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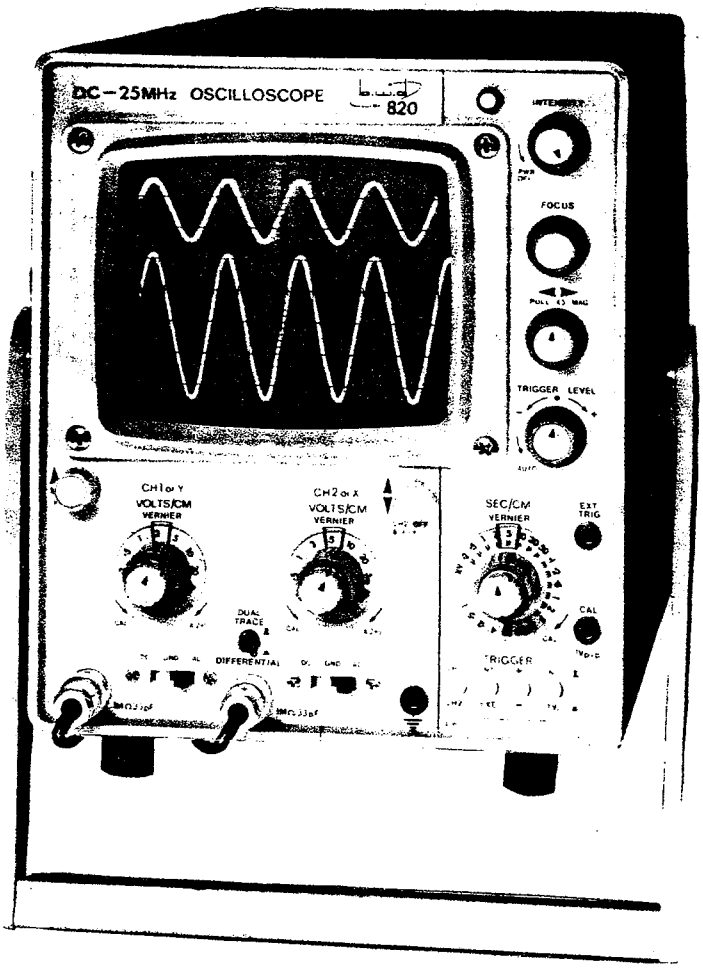
BWD INSTRUMENTS

820

DC to 25 MHz DUAL TRACE OSCILLOSCOPE

INSTRUCTION MANUAL

ISSUE 9



bwd 820 DUAL TRACE OSCILLOSCOPE

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MODEL BWD 820

DC to 25MHz DUAL TRACE OSCILLOSCOPE

1. INTRODUCTION:

BWD 820 Portable Oscilloscope provides an accurate measurement capability from DC to <25MHz with a sensitivity range from 2mV to 20V/cm and selection of either normal dual channel or a single channel differential operation. Time-base and trigger facilities complement the vertical amplifiers with a 40nSec to 5 Sec/cm sweep range and triggering from 2Hz to 40MHz.

Operation is virtually automatic with the BWD "all buttons out" feature for normal dual trace operation. Changeover from chopped to alternate display and frame to line video triggering is controlled by the time-base range switch.

Calibration accuracy is maintained within 3% over widely varying conditions of temperature and supply voltages by electronically regulated supplies throughout.

High brightness, even with low repetition rate signals is provided by the 4kV EHT supply for the high definition mesh PDA CRT.

Identical X-Y sensitivities, phase compensated from DC to 100kHz are incorporated for phase measurements of amplifiers, filters, etc.

A DC coupled TTL compatible Z modulation input enables the BWD 820 to be applied to digital measurements and display video readouts as a DC coupled X-Y-Z monitor.

The regulated supplies and low power consumption, together with the high stability of the integrated circuit amplifiers reduces drift or trace movement to a very low level in both monitoring and measurement applications.

For TV or VTR applications, an active sync separator ensures stable video displays with polarity selection and automatic changeover from frame to line.

An additional feature of the TV trigger is as an AM demodulator to lock modulation waveforms and as a filter when measuring noisy signals.

The BWD 820 is designed to closely conform to IEC 348 recommendation and has been subjected to a wide range of environmental conditions to ensure a reliable long life. Its advanced low power consumption circuitry employs both analogue and digital I.C.'s and a DC to DC switching converter power supply. No ventilation holes are needed, due to the low temperature rise, thus minimising dust ingress. However, like all electronic instruments, it is advisable to store it out of direct sunlight to minimise temperature cycling.

To get the maximum use from your oscilloscope, many accessories such as probes, cameras, dust covers, etc., together with a wide range of other BWD instruments are available either direct from BWD Instruments or your local supplier.

2. A GUIDE TO THE CHARACTERISTICS & METHODS OF SPECIFYING BWD OSCILLOSCOPES:

(The following notes can be used in conjunction with the Specifications in Section 3).

2.1 VERTICAL AMPLIFIERS:

(a) Bandwidth, Spec.

DC or 2Hz to 25MHz-3db referred to 6cm deflection at 50kHz.

Method of Measurement

Attenuator set to 50mV/cm. Time base at 100μSec and switched to AUTO.

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 6cm peak to peak deflection.

The oscillator frequency is now increased and the deflection noted until it drops to 4.2cms or 0.707 of the original level. This will be at 25MHz or higher and is the -3db point.

NOTE: This does not mean a 3db increase in the signal input at 25MHz will return the display back to 6cm. It is due to inherent limitations in 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 25MHz amplifier starts to roll off around 10MHz and calibration accuracy is only applicable to this point. A chart on p3-3E gives approximate calibration up to 40MHz and extends the useful measuring range to this limit.

(ii) Full screen deflection is available up to 10 MHz. See chart p 3-3E.

(b) 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 (100nF) 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 and square waves will 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.

2. A GUIDE TO THE CHARACTERISTICS & METHODS OF SPECIFYING BWD OSCILLOSCOPES: (Cont'd)

(c) Rise Time, Spec.

13nSec over 6cm 10% to 90% Levels.

Method of Measurement

This is most accurately obtained by interpolation. The formula, based on a step response with less than 2% overshoot or ringing is:-

$$\text{Rise Time} = \frac{350}{\text{Bandwidth (-3db)}} \text{ nano Sec. e.g. } \frac{350}{25} = 14$$

NOTE: The BWD 820 rise time is approximately 13nSec as the amplifier bandwidth is in excess of 25MHz.

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 chart on p7-4E provides direct readout 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, (i.e. 6cm for above example) for greatest accuracy of rise time.

(d) Input Impedance

This invariably consists of a 1MΩ resistance in parallel with a capacitive component. As the capacitance consists of strays and F.E.T. input capacitance, it is measured with the instrument working by a direct reading capacitance meter. Measurements are made at any attenuator setting.

NOTE: As input capacitance is added to lead capacitance when making direct measurements, it is always recommended a 10:1 high impedance probe be used to reduce this capacitive component down to 10-12pF where signal levels permit. (BWD P32 Duo Probe).

2.2 HORIZONTAL AMPLIFIER:

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

(a) Bandwidth, Spec.

DC to 1MHz - 3db referred to 8cm at 50kHz at X1 mag.

2. A GUIDE TO THE CHARACTERISTICS & METHODS OF SPECIFYING BWD OSCILLOSCOPES: (Cont'd)

Method of Measurement

With X-Y selected, Horz. position pulled out for X5 mag and spot centered. 50kHz sine wave is coupled in to Ch.2 and set to 8cm deflection. Increase input frequency until trace width drops to 5.6cm; 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, low frequency response, etc.

(b) Input Impedance

This is 1MΩ and 33pf as specified for the vert. amplifier.

2.3 TIME BASE:

This section is divided into the following sections:-

(a) Time-base; (b) Magnification; (c) Triggering.

(a) Time-base, Spec.

0.2μSec to 1Sec in 21 steps, calibration <3%.

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 ±3mm 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 10cm deflection.

(b) Magnification, Spec.

3% accuracy at X1 and 5% at X5.

Method of Measurement

After calibration (2.3(a)) switch to 1mSec/cm and X5 mag. 1kHz calibration pulses should be 5cm apart ±2.5mm.

(c) Triggering, Spec.

INT AUTO 1cm defl. 10Hz to 20MHz and 2cm 10Hz to >30MHz.

This implies when the time base is adjusted for convenient viewing of input (i.e. 5-10 sine waves visible across screen 1cm high irrespective of attenuator setting) the time-base will present a stable display over the range 10Hz to 20MHz. If the display is increased to 2cms, the high frequency trigger extends to over 30MHz.

Level Select

±4cm range <5Hz to 30MHz.

If the Select Control is turned clockwise from AUTO, the triggering point can be selected over an 8cm range. At the upper or lower frequency limits of the trigger range, the level range reduces and becomes a little more critical to adjust. Min. Level Select range is less than 0.5cm.

EXT	AUTO	1V p-p 10Hz to 25MHz
EXT	LEVEL SELECT	±5V p-p <5Hz to 40MHz

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

NOTE: Input levels to EXT TRIG socket is limited to 100V p-p or 30V RMS. Do not exceed these limits or failure of input transistor may result.

2.4 Z MODULATION: Spec +5V to blank at normal intensity

Set T.B. to 1mSec/cm, feed in a 1kHz square wave +5Vpeak from low Z source. Trace should blank out each cm across the screen. A positive signal blanks trace, making it TTL compatible.

3. DETAILED SPECIFICATION:

3.1 VERTICAL AMPLIFIERS CH.1 & CH.2:

Display Modes: Dual Trace, Ch.1 & Ch.2 alternate or chopped (250kHz) with automatic changeover: Ch.1 only: Identical X-Y Differential operation Ch.1+ Ch.2-.

DUAL TRACE OPERATION or Ch.1 Only:

Bandwidth: DC or 2Hz (AC coupled) to 25MHz -3db (5mV to 20V/cm)
DC or 2Hz (AC coupled) to >15MHz -3db at 2mV/cm referred to 6cm deflection at 50kHz.

Rise Time: 13nSec (5mV - 20V), 20nSec at 2mV/cm over 6cm deflection.

Sensitivity: 2mV to 20V/cm. 12 steps in a 1,2,5,10 sequence from 5mV to 20V plus a 2.5:1 calibrated vernier control.

Input Impedance: 1MΩ and 33pF constant.

Max. Input: ±400V (DC and peak AC). AC component 400V p-p max. at 1kHz or less.

DIFFERENTIAL OPERATION (Ch.1+ Ch.2-):

Bandwidth: Rise Time: Sensitivity: Input: as above.

CMRR: 2mV to 20V/cm
≥20db DC to 5MHz
with verniers adjusted for minimum deflection.

Max. CMR Input: 8cm Deflection.

X-Y OPERATION (Ch.1-Y Ch.2-X):

Bandwidth: DC or 2Hz (AC coupled) to 1MHz - 3db.

Sensitivity: 2mV to 20V/cm.

Phase Shift: $<3^{\circ}$ DC to 100kHz.

CALIBRATION:

Ch.1 & Ch.2: 5mV to 20V/cm 3% with vernier to CAL.

2mV Sensitivity: 5%.

Ch.2 as X: 5%.

3. DETAILED SPECIFICATION: (Cont'd)

3.2 TIME BASE:

Range: 200nSec to 1Sec/cm in 21 switched ranges with 5:1 vernier extending range down to 5Sec/cm.

Magnification: X1 & X5 Switched, extends max. time-base speed to 40nSec/cm. Calibration X1 <3% and X5 <4% after first 40nSec.

3.3 TRIGGERING:

Selection:

Source	Slope	Coupling	Mode
Ch.1 or Ch.2	+	Norm.	AUTO
Ext.	-	T.V.	Select Level

Sensitivity:

Int. AUTO:	>1cm 10Hz to 20MHz >2cm 10Hz to 30MHz
Min. AUTO sensitivity:	0.5cm
Int. Select:	>1cm 5Hz to 25MHz >2cm <5Hz to 40MHz
Int. Select Range:	±4cm min. at 50kHz.
Ext. AUTO:	>1V p-p 10Hz to 25MHz
Ext. Select:	1V to 10V p-p <5Hz to 40MHz
Max. Ext. Input:	100V p-p Max. or 30V RMS
Input Impedance:	180kΩ & 15pF approx.

T.V. Sync.: Automatic changeo ver from line to frame trigger by time-base range switch.

Sensitivity: 2cm to 8cm composite video waveform with polarity selection.

Demodulation or HF Reject: T.V. Selection also provides stable locking of modulated R.F. waveforms and eliminates HF noise from trigger signals below 10kHz approx.

Power Line Trigger: Available by link connection from CAL output to Ext. trigger input.

3.4 HORIZONTAL AMPLIFIER: See X-Y Operation under para 3.1

3. DETAILED SPECIFICATION: (Cont'd)

3.5 CRT: 130mm Type 130BT incorporating a mesh PDA and operating with a stabilised 4kV EHT.

Phosphor: P31 Normally supplied. P7 available as Option 04.

Graticule: Light blue filter calibrated 8 x 10cm with 2mm sub-divisions on major axis.

Deflection: 8cm vertically x 10cm horizontally.

3.6 GENERAL DETAILS:

Z Modulation: DC to 10MHz Bandwidth. +5V Required to blank trace at normal intensity. TTL compatible.
Input impedance 10kΩ. Max. input ±50V p-p.

Trace Rotation: Rear panel control enables trace to be accurately aligned to the graticule.

Calibrator: Line frequency rectangular wave 1V p-p, 1% accuracy. Positive going to ground, 25μSec rise and fall time into <1MΩ and less than 40pF.

Calibration Accuracy: All calibration figures in the preceding specification are maintained from 5°C to 45°C and AC input voltage range 100 to 135V or 200 to 270V as selected.

Time Base Output: 0 to 10V Positive going sawtooth.

Power Requirements: 16 Watts approx. 100V - 135V) 48-440Hz
200V - 270V)

Other ranges to special order.

Dimensions: 25cm high x 19cm wide x 42cm deep overall, (incl. feet, handle, knobs etc.).

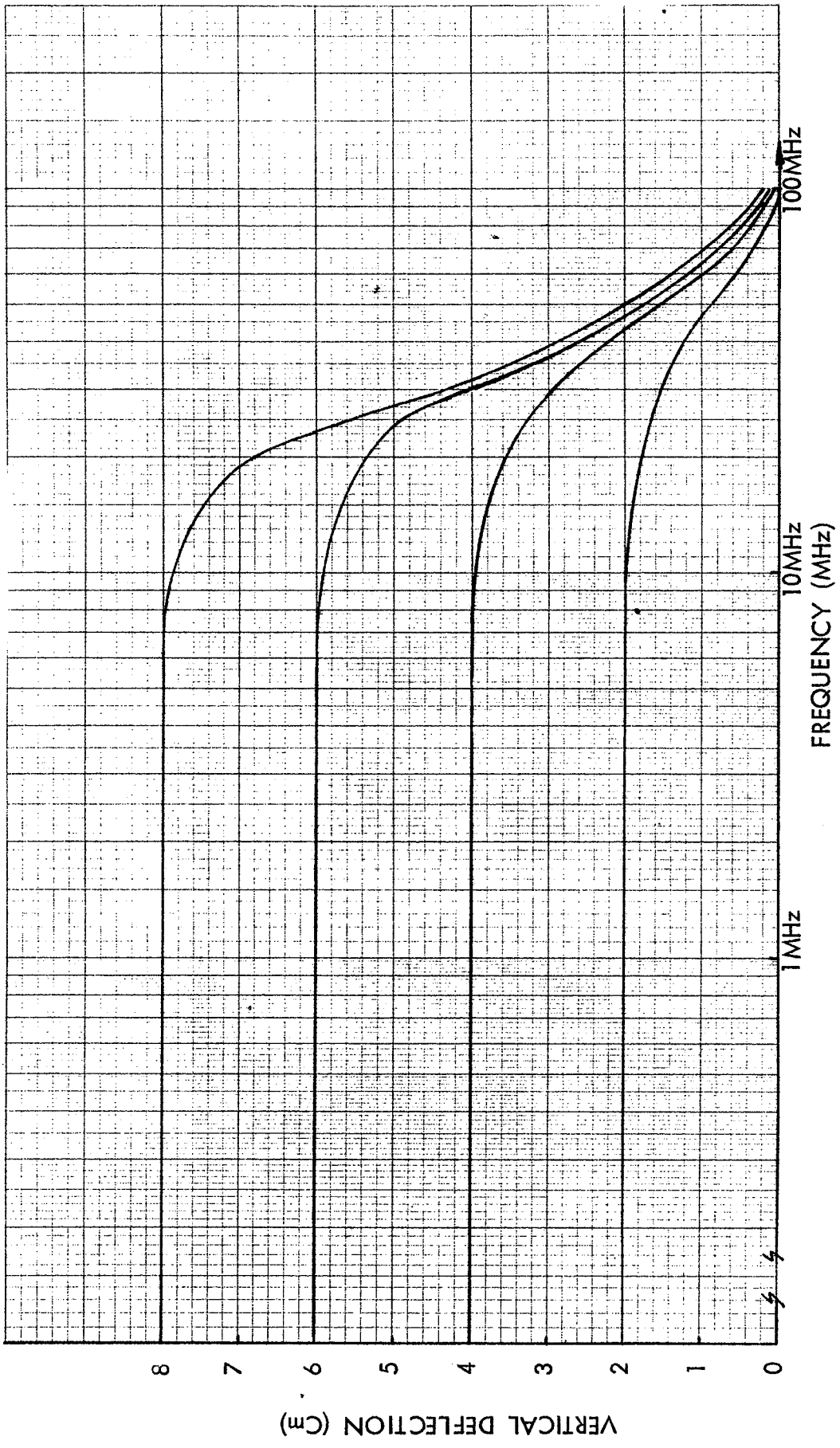
Weight: 6.3kg. Packed: 7.2kg.

Optional Accessories:

Probes 1:1	(1MΩ & 100pF approx.)	P30
10:1	(10MΩ & 11pF)	P40
1:1 & 10:1	Switched Duo Probe	P32
100:1	(100MΩ & 4pF)	P37
	Demodulator (100kHz to 350MHz)	P35
Carrying Case		C52
Vinyl Dust Cover		D12
Light Shield		H46
19" x 8 3/4" Rack Mounted Adaptor		

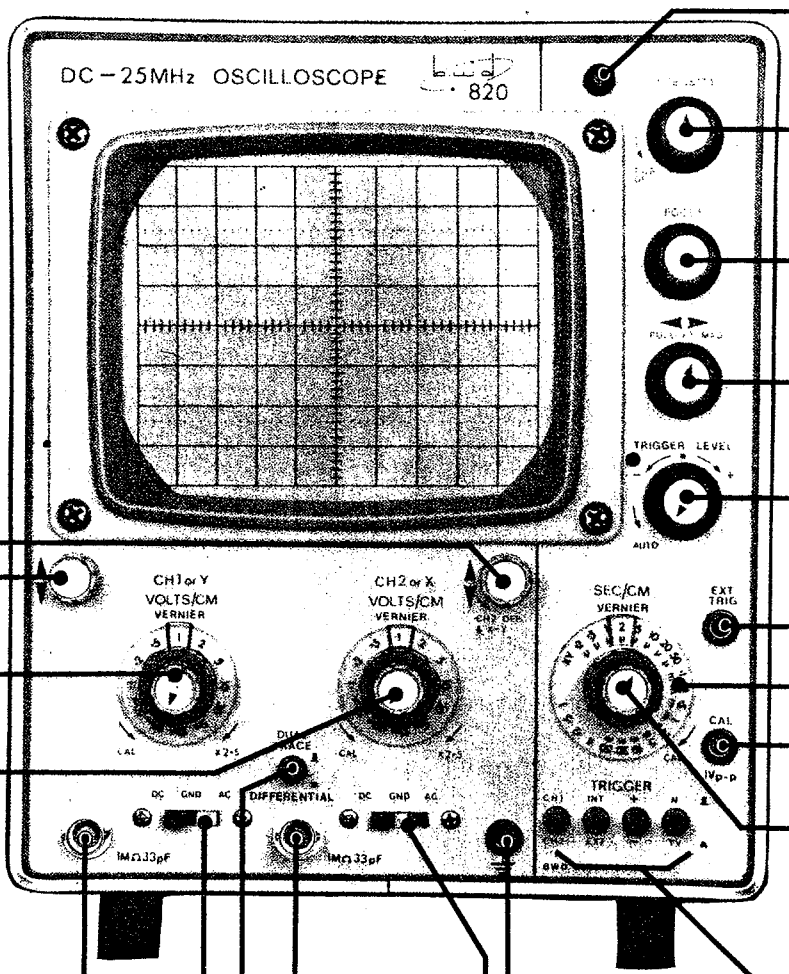
NOTE: Characteristics expressed in numerical values with tolerances stated are guaranteed by the factory. Numerical values without tolerances represent the values of an average instrument.

