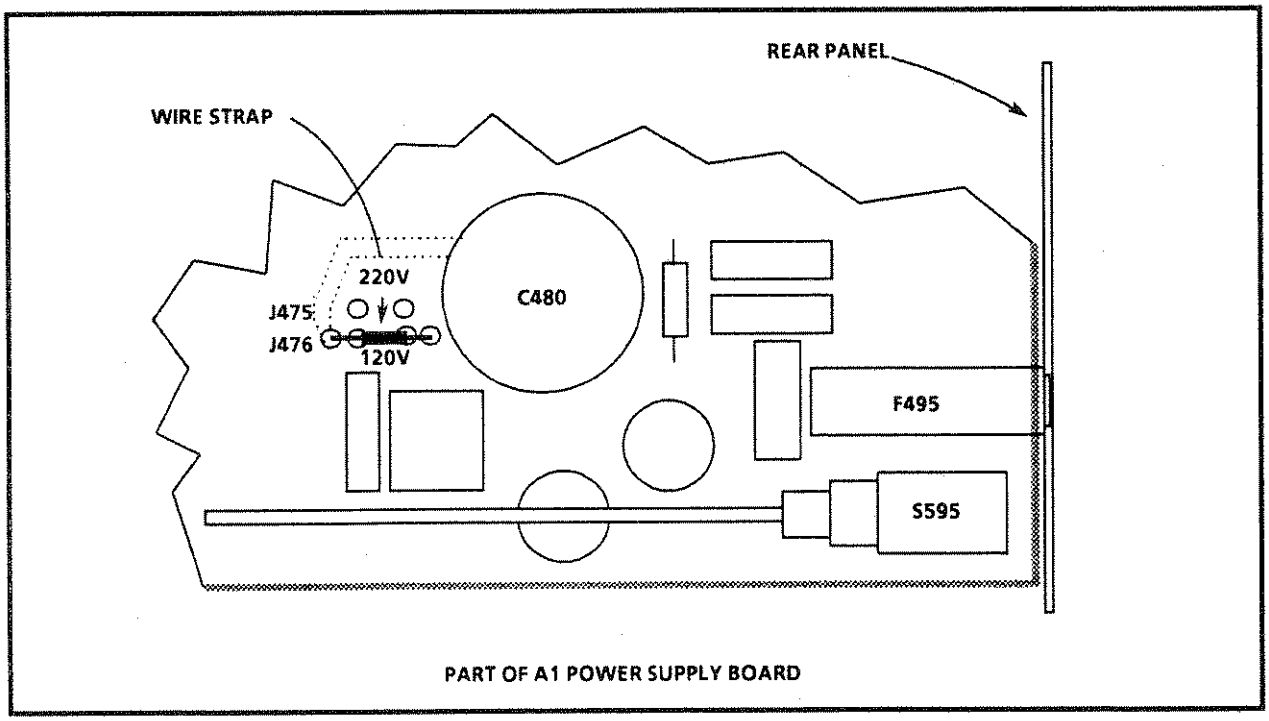

Fig. 3-2. Strap across J476 sets mains voltage to 120 V.

Table 3-1
Internal Jumper Selection

Jumper Number	Name	Position	Purpose
J197	CH-A Input Coupling	1–2	ac coupled (factory preset)
		2–3	dc coupled
J699	CH-B Input Coupling	1–2	ac coupled (factory preset)
		2–3	dc coupled
J456	RGB/YRGB	1–2	RGB, 3-step parade display (factory preset)
		2–3	YRGB, 4-step parade display
J504	50/60 Hz	1–2	50 Hz line rate (factory set for 1731 PAL)
		2–3	60 Hz line rate (factory set for 1730 and 1731 PAL-M)
J635	Remote Sync Polarity	1–2	Positive sync polarity (factory preset)
		2–3	Negative sync polarity

RGB OFFSET and COMPENSATION

Television cameras vary in output dc level; R856 is provided to compensate for this variation in dc level. C953 is the compensation adjustment. See Fig. 3-3 for their locations.

Procedure for setting RGB Offset — Each time the camera input to the 1730–Series is changed the RGB Offset will probably have to be reset. The following procedure provides a simple means to retweak this adjustment.

1. Display any standard television waveform (do not have the rear-panel RGB Enable set low).
2. Set the 1730–Series HORIZONTAL POSITION control so that the display is aligned with the graticule.
3. Activate the RGB Enable, apply the camera staircase output to the RGB Staircase input, and apply the camera's video output to the 1730–Series INPUT (CH–A or CH–B).
4. ADJUST — R856 to center the RGB or YRGB signal on the 1730–Series graticule. See Fig. 3-3 for the location of R856.
5. ADJUST — C953 for the best looking display on the 1730–Series.

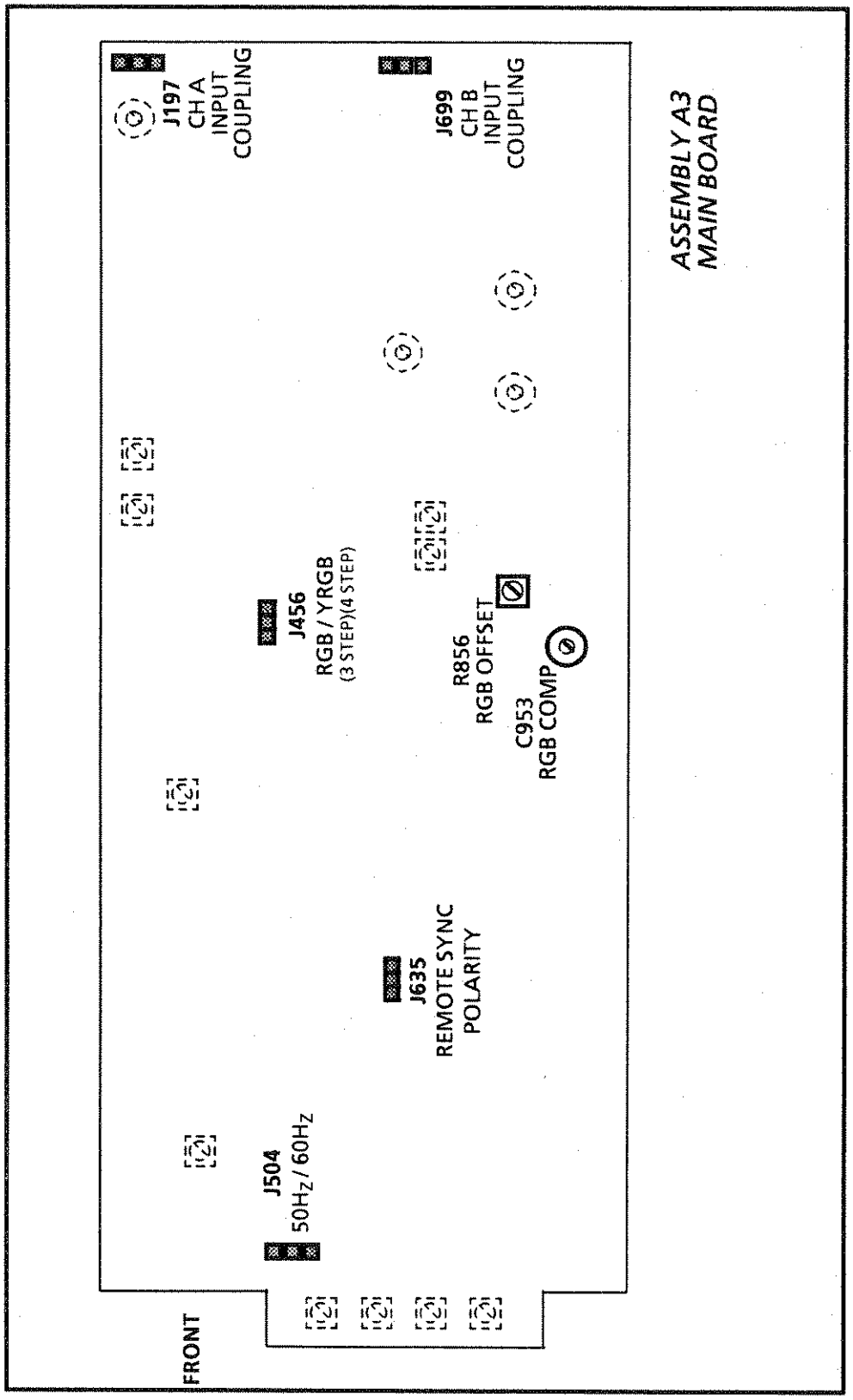

Fig. 3-3. Location of plug jumpers and RGB adjustments when the instrument is on its left side.

REMOTE Connector

The rear-panel REMOTE connector is a 15-pin, D-type connector. It provides the Remote Control Interface, the input connector for RGB signals, and the input for Remote Sync.

Remote functions, which provide switching and storing of front-panel setups at a remote location, are enabled by ground closures (TTL lows). In addition to the four front-panel RECALL SETUPs that can be called up remotely, there are four additional factory-programmed Presets that can only be called up through the REMOTE connector.

The RGB input provides a stable, nine-division parade display of RGB or YRGB with an approximate 10 volt input.

Remote sync requires approximately 2 to 5 V input of 25–30 Hz or 50–60 Hz signal to synchronize the 1730; polarity is internal jumper selected, see Table 3-1.

Pin assignments for the REMOTE connector are shown in Fig. 3-4 and Table 3-2.

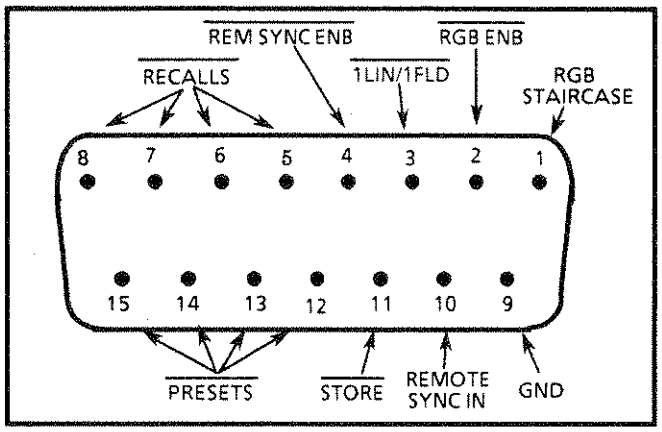

Fig. 3-4. Rear view of 1730–Series rear panel showing REMOTE connector pins with their functions.

