b.w.d

# INSTRUMENT HANDBOOK

# Portascope 301

b.w.d electronics pty. ltd.

## HANDBOOK OF PERFORMANCE, OPERATING & MAINTENANCE INSTRUCTIONS

## MODEL PORTASCOPE 301

1. GENERAL Model Portascope 301 is a reliable, low cost instrument providing an unusually high degree of performance for this class of instrument. It is particularly easy to use even by untrained personnel and is therefore very suitable for school or University use.

The calibrated D.C. amplifier enables it to be used to measure D.C. or A.C. voltages and waveforms from below 50 mV to over 500V and the 0.1 uSec rise time permits excellent displays of pulse or square waves to over 1 Mc's. The calibrated time base covering 1 c's to 100 Kc's enables full use to be made of the vertical amplifier capabilities.

Synchronising is very stable and completely automatic other than the switched selection of positive or negative internal, 50 c's or external sync. as required.

To enable X-Y displays to be made, the horizontal amplifier is also D.C. coupled and provided with a two step attenuator and 12-1 vernier control.

The high sensitivity CRT operating at 1100V has a high light output from the H phosphor and the contrast is enhanced at high ambient light levels by a detachable green filter.

2. C.R.T. $2\frac{3}{4}$" diam. Type DH7/91 or 3AFP1 operating at approx 1100V. Fitted with a detachable graticule calibrated in cm. squares, and green light filter.

3. PERFORMANCE

VERTICAL AMPLIFIER

Bandwidth D.C. to 3.5Mc's + 0 -3db from 100mV p-p/cm to 30V p-p/cm.
D.C. to 1 Mc's + 0 -3db at 50mV p-p/cm.
A.C. input is -3db at 2 c's.

Rise Time 0.1 uSec from 100mV 0.2 uSec at 50mV.

Sensitivity Switched calibrated attenuator with the following ranges, 50, 100, 300mV. 1,3,10,30V p-p/cm. A 3-1 uncalibrated vernier control varies the sensitivity between each step and extends the maximum input to 100V p-p/cm.

Calibration Within ± 10% in calibrated position of vernier control.

Deflection Over full screen diameter up to 3 Mc's.

**Linearity** Within 2% at 3 cm. and 5% at full screen diameter.

**Trace Stability** Free of bounce or movement through mains variations.

**HORIZONTAL AMPLIFIER**

**Bandwidth** D.C. or 3 c's A.C. coupled to 250 Kc's -3db (500 Kc's -6db approx.).

**Sensitivity** Two switched ranges with 12-1 vernier control 100mV p-p/cm. to 1.2V p-p/cm. and 1V. p-p/cm to 12V p-p/cm.

**Input Impedance** 1 M ohm and approx. 25 pf.

**TIME BASE**

**Range** 1 c's to 100 Kc's in five overlapping ranges with an approx. calibrated vernier control.

**Expansion** Continuously variable between 0.5 and 3 times screen diameter.

**Linearity** Within 2% at X1 expansion and 5% at X3.

**Synchronising** Internal +ve or -ve. External or 50 c's +ve or -ve by switch selection. Sync is completely automatic, eliminating the usual manual amplitude control.

**Sensitivity** Trace can be locked by any signal between 10 c's & 1 Mc with a deflection of 1 cm. or greater, or 1V p-p external.

**Flyback Blanking** Completely blanked out at all time base speeds, at normal intensity setting.

**Z Input** A.C. coupled to CRT grid 0.01 MFD and 10 K ohms input.

**Time Base Output** Greater than 20V p-p superimposed on approx 30V D.C. Output impedance approx. 3000 ohms.

4. **POWER REQUIREMENTS** 210 - 240 V A.C. 50-60 c's 60 Watts.

5. **DIMENSIONS** 6½" wide x 9¾" high x 13" deep.

**WEIGHT** 18 lbs. approx.

## 6. FUNCTION OF CONTROLS

The controls on the panel are largely self explanatory and are grouped for ease of use, their respective operations are listed below.

