INSTRUMENT HANDBOOK

Applicable to Serial No. A.5444

MODEL bwd 539A

5" DUAL TRACE OSCILLOSCOPE

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A GUIDE TO THE CHARACTERISTICS & METHODS OF SPECIFYING BWD OSCILLOSCOPES

1. VERTICAL AMPLIFIER(s)

1a. Bandwidth, Typical Spec.

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

Method of Measurement

Attenuator set to maximum sensitivity. (Below 5mV where noise may be present, the attenuator is set a decade back, i.e. 50mV in lieu of 5mV). Vernier, if incorporated set to CAL. Time base at 100μSec and switched to AUTO.

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

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

If reference level is 5 or 6 cm etc. then input should be set to this level and -3db point is reached when deflection falls by 30%, i.e. 3.5 cm for 5 cm and 4.2 cm for 6 cm.

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

Oscilloscope amplifier characteristics to note are : -

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

(ii) Full screen deflection is not normally available at the maximum bandwidth.

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

1b. Low Frequency Response

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

1c. Rise Time, Typical Spec.

35nSec over 4 cm.

Method of Measurement

This is most accurately obtained by interpolation. The formula, based on a step response

with less than 2% overshoot or ringing and applicable to all BWD oscilloscopes is rise tim
$= \frac{350}{\text{bandwidth (-3db)}}$ nano Sec. e.g. $\frac{350}{10} = 35$nSec.

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

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

1d. Input Impedance

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

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

2. HORIZONTAL AMPLIFIER

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

2a. Bandwidth, Typical Spec.

DC to 750kHz -3db referred to 6 cm at 50kHz at max. gain.

Method of Measurement

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

2b. Input Impedance

Many horizontal input amplifiers are transistors with a relative low input impedance, therefore input specifications vary widely from 56KΩ to 1MΩ, and capacitance varies from 10pf to 50pf. Input capacitance and resistance is measured at max. gain.

3. TIME BASE

This section is divided into the following sections : -

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

3a. Time Base, Typical Spec.

200nSec to 2 Sec in 22 steps, calibration < 3%.

Method of Measurement

Set time base to 1mSec and vernier fully clockwise to CAL. Feed in a 1kHz square wave or pulse with better than 0.1% frequency accuracy. When the first pulse is lined

up with the first graticule line, then the 10th pulse should be within ±3 mm of the 10th graticule line, Checks made at all other time base steps with corresponding calibration pulses should be within the same limits.

NOTE : Calibration accuracy is not the accuracy of each individual division (unless specifically stated) but the overall accuracy, where any variation in trace linearity is averaged over the 10 div. (cm) deflection.
Where linearity is specified, it is usually measured between the 1st and 9th graticule lines to eliminate compression effects around the perimeter of the CRT.

3b. Magnification, Typical Spec.

3% accuracy at X1 and 5% at X5 up to 1μSec/cm.

Method of Measurement

After calibration check as above at 1mSec/cm trace is expanded to X5. 1kHz calibration pulses should be 5 cm apart ± 2.5 mm. With trace at X5, time base is increased to 5μSec/cm producing a 1μSec/cm magnified sweep. This is the limit of specified calibration although it is normally within spec. at X10 this sweep speed over most the trace length.

3c. Triggering, Typical Spec.

INT AUTO 1 cm defl. 5Hz to 10MHz.

This implies when the time base is adjusted for convenient viewing of input, i.e. 5-10 sine waves visible across screen 1 cm high irrespective of attenuator setting, the time base will present a stable display. Above a few MHz it may be necessary to select + or - slope to obtain greatest clarity of display.
NOTE : All bwd oscilloscopes incorporate an AUTO circuit which varies its rate as the time base range switch is changed, they also have a unique feature which increases the sensitivity of the time base if the trigger level drops at high frequencies - a feature which accounts for their superior triggering characteristics. At low frequencies the AUTO rate may exhibit an intermittant repetition rate. This is quite normal and in no way effects its excellent locking ability when a signal is present.

Typical Spec. Level Select ± 3 cm range 3Hz to 10MHz.

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

NOTE : On oscilloscopes with DC coupled trigger (bwd 521, 522 and 525) time base trigger can be initiated by a change in the DC level of the displayed signal or any frequency down to zero with full selection of the trigger level.

Spec. EXT AUTO 1V P-P 5Hz to 10MHz.
EXT LEVEL SELECT ± 5V P-P 3Hz to 10MHz.

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

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

Z MODULATION Typical Spec. -20V to modulate at normal intensity.
Set T.B to 1mSec/cm, feed in a 1kHz sine wave 20V P-P from low Z source. Trace should clearly change brightness level each cm.

INSTRUMENT HANDBOOK

MODEL bwd539A OSCILLOSCOPE

1. GENERAL

An oscilloscope that thoroughly commends itself for use in Research, Education or Servicing must be stable, have a high performance and be virtually self operating.

These are the characteristics you will find after a short time at the controls of this versatile Model bwd539A Dual Trace Oscilloscope.

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.

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

For addtional 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.

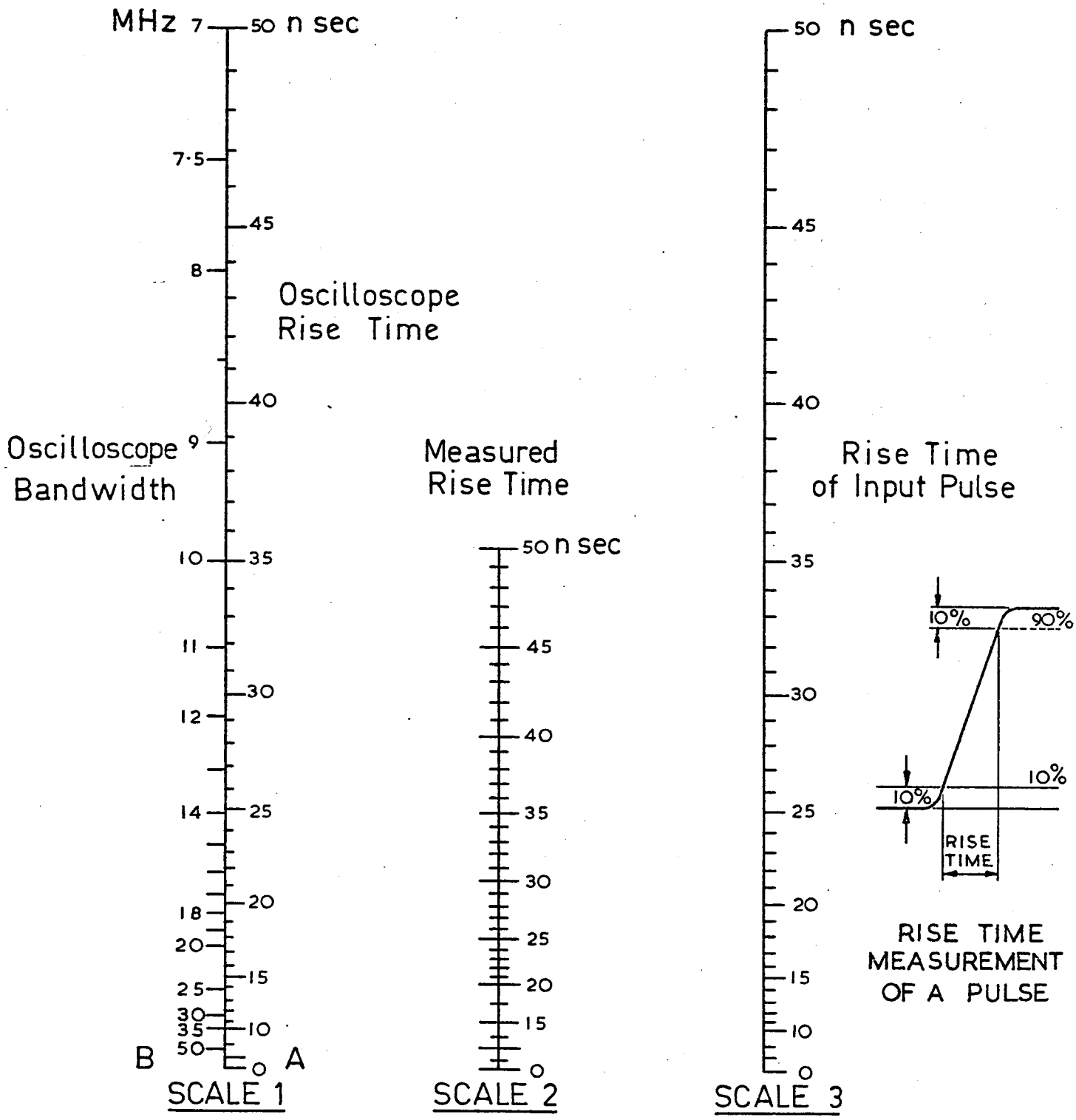
Application notes are contained in Section 4 of this handbook.

Model bwd 539 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 the supplier, together with a full range of accessories.

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 on green light filter.
	Deflection	8 cm. vertically x 10 cm. horizontally.



To use the above chart read the rise time of the displayed waveform on the CRT between its 10% and 90% points. Find the point corresponding to this value on Scale 2. Join this with a straight edge to the value corresponding to the oscilloscope bandwidth on Scale 1B, the projection on Scale 3 is the true rise time of the input pulse.

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

2. SPECIFICATION (Cont'd)

2.2 VERTICAL AMPLIFIER (Channel A & B Identical)

Sensitivity 10mV to 50V per cm. in 12 direct reading steps in a 1,2,5, 10 Sequence.

Bandwidth DC or 2Hz (AC coupled) to 10MHz-3db., referred to 4cm. deflection at 50kHz.

Rise Time 23nSec. for 4 cm. deflection.

Input Impedance 1mΩ and 40pf constant.

Calibration <5% including 10% line change. Trace drift <±1cm.

Deflection 2 Screen diameters up to 1MHz.

Input Voltage Protection ± 400V DC or 280V AC RMS.

Display Mode Single beam Channel B Only chopped (100KHz) and alternate.
Dual trace A & B chopped at 100kHz approx.
A & B Alternate.

Trace Divergance <2mm at centre screen on low time base speeds.

2.3 TIME BASE

Range 1uS to .5Sec/cm. in 18 switched ranges with 5-1 vernier extending range down to 2 Sec/cm. Calibration <5%.

Magnification X1 to X5 continuously variable, calibration <5% at X1 and at X5 up to max. sweep speed of 1uSec/cm.

2.4 TRIGGERING - Channel A or B by switch selection.

Selection	Coupling	Slope	Source	Mode
	Norm.	+	Int.	AUTO
	T.V.	-	Ext	Select Level

Sensitivity			
	Int. AUTO	1cm. defl.	5Hz to 5MHz
		2cm. defl.	2.5Hz to >10MHz (+ve slope)
	Int. Select	±3cm. max.	5Hz to>2MHz
	Ext. AUTO	1V RMS	2.5Hz to >10MHz
	Ext. Select	>1V RMS	2.5Hz to >5MHz

Max. Ext Input 100V p-p Max. or 30V RMS.

T.V. Sync. Triggers on Line in AUTO position. Triggers on Frame with Trig Level fully clockwise.

Sensitivity 2 cm. to over 8 cm. composite video waveform. Displays frame pulses, equalising pulses, colour burst, etc.

Demodulation or HF Reject. T.V. Selection also provides stable locking of modulated R.F. Waveforms and eliminates HF noise from trigger signals below 2kHz approx.

3. FUNCTION OF CONTROLS (Cont'd)

3.1 Cont'd.

± 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 on Channel A or B or an external waveform.

Vertical Position Channel A & B (Red Knobs)

Moves the traces up and down the C.R.T. Channel A position control also switches off Channel A when rotated fully anticlockwise until it operates the switch detent when single beam operation is required.

Volts/cm (Attenuator) Channel A & B

Switches adjust the sensitivity of the Vertical Amplifiers 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.

DC-AC Switches (Channel A & B)

In the DC position of this switch the amplifiers are directly coupled from input to output. In the AC position a capacitor is placed in series with the inputs to eliminate any DC component and attenuate all frequencies below 2Hz.

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.

In Alt)
Out Chop) Push Pull Switch

For time base speeds above 2mSec/cm, switch should be pushed to ALT position. Below 2mSec/cm use in chopped position to eliminate trace flicker between displays.

When Channel A is switched off for single beam operation, push switch into ALT position. For X-Y operation with external Time Base push to ALT for single beam operation and pull to CHOP for dual beam display.

Trig Select — Push-Push Switch
Select A or B Trigger

2. SPECIFICATION (Cont'd)

2.5 HORIZONTAL AMPLIFIER

Sensitivity	Approx. .70V to approx. 10V/cm. continuously variable.
Bandwidth	DC to 1 MHZ -3db.
Input Impedance	56KΩ and 10pf approx.
Max. Input	±160V or 60V rms.

2.6 Z MODULATION

Input to CRT grid. 0.01uF + 22KΩ.+30V required blank CRT at normal intensity

Calibrator	Line Frequency 1V p-p square wave 2% accuracy.
Time Base Output	0 to 25V positive going sawtooth max. Load 22KΩ min.
Power Requirements	30 Watts approx. 85 V - 135V in 3 ranges / 190 V - 265V in 3 ranges } 50 - 60 Hz
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. (10 kg.).