Table 3-2
REMOTE Connector Pin Assignments

Pin #	Use
1	RGB Staircase
2	$\overline{\text{RGB Enable}}$
3	$\overline{\text{1LIN/1FLD}}$
4	$\overline{\text{Remote Sync Enable}}$
5	$\overline{\text{Recall 2}}$
6	$\overline{\text{Recall 3}}$
7	$\overline{\text{Recall 1}}$
8	$\overline{\text{Recall 4}}$
9	Ground
10	Remote Sync In
11	$\overline{\text{Store}}$
12	$\overline{\text{Front Panel Preset 4}}$
13	$\overline{\text{Front Panel Preset 1}}$
14	$\overline{\text{Front Panel Preset 2}}$
15	$\overline{\text{Front Panel Preset 3}}$

AUXILIARY Connector

The rear-panel AUXILIARY connector is a 9-pin, D-type connector. It is used to operate a companion 1720–Series Vectorscope. Line and Field selection information is provided to the Vectorscope over the bus that is contained in this interface. Fig. 3-5 shows the AUXILIARY connector pin assignments.

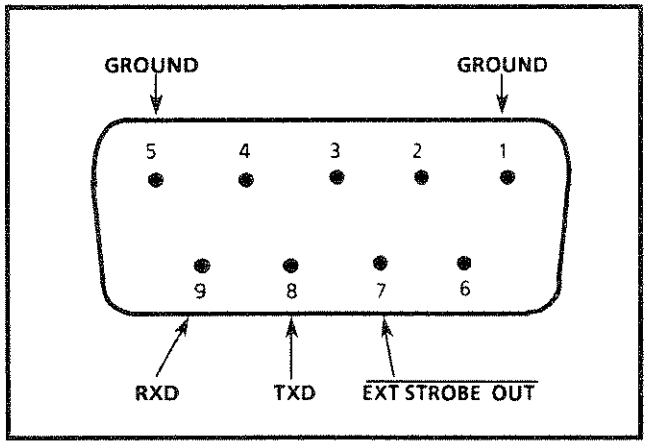

Fig. 3-5. Rear view of the 1730-Series rear panel showing AUXILIARY connector pins with their functions.

MECHANICAL INSTALLATION

Rackmounting

The 1730-Series requires a metal cabinet for safe operation. In addition, electrical specifications are valid only when the instrument is properly shielded by a cabinet. Any of the field installable upgrades (1700F00, 1700F02, or 1700F051) satisfy these requirements. The plain metal cabinet, 1700F00, has four 0.156 inch diameter holes in the bottom of the cabinet depression that are used to mount the instrument solidly to a surface such as a metal shelf in a rack.

With the optional 1700F05 Side-by-Side Rack Adapter the 1700-Series instrument can be mounted in a standard 19-inch rack, side by side with another half-rack-sized instrument, such as a companion 1700-Series instrument (1720 and 1730 operating together). The adapter includes two attached cabinets that are equipped for rack-mounting.

If only one instrument is mounted in the rack adapter, a blank panel assembly (1700F06) is available to insert in the empty rack adapter cabinet. Fig. 3-6 shows the details of this type of rack installation.

The rack adapter and panel (1700F05 and 1700F06) are available through your local Tektronix field office or representative.

Custom Installation.

Fig. 3-7 shows a typical custom installation and is provided as a reference for installations in applications such as consoles. It is possible to mount the instrument with either a flush front panel or have the front casting protruding. The limiting factors are the depth available and the size of the opening cut in the console. In both cases plan for approximately 3 inches of rear clearance for bnc and power cord connections.

In order to safely hold the 1700-Series instrument, the cabinet should be attached to a shelf strong enough to hold the instrument's weight. The holes in the cabinet, that normally are used to mount the feet, can be used to attach it to such a shelf.

Cabinet Options

All qualification testing for the 1730-Series was performed with a cabinet (1700F00) installed; in order to guarantee compliance with all specifications the instrument should be operated in a cabinet. There are two cabinets that can be ordered as optional accessories for the 1700-Series instruments. The two cabinets are similar. One, the 1700F02 (which is the cabinet designed for portable applications), has a carrying handle; the standard cabinet does not have a handle. The plain cabinet (1700F00) is used for custom installations or for using the instrument on a bench. Fig. 3-8 is a dimensional drawing of the 1700F00 cabinet.

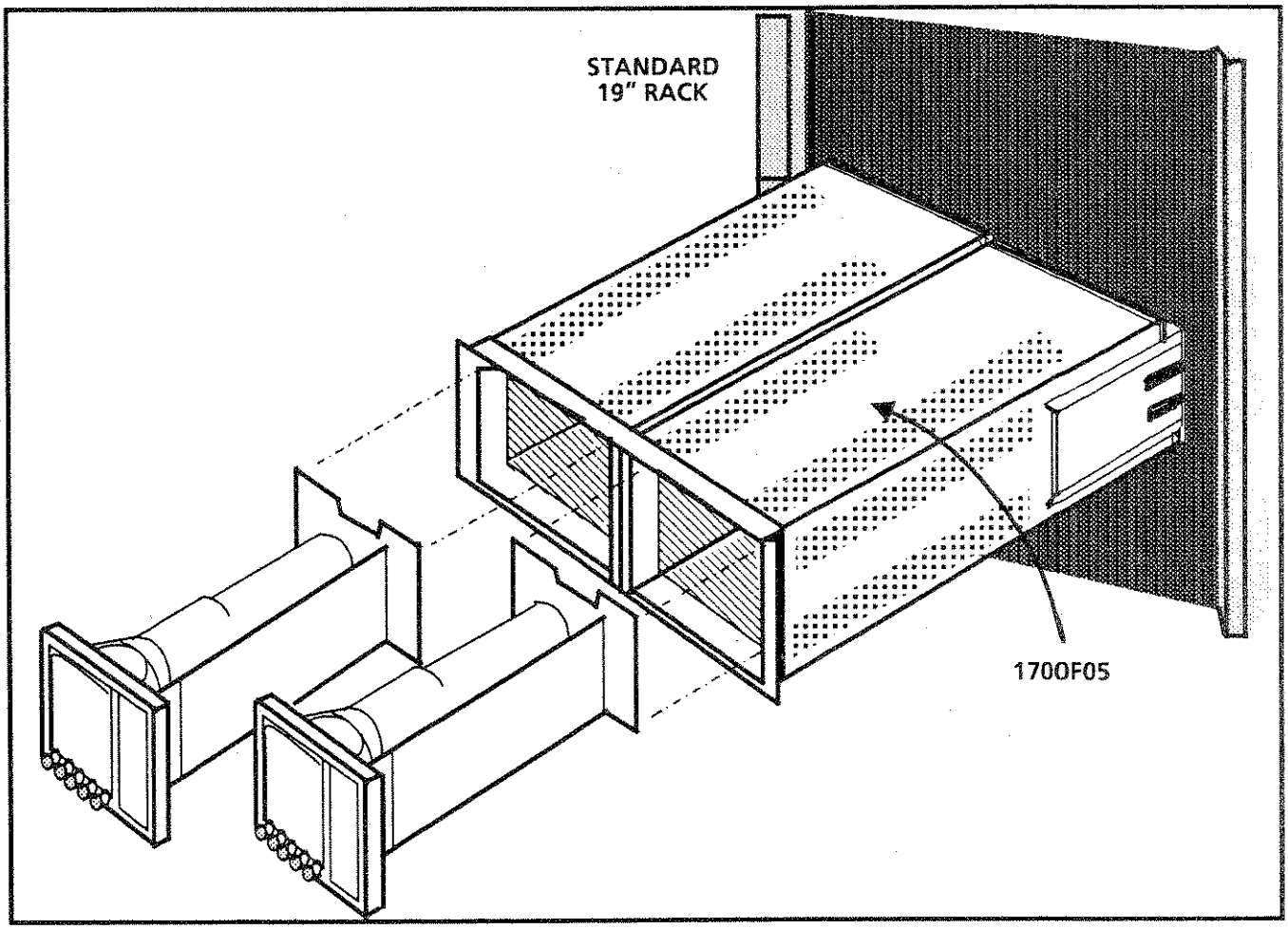

Fig. 3-6. 1700F05 rack mounting for two 5-1/4-inch units, such as a 1730–Series and its companion 1720–Series.

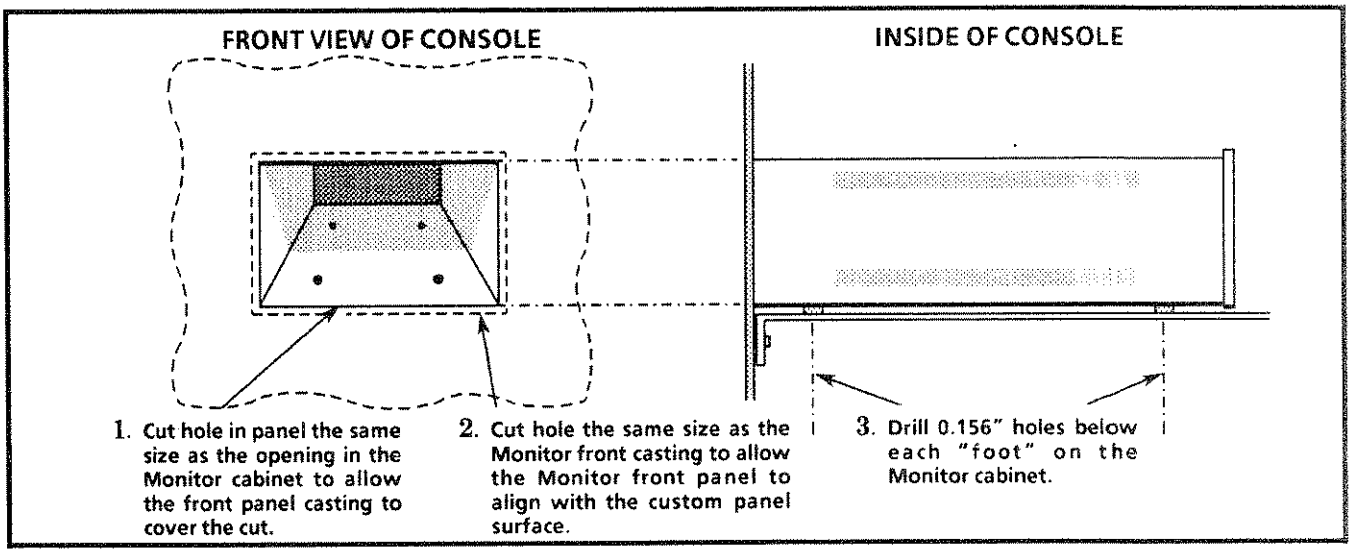

Fig. 3-7. Typical custom installation.