PILOT INDICATOR indicates instrument is switched on.

INTENSITY controls the brightness of the CRT trace - clockwise rotation increases intensity.

OFF-ON A.C. power switch.

FOCUS & ASTIGMATISM These two co-axial knobs control the sharpness of the trace. They require adjusting with a waveform displayed - e.g. the CALIBRATE signal and should be adjusted in conjunction with each other. When the grey astigmatism knob is correctly set it should require no further adjustment. The red focus control may need slight adjustment if the intensity control is re-adjusted.

HORIZONTAL GAIN When used in conjunction with the internal time base it will enable the trace to be expanded from approx. $\frac{1}{2}$ to over 3 times screen diameter. When the external 'X' input is used it operates as a 12-1 vernier in conjunction with the switched attenuator at the bottom of the panel.

HORIZONTAL SHIFT Moves the trace horizontally.

SPEED (time base) 10-1 vernier control for the 5 switched time base ranges.

TIME BASE 5 position switch selects 5 decade ranges and provides from 1 c's to 100 Kc's in conjunction with the SPEED vernier.

SYNCHRONISING Switch selects either external signals, internal with positive or negative selection, A.C. mains frequency (50c's) or when rotated fully clockwise switches off the internal time base and connects the external A.C. or D.C. input sockets through the two step attenuators to the horizontal amplifier.

VERTICAL SHIFT Moves the trace vertically.

FINE GAIN 3-1 vernier control for the switched attenuator ranges.

ATTENUATOR (Vertical Amplifier)
Attenuates the input signal in the steps provided form 50mV to 30V p-p/cm. Each step is frequency compensated over the range of the vertical amplifier.

PRESET CONTROLS

BALANCE — Sets the D.C. balance of the amplifier so that no movement of trace occurs when the ....

FINE GAIN — control is rotated.
See maintenance section for setting procedure.

INPUT TERMINALS

Vertical Amplifier A.C. input connects input signal to vertical attenuator via a 0.1 MFD 400VW (600V PK) capacitor

D.C. INPUT — Connects the input signal directly to the input attenuator.

E — Earth terminal connected to instrument chassis.

EXT SYNC — Input socket for external synchronising signals for time base.

EXT. HORZ. INPUT A.C. — Connects input signal to horizontal attenuator via a 0.047 MFD 400V (600V PK) capacitor.
D.C. Connects input signal directly to horizontal attenuator.

'Z' INPUT — (rear panel) input for signal to modulate the intensity of the trace when either internal or external time bases are employed. A signal of -20V peak is required to blank the trace at normal brightness.

OUTPUT SOCKETS

TIME BASE OUTPUT

The internal time base signal is available for display purposes or to drive sweep generators requiring an external signal. Level is greater than 20V p-p and is superimposed on approx. 30V D.C.

## 7. OPERATION OF INSTRUMENT

### PREPARATION FOR USE

Turn INTENSITY Control to approx. half rotation, connect the mains power cord to a power point and switch the power switch ON. The indicator light will light to show power is on. Centre both shift controls. Set vertical attenuator to CALIBRATE, fine gain fully clockwise, and horizontal gain fully anti-clockwise. Set time base 10-100 range, vernier speed to approx. 2, Sync switch to + INTERNAL.

If no trace appears rotate intensity control clockwise until a suitable intensity of trace is obtained. Adjust vernier speed control to lock trace if it is moving. Centre display and expand to full screen diameter with Horz. gain. Now adjust Astigmatism control for sharpest trace then the Focus control to further improve sharpness and repeat operation until a well defined trace is displayed.

Endeavour to operate the oscilloscope with the intensity control in the minimum position for convenient viewing to prolong the life of the CRT screen.

Operate the shift controls, vertical fine gain control and horizontal gain to become accustomed with the range available in each control.

Switch the synchronising selector switch to -INT and note that the waveform will move along and appear to start from the opposite side of the wave. Similarly switching to ± 50 c's will sync the calibrate waveform directly to the A.C. supply from the transformer.

