G & E BRADLEY OSCILLOSCOPE CALIBRATOR TYPE 192

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

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PREFACE

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New or amended technical matter will be indicated by black triangles positioned in the text thus:-◀ --------- ▶ to show the extent of amended text, and thus:- ▶◀ to show where text has been deleted. When a Section is issued in a completely revised form, the triangles will not appear.

OSCILLOSCOPE CALIBRATOR 192

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ILLUSTRATIONS

SECTION 1

INTRODUCTION

1.1 The Bradley Oscilloscope Calibrator is really a number of instruments in one case, to provide the facilities normally required for calibrating modern precision oscilloscopes. It is simple to use. The operator sets the amplitude or time control to the value required, depresses the appropriate function and multiplier buttons and observes the waveform on the oscilloscope. If the trace does not coincide with the appropriate graticule, the deviation control is adjusted until it does, when the error can be read directly off the meter as a percentage. In addition to the facilities for amplitude and time calibration, outputs are available for risetime calibration and for checking synchronisation/triggering at line frequency.

1.2 VOLTAGE CALIBRATOR

An accurate DC voltage, either positive or negative or zero, or a 1kHz positive going square wave is provided for amplitude calibration of the Y amplifier.

The main voltage control switch is designed to correspond with that on the oscilloscope. It is calibrated in 1, 2, 5 steps over the range 10 microvolts per division to 20 volts per division and in use is set to the same setting as on the oscilloscope. Push button switches give X, 3, 4, 5, 6, 8 or 10 multiplication of the output so that the display may be expanded to suit the CRT graticule markings and to give a suitable picture size.

The deviation control enables the output to be adjusted until the trace coincides exactly with the graticule divisions. The meter will then indicate the percentage error.

The 1kHz square wave is crystal controlled. The voltage reference is a high quality zener diode. The amplitude accuracy is 0.25%.

1.3 TIME CALIBRATION

A high quality time-mark generator provides pulses for time calibration. This section is split into two ranges, each with its own output socket. The main range covers from 100 nanoseconds per division to 0.5 seconds per division in 1, 2, 5 steps. The time per division switch settings correspond to those on the oscilloscope and as with the volts per division switch, is set to the same setting as that on the oscilloscope. Push button switches give X 1, 2, 5 or 10 multiplication of the output so that the display may be expanded to suit the CRT graticule markings.

As with voltage calibration the deviation control varies the spacing until the waveform coincides exactly with the scale divisions. The percentage error can then be read directly from the meter.

The pulses are in spike form and have fast risetimes. The width at the base of each pulse is generally 10% of the pulse interval.

The second range provides the faster speeds of 10, 20, 50 nanoseconds. The sinewave output has no multiplication or deviation facilities.

1.4 RISETIME CALIBRATOR

An extremely fast risetime square wave output is provided for risetime measurements. The amplitude is continuously variable over the range 200 to 250mV (into 50 ohms). There is sufficient adjustment to provide a display of 4 or 5 divisions on oscilloscopes of 50mV/division without using the oscilloscope variable volts/division control.

1.5 SYNCHRONISATION/TRIGGER CHECK

A 50/60Hz sinewave output of variable amplitude is available for checking trigger circuits at line frequency.

SECTION 2

SPECIFICATION

2.1 VOLTAGE CALIBRATOR

2.1.1	Ranges	
	(a) Volts/division	$10\mu V$ to 20V in 1, 2, 5 steps
	(b) Number of divisions multiplier	X 3, 4, 5, 6, 8, 10.
2.1.2	Deviation ranges	±3%, ±10%.
2.1.3	Output Modes	AC 1kHz positive going square wave DC Positive DC negative ZERO
2.1.4	Accuracy (EMF)	Better than ±0.25%
2.1.5	Offset	Better than $\pm 5\mu V$ below 50mV. (After use on ranges on and above 50mV, a five minute settling time is required). Better than $\pm 50\mu V$ above 50mV. Note: The same offset is obtained on all output modes including zero.
2.1.6	Ripple and Hum	Better than 0.1% $+2\mu V$ p-p.
2.1.7	Square wave risetime	Less than $5\mu s$
2.1.8	Square wave overshoot	Less than 0.5%
2.1.9	Regulation (for 1MΩ load)	Varies between 0 and 0, 27% depending on setting. (Correction curve in Section C).
2.1.10	Deviation Accuracy	±1% FSD +2.5% of reading
2.1.11	Overload Protection	1 minute limit. (See para 3.11). Protection is provided against intermittent short circuit of the outputs.
2.1.12	Reference	High quality zener diode, T.C. 0.002% per °C
2.1.13	T.C. of Output (10-30°C)	Better than 0.01% per °C.

2.1.14	Line Regulation for ±10% mains	0.02% max
2.1.15	Stability	0.10% per year max
2.2	TIME CALIBRATOR	
2.2.1	Ranges	
	(a) Time/division	10nsec to 0.5sec/div in 1, 2, 5 steps
	(b) Multiplier (Number of Divisions)	X 1, 2, 5, 10 on 100nsec to 0.5secs/div only.
2.2.2	Deviation Ranges for 100nsec/div and greater	±3% and ±10%
2.2.3	Accuracy	
	(a) Crystal locked	0.01%
	(b) Deviation 3%	0.1%
	(c) Deviation 10%	0.2%
2.2.4	Amplitude	
	100nsec/div to 0.5sec/div	1.0V typical into 50Ω
	below 100nsec/div	1.0V p-p typical into 50Ω
2.2.5	Pulse shape and width	
	100nsec/div to 0.5sec/div	Spike: width at base 10% of pulse interval
	below 100nsec/div	Sinewave
2.3	RISETIME CALIBRATOR AND TRIGGER OUTPUT	
2.3.1	Amplitude	200mV-250mV continuously variable into 50Ω (400mV-500mV EMF)
2.3.2	Risetime	Less than 1nsec positive going
2.3.3	Period	1μsec to 1sec in decade steps
2.3.4	Waveform	Square
2.3.5	Overshoot	Less than 2%

2.3.6	Accuracy	As for Time Calibrator (see para 2.2.3).

2.4 50Hz SYNC. OUTPUT

2.4.1	Amplitude	Continuously variable 0-1V peak-to-peak from 2kΩ source max.
2.4.2	Waveform	As Mains supply

2.5 POWER SUPPLIES

The instrument will operate from supplies of 50/60Hz and 100/125 and 200/250 volts r.m.s., 17W.

2.6 ENVIRONMENT

Operating temperature 0°C to +50°C ambient.

Storage temperature -30°C to +70°C ambient.

2.7 SIZE

Full rack, 5.1/4" high x 12" deep overall. 133,5 mm x 304.8 mm.

2.8 WEIGHT

15 lbs 8 oz - 7.08 kg.

SECTION 3

OPERATING INSTRUCTIONS

3.1 INSTALLATION

3.1.1 Supply Voltage

Set the voltage selector plug on the rear panel to the supply voltage.

Fuse Ratings for - 200/250V operation. 0.5A (supplied.
for - 100/125V operation. 1A.

3.1.2 Supply Connection

Brown	-	Line
Blue	-	Neutral
Green/Yellow	-	Earth

3.2 FACILITIES

3.2.1 Output Connections

Five output BNC sockets are provided.

(i) Line Frequency - with continuously variable peak to peak voltage 0 to 1V sine wave for checking trigger circuits at line frequency.

(ii) Volts - Provides an accurate d.c. voltage, positive or negative or zero. Provides also a 1kHz square wave positive going output for calibration of the Y amplifier.

(iii) Time Calibration Output - Two output sockets provide normal or H.F. The normal socket provides for outputs from 100ns to 0.5 secs per division in 1, 2, 5 steps. The assosciated push buttons provide multiplication of X 1, 2, 5 or 10 to enable the display to be expanded to suit the oscilloscope CRT graticules.

The H.F. range provides the faster speeds of 10, 20 and 50ns.

The output is sinewave. No multiplier or deviation facilities are provided on this range.

(iv)	Risetime Output	- Provides an output square wave with a risetime better than 1ns. The amplitude is continuously variable over the range 200 to 250mV. Frequency is variable from 1Hz to 1MHz in decade steps.

3.3 PUSH BUTTONS

3.3.1 All front panel legends above push buttons refer to the situation existing when a button is depressed.

3.3.2 Four buttons are mechanically independent. They are press to select, press to release type.

These are:

X2	-	Voltage Divisions
X2) X5)	-	Time Divisions
ms/μs	-	Fast-Rise Period

All other buttons are mechanically linked in groups so that depressing one button releases any other button in the group.

Correct operation is obtained by depressing the required button fully so that only one button per group remains depressed.

No damage will result if all buttons are "out" or if more than one is "in".

3.4 VOLTAGE CALIBRATION

The VOLTS output provides an accurate d.c. voltage either positive or negative or zero. The VOLTS/DIV control on the 192 provides from 10μ volts to 20 volts per division in 1, 2, 5 steps.

Method

Connect the oscilloscope to the VOLTS output socket using co-axial lead with BNC terminations.

(i) Select the required range on the VOLTS/DIV switch to match the voltage range setting of the oscilloscope.

(ii) Using the mode push buttons select the required mode:

negative d.c.
zero
positive d.c.
positive going square wave

(iii) Selected the required number of display divisions by depressing fully the 3, 4 or 5 division button and if required the X2 multiplier button which is of the push on-push off type.

(iv) For a calibrated output press the Deviation 'Off' button.

(v) To measure the oscilloscope calibration error on the deviation meter, depress the Deviation V button and select the 3 or 10 per cent meter range. The indicator lamp to the right of the meter will be illuminated.

Adjust the display on the CRT to align with the graticule by rotating the Deviate Control (concentric with the VOLTS/DIV switch.) Read the percentage error directly off the meter.

3.5 VOLTAGE ERRORS

Loading

The VOLTAGE output is specified unloaded. A small error is caused by a 1MΩ load, as indicated below.

Volts/Div	Output Resistance	% Error with 1MΩ load
20V	220Ω	.022
10V or 10mV	2.72kΩ	.272
5V or 5mV	2.09kΩ	.209
2V or 2mV	1.12kΩ	.112
1V or 1mV	695Ω	.070
0.5V or 0.5mV	463Ω	.046
0.2V or 0.2mV	319Ω	.032
0.1V or 0.1mV	270Ω	.027
50mV or 50μV	245Ω	.025
20mV -	320Ω	.032
20μV	230Ω	.023
10μV	225Ω	.023

d.c. offset

At Volts/division settings of 50mV and above the output attenuator dissipates sufficent heat to produce thermo-electric offsets of a few μV on the lower settings. Therefore at least 5 minutes should be allowed for the attenuator to cool down if it has been set to 50mV/ division or above before using the low voltage outputs.

Do not use the switch on the oscilloscope itself, but use the '0' mode of the 192 voltage output to provide the zero reference for the oscilloscope, in order to eliminate any remaining thermal effect in the attenuator resistors or the interconnections to the oscilloscope.

Warm-up

The drift to be expected during the first 20 minutes is approximately .02% and is therefore of no significance for normal operation.

3.6 RISETIME MEASUREMENT

Amplitude

It is usual to measure the risetime of an oscilloscope on the range where its attenuator is in the straight through position.

The 192 Fast-rise output provides 0.25 volts into 50Ω, or 0.5 volts unterminated, and will, therefore, produce 5 divisions of defelction on oscilloscopes of sensitivities of 50mV or even 100mV per division.

The amplitude control provides variation for oscilloscopes which require 4 divisions, and for adjusting the display to the exact height, as the transient response of most oscilloscopes deteriorates when the variable volts per division control is used.

For more sensitive oscilloscopes, 50Ω co-axial attenuators should be used.

Cable Matching

The impedance of the interconnecting cable should be 50Ω ±2%.

A slight reflection which may occur due to source mismatch can be removed by a 50Ω termination at the oscilloscope input. This reflection will only be noticeable on very fast oscilloscopes, and will occur 3nsec per foot of cable after the main rise.

Another effect of a termination is to reduce the source impedance to the oscilloscope from 50 to 25Ω, which may result in a slightly faster oscilloscope risetime.

In practice the effect on the shape of response due to a terminating resistance on oscilloscopes of bandwidths up to 50MHz is not normally noticeable.

Display Perturbations

The overshoot on the positive going edge of the Fast-rise output of 2% maximum amplitude and about 1nsec duration is not visible on even a 250MHz oscilloscope. Experience has shown that any preshoot, overshoot or other positive edge or top perturbations visible on oscilloscopes of up to 250MHz bandwidth are invariably caused by the oscilloscope itself.

This contention may be verified by (a) if other fast-rise sources are available, checking that perburtations are independent of source, or (b) if other oscilloscopes or channels are available, check that substitution does alter the perturbations.

Measurement Accuracy

Before measuring the risetime of an oscilloscope the calibration of the time range to be used should be checked.

The 1nsec going edge will increase the observed risetime of a 50MHz oscilloscope (7nsec risetime) by only 1%, and therefore for slower oscilloscopes the observed risetime may be taken to be the true risetime.

For faster oscilloscopes the true risetime is given by:-

$$\text{True Risetime} = \sqrt{(\text{Observed Risetime})^2 - (\text{Source Risetime})^2}$$

The error due to taking the source risetime to be 1nsec when it differs from this by 10% is negligible (< 1%) for oscilloscopes up to 150MHz, and is 5% for oscilloscopes of 250MHz.

Measurement

Connect fast-rise output to oscilloscope input by a 50Ω ±2% BNC cable, with a 50Ω termination at the oscilloscope. If required insert 50Ω coaxial attenuators in the line to attenuate from 50mV/div to the mV/div of the range in use.

Select the desired repetition period, for example 1μsec by releasing the 'msec' button to its 'μsec OUT' position and pressing the '1' button. Use the Fast-rise amplitude control and the oscilloscope vertical level control to align the upper and lower levels of the waveform with the chosen 100% and 0% reference levels on the graticule. Measure the time difference between the 10% and 90% levels.

Bandwidth Calculation

The bandwidth of an oscilloscope may be calculated from its risetime by the formula:-

$$\text{Bandwidth in MHz} = \frac{350}{\text{True risetime, in nanoseconds}}$$

The bandwidth may be more accurately measured by a variable frequency sinewave source of known, or constant amplitude. However, unless the oscilloscope is to be used to measure the amplitudes of sinewave near to its cut-off frequency, the measurement of risetime, and observation of the transient response, are more useful in deciding what waveform distortions are caused by the oscilloscope.

