bwd
INSTRUMENTS

845

DC to 30MHz STORAGE OSCILLOSCOPE

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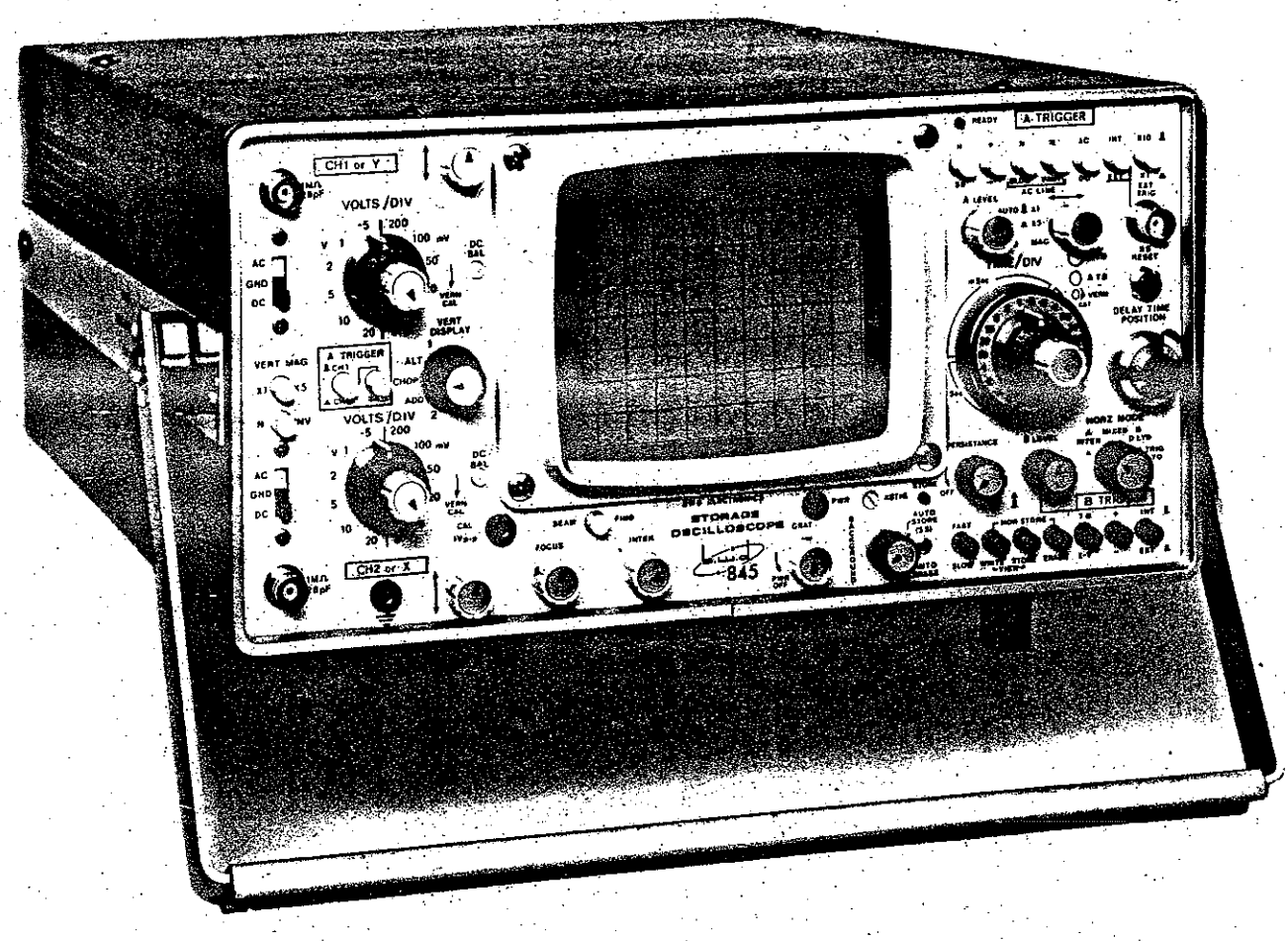

BWD 845

DUAL TRACE STORAGE OSCILLOSCOPE

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MODEL BWD 845

DUAL TRACE STORAGE OSCILLOSCOPE

1. INTRODUCTION:

1.1 The BWD 845 is a high performance, portable variable persistence, storage oscilloscope. It incorporates a delayed, mixed or delayed trigger time base, vertical amplifiers with a 1mV sensitivity on both channels and can be powered by AC, DC or an optional battery pack.

The variable persistence/storage facility enables the user to view and measure intermittent signals and transients that cannot be detected on a normal oscilloscope. It also retains wave forms at very slow sweep speeds allowing the entire waveform to be viewed rather than a moving dot. If persistence is adjusted to overlap traces, fast signals at low repetition rates can be integrated to make them readily visible. This technique makes it possible to view and store signals that are faster than the CRT writing rate, in fact up to 30MHz.

Storage oscilloscopes are more complex than non-store models, so several features have been incorporated to simplify the comprehensive facilities provided.

A standard feature of all BWD oscilloscopes is the ALL BUTTONS OUT condition for normal operation. This is incorporated in the BWD 845 and is a major contribution in simplifying operation.

1.2 An AUTO ERASE cycle eases the task of setting up the CRT controls in the storage mode. View time is approximately 4 seconds after each writing sweep is completed. It is then erased to await the next sweep. In the CHOP mode two traces may be written and viewed simultaneously or alternately in the ALT mode. This mode may also be used for viewing repetitive single shot signals that contain non-repetitive waveforms.

When a long waiting time occurs before a signal is received to trigger the time base and write a stored display the screen may fade green all over. An AUTO STORE facility in the BWD 845 eliminates this problem by holding the CRT in the erase condition until the time base is triggered by a signal, thus extending the pre-trigger period to hours instead of minutes. It then automatically switches to store and a LED indicator signifies this condition.

The CRT characteristics themselves form the major control on writing speed and storage. It has a burn resistant screen and operates at 7.5KV EHT to provide a well focused trace in all operating modes. To optimise its operation for both fast writing and long viewing/storage times, two switch selectable settings are provided - slow or fast. By writing in fast then switching to the lower intensity slow condition, storage or viewing times can be greatly extended. The backing electrode is also adjustable over a limited range by the front panel background control for best signal to background contrast.

The combination of these wide range storage and oscilloscope functions make the BWD 845 a very powerful tool for a wide range of measurement and analysis.

2. SPECIFICATIONS:

Storage Characteristics:

2.1 OPERATING MODES:

Selection of seven operating modes for best display of waveform under observation. Write, store, view, variable persistence, auto-store, auto-erase and non-store (conventional).

Storage Writing Speed:

Fast, <1cm/1μSec. (Max. speed 5cm/μ Sec over most of screen area).
Slow, 1cm/10μSec.

Storage Time:

Fast, >15 Sec at 1cm/μSec writing speed) Both times may be increased by
> 3 min at 1cm/10μSec writing speed) switching to store after writing.
50 mins at 20cm/Sec by writing Fast and then switching to Slow.
Slow, Up to 30 mins.

Extended Storage Time: Extended storage times shown are with the display available for continuous viewing. However if the Write button is released the display can be retained up to 3 hours without viewing. It may be viewed or have signals added to it any time by re-engaging the Write button.

Persistence: Non-store, similar to P31 phosphor (approx. 40μSec.)
Variable approx. 200mSec to 50 Sec.

Auto Store: Instrument held in erase condition ready to trigger and store a single event for minimum of 2 hours, typically >4 hours. Viewing time after trigger, up to 30 min. at slow writing speed. >3 min at fast writing speed. Stored condition indicated by LED indicator lamp. Time Base gate output (1KΩ source resistance, +4V falling to 0V for duration of sweep) can also be used to initiate an external indicator or alarm as the trace is being written.

Auto Erase: Instrument cycles continuously,

Erase,	800mSec
Write,	Dependent on T.B. setting
Viewing,	Preset to 4 Sec approx.

Erase Manual: Push button control, erase time 800mSec (independent of time Erase button is held depressed).

Erase External: Rear panel sockets, short together to erase. Erase time 800mSec independent of closure time.

Instrument OFF, with a trace stored and instrument switched off and disconnected from all power supply sources, trace will remain stored for up to 7 days. See p6-3.

2.2 VERTICAL AMPLIFIERS:

Bandwidth: (5mV to 20V/div). DC to 30MHz - 3db.
Referred to 8 div. deflection at 50kHz from a terminated 50Ω source with vernier to Cal. position.

Bandwidth: (x5 gain) DC to 25MHz - 3db.

AC coupling >2Hz - 3db direct input or >0.2Hz with 10:1 probe.

Rise Time: 10nSec (5mV to 20V/div). <12nSec x5 gain measured between 10% and 90% points on a 6 div. input.

2. SPECIFICATIONS:

Sensitivity: (Both channels) 5mV to 20V/div in 12 calibrated steps (1,2,5 sequence). 1mV to 4/div at x5 gain. 1 div = 9.5mV.

Calibration Accuracy: Within 3% at switch settings with vernier to cal. (5% at x5 gain). Uncalibrated Vernier continuously variable between steps, extends range to 50V/div.

Input R & C: 1MΩ within 2% and 30pF within 2pF.

Max. Input Voltage: 500V (DC + Peak AC) AC component 500V p-p maximum 1kHz or less.

Min. Deflection: 8 div at 25MHz.

Display Modes: Ch. 1, Ch. 2, Alt. Chop, Add or Subtract. Chopping Frequency, approximately 350kHz.

Delay Line: Permits viewing of leading edge of displayed waveform.

Trace Inversion: Push-push switch enables Channel 2 to be inverted for display convenience or when the two amplifiers are used in the ADD mode to provide a differential input facility.

CMRR (in ADD Mode): At least 20db from DC to 10MHz. Common mode signal amplitude <8 div with one vernier adjusted for optimum rejection.

Noise: (Tangentially measured). Full bandwidth all sensitivities 0.05 division. x5 gain, <0.2 div all sensitivities.

2.3 Channel 2 as X Amplifier in X-Y Mode:

Bandwidth: DC to 1MHz from 1mV to 50V/div referred to 6 div. defl.
Phase Shift: <2° from DC to 100kHz.

2.4 Probes:

The probes provided incorporate a 3 position slide switch for 1:1, 10:1 and REF Off position. Oscilloscope bandwidth is unaffected by the probe in the 10:1 position. Input C and R is 11pF and 10MΩ.
The bandwidth in the 1:1 position is limited to approximately 8MHz.
Input C and R is 68pF and 1MΩ.

2.5 TIME BASE:

Time Base 'A' (Main or Delaying)

Sweep Rate: 100nSec to 2 sec/div in 23 steps of 1,2,5,10 sequence. Max. sweep speed is 20nSec/div. at x5 magnification.

A vernier control covers range between each step and extends range to >6 Sec/div. Note: Vernier is operative on 'A' TB only when 'A' is selected. It is operative on 'B' TB in the intensified, mixed and delayed modes.

2. SPECIFICATIONS

Sweep Accuracy: Measured over centre 8 div of CRT.

x1 Magnification	
+15° to +35°C	0°- 50°C
3%	5%

x5 Magnification over Sweep range 0.2µS/div to 2 Sec/div. (excluding first 30nSec of display)	
+15° to +35°C	0°- 50°C
5%	6%

Calibrated Sweep Delay:

Delay Time Range:	As Sweep Rate above.
Delay Time Accuracy:	3% over calibrated range.
Delay Multiplier:	0.5 to 10X Time/div setting.
Delay Jitter:	1 in 10,000 of maximum delay time (0.01%).
Multiplier Linearity:	1% of full scale.

'A' Time Base Sweep Modes:

Mode: Auto (with level select) Non-Auto or Single Sweep with Reset button and Ready Lamp. Ready lamp indicates trace readiness prior to commencement of sweep in all operating modes. Trace free runs in Auto with no trigger signal.

Time Base 'A' Trigger:
Internal:

Source: Ch 1, Ch 2, mixed displays or line frequency.
Coupling: AC, DC, Slow (or TV frame) and Fast.
Slope: + or - with level select over 8 div.

Sensitivity:
0.4 div defl. DC to >15MHz increasing to 1.5 div deflection at 30MHz.
In Chopped mode trigger bandwidth is limited to approximately 1MHz.
Video Trigger: <2 div of composite waveform to over full screen deflection for line or frame lock.

External:
Source: Ext x1 or x10.
Coupling: AC or DC
Slope: + or - with level select over ± 3V at x10 and ± 30V at x1.
Sensitivity: 200mV p-p DC to 10MHz increasing to 500mV p-p at 30MHz.
External trigger bandwidth is not limited in chopped mode.
External input impedance: 1MΩ & 30pF.
Max. Input Voltage: 500V (DC + Peak AC). AC component 500V p-p up to 1kHz.

2.6 'B' TIME BASE (DELAYED):

Sweep Base: 100nSec to 0.5Sec/div in 21 steps of 1,2,5,10 sequence. Uncalibrated Vernier covers range between steps and extends range to at least 1.5Sec/div.

2. SPECIFICATIONS

Sweep Accuracy: Measured over centre 8 div of CRT.

x1 Magnification	
+15 to +35°C	0 - 50°C
3%	5%

X5 Magnification over Sweep range 0.2 S/div to 2µSec/d (excluding first 30nSec of display)	
+15 to +35°C	0 - 50°C
5%	6%

Time Base 'B' Trigger:

Internal:
Source: Ch. 1 or 2.
Coupling: DC.
Slope: + or - with level select over >6 div.
Sensitivity: 1 div DC to 15MHz increasing to 2 div at 30MHz.
External:
Coupling, AC or DC.
Slope: + or - with level select over ± 3V at x10 or ± 30V at x1.
Sensitivity: 200mV p-p 10Hz to 10MHz, 500mV p-p DC to 25MHz, 1V p-p at 30MHz.
Mixed Sweep:

Accuracy: Identical to A and B sweep accuracy excluding 0.5 div of start of main sweep and 0.2 div or 0.1µSec (whichever is greater) either side of transition from main to delayed sweep.

NOTE:
Transition from A to B sweep is delayed compared to the Time Div x multiplier setting until B time base reaches the same voltage as A time base and takes over the display.

2.7 Magnification: x1 or x5

Max. Sweep Speed: 20nSec/div.

2.8 GENERAL DETAILS:

CRT:	8 x 10 div (1 div = 9.5mm) rectangular variable persistence storage. P31 Phosphor.
EHT:	7.5KV
Graticule:	Internal, parallax free with variable illumination. Fitted light blue filter.
Z Modulation:	2V positive will blank trace at normal intensities from DC to >10MHz input impedance 4.7KΩ and 10pf. Max. input ± 30V p-p.
Trace Find:	Push button returns trace to within limits of CRT screen and over rules intensity setting.

2. SPECIFICATIONS:

Calibrator:	Output, rectangular, positive going from ground 1V p-p, 1kHz approx. Accuracy 1% + 15 to +35°C, 2% 0 to 50°C. Rise time <1μSec.
Output Waveforms:	A time base gate +4V falling to 0V during sweep. 1kΩ source impedance. B time base gate +4V falling to 0V during sweep. 1kΩ source impedance.
Power Requirements:	AC 98 to 135V and 195 to 270V. Selection by changeover switch. 48 to 440Hz 40 watts max. DC 20V to 30V at 1.3 Amps. Battery Pack (optional extra) 4 hours per recharge. Battery charger incorporated in standard instrument. Recharging from AC or 32V DC. Approximately 12 hours charging time from minimum usable charge condition to full charge.
Low Voltage Indicator:	When voltage powering oscilloscope (AC, DC or battery) falls below correct operating level, the front panel indicator changes from a steady to a flashing state.
Environmental:	Specification is met within power supply range shown and from +5°C to +35° to 80% RH unless otherwise stated, add 2% to specification for 0 - 50°C and 0 to 80% RH Storage -20°C to +70°C.
Finish:	Instrument contained in a sage green vinyl covered cabinet with tinted yellow panels.
Dimensions:	As shown on page 2-6.
Weight:	Nett Instrument: 9.5kg Battery Pack 6.3kg Packed Instrument: 12kg Battery Pack 8kg.
Warranty:	The instrument is guaranteed for a period of twelve (12) months against faulty workmanship and materials except that the CRT is not guaranteed against screen or storage mesh burns. Refer to conditions of sale for further details.
Accessories Supplied:	1:1 and 10:1 Duo Probe, Type P32 (2 off) and instruction manual.
Options:	Battery Pack BP3.

2.9 Optional Accessories:

1:1 and 10:1 Duo Probe	P32
10:1 Probe	P40
100kHz - 300MHz Demodulator Probe	P34
Folding Viewing Hood	H46
Dust Cover	D27

2. SPECIFICATIONS

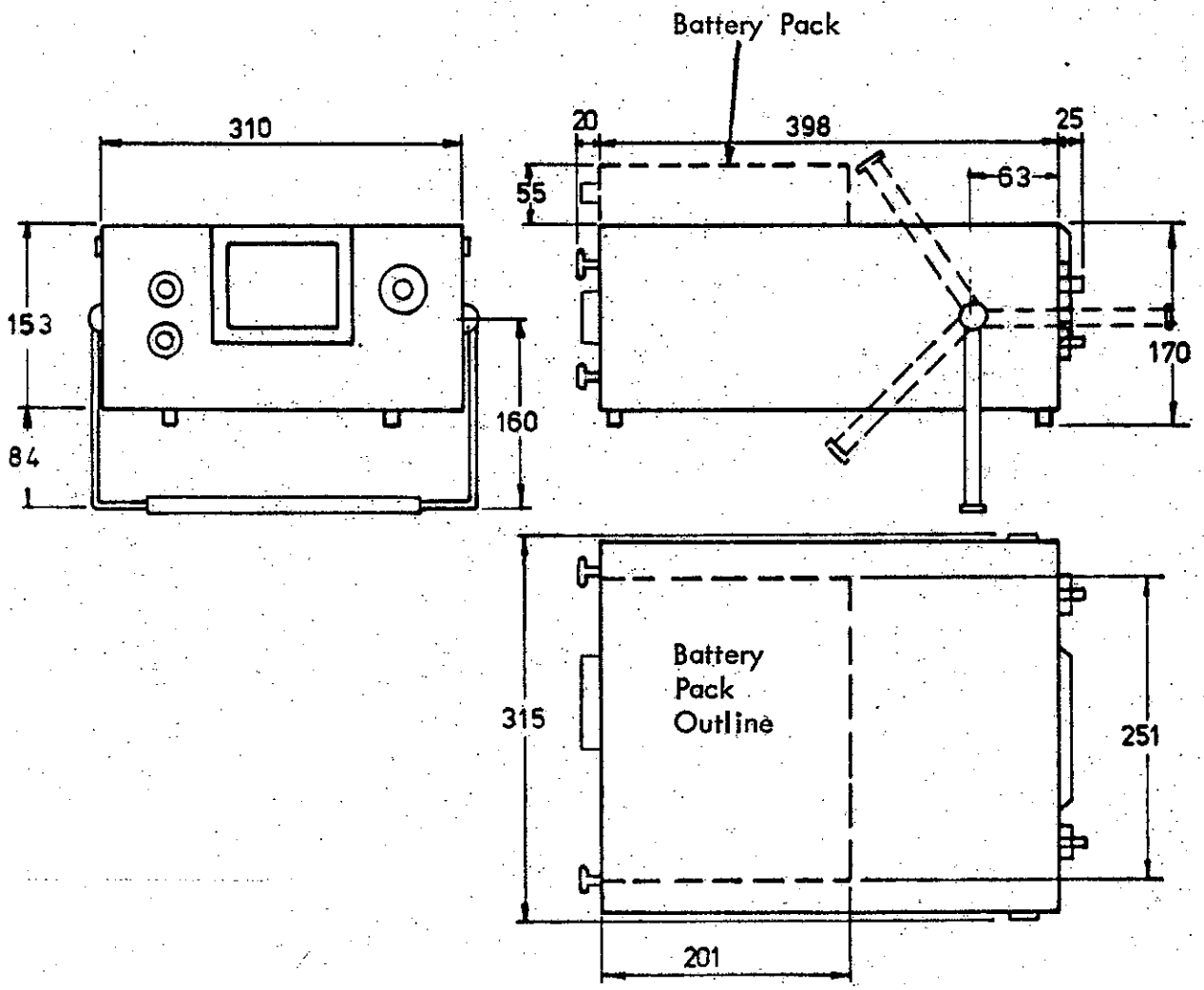
2.9 Optional Accessories: (Cont'd)

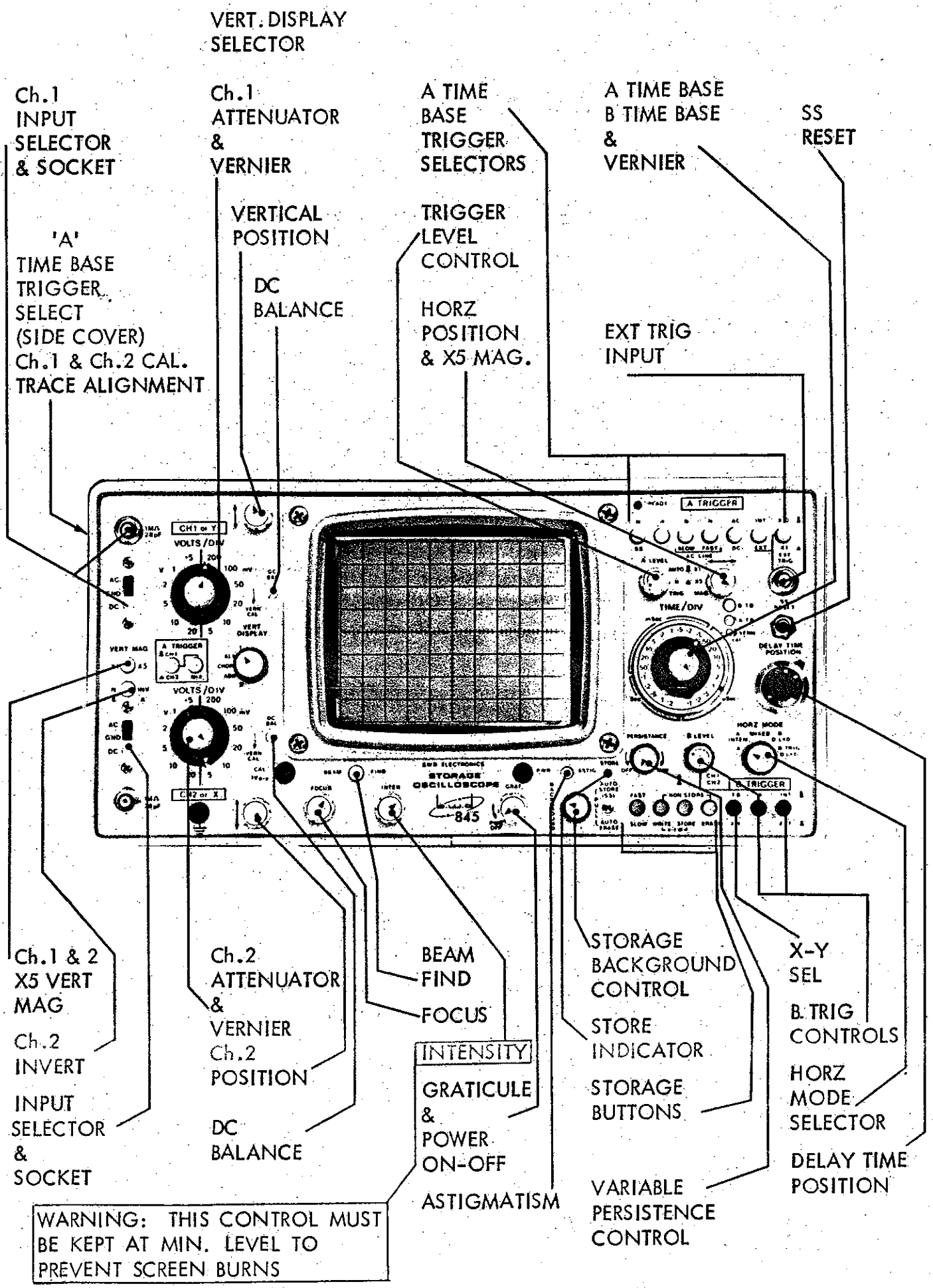
Front Panel protective cover	SC52
Carrying Case	~~C56~~ C108 @ $250
Oscilloscope trolley	T61
Cameras - Details on request	

2.10 Battery Pack:

The type BP3 pack is readily attached or detached from model BWD 845. It is fixed by two screws and connects via a plug to the rear panel socket. If desired the battery pack can be carried separately to the oscilloscope and is provided with a handle for this use. Recharge time of 14 hours provides approximately 4 hours running time.

2.11 Dimensions:





BWD 845 CONTROL FUNCTIONS

3. FUNCTION OF CONTROLS

3.1 Vertical Amplifier Section:

Ch. 1 and Ch. 2 Volts/Div. - selects the vertical deflection factor in a 1,2,5 sequence (Vernier control must be in the calibrated detent for the indicated deflection factor). Calibrated accuracy is within 3%.

Vernier - provides continuously variable uncalibrated deflection factors between the calibrated settings of the volts /div switch.

Positions the display vertically.

Input Connectors - for application of external signals to the inputs of the vertical amplifier. In the X-Y mode of operation, the signal connected to the Ch. 2 connector provides horizontal deflection and the signal connected to the Ch. 1 connector provides the vertical deflection. Input impedance is 1 megohm paralleled by approximately 28pf. Minimum bandwidth in the normal mode of operation is DC to 30MHz from 5mV to 20V/div and DC to 25MHz at x5 gain, both channels.

X-axis has a bandwidth in X-Y operation of DC to 1MHz and is compensated to have 2° or less phase difference with relation to the Y axis from DC to 100kHz.

AC, GND, DC: This switch selects the input coupling to the vertical amplifier. In the AC position, signals are capacitively coupled to the vertical amplifier. The DC component of the input signal is blocked. Low frequency -3db point is below 2Hz. In the DC position, all components of the input signal are passed to the input amplifier. In the GND position, the input of the vertical amplifier is disconnected from the input connector and grounded.

Gain x1 or x5 - Push button out gain is 5mV to 20V/div. Button in, gain is increased by x5 providing 1mV and 2mV sensitivity. Above 5mV use the x1 gain.

Invert - Chan 2 display is inverted when the button is pressed in.

VERTICAL DISPLAY - Selects mode of operation for vertical amplifier system.

1. Chan 1 only is displayed. Must also be selected for X-Y operation.

ALT: Dual trace display of the signals of both channels. Display is switched between channels at the end of each sweep.

CHOP: Dual trace display of the signals of both channels. Display is switched between channels at a repetition rate of approximately 300kHz.

ADD: Signals applied to the Ch. 1 and Ch. 2 input connectors are algebraically added, and the algebriac sum is displayed on the CRT. With the Ch. 2 INVERT switch engaged, the display is Ch. 1 minus Ch. 2 (Differential Operation).

2. Channel 2 only is displayed.

DC BAL: Preset controls to balance input stage to eliminate trace movement when Vernier controls are operated.

3.2 'A' Trig (Main or Delaying Time Base)
CH 1 - CH 2, NORM - MIX
Two push buttons select the required internal trigger source. The left button selects Ch. 1 when out and Ch. 2 when in. The RH button supplies Ch. 1 or 2 as selected by the LH button in the out position and from Ch. 1 and 2 alternately in the Mix position. When Ch. 1, CHOP or Ch. 2 is selected, leave the RH button out and select Ch. 1 or Ch. 2 trigger as required.

3.3 Time Base Section:

Two complete time base generators and associated circuits are located within the RH panel section. Layout and operation of the controls is straight forward and familiarisation will only take a few minutes. The time bases are referred to as A (main) and B (delayed). The time base to provide the CRT display is selected by the five position HORZ MODE rotary switch.

3.4 'A' Trigger Select Buttons (Yellow) (in sequence from L to R)

S.S: Trace is normal with button out, immediately it is depressed, the next sweep will latch the circuit and prevent further sweeps from occurring.

±: Button out enables the positive or rising slope of the trigger waveform to initiate the time base. With the button in the negative or falling slope triggers the time base.

SLOW: Button out, coupling is normal, when pressed in, a CR network attenuates signals above 5kHz. This button also provides frame lock for composite video signals above 2 div amplitude.

FAST: Button out, coupling is normal, when in, a series capacitor attenuates signals below 10kHz and also eliminates DC coupling.

LINE: When both SLOW and FAST buttons are depressed the line frequency powering the oscilloscope is coupled to the trigger circuit to lock the trace. The phase of the line frequency trigger point may be adjusted by the LEVEL control and the ± switch.

NOTE: Line facility is in-operative on DC or battery operation.

AC-DC: Button out, trigger circuit is AC coupled, response is approximately -3db at 10Hz. With button depressed circuit is DC coupled and signals down to zero frequency will trigger the trace.

INT-EXT: Button out, trigger signal is as selected by A Trig push buttons located between the vertical amplifier attenuators. External signals are selected when the button is pressed.

EXT x1 or x10: Button out x1. Gain increased x10 with button in for external trigger signals.

3.5 External Input Socket: External input for both A and B trigger circuits.

Ready Light: Located above S.S. button indicates trigger readiness in all sweep modes including when trace has been reset in the S.S. mode.

Level Control: Selects the precise point on the triggering waveform that initiates the time base trace. Selection is available of the full 8 div. of CRT display or up to ± 3V p of external trigger at x10 or ± 30V p at x1.

When LEVEL knob is pushed in, the time base will free run and display an AUTO base line if a trigger signal is not present or if the control is turned until it is out of the range of the trigger signal.

With the knob out, the automatic base line is eliminated and trace is not present in the absence of a trigger signal.

3.6 Time/Div: Triple concentric knob.

The large outer knob controls B time base range from 100 nanoSec to 0.5Sec/div only.

The winged green knob is the main A time base range and covers the entire range from 100nSec to 2Sec/div.

NOTE: The two knobs are interlocked so that B time base range cannot be switched to a slower speed than the A time base thus eliminating incorrect displays.

The small white knob doubles for both A & B time base vernier control. When the HORZ MODE is set to A it operates as 'A' time base vernier and provides a 5 - 1 range overlapping each step and extends the range down to >10Sec/div.

When the HORZ MODE switch is turned to the remaining 4 positions the control becomes the B time base vernier providing a 5-1 range and extends the range down to >2.5Sec/div. This method of changeover ensures that the A time base in its delaying mode is always calibrated and the delay period is the selected time/div x the multiplier setting.

Reset:

Push button will reset the time base when the single sweep (SS) button is pressed.

3.7 Horizontal Position and x5 Mag:

Positions the trace horizontally on the CRT. When the knob is pressed in the trace is at x1 magnification. When pulled out sweep speed is magnified x5.

3.8 Horz. Mode :

A	Normal A time base operation with no delay.
INTEN	A time base brightened over a selected portion as determined by B time base and the 10 turn Delay Multiplier.
MIXED	A time base is displayed by the left section of the trace and B time base for the remainder. The change point is set by the Delay Multiplier.
B DL'YD) BY A.)	Only the portion of the trace intensified at the INTEN switch step will be shown on the CRT.

3.8 Horz. Display (Cont'd)

B TRIGGER) As for previous step but trace will only be initiated by a trigger
D'YD BY A) pulse applied to B time base.

Delay Multiplier:

Multiplies the TIME/DIV as selected by A time range switch over the range x0.5 to x10 providing a delay range from 200nSec to 20Sec.

3.9 B TIME BASE Trigger Controls:
Level Control/Ch. 1 or 2 selector: (Dual function control)

With control pushed in, Ch 1 provides the internal 'B' time base trigger. Ch. 2 supplies the trigger when the knob is out. The control either in or out selects the trigger level of the waveform that initiates the B time base over a minimum of 6 div internal or ± 3V p external with Ext x10 selected or ± 30V p Ext x1 selected.

Push Buttons (green) R to L:

INT - EXT:

With button out, Ch. 1 or 2 is available to trigger the B (delayed) time base. External signals via the BNC socket at the top of the panel are coupled in when the button is in .

±:

The positive slope of the trigger signal initiates the B time base with the button out , negative slope initiates with the button in .

3.10 NORM/X-Y:

Button out , selected time base supplies the horizontal trace. When in and x5 Horizontal Mag. switch is operated, Ch. 2 amplifier is coupled to the horizontal deflection amplifier to provide the X deflection.

3.11 Storage Controls (Blue):

Push-Buttons (R to L)

ERASE: Spring return button erases trace. Erase pulse length is independent of the length of time that the button is depressed.

NORM-WRITE: Button is out for non-store operation. When in, signals displayed on CRT will be written.

NORM-STORE: When a written trace is to be stored, the Store button is pressed in - leaving the Write Button in also. The trace is then stored and all other oscilloscope functions are in-operative other than Erase. The display can be turned off by releasing the Write button leaving the CRT blanked out. The display can be brought back by engaging the Write button again.

3. FUNCTION OF CONTROLS

FAST-SLOW: With button engaged (SLOW) maximum writing speed is approximately 10μSec/div. With button OUT writing speed is increased to <1μSec/div but as background illumination must also be increased for fast writing, CRT contrast level and storage time are reduced. Signals written in the Fast mode may be stored or viewed in the Slow mode to increase the storage or viewing time available.

Persistence Control: Maximum storage time is with control switched fully counter-clockwise. When control is rotated out of the detent, storage time will reduce until in the clockwise position the trace fades in less than 1 second. With slow speed repetitive signals, trace fade can be adjusted to just overlap each sweep.

Background Control/Auto View and Auto Store: With the control pushed IN, the various storage functions are manually controlled. The Background level may be adjusted by the control from completely black in the counter clock position to a green background clockwise. The level of background together with the intensity of the writing beam control the writing speed. The Background control operates whether push-in or out.

Two functions are available when the knob is pulled out, AUTO View or AUTO Store. The S.S. push button in the top row of A time base trigger buttons, selects the function. With the SS button OUT, Auto View is selected, with the SS button IN Auto Store is enabled.

Store Led: Indicates when illuminated that a signal is stored in either the normal Store Mode or in Auto Store.

3.12 CRT Controls:

Graticule/Power On-Off. Fully anticlockwise switches AC power to the instrument off - this includes charging current when rear panel switch is in CHARGE position but NOT DC or battery supplies.

Clockwise rotation turns on power and adjusts internal graticule illumination.

Focus: Adjusts sharpness of trace, control should be set initially in conjunction with the ASTIGMATISM preset for best overall trace sharpness.

Intensity: Adjusts the trace intensity. KEEP AT MIN. LEVEL TO PREVENT CRT SCREEN BURNS.

Power Indicator: When power input voltage is above minimum necessary for correct calibration light will be on and continuous. If supply voltage falls below correct level - AC, DC or battery, the light flashes on and off at a 1 second rate approx.

Cal. 1V p-p: Approx. 1kHz rectangular positive going waveform of 1V p-p amplitude. Rise time is <1μSec into a 10MΩ probe.

Ground Socket: 4mm socket for instrument chassis connections.

Beam Find: Push button reduces X and Y deflection to within screen limits, and over-rides intensity setting to bring display within limits of CRT. DO NOT HOLD IN OR CRT SCREEN MAY BE BURNT.

3.13 Rear Panel Facilities:

Use/Charge switch: Changes the 845 power supplies from normal operating condition when switched to USE to a battery charging condition (and instrument switched off) in the CHARGE position. Switch must be in USE position for normal operating from AC, DC or battery supplies.

Battery Socket: This takes the battery plug attached to the battery pack. It should not be used for any other purpose if a battery is not attached.

DC Input Terminals: As both terminals are isolated from ground the external DC input may be grounded either side or floating with respect to chassis. The DC input may be floated to a maximum of ±50V from chassis potential.

Z Mod. BNC socket: Modulation requires positive input to blank trace, +2V is all that is necessary to turn trace off at normal intensity. Input is TTL compatible.

External Erase Sockets: Two 4mm sockets when shorted together operate the erase function.

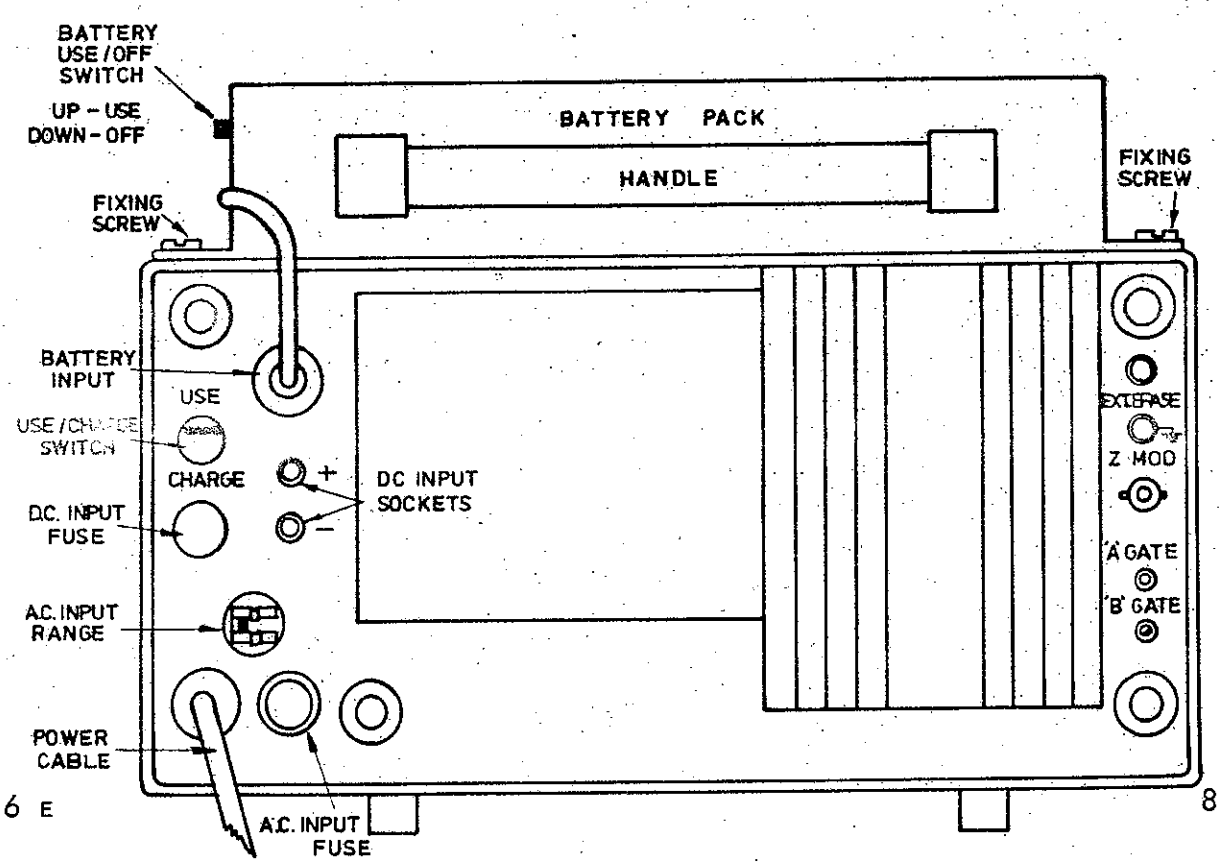
A Gate: Waveform coincides with A time base sweep. It is positive going when trace is blanked out. Output 0 to +4V approx. from 1K source.

B Gate: Waveform coincides with B time base sweep. It is positive going when trace is blanked out. Output 0 to +4V from 1K source.

117 - 235V AC Switch: Switch may be moved to either position with the aid of a small screwdriver when instrument is switched off.

3.14 Side Rail Presets:

L.H. side of instrument Ch. 1 and Ch. 2 preset calibrate controls and trace alignment preset to enable trace to be accurately aligned with graticule.



4. INITIAL CHECKING:

The following sections of this Handbook provide information to allow a user to become familiar with the instrument's power requirements, function of controls and connectors, and also provides some methods of making several measurements of electrical phenomena. Also included is a procedure for checking the instrument's calibration.

4.1 Oscilloscope Operation from AC Supplies:

This instrument is designed for operation from a power source with its neutral at or near earth (ground) potential with a separate safety-earth conductor. It is not intended for operation from two phases of a multi-phase system, or across the legs of a single-phase three-wire system.

This instrument can be operated from either a 117 - volt or a 235 - volt nominal line voltage source, 48 to 440hertz. This instrument may be damaged if operated with the line voltage switched to the incorrect position for the line voltage applied.

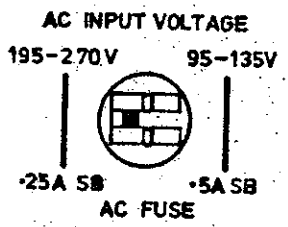
4.2 Oscilloscope Connection to AC Supplies:

The BWD 845 is designed to be used with a three-wire A.C. power system, with the green/yellow wire connected to ground. Failure to complete the ground system may allow the case of this instrument to be elevated above ground potential and pose a shock hazard.

NOTE: Colour-coding of the cord conductors is as follows:-

		(U.S.A.& Canada Only)
Line	Brown	Black
Neutral	Blue	White
Safety earth (ground)	Green/yellow stripe	Green

Input selection of A.C. voltage range is made via the slide switch recessed in the rear of the cabinet. Switch dolly must be pushed (with the aid of a small screwdriver) towards the voltage range corresponding to the available supply.



NOTE: When the AC voltage range switch is changed it is necessary that the A.C. Fuse be the correct rating as indicated on the rear panel. Failure to correct the fuse could result in damage to the equipment.

Under no circumstances should the selector switch be changed from one range to the other with power applied to the instrument.

4.3 Oscilloscope Operation from DC Supplies:

The rear panel terminals for the DC input are isolated from the chassis. This enables supplies with either polarity grounded or floating up to 50V from ground to power the BWD 845 oscilloscope. Normal requirement is 20 to 30V at approx. 1.3 amps. Input circuit for DC operation is protected against reversed polarity connection and will withstand over-voltage pulses to 40V peak.

NOTE: The front panel Power ON-OFF switch does not disconnect the DC supply. This must be done by removing the supply externally. If both AC and DC supplies are applied simultaneously the source supplying the higher voltage will power the oscilloscope. This would enable a standby DC supply to take over from the AC power in the event of an AC failure.

If the input DC supply falls below minimum operating requirements the front panel lamp will blink on and off to indicate loss of calibration.

4.4 BP 3 Battery Pack Operation:

The battery pack attaches to the top of the BWD 845 Oscilloscope by the two rear top cover holding down screws. A three pin plug on a short cable mates with the socket on the rear panel.

Two switches control the battery supply. On the pack itself the switch turns the batteries on or off. When battery operation is NOT required or they are not being charged turn the switch to OFF.
When the batteries are to power the oscilloscope or require charging, turn the switch to ON.