### INPUT SIGNAL CONNECTIONS

The electrical waveform to be observed is applied to one of the input connectors. The waveform is then connected through the vertical deflection system to the cathode ray tube vertical deflection plates to cause the spot to be deflected vertically and to trace out the waveform on the screen of the CRT. The vertical size of the displayed waveform is adjusted with the Volts or Millivolts/cm. switch.

The calibrated control, when used in conjunction with the calibrated graticule, allows voltage measurements to be made from the displayed waveform.

Certain precautions must be taken when connecting the oscilloscope to the input signal source to ensure that accurate information is obtained from the display. Care must be taken when low level signals are being observed to ensure no hum pick up is obtained by using short leads or screened leads. Screened leads may cause attenuation of high frequencies when observing square or pulse waveforms by the additional capacity added to the circuit by the cable itself. Short direct leads are recommended for this application.

## A.C. VOLTAGE MEASUREMENTS

Set vertical amplifier attenuator to 30 V, and Fine gain fully clockwise. Connect a ground lead from the chassis of the equipment under test to the E terminal on the panel and another lead from the A.C. terminal to the point where the waveform is developed. (During initial trials with the instrument a sine & square wave generator such as B.W.D. Model 111 makes an excellent source of A.C. voltage to check the operation of the oscilloscope).

If the display is too small, switch the attenuator until a large display is obtained. Then with Time Base switch and vernier speed control (sync. switch set to +INT), lock the display so that it may be easily seen. It may be necessary to slightly adjust the Intensity and Focus control for the sharpest display.

When the trace is stable the vertical amplitude may be read directly from the graticule, e.g. a 3 cm. high display with the attenuator set to 3V p-p/cm. indicates the waveform is 3 times 3V p-p = 9V p-p.

To obtain RMS voltages, the peak to peak voltage should be divided by 2.8.

The frequency of a waveform may be obtained by noting the setting of the time base switch and vernier control and the number of wavefor ms displayed. e.g. Switch setting 100-1 Kc and vernier on 5 indicates the time base speed is 500 c's. If 4 waveforms are being displayed then the frequency of each is $\frac{500}{4}$ = 125 c's.

Time measurements may be made by using the reciprocal of the time base speed, i.e. 1000 c's = 1 millisecond, 250 c's = 4 milliseconds etc. Once a display is locked at a given speed it can be expanded to 5 or 6 cms. and time measurements made on the displayed waveform.

## D.C. MEASUREMENTS

Set up the oscilloscope as for A.C. displays. If a positive voltage is to be measured set the trace 2 cms down from the centre line. Connect the lead from the D.C. terminal to the potential waveform to be measured, the trace will be deflected upwards and as with A.C. measurements previously described, the D.C. voltage present is the distance the trace travels upwards from its original position in cms. multiplied by the attenuator setting. This form of direct coupled measurement can be used to show the effect of bias on a valve by displaying the output of say, a triode valve into which a small A.C. signal is fed to its grid, the D.C. bias on the grid is then varied to show the effect due to cut off or grid drive.

## EXTERNAL TIME BASE

When it is required to use an external horizontal display as in X-Y measurements or with sweep alignment oscillators, switch the Synchronising switch fully clockwise to the X1 or X10 positions and couple in the waveform to either the A.C. or D.C. sockets as appropriate. The width of the trace can be controlled by the two step attenuator and Horizontal Gain control.

## EXTERNAL SYNCHRONISING

To synchronise a waveform being displayed by another signal, turn the synchronising selector to EXT and couple in the sync. signal to the appropriate socket, e.g. an RF modulated waveform will not lock properly as both the modulation frequency and the carrier attempt to control the time base and the modulation signal must therefore be connected to the EXT input to synchronise the signal.

