INSTRUMENT HANDBOOK

Applicable to Serial No. 12621..

301216

MODEL bwd 511

SOLID STATE 5" OSCILLOSCOPE

B.W.D. ELECTRONICS PTY.LTD.,
331-333 Burke Rd. GARDINER, 3146
VICTORIA AUSTRALIA

Telephone: 25-4425

B.W.D. ELECTRONICS PTY.LTD.,
127 Blue Points Rd. NORTH SYDNEY,
NEW SOUTH WALES. AUSTRALIA.

Telephone: 929-7452

MODEL bwd - 511

SOLID STATE 5" OSCILLOSCOPE

INDEX

SECTION	PAGE	CONTENTS
1	1	General
2	1	Specification
3	3	Function of Controls
4	6	First Time Operation
5	7	Measurement of DC Voltages
6	8	Measurement of AC Voltages
7	8	Inverted Displays
8	8	Balanced or Differential Measurements
8.1	10	AC Measurements
8.2	9	Differential Measurements
9	10	Isolated Measurements, AC or DC
10	10	Current Measurements, AC or DC
11	10	Measurements with an External Horizontal Input
12	10	Mechanical Contract Trigger
13	10	Circuit Description
14	14	Adjustments and Maintenance
15	17	Accessories
16	17	Replacement Parts
17	17	Warranty

INSTRUMENT HANDBOOK

MODEL bwd 511

1. GENERAL

Model bwd 511 Oscilloscope is a highly versatile instrument designed for simplicity of operation and reliable long life. Special attention has been paid to isolating the complete circuitry so that it is practically impossible to damage either the oscilloscope or equipment connected to it by incorrect connection. The external cabinet is grounded to the mains earth for complete safety.

1.1 Both vertical and Horizontal amplifiers are directly coupled enabling the oscilloscope to be used as an AC or DC volt or milli voltmeter, DC plotting table, LF phase comparator, and with a suitable resistor across the input, (e.g. 1Ω) it will operate as a direct reading amp or milliamp meter in addition to all normal oscilloscope functions over the entire amplifier range.

1.2 The balanced input also allows measurement to be made across any circuit, from 240V AC power lines to transistors, without any possibility of shorting or loading.

1.3 The Time Base has a 25 x 10^6 to 1 frequency range of 0.2μSec/cm to 5Sec/cm and incorporates completely Automatic Triggering, Selective Trigger or Preset Trigger from Internal, External or 50Hz. The stability control has been completely eliminated, the new solid state trigger circuit being self setting and always ready to receive any input signal up to 10MHz to provide steady triggering of any waveform.

1.4 The wide band (>10MHz) at sensitivity of 10mV/cm and 3MHz at 1mV/cm enables low level high speed transistor signals to be displayed whilst waveforms of SCR's operating directly in the power mains can just as readily be displayed at the other end of the attenuator range. The rear panel mechanical or contact trigger can be used where either a make or break contact is required to initiate a single trace.

1.5 To enable Model bwd 511 to be used to its maximum capacity in fields ranging from servo circuits, medical and biological applications, computors, laboratory and industrial electronics, T.V. and pulse techniques, two different phosphors are available for the C.R.T., together with a range of probes, cameras and accessories.

1.6 Other options available include either BNC (standard) or UHF type input connectors and direct capacitive connections to C.R.T. vertical plates for HF displays to over 100MHz.

2. SPECIFICATION

2.1 C.R.T.

Type	5" flat faced, type 13/27 (GH) incorporating a spiral PDA, DC coupled Beam Blanking.
Phosphor	GH, (P31) normally supplied, GM(P7) available to order.
EHT	3kV.
Graticule	8 x 10cm graticule with 2mm subdivisions on X & Y centreline and green light filter (orange filter for P7 phosphor if specified).

2.2 VERTICAL AMPLIFIER WIDE BAND

Bandwidth DC or 2Hz (AC coupled) to 10MHz -3db at all sensitivities referred to 4cm deflection at 1kHz.

Sensitivity 10, 20, 50, 100, 200, 500mV, 1, 2, 5, 10, 20 and 50V per cm.

Rise Time 30 nano seconds for 4cm deflection.

NOTE: When option 22 is incorporated providing direct capacitive input to Y plates, bandwidth reduces to 8MHz -3db and rise time increases to 45 nano seconds.

Calibration Better than 5%.

Input Impedance 1MΩ and approximately 40pF single ended.
2MΩ and 25pF balanced input.

Differential Rejection Ratio
>100-1 at 1mV & 10mV/cm. >20-1 at all other sensitivities.

Max. Input Voltage 400DC or 250AC or 400V AC and DC p-p combined.

Common Terminal to Ground 0.47μF and 1MΩ in parallel. Maximum Voltage common to ground ±400V DC or 250V AC.

2.3 NARROW BAND (X10 GAIN AC)

Bandwidth 5Hz to 3MHz -3db at all sensitivities. (Input should be switched to AC when using X10 GAIN).

Sensitivity X10 wide band, i.e. 1mV to 5V per cm.

Rise Time 70 nano Seconds.

2.4 TIME BASE

Range 0.2μSec/cm to 2 Sec/cm in 22 stepped ranges with an uncalibrated vernier control between each step, extending range to 6 Sec/cm.

Calibration Better than 5% at all settings at X1 magnification.

Expansion X1 to X5 continuously variable, calibrated < 10% up to sweep speeds of 1μSec. Maximum sweep speed < 100nSec/cm.

Blanking Direct coupled to C.R.T. Blanking Electrode.

2.5 TRIGGER

Facilities 3 switches provide selection of following characteristics:

1	2	3
INT	NORM	
50Hz	LF (approx. 2kHz crossover)	+
EXT	HF (approx. 2kHz crossover)	-

Sensitivity Auto - 20Hz to over 10MHz with 1cm deflection or 1V p-p external, sine or square wave.

Level Select - 1Hz to 3MHz with 1cm deflection or 1V p-p external.
Preset -5Hz to 1MHz for 1cm deflection or 2V p-p external.

Level Select Range	± 5V external. ± 3cm internal.
Ext. Trigger Impedance	200KΩ and 50pF approximately.
Mechanical Trigger	Rear panel sockets. With selector to PRESET and trigger source switched to EXT an opening or closing contact across the sockets will initiate the trace for a single shot display.

2.6 HORIZONTAL AMPLIFIER

Bandwidth	DC or 2Hz (AC coupled) to 350kHz (-3db) at min.gain.
Sensitivity	300mV to 1.5V per cm approx. continuously variable.
Input Impedance	1MΩ and 50pF approx.

2.7 'Z'MODULATION

Rear socket input to C.R.T. grid, input time constant 0.01 MFD and 560KΩ. -20V will completely blank trace at normal intensity.

Calibrate Waveform	1V p-p square wave 50Hz accuracy 2%. (balanced either side of common) *
Time Base Output	Rear panel sockets. 16V positive going sawtooth from -4V to +12V. Min external load 100KΩ.
'Y' Plate Input (Option 22)	Sensitivity 3V RMS/cm. Input 6.6KΩ Y1 to Y2 or 3.3KΩ each side to ground.
NOTE: Specification Characteristics.	Characteristics expressed in numerical values with tolerances stated are guaranteed by the factory. Numerical values without tolerances represent the values of an averate instrument. All data applies in case of nominal mains voltage unless otherwise stated.

2.8 POWER REQUIREMENTS

190 to 260V, 50 to 50Hz, approximately 35 watts.

Dimensions	9" (23cm) high x 7" (18cm) wide x 16" (41cm) deep.
Weight	Approximately 18 lbs. (8.10kg). 24 lbs. (10.80kg) packed.
Accessories	Supplied with instrument: 1 Standard Handbook 1 Power Cord, complete with 8 pin plug
Optional Accessories	Refer Section 15, page 17 of this Handbook.

3. FUNCTION OF CONTROLS

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

Insensity Control	Fully anti-clockwise, this control switches the instrument OFF. When rotated clockwide 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 re-adjustment over the full intensity control range.

Astigmatism Preset concentric with FOCUS, adjusts beam for optimum focus over entire screen area.

Horz. Shift (Red Knob) moves the trace horizontally on the C.R.T.

Horz. Gain (Grey Knob) when the Time Base is in use, this control varies the length of the trace from 10cms to 50cms, providing X5 expansion. When an external Horizontal Input is used, the Horz. Gain varies the sensitivity from 300mV (0.3V) to 4V per cm approximately.

T.B. Vernier Varies the Time Base speed over a range greater than X3 to provide a continuously variable range in conjunction with the TIME/CM switch of 6 Sec/cm to 0.2μSec/cm. When the VERNIER control is turned and switched fully anti-clockwise it switches off the internal Time Base permitting an external signal to be fed into the HORZ. AC or DC INPUT sockets.

Time/cm (Time Base) Switch When the Time Base Vernier control is fully clockwise in the CAL position the 22 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 X3, e.g. on the 1mSec range the Vernier will vary the time base from 1mSec down to approx. 3mSec/cm when fully anti-clockwise.

+ - Switch Selects the positive (+) or negative (-) slope of the displayed signal or external trigger waveform to initiate the time base.

INT-50Hz-EXT-Switch Selects the trigger signal from the displayed waveform, from the input line frequency or an external waveform to trigger the time base.

AC-HF-LF Switch Selects the full frequency range of the trigger signal in AC position, frequencies above 2kHz in HF and below 2kHz in LF.

Vertical Shift Moves the trace up and down the C.R.T.

Atten. Balance With trace centred and attenuator Vernier set anti-clockwise Preset Balance is adjusted to eliminate vertical trace movement when Vernier is turned clockwise.

Auto, Trigger Level & Preset Fully anti-clockwise, and switched to the AUTO position, any signal greater than 0.5cm in amplitude will trigger the time base and with no input signal an Automatic trigger pulse is generated to produce a base line, the trigger rate increases as the Time Base speed range increases. When the knob is switched out of the AUTO position, it selects the Level on a displayed waveform of ± 3cm or more to trigger the Time Base and fully clockwise selects the PRESET LEVEL position in which signals over 1 cm will trigger the Time Base but no trace will be present when signal is absent.

Volts/cm (Attenuator) Switch adjusts the sensitivity of the Vertical Amplifier from 10mV per cm to 50V per cm in a 1,2,5,10 series of steps. Attenuator accuracy is 2% and the overall oscilloscope accuracy is within 5% on any step. The attenuator varies the sensitivity of both + and - inputs simultaneously to maintain balanced input attenuation.

Attenuator Vernier — Adjusts the vertical gain over a 3-1 range between the attenuator stops. When knob is pulled out amplifier gain is increased by X10 (AC only above 5kHz, DC gain remains constant).

DC-AC Push-Pull Switch — In the DC position of this switch (out) the amplifier is direct coupled from input to output other than in the X10 gain condition. In the AC position (in), capacitors are placed in series with the inputs to eliminate any DC component and attenuate all frequencies below 2Hz. (5Hz on X10 setting).

3.2. TERMINALS AND SOCKETS FRONT PANEL

Vertical Input

+ Co-ax socket — A positive input will cause the trace to move upwards; a negative input will cause the trace to move downwards.

