INSTRUMENT HANDBOOK

ISSUE 3 (246)

Applicable to Serial No. ....

MODEL bwd 509B

5" SINGLE BEAM OSCILLOSCOPE.

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A GUIDE TO THE CHARACTERISTICS & METHODS OF SPECIFYING BWD 509B OSCILLOSCOPE

1. VERTICAL AMPLIFIER

1a. Bandwidth Specification

DC or 2Hz to 10MHz -3db referred to 4 cm deflection at 50kHz.

Method of Measurement

Attenuator set to 10mV/cm and Time Base at 100μSec and switched to Auto trigger.

A low distortion sine wave oscillator with an accurately monitored output (at the point of termination) or one with less than 1% change in level is coupled to the input-socket and correctly terminated. Frequency is set to 50kHz and input level adjusted for 4 cm peak to peak deflection.

The oscillator frequency is now increased and the level noted until it drops to 2.84 cm = -3db or 0.707 of the original level. This will be at 10MHz or higher.

If reference level is increased to 6 cm, the -3db point is now at 4.2 cm. This will be at a frequency of 5MHz or greater.

NOTE : It does not mean a 3db increase in the signal input will return the display back to 4 cm. This is due to inherent limitations in output amplifier deflection capabilities which largely determine the oscilloscope bandwidth.

Oscilloscope amplifier characteristics to note are : -

(i) The response starts to fall around 30% of the bandwidth, i.e. a -3db 10MHz amplifier starts to roll off around 2MHz and,

(ii) Full screen deflection is only available up to approx. 5MHz.

In low cost instruments it is available to approx. 50% of the bandwidth, i.e. up to 5MHz in a 10MHz oscilloscope, but in high performance and relatively high cost models it is available to over 80% of the bandwidth. Overdrive will produce a triangulated sine wave when deflection limit is reached.

1b. Low Frequency Response

With the input switched to DC, the amplifier response is constant (flat) down to zero frequency, enabling the oscilloscope to be used as a DC voltmeter. If the input is changed to AC, a capacitor (usual 0.1μF) is placed in series with the input, removing the DC component and attenuating the low frequency AC signal. 2Hz is slightly less than -3db down from the reference level. Square waves display sloping faces below about 200Hz. A 10-1 divider probe will extend this frequency response down by a factor of 10, i.e. -3db at 0.2Hz.

1c. Rise Time Specification

35nSec. over 4 cm.

Method of Measurement

This is most accurately obtained by interpolation. The formula, based on a step response with less than 2% overshoot or ringing and applicable to all BWD oscilloscopes is rise time $= \frac{350}{\text{bandwidth (-3db)}}$ nano Sec. e.g. $\frac{350}{10} = 35$nSec.

A measured rise time on an oscilloscope must also accommodate the input pulse rise time. The formula for this is t display = t^2 pulse + t^2 oscilloscope. The accompanying chart on page 4C provides direct read-out of the values.

NOTE : When measuring near the upper limit of oscilloscope, pulse amplitude should be contained within the limit of the bandwidth reference level, (e.g. 4 cm from above example) for greatest accuracy of rise time.

1d. Input Impedance

This invariably consists of a 1MΩ resistance in parallel with a capacitive component. As the capacitance consists of strays and FET input capacitance it is measured with the instrument working by a direct reading capacitance meter. In high sensitivity instruments an overvoltage applied by the meter can operate the protection circuits and change the input capacitance reading, so measurements are made at 100mV/cm.

NOTE : As input capacitance is added to lead capacitance when making direct measurements, it is always recommended a - 10 high impedance probe be used to reduce this capacitive component down to 10-12pF where signal levels permit.

2. HORIZONTAL AMPLIFIER

General Specifications and measurement techniques are similar to vertical amplifier and will be referred to where applicable.

2a. Bandwidth Specification

DC to 1MHz -3db referred to 6 cm at 50kHz at max. gain.

Method of Measurement

Horizontal gain vernier turned fully clockwise to max. gain, spot centered. 50kHz sine wave is coupled in and set to 6 cm deflection. Increase input frequency until trace width drops to 4.2 cm, this is the -3db point. All notes relative to vertical amplifier section should also be applied to this section, i.e. max. deflection, roll off, rise time, etc.

2b. Input Impedance

The horizontal input amplifier is a transistor with a relative low input impedance, therefore the input specification varies from the vertical input. It is 56kΩ and capacitance is 20pF. Input capacitance and resistance are measured at max. gain.

3. TIME BASE

This section is divided into the following sections : -

(i) Time Base; (ii) Magnification; (iii) Triggering.

3a. Time Base Specification

1µSec to 0.1 Sec in 6 steps, calibration <5%.

Method of Measurement

Set time base to 1mSec and vernier fully clockwise to Cal. Feed in a 1kHz square wave or pulse with better than 0.1% frequency accuracy. When the first pulse is lined up with the first graticule line, then the 10th pulse should be within ±5 mm of the 10th graticule line. Checks made at all other time base steps with corresponding calibration pulses should be within the same limits.

NOTE : Calibration accuracy is not the accuracy of each individual division, but the overall accuracy, where any variation in trace linearity is averaged over the 10 cm deflection.

Where linearity is specified, it is usually measured between the 1st and 9th graticule lines to eliminate compression effects around the perimeter of the CRT.

3b. Magnification Specification

5% accuracy at x1 and 10% at x5.

Method of Measurement

After calibration check as above at 1mSec/cm trace is expanded to x5. 1kHz calibration pulses should be 5 cm apart ± 5 mm. With trace at x5, time base is increased to 1µSec/cm producing a 200nSec/cm magnified sweep.

3c. Triggering Specification

Int Auto 1 cm deflection 5Hz to 10MHz.

This implies when the time base is adjusted for convenient viewing of input, i.e. 5-10 sine waves visible across screen 1 cm high irrespective of attenuator setting, the time base will present a stable display. Above a few MHz it may be necessary to select + or - slope to obtain greatest clarity of display.

NOTE : All bwd oscilloscopes incorporate an Auto circuit which varies its rate as the time base range switch is changed, they also have a unique feature which increases the sensitivity of the time base, if the trigger level drops at high frequencies, a feature which accounts for their superior triggering characteristics. At low frequencies the Auto rate may exhibit an intermittant repetition rate. This is quite normal and in no way effects its excellent locking ability when a signal is present.

Typical Specification : Level Select ± 3 cm range (at 1kHz).

If the Select Control is turned clockwise from Auto, the triggering point can be selected over a 6 cm range. At the upper and lower frequencies of the trigger range the level range reduces and becomes more critical to adjust.

Specification : EXT AUTO 1C p-p 7Hz to 10MHz.
EXT LEVEL SELECT ± 5V p-p

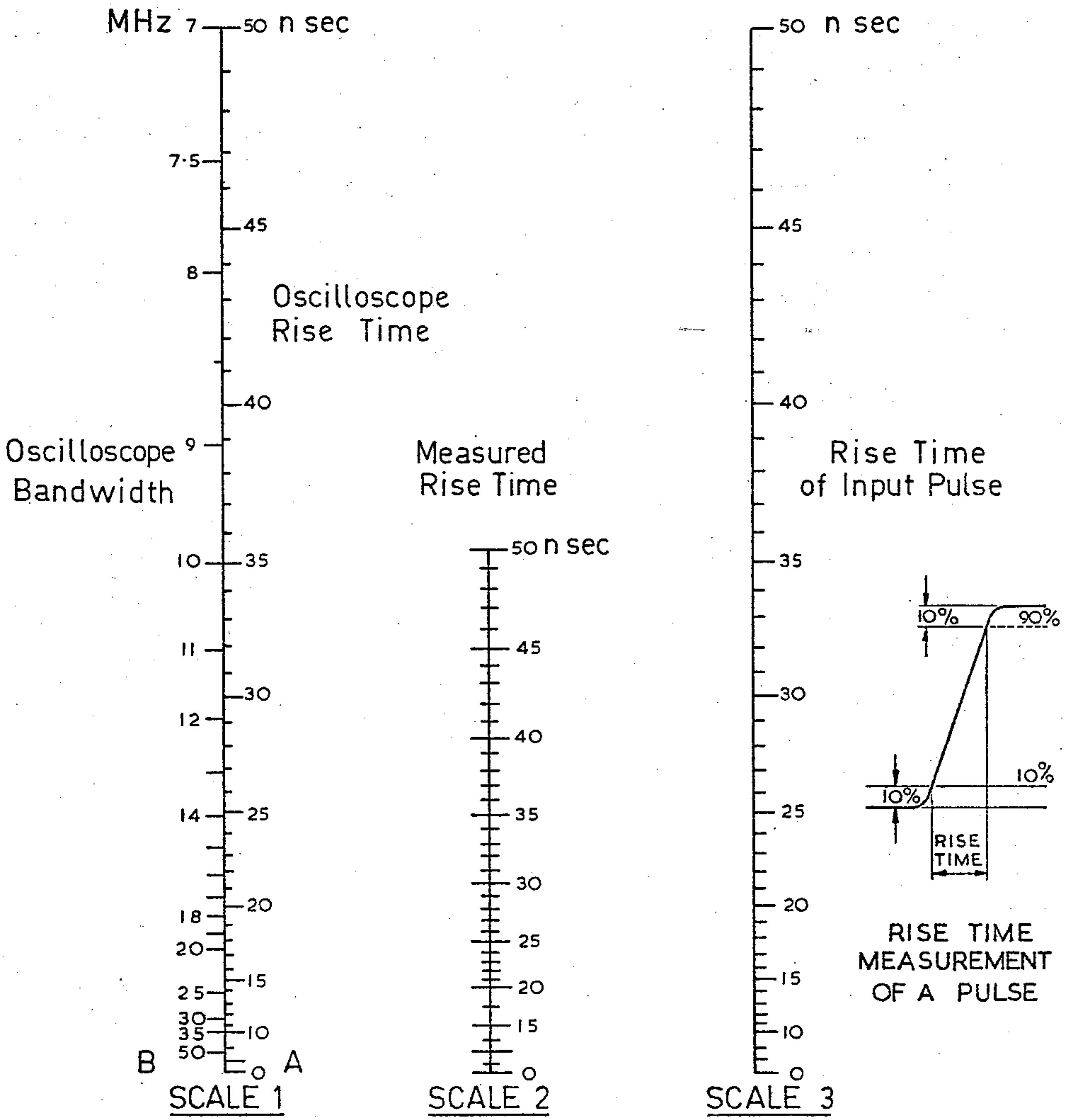
Characteristics are as specified for internal trigger, but refer to an external trigger signal applied to the EXT trigger socket.

