Bwd-506_0084_1

INSTRUMENT HANDBOOK

MODEL bwd 506 OSCILLOSCOPE

1. GENERAL:

Model bwd 506 embodies some unique features together with an excellent all round performance that makes it an outstanding instrument.

The 100% silicon solid state design is extremely stable in operation, amplifier and time base are compensated against input line voltage changes both for sensitivity and positional movement. Input FET amplifiers are protected against both + and - input over-voltage conditions up to 400V peak.

Its isolated ground enables 'incircuit' measurement to be made up to 400V from ground, it also eliminates ground loops and noise from low level measurements.

An active T.V. sync circuit provides line or frame lock which permits viewing of individual frame pulses, colour burst or equilising pulses.

For additional versatility the sync separator also provides an HF reject trigger selection and a demodulated trigger waveform for stable viewing of A.M. or single sideband R.F. displays.

Application notes are contained in Section 4 of this handbook.

Model bwd 506 has been designed for reliable long-term use - it has been subjected to environmental tests and each instrument is heat soaked and vibrated as part of its alignment procedure.

For maximum reliability it is advisable to replace the power supply protection fuse every 2000 hours of operation to guard against thermal stress failure. Additionally, if the instrument is to be left non-operating for long periods and is stored in a dusty atmosphere, it is wise to drop a plastic protection cover over it to minimise dust ingress into switch wafers, etc. A storage cover and a carrying case are available from B.W.D. Electronics Pty. Ltd., together with a full range of accessories (see catalogue).

2. SPECIFICATION

2.1	C.R.T.	Type	5" Diameter Type D13-27GH incorporating a spiral PDA & DC coupled Beam blanking.
		Phosphor	P31 normally supplied. P7 available as Option 04.
		EHT	3.0kV.
		Graticule	8 x 10 cm. graticule with .2mm subdivisions on major axis and detachable green light filter.
		Deflection	8 cm. vertically x 10 cm. horizontally.

2. SPECIFICATION (Cont'd)

2.2 VERTICAL AMPLIFIER

Sensitivity	5mV to 20V per cm. in 12 direct reading steps in a 1, 2, 5, 10 sequence.
Bandwidth	DC or 2Hz (AC coupled) to 15MHz - 3db., referred to 4cm. at 50kHz.
Rise Time	23nSec for 4cm. deflection.
Input Impedance	1mΩ and 35pf constant.
Calibration	<5% including 10% line change.
Deflection	8cm. CRT. 15cm. amplifier up to 1MHz.
Input Voltage Protection	± 400V(DC + peak AC.)

2.3 TIME BASE

Range	200nSec to 2Sec/cm. in 22 switched ranges with 5-1 vernier extending range down to 10Sec/cm.
Magnification	X1 to X5 continuously variable, calibrated both settings. Max. sweep speed ≃ 40nSec/cm. mag. sweep.

2.4 TRIGGERING

Selection	Coupling	Slope	Source	Mode
	Norm.	+	Int.	AUTO
	T.V.	-	Ext.	Select Level
Sensitivity	Int. AUTO	0.5cm. defl.	10Hz to 5MHz	
		1cm. defl.	8Hz to 10MHz	
		3cm. defl.	1Hz to 15MHz	
	Int. Select	± 4cm. max.	1Hz to 15MHz	
	Ext. AUTO	1V RMS	1Hz to 15MHz	
	Ext. Select	>1V RMS	1Hz to 15MHz	
	Max. Ext Input 100V p-p			

T.V. Sync	Triggers on Line in AUTO position. Triggers on Frame with Select Level fully clockwise.
Sensitivity	2cm. to over 8cm. composite video waveform. Displays frame pulses, equalising pulses, colour burst, etc.
Demodulation or HF Reject.	T.V. Selection also provides stable locking of modulated RF Waveforms and eliminates HF noise from trigger signals below 2kHz approx.

2.5 HORIZONTAL AMPLIFIER

Sensitivity	Approx. 0.75V to >5V/cm. continuously variable.
Bandwidth	DC to 1MHz - 3db.

2. SPECIFICATION (Cont'd)

2.5 HORIZONTAL AMPLIFIER (Cont'd)

Input Impedance 56KΩ and 10pf approx.

Max. Input ±100V or 60V RMS

AMPLIFIER PHASE SHIFT Less than 1° from DC to >100kHz.

2.6 Z MODULATION

Input to CRT grid. 0.01uF + 560KΩ. -20V required blank CRT at normal intensity.

Option 25 - High Sensitivity DC Coupled Z Modulation provides + 1V turn off sensitivity. Input DC coupled 500nSec Rise Time.

Calibrator Line Frequency 1V p-p square wave 2% accuracy.

Time Base Output 0 to 25V positive going sawtooth max. load 22KΩ.

Power Requirements 30 watts approx. 85V - 135V in 3 ranges } 50 - 60Hz.
190V - 265V in 3 ranges }

Dimensions 9.1/4" high x 7.1/2" wide x 16.1/2" deep overall feet, handle, knobs, etc.

Weight 16 lb. (7kg). Domestic / Air Freight Pack: 17.3/4 lb. (8 kg.) Export Pack: 22 lb. (10kg).

Optional Accessories

Probes X1	P30
X10	P23
X1 & X10 Kit	P22
X1, X10 & Demod.	P29
Demodulator	P35
Carrying Case	C52
Vinyl Dust Cover	C12
Light Shield	H44
19" x 8.3/4" Rack Mount Adaptor	R77

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. All data applies in case of nominal mains voltage unless otherwise stated.

3. FUNCTION OF CONTROLS

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

Intensity Control Fully anti-clockwise, this control switches the instrument OFF. When rotated clockwise the instrument is switched ON and further rotation controls the trace intensity (brightness) from zero to max.

3. FUNCTION OF CONTROLS (Cont'd)

3.1 Cont'd

Focus Controls the sharpness of the trace. May require a slight re-adjustment over the full intensity control range.

Astigmatism Preset rear panel control, adjusts beam for optimum shape 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 10 cms. to 50 cms., providing X5 expansion. When an external Horizontal Input is used, the Horizontal Gain varies the sensitivity from .75V to >5V per cm. approximately.

T.B. Vernier Varies the Time Base speed over a range greater than X5 to provide a continuously variable range in conjunction with the TIME/CM switch of 10Sec/cm. to 0.2uSec/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 X INPUT socket.

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 5%. The switch speeds represent the fastest speed on each range; rotation of the Time Base Vernier Control anti-clockwise will reduce the selected speed over a range greater than X5, e.g. on the 1mSec range the Vernier will vary the time base from 1mSec down to 5mSec/cm.

Norm-T.V. Switch
In Norm. position triggering is controlled by + & - switch and trig. level control. In the T.V. position a sync separator is brought into circuit and the Trig Level control assumes dual function. In the AUTO position stable LINE lock is provided and when the control is turned fully clockwise very stable FRAME lock is obtained even from noisy video signals. See Section 4 for further details.

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

INT-EXT Switch
Selects the trigger source from the displayed waveform or an external waveform.

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

3 FUNCTION OF CONTROLS (Cont'd)

3.1 Cont'd

D.C. Balance — Preset in centre of shift control, 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 Control — Fully anti-clockwise, and switched to the AUTO position, any signal greater than 0.5 cm. in amplitude will trigger the time base, however with no signal present, an Automatic trigger pulse is generated to produce a base line, the trigger rate increases as the Time Base Speed range increases, producing a bright reference line at all sweep speeds. When the knob is switched out of the AUTO position, it selects the Level on a displayed waveform of ± 4 cm. to trigger the Time Base.

Volts/cm. (Attenuator) — Switch adjusts the sensitivity of the Vertical Amplifier 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 5% on any step.

Attenuator Vernier — Adjusts the vertical gain over a 2.5 - 1 range between the attenuator steps.

AC-OFF-DC Switch — In the DC position of this switch the amplifier is direct coupled from input to output. In the AC position a capacitor is placed in series with the input to eliminate any DC component and attenuate all frequencies below 2Hz. In the OFF position the input is disconnected and the amplifier AC grounded to common.

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.

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. If isolated operation is not required ground to earth terminal with link.

Chassis — Green terminal grounded to chassis may be linked to common terminal when isolated input not required.

3 FUNCTION OF CONTROLS (Cont'd)

3.2 TERMINALS AND SOCKETS FRONT PANEL (Cont'd)

X Input When the Time Base Vernier is turned anti-clockwise to "T.B. OFF" signals may be fed into socket to produce a horizontal display, input is DC coupled. For AC coupled inputs an external capacitor must be placed in series with the lead. Max. input is ±100V or 60V AC.

CAL. 1V p-p A 1V peak to peak square waveform is available 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 or AUTO with positive or negative selection and T.V. selection is available.

3.3 REAR PANEL

Z Modulation A 30V p-p square wave or a sine wave of 6V RMS or greater will blank the trace at normal intensity. Negative going signals blank the trace. Positive signals brighten the trace. A high sensitivity DC coupled Z Modulation option increases blanking sensitivity to 1V p-p.

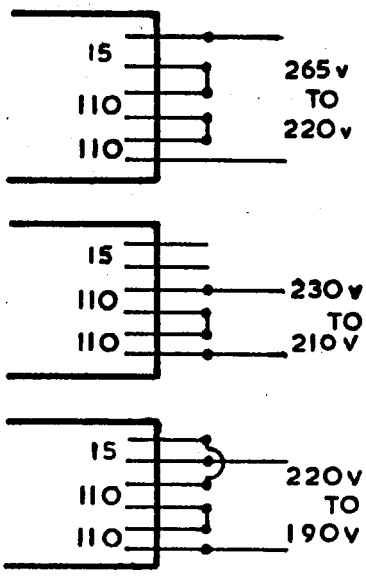
Time Base Output
A 25V p-p sawtooth swinging approx. 0 to +25V to common is available at low impedance. Min. external loading 22KΩ.