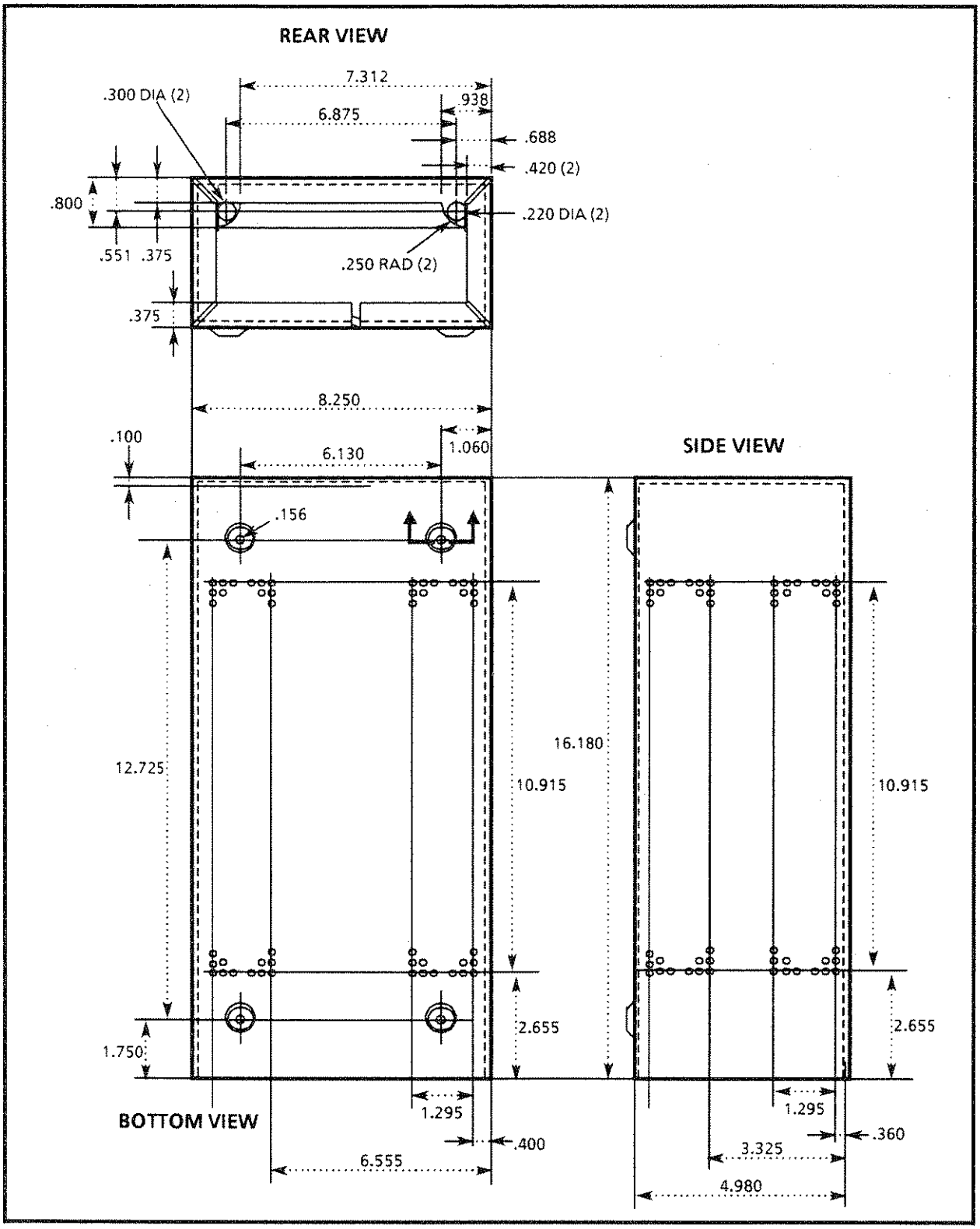

Fig. 3-8. Dimensional drawing of the 1700F00 cabinet.

Cabinetizing

There are two screws used to secure the instrument in its cabinet. See Fig 3-9. They are installed in the upper corners of the instrument rear panel.

WARNING

Do not attempt to carry a cabinetized instrument without installing the mounting screws. There is nothing to hold the instrument in the cabinet if it is tipped forward.

DC Power Supply Field Upgrade

The 1730–Series can be operated from a 12 Vdc source. In order to power this instrument from a dc source it is necessary to add a TEKTRONIX 1700F10 Field Upgrade Kit. The kit consists of a small etched circuit board, rear-panel plug, and the associated cabling. Installation requires only common hand tools, a soldering iron, and about 30 minutes of labor.

Once a 1700F10 Field Upgrade Kit has been installed, the Waveform Monitor can be operated from a 12 Vdc source, including a TEKTRONIX BP1 Battery Pack, or its rated ac mains voltage.

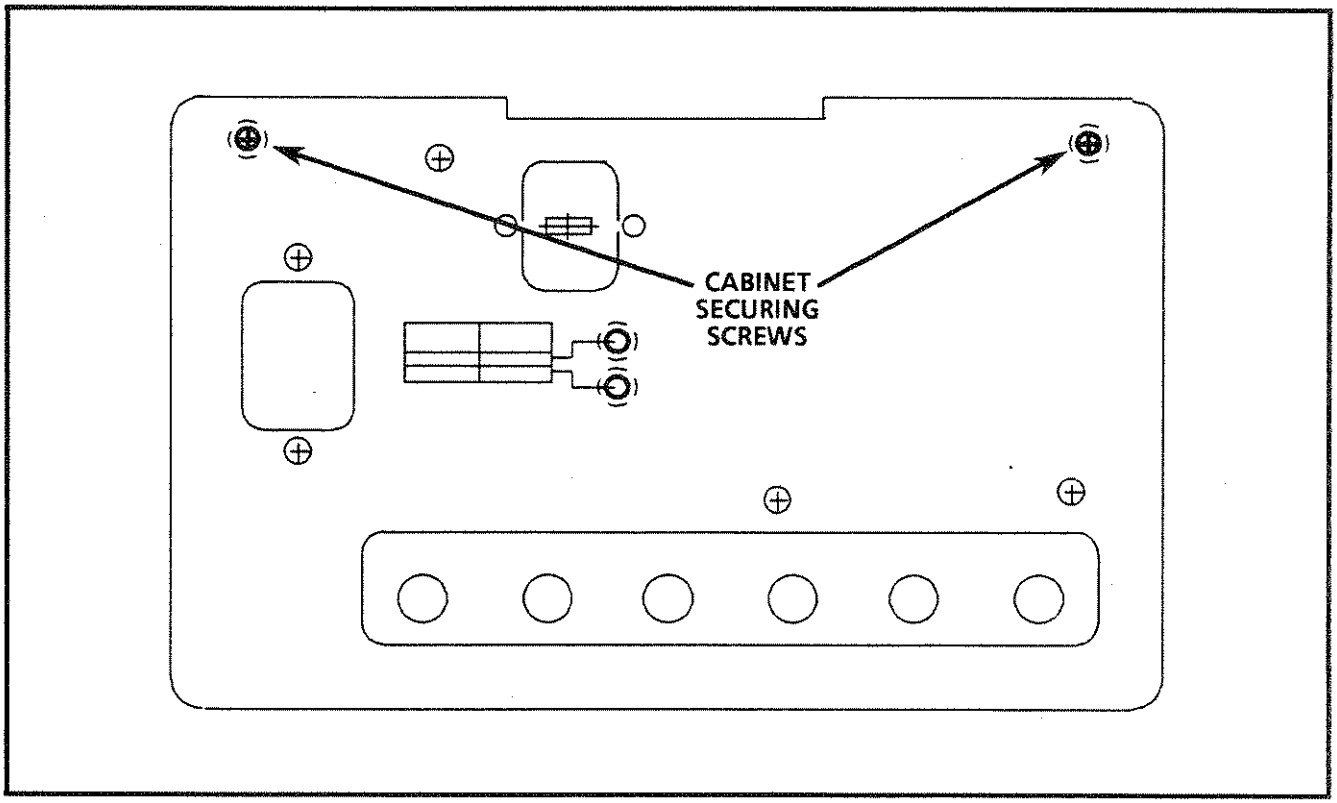

Fig. 3-9. Screws used to mount the 1730–Series Waveform Monitor in a cabinet or carrying case.

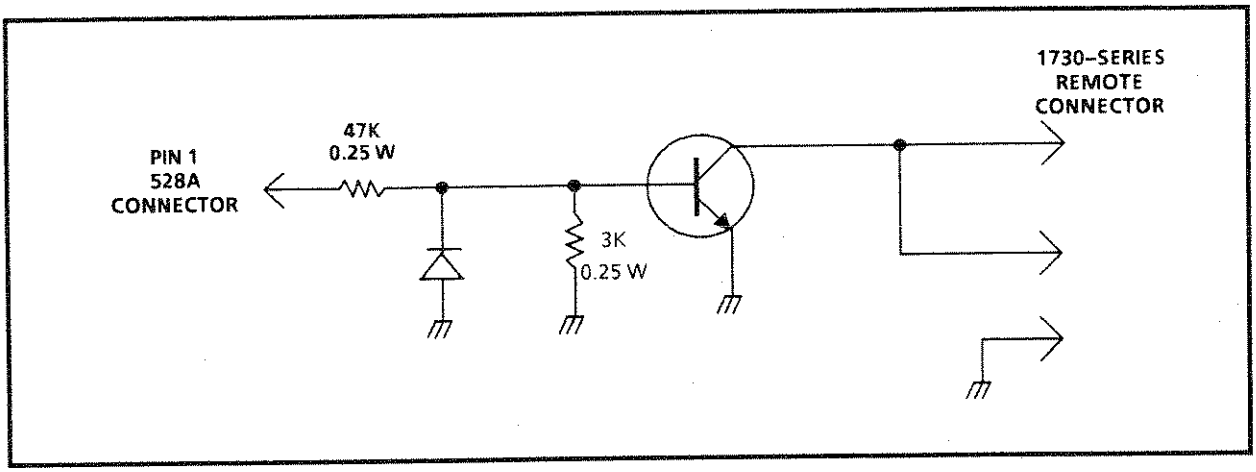

Fig. 3-10. Common parts used to convert from 28 Vdc to 0 Vdc.

DC Voltage Level - TTL Converter

When the 1730-Series Waveform Monitor is substituted for a TEKTRONIX 528 or 528A Waveform Monitor, the enable levels must be converted from 28 Vdc to 0 Vdc. This conversion requires only a few common parts. See Fig. 3-10.

SECTION 4
THEORY OF OPERATION

The material in this section is subdivided into a general description (which is supported by the main block diagram and simplified block diagrams) and detailed circuit descriptions that use the schematic diagrams as illustrations. A thorough under-standing of the instrument starts with knowing how the major circuit blocks fit together, followed by an understanding of the individual circuit's functions. These discussions of the 1730–Series Waveform Monitor begin with a brief, fundamental overview, then proceed on to the block diagram, and then go into individual circuit descriptions.

