BWD ELECTRONICS

INSTRUCTION MANUAL

BWD ELECTRONICS PTY LTD
MILES STREET
MULGRAVE VIC 3170
AUSTRALIA

P O BOX 325
SPRINGVALE VIC 3171

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CABLES 'OSCILLOSCOPE'

THIS INSTRUMENT HAS BEEN SET TO
OPERATE FROM A 235 VOLT MAINS SUPPLY

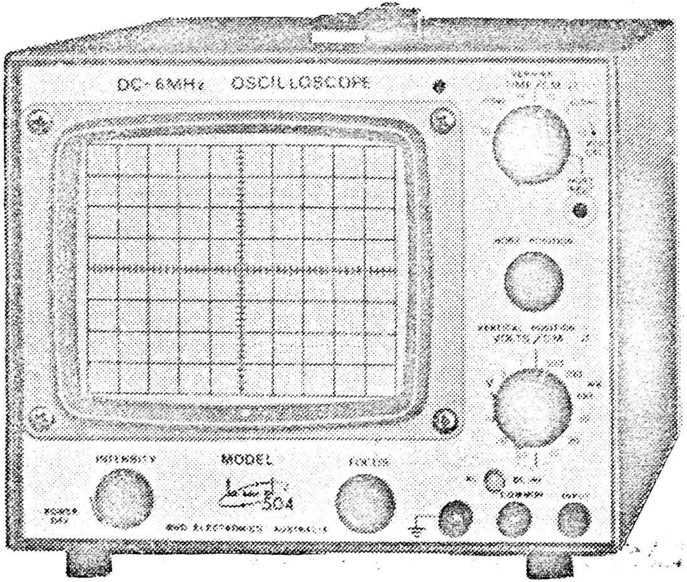
BROWN LEAD	— ACTIVE (LIVE)
BLUE LEAD	— NEUTRAL
GREEN/YELLOW LEAD	— EARTH (CHASSIS)

BWD F 103 1

504

OSCILLOSCOPE

ISSUE 2, JAN 1976
APPLICABLE FROM SERIAL No.
33190



I N D E X

CAUTION

Input voltage protection of the Model 504 oscilloscope is provided up to:-

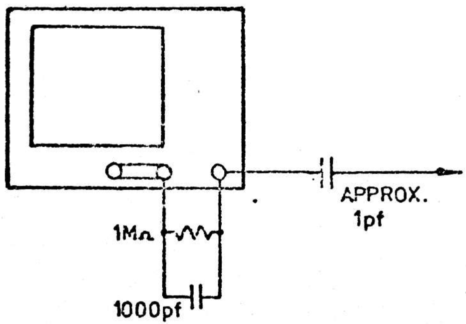
280V RMS, 800V P-P, ± 400V DC

Input voltages in excess, may cause damage to the input circuitry, which is not covered under the GUARANTEE.

Do not connect <u>directly</u> to high voltage circuits, such as electric fences, ignition systems, TV line outputs, etc.

These high voltages must be reduced to a workable level before coupling into the oscilloscope.

Use only with a high voltage probe having suitable attenuation characteristics, or a capacitance divider network, typically as shown below:-



504/642/mb

INSTRUMENT HANDBOOK

MODEL bwd 504

1. GENERAL. Although deceptively simple in appearance and operation the bwd 504 is a calibrated oscilloscope with a wide measurement capability in Voltage, Time, Frequency, Phase & Current.

When required the input terminals can be isolated from the power line ground by removal of a ground link. This enables measurements to be made between voltages not at ground potential up to a limit of±400V DC. It may also be used to eliminate ground loops from low level signals. Additionally it prevents accidental connection of a lead from the ground terminal to a live voltage from shorting out equipment - a particularly useful feature in educational areas.

As both vertical and horizontal amplifiers are DC coupled the bwd 504 will measure both DC and AC voltages from the milli volt range to over 400V. If a1Ω resistor is placed across the input terminals the current flowing through it when connected into a circuit is displayed on the CRT directly in milli amps or amps.

Time periods from less than 0.5μ Sec to 1 Sec are readily measured or degrees of phase shift over the range DC to 50kHz. Frequency comparison by lissajous figures can extend from zero frequency to beyond 1MHz.

Although the specified bandwidths of the bwd 504 is 6MHz at - 3db its amplifier response does in fact extend to well over 25MHz. A chart in the operation section shows how to make measurements over this extended frequency range, together with charts for rise time and phase measurements. A range of high impedance and demodulator probes are available to further extend the measurement ability of your bwd 504. Check the bwd accessory list.

2. SPECIFICATION

2.1 CRT. 13cm type 130BE/P31 providing a flat 8x10cm display.
EHT. 1.6KV producing a high intensity well focused trace.
Phosphor: P31 normally supplied P7 available as Option 04.
Graticule: 8X10cm lines with 2mm subdivisions. Rise Time reference lines at 10% and 90% also provided.

Graticule printed on light blue filter (amber for P7 option).

2.2 VERTICAL AMPLIFIER. Sensitivity: 10mV to 50/cm in 12 calibrated steps of 1,2,5,10 sequence.

Bandwidth: DC to 6MHz - db at all sensitivities referred to 6 cm deflection at 50kHz. Typically - 6db at 10MHz.

Rise Time: 55 nano seconds.

Input Impedance: 1MΩ & 30pf.

Calibration: Better than 5% including 10% line variation.

Max. Input: Fully protected to ± 400V from DC to 500kHz at any attenuator setting.

Isolated Input: Input Common can be isolated by removal of front panel link from chassis and power line ground.

2.3 TIME BASE. Range: 0.5μ Sec to 0.1 sec/cm in 5 decade ranges plus additional 0.5μ Sec range.

Calibration: <5% with vernier at Cal.

Vernier: 12:1 continuous control between each range.

2.4 TRIGGERING. AUTO lock with no manual controls.

Sensitivity: >1cm deflection 10Hz to >10MHz typically to >15MHz at 2cm.

L.F. trigger extends below 5Hz with 2cm deflection. Trigger circuit locks to the mean value of the displayed waveform. It will lock to almost any waveshape including sine, square, triangle, pulse and T.V. video signals. When no signal is present or repetition rate is below 5Hz the trace free runs producing a bright base line.

2.5 HORIZONTAL AMPLIFIER. Sensitivity: Approx. 500mV to 50V/cm continuously variable.

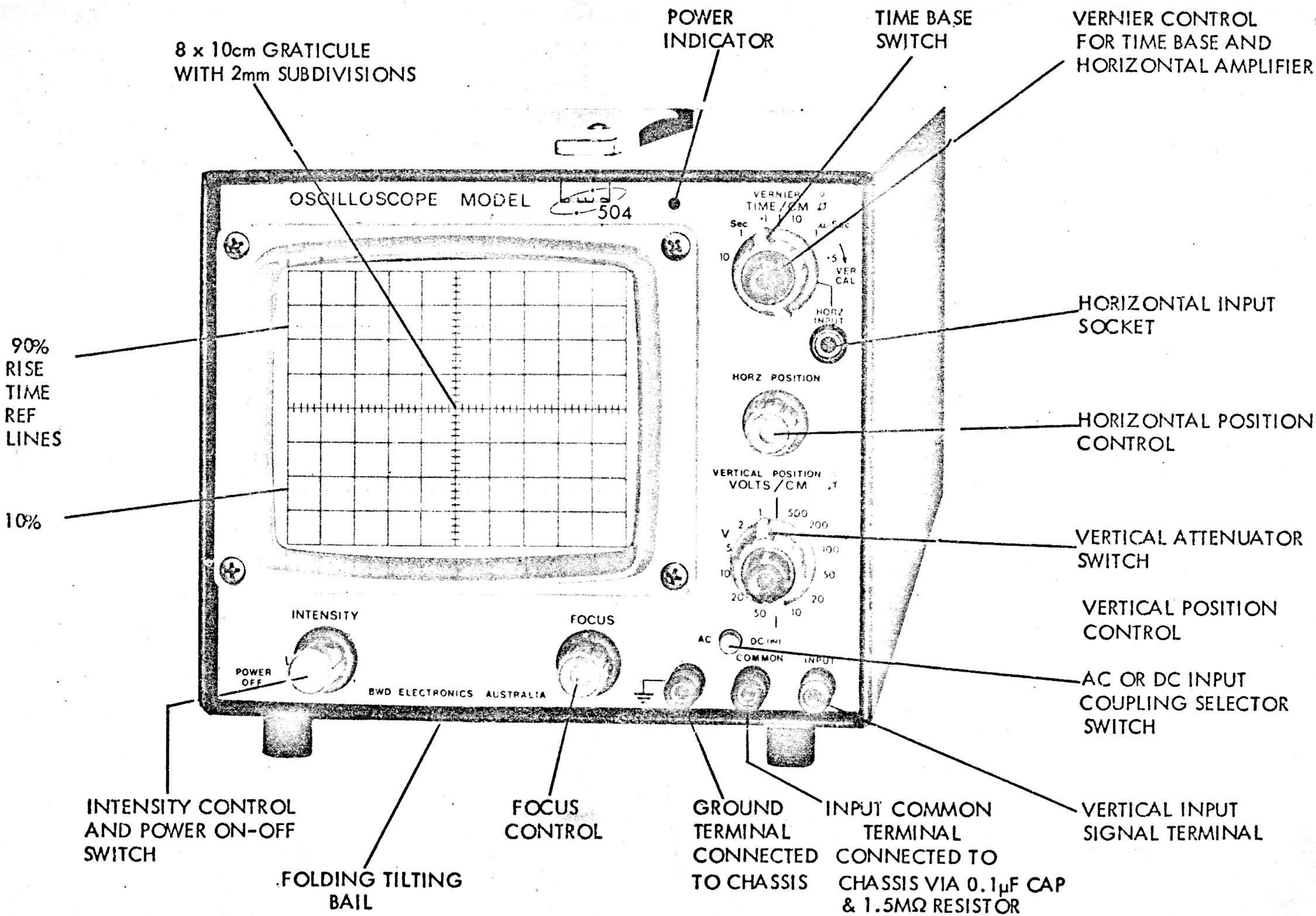
Bandwidth: DC to 1MHz-3db referred to 6cm deflection at max. gain.