## 8. CIRCUIT DESCRIPTION

## VERTICAL AMPLIFIER

Input signals applied to the D.C. terminal are connected directly to S1 attenuator connections made to the A.C. terminal are connected via C1 to the switch. Switch section S1a & b select CR networks in sequence to attenuate the input signal by ratios which produce the sensitivity steps shown on the front panel. The 50mV step is obtained by increasing the gain of the amplifier, section S1c is used for this purpose as described later.

The amplifier consists of two triode pentodes V1 & V2. The triodes of each valve form the input amplifier, the input signal is coupled into V1a grid V2a is taken to ground.

The cathodes of the valves are coupled through the FINE GAIN Potentiometer and BALANCE pre-set and then through R21 which is the common cathode load to a negative supply. In this configuration which is a differential amplifier or long tailed pair, half the signal at the grid of V1a appears at the cathode when RV2 is fully clockwise and is in effect a short circuit between the cathodes. This signal drives the cathode of V2a and as V1a is driven by its grid in the same phase signal, the signals appearing on their respective anodes will be in anti-phase and approximately equal in amplitude.

If the FINE GAIN RV2 control is rotated to put some resistance between the cathodes, each valve will not present a load to the other and degeneration will occur in the un-bypassed cathode load formed by RV2, R19, R208, RV3. This reduces the gain and further rotation of RV2 to its maximum value reduces the gain by a factor of 3 times. The BALANCE control RV3 varies the value of the resistance in the cathode circuits and compensates when correctly set for the unbalance in the two input valves by balancing the current in each valve so that the cathode potentials are identical.

The anode load of V1a & V2a are compensated by L1 & L2 high frequency shunt inductors to obtain the required bandwidths. The vertical shift control RV1 which is between the input stage anode loads varies the resistance present in each circuit and therefore the voltage present at each valve anode in proportion to the resistance of the divider. As the output from V1a & V2a is directly coupled to the output pentodes in each valve the change in standing voltage caused by the shift control results in a change in bias on the output stage which in turn varies the current through each valve - as one increases the other decreases resulting in an amplified change in voltage at the anodes which is then coupled directly to the vertical deflection plates to deflect the spot up and down. The signal follows the same path, being superimposed on the shift voltage. High frequency compensation is incorporated in the anode loads of V1b & V2b by L3 & L4 variable inductors.

Gain calibration is adjusted by RV4 placed between the cathodes of the output stage. Variation of RV4 controls the amount of degeneration in the cathodes and therefore varies the gain in the same manner as RV2, FINE GAIN control in the input stage. Additional high frequency compensation is made by bypassing RV4 by C11 and C12 capacitors. These have negligible effect at low frequencies but as the frequency of an input signal increases the impedance of the capacitors fall and shunts the pre-set gain control, thereby increasing the gain.

Sync. take off to the phase splitter V8a is via a resistance divider R29 & R30 to minimise capacity loading on the output of V2b. Sync. signals of opposite polarity from V8a are taken to S4B synchronising selector switch.

## TIME BASE

The basic time base employed in this oscilloscope is a Miller integrator sawtooth generator controlled by a multivibrator.

V5b is the integrator V5a the charging valve and V6A the switching valve controlling the trace length and synchronising.

The circuit functions as follows -
S3 is switched to select C23 timing capacitor and R66, the timing resistor, is connected to RV6 the vernier SPEED control. Assume that V6a is conducting and its anode has fallen to approx. 80 volts, V5a charging valve connected directly to it will be cut off and V5b will be conducting. As the anode of V5b falls the signal is fed back to its own grid via C23. However, the grid is trying to rise to the potential present on RV6 to which R66 is connected. Because of the high gain in the Miller valve (over 200) it effectively increases the charging voltage to which the capacitor is being taken, by this factor and as only about 1% of this voltage is employed the linearity of the sawtooth voltage generated is better than 0.2% over the range to 10 Kc's, deteriorating slightly at the extreme top frequency where stray capacities take effect.