4. FIRST TIME OPERATION

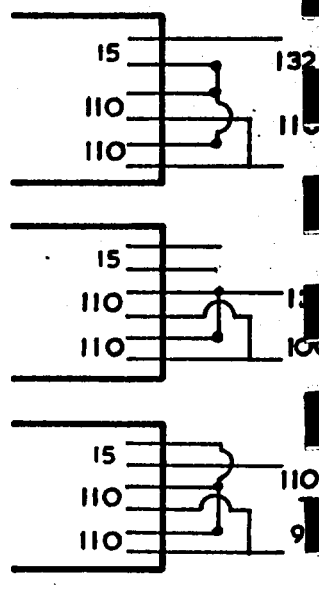
Check tapping on Power Transformer for correct connection for local supply mains. Instrument is fitted with universal primary for 100 to 240V operation, connect as shown below to suit local power line voltage .

TRANSFORMER CONNECTIONS:

200-240V CONNECTIONS



100-120V CONNECTIONS



4. FIRST TIME OPERATION (Cont'd)

4.1 Set controls as follows : -

Intensity	-	OFF (anticlock)
Focus	-	mid-position
Amplifiers		
ATTENUATOR	-	.2V/cm.
Vernier	-	fully clockwise
Vert. Shift	-	mid position
Input Selector	-	AC
Time Base		
Time Base Range	-	10mSec/cm.
Vernier	-	clockwise (Cal).
Trigger Level	-	AUTO (anticlockwise)
± Select	-	+
NORM - T.V.	-	NORM
INT-EXT	-	INT
HOR. GAIN	-	Anti-clockwise X1
HOR. SHIFT	-	mid-position

4.2 Connect instrument to power mains, (check transformer tapping as in 4.1) then switch instrument on. After about 10 seconds when trace appear, adjust beam for suitable intensity and sharp focus. Now position trace centrally across screen. Connect a lead from the CAL socket to the amplifier input socket. A 50Hz square wave will be displayed with the top and bottom faces of the waveform sloping. Switch the input selector to D.C. The square wave will be displayed positive going to the base line. Recentre with shift control. Now switch to OFF, the signal is disconnected leaving a reference base line. Switch back to DC. Adjust Time Base range switch and vernier to check characteristics with two (2) waveforms displayed, change over ± trigger selector switch. Turn the Level Selector control clockwise. This switches off AUTO, the trace will disappear than re-appear as control is rotated and the point at which the trace is initiated will move up or down the edge of the waveform as selected by the ± selector. It will disappear when almost fully clockwise.

Return the control to AUTO and adjust the TIME/CM switch to give five (5) waveforms across the CRT, then turn the HORZ. GAIN control clockwise until one (1) waveform is 10 cm. long; this illustrates the trace expansion facility. If the horizontal shift is turned the trace can be tracked along to view any part of it from one end to the other.

To check the X INPUT, turn the T.B. Vernier to T.B. OFF. Connect a lead from the CAL socket to the X INPUT socket, a horizontal line will appear whose length can be varied by the HORZ. GAIN control from 1 cm. down to less than .2 cm. The Horizontal position of the trace can be set by the HORZ. SHIFT contrd.

Z Modulation - Feed an oscillator into the RED rear panel socket marked Z Modulation, ground connected to the BLACK socket on front panel.

4. FIRST TIME OPERATION (Cont'd)

4.2 Cont'd

With an input of 6V RMS or 20V p-p approx., the trace at normal brightness level will be intensity modulated. Upper Bandwidth is only limited by oscillator drive ability at high output levels.

The following sections explain the operation of Model bwd 506 when used to make specific measurements.

4.3 MEASUREMENT OF DC (DIRECT) VOLTAGES

Set T.B. LEVEL CONTROL to AUTO. Switch the Vertical Amplifier AC-DC-OFF 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 3 cm., i.e. 3 x 0.5V ± 1.5V. Now reverse the connections to the battery and note how the trace moves down 3 cm. This illustrates how an oscilloscope can display positive or negative voltages or both simultaneously, e.g. when viewing a sine input or square wave.

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

NOTE: The 1MΩ input impedance of the oscilloscope must be taken into account when measuring high impedance points such as anode, grid or screen voltages of valves or the gate of FET's working with high value loads. To obtain a higher input use a bwd P22 high impedance probe which increases the input to 10MΩ shunted by <14 pf.

4.4 MEASUREMENT OF AN AC (ALTERNATING) VOLTAGE

Set the Amplifier AC-DC-OFF switch to AC and the Attenuator to 20V (if the input voltage is unknown). Connect a lead from the BLACK input terminal to the ground (earth) side of the signal to be measured, then connect a lead from the input socket to the signal source. (B.W.D. Models 112B, 140A or 602 Oscillators are suitable for initial experiments in this test).

Increase the Vertical sensitivity by the VOLTS/CM switch until a display between 3 and say, 8 cm. exists. Now adjust the Time Base Switch and Vernier to enable the waveform to be readily seen. To measure the amplitude of a displayed waveform, measure its overall height in divisions by the calibrated graticule, then multiply this by the attenuator setting and the result is in Volts p-p, e.g. if the display is 6 cm. high and the attenuator is set to 0.5V then the amplitude is 6 x 0.5 = 3V peak to peak, to convert to RMS voltage for sine waves, divide the 3V by 2.84, e.g.

$$\frac{3.00}{2.84} = 1.06\text{V RMS}$$

4. FIRST TIME OPERATION (Cont'd)

4.4 MEASUREMENT OF AN AC (ALTERNATING) VOLTAGE (Cont'd)

The frequency of a 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 2 cm. long and the switch is on 100μSec, then the duration of the waveform is 2 x100μSec. The frequency can be determined by dividing 1 second, i.e. 1,000,000μSec. by the duration of the waveform -

$$\frac{1,000,000}{200} = 5,000\text{Hz} = 5\text{KHz}.$$

5. ISOLATED MEASUREMENT AC OR DC

5.1 With the isolated ground facility measurements can be made virtually between any two (2) points of a circuit.

As the COMMON terminal has an impedance to ground of 1MΩ paralled by .27uF. This terminal should be connected to the lowest impedance point in the circuit and then the higher impedance point to the vertical input socket either direct or via a x10 high impedance probe. e.g. To measure the waveform at the collector of a transistor with respect to the supply rail, connect the COMMON terminal to the H.T. rail - REMOVE THE GROUND LINK ON THE OSCILLOSCOPE FIRST - Then apply the signal on the transistor collector to the vertical input co-ax socket, switch input OFF, centre trace, switch to DC and adjust attenuator for an 'on screen' display. The resultant display is the waveform between HT and the transistor, calibration and polarity remains constant as for normal grounded measurements.

NOTE: If a large AC signal exists on the COMMON line during isolated measurements it may be necessary to connect a link from the COMMON terminal to the X INPUT to eliminate horizontal jitter than may be picked up.

MAXIMUM voltage applied to the COMMON input must not exceed + or - 400V DC or AC & DC combined. Input to vertical amplifier AC or DC coupled is + or - 400V W. R. T. COMMON terminal.

An additional use for the isolated input is to eliminate hum and ground loops from low level measurements in the millivolt region. In this application, remove the ground link and connect a lead from the COMMON terminal the the nearest ground point of the circuit under test. Measurements are then made normally either AC or DC coupled - without ground line interference.

6. CURRENT MEASUREMENTS AC OR DC

6.1 Another use for the isolated ground is 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 of the oscilloscope.

6. CURRENT MEASUREMENTS AC OR DC (Cont'd)

6.1 Cont'd

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.

7. MEASUREMENTS WITH AN EXTERNAL HORIZONTAL INPUT

7.1 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 1 cm. 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 sensitivities as required).

Remove the CAL. waveform and centre the spot. Positive or negative voltages may be now 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 2° phase shift exists up to 10kHz and 5° at 20kHz between X and Y inputs.

8. TELEVISION WAVEFORM DISPLAYS

8.1 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 +, if video is negative going - video signal not sync, then select - ve.

To lock the signal to line frequency set the TRIG. LEVEL to AUTO (line) then turn TIME/CM switch to view line waveform. To lock signal to frame frequency rotate the TRIG. LEVEL fully clockwise and adjust T.B. speed to view one or two frames as required. Detailed examination of the frame pulse and following equalising pulses etc. can be made by increasing time base speed and/or using the X5 expansion. As the repetition rate is only 50Hz or 60Hz, the trace intensity falls with increasing time base speed however, detailed observation can be readily made and by backing off the TRIG LEVEL control more of the frame pulse can be viewed than is available in the preset position.

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 5MHz for a 4 cm. display.

9. CIRCUIT DESCRIPTION

The circuit is divided into three (3) sections -

(a) Vertical amplifiers.
(b) Trigger circuits and T.B.
(c) CRT EHT and Power Supplies.

9. CIRCUIT DESCRIPTION (Cont'd)

9.1 Vertical Amplifiers.

Signals at the input socket are connected by S1 either directly or via C1 capacitor which removes the DC component to the attenuator switch S2A-D. This switch is in two (2) sections, S2A & B attenuates the input in a repetative 1, 10, 100 and 1000 sequence whilst S2C and D further attenuate the signal in a 1, 2, 5 sequence. The effect of cascading these two (2) sections is to attenuate signals in a 1, 2, 5, 10 sequence in twelve (12) steps. Correct step response is maintained by making the series or shunt capacitors adjustable, whilst constant input capacitance is maintained by C5, 7, 9, 15 & 16.

To protect the input FET stage Q1 from large overloads the input is divided down by R12, R14 to put a high impedance in series with the input to the FET gate. High frequencies are compensated by C21 and C22.

The amplifier is a balanced design from input to output with Q1 and Q2 FET input stage IC1 integrated circuit amplifier stage and Q3 - Q6 cascade CRT driver stage.

Q1 and 2 are FET's operate as a balanced amplifier with a common source load, R16, 17, 18 and RV1 balance control.