The slide switch on the oscilloscope must be left in the USE position for all modes of operation and all power supply sources. It is only switched to CHARGE when required for that purpose. It should only be switched from USE to CHARGE with power switched off to minimise risk of damage.

NOTE: The front panel power ON-OFF switch does not disconnect the battery supply; this must be done by the switch on the battery pack itself.

Approximately 14 hours is required to charge the battery pack when it is discharged to minimum operating voltage. A fully charged pack will provide approximately 4 hours operation. Actual operating time can be affected by temperature and age of batteries.

When the batteries have discharged to their minimum operating condition, the front panel light will blink to indicate loss of calibration. Batteries should be recharged and not left on when light is blinking.

For transport purposes the pack may be detached from the oscilloscope and carried separately by the handle provided.

5. FIRST TIME OPERATION:

One of the major features of the BWD 845 Oscilloscope is that normal Non-Store operation is obtained when all push buttons are 'Out'. A quick scan over the panel therefore immediately indicates any variation to normal and assists in quick familiarisation with the instrument's operation.

The panel is divided into 4 operating areas.

L.H. side is the vertical section - Channels 1 and 2.
R.H. side is the A & B Time Base section. A time base (yellow), B time base (green).
Bottom right of the CRT, Storage controls (blue).
Under the CRT are its controls, power switch and calibrator.

5.1 For first time operation, if unfamiliar with this class of oscilloscope, set the controls as below and follow the steps outlined until each feature is understood:-

Set all switch buttons in the OUT position.

Vertical Amplifiers:

Attenuators	0.2V/div
Verniers	CAL (clockwise)
Input switches	AC
x1 - x5 gain	x1
Norm/Invert (Ch. 2)	Norm.
Trigger select	Ch. 1 (both buttons OUT)
Vertical Display	1.

Time Base:

Trigger buttons	All out.
←→ & Mag.	Centered and pushed in for x1 mag.
Trigger level	Centered and pushed in
Time/div switches	B time base 0.1μSec (outer ring) A time base 0.5mSec (winged knob)
Vernier	CAL (Clockwise)
Horizontal Mode	A time base (CCW)
Bottom push buttons	All out.
B trigger level	Centered and pushed in
Multiplier	Any setting.

Storage :

Persistence control	Fully counter-clockwise to off.
Background control	Fully counter-clockwise and pushed in.

CRT Controls:

Focus	Centered
Intensity	Counter-clockwise.
Graticule ON/OFF	OFF, (CCW)
Astig	Centered or leave as supplied.

5. FIRST TIME OPERATION

5.2 Connect power lead to 48 - 440Hz AC supply or leads to 20 - 30V DC supply and switch instrument on. Turn intensity control to approx. 2 o'clock position, after a few seconds trace will appear. Adjust intensity and focus, then position it centrally across screen. If trace is not horizontal, adjust the Trace Alignment preset on LH side panel until it aligns with the graticule line.

> WARNING: CRT Intensity should be left at the lowest practical level to minimise possibility of storage mesh-burns under all conditions of operation.

Turn vernier control of Ch. 1 counter-clockwise, centre trace with vertical position control, then rotate vernier back to Cal., if trace moves re-centre with DC Bal control. Repeat if necessary to eliminate movement.
Connect a 1:1 probe, BWD P32 from the 1V calibrator socket to Ch. 1 input, centre trace.. Waveform should be 5 div high with vernier to cal. If not, adjust calibration at L.H. side of cabinet. Position waveform about graticule centre line.

The 1kHz square wave will be 5 div high and approx., one waveform per 2 divisions horizontally. Slide Ch. 1 input switch to DC - the trace will rise and the bottom of the waveform will now correspond with the CRT centreline indicating the input signal is a waveform positive going with respect to ground. Switch to GND on Ch. 1, the trace will disappear then after approx. 0.3 sec., a bright reference base line will appear as the Auto time base operates. The GND switch disconnects the input signal in this condition but grounds the amplifier. Switch back to DC and trace will again be standing on the centre-line.

Slide switch to AC position, then rotate position control and note display can be moved off CRT above and below, but without losing the trigger.

5.3 High Impedance Probes:

For high frequency measurements the input loading on circuits particularly capacitance must be kept to minimum levels. The simplest way to achieve this is by use of a high impedance probe which reduces the input signal by a factor of 10 but simultaneously reduces the input capacitance to approximately 11pf and increases the input resistance to 10MΩ. Two types are available for this model. The BWD P32 and the BWD P40 probes. Both will provide full bandwidth operation. The P32 duo probe has the additional advantage of a switch to provide 1:1 operation and an OFF reference position.

To align a probe, couple it to Channel 1 input jack. Set attenuator to 20mV/div. and time base to 0.2m Sec/div. Place the point of the 10:1 probe tip on the 1V main frame calibrator socket, a square wave will appear probably with the top and bottom faces tilted in or out. With a small screwdriver supplied, adjust the screw in the side of the probe housing until waveform is square.
It will remain correct at all attenuator settings.

5.4 Dual Trace Operation:

Set Ch. 2 amplifier as for Ch. 1, then switch Vertical Display to 2 and depress Trigger Selector Ch. 2 button.

5.4 Dual Trace Operation

Connect the 1V calibrator output to Ch. 2 input. Set balance and Cal as previously described for Ch. 1. Now apply the 1V 1kHz square wave to both inputs. Reduce attenuator settings on both amplifiers to 0.5V/div then switch Vertical Display to ALT. Two traces will appear which can be positioned above and below CRT centreline.

With the traces positioned above each other, set the time base range switch to slower sweep speeds and observe how flicker between the traces increases until at 10mSec/div the switching between the traces is readily visible. This is the useful lower limit of the Alternate switching in a non-store mode.

Now increase the time base speed, the traces will remain locked right through to 0.1μSec/div. Return time base range to 1mSec/div again then switch the main frame Vertical Display to CHOP. Trace flicker immediately stops. When the time base frequency is reduced, the two traces appear simultaneously down to the lowest sweep frequency.

Return switch to 1mSec/div and then increase time base speed. At speeds around 50μSec/div the waveforms will start to show the individual chopping sections indicating the useful upper limit of CHOP displays.

As has been seen, a wide overlap exists where both forms of dual trace display can be used satisfactorily.

With the time base returned to 1mSec/div and both attenuators set to 0.5V/div., the traces will be 2 div high. In this condition, set the Vertical Mode to ADD. A single trace will appear with a 4 div. display, i.e. the two traces have been added together. Now press the Invert button on Ch. 2, the waveform will disappear leaving only a line. This is the difference between the two signals or the result when one is subtracted from the other. Applications for this form of measurement are described later. Return switches to ALT and normal.

5.5 Time Base Operation:

Replace the input signal to Ch. 1 with a 2kHz (approx.) sine wave and adjust attenuator or input for 6 div. display. Time Base to 0.2mSec/div.

Trigger Level:

With knob pushed in, turn the control and observe that the trigger point moves up and down the wavefront. When it reaches the top or bottom of the waveform the trace blanks out for a fraction of a second when trigger is lost, then the trace free runs in the Auto condition until the level control is readjusted to select a trigger signal. Now push in the ± button to select -ve trigger. The waveform will now trigger on a -ve going slope. Clockwise rotation of the level control will increase the trigger point level towards the positive point of the waveform, anticlock rotation towards the negative point.

Revert to + ve trigger selection, then pull out the Level Control knob. Auto is now switched off, turn the knob to select level and note the trace disappears when the level extends past the waveform limits.

5. FIRST TIME OPERATION:

Trigger level

Push knob in again and reduce amplitude of displayed signal, with Level Control carefully adjusted, signal can be reduced to less than 4mm with a stable lock still obtained. The control has an expanded section at the centre of its operating range to assist trigger selection of low amplitude signals.

T.B. Vernier:

Turn Vernier anticlockwise - observe approx. x5 the number of waveforms on CRT when fully anticlockwise. Return to Cal position. Note: Vernier control only operates with A time base with HORZ DISPLAY to A. It operates with B time base in all other modes.

5.6 Magnification:

Adjust input frequency to produce one sine wave per div. and locate the peak of each waveform on a vertical graticule line. Pull out the horizontal position control. Each peak will now be 5 div apart indicating a x5 magnification.

The trace will expand either side of the centre and any portion of it can be viewed by rotating the position control Return to x1 and recentre trace horizontally.

5.7 Single Sweep Operation:

This feature is primarily used in conjunction with a camera for recording single waveforms, but can also be used at slow sweep speeds for manually initiating the trace to coincide with other functions. Two modes of operation are available to suit these applications.

For photographic application the Trig LEVEL knob should be pulled out to Non-Auto and adjusted for correct setting on a similar amplitude waveform. Setting should be slightly away from max. sensitivity to eliminate the possibility of false triggering by noise, hum, etc., which may be present on the input signal.

Next press the SS button, place camera over CRT and open shutter. Apply the input signal which will initiate the time base for one sweep. The trace will then remain blanked out, and latched in a locked-out condition. Release the camera shutter then press the Reset button to release the time base and ready it for the next input signal. The ready condition is indicated by the LED Lamp above the SS button glowing.

Where manual initiation of the time base is required, push the Level knob in for Auto operation. Each time the Reset button is pressed, the trace will immediately sweep across the screen once and not wait for a trigger pulse to initiate it.

5.8 Delayed Time Base Operation:

Three types of display are available to view a waveform delayed in time by the BWD 845 time base; there are MIXED, DELAYED SWEEP (B delayed by A) and DELAYED TRIGGER. (B trigger delayed by A).

The HORZ . MODE selects the three modes together with A time base only and A intensified by B.

5.9 In the MIXED mode a combined trace displays the 'A' or main time base to the left, then at the point selected by the Delay Multiplier dial the delayed or 'B' time base completes the trace at a fast speed, thus presenting a non-magnified and magnified waveform simultaneously.

With the Delayed Sweep mode, no display is presented during the delaying period, but immediately following this period the B time base is displayed. If very long delay periods are involved > 10,000:1 jitter of the waveform and the inherent jitter of the time base may produce an unstable display in this mode. A stable presentation of the delayed waveform is available, however, when Delayed Trigger is employed.

In Delayed Trigger mode no display is present during the delaying period, but immediately after the B time base is armed in readiness to receive a trigger signal. When this is received, B time base will fire and present a stable display even with delay periods of > 20,000 - 1.

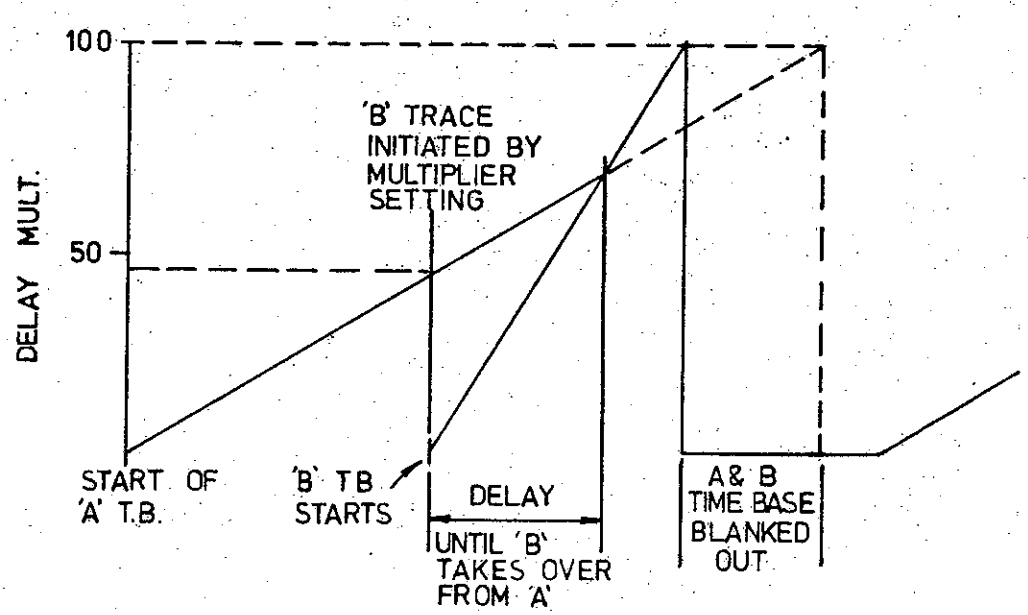
5.10 Operation of the delay time base facility is as follows:-

With all push buttons "Out' feed in a 10kHz signal to Ch. 1 amplifier, set to approx. 4 div amplitude and set A time base to 0.5mSec/div. Five waveforms will appear per div. Align the start of the trace with the first graticule mark. Now set the B time base to 50µSec/div. (Vernier to Cal) and the 10 turn Delay Multiplier to 50.

Turn the DISPLAY switch to INTEN (A intensified by B) a section one div. long starting at the 5th div. (CRT centre) will be brightened. Turn the Delay Multiplier down to zero and then up to 100 and note how the intensified portion tracks accurately with the dial calibration between 10 and 100, return dial to 50, now turn the B time base Time/div switch and note how the segment becomes shorter at higher sweep speeds and vice versa.

With the aid of both controls any section of the main display can be selected for delayed presentation. With the B time base returned to 50µSec. turn the DISPLAY switch to MIXED. The first 5 div of trace will remain as before, but the remaining 5 divisions will be displayed at 50µSec/div. Turn the Delayed Multiplier and note how the waveforms appear to "peel off" the main display. Changing the B time base speed will change the magnification of the waveforms on the right.

NOTE: The point at which the transition from time base A to B occurs in the MIXED displa is slightly delayed to the start of the intensified section. This is shown in the illustration below:-



5.11 To display only the delayed or B time base, move the Display Switch to B delayed by A. The start point of the delayed trace is now accurately controlled by the Delay Multiplier dial. If for example a pulse is brought in line with the first graticule mark using the B delayed by A mode, the A time base speed is 0.5mSec/div and the Delay Multi dial reads 50, then the pulse is 0.5mSec x 5 = 2.5mSec from the pulse which initially triggered the A time base. The displayed pulse width etc., can be read off directly from the CRT screen - remember the displayed sweep speed is set by B time base and the vernier.

If in the previous example the trace is jittering due to an unstable signal or noise etc., then the Display Switch is turned to its final step B trigger delayed by A. The B time base will not commence immediately after the delay period, instead the B time base will be set ready to receive a trigger pulse to initiate the trace to ensure a stable trace.

5.12 B. Trig. Delayed By A:

The signal to trigger the B time base can be obtained from three sources. It can be selected from either internal channel or from an external source. The ch. select switch on the LEVEL control, INT - EXT and ± push buttons control the source and polarity of the trigger signal. The trigger point on the waveform can be selected by the 'B" LEVEL control. When triggering to frequencies above 20MHz , care must be taken with the level control as the adjustment is more critical.

5.13 Horizontal Amplifier:

Identical X - Y

Parallel and 2kHz sine wave into Ch. 1 and 2, set Vertical Display to 1, engage X - Y button and pull out x5 mag. Ch. 1 will now present the vertical display and Ch. 2 the horizontal. To position the display horizontally use Ch. 2 position control leaving the horizontal position control centered.

The horizontal deflection may be reversed in polarity by pressing the INVERT switch. Vernier control between attenuator steps is available for both the vertical and horizontal axis. For zero phase shift between X-Y inputs at low frequencies it is essential to use DC coupling on both channels.

NOTE: X-Y displays should be contained within the 8 x 10 div graticule to eliminate distortion due to signal overdrive.

5.14 Z Modulation:

Reset all push buttons to 'Out', connect 1V p-p sine wave to Ch. 1, switch attenuator to 0.5V/div. Set Vertical Display to ALT. Position displays one above the other. Now parallel the 1V signal into rear panel Z mod. socket. The tops of each displayed sine wave will diminish in intensity and the Ch. 2 trace will be broken into a series of light and dark sections.

WARNING: CRT Intensity must always be left at the lowest practical level to minimise possibility of storage-mesh burns under all conditions of operation.

6. STORAGE:

6.1 The many storage conditions available on the BWD 845 are described in the following sections:

Definition of control terms.

Persistence:	The length of time a written display remains on the CRT screen.
Write:	To retain a signal being displayed on the CRT in the storage mode.
Store:	To retain the stored signal and to lock out any further signals.
Erase:	To remove all written and stored displays on the CRT.
Background:	The green illumination visible on CRT.
Intensity:	The brightness of display controlled by the Intensity control as it is written on the CRT.
Bloom:	A visible non-symetrical broadening of a written line on the CRT.
Fade Positive:	Increase in background illumination until display is obscured.

6.2 Operation:

Variable Persistence:

Set up oscilloscope as for normal use, then apply a 10Hz sine wave to Ch. 1 and adjust for 6 div deflection. Set time base to 100mSec/div, keep intensity low. Turn background counter-clockwise and the Variable Persistence control clockwise out of its detent positions. Engage the Write button. The CRT background will be an even green colour. Reduce intensity level if trace blooms. Adjust Variable Persistence control until trace is displayed as a continuous pattern. Change input frequency and note how a continuous display is available down to the slowest calibrated sweep speed at max. persistence. If desired the oscilloscope can be used in this mode for normal operation with the Variable Persistence control set at minimum. This will provide displays of a higher brightness level but fast changing signals may cause the display to blur.

6.3 Normal Storage:

Set up as for Variable Persistence but turn Persistence control to OFF. (counter-clockwise). Press Erase button and release. Adjust Intensity for required display, when it is written correctly, press the Store button. Trace will be retained but all other functions except erase are locked out. If it is desired to retain the trace for a long time, engage the Slow button. By releasing the Write button, extended store time is available. Engaging the Write button brings display back for viewing. As the background does not fade green as quickly at slow writing speed as it does on fast, it may be advantageous to use slow when a considerable waiting time is involved before the trace is written or if several traces require writing for comparison without erasing between them.

6.4 Multiple Display Store:

To store more than one display, operate controls as follows:-

Set writing speed Slow, Variable Persistence to OFF, engage Write button, press and release Erase, then write first display on CRT. Return Intensity control to fully CCW. Apply second signal to be stored, reset vertical position if signal is not to be stored on top of first display. Increase intensity and write second signal. Repeat as necessary for other displays, then engage Store button.

6.5 Single Sweep Storage:

To facilitate writing and Storing single sweep signals, an AUTO ERASE feature is incorporated to enable controls to be optimised before attempting to store the signal.

Set up controls for normal storage, i.e. Var. Persistence OFF, Fast/Slow button OUT. Write button engaged. Now pull Out the BACKGROUND control, leave control knob fully CCW. Press and release Erase button. Apply a continuous signal of similar characteristics to the S.S. one to be stored. Adjust time base and amplifier(s) to appropriate settings. Pull out trigger level control for Non-Auto operation.

The CRT will now follow a continuous sequence of Erase, Write and Store. Adjust Intensity, Focus, Amplifier and Time Base controls to write the signal each cycle. If the signal is high speed it may be necessary to turn the Background control clockwise until a satisfactory trace is written. At maximum writing speed the CRT background will be at a fairly high level of illumination.

NOTE: Background is not even over the entire CRT area, but is adjusted internally for optimum coverage. Auto Erase operates at all time base speeds up to the limit of storage writing speed.

Now replace simulated signal with the required input and engage the SS button (LH end of top row of trigger buttons). Push background control IN but do not turn it, leave trigger level control OUT in the Non-Auto position. Press and release the Erase button, this will simultaneously erase the previous display and reset the SS circuit. When the signal is received it will initiate the time base and write the display. Switch to Store and Slow to retain the display.

6.6

If periods up to several hours are likely to occur between erasing the previous display and receiving a signal to write the next display, the AUTO STORE feature is used.

As the primary use is for single sweep signals, the setting up procedure is almost the same as that previously described, using Auto Erase to adjust all controls to their optimum position. The only difference is that SLOW writing speed should be engaged if considerable time may elapse between the trace being stored and eventually viewed.

When display with simulated signal is correct, leave the Background control OUT and engage the SS button. Press and release Erase button. The CRT will remain in the Erased condition, i.e. bright green all over until a signal is received to trigger the time base. This will release the erase circuit so that the signal can be written. It will then automatically switch to a stored condition with the trace displayed and the red Store light illuminated. If fast writing speed was used it should be switched to slow to provide maximum retention time of the stored trace.

By using the A time base gate pulse available at the rear panel, an external alarm can be triggered by the sweep as it writes the display, so eliminating the need to continuously monitor the oscilloscope whilst awaiting the signal. The signal available at the A gate output is +4V whilst awaiting the signal, it falls to 0V during the sweep period then returns to +4V at end of sweep. Source impedance is 1kΩ.

6. STORAGE

6.7 External Erase:

A mechanical contact or PNP transistor switch placed across the rear panel Ext Erase sockets will erase a stored display on each closing of the switch. The voltage at the sockets is 0 and -15V via a 100kΩ resistor. Contact closure should be >1mSec and may be repeated at intervals of >2 seconds.

An external timer can provide the AUTO ERASE facility but with viewing time adjustable from 2 secs to almost one hour. AUTO STORE and AUTO ERASE can be combined when long periods may elapse before the signal arrives after erasing as the external switch also resets the SS condition. Mechanical, hydraulic and electrical machines can cycle a BWD 845 to present and erase signals simultaneously with their operation.

To operate in this mode, connect the external switch across the sockets. Press the SS and Write buttons. Apply the input signal and adjust Intensity for a correctly written display. Recycle with the external switch. If long delays occur between erase and the next signal, pull out the Background control. Use the Slow writing speed when possible, as this provides the most even writing over the screen face and the longest retention of stored displays.

6.8 Long Term Storage:

Two conditions are available to increase the time a stored trace is retained, the first with the instrument switched on can provide storage up to several hours by the following procedure.

With the required trace stored, press the Slow button (if Fast was used to Write) and release the WRITE button. If the BACKGROUND control has been advanced return the control to its counter clockwise position. A high contrast trace will remain stored for up to 3 hours.

To view the trace when required, depress the WRITE button and increase the BACKGROUND control if necessary to obtain a trace. The contrast ratio between background and stored trace will depend on the elapsed time of storage and the original contrast ratio.

Longer periods of stored display retention can be achieved by switching the oscilloscope off after the trace is obtained by the following procedure. With the required trace stored, release the WRITE button and depress the blue SLOW button. If the background control has been advanced, return the control to its counter clockwise position. Disconnect all power sources from the instrument. Trace can be retained in its stored condition up to 7 days.

To view the trace, leave all controls as they were when instrument was switched off. Apply power, switch on and depress WRITE button. Trace should appear within 30 seconds. If level is too low increase BACKGROUND control to obtain best contrast.

WARNING: CRT Intensity must always be left at the lowest practical level to minimise possibility of storage-mesh burns under all conditions of operation.

The following sections describe the method of making specific measurements with the BWD 845 Oscilloscope.

Start with controls set as follows:-

All buttons out, T.B. to 1mSec., Trigger Level centered. Vertical Display to Ch. 1 Connect a P32 probe switched to x1 to Ch. 1 input.

7.1 Measurement of DC (Direct) Voltages:

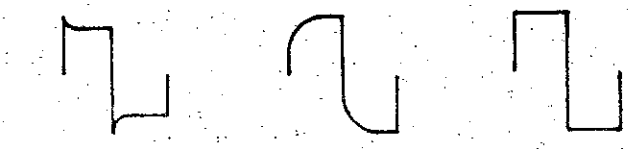
Switch Ch. 1 AC and DC switch to DC, the attenuator to 0.5V and set the trace to the centre of the graticule. For an initial test, take a $1\frac{1}{2}$V Dry Cell, connect the negative end to the flying ground-lead clip, touch the point of the probe on the positive end of the battery, the trace will move up 3 div., i.e. 3 x 0.5V ± 1.5V. Now reverse the connections to the battery and note how the trace moves down 3 div. This illustrates how an oscilloscope displays positive or negative voltages or both simultaneously, i.e. when viewing a sine or square wave.

The DC input facility may be used to measure AC waveforms swinging about a DC voltage, as at the collector of a transistor to check for bias settings or collector limiting, etc. Maximum DC input should not exceed x10 input attenuator setting if it is required to recentre the trace to view a signal superimposed on it.

NOTE:

The 1MΩ input impedance of the oscilloscope must be taken into account when measuring high impedance points such as the base of transistors or the gate of FET's working with high value loads. If a higher input impedance is required, use the BWD P32 probe switched to 10:1 to increase its input to 10MΩ and 11pf.

To align a probe couple it to Channel 1 input socket, set the attenuator to 20mV/cm and time base to 0.2mSec/cm. Place the point of the probe tip on the 1V calibrator socket and adjust the screw in the side of the probe housing until the waveform is square.



NOTE:
No adjustment is required when the button on the P32 is pressed for 1:1 operation as no signal division occurs in the probe

7.2 Measurement of an AC (Alternating) Voltage:

Amplitude:

Set the amplifier AC,GND,DC switch to AC and the attenuator to 20V (if the input voltage is unknown). Connect the probe ground lead to the ground side of the signal to be measured, then connect the probe tip to the signal source. BWD oscillators such as models 112B,141, 160A or 603B are suitable for initial experiments in this test.

7. MEASUREMENT OF VOLTAGE AND TIME

Amplitude:

Increase the vertical sensitivity by the Volts/Div switch until a display between 3 divisions and 8 div exists. Now adjust the Time Base switch to enable the waveform to be readily seen. To measure the amplitude of a displayed waveform measure its overall height in divisions against the calibrated graticule, then multiply this by the attenuator setting. The result is in Volts p-p, e.g. if the display is 6 div high and the attenuator is set at 0.5V, then the amplitude is 6 x 0.5V = 3V peak to peak: to convert a p-p sine wave voltage to RMS, divide the 3V p-p by $2\sqrt{2}$ (2.84) e.g. $\frac{3.00}{2.84}$ = 1.06V rms.

Frequency:

The frequency of a waveform can be found by switching the Time/Div switch to a range where the signal can be clearly seen, e.g. if a waveform is 5 div. long and the switch is at 100μSec, then the duration of the waveform is 5 x 100μSec = 500μSec. The frequency can be determined dividing 1 Sec, i.e. 1,000,000μSec by the duration of the waveform

$$\frac{1,000,000}{500} = 2,000\text{Hz or } 2\text{kHz}.$$

7.3 Inverted Displays:

Where it is required to display a waveform inverted on the CRT, apply it to Ch.2 input then push the Invert switch button. All information relating to display and measurement of Inverted signals is identical to the normal input details. The calibration and accuracy are as detailed in the specification.

7.4 Balanced or Differential Measurements (Single Channel)

AC Measurements:

To measure a signal appearing between two points in a circuit, neither of which is at earth (ground) potential, .e.g across a push-pull primary of an output transformer or between emitter and collector of a transistor circuit and at the same time suppress any signal common to both points as much as possible, such as HT ripple or AC power line frequency the following method is used.

Connect a probe from Ch. 1 input socket to one side of the component across which the waveform is developed, and another probe from Ch. 2 input socket to the other side. Engage the Ch.2. Invert button and switch the Vertical Display to ADD. Attenuators are adjusted to identical settings to present a suitable display.

The resultant CRT trace is the waveform being developed between the points to which the leads are coupled. Measurement of voltage and time may be made as described previously as the calibration remains constant irrespective of the input facility employed.

NOTE: When using the 'ADD' facility between Ch. 1 and 2 the following limitations must be considered:

Max. AC or DC Common Mode signal should not be greater than 8 div. deflection, if a larger DC signal exists, it should be eliminated by using AC coupling into the amplifiers.

7. MEASUREMENT OF VOLTAGE AND TIME

Balanced or Differential Measurements (Single Channel)

The differential input coupling is often essential when making low level measurements in the millivolt region even when one side of the signal source is grounded. This is because hum and noise generated in ground loops and can completely mask the signal. It can be minimised to connecting the probe from the Ch. 1 socket to the signal to be observed and a probe from the Ch. 2 socket to the nearest ground or common point to the signal on the equipment under test.

7.5 Differential DC Measurements:

When low frequencies or signals with both AC and DC components are to be measured differentially, the mode of operation is almost identical to AC measurements.

The following limits should be observed:-

Differential rejection will only operate if the Common Mode signal to be rejected is < 8 div., e.g. with the attenuator set at 1V/div. the Common Mode signal must not be greater than 8V AC p-p or ± 4V DC, or the input amplifier may be overloaded and the signal will be distorted.

The accuracy of the input attenuator resistors also controls the rejection ratio and the other than 5mV settings may reduce the rejection to only 20-1 which means, in the case of a 100V p-p AC signal, a 5V p-p signal could still appear with the required signal superimposed on it. Adjustment of Ch. 1 or 2 vernier control will reduce the level to the minimum obtainable but will affect accuracy of calibration.

Provided the limits and methods of connection indicated above are observed when making measurements with a differential amplifier, far more information can often be extracted from a circuit than with single ended amplifier operation, with only one signal lead and one side grounded.

7.6 Current Measurements AC or DC:

If a resistor can be included in a circuit, the voltage drop across it can provide a direct conversion to the current through it by use of Ohms Law. At low currents a 1Ω resistor connected across Ch.1 or Ch.2 input will enable the oscilloscope to read directly in mA or Amps in lieu of mV and Volts. Current through the 1Ω resistor will develop 1mV for every 1mA flowing and provides the direct conversion for currents to at least 2 Amps. This configuration will read both AC or DC currents and unlike an ammeter will show the actual current waveform. Practical applications are the charging currents in a filter capacitor of a power supply or the current through a rectifier, or high speed displays of pulse currents.

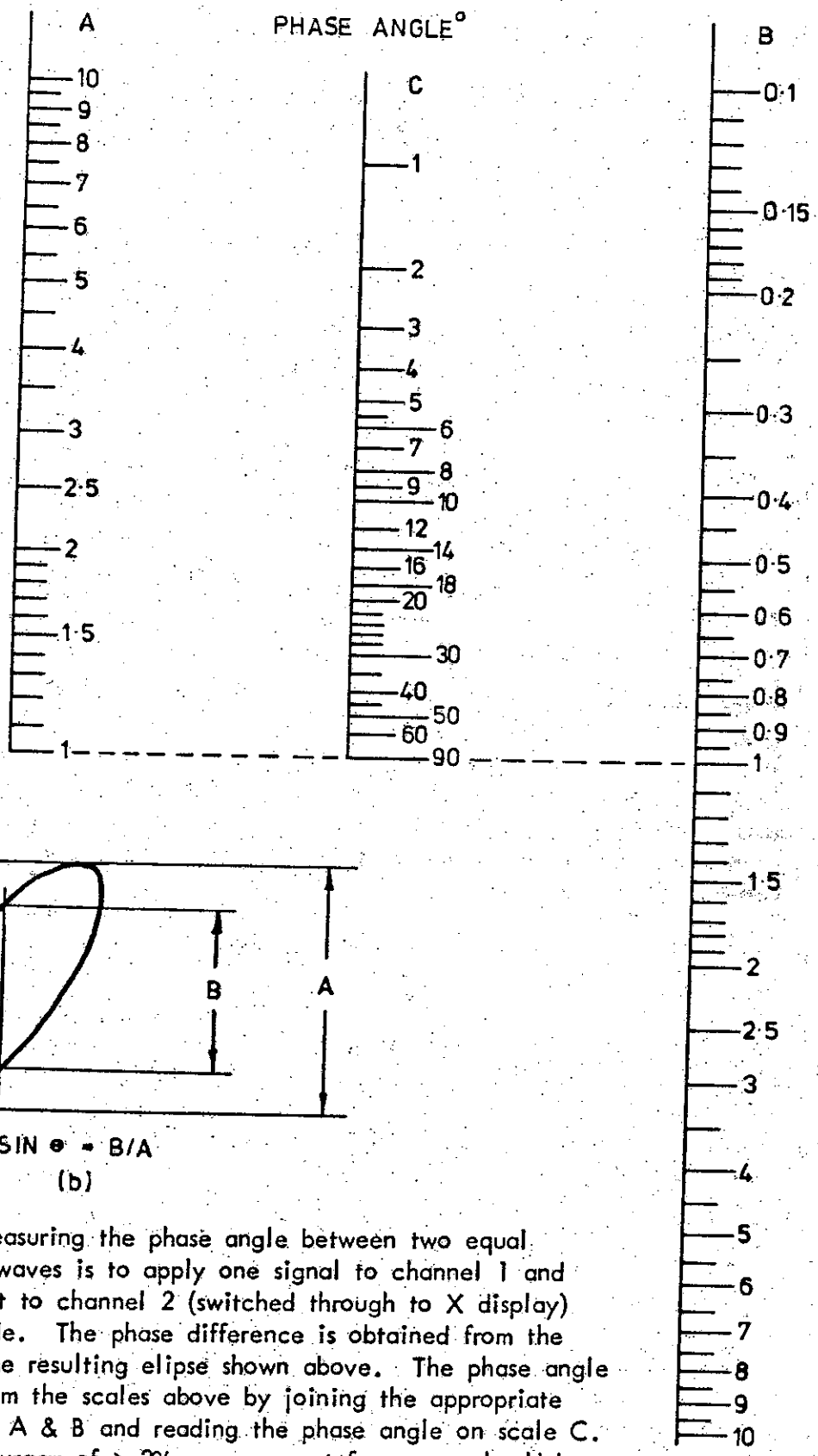
7.7 Identical X - Y Operation:

Start with all buttons out. Then set following controls:-

Vertical Display - Ch. 1. Depress X - Y button and pull out Horz. position control for x5 mag.

The signal for vertical display is fed into Ch. 1 and to Ch. 2 for horizontal display. If phase measurements are to be made on frequencies below 100Hz, the two amplifiers must be DC coupled to minimise variations in the input circuit time constants.

7.8 Measurement of Phase:



SIN θ = B/A

(b)

A method of measuring the phase angle between two equal frequency sine waves is to apply one signal to channel 1 and the second input to channel 2 (switched through to X display) in the X-Y mode. The phase difference is obtained from the dimensions of the resulting elipse shown above. The phase angle may be read from the scales above by joining the appropriate points on scales A & B and reading the phase angle on scale C. For a phase accuracy of > 2% measurement frequency should be below 100kHz.

If zero phase shift exists the line will be straight up to 100kHz. Phase between the two signals can be determined from the chart.

NOTE: 10:1 probes will produce additional phase shift and they must be checked and matched from a common signal source over the range to be measured if it is essential to use them.

7.9 Line Trigger:

To retain a continuously locked display with a constant phase relationship when exploring signals locked to power line frequencies, e.g. in a power supply, or when tracing hum in circuits, push both SLOW and FAST buttons to select Line. Adjustment of the level control and ± switch will provide phase variation of the displayed waveform.

7.10 Video (TV) Waveform Displays:

Video signals from closed circuit system, black and white or colour receivers, or TV Studio signals can be displayed on the BWD 845. A composite signal should be a minimum of 2 div. amplitude. Stable lock can be maintained with signal amplitudes from 2 div. to over 8 div.

If the video sync pulses are negative going, select -ve trigger and vice-versa.

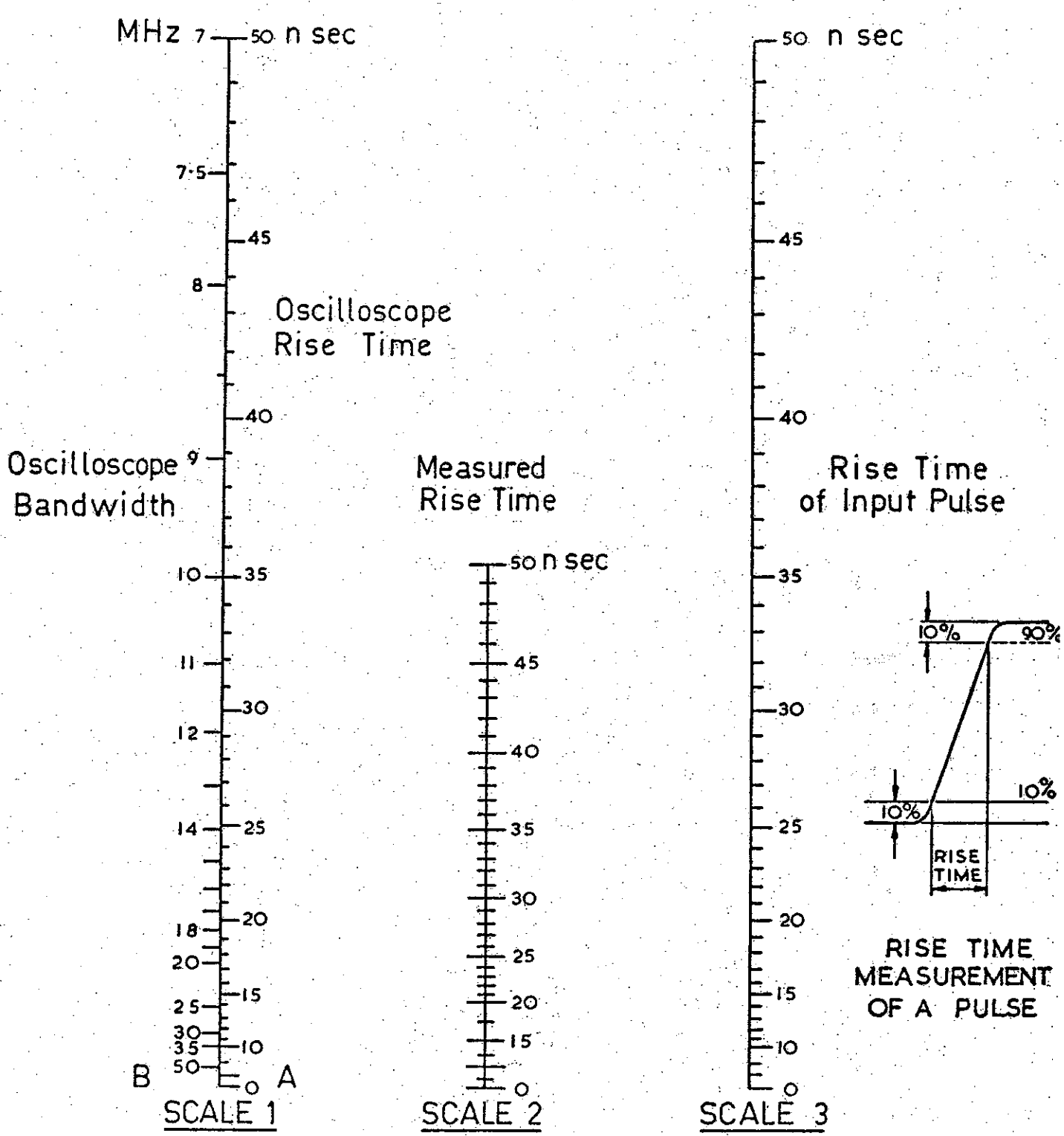
To lock to a frame pulse engage the Slow button, then adjust level for a stable lock. If the time base range is increased, the individual equalising pulses and frame pulse serations can be displayed. By utilising the higher speeds and x5 magnification, the lines preceeding the video information containing special test signals can be readily viewed.

To lock to a random line disengage the Slow button and adjust the Level control for a stable display.

Where it is required to select a particular line from the video signal, switch HORIZONTAL MODE switch to Intensified. With B time base at 10µSec, turn the Delay Multiplier 10 turn control until the desired line is intensified, turn display switch to B time base and the selected line will be presented. If the line is unstable select B TRIG DELAYED by A then with ± slope selected to suit display polarity, adjust the B Trig. Level Control to display the line with complete stability.

7.11 Rise Time:

To measure the rise or fall time of a wave front, adjust the top and bottom limits of the waveform to 6 div. deflection. Set the time base to the fastest practical speed to suit the wave front. Align the point 0.6 division (10%) up to the wave-front with a vertical graticule line, then note the 90% point (0.6 div.) down from the top and count the number of horizontal divisions between them. If for example the 10 and 90% points were 5.4 div apart and the time base was at 10µSec/div., the rise time = 5.4 x 10µS = 54µSec. Use the chart on page 7.6 for rise times faster than 50nSec when maximum accuracy is required.



RISE TIME MEASUREMENT OF A PULSE

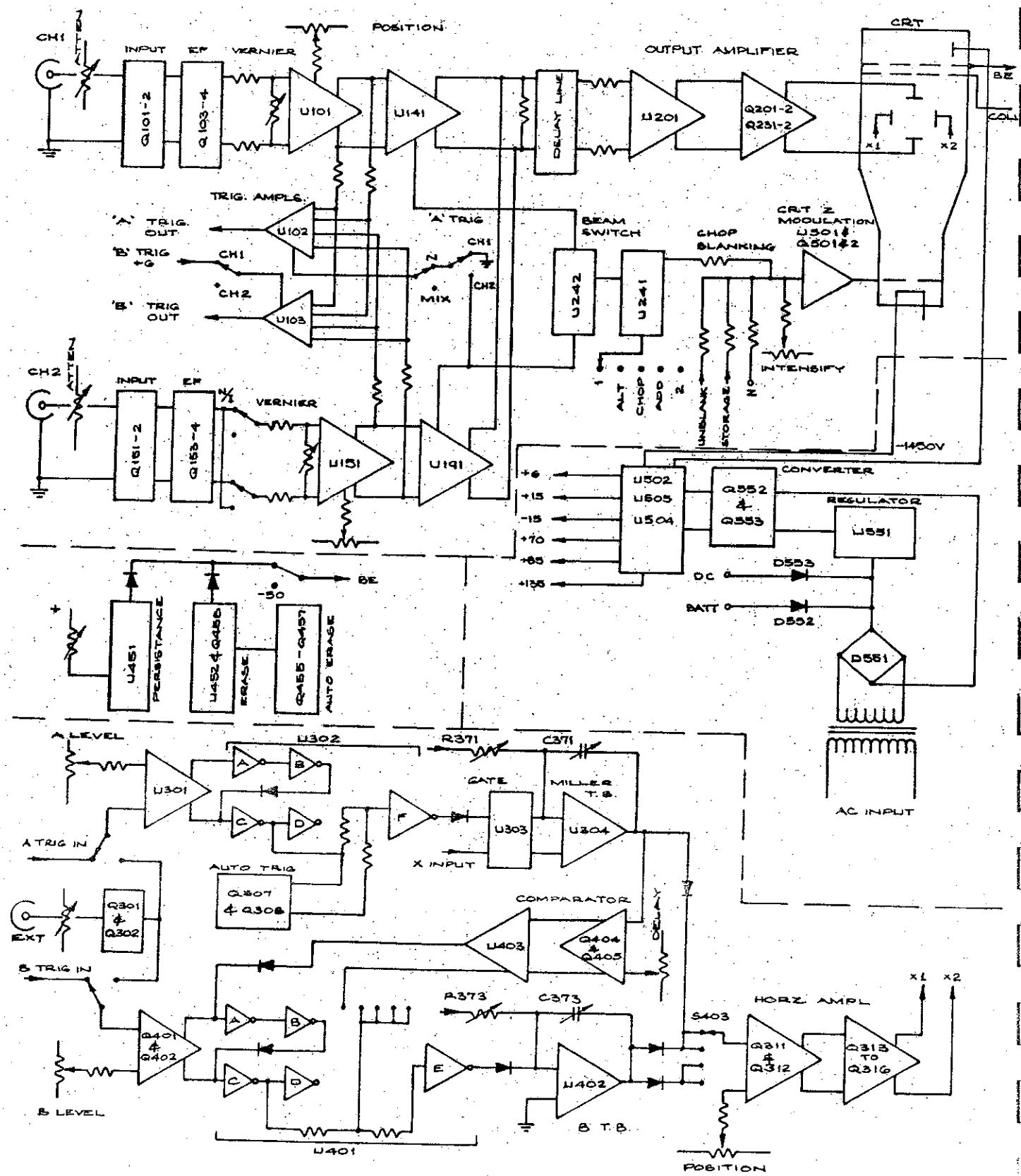
To use the above chart read the rise time of the displayed waveform on the CRT between its 10% and 90% points. Find the point corresponding to this value on Scale 2. Join this with a straight edge to the value corresponding to the oscilloscope bandwidth on Scale 1B, the projection Scale 3 is the true rise time of the input pulse.