V5b will continue its linear fall until the cathode of V5a (which is connected directly to V5b anode) reaches its own grid potential so causing V5a to conduct. This conduction results in a voltage drop across R38 which is immediately communicated to V6a grid via C24. This negative fall on the grid reduces the conduction of V6a and its anode voltage rises, making V5a conduct more heavily, thus its anode potential falls further and a rapid switching action takes place between the two valves until V6a is cut off and V5b is drawing grid current. The series impedance of V5a under these conditions is very low to the discharge capacitor C23 is rapidly charged to 150V - the potential to which the grid of V5a rises. During this flyback period when the grid of V5b is drawing grid current due to the positive charge being applied to the grid through C23, the screen voltage drops sharply.

This negative fall is capacitively coupled through C25 to the grid of the CRT to blank out the trace during the flyback period.

As C23 charges up, the current drawn through V5b reduces, this in turn reduces the voltage drop across R38 anode load. The voltage charge is again coupled to V6b pulling it in a positive direction.

As soon as it reaches a point when V6a starts conducting the anode voltage falls cut of V5a the anode rises to full HT, pulls V6a into full conduction until it bottoms and V5b starts to dischargeC23 as V5a is no longer clamping it at 150V. The inital fall of about 2V on V5b anode is transferred to V5b grid via the timing capacitor, this biases the valve to its correct working position and arrests the rapid fall as the valve is now biased as a class A amplifier. The linear fall at the anode of V5b now commences again and the next cycle starts.

To enable the time base to be locked to a signal, it is fed into S4b which selects the required signal then through C26 to the grid of V6b. Diode D2 prevents the signal from driving the grid of V6b positive with resultant over-synchronisation. Sync. is injected into the time base by V6b by a common cathode coupling between V6a & b and a common screen resistor. A positive signal applied to the grid of V6b will cause the cathode to rise, this will reduce the bias on V6a and cause the anode to rise slightly.

If this rise takes place towards the end of the sawtooth run down it will cause V5a to conduct and initiate the flyback. By limiting the effect V6b can home on V6a by diode clamping and by controlling the circuit constants,over-synchronising which causes trace shortening and trace linearity is eliminated along with the need for manual control.

The sawtooth waveform from the time base is directly coupled to the balanced horizontal amplifier V8b & V7a via a frequency compensated divider consisting of R50 being returned to RV11 Horizontal Shift control.

Movement of the slider on RV11 will vary the potential on it and therefore charge the standing potential at the grid of the horizontal amplifier V8b. This changes the current through the valve and so causes a variation of voltage at the anode of V8b, producing a horizontal shift of the spot. The sawtooth voltage is fed into the same grid as the shift and is therefore superimposed on it. A degenerative gain control between the cathodes of the V8b & V7a horizontal amplifiers enables the trace to be expanded from approx. 3 cm. to over 20 cms. when the control is adjusted to zero.

Horizontal input signals are taken via S4c to the gris of V7b triode amplifier which is directly coupled to V7a pentode. The anode load of V7b is divided into three resistors. These are arranged to control the amount of negative feedback applied to V7b anode and thereby sets the max. gain available and the range of the vernier gain control RV7 which provides 12-1 change under these conditions.

## POWER SUPPLIES & C.R.T.

The main +320V supply is half wave rectified by V4 and filtered by C14a & b & C15. R33 is in the return lead of the transformer to chassis and a -85V negative supply is developed across it. This is filtered by R34 & C16 before it is supplied to the vertical and horizontal amplifiers at -45V.

EHT for the CRT is a half wave rectified from the full transformer secondary to which is added the -85V supply of the main neg. rail. EHT filtering is by C17 & 18 & R35 before supplying the resistor divider chain from which the CRT supplies are taken for intensity and focus.

Z input is taken to the grid of the CRT through a 0.01 MFD capacitor and signals are fed in simultaneously with the flyback blanking waveform.

## 9. ADJUSTMENTS & MAINTENANCE

A number of pre-set controls are contained in this instrument and may require periodical adjustment to maintain the instrument 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 panel may be removed by unscrewing the rubber feet.

