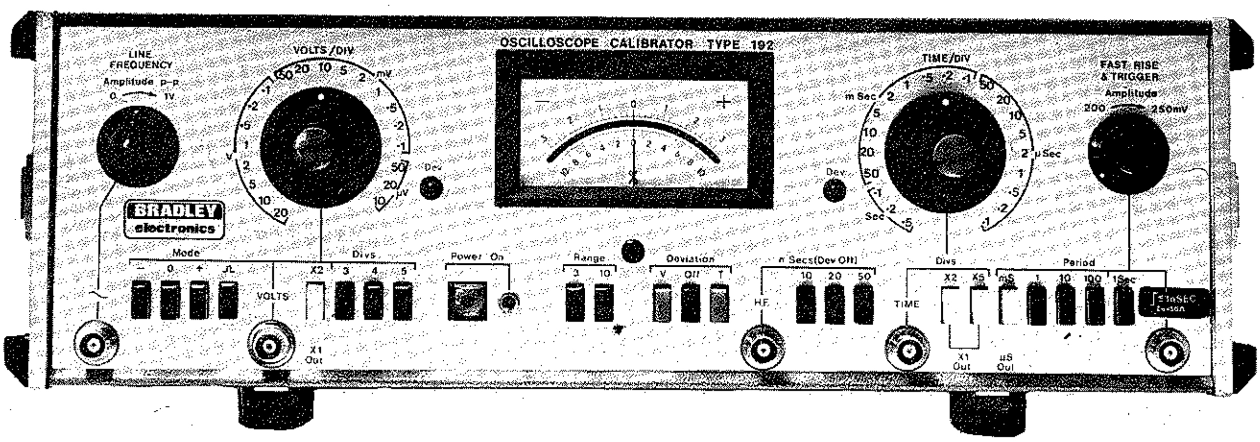
Oscilloscope Calibrator Type 192



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Modifications

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ILLUSTRATIONS

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.

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.

SYNCHRONISATION/TRIGGER CHECK

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

2. Specification

2.1	VOLTAGE CALIBRATOR	
2.1.1	Ranges	
	(a) Volts/division	10μV 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 ±5μV below 50mV. (After use on ranges on and above 50mV, a five minute settling time is required). Better than ±50μV above 50mV. Note: The same offset is obtained on all output modes including zero.
2.1.6	Ripple and Hum	Better than 0.1% +2μV p-p.
2.1.7	Square wave risetime	Less than 5μs
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.
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.

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 associated 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) Select 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, over-shoot 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 triggeri ng 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

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.

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 are 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.(v) and 3.7.5. the error mentioned is the percentage, positive or negative, by which the actual parameters of a signal (voltage or duration) exceed, or are less than the values indicated by the oscilloscope. If, for instance, +25% deviation is required to align calibrator voltage signals with the appropriate horizontal graticule lines when on the 1V/c.m. range, then 1.25V instead of 1V is required for every c.m. of vertical deflection. Similarly a +10% deviation in the time measurement mode indicates that all waveform periods measured on the oscilloscope must be increased by 10% to obtain their true values. Negative deviation values indicate that the observed quantities must be decreased by the percentage concerned. The calculation of the true voltage, or time, values of oscilloscope inputs from the indications provided, must only be carried out as described above.

3.12.6 Push Button Selection - Valid and Invalid Outputs

White Buttons

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.

Black Buttons

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

Red Buttons

Caution: Depressing either of the RED V, T, DEVIATION buttons deliberately takes the equipment out of its specified calibration accuracy, set by the other controls, except when the % Deviation meter is at zero. This potentialy uncalibrated feature is highlighted in later models by the addition of warning LEDs adjacent to the meter.