3.7 TIME CALIBRATION

1. Connect the TIME output to the oscilloscope voltage input by a co-axial lead (preferably 50Ω) with BNC terminations.

2. Set the TIME/DIV switch (large knob) to the same setting as the oscilloscope timebase to be calibrated.

3. Select the desired number of divisions spacing between time markers on the oscilloscope screen by the X2 and X5 DIVS buttons. These are of the push-on push-off type and provide a choice of 1, 2, 5 or 10 divisions.

4. For a calibrated output press the 'Deviation Off' button.

5. To measure the oscilloscope calibration error, press the 'Deviation T' button, and select the 3% or 10% meter range. The indicator lamp to the left of the meter will light. Rotate the 'Deviate' control (the smaller knob concentric with TIME/DIV) to align the right-hand reference marker with the graticule keeping the left-hand marker aligned by means of the oscilloscope horizontal position control. Read the error directly off the meter.

3.8 HF OUTPUTS

When the Deviation 'Off' or 'V' button is depressed, a sinewave of 10, 20 or 50 nanoseconds period is available at the 'HF' socket.

These frequencies are fixed, and the amplitudes are approximately 1V peak-to-peak into 50Ω.

It may be necessary to terminate the connecting cable.

If difficulty in triggering the oscilloscope is encountered, an external trigger may be obtained from the TIME or Fast Rise and Trigger output, for example set to the 1μsec period.

3.9 LINE FREQUENCY OUTPUT

A sinewave of amplitudes variable from 0 to 1V peak-to-peak from a 2kΩ max. source impedance is provided at this output.

It is derived from the supply, filtered to remove higher frequency interference. This output is useful for checking the sensitivity and correct operation of oscilloscope trigger circuits.

3.10 EXTERNAL TRIGGERING

Because the frequencies of all outputs (except Line Frequency) are obtained by division from one oscillator, any output may be used to externally trigger the oscilloscope. In general the trigger frequency should be the same as or lower than the observed frequency.

3.11 OVERLOADS

<u>It is important to note that on models of Serial No. 100 to 299 the instrument is proof against overload for one minute limit only.</u>

For users who may require continuous operation in overload condition a retrospective modification is available.

3.12 EXPLANATORY NOTES ON OPERATION

3.12.1 Voltage Output Multiplier

The multiplier is arranged so that the user can obtain the number of divisions he requires directly on the oscilloscope under test without having to calculate the voltage it is necessary to apply.

For example if an oscilloscope needs 4 volts to give the required display this can be obtained by selecting 1 volt per division, the multiplier to X1 (i.e. X2 not depressed) and the division button set to 4.

Because users do not normally wish to check a display size of one division no provision has been made for this. It is not intended that the user should always take voltage off the main volts per division dial directly.

3.12.1 Time Multiplier

In this case we are dealing with period. Thus if the period is multiplied by depressing the X2 button, the period displayed on the oscilloscope would be twice as great as with no multiplier depressed (i.e X1). Thus if the period is multiplied, the frequency is divided. This is logical since the oscilloscope ranges are calibrated in period.

3.12.3 Time-base Calibrating Waveform

The time output gives spikes from 0.5 sec (extended to one spike over 5 secs when using the multiplier) up to 1μs but after the 1μs position there is some degradation in the shape of the spikes so that at the 0.1μs position the waveform tends to look more like a sine wave.

This "degradation" in no way affects the use and application of the calibrator since the time accuracy is maintained and each waveform has edges or points which are sharp and well enough defined to allow accurate alignment with the oscilloscope graticule, (see photograph, page 14).

3.12.4 Fast Sine Wave Outputs

The 10, 20 and 50ns HF outputs are sinewaves. This is usual in time-mark generators operating at this high frequency. The comments made in the previous paragraph also apply. These waveforms are more than adequate for checking time-base accuracy and should give no operator difficulty.

3.12.5 % Deviation

In 3.4 and 3.7 the error mentioned is in the <u>deflection factor</u> of the oscilloscope. For example, when calibrating the 1V/cm range if the deviation reading is +25% when the display is aligned with the graticule, 1.25V is being supplied to the oscilloscope and its deflection factor is 1.25V/cm and the oscilloscope is in error by +25%.

When a true 1V is supplied to this oscilloscope it will read $\frac{1V}{1.25} = 0.8V$. It is a common misunderstanding to say that the oscilloscope "reads low" therefore its error is negative, in this case -20%. This would be true if the oscilloscope were calibrated in cm/V instead of V/cm.

When using the calibrated oscilloscope to measure an unknown voltage the convention that the oscilloscope "reads low" is of no interest. The operator observes the display (say 2.4cm) multiplies by the deflection factor (1 volt +25%) to give the true level at 3 volts.

A related confusion may occur when checking the accuracy of time deviation of the 192. The deviation meter is calibrated in terms of period, and an error will be indicated if checked as a frequency.

For instance +10% error in time/cm or period is $\frac{100}{110} = .909$, i.e. -9.1% in frequency.

3.12.6 Push Button Selection - Valid and Invalid Outputs

<u>White Buttons</u>

It is stressed that a valid output is obtained whatever the positions of the white buttons. For example on the time-side if the X2 and X5 buttons are depressed at the same time the output is multiplied by 10. If no white button is depressed the output is as selected on the rotary control. Any combination may be used to give the desired output.

<u>Black Buttons</u>

For a valid output a least one and no more than one black button of the group must be depressed. If none or two or more are depressed the output will be invalid.

FAULT FINDING GUIDE

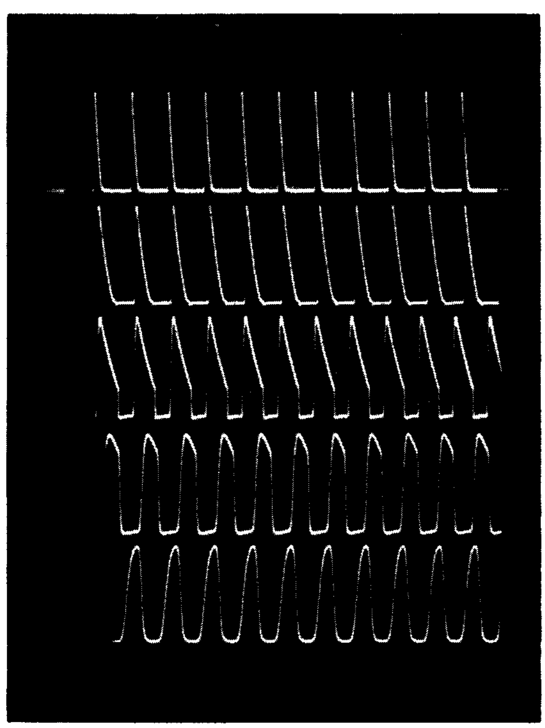
1. Meter Not Centred When Deviation Is Off

This indicates that the time section is not calibrated. Probably due to maladjustment of C415 or RV470 (LOCK).

2. Meter not Sweeping Cleanly Between End Stops on 10% Time Range

First ascertain whether the PERIOD deviation of any time output agrees with the meter by measurement using an oscilloscope, or preferably a counter. If it does not agree and still deviates correctly the fault is in section 700. Check that the 1MHz signal on the right hand side of R744 has a 50-50 mark to space ratio ±5%. If not change the value of R745 until it does. If the needle reverses, or stops at the centre, the fault if in X710, 720, 730 or X510b.

If it does agree the fault is in the variable master oscillator TR430/440 or the divider chain section 500. If the oscillator supply has incorrect deviation range, adjust RV434 (-LIM) for the negative meter excursion (it should just touch the end stop on the 10% range). Then adjust RV472 (+LIM) for the positive excursion.



1 — 2μs
2 — 1μs
3 — 0.5μs
4 — 0.2μs
5 — 0.1μs

A photograph of an oscilloscope display showing Waveforms at different time bases.

SECTION 4

TECHNICAL DESCRIPTION

4.1 VOLTAGE FUNCTIONS

TR104A and TR104B are the two halves of a long tail pair which sense the difference in potentials between the negative end of the reference zener D113 and the virutal earth point of the reference chain (R119 to R127).

The difference is amplified and fed via emitter follower TR103 and series regulator TR102 to control the collector potential of TR107. The reference chain itself is supplied from the positive end of the reference diode D113. The output voltage is determined by the ratio of the resistance either side of the virtual earth point. Resistors selected by the DIVS switch S102, fix the ratios so that for settings of 3, 4, 5, 6, 8 and 10 DIVS, the voltages at collector TR107 are 60, 80, 100, 120, 160 and 200 volts respectively.

Voltage deviation is provided either by injecting or by extracting current from the reference chain at the virtual earth point for positive or negative deviation respectively. The DEVIATION control RV101 connected via switch S702 enables the current in the lower limb of the reference chain and the final voltage output to be varied by ±10%.

TR107 is normally in a saturated mode to provide a low and stable voltage drop from the stabilised line to the output. TR108 forms a switch which enables the output to be modulated by a 1kHz square wave derived from the TIME board. For the high state of the square wave voltage output, TR108 is off and TR107 is saturated. In the low state, TR108 is saturated and TR107 is off.

In the low voltage state at the 20 VOLTS/DIV setting, transistor TR109 eliminates small errors caused by reverse current flow into the VOLTS output socket from the oscilloscope blocking capacitor. TR109 becomes effective only when the calibrator is used in the square wave mode and the oscilloscope under test is AC coupled.

Four voltage modes are available.

(i) Positive DC level.

(ii) Positive going square wave derived from the positive DC level.

(iii) Negative DC level, by operation of the polarity change-over switch.

(iv) Zero voltage - obtained by shorting the input end of the attenuator.

The voltage output socket is insulated to allow the circuit to float about one end of R152 to earth. This reduces the effect of stray earth loops between the oscilloscope and the calibrator which would otherwise appear as noise on the oscilloscope trace.

4.2 TIME FUNCTIONS

Multivibrator TR430, 440 with centre frequency of 20MHz (50μsec period) is the variable master oscillator providing signal frequencies via the divider chain X510a to X590.

The time deviation control varies the period of the multivibrator by ±10%. The deviation is measured by X710, 720, 730 which drive the meter (with reference to the 1MHz crystal oscillator X740.) When time deviation is switched off, power is supplied to the 100MHz crystal oscillator X411, TR410, which then locks the multivibrator to 20 MHz.

4.2.1 Variable Master Oscillator

The Master Oscillator, comprising TR430 and TR440 is an emitter-coupled multivibrator, whose timing capacity is provided by D430/C440. With TIME DEVIATION ON RV741 (or with TIME DEVIATION OFF, RV470) enables the d.c. voltage to D430 to be varied, thus varying the capacitance. RV472 limits the positive excursion of this variable voltage to restrict the maximum positive period deviation.

Filter network R472, C474 and R474 reduces any time jitter of the multivibrator. RV434 adjusts the period of the multivibrator by varying the amplitudes of the ramps at the emitters of TR430 and TR440.

RV430 adjusts the mark to space ratio, to virtual unity to ensure the best safe locking range for synchronisation with the 10nsec sinewave supplied to TR430 base.

The multivibrator is synchronised on each half cycle, i.e. every 2.1/2 cycles of incoming signal. This technique doubles the safe locking range compared with the conventional method of synchronisation.

4.2.2 Time Output

The 20MHz signal from the variable master oscillator is a.c. coupled to the type D flip-flop X510a, to which feedback is applied so that it divides by two, providing 10MHz, or 0.1μsec period. X520 then divides this signal by 5, giving a 0.5μsec period. The next six stages, X530 to X580 each divide by two and five in series, providing the output 1, 5, 10, 50μsec et seq: to 0.5 sec

These signals are brought out ot the TIME/DIV switch S500, and directly selected by wafer 4F when they coincide with the required output. Signals of periods divisible by two are generated by the ÷ 2 section of X520 from the frequency, selected by wafer 4R.

Wafer 3 connects either the direct signal from 4F, or the divided by two signal from X520. The output from wafer 3 coincides with the output selected on the TIME/DIV switch.

When the oscilloscope Time/Division setting coincides with that of the 192, the number of divisions between markers is selected by S601, S602, which switch into the path the ÷ 2 and ÷ 5 sections of X610 as required.

The signal is then "cleaned up" by TR630 and the positive edge is differentiated by C651 to C661. The current drain is provided by R642 (attenua ed also by R641).

D642 conducts in the quiescent state and removes the negative differentiated edge. R643 limits the current through D642.

D640 and D641 raise the voltage at the base of TR640 so that it is on the verge of conducting in the quiescent state.

Emitter follower TR460 provides the low impedance necessary to drive the capacitance of a coaxial cable. R647 provides matching for a 50Ω cable.

4.2.3 Time Deviation Measuring Circuit

This circuit is similar to the normal pulse counting frequency measuring circuit, in which pulses of constant amplitude and width are integrated to provide a d.c. output proportional to their frequency.

Type D flip-flop X710a subtracts the variable frequency, (nominally 1μsec period), of X530 from the fixed 1MHz of crystal oscillator X740. X710b, acting as the second stage of a shift register. repeats the output of X710a, delayed by one period of the variable 1MHz.

The connections to AND gates X730 from X710a Q and X710b $\overline{Q}$ provide a pulse whose width is equal to one period of the variable 1MHz, and whose prf is the difference frequency.

Assuming that logical 1's are present on the other two connections to X730a for the duration of this pulse. The gate output is the free collector of a grounded emitter transistor. When the pulse is present, current flows from the +5V supply via the 3% switch S701, through two arms of the resistor network. When the 3% range is selected the current flows through R703 and R704. One of these current has to flow through C730 which has a very large capacitance to filter the a.c. component so that negligible voltage drop occurs and only the d.c. component of this pulsed current passes through the meter.