Overview

The 1730–Series is a specialized oscilloscope, designed to monitor and measure television base-band signals. Signals input through either of the rear-panel 75 Ω bridging loop-through inputs are displayed on the crt. In addition, an alpha-numeric line and field readout is provided on the crt for use with the LINE SELECT mode of operation.

Front-panel mode switching is accomplished by a series of push-button switches whose status is being constantly polled by a Microprocessor. In turn, the Microprocessor controls switching functions and circuit gains so that the instrument can perform as a monitor or be used to make specific measurements. The Microprocessor is an 8051 type. See Fig. 4-1.

The Low Voltage Power Supply is a high-efficiency switching type. The High Voltage Power Supply provides 13 kV acceleration potential.

Block Diagram

The main block diagram for the 1730–Series Waveform Monitor is located on a pullout diagram in SECTION 9 of this manual. The following functional description uses this diagram as its illustration. The numbers on the circuit blocks correspond to the schematic diagram for that circuit.

Circuit Blocks

Vertical

Color-encoded video signals are input through the bridging Channel A and Channel B inputs. The input amplifiers are shunted by sample-and-hold-type clamps, that are timed by a Back Porch Sample from the Back Porch Generator. Switching at the output of the amplifiers provides for display of either signal or a combination of both in all sweep modes. In the combination mode, the Channel A signal is displayed on the left of the CRT with the Channel B following. This clamped signal, prior to any filtering, is also the rear-panel Picture Monitor Output. In LINE SELECT modes, a strobe, that acts as a bright-up pulse, is added to the Picture Monitor Output to identify the selected line (or block of lines in 15 Line).

Front-panel switching selects a Flat (unfiltered), Low Pass, or Chroma filtered signal for display. Low-pass filtering can be used with Flat as part of a dual filter mode for all sweep modes. In the dual filter mode, the low-passed signal is displayed to the left with the unfiltered (flat) signal following. When the calibrator signal is selected (from the front-panel switching), a 1 volt, 100 kHz signal is applied to the input of the Gain Cell instead of input video. The calibrator signal is used to set up both Vertical Gain (Volts Full Scale) or Horizontal Gain (Sweep rate) from a self-contained source.

Signal amplitude can be adjusted at the Gain Cell using either the front-panel V GAIN or VARIABLE gain control. The output signal from the Gain Cell drives another clamped amplifier. This second clamped amplifier has a loop-compensated sample-and-hold circuit that provides the fast clamping needed for the Fast DC Restorer. Clamping, as with the first clamp, occurs at the back porch.

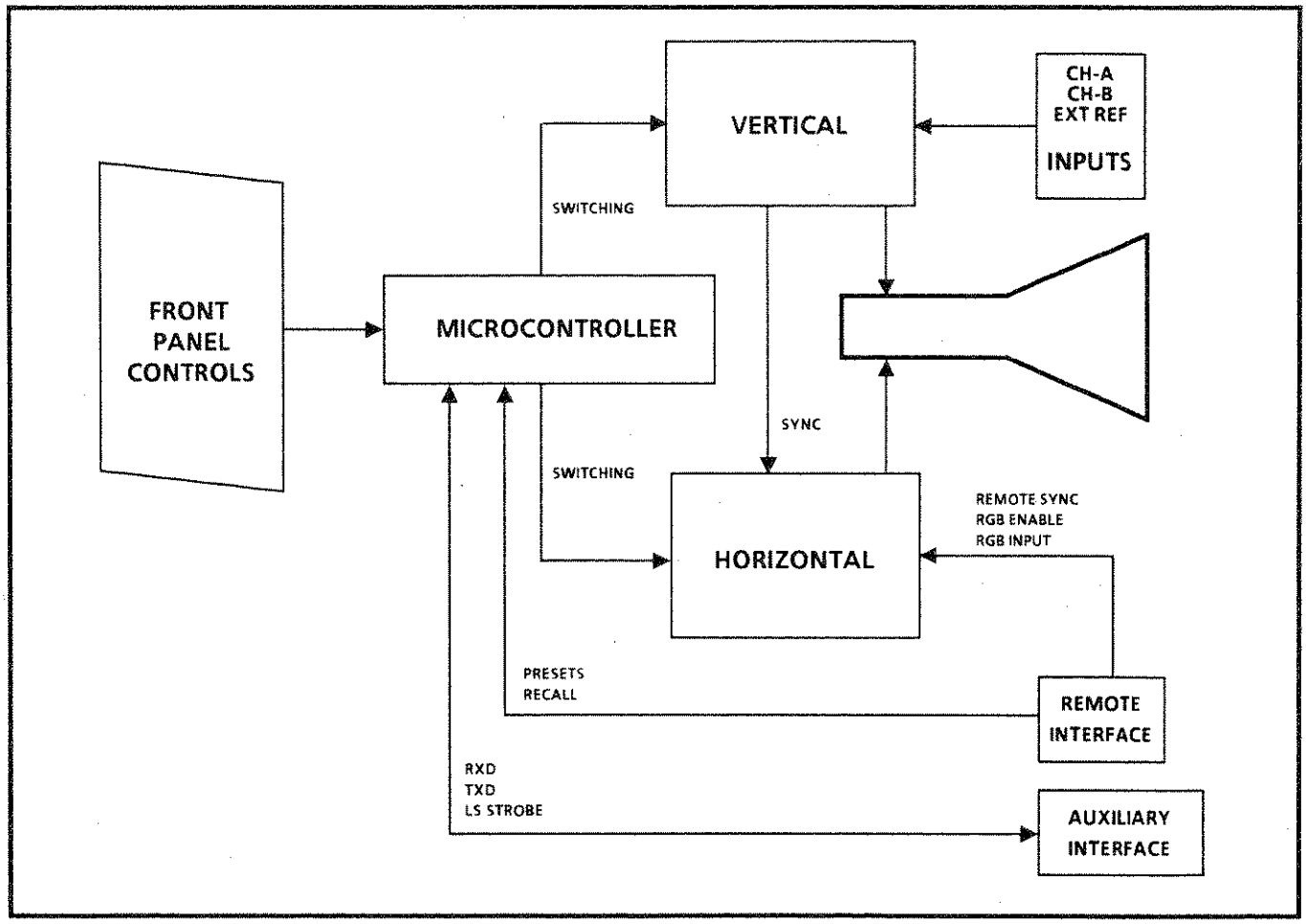

Fig. 4-1. Simplified representation of the 1730–Series Waveform Monitor.

A Vertical Positioning voltage, along with the conditioned video signal, is input to the Switchable Gain Amplifier. Amplifier gain and positioning range are increased by a factor of 5 when X5 Gain is selected at the front panel. The limiter stage that follows this amplifier prevents overdriving of the Output Amplifier.

The conditioned video signal and the Y component of the Readout (from the Microprocessor) are input to the Vertical Output Amplifier, which matches impedances and normalizes gain (approximately 40 V for 8 cm of vertical deflection) to drive the crt vertical deflection plates.

Horizontal

Composite video from either internal (Channel A or B) or external reference has all active video stripped away by the Sync Stripper to leave only sync for the Sweep Trigger. Remote sync bypasses the Sync Stripper and triggers the sweep directly when enabled. Any of these three sync sources can be used the REMOTE connector to provide the Parade display.

A plug-jumper determines the polarity of the remote sync for internal triggering: NORMAL provides line rate triggering off a NEGATIVE edge and field rate triggering off a POSITIVE edge, while INVERTED provides line rate triggering off a POSITIVE edge and field rate triggering off a NEGATIVE edge.

The output of the Sync Stripper (or remote sync) drives the Back Porch Generator, Vertical Sync Recognition, and Horizontal AFC. Outputs from the Vertical Sync Recognition and Horizontal AFC are used by the Field ID and Trigger Select to trigger the Sweep Generator. If Calibrator is selected, the Cal Drive signal from the Microprocessor provides the triggering signal instead.

The Horizontal AFC output, in conjunction with Microprocessor control, drives the Line Select, whose output provides a pulse that:

1. Drives the Z-Axis Control to unblank the crt at selected line(s).

2. Provides a bright-up strobe at the selected line(s) for 2 Field Sweep.

3. Provides the Picture Monitor Output bright-up strobe.

4. Generates the Auxiliary Blanking strobe that is used by a companion 1720–Series for line select.

The ramp output signal by the Sweep Generator drives the Mag Amplifier, which has three gain ranges, X1 (Un-Magnified Sweep), X10 (1 µs/div. in 2 Line Sweep), and X25 (to display the full vertical interval in 2 Field Sweep and provide 0.2 µs/div. in 1 Line Sweep). The Horizontal Positioning offset voltage is input to this amplifier guaranteeing sufficient range to position any part of the display onto the graticule.

When the RGB Parade display is enabled, the sweep is shortened and is offset by the RGB Staircase input signal to produce three short ramps that are displayed in sequence as a normal-sized sweep.

The output of the Mag Amplifier and the X component of the Readout (from the Microprocessor) drive the Horizontal Output Amplifier, which matches impedances and normalizes gain (approximately 100 V for a 10-cm sweep length) to drive the CRT horizontal deflection plates.

CRT, Unblanking, and High Voltage

The blanking signal (from Line Select) and the Intensity and Readout voltages are used by the Z-Axis Control to unblank the crt during sweep time; when sweep is magnified, the off-screen portion of the sweep is blanked to increase contrast ratio. The Focus Amplifier, controlled by the front-panel control, provides a voltage to the crt focus ring.

Trace Rotation provides compensation for the magnetic field surrounding the crt. The crt is of the Post Acceleration type, which requires a relatively high potential difference between the cathode and post anode. The boost in 2nd anode voltage is provided by an encapsulated 4X Multiplier.

DIAGRAM 1
VERTICAL INPUT

This diagram contains the input channels, external sync input and sync source switch, the channel switch, the filter switching, and the Sync Stripper and Calibrator circuits.

Input Amplifiers

The rear-panel Channel A and B inputs are two high-impedance loop-throughs compensated for 75Ω. Each amplifier has a DC Restorer that is turned off or on by the front-panel REST switch. The restorers are turned on and off together. The two input amplifiers are identical, so specific information is only given for CH–A.

The CH–A Input Amplifier is an inverting feedback operational amplifier with a gain of –1; R196 (15 k) is the input resistor and R198 (15 k) is the feedback resistor. J197 is factory set to the 1–2 position to ac couple the input. It can be moved to the 2–3 position for dc coupling; this bypasses C197, the ac-coupling capacitor.