NOTE : Input levels to EXT trigger socket are limited to ±60V or 100V rms. Do not exceed these limits or failure of input transistor may result.

4. Z MODULATION

Specification : +20V to modulate at normal intensity.

Set T.B. to 1mSec/cm, feed in a 1kHz sine wave 20V p-p from low Z source. Trace should clearly change brightness level each cm.



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 on Scale 3 is the true rise time of the input pulse.

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

INSTRUMENT HANDBOOK

MODEL bwd 509B

OSCILLOSCOPE

1. GENERAL

The major requirements in a modern oscilloscope are simplicity of operation, compactness, reliability and of course a first class performance. How well these features have been combined in this oscilloscope becomes self evident as soon as a signal is displayed. Direct reading controls enable voltages below 10mV to over 500V from DC to over 10MHz to be measured against time scales from 1 sec. to 200nSec. - a range of 5 million to 1.

1.1 The bug-bear of a stability control needed on many oscilloscopes to set up the trigger condition is completely eliminated in this model either externally or internally, instead diode clamps lock the all solid state circuit in a sensitive ready state, which is completely unaffected by input voltage changes from 170 to 265V or 85 to 132V - a truly stable circuit.

1.2 The time base and trigger circuit also incorporates other new techniques to ensure rock steady triggering. The gated AUTOmatic time base produces a bright reference line at all time base speeds - even at 1µSec/cm with no signal present and is teamed with a wide band trigger circuit, which is preset for optimum sensitivity. As the trigger circuit does not contain the AUTO circuit, it is not subject to annoying beats and jitter, which often occur when input signal and the AUTO free run rate interact, particularly when displaying low level pulse waveforms.

1.3 To ensure that readings of voltage or time are within specification irrespective of variations of local power lines, both the amplifier and time base are compensated to accommodate ±10% line change. Tappings on power transformer permit larger variations to be accepted to suit local supply conditions.

2. SPECIFICATION

2.1 C.R.T.

Type : 5" flat faced, 130 BE B31 incorporating pulse modulated beam blanking to the control grid.

Phosphor : P31 normally supplied, P7 available as an option.

EHT : 1.6kV.

Graticule : 8 x 10 cm graticule with 2 mm subdivisions on X & Y centreline and green filter (orange filter for P7 phosphor option).

2.2 Vertical Amplifier

Bandwidth : DC or 1.6Hz (AC coupled) to 10MHz -3db at all sensitivities referred to 4 cm deflection at <50kHz. DC to 5MHz -3db referred to 6 cm deflection.

Sensitivity : 10, 20, 50, 100, 200, 500mV, 1, 2, 5, 10, 10 & 50V/cm.

Rise Time : 35nSec. for 4 cm deflection.

2.2 Vertical Amplifier (Cont'd)

Calibration :	Better than 5%.
Input Impedance :	1MΩ and approximately 40pF.
Max. Input Voltage :	400DC or 250AC or 400V AC and DC p-p combined.

2.3 Time Base

Range :	1µSec/cm to 100mSec/cm in 6 decade ranges with an uncalibrated vernier control between each step, extending range to > 1Sec/cm.
Calibration :	Better than 5% at all settings at x1 magnification, 1µSec. to 10mSec/cm. < 10% all positions at x5 magnification.
Expansion :	x1 to x5 continuously variable. Maximum sweep speed 200nSec/cm at x5 magnification.
Blanking :	Direct coupled to CRT Grid.

2.4 Trigger

Facilities : 2 switches and one switched potentiometer provide selection of following characteristics : -

(i) INT or EXT

(ii) + or -

(iii) AUTO or LEVEL SELECT

Sensitivity : Int. AUTO 5Hz to >10MHz with 1 cm deflection sine or square wave.

Int. Level Select Range ± 3 cm deflection.

Sensitivity : Ext. AUTO 2V p-p 5Hz to 10MHz sine or square wave.

Ext. Level Select Range ± 10V p-p min.

Ext.Trigger Imp.: 100kΩ and 20pF approximately. Max. input ± 30V AC, DC or AC and DC combined.

2.5 Horizontal Amplifier

Bandwidth :	DC to 1MHz (-3db) at all sensitivities.
Sensitivity :	600mV to 6V per cm approx. continuously variable.
Input Impedance :	56KΩ and 15pf approx. MAX INPUT 30V RMS on 100V p-p.
Vertical to Horz. Amplifier Phase Shift :	Less than 1° from DC to>200kHz at max. amplifier sensitivity.

2.6 General

'Z' Modulation :	Rear socket input to CRT grid, input time constant 0.01MFD and 47kΩ. + 20V will modulate trace at normal intensity.
Calibrate Waveform :	1V p-p sine wave at line frequency, unstabilised.
Power Requirements :	190 to 260V, 50 to 60Hz, approx. 30 Watts. 95 to 130V, 50 to 60Hz
Dimensions :	23cm (9") high x 18cm (7") wide x 41cm (16") deep.
Weight :	Approx. 7.25 kg (16 lbs).
Accessories :	Supplied with instrument. 1 Handbook, Circuit and Parts List, 1 Power Cord.
Optional Accessories :	Refer Section 13, Page 15 of this Handbook.

3. FUNCTION OF CONTROLS

3.1 Front panel controls are grouped for ease of use and are clearly designated. The functions of these controls are as described below : -

Intensity Control :	Fully anti-clockwise, this control switches the instrument OFF. When rotated clockwise the instrument is switched ON and further rotation controls the trace intensity (brightness) from zero to max.
Focus :	Controls the sharpness of the trace. May require a slight readjustment over the full intensity control range.
Astigmatism (Preset) :	Located co-axially with focus control and screw-driver adjusted. This preset is adjusted to obtain the best focus over the entire screen area.
Horz. Position :	(Red Knob) moves the trace horizontally on the CRT.
Horz. Mag :	(Grey Knob) when the Time Base is in use, this control varies the length of the trace from 10 cm to 50 cm, providing x5 magnification. When an External Horizontal Input is used, the Horz. Gain varies the sensitivity from 600mV to 6V/cm approximately.
T.B. Vernier :	Varies the time base speed over a 12-1 range approx. to provide a continuously variable range in conjunction with the TIME/CM switch from 1Sec/cm to 1µSec/cm. When the Vernier control is turned and switched fully anti-clockwise it switches off the internal time base permitting an external signal to be fed into the Horz. Input socket.
Time/cm (Time Base) Switch :	When the Time Base Vernier control is fully clockwise in the CAL position, the 6 time base speeds on this control will be accurate to within 5%. The switch speeds represent the fastest speed on each range. Rotation of the Time Base Vernier control anti-clockwise will reduce the selected speed over a range will reduce the selected speed over a range greater than x12, e.g. on the 1mSec. range the vernier will vary the time base from 1mSec. down to approx. 12mSec/cm when fully anti-clockwise.

+ - Slope Selection	Selects the positive (+) or negative (-) slope of the displayed signal or external trigger waveform to initiate the time base.
Int.Ext. Switch	Selects the trigger signal from either the displayed waveform, or an external waveform applied to the EXT trigger socket. Line frequency trigger is available by link connection from the 1V p-p CAL socket to EXT trigger socket and by switching the EXT.
Vertical Position	Positions the trace vertically on the CRT face.
Auto/Trigger Level	Fully anti-clockwise, and switched to the AUTO position, any signal greater than 0.5 cm in amplitude will trigger the time base but with no input the time base operates automatically producing a bright base line, the automatic rate increases as the time base speed range increases. When the knob is switched away from the AUTO position it permits selection of the point on the displayed or externally coupled waveform, which will trigger the time base over a range of ± 3 cm.
Volts/cm (Attenuator)	Switch adjusts the sensitivity of the Vertical Amplifier from 10mV (0.01V) per cm to 50V per cm in a 1,2,5,10 series of steps. Attenuator accuracy is 2% and the overall oscilloscope accuracy is within 5% on any step.
DC-AC Switch	In the DC position of this switch the amplifier is directly coupled from input to output. In the AC position a capacitor is placed in series with the input to block the DC component of a signal. The AC component also is attenuated -3db at 1.6Hz approx.

3.2 Terminals and Sockets Front Panel

Vertical Input Socket	A positive input will cause the trace to move upwards, a negative input will cause the trace to move downwards. Black terminal should be connected to the ground side of the signal being measured.
Horizontal Input	When the Time Base Vernier is turned anti-clockwise to "T.B. OFF" signals may be fed into the horizontal input socket to produce a horizontal display. Input is DC coupled. If sufficient DC is present on the signal to bias the trace off the screen, a blocking capacitor must be placed in series with the input signal to remove the DC.
Cal. 1V p-p	A 1V p-p (approx.) sine waveform is available to check the oscilloscope operation, T.B. calibration, or if linked to the EXT trigger input to provide line frequency triggering.