- Co-ax socket — A positive input will cause the trace to move downwards, i.e. opposite to the + input. This provides a Balanced Input to the instrument and enables measurement to be made across practically any circuit as an impedance of 1MΩ exists on each input to common.

Common — Black terminal, should be connected to the ground side of the signal being measured. This terminal is not connected to the oscilloscope chassis and may be taken to ±400V from ground or even connected directly to the 240V mains for special application.

Chassis — Green terminal grounded to chassis may be linked to common terminal.

Horz. Input (AC & DC Inputs) — When the Time Base Vernier is turned anti-clockwise to "T.B.OFF" signals may be fed into either socket to produce a horizontal display, Input may be AC or DC coupled as selected. The AC input must be used if sufficient DC is present on the signal to bias the trace of the screen.

CAL. 1V p-p — A 1V peak to peak square waveform is available with fast rise and fall times to check the amplifier calibration. T.B. calibration, probe alignment or for use as an external signal.

Ext. Trigger — When the Trigger Selection switch is in the EXT position, signals from 1 to 20V will trigger the time base. Full selection of amplitude over a range of ±5V, PRESET 1V p-p or greater or AUTO with positive or negative selection is available.

3.3. REAR PANEL

Z Modulation — A 20V p-p square wave or a sine wave of 6V RMS or greater will blank the trace. Negative going signals blank the trace. Positive signals brighten the trace.

Mechanical Trigger — A switch or contacts connected across the pair of sockets will initiate the trace for single shot operation at each closure of the contacts.

Time Base Output — A 16V p-p sawtooth swinging approx. -4 to +12V to ground is available at low impedance. Min. external loading 100KΩ.

Y Plates — (Option 22) capacitive connection direct to 'Y' plates, 3V RMS/cm sensitivity. Input impedance 5KΩ each plate to ground.

4. FIRST TIME OPERATION

4.1. Set the controls of Model bwd 511 as follows before switching on:

INTENSITY	Fully anti-clockwise
FOCUS	Centred
HORZ. SHIFT	Centred
HORZ. GAIN	Anti-clockwise
TIME BASE VERNIER	Clockwise - CAL
TIME/CM	10mSec
+ - SELECTOR	+
INT-50Hz-EXT TRIGGER	INT
AC-HF-LF	AC
VERT SHIFT	Centred
TRIGGER LEVEL	Fully anti-clockwise - AUTO
VOLTS/CM	0.2V
DC - AC	DC
VERNIER-ATTEN.	Clockwise (calibrated position)

4.2. Connect instrument to power mains. (210 to 250V AC, 50 to 60Hz)

Connect a link of wire from the CAL 1V p-p front panel socket to the + co-ax socket on the L.H. side.

Switch on by rotating the INTENSITY control about ¾ of a turn. A display will appear after about 10 seconds.

5 cycles of the calibration waveform should be present on the C.R.T. Adjust the HORIZONTAL & VERTICAL SHIFT controls to centre the display and the FOCUS & INTENSITY for a sharp, bright image.

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

4.4. Return the attenuator to the 0.2V position. The effect of the DC - AC switch on low frequencies can now be seen by sliding the switch to the AC position. The top and bottom edges of the display will tilt indicating a loss of the DC and the lowest frequency components in the square wave. Always use the DC position for frequencies below 100Hz provided no DC potential exists on the waveform sufficient to cause it to deflect off the C.R.T. Now turn the Time Base Vernier control; the waveforms will compress together. Switch the TIME/CM switch to 5mSec to give two complete waveforms on the C.R.T. Now turn the TRIGGER LEVEL knob clockwise; the display will disappear, then as the control is turned it will re-appear. Notice how the start of the display moves slowly up the edge of the waveform until it disappears again at the top. Bring the control back to centre and change the + and - trigger switch over to - ; the display will change so that the negative or falling slope of the waveform is triggering the display. Rotation of the LEVEL control will again move the triggering point up or down the waveform.

Now turn the LEVEL CONTROL fully clockwise to the PRESET position. Again vary the amplitude of the signal by the attenuator and note how the trace disappears when the signal drops below 1cm deflection. The greatest use of this facility is at low frequencies where the AUTO trigger cannot be used, eliminating the need to set the LEVEL CONTROL.

4.5. Return the control to AUTO and adjust the TIME/CM switch to give 5 waveforms across the C.R.T., then turn the HORZ. GAIN control clockwise until 1 waveform is 10cm long; this illustrates the trace expansion facility. If the HORZ. SHIFT is turned, the trace can be tracked along to view any part of it from one end to the other, trace linearity being better than 5% over the full trace length.

4.6. To check the HORZ. INPUT, turn the Time Base Vernier to T.B. 'OFF' (anti-clockwise). Connect a lead from the CAL socket to the DC HORZ. INPUT socket directly above it. A horizontal line will appear whose length can be varied by the HORZ. GAIN control from approximately 4cm down to less than 2mm. The HORIZONTAL position of the trace can be set by the HORZ. SHIFT control.

4.7. To operate the mechanical or contact trigger set controls as follows:

+ - selector to -; INT. 50Hz to EXT; NORM-HF-LF to NORM; LEVEL CONTROL to PRESET; T.B. RANGE to 1 Sec; VERNIER to CAL.

Short the rear panel TRIGGER SOCKET - yellow and black with a link of wire (only +6V exists on the yellow socket) and note how the trace is initiated each time the contact makes. Now switch to + on the +- switch; trace will be initiated each time the contact BREAKS.

4.8. Z Modulation - Feed in an oscillator to the RED rear panel socket marked Z - ground connected to the BLACK trigger socket or BLACK front panel COMMON terminal.

With an input of 6VRMS or ± 10V approx., trace at normal brightness level will be fully intensity modulated.

4.9. Y plate connections (if fitted) provide direct access via .0022μF capacitors to the vertical deflection plates. They may be used with high level oscillators, transmitters, etc. for observation of RF signals up to 100MHz. Input sensitivity is approximately 10V p-p/cm (3VRMS/cm). For stationary displays of modulated signals, feed the modulated signal to the EXT trigger input, switch to EXT AC and adjust T.B. speed for suitable display.

4.10. The following sections explain the operation of Model bwd 511 when used to make specific measurements.

NOTE: Measurements can be made using either the +ve socket and the Black (common) or -ve sockets and common. For most applications other than differential measurements the +ve and BLACK should be used.

5. MEASUREMENT OF DC (DIRECT) VOLTAGES

5.1. Set LEVEL CONTROL to AUTO. Switch the DC - AC switch to DC. For an initial test take a 1½V dry cell and set the attenuator to 0.5V. Connect the negative end to the BLACK COMMON terminal, set the trace to the centre of the graticule, touch a lead from positive end of the battery to the + socket; the trace will move up 3cms, i.e. 3 x 0.5V = 1.5V. Now reverse the connections to the battery and note how the trace moves down 3cms. This illustrates how an oscilloscope can display positive and negative voltages or both simultaneously, e.g. when viewing a sine output or square wave.

5.2. NOTE: The 1MΩ input impedance of the oscilloscope must be taken into account when measuring high impedance points such as anode, grid or screen voltages of valves or the gate of F.E.T's working with high value loads. Where loading is critical a bwd high impedance probe, type F22, with an input of 10MΩ shunted by 12 pF should be used.

The DC input facility may be used to measure AC waveforms swinging about a DC voltage, as at the collector of a transistor or the anode of a valve, to check for bias settings or anode bottoming, etc. Maximum DC input should not exceed X10 input attenuator setting if it is required to re-centre the trace to view a signal superimposed on it.

6. MEASUREMENT OF AN AC (ALTERNATING) VOLTAGE

6.1. Set the DC - AC switch to AC and the Attenuator to 50V (if the input voltage is unknown). Connect a lead from the COMMON (black) input terminal to the ground (earth) side of the signal to be measured, then connect a lead from the + input socket to the signal source. (B.W.D. Models 112, 140 or 602 Sine Wave Oscillators are suitable for initial experiments in this test).

Increase the Vertical sensitivity by the VOLTS/CM switch until a display between 2 and, say, 8cm exists. Now adjust the Time Base switch and Vernier to enable the waveform to be readily seen. To measure the voltage of the displayed waveform, measure its overall height in centimetres 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 peak to peak. To convert the RMS voltage for sine waves, divide the 3V by 2.84, e.g. $\frac{3}{2.84} = 1.06\text{V RMS}$

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

7. INVERTED DISPLAYS

7.1. Where it is required to display a waveform inverted on the C.R.I., feed the signal into the -ve socket and set the input selector to either AC or DC as required. All information relating to display and measurement of signals applied to -ve input is identical to the +ve input details. The calibration and accuracy are constant for either input.

8. BALANCED OR DIFFERENTIAL MEASUREMENTS

8.1. AC Measurements

To measure a signal appearing between two points in a circuit, neither of which is at earth (ground) potential, e.g. across a push-pull primary of an output transformer between cathode and grid of a valve or emitter to collector of a transistor circuit, or at the other extreme, across a thyratron or S.C.R. load connected directly in a 400V AC power line with no isolation, and at the same time suppress any signal common to both points such as H.T. ripple or AC power line frequency as much as possible, the following method is used:-

Connect a lead from the +ve input socket to one side of the component across which the waveform is developed and another lead from the -ve socket to the other side. The attenuator is adjusted to present a suitable display and the resultant C.R.T. trace is then a true indication of the waveform being developed between the points to which the leads are coupled. Measurement of voltage and time may be made as described previously as the calibration remains constant irrespective of the input facility employed.

If a large 'Common Mode' signal appears on the display, particularly when measuring signals on equipment connected in the AC supply, the COMMON terminal should be connected to the source of the interfering signal to obtain complete rejection of it. Disconnect the ground link from chassis terminal before connecting common to any point not at ground potential.

The differential input coupling is almost essential when making low level measurements in the millivolt region even when one side of the signal source is grounded. This is because troubles due to ground loops generating hum and noise occur and can completely mask the signal. Connect leads from the +ve socket to the signal to be observed, the -ve socket to the nearest ground or common point to the signal on the equipment under test, and the COMMON to ground.

To measure AC signals which are superimposed on a high DC potential which would overload the input capacitors (400V DC or AC p-p + DC combined) the COMMON terminal is taken to the DC potential around which the AC signal is swinging, subject to a maximum of ±400V DC. If still larger signals need to be accommodated a 10-1 high impedance probe, bwd Type P22, should be employed when signals to ±1000V DC or AC p-p may be displayed.

8.2. DIFFERENTIAL DC MEASUREMENTS

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

8.3. Connect a lead from the COMMON terminal to the nearest DC potential of the signal being measured, e.g. if it is swinging about ground then it should be connected to ground or chassis; if it is say, a swinging signal between the anodes of two valves then it should be taken to the -ve rail with a maximum limit of ±400V DC to which the common terminal can be taken. The display signal in the DC differential mode can be measured directly as calibration remains constant.

8.4. NOTE: Almost infinite COMMON MODE REJECTION can be made with Model bwd 511 by connecting the COMMON (black) terminal to the signal to be rejected when it is a low impedance source and can drive a .47μF capacitor and a 1MΩ resistor in parallel. However, if this is not possible the following limitations must be considered:-

8.5. Differential rejection will only operate if the Common Mode signal to be rejected is less than X500 the Attenuator setting, e.g. with the attenuator set at 1V/cm the common mode signal must not be greater than 500V AC p-p or ±250V DC, or the input amplifier will be overloaded and the signal will be distorted. If the common mode signal is 240V AC the peak voltage is approximately 700V and the attenuator should not be used below 1.4V cm, the nearest actual setting being 2V per cm.