Thus:

$$\text{Meter Current} \propto \text{pulse width x prf.}$$

$$\propto Tv\ (fo - fv)$$

$$\propto Tv\ \left(\frac{1}{To} - \frac{1}{Tv}\right)$$

$$\propto \frac{(Tv - To)}{To}$$

$$\propto \text{Percentage period deviation}$$

Polarity information is provided by X720. X720b provides an output at the variable 1MHz frequency but 90° out of phase with that from X530. X720a subtracts this from the crystal 1MHz, producing a similar output at the difference frequency, but again 90° out of phase. Thus whilst X710 generates a pulse X720a will be providing steady outputs, and will open either X730a when the variable 1MHz signal is higher than the crystal frequency or 730b when the signal frequency is lower than the crystal frequency.

At vey low difference frequencies the slightest frequency or phase modulation on either of the input frequencies will cause multiple pulsing giving jitter of the meter needle when close to zero. X510b is clocked on the negative edge at X710a Q output and reads the information on X720a, but supplies it to gates 730 by crossed connections. Both gates are thus "cut off" unless X720a changes after X710a Q falls. However ragged the edges of the difference frequency squarewave, there can be only one pulse per cycle of the difference frequency.

4.2.4 1MHz Crystal Oscillator

This circuit provides a nominally symmetrical output without over-driving the crystal to reduce the risk of operation at an overtone.

Both positive and negative inputs of X740 are biased at 0V. R741 provides the positive bias, the negative bias is provided by negative feedback through R742/C742.

The output voltage attenuated by R744 and R742, drives the crystal which is operated at series resonance to provide positive feedback. The current path is completed through R742, C742 and R741.

There is negligible d.c. drop across R742 because only the small input bias current is passed. The quiescent output voltage is therefore +1.4V matching the logic threshold voltage. This also ensures that the oscillator is self starting.

4.3 HIGH FREQUENCY OUTPUTS

When time deviation is switched off, S703 supplies -10V to the 100MHz (10nsec) crystal oscillator TR410, locking multivibrator TR430, 440 to 50nsec. S703 also supplies -10V to S401, S402 and S403. S401 allows sufficient current to pass via R419 to open diode gate D419 for the transmission of a 1V peak-to-peak sinewave from the winding on L414, via C419 to the output.

S402 supplies -10V to the 20nsec oscillator TR420 and at the same time opens diode gate D429. TR420 is locked to the correct frequency by the 10nsec oscillator via R423 and C423.

Similarly S403 powers the tuned amplifier TR450 which converts the square wave from the multivibrator to a sinewave.

S401, S402 and S403 are mutually cancelling so that only one output is present.

4.4 TRIGGER/RISETIME

S801 and S804 select the required frequency from the divider chain decade outputs from X530 to X590. X590 is an extra ÷ 2 stage providing 1 sec period for trigger purposes.

Output transistor TR850 is used in common base to provide the minimum break through of unwanted fast signals and purturbations to the output. The calibrating edge is the positive one produced as the transistor turns off, and its collector voltage rises to ground potential. The top of this waveform is thud free from droop. Overshoot may occur in the output loop due to the inductance and the collector base capacitance. R854 and R855 are therefore included to damp the loop beyond the critical point, to prevent overshoot.

TR850 is driven from common base transistor TR840, also with collector circuit damping resistor. R844 and TR830 provide further isolation of the output from noisy parts of the circuit.

Inverters TR810 and TR820 provide sufficient speed and drive for TR830. The components between them improve the turn off drive to TR820 and slow the negative edge at the output.

4.5 POWER SUPPLIES

Both supplies are regulated, the +5V being reference to the -10V.

RV961 provides the major part of the bias current for zener diode D96 from the stabilised -10V. R963 and D961 ensure that the circuit is self starting. R934 and R974 limit the available base currents for the output transistors, providing short-circuit protection of the supplies.

4.6 LINE FREQUENCY OUTPUT

The Line frequency output is taken from the mains transformer and filtered by R160/C120 to provide a clean sinusoidal output suitable for checking trigger circuits of the oscilloscope under test.

SECTION 5

SERVICING AND ADJUSTMENTS

5.1 GENERAL

Before attempting to trace a fault or effect a repair read the Technical Description given in Section 4.

This section together with Section 4 is intended to provide the user with sufficient information to allow most repairs and to allow calibration of the instrument after servicing.

5.2 MECHANICAL DETAILS

To remove the top cover loosen the two screws on the rear upper face of the cover. The cover is lipped front and rear. Release the front lip by easing the cover forward. The cover can now be lifted clear of the rear lip and removed.

This gives access to the main board and to most of the major components.

If it should become necessary to replace a component on the printed circuit board the bottom cover may be removed by undoing the four screws in the cover, do not remove the small feet. Access can now be gained to the underside of the main board.

5.3 TEST EQUIPMENT

1. Variac

2. Avo Model 8 or 9.

3. Bradley Multimeter.

4. DC Differential Voltmeter. Fluke 895A.

5. Oscilloscope - Tektronix with 5mV plug in unit also capable of accepting the ISI sampling unit.

6. BNC to BNC cable. 3 ft length 50Ω ±2%.

7 Flexible leads with small probe clips. (Radiospares or similar).

8. BNC to Banana type conversion piece UG5 14/U.

9. Low voltage d.c. supply 1V d.c. I.E. or similar.

10. 2.2MΩ resistor ±2% insulated body with stiff insulated flying leads.

11. 1MΩ resistor ±2% wired across a BNC plug and fully insulated.

12. BNC T piece.

5.4 TRANSFORMER CONNECTIONS

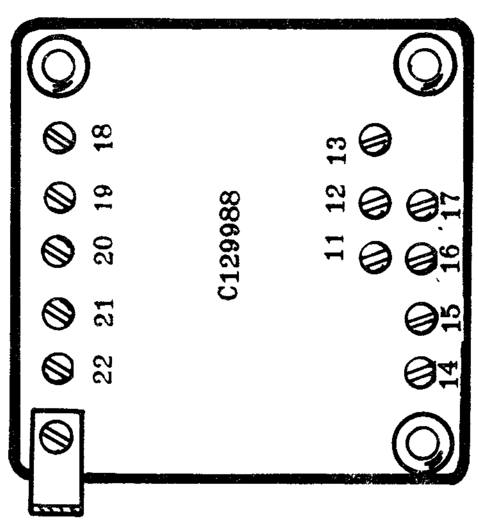
Checking the Mains Transformer Secondary Voltages.

1. Adjust the voltage selector for 250V.

2. Connect the multimeter (3) set to 40V a.c. across the transformer high voltage terminals No. 14 and 15.

3. Supply the unit with 25V 50Hz from Variac (1) monitoring the supply to the instrument with Avo (2).

4. Switch the instrument ON and note the reading on meter (3). Let this voltage be E.



MAINS TRANSFORMER

5. Repeat 3 and 4, supplying the instrument with 1/10 of nominal selector panel voltage for all other voltage selector panel settings.

   Verify E does not vary by more than 3.5%.

6. Check at any one of the settings that the secondary voltages are approximately as follows·

Trans Pins	Voltage
14 - 15	22V
16 - 17	1.5V
21 - 22	1.5V
18 - 20	1.5V

TIME CALIBRATION

5.5 Power Supplies (use Multimeter, Variac).

1. Set mains voltage selector to 240V.

2. Apply 210V

3. Switch Power On, check that lamp lights.

4. Select 'Deviation Off'.

5. Adjust RV951 to give +5.00V at TR940 collector.

6. Read ripple at same point. 1.5mV max.

7. Read voltage at TR980 collector. -10V ±0.5V.

8. Read ripple at same point. 2.5mV max.

9 Reset mains voltage to 240V.

5.6 TIME OUTPUTS (Using the 30MHz Oscilloscope)

1. Connect the instrument to the oscilloscope using the 50Ω BNC lead with T-piece at oscilloscope. Switch 192 Time/Div to 0.1μsec and select x5 divs.

   Switch oscilloscope to 1V/cm and 0.1μsec/cm.

2. Select Deviation 'T'. Turn 'Deviate" fully anti-clockwise. Set 'BAL' RV430 midway. Adjust '-LIM' RV343 to give about 4.4 cms between pips.

3. Turn 'Deviate' fully clockwise. Adjust '-LIM' RV472 to give about 5.6 cms between pips.

4. Adjust 'Deviate' until the meter reads approximately zero. Adjust oscilloscope horizontal control so that the three pips roughly line up with the graticule end and centre.

5. Switch the two Time/Divs anti-clockwise keeping each in step. Allowing for oscilloscope errors, check that the spacing remains constant on all ranges. It is important to check that the concentric Deviation control is not dragged round whilst switching by observing that the meter needle remains at zero.

6. Return both switches to 0.1μsec. Press the x2 Divs button. Check that the spacing becomes 10cm. Release both x2 and x5. Check that the spacing is now 1cm.

7. In this test the amplitude at all settings of the Time/Div switch must be between 1.5 and 2.5V. Rotate the 192 Time/Div switch three steps to 1μsec, so that the spacing is 10cm. Then rotate both switches two steps to 5μsec on the 192.

   Rotate both switches a further 10 steps to 10msec on the 192. Check that the base width is 1cm ±30% in each case. (The spacing should remain at 10cm).

8. Add 50Ω termination at the oscilloscope. Check that the amplitude is reduced by a factor of two.

5.7 FAST RISE SQUAREWAVES (using 30MHz Oscilloscope)

1. Connect the 192 to the oscilloscope using the 50Ω BNC lead terminated in 50Ω. Set oscilloscope to 50mV/cm. (Ensure that the oscilloscope is correctly calibrated).

2. Select 1μsec period by releasing the 'mS' button and depressing the '1' button. Set oscilloscope to 0.1μsec. Observe the squarewave 10cm period, amplitude varaible over the range 0.180 to 0.275 volts.

3. Switch oscilloscope Time/cm 3 steps each time, selecting 10μ, 100μ, 1m, 10m, 100m and 1 Sec in turn. Check that period remains at 10cm.

5.8 TIME DEVIATION (Using Crystal Oscillators or a Counter/Timer)

1. Check meter zero with Power Off and Time Deviation selected.

2. Switch Power on, select 3% range.

Set Deviation to -2.5% either by:

(a) locking to crystal oscillator frequency, or by

(b) adjusting Deviation control, measuring the period in μsecs of the Fast-Rise output at 10msec.

Adjust -3% range potentiometer, RV703 so that meter reads -2.5%.

3. Set Deviation to +2.5%, adjust 3% range potentiometer RV704 so that meter reads +2.5%.

4. Select 10% meter range, set Deviation to -8% and adjust the meter to this value by adjusting -10% potentiometer RV710.

5. Set Deviation to +8% and adjust meter to this value by adjusting the +10% range potentiometer RV711.

6. Select 3% range, check -2.5% and +2.5% points.

Readjust if necessary.

5.9 HF OUTPUTS (Using the Sampling Oscilloscope).

1. Select Time Deviation 10% range. Adjust BAL to give the most -ve meter reading.

2. Set the sampling oscilloscope to 200mV, 10nsec/cm. Connect the 192 HF output to 50Ω input of sampling unit, using the 50Ω BNC cable with GR adaptor.

3. Select Deviation Off and HF output to 10nsecs. Starting from minimum capacitance point, adjust C415 clockwise to give a sinewave of maximum amplitude 10nsec. Back off to reduce peak to peak amplitude by about 20%.

4. Adjust "LOCK" potentiometer RV470 so that Deviation needle goes to the centre of the scale. Temporarily remove BNC lead from 192. Check that the needle remains at the centre of the scale.

5. Select 20nsecs. Adjust C425 to centre of safe range. TAKE CARE.

6. Select 50nsecs. Adjust LOCK to keep the needle at centre of the scale. Adjust C455 to give nearly maximum amplitude where waveform is clearer.

7. Choose the best position of the BALANCE to allow the maximum anti-clockwise rotation of LOCK with the meter needle remaining locked at centre.

Note the range of the LOCK potentiometer for which the needle remains locked. It should be about half a turn or more. Set LOCK to centre of this range.

8. Select Time Deviation 10% range. Turn 'Deviate' control fully anti-clockwise. Turn '-LIM' clockwise to bring the meter needle on the scale, then back it off until the needle just rests on the left end stop.

9 Turn 'Deviate' fully clockwise. Turn '+LIM' anti-clockwise to bring the needle on the scale, then back it off until the needle just rests on the right end stop.

10. Check that the 'Deviate' control sweeps the needle smoothly across the meter, with less than 20° excess rotation at each end.

11. Select Deviation Off and check that the needle remains centred for 10, 20 and 50 nsec outputs both with the sampling oscilloscope connected and with the lead disconnected from the 192 HF output.

5.10 FAST-RISETIME (using sampling oscilloscope)

1. Connect 192 output to sampling oscilloscope 50Ω input. Set 1μsec period, and sensitivity of 50mV/cm on the oscilloscope.

2. Adjust 192 amplitude control to give exactly 5cm. Measure the risetime of the positive edge over centre 4cm (10 to 90%). Allow for the oscilloscope risetime which should be known. Use the table to give true risetime. Record this. Limits : 1nsec max.

3. Set the oscilloscope sensitivity to 2nsec/cm and 5mV/cm. Measure overshoot on positive edge. Scale is 2%/cm. Limits : 2% max. Check that the overshoot remains less than 1cm for any position of the 192 amplitude control.

5.11 VOLTS CALIBRATION

RESISTANCES (Using Multimeter Ωx100 range)

1. Switch Power Off.

2. Measure resistance across outer insulated band of VOLTS output socket. Limits 100Ω ±20%.

3. Measure resistance across normal inner to outer of VOLTS socket. This should be 220Ω at 10μV increasing on each range to 3.2kΩ at 10mV. (Allow for multimeter error).

5.12 SUPPLIES and SHORTED OUTPUT (Using Multimeter)

1. Switch multimeter to 400V DC range. Apply 240V ±1V mains (AVO). Set mains voltage selector to 240V.

Select:	Volts/Div	20
	Mode	+
	Divs	10
	Deviation	Off

Output voltage to be +170 to +230V

2. Switch multimeter to I DC thus shorting output. Limits 31 to 37mA.

3 Switch back to 400V DC and check that the voltage returns.

4. Select: Mode 0.

Record the voltages across·

	Limits
C104	300 to 350V
C105	16 to 19V
C106	18.3 to 21.3V

(All +ve to left hand end of instrument).