Ext. Trigger

When the Trigger Selection switch is in the EXT position, signals from 1 to 20V will trigger the time base. Full selection of amplitude over a range of ±10V or AUTO with positive or negative selection is available.

3.3 Rear Panel

'Z' Modulation

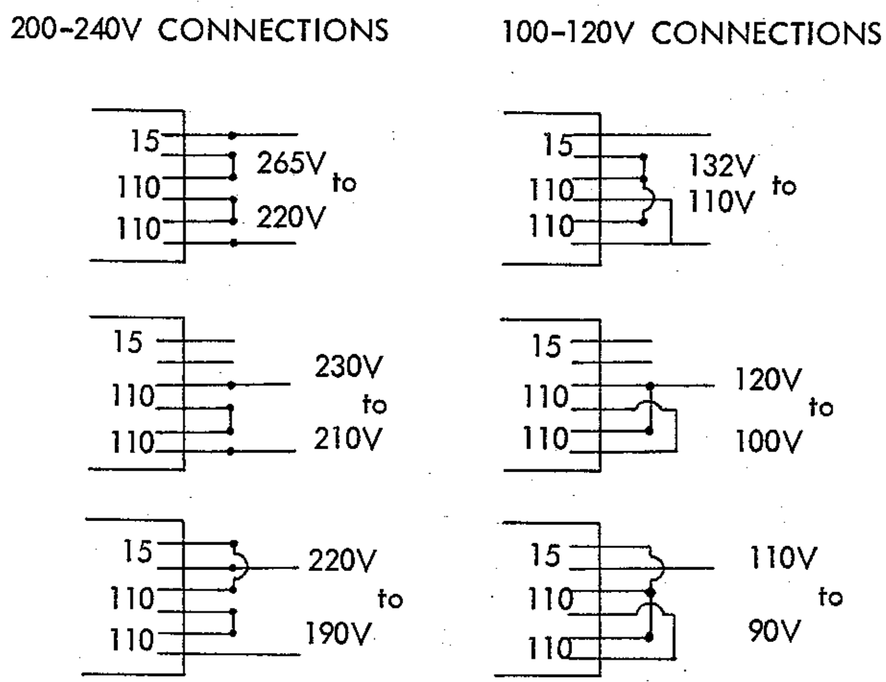
A 20V p-p square wave or a sine wave of >6V will blank the trace. Positive going waveforms blank the trace. Negative waveforms brighten the trace.

4. FIRST TIME OPERATION

Check tapping on power transformer for correct connection for local supply mains. Instrument is fitted with universal primary for 100 to 240V operation, connect as shown below to suit local power line voltage.

Instruments connected for other than 220-265V tapping have a label attached stating supply voltage.

TRANSFORMER CONNECTIONS



4.1 Set the controls as follows before switching on : -

Intensity	Fully anti-clockwise
Focus	Centred
Horz. Position	Centred
Horz. Mag.	Anti-clockwise (x1)
Time Base Vernier	Clockwise - CAL
Time/cm	10mSec.
+ - Selector	+
Int.-Ext. Trigger	Int
Vertical Position	Centred
Trigger Level	Fully anti-clockwise - AUTO
Volts/cm	0.2V
DC - AC	DC

4.2 Plug instrument into power line outlet. Connect a link of wire from the CAL 1V p-p front panel socket to the vertical input socket on the L.H. side.

Switch on by rotating the intensity control about 3/4 of a turn. A display will appear after a few seconds.

5 cycles of the calibration waveform should be present on the CRT. Adjust the horizontal and vertical position controls to centre the display and the focus and intensity for a sharp, bright image.

4.3 Now turn the Volts/cm switch to 0.1V and the display will expand over full screen height, turning the knob around to 0.5V, 1,2, etc. will progressively reduce the height of the display, below 0.5 cm amplitude the trace may start to lose stability.

4.4 Return the attenuator to the 0.2V position and feed in a 1V p-p square wave at 50Hz. The effect of the DC - AC switch on low frequencies can now be seen by sliding the switch to the AC position. The top and bottom edges of the display will tilt indicating a loss of the DC and the lowest frequency components in the square wave. Always use the DC position for frequencies below 100Hz, provided the waveform can be positioned on the screen with the vertical position control, if DC is present on the signal. Change input back to the Cal waveform as in 4.2. Now turn the Time Base Vernier control, the waveforms will compress together. Switch the Time/cm switch to 1mSec and adjust the vernier to give two complete waveforms on the CRT.

Next turn the Trigger Level knob clockwise; the display will disappear, then as the control is turned it will re-appear. Notice how the start of the display moves slowly up the edge of the waveform until it disappears again at the top. Bring the control back to centre and change the + and - trigger switch over to -. The display will change so that the negative or falling slope of the waveform is triggering the display. Rotation of the Level control will again move the triggering point up or down the waveform.

4.5 Return the control to Auto and adjust the Time/cm switch to give 5 waveforms across the CRT, then turn the Horizontal Gain control fully clockwise, 1 waveform will expand to 10 cm, this illustrates the trace expansion facility. If the Horizontal Position control is turned, the trace can be tracked along to view any part of it from one end to the other.

4.6 To check the Horizontal Input, turn the Time Base Vernier to T.B. Off (anti-clockwise). Connect a lead from the Cal socket to the Horizontal Input socket directly above it. A horizontal line will appear, whose length can be varied by the Horizontal Gain control from approximately 2 cm down to less then 2 mm. The horizontal position of the trace can be set by the Horizontal Position control.

4.7 'Z' Modulation

Feed in a 1kHz oscillator to the Red rear panel socket marked 'Z' Mod. With an input of 6V rms or ± 10Vapprox. and the trace at normal brightness level the base line will be intensity modulated. Positive going signals blank the trace, whilst negative going signals brighten the trace.

5. MEASUREMENT OF DC (DIRECT) VOLTAGES

5.1 Set Level Control to Auto. Switch the DC - AC switch to DC. For an initial test take a $1\frac{1}{2}$V dry cell and set the attenuator to 0.5V. Connect the negative end to the black terminal, set the trace to the centre of the graticule, touch a lead from positive end of the battery to the Red Input socket; the trace will move up 3 cm, thus 3 x 0.5V = 1.5V. Now reverse the connections to the battery and note how the trace moves down 3 cm. This illustrates how an oscilloscope can display positive and negative voltages or both simultaneously, e.g. when viewing a sine or square wave.

5.2 The DC input facility may be used to measure AC waveforms swinging about a DC voltage, as at the collector of a transistor or the anode of a valve, to check for bias settings or anode bottoming, etc. Maximum DC input should not exceed x10 input attenuator setting if it is required to re-centre 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 anode, grid or screen voltages of valve or the gate of FET's working with high value loads. Where loading is critical a bwd high impedance probe, type P23 with an input of 10MΩ shunted by 12pF should be used.

6. MEASUREMENT OF AN AC (ALTERNATING) VOLTAGE

6.1 Set the DC - AC switch to AC and the attenuator to 50V (if the input voltage is unknown). Connect a lead from the ⏚ (Black) input terminal to the ground (earth) side of the signal to be measured, then connect a lead from the Red input socket to the signal source.

(Models bwd 112B, 141, or 603 Sine Wave Oscillators are suitable for initial experiments in this test).

Increase the vertical sensitivity by the Volts/cm switch until a display between 2 and say 8 cm exists. Now adjust the Time Base switch and Vernier to enable the waveform to be readily seen. To measure the voltage of the displayed waveform, measure its overall height in 'cm' by the calibrated graticule, then multiply this by the attenuator setting and the result is in Volts p-p, e.g. if the display is 6 cm high and the attenuator is set to 0.5V, then the amplitude is 6 x 0.5 = 3V p-p. To convert to rms voltage for sine waves, divide the 3V by 2.84, e.g. $\frac{3}{2.84}$ = 1.06V rms.

Remember rms voltage is what an AC meter reads, an oscilloscope reads p-p voltage.

7. TIME and FREQUENCY MEASUREMENT

7.1 The frequency of the waveform can be found by turning the Time Base Vernier to Cal (clockwise) then switch the Time/cm switch to a range where the signal can be clearly seen, e.g. if a waveform is 3 cm long and the switch is on 100µSec, then the duration of the waveform is 3 x 100µSec = 300µSec. The frequency can be determined by dividing 1 Sec., i.e. 1,000,000µSec by the duration of the waveform - $\frac{1,000,000}{300}$ = 3,333Hz.

8. MEASUREMENTS WITH AN EXTERNAL HORIZONTAL INPUT

8.1 As the Horizontal Input is directly coupled, the CRT display can be used for X-Y plotting over an 8 x 10 cm area.

Switch Time Base Vernier to T.B. Off, centre display and adjust focus and intensity for a fine spot. Positive or negative voltages may now be applied to X and Y inputs and the result plotted on tracing paper placed over the CRT or transferred to a ruled graph paper. AC signals will show phase displays or Lissajous figures. Less than 1° phase shift exists from DC to>100kHz between X and Y inputs, so accurate phase measurements can be made over this range.

9. CIRCUIT DESCRIPTION

9.1 Vertical Amplifier

Signals applied to the Input terminal are switched straight through to the attenuator in the DC position of S1 or via C1 (which blocks the DC component) in the AC position. Switch S2A - D attenuates the input signal in a 1,2,5,10 sequence to an amplitude suitable for displaying on the CRT. Section S2A and B attenuates the signal in a 1,10,100,1000 sequence every 3rd step. Section S2C and S2D steps the input down in the 1,2,5 sequence, therefore the two sections cascaded produce the 1,2,5,10 attenuation steps. To maintain a constant AC to DC attenuation ratio, the resistors are bypassed by capacitors adjusted so that the C x R value of the series arm is equal to the C x R shunt arm at each step. Constant input capacitance is maintained by C3 and C5 input shunt capacitors.