Input Impedance: 100KΩ and 20pf approx.

X - Y Phase Shift: < 3° from DC to 50kHz.

2.6 GENERAL.

Tilting Bail: Fitted with folding tilting bail to raise instrument to a convenient viewing angle.


POWER INDICATOR
TIME BASE SWITCH
VERNIER CONTROL FOR TIME BASE AND HORIZONTAL AMPLIFIER
8 x 10cm GRATICULE WITH 2mm SUBDIVISIONS
OSCILLOSCOPE MODEL 504
90% RISE TIME REF LINES
10%
HORIZONTAL INPUT SOCKET
HORIZONTAL POSITION CONTROL
VERTICAL ATTENUATOR SWITCH
VERTICAL POSITION CONTROL
AC OR DC INPUT COUPLING SELECTOR SWITCH
INTENSITY
FOCUS
POWER OFF
BWD ELECTRONICS AUSTRALIA
INTENSITY CONTROL AND POWER ON-OFF SWITCH
FOLDING TILTING BAIL
FOCUS CONTROL
GROUND TERMINAL CONNECTED TO CHASSIS
INPUT COMMON TERMINAL CONNECTED TO CHASSIS VIA 0.1μF CAP & 1.5MΩ RESISTOR
VERTICAL INPUT SIGNAL TERMINAL

Power: 100 to 135V and 200 to 265V in two ranges. 48-440Hz 15W.

Dimensions: 182mm high x 200mm wide x 405 mm deep overall.

Weight: 4.5kg packed 5kg.

Accessories Supplied: Handbook, x1 probe, ground prod and protective moulded pack.

3. FUNCTION OF CONTROLS. Front panel controls are grouped for ease of use and are clearly designated. The functions of these controls are described below.

3.1 INTENSITY CONTROLS & ON-OFF SWITCH. 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.

3.2 FOCUS. Controls the sharpness of the trace. May require slight readjustment over the full intensity control range.

3.3 TIME/CM (TIME BASE) SWITCH. When the Time Base Vernier control is turned clockwise to the CAL position, the six time base speeds on this control will be accurate to within 5%. The speeds of 10 and 1mSec. and 100, 10, 1 and 0.5μ Sec represent the fastest speed on each range; anti-clockwise rotation of the Vernier Control will reduce the selected speed over a 12-1 range, e.g. on the 1mSec range the Vernier will vary the time base from 1m Sec down to less than 10m Sec/cm when fully anti-clockwise.

3.4 HORZ. VERNIER. Varies the Time Base speed over a 12-1 range to provide a continuously variable rate in conjunction with the TIME/CM switch from 0.1 Sec/cm to 0.5μ Sec/cm. When the TIME/CM switch is turned and switched to HORZ INPUT it switches off the internal Time Base, permitting an external signal to be fed into the HORZ INPUT socket. The Horizontal Vernier now varies the sensitivity from 0.5V to 50V per cm approximately.

3.5 HORZ. POSITION. Moves the trace horizontally on the CRT.

3.6 VOLTS/CM (ATTENUATOR). switch adjusts the sensitivity of the Vertical amplifier from 10mV per cm to 50V per cm in a 1,2,5,10 series of steps. Attenuator accuracy is 2% and the overall Oscilloscope accuracy within 5% on any step.

3.7 VERTICAL POSITION. Moves the trace vertically on the CRT.

3.8 AC-DC SWITCH. The DC position (in) provides direct coupling to the amplifier the AC position (out) places a capacitor in series with the input to block the DC component.

3.9 TERMINALS & SOCKETS.

3.10 INPUT. Red terminal is the signal input connection to the vertical amplifier.

3.11 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 when the link between it and the Ground terminal is removed.

3.12 HORIZONTAL INPUT. When the TIME/CM Switch is turned anti-clockwise to HORZ. INPUT, signals may be fed into this socket to produce a horizontal display, input is DC coupled. An external capacitor must be used if a high voltage DC is present on the signal to be displayed, which causes the trace to be deflected off the screen.

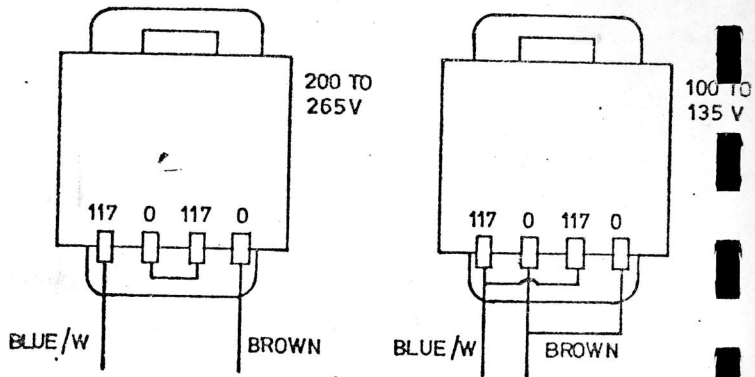
4. INITIAL CHECKING. The voltage range for Model bwd 504 is marked on the label attached to the power cable.

Two voltage ranges are provided, from 100 to 135V or 200 to 270V. They may be changed over by reconnecting links on the transformer as shown in the sketch. This model is fitted with a 3 wire AC power card in which the GREEN/YELLOW wire must be connected to ground. Failure to do so may pose a shock hazard. Power cord colour coding is as follows:

Line (Active) BROWN. Neutral BLUE. Ground GREEN/YELLOW.

USA & CANADA ONLY

Line BLACK. Neutral WHITE. Ground GREEN.



5. FIRST TIME OPERATION

5.1 If you are unfamiliar with an oscilloscope set the controls as below and follow the steps outlined until each feature is understood.

Intensity	Off	Focus	Centre
Time Base	10mSec	T.B. Vernier	Cal (Clock-wise)
Horz. Position	Centre	Vert. Position	Centre
Attenuator	5V	AC-DC switch.	DC(push in)

5.2 Plug instrument into a power line outlet. Switch on by rotating the intensity control about 3/4 turn. A display will appear after a few seconds. Adjust the horizontal and vertical controls to centre the trace and the focus and intensity controls for a sharp bright trace.

5.3 Plug the black ground prod into the black Common terminal, with the earth link in position between the Common and Ground terminals. Next plug the red signal prod into the Red input terminal.

To check the amplifier and time base operation a suitable source of AC signal is required. This may be an oscillator such as a bwd 112B, 141 or 160 etc., or the secondary of a step down transformer providing 6.3V AC.

5.4 Connect the signal and ground prods to the 6.3V source or an oscillator set to 50Hz and 20Vp-p output or max. available. 5 Cycles of the input waveform should appear across the screen. Switch the Volts/cm knob to a higher sensitivity, i.e. clockwise. The waveform will increase in height until it deflects off the screen. This is now past maximum useable sensitivity. Turn the Volts/CM switch counter clockwise to reduce the sensitivity, the waveform will reduce in height. When it drops below 0.5cm deflection it will lose trigger stability, this is the minimum useable sensitivity when a triggered display is required. The most useful range to view a waveform is between 2 and 8 cms and the attenuator should be adjusted to provide this when making measurements.

5.5 The time base can now be checked. Turn the Time base Vernier control counter clockwise and note how more waveforms appear on the screen as the time base sweeps at a slower speed. When the control is fully counter clock-wise switch the time base switch clockwise to 1mSec/cm, the display will return to the five or six wave-forms we started with.

5. FIRST TIME OPERATION (continued)

Turn the Vernier control clockwise towards CAL. The number of waveforms will progressively decrease until only a line sweeping towards the top of the screen is present.

This condition illustrates how the 504 can be used to expand out the leading edge of a waveform to view it in detail or to measure its rise time.

5.6 The HORZ. INPUT should be checked with an oscillator. Connect an additional lead from the oscillator output to the yellow HORZ.INPUT socket then switch the time base switch fully clockwise. The time base Vernier control now becomes the Horizontal Sensitivity control, adjust it until the horizontal deflection is the same as the vertical, set it to about 6 cm. A single line should now be present on the screen sweeping diagonally from top right to bottom left of the screen. Increase the oscillator frequency and note that when the input frequency increases beyond 50kHz the line becomes an elipse indicating phase shift exists in the oscilloscope between the X & Y inputs. This is the limit for accurate phase measurement but the horizontal amplifier may be used for lissajous figures etc., to beyond 1MHz.