FAULT FINDING GUIDE

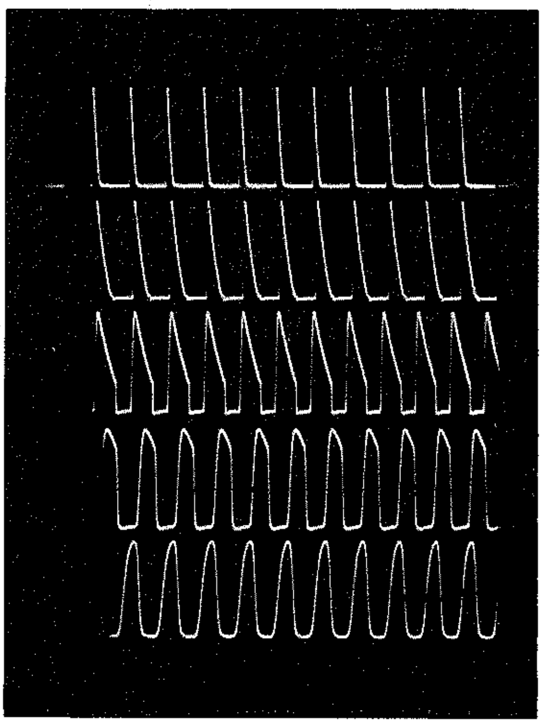
1. Meter Not Centred When Deviation Is Off

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.

4. Technical description

4.1 VOLTAGE FUNCTIONS (Figure 3)

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 virtual 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 (Figure 4)

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 the 'T' DEVIATION button depressed RV471 (or with the OFF DEVIATION button depressed, 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 (attenuated 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 TR640 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.

The type D flip flop X710a, receives the variable frequency output (nominally 1MHz) of X530a as a clock pulse and the fixed 1MHz output of the crystal oscillator X740 as a D-input; it gives a pulse output whose repetition rate is the difference between the fixed and variable frequencies. X710b, which is of the same type as X710a, acts as a shift register and repeats the output of X710a when clocked.

The Q output of X710a and the $\bar{Q}$ output of X710b are applied to a pair of inputs on each of the four-input AND gates X730a and X730b. When the Q output of X710a goes to logic 1, the Q and $\bar{Q}$ outputs of X710b remain at logic O and logic 1 respectively for one period of the variable frequency before changing over. Thus, when the other two inputs to a gate are at logic 1, the gate receives and passes a train of pulses at the difference frequency rate and variable frequency period.

When the RANGE switch S701 is operated by the 3% button, the output terminals of X730a and X730b are connected to the +5V supply via R703/RV703 and R704/RV704 respectively; when the switch is operated by the 10% button the interconnections are via R701/RV710 and R711/RV711. If X730a conducts, current flows through the deviation meter M700 from the junction of R711 and R704 and a positive deviation reading is obtained; conversely if X730b conducts, the current flows from junction R710/ R703 and the meter indication is negative. C730, in parallel with the meter, is a reservoir for the pulses, and a d.c. level proportioned to the percentage deviation is built up across it.

Mathematically:

$$\text{Meter current} \propto \text{pulse width} \times \text{prf}$$

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

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

$$\propto \text{percentage deviation}$$

Where fo = crystal oscillator frequency (1MHz)

Where To = period of crystal oscillator output (1μSec)

Where fr = variable frequency

Where Tv = period of variable frequency $= \left(\frac{1}{fv}\right)$

The percentage deviation is the amount by which period indications of the oscilloscope must be increased (if positive) or decreased (if negative) to obtain the true period of an input waveform.

X720, determines whether X730a, or X730b is to conduct. X720b, gives output pulses at the variable frequency, but displaced by 90°. X720a receives the 1MHz crystal frequency and is clocked by X720b; its Q and $\bar{Q}$ pulses are both at 90° to those produced at the gates by X710. When the variable frequency exceeds 1MHz (negative deviation) the Q output of X720a is at logic 1 while the outputs of X710 are at logic 1, and X730a is then ready to conduct; if the frequency is less than 1MHz (positive deviation) X730b is ready to conduct.

The fourth input to each gate is provided by X510b. At very low difference frequencies the slightest frequency or phase modulation of the 1MHz crystal frequency, or of the variable frequency results in multiple pulsing (both gates momentarily conducting simultaneously) causing jitter of the meter needle when near centre zero. X510b prevents this by sampling the polarity of the X710a logic inputs to the gates and feeding an opposite input to each gate as the pulse from X710a ceases. Both gates thus become cut-off and the originally open gate can only reopen on the next pair of pulse inputs from X710 when X720a has resumed its original state. However ragged the edges of the difference frequency square wave, there can thus be only one pulse per cycle of the difference frequency.