Optional Accessories

Probes X1	P30
X1 & X10 Kit	P22A
X1, X10 and Demod.	P29
Demodulator	P35A
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 detailed 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)

3.2 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 ±10V or AUTO operation with positive or negative and T.V. selection is available.

3.3 REAR PANEL

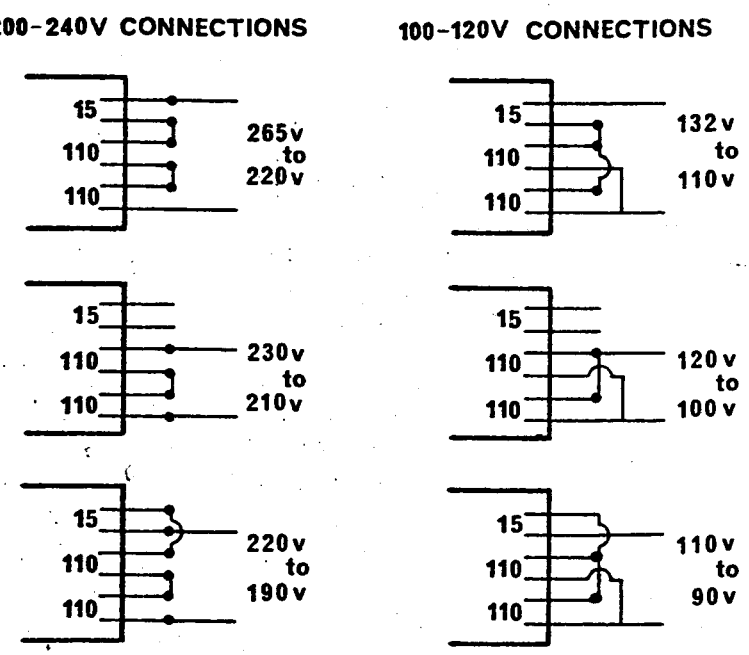
Z Modulation — A 30V p-p square wave or a sine wave of 10V RMS or greater will blank the trace at normal intensity. Negative going signals blank the trace. Positive signals brighten the trace.

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



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.

Horiz. Position — (Red Knob) moves the trace horizontally on the C.R.T.

Horiz. Mag — (Grey Knob) when the Time Base is in use, this control varies the length of the trace from 10 cm. to 50 cm., providing X5 expansion. When an external Horizontal Input is used, the Horizontal Gain varies the sensitivity from .7V to approx. 10V per cm. approx.

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.

T.B. Vernier (co-ax with Time/cm. Switch). — 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 2 Sec/cm. to 1μSec/cm. When the VERNIER control is turned and switched fully anti-clockwise it switches off the internal Time Base permitting an external signal to be fed into the X INPUT socket.

Time/cm. (Time Base) Switch — When the Time Base Vernier control is fully clockwise in the CAL position, the 18 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 + and - 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.

4. FIRST TIME OPERATION (Cont'd).

4.5 Cont'd

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 cms. by the calibrated graticule, then multiply this by the attenuator setting and the result is in Volts p-p, e.g. if the display is 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.

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

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 5cm long and the switch is on 100uSec., then the duration of the waveform is 5 x 100uSec. The frequency can be determined by dividing 1 Sec., i.e. 1,000,000uSec. by the duration of the waveform.

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

4.6 CURRENT MEASUREMENTS AC OR DC.

Where it is possible to place a low value resistor in the earthy end of a circuit the current through this resistor can be found by viewing the voltage across it and converting it by ohms Law to current. By using a 1Ω resistor the attenuator calibrations read directly in mA or A in lieu of mV or W. hen the oscilloscope is connected across it.

This will display AC or DC current and, unlike an ammeter, will show the actual current waveform. Practical applications are the charging currents in a filter capacitor of a power supply or the current through a rectifier via the centre tap of a transformer etc.

4.7 MEASUREMENTS WITH AN EXTERNAL HORIZONTAL INPUT.

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

Switch to "T.B. OFF" and calibrate the Horizontal Amplifier by feeding in the CAL waveform and adjusting the HORIZ. MAG. 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 sensitivies 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. Dual trace displays can be obtained by pulling out the CHOP mode switch knob.

4. FIRST TIME OPERATION. (Cont'd)

4.1 Set controls as follows:-

Intensity	-	OFF (anticlockwise)
Focus	-	mid-position

Amplifiers A & B

Attenuator	-	.2V/cm.
Vert. Position	-	mid-position
Input Selectors	-	AC
Alt-Chop Switch	-	Chop (pulled out).

Time Base.

Time Base Range	-	10mSec/cm.
Vernier	-	Clockwise (Cal).
Trigger Level	-	AUTO (anticlockwise)
± Select	-	+
NORM - T.V.	-	NORM
INT-EXT.	-	INT
HOR. MAG	-	Anti-Clockwise X1
HOR. POSITION	-	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 traces appear, adjust beam for suitable intensity and sharp focus. Now position traces centrally across screen. Connect a lead from the CAL socket to the 'B Channel' input socket. A 50Hz square wave will be displayed with the top and bottom faces of the waveform sloping. Switch the input selector to DC. The square wave will be displayed positive going to the base line. Recentre with position control. Adjust Time Base range switch and vernier to check characteristics with two waveforms displayed, change over ± trigger selector switch. Turn the Level Selector control clockwise. This switches off AUTO, the trace will disappear then 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 waveforms across the CRT, then turn the HORIZ. MAG control clockwise until one waveform is 10 cm. long; this illustrates the trace expansion facility. If the horizontal position 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 HORIZ. MAG control from 1 cm. down to less than .2 cm. The Horizontal position of the trace can be set by the HORIZ. POSITION control.

Instead of the CAL waveform connect an audio oscillator (e.g. Models 140A, 112B or 602) to Channel 'B' input. Set input frequency to 1kHz - increase Time Base speed and note how in the Chopped mode, the individual chopped segments of the waveform appear. Push the switch in to the Alternate position. The chopping

4.8 TELEVISION WAVEFORM DISPLAYS.

Very stable displays of frame or line signals may be obtained by switching trigger coupling to T.V. With a positive video waveform displayed select T.V. and +, 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 visible 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 approx. 5% up to 5MHz for a 4 cm. display.

5. CIRCUIT DESCRIPTION. (Drg. No. 1014 and 1019)

The circuit is divided into three (3) sections –

(a) Vertical Amplifiers. (Drg. No. 1014)
(b) Trigger Circuits and T.B. (Drg. No. 1019)
(c) CRT EHT and Power Supplies. (Drg. No. 1019)

5.1 VERTICAL AMPLIFIER. (Channel 'B'). (Drg. No. 1014)

Signals at the input socket are connected by S3 either directly or via C30 capacitor which removes the DC component to the attenuator switch S4A–D. This switch is in two sections, S4A and B attenuates the input in a stepped 1, 10, 100 and 1,000 sequence whilst S4C and D attenuate the signal in a repetative 1, 2, 5 sequence. The effect of cascading these two sections is to attenuate signals in a 1, 2, 5, 10 sequence in twelve steps. Correct step response is maintained by making the series or shunt capacitors adjustable, whilst constant input capacitance is maintained by C32, 36, 39 and 41.

To protect the input FET stage Q11 from large overloads the input is taken through a high impedance in series with the input to the FET gate. Back to back diodes D7 and D8 taken to –3.5 and + 3V rails prevent the input from exceeding these limits.

The amplifier is a balanced design from input to output with Q11 and Q12 FET input stage, Q13, Q14 amplifier stage and Q7 – Q10 cascode CRT driver stage.

Q11 and Q12 are FET's operated as a balance amplifier with a common source load, R57 and R58. Positioning voltage is applied to the drains via R59 and R60 from RV3 position control. A zener diode is also in the source load and serves to keep the gain of the stage constant when line voltage changes occur. The drain load for Q11 and Q12 consists of R61 and 62 shunted by the input impedance of the Q13 and 14.

4.2 Cont'd.

waveform disappears and two flicker free traces appear. In general, the Alternate position is used when viewing frequencies above 100Hz and the Chopped mode below this. For single beam displays with Channel A off always push the switch in to the ALT position to eliminate chopping pulses on the trace.

4.3 Z MODULATION.

Feed an oscillator into the red rear panel socket marked 'Z'. With an input of 10V RMS or 30V p-p approx., the trace at normal brightness level will be intensity modulated. Z Modulation is not available in the chopped amplifier mode.

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

4.4 MEASUREMENT OF DC (DIRECT) VOLTAGES.

Set T.B. LEVEL CONTROL to AUTO. Switch the Vertical Amplifier AC-DC Switch to DC. For an initial test take a $1\frac{1}{2}$V dry cell and set the attenuator to 0.5V. Connect the negative end to the BLACK COMMON terminal, set the trace to the centre of the graticule, touch a lead from positive end of the battery to the input socket; the trace will move up to 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 P22 high impedance probe which increases the input to 10MΩ shunted by <14pf.

4.5 MEASUREMENT OF AN AC ALTERNATING VOLTAGE.

Set the Amplifier AC - DC 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. (Models 112B, 140A or 602 Oscillators are suitable for initial experiments in this test).

4.5 Cont'd

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 cms. by the calibrated graticule, then multiply this by the attenuator setting and the result is in Volts p-p, e.g. if the display is 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.

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

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 5cm long and the switch is on 100uSec., then the duration of the waveform is 5 x 100uSec. The frequency can be determined by dividing 1 Sec., i.e. 1,000,000uSec. by the duration of the waveform.

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

4.6 CURRENT MEASUREMENTS AC OR DC.

Where it is possible to place a low value resistor in the earthy end of a circuit the current through this resistor can be found by viewing the voltage across it and converting it by ohms Law to current. By using a 1Ω resistor the attenuator calibrations read directly in mA or A in lieu of mV or W. hen the oscilloscope is connected across it.

This will display AC or DC current and, unlike an ammeter, will show the actual current waveform. Practical applications are the charging currents in a filter capacitor of a power supply or the current through a rectifier via the centre tap of a transformer etc.

4.7 MEASUREMENTS WITH AN EXTERNAL HORIZONTAL INPUT.

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

Switch to "T.B. OFF" and calibrate the Horizontal Amplifier by feeding in the CAL waveform and adjusting the HORIZ. MAG. 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 sensitivies 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. Dual trace displays can be obtained by pulling out the CHOP mode switch knob.

4. FIRST TIME OPERATION. (Cont'd)

4.1 Set controls as follows:-

Intensity	-	OFF (anticlockwise)
Focus	-	mid-position

Amplifiers A & B

Attenuator	-	.2V/cm.
Vert. Position	-	mid-position
Input Selectors	-	AC
Alt-Chop Switch	-	Chop (pulled out).

Time Base.

Time Base Range	-	10mSec/cm.
Vernier	-	Clockwise (Cal).
Trigger Level	-	AUTO (anticlockwise)
± Select	-	+
NORM - T.V.	-	NORM
INT-EXT.	-	INT
HOR. MAG	-	Anti-Clockwise X1
HOR. POSITION	-	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 traces appear, adjust beam for suitable intensity and sharp focus. Now position traces centrally across screen. Connect a lead from the CAL socket to the 'B Channel' input socket. A 50Hz square wave will be displayed with the top and bottom faces of the waveform sloping. Switch the input selector to DC. The square wave will be displayed positive going to the base line. Recentre with position control. Adjust Time Base range switch and vernier to check characteristics with two waveforms displayed, change over ± trigger selector switch. Turn the Level Selector control clockwise. This switches off AUTO, the trace will disappear then 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 waveforms across the CRT, then turn the HORIZ. MAG control clockwise until one waveform is 10 cm. long; this illustrates the trace expansion facility. If the horizontal position 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 HORIZ. MAG control from 1 cm. down to less than .2 cm. The Horizontal position of the trace can be set by the HORIZ. POSITION control.

Instead of the CAL waveform connect an audio oscillator (e.g. Models 140A, 112B or 602) to Channel 'B' input. Set input frequency to 1kHz - increase Time Base speed and note how in the Chopped mode, the individual chopped segments of the waveform appear. Push the switch in to the Alternate position. The chopping

5. CIRCUIT DESCRIPTION. (Cont'd).

5.1 VERTICAL AMPLIFIER (Channel 'B') (Cont'd).

Q13 and 14 is a series compensated stage, RV26and C48 compensate for H.F. response and RV4 preset gain control adjusts calibration. Negligible change in response occurs with adjustment of RV4.

The trigger amplifier is a high gain wideband integrated circuit driven from the common source connection of,Q11 and 12 when S14 is switched to 'B' & Q1 & 2 when switched to 'A'.
Signals to the in-phase input pass through R15, signals to the anti-phase input are filtered out by R18 and C22. This applies a balanced DC input to the I.C. Feedback to control the I.C. gain is taken from the output via R14 to the -ve input. The AC gain is approx. 470 - the ratio of R14 to R15 but the DC gain which controls the stability of the amplifier when line or temperature changes occur is only 55 - the ratio of R14 to R16 and R18 in series. H.F. Stability is maintained by C21. The H.F. response is attenuated by C18 and R13 when the chopped mode is employed to prevent switching spikes from feeding through to the trigger circuit.