The accuracy of the input attenuator resistors also controls the rejection ratio and other than the 10mV settings may reduce the rejection to only 20-1 which means, in the case of a 240V AC signal, a 35V p-p signal could still appear with the required signal superimposed on it at 2V p-p/cm, unless the COMMON TERMINAL is also connected to the 240V supply as mentioned in the previous paragraph.

Connect a lead from the +ve input socket to one side of the component across which the waveform is developed and another lead from the -ve socket to the other side. The attenuator is adjusted to present a suitable display and the resultant C.R.T. trace is then a true indication of the waveform being developed between the points to which the leads are coupled. Measurement of voltage and time may be made as described previously as the calibration remains constant irrespective of the input facility employed.

If a large 'Common Mode' signal appears on the display, particularly when measuring signals on equipment connected in the AC supply, the COMMON terminal should be connected to the source of the interfering signal to obtain complete rejection of it. Disconnect the ground link from chassis terminal before connecting common to any point not at ground potential.

The differential input coupling is almost essential when making low level measurements in the millivolt region even when one side of the signal source is grounded. This is because troubles due to ground loops generating hum and noise occur and can completely mask the signal. Connect leads from the +ve socket to the signal to be observed, the -ve socket to the nearest ground or common point to the signal on the equipment under test, and the COMMON to ground.

To measure AC signals which are superimposed on a high DC potential which would overload the input capacitors (400V DC or AC p-p + DC combined) the COMMON terminal is taken to the DC potential around which the AC signal is swinging, subject to a maximum of ±400V DC. If still larger signals need to be accommodated a 10-1 high impedance probe, bwd Type P22, should be employed when signals to ±1000V DC or AC p-p may be displayed.

8.2. DIFFERENTIAL DC MEASUREMENTS

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

8.3. Connect a lead from the COMMON terminal to the nearest DC potential of the signal being measured, e.g. if it is swinging about ground then it should be connected to ground or chassis; if it is say, a swinging signal between the anodes of two valves then it should be taken to the -ve rail with a maximum limit of ±400V DC to which the common terminal can be taken. The display signal in the DC differential mode can be measured directly as calibration remains constant.

8.4. NOTE: Almost infinite COMMON MODE REJECTION can be made with Model bwd 511 by connecting the COMMON (black) terminal to the signal to be rejected when it is a low impedance source and can drive a .47µF capacitor and a 1MΩ resistor in parallel. However, if this is not possible the following limitations must be considered:-

8.5. Differential rejection will only operate if the Common Mode signal to be rejected is less than X500 the Attenuator setting, e.g. with the attenuator set at 1V/cm the common mode signal must not be greater than 500V AC p-p or ±250V DC, or the input amplifier will be overloaded and the signal will be distorted. If the common mode signal is 240V AC the peak voltage is approximately 700V and the attenuator should not be used below 1.4V cm, the nearest actual setting being 2V per cm.

The accuracy of the input attenuator resistors also controls the rejection ratio and other than the 10mV settings may reduce the rejection to only 20-1 which means, in the case of a 240V AC signal, a 35V p-p signal could still appear with the required signal superimposed on it at 2V p-p/cm, unless the COMMON TERMINAL is also connected to the 240V supply as mentioned in the previous paragraph.

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

9. ISOLATED MEASUREMENTS AC OR DC

9.1. With the isolated ground of Model bwd 511, measurements can be made between any two points of a circuit, even if neither is at ground potential. The COMMON terminal has an impedance to ground of 1MΩ and is shunted by a 0.47μF capacitor - this must be taken into account when connecting the COMMON to a point of high impedance. Maximum voltage that may be applied to the COMMON terminal is ±400V DC or 240V AC.

10. CURRENT MEASUREMENTS AC OR DC

10.1. As this Model is isolated, it may be used to measure the voltage drop across a known resistor, and by use of Ohms Law, this may be converted to current. Simpler still, at low currents, place a 1Ω resistor across the vertical input terminals (+ and Common, or - and Common) of the oscilloscope. The attenuator will then read directly in mA or Amps in lieu of mV and Volts when the oscilloscope is connected between source and load. This configuration will read current either AC or DC and, unlike 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, etc.

11. MEASUREMENTS WITH AN EXTERNAL HORIZONTAL INPUT

11.1. As the HORZ. INPUT is directly coupled, the C.R.T. display can be used for X - Y plotting over an 8 x 10 cm area.

First calibrate the Horizontal Amplifier by feeding in the CAL waveform and adjusting the HORZ. GAIN until the display equals 1cm. Set the Vertical Attenuator to 1V/cm. The oscilloscope has now identical X and Y sensitivities, of 1V p-p/cm. (Other sensitivities can be used with equal or unequal sensitivites as required).

Remove the CAL. waveform and centre the spot. Positive or negative voltages may now be applied to X and Y inputs and the result plotted on tracing paper placed over the C.R.T. or transferred to a ruled graph paper. AC signals will show phase displays or Lissajous figures. With the vertical input switched to DC less than 1° phase shift exists up to 5kHz and 5° at 20kHz between X and Y inputs.

The balanced inputs also permit algebraic subtractions to be incorporated in this type of display, e.g. +3V applied to the +ve input and +1V to the -ve input will produce only +2V deflection of the C.R.T.

12. MECHANICAL CONTACT TRIGGER

12.1. Set front panel trigger switches to EXT., NORM, and -, and Trigger Level Control to PRESET. A pair of contacts, switch, etc. placed across the Yellow and Black rear panel sockets will initiate one sweep for each CLOSING of the contact. If the + and - selector switch is now switched to + an OPENING contact will initiate the display.

13. CIRCUIT DESCRIPTION

13.1. NOTE: As the circuit is isolated from ground, all measurements must be made with respect to the COMMON line and not to the chassis frame.

13.2. Vertical Amplifier

The balanced inputs via the +ve and -ve input terminals are connected to the AC - DC slide switch S1A and B. In the DC position, C1 and C21 are shorted out, but in the AC position they block DC and very low frequency signals. From S1 the signal passes through the dual attenuator S2A to D and S2E to H which attenuate the inputs in a 1,2,5,10,20,50,100,200,500 ratio, S2A to D attenuates +ve input, S2E to H the -ve input.

The Vertical Amplifier is a 3-stage balanced circuit with emitter follower driver stages between amplifiers.

V1A and V1B functions as a low gain high impedance balanced input stage with a gain of approximately X2. Cross neutralising compensates for coupling in the valve and input circuitry. The VDR in the cathode circuit holds the vertical amplifier gain stable within 1% over a mains change of 200V to 260V. C43 and the VDR form a long time constant filter to eliminate time base and mains fluctuations from affecting the vertical amplifier. Output potentials across R30 and R34 are balanced (with no input signal) by RV2A front panel ATTEN. BAL. preset. V1A and V1B anodes are directly connected to Q1 and Q2 emitter followers which in turn drive Q3 and Q4 amplifiers. H.F. compensation is obtained by C46 shunted across R43. The vertical calibrate control RV1 is placed in series with the VERNIER control and R43 between the emitters to control gain by degeneration across the emitter loads.

When the VERNIER panel control is pulled out, S10A closes, placing C48 across R48 and RV1, increasing the AC gain above 5Hz by approximately X8. RV5 permits the overall amplifier gain to be set to X10 by being effectively in series with C48. By placing RV5 in the emitter leg of Q3 it applies a polarising potential to C48 with respect to Q4 emitter to which C48 returns via RV3.

Vertical shift is applied to the collector loads of Q3 and Q4 by RV2B and R42 and R46 build-out resistors.

Q5 and Q6 emitter followers provide a high input impedance for Q3 and Q4 and a low output impedance to drive the output stage Q7 and Q8.

The hybrid output stage provides a large output swing necessary to drive the C.R.T. plates. Q7 and Q8 current drivers drive the cathodes of V2A and B with an overall characteristic similar to that of a pentode stage.

High frequency compensation is controlled by C50, C51 & R54, and RV4 & C49. Trigger take-off is from V2B anode via R62 and C55 to the INT-50Hz-EXT selector switch S3B. S10B in series with R59 and associated compensating components increases the output stage gain approximately X1.5 when the X10 gain switch closes. This, together with the X8 gain of Q3 and Q4, provides the overall gain requirement of X10.

13.3. Trigger Circuit

Four trigger sources can be applied to the trigger circuit. Internal trigger from the Vertical Amplifier, line frequency (50Hz) from the 6.3V rail via R75, External Trigger via R76 and C65 or the Mechanical Trigger pulse, also via R76, C65, which is generated when R78 is shorted out, producing a negative pulse which feeds through C67, C66 and R77.

S3B selects the INT-50Hz-EXT trigger source which is coupled through S4A and B NORM-HF-LF selector to C71 and Q10 phase splitter. The required output phase is selected by S5B + and - switch and then coupled to Q11 emitter follower drive stage through C73. Two controls in the emitter circuit adjust the trigger level. RV10 TRIGGER LEVEL Control varies the base voltage and therefore the emitter voltage which in turn controls the trigger point of the following Schmitt

Trigger pair Q12 and Q13. When it is rotated fully clockwise to the PRESET position the pick-up arm of the potentiometer disconnects from the track and the divider R91 and RV111 take over to control the trigger level.

Q12 and 13 generate a precise amplitude square to pulse wave from any amplitude input. When S6 is closed the action is as follows: with Q13 conducting, its collector will bottom and Q13 will be cut off by the voltage divider action across R95 and R97. A negative going input signal will cut off Q12, its collector will rise pulling Q13 base positive, so turning Q13 on, producing a negative trigger pulse at the collector. As the emitters are coupled together, the current through Q13 will now hold Q12 off until its base rises above the common emitter potential and the switching action is reversed. When S6B is opened, C76, together with C77 to C80 as selected by S7A, couple the emitters of Q12 and Q13 forming an emitter coupled bi-stable circuit which will free run at a time constant determined by the capacitors and the emitter impedances. As the capacitors reduce as the Time Base speed increases, the free running rate of the AUTO trigger also increases maintaining a constant trace brightness with no input signal.

13.4. Time Base Circuit

The Time Base sawtooth generator consists of Q14 and 15 bi-stable trigger, V3A Miller sawtooth generator and V3B cathode follower with associated clamping diodes D7, 8, 10, 11 and 12. The function is as follows:-

Assuming Q14 is conducting, Q15 will be cut off, its collector will rise and D11 will be conducting, pulling the grid of V3A positive. The anode of V3A will fall to approx. +60V and by the coupling through B1, R128 and C89, the cathode of V3B will fall to -1V until D10 conducts through R129 and 130 and attempts to pull D11 out of conduction. In this direct coupled quiescent state, the trace will be ready for a trigger input pulse from Q13 via C81. A negative pulse on Q14 base will cause the collector to rise taking Q15 base positive. This causes current to flow through Q15 into the emitter resistor R111, biasing Q14 off further and a rapid cumulative action occurs in which Q14 cuts off and Q15 saturates. D11 becomes reverse biased, V3A is left with its grid at -0.5V approx. and connected through the timing resistor R116 to R122 to a negative potential on RV13 which will pull V3A towards cut-off.