For other rise time ranges Scale 1A, 2 and 3 can be multiplied by a conversion factor, e.g. 2,5,10. Scale 1B must be divided by the same factor.

RISE TIME CHART

The following circuit descriptions are divided into categories shown below:-

8.1	Channel 1 Vertical Amplifier	8.8 to 8.21	'A' Time Base
8.2	Channel 2 Vertical Amplifier	8.22	Horizontal Amplifier
8.3	A time base trigger Amplifier	8.23 to 8.29	Storage
8.4	B time base trigger Amplifier	8.30	CRT
8.5	Beam Switch Amplifiers	8.31	Z Modulation
8.6	Beam Switch Generator	8.32 to 8.37	Power Supplies
8.7	Vertical Output Stage	8.38	Calibrator



CIRCUIT DESCRIPTION:

8.1 Vertical Amplifiers: (Channel 1)

Input signals to the BNC jack are capacitively coupled via C1 and S1, AC-GND-DC switch to the attenuator in the AC position of S1 or directly in the DC position. When S1 is in the GND position the input signal is disconnected whilst the attenuator input is grounded via R20. The attenuator S2 comprises 3 sections which are used independently or in series to provide the selected attenuator step.

In the 5mV position, no attenuation occurs and the signal passes straight through. At the 10mV setting R10 and R14 (together with R15 in parallel) divides the input signal by 2.

Capacitor C12 and C16 divide the signal by 2 at high frequencies to maintain a constant bandwidth.

C17 maintains a constant input capacitance for that step. The 20mV step brings in R11 and R13, (R15 always remains in parallel with the shunt element). This reduces the signal by 4. C13 and C14 compensate for higher frequencies whilst C15 maintains input capacitance.

At the 50mV setting switch section, S2B brings R8 and R7 together with C7, C8 and 9 into circuit to provide a ÷10 attenuator. C11 maintains constant input capacity.

This section then remains in circuit and the ÷2 and ÷4 networks are sequenced with it to provide 100 and 200mV steps. When 500mV is selected the S2B by passes the ÷10 section and R8 - C4 and R4 - C3 are switched in by S2A to attenuate the signal by ÷100. This section now remains in circuit on all remaining steps up to 20V/div. The ÷1, ÷2 and ÷4 sections selected by S2C are cascaded with ÷100 section to increase the steps through 1V and 2V. At 5V the ÷10 section selected by S2B is added in to provide ÷1000 attenuation, which together with the ÷2 and ÷4 produces the final 10 and 20V steps.

From the attenuator the signal is taken through R16, R101 and C101 limiting components to Q101 FET source follower. Protection for the input gate is provided by diodes D101 for positive overload spikes and D102 for negative overload.

Q101 and Q102 monolythic dual FET's provide an identical source impedance to the following stage together with electrical and thermal balance necessary for long term display stability. DC balance is set by RV101 the front panel DC BAL preset control.

The input FET stage drives a matched pair of emitter followers Q103 and 104 which provide a low impedance to drive the vertical input amplifier and the amplifier gain vernier which is placed across the output of Q103 and 104 transistors. R111, 113, 112 and RV102 gain control form a TT network. Variation of RV102 shunt element controls the gain over a 2.5:1 range.

Channel 1 input amplifier is an integrated circuit type 733. The IC is a wide band balanced series - shunt circuit amplifier with the input transistor emitters brought out at pin 4 and 11 and a further gain control junction at pins 3 and 12. RV103 preset CAL pot is placed across the gain control pins 3 and 12, whilst RV107 POSITION control changes the current taken from Pins 4 and 11.

To compensate for the current drawn by RV107, R115 and 116 from U101 to the -15V rail, R118, 117, 119 and R105 supply a similar amount from the +15V rail. x5 gain increase is made by shunting pins 4 and 11 by R117, RV104 (x5 CAL) and RV105 when S152 is engaged. As trigger take off is after U101, the trigger sensitivity also increases with the amplifier gain increase.

The output of U101 to U102 feeds three circuits, via R122 and R124 to U141 beam switching amplifier, and via R123 and R126 shunted by R125 to U102 and U152 trigger amplifiers for A and B time bases respectively.

8.2 Channel 2:

The attenuator circuit is identical to Channel 1, however the amplifier differs by the inclusion of S151 NORM-INVERT switch which reverses the input connections to amplifier U151 when the switch is engaged. U151 drives four outputs as the 'X' channel signal for identical X-Y operation is also obtained from Pin 8 via R183, R184, R185, RV157 and R186 with C160 and 161 phase compensating components. Output to the beam switching stage is via R173 and 174 and to the A and B time base trigger amplifiers via R176 and 175 shunted by R177.

8.3 A Time Base Trigger Amplifier:

U102 is a dual input gated amplifier type 1445. The input to pins 3 and 4 or 5 and 6 can be individually selected by a changing the potential on Pin 2. When grounded, input to 3 and 4 from Ch. 1 is selected when raised above +4V Channel 2 input to 5 and 6 is enabled, The amplified output appears at Pin 1.

To adjust the output level to zero, two divider networks are used. R127 and 128 with RV106 biases Ch. 1 input slightly below ground and R178, 179 with RV156 sets Ch. 2 input. The output of U102 is also divided down by R129 and 130 to the -15V rail. RV106 sets the voltage at the junction of R129, 130 to zero volts when Ch. 1 trace is centered. RV156 does the same for Ch. 2.

The channel to be selected is controlled by trigger selector switches S101A N-MIX and S101B, Ch 1 - Ch 2. With S101A at Norm, Ch. 1 is selected when S101B grounds pin 2 and Ch. 2 when it is opened. When S101A is engaged S101B is disconnected and instead the beam switch signal from pin 6 of U242 bistable IC turns the channels on and off in step with the displayed signal when switched to either ALT or CHOP, NOTE: As the MIX trigger signal on CHOP contains the chopping waveform it should not be employed, Ch. 1 or 2 should be selected in lieu.

To maintain a flat response from the output of U102, the voltage divider resistor R129 is by-passed by capacitor C110 switched in by S241B in all positions except CHOP. In this position it grounds C110 forming a simple RC integrator with R129 and 130. This attenuates frequencies above 100kHz and thus prevents switching spikes present on the trigger waveform in the CHOP display from affecting the trigger stability.

8.4 B. Time Base Trigger Amplifier:

This is similar to the A time base amplifier except that selection of Ch. 1 or 2 is available by manual selection only.

CIRCUIT DESCRIPTION:

B Time Base Trigger Amplifier

The voltage on Pin 2 of U152 is switched by S402 on the rear of RV401, B time base level control. When IN channel 1 is selected (inputs 5 and 6), when OUT Ch. 2 is selected (inputs 3 and 4). Output signals to B time base pass via voltage divider R180 and 181 with high frequency signals by-passed by C159.

8.5 Beam Switch Amplifier:

I.C.'s U141 and U191 are dual differential amplifiers which can be gated on or off by a signal applied to pins 9 & 13. Each amplifier has independent emitter loads, R141, 142 and 143 with compensation network RV141 and C141 for channel 1 amplifier V141 and R191, 192 and 193 with compensation network RV191 and C191 for channel 2 amplifier U191. Both amplifiersshare the common collector loads consisting of the balanced delay line DL201 and terminating resistors R201, 202 and 203.

8.6 Beam Switch Generator:

The beam switching signals are obtained from U242 an edge triggered flip flop which supplies complementary outputs at pins 6 and 8 from each input received at pin 12. When only channel 1 is required, U242 is switched by S241C to ground pin 2 forcing pin 8 LO and pin 6 HI. For channel 2 only, pin 13 is grounded, switching pin 6 LO and 8 HI.

By grounding both pins 2 and 13 (via diodes D241 and 242) both 6 and 8 go LO turning on both amplifier channels in the ADD mode. The additional current required in the common collector loads of the beam switched amplifiers when both conduct is supplied by taking R204 and 205 to +15V by switch wafer S241A.

The chopped and alternate signals to drive U242 are supplied by U241. Inverters a, b and c form a free running oscillator from which two outputs are taken. From pin 2 via R243 to U 242 and from the junction of R242 and C24 through C245 to inverter U242C to generate the chopped blanking signal. The oscillator is only allowed to free run in the CHOP mode, in all other positions pin 1 of inverter 'a' is taken by S241D to +6V or in the ALT position to pin 12 of inverter 'e' which buffers the alternate gate signal. R243 and C242 delay the switching signal to U242 until the blanking signal from inverter 'c' has blanked the CRT.

8.7 Output Stages:

U201 is wired as a shunt feedback amplifier which presents a virtual zero input impedance and a low output impedance via emitter follower to drive the final cascode stage. Q231 and 232 transistors drive the CRT deflection plates through the tapped high frequency compensating inductors L231 and 232. Additional high frequency compensation is provided between the emitters of Q201 and 202 the bottom pair of the output cascode stage.

Switch S501C in the output stage collector supply is part of the trace find switch. When engaged it opens the direct connection to the +70V rail leaving R240 in series with the collector loads. This reduces the HT and prevents the output stage driving the trace outside the screen limits.

TIME BASE CIRCUITS:

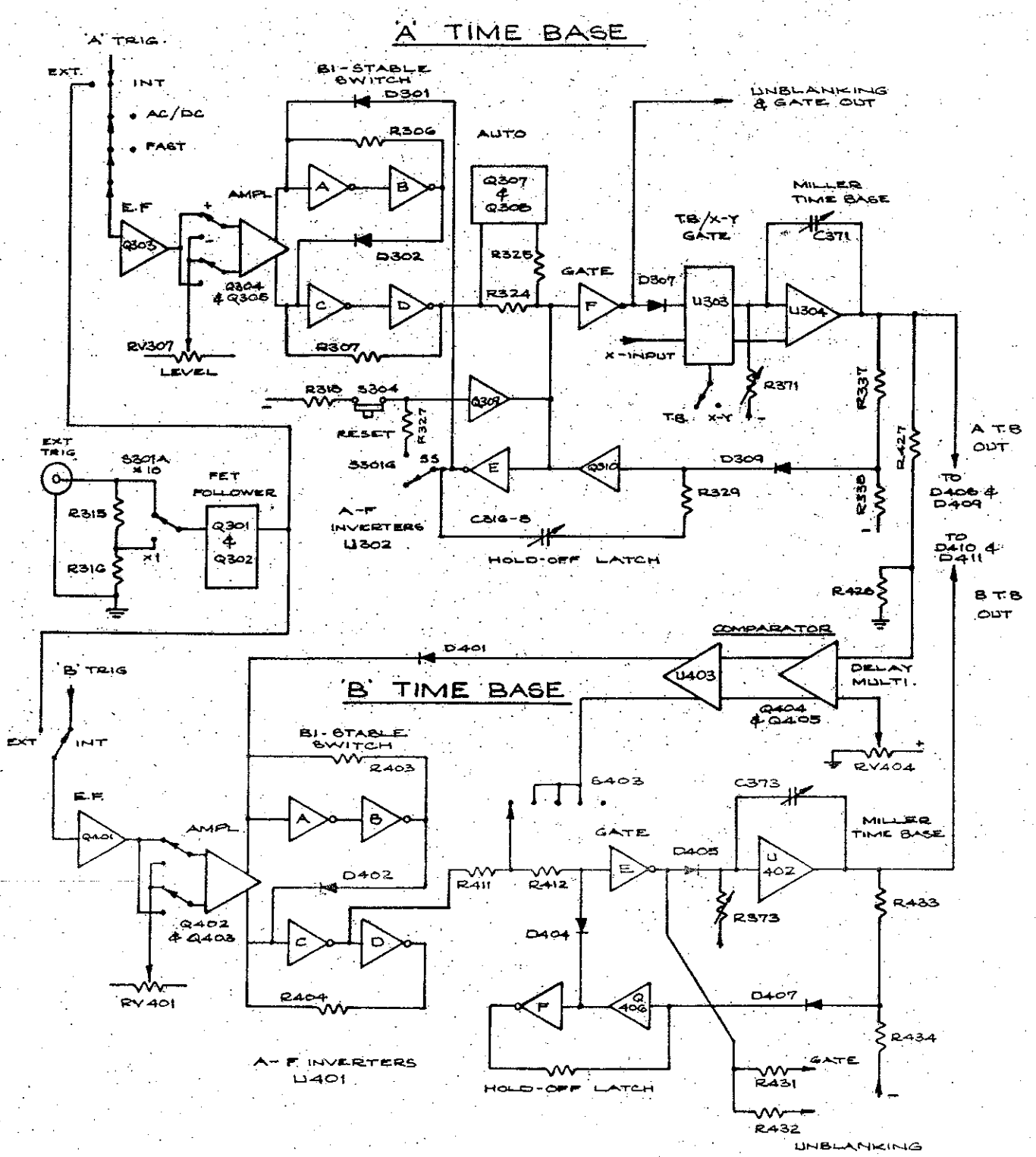
The Time Base is divided into the following sections and shown in their inter-relationship below:-

8.8 'A' TIME BASE:

- 8.9 Trigger Amplifier
- 8.10 Dual Schmitt Trigger
- 8.11 Auto Free run
- 8.12 Time Base generator
- 8.13 Single Sweep
- 8.14 X-Y operation

8.15 'B' TIME BASE:

- 8.17 Time base trigger
- 8.18 Time Base Generator
  B intensified
- 8.19 Mixed time bases
- 8.20 B delayed by A
- 8.21 B trigger delayed by A



TIME BASE BLOCK DIAGRAM

CIRCUIT DESCRIPTION:

'A' (MAIN OR DELAYING) TIME BASE:

8.9 Trigger Amplifier:

Signals to trigger A time base are selected by S301B from either the internal source or via the EXT trigger input socket and source followers Q301 and 302. External signals pass through an input divider R317 by-passed by C308 to one section of the AC-DC switch S301C and then to R315 and R316. The x10 or x1 switch S301A picks off the selected amplitude and applies it to Q301 FET source follower. Q302 is constant current load is closely matched to Q301 and contained in the same package to virtually eliminate variations in output level due to temperature changes.

Following S301A Int-Ext selector:

S301C AC-DC switch places C302 and 303 in series with the signal when AC coupled or it passes directly through when switched to DC. S301D places C304 in series with the signal in the Fast position or connects directly to S301E in the normal position.

S301E selects the path through R302 and C301 when engaged for slow or couples directly to S301F in the normal mode.

S301F + or - polarity selector connects either the trigger signal or the voltage from the level control RV306 via VDR301 and 314 to the emitter followers Q303 and 306.

The outputs from Q303 and 306 are coupled to a balanced transistor pair Q304 and 305. The common emitter load of this pair R310 is taken to RV301 trigger sensitivity preset. Q303, 4, 5, 6 and 7 are contained in U301 transistor array. Q304 is directly coupled to U302A whilst Q306 is connected to U302C.

8.10 DUAL SCHMITT TRIGGER:

U302 is a hex inverter, sections A-B and C-D are connected as a Schmitt trigger by R306 and R307. U302B output is coupled into the input of U302C via D302. In operation with no input signal and RV301 trigger level adjusted to centre, the collectors of Q304 and 305 will hold the inputs to U302 A & C HI.

The anode of D301 from inverter U302E is held LO, leaving D301 reversed biased. When Q304 is pulled into conduction by an input signal, U302A is pulled down. Current will also flow through R306, a voltage drop develops and the input at 1 goes to LO. Pin 2 and 3 go HI so the output on pin 4 goes LO and U302A and B latch in the LO state and disconnect D302.

When the input trigger signal reverses phase it causes Q306 to conduct, pulling current through R307. As pin 13 goes LO, 12 and 11 go HI and 10 goes LO and latches in. Both triggers are latched to low state and cannot recover until an input to pin 1 goes HI via D301 during the hold off period when it is reset.

The output from the trigger IC is taken from the junction of pins 11 and 12 to two circuits. To the AUTO transistors Q307 and 308 and via R324 to the input of U302F inverter.

8. 11 AUTO FREE RUN:

When no signal is applied to the trigger circuit and diode D301 has reset U302A and B bi-stable and D302 has reset U302C and D at the completion of the last sweep, the junction of inverter gates at pins 11 and 12 will be LO.

CIRCUIT DESCRIPTION:

AUTO FREE RUN

The junction of R321 and 322 and the base of Q307 will be at approx. +4.2V therefore the emitter of Q307 will fall as C314 discharges through R323. Q308 has its emitter tied to the +6V rail so base current will now be drawn via D304 through R323 to ground. Q308 will conduct and pull the gate of U302F positive via R325 until U302F switches to start a new sweep. Q308 remains conducting until a trigger signal appears that causes the junction of R321 and 322 to rise taking the base of Q307 positive to approx. +7.7V and hence the emitter to +7V, charging C314 in the process and reverse biasing D304. This cuts off Q308 and it no longer conducts to pull the input of U302F positive. It remains in this state until the trigger signals are removed or the frequency drops below approximately 10Hz allowing C314 to discharge through R323 and so pull Q307 into conduction.

8.12 TIME BASE GENERATOR:

The time base generator U304 and its associated C and R charging components is controlled by a quad FET gate U303. It is turned on by inverter U302F and diodes D307, D308 and turned off by the mono stable latch Q310 and inverter U302E.

In the time base mode U303(when pins 6 and 13 are at +6 and 5 and 12 are at -6V) connects D307 cathode together with the charging capacitor and resistors selected by S371 time base range switch to the inverting input (pin 2) of U304 operational amplifier. At the same time U303 connects the non-inverting input at pin 3 to ground.

When either pins 11 and 12 of U302C and D go HI or Q308 conducts pin 9 of U302F goes HI, its output goes LO, D307 and 308 are reversed biased. Pin 2 of U304 is pulled negatively by the selected timing resistor R371 which is taken via S403D to the negative voltage on Q407 emitter or on RV407 time base vernier control. Immediately the inverting input of U304 moves negatively an amplified positive output appears at the output on pin 6. This signal is connected directly to the selected time base timing capacitors C371 and applies a positive charging voltage to it in opposition to the negative charge applied through the resistor R371. As U304 has a very high gain it applies a very large amount of negative feedback to the charging capacitor resulting in a very linear sweep waveform at the output on Pin 6.

The output of U304 is fed to three circuits. To R336 for X-Y operation, to the horizontal amplifier Q311 to 316 via S403E, R339, RV303 and to R337. The latter with R338 forms a divider between the output and -15V. At the start of the trace, D309 is reversed biased but as the sawtooth rises from 0V the junction at D309 anode also rises until the output is approximately +9V then D309 conducts into Q310 base turning it on. As Q310 conducts its collector falls until U302E inverter input is pulled below its threshold level causing its output on 6 to rise and via the hold-off capacitor C316 and C317 or 318 if selected pulls the base of Q310 further positive.

The cumulative action latches Q310 on and in turn D306 conducts pulling U302F input LO, its output at 8 goes HI and D307 via R332 conducts. Pin 2 of U304 is pulled positive to pin 3 causing the output on pin 6 to fall rapidly discharging the timing capacitor C371 via current supplied by U302F through R332 and D307. As the output of U304 swings towards 0 volts, D308 will conduct pulling the voltage across R332 down until the cathode of D307 is at 0 volts where the circuit will wait in a quiescent condition. When U302E output is HI during retrace diode D301 conducts pulling U302A high. Pin 2 and 3 fall so 4 goes HI and in turn pulls U302C input HI via D302 so resetting both Schmitt triggers.

TIME BASE GENERATOR (continued)

The hold-off capacitors prevent Q310 from resetting until the retrace cycle is complete. When C328 (and C317 or 318) have discharged through R329 into the base of Q310 no other source of base current is available so Q310 stops conducting its collector is pulled positive by R330, D306 disconnects and U302E input goes HI, its output falls to LO and Q310 is cut off.

When D306 disconnects, U302F input can be pulled positively by Q308 if it is conducting or by pins 11 and 12 of U302C and D going HI when a trigger signal is received. When pin 9 is pulled HI pin 8 goes LO, D307 is reversed biased and the next sweep ramp voltage commences.

8.13 SINGLE SWEEP OPERATION:

A second transistor Q309 is connected with its emitter and collector in parallel with Q310. Input signals to Q309 base can therefore also be used to control the time base start and finish. Q309 with U302E also control the AUTO STORE and AUTO ERASE sequences.

When S301G is engaged in the SS position the output at pin 6 of U302E is directly coupled to Q309 base via R327. Assuming Pin 6 is LO and Q309 and 310 are cut off, the time base circuit will complete one sweep until D309 conducts, turns Q310 on pulling U302E input LO. The output at 6 goes HI pulling Q309 hard into conduction via base resistor R327. It in turn holds pin 5 LO and the circuit remains in this condition. The time base returns to its quiescent condition, the trigger circuit is reset by D301 pulling pin 1 of U302A HI holding it there so no further trigger pulses can be generated. The Ready LED D305 is turned off as both pin 6 of U302E and pin 8 of U302F to which it is connected via R326 are LO.

The circuit is reset to normal by closing S303 which applies the negative charge on C311 to Q309 base. Q309 cuts off, its collector rises, Q302E output goes LO removing the bias from Q309 base, D306 disconnects, D305 lights as pin 6 is high but 8 remains LO and the circuit is ready for another sweep on arrival of a trigger pulse to pull pin 9 of U302F HI. The circuit will continue to provide single sweep operation until S301G is released.

8.14 X - Y OPERATION: is enabled when pins 5 and 12 of U303 are taken to +6 by S401C and pins 6 and 13 are pulled to -6V via R304 and the divider R333 and R334 between ground and -15V. Pin 2 of U304 is then connected to the junction of R335, R336 and RV302. This network sets the gain of U304 to approximately x5 and centers the output at pin 6 to approximately +6V. The inverting input at pin 2 is taken to the connection from channel 2 'X' output. Q310 base is switched to ground by S401C to stop the time base from working by preventing it from resetting. Pin 8 of U302F therefore remains high and the unblanking is turned on.

The 'X' signal to pin 3 is amplified, inverted and fed to the horizontal amplifier via S403C and RV303 in the same manner as the time base.

8.15 DELAYED 'B' TIME BASE: (#1404)

This circuit is similar to the main 'A' time base but simpler. It is gated on by comparator U403 when the main A time base ramp coincides with the potential on the Delay Multiplier control RV404.

CIRCUIT DESCRIPTION:

DELAYED 'B' TIME BASE

Switch S403 selects the operating mode of the delayed B time base.

In the position shown, A time base is operative. B time base is disconnected by S403A. S403C selects the A time base sweep for the horizontal amplifier. S403E selects the A time base unblanking waveform via R436 and connects it to the CRT intensity modulation amplifier. S403F applies -15V to R423 to bias the comparator voltage input to Q405 out of operating range rendering it in-operative.

The time base Vernier control RV407 is changed over by S403D.

The Vernier control is always connected to B time base timing resistors R373 A-J. A time base timing resistors R371A-I are connected to the R407 wiper in the A only position shown. When the switch is turned clockwise to all other positions, S403D connects R371 A-J resistors to the emitter of Q407 so that A time base calibration is unaffected by the position of the Vernier Control.

One other circuit affected by S403 is the B trigger amplifier Q402 and 403 whose common emitter resistors RV402 and R405 are returned to the negative rail when section S403F is fully clockwise in the B trigger delayed by A position.

8.16 B TIME BASE TRIGGER CIRCUIT:

S401A selects either the internal or external trigger source. Internal signals are taken from U152 gated amplifier via R180 and C159 whilst external signals are taken from Q301 source follower.

Q401 emitter follower drives Q402 and 403 balanced amplifier via S401B ± selector switch. RV402 sets the trigger sensitivity. The collectors of Q402 and 403 are taken directly to U401A, B, C and D hex inverters connected as dual schmitt triggers.

The circuit operates as follows. Assuming R405 is connected to -15V via S403F switch, pins 1 and 13 of U401 are both HI and D401 is reverse biased.

A negative going signal received at Q401 base will via S401B take Q403 base negative, its emitter will attempt to follow but as it is directly connected to Q402 emitter it will be prevented from falling so Q403 is cut off and Q402 takes all the emitter current through RV402 and 405. This will cause the collector current in Q402 to produce a voltage drop across R403 causing the input gate at pin 1 to drop below its hysterisis point. The output at 2 and 3 will become HI and therefore 4 will go LO. As R403 is connected to pin 4 it will latch pin 1 LO by removing the source of voltage to pull 1 HI. D402 will now be reversed biased leaving Q403 free to control the second schmitt trigger U401C and 401D.

When the input signal to Q401 base reverses phase and swings positively Q403 base and emitter will follow until Q403 takes the current through RV402 and R405 away from Q402. As Q403 conducts a voltage drop is developed in R404 until pin 13 falls below the hysterisis level then pins 11 and 12 go HI and 10 goes LO, latching the circuit in that state. The two schmitt triggers will remain latched until D401 conducts to pull pin 1 HI which in turn causes 2 and 3 to go LO, 4 to go HI and via D402 pulls 13 HI. In turn 11 and 12 go LO and 10 HI.

CIRCUIT DESCRIPTION:

Output from the latching trigger circuit is taken from Pin 12 and drives another section of the same IC gate U401E via two resistors R411 and 418. The resistors are used to inject the signal from the comparator via S403A and from D404 to terminate the sweep.

8.17 GATING CIRCUITS:

S403A wafer of the Horizontal Display selects the mode of triggering the B time base. As shown, S403 is switched to A time base.

The next position of S403 (A intensified) connects the output at pin 9 of U403 comparator to the junction of R411 and 418. R425 is released from the -15V rail, allowing Q405 gate to rise to the voltage on RV404 Delay Multiplier potentiometer.

When the A time base sweep voltage via R427 and R428 divider fed to Q404 gate rises to the potential on Q405 gate, U403 comparator input to pin 4 will rise above 3 switching the outputs on 9 and 11. The output on 11 will have no effect but the change from LO to HI on 9 will, via R418 cause U401E input to rise, its output will go to LO to initiate the B time base. D405 is disconnected permitting U402 Miller circuit to sweep.

8.18 TIME BASE GENERATOR:

The voltage at R433 and 434 junction controls the end of the sweep when it rises to +1.4V and biases Q406 into conduction. This pulls input 5 of U401F LO, its output rises and pulls the base of Q406 positive via R420 and latches the bi-stable circuit. D404 conducts and pulls input 9 LO, a HI appears on 8 which via R424 pulls D405 into conduction. The inverting input of U402 is pulled positively so its output at 6 falls rapidly, until D406 conducts. During the return trace the timing capacitors are selected by S371B, are discharged by the current flowing in D405, R424 and the current supplied by U402.

When the output of U402 falls to approximately +1V D406 conducts and current flows through R424 into U402 output and will continue to flow until D405 is pulled down until its cathode and pin 2 of U402 is at 0V. Then a stable quiescent state is reached.

The output of U401E is also connected to the unblanking circuits via R432 and D412 diode to S403E, S403F applies -15V through R435 to pre-biasthe 'B' unblanking waveform negatively with respect to 'A' unblanking level.

The resultant unblanking pulse fed out to the Z modulation amplifiers causes an increase in trace intensity during the period of the B time base, producing a display with an intensified section.

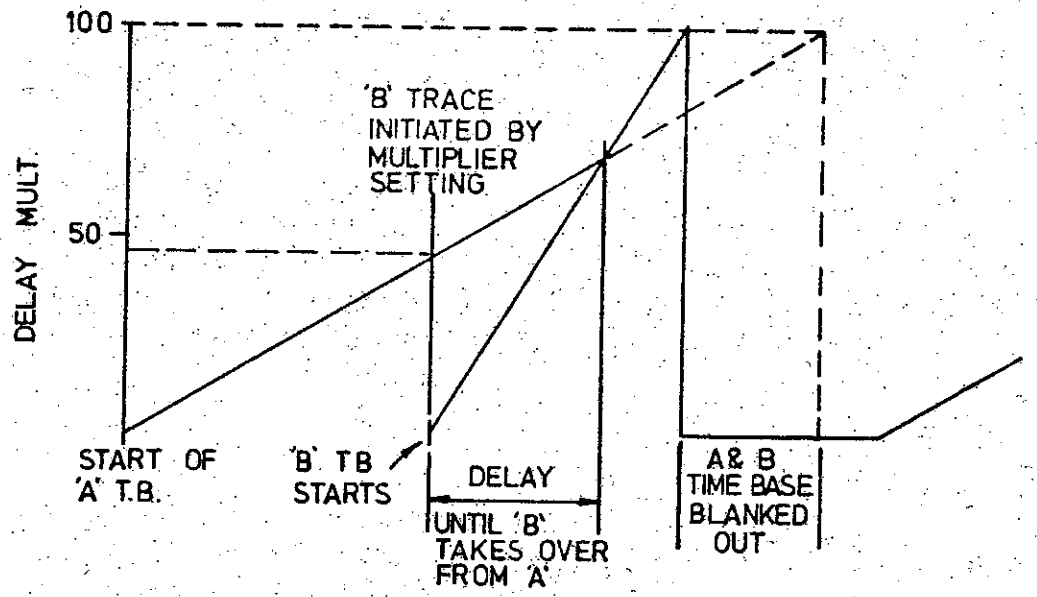
In the A intensified position of S403 only the A time base sweep waveform is selected by S403C and D408. The bi-stable latch U401F and Q406 is reset at the start of the next A sweep by a negative pulse from U302E via R426 and C410 to Q406 base.

8.19 The third position of S403 selects MIXED display. S403F disconnects B intensified unblanking but sweep signals from both A and B time bases are connected to the horizontal amplifier by S403C via diodes D409 and D410.

The gating circuit is identical to the intensified condition in that the B time base is initiated when comparator U403 switches pin 9 HI and U401E output goes LO. Once B time base is initiated the sweep waveform at pin 6 of U402 will appear on D410 anode and take it positive.

D409 is already conducting as A time base output sweeps positively towards +9V. At a point in time determined by the setting of the Delay Multiplier and the B time base range setting the signal on D410 will rise positively to D409 cutting off the sweep from A time base and feeding B time base through to the output amplifier instead.

The resultant display is that the slower A time base appears on the left hand side of the display followed by the higher speed B time base. See sketch below:-



At the end of the B sweep the output of Q406 is fed to U401E via D404 to end the sweep and then the positive going output of U401F is fed via D403, S403F and R442 to blank out the remainder of the A sweep. If the Delay Multiplier is set near the maximum delay and there is little difference between A and B sweep speeds, A time base may finish first in which case U302E gates Q406 via C410 and R426 to end both time bases.

8.20 The fourth step of S403 is B time base delayed by A. The only difference introduced by the switches is that only B sweep only is selected by S403C and B unblanking only by S403E. Therefore no display will be present on the CRT until B time base starts when B unblanking the CRT displays B sweep only.

8.21 The final position of S403 is B trigger delayed by A. Two changes to the switching occur. U401E is not pulled into conduction by U403, instead diode D401 releases U401A and allows the trigger signal generated by the 'B' trigger circuit U401 to pull U401E input HI via R411 and 418. This causes U401E output to go LO and start the B sweep. S403F connects R405 directly to -15V thus bringing the trigger circuit into operation.

Initiation of B time base by a trigger input can only take place when U403 clamp voltage via D401 is removed. This only occurs when U403 comparator output on 11 goes to its LO state. As the input to Q401 will normally be in a LO state U401 A and B will latch into a LO when D401 disconnects thus releasing D402 leaving U401 C and D latch ready to switch on receiving the next positive trigger signal. Then the input to Q403 goes positive causing pin 13 to go LO, 11 and 12 will go HI and 10 LO to latch the trigger until it is reset by U403 and D401 during the next sweep.

HORIZONTAL AMPLIFIER (# 1403)

8.22 Q311, 312, 313 and 314 are a balanced series - shunt feed back stage with Q315 and Q316 emitter follower outputs.

Input signals selected by S403C are fed to Q311 base via R339 and RV303 trace length control. Horizontal position voltage is applied to Q312 base via R357 and 354 divider from RV305 control. The outputs from Q311 and 312 collectors developed across R347 and 348 are directly coupled to Q313 and 314 bases. The collector load of Q313 is R343 and 344 with high frequency bootstrapping capacitor C324. R355 is the load for Q314.

When Q313 is conducting diode D311 is forward biased so the deflection plate is directly connected to the collector. However when it is being cut off and its collector is pulled positively by the load, the D311 tends to cut off leaving the emitter follower Q315 to supply the deflection voltage. It is pulled up by the collector load R343 and 344 which is connected to Q315 base. Q315 also supplies the shunt feedback signal via R342. Both sides of the amplifier act in a similar manner. Feedback to the input stage is applied via R342 and R353 to Q311 and 312 emitters. The amount of feedback is set by the common emitter resistor R346 in the x1 mag. condition and by R346 shunted by RV304 when S304 is closed at x5 mag. Amplifier balance is set by RV306 for zero trace movement when changing from x1 to x5 magnification.

STORAGE: (#1405)

8.23 The electrode in the CRT that controls whether displays will be stored or just viewed and not stored in the Backing Electrode. The main function of the circuits on drg. 1405 are to control the voltages applied to this electrode in the various operating modes.

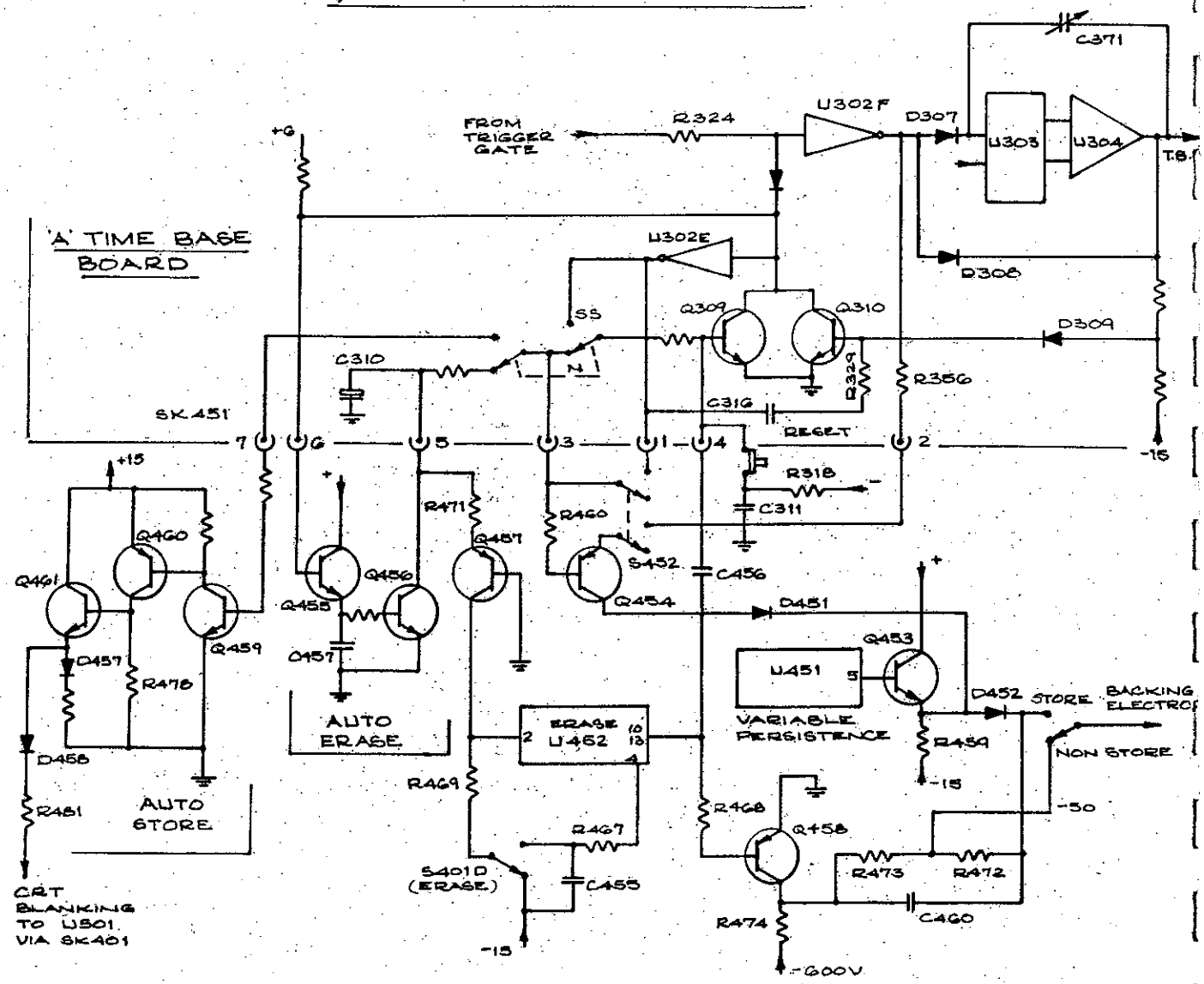
In the non-stored condition switch S401F connects the backing electrode to -60V. This voltage is taken from a divider across the CRT negative EHT supply which includes the focus control, R474, 473 and 472 and returns to a near ground potential of Q453 emitter via D452.

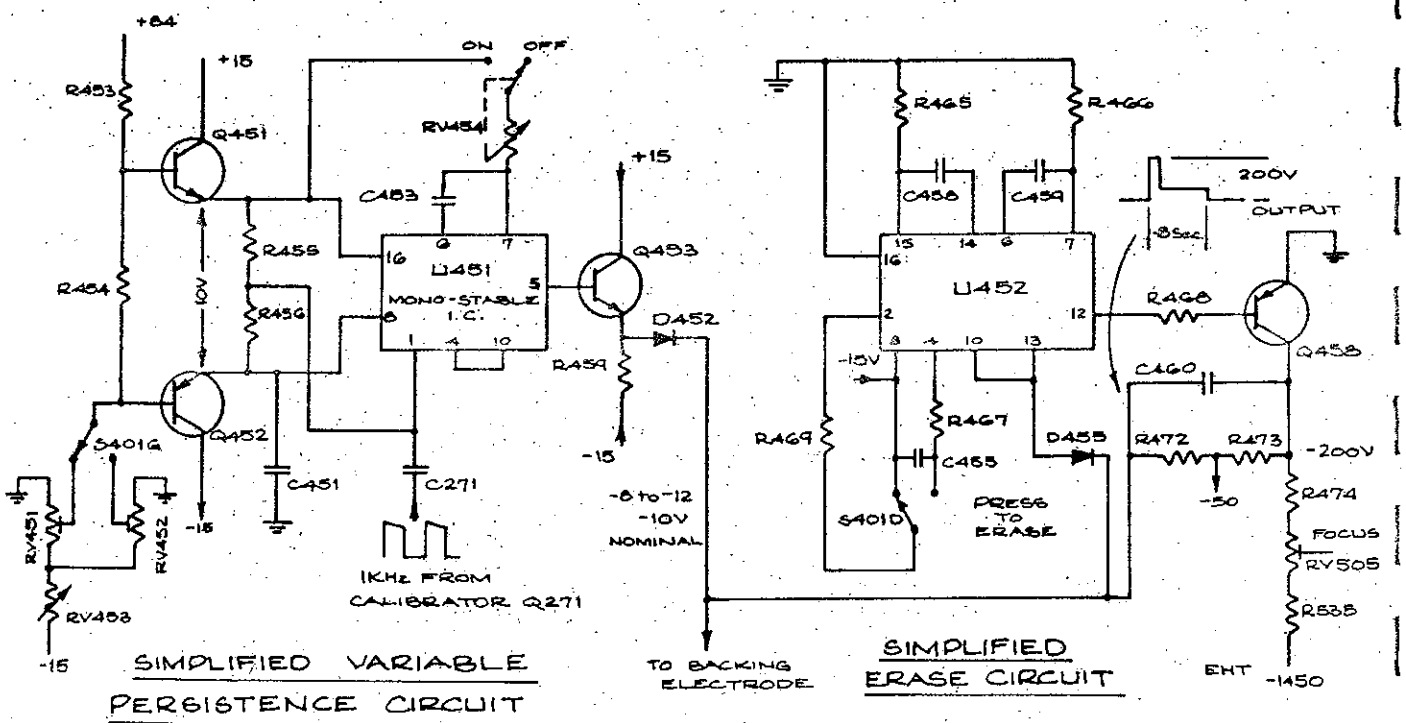
8.24 WRITE:

When the Write button S40F is engaged the Backing Electrode is connected to the end of R472 which is held between -5 and -12V depending on the adjustment of RV453 Background control. When RV453 is shorted out (fully counter clock) the backing electrode voltage is set by RV452 when Fast Writing is selected by S401 and by RV457 when Slow is engaged.

Q451 is an emitter follower with R453 and 454 emitter loads. Q452 emitter follower connected to the junction of R453 and 454 follows the voltage applied to Q451 base by S401G but +10V (approximately) positive to it. I.C. U451 operating voltage is supplied by the two emitter followers and is floating with respect to ground. Pin 8 is the floating 'ground' connection and pin 5 output is normally at Pin 8 voltage when S451 is open (Variable Persistence Control fully counter clockwise). As the base of Q453 emitter follower is connected to pin 5, its emitter via D452 will hold the backing electrode at approx. 1.4V below Q451 base. Other CRT electrodes which are affected during store conditions are the Flood Gun Focusing electrodes FG2 and FG3and the Flood Gun Collector. The voltage on these three electrodes which control the even spread of flood gun electrons over the screen area are selected by S401G Fast-Slow switch. In the Fast position the Collector is taken to +135 and FG2 to +25 whilst FG2 is preset by RV455.

SIMPLIFIED AUTO ERASE & AUTO STORE CIRCUIT





WRITE

The high collector voltage permits the fastest writing speed but because of the higher current passing to the storage mesh the display will also fade positive more rapidly.