5.7 The use of the AC/DC switch and the ground link are described in Section 6 which outlines methods of measuring waveforms.

6. The following section explains the operation of Model bwd 504 when used to make specific measurements of VOLTAGE, TIME, FREQUENCY, PHASE, & CURRENT.

6.1 MEASUREMENT OF DIRECT VOLTAGES.

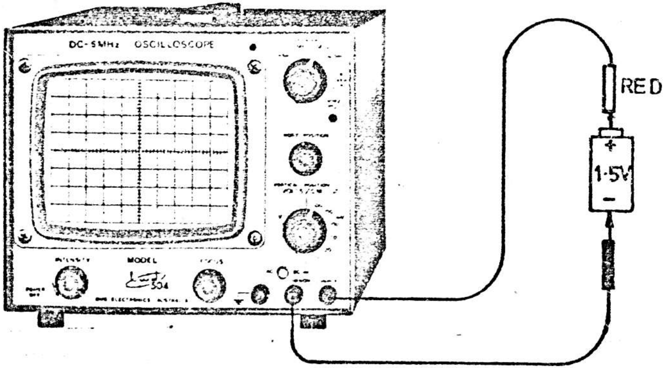
Set the same control positions as for the first time operation except the attenuator which should be set to 0.5V/cm. Use a 1.5V dry cell for the test and connect the black ground prod to the negative end and the red prod to the positive end of the battery.

The CRT trace will move up 3cm from the centre line indicating the voltage is positive and 3 x 0.5V = 1.5V. Now reverse the leads, the trace will move down 3cm indicating the voltage is negative and again 3cm x 0.5V = 1.5V.

The ability of an oscilloscope to measure both positive and negative DC voltages is particularly useful when measuring power supply rails and AC voltages swinging between them and ground. To enable the maximum signal amplitude to be displayed when DC coupled, the trace may be set at the bottom of the graticule for positive voltage measurements and the top of the graticule for negative voltage measurements.

If the signal deflects the trace off the screen reduce sensitivity until deflection is within the graticule limits.

6.2 NOTE: The 1MΩ input resistance of the oscilloscope must be taken into account when measuring high impedance points such as the gate of a FET or similar circuits. A 10:1 probe such as the bwd P32/4mm duo head probe will increase the input impedance to 10MΩ and so reduce the shunt effect of the oscilloscope input by a factor of 10 although sensitivity is reduced by the same amount.



7. MEASUREMENT OF AC (ALTERNATING) VOLTAGES.

7.1 Set the Attenuator to 50V (if the input voltage is unknown). Connect a lead from the COMMON (Black) input terminal to the ground (earth) side of the signal source. (Model bwd 112B, 141 or 160 Oscillators are ideal for initial experiments in this test).

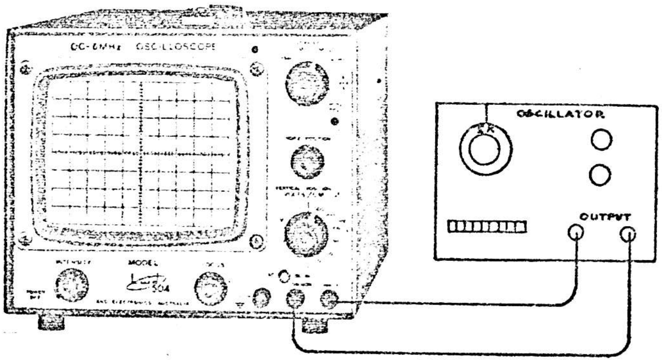
Increase the Vertical sensitivity by the VOLTS/CM switch until a display between 2 and 8 cm exists. Now adjust the Time Base switch and Vernier to enable the waveform to be readily seen. To measure the voltage of the displayed waveform measure its overall height in centimetres by the calibrated graticule, then multiply this by the Attenuator setting and the result is in Volts p-p, e.g. if the display is 6cm high and the Attenuator is set to 0.5V then the amplitude is 6 x 0.5 = 3V peak to peak, to convert to RMS voltage for sine waves - divide the 3V by 2.83, e.g.

$$\frac{3}{2.83} = 1.06\text{V RMS}$$

It is important to remember that oscilloscopes indicate peak to peak voltages NOT rms as on AC meter does. To obtain RMS voltages it is necessary to convert the p-p as shown above.

7.2 The frequency of the waveform can be found by turning the Time Base VERNIER to CAL (clockwise), then switch the TIME/CM switch to a range where the signal can be clearly seen, e.g. if a waveform is 2cm long and the switch is on 100µ Sec, then the duration of the waveform is 2 x 100µ Sec. The frequency of the displayed waveform can be found by dividing 1 second, which equals 1,000,000µ Sec by the waveform duration, e.g.

$$\frac{1,000,000\mu\ \text{Sec}}{200\mu\ \text{Sec}} = 5000\text{Hz}$$



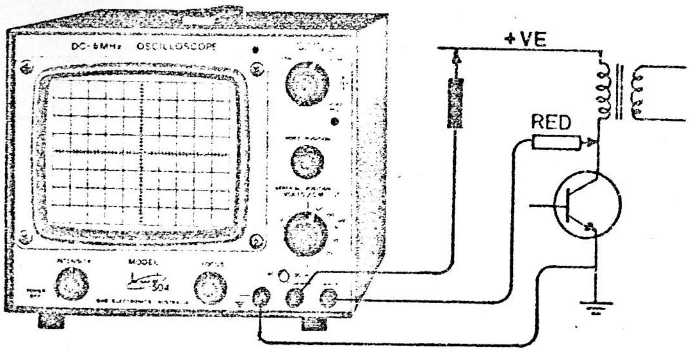
8. <u>AC-DC INPUT SWITCH.</u> All measuremen described under Sections 6 & 7 have been made with the input selector pushed in for DC. If however it is necessary to measure the amplitude of a low lev AC waveform which is superimposed on a high DC voltage the DC component must be removed. By setting the input selector to AC (out position) a 0.1µF capacitor is placed in series with the input signal and effectively removes the DC voltage and very low frequencies. The amplifier response is now - 3db down (0.707 amplitude compared with 1kHz) at 1.6Hz approx. This will produce noticeable tilt on any square wave below 100Hz. To view low frequencies other than sine waves it is necessary therefore to use DC coupling if the waveshape is not to be distorted.

The low frequency response when AC coupled can be extended down by another decade by using a 10:1 high impedance divider probe (bwd P32/4mm or P40 4mm) on the input. The - 3db point is then 0.16Hz negligible tilt.

9. <u>ISOLATED MEASUREMENTS AC OR DC.</u>
When the ground link is removed from the Common and Ground terminals the input circuit is isolated from ground enabling measurements to be made between any two points of a circuit, even if neith is at ground potential.

9. ISOLATED MEASUREMENTS AC OR DC. (continued)

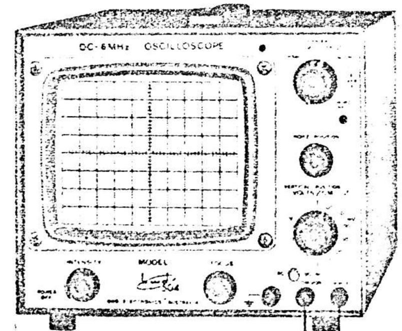
The COMMON terminal has an impedance to ground of 1.5MΩ and is shunted by a 0.1μF capacitor - this must be taken into account if connecting the COMMON to a point of high impedance. Maximum voltage that may be applied to the COMMON terminal is + or - 400V DC.



10. CURRENT MEASUREMENTS AC OR DC.

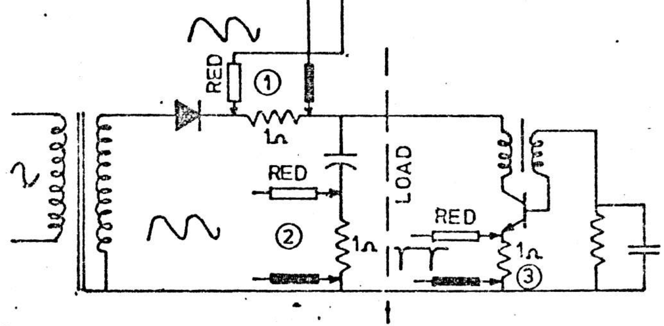
Another application of the isolated ground is the ability to measure the voltage drop across a known resistor, and by use of Ohms Low, this may be converted to current. With a 1Ω resistor across the vertical input terminals, the attenuator reads in mA and AMPS directly.

10.1 If this resistor is placed in series between a source and load, the Oscilloscope will read the current flowing, both AC & DC in mA or AMPS, e.g. 0.1V on the Attenuator = 0.1A, 0.2V = 0.2A, etc., and unlike a meter will show the actual current waveform - a practical application is the charging current in a filter capacitor of a power supply or the current through a rectifier, etc.



Three examples of resistor placements used to measure current.