To assist in fault finding voltages are shown on the circuit as measured with a 20,000 ohm per voltmeter with the oscilloscope operating from a 240V A.C. supply and the mains tap selection on 240V. Voltages measured with meters down to 6000 ohms/volt will not greatly affect the readings.

### PRE-SET ADJUSTMENTS
### FRONT PANEL BALANCE CONTROL RV3

Turn FINE GAIN fully clockwise, centre trace with vertical shift. Turn fine gain fully anti-clockwise, recentre trace with BALANCE control.

RV4 located on a tag strip at the lower centre of the CRT side of the chassis Switch attenuator to CALIBRATE. Set FINE GAIN to fully clockwise position and adjust potentiometer to produce a display 3 cm. high.

RV5 Located at front of sub-chassis, behind vernier SPEED control. Switch to CALIBRATE or attenuator, Time Base switch to 10-100, vernier speed control half way between 2 & 3 (on line joining vernier to switch). Adjust RV5 until two complete waveforms appear, check at 5 for one waveform.

RV8. Located on main chassis under sub-chassis. Adjust until voltages at anodes of V8b & V7a are identical to voltages at anodes of V1b & V2b. (No vertical input - trace centred. Time Base operating in 1K to 10K range).

When replacing valves the following controls will require resetting as previously described.

| | |
|---|---|
| V1 or V2 | Readjust RV3 BALANCE & RV4 gain. |
| V3 CRT | " RV4 gain. |
| V4 | No adjustment. |
| V5 | " |
| V6 | Readjust RV5. Time base frequency. |
| V7 | " |
| V8 | " |

NOTE: When replacing V1 or V2 it may be necessary to select a pair showing reasonable balance or the shift control will not have enough range to deflect the beam off the CRT. All valves in this instrument are type 6BL8 other than the rectifier and it is fairly simple to find a pair from them to fit into the V1 and V2 sockets.

**MAIN FUSE** 1 amp delay - Standard $1\frac{1}{4}$" x $\frac{1}{4}$" glass cartridge fuse.

Every effort is made to keep the circuit diagram up to date but the right is reserved to adjust values or amend the circuit without notice.