However, the timing capacitor C90 - C98 as selected by S7D is connected between V3A grid and anode via the DC coupling of B1, R128, C89 and R127 and V3B.

As V3B grid attempts to fall and charge the timing capacitor, its anode will rise. This rise is communicated back to its own control grid via the DC coupling, V3B and the selected timing capacitor.

The result of this negative feedback is to linearise the charging rate of the timing capacitor and to produce a positive going sawtooth waveform at the anode of V3A and via the DC coupling to V3B where it appears at low impedance at the cathode. The sawtooth continues to rise until the potential at the junction of R129 and R130 reaches approx. -6V, D12 then conducts and charges C82 to C86 as selected by S7B. It also takes the base of Q14 positive to its emitter potential and continues positively until Q14 conducts causing its collector to fall, cutting off Q15 and at the same time transferring the emitter current from Q15 to Q14. D11 conducts pulling the grid of V3A positively and its anode falls, rapidly discharging the timing capacitor until V3B cathode falls sufficiently to cause D10 to conduct to pull D11 back to a quiescent condition and stabilise the valve condition ready for the next trigger pulse, which will initiate the next trace once the hold-off capacitor C82 - 86 have discharged sufficiently through R99 and the base current of Q14.

C.R.T. Blanking by the Time Base circuit is accomplished by directly coupling the C.R.T. blanking electrode to Q16 collector which is driven between the clamping diode limits of +6.2V (D9) and +54V (D2).

Q16 is driven by Q20 via R126 common emitter resistor and conducts during return trace, but is biased off during the forward trace. C117 and C88 speed up capacitors ensure sharp turn on and turn off times of the blanking waveform.

13.5. Horizontal Amplifier

Two pentodes V4 and 5, and transistor Q20 are employed to drive the horizontal display. These provide good linearity at high gain with good frequency response. The Time Base output from V3B cathode is divided down through R131 and R133 to feed to V4 grid. Horizontal shift voltage is supplied to the bottom of the divider from RV14A HORZ. SHIFT control.

HORZ. GAIN control RV14B between the cathodes of V4 and 5 controls the degeneration and hence the stage gain. It operates between min. and max. limits set by RV15 and 16. High frequency compensation is provided by C102 and 103. T.B. output at rear panel is connected to V4 cathode via R153 for a low impedance drive (2000Ω approx.)

When the Time Base VERNIER is turned anti-clockwise to T.B. OFF, S8A opens to disable the Time Base circuit and S8B opens RV15 min. gain control to increase the range of the Horizontal Amplifier from 5-1 to over 10-1.

13.6. C.R.T. and Supplies

Type D13/27 C.R.T. requires approximately equal positive and negative E.H.T. supplies for correct operation. The negative supply is a voltage doubler consisting of D5 and 6 with C57, C58, C59 and C60 capacitors. A second stage of filtering by R67 and C56 reduces ripple to a low level. RV8 INTENSITY control varies the impedance of the divider between grid and cathode and so varies the potential between them.

'Z' modulation is coupled through C64 to the C.R.T. grid. Focus potentials for RV6B are obtained from the E.H.T. divider R70, RV6B, R71, RV8 and R72. All other electrode voltages are preset, RV6A Astigmatism control, RV7 Geometry control, together with RV18 and R69 divider to the deflection plate shield, are adjusted for optimum focus and pattern geometry.

The P.D.A. supply, like the negative E.H.T. supply, is a voltage doubler rectifier by D3 and D4 with C62 filter and C63 coupling capacitor. D4 is returned to the +266V rail to add this potential to the PDA voltage.

13.7. Power Supplies

Two secondary windings provide the main DC supplies. +64V and -64V is obtained from the 51V winding by half wave rectifying, followed by three stages of filtering for the various circuits. The +266V rail is obtained by doubling the 82V winding and adding it to the +64V supply. All valve heaters other than V1 are taken to a 6.3V rail. V1 is supplied by a 5.6V DC supply. 9V AC is rectified by D19, filtered by C105 and stabilised by Q17 emitter follower using zener diode D1 reference.

13.8. Calibrator

The 51V AC supply is fed to Q9 base via R87. Q9 is wired between the regulated +5.6V supply and common so that the collector swings from 0 to approx. +5.4V. Potentiometer RV9 in series with R82 picks off 1V p-p of the collector swing and this square wave is fed through C70 to the CAL socket.

14. ADJUSTMENTS AND MAINTENANCE

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

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

To aid fault finding the voltages at various points are shown on the circuit.

NOTE: Voltages, unless otherwise stated, are shown with respect to the COMMON line - measurement cannot be made by using the instrument frame as a meter connection.

Valve replacements will not affect the calibration of this instrument. However, V1 needs to be reasonably balanced so that the Vernier Balance control has adequate range to operate. If a replacement valve does not provide the required degree of balance try interchanging the 6DJ8 with V2 output stage. Other valves require no selection.

14.2. Model bwd 511 Alignment Procedure

With instrument functioning and trace aligned to graticule, check the following details prior to alignment with TRIGGER LEVEL set to AUTO and T.B. to 1mSec.

(a) ATTEN. to 1V, VERNIER anti-clockwise, centre trace with shift. Turn VERNIER clockwise and re-centre with ATTEN. BAL. Preset located in centre of vertical shift knob. Repeat if necessary to eliminate trace movement when Vernier is turned.

(b) Check operation of T.B. VERNIER.

(c) Turn VERNIER to T.B. OFF. Spot should move ±5cm with HORIZONTAL SHIFT control.

(d) General check of controls:

(i)	Intensity:	Linear control over intensity range.
(ii)	Focus:	Approx. centre with movement either side.
(iii)	Horz. Gain:	Trace should expand equally either side of centre.
(iv)	Vert. Shift:	Trace should move completely off screen above and below centre.
(v)	Trigger Level:	With ATTEN. at 0.2V and CAL signal fed into +ve input, check AUTO, Level Select and PRESET operation.
(vi)	AC - DC Switch:	Set up as for (v), charge from AC to DC; trace will display a partly differentiated wave on AC and square wave on DC.
(vii)	+ - Switch:	Set up as for (v), Trigger point should change over as indicated by switch.
(viii)	Horz. Input & Gain:	Feed CAL signal into Horz. Input socket with T.B.VERNIER turned to T.B. OFF. HORZ.GAIN should display from 2mm to 4cm approx.

(e) C.R.T. Trace Alignment - If a 1000Hz square wave signal is available, feed this into the VERT. AMPLIFIER and adjust waveform to fill the screen. T.B. to 2mSec, VERNIER to CAL. If a square wave is not available use the CAL waveform, T.B. to 20mSec, VERNIER to CAL.

RV6A concentric preset with the Focus knob is adjusted in conjunction with the FOCUS control to obtain the best resolution over the entire screen area.

RV7 adjusts the pattern geometry and should be set to display vertical and horizontal lines with minimum of pincushion or barrel distortion. RV6A may need slight readjustment after RV7 has been set as some interaction occurs.

RV18 adjusts the interplate shield potential and should be set for optimum focus over the entire screen area. As RV6A, 6B, 7 and 18 interact the best result will only be found after several re-adjustments of each control.

(f) Attenuator Alignment - Test equipment required: 1kHz square wave generator with better than 1% amplitude accuracy.

(g) Set ATTENUATOR to 0.2V, feed in 1V p-p (1% accuracy) square wave.

(h) Set RV1, Vertical Amplifier Calibrate Control to display 5cm deflection.

(i) Neutralising Adjustment - Test equipment required: 1kHz. square wave generator with better than 1µSec rise time and variable output from 50mV to 20V p-p (Model bwd 602 and 114 are suitable).

The instrument should be inverted and a 4" to 5" wide metal plate placed across chassis side rails covering attenuator assembly. Set attenuator to 0.01V p-p, T.B. to 500µSec. VERNIER to CAL, Input 1kHz 50mV amplitude between +ve and BLACK terminals.

Adjust C44 screw trimmer (located under P/C board close to V1) for optimum square wave shape. Change input to -ve and BLACK terminals and adjust C45 for optimum square wave. Repeat operation.

(j) Remove screening plate over attenuator and set attenuator switch to 0.02V. Apply 1kHz square wave between +ve or -ve and common terminal. The following list indicates the capacitors to adjust to correct the response at each attenuator setting:

ATTEN. RANGE	CAPACITOR +VE INPUT	-VE INPUT
10mV	-	-
20mV	C7	C28
50mV	C8	C29
100mV	C18	C39
200mV	C9	C30
500mV	-	-
1V	C15	C37
2V	C10	C31
5V	-	-
10V	C17	C38
20V	C11	C33
50V	-	-

(k) Input Capacitance Adjustment - Test equipment required: Capacitance meter reading from 0 - 100pF. Connect capacitance meter across +ve or -ve input to common. Check input capacitance at the 10mV position, then adjust capacitor settings as shown below. To make input capacitance equal to value of 10mV (approx. 40pF).

ATTEN. RANGE	+VE INPUT	-VE INPUT
10mV	-	-
20mV	C2	C23
50mV	C3	C24
100mV to 50V	None	None

Where no capacitor adjustment is indicated attenuator is automatically correct by previous adjustment on other ranges.

(l) Vertical Amplifier Alignment - Test equipment required: 200kHz square wave generator less than 50 nanoSec. rise time and constant amplitude signal generator from 50kHz to 25MHz minimum.

(m) Attenuator to 0.1V, input to +ve and BLACK terminals, signal input 400mV p-p T.B. range 1µSec, VERNIER to CAL.

Adjust C49 (underside of P/C board) and RV4 (forward of V2) for optimum square wave shape, and C46 for fastest rise time with minimum overshoot.

(n) Check bandwidth, 4cms deflection below 50kHz should drop to not less than 2.8cm at 10MHz. (NOTE: If direct connection is fitted to vertical plates Option 22 bandwidth will be restricted to approx. 8MHz due to additional capacity loading).

(o) Time Base Alignment - Test equipment required: Crystal controlled oscillator and frequency divider with 1, 10 and 100µSec, 1, 10 and 100mSec output.

(p) Feed in 1mSec pulse (1kHz) T.B. to 1mSec, VERNIER to CAL.

(q) Adjust RV15 (centre front of P/C board) for trace 10.5cm long.

(r) Now adjust RV11 (front R.H. side) for 1 pulse/cm.

(s) Turn T.B. to 100µSec and check with 100µSec Pulse (10kHz).

(t) Turn T.B. to 10µSec and check with 10µSec pulse (100kHz). Adjust by C93 (top of T.B. printed circuit wafer) for 1 pulse/cm.

(u) Turn T.B. to 1µSec and check with 1µSec pulse (1MHz). Adjust by C92 (second trimmer down on P/C wafer) for 1 pulse/cm.

(v) Turn T.B. to 0.5µSec input 1 µSec pulse adjust, C91 (third trimmer down on P/C wafer) for 1 pulse/2cm.

(w) Turn T.B. to 0.2µSec, Input 1µSec pulse, adjust C90 (bottom trimmer) for 1 pulse/5cm.