Azeneris also in the source loqd and serves to keep the gain of the stage constant when line voltage changes occur. The drain load for Q1 and Q2 consists of R17 and 20 shunt by the input impedance of the I.C. Whilst the VDR compensates for changes in sensitivity due to line changes it tends to accentuate unbalance changes in the input stage. This is corrected by the divider R23 and 24 controlling the potential on RV2 and R21 and 22. Variation of RV2 enables a compensating signal to be applied to the drain of Q1 and 2 in opposition to an unbalanced caused by changes in drain current. Correctly adjusted, the trace can be maintained within four (4) cm. over a 200 to 260V line change.

The IC stage is a wide band (approx 80MHz) series-shunt compensated stage with emitter follower outputs. Gain and position are controlled in this stage. RV4 preset gain in series with front panel VERNIER RV3 and R25 sets the stage gain.

Positioning of the trace is accomplished by bypassing current to the emitters of the series stage by RV5, R27 and 28. This changes the signal levels but does not effect the balance or gain.

The output is a cascode stage, series compensated between the emitters of Q3 and Q4 for high frequency response.

Trigger take off if via R44 and 45 divider to Q7 emitter follower which feeds S4A trigger source selector switch.

9.2 S4 selects the internal or external source of trigger which is fed via C47 to Q9 phase splitter. S5A selects + or - slope before applying the signal via S6A to Q10 or direct to the Q11 emitter follower. In the T.V. position Q10 which is permanently conducting, DC restores the signal by base current conduction. As the signal applied to Q10 is negative going only the positive going sync pulses will be amplified, the video signal driving the stage into cut off. Frame pulses are integrated by R62 and C50 producing a composite sync signal of low level line pulses and a 5V frame pulse.

9. CIRCUIT DESCRIPTION (Cont'd)

9.2 Cont'd

In this way AUTO trigger operates on the low level line signal but only the high amplitude frame pulse operates in trigger level.

S6B selects the normal or T.V. sync signal which passes via C51 to Q11 emitter follower.

In the AUTO position S7A is open allowing R65 and 66 with RV8 to set trigger sensitivity. When S7A closes in Trigger Level condition additional positive or negative voltage from RV7 via R63 overides the preset condition and provides a selection level of the trigger waveform.

Q11 drives a Schmitt trigger stage Q12 and 13. This produces a sharp rectangular output waveform from any shape input.

The action is as follows, with Q12 conducting, its collector will bottom and Q13 will be cut off by the voltage divider action across R69 and R71. A negative going input signal from the trigger amplifier will cut off Q12, its collector will rise pulling Q13 base positive, so turning Q13 on producing a negative pulse at its collector. As the emitters are coupled together, the current through Q13 will now hold Q12 off until its base is driven positive above the common emitter potential and the switching action is reversed. The sharp negative fall across R72 is differentiated by C54 then applied to Q14 base in the time base circuit.

9.3 TIME BASE CIRCUIT.

The Time Base sawtooth generator consists of Q14 and 15 bi-stable trigger, Q19 source follower Q18 Miller sawtooth generator and Q20 emitter follower with associated clamping diodes D6,8,9,10 and 11. The function is as follows:-

Assuming Q14 is conducting, Q15 will be cut off, its collector will rise and D9 will conduct, pulling the gate of Q19 and hence the base of Q18 positive. The collector of Q18 will fall to approximately -5V together with Q20 base. At this point diode D10 connected into the emitter load of Q20 passes below zero and starts to conduct pulling D9 to a lower conduction level creating a static stable condition.

In this direct coupled quiescent state, the trace will be ready for a trigger input pulse. 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 R80, biasing Q14 off further and a rapid cumulative action occurs in which Q14 cuts off and Q15 saturates. D9 becomes reverse biased, Q19 is left with its gate at -1.5V approximately and connected through the timing resistor R88 to &95 to a negative potential on RV11 which will pull Q19 and thereby Q18 towards cut-off. However, the timing capacitors selected by S8D are effectively in circuit between the base and collector of the Miller Transistor Q18 and prevent a sudden rise at Q18 collector by the action of negative feedback, which linearises the charging current to the timing capacitor and produces a sawtooth waveform with a 0.1% linearity.

Q19 FET source follower presents a high impedance to the charging circuit enabling high value charging resistors to be utilised with small high stability timing capacitors. Q20 emitter follower provides a low output impedance to charge the

9. CIRCUIT DESCRIPTION (Cont'd)

9.3 TIME BASE CIRCUIT (Cont'd)

capacitors and drive the output and gating circuits. As Q15 gate and Q18 base fall, Q18 collector rises and via Q20, R100 and C75 a charge is applied to the selected timing capacitor on S8D. The result of this negative feedback is to linearise the charging rate to the timing capacitor and to produce a positive going sawtooth waveform at the collector of Q18 and base of Q20 where it appears at low impedance at its emitter. The sawtooth continues to rise until the potential at the junction on RV9 reaches approx. -4V. D11 conducts and charges C60 and C61 - 64 as selected by S8B. 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. D9 conducts pulling the gate of Q19 positively, Q18 collector falls, rapidly discharging the timing capacitor until Q20 emitter falls sufficiently to cause D10 to conduct to pull D9 back to a quiescent condition and stabilise the circuit ready for the next trigger pulse. This will initiate the next trace once the hold-off capacitors C60 - 64 have discharged sufficiently through R76 and the base current of Q14.

AUTO Time base operation is obtained by allowing the clamping network for Q14 base to run down at a controlled rate until the time base automatically turns itself on if no trigger pulse arrives during the run down. Q16 clamp discharges C55 - 58 as selected by S8A and holds the top of R74 at -0.2V during the normal sweep period as its base is held negative to its emitter by current through R86 and Q15. During the return trace when Q15 rises it cuts off Q16 thus permitting C55 & 56 - 58 as selected, to charge negatively through R74, 5 and 6. When the junction of R74 and 5 falls below the emitter potential of Q14 it ceases to conduct, its collector rises and the cumulative switching action previously described occurs with the resultant sawtooth sweep generation. During this period Q16 is pulled into conduction to discharge the AUTO capacitors in readiness for the next run down.

The progressive reduction in capacitor value as the sweep speed rises results in a bright reference base line at all time base speeds and provides more reliable triggering at very high frequencies.

C.R.T. Blanking by the Time Base circuit is accomplished by directly coupling the C.R.T. blanking electrode to Q17 collector which is driven between the clamping limits of +0V and +58V. Q17 is driven by Q14 via R81 base resistor and conducts during the forward trace, but is biased off during the return trace. R84 connected to +175V pulls the blanking voltage up rapidly until it is clamped by D14 at +58 when the beam is cut off.

In models up to Serial Number 12387 blanking is generated by transistors Q16 and Q17 swinging between 0 - 48V. Q16 conducts during the forward trace providing a rapid turn on of the blanking pulse whilst Q17 is turned on during the return trace to minimise the return trace at high sweep speeds.

9.4 HORIZONTAL AMPLIFIER.

Three transistors Q21, 22 and 23 amplify the Time Base and horizontal input to provide the high voltage horizontal deflection voltages.

9. CIRCUIT DESCRIPTION (Cont'd)

9.4 HORIZONTAL AMPLIFIER (Cont'd)

Q21 is a shunt feedback stage, RV10B (HORIZ. GAIN) varies the feedback and hence the stage gain. RV13 presets the minimum gain (x1 Mag).

The time base sawtooth, the horizontal X Input and the Horizontal Shift are all applied to Q21 base via mixing resistors R104, R120 and R106.

The low impedance output from Q21 feeds Q22 and Q23 long tail pair which in turn drive the C.R.T. deflection plates directly. Horizontal centreing is preset by RV14.

9.5 C.R.T. AND SUPPLIES

Type D13/27 C.R.T. requires approximately equal + and - E.H.T. supplies for correct operation. The negative supply is a voltage doubler consisting of D201 and 202 with C201 to 204 capacitors. A second stage of filtering R205 and C205 reduces ripple to a low level. C.R.T. potentials are taken from a divider across the -1400 supply consisting of R215, RV204 Focus Control, R216, RV202 Intensity Control and R206.

The C.R.T. grid is returned to the -1400V rail via R208 grid resistor RV8 INTENSITY control varies the impedance of the divider between grid and cathode and so varies the potential between them thus changing the beam current and trace brightness.

Z Modulation is coupled through C207 to the C.R.T. grid. All other electrode voltages are preset RV205 Astigmatism control and RV203 Geometry controls are located between low voltage rails.

The PDA supply, like the negative E.H.T. supply, is a voltage doubler rectified by D203 and D204 with C209 and C210 coupling capacitor and filter D204 is returned to the +58 rail to add this potential to the PDA voltage.

9.6 LOW VOLTAGE POWER SUPPLIES

Two (2) secondary windings provide the main DC supplies. + and -64V is obtained from the 51V winding by half wave rectifying by D3 & 4 followed by three stages of filtering for the various circuits. The +200V rail is obtained by doubling the 82V winding by D1 and D2. Separate filters are used for the vertical and horizontal amplifiers, R48 and C36 for the vertical and R50, C35 for horizontal.

9.7 CALIBRATOR

The 51V AC supply is fed to Q201 emitter. Q201 clamps signals going positively by its zener diode action and negatively by its forward diode action. The resultant square wave is divided down by R210 and RV201 to supply 1V p-p output at the front panel socket.

10. ADJUSTMENTS AND MAINTENANCE

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 (2) screws holding the handle and withdraw the cover. The bottom cover may be removed by unscrewing the four (4) feet.

To aid fault finding the voltages present 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 using the instrument frame as a meter connection unless the ground link is in place between the black and green front panel terminals

11. ALIGNMENT PROCEDURE

Before attempting re-alignment of any section of this Oscilloscope, check the instruments 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.