The DC Restorer is a feedback sample-and-hold circuit. The sampling occurs when one section (pins 2 and 3) of U395 (an analog switch) closes at back porch time and the hold cap, C398, charges. If REST is selected, another segment of U395 (pins 14 and 15) is closed and the Buffer Amplifier, U495A, which is loop-compensated, drives the summing junction through R197. This restorer has a time constant that will not attenuate 50/60 Hz hum more that 10% with the restorer turned on. The choice of FAST or SLOW time constant is made with another restorer that is shown on Diagram 2.

Channel Switch

The output signals from the CH-A or $\overline{\text{CH-B}}$ Input Amplifiers are input to the channel switch, U492, through pins 2 and 3, respectively. The selection of either Channel A or B is determined by the level of the $\overline{\text{CH-B}}$ signal at pin 10 of U492. When low, $\overline{\text{CH-B}}$ is selected; if its high, the choice is CH-A. The output, pin 6, drives a current mirror with three output sources. One of these sources, Q793, drives the rear-panel Picture Monitor Output Amplifier. Q792 is the source for the internal sync signal and Q791 is the driving source for the remainder of the vertical. With a 1V input signal and R392 (or R393) at 900 Ω there will be 1.11 mA of signal current flowing into the channel switch. This much signal current is available from Q791 and Q793; however, Q792 can only provide 0.5 mA of signal current because its emitter resistor, R694, is twice the resistance of R792.

External Sync Input and Source Switch

The external sync signal from the rear-panel EXT REF loop-through is buffered by an operational amplifier in U795. It has a gain of -1 that is determined by the combination of input resistor R997 (15 k) and feedback resistor R898 (15 k). This amplifier drives Q798, the current source for the sync switch.

The internal sync source is from the collector of Q792. It is one input to the sync source switch, which is comprised of U795, CR696, CR697, CR698, and CR699. Switching between internal and external is accomplished with the emitter-coupled pair in U795 (pins 1, 2, 3, 4, and 5). When pin 2 of U795 is pulled low, external sync is selected; when it is high, internal sync is selected. In either case, the signal current from Q798 or Q792 is directed into common base stage Q799 and is developed across R797 (2 k). When this signal current is 0.5 mA there will be 1 V of video from either the internal or external sync source driving the Sync Stripper through C998 and R993.

Sync Stripper

The Sync Stripper, which consists of Q992 and U892, processes the sync source signal and regenerates COMP SYNC to control the timing circuitry. The Sync Stripper input is from Q799 through C998 and R993 into the base of Q992, a summing junction. Q992 and one section of U892 (pins 7, 8, and 9) form an operational amplifier that clips sync near the sync tip and inverts it. Gain resistors, R_iR993 and R_fR992, provide high gain to the sync tip portion of the signal, but clip anything slightly above the sync tip level.

During sync time, the clamp circuit (U892 1, 2, 3 and U892 13, 14, 15) maintains the output of the first amplifier stage at about +5 V. This output feeds back to the clamp circuit to maintain the proper level.

During non-sync times (active video), diodes CR988 and CR989 are both on, shunting U892C. This greatly reduces the gain during active video time and limits the saturation of U892C so that it can react quickly to the next sync transition.

The second amplifier is U892B (an inverting amplifier). It provides the negative-going sync and cleans up any remaining noise or video on the signal. The output of U892B is fed back to the clamp circuit through CR887.

Filter Selection

The three filters are driven from current source Q791 through analog switch U786. Only one switch section will be closed at a time. Bias current for the ac-coupled filters (3.58 and 4.43 MHz) is supplied through Q774. If the band pass filter (Chroma) is selected, CR670 (3.58 MHz) or CR671 (4.43 MHz) turns on Q775 and saturates Q774 to put +11.8 V on one end of R773. The other end of this resistor connects to an emitter of a common base amplifier in the Gain Cell (Diagram 2). At 0 V, 2 mA of bias current flows into the emitter with 1 mA of signal current.

Calibrator

The Calibrator consists of Q587, which is driven with a 100 kHz square wave from the Microprocessor. Q587 is switched at this rate and its emitter current drives the Low Pass filter through U585, pins 10 and 11.

VERTICAL OUTPUT DIAGRAM 2

This diagram contains the Gain Cell, Gain Cell Amplifier, Switchable Amplifier, 2nd DC Restorer, Output Amplifier, and Pix Monitor circuits.

Gain Cell

The video signal driving the Gain Cell is through Q684, a common base amplifier. It has a low input impedance to terminate the filters. The collector signal is developed across R682 and R580 (in parallel) and will be 0.5 V. The Gain Cell (U578) is driven differentially with R675 determining the maximum gain. Pin 1 of U578 is the signal current input driven by Q684, its level is -3 Vdc. The gain is controlled by varying the difference between the bases of the two-transistor pairs to control signal current to pin 6 or pin 12. Pin 6 drives the Gain Cell Amplifier, pin 12 has R480 as a collector load. The front-panel GAIN control is connected to pin 10 through U585 (an analog switch). This switch is closed when Variable has been selected from the front panel. R700 is the front-panel V CAL control.

Gain Cell Amplifier

The Gain Cell Amplifier is a clamped inverting amplifier used to drive the 2nd DC Restorer and Switchable Gain Amplifier. It consists of Q673, Q674, and Q669, with the output at the emitter of Q669. DC Restorer drive is coupled through R474 into the analog switch (U277) which is activated by the $\overline{\text{BACKPORCH}}$ signal.

2nd DC Restorer

U277, pins 6 and 7, are closed during back porch time to charge the hold cap, C484. The Error Amplifier (U488) drives the Gain Cell Amplifier through a section of analog switch U585. For Slow Restorer, R484 is in the loop compensation; however, for Fast Restorer, R484 is shorted through U277 (pins 10 and 11) to speed up the loop time constant. The output of the Error Amplifier drives the summing junction of the Gain Cell Amplifier through R676.

Switchable Gain Amplifier

The Switchable Gain Amplifier consists of Q476, Q477, and Q478, with Q469 as the switching element. When the base of Q469 is pulled low through R472, amplifier gain is minus one. R_i is R475 and R_f is the sum of R367 and R368. When its base is high, Q469 saturates and grounds the collector end of R470 to put an attenuator in the feedback path to increase gain by a factor of five. The output, at the collector of Q476, drives a limiter comprised of CR280 and CR380.

Vertical Output Amplifier (SN B020000 & Up)

R374, R377, and R378 form a level shift network which terminates the bridge limiter and provides the correct dc bias for the output stage. The level shifter signal is applied to the base of Q383 through the switch at pins 14 and 15 of U277. This signal is disconnected while the Line Select readout is displayed, and Q383 receives the Y-Axis signal through pins 2 and 3 of U277. This provides the vertical component of the readout deflection.

Q382 and Q383 form a shunt-feedback amplifier. Q382 amplifies and inverts the collector current of Q383, providing most of the signal current through R485. Since Q382 provides a nearly constant current in Q383, the input-signal voltage is applied across its emitter resistor, R485, with very little distortion. The negative feedback improves linearity and reduces thermal distortions introduced by Q383, and increases its input impedance. The series connection R384 and C384 provides bandwidth and stability compensation.

Q385 and Q387 form an identical shunt-feedback amplifier, with signal current input through R485. Due to the feedback in this stage, the signal current is provided by Q387, and is equal to and opposite from the current change in Q382. The Limit Center, R489, adjusts the balance in the bias currents in Q382 and Q387. R387 and C387 provide bandwidth and stability compensation in this stage. R486 and C389 provide high-frequency peaking to improve the flat response. R385 and C385 improve the low-frequency transient response.

Q280 and Q289 form common-base stages to couple the complementary signal currents to the non-inductive crt load resistors, R184 and R186. The resulting signal voltages are coupled to the crt's vertical deflection plates. R183 and R187 shunt the load resistors to provide the proper load resistance for the high-bandwidth output signal. L180 and L190 are adjustable shunt-peaking coils which increase the vertical bandwidth and allow precise flat-response adjustment.

Vertical Output Amplifier (SN B019999 & Below)

The Vertical Output Amplifier converts the approximate 1 V video signal amplitude into a push-pull signal of sufficient amplitude to drive the CRT. U188 is a transistor array that contains four of the Output Amplifier transistors. The signal is applied to the base of Q180, which is wired up in a common emitter configuration with Q181, which converts the incoming vertical signal to a differential signal that drives two of the bases of U188 (pins 3 and 16), a differential amplifier. Q179 is the current source for Q180 and Q181. The collector signals from this amplifier stage drive the emitters of common base transistors (pins 8 and 11).

The collectors of these common base stages drive the output stages (Q380 and Q386), which are also connected in a common base configuration. The load resistors for these output stages are R384 and R385. C280 is HF compensation for the Output Amplifier. The CRT deflection plates are driven by the collectors of Q370 and Q386 through 5.5 µH inductors.

The amplifier employs negative feedback to minimize distortion. The emitter and base impedances of the common base transistors (pins 6 and 10 of U188) are very close to the emitter and base impedances of differential transistor pair (pins 3 and 16 of U188). Any distortion from transistor pair pins 3 and 16 will be at the emitters of pins 8 and 11. Q290 and Q291 invert this distortion and feed it back out of phase to the emitters of the output transistors, which effectively subtracts it from the output.

The Y-Axis signal that is used for the vertical readout is processed for output in exactly the same way as video. Analog switch U277 has the two sections (pins 14 and 15 for video and pins 2 and 3 for readout) that couple the vertical or Y-Axis to the Output Amplifier at all times so that one of these signals drives the Vertical Output Amplifier.

Pix Monitor

The Picture Monitor Output Amplifier consists of U978 and Q877. The input for the amplifier is at pin 2 of U978 and the output is at pin 7. R883 and R884, on the amplifier input, develop the signal voltage 0.554V (1 mA * 554 Ω). The overall gain for this non-inverting amplifier is set by feedback divider resistors, R975 and R876.

The signal amplitude at pin 7 is 2 V (0.554 * (1+3570/1370)). Q973 offsets the video during LINE SELECT mode to provide a bright-up pulse. The amount of offset is determined by R870, the emitter resistor for Q973.

TIMING DIAGRAM 3

This diagram contains the Horizontal AFC, Vertical Sync Generator, RGB Amplifier, and the Field ID and Trigger Select circuits of the 1730-Series horizontal sweep.

Horizontal AFC

Composite sync from U735-13 drives a non-retriggerable one-shot, U844B, that locks out the twice line rate pulses in the vertical interval. This line rate signal, at pin 5 of U844B, drives the Back Porch Generator (U844A), the Horizontal AFC (U644), and the sweep trigger selector (U535).