(x) Horz. Expansion - T.B. to 1mSec, VERNIER to CAL. Feed 1kHz square wave in, adjust VERNIER or Input frequency to display 1 waveform/cm. Turn HORZ. GAIN fully clockwise, adjust RV16 (centre front) to display 1 waveform/5cm.

(y) Horizontal Amplifier Check - Switch to Horizontal Input min. gain. Feed sine wave at 1kHz into the HORZ. INPUT socket, adjust for 6cm deflection. Amplitude should not fall below 4.2cm at 350kHz.

(z) Sensitivity - Min. gain approximately 4V p-p/cm. Max. gain approximately 0.3V p-p/cm.

(aa) Calibrator - ATTEN. to 0.2V, Input DC, feed in CAL waveform. Adjust RV19 (EHT board) for 5cm deflection after checking calibration of Amplifier from known voltage source.

15. ACCESSORIES FOR MODEL bwd 511 OSCILLOSCOPE

Demodulator Probe	Type P35	(100kHz to 100MHz 30V p-p max.)
High Impedance Probe	Type P22/BNC or UHF as required	(10MΩ and 12 pF)
Screened leads with Prods	Type P30	(complete with prod and crocodile clip)
4mm Plugs	Various colours	
Leather Carrying Case		
Instrument Trolley	Type T60	(Available with or without accessory drawer)

16. REPLACEMENT PARTS

16.1. Spares are normally available directly from the manufacturer, B.W.D. ELECTRONICS PTY. LTD. When ordering it is necessary to indicate the serial number of the instrument. If exact replacement parts are not to hand, locally available alternatives may be used, provided they possess a specification not less than, or physical size not greater than, the original components.

As the policy of B.W.D. ELECTRONICS PTY. LTD. is one of continuing research and development, the company reserves the right to supply the latest equipment and make amendments to the circuits and parts without notice.

17. WARRANTY

17.1. The equipment is guaranteed for a period of twelve (12) months from the date of purchase, with the exception of cathode ray tubes, which are covered by their manufacturers own warranty.

Please refer to Guarantee Registration Card No. ..8.6.8.1.. which accompanied instrument for full details of conditions of warranty.

15. ACCESSORIES FOR MODEL bwd 511 OSCILLOSCOPE

Demodulator Probe	Type P35	(100kHz to 100MHz 30V p-p max.)
High Impedance Probe	Type P22/BNC or UHF as required	(10MΩ and 12 pF)
Screened leads with Prods	Type P30	(complete with prod and crocodile clip)
4mm Plugs	Various colours	
Leather Carrying Case		
Instrument Trolley	Type T60	(Available with or without accessory drawer)

16. REPLACEMENT PARTS

16.1. Spares are normally available directly from the manufacturer, B.W.D. ELECTRONICS PTY. LTD. When ordering it is necessary to indicate the serial number of the instrument. If exact replacement parts are not to hand, locally available alternatives may be used, provided they possess a specification not less than, or physical size not greater than, the original components.

As the policy of B.W.D. ELECTRONICS PTY. LTD. is one of continuing research and development, the company reserves the right to supply the latest equipment and make amendments to the circuits and parts without notice.

17. WARRANTY

17.1. The equipment is guaranteed for a period of twelve (12) months from the date of purchase, with the exception of cathode ray tubes, which are covered by their manufacturers own warranty.

Please refer to Guarantee Registration Card No. ..8681.. which accompanied instrument for full details of conditions of warranty.

R	MODIFICATIONS
C 133	ISSUE 9 REDRAWN WITH MODIFIED S7 INCORPORATED
Q 20	ISSUE 10 C133 ADDED
V 5	ALTERNATIVE S7A SWITCH DECK ADDED
D 19	

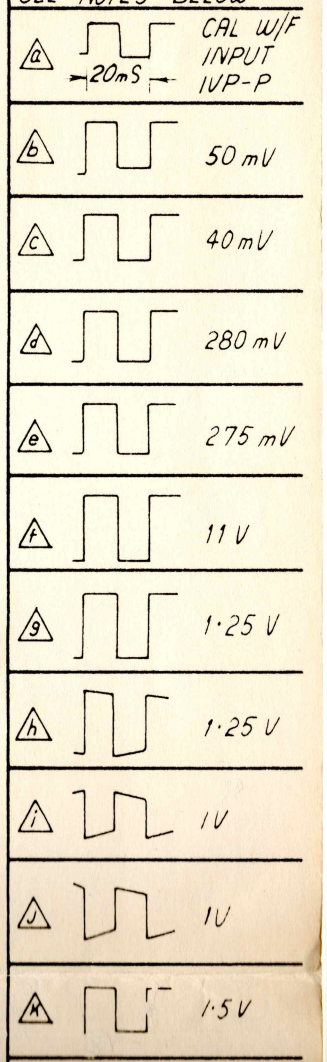
SWITCHES

S1A & B	AC-DC INPUT SELECT
S2A-H	INPUT ATTENUATOR
S3A & B	TRIG SELECTOR. INT-LINE-EXT
S4A & B	TRIG SELECTOR NORM H.F.-L.F
S5A & B	TRIG SELECTOR + OR -
S6A & B	TRIG SELECTOR AUTO-LEVEL SELECT
S7A-D	TIME BASE RANGE
S8A & B	TIME BASE RANGE INT-EXT (REAR RV13)
S9A & B	POWER ON-OFF (REAR RV8)
S10A & B	X1 - X10 VERTICAL GAIN (REAR RV3)

CONTROLS

RV1	CAL VERT. AMPL.
+ RV2A	ATTEN BALANCE
+ RV2B	VERTICAL SHIFT
+ RV3	VERTICAL GAIN - VERNIER
RV4	H.F. COMP.
RV5	x 10 CAL
+ RV6A	ASTIGMATISM
+ RV6B	FOCUS

WAVEFORMS SEE NOTES BELOW



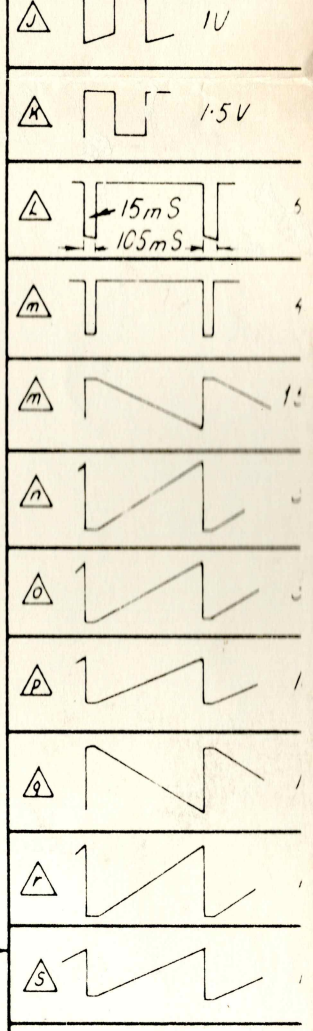
RV4	H.F. COMP.
RV5	x 10 CAL
f RV6A	ASTIGMATISM
f RV6B	FOCUS
RV7	GEOMETRY
f RV8	INTENSITY
RV9	CAL SIGNAL 1V P-P
f RV10	TRIGGER LEVEL
RV11	TRIGGER PRESET LEVEL
RV12	T.B. CAL
f RV13	T.B. VERNIER
f RV14A	HORZ SHIFT
f RV14B	HORZ GAIN
RV15	HORZ x 1 PRESET
RV16	HORZ x 5 PRESET

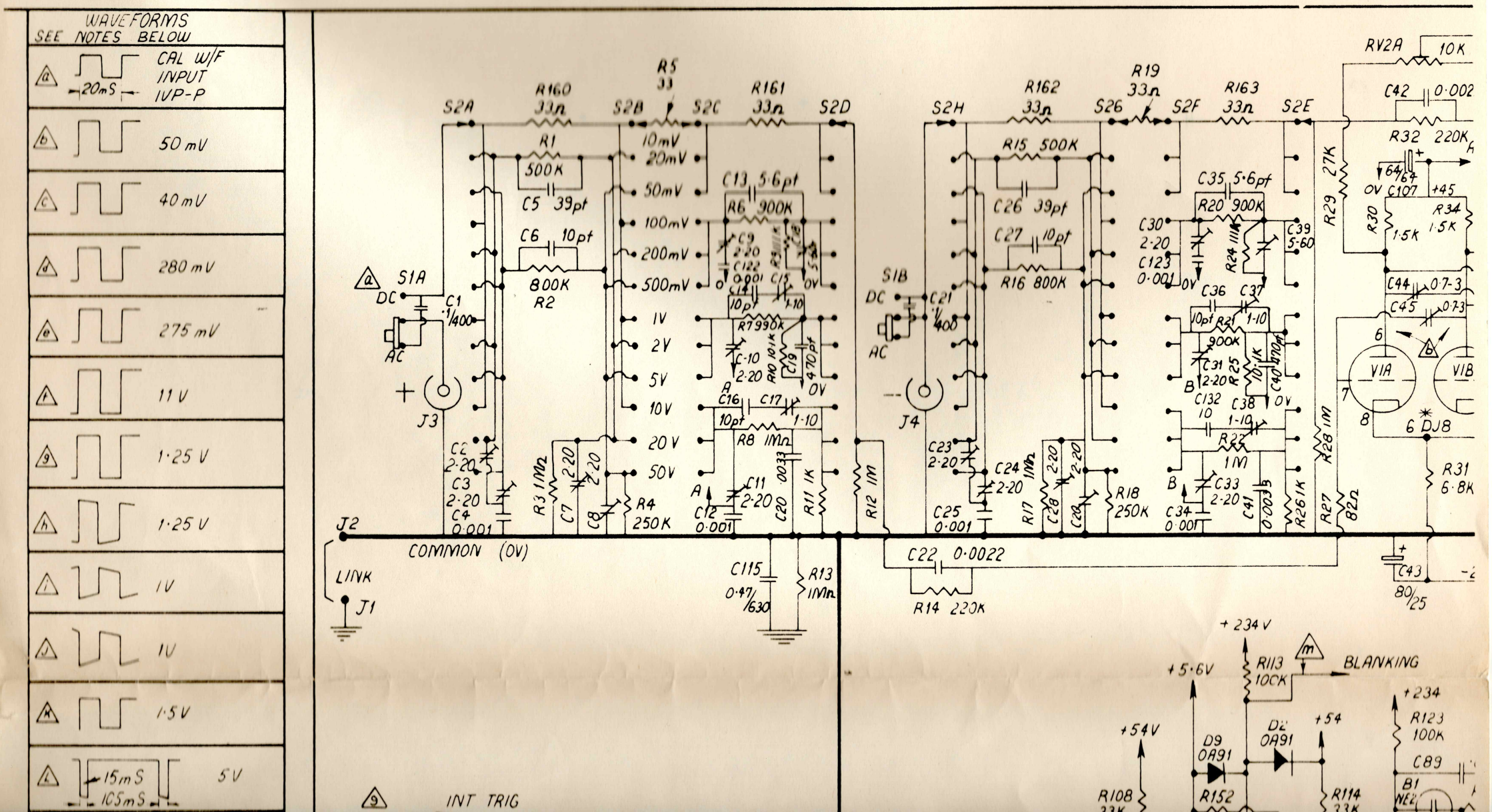
f DENOTES FRONT PANEL CONTROL

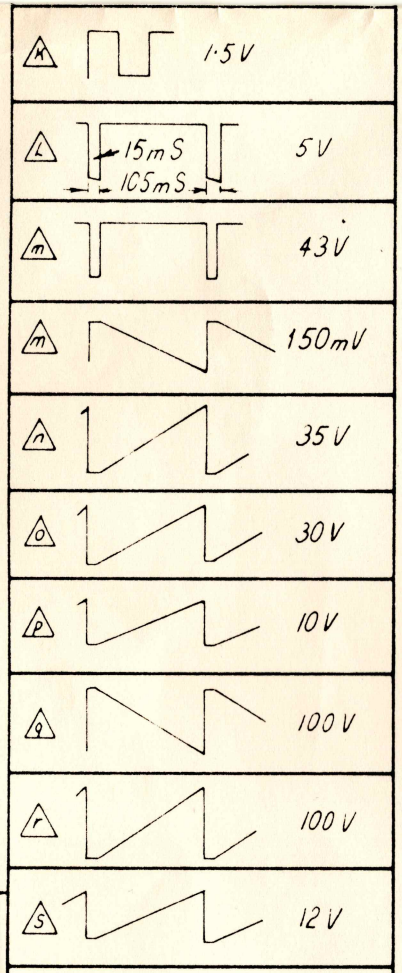
NOTE: WAVEFORMS SHOWN ARE OBTAINED USING 1VP-P CALWAVEFORM (50 Hz - 20m Sec)