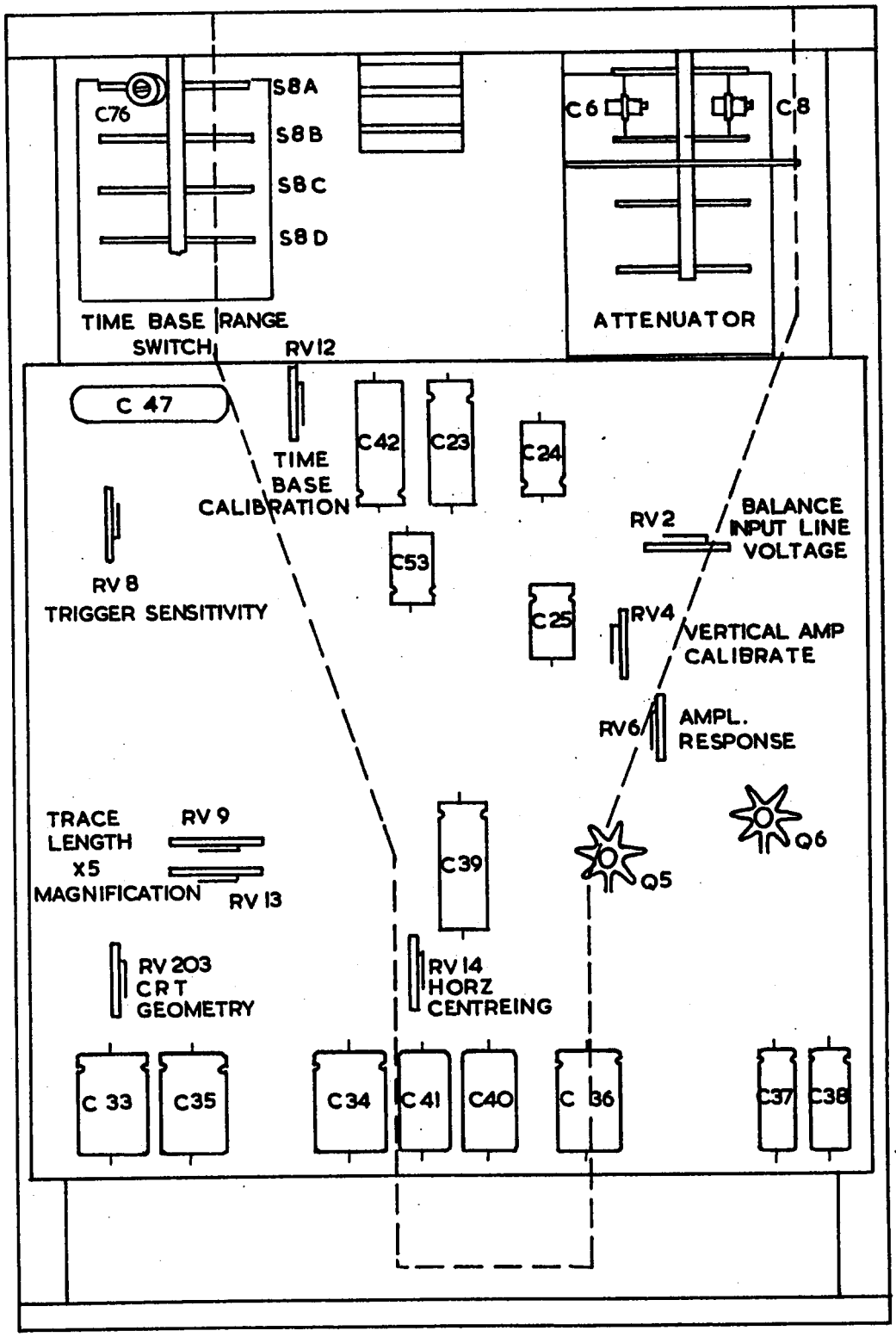
11.1 General check of controls -

(a)	Intensity	Linear control over intensity range.
(b)	Focus	Approx. centre with adjustment either side.
(c)	Horiz. Gain	Trace should expand equally either side of centre.
(d)	Vert. Shift	Trace should move completely off screen above and below centre.
(e)	Trigger Level	With Atten. at 0.2V and CAL signal fed into AC Input check AUTO and Level Select operation.
(f)	+ - Switch	Set up as for (e) Trigger point should change over as indicated by switch.
(g)	Horiz. Input & Gain	Feed CAL signal into Horiz. Input socket with T.B. VERNIER turned to T.B. OFF HORIZ. GAIN should vary display from 2 mm to over 1 cm.

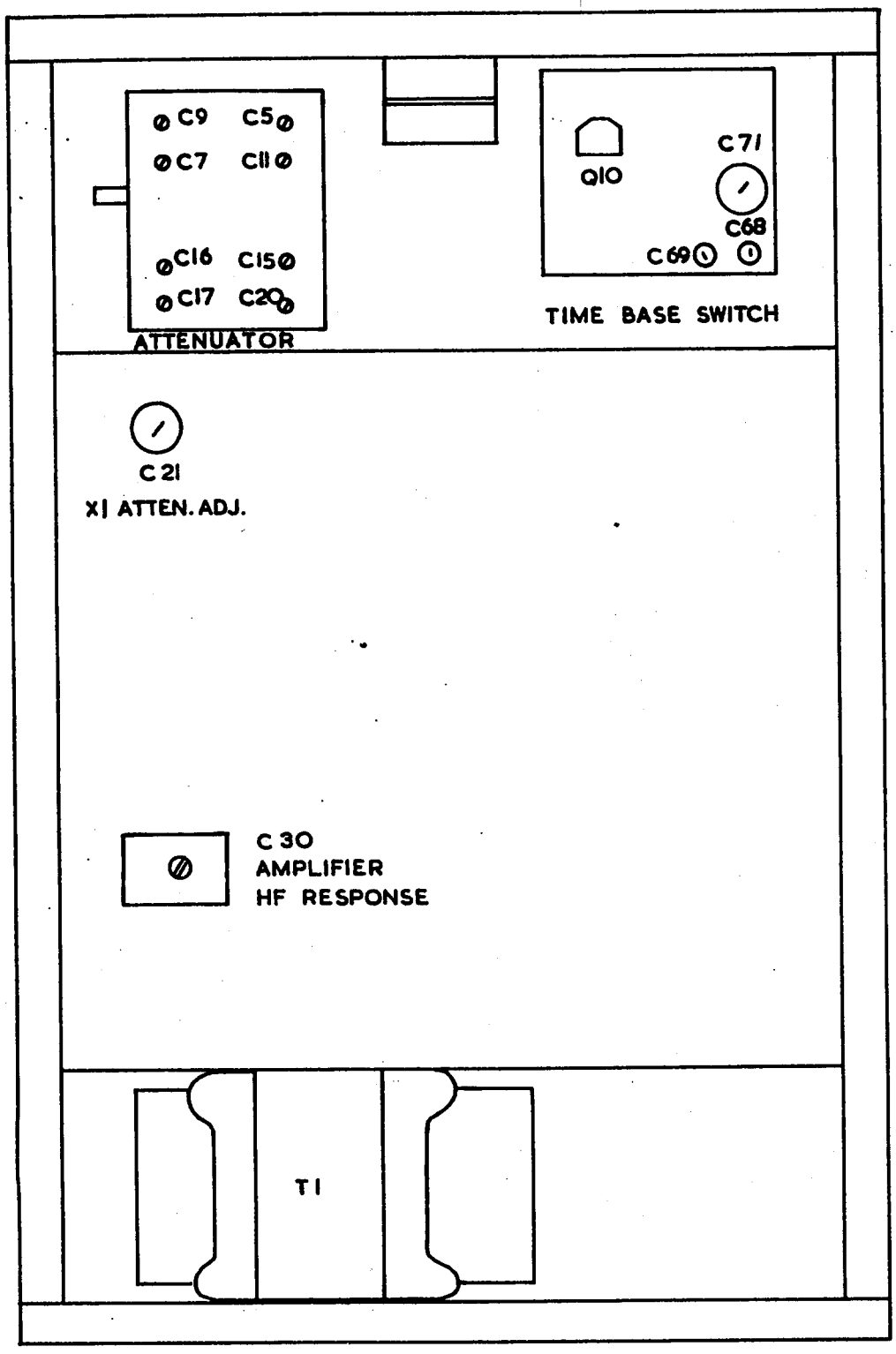
11.2 C.R.T. TRACE ALIGNMENT

If a 1000Hz square wave signal is available, feed this into the VERTICAL AMPLIFIER and adjust wave form to fill the screen. T.B. to 1mSec. VERNIER CAL. If a square wave is not available use the CAL waveform. T.B. to 10mSec. VERNIER CAL.

RV205 Rear Panel astigmatism control is adjusted in conjunction with the FOCUS control to obtain the best resolution over the entire screen area.



TOP VIEW OF P.C. BOARD
SHOWING LOCATION OF PRESETS



UNDERSIDE OF P.C. BOARD
SHOWING LOCATION OF PRESETS

11 ALIGNMENT PROCEDURE (Cont'd)

11.2 C.R.T. TRACE ALIGNMENT

RV203 at rear of main board adjusts the pattern geometry. It should be set to display vertical and horizontal lines with minimum of pincushion or barrel distortion. RV205 may need slight re-adjustment after RV203 has been set as some interaction occurs.

Equipment required for complete calibration procedure.

20,000Ω/V meter or DVM.
Pulse generator 10nSec rise time or better.
Voltage calibrator >0.5% accuracy .20mV to 100V p-p.
Low frequency sine wave generator 1Hz to 1MHz (bwd 140A).
High frequency constant amplitude generator. 50kHz to 50MHz.
Time pulse generator 0.1uSec to 1Sec in decade steps >0.5% accuracy
Variable voltage input transformer 'Variac'

11.3 VERTICAL AMPLIFIER ALIGNMENT

(a) Set attenuator to .005, Vernier to CAL. Feed in 20mV p-p 1% 1kHz square wave.

(b) Adjust RV4 LH side main board for 4 cm. deflection. Check all attenuator steps for correct calibration. Remove input signal.

(c) Connect oscilloscope to Variac and adjust input to 235V (115V on 115V models). Centre trace with shift.

(d) Balance vernier control Turn Vernier anticlockwise, recentre trace with shift, turn vernier back to CAL, recentre with panel BALANCE control. Repeat as necessary to eliminate movement.