Positive (+ve) supply to the I.C. is part of output amplifier stage emitter current bypassed by C25. The negative supply is via R17 from the -54V rail and filtered by C20.

Channel A is identical to Channel B, the position control having a switch incorporated (S6) which disables the beam switching circuit when only single beam operation is required.

To enable both inputs to be displayed on a single beam CRT the A & B amplifiers are alternatively connected to the common amplifier stage on a 50-50 time sharing basis.

At low time base speeds the time sharing is operated in CHOPPED Mode when the beam switch free-runs at 150kHz. At higher time base speeds when persistance of vision eliminates the visible effect of time sharing the beams switch changes over during the return period of the time base sweep providing on ALTERNATE display.

The methods of coupling the amplifiers to Q5 and 6 is via diodes. Assuming Channel A is being displayed and B is cut off. The voltage at the junction of D3 and D4 is pulled down to +11 by the bi-stable switch Q15 and 16, well below the + 15 at the base of Q5 and 6 so D3 and 4 are cut off. Q3 and Q4 are always biased in a conducting condition so the only source of collector current is via the shunt feed back resistors R28 and 29 across Q5 and 6. This puts the coupling diodes D5 and 6 into conduction and completes the amplifier chain. To cut off Channel B, D9 and D10 are pulled into conduction by the action of the bi-stable switch Q15 and 16 which raises the voltage at the junction of D9 and D10 to approximately +18. This turns off the coupling diodes D11 and 12 preventing any signal transfer to Q5 and Q6. Collector current for Q13 and 14 is now obtained from the bi-stable collector load R66 via D9 and 10. The conduction of D9 and 10 also shunts the collectors Q13 and 14 so minimising feed through of Channel B signals.

5. CIRCUIT DESCRIPTION. (Cont'd.)

5.3 TRIGGER CIRCUIT. (Cont'd).

In the AUTO position S10A is open allowing R105 and 107 to set trigger level. When S10A closes in Trigger Level condition additional positive or negative voltage from RV9 via R106 overrides the preset condition and provides a selection level of the trigger waveform.

The schmitt trigger stage Q21 and 22 produces a sharp rectangular output waveform from any shape input.

The action is as follows, with Q21 conducting, its collector will bottom and Q22 will be cut off by the voltage divider action across R110, R111 and RV10. A negative going input signal from the phase splitter will cut off Q21, its collector will rise pulling Q22 base positive, so turning Q22 on, producing a negative pulse at its collector. As the emitters are coupled together, the current through Q22 will now hold Q21 off until its base is driven positive above the common emitter potential and the switching action is reversed. The sharp negative fall across R113 is differentiated by C76 then applied to Q24 base in the time base circuit. Trigger sensitivity is set by RV10.

5.4 TIME BASE CIRCUIT. (Drg. No. 1019)

The Time Base sawtooth generator consists of Q24 and 25 bi-stable trigger, Q27 source follower Q28 Miller sawtooth generator and Q29 emitter follower with associated clamping diodes D15, 16, 17, 18 and 19. The function is as follows:

Assuming Q24 is conducting, Q25 will be cut off, its collector will rise and D18 will conduct, pulling the gate of Q27 and hence the base of Q28 positive. The collector of Q28 will fall to approximately +5V together with Q29 base. At this point diode D19 connected into the emitter load of Q29 passes below zero and starts to conduct pulling D18 to a lower conduction level producing a static stable condition.

In this direct coupled quiescent state, the trace will be ready for a trigger input pulse. A negative pulse on Q24 base will cause the collector to rise taking Q25 base positive. This causes current to flow through Q25 into the emitter resistor R127, biasing Q24 off further and a rapid cumulative action occurs in which Q24 cuts off and Q25 saturates. D18 becomes reverse biased, Q27 is left with its gate at -1.5V approximately and connected through the timing resistor R99 to R104 to a negative potential on RV11 which will pull Q27 and thereby Q28 towards cut-off.

Q27 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. Q29 emitter follower provides a low output impedance to charge the capacitors and drive the output and gating circuits. As Q27 gate and Q28 base fall, Q28 collector rises and via Q29, R135 and C83, a charge is applied to the selected timing capacitor on S11D. The result of this negative feedback is to linearise the charging rate to the timing capacitor by keeping the voltage across the charging resistor constant and thereby the charging current. A positive going sawtooth waveform is generated at the collector of Q28 and base of Q29 where it appears at low impedance at its emitter.

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5. CIRCUIT DESCRIPTION. (Cont'd)

5.1 VERTICAL AMPLIFIER. (Channel 'B' (cont'd).

When the bi-stable switches changes over the above action is reversed Channel A is cut off and Channel B conducts through D11 and 12.

Q5 and Q6 shunt feed back stage has a low input and output impedance. As a result of the low input impedance, capacitive loading of the two amplifiers and diode gates etc., has little effect on high frequency fall off. Similarly the low output impedance enables the stage to drive Q7 and Q8 cascode drivers directly. The C.R.T. deflection plate drivers are emitter coupled to Q7 and Q8 to minimise capacitive feedback and so maintain a wide bandwidth. H.F. compensation for the stage is provided by RV5 C27 and C26.

5.2 BEAM SWITCH CIRCUIT. (Drg. No. 1014)

Q15 and Q16 are a bi-stable switch, combining both collector and emitter coupling. In the CHOP Mode separate emitter resistors R68 and R75 are connected to ground via S5B and Q17 which is always conducting by the forward bias through R72. C52 between the emitters together with R67, R73 and C51 on one side and R69, C50 and R77 on the other cause the stage to oscillate at a frequency <100kHz. The resulting push-pull square waves at the collectors gate Channel A & B off and on. To eliminate the display when switching occurs a positive pulse is taken from C53 and C54 junction to Q18. The pulses turn on Q18, pull the collector down producing a sharp negative going pulse which is applied to the C.R.T. blanking electrode.

When S5B is switched to ALT Q15 and Q16 emitters are coupled together by D13 and D14 and then taken by R70 to the collector of Q17. This sets the circuit as a bi-stable switch. When a negative going pulse is received from the time base, Q17 cuts off, the emitters of Q15 and Q16 rise. If we assume Q15 was conducting it will cut off, its collector rises and via C50 pulls Q16 base more positive than Q15 base. Therefore, when the pulse to Q17 base is removed, Q17 conducts pulling Q16 into conduction before Q15, thereby changing the state of the bi-stable.

5.3 TRIGGER CIRCUIT. (Drg. No. 1019)

S7 selects the internal or external source of trigger which is then fed via C61 to Q19 phase splitter. S8A selects + or - slope before applying the signal via S9A to Q20 or direct to the Schmitt trigger. In the T.V. position Q20 which is permanently conducting, D.C. restores the signal by base current conduction. As the signal applied to Q20 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 R98 and C65 producing a composite sync signal of low level line pulses and a 15V frame pulse.

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

S9B selects the normal or T.V. sync signal which passes via C74 to Q21.

5. CIRCUIT DESCRIPTION. (Cont'd).

5.4 TIME BASE. (Cont'd).

The sawtooth continues to rise until the potential at the junction on RV13 reaches approx. -4V. D17 conducts and charges C78 and C68 and C69 as selected by S11B. It also takes the base of Q24 positive to its emitter potential and continues positively until Q24 conducts causing its collector to fall cutting off Q25 and at the same time transferring the emitter current from Q25 to Q24. D18 conducts pulling the gate of Q27 positively, Q28 collector falls, the timing capacitor is rapidly discharged until Q29 emitter falls sufficiently to cause D19 to conduct to pull D18 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 C79 and 66 - 67 as selected by S11A have discharged sufficiently through R117 and the base current of Q24 to allow a trigger pulse to cut Q24 off.

AUTO Time base operation is obtained by allowing the clamping network for Q24 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. Q26 clamp discharges C79 and 66 - 67 as selected by S11A and holds the top of R117 at -0.2V during the normal sweep period as its base is held negative to its emitter by current through R129 and Q25. During the return trace when Q25 rises it cuts off Q26 thus permitting Q79 and 66 - 67 as selected, to charge negatively through R117, 118 and 119. When the junction of R117 and 8 falls below the emitter potential of Q24 it ceases to conduct, its collector rises and the cumulative switching action previously described occurs, with the resultant sawtooth sweep generation. During this period Q26 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 Q23 collector which is driven between the clamping limits of +OV and +54V. Q23 is driven by Q24 via R116 base resistor and conducts during the forward trace, but is biased off during the return trace.

The square wave at Q24 collector is differentiated and limited by C80 and R123 before it is applied to Q17 base to switch the bi-stable beam switch during the return trace period.

5.5 HORIZONTAL AMPLIFIER. (Drg. No. 1019)

Three transistors Q30, 31 and 32 amplify the Time Base and Horizontal Input to provide the high voltage horizontal deflection voltages.

5. CIRCUIT DESCRIPTION. (Cont'd).

5.5 HORIZONTAL AMPLIFIER. (Cont'd).

Q30 is a shunt feedback stage, RV14B (HORIZ. MAG.) varies the feedback and hence the stage gain. RV15 presets the minimum gain (x1 Mag.).

The time base sawtooth, the horizontal X Input and the Horizontal position are all applied to Q30 base via mixing resistors R138, R139 and R140.

The low impedance output from Q30 feeds Q31 and Q32 long tail pair which in turn drive the C.R.T. deflection plates directly. Horizontal centreing is preset by RV16.

5.6 C.R.T. AND SUPPLIES. (Drg. No. 1019)

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 R160, RV19 Focus Control, R161, RV24 Intensity Control and RV206 Intensity range preset.

The C.R.T. grid is returned to the -1400V rail via R208 grid resistor. RV24 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 RV18 Astigmatism control and RV17 Geometry controls are located between low voltage rails.

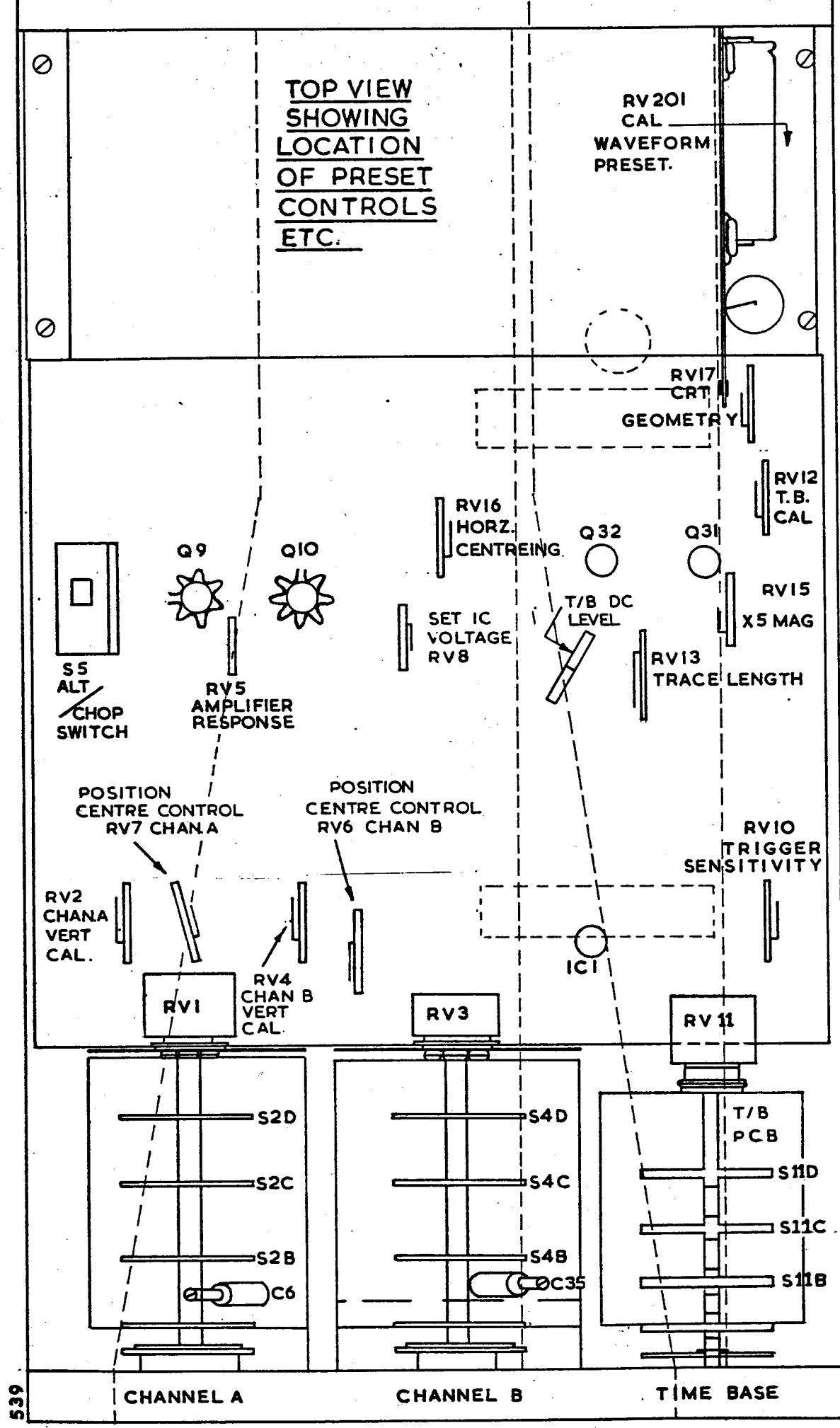
The PDA supply, like the negative E.H.T. supply, is a voltage doubler rectified by D203 and D204 with C210 and C209 coupling capacitor and filter. D204 is returned to the +53 rail to add this potential to the PDA voltage.