5.13 REGULATION (Using DC Differential Voltmeter Fluke 895A)

1. Supply the unit with 240 ±1V r.m.s. from variac (1) using the AVO (2) to monitor the voltage.

2. Select: Mode + (positive).

3. Monitor the VOLTAGE output via T piece, BNC lead and adaptor (8) with Fluke set to 200V and 100mV full scale. Adjust RV104 to centre the meter ±20mV. RECORD voltage.

4. Reduce the variac output so that the AVO reads 216V ±1V. RECORD change in output.

Limit: 40mV max.

5. Reset the variac to 240V.

6. Connect the 1MΩ termination (11) onto the T piece. RECORD the fall in output voltage.

Limit · 0.1V max.

5.14 VOLTAGE DEVIATION (Fluke)

1. Select· Deviation Volts.

2. Select the 10% deviation range and adjust the voltage output using the DEVIATION control, to 220V ±40mV measured on meter 4.

3. Adjust RV102 so that the meter needle reads FSD on the 10% scale readjusting the DEVIATION control if found necessary to maintain 220V ±40mV.

4. Turn the deviation control anticlockwise until the meter reads -10%. Measure the voltage output and calculate the deviation from 180.00 volts. Let this voltage be E_D. The voltage E_D must not exceed ±0.6 volts.

5. Turn the DEVIATION control slightly to bring the output voltage nearer to 180.00 volts by shifting the voltage by half the calculated deviation $E_D/2$ determined in para 4 above.

6. Readjust RV102 to obtain -10% on scale (FSD).

7. Turn the DEVIATION control clockwise so that the meter reads +10% (FSD). Measure the output voltage and verify that the voltage is 220V $\pm E_D/2$ ±100mV approximately.

   i.e. in the range 220.40 to 219.60 volts.

   NOTE: Tests 5 - 7 are not necessary if E_D is less than 100mV.

8. Select 3% voltage deviation range and adjust the deviation control so that the instrument meter reads +3% (FSD) on the 3% scale.

9. Adjust RV103 so that the voltage output indicated on meter (4) reads 206V ±20mV

10. Turn the DEVIATION control anticlockwise so that the meter reads -3% (FSD). Measure the voltage and calculate the deviation from 194.00V. Let the voltage be V_D. This deviation voltage should not exceed 0.2 volts.

    NOTE: Tests 11 and 12 are not necessary if V_D <40mV.

11. Readjust RV103 to bring the output voltage nearer to 194.00 volts by shifting by an amount $V_D/2$.

12. Turn the DEVIATION control clockwise so that the meter reads

+3% (FSD). Measure the output voltage and verify that it is 206 $\pm V_D/2$ ±40mV approximately, that is 206.120 to 205.88 volts.

5.15 ATTENUATOR RATIOS (Using DC Differential Voltmeter Fluke 895A)

1. Select: Deviation Off.

   RECORD output voltage

   Readjust RV104 to give 200V ±20mV.

2. Taking care not to touch any high voltages on the voltage attenuator, connect Fluke 895A (4) via flexible leads (7) across R146 and R147 in turn and note the readings.

   Solder resistors according to the following table across R146 and R147.

   If V_m is the measured voltage and E is the error from the required voltage in mV.

   $$E = (V_m - 100) \text{ mV}$$

	Measured Voltage	FOT Required	TOL Required
R146	V_m = 100mV + E	$500/_E$	$5/_E$
R147	V_m = 100mV + E	$500/_E$	$5/_E$

where E and V_m are in mV.

   Switch the instrument off when fitting FOT resistors.

3. RECORD the voltage across R146 and R147 and verify that they are 0.1V ±100μV after a period of 5 minutes with the instrument ON.

4. Connect Fluke 895A (4) to the VOLTAGE output socket via co-axial lead (6) and adaptor (8).

5. RECORD the voltages at the following switch positions and verify that they fall within the required tolerance.

MODE	DIVS	VOLTS/DIV	VOLTAGE MEASURED	OUTPUT LIMITS
+	10	20		200V ±20mV
+	10	10		100V ±100mV
+	10	5		50V ±50mV
+	10	2		20V ±20mV
+	10	1		10V ±10mV
+	10	0.5		5V ±5mV
+	10	0.2		2V ±2mV
+	10	0.1		1V ±1mV
+	10	50mV		0.5V ±500μV

6. Select 20mV/DEV with VOLTS/DIV switch and adjust the output voltage to 0.2 volts ±20μV by RV106.

7. Select: Mode - and 20V/Div. Verify that the voltage is -200V ±20mV.

5.16 OPTIMUM REFERENCE SETTING (Using DC Differential Voltmeter Fluke 895A).

1. Select: Volts/Div 20
   Mode + (positive).

2. RECORD the errors for all DIVS settings in the following table under "Initial Errors, mV".

3. Plot a graph of error against nominal voltage as shown in Fig.A. (to be found at the end of this section).

4. Rule two lines A and B from the origin (0 volts) through the plots that provide the two extreme values of slope.

5. Draw a vertical line at 200 volts. Measure the difference between the two intersections with the slope lines A and B. RECORD under "Error spread, mV".

6. Mark off the centre point between the two intersections. RECORD the value under "Mean Error, mV".

7. Change sign of Mean Error and add to initial 200V error. RECORD under "Final 200V Error".

8. Select: Divs 10.

   Adjust 200V error to "Final error"

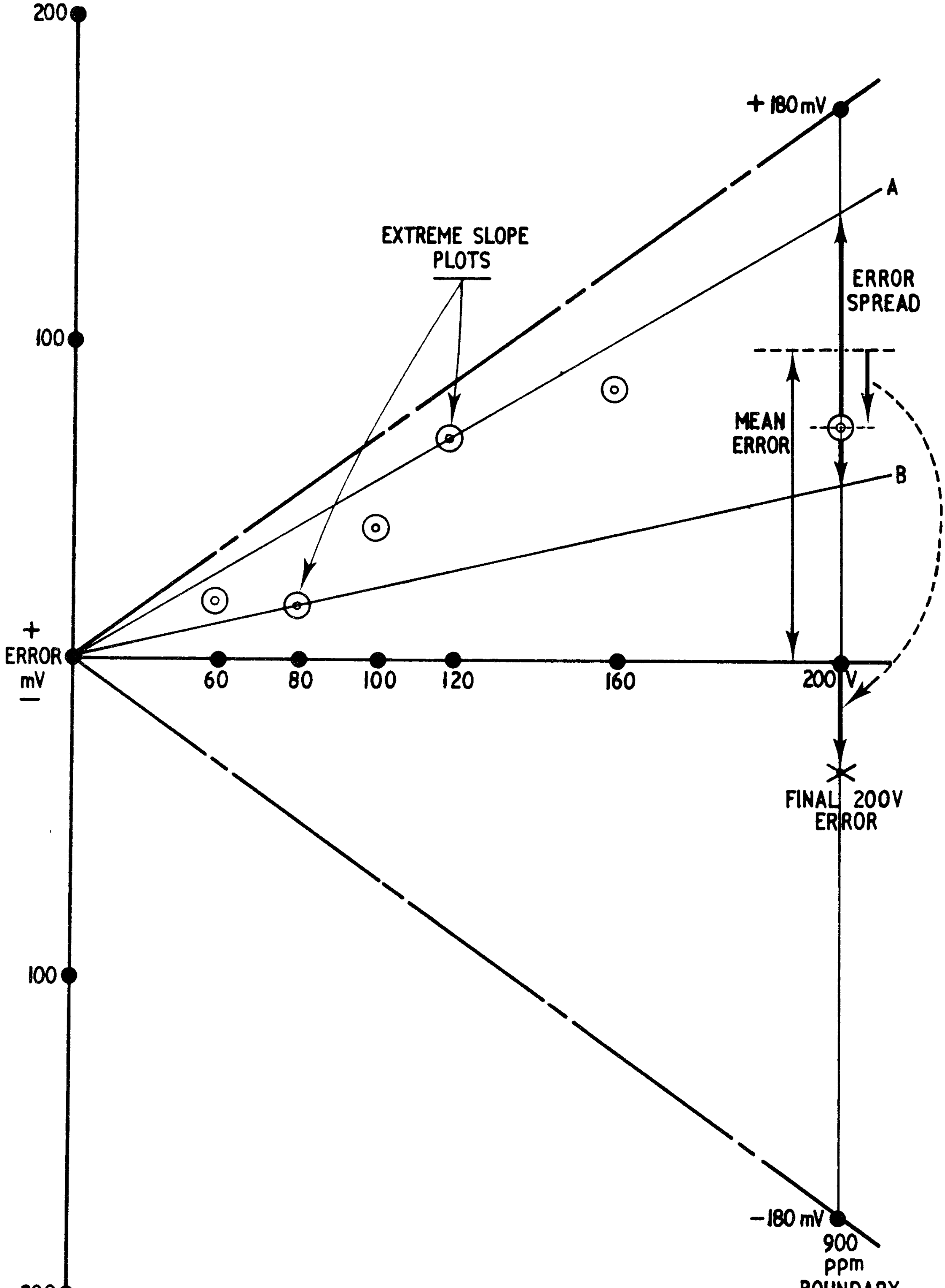

200
100
100
200
+
ERROR
mV
—
60
80
100
120
160
200 V
+ 180 mV
A
B
EXTREME SLOPE
PLOTS
ERROR
SPREAD
MEAN
ERROR
FINAL 200V
ERROR
-180 mV
900
ppm
BOUNDARY

FIGURE A

DIVISION SETTING ERRORS

Divs	Nominal Voltage	Initial Errors mV	Error Spread mV	Mean Error mV	Final 200V Error, mV
10	200				
8	160				
6	120				
5	100				
4	80				
3	60				

5.17 SQUARE WAVE ZERO LEVEL (Using DC Differential Voltmeter Fluke 895A)

1. Select the following controls:

MODE	+ (positive)
DIVS	10
VOLTS/DIV	20
DEV	OFF

2. Connect a low voltage d. c. supply set at 1V ±0. 02V across emitter TR108 and junction of R130 to R131 making the positive connection to the junction of the resistors. Two pins TP1 and TP2 are provided for connecting the wires. Check the low voltage using meter (3).

3. Monitor the VOLTAGE output with meter (4) and switch the instrument ON.

4. Switch on the low voltage d. c. supply and verify that the voltage output changes from 200V to approximately 0V

5. Set RV105 to obtain zero volts ±5mV.

6. Place 2. 2mΩ resistor (1) momentarily across collector and emitter of TR107 and verify that the output voltage does not rise to more than +0. 05 volts.

7. Switch off the instrument and disconnect the low voltage d. c. supply before changing any front panel settings.

5.18 VOLTAGE SQUARE WAVE (Using Oscilloscope 5).

1. Select the following controls:

MODE	+
DIVS	10
VOLTS/DIV	10
DEVIATION	OFF

2. Monitor the VOLTAGE output with the oscilloscope (5) set to 20V/div 1ms/div via coaxial cable (6). The oscilloscope should be d.c. coupled.

   A square wave of 5 divisions amplitude and 1 division period should be displayed.

3. Reduce the calibrator VOLTS/DIV switch setting to 50mV/div and the oscilloscope to 0.1V/cm. Adjust the oscilloscope to display the leading edge.

   Note the rise-time between 10% and 90% of the amplitude and verify that it is less than 5μS with overshoot better than 0.5%.

4. Reduce the VOLTS/DIV switch setting to 20mV/div and adjust the oscilloscope for a display similar to that seen in test 3 above. Trim the capacitor C111 to eliminate any roll up or overshoot.

5. As far as possible check all output levels and ensure that there are no abnormalities.

5.19 RIPPLE (Using Oscilloscope (5))

1. Set the variac to give 216 ±1V.

2. Select the following controls:

MODE	+
DIVS	10
VOLTS/DIV	20
DEVIATION	OFF

3. Monitor the VOLTS output with oscilloscope (5) set to 0.1V/cm a.c. coupled 10ms/cm.

   Verify that the ripple is less than 0.2V peak-to-peak.

4. Reset the variac at 240V ±1V.

5.20 LINE FREQUENCY AMPLITUDE (Using Oscilloscope 5).

Monitor the LINE FREQUENCY output socket using oscilloscope (5) set to 0.5V/cm. Verify that at least 1 volt peak-to-peak sine wave can be obtained and check visually that it has a low harmonic content.

SECTION 6

PARTS LIST

When ordering spare parts please quote the instrument type and Serial Number, and the value and reference number of the components required.