The vertical amplifier comprises a balanced series - shunt compensated stage driving the cascade deflection amplifiers.

Q1 and Q2 FET's are the input series compensated amplifiers which provide a high impedance for the input signal from the attenuator and a constant current source for the following shunt compensated stage. Input protection for Q2 is provided by reversed biased low leakage diodes D1 and D1A. In the event of a positive overvoltage being applied to the input, D1 will conduct into the low impedance of C69 and R30, whilst D1A conducts via C18 and the zener with large negative signals.

The zener in the sources of Q1 and Q2 changes the amplifier gain in opposition to changes of line voltage and thus maintain a constant calibration sensitivity irrespective of line voltage variation. To further minimise line effects from the display Q1 and Q2 are accurately matched for both gain and operating current and RV3 balance potentiometer provides the final adjustment to virtually eliminate all line or signal variations on the DC rails.

Amplifier calibration is adjusted by shunt resistor RV 2, whilst positioning voltages are applied from RV1 via R13 and R14 and mixed with the input signal at Q1 and Q2 drains where it is directly coupled to the shunt feed back stage Q4 and Q3. This stage provides a high gain and wide bandwidth with very low output impedance which can drive the output stage directly. HF compensation in the cascade stage Q5 to Q8 is adjusted by C19 located between Q5 and Q6 emitters together with R102 and R108, C20 and C68.

CRT Y-plates are directly coupled to Q7 and Q8 collectors and internal trigger take off is from Q7 collector via the low capacity divider C21, R32 and R31.

9.2 Trigger Circuit

Internal or external trigger signals are selected by S3 and applied via C32 to Q11 phase splitter. S4A selects the + or - trigger signal whilst S4B by-passes Q11 emitter in the +ve position to increase HF amplification on +ve output.

Q12 and Q13 form a Schmitt Trigger which generates a precise amplitude fast rise and fall pulse from any input signal large enough to trigger it. Assuming S5A is open, the action is as follows : -
With Q12 conducting its collector will bottom and Q13 will be cut off by the voltage divider across R55, 57, 58 and RV7. A negative going input will cut off Q12, its collector will rise pulling Q13 into conduction producing a negative going voltage drop across its collector load. Q12 and Q13 have a common emitter load, therefore current through Q13 will hold Q12 cut off until the input signal changes polarity and rises positively reversing the switching action.

When S5A is closed the trigger point of the input waveform is no longer preset by R52 and R53, but can be pulled + or - by the potential on RV6, thus providing level selection of the trigger point on the input waveform.

Trigger sensitivity in the Auto position is set by RV7 sensitivity preset.

9.3 Time Base

This circuit consists of Q14 and Q15 bi-stable trigger, Q17 FET source follower driving Q18 Miller integrator and Q19 emitter follower output. D14 is the Auto gating diode driven by Q16 the blanking generator. Diode D15 gates the Miller stage, D4 and D5 clamp Q14 and Q15, D6 sets the trace length and D7 the starting level of the saw tooth waveform.

9.4 The operation is as follows :(with S5B closed, i.e. trigger Level Select in use). Assuming Q14 is conducting, Q15 will be cut off, its collector will rise and D15 will conduct, pulling the gate of Q17 and hence the base of Q18 positive. The collector of Q18 will fall to approximately +3V pulling down Q19 base. At this point diode D7 connected into the emitter load of Q19 passes below zero, conducts and pulls Q15 collector down reducing the conduction of D15.

9.5 The circuit stabilises in this quiescent state with the trace ready for a trigger input pulse from Q13 via C37. A negative pulse on Q14 base will cause its collector to rise taking Q15 base positive. This causes current to flow through Q15 through the emitter resistor R72, biasing Q14 off further, thus producing a rapid cumulative action in which Q14 cuts off and Q15 saturates. D15 becomes reverse biased, Q17 is left with its gate at -1V approximately and connected through the timing resistor R74, 75 and 76 or RV11 as selected by S6C to a negative potential on RV8, which will endeavour to pull Q17 towards cut-off. However, the timing capacitors selected by S6D are in circuit between the base and collector of the Miller transistor Q18 and will be charged up by the current through the timing resistor.

9.6 Q17 FET source follower presents a high impedance to the charging circuit enabling high value charging resistors to be utilised with small high stability timing capacitors. Q19 emitter follower provides a low output impedance to charge the timing capacitors and drive the output amplifier and gating circuits. As Q17 gate and Q18 base fall, Q18 collector rises and via Q19, R81 and C54 a charge is applied to the selected timing capacitor on S6D.

The result of this negative feedback is to linearise the charging rate of the timing capacitor and to produce a positive going sawtooth waveform at the collector of Q18 and via the DC coupling to Q19 where it appears at low impedance at the emitter. The sawtooth continues to rise until the potential at the junction of RV12 and D6 reaches approx. -6V, D6 then conducts and charges C41 to C44 and C45 as selected by S6B. It also takes the base of Q14 positive to its emitter potential and continues positively until Q14 conducts causing its collector to fall, cutting off Q15 and at the same time transferring the emitter current from Q15 to Q14. D15 conducts pulling the gate of Q17 positively, Q18 collector falls, rapidly discharging the timing capacitor until Q19 emitter falls sufficiently to cause D7 to conduct and pull D15 back to a quiescent condition and stabilise the circuit condition ready for the next trigger pulse. This will initiate the next trace once the hold-off capacitor C41 to C44 have discharged through R61 and the base current of Q14 to allow D4 to clamp the base of Q14 in its ready state.

9.7 Auto Time base operation is obtained when S5B is opened. During the sweep time Q15 is conducting its collector is negative to ground so Q16 whose base is connected via R71 to Q15 collector conducts and via D14 clamps R59 near ground potential discharging capacitors C38 and C40-43 as selected by S6A. During the return trace period Q15 ceases to conduct, its collector rises and turns off Q16, D14 disconnects allowing the selected Auto capacitor to charge through the divider R59, 60 and 61. The junction of R59 and 60 falls and if no trigger signal is present to initiate the circuit, it will continue negatively until D4 becomes forward biased pulling down the diode clamp divider and causing Q14 to become reversed biased thus initiating the time base to produce one sweep. This action is repeated until a trigger pulse is generated to lock the time base, thus providing a bright base line at all sweep speeds.

9.8 CRT blanking during the return trace is performed by three transistors Q16, 9 and 10. Q16 PNP transistor is held by the divider R70 and R71. When Q15 is cut off during the return trace its collector rises and via R70 and 71 Q16 cuts off causing its collector to fall towards -54V. The fall in voltage is communicated to the CRT grid via C30 to blank the trace. Q9 and 10 are a gated multivibrator with a wide mark to space ratio operating at 20kHz approx. When Q16 collector falls towards -54, it also pulls down R103 base resistor of Q9, applies base current to Q9 and the multivibrator starts immediately producing wide negative going pulses of -50V amplitude. These are coupled through C25 to DC restoring diode D3 and thence to the CRT grid through R33, which in conjunction with C30 filters out the pulse leaving a low ripple DC voltage on the CRT grid to continue blanking the CRT following the initial pulse applied through C30.

At the start of the forward trace Q15 conducts heavily biasing Q16 on via R71. The collector rises rapidly to -0.2V turning Q9 and 10 multi off and C30 feeds the positive going pulse from Q16 collector to the CRT grid to unblank it.

9.9 Horizontal Amplifier

Q20 together with Q21 and 22 amplifies the time base sawtooth waveform or an external horizontal input.

Q20 is a shunt feed back stage with RV13B horizontal magnification control in the feed back arm.

Six input signals feed Q20 base, these are : -

1. Via R82 from Q19,
2. Via R85 from the X input socket,
3. Horizontal position voltage via R86 from position control RV13A,
4. A centering voltage via R87 from the -46V rail,
5. Negative feed back via RV13B horizontal MAG control and
6. Via RV14, the x5 mag. preset, when S7B is closed during normal time base operation.

The shunt feed back path around Q20 produces a very low impedance output at its collector, capable of driving Q21 and 22 long tailed pair directly. Horizontal centering is preset by RV15.

When the time base is turned off for X-Y operation, all switching is accomplished by S7A and B. S7A disconnects R72 from the -46V rail and turns off the time base, R87 is also disconnected. Q16 conducts, turns off Q9 and 10, thus leaving the CRT unblanked. Q19 falls to zero leaving all inputs to Q20 at approx. zero potential and the position control able to vary it over a + and - range.

As the Ext. input is applied to the same input transistor as the positive going time base signal, +ve inputs will deflect the spot to the right.

9.11 C.R.T.

Negative EHT is obtained by voltage doubling the 550V AC winding by D12 and 13 and capacitors C26-29 both doubling and filtering. Blanking is obtained as discussed in para. 9.8, whilst intensity is adjusted by RV5 connected in a divider with R42, focus control RV4A and R43 across the EHT supply.

Astigmatism is preset by RV4B set co-axially with the front panel focus control.

9.12 Power Supplies

+44V. A half wave rectified 51V AC winding followed by a three stage filter C62, C61 and C60 supplies all the +44V requirements.

-46V. The same 51V AC winding is also half wave rectified by D8 and followed by C65, 64 and 63 three stage filter for the -ve 46V supply.

The -54V tapping on the filters used to supply Q16 and Q10 in the blanking circuit and Q1 and 2 input amplifiers.

+190V. An 82V winding is doubled by D11 and D10, C58 and C59 and filtered by a single stage R100 and C57 for the horizontal amplifier and an additional stage R101 and C56 for the vertical amplifier 180V supply.

10. ADJUSTMENTS & MAINTENANCE

10.1 A number of preset controls are contained in this instrument which may require periodical adjustments to maintain its full calibration.

Before removing the top cover, disconnect the instrument from the mains. Remove the two screws holding the handle, then withdraw the cover. The bottom cover may be removed by unscrewing the feet.