(e) Reduce input voltages with Variac down to 210V (100V), recentre trace with shift control. Return input to 235V, (115V) recentre trace with RV2. Repeat operation until trace has minimum movement on screen.

(f) Then rebalance vernier control as in (d) and finally check as in (e) again.

11.4 CALIBRATION

(a) Turn attenuator to .005V, feed in 20mV to recheck for 4 cm. deflection calibration, reset RV4 if necessary.

11.5 HIGH FREQUENCY ADJUSTMENT

(a) Attenuator to .005V, 2.5kHz square wave input. Set input for 4 cm. deflection. Adjust C21 underside board front, for optimum square wave shape. Increase input frequency to 1MHz now adjust RV6 and C30 at rear of main board for optimum response.

(b) Replace square wave input with constant amplitude generator. Set reference frequency 50kHz to 4 cm. deflection. Check response is not less than 2.8 cm. deflection at 15MHz.

11. ALIGNMENT PROCEDURE (Cont'd)

11.6 ATTENUATOR ALIGNMENT

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

Attenuator Setting	Input Voltage	Adjust for Square Wave	Adjust for Input Capacitance
.005V	20mV	-	-
.01	50mV	C17	-
.02	.1V	C20	-
.05	.2V	C11	C5
.1	.5V	C16	-
.2	1V	C15	-
.5	2V	C 6	C7
1	5V	-	-
2	10V	-	-
5	20V	C 8	C9
10	50V	-	-
20	100V	-	-

Attenuator will be automatically aligned at attenuator position where no capacitor is noted.

11.7 CALIBRATOR ADJUSTMENT

When amplifier is correctly calibrated against an external standard set its attenuator to .2V, Vernier to CAL and feed in the 1V calibrate waveform (input switched to DC). Adjust RV201 on the bottom of vertical board deflection for 5 cm.

11.8 TIME BASE ALIGNMENT

(a) Set T.B. Range to 1mSec Vernier to CAL. Check trace length is 10.5 cm. approx. Set with RV9 if necessary.

(b) Feed into amplifier 1mSec. pulses. Adjust No. 1 pulse to correspond to 1st graticule line. Adjust RV12(front centre main board) for 1 pulse/cm. Expand trace to X5. Adjust RV13 (for 1 pulse/5cm.) Return to X1 and reset RV12 if necessary for 1 Pulse/cm.

(c) Now check lower time base speeds down to 2 Seconds/cm. and at higher speeds up to 50µSec/cm. If it is noticed that most ranges appear slightly slower or faster than the nominal, RV12 may be reset to obtain the best overall calibration accuracy.

(d) Turn the range switch to 10µSec/cm. Feed in a 10µSec pulse. Calibration may now be adjusted by C71 (large trimer) on lower side of T.B. Switch. Check calibration from 20µSec to 1µSec and if necessary reset C71 for best calibration over range.

11. ALIGNMENT PROCEDURE. (Cont'd)

11.8 Cont'd.

(e) 0.5uSec/cm. is correctly set by C69 on lower side of T.B. Switch and 0.2u Sec/ by C68.

11.9 TRIGGERING.

(a) Set Time Base to 10uSec/cm. AUTO Trig. + and NORM. Selection. Couple a 50kHz input to a vertical amplifier. Progressively reduce input level and adjust RV8 for lock down to smallest level attainable.

(b) Change from + to - slope. Reset RV8 if necessary to optimise setting.

(c) Increase input to 1 cm. increase frequency up to 10MHz maintaining 1cm. signal level trace should remain locked + and - at highest time base speeds.

(d) At low frequencies trace will lock to a sine wave at 8Hz with 1cm. deflection. Increase signal to fill screen at 1kHz, check operation of TRIG LEVEL control over full range both + and - slope.

11.10 HORIZONTAL AMPLIFIER.

(a) Turn T.B. Vernier to T.B. OFF, increase MAG to x5, centre spot. Feed a 50kHz signal into X input socket. Adjust input for 6cm. horizontal display. Increase frequency to 1MHz. Amplitude should not drop below 4.2cm.

(b) Switch T.B. VERNIER to off, rotate switch TRIG LEVEL fully clockwise and set attenuator to 1 volt/cm. Feed 6V p-p of 100kHz sine wave to X and Y inputs. Adjust HORZ GAIN for a display at 45°. Adjust C76 for a straight line display.

12. REPLACEMENT PARTS.

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

As the policy of the manufacturer 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.

13. WARRANTY.

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

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

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B.W.D. ELECTRONICS PTY.LTD.

REPLACEABLE PARTS

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

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

2. Ordering - Please quote Model Type No., e.g. bwd 511, Serial No. Circuit Reference No. and component details as listed in parts list.

COMPONENT DESIGNATORS

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

ABBREVIATIONS

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

COMPONENT ABBREVIATIONS (cont.)

PL	Plug
PS	Socket
Preset	Internal Preset
PYE	Polyester
pot	Potentiometer
prec	Precision
PC	Printed circuit
PIV	Peak Inverse Voltage
PYS	Polystyrene
p-p	Peak to Peak
P.Shaft	Plain Shaft
Q	Transistor
R	Resistor
rot	rotary
R log	Reverse Logarithmic Taper
rms	Root Mean Squared
SPDT	Single Pole Double Throw
SPST	Single Pole Single Throw
S.Shaft	Slotted Shaft
Si	Silicon
Ta	Tantalum
tol	Tolerance
trim	trimmer
V	Volt(s) ...
var	variable
vdcw	Volts Direct Current Working
w	Watt(s)
ww	Wire Wound
Z	Zener
*	Factory Selected value, nominal value may be shown
**	Special component, no part no. assigned

MANUFACTURERS ABBREVIATIONS

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

PARTS LIST

CCT Ref.	DESCRIPTION				Mfr. or Supplier	Part No.	
R1	900KΩ		1%	MO	ELECTROSIL	TR5	
R2	990KΩ		1%	MO	ELECTROSIL	TR5	
R3	1MΩ		1%	MO	ELECTROSIL	TR5	
R4	111KΩ		1%	MO	ELECTROSIL	TR5	
R5	10.1KΩ		1%	MO	ELECTROSIL	TR5	
R6	1KΩ		1%	MO	ELECTROSIL	TR5	
R7	33Ω	½W	5%	CC	PI		
R8	500KΩ		1%	MO	ELECTROSIL	TR5	
R9	750KΩ		1%	MO	ELECTROSIL	TR5	
R10	1MΩ		1%	MO	ELECTROSIL	TR5	
R11	333KΩ		1%	MO	ELECTROSIL	TR5	
R12	100KΩ		1%	MO	ELECTROSIL	TR5	
R13	900KΩ		1%	MO	ELECTROSIL	TR5	
R14	150KΩ	½W	5%	CC	PI		
R15/15A	47Ω	½W	5%	CC	PI		
R16	82Ω	½W	5%	CC	PI		
R17	390Ω	½W	5%	CC	PI		
R18	2.2KΩ	½W	5%	CC	PI		
R19	2.2KΩ	½W	5%	CC	PI		
R20	390Ω	½W	5%	CC	PI		
R21	4.7K	½W	5%	CC	PI		
R22	4.7K	½W	5%	CC	PI		
R23	2.2K	½W	5%	CC	PI		
R24							
R25	470Ω	½W	5%	CC	PI		
R26	47Ω	½W	5%	CC	PI		
R27	8.2KΩ	½W	5%	CC	PI		
R28	8.2KΩ	½W	5%	CC	PI		
R29	390Ω	½W	5%	CC	PI		
R30	470Ω	½W	5%	CC	PI		
R31	120Ω	½W	5%	CC	PI		
R32	100Ω	½W	5%	CC	PI		
R33	100Ω	½W	5%	CC	PI		
R34	120Ω	½W	5%	CC	PI		
R35	1.2KΩ	½W	5%	CC	PI		
R36	680Ω	½W	5%	CC	PI		
R37	680Ω	½W	5%	CC	PI		
R38	47Ω	½W	5%	CC	PI		
R39	390Ω	½W	5%	CC	PI		
R40	4.7KΩ	1W	5%	CC	PI		
R41	4.7KΩ	1W	5%	CC	PI		
R42							
R43	33Ω	½W	5%	CC	PI		

PARTS LIST

CCT Ref.	DESCRIPTION				Mfr. or Supplier	Part No.	
R44	100KΩ	½W	5%	CC	PI		
R45	22KΩ	½W	5%	CC	PI		
R46	15KΩ	½W	5%	CC	PI		
R47	1MΩ	1W	5%	CC	PI		
R48	1KΩ	1W	5%	CC	PI		
R49	1KΩ	1W	5%	CC	PI		
R50	1.8KΩ	1W	5%	CC	PI		
R51	330Ω	½W	5%	CC	PI		
R52	330Ω	½W	5%	CC	PI		
R53	470Ω	½W	5%	CC	PI		
R54	470Ω	½W	5%	CC	PI		
R55	220KΩ	½W	5%	CC	PI		
R56	100KΩ	½W	5%	CC	PI		
R57	10KΩ	½W	5%	CC	PI		
R58	1KΩ	½W	5%	CC	PI		
R59	1KΩ	½W	5%	CC	PI		
R60	1.8MΩ	½W	5%	CC	PI		
R61	27KΩ	½W	5%	CC	PI		
R62	6.8KΩ	½W	5%	CC	PI		
R63	150KΩ	½W	5%	CC	PI		
R64	220Ω	½W	5%	CC	PI		
R65	22KΩ	½W	5%	CC	PI		
R66	33KΩ	½W	5%	CC	PI		
R67	27KΩ	½W	5%	CC	PI		
R68	120Ω	½W	5%	CC	PI		
R69	2.2KΩ	½W	5%	CC	PI		
R70	2.2KΩ	½W	5%	CC	PI		
R71	10KΩ	½W	5%	CC	PI		
R72	470Ω	½W	5%	CC	PI		
R73	150Ω	½W	5%	CC	PI		
R74	39KΩ	½W	5%	CC	PI		
R75	2.2KΩ	½W	5%	CC	PI		
R76	220KΩ	½W	5%	CC	PI		
R77	6.8KΩ	½W	5%	CC	PI		
R78	47KΩ	½W	5%	CC	PI		
R79	33KΩ	½W	5%	CC	PI		
R80	22KΩ	½W	5%	CC	PI		
R81	3.3KΩ	½W	5%	CC	PI		
R82	15KΩ	½W	5%	CC	PI		
R83	120KΩ	½W	5%	CC	PI		
R84							
R85	56K	½W	5%	CC	PI		