5.7 LOW VOLTAGE POWER SUPPLIES. (Drg. No. 1019)

Two secondary windings provide the main DC supplies. + and -64V is obtained from the 51V winding by half wave rectifying by D22 and 23 followed by three stages of filtering for the various circuits. +200V is obtained by doubling the 82V winding by D20 and D21. Separate filters are used for the vertical and horizontal amplifiers, R152 and 153 and C89 for the vertical and R155, C88 for horizontal.

5.8 CALIBRATOR. (Drg. No. 1014)

The 51V AC supply is fed to Q201 emitter. Q201 clamps the signal 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.


TOP VIEW SHOWING LOCATION OF PRESET CONTROLS ETC.
RV201 CAL WAVEFORM PRESET.
RV17 CRT GEOMETRY
RV12 T.B. CAL
RV16 HORZ. CENTREING
Q32
Q31
Q9
Q10
RV15 X5 MAG
T/B DC LEVEL
SET IC VOLTAGE RV8
RV13 TRACE LENGTH
S5 ALT / CHOP SWITCH
RV5 AMPLIFIER RESPONSE
POSITION CENTRE CONTROL RV7 CHAN A
POSITION CENTRE CONTROL RV6 CHAN B
RV10 TRIGGER SENSITIVITY
RV2 CHAN A VERT CAL.
IC1
RV1
RV4 CHAN B VERT CAL
RV3
RV11
S2D
S2C
S2B
C6
S4D
S4C
S4B
C35
T/B PCB
S11D
S11C
S11B
CHANNEL A
CHANNEL B
TIME BASE
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6. 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 screws holding the handle and withdraw the cover. The bottom cover may be removed by unscrewing the four feet.

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

6.1 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.

6.2 General check of controls -

(a)	Intensity	Linear control over intensity range.
(b)	Focus	Approx. centre with adjustment either side.
(c)	Horiz. Mag.	Trace should expand equally either side of centre.
(d)	Vert. Positions	Traces should move completely off screen above and below centre.
(e)	Trigger Level	With Atten. at 0.2V 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)	X Input & Mag.	Feed CAL signal into Horiz. Input socket with T.B. VERNIER turned to T.B. OFF HORIZ. MAG should vary display from 2mm to over 1cm.

6.3 C.R.T. TRACE ALIGNMENT.

Feed a 1,000Hz square wave signal into the Channel B and adjust wave form to fill the screen. T.B. to 1mSec. VERNIER CAL.

RV18 Rear Panel astigmatism control is adjusted in conjunction with the FOCUS control to obtain the best resolution over the entire screen area.

RV17 at rear of main board adjusts the pattern geometry. It should be set to display vertical and horizontal lines with minimum of pin cushion or barrel distortion. RV18 may need slight re-adjustment after RV17 has been set as some interaction occurs.

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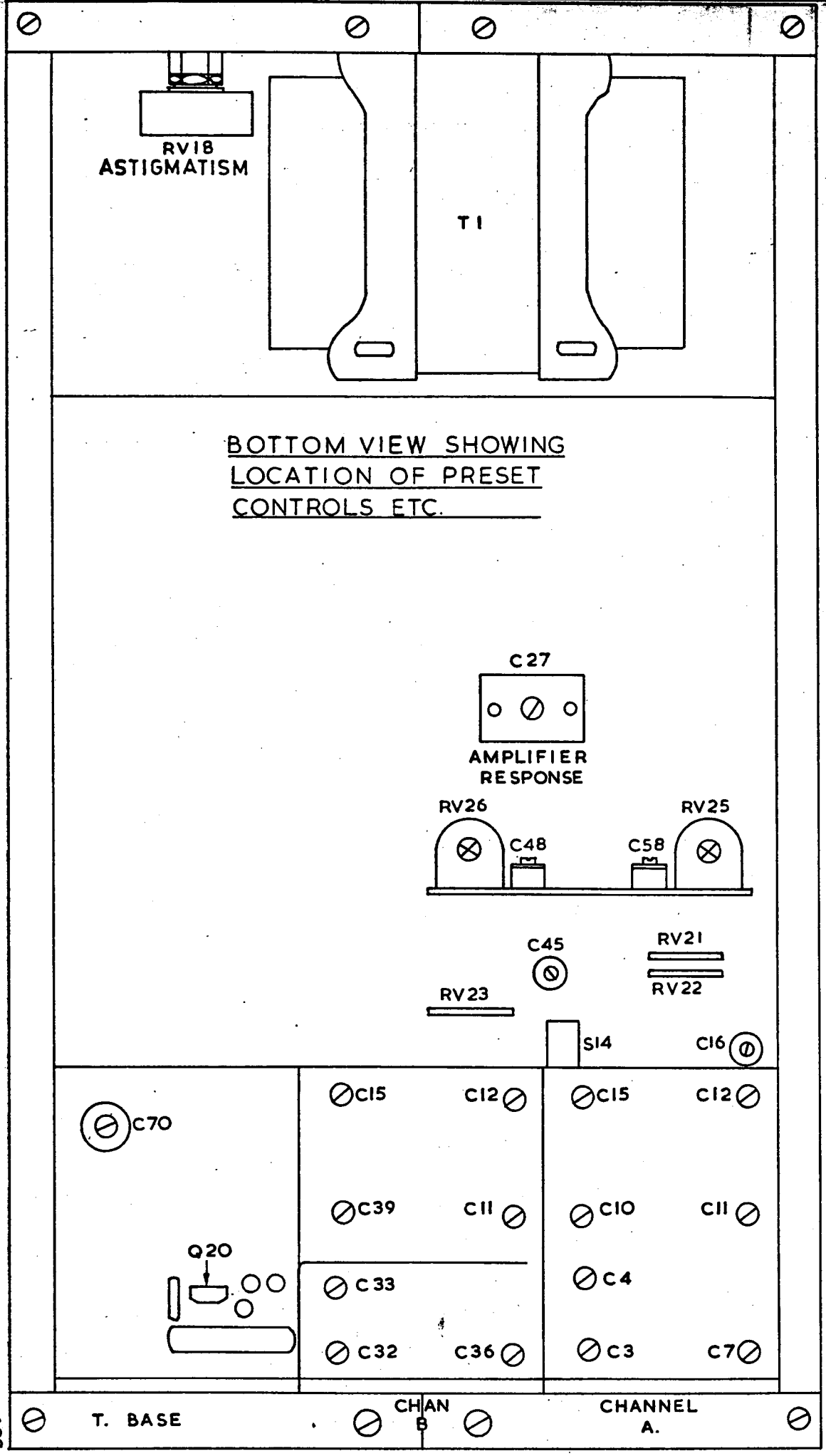
RV18
ASTIGMATISM
T1
BOTTOM VIEW SHOWING
LOCATION OF PRESET
CONTROLS ETC.
C27
AMPLIFIER
RESPONSE
RV26
C48
C58
RV25
C45
RV21
RV22
RV23
S14
C16
C70
C15
C12
C15
C12
C39
C11
C10
C11
Q20
C33
C4
C32
C36
C3
C7
T. BASE
CHAN
B
CHANNEL
A.

7. 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 posses a specification not less than, or physical size not greater than, the original components.

As the policy of the supplier 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.

8. WARRANTY

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

Please refer to Guarantee Registration Card No. 16327 which accompanied instrument for full details of conditions of warranty.

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6. ALIGNMENT PROCEDURE (Cont'd.)

6.3 C.R.T. TRACE ALIGNMENT (Cont'd.)

EQUIPMENT REQUIRED FOR COMPLETE CALIBRATION -

20,000Ω/V meter or DVM. Pulse generator <10nS t.r.
Voltage calibrator 0.5% accuracy 20mV to 100V p-p.
Sine wave generator 1Hz to 1MHz.
Constant amplitude generator 50KHz to 50MHz.

6.4 VERTICAL ALIGNMENT

(a) Set all presets to mid position and adjust RV8 for 5.8V between pins 3 & 4 for IC1.

(b) Set both attenuators to 0.01V, feed a 50mV p-p square wave to both inputs and adjust RV2 and RV4 for a 5 cm. display on Channels A & B respectively. Check other positions.

(c) Set time base to 0.1 sec/cm, and with no input signal adjust RV21 for ≤±1cm trace shift for a ±10% mains voltage charge and <2mm trace deviation at centre screen. Repeat for Channel B (RV23).

(d) Set vertical shift to mid rotation and adjust RV7 for trace centering. Check that shift control moves trace equally up and down - if not reset RV7. Repeat for Channel B (RV6).

(e) Adjust RV22 for zero volts between A and B on S14.

(f) Adjust RV26 & C48 for best square wave response on Channel B. Input 500KHz and 3 cm. display.

(g) Adjust RV25 & C58 on Channel A for similar square wave response to Channel B.

6.5 ATTENUATOR ALIGNMENT

Initially set attenuators to .02V and set C42 and C12 to mid positions and adjust C45 (16) for best square wave response. Figures in brackets are Channel A.

Attenuator Setting	Input Voltage	Adjust for Square Wave	Adjust for Input Capacitance
0.5V	200mV	C40 (15)	-
0.1V	500mV	C33 (4)	C32 (3)
0.2	1V	C41 (11)	-
0.5	2V	C39 (10)	-
1	5V	C35 (6)	C36 (7)

Attenuators will be automatically aligned at all other positions.

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

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6. ALIGNMENT PROCEDURE. (Cont'd)

6.6 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 for 5 cm. deflection.

6.7 TIME BASE ALIGNMENT.

(a) Set T.B. Range to 1mSec. Vernier to CAL. Check trace length is 10.5 cm. approx. Set with RV13 if necessary.

(b) Feed into amplifier 1mSec. pulses. Adjust No. 1. pulse to correspond to 1st graticule line. Adjust RV11 (rear main board) for 1 pulse/cm. Expand trace to X5. Adjust RV15 (for 1 pulse/ 5 cm.) Return to X1 and reset RV11 if necessary for 1 pulse/cm.

(c) Now check lower time base speeds down to .5 seconds/cm. and at higher speeds up to 50uSec/cm. If it is noticed that most ranges appear slightly slower or faster than the nominal, RV11 may be reset to obtain the best overall calibration accuracy.

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

6.8 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 to below 1 cm. When trace fails to lock adjust RV10 for lock and continue reducing input - until RV10 fails to lock trace.

(b) Change from + to - slope. Reset RV10 if necessary to optimise setting.

(c) Increase input to 1cm., increase frequency up to 10MHz maintaining 1cm. signal level trace should remain locked on +ve at highest time base speeds, and up to approx. 8 MHz on -ve selection.

(d) At low frequencies trace will lock at 5Hz with 1 cm. deflection. Increase signal to fill screen at 1kHz, check operation of TRIG LEVEL control over full range both + and - slope.

(e) Adjustment of RV22. Feed two different frequencies into channels A and B, adjust RV22 so that the time base locks instantly when changing trigger source from channel A to channel B.

6.9 HORIZONTAL AMPLIFIER

(a) Turn T.B. Vernier to T.B. OFF, increase MAG to x5, centre spot. Feed in 50kHz signal. Adjust input for 6 cm. horizontal display. Increase frequency to 500kHz. Amplitude should not drop below 4.2 cm.

(b) Instrument is now calibrated.