When Slow is engaged the Collector is dropped to +15 FG2 to +6, whilst FG3 is adjusted by RV456. Writing speed is now decreased but viewing time is lengthened although at reduced brightness.

8.25 VIEW:

When the Store button S401E is engaged the CRT writing gun is biased off by R481 by pulling R481 to +15V. If the Write button is released when the View button is engaged the backing electrode will be switched back to -60V by S401F. The stored trace will be retained but not visible until the Store button is again engaged. This is the extend store mode.

8.26 ERASE:

The stored display is erased by taking the Backing Electrode 200V positive to ground for 200mSec then reducing the voltage to ground (+15 wrt to flood gun cathode) for 600mSec then returning it to its selected operating voltage. The timing sequence is set by the dual mono-stable I.C. 452. When S401D is pressed pin 2 of U452 is pulled from -15 to which S401D held it to the 0 volts on pin 4 via R467. This initiates the 800mSec mono-stable time set by R465 and C458 causing pin 13 to rise pulling pin 10 with it, thus initiating the second 200mSec mono timed by R466 and C459. When the 800mSec time actuates, pin 4 is pulled negative to bias pin 2 off again. The time constant of R467 and C455 prevents contact bounce or how long the button is held in from affecting the timing sequence.

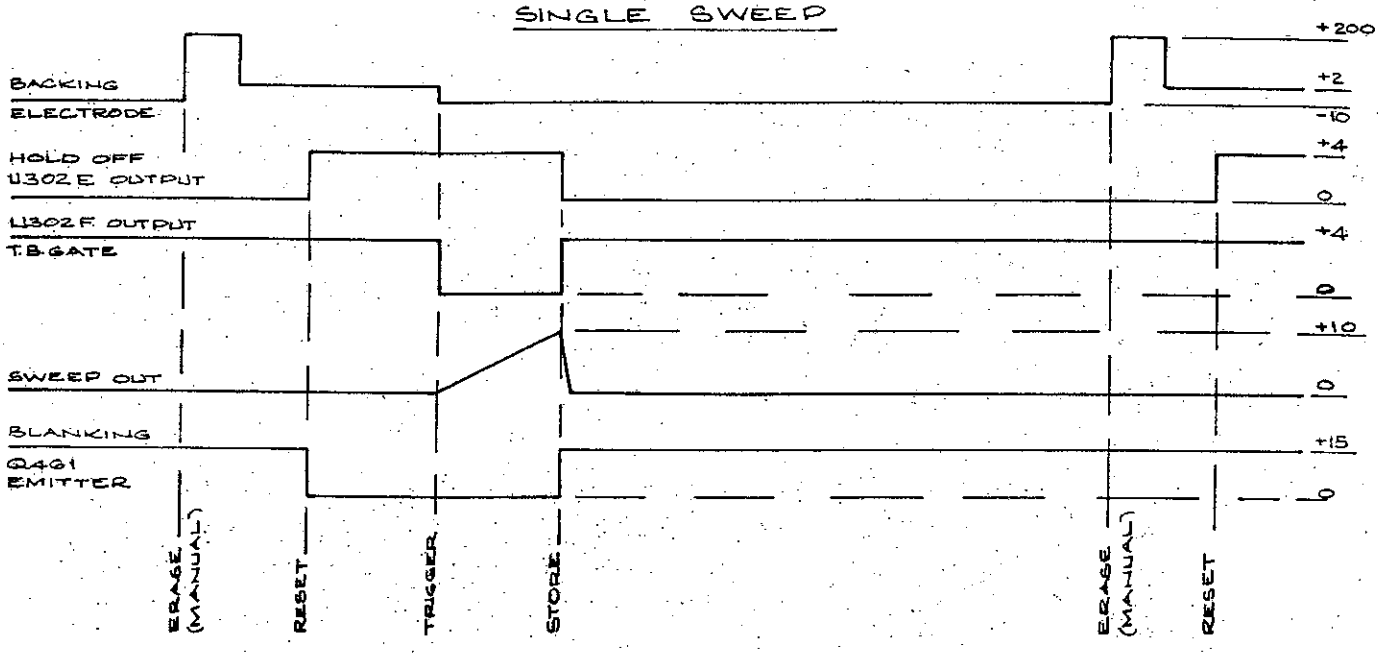
Pin 12 is the output for the 200mSec timer, it goes from zero to -15V and in doing so, pulls Q458 hard into conduction via R468 base resistor. The collector of Q458 is connected to a -200V point on a divider across the CRT EHT Supply. In parallel with R472 and 473 is C460. When Q458 conducts its collector rises rapidly towards ground. C460 communicates this 200V rise to the backing electrode via S401F. D452 is reversed biased and cuts off the backing voltage set by Q453. The +200V pulse will only discharge about 5% through R472 and 3 before the 200mSec pulse to Q458 terminates and cuts the transistor off. Current from the EHT supply via R474 etc., pulls the collector and backing electrode (via C460) rapidly negative until diode D455 which is also connected to pin 10 of U452 is brought into conduction. It halts the fall in voltage and clamps the backing electrode at -0.7V until the 800mSec time period ends when pin 10 will drop to -15 allowing the backing electrode to fall below ground until D452 again conducts and clamps the electrode at 1.4V below Q453 emitter voltage. Diodes D453, 454 and 456 are for protection of U452 and Q458.

8.27 VARIABLE PERSISTENCE:

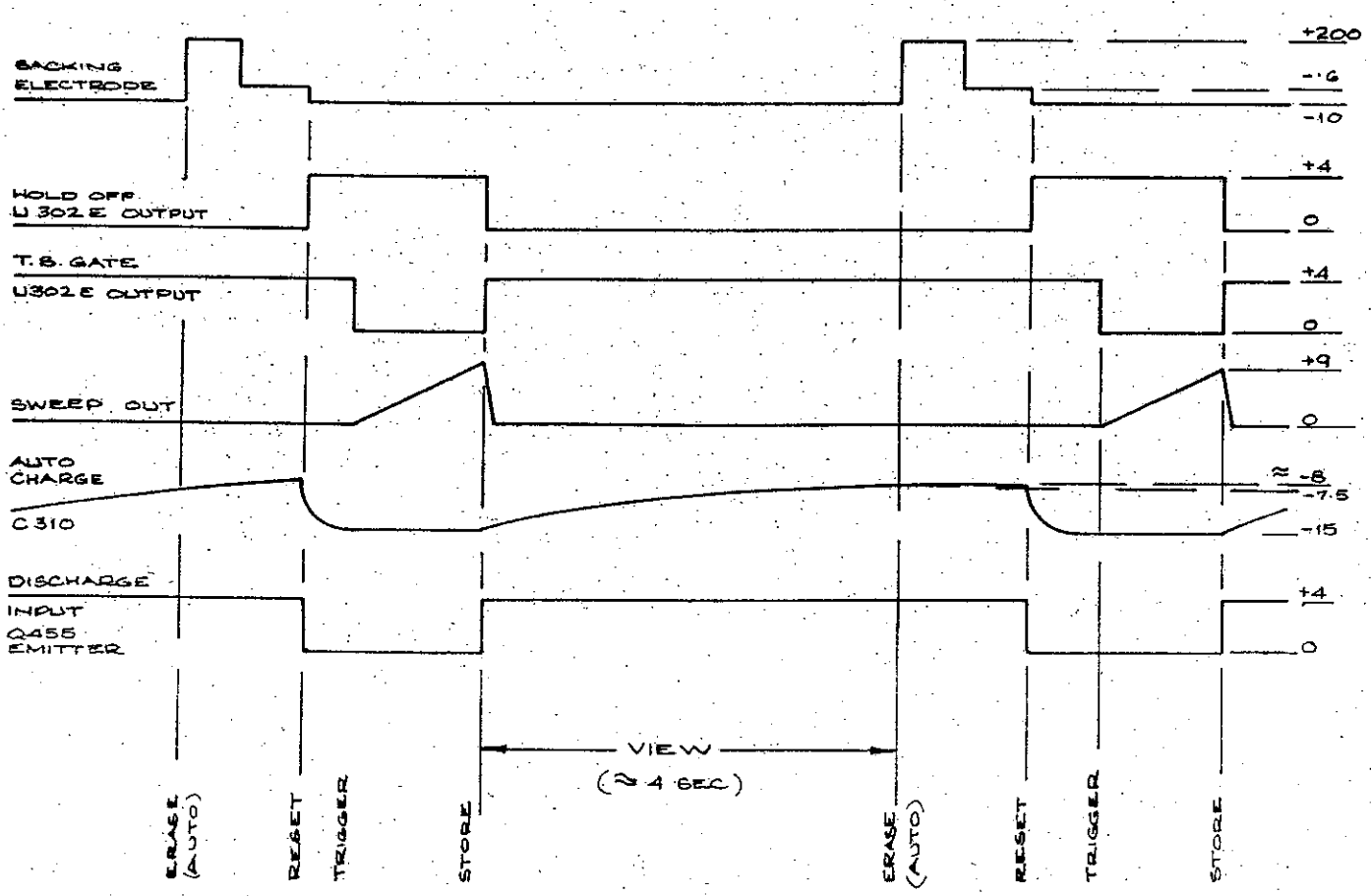
The storage time of the CRT can be reduced to suit repetitive slow speed displays by taking the backing electrode positive for short periods to partially erase the trace.

Dual monostable U451 is gated at a 1kHz rate by a pulse from the Calibrator circuit which is applied to pin 1. An output pulse at the same rate is taken from pin 4 to pin 10 to initiate the variable width mono controlled by C453 and RV454 and R458.

AUTO STORE SEQUENCE
SINGLE SWEEP



AUTO ERASE SEQUENCE
CONTINUOUS SWEEP



STORAGE

VARIABLE PERSISTENCE

When the Variable Persistence control RV454 is turned clockwise S451 closes supplying voltage to R451 enabling the buffer mono to pulse the second mono via pin 10. The pulse width can be varied from 200nSec to 200μSec approx., giving a variable persistence time of 1 minute to 0.2Sec approximately.

The output of U451 is taken via pin 5 to Q453 emitter follower which supplies the necessary current to pulse the capacitive load of the backing electrode with 1kHz 10V pulses.

8.28 AUTO STORE:

The actions of pulling out the Background control knob to close S452 and engaging the single sweep button S301G switches the CRT to an erase condition. This in turn via C456 resets the time base in readiness for a single sweep, by leaving the CRT in the erase condition until the time base is triggered ensures that background illumination will be minimum and will therefore provide the longest viewing time after writing.

When switch S452 (on rear of RV452 Background control) is closed, Q454 is brought into operation. Its emitter is returned via R356 to the output of U302F main time base gate. Q454base connects via R460 to the output of U302E gate which is also joined by S452 to S301G Norm - Single sweep switch. S301G being engaged will also connect pin 6 of U302E to the input of Q459 via R457.

In operation the CRT is first erased by closing S401D, the erase sequence previously outlined follows but in addition as the output at pin 10 of U452 erase mono is also connected via C456 and R483 to Q309 base the single sweep circuit will be automatically reset as pin 10 falls to -15V at the end of the erase pulse.

This ensures that pin 8 of U302F is HI and pin 6 of U302E is LO. Q454 will therefore be held in conduction and will hold the Backing Electrode positive via D451 and 452 slightly above ground and in an erase condition, Q453 will be reverse biased as its emitter is pulled positive to its base.

When a trigger signal initiates the time base, pin 8 of U302F will fall to 0.2V. Q454 will be cut off and the Backing electrode will be pulled down by the negative EHT supply divider until the emitter of Q453 falls to 0.7V below its base and it again conducts. The BE is held in the Write condition whilst the CRT is being written by the display that triggered the time base.

When the sweep terminates in the normal way by Q310 conducting pulling pins 5 and 9 of U302 E & F,LO so causing pins 6 and 8 to go HI, Q454 remains cut off as its base is now positive to its emitter. However pin 6 is connected by S452 and half of S301G to R475 and as it is HI, Q459 is pulled into conduction. It in turn pulls Q460 hard on, and the rise in voltage on its collector being connected directly to Q461 emitter followers pulls it positive also. Q461 conducts on the positive signal and supplies current to two circuits. Via R479 it lights D457 LED to indicate a stored signal and via D458, S401E and R481 to the CRT blanking circuit to turn off the CRT writing gun to prevent any other signals from affecting the display. Pressing the Erase button is all that is necessary to reset the circuits back to the initial condition. When the erase mono U452 operates, it resets the trigger circuit at the end of the erase cycle via C456. This in turn cuts off Q459, Q460 and Q461 which removes the bias applied to the CRT grid via R481 and turns off D457 store light.

8.29 AUTO VIEW:

This is enabled by pulling out the Background control but leaving the single sweep button out in its normal condition and engaging the write button. When S452 closes R327 is connected to pin 6 of U302E via S301G making U302E and Q309 a bi-stable circuit.

The cycle is initiated by pressing the Erase switch which completes an erase cycle previously described and also resets U302E and Q309 bi-stable via C456 and R483 in readiness for the next sweep.

Assuming a signal is received and the trigger circuit latches, Pin 9 of U302F will be pulled HI pin 8 goes LO and a sweep commences. At the end of the sweep D309 conducts to supply base current to Q310, it conducts, pulls pin 5 of U302E LO, pin 6 goes HI and via S452, S301G and R327. Q309 is also pulled into conduction pulling pin 5 down and latching the bistable circuit in the lock out condition. When pin 6 goes HI it also applies this rise to R319 via one half of S301G and C310 charges positively. C310 is connected to R471 in the emitter of Q457 and after approximately 4 seconds the emitter is pulled positive with respect to its base Q457 will conduct and initiate the erase cycle by pulling pin 2 positively. At the end of the erase period Q309 and U302E are unlatched by the pulse through C456.

The next trigger pulse initiates the sweep and the cycle repeats itself. During the sweep period the positive voltage on Q309 & 310 collectors is connected via SK301 to the base of Q455 emitter follower. This pulls Q456 hard into conduction making it discharge C310 in readiness for the next viewing period on completion of the sweep.

CRT (#1406)

8.30 The CRT consists of two separate gun structures. One is the writing gun with normal X and Y deflection plates, the other is a flood gun used to provide an even spread of electrons over the display area to write the stored pattern on the backing electrode.

The writing gun cathode is held at -1450V and the PDA at +6KV. The focus control RV505 is part of a divider chain from the -1450V rail consisting of R535, RV505, R474, R473 and R472 which returns to the backing electrode potential at approx., ground potential. Astigmatism control RV506 is placed between ground and +70 whilst the geometry control is between +15 and +84. PDA supply is a 4 stage multiplier (one section is on the converter board drg #1407). It supplies +6KV to the CRT from the 3KV p-p square wave output of transformer T552.

Beam alignment coil L501 has one end at +6V and the other taken to RV508 control between +15V via R533 and ground. The two flood gun cathodes are at -15V. To provide equal emission from each they are taken to each end of RV507 balancing control. Its centre wiper is returned to the -15V rail. The heaters are operated from the -18V rail and dropped to -12V by D509 zener in parallel with R534.

The focusing electrodes for the flood gun are FG1, 2 and 3. FG1 is connected to -15V, FG2 via S401G connects to either +25 (Fast) or +6 (Slow). FG3 via S401G connects to RV455 (Fast) or RV456 (Slow). Presets to optimise the evenness of the flood gun electrons. The collector is also switched by a section of S401G from +135 (Fast) or +15 (slow).

The backing electrode is controlled as previously described in the storage section.

Z MODULATION AND BLANKING:

8.31 The Z modulation stage consists of a high voltage amplifier U501, Q501 and 502, which modulates a constant amplitude 22kHz square wave and a demodulation circuit on the CRT writing gun control grid.

U501 is a five transistor array, interconnected on the P.C.B. as a common base input stage driving via limiting diodes on emitter follower.

All intensity modulation signals are connected via resistors to the emitter input of the common base stage through pins 9, 11 and 13. The signals appear across R506 collector load then pass via a diode to an emitter follower and are available across the emitter load R513 and 514. Q501 and 502 are connected as a complementary output stage with a fixed quiescent current of 5mA set by emitter load R511 and base divider R510 and 508. Q502 is directly coupled to the emitter follower output via R513. The amplified signal that appears at its collector is applied as negative feedback via R535 to the input of the emitter follower in U501 to stabilise the gain. The fast leading edge of the intensity modulation blanking waveforms is capacitively coupled into Q501 via C501. When a negative output appears at pin 3 Q502 drive is reduced and its collector rises. Simultaneously the signal to Q501 base turns it on causing its collector to rise rapidly pulling up Q502, to produce a fast rising waveform. The opposite occurs with fast positive going signals at pin 3. Q502 turns hard on, Q501 is turned off and a fast falling wavefront appears at the collector junction.

The high speed part of the modulation signal is coupled through C516 to the CRT grid. The slow speed and DC component is applied by a modulated signal.

On the converter plug-in board, the ±85V 22kHz square wave is taken through R560 to the anode of D557. Its cathode is connected to the slide of preset control RV553 which with R561 in series is across the +70V DC rail. All signal excusions positive to the voltage on RV553 conduct through D557 and are clipped to that value.

D507 is also connected to D557 anode and it clamps any signal excusion that is negative to the voltage at the collectors of Q501 and 502. Theremaining signal has a peak to peak amplitude equal to the DC component of the required CRT grid signal. It is connected via C517 coupling capacitor, DC restored by D508 with respect to the CRT cathode then via D506 to the CRT grid where it is combined with the high frequency component of the signal to reconstitute the input waveform plus a fixed DC bias set by RV553.

8.32 POWER SUPPLIES:

The BWD 845 Power Supply System is designed to provide operation from either AC, DC or rechargeable battery sources.

8.33 AC SUPPLIES:

AC input passes via filter C551 and 552 to the power switch S551 on the rear of the graticule illumination control and then via S552 117 - 235V range switch on the rear panel to the primary of T551 power transformer. One secondary winding supplies bridge rectifier D551 and another supplies the graticule lights and the Main Time Base line trigger voltage via R551.

When S553 is switched to USE the nominal rectified voltage across C554 filter capacitor is 24V.

8.34 DC SUPPLIES:

The secondary rectified supply is not directly grounded to the chassis, instead it is floating and connected to the chassis by C553 and R552. This permits DC supplies of either polarity to ground or even floating supplies to power the oscilloscope. DC input is via D553 and F552. Battery input is via D552 and F552.

8.35 REGULATOR:

The highest voltage from AC, DC or battery source will power the oscilloscope as the lower voltage sources diodes will be reverse biased and non-conducting. The supply is regulated by U551 three terminal regulator. Its output voltage is set by the voltage developed across R555. This is controlled by divider RV551, R556 and RV552 with Q551 in parallel. With S553 in the USE position, the output of U551 is connected to the converter transformer centre tap at pin 5. It is also connected to R557 which supplies approximately 3mA of base current to Q551 pulling it hard into saturation so effectively shorting out RV552 and connecting R556 to the 0V rail.

The regulator output voltage is set by RV551 to produce the correct voltage on the +70V rail. (Approx. +17.6V output from the regulator).

If S553 is switched to CHARGE S553 disconnects the converter circuit from the regulator and connects it to the +ve pin of the battery socket.

When the converter is disconnected, base current to Q551 via R557 is also removed so Q551 becomes a virtual open circuit and RV552 is brought into circuit. RV552 is set for 28V at the regulator output and this, together with the current and thermal overload features of the LM317T I.C., set the battery charging current and voltage limits.

8.36 DC to DC CONVERTER:

All supplies to operate the oscilloscope are obtained from the secondary of the converter transformer T552. As the input is highly stabilised the output voltages are similarly stabilised and due to the low impedance of the transformer, also well regulated against load changes. However to reduce the output impedance of the + and -15V rails and the -ve EHT, additional regulators are incorporated in these rails.

The ±15V regulators are supplied from full wave rectified +18V rails. D558 and 559 with C561 filter capacitor supplies +18V whilst D560 and 561 with C562 supplies -18V. +70V rail is also full wave rectified by D555 and 556 with C558 filter but only half wave rectifying by D554 and C559 is employed for the lower current +85V rail. The 6.2V CRT heater supply is not rectified and filtered.

One winding supplies the -ve EHT and the PDA supply. A stabiliser circuit compensates for slight variations in the -ve EHT voltage with changes of CRT beam current.

The supply is rectified by D562 and filtered by C565, R565 and C518 (Drg. #1406). A divider R564, R563 and RV554 is placed across the -ve EHT rail and the +70V rail. The voltage at the junction of R563 and 564 is applied to the base of Q556 PNP emitter follower. This controls the base current of Q555 regulator supplied by R565.

The low voltage end of the EHT winding is taken through R562 to +85V, but by-passed to ground for AC by C564.

DC to DC CONVERTER

Q555 collector is connected to junction of the EHT winding and R556. At low levels of CRT intensity the voltage at Q555 collector is adjusted by RV554 to approximately +70V. (White lead at top of converter board).

An increase in beam current will result in a small drop in EHT voltage, this results in a slight positive change at Q556 base and so reduces the current it is drawing through its emitter load R565. More base current is available for Q555, so its collector current increases and produces a larger voltage drop across R562. This negative going fall applied to the 'ground' end of the EHT winding also appears at the rectifier diode D562 adds the additional negative voltage to the rectified voltage.

Q555 collector will continue to fall until the EHT voltage returns to its original value and hence the voltage at R563 and 564 junction at Q556 base. The circuit stabilises at this point until a change in beam current demands further compensation.

As the PDA 4 stage multiplier is AC coupled into the first diode D563 the regulator circuit does not effect it. The final PDA voltage of +6KV is applied to the CRT via R532 to limit discharge current to a safe value in case of an internal CRT flash over.

± 15V, +6V and +135V supplies (Drg. #1406). The ±18V rails each have an additional stage of filtering by R527, C508 (-18V) and R528, C509 (+18V) before feeding the -15V regulator U504 and +15V regulator U505. Output voltages are set by RV502 and RV503 respectively.

U502 fixed +6V regulator supplies that rail aided by additional parallel current through the vertical output stage and R210 (drg. #1402).

The CRT storage colminator electrode requires +135V (+150V wrt the flood gun cathode) and this is obtained by voltage doubling the 70V AC rail by C513, D502, D501 and filter C512.

8.37 LOW VOLTAGE INDICATOR:

To provide a visual indicator of uncalibrated operation caused by low power input voltages particularly batteries, the power indicator is made to flash. The circuit consists of U503 free running oscillator and Q503 clamp transistor. Q503 PNP transistor has its base emitter junctions connected across R523 which is in series with R524 between the +18 input to U505 regulator and the +15V output. If the voltage drops below correct operating level the +18V rail will fall but not the +15V initially. R523 and 524 are selected to just hold Q503 in conduction under normal conditions and consequently it will draw collecto current. R536 forms the collector load and as it is a high value Q503 will saturate and pull pin 3 of U503 to approximately +16V.

U503 is connected as a free running oscillator. Its output at pin 6 is fed back to the non-inverting input at pin 3 via R520. The signal at pin 3 is limited by R521 and 536 divider to hold it within the operating range of U503. If pin 6 goes high, pin 3 will also go HI and C505 will be charged positively by current through R522. C505 is connected to the inverting input so when it passes the potential on pin 3 it causes the output at 6 to switch to its lowest state, reversing the cycle. The front panel LED is connected in series with U503 output via R519 and R540 .

LOW VOLTAGE INDICATOR

When the output is switching from HI to LO the lamp flashes accordingly but when Q503 is conducting under normal conditions pin 3 is held HI and therefore Pin 6 is HI and the LED is permanently on.

When the +18V rail falls below its correct operating voltage U505 continues to supply its correct output voltage until the voltage across it drops from approximately 3 to 2 volts. As soon as the voltage difference falls below 3V, Q502 is no longer held in conduction as its collector current cuts off and R521 and 536 resume their normal use as dividers enabling U503 to operate as a free running oscillator.

8.38 CALIBRATOR: (Drg. #1402)

Q271 and Q272 comprise a free running emitter coupled multivibrator operating at approximately 1kHz. The output voltage across R274 is limited in a positive direction (when Q272 cuts off) by the divider action of D271, R274 and RV271, the output calibration control. In a negative direction Q272 pulls the collector below ground, so D271 cuts off and the output signal swings between ground and approximately +1.8V. 1V p-p output level is set by RV701.

An additional output at a higher level is taken from Q271 collector via C271 to the variable persistence mono stable U451 pin 1 to provide a 1kHz trigger rate. (Drg. #1405).

ALIGNMENT AND MAINTENANCE:

1. The following section describes the procedures used to assess the nature of faults and then to align the complete instrument to perform in accordance with the specification in Section 2.

   The entire alignment procedure may be carried out following each step in order or any separate adjustment can be made by following the steps outlined in the appropriate paragraph.

   Location of controls are shown in detailed sketches with each alignment step. Additional information pertaining to each circuit and its associated voltages and waveforms is included on the circuits at the end of this handbook.

2. WARNING:

   The Storage CRT in a BWD 845 must be treated carefully. It must not be subjected to high magnetic fields nor must the CRT be placed face down either in or out of the instrument. This is to eliminate a possibility that loose particles inside the envelope may fall on the mesh and become lodged there, and cause dark spots on a stored display.

   When aligning as with operating, always run the CRT intensity at the lowest level to reduce possibility of screen damage.

3. ALIGNMENT PROCEDURES:

   When setting preset controls always use a non-metalic screw driver and ensure the test equipment is accurately calibrated. The test equipment and other materials are detailed for each step. Where a specific product is noted, it is only as a guide and other similar specification instruments may be used.

4. REMOVAL OF COVERS AND SHIELDS:

   Ensure that all input power sources are removed from the instrument. The top cover is removed by unscrewing the four screws in the top of the panel. Slide the panel backwards to clear the rear panel lip, then lift off.

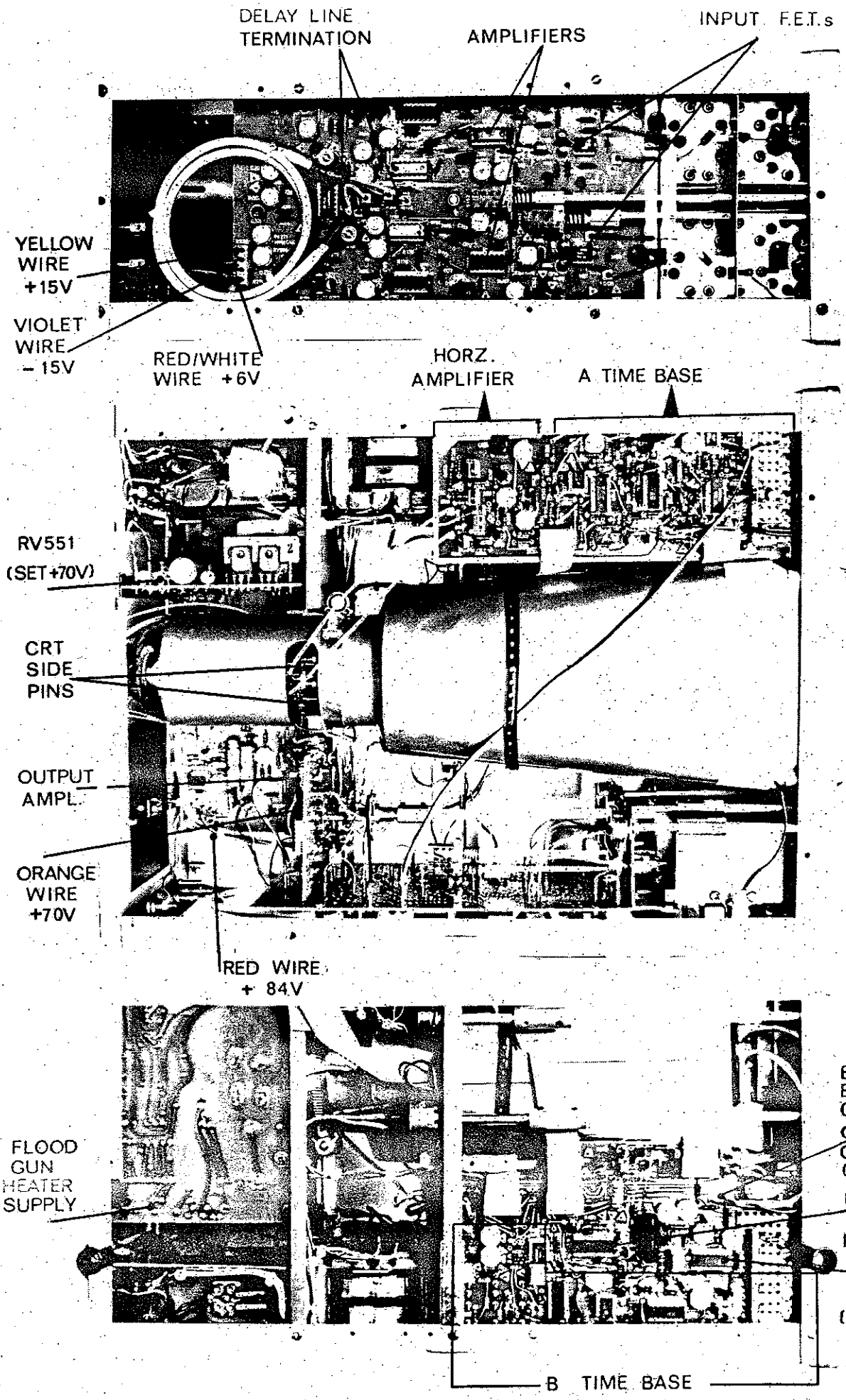
   The bottom cover is removed by unscrewing the four feet and lifting off.

   If necessary the handle support rails can be taken off by removing the screws at each end of the rails.

   Access to the rear is obtained by undoing two screws and taking off the rear cover plate. Take care if standing the instrument on its rear panel feet when the cover is removed. The CRT neck extends out through the rear and may be broken if tools or parts are under the instrument when it is stood up.

   Shields around the converter power supply are removed by undoing the appropriate screws in each. The top angle cover slides out vertically once the screws are removed.

   Follow the reverse procedure when replacing shields on panels taking care that when the angle shield is replaced the wires leading to the CRT socket are clear as the shield slides down into place.


DELAY LINE TERMINATION
AMPLIFIERS
INPUT F.E.T.s
YELLOW WIRE +15V
VIOLET WIRE -15V
RED/WHITE WIRE +6V
HORZ. AMPLIFIER
A TIME BASE
RV551 (SET +70V)
CRT SIDE PINS
OUTPUT AMPL.
ORANGE WIRE +70V
RED WIRE + 84V
FLOOD GUN HEATER SUPPLY
BACKING ELECTRODE (RED) & CRT COLLECTOR (WHITE)
U451 (VARIABLE PERSISTENCE)
U452 (ERASE)
B TIME BASE

5. COLOUR CODES:

To assist in checking voltages and tracing leads, the following wire colours are adopted: -15V violet, ground black, +6V red/white, +15 yellow, +70 orange/yellow +84 red.

AC power line input. Active, brown. Neutral blue. Ground, green/yellow.

AC power line after power switch. Active brown/white. Neutral, blue/white.

In the rectifier/filter circuit. Positive is red, negative is blue.

6. FAULT FINDING:

The following chart suggests steps to be followed to localise a fault causing instrument failure:-

1. Non operating.
2. Check input supply.
3. Check 117 - 235V input range switch.
4. Check fuses.
5. Check USE/CHARGE switch is switched to USE.
6. Panel indicator OFF. Check through regulator and converter circuits.
7. Panel indicator ON. Audible buzzing indicates converter is overloaded.
8. Check all voltage rails + 6 Red/White wire, +15 Yellow -15 Violet, +70 orange/yellow +84 red.

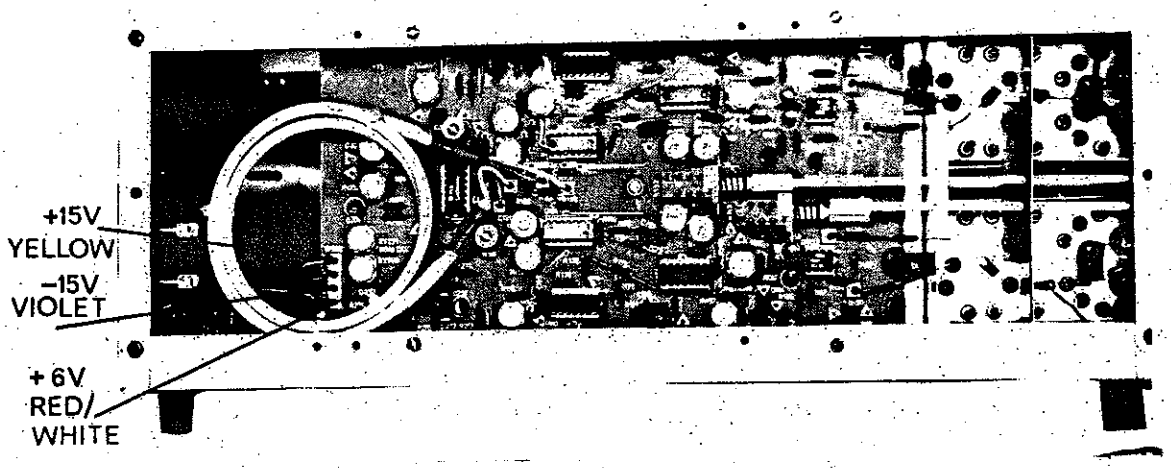
   If faults are located in converter power supply board, it may be unplugged and slipped out of frame for access to its components. Short circuits to any output of the converter will cause circuit to shut down or emit an audible sound which indicates a fault condition. This feature together with the current and thermal overload limiting of the regulators makes the BWD 845 power supplies extremely reliable under all conditions including overload or short circuits.
9. Press trace find and check vertical and horizontal position.
10. Check all ribbon cable plugs are properly mated and crimp connected wires are firmly in place.

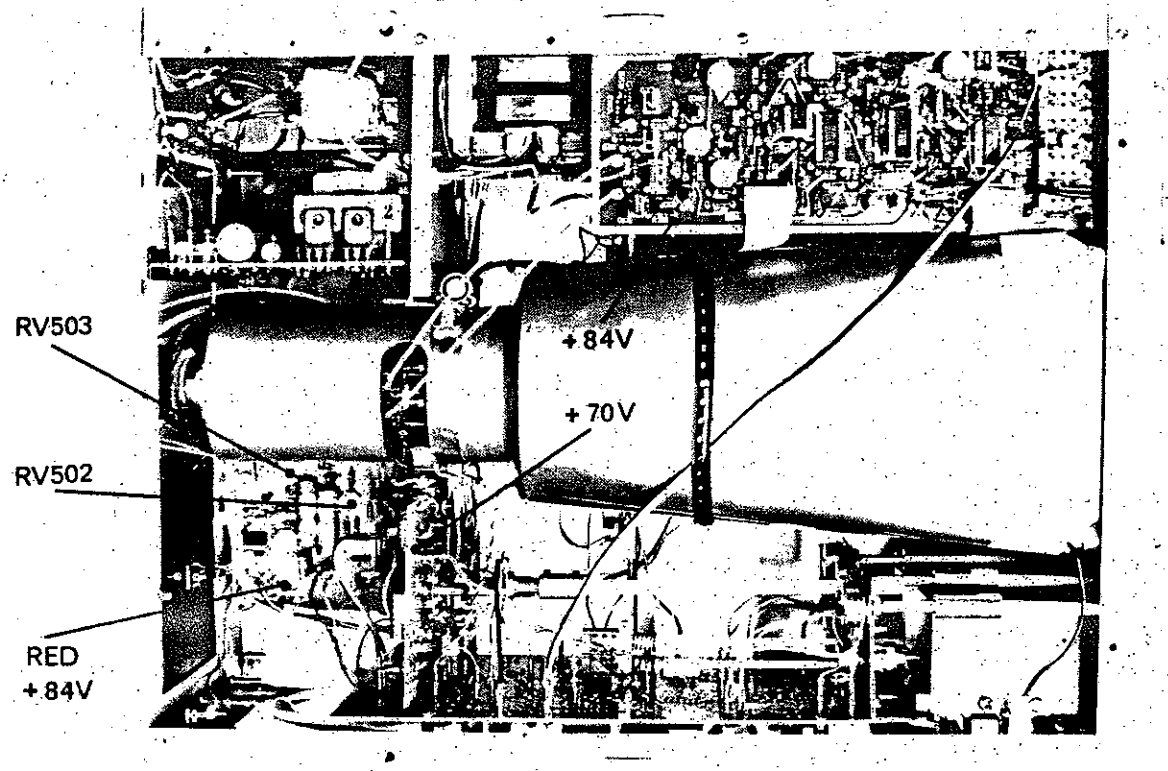
7. A. TB OK. NO VERTICAL

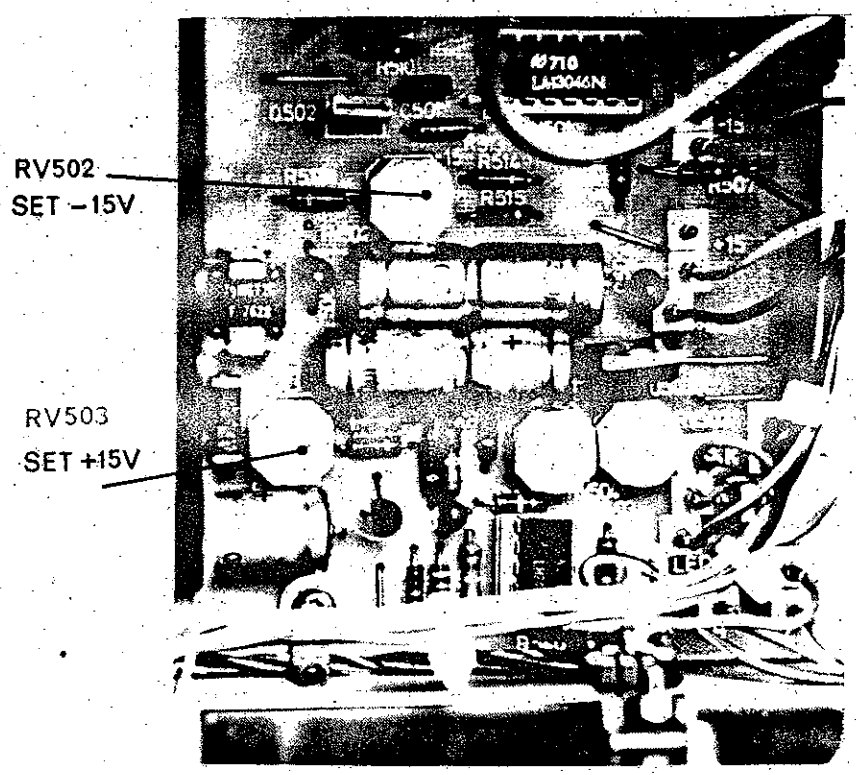
Switch to Ch. 1 if still faulty, Check Ch. 2

i. VERTICAL OK. NO TIME BASE

Make sure Horz. Display switch is in 'A' only position and LEVEL knob is pushed in for AUTO and SS button to OUT.


+15V
YELLOW
–15V
VIOLET
+6V
RED/
WHITE


RV503
RV502
RED
+84V
+84V
+70V


RV502
SET –15V
RV503
SET +15V
R502
R514
R515

7. B. If one Ch. faultycheck that input FET's and amplifier.

C. Check DC BAL adjust as described in Para. 5.2.

D. If both faulty, check delay line for O/C.

E. Check output drive stages for balance.

F. If correct through to deflection plates, check CRT.

ii. Press X-Y button. Spot should be present and Horizontal position should move spot.

iii. If faulty check Horizontal Amp.

iv. If okay, check time base.

v. 'A' time base okay No. B. T.B. check comparator outputs when switched to INTENSIFIED.

vi. If okay; check B time base circuit.

8. ALL FUNCTIONS NORMAL BUT NO STORAGE:

a. Check red and white wires from button of CRT faceplate are firmly connected to PC board.

b. Check flood gun heater supply and CRT heater itself for continuity (pins 10 and 11).

c. Normal storage but no Variable Persistence.

d. Storage and Variable persistence but no Erase. Check circuit particularly U452 and Q458.

9. After locating and correcting a fault the section should be realigned according to the appropriate paragraph in the following sections.

10. Before aligning, set all controls as for first time use in section 5 - 1 of this handbook. Keep intensity as low as possible at all times.