FREQUENCY RESPONSE CHART



MODEL BWD 820

LAYOUT OF FRONT PANEL CONTROLS



4. FUNCTION OF CONTROLS:

4.1 Front Panel Controls are grouped for ease of use and are clearly designated. The functions of these controls are as detailed below:-

Intensity:	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):	Rear panel preset control, adjusts beam for optimum shape over entire screen area in conjunction with the focus control.
	Moves the trace horizontally on the CRT.
X5 Mag:	When horz. position knob is pulled out, trace speed is increased X5.
Auto/Trigger Level:	Fully anti-clockwise and switched to the AUTO position, any signal greater than 1cm in amplitude will trigger the time-base. However, with no signal present, the time-base free runs to generate a bright base line at all sweep speeds. When the knob is switched out of the AUTO position, it enables the time base to be triggered at any selected level on the displayed waveform.
Time-base Vernier: (co-ax with Sec/cm Switch)	Varies the time-base speed over a range greater than 5:1 to provide a continuously variable range in conjunction with the Sec/cm Switch of 0.2μSec to 5Sec/cm.
Sec/cm (Time-base Switch)	When the time-base vernier control is fully clockwise in the CAL position, the 21 time-base speeds on this control will be accurate to within 3%. 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 greater than 5:1. e.g. On the 1mSec range, the vernier will vary the time-base from 1mSec down to 5mSec/cm.
X-Y Operation:	When the time-base range switch is turned fully clockwise, and the X5 mag control is pulled out Ch.2 amplifier will provide the horizontal display. Sensitivity range is 2mV - 20V/cm.

Trigger Selector Push Buttons: (a-d)

(a)	Ch.1 or Ch.2:	Out position selects Ch.1 to provide the trigger signal. The in position selects Ch.2.
(b)	Int-Ext:	Selects the trigger source from the displayed waveform on Ch.1 or Ch.2 or an external waveform supplied to the EXT TRIG socket.

4. FUNCTION OF CONTROLS: (Cont'd)

(c) ±: Out selects the positive (+) and in selects negative (-) slope of the displayed signal or external trigger waveform to initiate the time-base.

(d) Norm - T.V.: In Norm. position, triggering is controlled by + and - switch and trig. level control. In the T.V. position a sync separator is brought into circuit. For time-base speeds up to 100μSec/cm frame lock is provided, whilst 50μSec and above selects line lock.

Vertical Position (Ch.1 & Ch.2): Moves the traces up and down the display. Ch.2 position control also switches off Ch.2 when single beam or identical X-Y operation is required by rotating it counter clockwise to operate the switch.

Volts/cm (Attenuator) (Ch.1 & Ch.2): Switches adjust the sensitivity of the Vertical Amplifiers from 5mV per cm to 20V per cm in a 1,2,5,10 series of steps. Attenuator accuracy is <2% and the overall oscilloscope accuracy is within 3% on any step.

Verniers (Ch.1 & Ch.2): These control the vertical sensitivity over a calibrated 2.5:1 range. The attenuator is calibrated when the controls are fully counter clockwise in the detent position. When rotated clockwise the amplifier sensitivity is increased providing a max sensitivity of 2mV/cm at the 5mV step.

AC-GND-DC Switches (Ch.1 & Ch.2): In the DC position of this switch, the amplifiers are directly coupled from input to output. In the AC position a capacitor is placed in series with the inputs to eliminate any DC component and attenuate all frequencies below 2Hz. In the GND (centre) position the input signal is disconnected and the amplifier grounded.

Vertical Input Socket: Co-ax socket. A positive input will cause the trace to move upwards. A negative input will cause the trace to move down. When amplifiers are switched to differential input a positive signal applied to Ch.2 input will cause the trace to move down. A negative signal will move the trace up. In the X-Y mode a positive signal to Ch.2 input will move the trace to the right.

Push Button Dual Trace/ Differential: Switch out selects dual trace operation. When switch is in, both channels are combined and Ch.2 is inverted, providing a single channel differential input facility.

4. FUNCTION OF CONTROLS: (Cont'd)

Cal 1V p-p:	A positive going rectangular wave to check calibration accuracy of amplifiers and time-base (if power line frequency is known to be accurate) for 10:1 probe alignment (Para 4.3) or as a source of signal enabling the time-base to be locked to the power line frequency by linking the Ext Trig socket to Cal output.

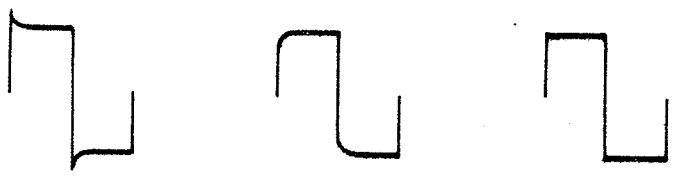
4.2 REAR PANEL:

Z Modulation:	+5V or greater will blank the trace at normal intensity. Negative going signals intensify the trace. Positive signals blank the trace. Input is DC coupled and TTL compatible.
Time Base Output:	An 0 to + 10V Sawtooth is available from a 10kΩ source impedance. Min. external loading resistance 22kΩ.
Trace Rotation Preset:	A preset control enables the trace to be accurately aligned with the graticule.
Astigmatism Preset:	Preset control adjusts shape of spot to enable it to be optimised over the screen face.

4.3 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 10:1 or 100:1, but simultaneously reduces the input capacitance to approximately 11pF and increases the input resistance to 10MΩ. The probe available for this model is the BWD P32 Duo Probe, providing both 1:1 and 10:1 division and a zero signal reference position on the selector switch.

To align a probe, couple it to Ch.1 input jack. Set attenuator to 20mV/cm and time-base to 5mSec/cm. Place the point of the probe tip on the 1V calibrator socket. A square wave will appear, probably with the leading edge over or under compensated. With the small plastic screwdriver supplied, adjust the screw in the side of the probe housing until waveform is square. It will remain correct at all attenuator settings.



OVERCOMPENSATED UNDERCOMPENSATED CORRECT

NOTE:

No adjustment is required when the switch on the P32 selects 1:1 operation as no signal division occurs in the probe.

5. INITIAL CHECKING:

This section of the Handbook is intended to 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 instruments calibration.

OPERATING VOLTAGE:

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.

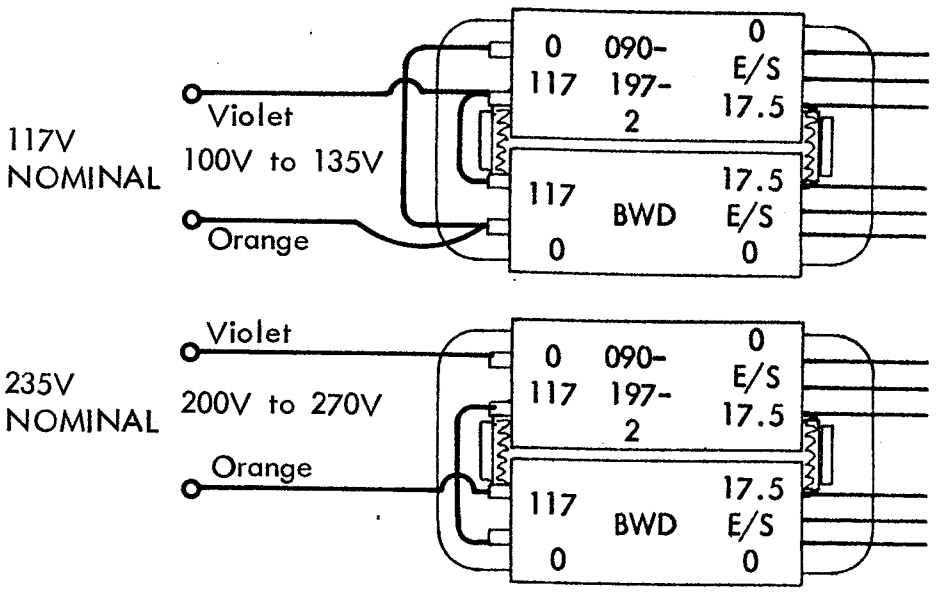
This instrument can be operated from either a 115 Volt or 230 Volt nominal line voltage source, 48 to 400Hz. This instrument may be damaged if operated with the line voltage connected to incorrect positions for the line voltage applied.

The BWD 820 is designed to be used with a three-wire AC power system, with the Green/Yellow wire connected to ground. Failure to complete the ground connection 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:-

Line	Brown
Neutral	Blue
Safety Earth (Ground)	Green/Yellow Stripe

The power transformer is provided with primary tappings which may be changed by resoldering the links to suit the local power line voltages. The connections are as shown below. Instruments sold in Australia are connected for 200-270V operation. Export instruments have a label attached stating the operating range the transformer has been set to.



NOTE: LINKS TO BE INSULATED HOOK-UP WIRE

6. FIRST TIME OPERATION:

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

	Intensity	:	OFF (counter clockwise)
	Focus	:	Centred
Amplifiers 1 & 2:	Attenuator	:	0.2V/cm
	Vernier	:	Cal (counter clockwise)
	Vertical Position	:	Centred
	Input Selectors	:	AC
	Dual Trace/Differential	:	Dual trace (out)
Time-base:	Time-base Range	:	10m Sec/cm
	Vernier	:	Cal (Clockwise)
	Level Select	:	AUTO Switched fully counterclock
	Ch.1 - Ch.2 Trigger	:	Ch.1)
	Int - Ext	:	Int.) All push buttons
	±	:	+) out
	N - T.V.	:	N)
	Horz Position	:	Centred
	Horz Mag	:	X1 (pushed in)

6.2 Connect power lead to 48 - 400Hz AC supply (see previous page for voltage tappings) and switch instrument on. Turn intensity control to approximately 2 o'clock position; after a few seconds the traces will appear. Adjust intensity and focus, then position them centrally across screen.

Connect a probe from Ch.1 input to the calibrator socket.

The line frequency square wave will be displayed 5cm high, but slightly differentiated. Now switch to DC input - the trace will rise and the bottom of the waveform will correspond approximately with the CRT centreline indicating the input signal is a waveform positive going with respect to ground. Switch to GND; the trace will disappear then after a short time a bright reference base line will appear as the Auto time-base operates. The GND switch open circuits the input socket, but grounds the amplifier.

Switch back to AC then rotate position controls and note the degree of movement available.

6.3 DUAL TRACE OPERATION:

Set Ch.2 amplifier as for Ch.1. Take a parallel signal from the 1V calibrator output to Ch.2 input (leave Ch.2 signal connected). Reduce attenuator settings on both amplifiers to 0.5V/cm then position them above and below CRT centre-line. When Ch.2 is moved up and down the screen it will be noticed the trigger is unaffected by the position control.

6. FIRST TIME OPERATION: (Cont'd)

6.4 DIFFERENTIAL OPERATION:

With the calibrator square wave displayed on both channels and the attenuators set to identical readings, press the Dual Trace/Differential button in. A single trace will be presented with no signal on it. This demonstrates the Common Mode Rejection feature of the amplifiers, i.e. their ability to reject signals that are common to both inputs so that it will amplify and display only difference signals. If the two probes to Ch.1 & Ch.2 are now connected, one to each side of the secondary of a transformer, for example, or to any similar waveform, the oscilloscope display will be the difference signal between them. This method of measurement is very useful when dealing with push pull circuits such as switching converters, amplifiers and where it is necessary to see the signal between two points in a circuit, neither of which is at ground potential. The only limits to observe are that both attenuators must be at the same sensitivity and the common mode signal must not be greater than 10cm deflection.

6.5 Ch.1 ONLY OPERATION:

When only single channel operation is needed without the differential capability, Ch.2 vertical position control should be turned fully counter clockwise to the detent position. This will provide maximum trace brightness and greater deflection amplitude than in the differential mode.

6.6 TIME-BASE OPERATION:

Connect a 2kHz (approx.) sine wave signal to Ch.1 input socket and adjust attenuator or input for 8cm display. Time-base to 0.2mSec/cm, and all trigger buttons out.

6.7 TRIGGER LEVEL:

Turn the Level Select control clockwise out of the Auto position. The trigger point will move up and down the wavefront. When it reaches the top or bottom extreme of the waveform the trace blanks out when trigger is lost. Now push in the ± button to select -ve trigger. The waveform will now trigger on the -ve going slope. Clockwise rotation of the level control will increase the trigger point level towards the negative point of the waveform, anticlockwise rotation towards the positive point as for + slope.

Reduce amplitude of display signal, with level control carefully adjusted, signal can be reduced to less than 5mm and stable lock is still obtained. Return level select to Auto.

6.8 TIME-BASE VERNIER:

Turn Vernier anti-clockwise - observe approximately X5 the number of waveforms on CRT when fully anti-clockwise. Return to Cal position.

6. FIRST TIME OPERATION: (Cont'd)

6.9 MAGNIFICATION:

Adjust input frequency to produce one sine wave per cm and locate the peak of each waveform on a vertical graticule line. Pull out the Horz. Position Control to obtain X5 mag. 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.

6.10 IDENTICAL X-Y:

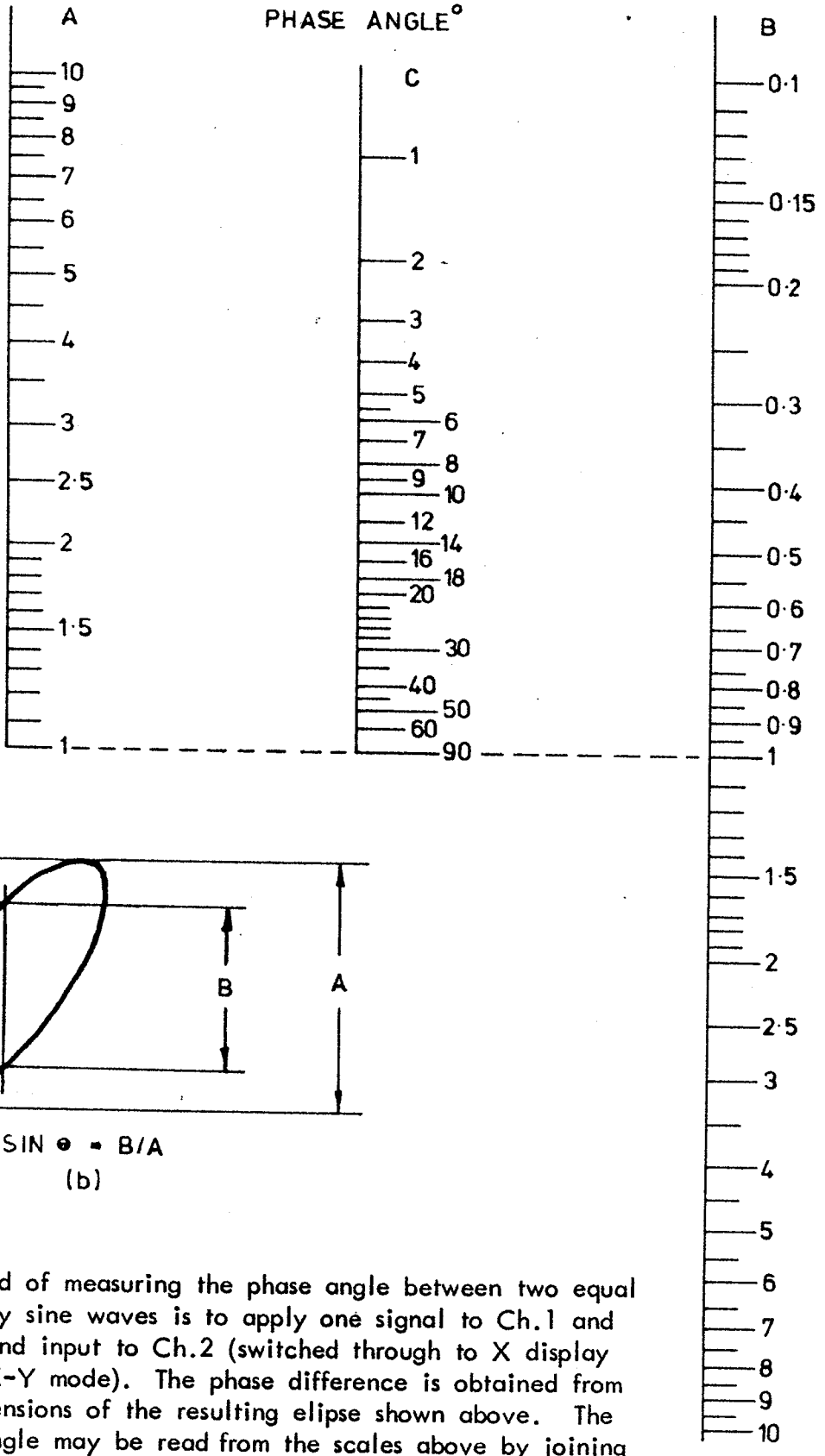
Connect a 1kHz sine wave source to Ch.1 and Ch.2 in parallel with both attenuators at the same sensitivity. Turn the time-base range switch fully clockwise to X-Y, pull out the horiz. position for X5 mag and switch Ch.2 off. A line will appear diagonally across the CRT. The input signal is being applied at identical sensitivity to X and Y inputs. Ch.1 is providing the vertical display and Ch.2 the horizontal. To position the horizontal display leave the Ch.2 control fully anti-clockwise switched off and use the horizontal position control to do the positioning.

NOTE: X-Y Displays should be contained on the 8 x 10cm area to eliminate distortion due to signal overdrive. For zero phase shift between the two traces at low frequencies, it is essential to use DC coupling for both Ch.1 & Ch.2. The chart following enables phase angles to be read off directly.

6.11 Z MODULATION:

Connect +5V 1kHz square wave to Ch.1, switch attenuator to 1V/cm. Set Ch.1 & Ch.2 displays one above the other. Now parallel the +5V signal into rear panel Z mod. socket. The top of each displayed wave will diminish in intensity and the Ch.2 trace will be broken into a series of light and dark sections. A positive going signal decreases the trace brightness. Input is DC coupled and will modulate from DC to over 10MHz. Z input is 10kΩ and approx. 20pF in parallel.

6.13 PHASE ANGLE CHART:



SIN Θ = B/A

(b)

A method of measuring the phase angle between two equal frequency sine waves is to apply one signal to Ch.1 and the second input to Ch.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.

7. MEASUREMENT OF VOLTAGE & TIME:

The following sections describe the method of making specific measurements with Model BWD 820 Oscilloscope.

Start with controls set as follows:-

All buttons out, time-base to 1mSec, Trigger Level to AUTO, Ch.2 turned to off.