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION					Mfr. or Supply	PART NO.
R48	9.1KΩ	1%		MO	H.S	Electro	TR5
R49	1KΩ	1%		MO	H.S	Electro	TR5
R50	33Ω	5%	½W	CC		P1	
R51	800KΩ	1%		MO		Electro	TR5
R52	500KΩ	1%		MO		Electro	TR5
R53	1MΩ	1%		MO		Electro	TR5
R54	250KΩ	1%		MO		Electro	TR5
R55	270KΩ	5%	½W	CC		P1	
R56	1MΩ	1%		MO		Electro	TR5
R57	1KΩ	5%	½W	CC		P1	
R58	2.2K	5%	½W	CC		P1	
R59	100KΩ	5%	½W	CC		P1	
R60	100KΩ	5%	½W	CC		P1	
R61	560Ω	5%	½W	CC		P1	
R62	560Ω	5%	½W	CC		P1	
R63	390Ω	5%	½W	CC		P1	
R64	12KΩ	5%	½W	CC		P1	
R65	12KΩ	5%	½W	CC		P1	
R66	2.2K	5%	½W	CC		P1	
R67	15KΩ	5%	½W	CC		P1	
R68	2.7KΩ	5%	½W	CC		P1	
R69	18KΩ	5%	½W	CC		P1	
R70	1.2KΩ	5%	½W	CC		P1	
R71	1.2K	5%	½W	CC		P1	
R72	220KΩ	5%	½W	CC		P1	
R73	18KΩ	5%	½W	CC		P1	
R74	2.2KΩ	5%	½W	CC		P1	
R75	2.7KΩ	5%	½W	CC		P1	
R76	470Ω	5%	½W	CC		P1	
R77	15KΩ	5%	½W	CC		P1	
R78	3.3KΩ	5%	½W	CC		P1	
R79	33KΩ	5%	½W	CC		P1	
R80	33Ω	5%	½W	CC		P1	
R90	220KΩ	5%	½W	CC		P1	
R91	330KΩ	5%	½W	CC		P1	
R92	180KΩ	5%	½W	CC		P1	
R93	10KΩ	5%	½W	CC		P1	
R94	4.7KΩ	5%	½W	CC		P1	
R95	10KΩ	5%	½W	CC		P1	
R96	8.2MΩ	5%	½W	CC		P1	
R97	100KΩ	5%	½W	CC		P1	
R98	6.8KΩ	5%	½W	CC		P1	

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION					Mfr. or Supply	PART NO.	
R1	900KΩ	1%		MO	H.S	Electro	TR5	
R2	111KΩ	1%		MO	H.S	Electro	TR5	
R3	990KΩ	1%		MO	H.S	Electro	TR5	
R4	9.1KΩ	1%		MO	H.S	Electro	TR5	
R5	1KΩ	1%		MO	H.S	Electro	TR5	
R6	33Ω	5%	½W	CC		P1		
R7	800KΩ	1%		MO	H.S	Electro	TR5	
R8	500KΩ	1%		MO	H.S	Electro	TR5	
R9	1MΩ	1%		MO	H.S	Electro	TR5	
R10	250KΩ	1%		MO	H.S	Electro	TR5	
R11	270KΩ	5%	½W	CC		P1		
R12	1MΩ	1%		MO	H.S	Electro	TR5	
R13	33Ω	10%	½W	C		MOR		
R14	470K	5%	½W	CC		P1		
R15	220Ω	5%	½W	CC		P1		
R16	1KΩ	5%	½W	CC		P1		
R17	8.2K	5%	½W	CC		P1		
R18	10KΩ	5%	½W	CC		P1		
R19	470Ω	5%	½W	CC		P1		
R20	100KΩ	5%	½W	CC		P1		
R21	100KΩ	5%	½W	CC		P1		
R22	560Ω	5%	½W	CC		P1		
R23	560Ω	5%	½W	CC		P1		
R24	390Ω	5%	½W	CC		P1		
R25	12KΩ	5%	½W	CC		P1		
R26	12KΩ	5%	½W	CC		P1		
R27	2.7KΩ	5%	½W	CC		P1		
R28	5.6KΩ	5%	½W	CC		P1		
R29	5.6KΩ	5%	½W	CC		P1		
R30	1.5KΩ	5%	½W	CC		P1		
R31	1.5KΩ	5%	½W	CC		P1		
R32	220Ω	5%	½W	CC		P1		
R33	680Ω	5%	½W	CC		P1		
R34	100Ω	5%	½W	CC		P1		
R35	100Ω	5%	½W	CC		P1		
R36	330Ω	5%	½W	CC		P1		
R37	680Ω	5%	½W	CC		P1		
R38	1KΩ	5%	½W	CC		P1		
R39	680Ω	5%	½W	CC		P1		
R40	680Ω	5%	½W	CC		P1		
R41	330Ω	5%	½W	CC		P1		
R42	5.6KΩ	5%	1W	CC		P1		
R43	5.6KΩ	5%	1W	CC		P1		
R44	900KΩ	1%		MO	H.S	Electro	TR5	
R45	111KΩ	1%		MO	H.S	Electro	TR5	
R46	990KΩ	1%		MO	H.S	Electro	TR5	

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION				Mfr or Supply	PART NO.	
R99	100KΩ	1%		MO	Electro	TR5	
R100	100KΩ	1%		MO	Electro	TR5	
R101	500KΩ	1%		MO	Electro	TR5	
R102	1MΩ	1%		MO	Electro	TR5	
R103	1MΩ	1%		MO	Electro	TR5	
R104	5MΩ	1%		MO	Electro	TR5	
R105	22KΩ	5%	½W	CC	P1		
R106	100KΩ	5%	½W	CC	P1		
R107	180KΩ	5%	½W	CC	P1		
R108	33KΩ	5%	½W	CC	P1		
R109	1KΩ	5%	½W	CC	P1		
R110	10KΩ	5%	½W	CC	P1		
R111	27KΩ	5%	½W	CC	P1		
R112	6.8KΩ	5%	½W	CC	P1		
R113	2.2K	5%	½W	CC	P1		
R114	47KΩ	5%	½W	CC	P1		
R115	47KΩ	5%	½W	CC	P1		
R116	3.3KΩ	5%	½W	CC	P1		
R117	39KΩ	5%	½W	CC	P1		
R118	2.2KΩ	5%	½W	CC	P1		
R119	180K	5%	½W	CC	P1		
R120	6.8KΩ	5%	½W	CC	P1		
R121	47KΩ	5%	½W	CC	P1		
R122	33KΩ	5%	½W	CC	P1		
R123	3.3K	5%	½W	CC	P1		
R124	150Ω	5%	½W	CC	P1		
R125	15KΩ	5%	½W	CC	P1		
R126	120KΩ	5%	½W	CC	P1		
R127	22KΩ	5%	½W	CC	P1		
R128	39KΩ	5%	½W	CC	P1		
R129	2.2KΩ	5%	½W	CC	P1		
R130	2.2KΩ	5%	½W	CC	P1		
R131	22KΩ	5%	½W	CC	P1		
R132	17K	5%	½W	CC	P1		
R133	150Ω	5%	½W	CC	P1		
R134	100KΩ	5%	½W	CC	P1		
R135	2.2KΩ	5%	½W	CC	P1		
R136	8.2K	5%	½W	CC	P1		
R137	15KΩ	5%	½W	CC	P1		
R138	18K	5%	½W	CC	P1		
R139	56KΩ	5%	½W	CC	P1		
R140	68KΩ	5%	½W	CC	P1		
R141	68KΩ	5%	½W	CC	P1		
R142	15KΩ	5%	½W	CC	P1		
R143	1.2KΩ	5%	½W	CC	P1		
R144	47KΩ	5%	½W	CC	P1		

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 Sidney
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 - MODEL bwd 539A

ITEM NO.	DESCRIPTION				Mfr or Supply	PART NO.	
R145	33KΩ	5%	1W	CC	P1		
R145A	270KΩ	5%	½W	CC	P1		
R146	390Ω	5%	½W	CC	P1		
R147	33KΩ	5%	1W	CC	P1		
R148	39KΩ	5%	½W	CC	P1		
R149	8.2KΩ	5%	½W	CC	P1		
R150	47KΩ	5%	½W	CC	P1		
R151	4.7KΩ	5%	½W	CC	P1		
R152	1KΩ	5%	1W	CC	P1		
R153	1KΩ	5%	1W	CC	P1		
R154							
R155	4.7KΩ	5%	1W	CC	P1		
R156	470Ω	5%	½W	CC	P1		
R157	330Ω	5%	½W	CC	P1		
R158	330Ω	5%	½W	CC	P1		
R159	330Ω	5%	½W	CC	P1		
R160	2.2MΩ	5%	½W	CC	P1		
R161	820K	5%	½W	CC	P1		
R162	100KΩ	5 or 10%	½W	C	MOR		
R201	1MΩ	5%	½W	CC	P1		
R202	1MΩ	5%	½W	CC	P1		
R203	1MΩ	5%	½W	CC	P1		
R204	1MΩ	5%	½W	CC	P1		
R105	68KΩ	5%	½W	CC	P1		
R207	10KΩ	5%	½W	CC	P1		
R208	100KΩ	5%	½W	CC	P1		
R209	1.8MΩ	5%	½W	CC	P1		
R210	27KΩ	5%	½W	CC	P1		
R211	27KΩ	5%	½W	CC	P1		
	POTENTIOMETERS						
RV1	220KΩ LIN. POT WITH DPST			C	PH	2322-357727-12	
RV2	1KΩ TRIM POT			C	PH	2322-411-02204	
RV3	250K LIN. POT			C	SOR	VCU	
RV4	1KΩ TRIM POT			C	PH	2322-411-02204	
RV5	100Ω TRIM POT			C	PH	2322-411-02201	

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION				Mfr or Supply	PART NO.	
C21	47pF	500V	5%	NPO	H.S	CDS	
C22	33uF	40V		ELECTR.	PH	2222-015-17339	
C23							
C24	0.1uF	100V	10%	GREEN-C	ELNA	TYPE N	
C25	150uF	16V		ELECTR.	PH	2222-016-15151	
C26	270pF	630V	5%	PYS	H.S	TCS605	
C27	20-220pF	TRIM			DUC	CWO	
C28	0.001uF	500V	5%	NPO	H.S	CDS	
C29	0.001uF	500V	5%	NPO	H.S	CDS	
C30	0.1uF	400V	10%	PYE	PH	2202-315-51104	
C31	5.6pF	500V	10%	NPO	H.S	CDS	
C32	1-12pF	TRIM			PH	C004CA/12E	
C32A	15pF	500V	10%		H.S	CDS	
C33	1-12pF	TRIM			PH	C004CA/12E	
C34	15pF	500V	5%	NPO	H.S	CDS	
C35	0.8-3pF	TRIM			PH	C004AA/3E	
C36	1-12pF	TRIM			PH	C004CA/12E	
C36A	15pF	500V	10%		H.S	CDS	
C37	470pF	500V	5%	SM	DUC	MSA	
C38	0.0047uF	400V	10%	PYE	PH	2202-315-51472	
C39	1-12pF	TRIM			PH	C004CA/12E	
C39A	3.3pF	500V	10%		H.S	CDS	
C40	1-12pF	TRIM			PH	C004CA/12E	
C41	1-12pF	TRIM			PH	C004CA/12E	
C42	1-12pF	TRIM			PH	C004CA/12E	
C43	33PF	500V	5%	NPO	HS	CDS	
C44	8.2pF	500V	5%	NPO	HS	CDS	
C45	4.5/20pF	TRIM			RHC	7S/02	
C46	0.0022uF	500V	5%	NPO	HS	CDS	
C47	220uF	16V		ELECTR.	PH	2222-016-15221	
C48	10-40pF	TRIM			STET	10S-06/10-40	
C49	0.1uF	100V	10%	GREENCAP	ELNA	TYPE N	
C50	100 pF	500V	5%	NPO	HS	CDS	
C51	100pF	500V	5%	NPO	HS	CDS	
C52	0.0033uF	400V	10%	PYE	PH		
C53	100pF	500V	5%	NPO	HS	CDS	
C54	100pF	500V	5%	NPO	HS	CDS	
C55	560pF	630V	5%	PYS	HS	TCS609	
C56	100uF	40V		ELECTR.	PH	2222-016-17101	
C57							
C58	10-40 pF	TRIMMER			STET	10S-06/10-40	
C59							
C60	10pF	500V	5%	NPO	HS	CDS	
C61	0.22uF	100V	10%	GREEN C	ELNA	TYPE N	
C62	0.001uF	500V	10%		HS	CDS	
C63	33pF	500V	5%	NPO	HS	CDS	
C64	0.1uF	100V	10%	GREEN C	SON		

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION				Mfr or Supply	PART NO.	
RV6	220Ω TRIM POT.			C	PH	2322-411-02202	
RV7	220Ω TRIM POT.			C	PH	2322-411-02202	
RV8	4.7K TRIM POT.			C	PH	2322-411-02206	
RV9	220K LIN.POT WITH DPST			SW	PH	2322-357727-12	
RV10	22KΩ TRIM POT.			C	PH	2322-411-02208	
RV11	220K LIN.POT.WITH SPST			SW	PH	2322-357727-12	
RV12	100KΩ TRIM POT.			C	PH	2322-411-02211	
RV13	4.7KΩ TRIM POT.			C	PH	2322-411-02206	
RV14A	100KΩ LIN.POTS.			C	1RH		
RV14B	10KΩ			C	1RH		
RV15	22KΩ TRIM POT.			C	PH	2322-411-02208	
RV16	1KΩ TRIM POT.			C	PH	2322-411-02204	
RV17	470KΩ TRIM POT.			C	PH	2322-411-02213	
RV18	100KΩ TRIM POT.			C	PH	2322-411-02211	
RV19	1MΩ LIN.POT.			C	SOR	VCU	
RV20	IKΩ TRIM POT.			C	PH	2322-411-02204	
RV21	100Ω TRIM POT.			C	PH	2322-411-02201	
RV22				C	PH	2322-411-02204	
RV23	100Ω TRIM POT.			C	PH	2322-411-02201	
RV24	220KΩ LIN.POT.WITH DPST			SW	PH	2322-357727-12	
RV25	1KΩ TRIM POT.			C	PH	2322-411-02205	
RV201	4.7KΩ TRIM POT.			C	PH	2322-411-02206	
RV206	100K TRIM POT.			C	PH	2322-411-02211	
	CAPACITOR						
C1	0.1uF	400V	10%	PYE	PH	2202-315-51104	
C2	5.6pF	500V	10%	NPO	H.S	CDS	
C3	1-12pF	TRIM			PH	C004CA-12E	
C3A	15pF	500V	10%				
C4	1-12pF	TRIM			PH	C004CA-12E	
C5	15pF	500V	10%	NPO	H.S	CDS	
C6	0.8-3pF	TRIM			PH	C004AA/3E	
C7	1-12pF	TRIM			PH	C004CA-12E	
C7A	15pF	500V	10%				
C8	470pF	500V	5%	SM	DUC	MSA	
C9	0.0047uF	400V	10%	PYE	PH		
C10	1-12pF	TRIM					
C10A	3.3pF	500V	10%				
C11	1-12pF	TRIM			PH	C004CA/12	
C12	1-12pF	TRIM			PH	C004CA/12E	
C13	33pF	500V	10%	N750	H.S	CDS	
C14	8.2pF	500V	10%				
C15	1-12pF	TRIM			PH	C004CA/12E	
C16	4.5/20pF	TRIM			STET	7S-02	
C17	0.0022uF	500V	10%	NPO		CDS	
C18	0.01uF	100V	10%	GREEN CAP	ELNA	TYPE N	
C19	0.1uF	100V	10%	GREEN CAP	ELNA	TYPE N	
C20	150uF	16V		ELECT.	PH	2222-016-15151	