VOLTS CIRCUIT (For additional items see Page 30 - 31)

RESISTORS, FIXED

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
R101	470	10	1/4	Morganite S	C130921
R102	39k	10	1/4	Morganite S	C130990
R103	4.7k	1.0	1/8	Welwyn 4033 100ppm	GR01146
R104	4.7k	1.0	1/8	Welwyn 4033 100ppm	GR01146
R105	120	2.0	1/2	Mullard MR30	GR00484
R106	2.2k	10	1/4	Morganite S	C130945
R107	1.5k	10	1/4	Morganite S	C130939
R108	5.6k	2.0	1/2	Mullard MR30	GR07894
R109	1.5k	10	1/4	Morganite S	C130939
R110	57.6k	1.0	1/8	Welwyn 4033 100ppm	GR00990
R111	2.2k	2.0	1/2	Mullard MR30	GR07841
R112	39k	2.0	1/2	Mullard MR30	GR07901
R113	2.7k	2.0	1/2	Mullard MR30	GR07830
R114	2.2k	2.0	1/2	Mullard MR30	GR01019
R115	18k	2.0	1/2	Mullard MR30	GR10074
R116	1.74k	1.0	1/8	Welwyn 4033 100ppm	GR01133
R117	30k	1.0	1/8	Welwyn 4033 100ppm	GR00897
R118	39k	1.0	1/8	Welwyn 4033 100ppm	GR01134
R119	220	1.0	1/8	Welwyn 4033 100ppm	GR00978
R120	220	1.0	1/8	Welwyn 4033 100ppm	GR00978
R121	3k	0.5	1/8	Welwyn 4333 25ppm	GR00984
R122	30k	0.02	0.4	Welwyn Vishay 4802	GR00988
R123	10k	0.1	1/8	Welwyn 4333 25ppm	GR00985
R124	10k	0.1	1/8	Welwyn 4333 25ppm	GR00985
R125	10k	0.1	1/8	Welwyn 4333 25ppm	GR00985

RESISTORS, FIXED (Cont'd)

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
R126	20k	0.1	1/8	Welwyn 4333 25ppm	GR00986
R127	20k	0.1	1/8	Welwyn 4333 25ppm	GR00986
R128	2.2k	2.0	1/2	Mullard MR30	GR01019
R129	1k	10	1/4	Morganite S	C120933
R130	470	10	1/4	Morganite S	C130921
R131	5.6k	10	1/4	Morganite S	C130960
R132	220k	2.0	1	Electrosil TR6	GR00971
R133	100k	0.25	1	Morganite FC75 15ppm	GR00999
R134	3M	1.0	1/4	Welwyn 4034 150ppm	GR00991
R135	100	0.1	1/8	Welwyn 4333 25ppm	GR00976
R136	2.5k	0.02	1.2	Welwyn Vishay 4805/11	GR00983
R137	2.5k	0.02	1.2	Welwyn Vishay 4805/11	GR00983
R138	2.5k	0.02	1.2	Welwyn Vishay 4805/11	GR00983
R139	1.5k	0.02	0.8	Welwyn Vishay 4804/11	GR00981
R140	500	0.1	1/4	Welwyn 4334 25ppm	GR00980
R141	250	0.1	1/8	Welwyn 4333 25ppm	GR00979
R142	150	0.1	1/8	Welwyn 4333 25ppm	GR00977
R143	50	0.1	1/8	Welwyn 4333 25ppm	GR00975
R144	25	0.1	0.4	Welwyn Vishay 4802/11	GR00974
R145	15	0.1	0.4	Welwyn Vishay 4802/11	GR00973
R146	5.05	1.0	1/8	Welwyn 4333 50ppm	GR00972
R147	5.05	1.0	1/8	Welwyn 4333 50ppm	GR00972
R148			0.4	F.O.T. MR25 Mullard	
R149			0.4	F.O.T. MR25 Mullard	
R150	NOT USED			NOT USED	
R151	220	1.0	1/8	Welwyn 4033 100ppm	GR00978
R152	100	5	1/2	Electrosil TR6	GR07113
R153	2.2M	10	1/4	Morganite S	C131053
R160	15k	2.0	1/2	MR30 Mullard	GR01023
R162	15k	2.0	1/2	MR30 Mullard	GR01023
R165	10k	2.0	0.4	MR25 Mullard	GR00777
R166	47	2.0	0.4	MR25 Mullard	GR00814
R181	56k	2.0	0.4	MR25 Mullard	GR01393

RESISTORS, FIXED (Cont'd)

Second choice Alternative for Fixed Resistors (Welwyn Resistors only)

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
R103	4.7k	1		Morganite FC65 100ppm	GR01148
R104	4.7k	1		Morganite FC65 100ppm	GR01148
R110	57.6k	1		Morganite FC65 100ppm	GR01093
R116	1.74k	1		Morganite FC65 100ppm	GR01135
R117	30k	1		Morganite FC65 100ppm	GR01091
R118	39k	1		Morganite FC65 100ppm	GR00960
R119	220	1		Morganite FC65 100ppm	GR01088
R120	220	1		Morganite FC65 100ppm	GR01088
R121	3k	0.5		Morganite FC65 25ppm	GR01098
R123	10k	0.1		Morganite FC65 25ppm	GR01099
R124	10k	0.1		Morganite FC65 25ppm	GR01099
R125	10k	0.1		Morganite FC65 25ppm	GR01099
R126	20k	0.1		Morganite FC65 25ppm	GR01100
R127	20k	0.1		Morganite FC65 25ppm	GR01100
R134	2.7M	1		Morganite FC70 100ppm	GR01102
R135	100	0.1		Morganite FC65 25ppm	GR01095
R140	500	0.1		Morganite FC70 25ppm	GR01103
R141	250	0.1		Morganite FC65 25ppm	GR01097
R142	150	0.1		Morganite FC65 25ppm	GR01096
R143	50	0.1		Morganite FC65 25ppm	GR01094
R146	10	0.5 }		Parallel Combination FC55 50ppm	GR01086
	10.2	0.5 }		Parallel Combination FC55 50ppm	GR01087
R147	10	0.5 }		Parallel Combination FC55 50ppm	GR01086
	10.2	0.5 }		Parallel Combination FC55 50ppm	GR01087
R151	220	1		Morganite FC65 100ppm	GR01088

RESISTORS, VARIABLE

RV101	10k	20	0.5	A-B Metal C45 LIN LAW	A129997
RV102	4.7k	20	0.25	Plessey MPD PC	GR07806
RV103	4.7k	20	0.25	Plessey MPD PC	GR07806
RV104	50k	10	0.75	Morganite 80F	GR01000
RV105	470	20		Plessey MOD PC	GR07804
RV106	500k	10	0.75	Morganite 80	GR01001
RV107	2.2k	20		A-B Metal C45 LOG LAW	GR01002

TRANSISTORS

CIRCUIT REF	MANUFACTURER OR STYLE		BRADLEY REF. NO.
	MANUFACTURER	TYPE	
TR101	RCA	40374	GV00496
TR102	Motorola	MPS6515	GV00532
TR103	Motorola	MPS6519	GV00919
TR104	S.G.S.	BFY81	BFY81
TR105	Mullard	BC108	BC108
TR106	Motorola	MPS6519	GV00919
TR107	Motorola *	2N3739	2N3739
TR108	Motorola *	2N3739	2N3739
TR109	Texas	BF258	BF258

* Alternatives MJE 3739 or 2N6176

CAPACITORS

CIRCUIT REF	VALUE F	TOL %	RATING V	MANUFACTURER OR STYLE	BRADLEY REF. NO.
C101	2μ	+50 -20	350	Erie L37/1 MEF118T	GC10111
C102	2μ	+50 -20	350	Erie L37/1 MEF118T	GC10111
C103	0.5μ	±20	600	Erie WF49 AF406K	GC22155
C104	8μ	+50 -20	350	Erie L37/1 JF403BT	GC02036
C105	250μ	+100 -20	25	Hunts L37 MEF35AT	GC10117
C106	250μ	+100 -20	25	Hunts L37 MEF35AT	GC10117
C107	0.01μ	+50 -25	25	Erie 831/T/25V	GC29045
C109	2μ	+50 -20	350	Erie L37/1 MEF118T	GC10111
C110	0.01μ	-25 +50	25	Erie 831/T/25V	GC29045
C111	0-3p		500	Mullard Trimmer C004EA/3E	GC22187
C112	2200p	±20	200	Erie K350081/AD	GC08097
C120	1μ	±20	100	STC PMA 1.0 M100	GC20155
C170	1000p	-20 +80	500	Erie Feed Through 361-K2600	GC22166

CAPACITORS (Cont'd)

CIRCUIT REF.	VALUE F	TOL %	RATING V	MANUFACTURER OR STYLE	BRADLEY REF. NO.
C171	1000p	-20 +80	500	Erie Feed Through 361-K2600	GC22166
C172	1000p	-20 +80	500	Erie Feed Through 361-K2600	GC22166
C173	1000p	-20 +80	500	Erie Feed Through 361-K2600	GC22166
C174	1000p	-20 +80	500	Erie Feed Through 361-K2600	GC22166
C175	1000p	-20 +80	500	Erie Feed Through 361-K2600	GC22166
C180	270p	5	500	Mullard 42722701 J	GC92116
DIODES					
D101				IR 10D4	GV01136
D102				IR 10D4	GV01136
D103				IR 10D4	GV01136
D104				IR 10D4	GV01136
D105				IR 10D4	GV01136
D106				IR 10D4	GV01136
D017				Mullard BAX13	BAX13
D108				Mullard BAX13	BAX13
D109				Mullard BZY88-C7V5	BZY88-C7V5
D110				Mullard BZY88-C4V7	BZY88-C4V7
D111				Mullard BZY88-C7V5	BZY88-C7V5
D112				Mullard BZY88-C7V5	BZY88-C7V5
D113				Mullard BZV12 (6.5V)	BZV12
D114				Mullard AAZ13	AAZ13
D115				Mullard BZY88-C7V5	BZY88-C7V5
D116				Mullard AAZ13	AAZ13

TIME CIRCUIT

RESISTORS, FIXED

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
R410	560	10	0.25	Morganite Type S	C130924
R411	2k2	10	0.25	Morganite Type S	C130945

RESISTORS, FIXED (Cont'd)

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
R412	1k	10	0.25	Morganite Type S	C130933
R418	47	10	0.25	Morganite Type S	C130885
R419	560	10	0.25	Morganite Type S	C130924
R420	1k5	10	0.25	Morganite Type S	C130939
R421	6k8	10	0.25	Morganite Type S	C130963
R422	3k3	10	0.25	Morganite Type S	C130951
R423	47	10	0.25	Morganite Type S	C130885
R429	680	10	0.25	Morganite Type S	C130927
R430	1k	2	0.5	Mullard MR30	GR00725
R431	2k2	2	0.5	Mullard MR30	GR01019
R432	5k6	2	0.5	Mullard MR30	GR01022
R433	22	10	0.25	Morganite Type S	C130873
R434	100	2	0.4	Mullard MR25	GR00560
R440	1k	2	0.5	Mullard MR30	GR00725
R442	5k6	2	0.5	Mullard MR30	GR01022
R444	220	10	0.25	Morganite Type S	C130909
R445	120	10	0.25	Morganite Type S	C130900
R450	1k	10	0.25	Morganite Type S	C130933
R451	6k8	10	0.25	Morganite Type S	C130963
R452	3k3	10	0.25	Morganite Type S	C130951
R459	680	10	0.25	Morganite Type S	C130927
R467	2k2	10	0.25	Morganite Type S	C130945
R472	1k8	10	0.25	Morganite Type S	C130942
R473	22k	10	0.25	Morganite Type S	C130981
R474	22k	10	0.25	Morganite Type S	C130981
R512	1k8	10	0.25	Morganite Type S	C130942
R560	100	2	0.4	Mullard MR25	GR00560
R600	68	10	0.25	Morganite Type S	C130891
R632	2k2	10	0.25	Morganite Type S	C130945
R633	560	10	0.25	Morganite Type S	C130924
R634	330	10	0.25	Morganite Type S	C130915
R635	68	10	0.25	Morganite Type S	C130891
R640	47	10	0.25	Morganite Type S	C130885
R641	2k2	10	0.25	Morganite Type S	C130945
R642	2k2	10	0.25	Morganite Type S	C130945
R643	27	10	0.25	Morganite Type S	C130876

RESISTORS, FIXED (Cont'd)

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
R647	47	10	0.25	Morganite Type S	C130885
R703	240	1	0.5	Mullard MR30	GR00626
R704	240	2	0.5	Mullard MR30	GR00626
R710	750	2	0.5	Mullard MR30	GR01015
R711	750	2	0.5	Mullard MR30	GR01015
R740	1k	10	0.25	Morganite Type S	C130933
R741	220	10	0.25	Morganite Type S	C130909
R742	100	10	0.25	Morganite Type S	C130897
R744	470	10	0.25	Morganite Type S	C130921
R745	2k7	10	0.25	Morganite Type S	C130948
R751	470	2	0.40	Mullard MR25	GR07740
R752	470	2	0.40	Mullard MR25	GR07740
R801	120	10	0.25	Morganite Type S	C130900
R802	120	10	0.25	Morganite Type S	C130900
R803	120	10	0.25	Morganite Type S	C130900
R804	120	10	0.25	Morganite Type S	C130900
R805	120	10	0.25	Morganite Type S	C130900
R806	120	10	0.25	Morganite Type S	C130900
R807	120	10	0.25	Morganite Type S	C130900
R813	390	10	0.25	Morganite Type S	C130918
R814	820	2	0.4	Mullard MR25	GR00565
R822	15k	2	0.4	Mullard MR25	GR00822
R823	2k2	2	0.4	Mullard MR25	GR00568
R824	100	2	0.4	Mullard MR25	GR00560
R830	220	10	0.25	Morganite XL	GR01130
R832	390	2	0.4	Mullard MR25	GR00815
R834	33	2	0.4	Mullard MR25	GR00552
R844	150	10	0.25	Morganite XL	GR01129
R850	100	2	0.4	Mullard MR25	GR00560
R851	1k2	2	0.4	Mullard MR25	GR00773
R852	510	2	0.5	Mullard MR30	GR07888
R854	150	10	0.25	Morganite XL	GR01129
R855	150	10	0.25	Morganite XL	GR01129
R856	470	2	0.5	Mullard MR30	GR00638
R857	82	2	0.5	Mullard MR30	GR00624
R858	100	2	0.4	Mullard MR25	GR00560
R859	100	2	0.4	Mullard MR25	GR00560
*R831	150	2		Mullard MR25	GR00575

* Not always fitted

RESISTORS, FIXED (Cont'd)

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
R901	1.5	10	2.5	Welwyn W21	GR01005
R910	2k	2	0.5	Mullard MR30	GR01018
R911	1k5	2	0.5	Mullard MR30	GR01016
R912	3k	2	0.5	Mullard MR30	GR01021
R924	680	2	0.5	Mullard MR30	GR01014
R934	390	10		Morganite Type S	C130918
R950	2k7	2	0.5	Mullard MR30	GR01020
R951	1k8	2	0.5	Mullard MR30	GR01017
R952	2k2	2	0.5	Mullard MR30	GR01019
R961	820	2	0.5	Mullard MR30	GR00750
R963	22k	10		Morganite Type S	C130981
R964	1k8	2	0.5	Mullard MR30	GR01017
R974	3k3	10		Morganite Type S	C130951
R991	2.7	10	2.5	Welwyn W21	GR01006

RESISTORS, VARIABLE

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
RV430	1k	±20	0.25	Plessey MP Dealer (PC)	GR07584
RV434	220	±10	1	Plessey WMP (PC)	GR00726
RV470	10k	±20	0.25	Plessey MP (PC)	GR07654
RV471	10k			AB/45 Long Spindle	A12999
RV472	10k	±20	0.25	Plessey MP (PC)	GR07654
RV703	100	±10	1	Plessey WMP (PC)	GR00633
RV704	100	±10	1	Plessey WMP (PC)	GR00633
RV710	330	±10	1	Plessey WMP (PC)	GR01003
RV711	330	±10	1	Plessey WMP (PC)	GR01003
RV800	10kLOG		0.5	AB/45 LOG	GR01128
RV951	1k	±20	0.25	Plessey MPD (PC)	FR07584