7.1 MEASUREMENT OF DC (DIRECT) VOLTAGES:

Connect a probe, set to 1:1 to Ch.1 and switch the input to DC. For an initial test take a 1½V Dry Cell and set the attenuator to 0.5V vernier to CAL. Connect the ground end of the probe to the negative end of the cell, set the trace to the centre of the graticule, touch the probe tip to the positive end of the battery. The trace will move up 3cm, i.e. 3 x 0.5 = 1.5V. Now reverse the connection to the battery and note how the trace moves down 3cm. This illustrates how an oscilloscope can display positive or negative voltages or both simultaneously, e.g. when viewing a sine or square wave.

The DC input facility may be used to measure not only DC voltages, but also 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 paralleling effect of the 1MΩ input impedance of the oscilloscope with the external load must be taken into account when measuring high impedance points such as the gate of FET's or base of a transistor working with high value loads.

If a higher input impedance is required, use a BWD P32 or P40 10:1 probe to increase input to 10MΩ and 11pF.

7.2 MEASUREMENT OF AN AC (ALTERNATING) VOLTAGE:

Set the Ch.1 input switch to AC, the attenuator to 20V and the vernier to CAL. Connect the ground lead of a probe to the ground side of the signal to be measured, then connect the probe tip to the signal source. (Models BWD 112B, 141, 160A, 170 or 603B Oscillators are suitable for initial experiments in this test).

Increase the Vertical sensitivity by the Ch.1 VOLTS/CM switch until a display between 3 and say 8cm 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 cms 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 6cm 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 only) divide the p-p voltage by $2\sqrt{2}$ (approximately 2.83).

$$\frac{3.00}{2.83} = 1.06 \text{ volts rms}$$

7. MEASUREMENT OF VOLTAGE & TIME: (Cont'd)

7.3 To measure the Time Period of a waveform, set the Time-base Vernier to Cal (clockwise), then switch the SEC/CM switch to a range where the signal can be clearly seen, e.g. if a waveform is 5cm long and the switch is on 100μSec, then the duration of the waveform is 5 x 100μSec. The frequency is the reciprocal of the time and is obtained by dividing 1 Sec, i.e. 1,000,000μSec by the duration of the waveform.

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

7.4 CURRENT MEASUREMENTS AC or DC:

Where it is possible to place a low value resistor in the earthy end of a circuit, the current through this resistor can be found by measuring the voltage across it and converting it to current using Ohms Law. Using a 1Ω resistor, the attenuator calibrations read directly in mA or A in lieu of mV or V, when the oscilloscope is connected across it. The differential input facility also permits the measurement to be made across a resistor located anywhere in a circuit subject to the maximum common mode limits.

This will display AC or DC current 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 via the centre tap of a transformer, etc.

7.5 DIFFERENTIAL MEASUREMENTS:

Couple 1:1 probes to Ch.1 & Ch. 2 inputs and select AC input coupling. Both attenuators must be set to the same range and verniers should preferably be set to Cal or X2.5. The probes may now be connected across any piece of equipment to measure voltages up to the limit of the oscilloscope. If higher voltages require measuring, the 10:1 probe can be used, but both channels must have 10:1 probes. Due to differences in the probes, the common mode signal may only be reduced by a factor of 10. If DC coupling is selected, the DC common mode signal must not exceed X10 the attenuator range or the amplifiers will distort the waveform. All measurements are made as described in para 7.1 to 7.4.

7.6 TELEVISION WAVEFORM DISPLAYS:

Very stable displays of frame or line signals may be obtained by switching trigger coupling to T.V. With a positive video waveform displayed, select T.V. and +ve. If video is negative going then select -ve. The changeover from frame lock to line lock occurs at the 100μSec - 50μSec step on the time-base range switch.

To lock the signal to line frequency, set the Trigger Level to AUTO, then turn SEC/CM switch to 50μSec or above. Frame lock is provided at all time-base speeds below 100μSec/cm. Detailed examination of the frame pulse and following equalising pulses, etc., can be made at high time-base speeds and/or using the X5 magnification. As the repetition rate is only 50Hz or 60Hz, the trace intensity falls with increasing time-base speed. However, the high intensity CRT enables detailed observations to be readily made.

7. MEASUREMENT OF VOLTAGE & TIME: (Cont'd)

When observing colour burst or chrominance signals, pulse and T bar displays, measurement will be accurate as the vertical bandwidth is flat within 5% up to 10MHz for a 6cm display. Low level signals, such as those across the recording and playback heads of VCR's can be monitored, using the differential input and locking the low level signal by careful adjustment of the trigger level control.

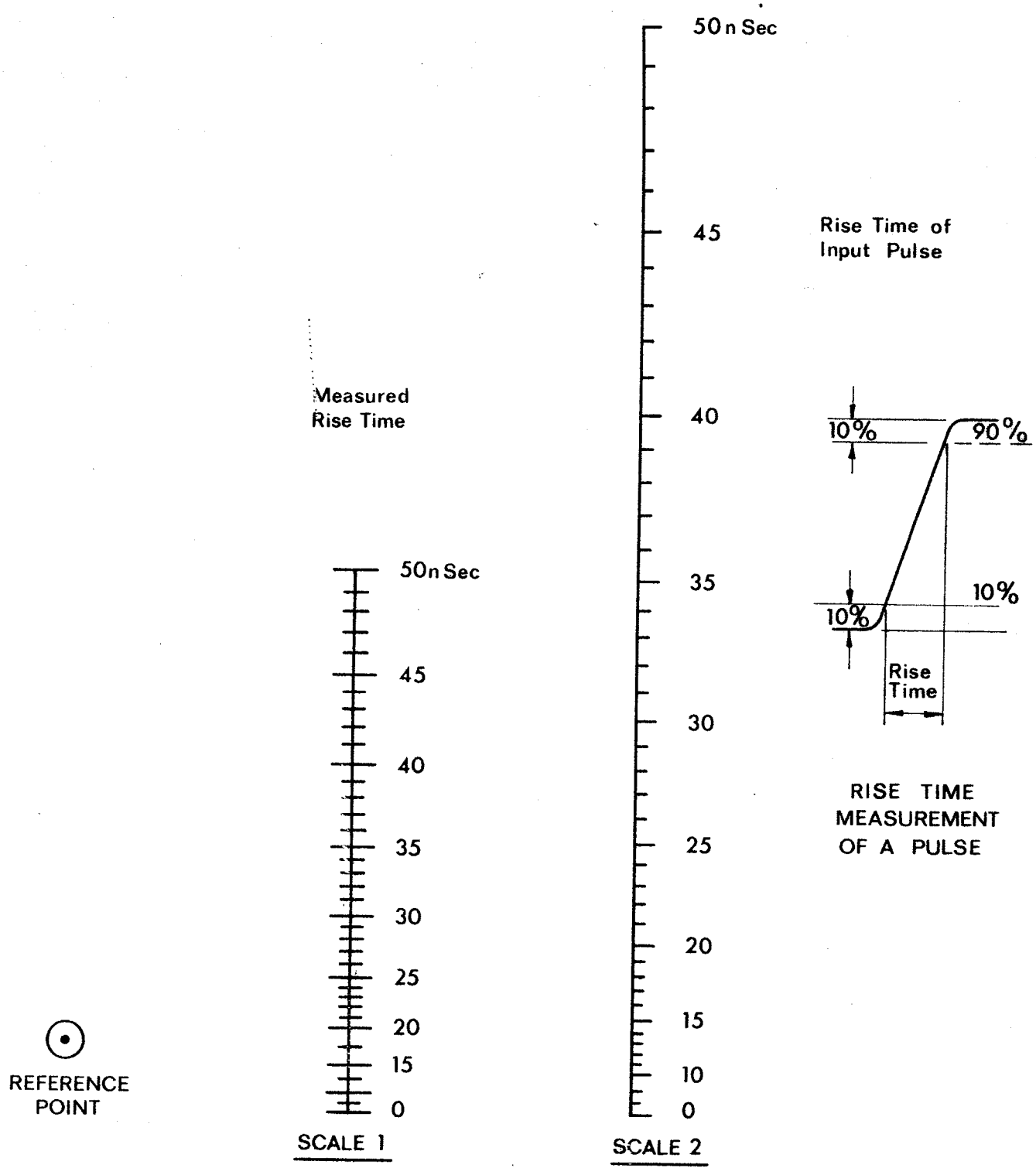
7.7 AC POWER LINE LOCK:

The rise and fall transition of the calibrate waveform correspond within 5^{o} to the zero crossover points of the instrument's power line waveform. If a link is placed between the Cal and Ext. trigger sockets, the time-base may be triggered by this waveform when the Ext. trigger select button is pressed. By also linking the Cal signal to one of the amplifiers, the time-base speed can be adjusted by use of the vernier to make a single displayed Cal waveform exactly 9cm long. This makes each cm equal to 40^{o}. Other ratios can be set up as required, e.g. with half the Cal waveform set to 9cm, each cm then equals 20^{o}. By using the ± trigger switch, either the first or second 180^{o} segment can be displayed.

When connecting to AC operated equipment to measure firing angles of triacs, etc., great care must be taken not to exceed either the oscilloscope or the coupling probe input voltage limitations. BWD P37, 100:1 probes are recommended for power line applications, or where high voltages are to be measured as they have a 1500Vpeak rating and an output resistance of 100MΩ.

7.8 EXTENDING THE USABLE CALIBRATED AMPLIFIER RANGE:

Calibration accuracy of any oscilloscope is only valid to approx. half the bandwidth limit as this is where the response starts to fall to its -3db level. To extend the accuracy of the BWD 820 to beyond the half bandwidth point the following amplifier response chart may be used to interpolate the real amplitude of the displayed waveform. NOTE: Signal amplitude should be kept below the 6cm response line for greatest accuracy.



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 1. Join this with a straight edge to the reference point at the left of the scale and project the line to the right, crossing Scale 2. The value shown by the intersection of the line and Scale 2 is the true risetime of the pulse.

8. CIRCUIT DESCRIPTION:

The circuit description is divided into the following sections:-

8.1 - 8.10	Attenuators & Vertical Amplifiers
8-11 - 8.15	Trigger & Time-base
8.16 - 8.19	X-Y & Horizontal Amplifier
8.20 - 8.21	Power Supplies
8.22 - 8.23	CRT, Z Modulation Amplifier & Calibrator

8.1 ATTENUATOR CH.1:

Input signals to Ch.1 BNC socket are connected to the attenuator via S1 input selector switch. In the DC position, signals pass directly to the attenuator or via C1 in the AC position. In the GND centre position, the input signal is disconnected, but the amplifier input is grounded. The attenuator switch S2A-C is in two sections. S2A & B attenuates the input in a 1,10,100,1000 sequence, whilst S2C attenuates the signal in a repetitive 1,2,5 sequence. The result of cascading the two sections is to attenuate signals in a 1,2,5,10 sequence over the 12 steps. As no attenuation takes place in the amplifier itself, problems of DC drift affecting the trace position when the attenuator is switched do not occur in the BWD 820. Response and constant input capacity is maintained at each attenuator step by adjustable series and shunt capacitors.

8.2 INPUT AMPLIFIER CH.1:

The input amplifier is a balanced FET differential stage. Input protection is provided by R101 & C101 and reverse biased diode D101 taken to -15V and D102 taken to +5.6V to prevent U101A gate from exceeding these limits. U101 A & B is a dual FET on a common substrate to minimise effects of temperature drift on the trace position. RV102 Vernier gain control is located between the FET sources. RV103 in parallel sets the minimum gain and is the 5mV/cm calibrate control. RV101 DC balance preset is adjusted for zero trace measurement when RV102 is varied.

The amplifier stage U102 is directly connected to U101A & B drains. The vertical position control RV104 and R109 & 110 limiting resistors are connected across them in such a way that movement of RV104 wiper changes the current balance in R106 & 107 and so superimposes a shift voltage on the signal.

RV105 sets the gain of amplifier U102 and is the 2mV calibrate control. Compensation C & R networks across RV105 correct for variations in the response.

8.3 BEAM SWITCH AMPLIFIERS:

A balanced output is taken from U102 to U103 beam switch amplifier and trigger output emitter follower. The amplifier transistors in U103 are connected as a series feedback pair with a gated transistor connected to the junction of R118 & 119 resistors between the amplifier emitters. RV106 & C108 provide additional high frequency compensation and R120 & TH101 correct for temperature gain variations.

8. CIRCUIT DESCRIPTION: (Cont'd)

Beam switching to select Ch.1 or Ch.2 is controlled by half of U161 'D' type flip flop. Ch.1 drive is via R116 to pin 12 of U103 and Ch.2 via R148 to pin 12 of U133.

The collectors of U103 and U133 amplifiers are joined together and then connected to the shunt feedback output amplifier. Thus the channel gated on supplies the drive and feedback current path to ground via either R117 or 152.

8.4 TRIGGER & 'X' AMPLIFIER OUTPUTS:

Trigger take-off from Ch.1 and Ch.2 is via emitter followers.

R114 is the emitter load of Ch.1, whilst a divider consisting of R145, R146, RV136 and R147 is Ch.2 emitter load. Ch.2 supplies the 'X' signal in the X-Y mode of operation which is centred about ground by a divider in which RV36 sets the zero level of the 'X' output voltage. As Ch.2 trigger signals are capacitively coupled to the trigger amplifier, they are taken from the top of the emitter follower load.

8.5 CH.2 AMPLIFIER:

The only difference between Ch.1 and Ch.2 amplifiers is the inclusion of a switch in series with RV134 vertical position control. This open circuits the position control when Ch.2 is turned off to prevent the trigger signal or 'X' output from being biased to one side. R142 provides a preset centering voltage to ensure that maximum output from U131 is available.

8.6 BEAM SWITCH GENERATOR:

At time-base speeds from 1Sec to 2mSec/cm the beam switch operates in the Chopped mode at approx. 250kHz.

U161 quad NOR gate sections A B & C are connected as a free running 250kHz oscillator, producing a square wave at pin 10 of gate C. In this condition, pin 1 of gate A and 12 of D are held LO except during return trace when the blanking pulse from Q302 via D310 forces pin 1 & 12 HI. However, from 1mSec to 200nSec wafer S303A of the time-base switch grounds the inputs to gate A of U303, forcing its output HI.

This takes pins 1 & 12 of U161 HI and stops the gates A, B & C from oscillating. In this Alternate mode positive pulses from U303D time-base gate whose leading edge is coincident with the CRT blanking pulse is connected to pin 6 of U161 gate B, thus each time a pulse appears, a positive output occurs at gate C, pin 10.

The Alternate or Chopped pulses at pin 10 are taken to one half of U162 dual 'D' flip flop at pin 11 and whilst pin 8 is held LO, the flip flop will operate as a bistable switch, changing over the outputs on 12 & 13 alternately on each pulse received.

8. CIRCUIT DESCRIPTION: (Cont'd)

8.7 CH.1 ONLY OPERATION:

When Ch.1 only is required, S131A is opened allowing R169 to pull pin 8 of U161 and 162 HI via D162. This prevents U161 acting as an oscillator, or from passing the alternate pulses to U162 and latches U162 with pin 13 HI and pin 12 LO, so that Ch.1 only is connected to the output amplifier.

8.8 DIFFERENTIAL OPERATION:

Both Ch.1 and 2 are turned on for this mode and this is enabled by S161C switch which takes pin 10 of J162 HI and via R170 pin 8 follows. If S131A is closed, D162 is reverse biased and permits pin 8 of both U161 and 162 to rise, so disabling U161. With pins 8 and 10 HI, pins 12 and 13 will both be HI, coupling Ch.1 and 2 to the output amplifier. S161 A & B reverse the polarity of Ch.2 signal, to provide the differential amplifier operation.

S161D connects R121 & 122 to the +101V rail via RV107 to supply the additional current drawn by the second amplifier.

8.9 CHOPPED BLANKING:

When U161 is oscillating, the waveform at the junction of R166 & 167 is taken via C163 to the inputs of gate D to produce a narrow positive pulse at pin 11 output, corresponding with the chopped beam switching transition. This is coupled to the cathode of diode D430 to blank the CRT grid through the Z amplifier, and eliminate smear between the traces.

8.10 OUTPUT AMPLIFIER:

Q201, 202, 203 & 204 are connected as a symmetrical push/pull constant current shut feedback stage. Current through the transistors is set by the emitter and base resistors of PNP stages Q201 and 204.

A current equal to this is also supplied by resistors R201 and 211 to the feedback resistors R205 and 215, which are connected to the output collectors of Q201-202 and 203-204. The current flows through R205 and 215 in the quiescent state as the amplifiers in U102 or 132 pass the same current that flows through R201 and 211. Signal drive to Q202 and Q203 bases is supplied via zener diodes D202 and 204 by-passed by C202 and 206 for high frequencies. Q201 and 204 provide the standing current at low frequencies, but at high frequencies, capacitors C203 and 208 drive the bases so they pull up the signal and provide a push/pull drive to the deflection plates on each side.

8.11 BEAM ROTATION AND ASTIGMATISM CONTROLS:

Mounted on the same board as the output amplifier on the rear panel is RV221 and 222. RV221 varies the current passing through the beam rotation coil from the +101V rail to the amplifier stage and so rotates the CRT beam, enabling it to be aligned with the graticule. RV222 sets the astigmatism voltage applied to pin 4 of the CRT.

8.12 TRIGGER & TIME BASE:

Trigger:

S301A selects Ch.1 or 2 as the internal trigger source which is then coupled to S301B Internal or External source selector. External signals are applied via C325 and R304-C303 in parallel to S301B.

The selected signal is applied to U301 emitter follower transistor U301A, which feeds the signal to the + and - polarity switch S301C. Also applied to S301C is the output of emitter follower transistor U301D. When AUTO is selected, S302A is open circuit, so that the standing voltage on the base of U301D is set by the base current through R316. R301 and RV308 in the base return of transistor U301A is adjusted for an identical base voltage for max trigger sensitivity and to ensure good thermal stability in the AUTO mode.

When Level Select is employed, S302A closes and approx. one eleventh of the voltage on RV302 is applied to U301D base.

Transistors U301 B & C are a differential pair whose bases connect to the + & - switch. When + is selected, the input signal passes to U301C and the level voltage to U301B. The reverse applies when - is selected. Current through the differential pair is set by R306 and RV301 emitter load.

8.13 TRIGGER LATCH:

U301 B & C collectors are taken to inputs of two OR/NOR ECL gates U302 wired with R303 and R310 to provide positive feedback from the OR outputs to the same input pin as the transistor collectors. RV301 is adjusted so that the current through R303 and R310 when no signal is present, is just above the input threshold of each gate.

When a positive signal appears at the trigger input, it will cause U301C to conduct, taking current away from U301B. However, it will not cause U302B to conduct, as another input at pin 4 is held HI by the output of U302A. When the signal swings negatively, U301B conducts and assuming pin 13 is low, the current through R303 will cause the U302A gate to conduct. Its output will fall and via R303 it will latch the gate in a LO state. This now releases pin 4 of U302B gate, so that the next positive swing of the trigger signal makes gate U302B latch and both gates will remain in this condition until reset.

Both the OR & NOR outputs of U302B are taken to Q301. When awaiting a trigger signal the OR output is positive to the NOR output and Q301 is reverse biased. When U302B latches, the outputs change over and Q301 is pulled into conduction, its collector rises pulling Q302 into conduction via base drive resistor R321, gating the time-base on.

8. CIRCUIT DESCRIPTION: (Cont'd)

8.14 TV TRIGGER:

When S301D is selected, a sync separator U301E is brought into operation to strip the sync pulses from the video waveform. U301C collector is switched from U302B gate to a collector load R313 and the signal developed across this is AC coupled to U301E via C308. It is biased on by R315 so that negative going video signals will bias the transistor beyond cut-off and only sync signals will appear at its collector to latch U302B gate to which it is connected. C307 from time-base switch wafer S303A to U301E collector removes the high frequency line pulses from .2Sec to 100µSec time-base speeds. From 50µSec to 200nSec, S303A is not in circuit, so that the line pulses provide the trigger. R309 provides an offset bias to increase the dynamic range of the sync circuit in the Auto mode.