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION				Mfr or Supply	PART NO.	
C65	0.01uF	100V	10%	GREEN C	SON		
C66	4.7uF	63V		ELECTR.	PH	2222-015-18478	
C67	10uF	25V		ELECTR.	PH	2222-015-15109	
C68	0.022uF	160V		PYE	PH		
C69	2.2uF	63V		PH	PH	2222-015-18228	

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION				Mfr or Supply	PART NO.	
C70	10-40PF	TRIM			STETNER	10S-06,10-40	
C71	82PF	500V	5%		H.S	CDS	
C72	0.01uF	100V		SELECT 2%	ELNA	TYPE N	
C73A)	1 uF	200V		GREEN CAP	ELNA	TYPE N	
C73B)				SELECT FOR 2%			
C74	1uF	200V	10%	GREEN	SON	TYPE N	
C75							
C76	15pF	500V	5%	NPO	H.S	CDS	
C77	0.1uF	100V	10%	GREEN CAP	SON	TYPE N	
C78	220pF	630V	5%	PYS	H.S	TCS604	
C79	0.01	100V	10%	GREEN CAP	ELNA	TYPE N	
C80	220pF	500V	5%	N750	H.S	CDS	
C81	22pF	500V	5%	N750	H.S	CDS	
C82	47pF	500V	5%	N750	H.S	CDS	
C82A	100pF	500V	5%	N750	H.S	CDS	
C83	0.01uF	100V	10%	GREEN C	ELNA	TYPE N	
C84	4.5-20pF	TRIM			STET	75-02	
C85	220pF	630V	5%	PYS	H.S	TCS 604	
C86	50uF	150V		ELECTR.	PH	2222-040-11509	
C87	50uF	150V		ELECTR.	PH	2222-040-11509	
C88	40uF	200V		ELECTR.	PH	2222-040-12409	
C89	40uF	200V		ELECTR.	PH	2222-040-12409	
C90	100uF	63V		ELECTR.	PH	2222-017-18101	
C91	220uF	63V		ELECTR.	PH	2222-017-18221	
C92	220uF	63V		ELECTR.	PH	2222-017-18221	
C93	100uF	63V		ELECTR.	PH	2222-017-18101	
C94	100uF	63V		ELECTR.	PH	2222-017-18101	
C95	100uF	63V		ELECTR.	PH	2222-017-18101	
C96	22pF	500V	10%	N750	H.S	CDS	
C96A	10pF	500V	10%	N750	H.S	CDS	
C97							
C83A	33pF	500V	5%	CER	H.S	CDS	
C201	8uF	450V		ELECTR.	DUC		
C202	8uF	450V		ELECTR.	DUC		
C203	8uF	450V		ELECTR.	DUC		
C204	8uF	450V		ELECTR.	DUC		
C205	0.1uF	1600V	20%	MHT	DUC	DUOSEAL	
C206							
C207	0.01uF	3000V		C DISK	DUC	CDH	
C208	0.1uF	160V	10%	PYE	PH	2202-315-31104	
C209	0.1uF	1600V	20%	MHT	DUC	DUOSEAL	
C210	0.01uF	3000V		C DISK	DUC	CDH	
C211	220pF	2000V	10%	C DISK	DUC	CDH	
C212	0.001	500V	10%	H1K	H.S	CDS	

PARTS LIST - MODEL bwd 539A

ITEM NO	DESCRIPTION	Mfr or Supply	PART NO.
	DIODES		
D1-D2) D7-D8)	AN210	F	
D9-D19) D3-D6)	75V PIV 30MA S1	F	AN206
D20-D23	400V PIV 500MA S1	STC	EM404
D201	SELENIUM RECT.	STC	K8/25
D202	SELENIUM RECT.	STC	K8/25
D203	SELENIUM RECT.	STC	K8/25
D204	SELENIUM RECT.	STC	K8/25
D205	75V PIV 30MA	F	AN206
D14A	33V ZENER	F	AN973B
	SWITCHES		
S1	2 POLE 2 POS.	SATO	SATO3570
S2A-D	4 POLE 12 POS.	BWD	SR73
S3	2 POLE 2 POS.	SATO	SATO3570
S4A-D	4 POLE 12 POS.	BWD	SR73
S5A&B	2 POLE 2 POS.	SATO	SATO3570
S6	2 POLE 2 POS. (REAR OF RV7)		
S7	2 POLE 2 POS.	McM	1299-02-01
S8A&B	2 POLE 2 POS.	McM	1299-02-01
S9A&B	2 POLE 2 POS.		
S10A&B	2 POLE 2 POS.(REAR OF RV9)		
S11A-D	4 POLE 18 POS.	BWD	SR72
S12A&B	2 POLE 2 POS.(REAR OF RV11)		
S13A&B	2 POLE 2 POS.(REAR OF RV19)		
S14	2 POLE 2 POS.ISOSTAT SWITCH	McM	934/1-SR80
	SUNDRY		
V1	CRT5"	PH	D13-27GH
B1	NEON LAMP	SATO	
F1	500MA CARTRIDGE FUSE Q/B	Y	
T1	POWER TRANSFORMER.	BWD	TP5698
	CRT MAGN.SHIELD.	BWD	DRG632
	ALL OTHER ITEMS ORDER BY DESCRIPTION		

PARTS LIST - MODEL bwd 539A

ITEM NO.	DESCRIPTION					Mfr or Supply	PART NO.
	SEMI-CONDUCTOR						
Q1,2	25V DS	N CHANNEL FET			S1	NS	2N3819 or MPF106
Q11,12	MATCHED QUAD						
Q3	25 Vce	Hfe	100	NPN	S1	PH	BF194
Q4	25 Vce	Hfe	100	NPN	S1		BF194
Q5	25 Vce	Hfe	100	NPN	S1	PH	BF194
Q6	25 Vce	Hfe	100	NPN	S1	PH	BF194
Q7	25 Vce	Hfe	100	NPN	S1	PH	BF194
Q8	25 Vce	Hfe	100	NPN	S1	PH	BF194
Q9	150Vce	Hfe	40	NPN	S1	PH	BF336
Q10	150Vce	Hfe	40	NPN	S1	PH	BF336
Q13	25Vce	Hfe	100	NPN	S1	PH	BF194
Q14	25Vce	Hfe	100	NPN	S1	PH	BF194
Q15	25Vce	Hfe	100	NPN	S1	PH	BF194
Q16	25Vce	Hfe	100	NPN	S1	PH	BF194
Q17	45Vce	Hfe	100	NPN	S1	PH	BF147
Q18	45Vce	Hfe	100	NPN	S1	PH	BC147
Q19	45Vce	Hfe	100	NPN	S1	PH	BC147
Q20	45Vce	Hfe	100	NPN	S1	PH	BC147
Q21	45Vce	Hfe	100	NPN	S1	PH	BC147
Q22	45Vce	Hfe	100	NPN	S1	PH	BC147
Q23	45Vce	Hfe	100	NPN	S1	PH	BC147
Q24	45Vce	Hfe	100	NPN	S1	PH	BC147
Q25	45Vce	Hfe	100	NPN	S1	PH	BC147
Q26	-45Vce	Hfe	75	PNP	S1	PH	BC157
Q27	25VDS	N CHANNEL FET			S1	T1	2N3819 or MPF106
Q28	45Vce	Hfe	100	NPN	S1	PH	BC147
Q29	45Vce	Hfe	100	NPN	S1	PH	BC147
Q30	45Vce	Hfe	100	NPN	S1	PH	BC147
Q31	250 Vce	Hfe	40	NPN	S1	PH	BF337
Q32	250 Vce	Hfe	40	NPN	S1	PH	BF337
Q33	-45 Vce	Hfe	50	PNP	S1	PH	BC157
Q201	-25Vce	Hfe	100	PNP	S1	F	AY1114
IC1	UA702C	AMPLIFIER				F	UA702C

R 84
C 58
Q 18 TO 201
D 14

MODIFICATIONS

ISSUE 2 - 6/72
R19A, 57A ADDED TO FET. GATES.

ISSUE 3 28-6-72
Q15/16 BF194 TO BC209B
C23 39pf TO 68pf
R24/63 470Ω TO 390Ω
C48 68pf TO 95pf

ISSUE 4 - 17-7-72
C23 68pf TO 33pf
C48 95pf TO 68pf

ISSUE 5 6-12-72
Q15/16 BC209B TO BF194
C48 68pf TO 10-40pf VAR
C23 REMOVED
C25 & C26 ADDED IN SERIES WITH C48 AND C58.

ISSUE 6 12-72
C20 125/16 to 150/16
C22 32/64 to 33/40
C25 125/16 to 150/16
C47 250/16 to 220/10

SWITCHES

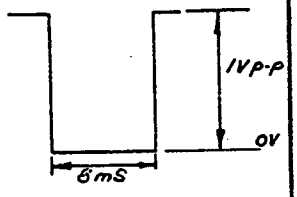
S1	AC-DC INPUT	CHANNEL 'A'
S2	A-D ATTENUATOR	CHANNEL 'A'
S3	AC-DC INPUT	CHANNEL 'B'
S4	A-D ATTENUATOR	CHANNEL 'B'
S5	A&B ALTERNATE - CHOPPED.	
S6	CHANNEL A ON-OFF (REAR RV7)	
S14	TRIGGER SELECT.	

CONTROLS

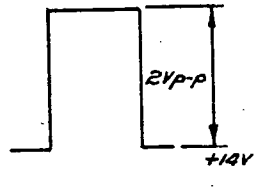
RV1	VERTICAL POSITION	CHANNEL 'A'
RV2	CALIBRATE	" 'A'
RV3	VERTICAL POSITION	" 'B'
RV4	CALIBRATE	" 'B'
RV5	AMPLIFIER RESPONSE	
RV6	DC BALANCE 'B'	
RV7	DC BALANCE 'A'	
RV8	SET I.C. VOLTAGE.	
RV201	SET CALIBRATE SIGNAL.	
RV21	MAINS BALANCE.	
RV22	TRIGGER BALANCE CONTROL.	
RV23	MAINS BALANCE.	
RV25	AMPLIFIER RESPONSE	CHANNEL 'A'
RV26	AMPLIFIER RESPONSE	CHANNEL 'B'

ATTEN .2V/cm ON CHANNEL A & B.
T/B 2 m/S cm, VERNIER CAL, TRIG 'B', NORM, + INT, ALT.

A



B



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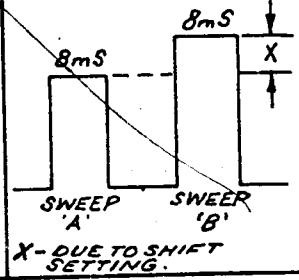
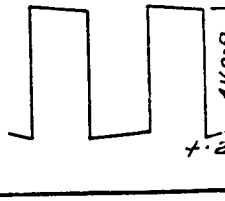


X - DUE TO SHIFT SETTING.

D



R 84

C 58

Q 18 TO 201

D 14

MODIFICATIONS

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R19A, 57A ADDED TO F.E.T. GATES.

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Q15/16 BF194 TO BC209B
C23 39pf TO 68pf
R24/63 470Ω TO 390Ω
C48 68pf TO 95pf

ISSUE 4 - 17-7-72
C23 68pf TO 33pf
C48 95pf TO 68pf

ISSUE 5 6-12-72
Q15/16 BC209B TO BF194
C48 68pf TO 10-40pf VAR
C23 REMOVED
C25 & C26 ADDED IN SERIES WITH C48 AND C58.

ISSUE 6 12-72
C20 125/16 to 150/16
C22 32/64 to 33/40
C25 125/16 to 150/16
C47 250/16 to 220/16

SWITCHES

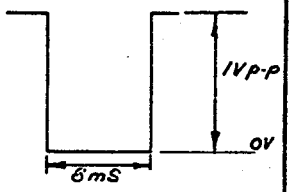
S1 AC-DC INPUT CHANNEL 'A'
S2A-D ATTENUATOR CHANNEL 'A'
S3 AC-DC INPUT CHANNEL 'B'
S4A-D ATTENUATOR CHANNEL 'B'
S5A&B ALTERNATE - CHOPPED.
S6 CHANNEL A ON-OFF (REAR RV7)
S14 TRIGGER SELECT.