TRANSISTORS

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
TR410				Mullard BSX20	BSX20
TR420				Mullard BSX20	BSX20
TR430				Mullard BSX20	BSX20
TR440				Mullard BSX20	BSX20
TR450				Mullard BSX20	BSX20

TRANSISTORS (Cont'd)

CIRCUIT REF	MANUFACTURER OR STYLE	BRADLEY REF. NO.
TR630	Mullard BSX20	BSX20
TR640	Mullard BSX20	BSX20
TR810	Mullard BSX20	BSX20
TR820	Mullard BSX20	BSX20
TR830	Mullard BFX89	BFX89
TR840	SGS BFX48	BFX48
TR850	Mullard BFX89	BFX89
TR910	Mullard BC108	BC108
TR920	Mullard BC108	BC108
TR930	Mullard BCY70	BCY70
TR940	Texas Instrument TIP30	GV01506
TR950	Mullard BCY70	BCY70
TR960	Mullard BCY70	BCY70
TR970	Mullard BC108	BC108
TR980	Mullard BFY51	BFY51

CAPACITORS

CIRCUIT REF	VALUE F	TOL %	RATING V	MANUFACTURER OR STYLE	BRADLEY REF. NO.
C410	10p	0.5	750	Erie NPO/AD	GC22156
C414	27p	5	750	Erie N220/AD	GC22158
C415	2-22p		50	Mullard 808	GC20227
C417	1000p	10	500	Hi-K/AD	GC22164
C418	1000p	10	500	Hi-K/AD	GC22164
C419	1000p	10	500	Hi-K/AD	GC22164
C420	68p	5	750	Erie N750/AD	GC22163
C423	39p	5	750	Erie N560/AD	GC22159
C425	2-22p		50	Mullard 808	GC20227
C427	10p		750	Erie NPO/AD	GC22156
C428	1000p	10	500	Hi-K/AD	GC22164
C429	1000p	10	500	Hi-K/AD	GC22164
C433	1000p	10	500	Hi-K/AD	GC22164
C438	0.1μ	20	100	STC PMA	GC22039
C440	1000p	10	500	Hi-K/AD	GC22164

CAPACITORS (Cont'd)

CIRCUIT REF.	VALUE F	TOL %	RATING V	MANUFACTURER OR STYLE	BRADLEY REF. NO.
C444	220p	10	500	Hi-K/AD	GC22173
C450	1000p	10	500	Hi-K/AD	GC22164
C453	1000p	10	500	Hi-K/AD	GC22164
C454	22p	5	750	Erie N220/AD	GC22157
C455	2-22p		400	Mullard 808	GC22187
C458	1000p	10	500	Hi-K/AD	GC22164
C459	1000p	10	500	Hi-K/AD	GC22164
C474	0.1μ	20	100	STC PMA	GC22039
C568	1μ	20	100	STC PMA	GC20155
C618	0.1μ	20	100	STC PMA	GC22039
C638	1μ	20	100	STC PMA	GC20155
C651	470p	10	500	Hi-K/AD	GC22111
C652	1000p	10	500	Hi-K/AD	GC22164
C653	2000μ	10	500	Hi-K/AD	GC22165
C654	4700μ	-20 +40	500	Hi-K/AD	GC12075
C655	.01μ	20	400	STC PMA	GC22152
C656	.022μ	20	400	STC PMA	GC22169
C657	.047μ	20	250	STC PMA	GC22170
C658	0.1μ	20	100	STC PMA	GC22039
C659	0.22μ	20	100	STC PMA	GC22171
C660	0.47μ	30	100	STC PMA	GC22072
C661	1μ	20	100	STC PMA	GC20155
C708	0.47μ	20	100	STC PMA	GC22072
C730	1μ	20	100	STC PMA	GC20155
C742	0.1μ	20	100	STC PMA	GC22039
C813	1000p	10	500	Hi-K/AD	GC22164
C814	56p	5	705	Erie N750/AD	GC22172
C828	0.47μ	20	100	STC PMA	GC22072
C830	3.3p	0.5pf	750	Erie NPO/AD	GC22138
C834	1000p	10	500	Hi-K/AD	GC22164
C851	1000p	10	500	Hi-K/AD	GC22164
C858	0.1μ	20	100	STC PMA	GC22039
C901	2000μ	-10 +50	10	Mullard C431 BR/D2000	GC20225
*C831	3.3p	025	750	Erie NPO/AD	GC22138

* Note. Not always fitted.

CAPACITORS (Cont'd)

CIRCUIT REF	VALUE F	TOL %	RATING V	MANUFACTURER OR STYLE	BRADLEY REF. NO.
C902	0.47μ	20 -10	100	STC PMA	GC22072
C944	330	+50 -10	16	Mullard 017-55331	GC26089
C984	200μ	+50 -10	10	Mullard C426BC/D200	GC20222
C991	800μ	+50	25	Mullard C431BR/F800	GC20224
C992	0.47μ	20	100	STC PMA	GC22072

DIODES

CIRCUIT REF	MANUFACTURER OR STYLE	BRADLEY REF. NO.
D419	SGS BAY82	BAY82
D429	Mullard BAX13	BAX13
D430	BA112	BA112
D441	Mullard BZY88-C3V3	BZY88-C3V3
D459	Mullard BAX13	BAX13
D640	Mullard BAX13	BAX13
D641	Mullard BAX13	BAX13
D642	Mullard BAX13	BAX13
D731	Mullard BAX13	BAX13
D732	Mullard BAX13	BAX13
D740	Mullard BZY88-C3V3	BZY88-C3V3
D822	Mullard BAX13	BAX13
D823	Mullard BAX13	BAX13
D901	International Rectifier 10D05	GV01411
D902	International Rectifier 10D05	GV01411
D961	Mullard BAX13	BAX13
D962	Mullard BZY88-C5V6	BZY88-C5V6
D991	International Rectifier 10D05	GV01411

INTEGRATED CIRCUITS

CIRCUIT REF.	VALUE	TOL	RATING	MANUFACTURER OR STYLE	BRADLEY REF. NO.
X510				Texas Instrument SN7474N	GV01513
X520				Texas Instrument SN7490N	GV00815
X530				Texas Instrument SN7490N	GV00815
X540				Texas Instrument SN7490N	GV00815
X550				Texas Instrument SN7490N	GV00815
X560				Texas Instrument SN7490N	GV00815
X570				Texas Instrument SN7490N	GV00815
X580				Texas Instrument SN7490N	GV00815
X590				Texas Instrument SN7472N	GV00817
X610				Texas Instrument SN7490N	GV00815
X710				Texas Instrument SN7474N	GV01513
X720				Texas Instrument SN7474N	GV01513
X730				Texas Instrument SN15844N	GV01465
X740				Texas Instrument SN72702N	GV01514
XL411	100MHz	0.1%	0-50°C	STC 4203/AT-5	GV00651
XL747	1MHz	0.1%	-20 +70°C	STC 4046/AT	GV01516
X412				Ferrite Bead. Mullard FX1242	A10355
M700				Meter. Sifam. 500μA f.s.d.	C128720
L414				Bradley	A129918
L424	0.47μH			Painton 58/10/0003/10	GT13384
L454	1.5μH			Painton 50/10/0006/10	GT13385

VOLTS CIRCUIT (ADDITIONAL ITEMS)

SWITCHES

CIRCUIT REF	VALUE	TOL	RATING	MANUFACTURER OR STYLE	BRADLEY REF. NO.
S101			250V 3A	Mains Toggle DPD.T. MST205N Waycom	GC01422
S102				VOLTS/DIV Push Button Isostat	A129993
S103				MODE Push Button Isostat	A129992
S104				VOLTS/DIV Rotary Wafer Switch Isostat	C129990

SWITCHES (Cont'd)

CIRCUIT REF	VALUE	TOL	RATING	MANUFACTURER OR STYLE	BRADLEY REF. NO.
S401					C129995
S402				HF O/P 10, 20, 50nSec Isostat	
S403					
S701				Range. 3, 10% Deviation Isostat	
S702				Deviation: Volts & Time	A129975
S703					
S601					
S602					
S801					
S802				x2 + x5, Period	A129996
S803					
S804					
S805					

BNC SOCKETS

SKT101				UG657/U	GP01584
SKT102				UG657/U Insulated	GP01583

INDICATOR LAMPS

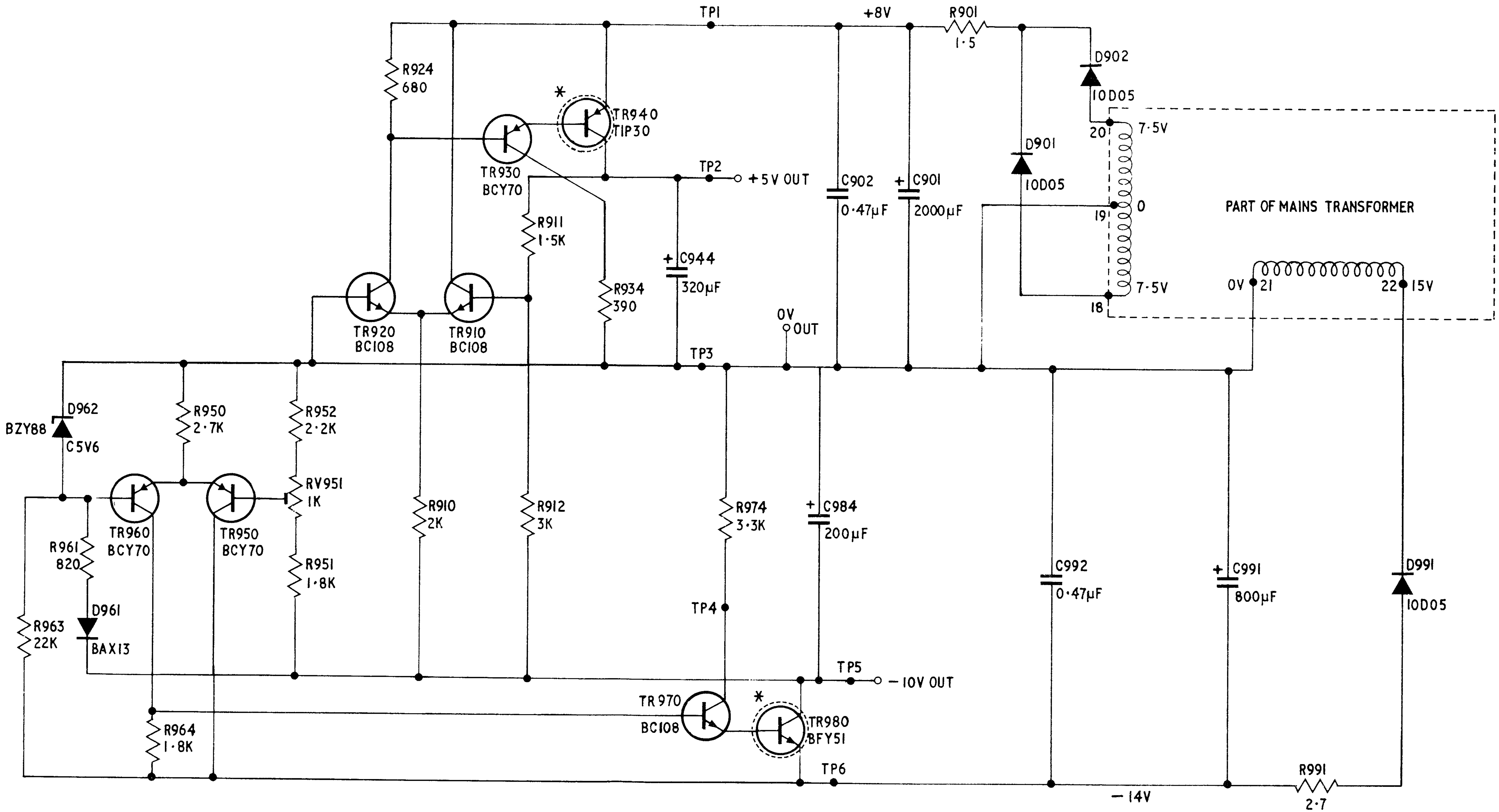
ILP101	12V		0.1A	Boss Industrial SM/A/1/79/TAMB	GV01485
ILP701				HP 5082-4440 Solid state lamp orange	GV01710
ILP702				"	"

TRANSFORMERS

T101				Mains Transformer with Input Selector Panel	C129988
T102				Radiospares Driver Transformer	GT13160