8.15 TIME BASE:

U304 is a BIFET op-amp operating as an integrator with the timing capacitors connected between the output at pin 6 and the inverting input at 2 to which the timing resistor R333A is also joined.

Operation is as follows:

Pin 3 of U304 is grounded by S303A and pin 2 is connected by R333 to a negative voltage on RV304 time-base vernier control. As pin 2 is pulled negatively, the output on 6 will rise. However, the timing capacitors C316A-D are also connected between 6 and 2, so that any change on 6 will be fed back to 2 as negative feedback. As the gain of U304 is very high, the effect of the feedback will be to generate an extremely linear sawtooth waveform.

The output will continue to rise to approx. +12V when the rise in voltage at the junction of R334 and R329 causes gate U303C to switch its output LO. The U303D input follows and its output at pin 11 goes HI. This output controls several circuits.

Via C314 U303D output pulls pin 8 of U303C HI and via R329 pin 9 is also taken HI, latching the output of U303D HI.

The ECL trigger latch is released by inputs 13 and 5 being taken above the threshold voltage. In turn Q301 is cut off removing Q302 base drive, so that its collector rises. This rise causes D303 to conduct via R325, pulling pin 2 positive so the output of U304 falls until D304 conducts at approx. zero volts. Current flows through D304 and between the base and emitter junction of Q303, pulling the junction of R325 and D303 down until pin 2 of U304 is at zero volts. A quiescent condition then exists, with the output of U304 pulling down an equal current to that pulled up by the resistor divider R323 and R325.

When Q303 base current flows, the transistor conducts and collector current flows through R326 and R329 until the junction of the resistors at pin 9 of U303C falls below the threshold, releasing one gate input.

8. CIRCUIT DESCRIPTION: (Cont'd)

The second input at pin 8 has a hold-off network associated with it. C314 capacitor provides hold-off from 20µSec to 200nSec/cm, C312 from 2mSec to 50µSec/cm and C313 from 1Sec to 5mSec/cm. The capacitors are charged up by the output of U303D directly or via D302, but cannot discharge via R327 and 328 until Q303 has pulled the junction of R326 and R328 below the gate threshold. They then discharge, pulling the second input to U303C LO. Its output rises taking the input of U303D with it. U303D output falls, releasing U302 in readiness for the next trigger signal to repeat the process again.

8.16 AUTO TRIGGER:

When operating with a continuous trigger source, Q301 conducts at the start of each sweep to initiate the time-base. It also charges C311 via D301, holding input 5 of U303B HI. Therefore, the output at 4 is LO and does not affect the transistor Q302. However, when a trigger signal is not present, Q301 does not conduct and C311 discharges through R318, pulling input 5 of U303B LO. As input 6 is held LO by U303D, the output at 4 will rise and via R320 will pull Q302 into conduction, initiating a time-base sweep. At the end of the sweep as previously described, U303D output rises and in addition to the hold-off function also takes pin 6 of U303B HI, causing its output to fall, so removing the base drive from Q302, allowing the return trace to start.

When the return trace and hold-off period is finished, U303D output falls, pulling pin 6 LO and unless a trigger signal has been received to charge up C311, the LO at input 5 will cause the output at 4 to rise, initiating another sweep.

8.17 UNBLANKING AND ALTERNATE DRIVE:

The output of U303D provides the alternate drive for the vertical amplifier beam switch into U161B, pin 6.

Time-base unblanking pulse to the CRT 'Z' amplifier input at the junction of D430 and R443/444 is taken from the collector of Q302 via R324.

8.18 X-Y OPERATION:

When the time-base switch S303 is turned fully clockwise to the X-Y position, the following changes occur in the time-base circuit to convert it to a wide band amplifier.

The timing capacitors C316 are replaced with a resistive feedback network consisting of R339 and RV306. R340 provides a centering voltage. The junction of R339 and RV306 are taken to S303A front wafer, where the rotor contact connects it back to S303B rear wafer and then via the wiper arm to U304 inverting input. RV306 adjusts the loop gain to approx. X2 and sets the X calibration.

The X signal from Ch.2 is taken from the junction of R146 and RV136, the latter being the horizontal centering preset, to pin 2 of U304. Normally this rail is grounded by S303A wafer, but is disconnected in the X-Y position.

8. CIRCUIT DESCRIPTION: (Cont'd)

Therefore, signals from Ch.2 are amplified by U304 and applied to the horizontal amplifier input via RV305 and R336 in the same manner as the time-base sweep waveform.

8.19 TIME-BASE OR CH.2 OUTPUT:

In the time-base mode the sawtooth output is available at the rear panel via R335 and Ch.2 signal is available in the X-Y mode at approx. 200mV p-p/cm of deflection on a standing DC voltage of approx. +6V.

8.20 HORIZONTAL AMPLIFIER:

Transistors Q304-309 are configured in a push/pull series - shunt feedback circuit.

Input is applied to Q304 on one side of the balanced amplifier and the horizontal position voltage from RV309 to Q305 on the other side. The collector signals are developed across R349 and R350 and applied directly to Q307 and Q308 bases. The collector load for Q307 is R346 and R347, whilst R348 is Q308 load. Emitter followers Q306 and Q308 feed the CRT X plates and also supply the negative feedback current through R344 and R345 back to Q304 & Q305 emitters.

Horizontal magnification is controlled by emitter resistors R343 (X1) and RV307 for X5.

8.21 POWER SUPPLIES:

AC input voltage is taken to S401 on-off power switch (located on the rear of RV425 intensity control).

It then passes through input fuse F401 to the transformer T401. The two primary windings are connected in series for 200 to 270V operation and in parallel for 100 to 135V. The centre tapped secondary winding is full wave rectified to supply + & - 22V (approx.) C401 filters the +ve rail and C402 the negative. The rails are stabilised by U401 & U402 to provide + & - 15V for direct connection to the amplifier and time-base circuits and via resistors R421 and R422 with additional filtering by C421 to the DC to DC converter circuit.

8.22 DC-DC CONVERTER:

The +101V, EHT rails and CRT heater supply are supplied from T421 transformer. This circuit uses a push/pull direct drive feedback oscillator operating at 22kHz approx., consisting of Q421 and Q422 transistors with R424 and R423 base supply divider. The +101V HT supply is full wave rectified by D421 and D422 and filtered back to the +15V rail to which the winding is connected. Additional filtering is by R425 and C323.

8. CIRCUIT DESCRIPTION: (Cont'd)

The negative EHT winding is half wave rectified by D425 and filtered by C430, R427 and C431 before being applied to the CRT cdthode. To provide additional stabilisation of the -1275V rail the ground end of the EHT winding is taken through transistor Q423 to the -15 rail. The negative EHT voltage is applied across the divider R429, R430 and RV421 and then returned to the +101V rail. Any variation at the junction of R429 and R430 is fed to Q424 base and then via its emitter to Q423 base to control its conduction and so stabilise the supply against changes in beam current.

The PDA voltage is obtained by a voltage doubler C427, D424 and D423 which is returned to the +101V rail. The +2900V supply is filtered by C428, R428 and C429 and supplied to the PDA CRT side connector.

8.23 CRT & Z MODULATION AMPLIFIER:

The 130BT mesh PDA CRT is supplied by the -1275V rail directly to its cathode. Its grid voltage is obtained by demodulating a signal derived from the 22kHz converter winding. Focus voltage is tapped off the divider R432, RV423 and R431. Geometry astigmatisms and A1 voltages are taken from low voltage rails or from preset potentiometers connected across them.

The Z or intensity modulation circuit derives its voltage from the +101 volt transformer output winding. It is taken through R436 to D429 which through R422 preset sets the maximum modulation voltage available to blank the CRT.

Q425, Q426 and Q427 modulation amplifier is a shunt feedback stage. Q425 supplies a constant current at low frequencies, but Q427 emitter follower drives both Q426 amplifier directly and Q425 via C436 at high frequencies to provide a push/pull drive. Input signals to Q427 base are supplied via D430 to prevent Q426 amplifier from saturating. Four signals - intensity voltage, external Z input, time-base blanking via R324 and chopped blanking via R165 are combined at the current input drive to Q427.
The combined current drive from the signals causes Q426 collector to swing from approx. +5V to +50V to modulate via D428 the clipped 22kHz square wave at R436 and D429 junction.

High frequency modulation signals drive the CRT grid directly via C433 and low frequency modulated signals are supplied by C432 to D426 and D427 demodulator diodes.

D426 conducts on positive signals DC restoring the waveform to the CRT cathode which is then conducted via D427 to combine with the AC coupled component at the CRT grid.

8.24 CALIBRATOR:

The second 'D' flip flop in U162 has the 17V AC transformer secondary voltage applied to the 'S' input via divider R171 and R172 which also centres the voltage about the threshold level. The resulting rectangular waveform at the Q output pin 2 is taken to RV161, where it is preset to 1V p-p and connected to the front panel socket.

9. ADJUSTMENTS AND MAINTENANCE:

To maintain the BWD 820 in full calibration, a number of preset controls may require periodical adjustment as detailed in the following section.

Before removing the covers, disconnect the instrument from the mains. Remove the two screws holding the handle and loosen the feet screws. The covers may then be slipped off. Remove the feet to take off the bottom plate.

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

9.1 ALIGNMENT PROCEDURE:

Before attempting re-alignment of any section of this oscilloscope, check the instrument's general operating characteristics and correct any apparent faults. Also check DC rails as variation in supply voltages caused by a fault may result in miscalibration.

9.2 GENERAL CHECK OF CONTROLS:

(a)	Intensity:	Linear control over intensity range.
(b)	Focus:	Approx. centre with adjustment either side.
(c)	X1 - X5 Hor. Mag.:	Trace should expand equally either side of centre.
(d)	Vert. Positions:	Traces should move completely off screen above and below centre.
(e)	Trigger Level:	With atten. at 0.2V feed CAL signal into Ch.1 and Ch.2 inputs, check AUTO and Level Select operation.
(f)	+ - Switch:	Set up as for (e), trigger point should change over as indicated by switch.

9.3 EQUIPMENT REQUIRED FOR COMPLETE CALIBRATION:

DVM with High Voltage Probe
Pulse Generator <10nSec Rise Time
Voltage Calibrator 10mV to 100V p-p 0.5% accuracy
Sine Wave Generator 1Hz to 1MHz (BWD 141 or BWD 160A)
Constant Amplitude Generator 50kHz to 50MHz
Time Marker Generator 100nSec to 1Sec/pulse

9.4 CRT TRACE ALIGNMENT:

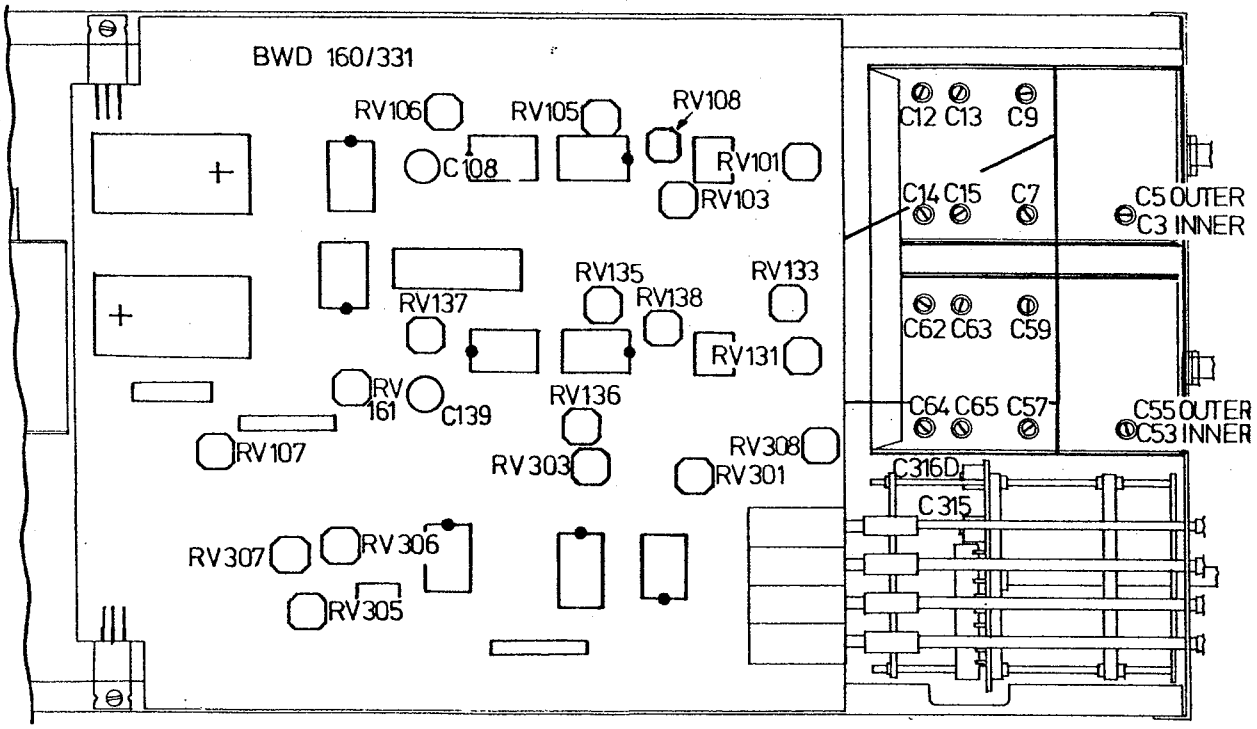
Trace rotation preset on rear panel should be set so that a single undeflected trace aligns precisely with the horizontal centreline of the graticule.

Next feed a 1kHz sine wave signal into the Ch.1 and adjust the waveform to fill screen. Time-base to 1mSec, VERNIER CAL.

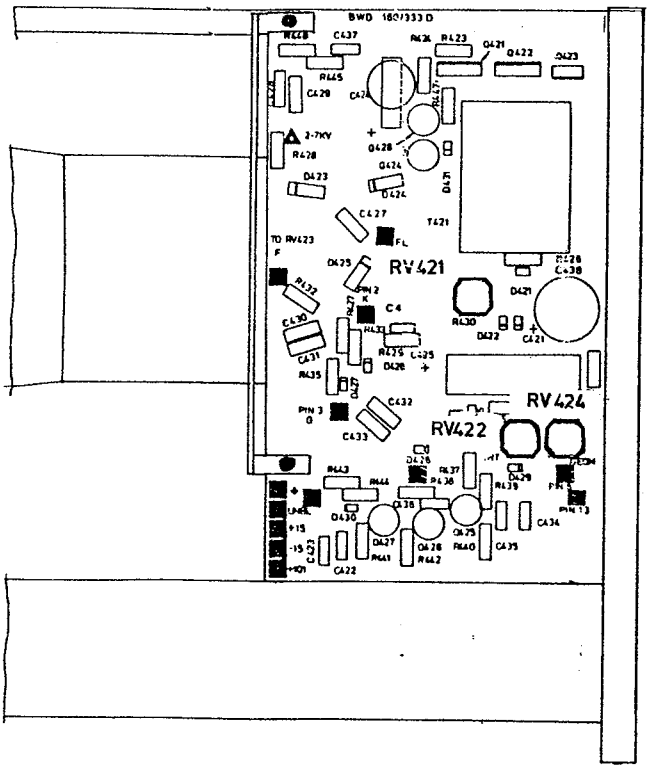
9. ADJUSTMENTS AND MAINTENANCE: (Cont'd)

Rear panel astigmatism preset control is adjusted in conjunction with the FOCUS control to obtain the best resolution over the entire screen area at normal viewing intensity.

RV424 on converter power supply board adjusts the pattern geometry. With the 1kHz sine wave displayed, reduce the time-base to 5mSec/cm, then adjust display for minimum of pin cushion or barrel distortion with RV424.



BOTTOM VIEW



R.H. REAR VIEW

9. ADJUSTMENTS AND MAINTENANCE: (Cont'd)

9.5 EHT SETTING:

NOTE:

The PDA (+2.8KV) voltage remains after the instrument has been switched off as the only discharge path is reverse diode or filter capacitor leakage.

Therefore discharge the PDA supply on the rear converter power supply board before working on it via a 1MΩ resistor to chassis -

NEVER DISCHARGE DIRECTLY TO CHASSIS VIA A SCREWDRIVER, ETC. AS THIS MAY DAMAGE THE INSTRUMENT.

With the Oscilloscope switched off, connect a high voltage DVM probe to the Brown CRT cathode lead connector on the power supply board and connect the low side of the DVM to chassis.

Switch on and set the -ve EHT voltage to -1275V (+0 -10V) by RV421. Switch instrument off and disconnect probe.

9.6 VERTICAL ALIGNMENT:

(a) Centre the trace with the vernier at CAL, then turn the vernier control to X2.5. If the trace moves, recentre it with RV101 for Ch.1 and RV131 for Ch.2. Return vernier to Cal and repeat adjustment of RV101 and RV131 until no movement occurs.

(b) Switch to Ch.1 only. Turn vernier to X2.5 (fully clockwise) and attenuator to 5mV/cm. Feed in a 1kHz 10mV p-p calibration square wave. Adjust RV105 for 5cm deflection.

(c) Turn the vernier control to CAL (counter clockwise). Increase the input signal to 25mV p-p. Now adjust RV103 for 5cm deflection. Recheck 9.6(a).

(d) Repeat (b & c) for Ch.2, setting RV135 for 2mV sensitivity and RV133 at 5mV/cm.

(e) With attenuators at 5mV and vernier to CAL apply a correctly terminated 1MHz <10nSec rise time square wave to Ch.1 input. Set amplitude for 6cm deflection. Adjust RV106 and C108 for best square wave response with a sharp wave front, but minimum aberation at the corner.

Repeat for Ch.2 adjusting RV137 and C139.

(f) Bandwidth check. Apply a 50kHz reference sine wave to Ch.1. Set attenuator to 5mV/cm. Set amplitude to 6cm. Increase oscillator frequency. Amplitude should not drop below 4.2cm deflection (-3db) at 25MHz. Repeat for Ch.2.

9. ADJUSTMENTS AND MAINTENANCE: (Cont'd)

(g) Repeat (f) with vernier to X2.5. Level should not drop below 4.2cm from a 6cm reference before 15MHz.

(h) Operate instrument in Auto mode with no input. Superimpose Ch.1 and Ch.2 on the graticule centreline. On the rear panel output board, measure the voltage to chassis at the connectors of the Figure 8 pair of wires from the main board. Press the Differential push button. Measure the voltage again and adjust R107 rear of main board to equilise it with the voltage in the dual trace mode.

9.7 ATTENUATOR ALIGNMENT:

The following figures indicate the input voltages, attenuator settings and the capacitors, which compensate the attenuator response. Figures in brackets are for Ch.2.

Attenuator steps not listed have no adjustment. They are automatically aligned at other settings.

Attenuator Setting	Input Voltage	Adjust for Square Wave	Adjust for Input Capacitance
0.005	-	- -	-
0.01	50mV	C14 (64)	-
0.02	100mV	C12 (62)	-
0.05	250mV	C7 (57)	C9 (59)
0.1	0.5V	C15 (65)	-
0.2	1V	C13 (63)	-
0.5	2.5V	C3 (53)	C5 (55)

9.8 CALIBRATOR ADJUSTMENT:

When Ch.1 is correctly calibrated against an external standard, set its attenuator to 0.2V. Feed in the 1V CAL Signal, input switched to DC, then adjust RV161 at rear of main board for 5cm deflection. If a calibration voltage other than 1V p-p is required, RV161 has a range from 0 to 5V p-p.