CONTROLS

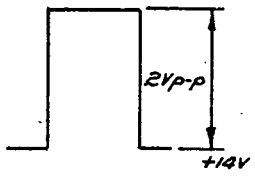
RV1 VERTICAL POSITION CHANNEL 'A'
RV2 CALIBRATE " 'A'
RV3 VERTICAL POSITION " 'B'
RV4 CALIBRATE " 'B'
RV5 AMPLIFIER RESPONSE
RV6 DC BALANCE 'B'
RV7 DC BALANCE 'A'
RV8 SET I.C. VOLTAGE.
RV201 SET CALIBRATE SIGNAL.
RV21 MAINS BALANCE.
RV22 TRIGGER BALANCE CONTROL.
RV23 MAINS BALANCE.
RV25 AMPLIFIER RESPONSE CHANNEL 'A'
RV26 AMPLIFIER RESPONSE CHANNEL 'B'

ATTEN ·2V/cm ON CHANNEL A & B.
T/B 2 m/S cm, VERNIER CAL, TRIG 'B', NORM, + INT, ALT.

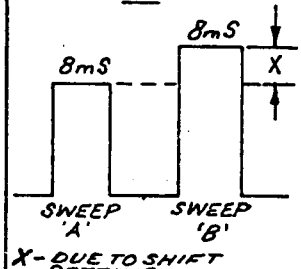
A



B

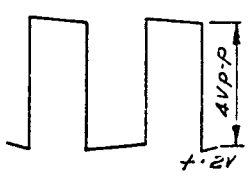


C



X - DUE TO SHIFT SETTING.

D



R 90-161
C 60-97
D 15-25
Q 19-33

MODIFICATIONS

ISSUE 2 6-72
C83A ADDED
R145A ADDED

ISSUE 3 6-72
C84 12pf to 4-10pf

ISSUE 4 11-72
C80 100pf to 220pf

ISSUE 5 12-72
C90 100/64 to 100/63
C91 160/64 to 220/63
C92 150/64 to 220/63
C93 100/64 to 100/63
C94 100/64 to 100/63
C95 100/64 to 100/63

ISSUE 6 2-73
C80 220pf to 100pf

SWITCHES

S7 INT-EXT TRIGGER
S8 A&B + OR −
S9 A&B NORM-TV SELECT
S10 A&B AUTO-SELECT (REAR RV9)
S11 A-D TIME BASE RANGE
S12 A&B INT-EXT TIME BASE (REAR RV11)
S13 A&B POWER ON & OFF (REAR RV19)

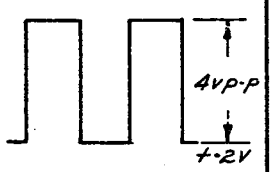
CONTROLS

RV9 TRIGGER LEVEL SELECT.
RV10 TRIGGER SENSITIVITY.
RV11 TIME BASE VERNIER
RV12 TIME BASE CALIBRATE.
RV13 TRACE LENGTH
RV14A HORZ POSITION
RV14B HORZ MAGNIFICATION
RV15 X5 MAG. CAL.
RV16 HORZ CENTREING
RV17 CRT GEOMETRY
RV18 ASTIGMATISM
RV19 FOCUS
RV20 T/B DC LEVEL.
RV24 INTENSITY.

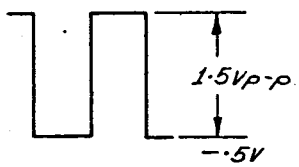
ATTEN .2Vp/cm. ON CHAN A&B.

T/B 2mS/cm, VERN, CAL, TRIG B, NORM, + INT, ALT.