PARTS LIST

CCT Ref.	DESCRIPTION				Mfr. or Supplier	Part No.	
R86	2.2KΩ	½W	5%	CC	PI		
R87							
R88	100KΩ		1%	MO	ELECTROSIL	TR5	
R89	100KΩ		1%	MO	ELECTROSIL	TR5	
R90	400KΩ		1%	MO	ELECTROSIL	TR5	
R91	1MΩ		1%	MO	ELECTROSIL	TR5	
R92	1MΩ		1%	MO	ELECTROSIL	TR5	
R93	4M99		1%	CC	AB		
R94	4M99		1%	CC	AB		
R95	10MΩ		1%	MO	WYLWIN	C23	
R96	47KΩ	½W	5%	CC	PI		
R97	150Ω	½W	5%	CC	PI		
R98	33KΩ	½W	5%	CC	PI		
R99	2.2KΩ	½W	5%	CC	PI		
R100	1.5KΩ	½W	5%	CC	PI		
R101	10KΩ	½W	5%	CC	PI		
R102	15KΩ	½W	5%	CC	PI		
R103	4.7KΩ	½W	5%	CC	PI		
R104	22KΩ	½W	5%	CC	PI		
R105	68KΩ	½W	5%	CC	PI		
R106	56K	½W	5%	CC	PI		
R107	2.2K	½W	5%	CC	PI		
R108	1.2K	½W	5%	CC	PI		
R109	1.2KΩ	½W	5%	CC	PI		
R110	47KΩ	½W	5%	CC	PI		
R111	8.2KΩ	1W	5%	CC	PI		
R112	8.2KΩ	1W	5%	CC	PI		
R113	8.2KΩ	1W	5%	CC	PI		
R114	8.2KΩ	1W	5%	CC	PI		
R115	180Ω	½W	5%	CC	PI		
R116	3.9K	½W	5%	CC	PI		
R117	8.2K	½W	5%	CC	PI		
R118	39KΩ	½W	5%	CC	PI		
R119	47KΩ	½W	5%	CC	PI		
R120	56KΩ	½W	5%	CC	PI		
R121	82Ω	½W	5%	CC	PI		
R200							
R201	1MΩ	½W	5%	CC	PI		
R202	1MΩ	½W	5%	CC	PI		
R203	1MΩ	½W	5%	CC	PI		

PARTS LIST

CCT Ref.	DESCRIPTION				Mfr. or Supplier	Part No.	
R204	1MΩ	½W	5%	CC	PI		
R205	68KΩ	½W	5%	CC	PI		
R206							
R207							
R208	1MΩ	½W	5%	CC	PI		
R209	1.8MΩ	½W	5%	CC	PI		
R210	22KΩ	½W	5%	CC	PI		
R211	22KΩ	½W	5%	CC	PI		
R212							
R213							
R214	1.8MΩ	1W	5%	CC	PI		
R215							
R216	680KΩ	½W	5%	CC	PI		
R217	100KΩ	½W	5%	CC	PI		
R6A	8.2Ω	½W	5%	CC	PI		
R118	39K	½W	5%	CC	PI		
	CAPACITOR						
C1	0.1uF	400V	10%	PYE	PH	2202-315-51104	
C2	0.0047uF	400V	10%	PYE	PH	2202-315-51472	
C3	0.22uF	630V	10%	PYE	PH	2222-342-61-224	
C4	5.6pf	500V	5%	NPO	H.S	CDS	
C5	1-12pf	TRIMMER		NPO	H.S	C004CA/12E	
C6	0.8-3pf	TRIMMER			PH	C00422/07	
C7	1-12pf	TRIMMER		NPO	H.S	C004CA/12E	
C8	0.8-3pf	TRIMMER			PH	C00422/07	
C9	1-12pf	TRIMMER		NPO	H.S	C004CA/12E	
C10	18pf	500V	5%	NPO	H.S	CDS	
C11	1-12pf	TRIMMER			PH	C004CA/12E	
C12	270pf	500V	5%	SM	DUC	MSA	
C13	0.001uF	500V	5%	SM	DUC	MSA	
C14	0.001uF	500V	5%	SM	DUC	MSA	
C15	1-12pf	TRIMMER			PH	C004CA/12E	
C16	1-12pf	TRIMMER			PH	C004CA/12E	
C17	1-12pf	TRIMMER			PH	C004CA/12E	
C18	18pf	500V	5%	NPO	H.S	CDS	
C19	8.2pf	500V	5%	NPO	H.S	CDS	
C20	1-12pf	TRIMMER			PH	C004CA/12E	
C21	10-40pf	TRIMMER			RHC	10S-06	
C22	33pf	500V	5%	NPO	H.S	CDS	
C23	330uF	16V		ELEC	PH	2222-017-15331	

PARTS LIST

CCT Ref.	DESCRIPTION				Mfr. or Supplier	Part No.	
C24	100uF	25V		ELEC	PH	2222-016-16101	
C25	100uF	25V		ELEC	PH	2222-016-16101	
C26	0.1uF	50V	20%	MSK	H.S	MSK	
C27	0.1uF	50V	20%	MSK	H.S	MSK	
C28	15pf	500V	5%	N750	H.S	CDS	
C29	150pf	630V	5%	PYS	H.S	TCS602	
C30	20-220pf	TRIMMER			P	CWO	
C30A	0.001uF	500V	20%	YY	H.S	CDS	
C31	0.001uF	500V	20%	YY	H.S	CDS	
C32	0.001uF	500V	20%	YY	H.S	CDS	
C33	50uF	150V		ELEC	PH	2222-040-12509	
C34	50uF	150V		ELEC	PH	2222-040-12509	
C35	40uF	200V		ELEC	PH	2222-040-12409	
C36	40uF	200V		ELEC	PH	2222-040-12409	
C37	220uF	63V		ELEC	PH	2222-017-18221	
C38	220uF	63V		ELEC	PH	2222-017-18221	
C39	100uF	63V		ELEC	PH	2222-017-18101	
C40	220uF	63V		ELEC	PH	2222-017-18221	
C41	100uF	63V		ELEC	PH	2222-017-18101	
C42	220uF	63V		ELEC	PH	2222-017-18221	
C43	3.3pf	500V	5%	NPO	H.S	CDS	
C44	0.1uF	50V	20%	MSK	H.S	MSK	
C45							
C46	5.6pf	500V	5%	NPO	H.S	CDS	
C47	1uF	200V	10%	PYE	SOR	TYPE N	
C48	22pf	500V	5%	NPO	H.S	CDS	
C49	0.1uF	100V	10%	PYE	SOR	TYPE N	
C50	0.01uF	100V	10%	PYE	SOR	TYPE N	
C51	4.7uF	63V		ELEC	PH	2222-015-18478	
C52	39pf	500V	5%	N750	H.S	CDS	
C53	100uF	25V		ELEC	PH	2222-016-16101	
C54	10pf	500V	5%	NPO	H.S	CDS	
C55	0.01uF	100V	10%	PYE	SOR	TYPE N	
C56	0.1uF	100V	10%	PYE	SOR	TYPE N	
C57	1uF	63V		ELEC	PH	2222-015-18108	
C58	10uF	25V		ELEC	PH	2222-015-16109	
C59	22uF	25V		ELEC	PH	2222-015-16229	
C60	68pF	500V	5%	N750	H.S	CDS	
C61	180pf	500V	5%	PYS	H.S	TCS603	
C62	680pF	500V	5%	PYS	H.S	TCS610	
C63	0.022uF	160V	10%	PYE	PH	2202-315-31223	
C64	2.2uF	40V		ELEC	PH	2222-015-17228	
C65	22pf	500V	5%	NPO	H.S	CDS	

PARTS LIST

CCT Ref	DESCRIPTION				Mfr. or Supplier	Part No.	
C66	68pf	500V	5%	N750	H.S	CDS	
C67	33pf	500V	5%	N750	H.S	CDS	
C68	4.5-20pf		TRIMMER		RHC	7S-02	
C69	4.5-20pf		TRIMMER		RHC	7S-02	
C70	82pf	500V	5%	N750	H.S	CDS	
C71	10-40pf		TRIMMER		STET	10S-06	
C72	0.01uF	400V	1%	PYS		TSC-D424	
C73A&B	1uF	200V	1%	PYE	SOR	TYPE N	
C74	47pf	500V	5%	N750	H.S	CDS	
C75	0.01uF	100V	10%	PYE	SOR	TYPE N	
C76	4-20pf		TRIMMER		RHC	10S-06	
C77	220pf	630V	5%	PYS	H.S	TCS-604	
C78	0.1uF	100V	10%	PYE	SOR	TYPE N	
C79							
C7,9/A	5.6pf	500V	5%	NPO	H.S		
	POTENTIOMETERS						
RV1	5KΩ	LIN POT REAR		RV5	IRH		
RV2	2.2KΩ	PRE SET POT		C	PH	2322-411-02205	
RV3	1KΩ	"A" CURVE		C	S		
RV4	470Ω	PRE SET POT		C	PH	2322-411-02203	
RV5	10KΩ	LIN POT		C			
RV6	100Ω	PRE SET		C	PH	2322-411-02201	
RV7	220KΩ	POT WITH DPST SW		C	PH	2322-357-727-12	
RV8	47KΩ	PRE SET POT		C	PH	2322-411-02209	
RV9	4.7KΩ	PRE SET POT		C	PH	2322-411-02206	
RV10A	100KΩ	LIN POT FRONT			IRH		
RV10B	10KΩ	LIN POT REAR					
RV11	220KΩ	LIN POT WITH DPST SW			PH	2322-357-727-12	
RV12	100KΩ	PRE SET POT			PH	2322-411-02211	
RV13	47KΩ	PRE SET POT			PH	2322-411-02209	
RV14	1KΩ	PRE SET POT			PH	2322-411-02204	
RV201	4.7KΩ	PRE SET POT		C	PH	2322-411-02206	
RV202	220KΩ	LIN POT WITH DPST SW			PH	2322-357-727-12	
RV203	470KΩ	PRE SET POT		C	PH	2322-411-02213	
RV204	1MΩ	LIN POT		C	S		
RV205	100KΩ	LIN POT		C	S		
RV206	100KΩ	PRE SET POT			PH	2322-411-02211	