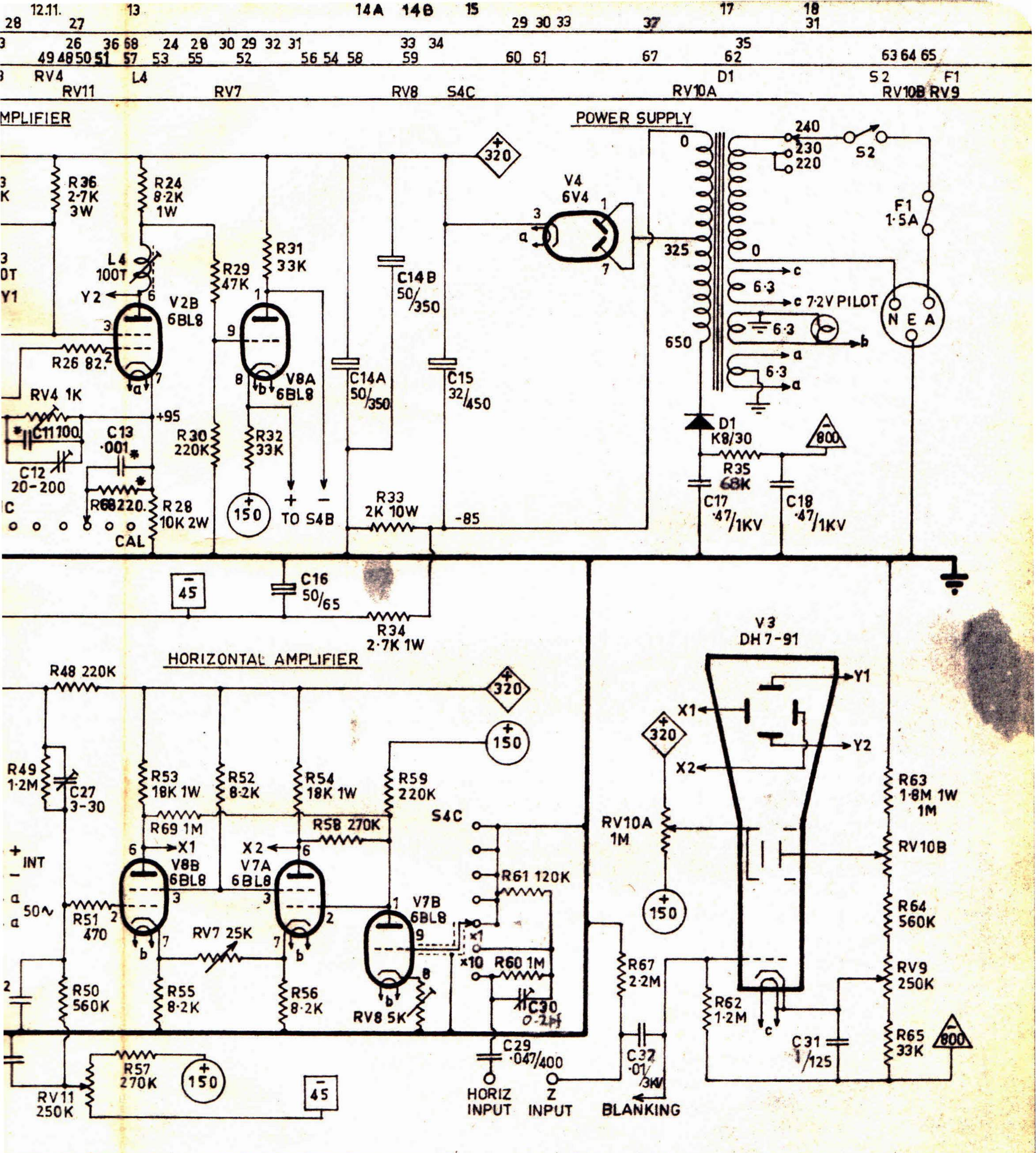
## III. ACCESSORIES (Optional Extras).

1. Viewing Hood.
2. Demodulator Probe.
3. High Impedance Probe.
4. Leather carrying case.
5. Connecting leads with prods and crocodile clips.

# CONTROL FUNCTIONS

| | |
|---|---|
| RV1 | VERTICAL SHIFT |
| RV2 | VERTICAL GAIN VERNIER |
| RV3 | D.C. BALANCE |
| RV4 | CALIBRATE PRESET |
| RV5 | CALIBRATE TIME BASE |
| RV6 | TIME BASE VERNIER |
| RV7 | HORIZONTAL GAIN |
| RV8 | HORIZONTAL CENTERING |
| RV9 | INTENSITY |
| RV10A | ASTIGMATISM |
| RV 10B | FOCUS |
| RV 11 | HORIZONTAL SHIFT |

| | |
|---|---|
| S1A-C | VERTICAL ATTENUATOR |
| S2 | A.C. POWER |
| S3 | TIME BASE RANGE |
| S4A-C | SYNC SELECTOR & HORIZONTAL ATTENUATOR |