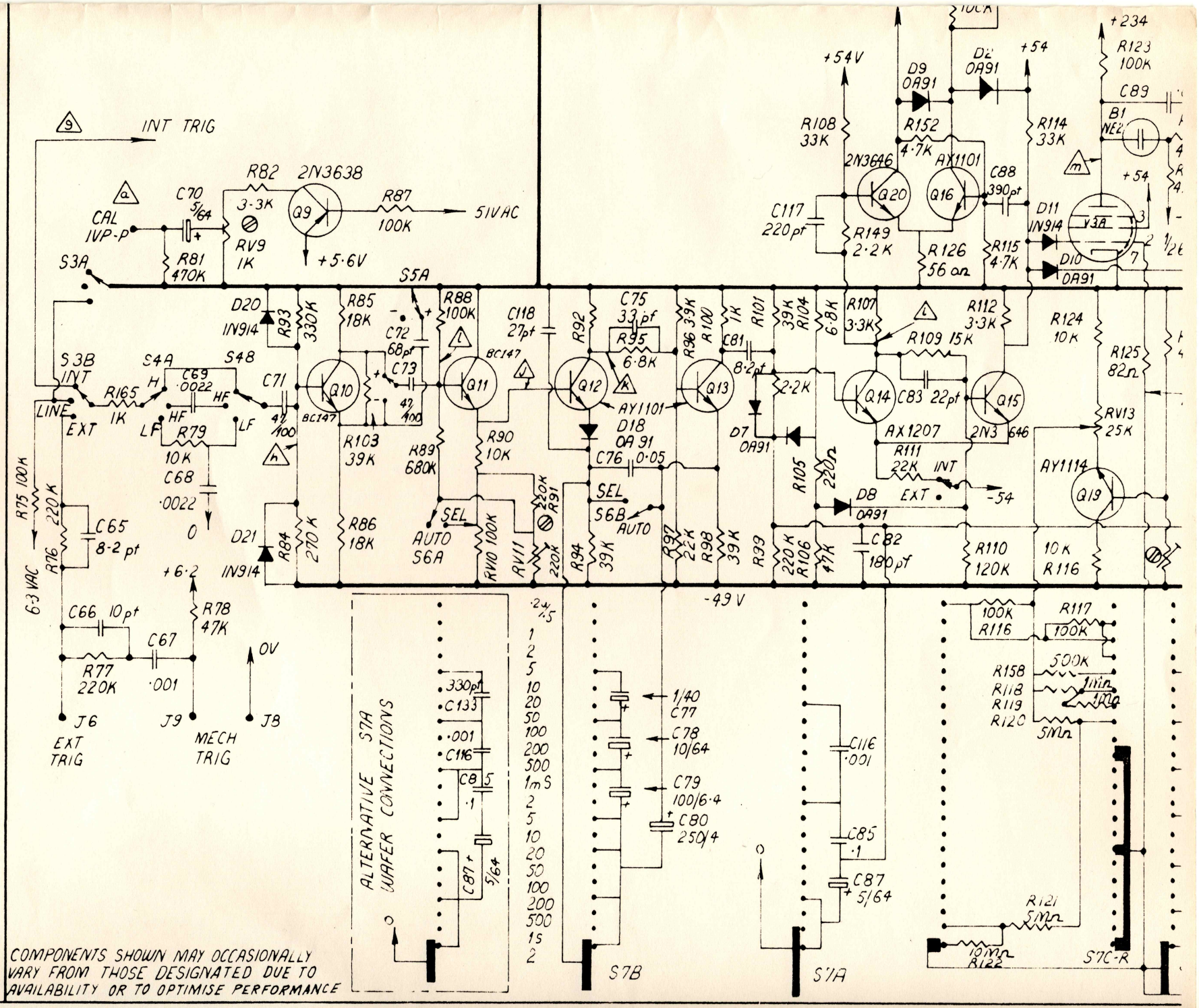
CONTROLS SET AS FOLLOWS

INPUT SELECTOR	D.C
ATTENUATOR	0·5 V
VERNIER GAIN	CAL
TRIG LEVEL	AUTO
TRIG SELECT SWITCHES	INT - NORM - +
TIME BASE	10m SEC
TIME BASE VERNIER	CAL
HORZ GAIN	x 1