ALIGNMENT PROCEDURE:

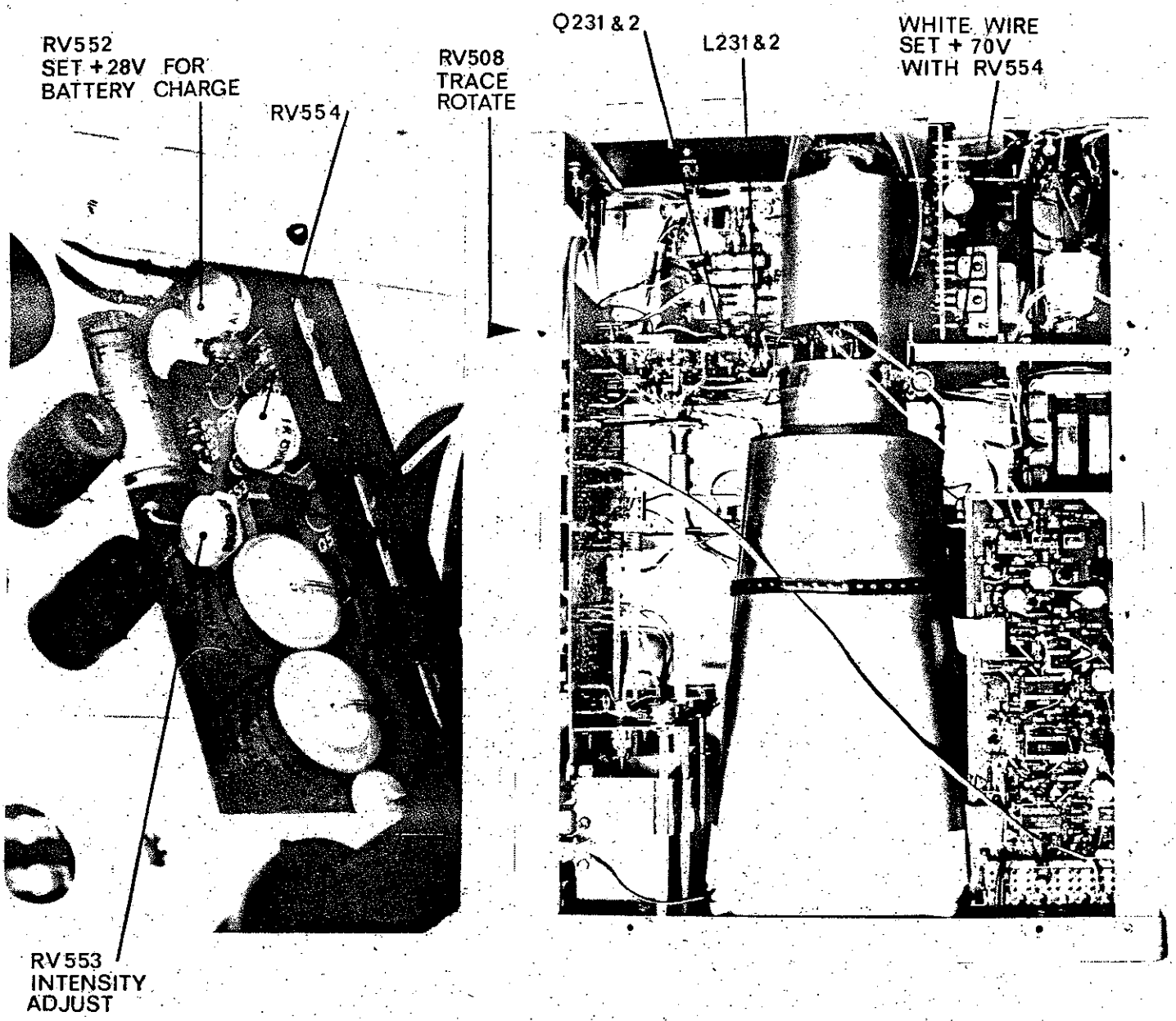
11. DC VOLTAGE RAILS:

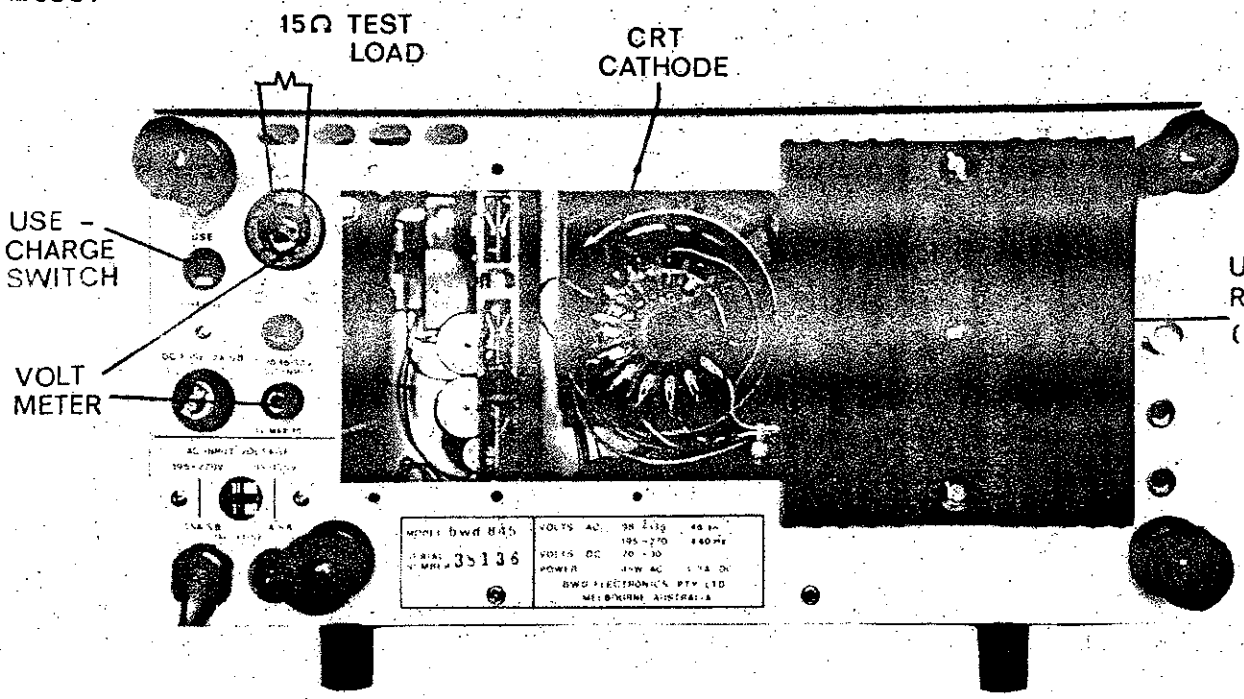
Test equipment: Digital Voltmeter, leads, insulated screw driver. Circuit # 1407 and 1406.

a. Connect meter between chassis and orange/white wire connector on vertical amplifier output board. Turn instrument ON and ensure input voltage is within the correct operating range. Adjust R551 at top rear of vertical plug-in converter board for +70V ±0.1V.

b. Remove meter lead from +70V and connect to Yellow wire connector at bottom rear of vertical amplifier board.
Adjust RV503 on board at bottom rear of instrument for +15V ±50mV.

c. Remove meter lead and reconnect to Violet wire connector alongside yellow wire. Adjust RV502 on board at bottom rear of instrument from -15V ±50mV.


RV552
SET +28V FOR
BATTERY CHARGE
RV554
RV508
TRACE
ROTATE
Q231 & 2
L231&2
WHITE WIRE
SET + 70V
WITH RV554
RV553
INTENSITY
ADJUST


15Ω TEST
LOAD
CRT
CATHODE
USE -
CHARGE
SWITCH
VOLT
METER
U551
REGULATOR
(INSIDE)

d. Remove meter lead and connect to red/white wire connector alongside violet wire. Check voltage is +6V ± .25V. No adjustment is available.

e. Remove meter lead, connect to red wire bottom rear board. Check voltage +84 ±1V no adjustment.

f. Remove meter lead.

If voltages cannot be set or are incorrect where no adjustment is available, check the circuits and circuit descriptions.

12. HIGH VOLTAGE (EHT) SUPPLY:

Test equipment as for para. 11, plus a high voltage probe.

a. Switch instrument off. Connect meter lead to white wire connector at top of converter vertical plug in board. Switch on and set intensity of CRT very low, adjust RV554 on the converter board for +70V. Switch off and remove lead.

b. Connect a high voltage probe to pin 9 of the CRT socket (blue wire) and ensure the meter ground wire is firmly connected to the oscilloscope chassis. Switch on, check voltage is -1450 ±25V.

13. BATTERY CHARGING:

a. Test equipment as for para 11 plus a 15Ω 25W resistor. With instrument off, move USE/CHARGE switch to CHARGE. Connect DVM between black terminal on rear panel and +ve pin on 3 pin battery socket.
Switch instrument on. Adjust RV552 on converter plug-in board for +28V.

b. Current limiting may be checked using either a discharged BWD BP/3 Battery Pack and measuring the current flowing in the positive lead or with an external resistor as described below.

c. Connect a 15Ω 20 Watt resistor in series with an ammeter across the + and - pins of the 3 pin battery plug. Also connect a DVM across the same pins. Switch on, the current should read 1.4 amps approximately and the voltage should fall to +21V.

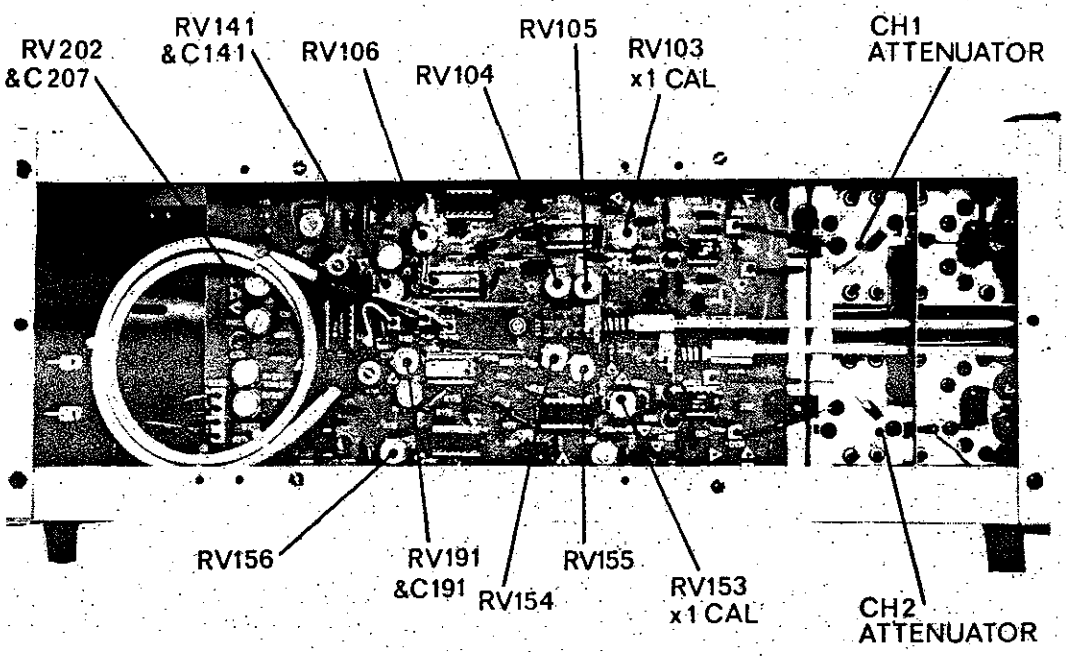
Current limiting is built into the regulator IC U551 and is not adjustable. Switch off, remove lead and meters.
Set USE/CHARGE switch back to USE.

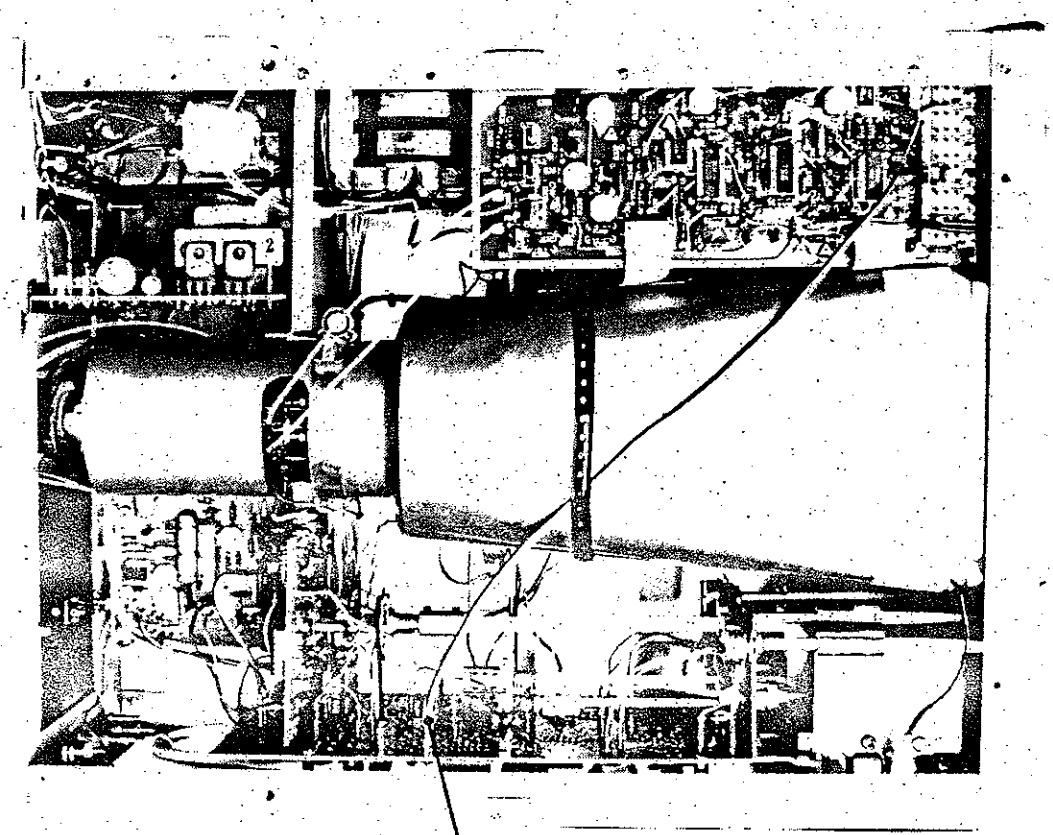
14. CRT GEOMETRY, FOCUS AND INTENSITY:

Test equipment as for para 11 and 50kHz oscillator (BWD 141A, 160A, etc.). Set controls as section 1, centre trace on CRT, align to centre line with trace rotate present RV 508 if necessary.

a. Measure voltage at the vertical output stage connection to CRT side pins. Collector of output transistors Q231 or 232 or pins or bases of peaking coils L231 and 232 are suitable points to connect to. Make sure the meter lead does not cause the output stage to oscillate or an incorrect reading will be obtained.

The mean voltage of the two output transistor collectors should be adjusted to +43V by RV201 on the rear of the main vertical amplifier board.


RV202
&C207
RV141
&C141
RV106
RV104
RV105
RV103
x1 CAL
CH1
ATTENUATOR
RV156
RV191
&C191
RV154
RV155
RV153
x1 CAL
CH2
ATTENUATOR


TRIGGER LEAD
TAKE OFF
(para 15c &d)

b. Connect generator to Ch. 1 input, set to 50kHz and adjust amplitude for 7.8 div deflection. Adjust Focus and Astigmatism for sharpest trace. TB 2mSec/div

c. Adjust RV504 on board at bottom rear of instrument for best compromise between straightness of vertical and horizontal edges of CRT display.

d. Remove input signal, then set A time base to 2Sec/div. Set intensity knob to 10 o'clock position. Adjust RV553 on converter printed circuit board for trace to just show under low ambient light conditions.

e. Return time base back to 0.5mSec/div and fit all shieldsaround converter supply and the rear cover.

15. VERTICAL AMPLIFIERS:

Test equipment: Voltage calibrator (5mV to 100V 1kHz square wave) 1MHz square wave generator with <3nSec rise time (Bradley 192 test set). 50kHz to 50MHz constant amplitude oscillator (Tek 191), oscilloscope (BWD 530A, 540).

a. Set controls as in section 5 - 1. Set trace on CRT centre line. Turn Ch.1Vernier control counter-clockwise. Recentre trace with position control. Return Vernier to Cal. position, recentre with DC BAL preset on front panel. Repeat until no movement occurs with rotation of vernier control.

b. Repeat above procedure for Ch. 2.

c. With trace centered, select Ch. 2 Trigger. Connect meter across connections to twin feeder cable passing from top of vertical amplifier board to trigger selector switches. Adjust voltage across pair to zero volts with RV156.

d. Repeat for Ch. 1, select Ch. 1 Trigger. Adjust RV106 for zero volts across pair of wires.

16. CH. 1 CALIBRATION:

a. Set attenuator to 5mV/div, vernier to CAL, x1 - x5 gain switch to x1, select Ch. 1 with Vertical Display switch, apply a 30mV pp 1kHz square wave from calibrator.

b. Centre waveform on CRT, adjust to 6 div deflection by RV103 calibrate preset.

c. Engage x5 gain push button, reduce input signal to 6mV pp.

d. Centre waveform with position control, adjust to 6 div., deflection by RV104.

e. Switch input AC-GND-DC selector to GND, release x5 gain button to x1, recentre trace with position control.

f. Engage x5 gain button and this time recentre trace with RV105. Slide AC-GND-DC switch back to AC and reset RV104 for 6 div deflection if necessary.

g. Release x5 gain, apply 40mV 1kHz square wave (8 div., deflection) check vertical position control moves display off screen in both directions.

17. CH. 2 CALIBRATION:

a Set attenuator to 5mV/div, Vernier to CAL, x1 - x5 gain switch to x1, Select Ch. 2 with Vertical Display switch. Apply a 30mV p-p 1kHz square wave from calibrator.

b. Centre waveform on CRT, adjust to 6 div deflection by RV153 calibrate preset.

c. Engage x5 gain push button, reduce input signal to 6mV p-p.

d. Centre waveform with position control, adjust to 6 div deflection by RV154.

e. Switch input AC-GND-DC selector to GND, release x5 gain button to x1, recentre trace with position control.

f. Engage x5 gain button and this time recentre trace with RV155, Slide AC-GND-DC switch back to AC and reset RV154 for 6 div deflection if necessary.

g. Release x5 gain, apply 40mV, 1kHz square wave (8 div deflection) check vertical position control moves display off screen in both directions.

18. CH. 1 and CH. 2 ATTENUATOR ALIGNMENT:

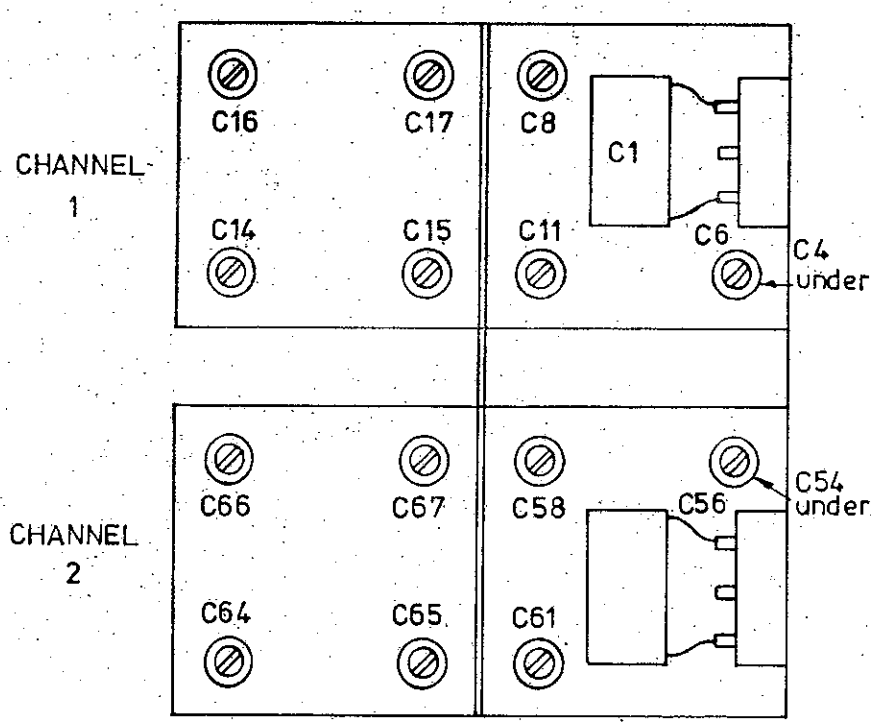
a. The attenuator adjustments are shown below together with the settings and the capacitor to be adjusted to compensate each range. No adjustment is provided or required when NONE appears in the column.

b. C4 and C54 are mounted co-axially with C6 and C56. They are set by first removing C6 and C56 adjustment screws, then by using a thin insulated screw-driver that will pass through the body of C6 or C56.

c. The input voltage in the second column is the p-p voltage of a square wave, frequency 1kHz. Attenuator trimers are adjusted for the best square wave shape.

d.

ATTENUATOR LAYOUT



e.

Attenuator Step	Input Voltage p-p	Response Adjustment Ch. 1	Ch. 2
5mV	20mV	None	None
10mV	50mV	C16	C66
20mV	100mV	C14	C64
50mV	200mV	C8	C58
100mV	500mV	C17	C67
200mV	1V	C15	C65
0.5V	2V	C4	C54
1V	5V	None	None
2V	10V	None	None
5V	20V	None	None
10V	50V	None	None
20V	100V	None	None

f. Attenuator input capacitance can be set in two ways:-

i. Measure input capacitance with a capacitance meter with the instrument operating at 20mV/div attenuator setting, then adjust C11 (Ch. 1) and C61 (Ch. 2) at 50mV/div and C6 (Ch. 1) and C56 (Ch. 2) at 0.5V/div to the same capacitance reading as 20mV/div.

ii. Connect a 10:1 probe (BWD P32) to Ch. 1 input socket. Set attenuator to 20mV/div, apply 1V p-p 1kHz square wave to probe tip. Adjust probe compensation for optimum square wave. Turn attenuator to 50mV/div, increase input to probe tip to 2V p-p then adjust C11 for best square wave. Repeat at 0.5V/div with 20V p-p applied to probe and adjust C6.
Connect probe to Ch. 2 and repeat above procedure adjusting C61 at 50mV/div and C54 at 0.5V/div.

19. HIGH FREQUENCY COMPENSATION:

a. Select Ch. 1, attenuator at 50mVΩdiv, 0.2μSec/div time base. Apply a 1MHz square wave with 1nSec rise time adjusted for approximately 6 div deflection.

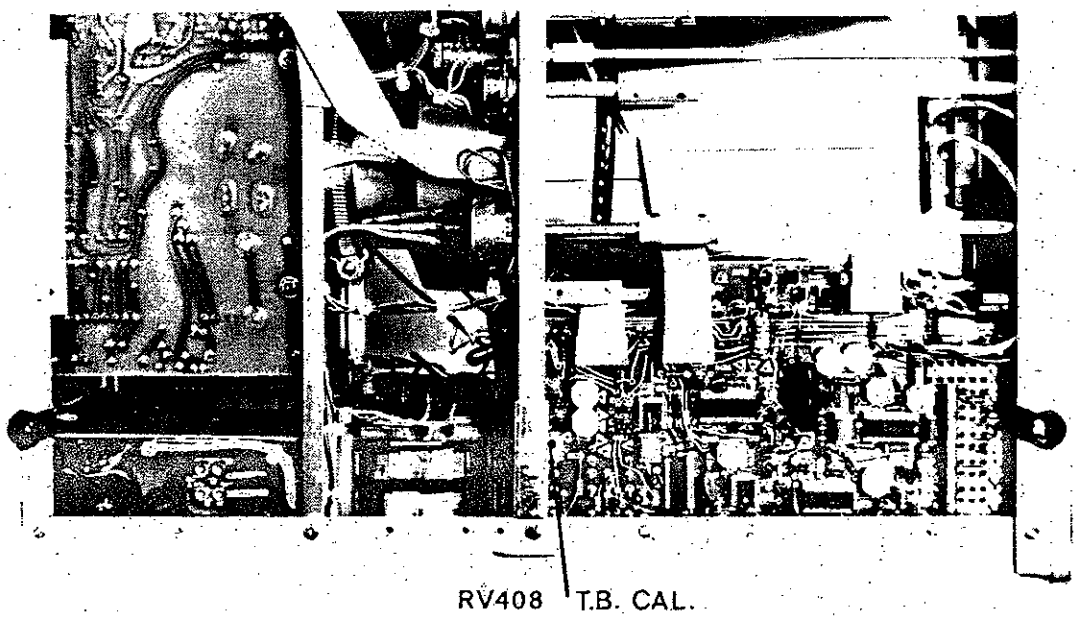
b. Set RV141 and C141 for best flatness across top of wave, then adjust C207 and RV202 for sharpest leading edge with minimum ringing or overshoot along top face.

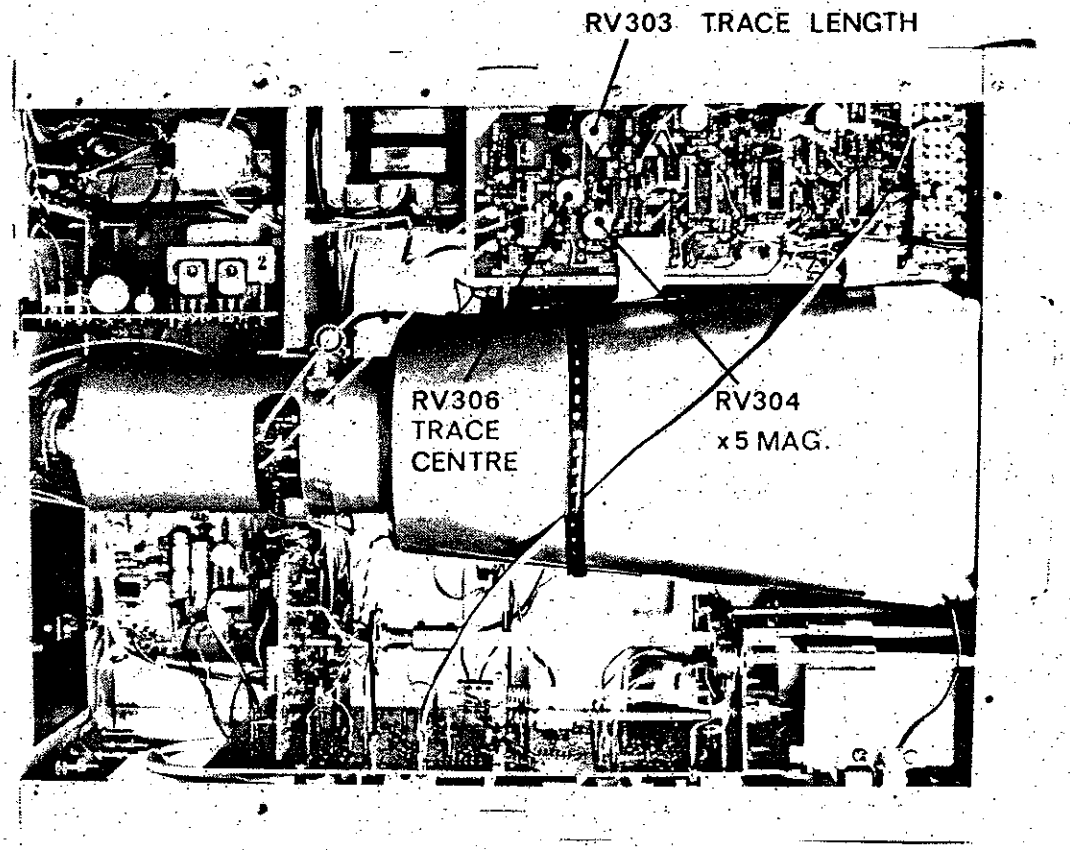
c. Select Ch. 2, attenuator at 50mV/div, apply 1MHz input then adjust C191 and RV191 for flat top to waveform. If necessary, optimise C207 and RV202 for best square wave response between both channels.

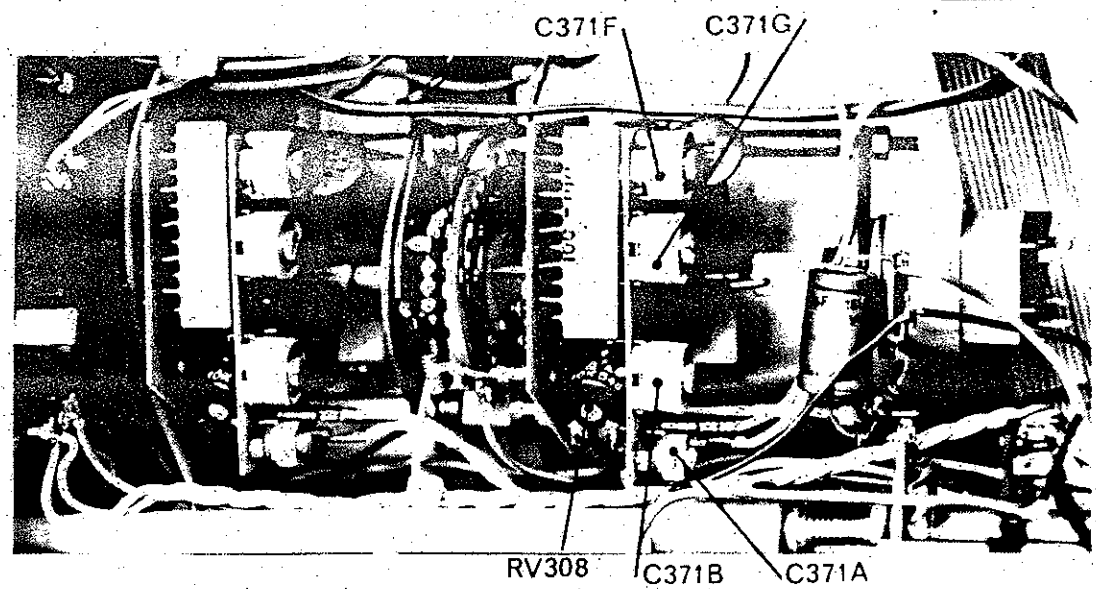
d. Check bandwidth with attenuators set to 5mV/div. Connect constant amplitude signal generator to Ch. 1, set deflection for 8 div at 50kHz. Increase frequency until amplitude drops to 5.6 div, this should be above 30MHz.

e. Repeat step d for Ch. 2.

f. Bandwidth at x5 gain. Repeat step d with x5 gain button engaged. Reset amplitude for 8 div as before at 50kHz. Increase frequency until amplitude drops to 5.6 div., this should be above 25MHz.


RV408
T.B. CAL.


RV303 TRACE LENGTH
RV306
TRACE
CENTRE
RV304
x5 MAG.


C371F
C371G
RV308
C371B
C371A

f (Cont'd) If bandwidth is not obtained, reset RV141 and C141 to sharpen leading edge until bandwidth is obtained (typically >34MHz at x1 gain).

20. COMMON MODE REJECTION:

a. Set both attenuators to 5mV/div, switch Vertical Display to ALT. Engage Ch. 2 INVERT push button. Apply 10MHz sine wave to both Ch. 1 and Ch. 2 inputs. Set input for 8 div display.

b. Turn Vertical Display to ADD. Displayed signal should fall to <0.8 div (=20db rejection). No adjustment is needed.

21. TIME BASE CALIBRATION:

Test equipment required. Time mark generator, output 1 second to 50nSec, accuracy <0.01%. Pulse jitter <50,000:1 (Bradley Model 192).
Low frequency oscillator 1Hz to 1MHz (BWD 141 or 160A).
High frequency generator to >30MHz (Tek 191).

22. 'A' TIME BASE:

a Select Vertical Display Ch. 1, attenuator 0.5V/div, 'A' time base 1mSec/div. Vernier to CAL.

b. Connect time mark generator to Ch. 1 input, set pulse output to 1mSec. Adjust trace length to 10.5 div by RV303 (Top TB board).

c. Set RV408. (Lower TB board) for 1 pulse per graticule division.

d. Reduce input pulse rate to 5mSec., centre middle waveform on graticule centre line. Pull out Horizontal Position control to x5 mag. Recentre with position control then push knob in without turning it. If the trace moves, centre the pulse with RV306, repeat until no movement occurs when x1 - x5 mag is operated.

e. Increase Pulse rate to 0.2mSec. Pull out x5 mag, adjust RV304 for 1 pulse/div. Push control in to x1 Mag.

f. Switch time base range to 10µsec/div., time mark input 10µSec. Adjust C371F at rear of T.B. switch for 1 pulse/div.

g. Increase to 0.5µSec/div time mark input 0.5µSec., adjust C371G for 1 pulse per div.

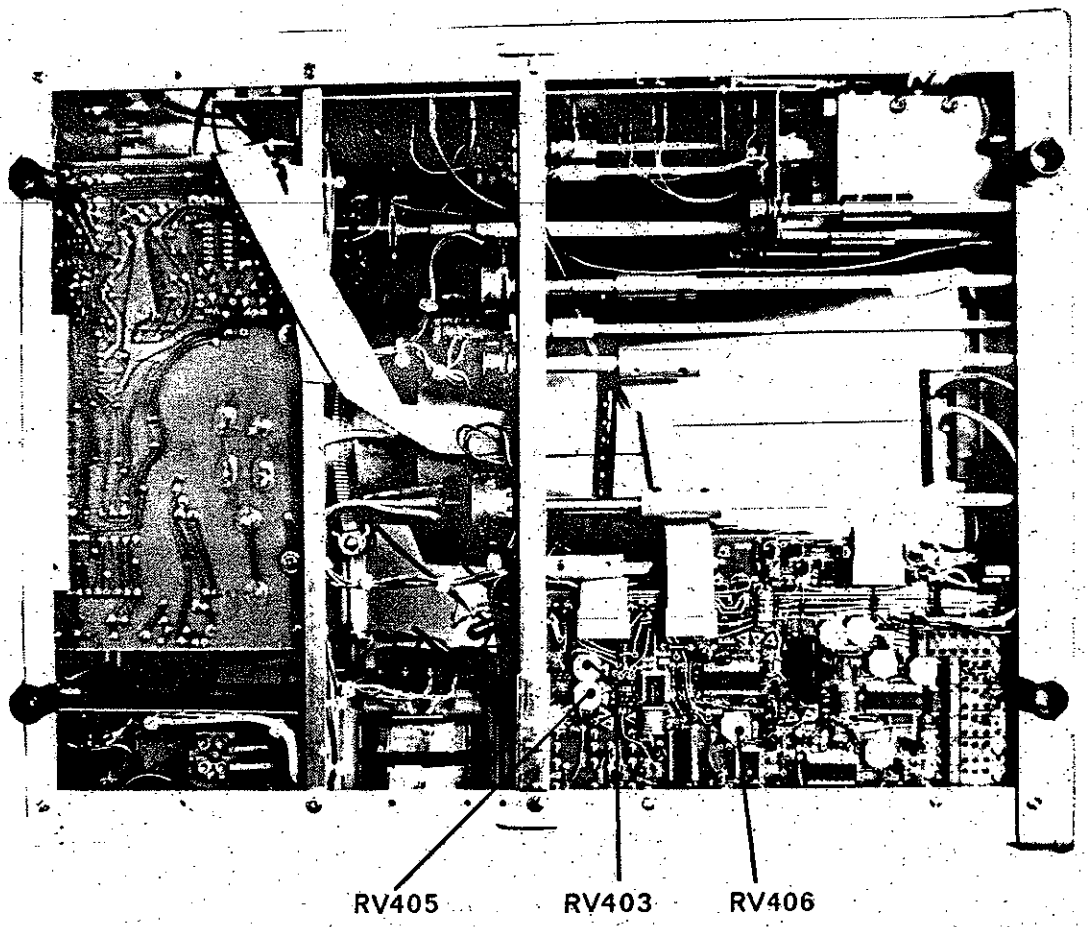
h. Repeat at 0.2µSec with 0.2µSec input pulse, adjust C371A.

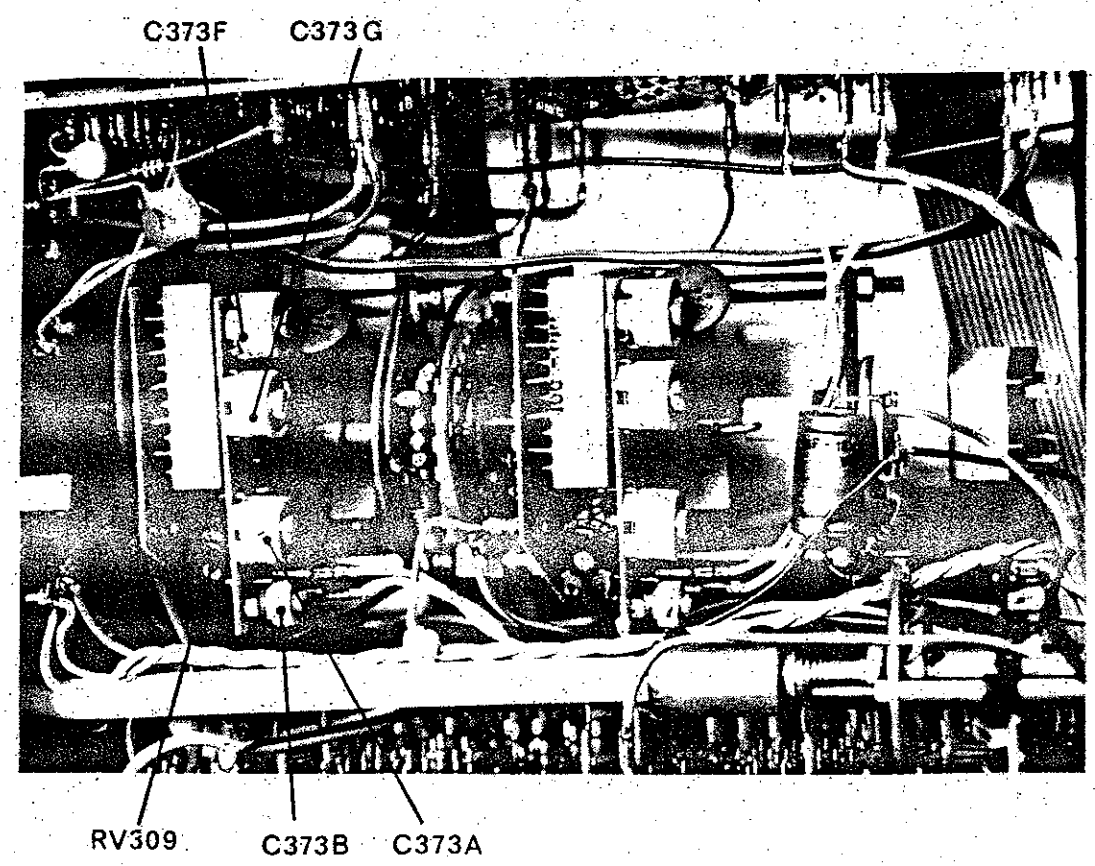
i. Repeat at 0.1µSec with 0.1µSec input pulse, adjust C371B for calibration and RV308 for linearity of first 2 divisions.

j. Select x5 Mag., check calibration and linearity, adjust RV308 together with wire trimmer across R324 for best linearity of first 10 div., of magnified trace.

k. Return to x1 Mag and check all ranges for <3% calibration accuracy with time mark generator.

l. Return range to 1mSec, time mark generator to 0.2mSec. Turn Vernier fully counter clockwise, pulses should reduce to at least 1 per div. No adjustment is provided, reduce R441 if insufficient.


RV405
RV403
RV406


C373F
C373G
RV309
C373B
C373A

23. 'B' TIME BASE:

a. Set A time base to 2mSec/div, set 'B' time base to 1mSec/div., TB vernier to CAL, Delay Time to 1.0 Horizontal Mode to B TRIG DELAYED (fully clock-wise). Feed in 1mSec time mark pulses, adjust 'B' level for stable display. Calibrate B time base for 1 pulse/graticule division with RV406 (lower TB board).

b. Set 'A' time base to 20µSec/div 'B' time base to 10µSec. other settings as per para a. Apply 10µSec pulses. Set calibration with C373F (rear of front section of time base switch).

c. Set A to 1µSec, B to 0.5µSec., 0.5µSec pulses. Set calibration with C373G.

d. Set A to 1µSec, B to 0.2µSec., 0.2µSec pulses. Set calibration with C373A.

e. Set A to 0.5µSec., B to 0.1µSec, 0.1µSec pulses. Set calibration with 373B and adjust RV309 for best linearity of first two divisions.

f. Leave settings as for e but increase input to 20nSec and select x5 mag. Check linearity of first 10 div., and check RV309 is adjusted for best linearity.

g. Return to x1 Mag and check all time base speeds for <3% accuracy.

24. DELAY TIME:

a. Set A time base to 1mSec/div and B time base to 10µSec/div, Vernier to CAL. Delay Time to 1.0. Apply 1mSec pulses to amplifier.

b. Turn Horizontal Mode switch to A INTEN., set intensity of trace so that intensified spot is readily visible. Position trace so that start is precisely aligned with first graticule mark. Align intensified spot to second graticule mark with RV405.

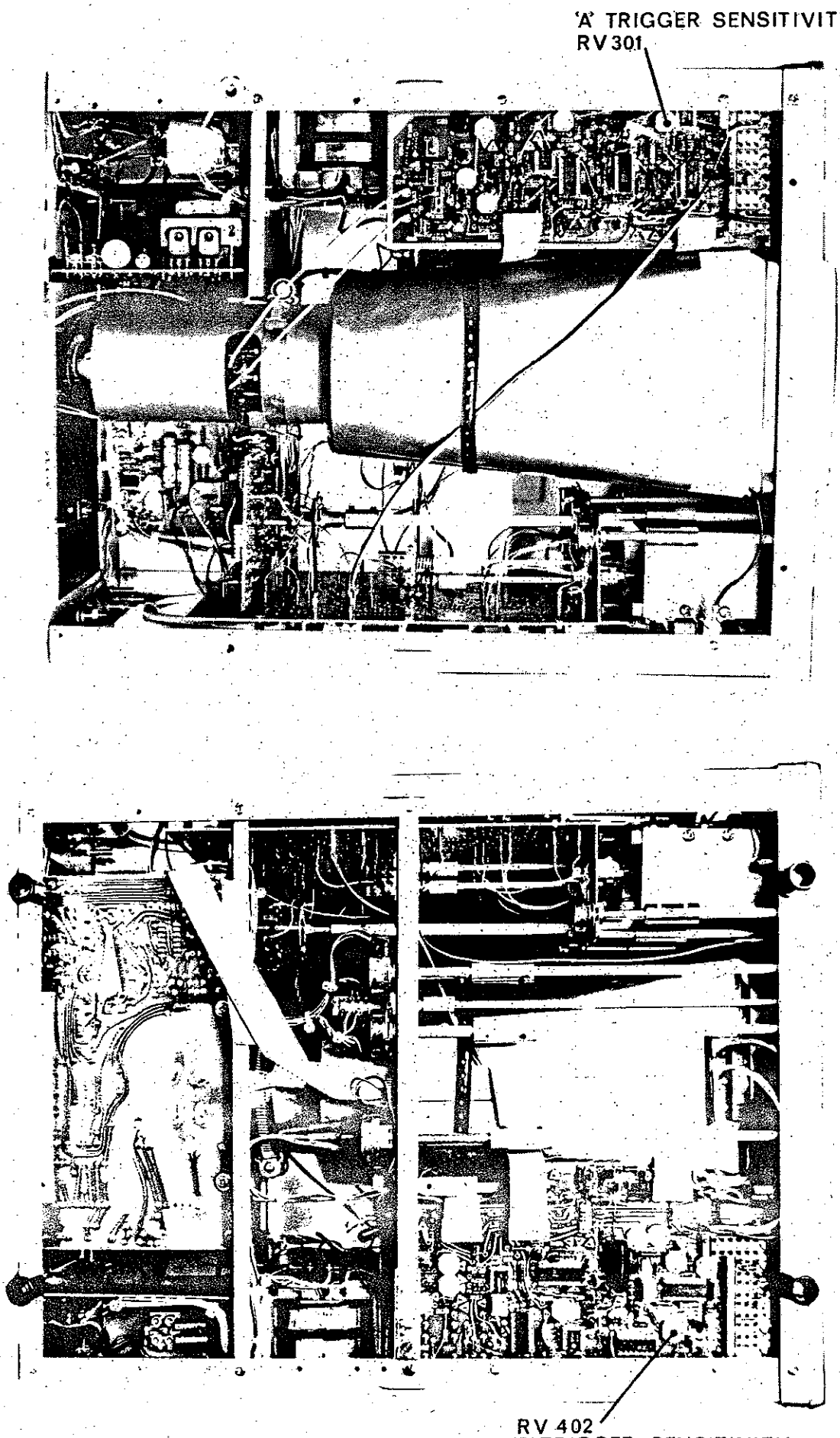
c. Now turn Delay Time control to 9.0. Align intensified spot to ninth graticule mark with RV403.

d. Repeat para B and c until no error is observed, then check intensified spot aligns with each graticule line between 1 and 9.

e. Switch to MIX. Increase input time pulses to 10µSec., check operation over Delay Time range.

f. Switch to 'B' DELAY. Check operation over the Delay Time Range.

g. Set A time base to 1mSec/div. B time base to 1µSec/div., Horizontal Mode to 'B' DELAY. Input pulse 10µSec. Adjust Delay Time to approximately 9.0 to place a pulse in the centre of the CRT. Check short term jitter of pulse in less than 1 div., i.e. 10,000:1.