U644 and the associated circuitry provide a flywheeled line rate square wave for faithful horizontal timing information to the Microprocessor even in the presence of large amounts of noise. R636 adjusts the signal phase so that the Microprocessor timing for some of the line rate switching (Flat/Low Pass and Line Select) occurs during horizontal sync time. This output signal is also used for field identification.

A back porch pulse for the DC Restorer is generated by U844A and Q737. C843 and R837 set the position of the pulse, and C848 and R849 determine the pulse width.

Vertical Sync Generator

Field rate synchronizing information is extracted from composite sync by U947A and U753B and the associated parts. U947A is an integrator whose output is normally low. The broad pulses in the vertical interval cause its output to ramp up. When the broad pulses end and the serrated pulses begin, the output starts ramping back down. This negative direction is passed by C853 to comparator U753B, which produces a vertical sync pulse, V SYNC.

RGB Amplifier

The staircase signal from the REMOTE connector drives an operational amplifier composed of Q856 and Q855. The amplifier is compensated, for optimum step definition, by C953. A dc level in the staircase can be adjusted out by R856, the RGB Offset adjustment.

Field ID and Trigger Select

Field identification is achieved by a D-type flip-flop internal to U535. The square wave line rate sync (HAFC) is the D input which is clocked by vertical sync on the clock input. Since there is a one-half-line offset in the vertical sync between fields, vertical sync will alternately clock a high or low HAFC level, enabling the outputs of the flip-flop, V TRIGGER and $\overline{\text{FIELD}}$, which will be a frame rate square wave, high for one field and low for the other. The V TRIGGER signal triggers the Field Rate Sweep Generator, while $\overline{\text{FIELD}}$ provides field rate timing information to the Microprocessor. In RGB and Remote Sync modes, no field identification occurs.

Non-standard sync inputs may cause the field identifying circuit to stop producing a field rate trigger signal for the Sweep Generator. When this happens, V SYNC is automatically used for triggering (without any field identification taking place). R907 and C907, in conjunction with Q806 and C906, detect the absence of field identified vertical sync. The field rate square wave, FIELD, keeps C906 charged and the input to pin 19 high when there is field identification.

A one-field trigger is accommodated with the remote $\overline{\text{1LIN-1FLD}}$ input by turning on Q821, which shuts off Q806 and allows C906 to discharge. The resulting low at U535–19 switches the V SYNC pulse to U535–14 for triggering of the Sweep Generator at a field rate.

V TRIG is the field rate trigger signal going to the Sweep Generator. A positive edge will trigger the Sweep Generator. FLD 1 or FLD 2 sweep triggering is selected by the FIELD1/FIELD2 control line from the processor. U535 also provides the logic for selecting either the applied sync or the Calibrator for line rate sync (H TRIG).

Displaying the appropriate lines in the LINE SELECT mode is achieved by blanking the crt beam the rest of the time. A LIN SEL signal from the Microprocessor is used by U735 to generate $\overline{\text{LINSTRB}}$, the blanking signal, and $\overline{\text{PIXSTRB}}$, the strobe signal, on the Picture Monitor Output on the rear panel. See Fig. 4-2.

Fig. 4-3 and Fig. 4-4 are timing diagrams that show the signal relationships for 2 Line and 1 Line sweep rates in the LINE SELECT mode.

SWEEP AND OUTPUT AMPLIFIERS DIAGRAM 4

This diagram contains the Sweep Generator, Magnifier Amplifier, and Horizontal Output Amplifier circuitry.

Sweep Generator

Integrators U552B and U552A are Line Rate and Field Rate Sweep Generators, respectively. One is disabled when the other is running. Transistors Q451 and Q450 discharge the feedback capacitors when a trigger pulse is applied to reset the sweep. Comparator U445A disables the Sweep Generator so that it can not accept a trigger signal until the ramp is about three-fourths complete. If no trigger signal appears, the sweep increases until it triggers U445B, which resets the Sweep Generator and provides a sweep with no input signal.

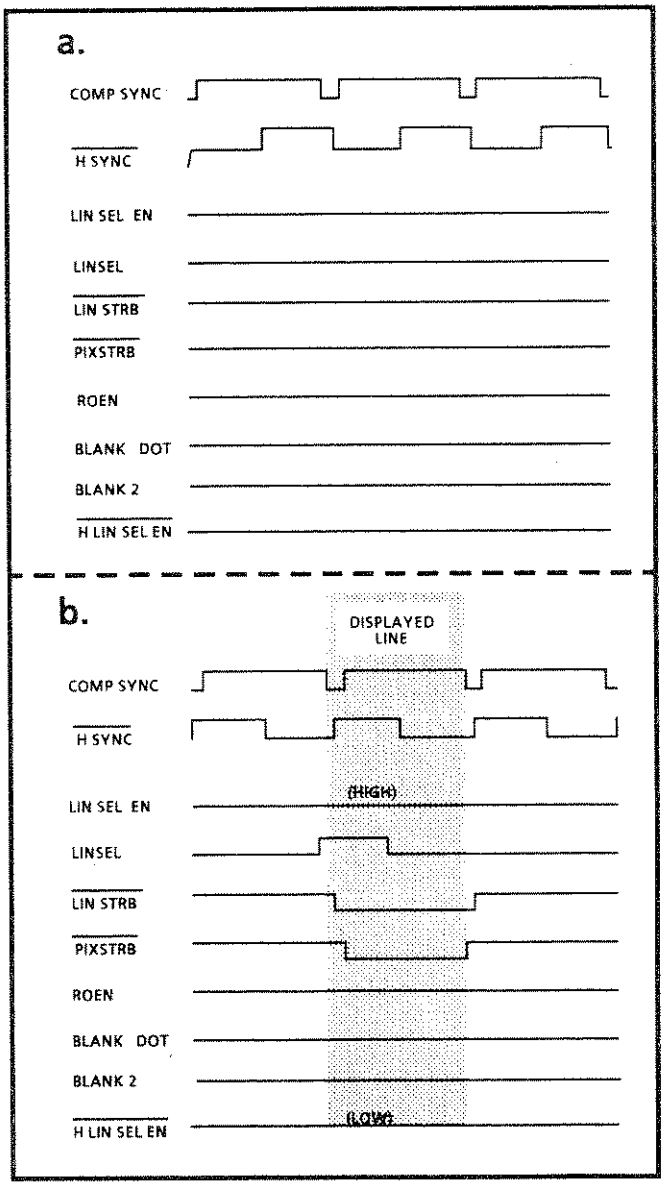

Fig. 4-2. Elements for line select timing: a) Line select off. b) 2 Field line select.

The Microcontroller can retrigger the Line Rate Sweep Generator via R646 for purposes of synchronizing the sweep in LINE SELECT, or during filter and input switching.

Retrace time is determined by one-shots U741A and U741B. Gate U334B combines the retrace signals to blank the beam during retrace. This gate also combines blanking and unblanking of the display when the instrument is in the LINE SELECT mode.

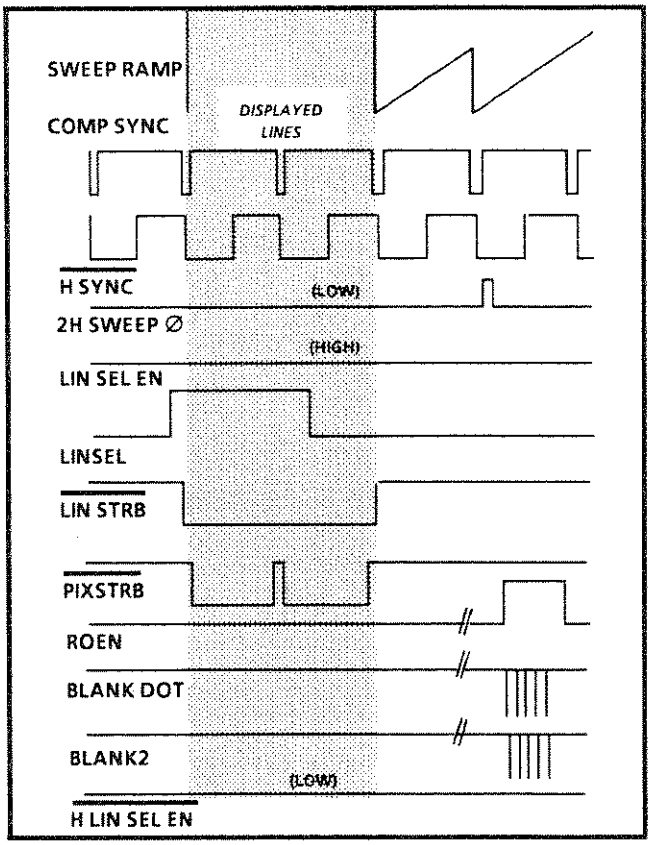

Fig. 4-3. Relative line select timing elements for the 2 Line display.

The ramp signal from the Sweep Generator drives the Horizontal Positioning and Magnifying Amplifier through R559.

Magnifier Amplifier

Transistors in U564A and Q566 form an operational amplifier which positions and magnifies the sweep signal. R557 and R558 are the feedback resistors. Gains when magnifying are set by R552 (1 µs Cal) and R553 (0.2 µs Cal). Horizontal positioning is controlled by U655B through R658. The staircase signal, when in the RGB mode, drives the amplifier through R657. The length of the sweep, when in RGB mode, can be set by jumper J456 to accommodate either three- or four-step shortened sweeps (for RGB and YRGB modes, respectively).

Comparators U465A and U465B sense the output of the Magnifier and Position Amplifier to turn off the crt beam when it is off the edge of the screen.

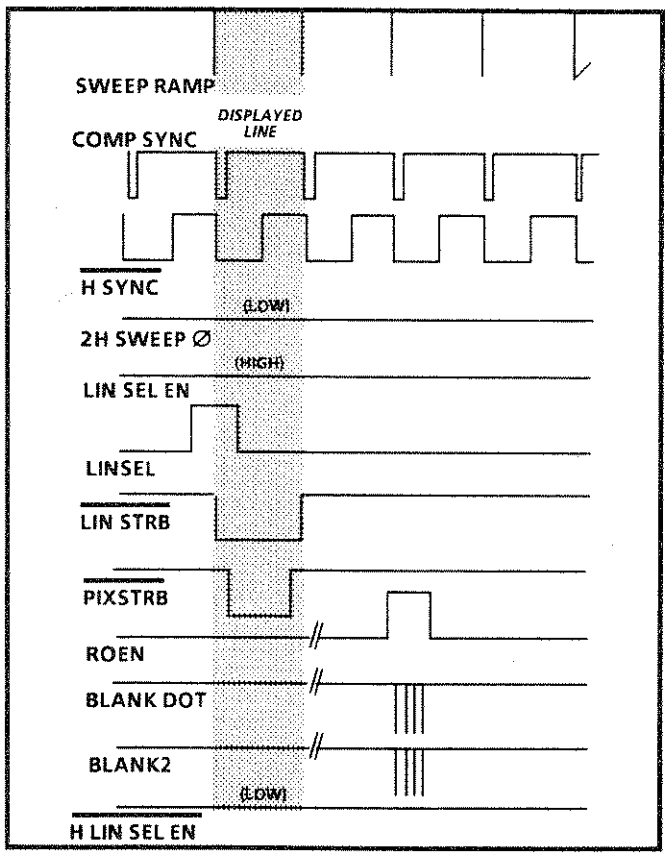

Fig. 4-4. Relative line select timing elements for the 1 Line display.