1. Total rectifier current.
2. Capacitor charging current.
3. Transistor emitter current.



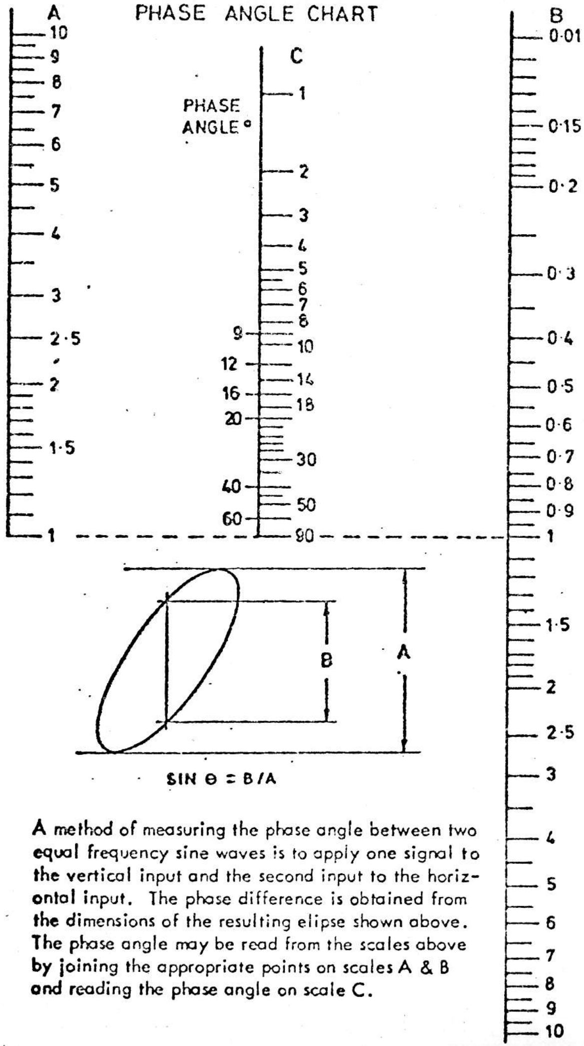
11. MEASUREMENTS WITH AN EXTERNAL HORIZONTAL INPUT.

As the Horz. input is directly coupled, the CRT display can be used for X-Y plotting over an 8 x 10 cm area, phase measurements from DC to >50kHz and frequency comparisons with lissajous figures to beyond 1MHz. Switch the Time Base Switch to HORZ. INPUT and centre spot.

11.1 For X-Y plotting first calibrate the Horizontal Amplifier by feeding in 5V p-p waveform and adjusting the HORZ. GAIN until the display equals 5 cm long; now set the Vertical Attenuator to 1V/cm. The Oscilloscope has now identical X and Y sensitivities, or 1V per cm. (Other sensitivities can be used with equal or unequal sensitivities, as required).

11.2 Remove the calibrating waveform and centre the spot. Positive or negative voltages may now be applied to X and Y inputs and the result plotted on tracing paper placed over the CRT or transferred to a ruled graph paper.

11.3 The phase shift in an amplifier or filter network etc., can be measured from DC to 50kHz using the graph opposite.



A method of measuring the phase angle between two equal frequency sine waves is to apply one signal to the vertical input and the second input to the horizontal input. The phase difference is obtained from the dimensions of the resulting elipse shown above. The phase angle may be read from the scales above by joining the appropriate points on scales A & B and reading the phase angle on scale C.

11. MEASUREMENTS WITH AN EXTERNAL HORIZONTAL INPUT (continued)

Apply a low distortion sine wave to the circuit under test and also to the vertical input of the oscilloscope. Now connect a lead from the output of the circuit or amplifier to the HORZ. INPUT socket. Adjust sensitivities for a display about 6 cm long. Vary the test oscillator frequency over the required range and note the variation of the display from a straight line. The width of the elipse should be measured and using the graph read off the phase angle.

11.4 Frequency comparison of one AC source against another may be readily made by feeding one input into the Vertical Amplifier and one into the Horizontal Input. The ratio of one frequency to the other can be determined from the example shown.

11.5 NOTE: Signals should not be fed into the HORZ INPUT when the time base is in use as this may cause interference with the time base.

11.7 Extending the Useable Calibrated Amplifier Range.

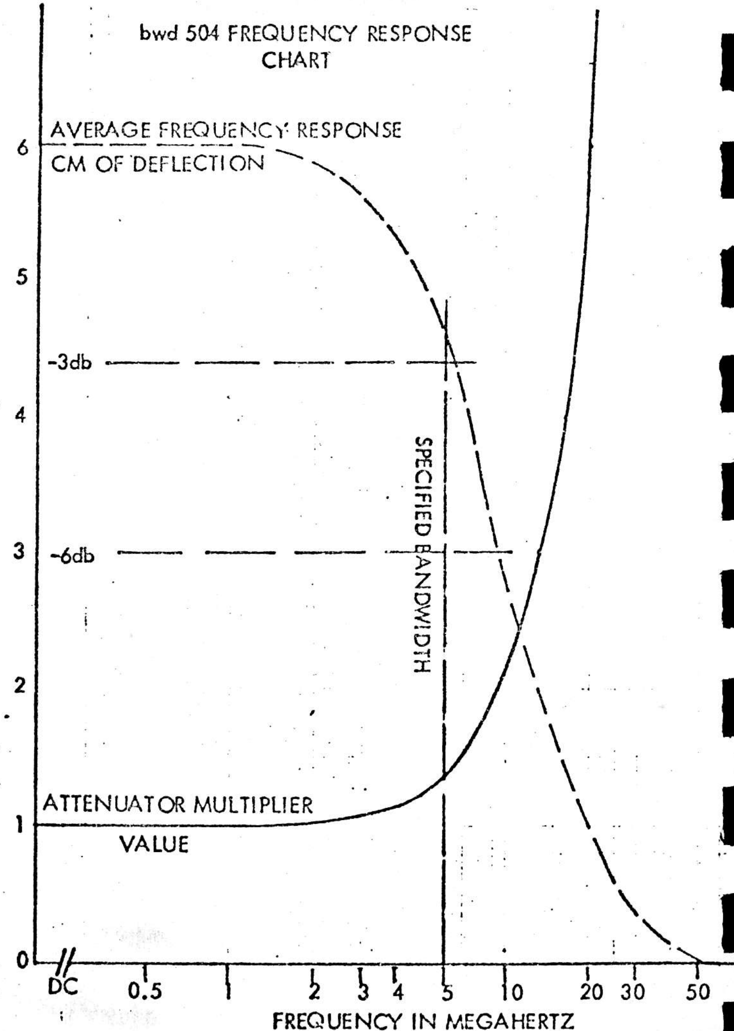
Although all oscilloscope amplifiers are specified as having a bandwidth of so many megahertz at - 3db it does not mean accurate amplitude measurements can be made at the -3db limit. In fact beyond approx. 1/3 of the specified bandwidth the calibration accuracy specification no longer applies. To enable the bwd 504 response to be used at sensitivities well beyond the 1/3 limit the chart below has been devised. The dotted line indicates the typical frequency response of the amplifier. The solid line indicates the attenuator multiplying factor required at any frequency to 20MHz.

It must be noted the curves can only be approximate as at frequencies above 10MHz the method of picking up the signal and applying it to the oscilloscope can effect its apparent amplitude. With a 10:1 P32 Duo Probe properly grounded by the flying ground lead, measurements can be made to beyond 80MHz so that it will have a negligible effect over the bandwidth range available with a bwd 504 oscilloscope.

NOTE: Max amplitude of signal should NOT exceed the amplitude shown on the response curve e.g. at 15MHz it should not exceed 1.6 cm. Below 3MHz amplitude can be extended to the full 8 cm deflection.

EXAMPLE: An input signal at 10MHz produces 2.5 cm deflection with the attenuator set to 50mV/cm. Actual amplitude of signal is 2.5 x 50 x Attenuator Multiplier value. At 10MHz Atten. Multiplier value is approx. 2.1 so the amplitude is therefore 2.5 x 50 x 2.1 = 253mV p-p.

NOTE: Max. Deflection curve indicates signal amplitude at 10MHz must be kept below 2cm or amplifier overload will occur.



12. CIRCUIT DESCRIPTION. NOTE: As the circuit is isolated from ground, all measurements must be made with the ground link in place between Ground and Common terminals on the front panel.

12.1 Attenuator. Signals applied to the input terminal are switched straight through to the attenuator in the DC position of S1 or via C2 to block the DC component in the AC position. Switch S2A-D attenuates the input signal in a 1,2,5,10 sequence. Section S2A & B attenuates the signal in a 1,10,100,1000 sequence every 3rd step. Sections S2C and D steps the input in the 1,2,5 sequence. As the two sections are cascaded the result follows a 1,2,5,10 sequence. To maintain constant AC or DC ratio the resistor dividers are paralleled by capacitors, adjusted such that the C x R value of the series arm is equal to the C x R value of the shunt arm to each step.

12.2 Vertical Amplifier. Q1 through Q8. The vertical amplifier comprises a balanced series shunt compensated stage driving a cascode deflection amplifier stage.

12. CIRCUIT DESCRIPTION (continued)

Q1 and Q2 FFT's are the input series compensated amplifiers which provide a high impedance for the input signal from the attenuator and a constant current source for the following shunt compensated stage. Input protection for Q1 is provided by reversed biased low leakage diodes D1 and D2. In the event of a positive over-voltage being applied to the input, D1 will conduct into the low impedance of C45 on the 5.6V rail, whilst D2 conducts into C17 with large negative signals.