'A' TRIGGER SENSITIVITY
RV301
RV 402
'B' TRIGGER SENSITIVITY

25. A TIME BASE TRIGGER - INTERNAL:

a. Set Vert Display to Ch. 1 and Ch. 1 input selector to GND. A time base to 1mSec, Horizontal Mode to A. +ve trigger, A level control pulled out to non-auto.

b. Turn RV301 counter-clockwise and adjust level control to approximately centre position where trace will free run. Turn RV301 slowly clockwise, adjusting the level control to detect if trace is still free running. Correct setting for RV301 is when trace just fails to free run at any setting of the level control with either + or - trigger selection.

c. Set up as in para a but input switch to DC.
Feed in 1kHz sine wave, adjust for stable trigger. Reduce signal amplitude down to 0.4 div. Trace should be triggable with both + and - selection.

d. Reduce signal frequency to 1Hz and select DC trigger button, check trigger, then switch back to AC coupling and increase to 15MHz where it should still be possible to lock to a stable display. When checking trigger above 20Hz the level control can be pushed in to AUTO to assist in checking trace position at lower trigger levels.

e. Increase input signal to 1.5 div deflection. Stable trigger should be obtained to beyond 30MHz.

f. Return time base to 1mSec input to 1kHz, increase amplitude to >8 div. Turn level control to check that selection is available over at least 8 div., for both + and - polarity.

26. A TIME BASE TRIGGER-EXTERNAL:

a. Leave set up as para 25 e. Parallel input to Ch. 1 to the EXT TRIG socket. Set amplitude of input to 150mV p-p - if external source is uncalibrated set Ch. 1 atten to 50mV/div and adjust input level for 3 div., deflection.

b. Switch INT-EXT trigger select button to EXT, AC-DC coupling to DC. Leave x1, x10 button out in x10 position. Check that trace can be triggered by adjustment of level control.

c. Reduce frequency to 1Hz and check trigger. Increase to 15MHz keeping level at 150mV. Check trigger.

d. Increase signal level to 500mV p-p, stable triggering should be available to >30MHz.

e. Return input frequency to 1kHz and A time base to 1mSec/div. Increase input amplitude to 3V p-p, check level selection available over full amplitude.

f. Increase external signal to 30V p-p and select x1 button adjacent to INT-EXT trigger. Check level selection available over full amplitude.

27. B TIME BASE TRIGGER-INTERNAL:

a. Set A time base to 1 mSec/div., B time base to 0.5mSec/div. Delay time to 1.0 and A level control pushed in to AUTO. Horizontal Mode to B TRIG DELAYED. Set RV402 as for RV301 in para 25 a, until trace just fails to free run at any setting of the B level control with + or - polarity selection.

b. Feed in a 1kHz signal to Ch. 1 and adjust for 1 div. deflection. Select Ch. 1 for Vertical display, A trigger and B trigger. Check trigger level and polarity of B time base operates. Increase to 8 div deflection, check level operates over $\geq \pm 3$ div. Reduce signal to 1 division.

c. Reduce A time base to 2 sec/div., B time base to 0.5 sec/div and input signal to 1Hz. Check for correct operation of B level and polarity control.

d. Set A time base to 1µSec/div., B time base to 0.1µSec/div and increase input signal to 15MHz (1 div deflection). Check for correct operation. NOTE: At upper and lower limits of frequency range Level control is very sensitive.

e. Increase input signal to 30MHz and 2 div deflection check for correct operation.

28. B TIME BASE TRIGGER - EXTERNAL:

a. Set up as for para 27 a. Parallel input signal to channel 1 into EXT trigger jack. x1 - x10 trigger button OUT at x10. Adjust level to 200mV p-p. Check correct operation of level control and ± polarity.

b. Set controls and input as para 27 c but increase level to 500mV p-p check for correct triggering.

c. Set controls and input as para 27 d, set signal level to 200mV p-p/div. Check correct triggering.

d. Increase input frequency to 30MHz and level to 1V p-p. Check correct triggering operation.

29. MIXED TRIGGER:

Set A time base to 0.1mSec/div, Horizontal Mode to A, level to AUTO, Vertical Display to ALT and A trigger to MIX. Apply 50kHz sine wave to Ch. 1 and 1kHz calibrator square wave to Ch. 2. Amplitudes approx. 3 div. each. Check both signals can be locked simultaneously by adjustment of level control.

30. TRIGGER COUPLING, SOURCE AND SELECTION:

Slow, Fast, Power Line lock and SS operation should be checked to verify specification in section 2.

Video frame trigger is also available when slow is selected from 2 div to 8 div of composite signal whilst line trigger may be obtained in the normal trigger condition with both Slow and Fast Buttons OUT.

31. X - Y OPERATION:

a. Set Horizontal Mode to A, Vertical Display to ALT, centre both traces on graticule centre line.

b. Switch Vert. Display to Ch. 1, and both attenuators to 5mV/div, apply 30mV p-p 1kHz calibrate signal to Ch. 1 check display is 6 div.

c. Select X-Y button, x5 mag (Horizontal) then apply 30mV p-p cal signal to Ch. 2 only. Adjust RV157 to centre signal, set RV302 (A TB board) for 6 div., deflection (horizontally). Repeat adjustment until centered and calibrated.

d. Apply sine wave input to both Ch. 1 and Ch. 2,8 div. amplitude. Increase frequency to 100kHz when diagonal line should not open more than 2mm at the centre of deflection indicating $<2^{o}$ phase shift.

e. Disconnect input to Ch. 1, reduce amplitude to 6 div. at 1kHz, increase signal frequency. Deflection should not drop below 4.2 div. at 1MHz.

32. CALIBRATOR:

Calibrate Ch. 1 as in para 16, then connect Calibrator output to Ch. 1 instead of the external calibration source. Set attenuator to 0.2V/div. Adjust RV271 (rear main amplifier PCB) for 5 div. deflection.

33. STORAGE - FAST:

a. Set all push buttons OUT. Turn Intensity fully counter clockwise - off.

Select WRITE, then press Erase button. Turn BACKGROUND control clockwise until screen is illuminated. Adjust RV455 until the edge of the illuminated area is just showing at edge of CRT. Press Erase button.

b. Adjust RV507, (Lower rear PCB) for most even illumination at low Background level setting. Press Erase. Readjust RV455 to put display edge just outside graticule area.

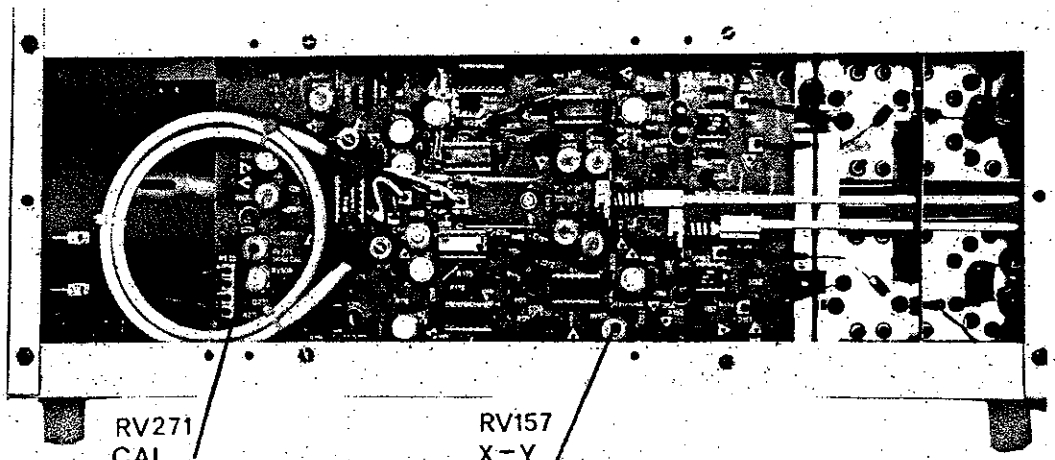
NOTE: Optimum settings of RV507 and RV455 may necessitate allowing the edge to intrude into the graticule area at some points. Press Erase.

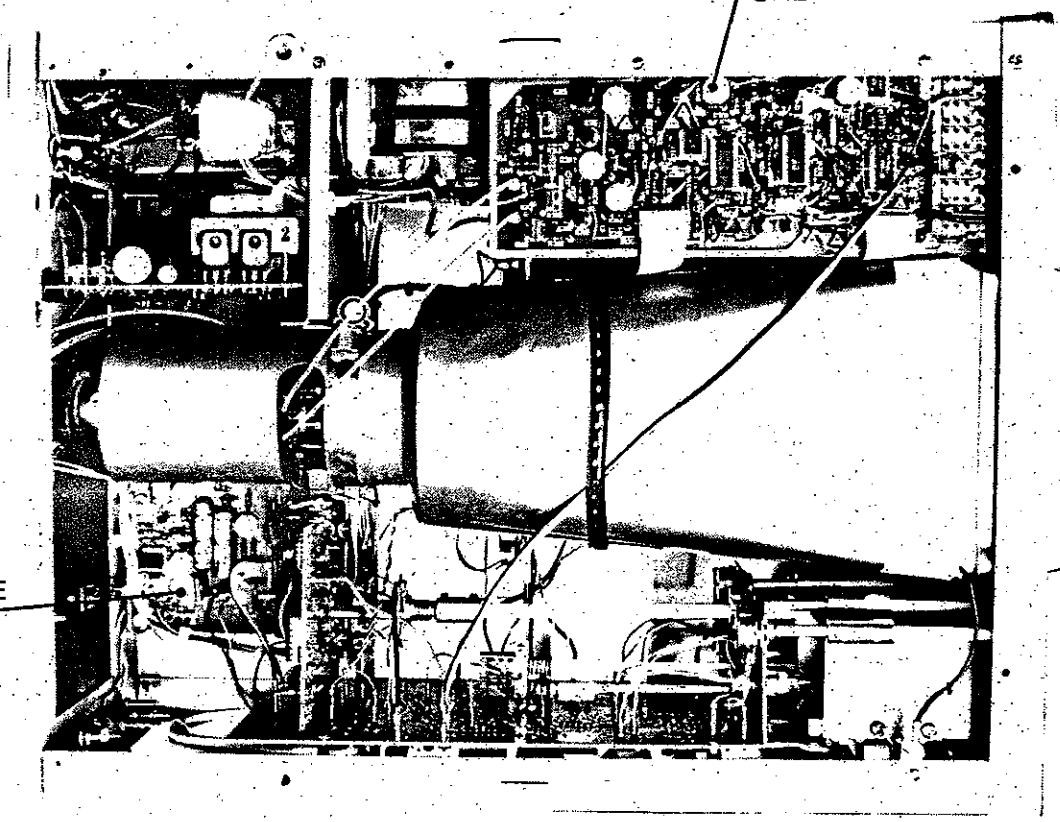
d. Turn background control to nine o'clock position. Adjust RV452 for no background colour on CRT.

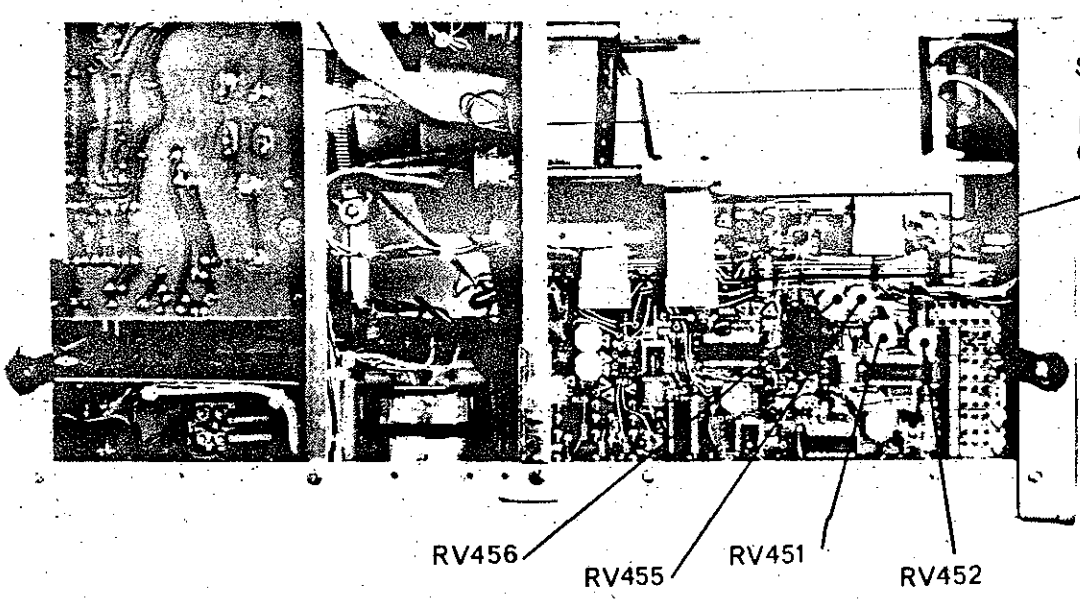
34. STORAGE SLOW:

a. Select WRITE and SLOW. Press Erase. Adjust Background control for even illumination over screen. Press Erase, adjust RV456 for display area just out side graticule area.

b. Turn background control to 9 o'clock position, press erase. Adjust RV451 for no background illumination.


RV271
CAL.
OUTPUT
RV157
X-Y
CENTRE


RV302
X-Y
CAL.
RV507
FLOOD
GUN
BALANCE


AUTO-
STORE &
AUTO-
ERASE
CIRCUITS
RV456
RV455
RV451
RV452

35. VARIABLE PERSISTENCE:

a. Set all buttons out, A time base 10mSec/div, Ch. 1 attenuator 0.5V/div. Apply 8 div amplitude 100Hz sine wave to Ch. 1. Switch attenuator to 50mV/div. (signal amplitude equivalent to 80 div). Adjust intensity control for normal display then select SS and pull A level control out for non-auto.

b. Turn Persistence control just out of switch detent position, select Write, press Erase, this will reset SS after erase period and write one trace. Time of retained display should be 200nSec, i.e. 4 div.

c. Turn Persistence control fully clockwise, switch A time base to 50mSec increase input signal to 50Hz. Press erase. Check period of retained display >50 seconds.

NOTE: Persistence is dependent on intensity setting, low intensity will produce shorter display time, high intensity will lengthen the time. Turn Persistence control to off.

36. WRITING SPEED AND STORE TIME:

a. FAST. Set A time base to 0.2mSec/div. Feed 4kHz sine wave to Ch. 1, adjust for 8 div. deflection. Press erase then adjust for even writing over screen area.

Press erase then STORE. Trace should be retained for at least 15 seconds before fading green.

b. SLOW. Reduce time base to 2mSec/div and input frequency to 400Hz. Press erase, adjust intensity for even writing over screen area. Press erase then STORE, check store time > 3 minutes.

37. AUTO STORE & AUTO ERASE:

Check operation as described in section 6.5 and 6.6.

38. Instrument is now fully aligned. Input and output levels of Z modulation, A and B time base gate pulses, can be checked according to specification in section 2. Range of power operation can be checked with a metered variable voltage transformer. Minimum operating voltage on 195-270V setting is 195V. Panel indicator lamp should blink below this voltage to indicate out of calibration. With the back panel range switch set to 95 - 135 the indicator lamp will blink below 95V.

DC operation should function from just below 20V to 32V. Maximum operating voltage is limited by dissipation in the series regulator. An automatic thermal overload will shut the regulator off with an over-voltage input.

10. REPLACEMENT PARTS:

Spares are normally available from the manufacturer. When ordering, it is necessary to indicate the serial number of the instrument. If exact replacements are not to hand, locally available alternatives may be used, provided they possess a specification not less than, or physical size not greater than, the original components.

As the policy of the supplier is one of continuing research and development, the Company reserves the right to supply the latest equipment and make amendments to circuits and parts without notice.

11. WARRANTY:

The equipment is guaranteed for a period of twelve (12) months from the date of purchas against faulty materials and workmanship other than the storage CRT which is not guaranteed against storage mesh or phosphor burns.

BWD INSTRUMENTS PTY. LTD.

REPLACEABLE PARTS.

1. This section contains information for ordering replacement parts, it provides the following details:-

   (a) Description of part (see list of abbreviations).
   (b) Typical manufacturer or supplier of the part (see list of abbreviations).
   (c) Manufacturer's Part Number and
   (d) Defence Stock Number, where applicable.

2. Ordering - Please quote Model Type No., e.g. BWD 845 Serial No. Circuit Reference number and component details as listed in parts list.

COMPONENT DESIGNATORS

A	Assembly	H	Heater	RV	Resistor Variable
B	Lamp	J	Jack (socket)	S	Switch
C	Capacitor	L	Inductor	T	Transformer
D	Diode	M	Meter	TH	Thermistor
DL	Delay Line	P	Plug	V	Valve
E	Misc. Elect. Part.	Q	Transistor	VDR	Voltage Dependent Resistor
F	Fuse	R	Resistor		

ABBREVIATIONS

Amp	Ampere	L	Inductor
C	Capacitor	Lin	Linear
cc	Cracked Carbon	Log	Logarithmic Taper
c	Carbon	m	Milli = 10^{-3}
cd	Deposited Carbon	MHz	Mega Hertz = 10^{6} Hz
comp	Composition	MF	Metal Film
CDS	Ceramic Disc Capacitor	ma	Milli Ampere
cer	ceramic	MΩ	Meg Ohm = 10^{6} Ω
Com 1	Common	mfr	Manufacturer
DPST	Double Pole Single Throw	MO	Metal Oxide
DPDT	Double Pole Double Throw	MHT	Polyester/Paper Capacitor
ELECTR	Electrolytic	MPC	Metalised Polyester Capacitor
F	Farad	Ne	Neon
f	fuse	NPO	Zero temperature co-efficient
FET	Field Effect Transistor	nsr	Not separately replaceable
Ge	Germanium	NC	Normally Closed
H	Henry(ies)	NO	Normally Open
H.S.	High Stability	ns	Nano second
HTC	High Temp. Coating	obd	Order by Description
ins	Insulated	OD	Outside Diameter
kHz	Kilo Hertz = 10^{3} Hz	P	Peak
KΩ	Kilo Ohm = 10^{3} Ω	pf	pico farad = 10^{-12}F
PL	Plug	SPDT	Single Pole Double Throw
PS	Socket	SPST	Single Pole Single Throw
Preset	Internal Preset	S. Shaft	Slotted Shaft
PYE	Polyester	Si	Silicon
pot	Potentiometer	Ta	Tantalum

COMPONENT ABBREVIATIONS (Cont'd)

prec	Precision
PC	Printed circuit
PIV	Peak Inverse Voltage
PYS	Polystyrene
p-p	Peak to Peak
P. Shaft	Plain Shaft
Q	Transistor
R	Resistor
rot	Rotary
R log	Reverse Logarithmic Taper
rms	Root Mean Squared
SM	Silver Mica
tol	Tolerance
trim	Trimmer
V	Volt (s)
var	Variable
vdcw	Volts Direct Current Working
w	Watt(s)
ww	Wire Wound
Z	Zener
*	Factory Selected value, nominal value may be shown
**	Special component, no part No. assigned.

MANUFACTURERS ABBREVIATIONS

AB	A.B. Electronics
AEE	AEE Capacitors
AC	Allied Capacitors
AST	Astronic Imports
AWA	Amalgamated Wireless of Aust.
ACM	Acme Engineering Pty. Ltd.
AMP	Aircraft Marine Products (Aust.) Pty. Limited
AR	A & R Transformers
AUS	Australux Fuses
AWV	Amalgamated Wireless Valve Co.
ACA	Amplifier Co. of Aust.
ARR	Arrow
BWD	BWD Instruments Pty. Ltd.
BL	Belling & Lee Pty. Ltd.
BR	Brentware (Vic.) Pty. Ltd.
BU	Bulgin
CF	Carr Fastener
CAN	Cannon Electrics Pty. Ltd.
CIN	Cinch
DAR	Darstan
DIS	Distributors Corporation Pty. Ltd.
ELN	Elna Capacitors (Sonar Elec. P/L)
ETD	Electron Tube Dist.
F.	Fairchild Australia Pty. Ltd.
GRA	General Radio Agencies
GE	General Electric (USA)
GEC	General Electric Co. (UK)
GES	General Electronic Services
HW	Hurtle Webster
HOL	R.G. Holloway
H	Haco Distributors (National)
HS	Hawker Sidley
J	Jabel
McH	McKenzie & Holland (Westinghouse)
MAS	Master Instrument Co. Pty. Ltd.
MOR	Morganite (Aust.) Pty. Ltd.
MSP	Manufac. Special Products (AWA)
McM	McMurdo (Aust.) Pty. Ltd.
MOT	Motorola
NU	Nu Vu Pty. Ltd.
NAU	A.G. Naunton Pty. Ltd.
NS	National Semiconductor
PA	Painton
PAL	Paton Elect. Pty. Ltd.
PI	Piher Resistors (Sonar Elec.)
PH	Philips Electrical Industries P/L.
PL	Plessey Pacific
PRO	Procel
PV	Peaston Vic.
RC	Radio Corporation (Electronic Ind.)
RCA	Radio Corporation of America
RHC	R.H. Cunningham
STC	Standard Telephone & Cables
SI	Siemens Electrical Industries
SIM	Simonson Pty. Ltd.
SF	Selectronic Components
SON	Sonar Electronics
TR	Trimax Erricson Transformers
TI	Texas Instruments Pty. Ltd.
TH	Thorn Atlas
UC	Union Carbide
W	Wellwyn Resistors (Cannon Elec. Pty. Ltd).
WH	Westinghouse
Z	Zephyr Prod. Pty. Ltd.

CCT REF	DESCRIPTION				MFR or SUPPLY	PART NO.
	RESISTORS:					
R1	100Ω					
R2	150Ω					
R3	68K					
R4	12Ω					
R5	990K	1/4W	1%	MG	IRH	GL1
R6	10K1	1/4W	1%	MG	IRH	RG1/4
R7	111K	1/4W	1%	MG	IRH	RG1/4
R8	900K	1/4W	1%	MG	IRH	GL1
R9	470K					
R10	500K	1/4W	1%	MG	IRH	GL1
R11	750K	1/4W	1%	MG	IRH	GL1
R12	47Ω					
R13	333K	1/4W	1%	MG	IRH	RG1/4
R14	1MΩ	1/4W	1%	MG	IRH	GL1
R15	1MΩ	1/4W	1%	MG	IRH	GL1
R16	47Ω					
R17	47Ω					
R18						
R19						
R20						
R21						
R51	100Ω					
R52	150Ω					
R53	68K					
R54	10Ω					
R55	990K	1/4W	1%	MG	IRH	GL1
R56	10K1	1/4W	1%	MG	IRH	RG1/4
R57	111K	1/4W	1%	MG	IRH	RG1/4
R58	900K	1/4W	1%	MG	IRH	GL1
R59	470K					
R60	500K	1/4W	1%	MG	IRH	GL1
R61	750K	1/4W	1%	MG	IRH	GL1
R62	47Ω					
R63	333K	1/4W	1%	MG	IRH	RG1/4
R64	1MΩ	1/4W	1%	MG	IRH	GL1
R65	1MΩ	1/4W	1%	MG	IRH	GL1
R66	47Ω					
R67	47Ω					
R68						
R69						
R70	ALL RESISTORS 1/4W 5% METAL GLAZE					
R71	TYPE RG 1/4 UNLESS MARKED.					

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO.
	RESISTORS (continued)		
R101	220K		
R102	33Ω		
R103	100Ω		
R104	100Ω		
R105	10Ω		
R106	6K8		
R107	6K8		
R108	100Ω		
R109	4K7		
R110	4K7		
R111	33Ω		
R112	33Ω		
R113	33Ω		
R114	390Ω		
R115	15K		
R116	15K		
R117	10Ω		
R118	22K		
R119	22K		
R120	33Ω		
R121	33Ω		
R122	33Ω		
R123	1KO		
R124	33Ω		
R125	560Ω		
R126	1KO		
R127	5K6		
R128	5K6		
R129	680Ω		
R130	33Ω		
R131	15K		
R132	150Ω		
R133	150Ω		
R134	ALL RESISTORS 1/4W 5%		
R135	METAL GLAZE TYPE RG1/4 UNLESS MARKED		
R141	2K2		
R142	2K2		
R143	120Ω		
R144	2K2		
R145	4K7		
R146			
R147			
R148			
R149			
R150			
R151	220K		
R152	33Ω		

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO.
	RESISTORS (continued)		
R153	100Ω		
R154	100Ω		
R155	10Ω		
R156	6K8		
R157	6K8		
R158	100Ω		
R159	4K7		
R160	4K7		
R161	33Ω		
R162	33Ω		
R163	18Ω		
R164	15Ω		
R165	390Ω		
R166	15K		
R167	15K		
R168	10Ω		
R169	22K		
R170	22K		
R171	33Ω		
R172	33Ω		
R173	33Ω		
R174	33Ω		
R175	1KO		
R176	1KO		
R177	560Ω		
R178	5K6		
R179	5K6		
R180	680Ω		
R181	15K		
R182	68Ω		
R183	2K7		
R184			
R185	5K6		
R186	8K2		
R187	10Ω		
R188	150Ω		
R189	150Ω		
R190	150Ω		
R191	2K2		
R192	2K2		
R193	120Ω		
R194	2K2		
R195	4K7		
R196	150Ω		

ALL RESISTORS 1/4W 5%
METAL GLAZE TYPE RG1/4 UNLESS MARKED

CCT REF	DESCRIPTION				MFR or SUPPLY	PART NO
	RESISTORS (continued)					
R201	180Ω					
R202	91Ω	1/4W	2%	MG	IRH	RG1/4
R203	91Ω	1/4W	2%	MG	IRH	RG1/4
R204	820Ω					
R205	820Ω					
R206	560Ω					
R207	560Ω					
R208	390Ω					
R209	10Ω					
R210	220Ω					
R211	390Ω					
R212	390Ω					
R213	180Ω					
R214	180Ω					
R215	68Ω					
R216	68Ω					
R217						
R218	2K2					
R219						
R220						
R221						
R231						
R232						
R233	330Ω	1W	5%	MG	IRH	GL1
R234	330Ω	1W	5%	MG	IRH	GL1
R235	330Ω	1W	5%	MG	IRH	GL1
R336	180Ω					
R237	330Ω	1W	5%	MG	IRH	GL1
R238	330Ω	1W	5%	MG	IRH	GL1
R239	330Ω	1W	5%	MG	IRH	GL1
R240	1KO					
R241	4K7					
R242	680Ω					
R243	680Ω					
R244	10Ω					
R245	33Ω					
R246	33K					
R247	8K2					
R248	2K2					
	ALL RESISTORS 1/4W 5% METAL GLAZE TYPE RG1/4 UNLESS STATED					

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO.
	RESISTORS (continued)		
R271	8K2		
R272	27K		
R273	27K		
R274	22K		
R275	27K		
R276	22K		
	ALL RESISTORS 1/4W 5% METAL GLAZE TYPE RG1/4 UNLESS STATED		
R301	220Ω		
R302	3K3		
R303	22Ω		
R304	150K		
R305	150K		
R306	560Ω		
R307	560Ω		
R308	1K		
R309	VDR (Red-blue-yellow)	PH	2322-553-2261
R310	1K2		
R311			
R312	10K		
R313			
R314	2K2		
R315	750K 1%		
R316	82K		
R317	180K		
R318	10M		
R319	180K		
R320			
R321	5K6		
R322	2K2		
R323	150K		
R324	560Ω		
R325	1KO		
R326	1KO		
R327	10K		
R328	10K		
R329	3K3		
R330	5K6		
R331	33K		
R332	2K2		
R333	5K6		
R334	10K		
R335	33K		
R336	15K		
R337	2K7		
R338	10K		

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO
	RESISTORS (continued)		
R339	5K6		
R340	10K		
R341	22K		
R342	27K		
R343	10K		
R344	10K		
R345	1MΩ		
R346	1K2		
R347	220Ω		
R348	820Ω		
R349	4K7		
R350	10K		
R351	4K7		
R352	68Ω		
R353	27K		
R354	4K7		
R355	18K		
R356	33K		
R357			
R358	10K		
R359	39K		
R360	3K3		
R371A-J	THICK FILM RESISTOR NETWORK	BWD	010-001
R373A-J	THICK FILM RESISTOR NETWORK	BWD	010-001
	ALL RESISTORS 1/4W 5% METAL GLAZE TYPE RG1/4 UNLESS OTHER WISE STATED		
R401	22K		
R402	120KΩ		
R403	1KO		
R404	1KO		
R405	2K2		
R406	4K7		
R407	VDR Red-Blue-Yellow	PH	2322-553-02261
R408	2K2		

PARTS LIST - MODEL BWD 845

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO
	RESISTORS (continued)		
R411	1KO		
R412	33Ω		
R413	100K		
R414	33Ω		
R415	1KO		
R416	10K		
R417	10K		
R418	1KO		
R419	1K		
R420	10K		
R421	18K		
R422	100K		
R423	12K		
R424	2K2		
R425	33K		
R426	1KO		
R427	2K2		
R428			
R429	10K		
R430	5K6		
R431	1KO		
R432	1KO		
R433	2K2		
R434	10K		
R435	5K6		
R436	1KO		
R437	1KO		
R438	15K		
R439	5K6		
R440	10K		
R441	1K2		
R442	2K2		
	ALL RESISTORS 1/4W 5% METAL GLAZE TYPE RG 1/4 UNLESS OTHERWISE MARKED		
R451	1KO		
R452	2K7		
R453	82K		
R454	12K		
R455	470K		
R456	470K		
R457	68K		
R458	1K2		
R459	10K		
R460	10K		
R461	3K3		
R462	3K3		
R463	1K8		

CCT REF	DESCRIPTION					MFR or SUPPLY	PART NO.
	CAPACITORS (continued)						
C241	150pF	630V	20%		CDS		
C242	330pF	630V	20%		CDS		
C243	100nF	63V			CDS	S	
C244	100nF	63V			CDS	S	
C245	330pF	630V	20%		CDS		
C271	10nF	400V	10%		PYC	SIEM	
C272	100nF	100V	10%		PYE	S	TYPE N
C301	1nF	630V	±20%		CDS		
C302	4µ7F	35V			Ta	ITT	TYPE TAG
C303	4µ7F	35V			Ta	ITT	TYPE TAG
C304	1nF	630V	±20%		CER		
C305	100nF	63V			CDS		
C306	100nF	63V			CDS		
C307	100nF	630V	±10%		PYE	ELNA	TYPE N
C308	56pF	630V	±5%	N750	CDS		
C309	100nF	63V			CDS		
C310	22µF	16V			Ta	ITT	TYPE TAG
C311	150pF	630V	±20%		CDS		
C312	18pF	630V	±5%	NPO	CDS		
C313	10µF	16V			Ta	ITT	TYPE TAG
C314	2µ2	40V	ELECTRO			PH	2222-015-17228
C315	100nF	100V	±10%		PYE	ELNA	TYPE N
C316	680pF	250V	±5%		PYS		
C317	2µ2	35V			Ta	ITT	TYPE TAG
C318	100nF	100V	±10%		PYE	ELNA	TYPE N
C319	330pF	630V	±20%		CDS		
C320	10µF	16V			Ta	ITT	TYPE TAG
C321	220pF	630V	±20%		CDS		
C322	12pF	630V	±1pF	NPO	CDS		
C323	100pF	630V	±5%	N750	CDS		
C324	39pF	630V	±5%	N750	CDS		
C325	100nF	250V	±10%		PYC	SIEM	B32541
C326	10µF	16V			Ta	ITT	TYPE TAG
C327	12pF	630V		NPO	CDS		
C328	18pF	630V	5%	N750	CDS		
C329	4p7	630V	10%	NPO	CDS		
C330	22pF	630V	±5%	N750	CDS		

CCT REF	DESCRIPTION					MFR or SUPPLY	PART NO
	CAPACITORS (continued)						
C371A	4-20pF	Trim			CER	STE	10S-06-4/20
C371B	4-20pF	Trim			CER	STE	10S-06-4/20
C371C	1µF	100V	±1%		PYC	BWD	
C371D	10nF	100V	±1%		PYC	BWD	
C371E	82pF	630V	±5%	NPO	CDS		
C371F	4-20pF	Trim			CER	STE	10S-06-4/20
C371G	4-20pF	Trim			CER	STE	10S-06-4/20
C372	47pF	630V		N750	CDS		
C373A	4-20pF	Trim			CER	STE	10S-06-4/20
C373B	4-20pF	Trim			CER	STE	10S-06-4/20
C373C	1µF	100V	±1%		PYC	BWD	
C373D	10nF	100V	±1%		PYC	BWD	
C373E	82pF	630V	±5%	NPO	CDS		
C373F	4-20pF	Trim			CER	STE	10S-06-4/20
C373G	4-20pF	Trim			CER	STE	10S-06-4/20
C374							
C375	47pF	630V		N750	CDS		
C401							
C402	22µF	16V			Ta	ITT	TYPE TAG
C403	100nF	63V			CDS		
C404	100nF	63V			CDS		
C405	22µF	10V			Ta	ITT	TYPE TAG
C406	100nF	63V			CDS		
C407	330pF	630V	±20%		CDS		
C408							
C409	1µF	100V	±10%		PYC	SIEM	B32541
C410	150pF	630V	±20%		CDS		
C411	220pF	630V	±5%	N750	CDS		
C412	10µF	16V			Ta	ITT	TYPE TAG
C413	100nF	100V	±10%		PYE	ELNA	TYPE N
C414	220µF	16V	ELECTRO			PH	2222-016-15221
C451	22µF	16V			Ta	ITT	TYPE TAG
C452	10nF	100V	10%		PYE	ELNA	TYPE N
C453	150pF	630V	20%		CDS		
C454	330pF	630V	20%		CDS		
C455	100nF	100V	10%		PYE	ELNA	TYPE N
C456	150pF	630V	20%		CDS		
C457	100nF	100V	10%		PYE	ELNA	TYPE N
C458	1µF	100V	10%		PYC	SIEM	B32541
C459	100nF	100V	10%		PYE	ELNA	TYPE N
C460	1µF	200V	10%		PYE	ELNA	TYPE N
C461	1nF	630V	20%		CDS		
C462	100nF	100V	10%		PYE	ELNA	TYPE N

CCT REF	DESCRIPTION				MFR or SUPPLY	PART NO.
	CAPACITORS (continued)					
C501	1nF	630V	10%	CDS		
C502	100nF	250V	10%		SIEM	B32541
C503	10µF	16V		Ta	ITT	TYPE TAG
C504	330µF	16V		ELEC	PH	2222-017-15331
C505	1µF	35V		Ta	ITT	TYPE TAG
C506	10µF	16V		Ta	ITT	TYPE TAG
C507	100nF	250V		PYC	SIEM	B22541
C508	100µF	25V		ELEC	PH	2222-016-16101
C509	100µF	25V		ELEC	PH	2222-016-16101
C510	10µF	160V		ELEC	PH	2222-041-11109
C511	10µF	160V		ELEC	PH	2222-041-11109
C512	10µF	16-V		ELEC	PH	2222-041-11109
C513	100nF	250V	10%	PYC	SIEM	B32541
C514	6n8	5kV		CDS	ERIE	TYPE 25U
C515	6n8	5kV		CDS	ERIE	TYPE 25U
C516	10nF	2.5kV		CDS		
C517	1nF	3kV		CDS		
C518	33nF	1.6kV		PYE	PH	2222-341-81333
C520	<1pF Wire Trimmer			ELEC	BWD	
C521	6n8	5kV		CDS	ERIE	TYPE25u
C522	330µF	16V		ELEC	PH	2222-017-15331
C550	2µ2	40V		ELEC	PH	2222-015-17228
C551	10nF	250AC Working			AEE	PME 271
C552	10nF	" " "			AEE	" "
C553	1µF	200V	10%	PYE	ELNA	TYPE N
C554	6800µF	50V		ELEC	"	TYPE L
C555	10µF	25V		ELEC	ELNA	TYPE RB-LL
C556	680µF	25V		ELEC	PH	2222-017-16681
C557	150µF	63V		ELEC	PH	2222-017-18151
C558	47µF	100V		ELEC		
C559	47µF	100V		ELEC		
C560	100nF	250V	10%	PYE	SIEM	B32541
C561	220µF	25V		ELEC	PH	2222-017-16221
C562	220µF	25V		ELEC	PH	2222-017-16221
C563	6n8	5kV		CDS	ERIE	TYPE Z5U
C564	100nF	250V	10%	PYC	SIEM	B32541
C565	10nF	250V	10%	PYC	SIEM	B32541
C566	100nF	250V	10%	PYC	SIEM	B32541
C567	1nF	3kV		CDS		
C568	100nF	100V	10%	PYE	S	TYPE NL

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO.
	SEMICONDUCTORS:		
D101	Signal Diode		IN3595
D102	Signal Diode		IN3595
D103	9.1V Zener Diode	PH	BZX79/C9V1
D151	Signal Diode		IN3595
D152	Signal Diode		IN3595
D241	Signal Diode		IN4148
D242	Signal Diode		IN4148
D243	Signal Diode		
D271	Signal Diode		IN4148
D301	Signal Diode		IN4148
D302	Signal Diode		IN4148
D303	Signal Diode		IN4148
D304	Signal Diode		IN4148
D305	L.E.D.	TI	TIL209A
D306	Signal Diode		IN4148
D307	Signal Diode		IN4148
D308	Signal Diode		IN4148
D309	Signal Diode		IN4148
D310	Signal Diode		IN4148
D311	Signal Diode		IN4148
D312	Signal Diode		IN4148
D313	Signal Diode		IN4148
D314	Signal Diode		IN4148
D315			
D316	3.3V Zener Diode		BZX79/C3V3
D317	3.3V Zener Diode		BZX79/C3V3
D401	Signal Diode		IN4148
D402	Signal Diode		IN4148
D403	Signal Diode		IN4148
D404	Signal Diode		IN4148
D405	Signal Diode		IN4148
D406	Signal Diode		IN4148

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO
	SEMICONDUCTORS (continued)		
D407	Signal Diode		IN4148
D408	Signal Diode		IN4148
D409	Signal Diode		IN4148
D410	Signal Diode		IN4148
D411	Signal Diode		IN4148
D412	Signal Diode		IN4148
D413	Signal Diode		IN4148
D414	Signal Diode		IN4148
D451	Signal Diode		IN4148
D452	High Speed Power Diode	PH	BY206
D453	Power Diode		IN4004
D454	High Speed Power Diode	PH	BY206
D455	High Speed Power Diode	PH	BY206
D456	Power Diode		IN4004
D457	L.E.D.	TI	TIL209A
D458	Signal Diode		IN4148
D501	High Speed Power Diode	PH	BY206
D502	High Speed Power Diode	PH	BY206
D503	High Voltage Diode	PH	BY409
D504	High Voltage Diode	PH	BY409
D505	High Voltage Diode	PH	BY409
D506	Signal Diode		IN4148
D507	Signal Diode		IN4148
D508	Signal Diode		IN4148
D509	5.6V Zener Diode	PH	BZX79/C5V6
D510	L.E.D.	F	FLV310
D511	Diode		IN4004
D550	Power Diode		IN4004
D551	Bridge Rectifier Assembly	S.F.	TYPE PW02
D552	Power Diode	MOT	MR501
D553	Power Diode	MOT	MR501
D554	High Speed Power Diode	PH	BY206
D555	High Speed Power Diode	PH	BY206
D556	High Speed Power Diode	PH	BY206
D557A	Signal Diode		IN4148
D557B	Zener Diode	PH	BZX79/C10
D558	High Speed Power Diode	PH	BAX12
D559	High Speed Power Diode	PH	BAX12
D560	High Speed Power Diode	PH	BAX12

CCT REF	DESCRIPTION		MFR or SUPPLY	PART NO
	SEMICONDUCTORS (continued)			
D561	High Speed Power Diode		PH	BAX12
D562	High Voltage Diode		PH	BY409
D563	High Voltage Diode		PH	BY409
D564	Power Diode		MOT	MR501
Q101) Q102)	Dual matched F.E.T.		NS	MPF 106
Q103)	Matched pair transistors		BWD	2N5770
Q104)			BWD	2N5770
Q151) Q152)	Dual matched F.E.T.		NS	MPF 106
Q153) Q154)	Matched Pair Transistors	NPN	BWD	2N5770 2N5770
Q201	Transistor) Matched pair	NPN	BWD	BFW17A
Q202	Transistor)	NPN	BWD	BFW17A
Q231	Transistor) Matched	NPN		2N2219
Q232	Transistor) Pair	NPN		2N2219
Q271	Transistor	NPN		2N5770
Q272	Transistor	NPN		2N5770
Q301) Q302)	Dual Matched F.E.T.		NS	NPD8303CN
Q303) Q304) Q305) Q306) Q307)	Transistor array see U301			
Q308	Transistor	PNP	F	PN4121
Q309	Transistor	NPN		2N5770
Q310	Transistor	NPN		2N5770
Q311	Transistor	PNP		2N4258
Q312	Transistor	PNP		2N4258
Q313	Transistor	NPN	PH	BF469
Q314	Transistor		PH	"

CCT REF	DESCRIPTION		MFR or SUPPLY	PART NO
	SEMICONDUCTORS (continued)			
Q315	Transistor	NPN		BF469
Q316	Transistor	NPN		BF469
Q401	Transistor	NPN		BC547A
Q402	Transistor	NPN		2N5770
Q403	Transistor	NPN		2N5770
Q404)	Dual Matched F.E.T.		N.S.	NPD8303CN
Q405)				
Q406	Transistor	NPN		2N5770
Q407	Transistor	PNP	F	PN3644
Q408	Transistor	NPN	PH	BC547
Q451	Transistor	PNP	F	PN3644
Q452	Transistor	NPN	F	PN3642
Q453	Transistor	NPN	F	PN3642
Q454	Transistor	PNP	F	PN3644
Q455	Transistor	NPN	PH	BC547
Q456	Transistor	NPN	PH	BC547
Q457	Transistor	PNP	F	PN3644
Q458	Transistor	PNP	PH	BF470
Q459	Transistor	NPN	F	PN3642
Q460	Transistor	PNP	F	PN3644
Q461	Transistor	NPN	F	PN3642
Q501	Transistor	PNP	PH	BF470
Q502	Transistor	NPN	PH	BF469
Q503	Transistor	PNP	F	PN4121
Q550	Transistor	PNP		PN3644
Q551	Transistor	NPN	F	PN3642
Q552	Transistor Matched Pair	NPN	MOT	MJE3055
Q553	Transistor h_{fe} >70	NPN	MOT	MJE3055
Q554				
Q555	Transistor	NPN	PH	BF469
Q556	Transistor	PNP	F	PN3644
U101	Wide band amplifier		NS	LM733C
U102	Gate Controlled Amplifier		MOT	MC1445L
U151	Wide band amplifier		NS	LM733C
U152	Gate controlled amplifier		MOT	MC1445L