Horizontal Output Amplifier

The Horizontal Output Amplifier is composed of transistors Q858, Q860, Q862, and Q864, and is fed by current sources Q863 and Q865. R960 provides differential mode feedback; resistors R958 and R959 provide common mode feedback for biasing the outputs at about 50 volts. The gain of the amplifier is determined by R660 (Sweep Length Adj.), and the magnified sweep registration by R661 (Mag Registration Adj.). In LINE SELECT, Q762 and Q763 switch in the (X-Axis) horizontal component of the line select readout.

MICROCONTROLLER DIAGRAM 5

Circuits on this diagram include the Microprocessor and its associated NOVRAM, De-Multiplexer, Latches, and Output Drivers.

Microprocessor

The 1730–Series Microcontroller is an Intel 8051-type Microprocessor, with self-contained ROM code. It operates in the 1730/1731 with an eight-bit multiplexed address/data bus, pins 32–39 of U522.

Port 1 (pins 1–8) scans the front-panel keyboard, where each key is a member of a 4 X 4 matrix.

Port 2 of the Microprocessor provides eight I/O lines, three for the NOVRAM (Chip Enable—pin 21, Data—pin 22, and Clock—pin 23), four lines that drive the 1730–Series analog switching functions (pins 25–28), and pin 24, which is the external communications enable for the Auxiliary function.

The Microprocessor (U522) uses three lines in Port 3 (pins 13, 14, and 15) to input horizontal (line) sync and vertical (field) sync. These inputs are used by the Microprocessor to decipher line select data and real-time switching functions (A/B and Low Pass/Flat switching). Pins 10 and 11, which are also Port 3, are used for the 1720–Series Auxiliary bus functions (TXD pin 11 and RXD pin 10). These lines are buffered by U809 and directly output to the rear-panel AUXILIARY connector.

Port 3–5 (pin 15) is an input to the Microprocessor that, when high, indicates that the instrument is running NTSC standard. This dictates Chroma filter selection and line numbering for the LINE SELECT mode. When pin 15 is low, the instrument is running the PAL standard.

Port 3–7 (pin 17) is the remote input enable for U731 and U809A. The Remote functions use Port 0 for an I/O.

There are a number of control lines, originating on the Microcontroller diagram. Table 4-1 lists these lines, the condition of the line, and the expected result.

Table 4-1
Control Line Functions

Signal Line	State	Result
X5	High	Enables 5X Vertical Magnifier.
BLANK DOT	High	Blanks between dots in Line Select readout.
LINSEL	High	Unblanks the crt for Line Selected line.
2H SWP PHASE	High	Resets 2H Sweep Generator for Line Select and real-time switching functions.
RXD	----	Used in serial port diagnostics and Auxiliary.
TXD	----	Sends data to companion 1720–Series.
CAL DR		100 kHz pulse to Calibrator.
CAL	Low	Enables Calibrator.
ROEN	High	Enables readout in Line Select.
LIN/FLD	High Low	1 or 2 Line display. 2 Field display.
TWO/ONE	High Low	2 Field or 2 Line display. 1 Line (no single field display possible).
MAG	High	Enables Horizontal Magnifier.
EXT	High Low	Enables internal sync reference. Enables external sync reference.
FLD 1/FLD 2	High Low	(NTSC) Field 1 trigger in 2 Field Sweep. (PAL and PAL-M) Field 2 trigger in 2 Field Sweep. (NTSC) Field 2 trigger in 2 Field Sweep. (PAL and PAL-M) Field 1 trigger in 2 Field Sweep.
LIN SEL EN	High	Blanks crt for Line Select, except during LINSEL high.
X-AXIS	----	Analog signal to horizontal deflection amplifier for Line Select readout.
Y-AXIS		Analog signal to vertical deflection amplifier for Line Select readout.
CH B	High Low	Enables CH–A input. Enables CH–B input.
ON DCR	Low	Enables DC Restorer.
3.58	Low	Enables NTSC AND PAL-M Chrominance filter.
4.43	Low	Enables PAL Chrominance filter.
LPASS	Low	Enables Low Pass filter.
FLAT	Low	Enables Flat (no filter).
VAR	Low	Enables vertical variable gain.
DCRF	Low	Enables fast DC Restorer if ON DCR is high.

U725 is the NOVRAM used to retain the current front-panel status and the front-panel status for the Stored Recalls (Auxiliary). Data is written in and read out through pins 3 and 4; pin 1 of U522 controls data in and out. Pin 2 of U522 provides the serial clock. Pin 14 provides the chip enable. These three lines (Clock, Read/Write, and Chip Enable) are active when:

1. power is turned on.
2. any front-panel switch is pressed.
3. a Store or Recall is requested.

U726 is the power down detection circuit. It detects the loss of instrument power in time for the NOVRAM (U725) to execute a save operation. When the +5 V supply drops a few hundred millivolts, pin 7 is pulled low, which causes U405 to Store its current status. The front-panel and Auxiliary (Store/Recall) data is saved in a matter of milliseconds when the power starts to drop below safe operating levels for the NOVRAM. U727 is a three-terminal regulator operating from the +15 V supply that comes onto the circuit board from the Power Supply circuit board. As soon as the +15 V raises enough to provide a +5 V output from U727, U725 recalls the data saved so that it will be available to the Microprocessor when all supplies are up to their operating tolerances.

U731 is a buffer for remote input that is enabled by pin 17 of the Microprocessor.

Switch Control

U884 is a serial-in/parallel-out register that is loaded with the real-time switching data from the Microprocessor serial port (pin 10) whenever U522, pin 24, is high. When U522, pin 24, is high it enables the U884 serial input, and disables the external communications input through U809B. The eight bits of serial data are then clocked out, in parallel by the leading edge of H (line) Sync, which clocks pin 12 of U884.

Address Demux

U527 is the Address De-Multiplexer used to decode the lower eight bits of the address line. Even though both addresses and data share the same Microprocessor port, only addresses are present when U527 is clocked from the Microprocessor ALE output.

Readout Drive

U325 and U231 A and B drive the X and Y axes of the dot-scanned line select readout on the CRT. U325 is a dual D/A Converter whose internal registers are loaded from the Microprocessor and clocked by the $\overline{WR}$ output of the Microprocessor.

I/O Data Latch

U532 is the data latch that is I/O to the 1730–Series non real-time switching and the readout enable ROEN. It uses addresses from U527 and is clocked by the $\overline{WR}$ output from the Microprocessor. The ROEN works in conjunction with the Microprocessor Blank Dot output (pin 26) to display the data from U325 on the crt.

Cal Drive

U331 divides down the ALE output of the Microprocessor to provide Cal Drive. U331 is enabled by the $\overline{CAL}$ from U532.

LED Drive

The front-panel LEDs are driven in six common banks by U407. U305 provides a common current drain that is enabled by U407. Data registers in U407 are written into by the Microprocessor over the eight-bit address bus.

AUTO Standard Determination (1735 Only)

When AUTO standard swtiching is selected, the 1735 microprocessor continuously monitors the field duration of the selected REFerence (INT = the selected input channel, A or B, and EXT = the external reference). The 1735 selects the 60 Hz (NTSC) mode of operation for field rates greater than 55 Hz, and the 50 Hz (PAL) mode for field rates less than 55 Hz. If a signal's field rate is very close to 55 Hz, the standard selection may be indeterminate and oscillate between 50 and 60 Hz. Automatic standard switching is delayed from the signal switching by several video frames, to insure that false switching does not occur. If loss of reference occurs, the current standard is maintained until reference is restored.

FRONT PANEL AND CONTROL CIRCUIT DIAGRAM 6

Circuits on this diagram include the front-panel switches, controls, and indicators. In addition, the on-board power supply regulators for the + and –11.8 V supplies appear here.

Indicators and Switches

The front-panel LED indicators are arranged in six columns returned to a current source by four returns. When a light is lit, there is a complete circuit from the Light Driver (Diagram 5) through the LED and back to the Light Driver. Switches complete a simple matrix that is read by the Microprocessor to determine the operating mode.

Z-Axis Control

U252 is a transistor array with two of the transistors connected as a differential current switch. The static output level (pin 8) is set by the front-panel INTENSITY control using Q243 as a current source. The Blanking signal is input to the switch through pin 9. When pin 9 goes high, the current output (pin 8) is shut off and the Z-Axis Amplifier (Diagram 8) blanks the crt. See Fig. 4-5.

In LINE SELECT mode, the intensity setting has to change to brighten up the line or lines. This is accomplished by increasing the current through the current source (Q243). U239A is an open collector dual comparator that goes low when Line Select Blanking occurs, which allows the full current across R238 and R241 to flow in the circuit.

The Focus control operation must also control two different display criteria. In the normal mode of operation, the Focus voltage will be selected by the control setting only (Q242 is off). When a Line Select Un-Blanking pulse occurs, U239B turns off and additional current flows through Q242. R245, the LS Focus adjustment, is adjusted for optimum focus in LINE SELECT at the normal display focus setting.