9.9 TIME-BASE ALIGNMENT:

(a) Set time-base range switch to 5mSec, Vernier anti-clockwise. Set trace length to 10.5cm (RV305).

(b) Set time-base to 1mSec, vernier to CAL (fully clockwise). Feed in 1mSec pulses. Adjust No. 1 pulse to correspond with 1st graticule line. Adjust RV303 for 1 pulse/cm.

(c) Turn time-base to 5mSec/cm. Feed in 5mSec pulses. Check for 1 pulse/cm.

9. ADJUSTMENTS AND MAINTENANCE: (Cont'd)

(d) Turn time-base to 20μSec/cm with 20μSec pulses. Adjust C316D on rear to time-base switch for calibration. Check calibration from 10μSec to 1μSec and set C316D for best overall calibration accuracy if slight variations occur between steps.

(e) Turn time-base to 0.2μSec/cm. Adjust C315 on rear of time-base switch for calibration with 0.2μSec pulses displayed for 1 per cm.

9.10 X5 MAG:

With the time-base set to 1mSec, vernier to CAL, switch to X5 Mag. Feed in 0.2mSec pulses. Adjust RV307 for 1 pulse/cm.

9.11 X-Y ADJUSTMENT:

a) Switch Ch.2 off (vert position fully counter clockwise). Position Ch.1 trace in centre of screen (AUTO operation, no input signal). Now turn time-base switch to X-Y position and select X5 MAG. Without touching front panel controls, centre spot horizontally with RV136.

Next, set both attenuators to 5mV/cm, vernier to Cal and apply a 1kHz sine wave to Ch.1 and Ch.2 inputs - DC coupled.

Adjust RV306 for identical horizontal deflection to vertical deflection.

b) Phase Shift. Feed in constant amplitude generator to both Ch.1 and Ch.2. Both attenuators to 5mV/cm. Input should be 1kHz, set for 6cm deflection, both vertically and horizontally, to produce a diagonal line on the CRT. Increase input frequency to 100kHz.

The diagonal line should be <2mm apart at the centre, indicating <2% phase shift.

(c) Horizontal Bandwidth. Switch Ch.1 to GND to leave a horizontal line on the CRT. From a reference of 50kHz at 6cm, the trace should not drop below 4.2cm before 1MHz.

9.12 TRIGGER SENSITIVITY:

a) Operate the oscilloscope in the dual trace mode with the time-base at 5mSec/cm, normal +ve internal trigger with level select knob approx. centred. Connect a 50Hz sine wave to Ch.1 and adjust for 1cm deflection. Lock trace with trigger level control. Now reduce signal amplitude adjusting RV301 to maintain a stable lock with no double triggering until a deflection of <0.5cm can be locked. Change the frequency and polarity to ensure double triggering does not occur.

(b) Leave the amplitude at the minimum trigger sensitivity and turn to AUTO operation. Adjust RV308 for maximum sensitivity and when the + & - switch is changed over.

Trace should remain locked over a frequency range from <10Hz to 20MHz with 1cm deflection. When signal level increases to 2cm or greater, upper frequency limit will extend past 30MHz.

(c) Revert to level select operation. Stable locking at 1cm deflection will extend from 3Hz to over 25MHz and an increase to 2cm will increase the upper range to over 40MHz.

(d) With a 50kHz sine wave input, increase deflection to 8cms. Check that level control operates over the full range when either + or - polarity is selected.

(e) Parallel the input signal via a T-piece to both Ch.1 and EXT TRIG input socket. Select EXT TRIG, then adjust signal level to 1V p-p. EXT TRIG should operate from 10Hz to 25MHz and from 3Hz to 40MHz when the input level is increased to 2V p-p or greater.

9.13 T.V. TRIGGER:

Apply a composite video waveform to Ch.1. Adjust amplitude for >2cm deflection, time-base to 2mSec, TV trigger button selected, Trigger Level to AUTO. The frame signal will be displayed. Increase amplitude to 8cm and display will still be locked. Increase time-base speed to 50µSec or faster and the line signal will be displayed. Trigger Level may be employed to lock video signals <2cm or >8cm deflection.

The BWD 820 Oscilloscope is now fully aligned.

10. REPLACEMENT PARTS & GUARANTEE:

10.1 Spares are normally available from the manufacturer BWD Instruments Pty. Ltd. When ordering it is necessary to indicate the model and 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.

10.2 Many of the semiconductors in Model BWD 820 have been factory selected for the particular position they occupy. It is most important that the handbook parts list be consulted before replacing any semiconductors since selected or matched devices can be obtained ONLY from the manufacturer BWD Instruments Pty. Ltd.

10.3 As the policy of BWD Instruments Pty. Ltd. 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.

10.4 GUARANTEE:

The equipment is guaranteed for a period of twelve (12) months from the date of purchase against faulty materials and workmanship.

Please refer to the Guarantee Registration Card which accompanied the instrument, for full details of conditions of warranty.

11. PARTS LIST:

COMPONENT DESIGNATIONS:

A	Assembly	J	Jack (Socket)	S	Switch
C	Capacitor	L	Indicator	T	Transformer
D	Diode	P	Plug	TH	Thermistor
E	Misc. Elec. Part.	Q	Transistor	U	Integrated Circuit
F	Fuse	R	Resistor	VDR	Volt Dependent Resistor
H	Heater	RV	Variable Resistor		

ABBREVIATIONS:

Amp	Ampere	MHT	Polyester/Paper Capacitors
cc	Cracked Carbon	MPC	Metalised Polyester Capacitor
CDS	Ceramic Disc	NPO	Zero Temperature Co-efficient
cer	Ceramic	pF	Pico Farad = 10^{-12}F
DPST	Double Pole Single Throw	preset	Internal Preset
DPDT	Double Pole Double Throw	PYE	Polyester
elec	Electrolytic	pot	Potentiometer
FET	Field Effect Transistor	PCB	Printed Circuit Board
kHz	kilohertz = 10^3Hz	PIV	Peak Inverse Voltage
kΩ	Kilohm = $10^3\Omega$	PYS	Polystyrene
lin	Linear	p-p	Peak to Peak
Log	Logarithmic Taper	rot	Rotary
m	Milli = $x10^{-3}$	rms	Root Mean Squared
MHz	Megahertz = 10^6Hz	si	Silicon
MF	Metal Film Resistor	Ta	Tantalum
MG	Metal Glaze Resistor	trim	Trimmer
mA	Milliampere = 10^{-3} Amp	V	Volts
MΩ	Megohm = $10^6\Omega$	var	Variable
mfr	Manufacturer	W	Watt

MANUFACTURER'S ABBREVIATIONS:

AC	Allied Capacitors	MOT	Motorola
BWD	BWD Instruments Pty. Ltd.	NS	N.S. Electronics
ELNA	Elna Capacitors	PH	Philips Industries Ltd.
F	Fairchild	PI	Piher
HIT	Hitachi	PL	Plessey
IRH	IRH Components	SIEM	Siemens Industries
McM	McMurdo Aust.	SON	Soanar Electronics
		STE	Stettner Capacitors Ltd.

When the manufacturer's code is omitted, any suitable component corresponding to the specified device may be used.

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
	RESISTORS					
R1	12Ω	5%	1/4W	MF or MG		
R2	990k	1%	1/4W	MF or MG		
R3	10k1	1%	1/4W	MF or MG		
R4	111k	1%	1/4W	MF or MG		
R5	900k	1%	1/4W	MF or MG		
R6	500k	1%	1/4W	MF or MG		
R7	47Ω	5%	1/4W	MF or MG		
R8	750k	1%	1/4W	MF or MG		
R9	47Ω	5%	1/4W	MF or MG		
R10	333k	1%	1/4W	MF or MG		
R11	1M	1%	1/4W	MF or MG		
R12	1M	1%	1/4W	MF or MG		
R13	47Ω	5%	1/4W	MF or MG		
R14	220k	5%	1/4W	MF or MG		
R51	12Ω	5%	1/4W	MF or MG		
R52	990k	1%	1/4W	MF or MG		
R53	10k1	1%	1/4W	MF or MG		
R54	111k	1%	1/4W	MF or MG		
R55	900k	1%	1/4W	MF or MG		
R56	500k	1%	1/4W	MF or MG		
R57	47Ω	5%	1/4W	MF or MG		
R58	750k	1%	1/4W	MF or MG		
R59	47Ω	5%	1/4W	MF or MG		
R60	333k	1%	1/4W	MF or MG		
R61	1M	1%	1/4W	MF or MG		
R62	1M	1%	1/4W	MF or MG		
R63	47Ω	5%	1/4W	MF or MG		
R64	220k	5%	1/4W	MF or MG		
R101	220k	5%	1/4W	MF or MG		
R102	390Ω	5%	1/4W	MF or MG		
R103	10k	5%	1/4W	MF or MG		
R104	10k	5%	1/4W	MF or MG		
R105	33Ω	5%	1/4W	MF or MG		
R106	620Ω	1%	1/4W	MF or MG		
R107	620Ω	1%	1/4W	MF or MG		
R108	220Ω	5%	1/4W	MF or MG		
R109	47k	5%	1/4W	MF or MG		

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
	RESISTORS (Cont'd)					
R110	47k	5%	1/4W	MF or MG		
R111	1k	5%	1/4W	MF or MG		
R112	680Ω	5%	1/4W	MF or MG		
R113	82Ω	5%	1/4W	MF or MG		
R114	10k	5%	1/4W	MF or MG		
R115	33Ω	5%	1/4W	MF or MG		
R116	390Ω	5%	1/4W	MF or MG		
R117	330Ω	5%	1/4W	MF or MG		
R118	150Ω	5%	1/4W	MF or MG		
R119	150Ω	5%	1/4W	MF or MG		
R120	470Ω	5%	1/4W	MF or MG		
R121	10k	5%	1W	MF or MG		
R122	10k	5%	1W	MF or MG		
R123	8k2	5%	1/4W	MF or MG		
R124	680Ω	5%	1/4W	MF or MG		
R131	220k	5%	1/4W	MF or MG		
R132	390Ω	5%	1/4W	MF or MG		
R133	10k	5%	1/4W	MF or MG		
R134	10k	5%	1/4W	MF or MG		
R135	33Ω	5%	1/4W	MF or MG		
R136	620Ω	1%	1/4W	MF or MG		
R137	620Ω	1%	1/4W	MF or MG		
R138	220Ω	5%	1/4W	MF or MG		
R139	47k	5%	1/4W	MF or MG		
R140	47k	5%	1/4W	MF or MG		
R141	1k	5%	1/4W	MF or MG		
R142	33Ω	5%	1/4W	MF or MG		
R143	680Ω	5%	1/4W	MF or MG		
R144	82Ω	5%	1/4W	MF or MG		
R145	2k7	5%	1/4W	MF or MG		
R146	6k8	5%	1/4W	MF or MG		
R147	10k	5%	1/4W	MF or MG		
R148	390Ω	5%	1/4W	MF or MG		
R149	150Ω	5%	1/4W	MF or MG		
R150	150Ω	5%	1/4W	MF or MG		
R151	470Ω	5%	1/4W	MF or MG		
R152	330Ω	5%	1/4W	MF or MG		
R153	8k2	5%	1/4W	MF or MG		
R154	680Ω	5%	1/4W	MF or MG		

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
	RESISTORS (Cont'd)					
R161	390Ω	5%	1/4W	MF or MG		
R162	33Ω	5%	1/4W	MF or MG		
R163	47k	5%	1/4W	MF or MG		
R164						
R165	4k7	5%	1/4W	MF or MG		
R166	10k	5%	1/4W	MF or MG		
R167	10k	5%	1/4W	MF or MG		
R168	10k	5%	1/4W	MF or MG		
R169	15k	5%	1/4W	MF or MG		
R170	56k	5%	1/4W	MF or MG		
R171	56k	5%	1/4W	MF or MG		
R172	56k	5%	1/4W	MF or MG		
R201	5k1	1%	1/4W	MF or MG		
R202	15k	5%	1/4W	MF or MG		
R203	82k	5%	1/4W	MF or MG		
R204	22k	5%	1/4W	MF or MG		
R205	3k3	5%	1/4W	MF or MG		
R206	33Ω	5%	1/4W	MF or MG		
R207	1k8	5%	1/4W	MF or MG		
R208	470Ω	5%	1/4W	MF or MG		
R209	39Ω	5%	1/4W	MF or MG		
R210	15k	5%	1/4W	MF or MG		
R211	5k1	1%	1/4W	MF or MG		
R212	82k	5%	1/4W	MF or MG		
R213	1k8	5%	1/4W	MF or MG		
R214	33Ω	5%	1/4W	MF or MG		
R215	3k3	5%	1/4W	MF or MG		
R216	22k	5%	1/4W	MF or MG		
R217						
R218						
R219						
R220						
R221	820Ω	5%	1/4W	MF or MG		
R300	1M	5%	1/4W	MF or MG		
R301	15K	5%	1/4W	MF or MG		
R302	3k9	5%	1/4W	MF or MG		
R303	220Ω	5%	1/4W	MF or MG		
R304	180k	5%	1/4W	MF or MG		

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
	RESISTORS (Cont'd)					
R305	10k	5%	1/4W	MF or MG		
R306	2k2	5%	1/4W	MF or MG		
R307	10k	5%	1/4W	MF or MG		
R308	33Ω	5%	1/4W	MF or MG		
R309	820k	5%	1/4W	MF or MG		
R310	220Ω	5%	1/4W	MF or MG		
R311	220Ω	5%	1/4W	MF or MG		
R312	2k7	5%	1/4W	MF or MG		
R313	2k7	5%	1/4W	MF or MG		
R314	2k7	5%	1/4W	MF or MG		
R315	1M	5%	1/4W	MF or MG		
R316	15k	5%	1/4W	MF or MG		
R317	39k	5%	1/4W	MF or MG		
R318	5M6	5%	1/2W	MF or MG	VR37	Phillips
R319	22k	5%	1/4W	MF or MG		
R320	6k8	5%	1/4W	MF or MG		
R321	4k7	5%	1/4W	MF or MG		
R322	12k	5%	1/4W	MF or MG		
R323	3k9	5%	1/4W	MF or MG		
R324	3k3	5%	1/4W	MF or MG		
R325	5k6	5%	1/4W	MF or MG		
R326	6k8	5%	1/4W	MF or MG		
R327	100k	5%	1/4W	MF or MG		
R328	100k	5%	1/4W	MF or MG		
R329	6k8	5%	1/4W	MF or MG		
R330	47k	5%	1/4W	MF or MG		
R331	820Ω	5%	1/4W	MF or MG		
R332	33k	5%	1/4W	MF or MG		
R333A-H	Thick Film Network				BWD	010-008
R334	18k	5%	1/4W	MF or MG		
R335	12k	5%	1/4W	MF or MG		
R336	10k	5%	1/4W	MF or MG		
R337	5k6	5%	1/4W	MF or MG		
R338	47k	5%	1/4W	MF or MG		
R339	10k	5%	1/4W	MF or MG		
R340	39k	5%	1/4W	MF or MG		
R341	5k6	5%	1/4W	MF or MG		
R342	33k	5%	1/4W	MF or MG		
R343	2k2	5%	1/4W	MF or MG		
R344	47k	5%	1/4W	MF or MG		
R345	47k	5%	1/4W	MF or MG		
R346	12k	5%	1/4W	MF or MG		
R347	10k	5%	1/4W	MF or MG		
R348	22k	5%	1/4W	MF or MG		
R349	1k	5%	1/4W	MF or MG		
R350	1k	5%	1/4W	MF or MG		
R351	220Ω	5%	1/4W	MF or MG		

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
	RESISTORS (Cont'd)					
R352	4k7	5%	1/4W	MF or MG		
R353						
R354	2k2	5%	1/4W	MF or MG		
R355	270k	5%	1/4W	MF or MG		
R356	12k	5%	1/4W	MF or MG		
R357	39k	5%	1/4W	MF or MG		
R358	150k	5%	1/4W	MF or MG		
R359	5k6	5%	1/4W	MF or MG		
R360	1M	5%	1/4W	MF or MG		
R362	220Ω	5%	1/4W	MF or MG		
R421	2Ω2	5%	1/4W	MF or MG		
R422	2Ω2	5%	1/4W	MF or MG		
R423	33Ω	5%	1/4W	MF or MG		
R424	4k7	5%	1W	MF or MG		
R425	10Ω	5%	1/4W	MF or MG		
R426	100k	5%	1/4W	MF or MG		
R427	15k	5%	1/4W	MF or MG		
R428	2M2	5%	1/2W	MG	PH	VR37
R429	10M	5%	1/2W	MG	PH	VR37
R430	820k	5%	1/4W	MF or MG		
R431	8M2	5%	1/2W	MG	PH	VR37
R432	2M2	5%	1/2W	MG	PH	VR37
R433	10k	5%	1/4W	MF or MG		
R434	47k	5%	1/4W	MF or MG		
R435	10M	5%	1/2W	MG	PH	VR37
R436	270k	5%	1/4W	MF or MG		
R437	15k	5%	1/4W	MF or MG		
R438	39k	5%	1/4W	MF or MG		
R439	100k	5%	1/4W	MF or MG		
R440	68k	5%	1/4W	MF or MG		
R441	33Ω	5%	1/4W	MF or MG		
R442	10k	5%	1/4W	MF or MG		
R443	15k	5%	1/4W	MF or MG		
R444	10k	5%	1/4W	MF or MG		
R445	1k	5%	1/4W	MF or MG		
R446						
R447						
R448						
R449	2k2	5%	1/4W	MF or MG		
	CAPACITORS					
C1	100nF	10%	600V	Green-Cap	Elna	Type N
C2	220pF	10%		Mica Disc	Erie	
C3	.7-3pF	Trim			PH	2222-801-20001
C4	6p8	10%	600V	NPO CDS		
C5	1-12pF	Trim			PH	2222-801-20008
C6	3p3	10%	600V	NPO CDS		
C7	1-12pF	Trim			PH	2222-801-20008
C8	10P	10%	600V	NPO CDS		
C9	1-12pF	Trim			PH	2222-801-20008

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
	CAPACITORS (Cont'd)					
C10	15pF	5%	600V	NPO CDS		
C11	4p7	5%	600V	NPO CDS		
C12	1-12pF	Trim			PH	2222-801-20008
C13	1-12pF	Trim			PH	2222-801-20008
C14	1-12pF	Trim			PH	2222-801-20008
C15	.7-3pF	Trim			PH	2222-801-20001
C16	4p7	10%	600V	NPO CDS		
C17	1p	±0.25p	600V	NPO CDS		
C51	100nF	10%	600V	Greencap	Elna	Type N
C52	220pF	10%		Mica Disc	Erie	
C53	.7-3pF	Trim			PH	2222-801-20001
C54	6p8	10%	600V	NPO CDS		
C55	1-12pF	Trim			PH	2222-801-20008
C56	3p3	10%	600V	NPO CDS		
C57	1-12pF	Trim			PH	2222-801-20008
C58	10pF	10%	600V	NPO CDS		
C59	1-12pF	Trim			PH	2222-801-20008
C60	15pF	5%	600V	NPO CDS		
C61	4p7	10%	600V	NPO CDS		
C62	1-12pF	Trim			PH	2222-801-20008
C63	1-12pF	Trim			PH	2222-801-20008
C64	1-12pF	Trim			PH	2222-801-20008
C65	.7-3pF	Trim			PH	2222-801-20001
C66	3p3			NPO CDS		
C67	1p	±0.25p	600V	NPO CDS		
C101	10nF	20%	600V	CDS		
C102	100nF	HI K	63V	CDS		
C103	68pF	5%	600V	N750 CDS		
C104	100nF	HI K	63V	CDS		
C105	4p7	10%	600V	NPO CDS		
C106	22pF	5%	600V	N750 CDS		
C107	100µF	20%	6.3V	Tant		or 10V RB electro
C108	10-40pF	Trim			STET	10S-06 -10-40
C109	1nF	10%	100V	Greencap	Elna	Type N
C110						