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO
	SEMICONDUCTORS (continued)		
U141	Transistor array	RCA	CA3054
U191	Transistor array	RCA	CA3054
U201	Transistor array	RCA	CA3046
U241	Hex inverter		74L04
U242	J-K Flip-flop		7470
U301	Transistor array	RCA	CA3046
U302	Hex inverter		74S04
U303	Quad analogue switch		4066
U304	Fet Input operational amplifier	NS	LF356N
U401	Hex inverter		74LS04
U402	Fet input operational amplifier	NS	LF356N
U403	Comparator	NS	LM361N
U451	Dual Monostable	NS	74C221
U452	Dual Monostable	NS	74C221
U501	Transistor array	RCA	CA3046
U502	+6V Positive regulator	NS	LM340T/6
U503	Operational amplifier	NS	LM341CN
U504	Negative adjustable regulator	F	79MGT2C
U505	Positive adjustable regulator	F	78MGT2C
U551	Positive adjustable regulator	NS	LM317K
	SWITCHES:		
S1A-B	3 Position 2 pole slide switch	NSF	SM2-3
S2A-C	3 Deck rotary switch	BWD	100/129/1

CCT REF	DESCRIPTION	MFR or SUPPLY	PART NO
	SWITCHES (continued)		
S51A-D	3 Position 2 pole slide switch	NSF	SM2-3
S52A-C	3 Deck rotary switch	BWD	100/129/1
S101A-B	2 x DPDP Push button switch	BWD	100/84/1
S151A-B	DPDT Push button switch	BWD	100/80/1
S152A-B	DPDT Push button switch	BWD	100/80/1
S241A-D	5 Position 2 deck rotary switch	BWD	100/148/1
S301	7 section Isostat	BWD	100/116/1
S302	(On rear of RV302)		
S303	(On rear of RV305)		
S304	Push button	Bulgin	HP16
S371	Dual concentric 23 position Rotary Switch	BWD	100/101/1
S401	4 Section Isostat	BWD	100/130/1
S402	(On rear of RV401)		
S403	5 Position 3 Deck Rotary Switch	BWD	100/119/1
S451	(On rear RV454)		
S452	(On rear RV453)		
S501	4 Pole single section Isostat	BWD	100/125/1
S551	2 Pole single throw on rear of RV 555		
S552	2 Pole change over slide switch	MSP	625-SL-56003-004
S553	" " " " "	MSP	"
	POTENTIOMETERS:		
RV101	500Ω Lin. Carbon	Noble	VMU
RV102	5KΩ Log. c/w Rev. switch	ERIE	510-S
RV103	1KO Lin. Preset cermet	Noble	VTP
RV104	100Ω Lin. Preset cermet	Noble	VTP
RV105	50Ω Lin. Preset cermet	Noble	VTP
RV106	1KΩ Lin. Preset cermet	Noble	VTP

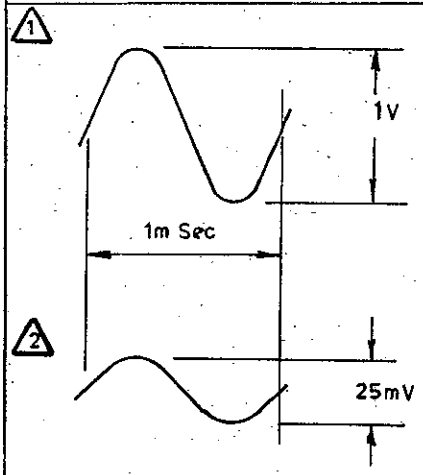
CCT REF		DESCRIPTION	MFR or SUPPLY	PART NO
	POTENTIOMETERS (continued)			
RV107	10K	Lin. Carbon	Noble	VMU
RV141	5K	Lin. Preset cermet	Noble	VTP
RV151	500Ω	Lin Carbon	Noble	VMU
RV152	5KΩ	Log c/w Rev. switch	ERIE	510-S
RV153	1KO	Lin. Preset cermet	Noble	VTP
RV154	100Ω	Lin. Preset cermet	Noble	VTP
RV155	50Ω	Lin. Preset cermet	Noble	VTP
RV156	1K	Lin. Preset cermet	Noble	VTP
RV157	10K	Lin. Preset cermet	Noble	VTP
RV158	10K	Lin. Carbon	Noble	VMU
RV191	5K	Lin. Preset cermet	Noble	VTP
RV201	100Ω	Lin. Preset cermet	Noble	VTP
RV271	2KΩ	Lin. Preset cermet	Noble	VTP
RV301	500Ω	Lin. Preset cermet	Noble	VTP
RV302	20K	Lin. Preset cermet	Noble	VTP
RV303	5K	Lin. Preset cermet	Noble	VTP
RV304	500Ω	Lin. Preset cermet	Noble	VTP
RV305	10K	Lin. Carbon with p-p switch	BWD	VM13A014
RV306	500Ω	Lin. Preset cermet	Noble	VTP
RV307	10K	Lin. Carbon with p-p switch	BWD	VM13A014
RV401	10K	Lin. Carbon with p-p switch	BWD	VM13A014
RV402	1K	Lin. Preset cermet	Noble	VTP
RV403	5K	Lin. Preset cermet	Noble	VTP
RV404	10K	10 Turn ww control	Spectrol	Series 530
RV405	1K	Lin. Preset cermet	Noble	VTP
RV406	25K	Lin. Preset cermet	Noble	VTP
RV407	5K	Log. Carbon c/w rev. switch	ERIE	510-S
RV408	5K	Lin. Preset cermet	Noble	VTP

CCT REF	DESCRIPTION		MFR or SUPPLY	PART NO
	POTENTIOMETERS (continued)			
RV451	10K	Lin. Preset cermet	Noble	VTP
RV452	10K	Lin. Preset cermet	Noble	VTP
RV453	10K	Lin. Carbon with p-p switch	BWD	VM13A014
RV454	500K	Log. Carbon with SPST switch	BWD	
RV455	10K	Lin. Preset cermet	Noble	VTP
RV456	10K	Lin. Preset cermet	Noble	VTP
RV501	5K	Lin. Carbon	Noble	VCU
RV502	1K	Lin. Preset cermet	Noble	VTP
RV503	1K	Lin. Preset cermet	Noble	VTP
RV504	500K	Lin. Preset cermet	Noble	VTP
RV505	3MO	Lin. Carbon	Noble	VCU
RV506	100K	Lin. Carbon	Noble	VCU
RV507	2K	Lin. Preset cermet	Noble	VTP
RV508	5K	Lin. Preset cermet	Noble	VTP
RV551	1K	Lin. Preset cermet	Noble	VTP
RV552	5K	Lin. Preset cermet	Noble	VTP
RV553	20K	Lin. Preset cermet	Noble	VTP
RV554	200K	Lin. Preset cermet	Noble	VTP
RV555	50Ω	WW c/w DPST rotary switch	BWD	
	MISCELLANEOUS			
T551	Power Transformer		BWD	090-137
T552	Converter Transformer		BWD	090-174-4
F1	.25A	Delayed		
	.5A	Delayed		
F2	2A	Delayed		
B551	6.3V	100mA L.E.S. Lamp		
B552	6.3V	100mA L.E.S. Lamp		
L101	22μH	Ferrite Cored Inductor	SEL	VPC 22
L102	22μH	Ferrite Cored Inductor	SEL	VPC 22
	ALL OTHER PARTS ORDER BY DESCRIPTION COMPLETE WITH MODEL NUMBER AND SERIAL NUMBER			

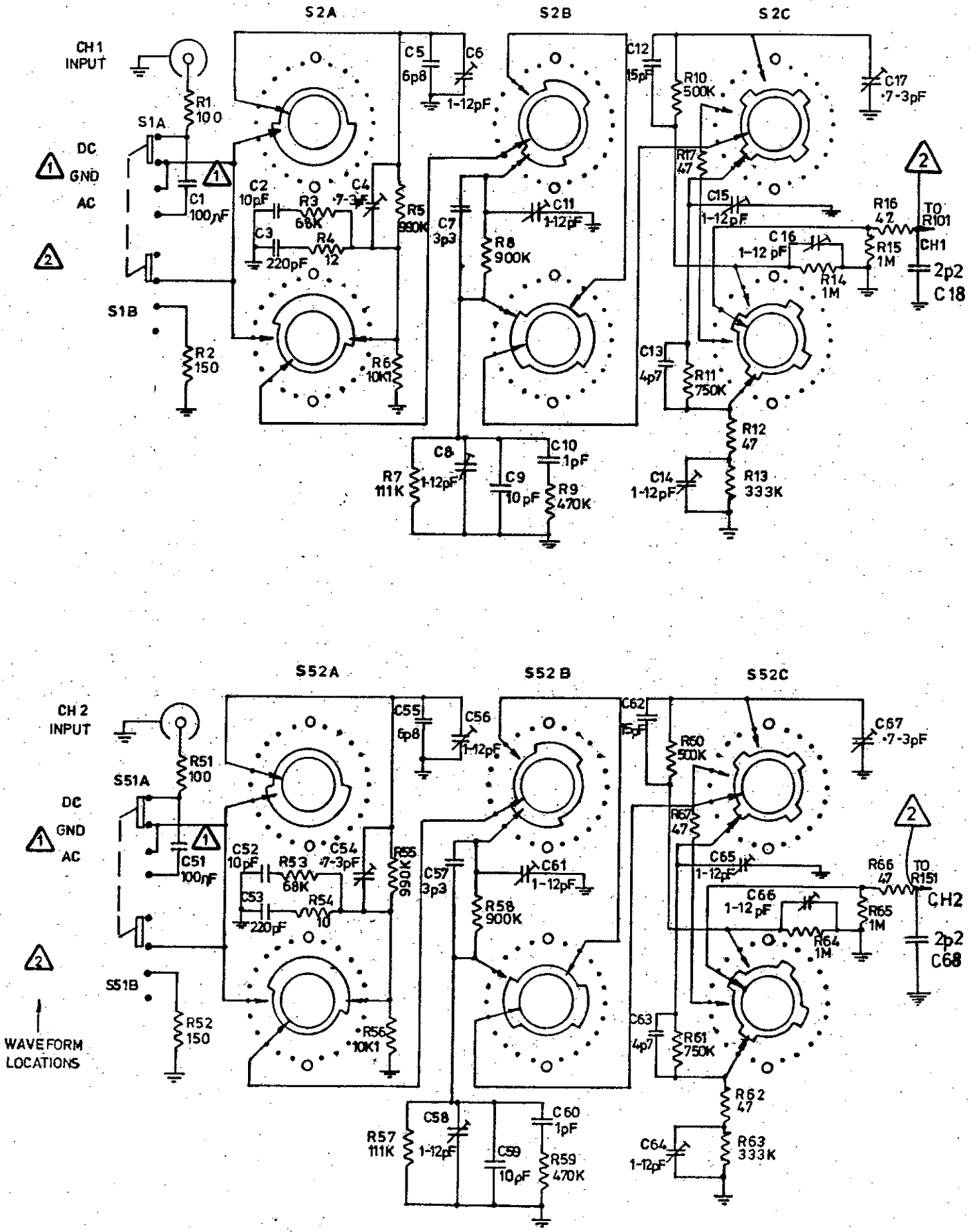
SWITCHES

S1A – B	CH1 AC-GND-DC SELECTOR
S2A – C	CH1 ATTENUATOR
S51A - B	CH2 AC-GND-DC SELECTOR
S52A-C	CH2 ATTENUATOR

WAVEFORMS



DRG No. 1400



2 0 / 5-81	DRAWN J B TRACED DEW CH'K'D DATE 20-7-77	BWD 845 ATTENUATORS	DRG. No. 1400

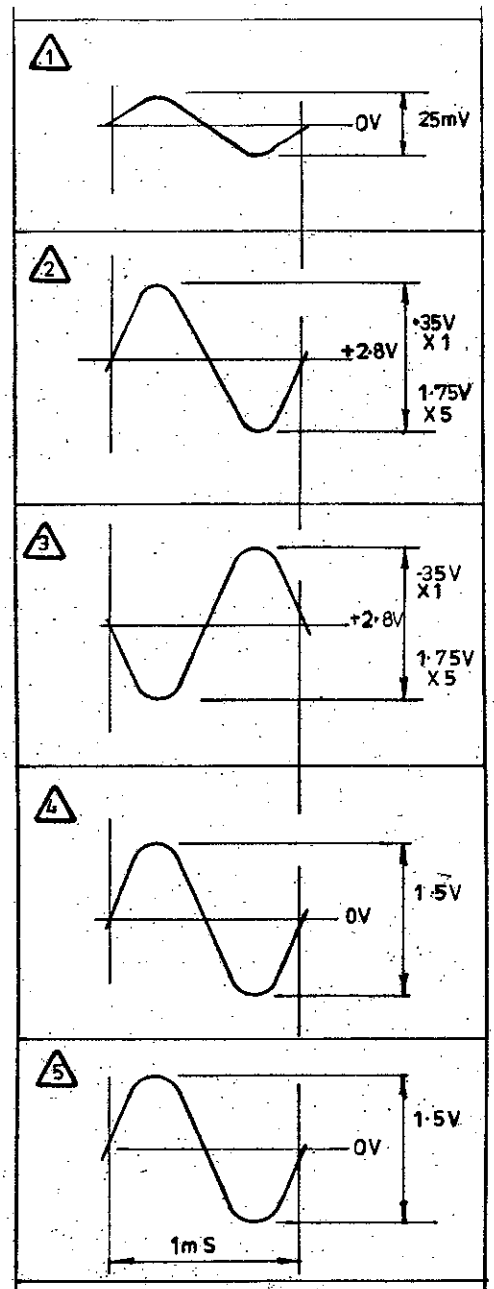
CONTROLS

RV101	CH1	DC BALANCE
RV102	"	VERNIER GAIN
RV103	"	CALIBRATE X1 GAIN
RV104	"	CALIBRATE X5 GAIN
RV105	"	DC BALANCE X5 GAIN
RV106	"	TRIGGER ZERO SET
RV107	"	VERTICAL POSITION

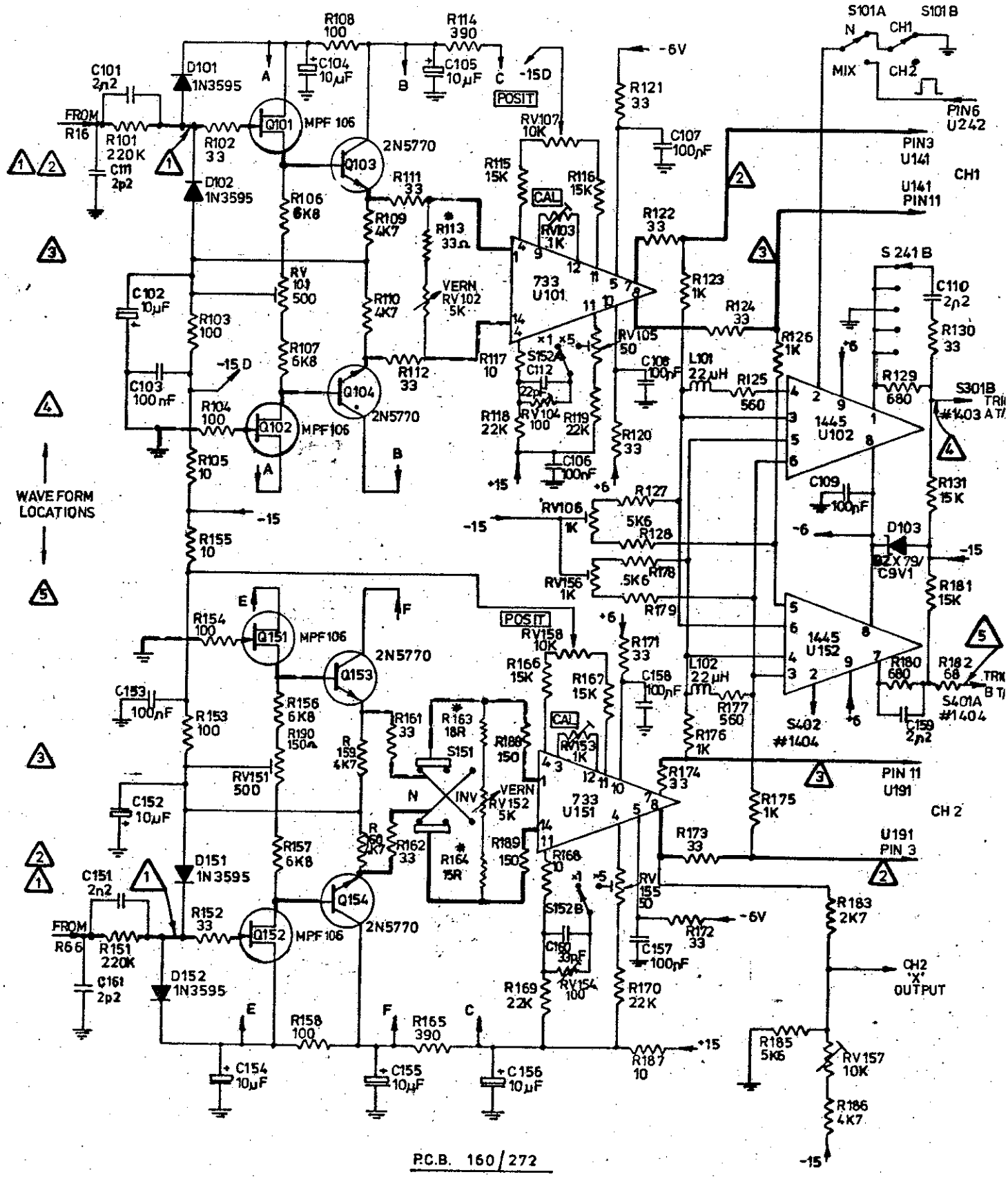
RV151	CH2	DC BALANCE
RV152	"	VERNIER GAIN
RV153	"	CALIBRATE X1 GAIN
RV154	"	CALIBRATE X5 GAIN
RV155	"	DC BALANCE X5 GAIN
RV156	"	TRIGGER ZERO SET
RV157	"	X-Y CENTREING
RV158	"	VERTICAL POSITION

SWITCHES

S101A&B	A TRIGGER SELECTOR
S151	CH2 NORM-INVERT
S152 A&B	CH1&CH2 X1-X5 GAIN
S241B	VERTICAL DISPLAY (PART OF)



DRG No 1401

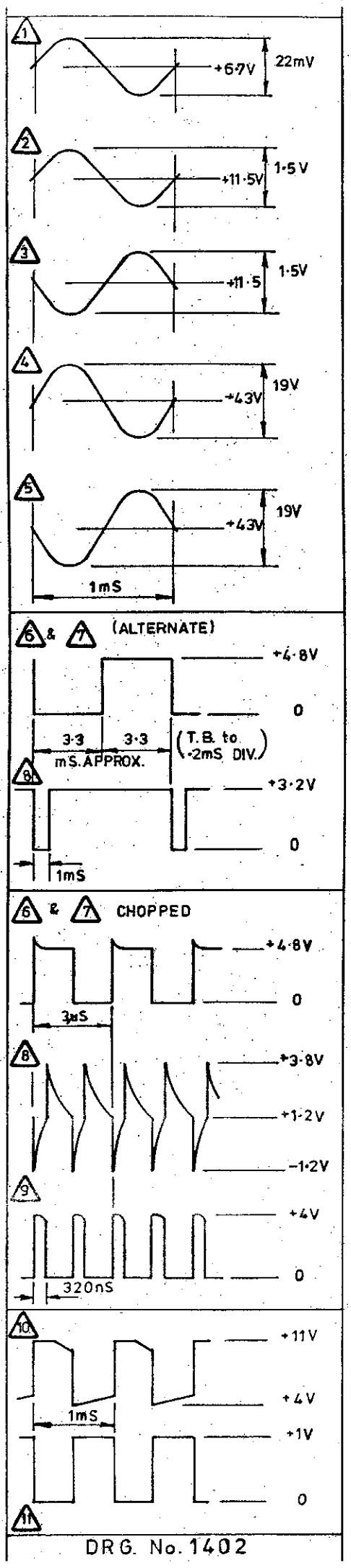

WAVE FORM LOCATIONS
P.C.B. 160/272
* COMPONENTS OPTIMIZED DURING TEST
BWD 845
VERT. INPUT AMPLIFIERS
DRG. No. 1401
DRAWN J.B
TRACED DEW
CH'K'D
DATE 21-7-77
20
5-81

CONTROLS

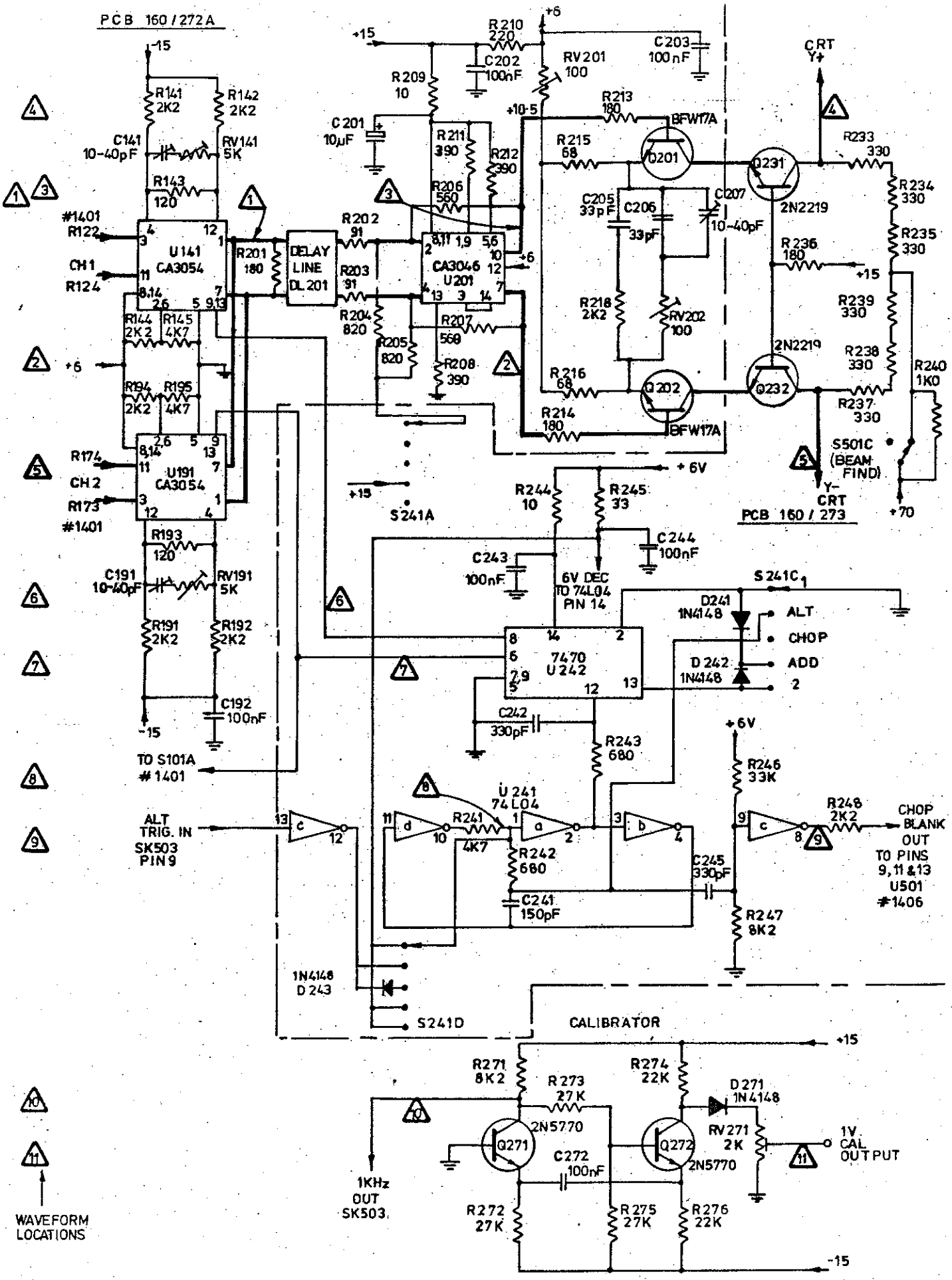
RV141	CH1	HF RESPONSE
RV191	CH2	HF RESPONSE
RV201	SET OUTPUT DC LEVEL	
RV202	HF RESPONSE	
RV271	SET 1V CALIBRATE WAVEFORM	

SWITCHES

S241A,C & D	VERTICAL DISPLAY
S501C	BEAM FIND



DRG. No. 1402



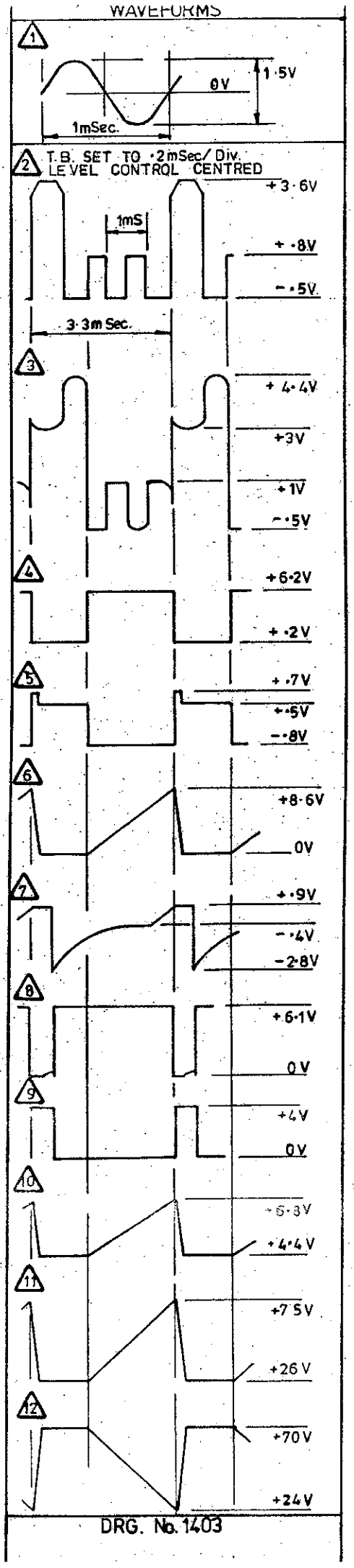
20 / 5-81	DRAWN J.B TRACED DEW CH'K'D DATE 25-7-77	BWD 845 VERT. OUTPUT & BEAM	DRG. No. 1402

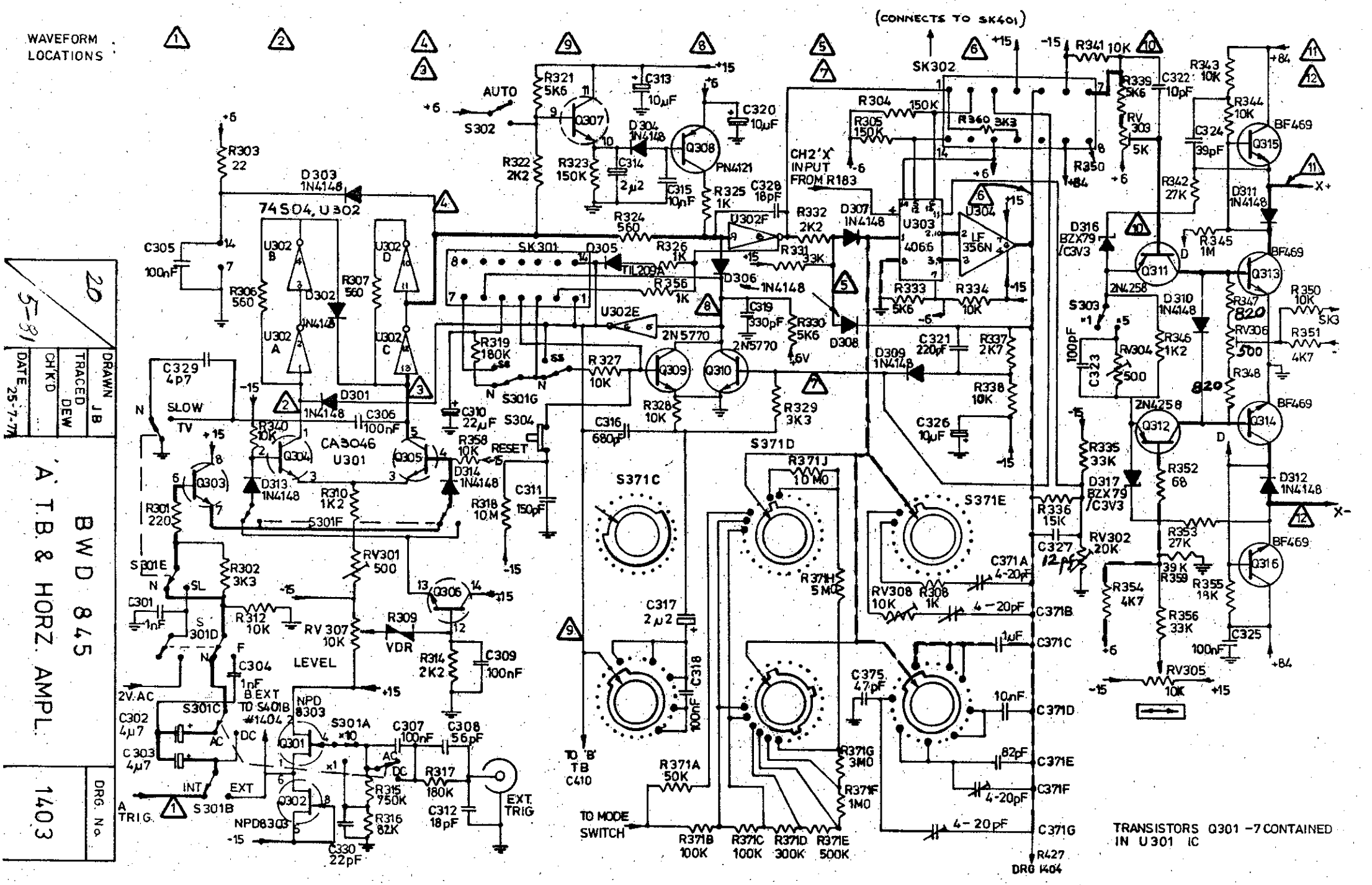
CONTROLS

RV 301	TRIGGER SENSITIVITY
RV 302	X-Y CALIBRATION
RV 303	X1 TRACE LENGTH
RV 304	X5 HORZ. MAGNIFICATION
RV 305	HORZ. POSITION
RV 306	X5 MAG. CENTREING
RV 307	A T.B. LEVEL SELECT

SWITCHES

S 301 A	X1 – X10 EXT. TRIG ATTEN.
S 301 B	INT-EXT TRIG.
S 301 C	AC-DC COUPLING
S 301 D	NORM-FAST COUPLING } BOTH ENGAGED
S 301 E	NORM-SLOW COUPLING } LINE FREQUENCY
S 301 F	± TRIGGER POLARITY
S 301 G	NORM.-SINGLE SWEEP
S302	AUTO-NON-AUTO (REAR RV 307)
S303	X1-X5 MAGNIFICATION (REAR RV 305)
S371A-D	A T.B. RANGE



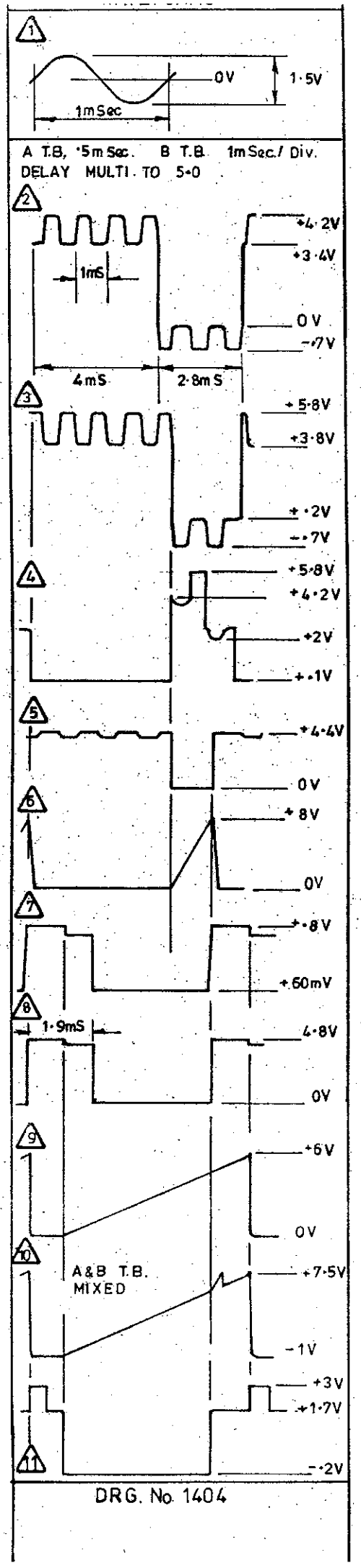

WAVEFORM LOCATIONS
(CONNECTS TO SK401)
SK302
AUTO
S302
+6
R303 22
D303 1N4148
74S04, U302
U302 B
U302 A
U302 C
U302 D
U302 E
U302 F
C305 100nF
R306 560
R307 560
D302 1N4148
R321 5K6
Q307
C313 10µF
D304 1N4148
Q308 PN4121
C320 10µF
R322 2K2
R323 150K
C314 2µ2
C315 10nF
R325 1K
C328 18pF
R324 560
SK301
Q305 TIL209A
R326 1K
R356 1K
D306 1N4148
R319 180K
C319 330pF
R330 5K6
2N5770
D308
R327 10K
Q309
Q310
R328 10K
R329 3K3
C316 680pF
C310 22µF
S304 RESET
R358 10K
C311 150pF
S301G
S301F
C329 4p7
SLOW
TV
D301 1N4148
C306 100nF
R340 10K
CA3046 U301
Q303
Q304
Q305
D313 1N4148
D314 1N4148
R310 1K2
R301 220
RV301 500
S301E
S301D
R302 3K3
R312 10K
RV307 10K
LEVEL
R309 VDR
Q306
R314 2K2
C309 100nF
C301 1nF
C304 1nF
2V.AC
S301C
C302 4µ7
C303 4µ7
AC
DC
INT
EXT
S301B
A TRIG.
B EXT TO S401B #1404
NPD 8303
Q301
Q302
S301A ×10 ×1
C307 100nF
C308 56pF
R315 750K
R316 82K
R317 180K
C312 18pF
EXT. TRIG
C330 22pF
S371C
S371D
S371E
R371J 10 MΩ
R371H 5 MΩ
C317 2µ2
C318 100nF
R371A 50K
R371G 3MΩ
R371F 1MΩ
R371B 100K
R371C 100K
R371D 300K
R371E 500K
TO MODE SWITCH
TO 'B' TB C410
C371A 4-20pF
C371B 4-20pF
C371C 1µF
C371D 10nF
C371E 82pF
C371F 4-20pF
C371G 4-20pF
C375 47pF
R427
DRG 1404
CH2 'X' INPUT FROM R183
R304 150K
R305 150K
R360 3K3
R350 484
R341 10K
R339 5K6
RV303 5K
C322 10pF
C324 39pF
R342 27K
R343 10K
R344 10K
R345 1M
D316 BZX79/C3V3
D317 BZX79/C3V3
D310 1N4148
D311 1N4148
D312 1N4148
Q311 2N4258
Q312 2N4258
Q313 BF469
Q314 BF469
Q315 BF469
Q316 BF469
S303
R346 1K2
RV304 500
C323 100pF
R347 820
RV306 500
R348 820
R350 10K
R351 4K7
5K3
R335 33K
R336 15K
C327 12pF
RV302 20K
R352 68
R353 27K
R354 4K7
R355 18K
R356 33K
R359 39K
C325 100nF
RV305 10K
R331 33K
R332 2K2
R333 5K6
R334 10K
U303 4066
U304 LF 356N
R338 10K
C321 220pF
R337 2K7
C326 10µF
D309 1N4148
X+
X-
+84
-15
+15
TRANSISTORS Q301 -7 CONTAINED IN U301 IC
20
5-31
DRAWN JB
DATE 25-7-77
CHK'D
TRACED DEW
A.T.B. & HORZ. AMPL.
BWD 845
DRG. No. 1403

CONTROLS

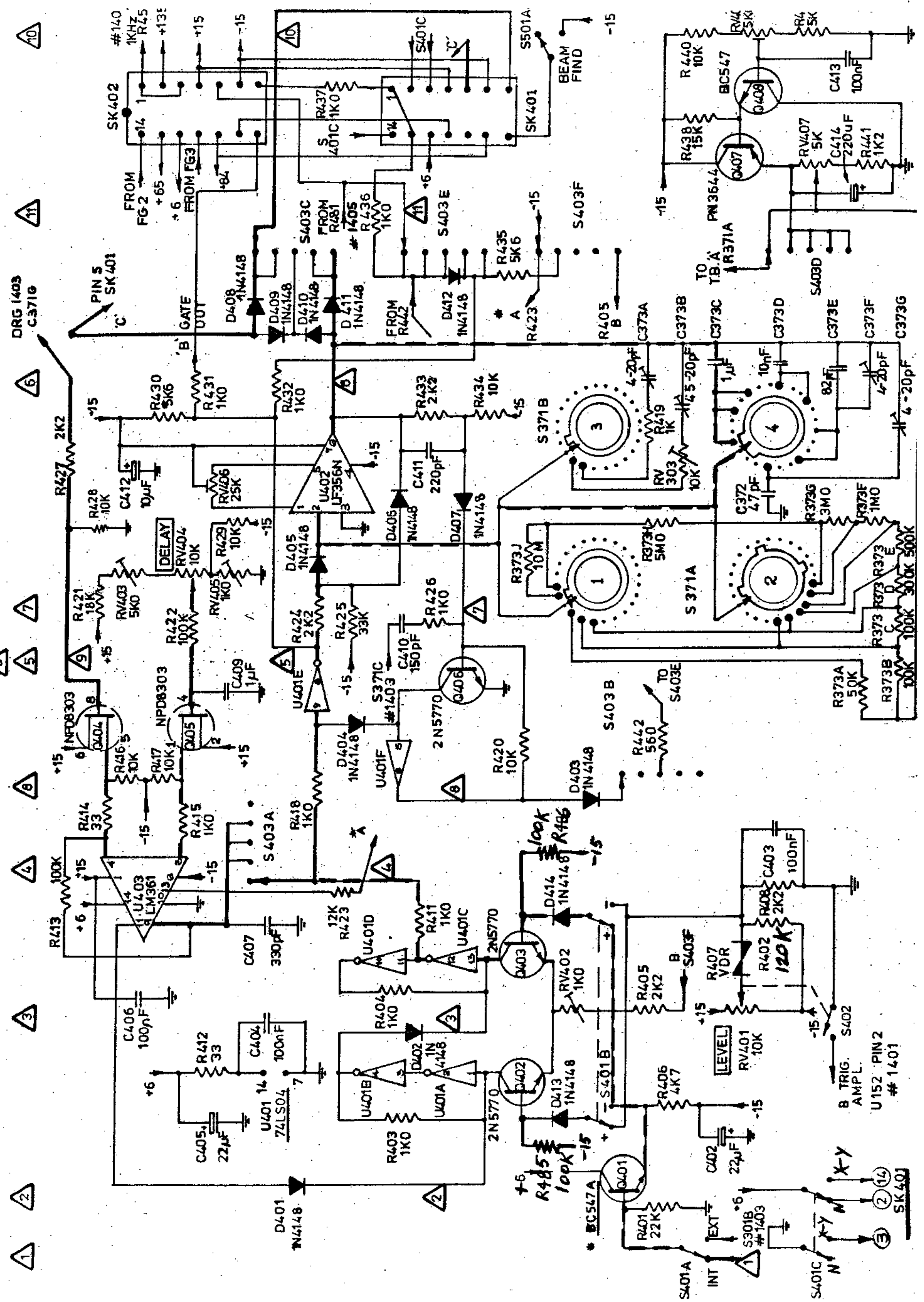
RV401	'B' TRIGGER LEVEL
RV402	TRIGGER SENSITIVITY
RV403	SET MAX. DELAY
RV404	DELAY MULTI.
RV405	SET MIN. DELAY
RV406	'B' T.B. CALIBRATE
RV407	T. B. VERNIER
RV408	'A' T.B CALIBRATE

SWITCHES

S401A	INT - EXT TRIGGER
S401B	TRIGGER POLARITY
S401C	T.B/X-Y SELECTOR
S402	CH1 OR CH2 TRIGGER (REAR RV 401)
S403A-D	HORZ. MODE
S371A&B	'B' T.B RANGE



DRG. No. 1404



DRAWN JB TRACED DEW CHECKED DATE	BWD 845 'B' T.B. & COMPARATOR	DRG. No. 1404

CONTROLS

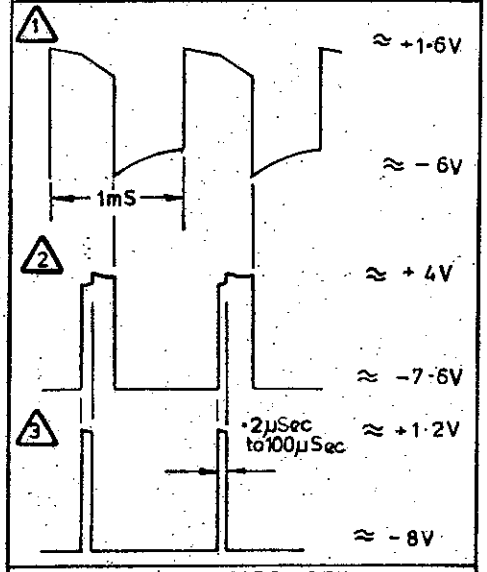
RV451	BACKING ELECTRODE (SLOW)
RV452	BACKING ELECTRODE (FAST)
RV453	BACKGROUND CONTROL
RV454	VARIABLE PERSISTENCE
RV455	FLOOD GUN 3 ADJUST (FAST)
RV456	FLOOD GUN 3 ADJUST (SLOW)

SWITCHES

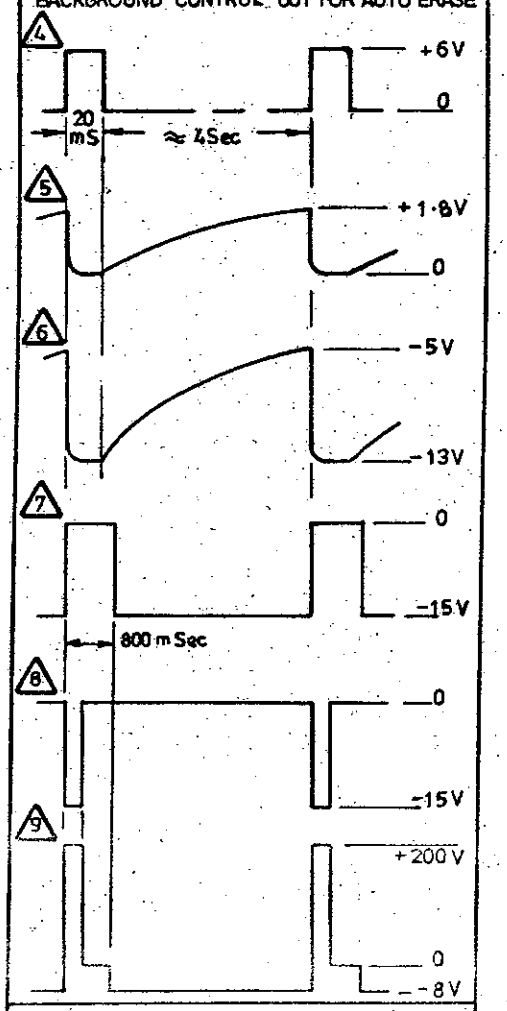
S401D	ERASE
S401E	STORE (NON-VIEWING) } BOTH IN VIEW
S401F	WRITE } BOTH IN VIEW
S401G	FAST / SLOW WRITING
S451	VAR. PERSISTENCE ON/OFF (REAR RV454)
S452	AUTO ERASE OR STORE (REAR RV453)

WAVE FORMS

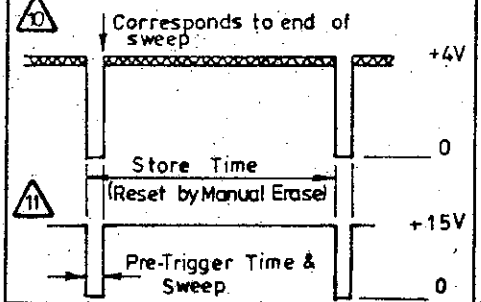
INPUT 100Hz. T.B. 2mS. SINEWAVE
VARIABLE PERSISTENCE SET FOR A CONTINUOUS DISPLAY.