MISCELLANEOUS

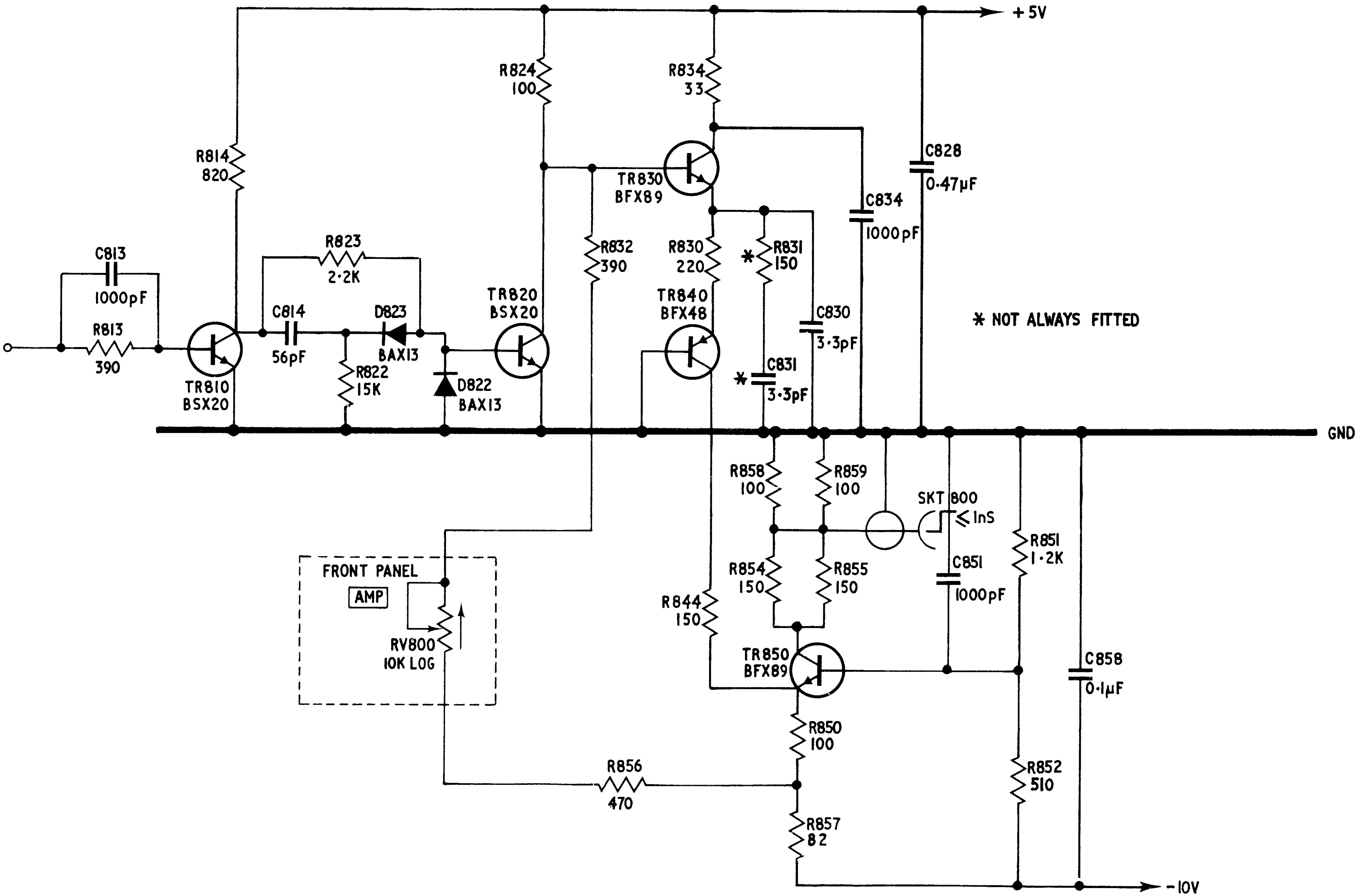
L101 } Not on all units				500mA Twin Suppressor	GT20276
L102 }				Choke Radiospares	GT20276
FS	200/250		500mA	Fuse Belling Lee L1055	GV17105
Part of T101				McMurdo Voltage Selector B279002/A	B130104



* TRANSISTORS MOUNTED WITH HEAT SINKS

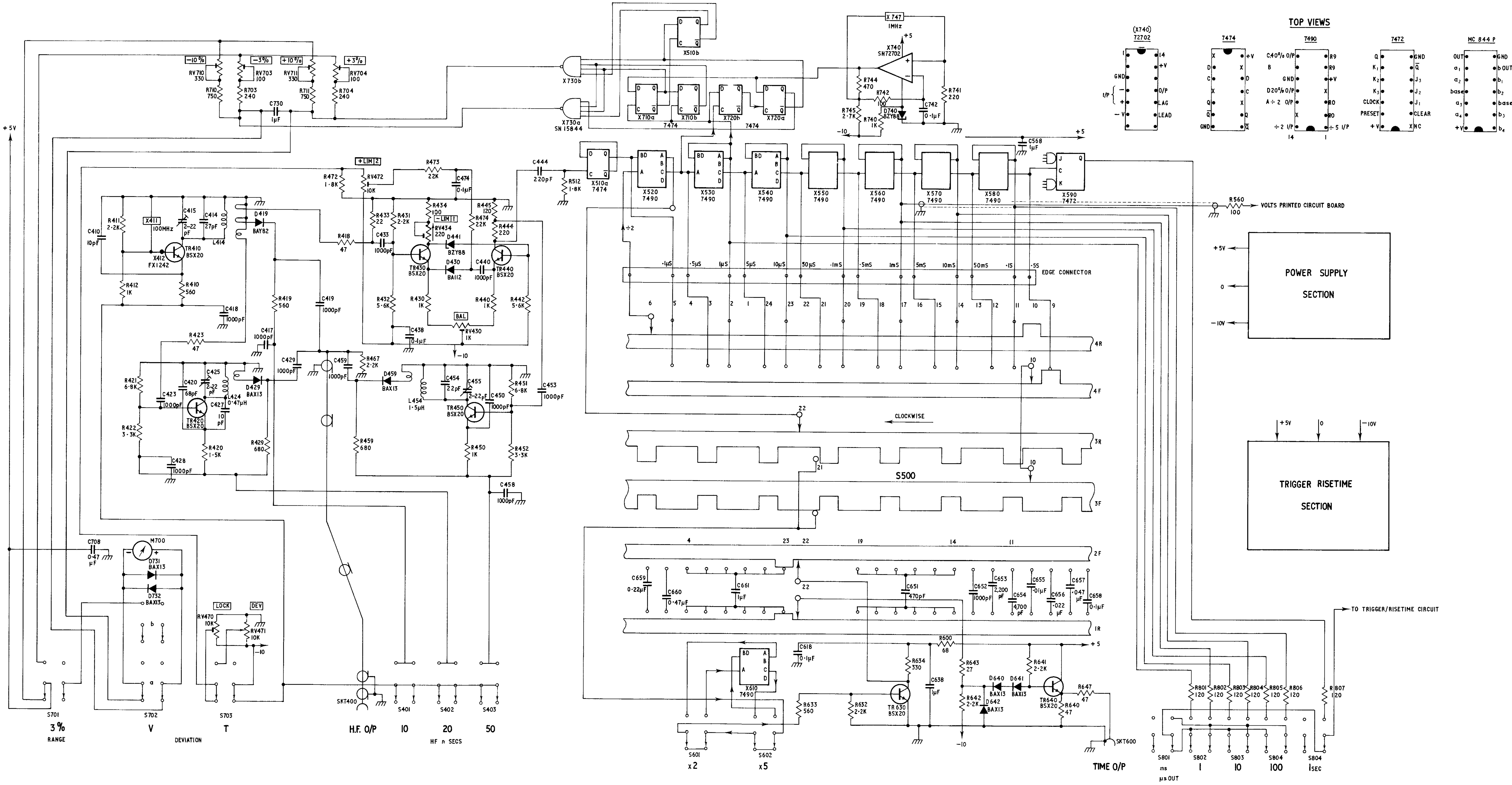
POWER SUPPLY CIRCUIT (TIME SIDE)

FIG. I



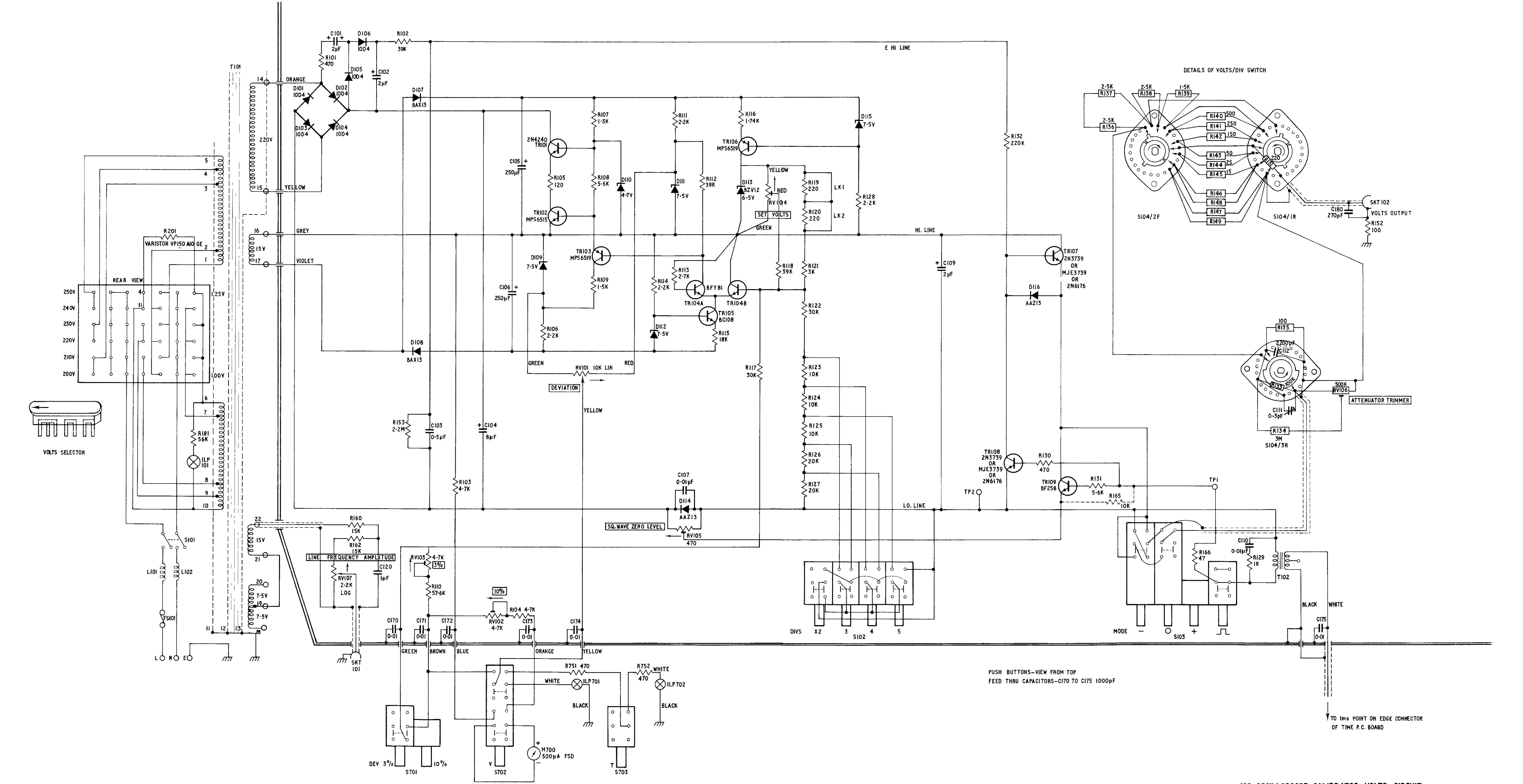
TRIGGER/RISETIME CIRCUIT

FIG. 2



192 OSCILLOSCOPE CALIBRATOR TIME CIRCUIT

FIG. 4



192 OSCILLOSCOPE CALIBRATOR VOLTS CIRCUIT

FIG.3

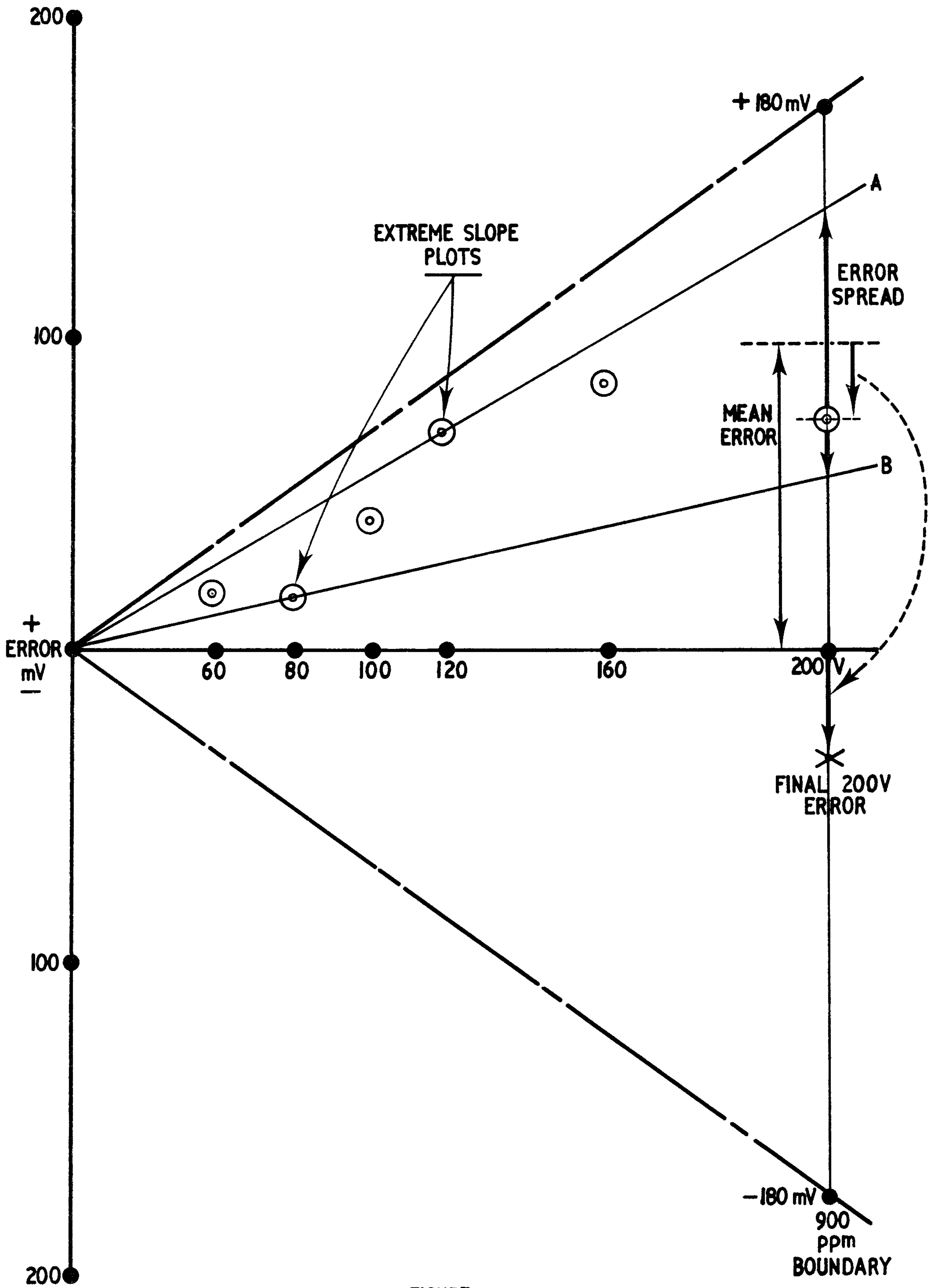


FIGURE 5.