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION					Mfr or Supply	PART NO.
	CAPACITORS (Cont'd)						
C131	10nF	20%	600V		CDS		
C132	100nF	HI K	63V		CDS		
C133	68pF	5%	600V	N750	CDS		
C134	100nF	HI K	63V		CDS		
C135	4p7	10%	600V	NPO	CDS		
C136	22pF	5%	600V	N750	CDS		
C137	100nF	HI K	63V		CDS		
C138	150pF	10%	600V		CDS		Adjusted on Test
C139	10-40pF	Trim				STE	10S-06-10-40
C139							
C140	1nF	10%	100V	Greencap		Elna	Type N
C141	2n2		630V		CDS		
C142	10pF	10%	600V	NPO	CDS		
C161	100nF	HI K	63V		CDS		
C162	10pF	10%	600V	NPO	CDS		
C163	47pF	5%	600V	N750	CDS		
C164	47pF	5%	600V	N750	CDS		
C165	10nF	5%	250V			Siem	
C166	10nF	HI K	63V		CDS		
C201	10nF	10%	100V	Greencap		Elna	Type N
C202	2n2	10%	100V	Greencap		Elna	Type N
C203	2n2	10%	100V	Greencap		Elna	Type N
C204	100nF	10%	400V			Siem	
C205	47nF	10%	160V	Greencap		Elna	
C206	2n2	10%	100V	Greencap		Elna	Type N
C207	10nF	10%	100V	Greencap		Elna	Type N
C208	2n2	10%	100V	Greencap		Elna	Type N
C209	100nF	10%	400V			Siem	
C210	39pF	5%	600V	N750	CDS		Adjusted on Test
C301	100nF	HI K	63V		CDS		
C302	1µF	10%	100V			Siem	
C303	4p7	10%	600V	NPO	CDS		
C304							
C305	47pF	5%	600V	N750	CDS		
C306							
C307	220nF	10%	100V	Greencap		Elna	Type N

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
	CAPACITORS (Cont'd)					
C308	100nF	10%	400V	MPC	Siem	
C309	330pF	20%	600V	CDS		
C310	100nF	HI K	63V	CDS		
C311	100nF	10%	400V	MPC	Siem	
C312	1nF	10%	100V	Greencap	Elna	Type N
C313	22nF	10%	100V	MPC	Siem	
C314	68pF	50%	600V	N750 MPC		
C315	4-20pF	Trim			Stet	10S-06-4-20
C316A	1µF	1% (selected)	100V	MPC	Siem	
C316B	10nF	1% "	400V	MPC	Siem	
C316C	82pF	5%	600V	N750 CDS		
C316D	4-20pF	Trim			Stet	10S-06-4-20
C317	33pF	5%	600V	NPO CDS		
C318	18pF	5%	600V	N750 CDS		
C319	4p7	10%	600V	NPO CDS		
C320	100pF	5%	600V	N750 CDS		
C321	1p5	±.25pF	600V	NPO CDS		
C322	100nF	HI K	63V	CDS		
C323	1µF	10%	200V	Greencap	Elna	Type N
C324	10pF	10%	600V	NPO CDS		
C325	1µF	10%	200V	Greencap	Elna	Type N
C401	2500µF		25V	Electro	Elna	RT
C402	2500µF		25V	Electro	Elna	RT
C403	10µF		16V	Tant		
C404	10µF		16V	Tant		
C421	1000µF		35V	Electro	Elna	RT
C422	100nF		63V	HI K CDS		
C423	100nF		63V	HI K CDS		
C424	100µF		63V	Electro	PH	2222-017-18101
C425	47µF		150V	Electro	Elna	RT
C426	100nF	10%	400V	MPC	Siem	
C427	10nF		3KV	Cer Disc		
C428	10nF		3KV	Cer Disc		
C429	10nF		3KV	Cer Disc		
C430	10nF		3KV	Cer Disc		
C431	10nF		3KV	Cer Disc		
C432	1nF		2KV	Cer Disc	Erie	
C433	10nF		3KV	Cer Disc		
C434	100nF	10%	400V	MPC	Siem	

CCT REF	DESCRIPTION	Mfr or Supply	PART NO.
	CAPACITORS (Cont'd)		
C435	100nF 10% 400V MPC	Siem	
C436	1nF 10% 100V Greencap	Elna	Type N
C437			
C438	100nF 5% 400V MPC	Siem	
C439	1nF 20% 2KV CDS	Erie	
	POTENTIOMETERS		
RV101	1k Cermet Preset	Noble	VTP
RV102	10k Linear Carbon with Rotary Switch	RH	
RV103	10k Cermet Preset	Noble	VTP
RV104	10k Linear Carbon	BWD	
RV105	500Ω Cermet Preset	Noble	VTP
RV106	1k Cermet Preset	Noble	VTP
RV107	2k Cermet Preset	Noble	VTP
RV108	100Ω Cermet Preset	Noble	VTP
RV131	1k Cermet Preset	Noble	VTP
RV132	10k Linear Carbon with Rotary Switch	PH	
RV133	10k Cermet Preset	Noble	VTP
RV134	10k Linear Carbon with DPST Rotary Switch	BWD	
RV135	500Ω Cermet Preset	Noble	VTP
RV136	10k Cermet Preset	Noble	VTP
RV137	1k Cermet Preset	Noble	VTP
RV138	100Ω Cermet Preset	Noble	VTP
RV161	5k Cermet Preset	Noble	VTP
RV221	1k Cermet Preset	Noble	VTP
RV222	100k Cermet Preset	Noble	VTP
RV301	5k Cermet Preset	Noble	VTP
RV302	220k Linear Carbon with DPST Rotary Switch	PH	
RV303	1k Cermet Preset	Noble	VTP
RV304	5k or 4k7 Linear Carbon with Reverse Acting SPST Rotary Switch	Radiohm	P161

CCT REF	DESCRIPTION		Mfr or Supply	PART NO.
RV305	10k	Cermet Preset	Noble	VTP
RV306	10k	Cermet Preset	Noble	VTP
RV307	1k	Cermet Preset	Noble	VTP
RV308	10k	Cermet Preset	Noble	VTP
RV309	100k	Linear Carbon with Push Pull DPST Switch	PH	
RV421	200k	Cermet Preset	Noble	VTP
RV422	200k	Cermet Preset	Noble	VTP
RV423	3M	Linear Carbon		
RV424	200k	Cermet Preset	Noble	VTP
RV425	10k	Linear Carbon with DPST Rotary Switch	PH	
	SEMI CONDUCTORS			
Q201	PN 4249	PNP Transistor Matched with Q204		
Q202	MPS 6544	NPN Transistor		
Q203	MPS 6544	NPN Transistor		
Q204	PN 4249	PNP Transistor Matched with Q201		

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION				Mfr or Supply	PART NO.
Q301	PN 4258	PNP	Transistor			
Q302	PN 5769	NPN	Transistor			
Q303	BC 547B	NPN	Transistor			
Q304	PN 4258	PNP	Transistor			
Q305	PN 4258	PNP	Transistor			
Q306	BF 469	NPN	Transistor			
Q307	BF 469	NPN	Transistor			
Q308	BF 469	NPN	Transistor			
Q309	BF 469	NPN	Transistor			
Q421	MJE 3055	NPN	Transistor)	Matched pair	MOT	
Q422	MJE 3055	NPN	Transistor)		MOT	
Q423	BF 469	NPN	Transistor			
Q424	BC 547B	NPN	Transistor			
Q425	PN 3645	PNP	Transistor			
Q426	MPS 6544	NPN	Transistor			
Q427	BC 547B	NPN	Transistor			
Q428						
U101A&B	NPD 8303	Dual FET				
U102	733	Amplifier				
U103	CA 3086	Transistor Array			RCA	
U131A&B	NPD 8303	Dual FET				
U132	733	Amplifier				
U133	CA 3086	Transistor Array			RCA	
U161	CD 4001B	Quadgate		CMOS		
U162	CD 4013B	Dual Flip Flop		CMOS		

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION	Mfr or Supply	PART NO.
U301	CA 3086 Transistor Array	RCA	
U302	MC 10109 Dual OR/NOR Gate ECL	MOT	
U303	CD 4001B Quadgate CMOS		
U304	LM 351 or 356 BIFET Amplifier	NS	
U401	LM 340T-15 +15V Regulator	NS	
U402	LM 320T-15 -15V Regulator	NS	
D101	IN 3595 Diode		
D102	IN 3595 Diode		
D103	IN 4148 or IN 914 Diode		
D104	IN 4148 or IN 914 Diode		
D105	IN 4148 or IN 914 Diode		
D131	IN 3595 Diode		
D132	IN 3595 Diode		
D161	BZX79/B5V6 Zener Diode	PH	
D162	IN 4148 or IN 914 Diode		
D201	BZX79/B24V Zener Diode	PH	
D202	BZX79/B24V Zener Diode	PH	
D203	BZX79/B24V Zener Diode	PH	
D204	BZX79/B24V Zener Diode	PH	

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION		Mfr or Supply	PART NO.
D221	FLV 340	Green LED	F	
D301	IN 4148	Diode		
D302	IN 4148	Diode		
D303	IN 4148	Diode		
D304	IN 4148	Diode		
D305	BZX79/C3V3	Zener Diode		
D306	BZX79/C3V3	Zener Diode		
D307	IN 4148	Diode		
D308	IN 4148	Diode		
D309	IN 4148	Diode		
D310	IN 4148	Diode		
D401	IN 4004	Diode		
D402	IN 4004	Diode		
D403	IN 4004	Diode		
D404	IN 4004	Diode		
D405	IN 4004	Diode		
D406	IN 4004	Diode		
D407	IN 4004	Diode		
D421	BY 406	Diode	PH	
D422	BY 406	Diode	PH	
D423	BY 409	Diode	PH	
D424	BY 409	Diode	PH	
D425	BY 409	Diode	PH	
D426	IN 4148	Diode		
D427	IN 4148	Diode		
D428	IN 4148	Diode		
D429	IN 4148	Diode		
D430	IN 4148	Diode		
D431				
D432				
D433	IN 4004	Diode		

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION			Mfr or Supply	PART NO.
	SWITCHES				
S1A-B	3 Pos	2 Pole	Slide Switch	NSF	SM 2-3
S2A-C	12 Pos	3 Deck	Rotary	BWD	100-129
S57A-B	3 Pos	2 Pole	Slide Switch	NSF	SM 2-3
S52A-C	12 Pos	3 Deck	Rotary	BWD	100-129
S131A&B	DPST	Rotary	Rear of RV 134		
S161A-D	4 Pole	Change Over - Isostat		BWD	100-126
S301A-D	4 Section	Change Over - Isostat		BWD	100-157
S302A-B	DPST	Rotary	Rear of RV 302		
S303A-B	22 Pos	2 Deck	Rotary	BWD	100-150
S304	SP	Push Pull	Rear of RV 308		
S401	DPST	Rotary	Rear of RV 425		

PARTS LIST - MODEL BWD 820

CCT REF	DESCRIPTION	Mfr or Supply	PART NO.
	SUNDRY		
L221	Beam Rotation Coil	BWD	090-214
CRT	130BTB31 or 7	Hitachi	
T401	Power Transformer	BWD	090-197
T421	Converter Transformer	BWD	090-201
F401	Fuse 5 x 20mm 100mA for 235V nominal 200mA for 117V nominal		
TH101	68Ω Thermistor	PH	2322-610-11689
TH131	68Ω Thermistor	PH	2322-610-11689
	Intensity Knob	BWD	K
	Focus Knob	BWD	K
	Horz Pos Knob	BWD	K
	Trigger Level Knob	BWD	K
	CH.1 Position Knob	BWD	K
	CH.2 Position Knob	BWD	K
	CH.1 Attenuator Knob	BWD	K
	CH.2 Attenuator Knob	BWD	K
	TB Range Knob	BWD	K
	CH.1 Vernier Knob	BWD	K
	CH.2 Vernier Knob	BWD	K
	TB Vernier Knob	BWD	K
	Push Button Knobs	BWD	K
	Escutcheon	BWD	510A
	Graticule (Blue SS)	BWD	136-010 Blue
	Graticule (Amber SS)	BWD	136-010 Amber
	4mm Sockets	Multicon	EB4 + Colour
	All other parts order by description quoting both serial and model number		

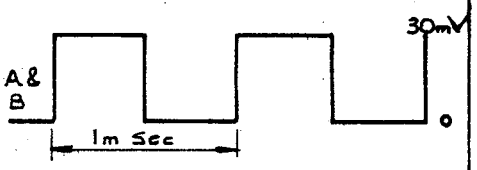
SWITCHES

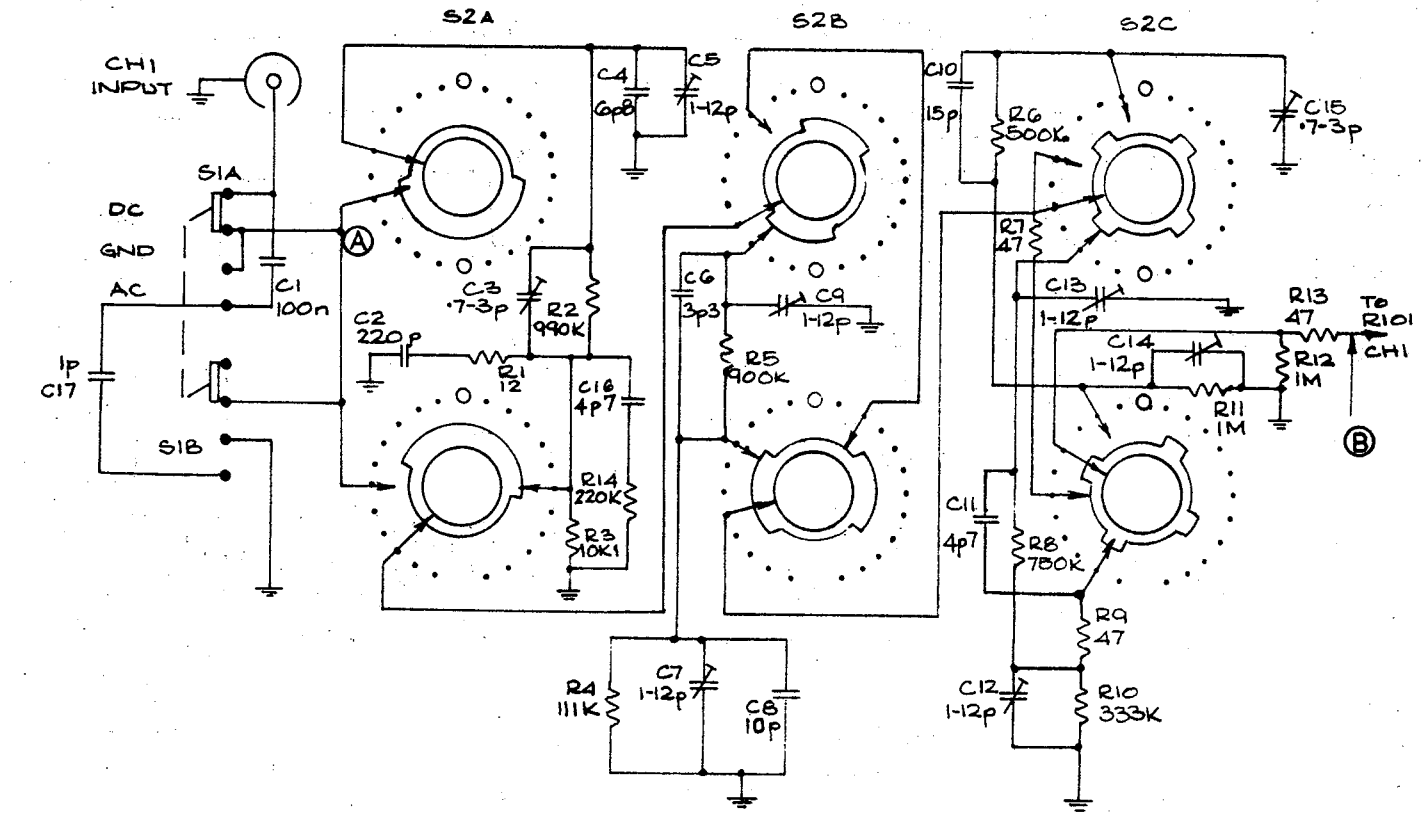
S1A&B	CH1	DC-GND-AC SELECTOR
S2A-C	CH1	ATTENUATOR
S51A&B	CH2	DC-GND-AC SELECTOR
S52A-C	CH2	ATTENUATOR

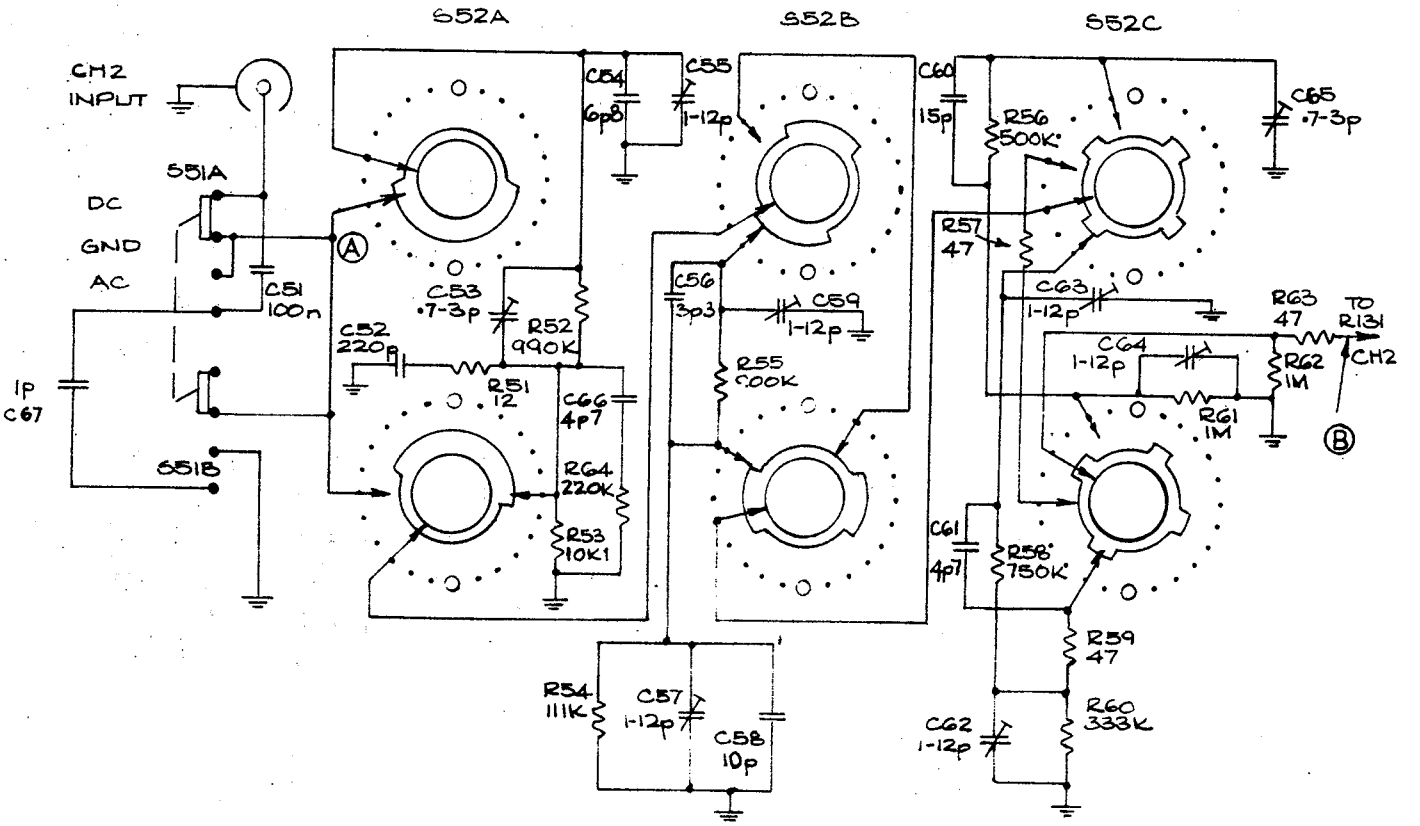
WAVEFORMS

IMPUT 30 m V P-P

1 KHz SQUARE WAVE




S2A
S2B
S2C
CH1 INPUT
S1A
DC
GND
AC
S1B
1p C17
C1 100n
C2 220p
C3 .7-3p
R2 990K
R1 12
C4 6p8
C5 1-12p
C6 3p3
C9 1-12p
R5 900K
C16 4p7
R14 220K
R3 10K1
R4 111K
C7 1-12p
C8 10p
C10 15p
R6 500K
C15 .7-3p
R7 47
C13 1-12p
R13 47
To R101 CH1
C14 1-12p
R12 1M
R11 1M
C11 4p7
R8 750K
R9 47
C12 1-12p
R10 333K
A
B