The zener diode D3 in the sources of Q1 and Q2 changes the amplifier gain in opposition to changes of line voltage to maintain a constant calibration sensitivity irrespective of line voltage variation. To further minimise line effects on the display, Q1 and Q2 are accurately matched for both gain and operating current to virtually eliminate the effects of variations on the DC rails.

Amplifier calibration is adjusted by shunt resistor RV2, whilst positioning voltages are applied from RV1 via R17 and R18 and mixed with the input signal at the junction of Q1 and Q2 drains and Q3 and Q4 bases.

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The output cascode stage Q5 to Q5 incorporates high frequency compensation capacitor C19 located between Q5 and Q6 emitters.

CRT Y - plates are directly coupled to Q7 and Q8 collector loads whilst internal trigger take off is from the collector of Q6 via C18.

12.3 Trigger Circuit. (Q40, U40 1.C sections F.D. & C).

The signal from Q6 via C18 passes through R40 build out resistor to Q40 emitter follower. Q40 feeds one section of U40 a Hex Inverter low power TTL 1C.

Two feedback paths are used around Q40 and inverter U40F, one via R42 to maintain the average DC operating level. The second path is via D40, D41 and R41. When assymetrical signals such as narrow pulses are supplied to the trigger circuit, D40 or 41 depending on the signal polarity will conduct. C40 will be charged by the conducting diode and the resultant DC level is fed back to Q40 input via R41 to ensure the output signal is correctly biased to switch the following inverter stages U40 D & C.

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CIRCUIT DESCRIPTION (continued)

U40 D & C are connected as a Schmitt Trigger by feed back resistor R46. In operation a negative signal to pin 9 causes a H1 at pins 8 & 5 and a L0 at pin 6. This L0 is communicated back to pin 9 via R46 pulling it more negative resulting in a cumulative action which causes the output on pin 6 to switch rapidly either high or low with the input signal.

12.4 AUTO CIRCUIT. (Q41 U40 I.C Section E). Another inverter section U40 E is connected to pins 8 & 5. Its output at pin 10 swings between approx. +4V and +0.2V when a signal is present, this output voltage is doubled by C41, D42, D43 and C42 and applied to the base of Q41 clamp transistor which controls the Auto operation.

12.5 TIME BASE CIRCUIT. (U40 I.C. Sections B & A, Q43 and 44). This circuit consists of a Miller Integrator gated by a bistable switch formed by the remaining two inverter gates U40B & 40A. Operation is as follows.

Assume pin 3 of U40 is H1, pins 4 & 1 will be L0 and therefore pin 2 will be H1.

Via divider R56 & R57 D49 will conduct turning Q43 on and its drain will fall, Q44 emitter follower will follow until the junction of R66 & D50 falls below zero volts and pulls D48 into conduction. The negative fall at the drain of Q43 and hence on the cathode of D48 will continue until the current flowing through the circuit R56, D48, R66 & 67 pulls D49 negatively and reduces the +ve current through it until it equals the negative charging current supplied to Q43 gate by R60 from RV40A time base Vernier control. The circuit will stabilise in this quescent state awaiting a trigger pulse to start the time base. When a trigger signal switches pin 6 of U40C L0, the leading edge of the pulse is fed by C43 and diode D44 to pin 3 of the time base bistable. It is driven L0, pins 4 &1 go H1 and 2 switches to L0. R52 communicates this L0 back to the input at 3 latching the circuit in this state. The divider R56 & 57 now cuts off D49 and 48 leaving only the charging resistor R60 connected to Q43 gate. Current through it pulls the gate negatively causing its drain to rise. This is followed by Q44 and D50 which is connected to one end of the timing capacitors C51 to C56 thus completing a negative feed back loop around Q43 & Q44.

CIRCUIT DESCRIPTION (continued)

The negative feedback maintains a constant charging current on the timing capacitors to produce a very linear sweep waveform.

The linear rising time base waveform continues until the junction of R66 & 67 pulls diode D47 into conduction. This pulls pin 3 positive, 4 & 1 go LO, 2 goes HI and R52 feeds back the charge to the input to latch it in the HI state. Divider R56 & 57 pulls D49 into conduction and Q43 gate positive, its drain falls until D48 again conducts and the circuit is in its quiescent low state awaiting the next rigger signal.

Whilst the time base waveform is being generated pin 4 of U40B I.C. is HI, this pulls diode D45 into conduction and the selected hold off capacitor that is switched into circuit by S40A is charged to approx. +4V. Diode D44 reverse biases and prevents the pull up by D45 from affecting the state of the bistable switch.

At the completion of the sweep waveform when diode D47 resets the bistable to HI, pin 4 falls to LO, D45 disconnects and the hold-off capacitor starts to discharge through R48 & 49.

The fall will continue until a negative trigger pulse fed via C43 can force pin 3 LO and so switch the bistable circuit over to start another trace.

If a trigger signal is not received to initiate the sweep the charge on C42 in the AUTO circuit falls to zero so removing the forward bias on Q41 clamp transistor. This enables R50 to pull the junction of R48 & 49 negatively until D44 conducts and latches the bistable over to start another trace.

12.6 BLANKING CIRCUIT. (Transistor Q42).
During the retrace period when pin 2 of U40A is HI, Q42 is pulled hard into conduction through D46. Its collector falls and this is capacitively coupled to the CRT grid by C59. When the time base starts pin 2 goes LO, disconnecting D46, turning off Q42, its collector rises until the feedback current through R54 stabilises the collector voltage at approx. + 45V. The rise in voltage turns the CRT on, diode D80 clamps the rise to prevent grid current flowing in the CRT.

12.7 HORIZONTAL AMPLIFIER. (Transistors Q45 46 & 47). The input amplifier Q45 has three inputs applied to its base.

CIRCUIT DESCRIPTION (continued)

The time base waveform via RV42 and R69, the horizontal position via R70 from RV41 position control, and negative feedback around the stage via R74 when switched in by S40C.

When the time base is in use R74 is switched in circuit and Q45 has a voltage gain of ÷ 10. In the Horz. Input position of S40C, R74 is disconnected increasing Q45 gain about 8 times and the horizontal input is brought into circuit. RV40B being the gain control and R68 the build out resistor. Q45 drives Q46 & 47 CRT deflection amplifiers which are directly coupled to the horizontal deflection plates.

12.8 POWER SUPPLIES. EHT. A 550V RMS winding on T80 is voltage doubled by D81 - 84 to produce -1540V. This is applied to the CRT cathode via the divider R85 and RV82 intensity control. A further section of the divider supplies RV81 focus control.

+120V Rail. A bridge rectifier D86-89 supplies +125V to C87. The rail is further filtered by R89 and C86. The front panel LED indicator D85 is also included in this rail.

+22V Rail D90 half wave rectifies a 21V AC winding and supplies +25 to C89. R81 & C88 provide additional filtering.

-22V Rail. D91 half wave rectifies 21V AC to supply -25 to C91. R82 & C90 provide additional filtering.

+5.1V Rail. Current through the vertical output stage and Q3 & 4 are used to supply the 5.1V rail which is stabilised by U41 I.C. The controlling input voltage to pin 3 of U41 is obtained from a divider R63, R64 & RV3 between +22 and -10 which maintains a constant +5.1V over a widely varying range of power line input voltage.

13. ADJUSTMENTS AND MAINTENANCE.

WARNING

DANGEROUS VOLTAGES EXIST AT SEVERAL POINTS THROUGHOUT THIS INSTRUMENT. WHEN OPERATING WITH THE COVERS REMOVED DO NOT TOUCH EXPOSED CONNECTIONS OR COMPONENTS. ALWAYS DISCONNECT THE INSTRUMENT FROM THE POWER OUTLET BEFORE CLEANING, SOLDERING AND REPLACING PARTS.

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

Before removing the top cover, disconnect the instrument from the power line. Turn the instrument over and remove the 4 feet and the two screws in the cover. Slide the bottom cover forward to remove. Turn the instrument correct side up, remove handle screws and carefully slide the cover off vertically.

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

13.2 If the input FET's require replacing they must be replaced with a selected pair balanced for current and gain to ensure correct calibration and minimum trace movement with input line charge.

13.3 ALIGNMENT PROCEDURE. With instrument functioning and trace aligned to graticule, check the following details prior to alignment with Time Base switched to 1m Sec.

Check operation of Time Base and Vernier on each Time Base range.

Turn Time Base switch to HORZ. AMP. spot should move at least ±5cm with Horizontal Shift.

13.4 GENERAL CHECK OF CONTROLS.

(a) Intensity: Complete control over intensity range.

(b) Focus: Adjustment available either si .

(c) Vert. Position: Trace should move completely off screen above and below centre.

13.5 CRT TRACE ALIGNMENT. Feed a 1000Hz sine wave signal into the Vertical Amplifier and adjust waveform for 6cm deflection T.B. to 1m Sec. Vernier at Col.

The astigmatism preset RV81 at the rear centre of the P.C. Board is adjusted in conjunction with the focus control for the best resolution over the entire screen area with intensity adjusted to a high brightness level.