OPTIMUM REFERENCE SETTING

G&E BRADLEY OSCILLOCOPE CALIBRATOR TYPE 192

GENERAL ORDERS AND MODIFICATIONS

BY COMMAND OF THE DEFENCE COUNCIL

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Ministry of Defence

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ROYAL AIR FORCE by DWSE (RAF)

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Service users should send their comments through
the channel prescribed for the purpose in.
AP3158 Vol. 2 leaflet No. D6 (ARMY and RAF)

Calibrator Oscilloscope, Type 192 (Ref No 10S/6625-99-117-8133) part of Calibrator Set, Oscilloscope, Type 192.

(CSDE/3000/4/3/ETE)

Amendment Instructions. Insert this leaflet (1 leaf) in correct sequence. Sign the Amendent Record Sheet.

1. INTRODUCTION

The Calibrator Oscilloscope, type 192, was developed as a commercial project and has been sold to Industry and both the RAF and Army. It has been subject to a number of production changes by the manufacturer, the incorporation of each change/and or modification being denoted by a specified strike off figure shown on the instruments modification record label. The purpose of this leaflet is to list the changes made so that all concerned are informed of the details of each change. Only some of these changes are to be incorporated retrospectively, thus equipments in Service with RAF and Army, may have gaps in the strike offs incorporated. Furthermore, modifications promulgated via the RMC will not start a 1 and run consecutively.

2. INFORMATION

Strike off No	Instrument Serial No	Service Mod No	Detail
1.	BGB200 onwards		Changes in tracking to Volts and Time Printed Boards to allow fitting of new heat sink and mounting method.
2.	BGB200 onwards		Rear mains connector added to meet IEC 320 requirements R560 added between Volts and Time PC Boards to reduce overloading of X560.
3.	BGB300 onwards	A4315	Fitting of 100 K Ω resistor R165
4.	BGB500 onwards		Change of value of R114, R128 and R434. Performed by the contractor if product fails to meet spec after repair.
5.	BGB500 onwards	Mod A awaiting RMC approval	Introduction of additional capacitor C180

Strike off No	Instrument Serial No	Service Mod No	Detail
6.	BGB560 onwards		R166 added between TP · and mode switch. Performed by Contractor i: product will not permi: calibration when RV105 is set up.

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Calibrator Oscilloscope (Ref No 10D/6625-99-117-8133) (formerly Ref No 10ZZ/205086) (RAF) part of Calibrator Set Oscilloscope Type 192 - Fitting of an Additional Resistor.

(Mod No A4315)

(Class C/3 on repair or recalibration (Army & RAF))

(ADSM25/M/2338)

(ADP No ZAA43150)

Amendment Instructions. Insert this leaflet (4 leaves) in correct numerical sequence and record the incorporation on the Amendment Record Sheet.

1. INTRODUCTION

It has been found that when the switch S103 is set for "DC MODE" operation the base of the transistor TR109 is left floating, since this transistor is operational only in 'Square Wave MODE'. This modification rectifies the circuitry by connecting a 10KΩ resistor R165 between the emitter and the base of the transistor TR109.

The modification is to be embodied in all Calibrators Oscilloscope (Ref No 10D/6625-99-117-8133) (formerly 10ZZ/205086 (RAF)).

(1) This modification does not supersede, partially supersde or satisfy the work called for by any other Modification, Command Modification STI, SI or SRIM.

2. EMBODIMENT

This modification is to be embodied by recalibration or repair authorities only (RAF).

3. APPROXIMATE TIME REQUIRED FOR EMBODIMENT

The work will take approximately ½ man hour.

4. DRAWINGS REQUIRED

Drawing No AP 117D-0910-2/B 1 /74 is incorporated in this leaflet.

5. PARTS AND SPECIAL TOOLS REQUIRED

(1) Parts and Materials

(a) A Modification Kit will not be assembled.

(b) The following service supply item is required:

Ref No	Nomenclature	Qty
10W/5905-99-013-6019	Resistor, Fixed, 10KΩ ± 2%	1

RAF units are to forward their demands for the individual referenced items direct to the appropriate ESD for non-SCC items (quoting the Mod number) and through SCC for SCC-controlled items. Other users are to demand their requirements in accordance with current regulations.

(c) The following materials are to be provided under Unit arrangements:

Ref No	Nomenclature	Qty
33C/1223	Ink, marking, Black	As Reqd

(2) Special Tools and Test Equipment

No special tools or test equipment are required for the embodiment of this modification.

6. MODIFICATION OF SPARES

No spares are affected by this modification.

7. CHANGE OF REFERENCE, PART AND ASSEMBLY NUMBERS

There are no changes of Reference, Part or Assembly Numbers as a result of this modification.

8. SEQUENCE OF OPERATIONS

The following is the sequence of operations:

NOTE: Before any electrical circuit is disturbed or disconnected, all electrical power supplies in, to or from the equipment are to be disconnected. Power supplies are to be reconnected only when the person responsible for embodying or inspecting the modification is satisfied that all action has been taken to make the equipment safe for reconnection.

Where nuclear safety may be affected, the prescribed routeing of electric cables must be strictly followed.

It is assumed that the Calibrator Oscilloscope Type 192 is on the workbench.

(a) Position the unit so that the bottom is uppermost. Remove and retain the four 4BA Phillips retaining screws, and remove and retain the bottom cover.

(b) Refer to the Drawing. To the underside of the volts PCB, connect by soldering, the 10KΩ resistor, between TP1 and the emitter of TR109.

(c) In the position shown in the drawing, annotate the circuit reference R165 using black marking ink.

(d) Refit the bottom cover and secure with the four Phillips 4BA screws retained in Operation 8(a).

(e) Strike through without obliterating the figure 3 on the Modification Record Label.

9. SPECIAL TESTS AFTER EMBODIMENT

No special tests are required after the embodiment of this modification.

10. RECORDING ACTION

Record on calibration/repair records (RAF).

11. DISPOSAL OF REDUNDANT PARTS

No parts are rendered redundant by the embodiment of this modification.

12. EFFECT ON WEIGHT

This modification has no effect on weight.

13. EFFECT ON AIRCRAFT OR EQUIPMENT OPERATION AND HANDLING

This modification does not affect the operation or handling of the equipment.

14. EFFECT ON SERVICING AND SERVICING SCHEDULE

(1) This modification does not affect the servicing of the equipment.

(2) This modification does not affect the servicing schedule.

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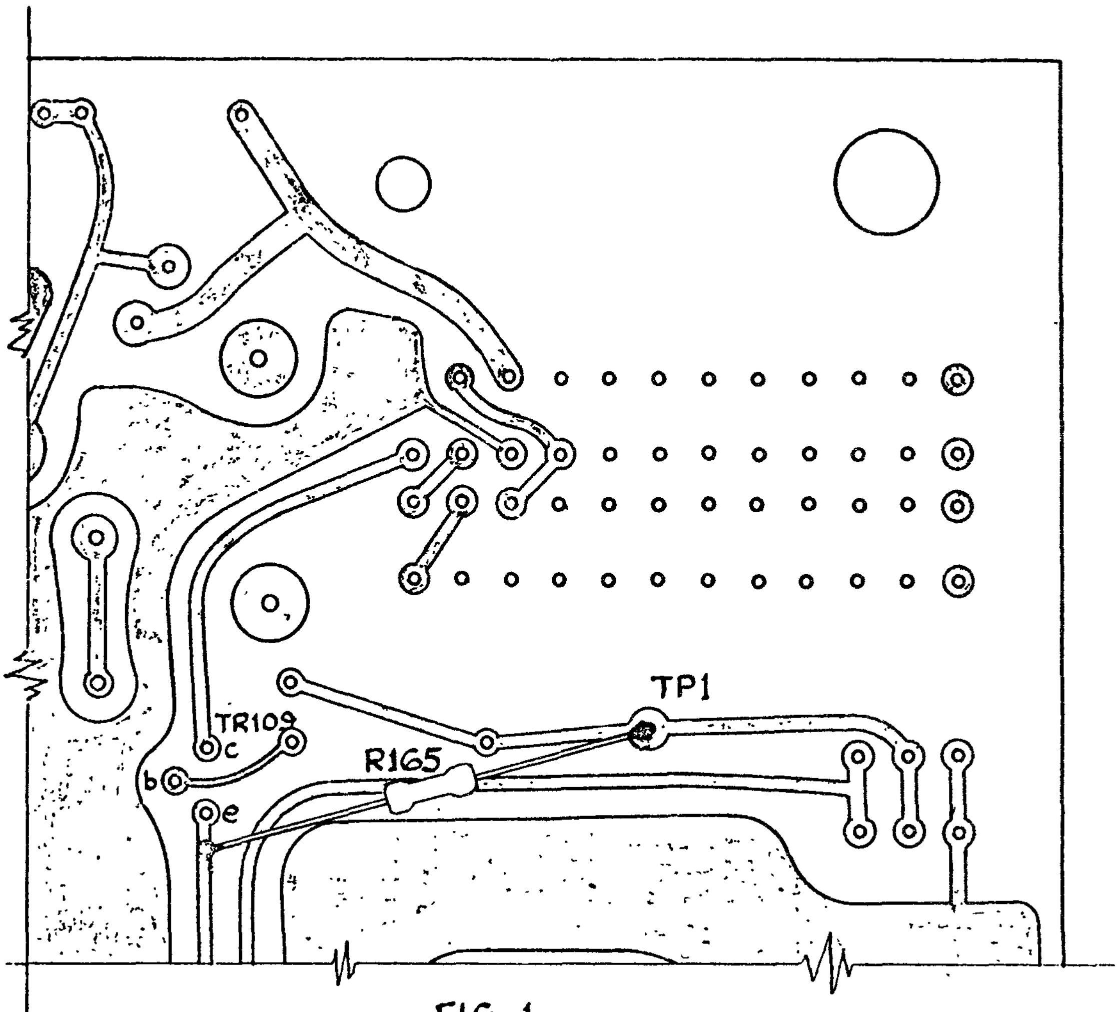

FIG. 1

Drg.No.AP.117D-0910-2/B1/74
Sheet No.1

Calibrator, Oscilloscope (Ref No 10D/6625-99-117-8133), part of Calibrator Set Oscilloscope Type 192 Introduction of new Capacitor C180.

(Mod No A5225/5)

(Class D/3 on recalibration)
(RAF & ARMY)

(ADSM25/M/27963)

(ADP No ZAA52250)

Amendment Instructions:- Insert this leaflet (2 leaves) in correct sequence. Sign the Amendment Record Sheet.

1. INTRODUCTION

It has been found that when the Calibrator Oscilloscope Type 192 is being used on "Square Wave" mode to check the voltage accuracy of high frequency oscilloscopes, modulation from the 1 MHz oscillator circuit causes a thicker trace to be displayed on the scope. To filter out this unwanted modulation a 300 pF capacitor C180 is connected across the inner and outer conductor of the voltage output socket SKT 102.

The modification is to be embodied on all Calibrators, Oscilloscope (Ref No 10D/6625-99-117-8133) below serial number BCB 500.

(1) This modification does not supersede, partially supersede or satisfy the work called for by any Modification Command, Naval Service Modification, STI, SI or SRIM.

2. EMBODIMENT

This modification is to be embodied by RAF Electronic Calibration Centres.

3. APPROXIMATE TIME REQUIRED FOR EMBODIMENT

The work will take approximately ½ man hour.

4. DRAWINGS REQUIRED

No drawings are required for the embodiment of this modification.

5. PARTS AND SPECIAL TOOLS REQUIRED

(1) Parts and Materials

(a) A Modification Kit will not be assembled.

(b) The following service supply items are required but not assembled as a Kit:-

Ref No	Drg/Part No	Nomenclature	Qty
10C/5910-99-012-0130	CPM-5B	Capacitor, Fixed, Metallised 300 pF ± 20%, 500V.	1

RAF units are to forward their demands for the individual referenced item direct to the appropriate ESD for non-SCC items (quoting the Mod number) and through SCC for SCC-controlled items. Other users are to demand their requirements in accordance with current regulations.

(2) Special Tools and Test Equipment

No special tools or test equipment are required for the embodiment of this modification.

6. MODIFICATION OF SPARES

No spares are affected by this modification.

7. CHANGE OF REFERENCE, PART AND ASSEMBLY NUMBERS

There are no changes of Reference, Part or Assembly Numbers as a result of this modification.

8. SEQUENCE OF OPERATIONS

The following is the sequence of operations:-

NOTE: Before any electrical circuit is disturbed or disconnected, all electrical power supplies in, to or from the equipment are to be disconnected. Power supplies are to be reconnected only when the person responsible for embodying or inspecting the modification is satisfied that all action has been taken to make the equipment safe for reconnection.

When nuclear safety may be affected, the prescribed routing of electric cables must be strictly followed.

It is assumed that the Calibrator Oscilloscope Type 192 is on the workbench.

(1) Position the Type 192 so that the bottom is uppermost. Unscrew, remove and retain the four 4BA posidriv screws securing the bottom cover, remove and retain the bottom cover.

(2) Locate and identify socket SKT102 (Square Wave mode) positioned on the bottom left hand of the front panel. Connect, by soldering, the 300 pF capacitor C180 between the inner conductor of SKT102 and the junction of resistor R152 and the outer conductor of SKT 102.

(3) Replace the bottom cover and secure it using the screws retained in operation (1).

(4) Strike through without obliterating the figure 5 on the Mod Record Label.

9. SPECIAL TESTS AFTER EMBODIMENT

No special tests are required after the embodiment of this modification.

10. RECORDING ACTION

Record in relevant unit documents.

11. DISPOSAL OF REDUNDANT PARTS

No parts are rendered redundant by the embodiment of this modification.

12. EFFECT ON WEIGHT

This modification has no effect on weight.

13. EFFECT ON AIRCRAFT OR EQUIPMENT OPERATION AND HANDLING

This modification does not affect the operation or handling of the equipment.

14. EFFECT ON SERVICING AND SERVICING SCHEDULE

This modification does not affect servicing or the servicing schedule.

15. EFFECT ON NUCLEAR SAFETY AND ELECTROMAGNETIC COMPATIBILITY

This modification has no effect on nuclear safety and electromagnetic compatibility.

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