4.2.4. 1MHz Crystal Oscillator

The circuit provides a nominally symmetrical output without over-driving the crystal thus reducing 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 20MHz. 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 100Mhz 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 second period for trigger purposes.

Output transistor TR850 is used in common base mode 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 thus 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 (Figure 1)

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

R961 provides the major part of the bias current for zener diode D962 from the stabilised -10 V. 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 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.

5. Servicing and adjustment

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. Sampling Unit for 5 above

7. Counter Timer Bradley Type 234

8. BNC to BNC to cable, 50Ω, 3ft long

9. Flexible leads with small probe clips - Quantity 2

10. BNC to banana socket adaptor 50Ω BNC

11. 50Ω BNC T-junction

12. 2.2MΩ ±2% resistor, insulated and with stiff insulated flying leads

13. 1MΩ ±2% resistor wired across a BNC plug and fully insulated

14. Small on/off switch (low voltage)

15. Potentiometer of any resistance from 100Ω to 1kM

16. 1.5V or 3V battery

5.4 TRANSFORMER CONNECTIONS

Checking the Mains Transformer Secondary Voltages (test gear items 1 and 3).

1. Adjust the voltage selector on the rear panel for 250V input.

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

3. Supply the type 192 with 25V a.c. ie 1/10 of its nominal input setting, from the variac. Monitor the supply with the multimeter.

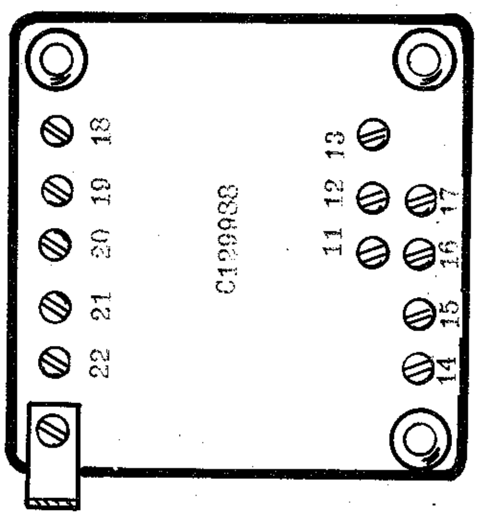
4. Switch the instrument ON and note the reading on meter. Let this voltage be E.

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



MAINS TRANSFORMER

TIME CALIBRATION

5.5 Power Supplies. (Test Gear items 1 and 3)

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. 1.0mV max.

7. Read voltage to chassis at TR980 collector. (Use adjacent end of R912 as test point). This should be -10 ±0.5V.

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

9. Reset mains voltage to 240V.

5.6. TIME OUTPUTS (Test Gear items 1 and 5)

1. Connect the type 192 TIME socket to the oscilloscope input, using a 50Ω BNC cable with a T-junction at the oscilloscope end. Switch the type 192 TIME/DIV control to 0.1μsec and depress the 'X5' DIVS time button. Set the oscilloscope for 1V/cm and 0.1μsec/cm.

2. Depress the 'T' DEVIATION button. Turn the time deviation control fully anti-clockwise. Set the BAL preset RV30 on board 4 to its centre position. Adjust the '-LIM' preset RV434 on board 4 to give about 4.4cm between pips.

3. Turn the deviation control fully clockwise. Adjust the "+LIM' preset RV472 on board 4 to give about 5.6cm between pips.

4. Adjust the time deviation control until the deviation meter reads centre zero approximately. Adjust the X shift control of the oscilloscope until there is one pip at each end and one at the centre of the trace.

5. Set the TIME/CM control of the oscilloscope and the TIME/DIV control of the type 192 to successively higher and equal positions, keeping the deviation meter reading at centre zero by adjustment of the time deviation control, if necessary. Check that the spacing of the pips remains constant at each setting.