13.6 ATTENUATOR AND CALIBRATION. Test equipment required - 1kHz Square Wave Generator.

Set attenuator to 0.01V, feed in 50mV p-p (1% accuracy) square wave. Adjust RV2 for 5cm display. Vertical amplifier of oscilloscope is now calibrated.

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

Attenuator Setting	Input Voltage	Adjustment for Square Wave
0.01	50mV	-
0.02	100mV	C12
0.05	200mV	C14
0.1	500mV	C3
0.2	1V	C11
0.5	2V	C13
1	5V	C6
2	10V	-
5	20V	-
10	50V	-
20	100V	-
50	100V	-

Attenuator will be automatically aligned at attenuator positions where there is no capacitor.

13.7 VERTICAL AMPLIFIER. Test equipment required 1MHz Square Wave Generator, less than 30n Sec. rise time and constant amplitude sine wave generator.

Attenuator to 0.1V, input selector to AC, signal input 0.5V p-p 1MHz, T.B. range 0.5μ Sec, Vernier to Cal. Check square wave is a good shape. Adjustment made for response by moving the wire attached to Q8 output transistor.

Check bandwidth with a constant amplitude sine wave generator. Adjust deflection for 6cm at 50kHz, display should not drop to less than 4.2cm at 6MHz.

13.8 HORIZONTAL AMPLIFIER. Test equipment 1Hz to 1MHz Sine Wave Generator (Model bwd 141). Switch TB to Horz. Input and turn Vernier control fully clockwise.

Connect oscillator to Horizontal Input. Adjust display for 6cm deflection at 1kHz, increase frequency and note frequency when trace drops to 4.2cm length- it should be above 1MHz.

SENSITIVITY: Feed in 1kHz square wave 5V p-p amplitude, trace should be approximately 10cm long at maximum gain and less than 1mm at minimum gain.

13.9 X-Y PHASE MEASUREMENT. Turn attenuator to 1V/cm, feed in 6V p-p 1kHz sine wave to both vertical and horizontal inputs. Adjust Horz. Vernier for a 45° line on CRT, i.e. equal X-Y sensitivities. Now increase frequency, line should not open in the centre of the wave more than 3mm below 50kHz.

13.10 TRIGGER SENSITIVITY. Feed in 50kHz sine wave, time base to 10μ Sec/cm. Reduce amplitude of input signal until trace ceases to lock, this should be below 0.5cm deflection. Increase deflection to 1cm, increase frequency to 10MHz maintaining 1cm deflection . Trace should lock at all frequencies. Increase frequency to 15MHz trace can be locked with 1cm defl by use of vernier if necessary.

To check low frequency trigger use a bwd 141 oscillator. 1cm deflection will trigger to 10Hz and 2cm down to 5Hz.

13.11 TIME BASE. Test equipment required <1% accuracy generator with 1μ Sec to 0.1 Sec output in decade steps. Set Time Base Range to 1m Sec, Vernier to Cal. Feed in 1m Sec pulse to amplifier and adjust RV42 (T.B. Cal. top front of P/c board) to display 1 pulse per cm. Check the following steps with the frequency indicated and if necessary adjust RV42 for a compromise setting to obtain the minimum error at each step.

T.B. RANGE	INPUT FREQUENCY	
10μ Sec	10kHz)	all ranges set by RV42.
1m Sec	1kHz)	
10m Sec	100Hz)	

Now feed a 1MHz pulse in with T.B. switched to 1μ Sec adjust C52 for 1 pulse/cm.

Next switch to 0.5μ Sec. Adjustment for 1 pulse/2cm is made by twisting C51 standing up from the P.C. Board along side the T.B. switch.

14. REPLACEMENT PARTS

14.1 Spares are normally available direct from the manufacturer.

REPLACEMENT PARTS (continued)

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 physical size greater than the original component.

14.2 As the policy 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.

PARTS LIST - 504

COMPONENT		MANUFACTURER - PART NO.	
C1	100nF 630V 10% TYPE N	Soanar	
C2	100nF 630V 10% TYPE N	Soanar	
C3	2-6pf TRIMMER IOS	Stet-Cun.	
C4	10pf 10% 500V NPO CDS	Soanar	
C5	47pf 5% 500V N750 CDS	Allied	
C6	2-6pf TRIMMER IOS	Stet-Cun.	
C7	15pf 5% NPO 500V CDS	Allied	
C8	330pf 630V 5% STY	Allied	TCS - 606
C9	3n3 100V GREENCAP	Soanar	
C10	2.2pf 500V NPO CDS	Soanar	
C11	2-6pf TRIMMER IOS	Stet-Cun.	
C12	4-20pf TRIMMER IOS	Stet-Cun.	
C13	4-20pf TRIMMER IOS	Stet-Cun.	
C14	2-6pf TRIMMER IOS	Stet-Cun.	
C15	22pf 500V N750 CDS	Soanar	
C16	2µ2 630V CDS	Soanar	
C17	100µF 10V ELECTRO	PHILIPS	2222-016-14101
C18	2.2µF 40V ELECTRO	PHILIPS	2222-015-17228
C19	680pf 630V STYRO	Allied	TCS-610
C20	100µF 25V ELECTRO	PHILIPS	2222-016-16101
C21	100nF 63V CER DISC.		

PARTS LIST - 504 (continued)

COMPONENT		MANUFACTURER - PART NO.	
C40	22µF 25V ELEC.	PHILIPS	2222-015-16229
C41	4.7µF 63V ELEC.	PHILIPS	2222-015-18478
C42	4.7µF 63V ELEC.	PHILIPS	2222-015-18478
C43	15pf 500V NPO CDS	Allied	
C44	100nF 63V CDS	Soanar	
C45	100µF 10V ELEC.	PHILIPS	2222-015-14101
C46	4n7 100V GREENCAP	Soanar	
C47	47nF 100V GREENCAP	Soanar	
C48	470nF 35V TANTALUM	STC	TAG
C49	4.7µF 63V ELEC.	PHILIPS	2222-015-18478
C50	22µF 25V ELEC.	PHILIPS	2222-015-16479
C51	2.2pf 500V NPO CDS	Soanar	
C52	4-20pf TRIMMER	Stet-Cun.	4-20/IOS
C53	95pF N750 CDS	Soanar	
C54	1nF 100V GREENCAP	Soanar	SELECTED
C55	10nF 100V GREENCAP	Soanar	"
C56	100nF 100V GREENCAP	Soanar	"
C57	10pf NPO CDS	Soanar	
C58	1nF CDS	Soanar	
C59	33nF 1600V	PHILIPS	
C60	2.2µF 40V ELECTRO.	PHILIPS	2222-015-17228

COMPONENT		MANUFACTURER - PART NO.	
C61	330pf 10% 500V CER. DISC.		
C62	2n2 630V CER. DISC.		
C80	100 nF 630V GREENCAP	Soanar	
C81	100 nF 630V GREENCAP	Soanar	
C82	8μF 450V ELEC.	Soanar	
C83	8μF 450V ELEC.	Soanar	
C84	8μF 450V ELEC.	Soanar	
C85	8μF 450V ELEC.	Soanar	
C86	50μF 150V ELEC.	PHILIPS	2222-040-11509
C87	50μF 150V ELEC.	PHILIPS	2222-040-11509
C88	1000μF 35V RB ELEC	PHILIPS	
C89	1000μF 35V RB ELEC	PHILIPS	
C90	1000μF 35V RB ELEC	PHILIPS	
C91	1000μF 35V RB ELEC	PHILIPS	
TH1	C23 THERMISTOR	PHILIPS	
CRT	130BE/B(x) x = 1 for P1 Phosphor x = 7 for P7 Phosphor x = 31 for P31 Phosphor		STC

COMPONENT		MANUFACTURER - PART NO.		
RV1	5K LINEAR CARBON POT			SON
RV2	470Ω LINEAR PRESET POT	Pi	PT10V	GES
RV3	22K LINEAR PRESET POT	Pi	PT10V	GES
RV40	100K + 100K LINEAR TANDEM CARBON POT		ELNA	SON
RV41	100K LINEAR CARBON POT			
RV42	10K LINEAR PRESET POT	Pi	PT10V	GES
RV80	100K LINEAR PRESET POT	Pi	PT15V	GES
RV81	1M LINEAR CARBON POT			SON
RV82	220K LINEAR CARBON POT WITH DPST ROTARY SWITCH			SON
S1	ISOSTAT SWITCH SINGLE SECTION	BWD	SR80	McM
S2	ROTARY SWITCH TYPE "F" 3 DECK 12 POSITIONS c/w PC BOARD LUGS AND SHIELD			
S40	ROTARY SWITCH TYPE "F" 2 DECK 7 POSITIONS c/w PC BOARD LUGS	BWD	SR111A	
T1	TRANSFORMER T143A	BWD	T143A	

D1	IN4148
D2	IN4148
D3	BZX79 C13 ZENER
D40	IN4148
D41	IN4148
D42	IN4148
D43	IN4148
D44	IN4148
D45	IN4148
D46	IN4148
D47	IN4148
D48	IN4148
D49	IN4148
D50	BZX79 C3V3 ZENER
D51	IN4148
D80	IN4148
D81	EM410
D82	EM410
D83	EM420
D84	EM410
D85	TIL209 LED