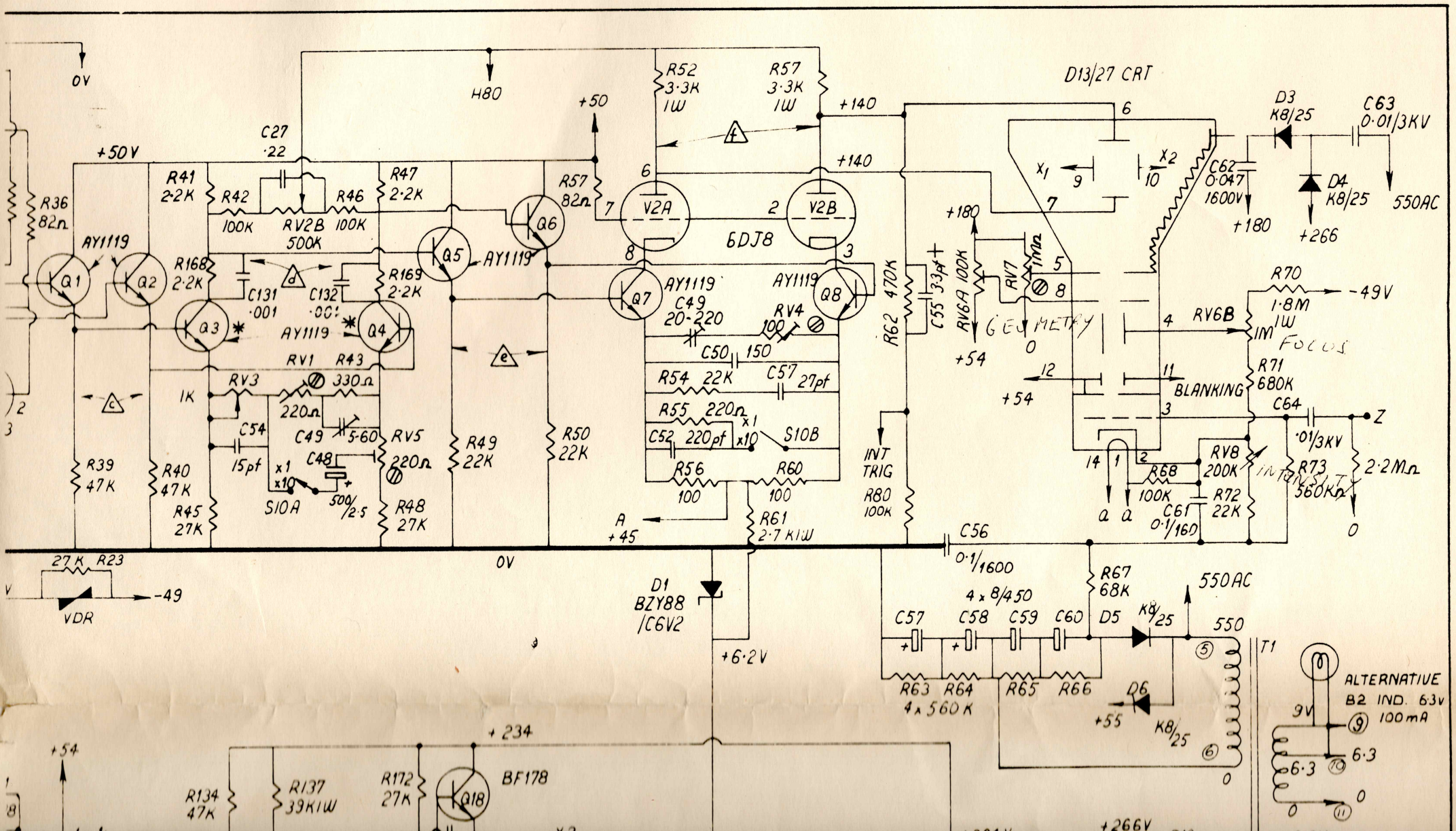


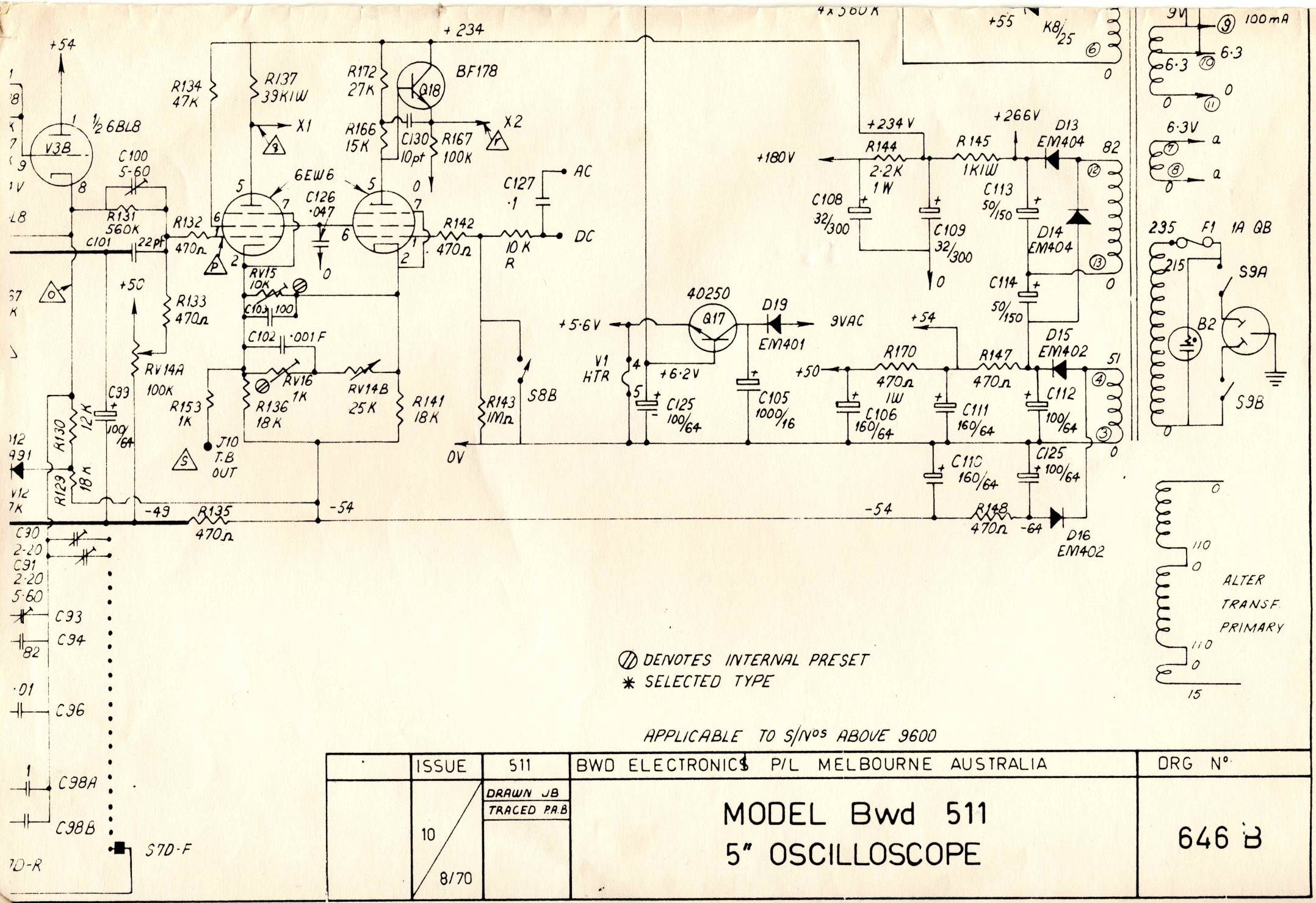

WAVEFORMS
SEE NOTES BELOW
CAL W/F INPUT IVP-P
20mS
50 mV
40 mV
280 mV
275 mV
11 V
1·25 V
1·25 V
1V
1V
1·5 V
15mS
105mS
5V
INT TRIG
S2A
S2B
S2C
S2D
S2H
S2G
S2F
S2E
R160 33Ω
R161 33Ω
R162 33Ω
R163 33Ω
R5 33
R19 33Ω
RV2A 10K
R1 500K
C5 39pf
C6 10pf
R2 800K
R15 500K
C26 39pf
C27 10pf
R16 800K
C13 5·6pf
R6 900K
C35 5·6pf
R20 900K
R24 111K
C36
C37
R21 1-10
C31 2-20
R25 10·1K
C38 1-10
R22 1M
C132 10
C33 2-20
C34 0·001
C41 0·0033
R26 1K
R27 82Ω
R28 1M
R29 27K
R30 1·5K
R34 1·5K
C42 0·002
R32 220K
C107 64/64
C44 0·7-3
C45 0·73
VIA
VIB
6 DJ8
R31 6·8K
C43 80/25
S1A
DC
AC
C1 1/400
J3
S1B
C21 1/400
J4
10mV
20mV
50mV
100mV
200mV
500mV
1V
2V
5V
10V
20V
50V
C9 2·20
C122 0·001
C15 1-10
C14 10pf
R7 990K
C10 2·20
R10 10·1K
C19 470pf
C16 10pf
C17 1-10
R8 1MΩ
C11 2·20
C12 0·001
C20 0·033
R11 1K
R12 1M
R3 1MΩ
C7 2·20
C8 2·20
R4 250K
C2 2·20
C3 2·20
C4 0·001
C23 2·20
C24 2·20
C25 0·001
R17 1MΩ
C28 2·20
C29 2·20
R18 250K
C30 2·20
C123 0·001
C39 5·60
C40 470pf
J2
COMMON (OV)
LINK
J1
C115 0·47/630
R13 1MΩ
C22 0·0022
R14 220K
+234V
+5·6V
R113 10CK
BLANKING
+54V
D9 OA91
D2 OA91
+54
+234
R123 100K
C89
R108
R152
R114
B1





COMPONENTS SHOWN MAY OCCASIONALLY VARY FROM THOSE DESIGNATED DUE TO AVAILABILITY OR TO OPTIMISE PERFORMANCE


0V
H80
+50
+50V
R52 3·3K 1W
R57 3·3K 1W
+140
D13/27 CRT
D3 K8/25
C63 0·01/3KV
C62 0·047 1600V
D4 K8/25
550AC
+180
+266
R36 82Ω
C27 ·22
R41 2·2K
R42 100K
RV2B 500K
R46 100K
R47 2·2K
R57 82Ω
V2A
V2B
6DJ8
AY1119
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
R168 2·2K
C131 ·001
C132 ·001
R169 2·2K
C49 20-220
RV4 100
C50 150
R54 22K
C57 27pf
R55 220Ω
C52 220pf
S10B
R56 100
R60 100
R61 2·7K1W
A +45
R62 470K
C55 3·3pf
RV6A 100K
RV7 1MΩ
GEOMETRY
+54
R70 1·8M 1W
-49V
RV6B 1M
FOCUS
R71 680K
BLANKING
C64 ·01/3KV
Z
RV8 200K
INTENSITY
R73 560KΩ
2·2MΩ
R68 100K
R72 22K
C61 0·1/160
RV1 R43
RV3 330Ω
220Ω
1K
C54 15pf
C49 5-60
C48 500/2·5
RV5 220Ω
S10A
R39 47K
R40 47K
R45 27K
R48 27K
R49 22K
R50 22K
INT TRIG
R80 100K
C56 0·1/1600
27K R23
VDR
-49
D1 BZY88 /C6V2
+6·2V
R67 68K
4 x 8/450
C57 C58 C59 C60
D5 K8/25
R63 R64 R65 R66
4 x 560K
D6 K8/25
+55
T1
ALTERNATIVE B2 IND. 6·3V 100mA
9V
6·3
+234
+54
R134 47K
R137 39K1W
R172 27K
Q18
BF178
+266V



⊘ DENOTES INTERNAL PRESET

✱ SELECTED TYPE

APPLICABLE TO S/Nos ABOVE 9600

	ISSUE	511	BWD ELECTRONICS P/L MELBOURNE AUSTRALIA	DRG N°
	10 / 8/70	DRAWN JB TRACED P.A.B	MODEL Bwd 511 5" OSCILLOSCOPE	646 B

	MODIFICATIONS
R	ISSUE 9
C 133	REDRAWN WITH MODIFIED S7 INCORPORATED
Q 20	ISSUE 10 C133 ADDED
V 5	ALTERNATIVE S7A SWITCH DECK ADDED
D 19	

SWITCHES

S1A & B	AC - DC INPUT SELECT
S2A - H	INPUT ATTENUATOR
S3A & B	TRIG SELECTOR. INT - LINE - EXT
S4A & B	TRIG SELECTOR NORM H.F - LF
S5A & B	TRIG SELECTOR + OR -
S6A & B	TRIG SELECTOR AUTO - LEVEL SELECT
S7A - D	TIME BASE RANGE
S8A & B	TIME BASE RANGE INT - EXT (REAR RV13)
S9A & B	POWER ON - OFF (REAR RV8)
S10A & B	X 1 - X 10 VERTICAL GAIN (REAR RV3)

CONTROLS

RV1	CAL VERT. AMPL.
f RV2A	ATTEN BALANCE
f RV2B	VERTICAL SHIFT
f RV3	VERTICAL GAIN - VERNIER
RV4	H.F. COMP.
RV5	x 10 CAL
f RV6A	ASTIGMATISM
f RV6B	FOCUS
RV7	GEOMETRY
f RV8	INTENSITY
RV9	CAL SIGNAL 1V P-P
f RV10	TRIGGER LEVEL
RV11	TRIGGER PRESET LEVEL
RV12	T.B. CAL
f RV13	T.B. VERNIER
f RV14A	HORZ SHIFT
f RV14B	HORZ GAIN
RV15	HORZ x 1 PRESET
RV16	HORZ x 5 PRESET