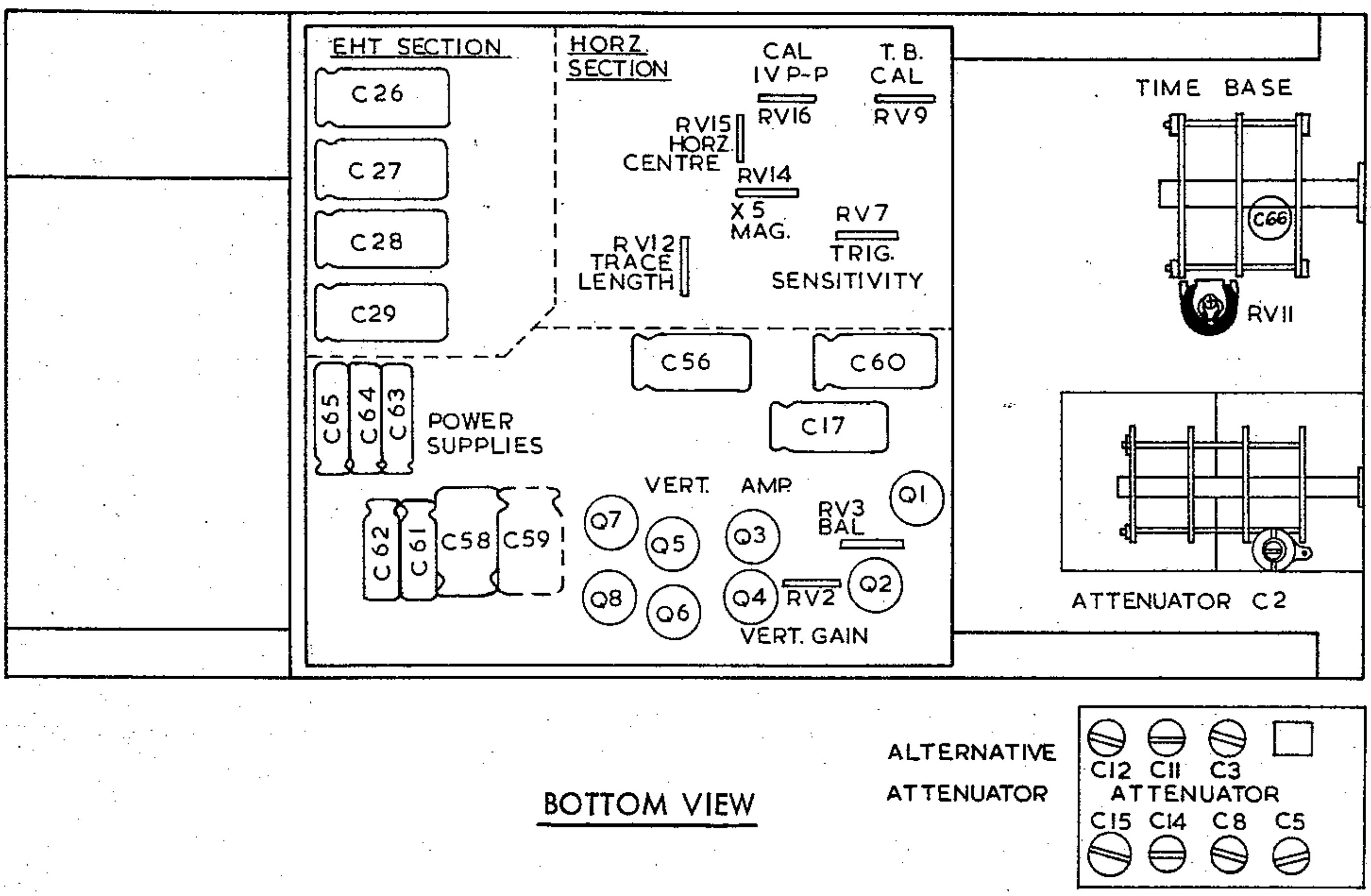
To aid fault finding, the voltages and waveforms present at various points are shown on the circuit.

10.2 Input FET must be selected for balanced current and gain to ensure correct calibration of this instrument and minimum trace movement with input line change.

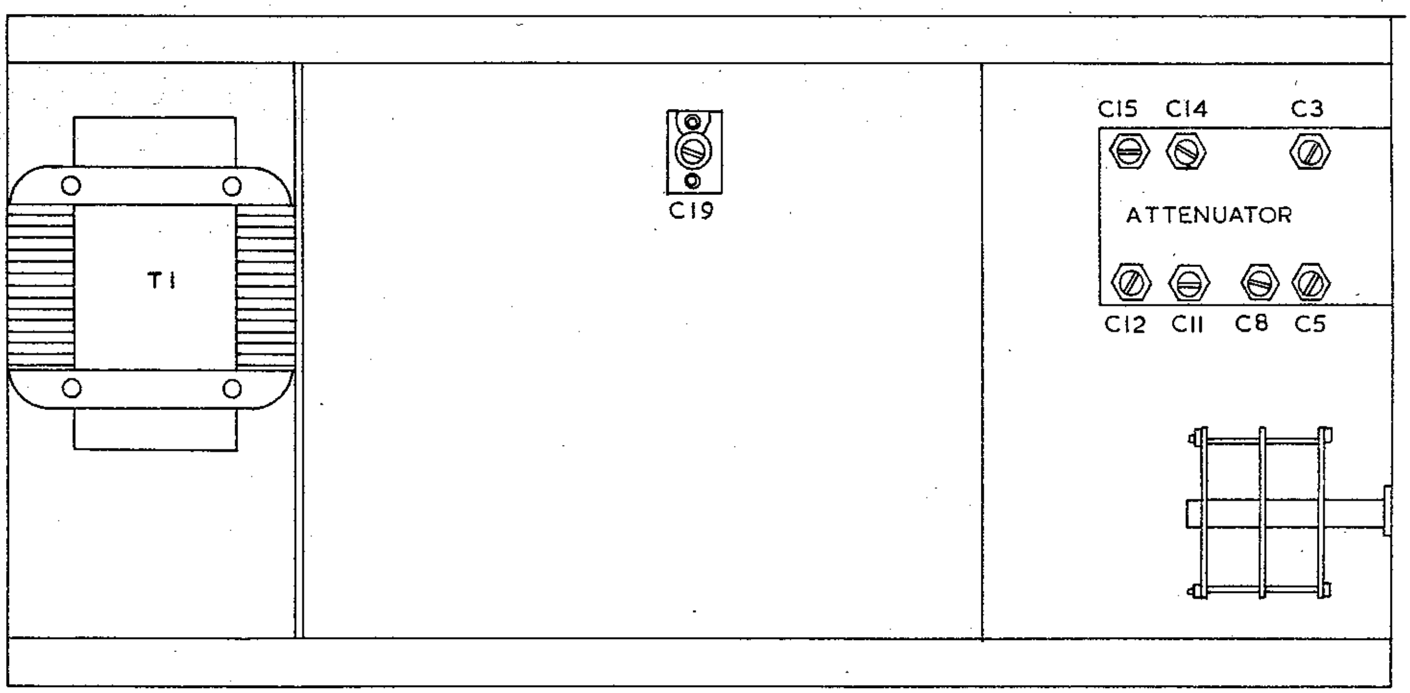
10.3 Alignment Procedure

When instrument functioning and trace aligned to graticule, check the following details prior to alignment with Time Base switched to 1mSec.

LAYOUT TOP VIEW



BOTTOM VIEW



10.4 Check operation of Time Base and Vernier on each Time Base range.

10.5 Turn Vernier to Time Base Off, spot should move ± 5 cm with Horizontal Shift.

10.6 General check of controls : -

a)	Intensity :	Complete control over intensity range.
b)	Focus :	Approx. centre with movement either side.
c)	Horz. Mag.:	Trace should expand equally either side of centre.
c)	Vert. Position :	Trace should move completely off screen above and below centre.

10.7 C.R.T. Trace Alignment

If a 1000Hz sine wave signal is available, feed this into the Vertical Amplifier and adjust waveform for 6 cm deflection T.B. to 1mSec. Vernier at Cal. If a square wave is not available use the Cal waveform. T.B. to 10mSec. Vernier to Cal.

The astigmatism preset in the centre of the focus knob is adjusted in conjunction with the Focus control to obtain the best resolution over the entire screen area when intensity is adjusted to max. brightness but without fly back showing.

10.8 Attenuator and Calibration

Test equipment required 2.5KHz Square Wave Generator.

Set attenuator to 0.01V, feed in 50mV p-p (1% accuracy) square wave. Adjust RV2 for 5 cm display. Vertical amplifier of oscilloscope is now correctly calibrated.

The following chart indicates the adjustments necessary to fully align the attenuator.

Attenuator Setting	Input Voltage	Adjustment for Square Wave	Input Capacitance
0.01	50mV	-	-
0.02	100mV	C12	-
0.05	200mV	C15	-
0.1	500mV	C8	C5
0.2	1V	C11	-
0.5	2V	C14	-
1	5V	C2	C3
2	10V	-	-
5	20V	-	-
10	50V	-	-
20	100V	-	-
50	100V	-	-

Attenuator will be automatically aligned at attanuator positions where no capacitor is indicated.

10.9 Vertical Amplifier

Test equipment required. 250kHz Square Wave Generator, less than 10nSec. rise time.

Attenuator to 0.1V, input selector to AC, signal input 400mV p-p 250kHz T.B. range 1µSec, Vernier to Cal.

Adjust C19 (underside of P/C board) for optimum square wave with minimum over or undershoot.

Check bandwidth, adjust deflection for 4 cm at 50kHz, display should not drop to less than 2.8 cm at 10MHz.