D86	IN4004
D87	IN4004
D88	IN4004
D89	IN4004
F80	250MA Delay 3AG - 117V 100MA Delay 3AG - 265V
KNOB	K2B-G-C-D3 2off
KNOB	K1A-G-C 3off
KNOB	K1-R-A 2off
Q1	MPF106) Matched
Q2	MPF106) Fets
Q3	2N5770) Matched
Q4	2N5770) 25%
Q5	2N5770) "
Q6	2N5770)
Q7	BF337) Matched
Q8	BF337) 25%
U40	74L04
U41	741
Q40	BC547

Q41	2N4121
Q42	BC547
Q43	MPF103 FET) Selected
Q44	BC547
Q45	BC547
Q46	BF337) Matched
Q47	BF337) 25%

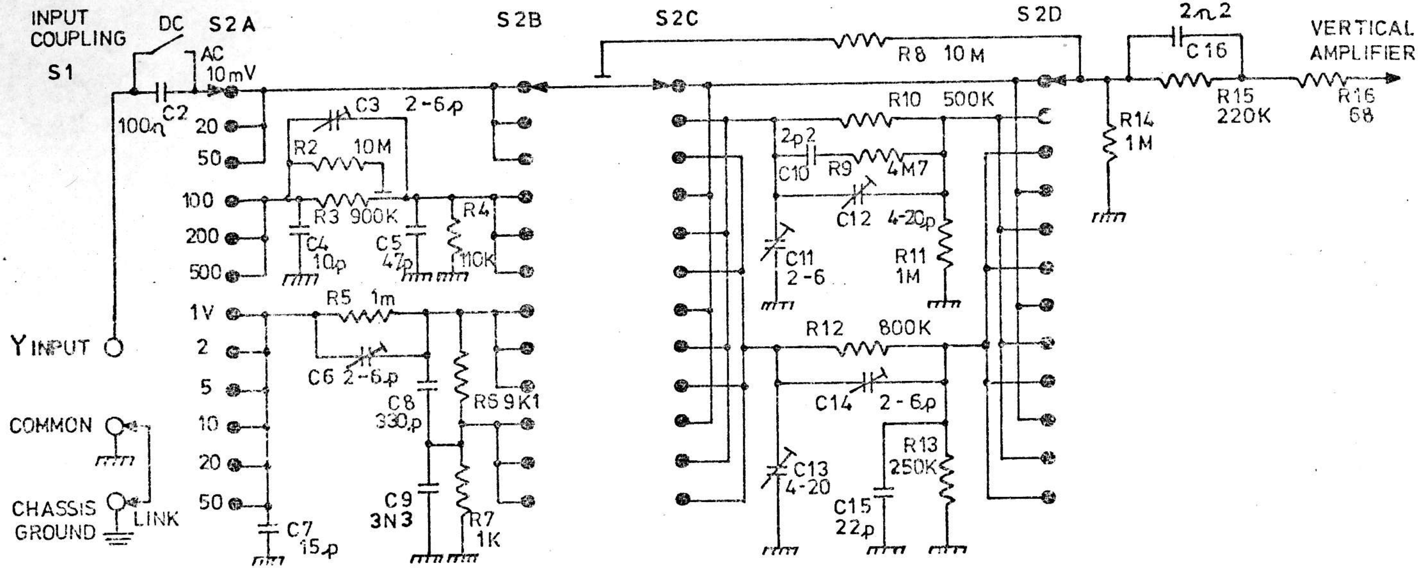
PARTS LIST - 504

All Resistors 1/4 Watt 5% Unless otherwise Indicated

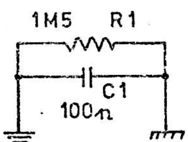
R1	1M5		R21	1K		R41	39K	
R2	10M		R22	68Ω		R42	56K	
R3	900K	2%	R23	8K2		R43	1K	
R4	110K	2%	R24	680		R44	1K	2%
R5	1M	2%	R25	1K2		R45	1K5	
R6	9K1	2%	R26	1K2		R46	22K	
R7	1K	2%	R27	680Ω		R47	100K	
R8	10M		R28	8K2		R48	1K	
R9	4M7		R29	680Ω		R49	1K8	
R10	500K	2%	R30	68Ω		R50	18K	2%
R11	1M	2%	R31	68Ω		R51	2K2	
R12	800K	2%	R32	68Ω		R52	3K9	
R13	250K	2%	R33	5K6	1.5W	R53	56K	
R14	1M	2%	R34	5K6	1.5W	R54	100K	
R15	220K		R35	68Ω		R56	5K6	
R16	68Ω		R36	68Ω		R57	56K	
R17	12K		R37	1K2		R58	12K	
R18	12K		R38	100Ω		R59	1M5	
R19	220Ω		R39	820Ω		R60	1M5	
R20	1K5		R40	1K				

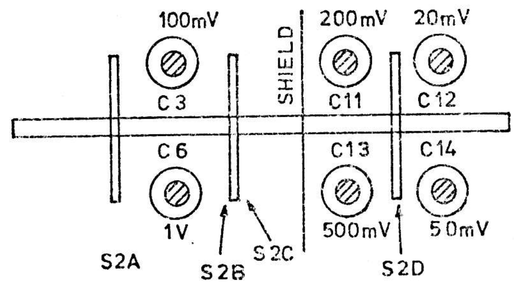
All Resistors 1/4 Watt 5% Unless Otherwise Indicated

R61	22K		R82	150Ω	
R62	100K		R83	10K	
R63	39K		R84	10M	
R64	47K		R85	22K	
R66	6K8		R86	390K	
R67	15K		R87	390K	
R68	56K		R88	2M7	1W
R69	15K		R89	220Ω	
R70	56K		R90	39K	
R71	12K		R91	22K	
R72	15K		R92	6K8	
R73	22K		R93	10Ω	
R74	2K2		R94	5K1	
R75	27K	1W			
R76	27K	1W			
R77	390Ω				
R78	4K7				
R79	1K5				
R80	5K6				
R81	100Ω				