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 of the pips at all settings of the TIME/DIV control must be between 1.5 and 2.5V. Set the TIME/DIV control to 5μSec and the TIME/CM control of the oscilloscope to 0.5μsec: the base width of the pips must be between 0.7 to 1.3 cm.

   Rotate both switches a further 10 steps to 10msec on the 192. Check that the base wisth is 1cm$\pm$30% in each case. (The spacing 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 (Test Gear items 1 and 5)

1. Connect the ⨍ $\leq$1μsec socket of 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 a 1μsec/on signal by releasing the 'mSec' button and depressing the '1' button. Set the oscilloscope for 1μSec/cm sweep. Observe the 10cm wide square wave display amplitude, which should be variable between 0.180 to 0.275 volts.

3. Switch the oscilloscope timebase speed to 10μsec/cm and 100sec/cm in turn and depress the appropriate type 192 PERIOD button to correspond (white 'mSec' button 'out'): check that the display width is 10cm in both tests. Continue with oscilloscope and type 192 settings for 1, 10 and 100mSec/cm (white 'mSec' button depressed) and, finally, for 1 sec/cm; the display width must be 10cm in all cases.

5.8 TIME DEVIATION (Test Gear items 1 and 7)

1. Check the mechanical zero of the type 192 meter by switching the power off <u>after</u> depressing the OFF DEVIATION button.

2. Switch power on and depress the 'T' DEVIATION and '3' RANGE buttons (3% time deviation). Select 10mSec TIME/DIV.

   Set the time circuitry to -2.5% time deviation by adjusting the DEVIATION control and measure the period at the Fast Rise output socket with a Counter Timer. The reading should be 9750 μs; if not, adjust the -3% range potentiometer RV703 until this reading is obtained with -2.5% on the deviation meter.

3. Set the time circuitry to +2.5% time deviation by adjusting the DEVIATION control and again measure the period at the Fast Rise output socket. The reading should now be 10250μs. Adjust the ±3% range potentiomerer RV704 until this reading coincides with a +2.5% reading on the deviation meter.

4. Select the 10% meter range. Set the time circuitry to -8% time deviation by adjusting the DEVIATION control and measure the period as before, the reading shall be 9200μs. If not, adjust the -10% range potentiometer RV710 as necessary.

5. Set the time circuitry to +8% time deviation by adjusting the DEVIATION control. The period should now read 10800μs. If not, adjust the +10% range potentiometer RV711.

6. Select again the 3% range. Check the -2.5% and +2.5% points. Readjust if necessary.

5.9 HF OUTPUTS (Test Gear items 1, 5 and 6)

1. Depress the T-DEVIATION and '10' RANGE buttons. Adjust the BAL preset RV430 to give the most negative deviation meter reading.

2. Set the oscilloscope for 200mV/cm and .1μSec/cm. Switch the magnification (MAG) control to 'X10'. Connect the type 192 HF socket to the oscilloscope channel 1 input, using a 50Ω cable terminated by a 50Ω through load.

3. Depress the 'OFF' DEVIATION and '10'nSec buttons. Commencing at minimum capacitance, adjust C15 on board 4 clockwise until a 10nSec sinewave of maximum amplitude is obtained. Note the p/p value, then turn the capacitor anti-clockwise until this is reduced by 20%.

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

5. Depress the 20nSec button. Adjust C425 for maximum amplitude It will be found that this is given over a considerable range of adjustment and the centre point should be carefully selected.

6. Depress the 50nSec button. Readjust the LOCK preset RV70 on board 4 to make the deviation % meter read at centre zero. Adjust C55 on board 4 to give nearly maximum amplitude, so that the waveform is clearer.

7. Make successive readjustments of the BAL preset RV30 on board 4 until that position is found where the LOCK preset can be adjusted farthest anti-clockwise without the meter pointer moving away from centre zero. Note the range of the LOCK preset over which the meter remains locked at zero; this should be at least a half-turn. Set the preset to the centre of this range.