S52A
S52B
S52C
CH2 INPUT
S51A
DC
GND
AC
S51B
1p C67
C51 100n
C52 220p
C53 .7-3p
R52 990K
R51 12
C54 6p8
C55 1-12p
C56 3p3
C59 1-12p
R55 900K
C66 4p7
RG4 220K
R53 10K1
R54 111K
C57 1-12p
C58 10p
C60 15p
R56 500K
C65 .7-3p
R57 47
CG3 1-12p
RG3 47
TO R131 CH2
CG4 1-12p
RG2 1M
RG1 1M
C61 4p7
R58 750K
R59 47
RG0 333K
CG2 1-12p
A
B

SWITCHES

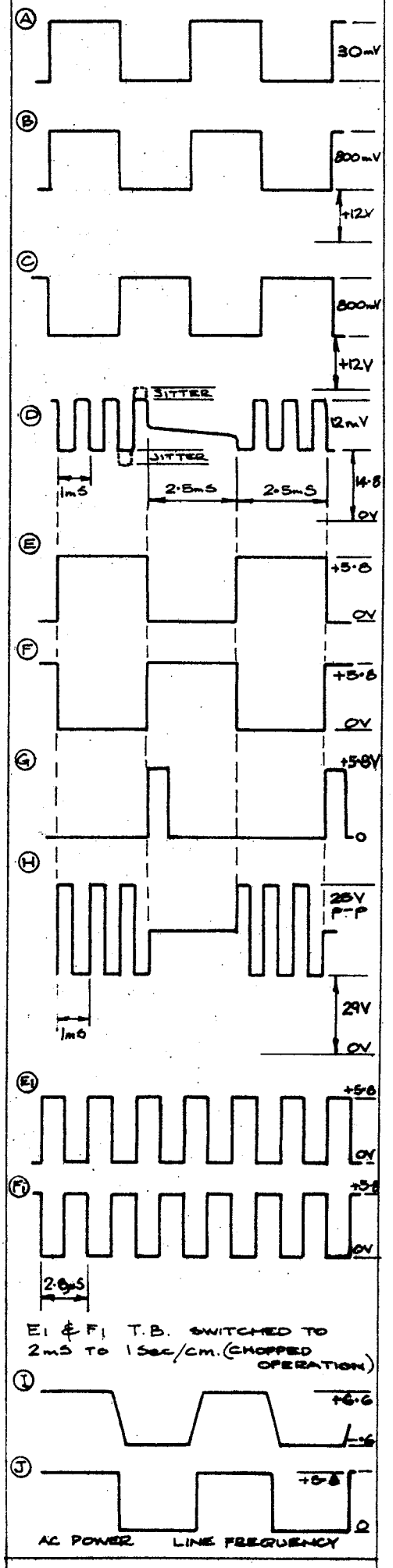
S131 A & B	CH2 OFF (REAR RV134)
S161 A - D	DUAL TRACE / DIFFERENTIAL

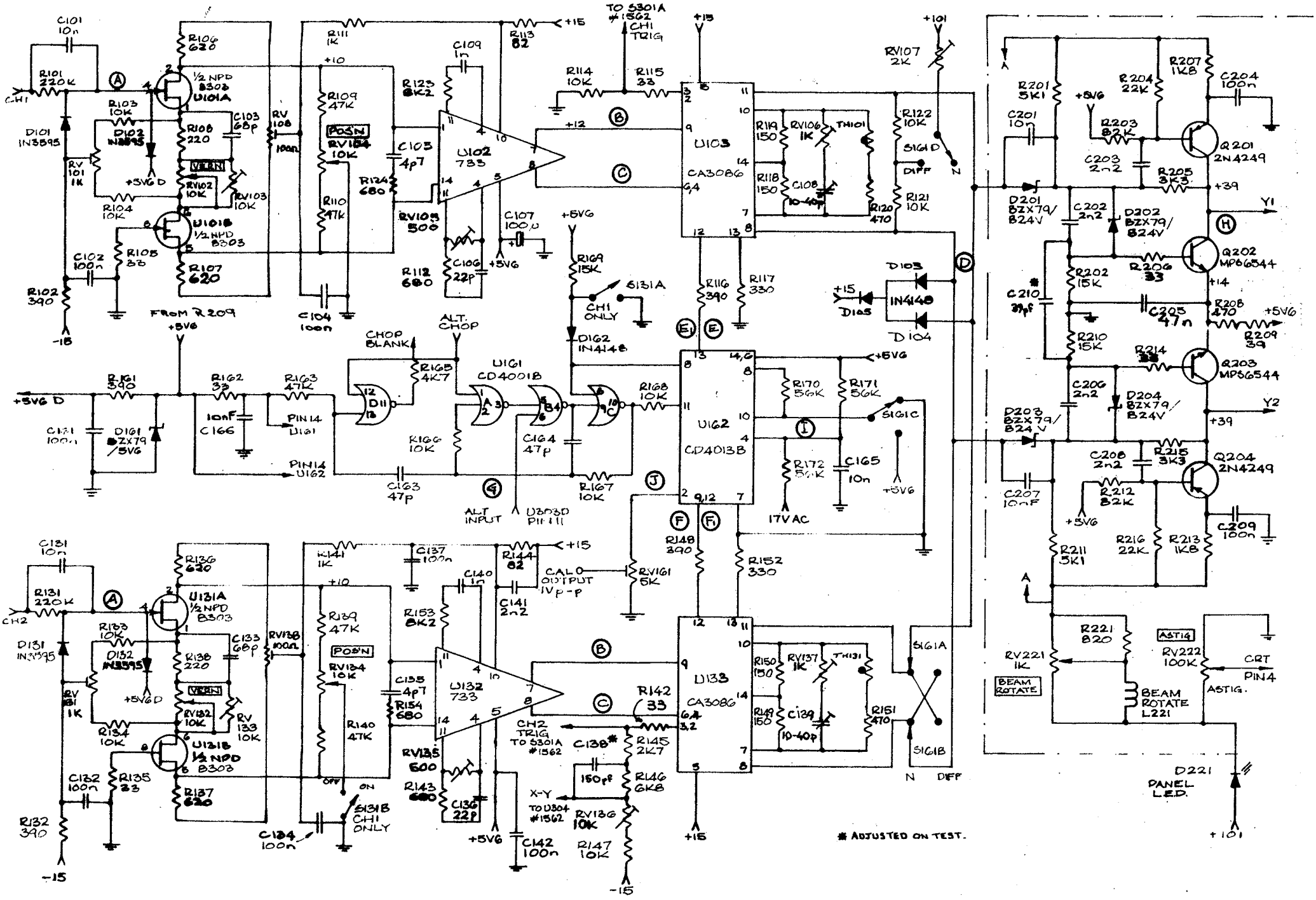
CONTROLS

RV101	CH1 DC BALANCE
RV102	CH1 VERNIER
RV103	CH1 SET 5mV CAL
RV 104	CH1 POSITION
RV 105	CH1 SET 2mV CAL
RV 106	CH1 HF RESPONSE
RV 107	SET DIFFERENTIAL DC CURRENT
RV 108	CH 1 CENTREING
RV 131	CH2 DC BALANCE
RV 132	CH2 VERNIER
RV 133	CH2 SET 5mV CAL
RV 134	CH2 POSITION
RV 135	CH2 SET 2mV CAL
RV 136	SET X POSITION (X-Y OPERATION)
RV 137	CH2 HF RESPONSE
RV 138	CH2 CENTREING
RV 161	SET 1V CAL OUTPUT
RV 221	BEAM ROTATE } REAR PANEL
RV222	CRT ASTIGMATISM } REAR PANEL

WAVEFORMS

(INPUT 1KHz SQUAREWAVE 6cm DEFLECTION)
T.B. TO ·1mSec/cm. DUAL TRACE




CH1
CH2
R101 220K
R131 220K
R102 390
R132 390
-15
+5V6 D
D101 IN3595
D131 IN3595
D102 IN3595
D132 IN3595
R103 10K
R133 10K
R104 10K
R134 10K
RV 101 1K
RV 131 1K
R105 88
R135 33
R106 620
R136 620
R107 620
R137 620
R108 220
R138 220
C101 10n
C131 10n
C102 100n
C132 100n
C103 68p
C133 68p
U101A ½ NPD 8303
U101B ½ NPD 8303
U131A ½ NPD 8303
U131B ½ NPD 8303
VERN
RV102 10K
RV103 10K
RV132 10K
RV 133 10K
RV 108 100n
RV138 100n
R111 1K
R141 1K
+10
R109 47K
R139 47K
POSN
RV134 10K
R110 47K
R140 47K
C104 100n
C134 100n
OFF
ON
S131B CHI ONLY
R113 82
R144 82
+15
C109 1n
C140 1n
R123 8K2
R153 8K2
C105 4p7
C135 4p7
R124 680
R154 680
U102 733
U132 733
RV105 500
RV135 500
C106 22p
C136 22p
R112 680
R143 680
C107 100µ
C137 100n
+5V6
C142 100n
R114 10K
R115 33
TO 5301A #1562 CH1 TRIG
CH2 TRIG TO 5301A #1562
C138* 150pF
R145 2K7
R146 6K8
X-Y TO U304 #1562
RV136 10K
R147 10K
+12
B
C
U103 CA3086
U133 CA3086
R116 390
R117 330
R148 390
R152 330
RV107 2K
R122 10K
S131D DIFF N
R121 10K
R120 470
R119 150
R118 150
RV106 1K
TH101
TH131
C108 10-40p
C139 10-40p
R150 150
R149 150
RV137 1K
R151 470
S131A CH1 ONLY
S131C
S131A
S131B
DIFF N
D103
D104
IN4148
Dias
R169 15K
D102 IN4148
R168 10K
R167 10K
R166 10K
R165 4K7
R161 390
R162 33
R163 47K
C161 100n
D161 BZX79/5V6
10nF C166
PIN14 U161
PIN14 U162
CHOP BLANK
ALT. CHOP
U161 CD4001B
C164 47p
C163 47p
ALT INPUT
U303D PIN 11
U162 CD4013B
R170 56K
R171 56K
R172 56K
C165 10n
17V AC
+5V6
CAL OUTPUT 1Vp-p
RV161 5K
R142 33
R152 330
D105 IN4148
D201 BZX79/B24V
D202 BZX79/B24V
D203 BZX79/B24V
D204 BZX79/B24V
R201 5K1
R211 5K1
R204 22K
R216 22K
R207 1K8
R213 1K8
R203 82K
R212 82K
R205 3K3
R215 3K3
C201 10n
C202 2n2
C203 2n2
C205 47n
C206 2n2
C208 2n2
C207 10nF
C204 100n
C209 100n
C210 39pF
R202 15K
R210 15K
R206 33
R214 33
R208 470
R209 39
Q201 2N4249
Q202 MPS6544
Q203 MPS6544
Q204 2N4249
+39
Y1
Y2
+14
R221 820
RV221 1K
BEAM ROTATE
RV222 100K
ASTIG.
CRT PIN4
BEAM ROTATE L221
D221 PANEL L.E.D.
+101
* ADJUSTED ON TEST.

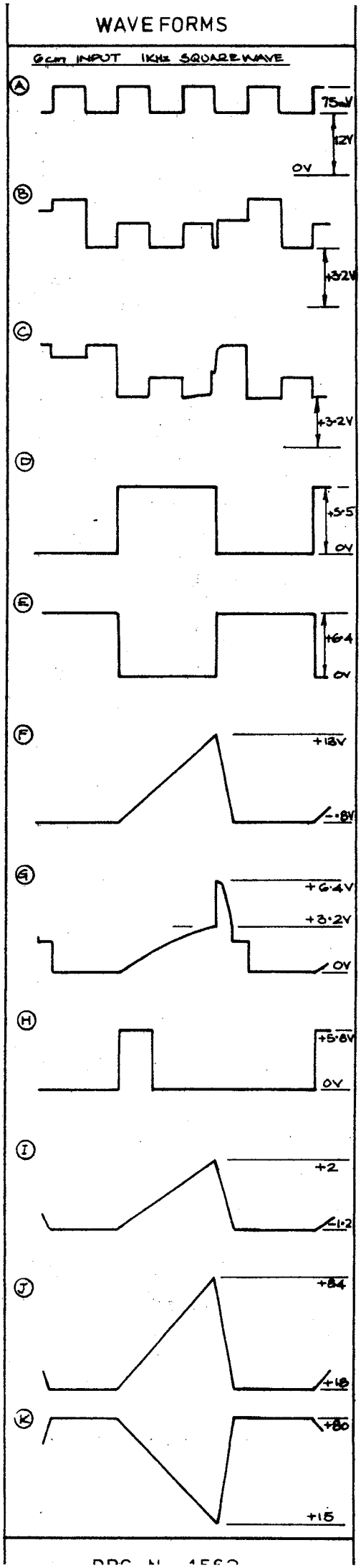
SWITCHES

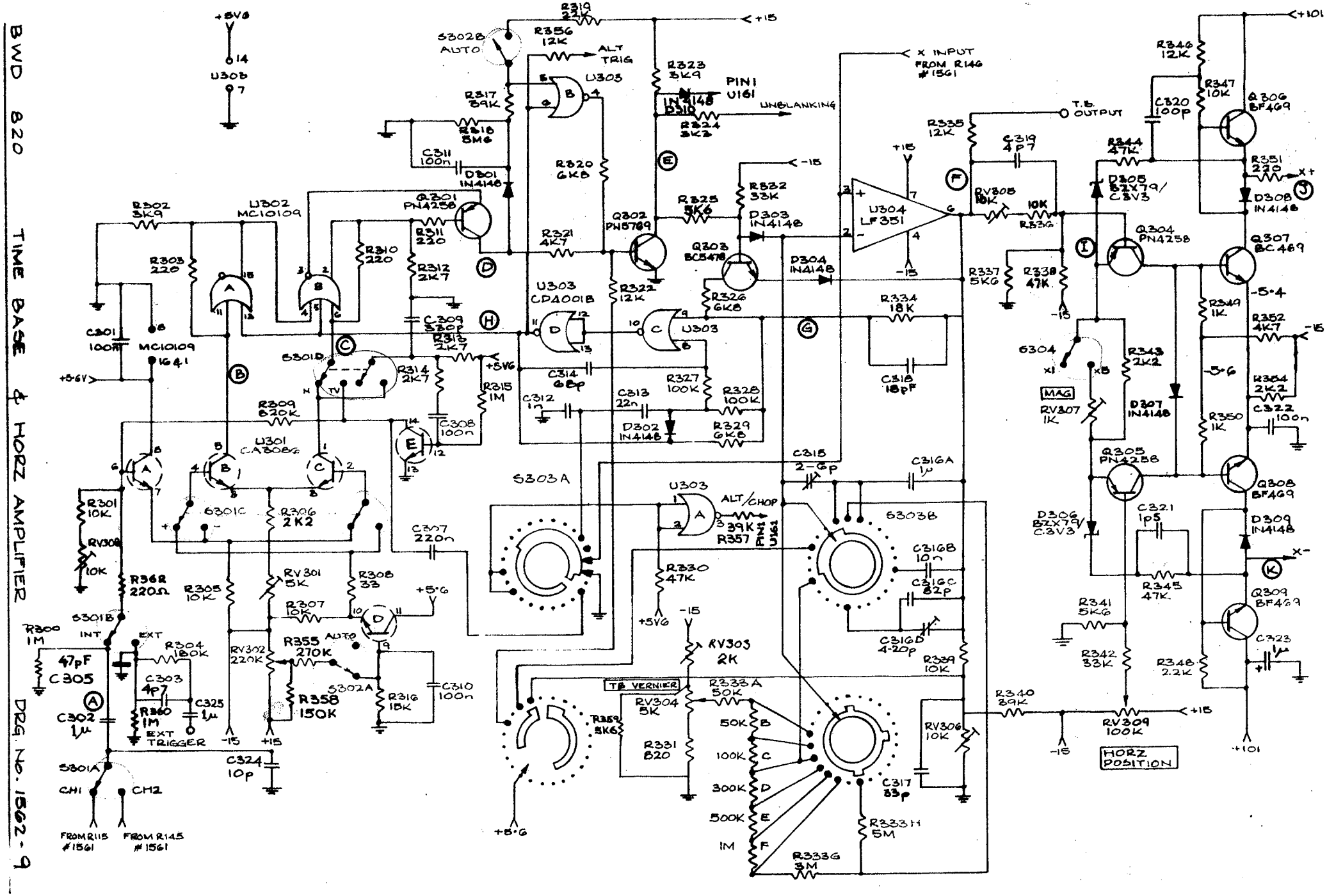
S301A	CH1 or CH2 TRIG. SELECT
S301B	INT. or EXT. TRIG. SELECT
S301C	+ or — TRIG. SELECT
S301D	N or TV TRIG. SELECT
S302A&B	AUTO or LEVEL SELECT (REAR RV302)
S303A&B	T. B. RANGE
S304	X1 or X5 MAGNIFICATION (REAR RV309)

CONTROLS

RV 301	SET SENSITIVITY
RV302	TRIGGER LEVEL
RV 303	T.B. CAL SET
RV 304	T. B. VERNIER
RV 305	SET X1 TRACE LENGTH
RV 306	SET X-Y CAL
RV 307	SET X 5 MAGNIFICATION