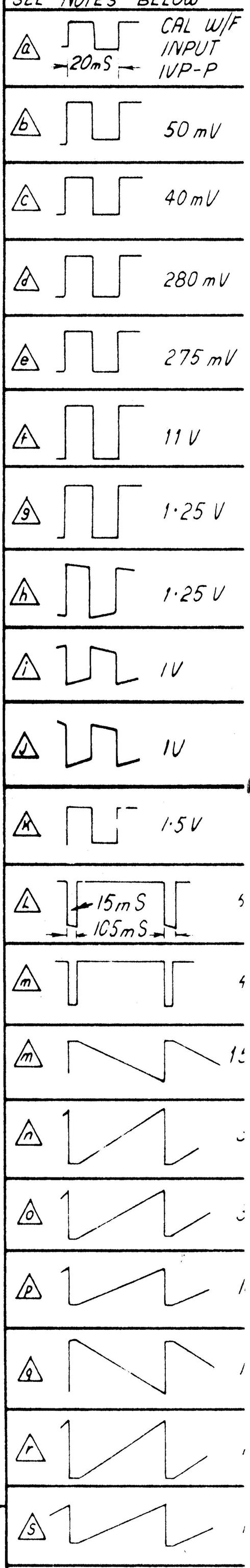
f DENOTES FRONT PANEL CONTROL

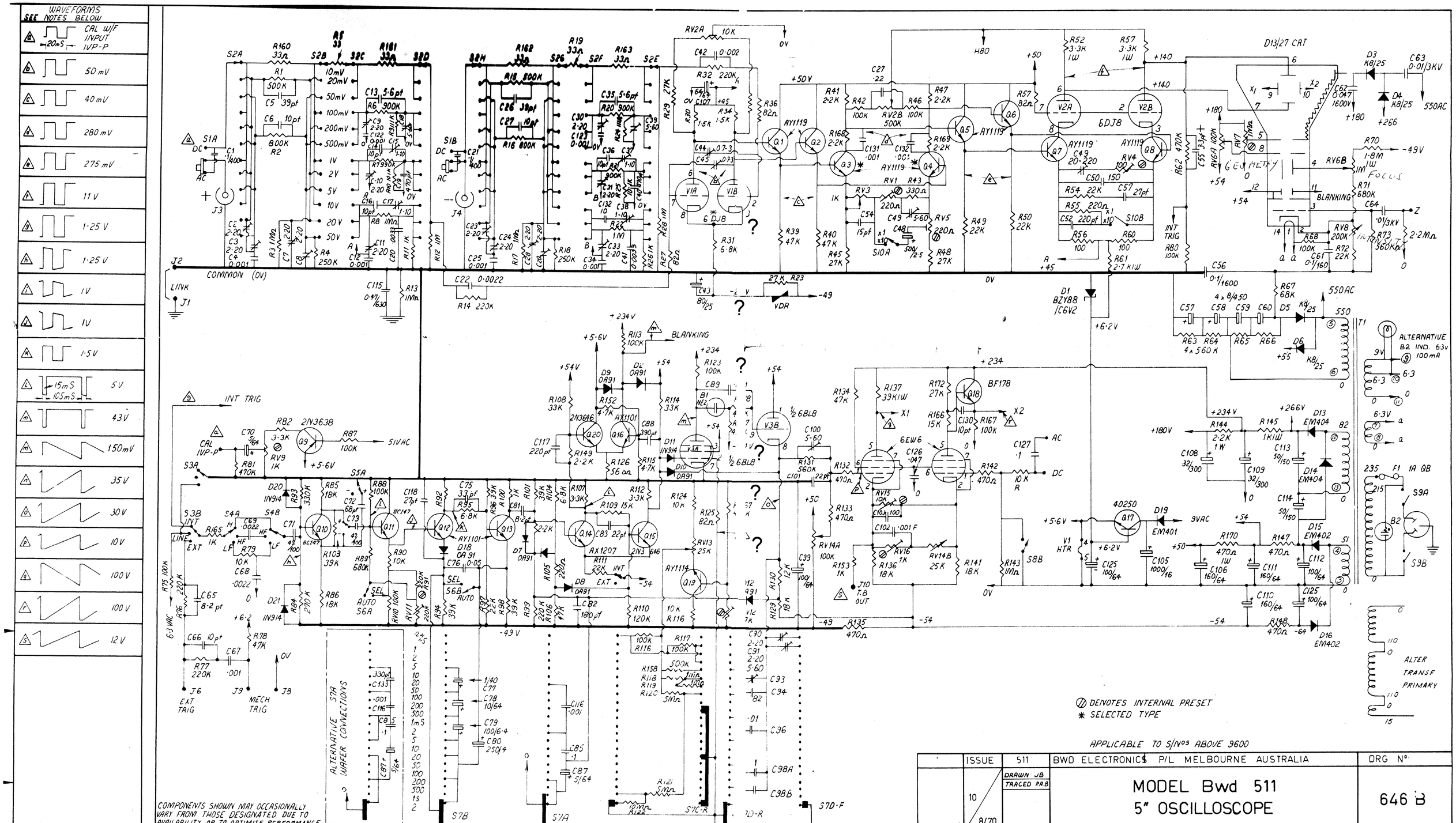
NOTE: WAVEFORMS SHOWN ARE OBTAINED USING 1VP-P CALWAVEFORM (50 Hz - 20m Sec)

CONTROLS SET AS FOLLOWS

INPUT SELECTOR	D.C
ATTENUATOR	0·5 V
VERNIER GAIN	CAL
TRIG LEVEL	AUTO
TRIG SELECT SWITCHES	INT - NORM - +
TIME BASE	10m SEC
TIME BASE VERNIER	CAL
HORZ GAIN	x 1

WAVEFORMS SEE NOTES BELOW




WAVEFORMS
SEE NOTES BELOW
CAL W/F INPUT IVP-P
50 mV
40 mV
280 mV
275 mV
11 V
1·25 V
1·25 V
1V
1V
1·5V
5V
43V
150mV
35V
30V
10V
100V
100V
12V
COMMON (0V)
LINK
INT TRIG
CAL IVP-P
EXT TRIG
MECH TRIG
ALTERNATIVE SWEEP CONNECTIONS
COMPONENTS SHOWN MAY OCCASIONALLY VARY FROM THOSE DESIGNATED DUE TO AVAILABILITY OR TO OPTIMISE PERFORMANCE
D13/27 CRT
6DJ8
6EW6
BF178
BLANKING
GEOMETRY
FOCUS
INT TRIG
ALTERNATIVE B2 IND. 6.3V 100mA
ALTER TRANSF PRIMARY
DENOTES INTERNAL PRESET
* SELECTED TYPE
APPLICABLE TO S/N°S ABOVE 9600
ISSUE 511
BWD ELECTRONICS P/L MELBOURNE AUSTRALIA
DRG N°
DRAWN JB
TRACED PAB
10
8/70
MODEL Bwd 511
5" OSCILLOSCOPE
646 B

R	MODIFICATIONS
C 133	ISSUE 9 REDRAWN WITH MODIFIED S7 INCORPORATED
Q 20	ISSUE 10 C133 ADDED
V 5	ALTERNATIVE S7A SWITCH DECK ADDED
D 19	

SWITCHES

S1A & B	AC-DC INPUT SELECT
S2A-H	INPUT ATTENUATOR
S3A & B	TRIG SELECTOR. INT-LINE-EXT
S4A & B	TRIG SELECTOR /NORM H.F-LF
S5A & B	TRIG SELECTOR + OR -
S6A & B	TRIG SELECTOR AUTO-LEVEL SELECT
S7A-D	TIME BASE RANGE
S8A & B	TIME BASE RANGE INT-EXT (REAR RV13)
S9A & B	POWER ON-OFF (REAR RV8)
S10A & B	X1-X10 VERTICAL GAIN (REAR RV3)

CONTROLS

RV1	CAL VERT AMPL.
† RV2A	ATTEN BALANCE
† RV2B	VERTICAL SHIFT
† RV3	VERTICAL GAIN-VERNIER
RV4	H.F. COMP.
RV5	x10 CAL
† RV6A	ASTIGMATISM
† RV6B	FOCUS
RV7	GEOMETRY
† RV8	INTENSITY
RV9	CAL SIGNAL 1V P-P
† RV10	TRIGGER LEVEL
RV11	TRIGGER PRESET LEVEL
RV12	T.B. CAL
† RV13	T.B. VERNIER
† RV14A	HORZ SHIFT
† RV14B	HORZ GAIN
RV15	HORZ x1 PRESET
RV16	HORZ x5 PRESET

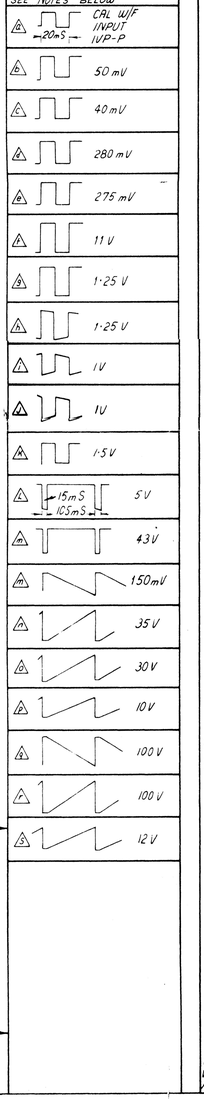
† DENOTES FRONT PANEL CONTROL

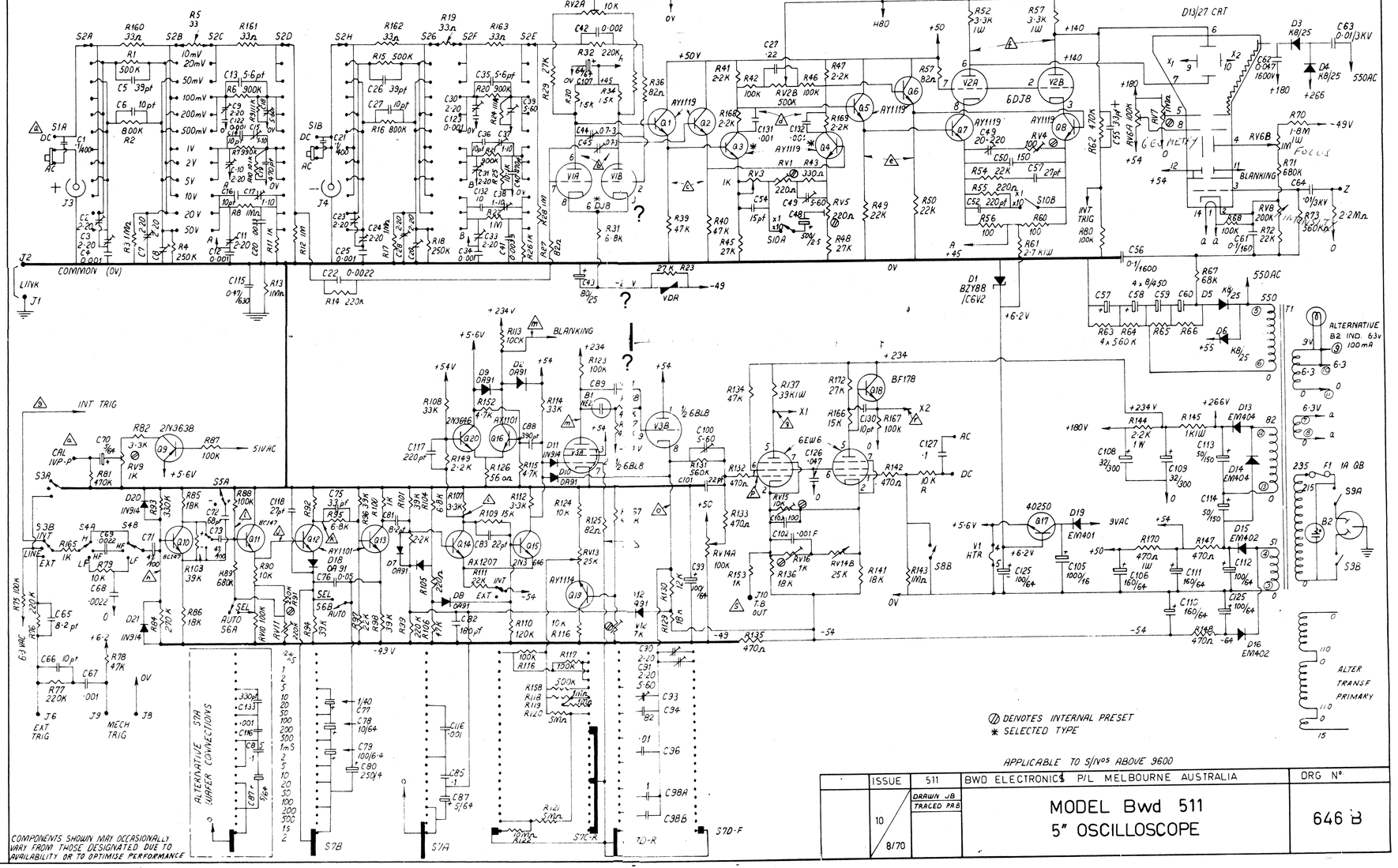
NOTE: WAVEFORMS SHOWN ARE OBTAINED USING 1VP-P CALWAVEFORM (50 Hz-20m Sec)

CONTROLS SET AS FOLLOWS

INPUT SELECTOR	D.C
ATTENUATOR	0·5 V
VERNIER GAIN	CAL
TRIG LEVEL	AUTO
TRIG SELECT SWITCHES	INT-NORM-+
TIME BASE	10m SEC
TIME BASE VERNIER	CAL
HORZ GAIN	x1

WAVEFORMS SEE NOTES BELOW





APPLICABLE TO S/N°s ABOVE 3600

ISSUE	511	BWD ELECTRONICS P/L MELBOURNE AUSTRALIA	DRG N°
10 / 8/70	DRAWN JB TRACED PRB	MODEL Bwd 511 5" OSCILLOSCOPE	646 B