10.10 Horizontal Amplifier

Test equipment 1Hz to 1MHz Sine Wave Generator (Model bwd 141). Feed in 50kHz sine wave to Vertical Amplifier, Time Base to Auto and 100µSec/cm, Horizontal Mag. to x1, Vernier anticlock with time base operating - not at T.B. Off. Adjust RV12 to set trace length to 10.2 cm.

Now disconnect oscillator from vertical input and reconnect to Horizontal Input. Adjust display for 6 cm deflection at 1kHz, increase frequency and note frequency when trace drops to 4.2 cm length - it should be above 1MHz.

Sensitivity : Feed in 1kHz square wave 6V p-p amplitude, trace should be approx. 10 cm long at max. gain and 1 cm long at x1.

10.11 X - Y Phase Measurement

Turn attenuator to 1V/cm, feed in 6V p-p 1kHz sine wave to both vertical and horizontal inputs. Adjust Horz. Mag. (T.B. Off) for a 45° line on CRT, i.e. equal X & Y sensitivities. Now increase frequency, line should not open in the centre of the wave than 1 mm at frequencies to 100kHz.

10.12 Trigger Sensitivity

Feed in 50kHz sine wave, time base to 10µSec/cm, Trigger to Auto and Int. +ve. Reduce amplitude of input signal until trace ceases to lock. Adjust RV7 (centre front of board) for maximum sensitivity of trigger - approx. 2-3 mm display amplitude. Increase display to 1 cm deflection increase frequency of input up to 10MHz, note trace remains locked both + or -ve selection.

To check low frequency trigger use a bwd 140A or 141 oscillator. 1 cm deflection will trigger on Auto to 5Hz.

Trigger Level

Input frequency 1kHz displayed signal 6 cm, turn Trigger Level control away from Auto, trigger point can now be selected over the range ± 3 cm either + or -.

10.13 External Auto

Repeat as in para. 10.12, but with a 1V p-p input to amplifier linked across to Ext. trigger socket. Switch to Ext. and check trigger lock over specified range. Increase input to 10V p-p check operation of Trigger Level Control.

10.14 Time Base

Test equipment required crystal controlled generator with 1µSec to 1 Sec. output in decade steps. Set Time Base Range to 1mSec, Vernier to Cal. Horizontal Mag. to x1. Feed in 1mSec pulse to amplifier and adjust RV9 (T.B. Cal. front right of P/C board) to display 1 pulse per cm. Check the following steps with the frequency indicated and if necessary adjust RV9 for a compromise setting to obtain the minimum error at each step.

T.B. Range	Input Frequency	
10µSec.	100kHz	Adjust C66 on T.B. switch.
100µSec.	10kHz	)
1mSec.	1kHz	) No individual adjustment.
10mSec.	100Hz	)
100mSec.	10Hz	(10% accuracy specified)

Now turn to 1µSec. and feed in 1µSec. pulses. Adjust RV11 located on Time Base switch for one pulse per cm.

Check trace expands x5 and remains linear over sweep length at all time base speeds.

11. REPLACEMENT PARTS

11.1 Spares are normally available direct 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 component.

11.2 As the policy 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.

12. WARRANTY

12.1 The equipment is guaranteed for a period of twelve (12) months from the date of purchase against faulty materials and workmanship, with the exception of cathode ray tubes, which are covered by their manufacturer's own warranty.

12.2 Please refer to Guarantee Card No. .... which accompanied instrument for full details of conditions of warranty.

13. ACCESSORIES FOR OSCILLOSCOPES

High Impedance Probe (x10)	Type P23/4mm	(10MΩ and 12pF)
Screened Leads with prods	Type P30	(complete with prod and crocodile clip)
Demodulator Probe	Type P35/4mm	(10kHz to 100MHz 30V max.)
High Impedance Probe (x10) and x1 Probe Kit	Type P22/4mm	
Probe Kit consisting of x1, x10 and demodulation barrels, 1 meter cable and clips, etc.	Type P29/4mm	

NOTE : If BNC input socket option is fitted to your bwd 509B, order probes as /BNC, i.e. P23/BNC.

COMPONENT ABBREVIATIONS (Cont'd)

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

MANUFACTURERS ABBREVIATIONS

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

PARTS LIST - MODEL bwd 509B

CCT Ref.	DESCRIPTION				Mfr. or Supply	PART NO.	
	RESISTORS						
R1	990KΩ	1%	1/4 Watt	HS			
R2	47KΩ	5%	1/2 Watt	C or CC			
R3	47KΩ	5%	1/2 Watt	C or CC			
R4	900KΩ	1%	1/4 Watt	HS			
R4A	10MΩ	5%	1/2 Watt	C or CC			
R5	111KΩ	1%	1/4 Watt	HS			
R5A	9.1KΩ	1%	1/4 Watt	HS			
R5B	1KΩ	1%	1/4 Watt	HS			
R6	500KΩ	1%	1/4 Watt	HS			
R6A	10MΩ	5%	1/2 Watt	C or CC			
R6B	800KΩ	1%	1/4 Watt	HS			
R7	250KΩ	1%	1/4 Watt	HS			
R8	1MΩ	1%	1/4 Watt	HS			
R9	1MΩ	1%	1/4 Watt	HS			
R10	220KΩ	5%	1/2 Watt	C or CC			
R11	82Ω	5%	1/2 Watt	C or CC			
R12	22KΩ	5%	1/2 Watt	C or CC			
R13	100KΩ	5%	1/2 Watt	C or CC			
R13A	100KΩ	5%	1/2 Watt	C or CC			
R14	100KΩ	5%	1/2 Watt	C or CC			
R15	THERMISTOR				STC	CZ3	
R16	22KΩ	5%	1/2 Watt	C or CC			
R17	2.2KΩ	5%	1/2 Watt	C or CC			
R18	5K6	5%	1/4 Watt	C or CC			
R19	1.2KΩ	5%	1/2 Watt	C or CC			
R20	1.2KΩ	5%	1/2 Watt	C or CC			
R21	5K6	5%	1/4 Watt	C or CC			
R22	1.5KΩ	5%	1/2 Watt	C or CC			
R23	2.7KΩ	5%	1/2 Watt	C or CC			
R24	82Ω	5%	1/2 Watt	C or CC			
R25	8.2KΩ	5%	1 Watt	C or CC			
R26	8.2KΩ	5%	1 Watt	C or CC			
R27	100Ω	5%	1/2 Watt	C or CC			
R28	100Ω	5%	1/2 Watt	C or CC			
R29	390Ω	5%	1/2 Watt	C or CC			
R30	390Ω	5%	1/2 Watt	C or CC			
R31	220KΩ	5%	1/2 Watt	C or CC			
R32	470KΩ	5%	1/2 Watt	C or CC			
R33	470KΩ	5%	1/2 Watt	C or CC			
R34	56KΩ	5%	1/2 Watt	C or CC			
R35	560KΩ	5%	1/2 Watt	C or CC			
R36	4.7KΩ	5%	1/2 Watt	C or CC			
R37	4.7KΩ	5%	1/2 Watt	C or CC			

CCT Ref.	DESCRIPTION				Mfr.or Supply	PART NO.	
	RESISTORS (Cont'd)						
R38	1MΩ	5%	1/2 Watt	C or CC			
R39	1MΩ	5%	1/2 Watt	C or CC			
R40	1MΩ	5%	1/2 Watt	C or CC			
R41	1MΩ	5%	1/2 Watt	C or CC			
R42	680KΩ	5%	1/2 Watt	C or CC			
R43	2.2MΩ	5%	1 Watt	C or CC			
R44	1MΩ	5%	1/2 Watt	C or CC			
R45	100KΩ	5%	1/2 Watt	C or CC			
R46	180KΩ	5%	1/2 Watt	C or CC			
R47	10KΩ	5%	1/2 Watt	C or CC			
R48	10KΩ	5%	1/2 Watt	C or CC			
R49	330KΩ	5%	1/2 Watt	C or CC			
R50	4.7KΩ	5%	1/2 Watt	C or CC			
R51	100KΩ	5%	1/2 Watt	C or CC			
R52	22KΩ	5%	1/2 Watt	C or CC			
R53	180KΩ	5%	1/2 Watt	C or CC			
R54	27KΩ	5%	1/2 Watt	C or CC			
R55	1KΩ	5%	1/2 Watt	C or CC			
R56	6.8KΩ	5%	1/2 Watt	C or CC			
R57	10KΩ	5%	1/2 Watt	C or CC			
R58	27KΩ	5%	1/2 Watt	C or CC			
R59	33KΩ	5%	1/2 Watt	C or CC			
R60	2.2KΩ	5%	1/2 Watt	C or CC			
R61	220KΩ	5%	1/2 Watt	C or CC			
R62	47KΩ	5%	1/2 Watt	C or CC			
R63	6.8KΩ	5%	1/2 Watt	C or CC			
R64	3.3KΩ	5%	1/2 Watt	C or CC			
R65	120KΩ	5%	1/2 Watt	C or CC			
R66	15KΩ	5%	1/2 Watt	C or CC			
R67	33KΩ	5%	1/2 Watt	C or CC			
R68	47KΩ	5%	1/2 Watt	C or CC			
R69	150Ω	5%	1/2 Watt	C or CC			
R70	56KΩ	5%	1/2 Watt	C or CC			
R71	1KΩ	5%	1/2 Watt	C or CC			
R72	22KΩ	5%	1/2 Watt	C or CC			
R73	22KΩ	5%	1/2 Watt	C or CC			
R74	1.2MΩ	5%	1/2 Watt	C or CC			
R75	10MΩ	5%	1/2 Watt	C or CC			
R76	1.2MΩ	5%	1/2 Watt	C or CC			
R77	33KΩ	5%	1/2 Watt	C or CC			
R78	27KΩ	5%	1/2 Watt	C or CC			
R79	33KΩ	5%	1/2 Watt	C or CC			