WAVE FORMS




BWD 820 TIME BASE & HORZ AMPLIFIER DRG. No. 1562-9
+5V6
U308
14
7
S302B AUTO
R356 12K
ALT TRIG
R319 22K
+15
U305
R317 89K
R318 5M6
C311 100n
D301 IN4148
R320 6K8
R323 3K9
PIN1 U161
UNBLANKING
D310 IN4148
R324 3K2
X INPUT FROM R146 #1561
T.B OUTPUT
R335 12K
C319 4P7
RV305 10K
R336 10K
R337 5K6
R338 47K
R346 12K
C320 100P
R347 10K
R344 47K
Q306 BF469
R351 220
X+
D308 IN4148
D305 BZX79/C3V3
Q304 PN4258
Q307 BC469
-5·4
R349 1K
R352 4K7
-15
R343 2K2
R354 2K2
C322 100n
R350 1K
-5·6
D307 IN4148
Q305 PN4258
Q308 BF469
D306 BZX79/C3V3
C321 1p5
D309 IN4148
X-
K
R345 47K
Q309 BF469
C323 1µ
+101
R341 5K6
R342 33K
R348 2.2K
R340 39K
RV309 100K
HORZ POSITION
6304
X1
X5
MAG
RV307 1K
R322 12K
R321 4K7
R325 5K6
R332 33K
D303 IN4148
Q302 PN5789
Q303 BC548
R326 6K8
D304 IN4148
U304 LF351
R334 18K
C318 18pF
U303 CD4001B
R327 100K
R328 100K
R329 6K8
C313 22n
C312 1n
C314 68p
D302 IN4148
C315 2-6p
C316A 1µ
C316B 10n
C316C 82p
C316D 4-20p
R339 10K
R330 47K
R357 39K
U361
RV303 2K
R333A 50K
R333B 5M
R333G 5M
R331 820
R359 5K6
RV304 5K
RV306 10K
C317 33p
R340 39K
RV309 100K
HORZ POSITION
S303A
S303B
50K B
100K C
300K D
500K E
1M F
U302 MC10109
R302 3K9
R303 220
R310 220
R311 220
R312 2K7
Q301 PN4258
C309 330p
R313 2K7
S301D
R314 2K7
R315 1M
C308 100n
C307 220n
U301 CA3086
R309 620K
S301C
R306 2K2
R308 33
RV301 5K
R307 10K
R305 10K
RV302 220K
R355 270K
AUTO
S302A
R358 150K
R316 18K
C310 100n
C324 10p
C325 1µ
R360 1M
EXT TRIGGER
C303 4p7
R304 180K
R362 220Ω
RV308 10K
R301 10K
R300 1M
S301B
INT
EXT
47pF C305
C302 1µ
S301A
CH1
CH2
FROM R115 #1561
FROM R145 #1561
C301 100n
MC10109 1641
+5V6
-15
+15
+5·6
-5·4
-5·6
+101

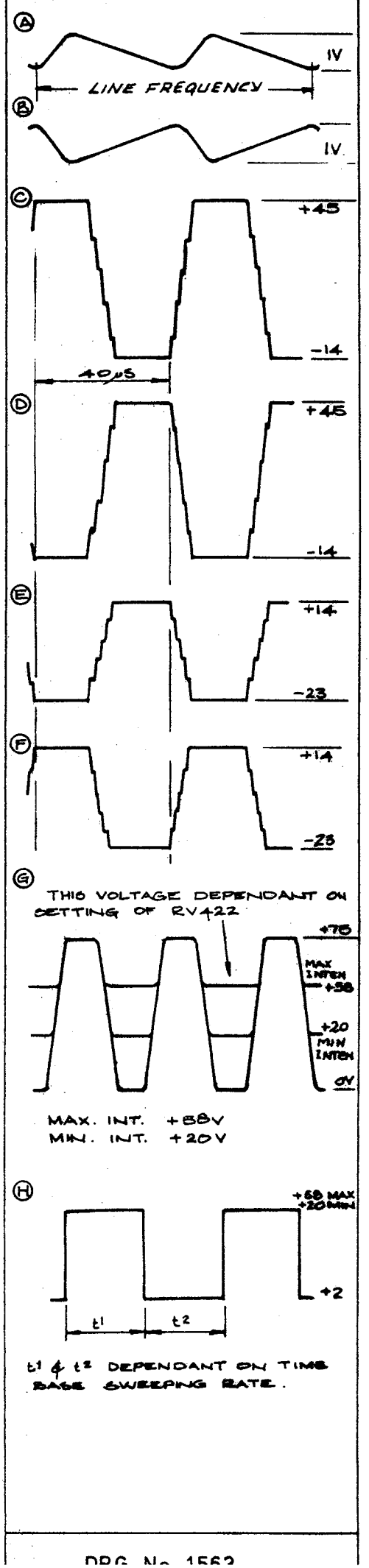
SWITCHES

S401 AC POWER (REAR RV425)

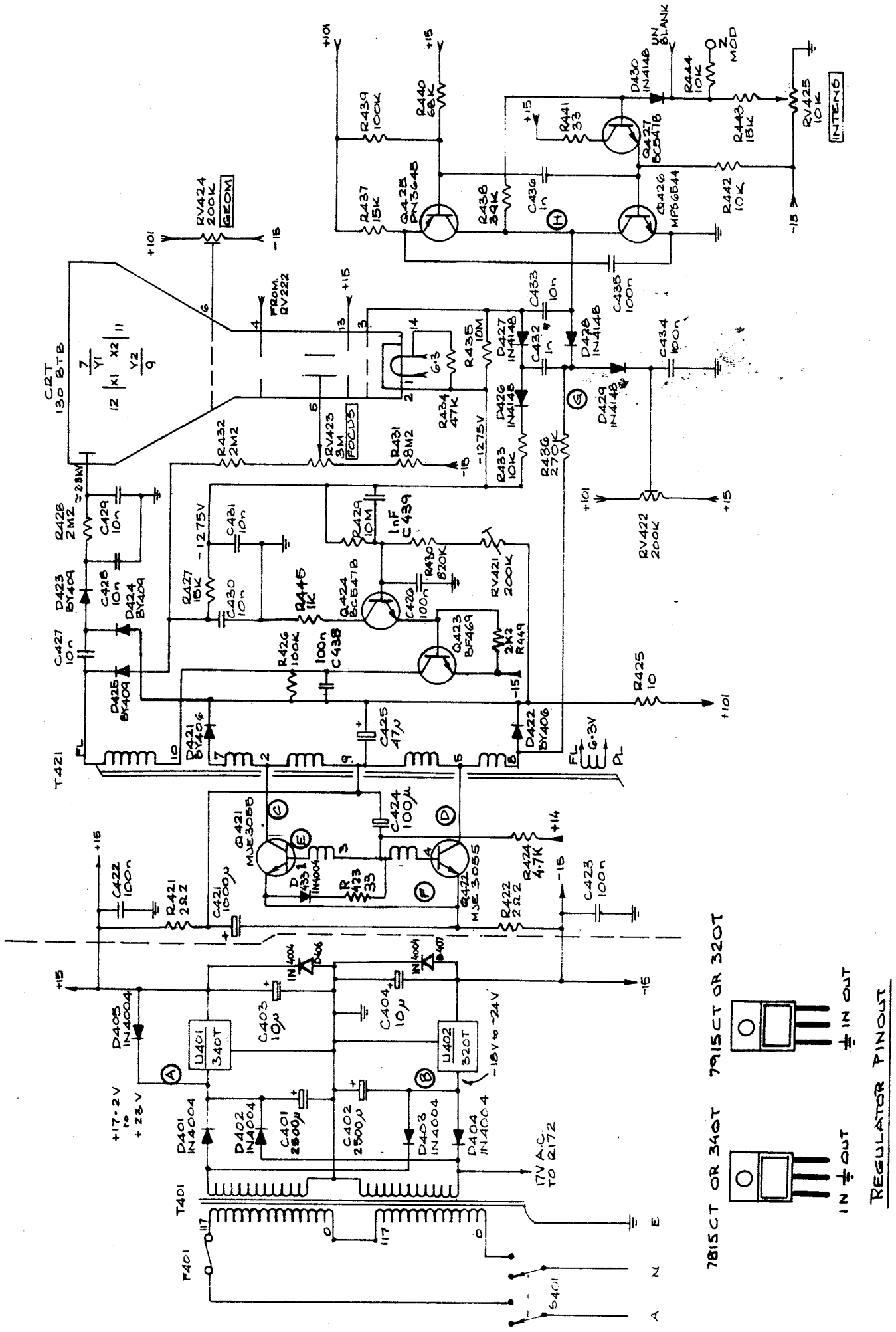
CONTROLS

RV421 SET EHT
RV422 SET INTENSITY RANGE
RV423 FOCUS
RV424 GEOMETRY
RV425 INTENSITY

WAVEFORMS



DRG No. 1562



BWD 820 POWER SUPPLIES DRG. No 1563-9

BWD INSTRUMENTS PTY. LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 820

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO	ISSUE	DATE
44774	2	8.4.80			

Issue	Sect.	Page	Cct.	AMENDMENT
2	2	2 & 3		Guide brought into line with Specification.
2	3-1	0		CMRR was >20db DC to 10MHz. Now DC to 5MHz.
2	3-1	0		Max CMR Input was 10cm deflection. Now 8cm.
2	3-3	1		TRIG Sen Int AUTO was >1cm 5Hz-20MHz. Now 10Hz-20MHz.
2	3-3	1		TRIG Sen Int AUTO was >2cm 5Hz-30MHz. Now 10Hz-30MHz.
2	3-3	1		TRIG Sen Int Select was >1cm 3Hz to 25MHz. Now 5Hz-25MHz.
2	3-3	1		TRIG Sen Int Select was >2cm 3Hz to 40MHz. Now 5Hz-40MHz.
2	3-3	1		TRIG Sen Ext AUTO >2V 3Hz to 25MHz REMOVED.
2	3-3	1		TRIG Sen Ext Select 1V to 10V was 2Hz to 40MHz. Now 5Hz to 40kHz.
2	8-6	2		Para 2 (below) replaced. See page 8-2 this book. U161 quad NOR gate sections A B & C are connected as a free running 250kHz oscillator, producing a square wave at pin 10 of gate C. In this condition, pin 1 of gate A is held LO. However, from 1mSec to 200nSec wafer S303A of the time-base switch grounds the inputs to gate A of U303, forcing its output HI.
2	9-12	6		Line 1 <10Hz to 20MHz. Was 5Hz to 20MHz.
2	11	2		R142 68Ω 5% 1/4W MF added.
2	11.	5		R446 10MΩ 5% 1/2W VR37 REMOVED.
2	11	5		R357 39K 5% 1/4W MF added.
2	11	5		R358 150K 5% 1/4W MF added.
2	11	7		C303 was 1pF 10%. Now 4p7 10% cap.
2	11	7		C305 was 2n2 20%. Now 47pF 5% cap.
2	11	8		C323 was 47µF 160V electro. Now 1µF 250V 10% Elna Type N.
2	11	9		C438 100nF 400V cap added.
2	11	9		C439 1nF 2K cap added.
2	11	13		D310 IN4148 diode added.
2	11	13		D431 IN4004 diode removed.
2			1561	R142 68Ω added between pin 2 & 3 of U133 & R145.
2			1562	C305 removed from between C324 & 5303A and replaced between R304 and ground. Value was 2n2. Now 47pF.

BWD INSTRUMENTS PTY. LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 820

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
44774	2	8.4.80			
45524	3	12.5.80			
44774	4	17.7.80			

Issue	Sect.	Page	Cct.	AMENDMENT
2			1562	C340 was 1pF. Now 4p7.
2			1562	R355 was 150K. Now 270K.
2			1562	R358 added across RV302.
2			1562	D310 added between Q302 collector and U161 pin 1.
2			1562	R357 added between R357 and U161 pin 1 & 12.
2			1562	C323 was 47µF 160V. Now 1µF 250V.
2			1563	D431 IN4004 removed. Replaced by C438 100nF 400V cap.
2			1563	R446 10MΩ in parallel with R430 removed.
2			1563	C439 1nF 2KV cap added across R429.
3			1561	C166 10nF 63V added
3	11	9	1561	RV101 & 131 WERE 500Ω
3	11	2	1561	R142 was 68Ω. R143 was 330Ω
3	11	10	1562	RV305 was 5k
3	11	8	1562	C318 was 27pF
3	11	5	1562	R355 was 150k
3	11	5	1562	R353 22k in parallel with R354 removed
3	11	4	1562	R338 was 39k
3	11	8	1562	C321 was 1pF
4				NOTE: The following changes apply to ALL models after Serial No. 44774
4	8	1		Change Q101A & B to read U101A & B. Change U101 to U102. Change U102 to U103.
4	8	2		Change U132 to U133, change U102 to U103.
4	11	11		U101A & B was Q101A & B, U102 was U101, U103 was U102. U131A & B was Q131A & B, U132 was U131, U133 was U132.
4			1561	U101A & B was Q101A & B, U102 was U101, U103 was U102, U131A & B was Q131A & B, U132 was U131, U133 was U132.
4	9	6E		1st Line 10Hz to 20MHz was 5Hz to 20MHz
4	9	2		Bottom view photograph. Channel 1. Atten C Numbers C12, 13 & 14 were interchanged with C14, 15 & 7. Channel 2. Atten C Numbers C62, 63 & 59 were interchanged with C64, 65 & 57.

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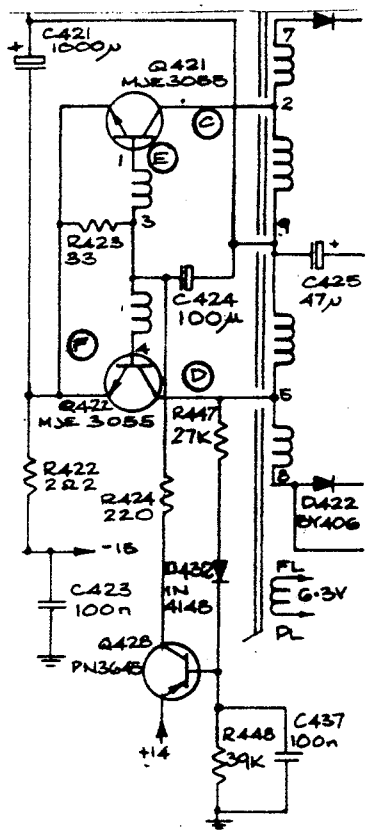
MANUAL CHANGE INFORMATION FOR MODEL BWD 820

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
46261	5 & 6	17.7.80			
46261	7	30.9.80			
47041	8	20.10.80			

Issue	Sect.	Page	Cct.	AMENDMENT
5	11	12	1561	D103 & 104 added.
6	11	12	1561	D105 added.
6	11	1 & 2	1561	R123 was 1W.
6	11	3	1562	R300 added.
6	5	0		117V & 235V nominal added to transformer diagram.
6	11	8		Full Part No. added to C315 & C316D.
6	11	10		Note added. Q201 & 204 matched pair.
6	11	11		Note added. Q421 & 422 matched pair.
6	11	13		D221 parts list error, was FLV304.
6	11	14		Part No's added to S1, S2, S52, S57, S161, S301 & S303.
6	11	15		F401 Fuse size was 3AG.
6	11	5	1563	R449 added across base-emitter Q423.
6	11	13	1563	D406 & 7 added across + & -15V rails.
6	11	6	1560	C17 & C67 ADDED.
6	11	7 & 8	1562	C302 Moved. C325 Added.
6	11	5	1562	R360 Added.
6	8	4		Para 12. Add 'C325' after via end of line 2. Para 12. Remove 'AC coupled via C302' and insert 'applied' in line 4.
7	All	All	All	Handbook upgraded.
8	11	5, 9, 11, 13	1563	Q428, C437, D432, R447 and R448 removed. R424 changed to 4k7 1W and taken to +14V as starting circuit not needed when D433 is added in series with R423.



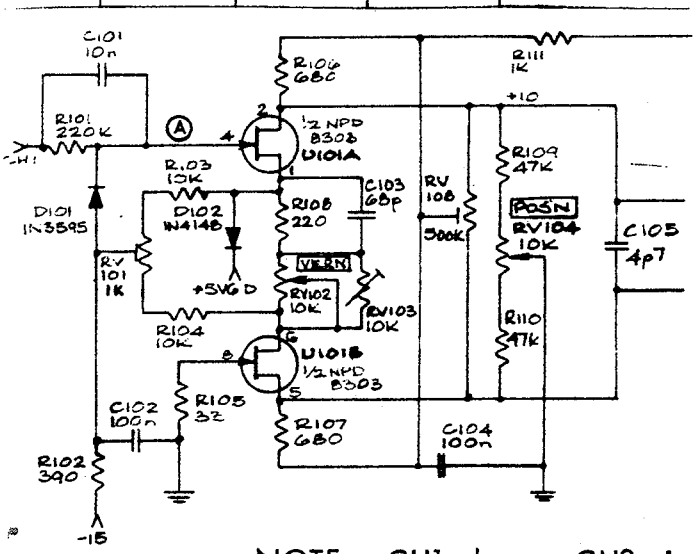
F13/033/bts

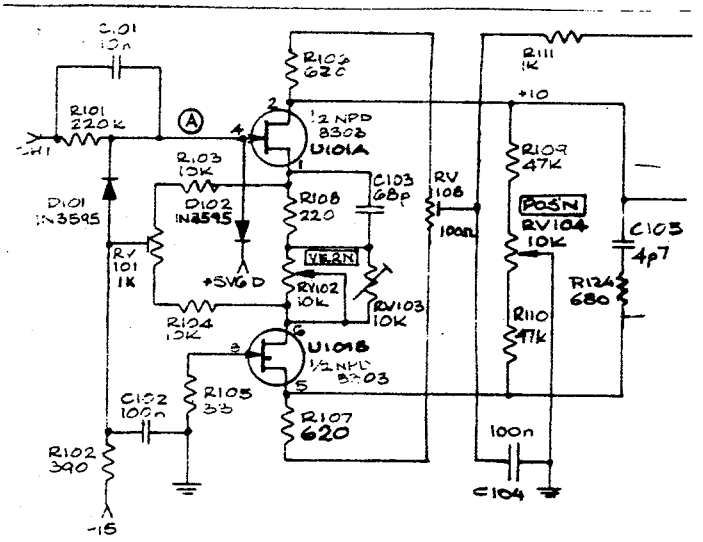
BWD INSTRUMENTS PTY. LTD.

MANUAL CHANGE INFORMATION FOR MODEL BWD 820

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
47041	8	20.10.80			
47241	9	30.11.80			

Issue	Sect.	Page	Cct.	AMENDMENT
8				Main PCB No. 160-313D
8	11	9	1561	RV108 & RV138 changed from 500K.
8	11	12	1561	D102 was IN4148.
8	11	12	1561	D132 was IN4148.
8	11	1 & 2	1561	R106, R107, R136 & R137 were 680Ω.
8	11	2	1561	R124 & R154 ADDED in series with C105 & C135.





NOTE: CH1 shown, CH2 similar.

Circuit applicable up to Serial No. 47040

Circuit applicable from Serial No. 47041

8	11	7	1561	C205 was 22n.
8	11	3	1561	R206 & R214 were 22Ω.
8	11	7	1561	C210 was 22pF C211 removed.
8	11	6 & 7	1561	C106 & C136 were 33P.
8	11	2	1561	R112 was 330Ω.
8	11	2	1561	R113 & R144 were 33Ω.
8	11	5 & 6	1560	C8 & C58 were 15P.
8	11	6	1561	C108 was C108A 4-20pF & C108B 10P
8	11	7	1561	C139 was C139A 4-20P & C139B 10P
8	11	4	1562	R306 was 3K3.
8	11	5	1562	R362 ADDED.
8	11	4	1562	R325 was 4k7.
8	11	5	1562	R359 ADDED.
9	11	5	1561	Larger beam rotation coil fitted.

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MANUAL CHANGE INFORMATION FOR MODEL BWD

FROM SERIAL NO.	ISSUE	DATE	FROM SERIAL NO.	ISSUE	DATE
47241	9	30.11.80			

Issue	Sect.	Page	Cct.	AMENDMENT
9	5	0	-	117V - 235V transformer connections redrawn.
9	-	-	1561	RV136 was 5k on drg. only.
9	11	4	1562	R334 was 22k, R336 was 12k.
9	11	7	1561	C138 & C210 "ADJUSTED ON TEST" ADDED.

F13/043/bts