8. Depress the '10' RANGE button and turn the TIME/DIV deviation control fully anti-clockwise. Adjust the -LIM preset RV34 on board 4 clockwise to bring the deviation meter pointer on the scale, then back it off until the pointer rests on the left end stop

9. Turn the TIME/DIV deviation control fully clockwise. Adjust the +LIM preset RV72 on board 4 anti-clockwise to bring the deviation meter pointer on the scale, then back it off until the pointer just rests on the right end stop.

10. Check that the TIME/DIV deviation control sweeps the meter pointer smoothly across the scale and that there is not more than 20% more movement of the control available after the scale limits are reached.

11. Depress the OFF DEVIATION button and check that the deviation meter reads at centre zero when the 10, 20 and 50nSEC (DEV OFF) buttons are successively depressed. Remove the co-axial cable from the HF socket and repeat the test for the same results.

5.10 FAST-RISETIME (Test Gear items 1, 5 and 6)

1 Connect the 1nSec socket of the type 192 to the channel 1 input socket of the oscilloscope using a 50Ω cable terminated with a 50Ω through load. Adjust the socilloscope for 50mV/cm and 1μSec/cm and switch the MAG control for 'X10'.

2. Adjust the type 192 FAST RISE AND TRIGGER control to give a display 5cm high. Measure the risetime of the positive edge over the centre 4cm (10% to 90% of height). If the width exceeds four small graticule divisions (4nSec) measure the oscilloscope risetime and apply the formula:

$$\text{Rise-time of type 192} = \sqrt{To^2 - Tm^2}$$

Where To = Oscilloscope risetime in nSec

Where Tm = Display risetime in nSec

This must not exceed 1nSec.

3. Connect the sampling unit first to the oscilloscope and adjust the controls for 2nSec/cm and 5mV/cm. Connect the .1nSec socket of the type 192 to the input of the sampling unit, using a 50Ω cable (no through load) with a GR to BNC adaptor. Check that the over-shoot on the waveform is not greater than 2% (1cm of display height).

5.11 VOLTS CALIBRATION

RESISTANCE MEASUREMENTS (Use item 2 set to its X100 ohms range)

1. Switch the type 192 off.

2. Measure the resistance to chassis of the outer part of the VOLTS output socket. This must be 100±20Ω.

3. Measure the resistance from the inner to the outer part of the VOLTS socket. This must be 220Ω at the 10μV setting of the VOLTS/DIV switch, increasing on each range to 3.2kΩ at the 10mV setting (allow for meter error).

5.12 SUPPLIES and SHORTED OUTPUT (Test Gear items 1 and 2)

1. Check that the type 192 mains selector is set for 240V. Adjust the variac item 1 for 240V ± 1V using multimeter, item 2 then switch on the type 192. Set the type 192 controls as follows:

VOLTS/DIV	-	20
MODE	-	depress '+' button
DIVS	-	depress the 'X2' and '5' buttons
DEVIATION	-	depress 'OFF' button

Monitor at the VOLTS socket with the multimeter item 2 (set to its 400V d.c. range): this must read +200 ±30 volts.

2. Disconnect the multimeter from the VOLTS socket and set it to its 100mA range. Reconnect the multimeter to the socket: the reading must be 34 ±3mA.

3. Disconnect the multimeter again, quickly switch it to its 400V d.c. range and reconnect it: the voltage must have returned to the value at sub-para 1.

4. Depress the '0' MODE button. Check the voltage is across each of C104, 105 and 106: these must be as follows:

C104	-	300 to 350V	Positive points at l.h. end of type 192 (looking from front).
C105	-	16 to 19V	
C106	-	18.3 to 21.3V	

5.13 REGULATION (Test Gear items 1, 2, 4, 5 and 13)

1. Adjust the variac output voltage to 240V using multimeter item 2. Connect variac output to the type 192 and switch on. Depress the '0' MODE and 'OFF' DEVIATION buttons. Connect oscilloscope item 5, direct to the mains supply.

2. Plug a 50Ω T-junction into the VOLTS output socket of the type 192 and connect a BNC to crocodile clip lead to one branch. With the oscilloscope, item 5, switched on, but with its CALIBRATOR switch off, plug a second BNC to crocodile clip lead into its CAL socket.