PARTS LIST - MODEL bwd 509B

CCT Ref.	DESCRIPTION				Mfr. or Supply	PART NO.	
	RESISTORS (cont'd)						
R80	150Ω	5%	1/2 Watt	C or CC			
R81	2.2KΩ	5%	1/2 Watt	C or CC			
R82	22KΩ	5%	1/2 Watt	C or CC			
R83	10KΩ	5%	1/2 Watt	C or CC			
R84	18KΩ	5%	1/2 Watt	C or CC			
R85	56KΩ	5%	1/2 Watt	C or CC			
R86	56KΩ	5%	1/2 Watt	C or CC			
R87	68K	5%	1/2 Watt	C or CC			
R88	15K	5%	1/2 Watt	C or CC			
R89	47K	5%	1/2 Watt	C or CC			
R90	1.2K	5%	1/2 Watt	C or CC			
R91	390Ω	5%	1/2 Watt	C or CC			
R92	33KΩ	5%	1 Watt	C or CC			
R93	33KΩ	5%	1 Watt	C or CC			
R94	8.2KΩ	5%	1/2 Watt	C or CC			
R95	27K	5%	1/2 Watt	C or CC			
R96	470Ω	5%	1/2 Watt	C or CC			
R97	680Ω	5%	1/2 Watt	C or CC			
R98	270Ω	5%	1/2 Watt	C or CC			
R99	470Ω	5%	1/2 Watt	C or CC			
R100	1KΩ	5%	1 Watt	C or CC			
R101	270Ω	5%	1/2 Watt	C or CC			
R102A&B	6.8Ω	Nominal Value					
R103	330KΩ	5%	1/2 Watt	C or CC			
R104	33Ω	5%	1/2 Watt	C or CC			
R105	1.8M	5%	1/2 Watt	C or CC			
R106							
R107	47KΩ	5%	1/2 Watt	C or CC			
R108	12KΩ	5%	1/2 Watt	C or CC			

CCT Ref.	DESCRIPTION				Mfr. or Supply	PART NO.	
	CAPACITORS						
C1	0.1uF	400V	10%	PYE	PH	2202-315-51104	
C2	0.7-3pF	Trim Cap.			PH	C004AA/3E	
C3	1-12pF	Trim Cap.			PH	C004CA/12E	
C3A	10pF	500V	5%	CDS	HS		
C4	470pF	MSA	1%	SM	DUC		
C4A	4700pF	400V	10%	PYE	PH	2202-315-51472	
C5	1-12pF	Trim Cap.			PH	C004CA/12E	
C5A	10pF	500V	5%	CDS	HS		
C6	0.1uF	100V	10%	PYE	TYPE N		
C7	5.6pF	500V	5%	CDS	HS		
C8	1-12pF	Trim Cap.			PH	C004CA/12E	
C9	22pF	500V	5%	CDS	HS		
C10	22pF	500V	5%	CDS	HS		
C11	1-12pF	Trim Cap.			PH	C004CA/12E	
C12	1-12pF	Trim Cap.			PH	C004CA/12E	
C13	5.6pF	500V	5%	CDS	HS		
C14	1-12pF	Trim Cap.			PH	C004CA/12E	
C15	1-12pF	Trim Cap.			PH	C004CA/12E	
C16	0.0022uF	500V	10%	CDS	HS		
C17	33uF	40V		Electr.	PH	2222-015-17339	
C18	100uF	25V		Electr.	PH	2222-016-16101	
C19	20-220pF	Trim Cap.			D	CWO	
C20	680pF	630V	10%	PYE	HS	TCS-610	
C21	3.3pF	500V	5%	CDS	HS		
C22	200pF	500V	5%	CDS	HS		
C23	560pF	630V	10%	PYE	HS	TCS-609	
C24	0.01uF	2kV		CDS	HS		
C25	0.001uF	2kV		CDS	HS		
C26	8uF	450V		Electr.	ELNA	CEO2D	
C27	8uF	450V		Electr.	ELNA	CEO2D	
C28	8uF	450V		Electr.	ELNA	CEO2D	
C29	8uF	450V		Electr.	ELNA	CEO2D	
C30	0.001uF	2kV		CDS	HS		
C31	10pF	500V	5%	CDS	HS		
C32	0.22uF	100V	10%	PYE	ELNA	TYPE N	
C33	0.001uF	500V	10%	CDS	HS		
C34	33pF	500V	5%	CDS	HS		
C35	1uF	200V	10%	PYE	ELNA	TYPE N	
C36	22pF	500V	5%	CDS	HS		
C37	15pF	500V	5%	CDS	HS		
C38	0.01uF	100V	10%	PYE	ELNA	TYPE N	
C39	22pF	500V	5%	CDS	HS		
C40	22uF	25V		Electr.	PH	2222-015-16229	

CCT Ref.	DESCRIPTION				Mfr. or Supply	PART NO.	
	CAPACITORS (Cont'd)						
C41	2.2uF	63V		Electr.	PH	2222-015-16109	
C42	0.1uF	160V	10%	PYE	PH	2202-315-31104	
C43	0.0047uF	400V	10%	PYE	PH	2202-315-51472	
C44	220pF	630V	10%	PYE	HS	TCS - 604	
C45	390pF	630V	10%	PYE	HS	TCS - 607	
C46							
C47	22pF	500V	5%	CDS			
C48	0.1uF	100V	10%	PYE	ELNA	TYPE N	
C49	0.01uF	100V	10%	PYE	ELNA	TYPE N	
C50	0.001uF	630V	10%	PYS	HS	TCS -	
C51	68pF	500V	5%	CDS	HS		
C52	100pF	500V	5%	CDS	HS		
C53	33pF	500V	5%	CDS	HS		
C54	0.01uF	100V	10%	PYE	ELNA	TYPE N	
C55	4-20pF	TRIMMER			STET	75 - 02	
C56	40uF	200V		Electr.	PH	2222-040-12409	
C57	40uF	200V		Electr.	PH	2222-040-12409	
C58	50uF	150V		Electr.	PH	2222-040-11509	
C59	50uF	150V		Electr.	PH	2222-040-11509	
C60	150uF	63V		Electr.	PH	2222-017-18151	
C61	68uF	63V		Electr.	PH	2222-017-18101	
C62	68uF	63V		Electr.	PH	2222-017-18101	
C63	150uF	63V		Electr.	PH	2222-017-18151	
C64	63uF	63V		Electr.	PH	2222-017-18101	
C65	63uF	63V		Electr.	PH	2222-017-18101	
C66	10-40pF	Trim Cap.			Stetner	105-06	
C67	0.1uF	50V		CDS	HS		
C68	100pF	500V	5%	CDS	HS		
C69	0.1uF	50V		CDS	HS		
C70	0.1uF	160V	10%	PYE	PH	2202-315-31103	
C71							
C72	0.1uF	100V	10%	PYE	ELNA	TYPE N	

CCT Ref.	DESCRIPTION	Mfr.or Supply	PART NO.	
	DIODES			
D1 & 1A	Low Leakage Silicon Diode	F	AN210	or FD300
D2	33V Zener Diode	F	AN973B	
D3	Silicon Signal Diode	F	AN206	or IN4148
D4	Silicon Signal Diode	F	AN206	"
D5	Silicon Signal Diode	F	AN206	"
D6	Silicon Signal Diode	F	AN206	"
D7	Silicon Signal Diode	F	AN206	"
D8	Silicon Power Diode	STC	EM404	
D9	Silicon Power Diode	STC	EM404	
D10	Silicon Power Diode	STC	EM404	
D11	Silicon Power Diode	STC	EM404	
D12	Selenium Rectifier	STC	K8/25	
D13	Selenium Rectifier	STC	K8/25	
D14	Silicon Signal Diode	F	AN206	or IN4148
D15	Silicon Signal Diode	F	AN206	"
D2	33V Zener Diode	F	AN973B	
	TRANSISTORS			
Q1	Silicon N Channel FET	NS	MPF106)	Matched Pair
Q2	Silicon N Channel FET	NS	MPF106)	
Q3	NPN Silicon Transistor	PH	BF197	
Q4	NPN Silicon Transistor	PH	BF197	
Q5	NPN Silicon Transistor	PH	BF197	
Q6	NPN Silicon Transistor	PH	BF197	
Q7	NPN Silicon Transistor	PH	BF337)	Matched Pair
Q8	NPN Silicon Transistor	PH	BF337)	
Q9	PNP Silicon Transistor	PH	BC157	
Q10	PNP Silicon Transistor	PH	BC157	
Q11	NPN Silicon Transistor	PH	BC147	
Q12	NPN Silicon Transistor	PH	BC147	
Q13	NPN Silicon Transistor	PH	BC147	
Q14	NPN Silicon Transistor	PH	BC147	
Q15	NPN Silicon Transistor	PH	BC147	
Q16	PNP Silicon Transistor	PH	BC157	
Q17	Silicon N Channel FET	NS	MPF103	Selected
Q18	NPN Silicon Transistor	PH	BC147	
Q19	NPN Silicon Transistor	PH	BC147	
Q20	NPN Silicon Transistor	PH	BC147	
Q21	NPN Silicon Transistor	PH	BF337)	Matched Pair
Q22	NPN Silicon Transistor	PH	BF337)	