Trace Rotation

Trace rotation is necessary to compensate for changes in the magnetic field surrounding the 1730–Series. Q142 and Q143 are emitter followers

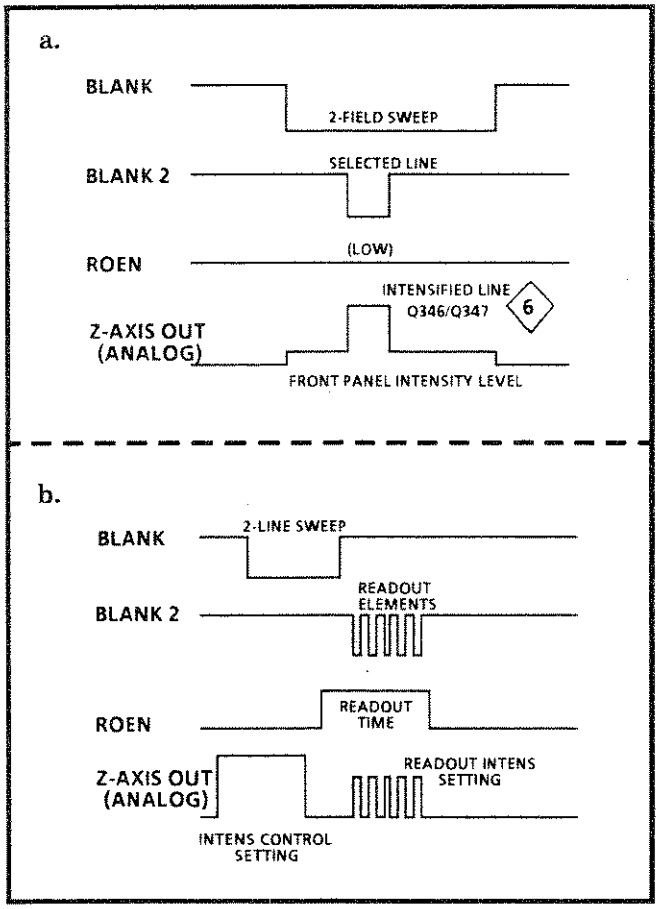

Fig. 4-5. Z-Axis timing for readout: a. 2 Field display intensifies the line (lines) to provide a bright-up strobe. b. In 1 or 2 line sweep, alphanumeric readout in the upper left corner of the CRT is used to convey the number of the first selected line.

that provide the Trace Rotation current to a coil located inside the CRT shield, around the tube. Current amplitude and polarity are controlled by the front-panel ROTATE screwdriver adjustment.

Graticule Illumination

U263A is a triangle generator whose output is compared to the front-panel SCALE control output level, by U263B (a comparator). Whenever the output of U263A is higher than the level from the front-panel SCALE control, Q158 is turned on and current is drawn through the bulbs (DS404 and DS804), through Q158 to ground. The duty cycle of Q158 is determined by the level set by the SCALE control.

Post Regulators

The + and –15 V supplies generated on the Power Supply circuit board are further regulated to meet the on-board needs of the 1730–Series Main (A3) circuit board. U164 and U172 are the post regulators for the –11.8 V and +11.8 V supplies. R167 is the –11.8 V Adjust and R168 is the +11.8 V Adjust.

LOW VOLTAGE POWER SUPPLY DIAGRAM 7

The Low Voltage Power Supply converts the mains line voltage (either 120 or 220 volts) to supply the instrument's circuits. The voltage supplied to operating circuits are +40 V, +5 V, +15 V, and –15 V.

Line Rectifier and Filter

The input line voltage is filtered to prevent any noise that is on the ac line from interfering with instrument performance, and to prevent any noise generated within the waveform monitor from getting back to the ac line. RT484 and RT582 are surge protection to limit initial turn-on current through the rectifier and capacitors.

The rectifier operates as a full-wave bridge for 220 V input, or as a full-wave doubler for 120 V input. Operating voltage is selected by the position of W476, which is soldered in place for 120 V input and removed for 220 V input. E576 is a spark gap that fires and blows the line fuse when 220 V is applied when W476 is installed for 120 V input. DS185, along with R192, C192, and R196, are a relaxation oscillator, with DS185 flashing whenever line voltage is present.

Kick Starter

When the instrument is first turned on, C287 is charged from the rectified power line through R197. When the voltage on the anode of Q293 gets 0.6 V higher than the gate (20 V), it saturates and turns on Q290, and the charge on C287 is impressed across the base drive and switching transistor to allow the Low Voltage Power Supply to start. Once the supply has started, the housekeeping winding supplies the base drive through CR357. If the Power Supply does not start, Q290, R186, and VR186 force the kick starter to cycle until it does start. Q290 diverts Q293's current so that most of the load consists of VR186 and R186. Once the voltage on C287 falls below about 6 V, Q293's load current falls off to such a small value that it turns off along with Q290 so that C287 can recharge.

Base Drive and Switching Transistor

The Low Voltage Power Supply is of the flyback type. Q367 is the main switching transistor, with T466 providing the base drive. R466 limits the forward base current used to turn on Q367. C471 charges to 0.6 V, with CR566 limiting the charge. This holds the base of Q367 negative when Q367 is off. T466 is polarized so that when Q463 is on, Q367 is driven on.

To efficiently turn Q367 off, base current must be drawn backwards from the base. This reverse base current is derived from magnetizing current stored in T466 and stabilized by Q363 and Q362. The resulting reverse base current in Q367 is at a relatively constant value. VR465 limits voltage spikes on Q463 to 30 V.

For troubleshooting purposes: The forward base current is about 130 mA and the reverse base current should vary between 70 mA and 130 mA, depending on line voltage and load current.

Pulse Width Modulator and Error Amplifier

The Pulse Width Modulator uses U558 for pulse width control. C557 and R557 set the operating frequency to about 30 kHz. Pin 15 is the power input, pin 16 supplies a 5 V reference, and pin 10 is the shutdown.

When pin 10 is pulled high, U558 is shut off; it is driven by the Current Limit. Pin 12 is the output, which controls the base driver. As the voltage on pin 9 is varied, the duty cycle, as seen at pin 12, changes from 0% to 50%. The duty cycle changes with line voltage and load changes in order to keep the output voltage constant. One volt or less on pin 9 produces a 0% duty cycle.

In order to isolate the load from the power line, all supplies are derived from the secondary of the power transformer. The control voltage fed back to the Pulse Width Modulator, from the Error Amplifier, is also isolated from the power line. An Opto-isolator, U455, is used to drive pin 9 of the Pulse Width Modulator.

The intensity of the light from an internal LED, driven by the Error Amplifier, sets the collector voltage for the light-sensitive transistor in U455. The resulting output voltage becomes the comparison input for U558 (pin 9) that, in turn, determines its duty cycle. R562, between pin 9 and the emitter of Q568, is the load resistor for U455.

The Opto-isolator is driven by the output of the Error Amplifier, U242, through Q344. The +5 V Adjust, R445, is part of U242's input voltage divider, and when it is adjusted sets the duty cycle of U558 (through U455).

Current Limit

Q565, Q570, and Q568 form the Current Limit circuit. R270 is the current sense resistor, providing base current to Q570 through a divider consisting of R568 and R567. C568 snubs high frequency voltage spikes. If the current in R270 gets high enough to turn on Q570, Q565 is turned off and the voltage across R564 pulls pin 10 of U558 high and shuts off U558.

In the Current Limit mode, the Power Supply runs in and out of current limit in an oscillatory fashion, which produces a high-pitched squealing sound, in short bursts. If the load causes the Current Limit to be active for more than a few hundred milliseconds, C567 charges and turns on Q568. Q568 and Q570 then turn each other on in a positive feedback reaction, which holds pin 9 of U558 low and shuts the Power Supply down until the housekeeping supply is depleted.

Once the housekeeping supply is depleted, the kick start capacitor charges from the power line and starts another kick start cycle.

Voltage Snubber

R170, L177, CR170, CR266, and C267 form a voltage snubber. The voltage spikes on the collector of Q367 are limited to around 850 V by this circuit. During voltage limiting, C267 is charged through CR266. When Q367 is turned on, CR170 conducts and C267 discharges through L177, readying it for the next snub cycle.

HIGH VOLTAGE POWER SUPPLY DIAGRAM 8

HV Osc and Error Amp

The High Voltage Power Supply is generated by a sine-wave oscillator and step-up transformer. Q134 and T332 are the principal elements of an Armstrong oscillator running at about 25 kHz. The Error Amplifier, U242, regulates the +100 V output, and keeps the High Voltage Power Supply constant under varying load conditions by controlling the base current to Q134, through Q237 and Q238. The +100 V output is monitored directly, while the High Voltage Power Supply is monitored through a feedback circuit.

R427, C427, and R143 form the High Voltage Power Supply positive feedback circuit. As the current from the High Voltage Power Supply is increased, the voltage to the + side of the Error Amplifier (U242) increases, which reduces the base drive to Q134, the HV Osc. This positive feedback compromises the regulation of the 100 V supply to keep the high voltage constant with varying intensities.

C138 and Q137 are a start delay circuit that holds the Error Amplifier output low, through CR138, until C138 is charged from the 15 V supply. Delaying the start of the high voltage oscillator allows the Low Voltage Power Supply to start, un-encumbered by the load from the high voltage oscillator.

Power Supply Outputs

CR222 is the high voltage rectifier. Smoothing capacitors C217 and C218 work with CR222 to provide -2750 volts to the crt cathode. U226 is a four-times multiplier, providing +11 kV to the crt anode.

Focus Amplifier

Q413 and Q313 form an operational amplifier that sets the voltage at the bottom of the focus divider. The front-panel focus pot determines the voltage at the bottom of the focus divider. The CTR Focus control, R213, is set for optimum beam focus, as viewed on the crt, with the front-panel FOCUS control set to mid range. Once the CTR Focus adjustment has been set, adjusting the front-panel FOCUS control changes the voltage at the bottom end of the divider and, consequently, the voltage on the crt focus anode.

Grid Drive Circuit

The grid and the cathode of the CRT are at a –2750 V potential with the grid effectively dc-coupled to the Z-Axis Amplifier by the grid drive circuit. The unrectified, 25 kHz sine wave output from the +100 V supply winding is input to a modulating circuit, where it is clipped and rectified for use as crt control grid bias.

The sine wave from the 100 V supply winding of T332 is coupled through C428 to a clipping circuit consisting of CR425 and CR426. Clipping level for the positive excursion of the sine wave is set by the crt Bias adjustment, R536; negative clipping level is set by the INTENSITY control through the Z-Axis Amplifier. The clipped sine wave is coupled through C220 to a rectifier made up of CR121 and CR122. The rectified, clipped sine wave is the crt control grid bias voltage. C219 is a speedup capacitor for the fast transitions of the blanking signal, from the Z-Axis Amplifier. DS118 and DS119 limit the crt grid to cathode voltage at instrument turn on and off.

Z-Axis Amplifier

This is a high gain inverting amplifier, with feedback. R410 stabilizes the gain at a low value. The input is the summing junction at pin 3 of J546, which is set to +5 V by R412 and R418, so that the Z-Axis Control circuit on the Main (A3) circuit board can drive this amplifier. When there is no input current from the Z-Axis Control, the output is set to +10 V by R411. When there is input current, the output is driven more positive. Q516 is an emitter follower that drives Q518, which with Q519 forms a cascade pair for good high frequency performance. Q419 is a constant current source that is the collector load for Q519. The collector of Q519 is the output of the Z-Axis Amplifier. C520 speeds up the constant current source, Q419, for the fast transitions of the blanking pulses. DS417 and DS416 are neon bulbs intended to prevent damage to the Z-Axis Amplifier if there is a crt high voltage discharge.