PARTS LIST

CCT Ref	DESCRIPTION	Mfr. or Supplier	Part No.	
	SWITCHES			
S1	2 POLE 3 POSITION	HAYCO	QSS 1012	
S2A-D	4 DECK 12 POSITION TYPE F	BWD	SR 73	
S3A&B	DPST Rear RV202	DUC		
S4A	2 POLE 2 POSITION	McM	1299-02-01	
S5A&B	2 POLE 2 POSITION	McM	1299-02-01	
S6A&B	2 POLE 2 POSITION	McM	1299-02-01	
S7A&B	DPST Rear RV7	DUC		
S8A-D	22 POSITION 4 DECK SWITCH	BWD	SR 70	
S9A&B	DPST Rear RV11	DUC		
	DIODES			
D1	400V PIV 500mA SI	STC	EM404	
D2	400V PIV 500mA SI	STC	EM404	
D3	400V PIV 500mA SI	STC	EM404	
D4	400V PIV 500mA SI	STC	EM404	
D5-D13	75V PIV 30mA SI	PH	IN914	
D14	Zener		BYZ88C13	
D15	Zener 5%		AN973	
D16	Low Leakage SI		AN210	
D201	SELENIUM RECT	STC	K8-25	
D202	SELENIUM RECT	STC	K8-25	
D203	SELENIUM RECT	STC	K8-25	
D204	SELENIUM RECT	STC	K8-25	
	TRANSISTORS			
Q1	25VDS N CHANNEL FET SI *	NS	Select 16-28	MPF106
Q2	25VDS N CHANNEL FET SI *	NS	Select 16-28	MPF106
Q3	25Vce NPN SI	PH	BF194/	
Q4	25Vce NPN SI	PH	BF194/	
Q5	150Vce NPN SI	PH	BF336 or 337	
Q6	150Vce NPN SI	PH	BF336 or 337	
Q7	45Vce NPN SI	PH	BC147	
Q8				
Q9	45Vce NPN SI	PH	BC147	
Q10	45Vce NPN SI	PH	BC147	
Q11	-45Vce PNP SI	PH	BC157	
Q12	25Vce NPN SI	PH	BF197/01	
Q13	25Vce NPN SI	PH	BF197/01	
	* selected			

506
P8
114

PARTS LIST

CCT Ref	DESCRIPTION	Mfr. or Supplier	Part No.
	TRANSISTORS (cont'd)		
Q14	45Vce NPN SI	PH	BC147
Q15	45Vce NPN SI	PH	BC147
Q16	-45Vce PNP SI	PH	BC157
Q17	45Vce NPN SI	PH	BC147
Q18	45Vce NPN SI	PH	BC147
Q19	25Vds N CHANNEL FET SI	NS	Select 6-20 MPF106
Q20	45Vce NPN SI	PH	BC147
Q21	45Vce NPN SI	PH	BC147
Q22	220Vce NPN SI	PH	BF337
Q23	220Vce NPN SI	PH	BF337
Q24	-45Vce PNP SI	PH	BC157
Q201	-25Vce hfe 100 PNP SI	F	AY1114
1CI	WIDE BAND AMPLIFIER	F	uA733
	SUNDRY		
V1	C.R.T.5"	PH	D13-27GH
B1	BRACKET LAMP RED	S	MB227
F1	500mA CARTRIDGE FUSE	Y	
T1	POWER TRANSFORMER	BWD	TP5698
	GRATICULE	BWD	Obd
	FILTER GREEN	BWD	Obd
	ESCHUTCHEON C.R.T.	BWD	Obd
	3/4" SHORTING LINK	GR	938L
	7ft. POWER CORD & 3 PIN PLUG	BWD	Obd
	ALL OTHER ITEMS ORDER BY DESCRIPTION		

R1-R54 R206 R217

C1-C43 C207 TO C217

D1-D4 & D14 D203 D204

Q1-Q7 Q201

MODIFICATIONS

ISSUE 3 FEB 72

Q12,13 BF194 TO BF197. ALL DIODES TO IN914.
Q19 2N3819 OR MPF106
R107 1·5K TO 2·2K
R110 56K TO 47K

ISSUE 4 16 JUN. 1972

C22 15→33pf
C79 DELETED
R15A ADDED 47Ω
R17A ADDED 47Ω
R17,20 680Ω TO 390Ω
R25 360Ω TO 470Ω
R29 470Ω TO 390Ω
R30 680Ω TO 470Ω
R31 150Ω TO 120Ω
R34 150Ω TO 120Ω
R39 470Ω TO 390Ω
D16 AN210 ADDED

ISSUE 5 NOV 1972

CAL ADDED.

ISSUE 6 DEC '72

C23 250/16 → 330/16
C24 125/16 → 100/25
C25 80/25 → 100/25
C37 160/64 → 220/63
C38 160/64 → 220/63
C39 100/64 → 100/63
C40 100/64 → 220/63
C41 100/64 → 100/63
C42 160/64 → 220/63

ISSUE 7 19-7-73

R16A 150Ω ADDED
THERMISTOR ADDED TH1

ISSUE 8 - 18-10-73

D17 ADDED

ISSUE 9 10-7-75

APPLICABLE FROM S/W 30,000.
IC1 733 NOW DIL
R55 ADDED TO CIRCUIT ONLY

ISSUE 10 7-76

REF. DRG. No. 1021

SWITCHES

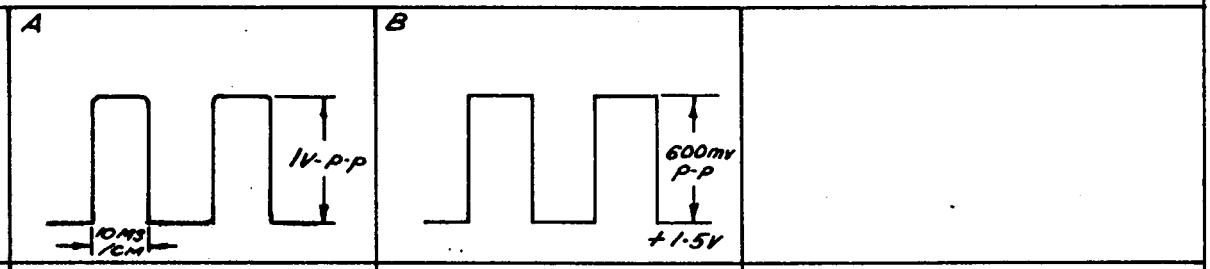
S1 DC - AC - OFF SELECT
S2A-D ATTENUATOR
S3A-B AC POWER SWITCH.