PARTS LIST - MODEL bwd 509B

CCT Ref.	DESCRIPTION	Mfr.or Supply	PART NO.	
	POTENTIOMETERS			
RV1	250K 'A' Curve Pot C	Elna	VCU	
RV2	470Ω Preset Pot C	PH	2322-411-02203	
RV3	470Ω Preset Pot C	PH	2322-411-02203	
RV4A	1MΩ 'A' Curve Front) Dual	IRH		
RV4B	100KΩ 'A' Curve Rear) Concent.			
RV5	220KΩ 'A' Curve Pot with DPST Sw.	PH	2322-357-727-12	
RV6	220KΩ 'A' Curve Pot with DPST Sw.	PH	2322-357-727-12	
RV7	22K Preset Pot C	PH	2322-411-02208	
RV8	220KΩ 'A' Curve Pot with DPST Sw.		2322-357-727-12	
RV9	100KΩ Preset Pot C	PH	2322-411-02211	
RV10				
RV11	220KΩ Preset Pot C	PH	2322-411-02212	
RV12	4.7KΩ Preset Pot C	PH	2322-411-02206	
RV13A	100KΩ 'A' Curve Pot) Dual	IRH		
RV13B	10KΩ 'A' Curve Pot) Concent.			
RV14	22KΩ Preset Pot C	PH	2322-411-02208	
RV15	1KΩ Preset Pot C	PH	2322-411-02204	
RV16	10KΩ Preset Pot C	PH	2322-411-02207	
	SUNDRIES			
V1	CRT 5" Single Gun P31 Phosphor		130BE-B31 *	
B1	Neon 240V Red	Sato	BN8	
T1	Power Transformer	Ericcson	TP5698	
S1	2 Pole 2 Pos. Slide Switch	McM	SW014-02-02	
S2A/B C/D	12 Pos. 4 Deck Rot. Switch	MSP	69003-011	
S3	2 Pole 2 Pos. Slide Switch	McM	SW014-02-02	
S4A/B	2 Pole 2 Pos. Slide Switch	McM	SW014-02-02	
S5A/B	2 Pole 2 Pos. Rear of RV6			
S6A/B C/D	6 Pos. 3 Deck 1 Pole	MSP	AK53853	
S7A/B	2 Pole 2 Pos. Rear of RV8			
S8A/B	2 Pole 2 Pos. Rear of RV5			
*	V1 may be fitted with either P31 or P7 where fitted with P7 Phosphor. Order	Phosphor P/No.	130BE-B7.	
	ALL OTHER ITEMS ORDER BY DESCRIPTION			

09B
150

R	109
C	72
Q	22
D	15

MODIFICATIONS

ISSUE 1 1/75
APPLICABLE FROM
SERIAL NO. 28 800

ISSUE 2 4/75
R18 FROM 4K7 TO 5K7
R21 FROM 4K7 TO 5K7
R95 FROM 39K TO 27K
APPLICABLE FROM
SERIAL No. 30,000

ISSUE 3 4/76
APPLICABLE FROM
SERIAL No. 33960
R15 1K8 → CZ3

ISSUE 4 11/76
R18 5K7 → 5K6
R21 5K7 → 5K6
APPLICABLE FROM
SERIAL No. 35637

ISSUE 5 10/78
R102 18Ω CHANGED
TO R102A&B 15Ω & 18Ω
NOMINAL VALUE 6·8Ω
APPLICABLE FROM
SERIAL No. 39800

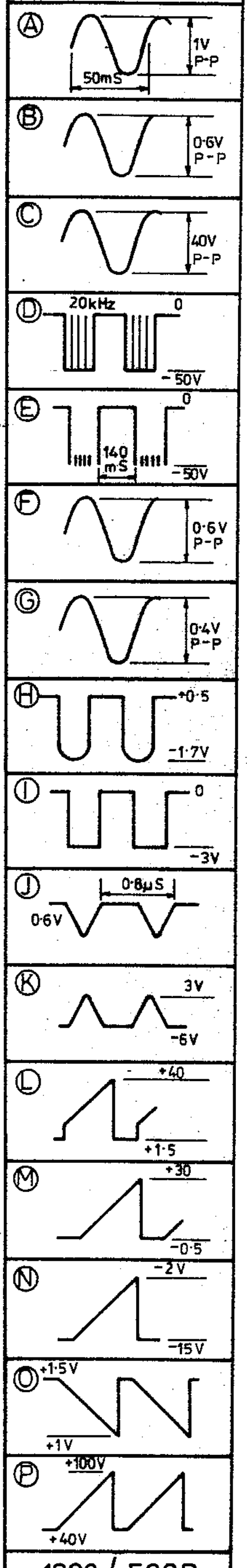
SWITCHES

S1	AC − DC INPUT
S2A − D	INPUT ATTENUATOR
S3	INT − EXT TRIGGER
S4A & B	+ OR − TRIGGER
S5A & B	AUTO OR LEVEL SELECT [REAR RV6]
S6A − D	TIME BASE RANGE
S7A & B	INT EXT TIME BASE [REAR RV8]
S8A & B	AC POWER ON − OFF [REAR RV5]

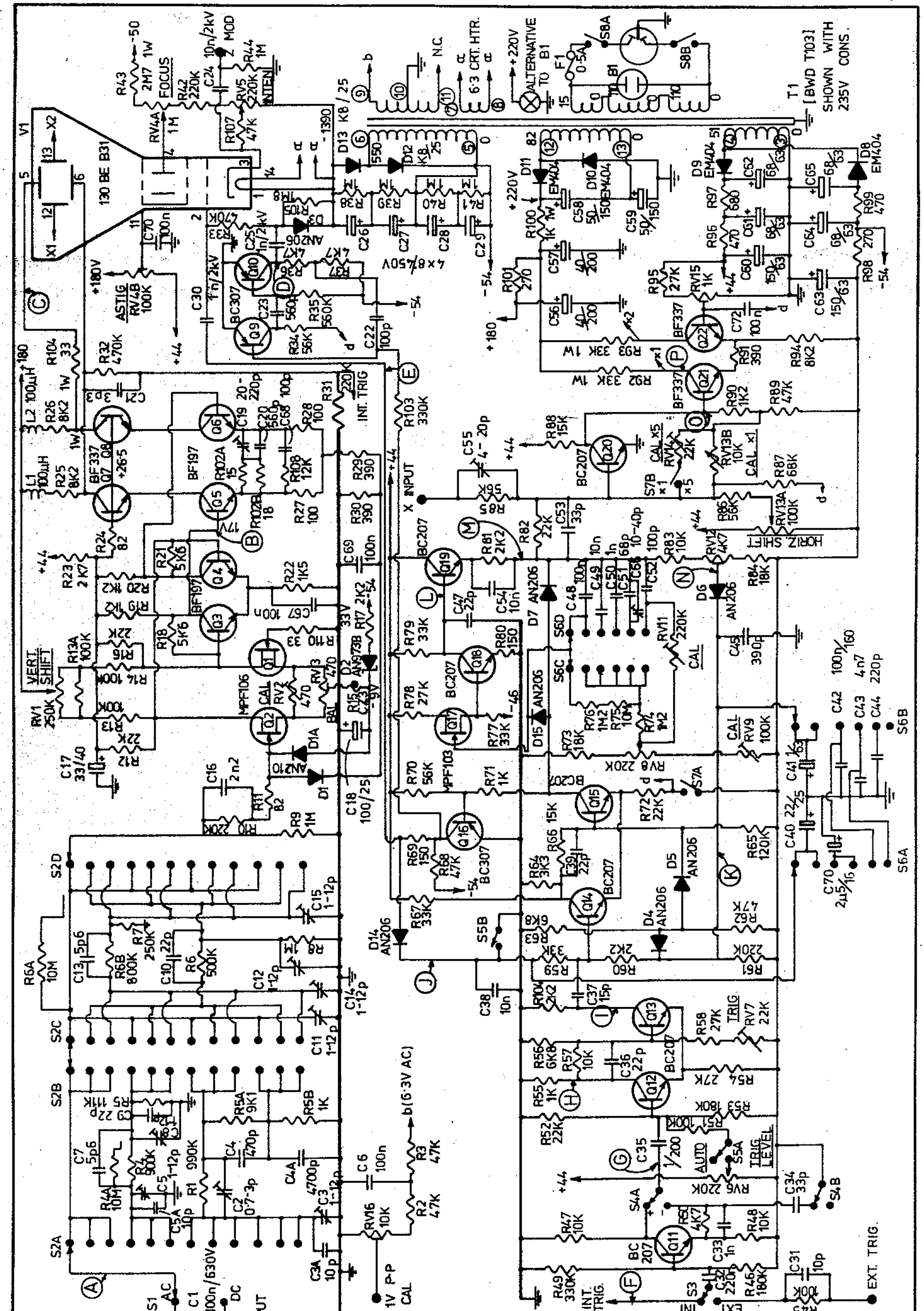
CONTROLS

RV1	VERTICAL SHIFT
RV2	CALIBRATE VERT. AMP. PRESET
RV3	DC BALANCE PRESET
RV4B	ASTIGMATISM PRESET
RV4A	FOCUS
RV5	INTENSITY
RV6	TRIGGER LEVEL
RV7	TRIGGER SENSITIVITY PRESET
RV8	TIME BASE VERNIER
RV9	TIME BASE CAL. PRESET
RV11	1µSEC / CM PRESET
RV12	TRACE LENGTH PRESET
RV13A	HORIZONTAL SHIFT
RV13B	HORIZONTAL GAIN ×1
RV14	×5 MAG. PRESET
RV15	HORIZONTAL CENTRE PRESET
RV16	1V P − P CAL. PRESET

WAVEFORMS



1208 / 509B



NOTE COMPONENT VALUES MAY VARY FROM THOSE DESIGNATED DUE TO AVAILABILITY OR TO OPTIMISE PERFORMANCE

10/75	DRAWN	MODEL bwd 509B	DRG. NO.
	TRACED	5" OSCILLOSCOPE	1208
	DATE 20·1·75		
	CHECKED		

PRINTED CIRCUIT BOARD - LAYOUT