INPUT ATTENUATOR 504

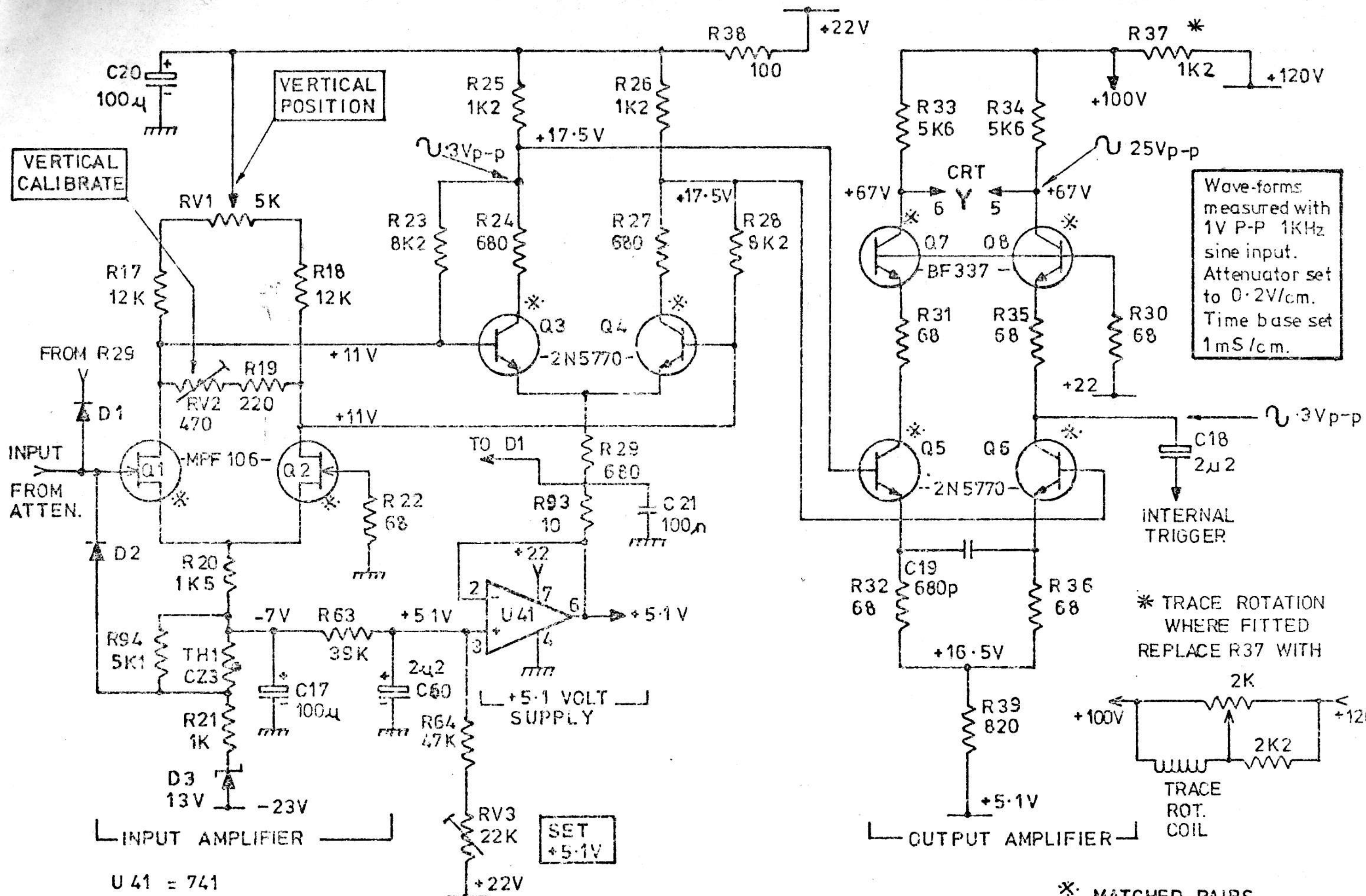




ATTENUATOR MECHANICAL LAYOUT

BWD ELECTRONICS 504-1268-3
APP. FROM S/No. 33190

BWD ELECTRONICS 504-1268-3



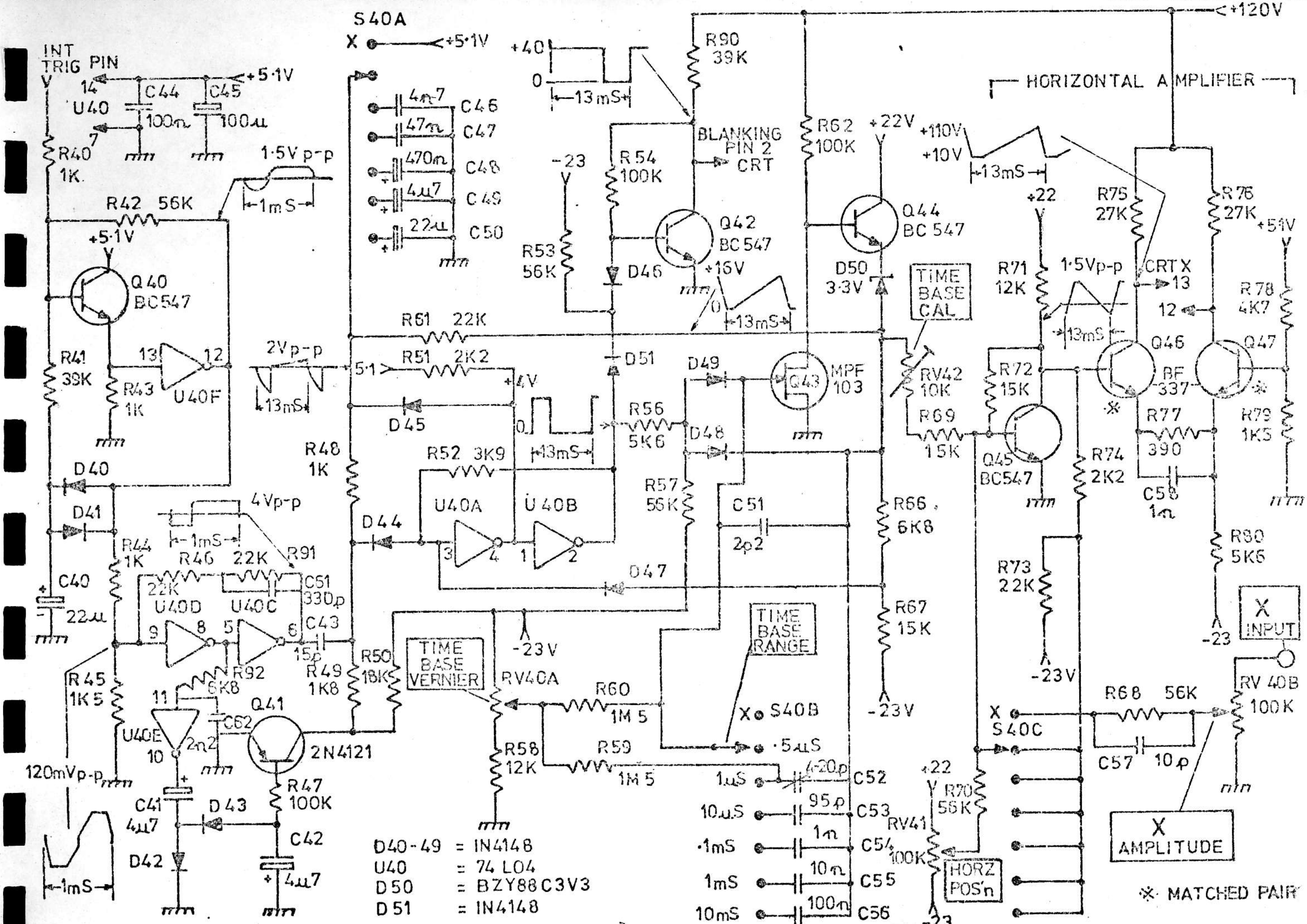
U 41 = 741

D1,2 = IN4148

APP. FROM S/No. 33190

VERTICAL AMPLIFIER 504

BWD ELECTRONICS 504-1269-3

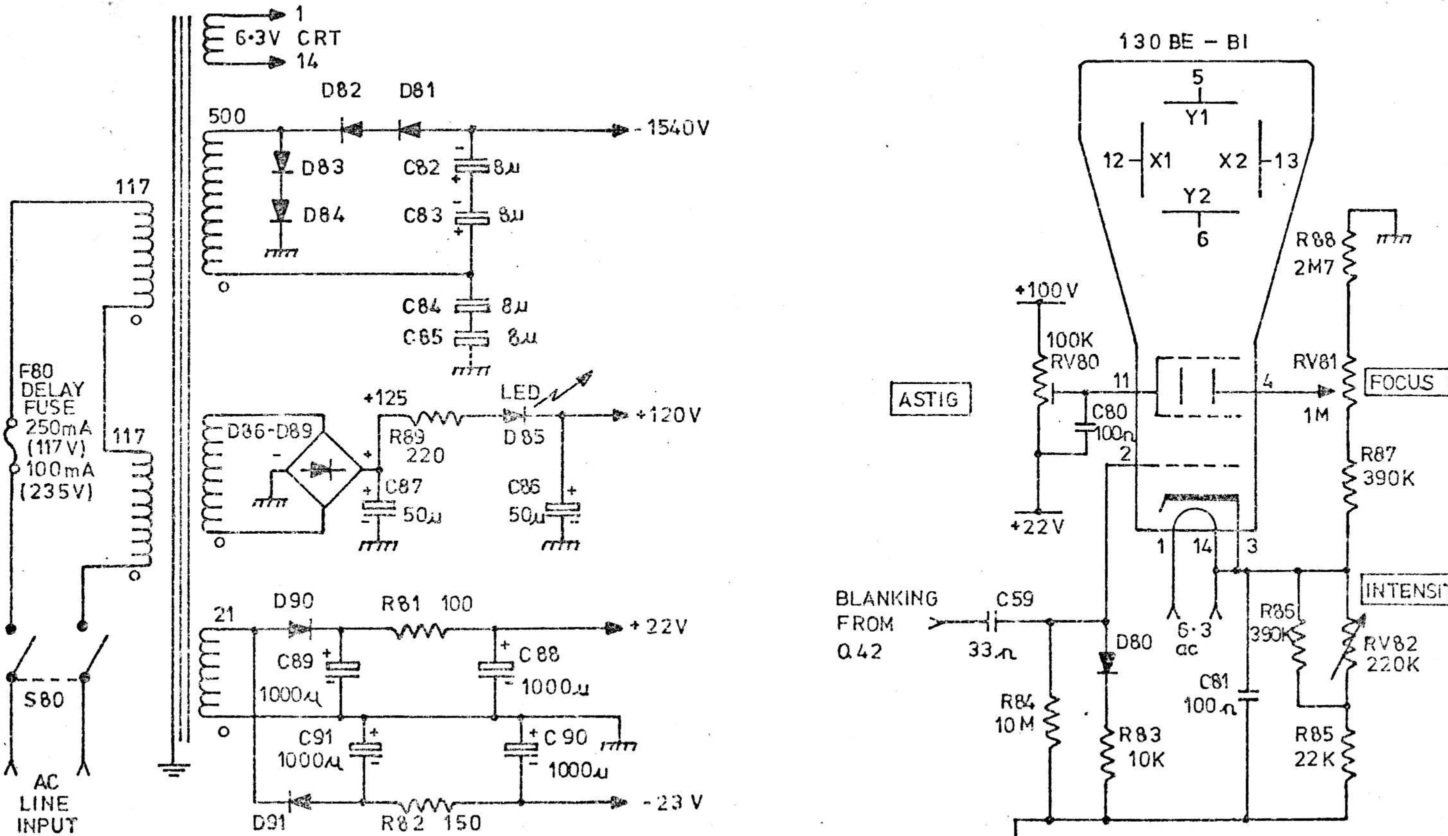


TIME BASE & HORIZONTAL INPUT

APP FROM S/No. 33190

BWD ELECTRONICS

504-1270-3



D80 = 1N 4148
D81-84 = EM 410
D85 = TIL 209A LED
D86-91 = 1N 4004

POWER SUPPLIES AND C.R.T. CIRCUIT 504

APP. FROM S/No. 33190

BWD ELECTRONICS 504-1271-3