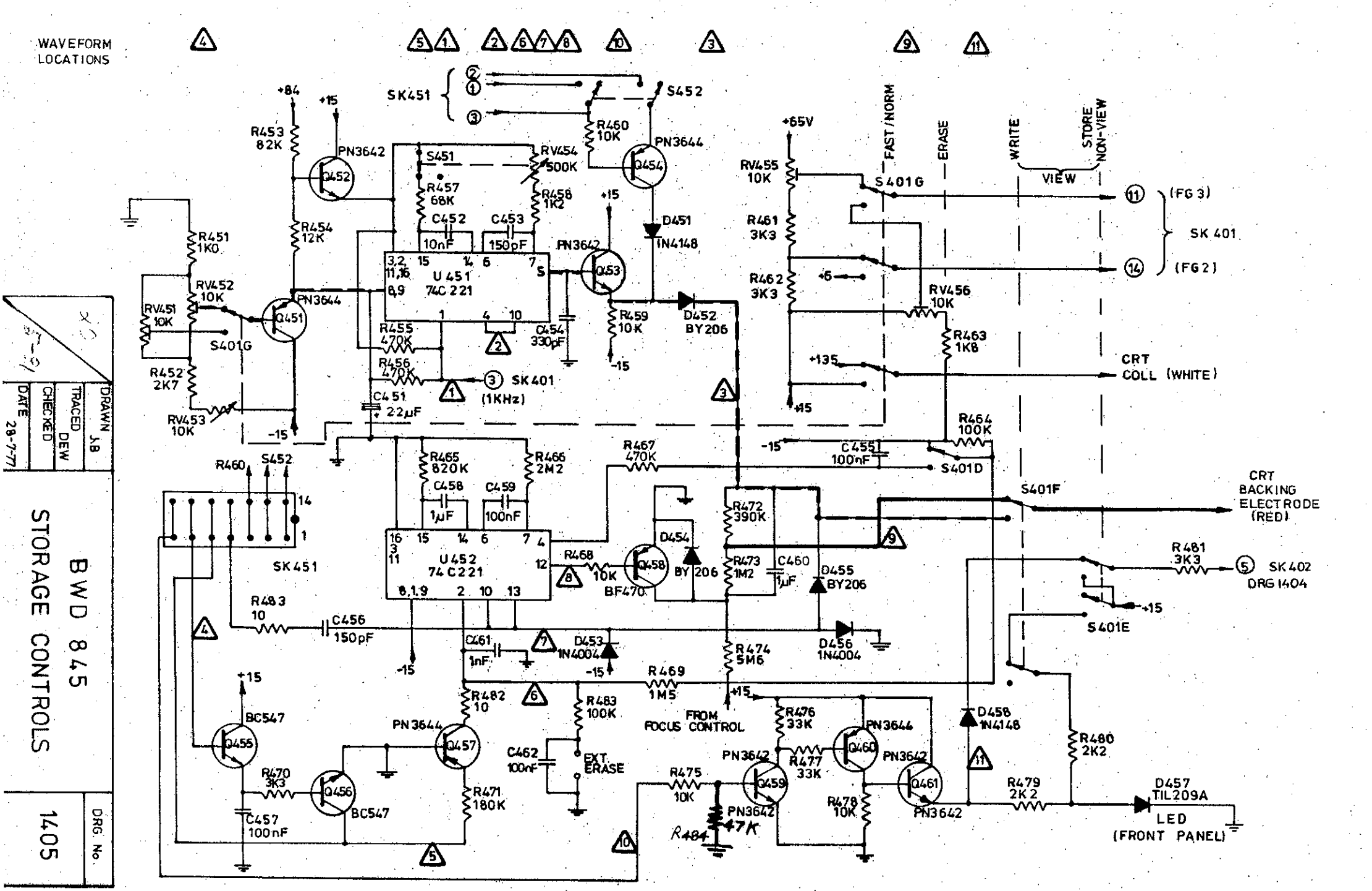
T.B. 2m Sec. VAR. PERS. OFF
BACKGROUND CONTROL OUT FOR AUTO ERASE



AS FOR 4 - 9 BUT SS BUTTON ENGAGED FOR AUTO STORE



DRG. No. 1405

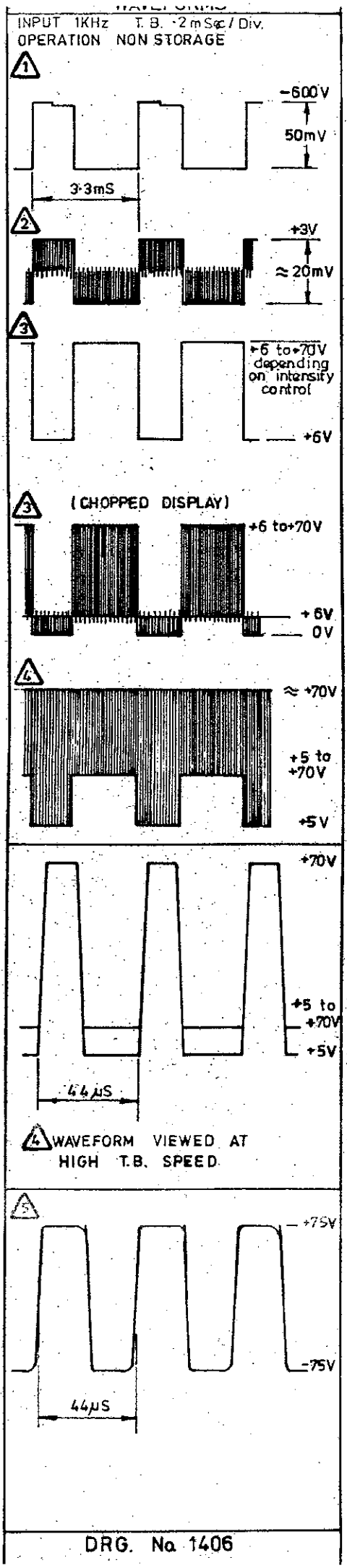

WAVEFORM LOCATIONS
SK451
S452
S451
R460 10K
PN3644
Q454
RV454 500K
R457 68K
R458 1K2
C452 10nF
C453 150pF
D451 1N4148
R453 82K
PN3642
Q452
R454 12K
R451 1K0
RV452 10K
RV451 10K
PN3644
Q451
S401G
R452 2K7
RV453 10K
U451 74C221
PN3642
Q53
R455 470K
R456 470K
C451 22µF
C454 330pF
R459 10K
D452 BY206
SK401 (1KHz)
+84
+15
-15
+65V
FAST/NORM
ERASE
WRITE
STORE NON-VIEW
VIEW
RV455 10K
R461 3K3
R462 3K3
S401G
SK401
(FG3)
(FG2)
+6
+135
+15
RV456 10K
R463 1K8
CRT COLL (WHITE)
R464 100K
C455 100nF
S401D
S401F
CRT BACKING ELECTRODE (RED)
R460
S452
SK451
R465 820K
R466 2M2
C458 1µF
C459 100nF
U452 74C221
R467 470K
R468 10K
Q458 BF470
D454 BY206
R472 390K
R473 1M2
C460 1µF
D455 BY206
R481 3K3
SK402 DRG1404
S401E
R483 10
C456 150pF
C461 1nF
D453 1N4004
D456 1N4004
R474 5M6
R469 1M5
FROM FOCUS CONTROL
R482 10
R483 100K
C462 100nF
EXT. ERASE
BC547
Q455
R470 3K3
C457 100nF
Q456 BC547
PN3644
Q457
R471 180K
R476 33K
R477 33K
PN3644
Q460
PN3642
Q459
R475 10K
R484 47K
PN3642
R478 10K
Q461
PN3642
D458 1N4148
R480 2K2
R479 2K2
D457 TIL209A
LED (FRONT PANEL)
BWD 845
STORAGE CONTROLS
1405
DRG. No
DRAWN JB
TRACED DEW
CHECKED
DATE 28-7-77

CONTROLS

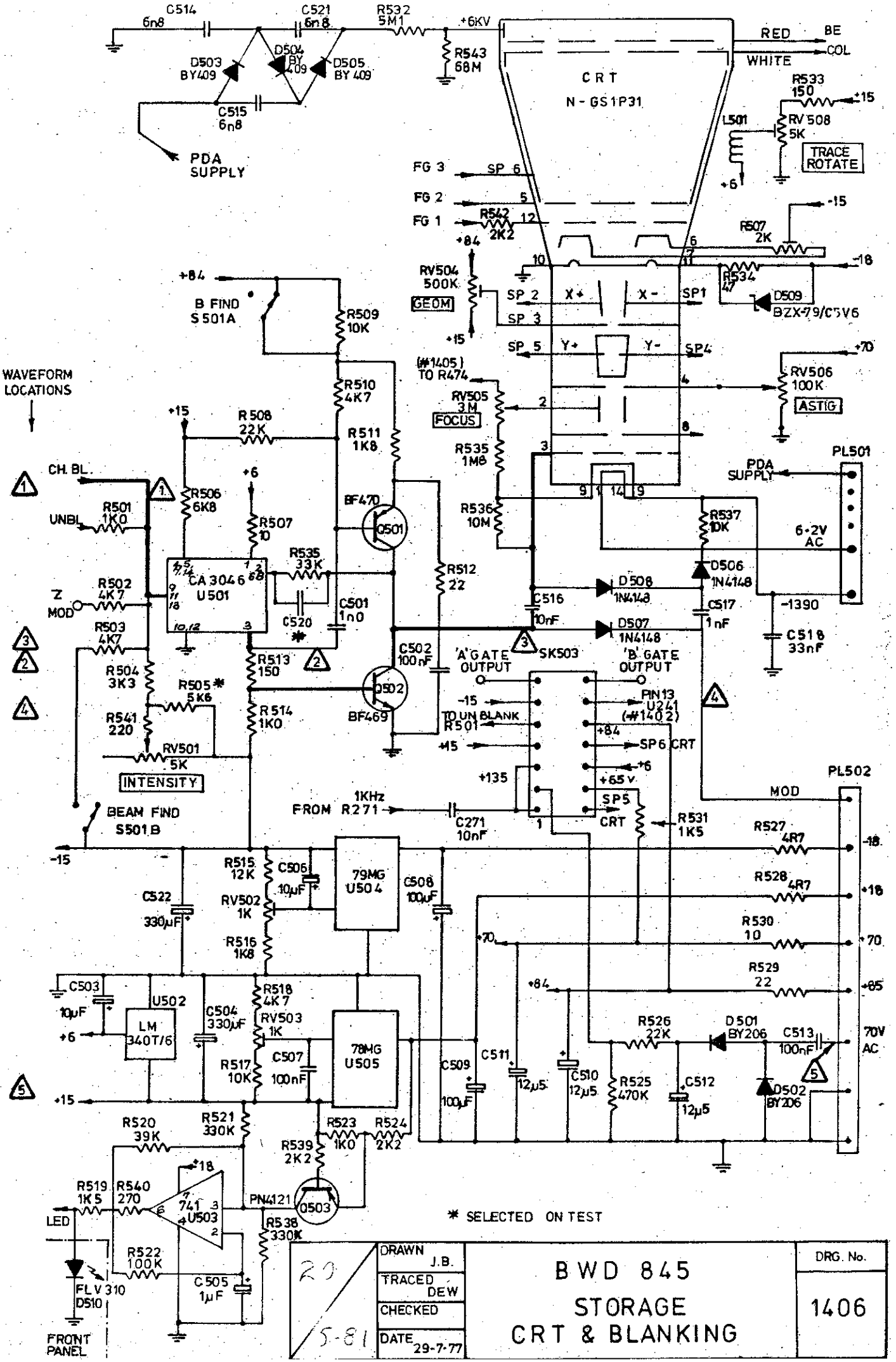
RV501	INTENSITY
RV502	SET -15V
RV503	SET +15V
RV504	CRT GEOMETRY
RV505	CRT FOCUS
RV506	CRT ASTIGMATISM
RV507	FLOODGUN BALANCE
RV508	TRACE ROTATION

SWITCHES

S501A& B BEAM FIND



DRG. No. 1406


C514 6n8
C521 6n8
R532 5M1
+6KV
D503 BY409
D504 BY 409
D505 BY 409
C515 6n8
R543 68M
PDA SUPPLY
CRT N-GS1P31
RED BE
WHITE COL
R533 150
+15
RV508 5K
L501
TRACE ROTATE
+6
FG 3
FG 2
FG 1
SP 6
5
12
R542 2K2
-15
R507 2K
+84
6
7
10
11
-18
RV504 500K
GEOM
R534 47
D509 BZX-79/C5V6
SP 2
X+
X-
SP1
SP 3
+15
SP 5
Y+
Y-
SP4
+70
(#1405) TO R474
RV506 100K
ASTIG
RV505 3M
FOCUS
4
2
8
3
R535 1M8
PL501
PDA SUPPLY
9
1
14
9
R536 10M
R537 10K
6·2V AC
D506 1N4148
D508 1N4148
C516 10nF
C517 1nF
-1390
C518 33nF
D507 1N4148
SK503
'A' GATE OUTPUT
'B' GATE OUTPUT
PIN13 U241 (#1402)
TO UNBLANK R501
SP6 CRT
+65 v.
SP5 CRT
R531 1K5
PL502
MOD
R527 4R7
-18
R528 4R7
+18
R530 10
+70
R529 22
+65
R526 22K
D501 BY206
C513 100nF
70V AC
D502 BY206
C511 12µ5
C510 12µ5
R525 470K
C512 12µ5
C509 100µF
C508 100µF
79MG U504
78MG U505
C506 10µF
R515 12K
RV502 1K
R516 1K8
C522 330µF
C503 10µF
U502
LM 340T/6
C504 330µF
R518 4K7
RV503 1K
R517 10K
C507 100nF
R520 39K
R521 330K
R523
R524 2K2
R539 2K2
1K0
+18
R519 1K5
R540 270
741 U503
PN4121
Q503
R538 330K
LED
R522 100K
C505 1µF
FLV 310 D510
FRONT PANEL
WAVEFORM LOCATIONS
CH. BL.
UNBL
R501 1K0
R506 6K8
+6
R507 10
R508 22K
+15
R509 10K
B FIND S501A
+84
R510 4K7
R511 1K8
BF470
Q501
R512 22
R535 33K
CA 3046 U501
C520 *
C501 1n0
Z MOD
R502 4K7
R503 4K7
R504 3K3
R505 * 5K6
R541 220
RV501 5K
INTENSITY
BEAM FIND S501.B
R513 150
R514 1K0
C502 100nF
Q502
BF469
1KHz FROM R271
C271 10nF
* SELECTED ON TEST
20
5-81
DRAWN J.B.
TRACED DEW
CHECKED
DATE 29-7-77
BWD 845
STORAGE
CRT & BLANKING
DRG. No.
1406

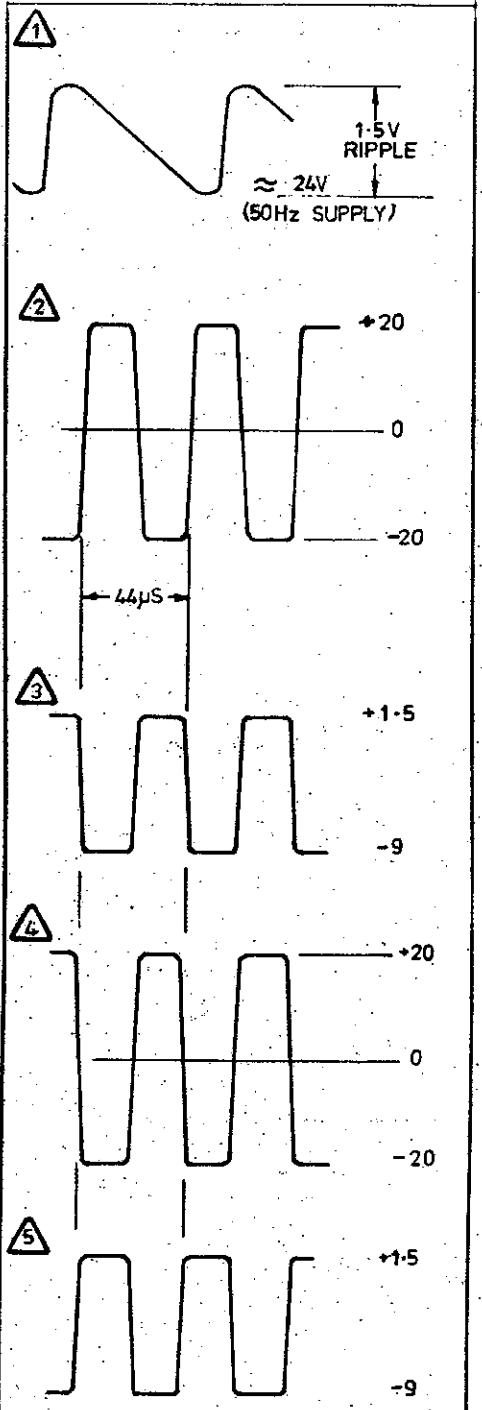
CONTROLS

RV551	SET OUTPUT VOLTAGE
RV552	SET CHARGE VOLTAGE
RV553	SET INTENSITY RANGE
RV554	SET EHT REGULATOR
RV555	GRATICULE LIGHTS

SWITCHES

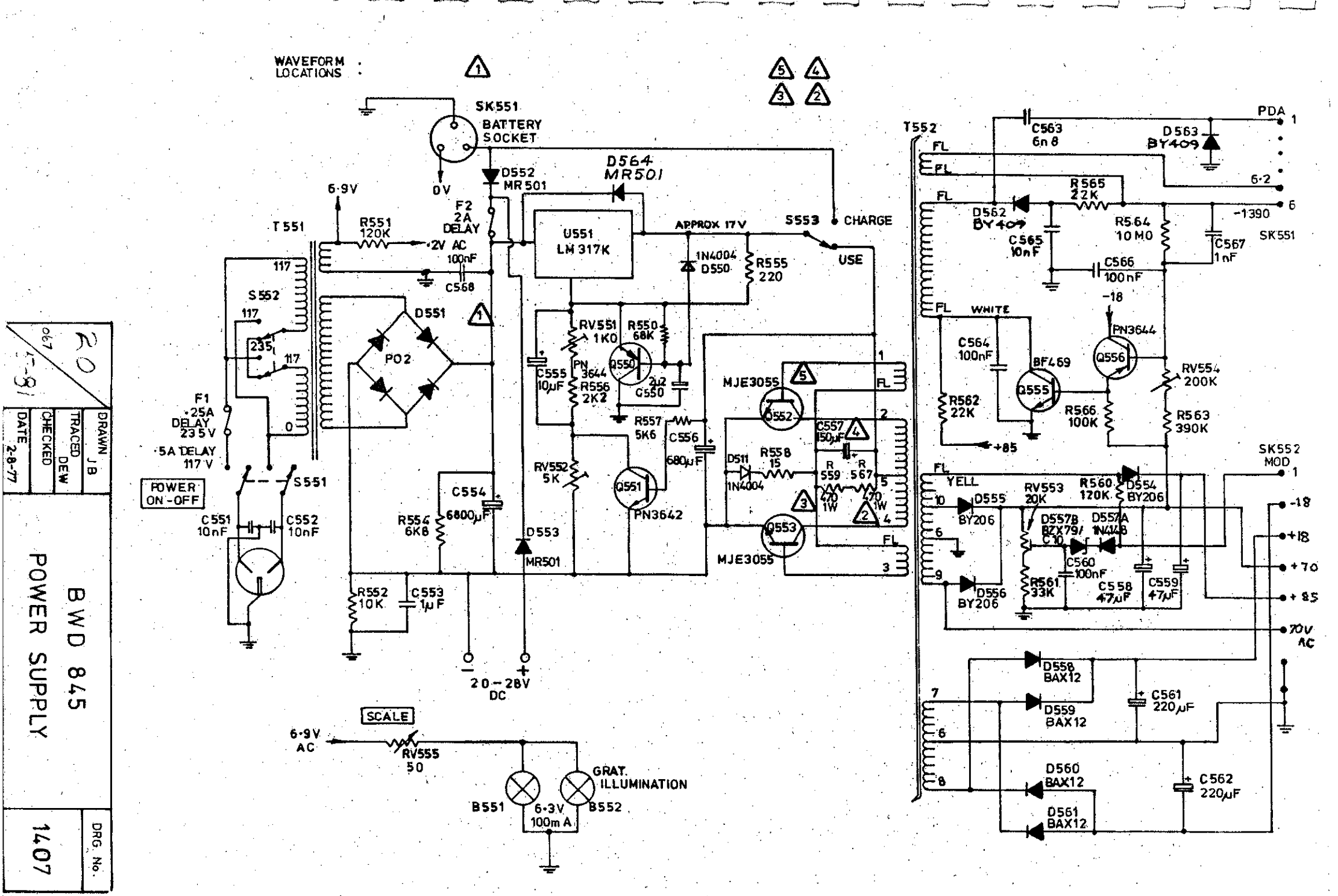
S551	AC POWER ON-OFF (REAR RV555)
S552	117 - 235 CHANGE OVER
S553	USE — CHARGE

WAVEFORMS



ALL SECONDARY WAVEFORMS OF T552 ARE IDENTICAL TO 2 OR 3 BUT OF DIFFERING AMPLITUDES.

DRG. No. 1407



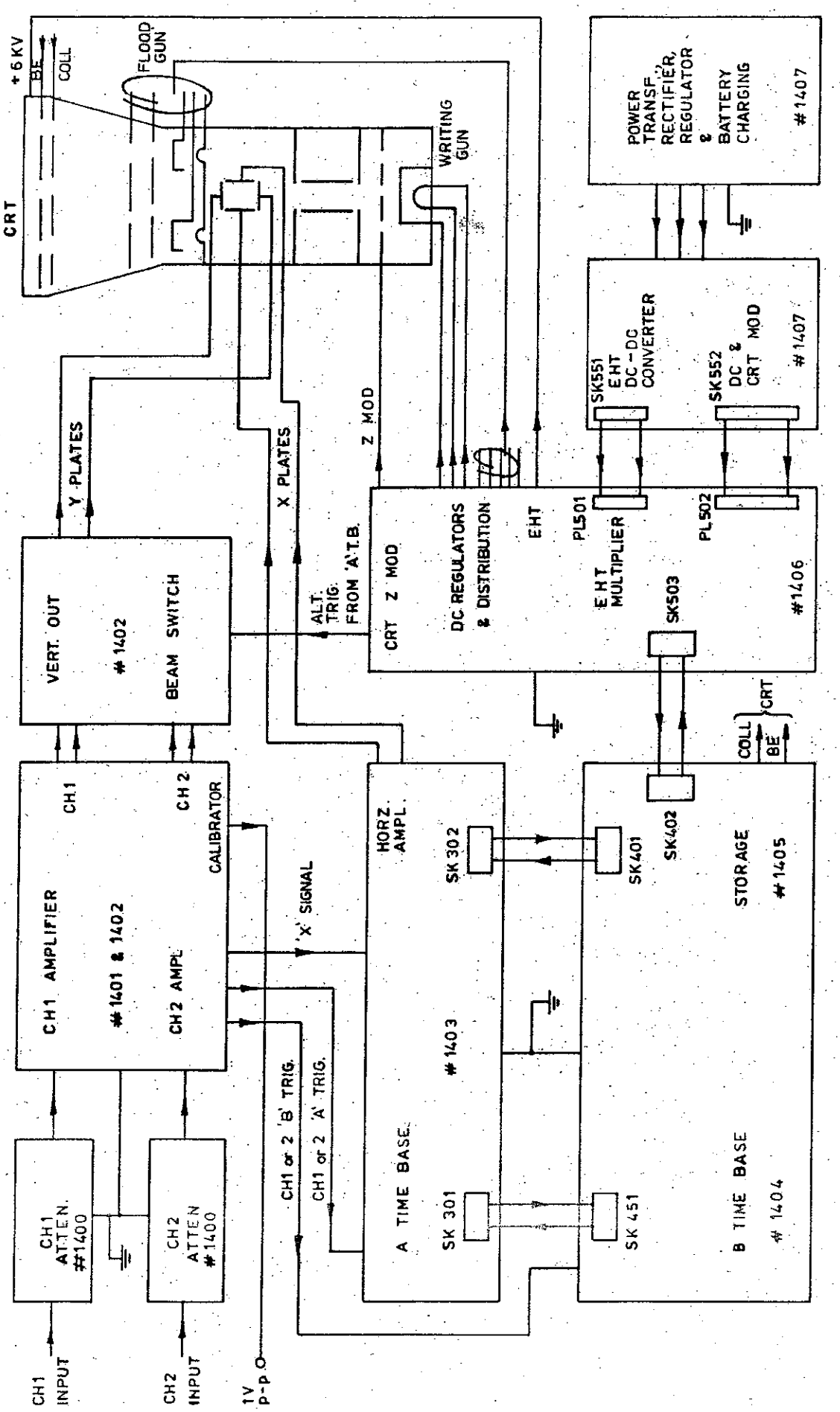
DRAWN J B	DRG. No.	
TRACED DEW		
CHECKED		
DATE 2-8-77		

BWD 845

POWER SUPPLY

1407

20 067 5-91



20 / 5-81	DRAWN J.B.	BWD 845 INTERCONNECTION LAYOUT	DRG. No. 1408
	TRACED DEW		
	CHECKED		
	DATE 18-9-77		

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MANUAL CHANGE INFORMATION FOR MODEL BWD 845

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
38950	3	23.2.'78			
40207	4	27.6.'78			
Applicable to all issues	5	11.7.'78			
40231 (incl.)	6	15.8.'78			

Issue	Sect.	Page	Cct.	AMENDMENT
3	12	19	1401	Q101, Q102 Matched pair NPD8303 changed to MPF106
	12	19	1401	Q151, Q152 Matched pair NPD8303 changed to MPF106
3	12	6	1402	R217 18K changed to 12K
	"	"	"	R218 2K7 changed to 1K8
	"	"	"	R232 1K Added across L232
	12	13	1402	C205 68pF changed to 47pF
	12	19	1402	Q201, Q202 Matched pair 2N5770 changed to BFW17A
3	12	11	1406	R541 220Ω Added in wiper of RV501 at junction of R504 and R505
3	12	11	1406	R542 2K2 Added from FG1 to pin 12 of CRT
4	12	7	1403	R317 100K changed to 180K
4	12	8	1403	R340 100K Added from base of Q304 to -15V
4	12	14	1403	C330 22pF Added from junction of R315 and R316 to Gnd.
4	12	11	1406	R543 68MΩ Added from R532 to Gnd.
5	12	12	1400	C12, C62 10pF changed to 15pF.
5	12	12	1400	C15, C16, C65, C66 .7-3pF changed to 1-12pF.
6			1407	Extension winding from T551 removed. S553A removed. S553B changed to S553.
6	8	17		Sect. 8.33 (para 1) was "...One secondary winding supplies bridge rectifier D551, another is in series with the rectifier supply to provide a boost voltage for battery changing and a third supplies the graticule lights and via R551 a 2V supply for the Main Time Base line trigger.
6	8	18		Sect. 8.35 (para 3) was "If S553 is switched to CHARGE an additional 6.3V AC winding is switched in series with the main secondary winding. Section S553B....."

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MANUAL CHANGE INFORMATION FOR MODEL BWD 845

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
Applicable to all					
issues	7	15.9.78			
41300	8	30.1.79			

Issue	Sect.	Page	Cct.	AMENDMENT
7	12	11	1406	R535 1M changed to 1M8.
7	6	3		Para. 6.7 Added as below.

6.7 Long Term Storage

Two conditions are available to increase the time a stored trace is retained.

Storage up to several hours can be obtained with the instrument still switched on by the following procedure.

With the required trace stored, release the WRITE button and depress the blue SLOW button. If the BACKGROUND control has been advanced return the control to its counter clockwise position.

To view the trace when required depress the WRITE button and increase the BACKGROUND control if necessary to obtain a trace. The contrast ratio between background and stored trace will depend on the elapsed time of storage and the original contrast ratio.

Longer periods of stored display retention can be achieved by switching the oscilloscope off after the trace is obtained by the following procedure.

With the required trace stored, release the WRITE button and depress the blue SLOW button. If the background control has been advanced return the control to its counter clockwise position. Disconnect all power sources from the instrument. Trace can be retained in its stored condition up to 7 days.

To view the trace, leave all controls as they were when instrument was switched off. Apply power, switch on and depress WRITE button. Trace should appear within 30 seconds. If level is too low increase BACKGROUND control to obtain best contrast.

8	2	1		Para. 2.5 Sweep Rate: "...Max. sweep speed is 20µSec/div..." changed to "...20nSec/div. ..."
8	3	0		"WARNING! This control must be kept at min. level to prevent screen burns" added.

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MANUAL CHANGE INFORMATION FOR MODEL BWD 845

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
41300	8	30.1.79			
41259	9	12.2.79			
Applicable to all issues	10	6.3.79			
42850	11	3.4.79			

Issue	Sect.	Page	Cct.	AMENDMENT
8	3	5		Para 3.12 now reads "Intensity: Adjusts the trace intensity. Keep at min. level to prevent CRT screen burns." "Beam Find: Push button reduces X and Y deflection to within screen limits and over-rides intensity setting to bring display within limits of CRT. Do not hold in or CRT screen may be burnt."
8	5	6E		"WARNING: CRT Intensity should be left at the lowest practical level to minimise possibility of storage mesh-burns under all conditions of operation." Added to both pages.
8	6	3E		
9	12	16	1407	C568 100nF Added
10	12	12	1400	C9, C59 15pF changed to 10pF
11	2	0		Section 2.1 para added: "Erase External: Rear panel sockets, short together to erase. Erase time 800mSec independent of closure time."
11	3	6E		Section 3.13 para added: "External Erase Sockets: Two 4mm sockets when shorted together, operate the erase function."
11	6	3E		New Section 6.7 "External Erase" inserted. Previous 6.7 "Long Term Storage" now becomes 6.8.
11	12	8	1404	R402 10kΩ removed, was from ⏚ to lower end of RV401 R402 33kΩ added from junction of R407 and R408 to -15V. RV401 lower end of track taken to -15V
11	12	10	1405	Ext-erase sockets added. Lower end to ⏚, upper via R483 to point 6.
11	12	10	1405	R483 100K added.
11	12	15	1405	C462 100n added across ext-erase sockets.
11			1407	D557B BZY88/C10 added in series with D557A.
11	12	9	1405	R458 2K2 changed to 1K2
11	12	24E	1401	L101 22μH added in series with R125
11	12	24E	1401	L102 22μH added in series with R177
11	12	7	1403	R308 2K2 removed. Was from junction of C429/C306 to junction of C304/S301D
11	12	8	1403	R340 100K changed to 10K
11	12	8	1403	R358 10K added from pin 4 U301
11	12	9	1404	R429 10K removed. Was from +5V to junction of RV404/RV405
11	12	14	1403	C327 1pF removed. Was in parallel with R353

BWD INSTRUMENTS PTY. LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 845

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
42850	11	3.4.79			
42860	12	5.10.79			
44000	13	8.11.79			

Issue	Sect.	Page	Cct.	AMENDMENT
11	12	15	1403	C374 2n2 added parallel with R305
11	12	15	1403	C375 47pF added from junction of C371G and S371E
11	12	17	1403	D315 IN4148 added in series with D307
11	12	11	1406	R533 1K changed to 150Ω
11	12	11	1407	R559 470Ω becomes R559A 270Ω and R559B 220Ω
11	12	18	1407	D557B BZY88/C10 changed to BZX79/C10
11	12	7	1403	R314 1K changed to 2K2
11	12	7	1403	R311 4K7 removed. Was from -15V to emitter Q303 (Pin 7 U301)
11	12	7	1403	R313 10K removed. Was from -15V to emitter Q306 (Pin 13 U301)
11	12	11	1407	R556 changed from 2K7 to 2K2 R560 changed from 220K to 120K
11	12	13	1402	C205 changed from 47pF to 33pF
11	12	16	1407	C557 100µF 25V changed to 47µF 40V
11			1404	Circuit error. Output from U403 to S403A should be from pin 9.
11	12	21	1407	U551 LM317T changed to LM317K
12	12	7	1403	R308 1K Added in series with C371A
12	12	8	1403	R345 270K changed to 1MΩ
12	12	8	1403	R349 15K Removed. Was from emitter Q315 to -15V
12	12	14	1403	C327 5p6 Added in parallel with R336
12	12	14	1403	C322 10pF changed to 12pF, disconnected from junction of R339 and RV303 and taken to base of Q311
12	12	14	1403	C323 68pF changed to 100pF
12	12	15	1403	C374 2n2 removed. Was parallel with R305
12	12	17	1403	D315 IN4148 removed. Was in series with D307
12	12	17	1403	D316 BZX79/C3V3 added in series with R342
12	12	17	1403	D317 BZX79/C3V3 added in series with R353
12	12	9	1404	R429 10K Added from junction of RV404 and RV405 to -15V
12	12	9	1404	R419 1K Added in series with C373A
12	12	15	1404	C372 47pF Added from junction of C373G to S371B
12			1407	Drawing error. Line from base Q553 to emitter Q551 removed
13	12	13	1402	C204 330pF changed to 220pF
13	12	16	1407	C554 was 4700µF 35V ELEC ELNA TYPE RG
13	12	16	1407	C557 was 47µF 40V ELEC PH 2222-016-16101

BWD INSTRUMENTS PTY. LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 845

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
44000	13	8.11.79			
45479	14	3.4.80			

Issue	Sect.	Page	Cct.	AMENDMENT
13	12	14	1403	C321 Changed from 150pF to 220pF
13	12	7	1403	R338 Changed from 6K8 to 10K
13	12	8	1403	R354 Changed from 3K9 to 4K7
13	-	-	1403	R357 to wiper RV305 mis-numbered should be R356. 33K
13	12	8	1403	R359 added 39K
13	12	9	1404	R427 Changed from 4K7 to 10Ω
13	12	9	1404	R428 10K Removed was from gate of Q404 to ⏚
13	12	9	1404	R438 Changed from 6K8 to 10K
13	12	9	1404	R440 Changed from 3K9 to 10K
13	12	9	1404	R441 Changed from 1K5 to 1K2
13	12	15	1404	C411 Changed from 100pF to 220pF
13	12	8	-	R356 Should be 33K Parts list error
13	12	8	-	Delete R357 Parts list error
13	12	16	1407	C569 10nF 100V added in parallel with R552
14	12	19	1401	Q101-102 Changed from 2x MPF106 (matched) to 1x NPD8303CN
14	12	19	1401	Q151-152 Changed from 2x MPF106 (matched) to 1x NPD8303CN
14	12	6	1402	R217 Removed. 12K was in series with C204 from emitter Q201 to emitter Q202.
14	12	13	1402	C204 Removed 220pF 400V PYS was in series with R217 from emitter Q202 to emitter Q201.
14	12	6	1402	R218 Changed from 1K8 to 3K3.
14	12	6	1402	R202 Changed from 75Ω to 82Ω.
14	12	6	1402	R203 Changed from 75Ω to 82Ω.
14	12	15	1405	C461 Changed from 820pF PYS to 1nF CDS.
14	12	11	1406	(R529 and R530 reversed on circuit diagram (R530 10Ω connected to +70V (R529 22Ω connected to +85V
14	-	-	-	PRINTED CIRCUIT BOARD 160/271C. C509 appears twice on legend. The one nearest the rear of the instrument is correct. The other one should be designated C522.
14			1406	The following circuit designations are to be changed as follows: C504 C552 C509 C504 C520 C509

BWD INSTRUMENTS PTY. LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 845

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
45479 *	14	3.4.80			
46000	15	8.5.80			
45479	16	7.7.80			

Issue	Sect.	Page	Cct.	AMENDMENT
14	12	16	-	C509 corrected to read:- 100µF 25V ELEC PH 2222-016-16101.
14	12	16	-	C522 added to parts list 330µF 16V ELEC PH 2222-017-15331
14	12	16	1406	C520 added <1pF WIRE TRIMMER (in parallel with R535)
14	12	23	1403	RV302 changed from 10KΩ to 20KΩ.
14	12	8	1403	R339 changed from 8K2 to 5K6.
14	12	12	1400	C18 added from ⚠2 Ch 1 to ⏚
14	12	12	1400	C68 added from ⚠2 Ch 2 to ⏚
* 14	12	21	-	Parts list error 4505 should be 78MGT2C applicale all units
15	12	15	1404	C401 22pF from Q401 emitter to ground removed
15	12	20	1404	Q401 was 2N5770
15			1407	C568 was fitted across R555
15	12	11,16,18 & 20	1407	R550, C550, D550 & Q550 ADDED (SLOW START CIRCUIT)
15	2	2		Ext trig sensitivity was 10Hz to 15MHz at 200mV sensitivity
15	2	3		Ext trig sensitivity was 10Hz to 15MHz at 200mV sensitivity
15	12	16	1407	C569 10nF cap removed from across RV552
15	12	17	1402	D243 added
15	12	19	1401	Q101 & 2, Q151 & 2 were NPD8303
15	12	9	1404	R421 was 15K. R427 was 10Ω
15	12	9	1404	R428 now 10K. R423 was 33K and originally connected to gate of Q405
				FOLLOWING CHANGES REQ'D FOR NEW DELAY LINES
15	12	6	1402	R201 was 150Ω 5%
15	12	6	1402	R202 & 203 were 75Ω 2%. R218 was 3K3
15	12	6	1402	R231 & 232 1K 1/4W removed
15			1402	L231 & L232 inductors removed
15	12	13&14	1402	C205 was 33pF. C206 was 39pF. C231 removed
15	12	7&8	1403	R320, 3K3 1/4W REMOVED. R360 ADDED.
15	12	4&5	1401	R113 was 47Ω, R163 was 22Ω, R164 was 22Ω.
16	12	13	1401	C111 & C161 included. R186 changed to 4K7. Component Numbers altered.
16	12		1402	U201 pins altered, wiring changed.
16	12		1403	Various changes to wiring and component identification.
16	12		1404	Various changes to wiring and component identification.
16	12	10	1405	R470 changed to 3K3.
16	12	10	1406	R505 changed to 5K6.
16	12		1408	Changes to labelling.

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MANUAL CHANGE INFORMATION FOR MODEL BWD 845

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
46361	17	14.8.80			
47001	18	29.9.80			
47001	19	10.12.80			
49080	20	14.5.81			
49080	21	17.12.81			

Issue	Sect.	Page	Cct.	AMENDMENT
17	13	12	1402	C205 changed from 22pf to 33pf
17	13	12	1401	C112, 22pf added
17	13	12	1401	C160, 33pf added
17	4 & 5	12	1401	R113 & R163 & R164 deleted, RV102 & RV152 relocated
17	4	12	1401	R132, R133 added
17	5	12	1401	R190, R196 added
18	12	11 & 18	1407	Diode D511 added R559 A & B made into R559, R567. Value changed fror 270Ω & 220Ω.
18	12	11 & 24	1407	R553 - 10Ω in series with RV555 removed when Issue 4 power transformer installed. (090-137-4)
18	12	11	1407	R558 changed from 27Ω
18	12	20	1407	MJE 3055. "Matched Pair h_{fe} >70" added
18	12	18	1406	D509 was BZX70 C5V6
19	12	14	1406	C271 ADDED to Parts List
19	12	18 & 19	1406	D503, D504, D505, D562, D563 were BY187
19	12	16	1407	C555 was tantalum type
19	12	4, 5	1401	R113, R163, R164 inserved, RV102 & RV152 relocated
19	12		1401	R132, R133, R190, R196 deleted
19	12	5	1401	R163 & R164 values reversed
20	12	10	1404	R485 & R486 added
20	12	8	1404	R402 changed to 120K
20	12	8	1403	R347 & R348 changed to 820Ω
20	12	23	1403	RV306 changed to 500Ω
20	12	14	1403	C327 changed to 12pF
20	12	10	1405	R484 added
20	12	19	1407	Diode D564 added
21	12	16	1407	C558, C559 changed to 47µF
21	2	283		Sweep accuracy temperature range corrected
22	12	10&11	1406	C527 C528 changed from 1Ω RES
22	12	24		to 47Ω 1W 5% RES TRANSFORMER changed from 090-174-3 to 090-174-4