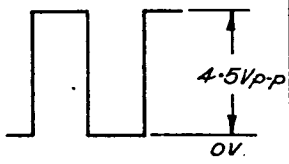
D



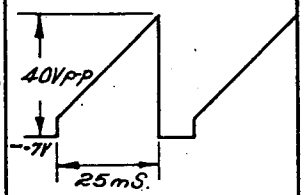
E

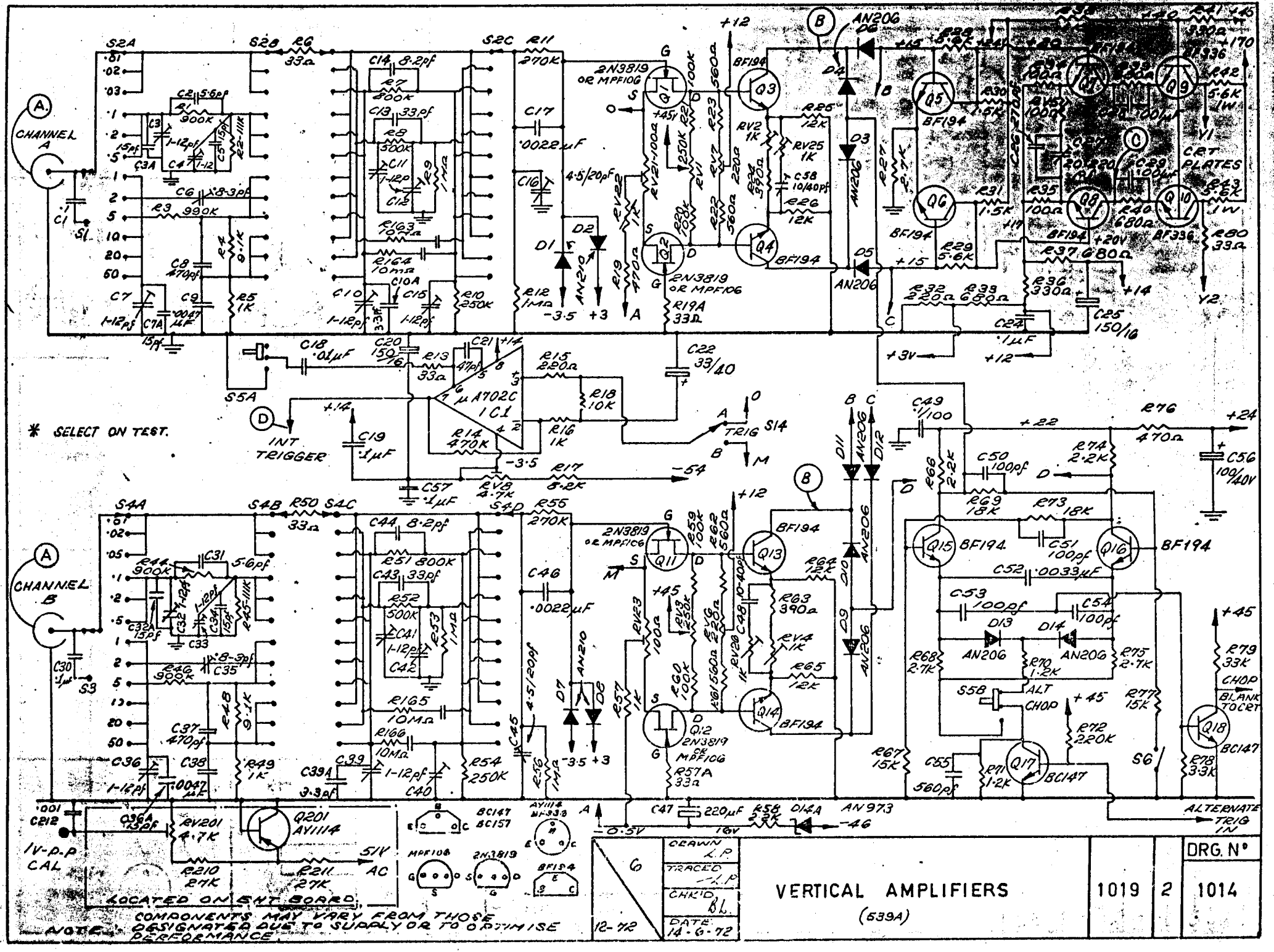


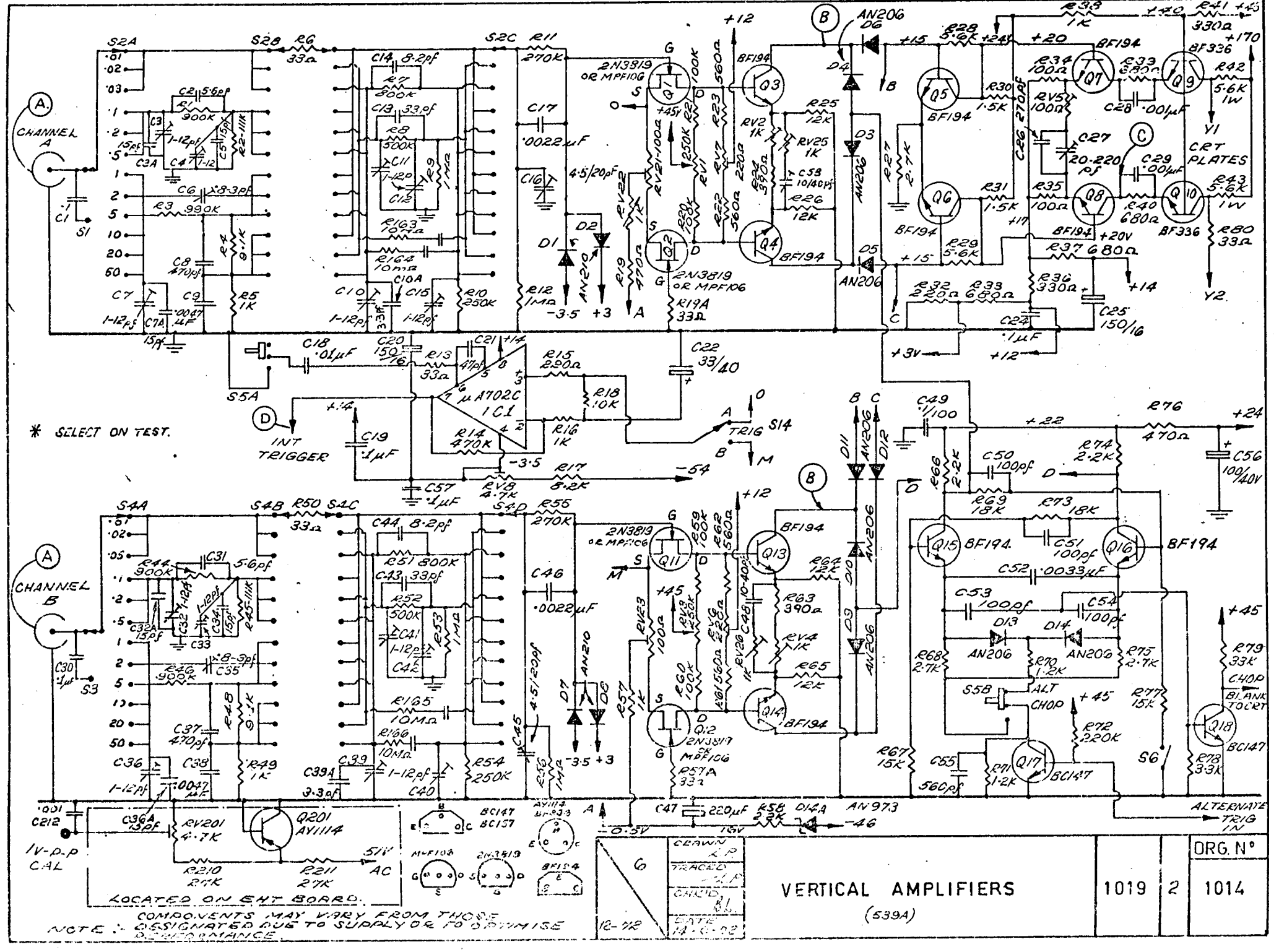
F

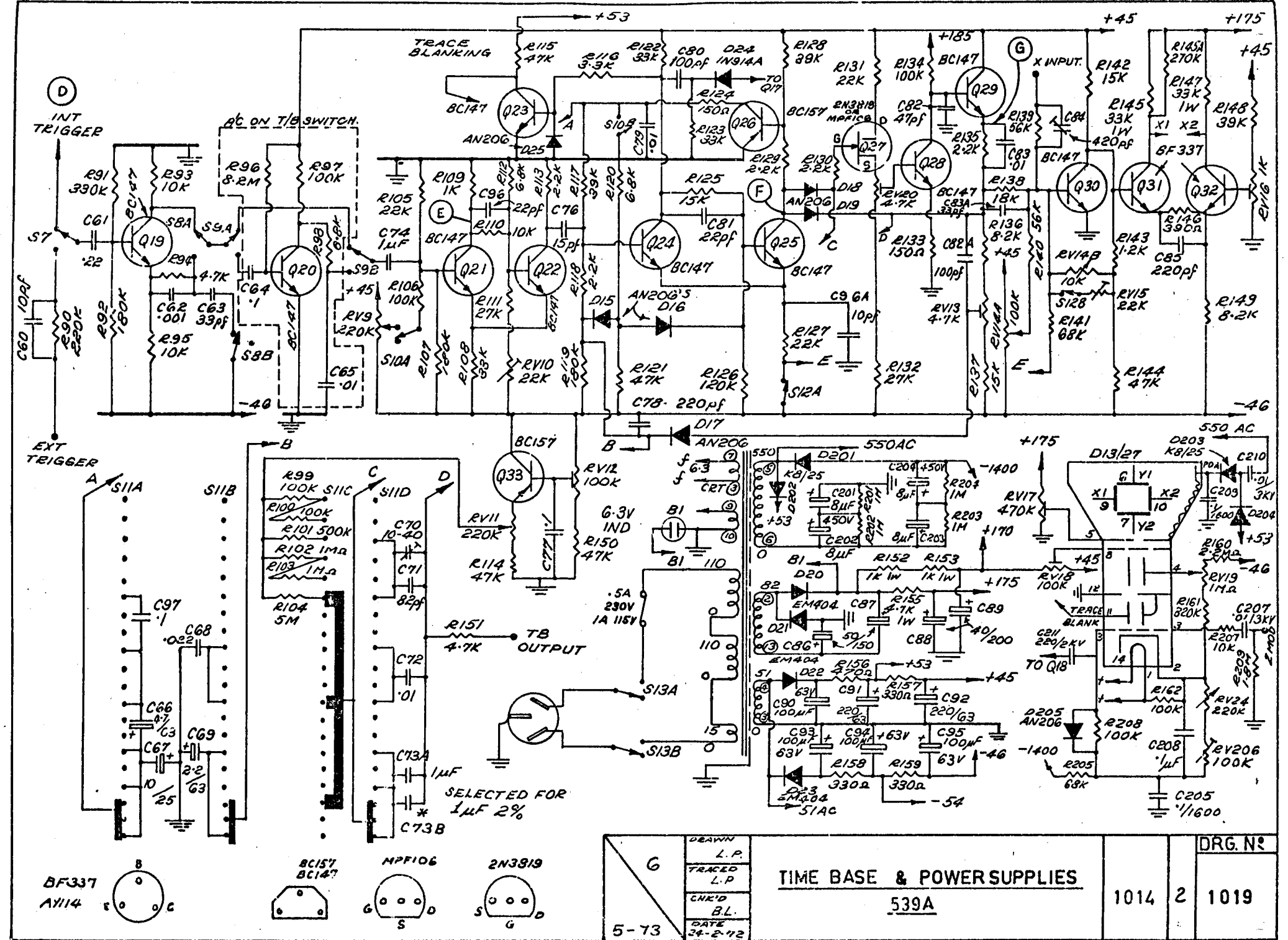


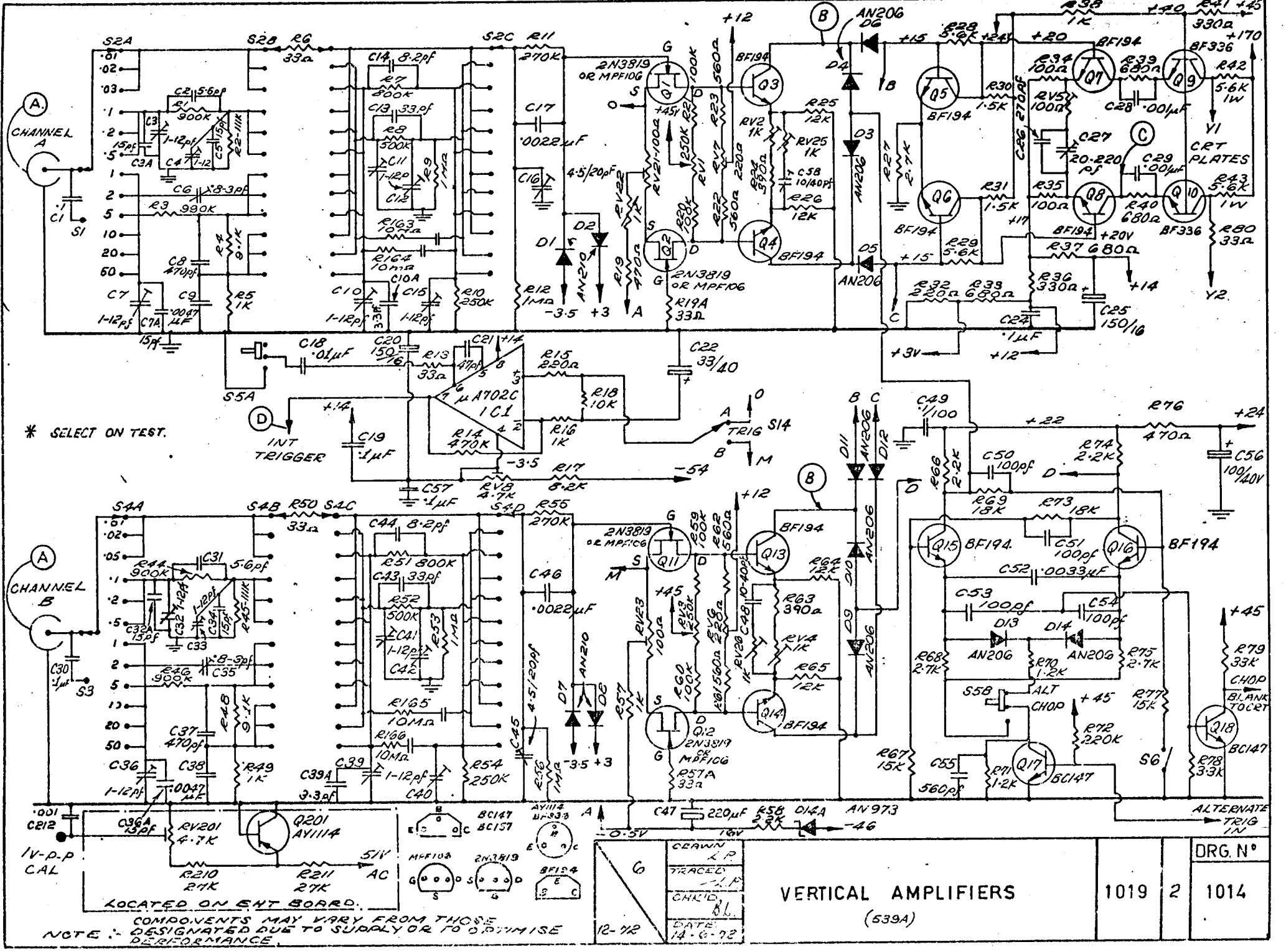
G

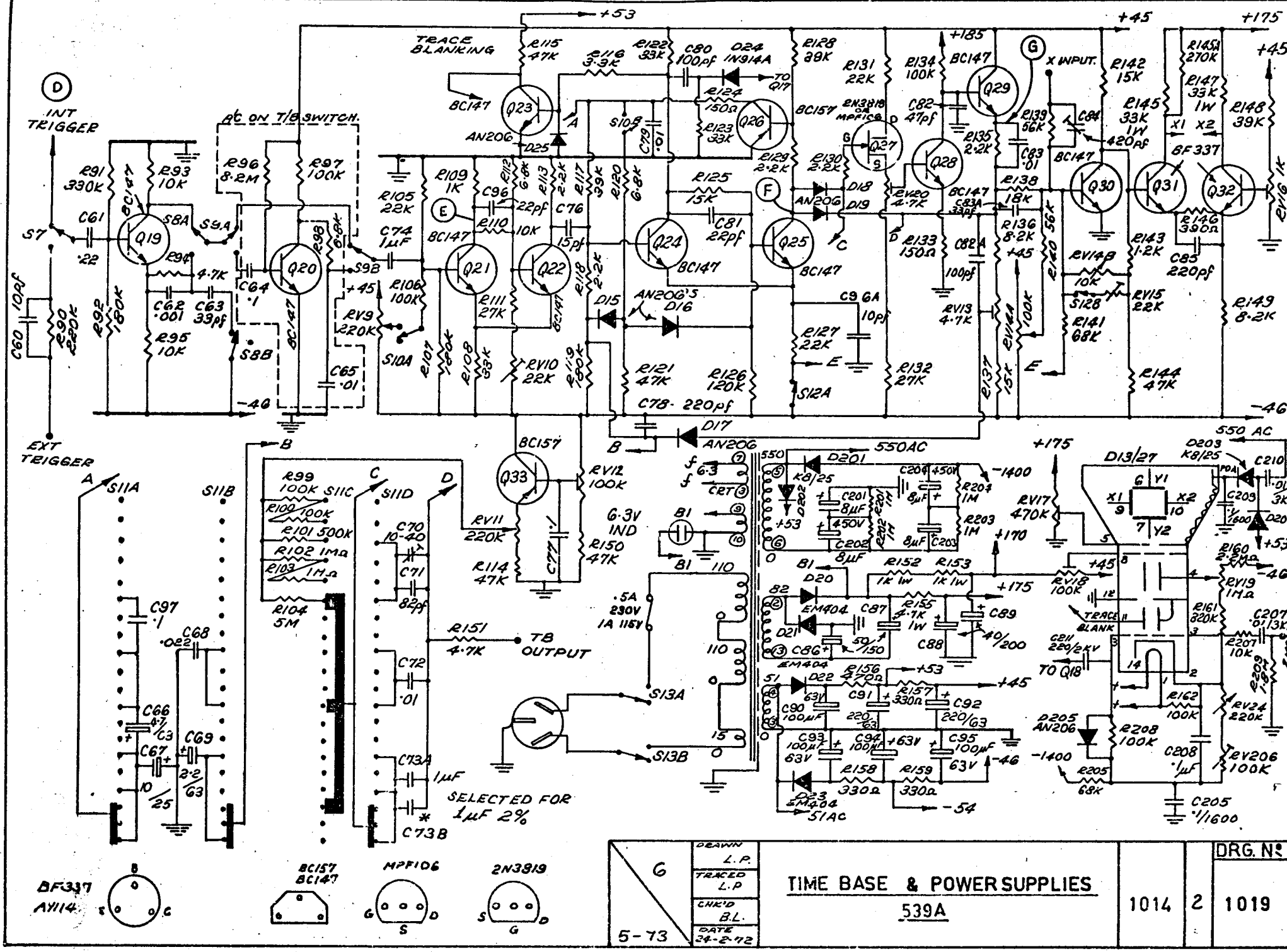



CHANNEL A
CHANNEL B
INT TRIGGER
* SELECT ON TEST.
1V P-P CAL
5V/V AC
LOCATED ON ENT BOARD
NOTE: COMPONENTS MAY VARY FROM THOSE DESIGNATED DUE TO SUPPLY OR TO OPTIMISE PERFORMANCE
ALTERNATE TRIG IN
CRT PLATES
CHOP
BLANK TO CRT
ALT CHOP
VERTICAL AMPLIFIERS
(639A)
DRAWN L.P.
TRACED L.P.
CHK'D B.L.
DATE 14-6-72
12-72
1019
2
1014
DRG. N°


VERTICAL AMPLIFIERS
(539A)
1019
2
1014
ORG. N°
DRAWN K.P.
TRACED
CHECKED B.L.
DATE 14-6-62
12-712
CHANNEL A
CHANNEL B
INT TRIGGER
TRIG
ALT CHOP
BLANK TO CRT
CRT PLATES
Y1
Y2
ALTERNATE TRIG IN
1V P-P CAL
AC
LOCATED ON EHT BOARD.
COMPONENTS MAY VARY FROM THOSE DESIGNATED DUE TO SUPPLY OR TO OPTIMISE PERFORMANCE
NOTE :-
* SELECT ON TEST.
2N3819 OR MPF106
BF194
BF336
BC147
AN206
AN210
AY1114
μA702C
IC1


TRACE BLANKING
INT TRIGGER
EXT TRIGGER
A/C ON T/B SWITCH
X INPUT.
TO Q17
TO Q18
TB OUTPUT
SELECTED FOR 1µF 2%
TIME BASE & POWER SUPPLIES
539A
DRAWN L.P.
TRACED L.P.
CHK'D B.L.
DATE 24-2-72
5-73
1014
2
1019
DRG. Nº


CHANNEL A
CHANNEL B
INT TRIGGER
SELECT ON TEST.
VERTICAL AMPLIFIERS
(539A)
1019
2
1014
DRG. N°
DRAWN
TRACED
CHKD
DATE 14-6-72
12-1/2
LOCATED ON ENT BOARD.
COMPONENTS MAY VARY FROM THOSE DESIGNATED DUE TO SUPPLY OR TO OPTIMISE PERFORMANCE.
NOTE :-
1V P-P CAL
5/1V AC
ALTERNATE TRIG IN
CRT PLATES
Y1
Y2
CHOP
ALT CHOP
BLANK TO CRT
TRIG
M
A
B
C
D


TRACE BLANKING
AC ON T/B SWITCH
INT TRIGGER
EXT TRIGGER
X INPUT
TB OUTPUT
SELECTED FOR 1µF 2%
TRACE BLANK
TO Q17
TO Q18
550 AC
550AC
+53
+45
+175
-46
-54
-1400
+185
+170
BC147
BC157
AN206
EM404
MPF106
2N3819
BF337
AY114
6·3V IND
.5A 230V 1A 115V
DRAWN L.P.
TRACED L.P.
CHK'D B.L.
DATE 24-2-72
5-73
TIME BASE & POWER SUPPLIES
539A
1014
2
DRG. Nº
1019