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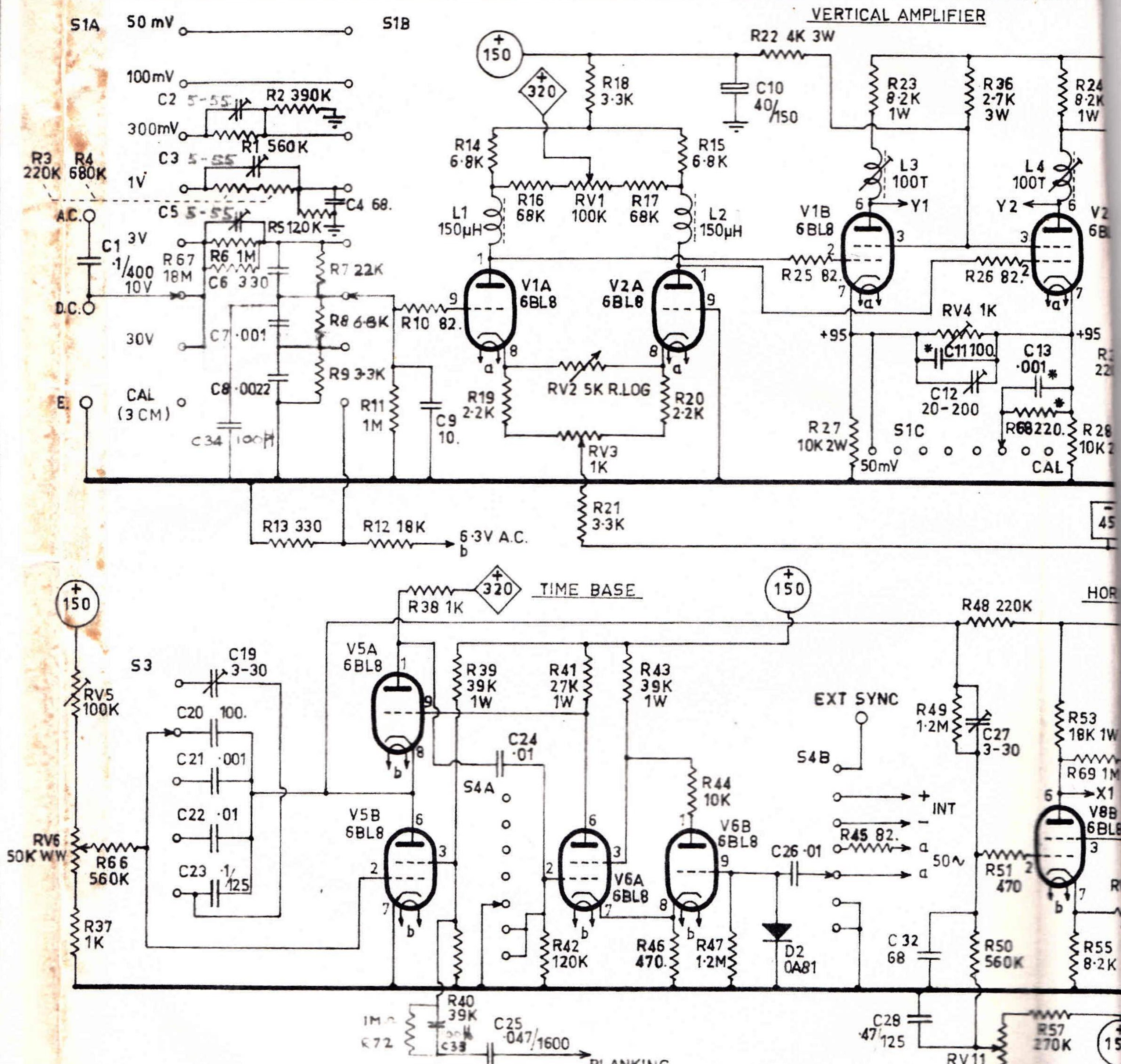
| | 301 | B. W. D. ELECTRONICS PTY. LTD. MELBOURNE. | DRG NO |
| | Drawn *J.B.* | | |
| | Traced *KFP* | PORTASCOPE 301 | 281 |

| | | |
|---|---|---|
| C | 1. 2.3.5. 6.7.8. 20to23.19 4. 9. 36 24 25 10 26 32 28 12.11. 27 13 | |
| R | 3. 4. 37 66 67 6.1. 2.5.13 7.8.9. 72 11 12 10 38 40 14 19 39 16 42 41 18 21 17 46 43 20 15 44 47 22 25 27 45 23 26 49 48 50 51 36 68 57 24 53 | |
| | S1A RV5 RV6 S3 S1B L1 S4A RV1 RV2 RV3 L2 D2 S4B S1C L3 RV4 RV11 L4 | |

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