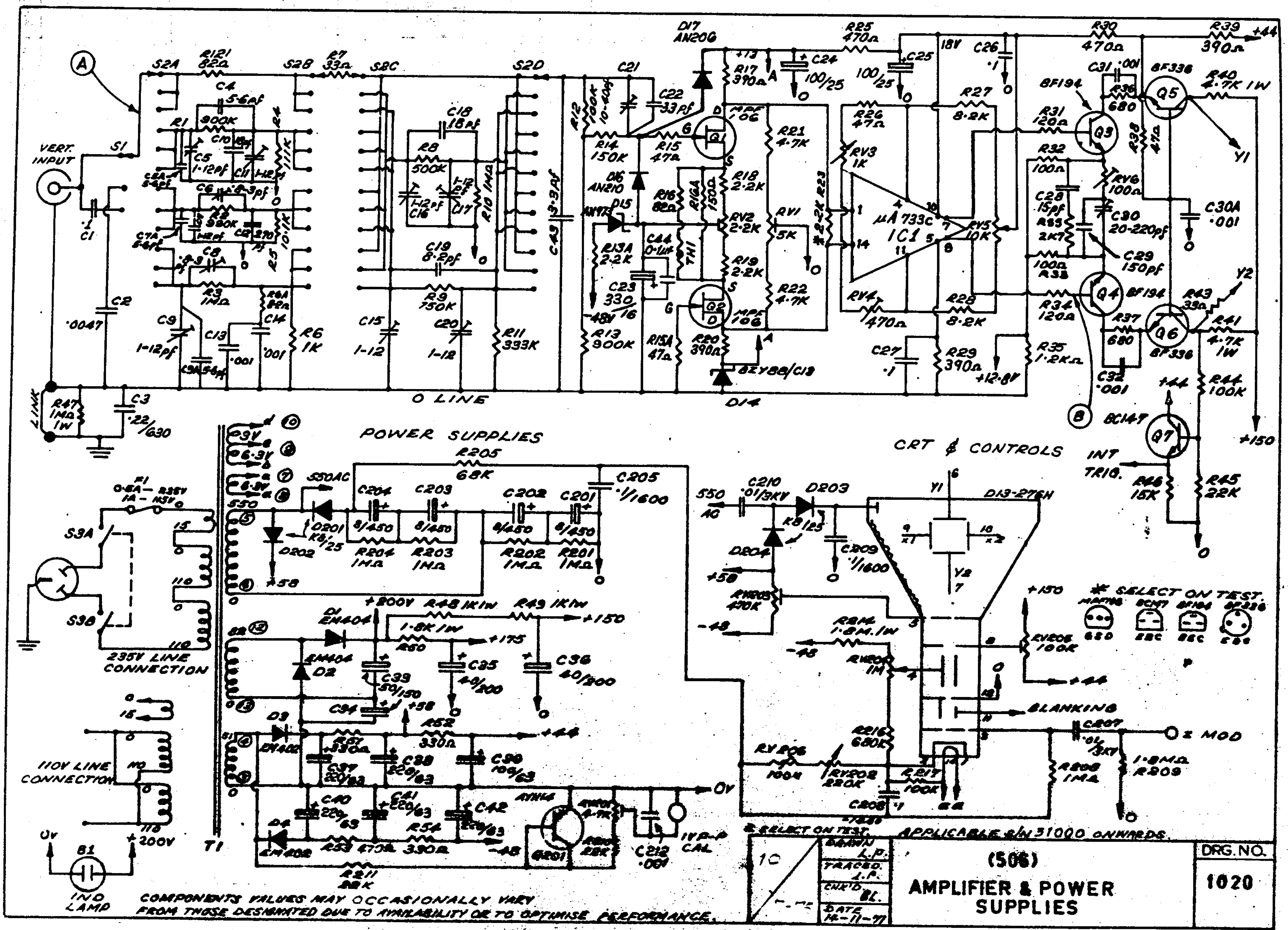
CONTROLS

RV1	DC BALANCE (VERNIER)
RV2	LINE COMPENSATION
RV3	AMPLIFIER VERNIER
RV4	CALIBRATE (AMP)
RV5	VERT POSITION
RV6	H.F. RESPONSE
RV201	1V CAL OUTPUT PRESET
RV202	INTENSITY
RV203	GEOMETRY PRESET
RV204	FOCUS
RV205	ASTIGMATISM.

CIRCUIT WAVEFORMS

ATTEN 0·2V/CM T/B 5m SEC/CM TRIG AUTO INT +




VERT. INPUT
LINK
O LINE
POWER SUPPLIES
CRT & CONTROLS
235V LINE CONNECTION
110V LINE CONNECTION
IND LAMP
INT TRIG.
BLANKING
Z MOD
µA 733C
IC1
D13-27GH
T1
* SELECT ON TEST.
COMPONENTS VALUES MAY OCCASIONALLY VARY FROM THOSE DESIGNATED DUE TO AVAILABILITY OR TO OPTIMISE PERFORMANCE.
APPLICABLE S/N 31000 ONWARDS.
DRAWN L.P.
TRACED L.P.
CHK'D BL.
DATE 14-11-77
(506)
AMPLIFIER & POWER SUPPLIES
DRG. NO.
1020

R55 TO R120

C42 TO C78

D9 TO D14

Q9 TO Q24

MODIFICATIONS

ISSUE 4 5-72

C59 ADDED

ISSUE 5 12-72

C57 1/40 → 1/63

C58 12-5/25 → 10/25

C59 25/25 → 22/25

C64 2-5/16 → 2-2/40

ALL DIODES IN914A ARE NOW AN206's.

ISSUE 6-9

APPLICABLE DRG. 1020

ISSUE 10 7-76

APPLICABLE FROM S/No. 32610

R94 5M → 4M99

R98 5M → 4M99

SWITCHES

S4A	INT-EXT TRIG SELECT.
S5A & B	+ OR - TRIG.
S6A & B	NORM TV SYNC.
S7A & B	AUTO LEVEL SELECT.
S8A - D	TIME BASE RANGE
S9A & B	INT - EXT TIME RANGE.

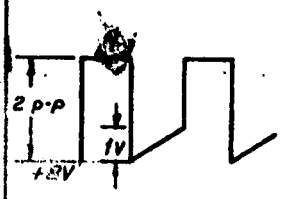
CONTROLS

RV7	TRIGGER LEVEL
RV8	TRIGGER SENSITIVITY
RV9	TRACE LENGTH
RV10A	HORZ SHIFT
RV10B	HORZ MAG.
RV11	T.B. VERNIER
RV12	T.B. CALIBRATE.
RV13	X5 MAG. CAL.
RV14	HORZ CENTRE

CIRCUIT WAVEFORMS

ATTEN 0·2V/CM T/B 5 mSEC/CM TRIG AUTO INT +

C



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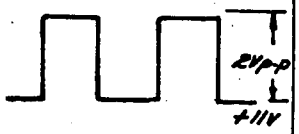

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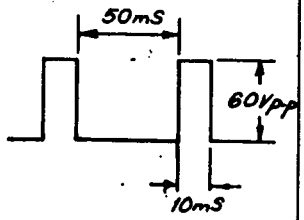

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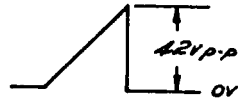

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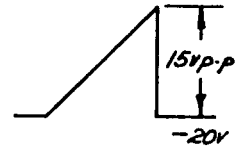

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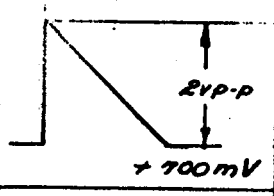

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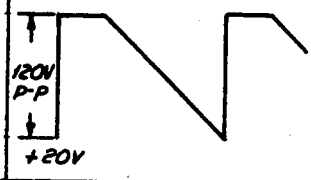
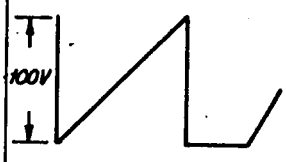
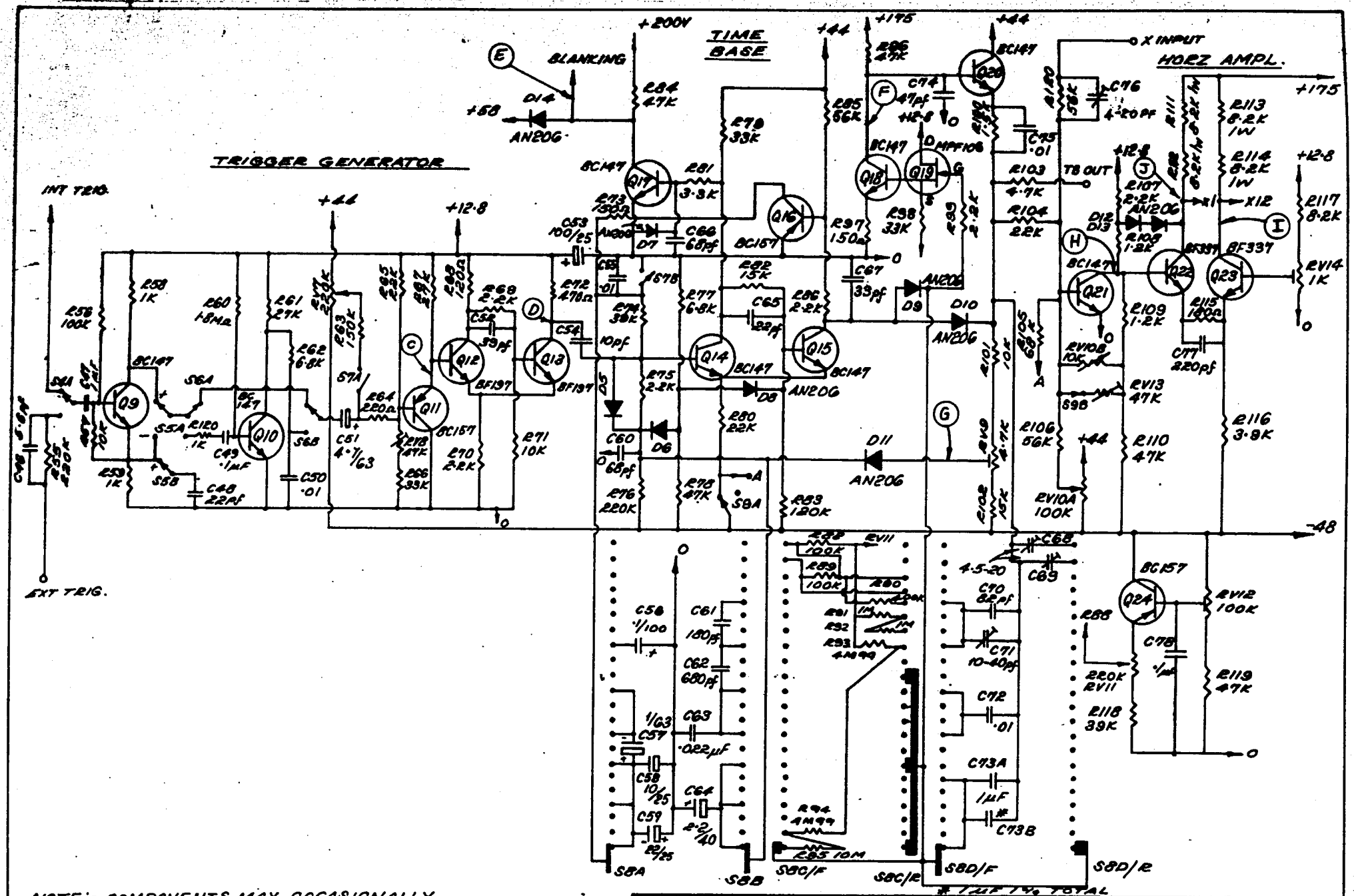


J



DRG N.° 1021


TRIGGER GENERATOR
TIME BASE
HORZ AMPL.
INT TRIG.
EXT TRIG.
BLANKING
+200V
+44
+12·8
+175
+58
-48
X INPUT
TB OUT
AN20G
BC147
BC157
BF197
BF337
MPF106
S8A
S8B
S8C/F
S8C/R
S8D/F
S8D/R
* 1% TOTAL
NOTE:- COMPONENTS MAY OCCASIONALLY VARY FROM THOSE DESIGNATED DUE TO AVAILABILITY OR TO OPTIMISE PERFORMANCE.
APPLICABLE TO S/N°S ABOVE. 19000
DRAWN L.P.
TRACED L.P.
CHK'D
DATE 22-2-72
10
7 76
TIME BASE & HORZ. AMPL.
(506)
DRG.N° 1021