3. Set voltmeter, item 4 to its 100V d.c. range; connect the live clip of the lead from the type 192 to the HIGH terminal and that of the lead from the oscilloscope to the LOW. Connect the braid clips of the two leads together and lightly insulate.

4. Put the CALIBRATOR switch of the oscilloscope to +100V DC wait until the voltmeter reading stabilizes, then note the (negative) reading. Depress the '+' mode button, await a stable (positive) reading again, then adjust RV4 on the '100' board until a reading of 200V ±20mV - the previous reading is obtained (required output from type 192 ≑ ±200V ±20mV).

5. Reduce the variac output voltage to 216V and note the change in the voltmeter reading: this must not exceed 40mV.

6. Reset the variac output to 240V. Note the voltmeter reading both with and without the 1MΩ resistor, item 13, plugged into the free branch of the T-junction: the difference in the reading must not exceed 0.1V. Unplug the resistor at the conclusion of the test.

5.14 VOLTAGE DEVIATION (Test Gear items 1, 2, 4 and 5)

1. Carry out 5.13.1, 5.13.2 and 5.13.3. Put the CALIBRATOR switch of the oscilloscope to '+100V DC'. Note the (negative) reading of the voltmeter after it has stabilised.

2. Depress the 'V' DEVIATION the '10' RANGE and the 'X 2' and '5' DIVs buttons. Subtract the reading obtained at sub-para 1 from 220V and adjust the type 192 voltage deviation control until the voltmeter indicates this figure within ±40mV. Note the reading obtained (actual output from VOLTS socket will then be within +220V ±40mV.

3. Adjust the preset RV2 on Board 1 until the deviation meter indicates +10% on its 10% scale. Keep the voltmeter reading constant by adjustment of the deviation control, if necessary, while doing this.

4. Adjust the deviation control anti-clockwise until the deviation meter indicates -10% exactly. Add the figure obtained at sub-para 1 to the voltmeter reading and subtract 180 volts. Note the figure obtained and call it E_D: this must not exceed 0.6V. If E_D is greater than 100mV, continue as at sub-para 5 and 6 below.

5. Readjust the deviation control until E_D is halved, then readjust RV102 to restore the -10% reading on the deviation meter.

6. Set the deviation control for a +10% meter reading and verify that the voltmeter reading is within D/2 volts ±100mV of that noted at sub-para 2.

7. Depress the '3' RANGE button and adjust the deviation control for a +3% reading on the 3% scale.

8. Subtract the reading noted at sub-para 1 from 206V and adjust the preset RV103 until the voltmeter indicates this difference ±20mV. Note the reading.

9. Turn the deviation control anti-clockwise until the deviation meter indicates -3% on its 3% scale. Add the reading noted at sub-para 1 to the voltmeter reading and subtract 194V: this gives the voltage deviation E_D from 194V and must not exceed 0.2V. Note the value of E_D and if it exceeds 40mV, continue with sub-para 10 and 11 below. Note also the voltmeter reading.

10 Readjust RV103 to halve the value of E_D, then adjust the deviation control for a +3% reading on the 3% scale of the deviation meter. Note the voltmeter reading and verify that this is $12 \pm E_D/2$ volts higher than the voltmeter reading noted at sub-para 9.

5.15 ATTENUATOR RATIOS (Test Gear items 1, 2, 4 and 5)

1. Proceed as at 5.13.1, 5.13.2, 5.13.3 and 5.13.4. Omit the T-junction and plug the respective lead direct into the VOLTS socket.

2. Put the CAL switch of the oscilloscope to OFF and depress the '0' MODE button of the type 192 (this is to avoid shocks or damage) then disconnect the voltmeter and oscilloscope and depress the wave MODE button.

3. Connect test prods to the HIGH and LOW terminals of the voltmeter and set it to its 100V range. Monitor across each of R146 and R147 in turn: the reading must be within 100mV ±0.25-V in each case.

NOTE: R146 and R147 are each groups of three parallel-connected resistors mounted on top of the VOLTS/DIV switch: R147 being on the extreme right (looking from the front) with R146 to its left.

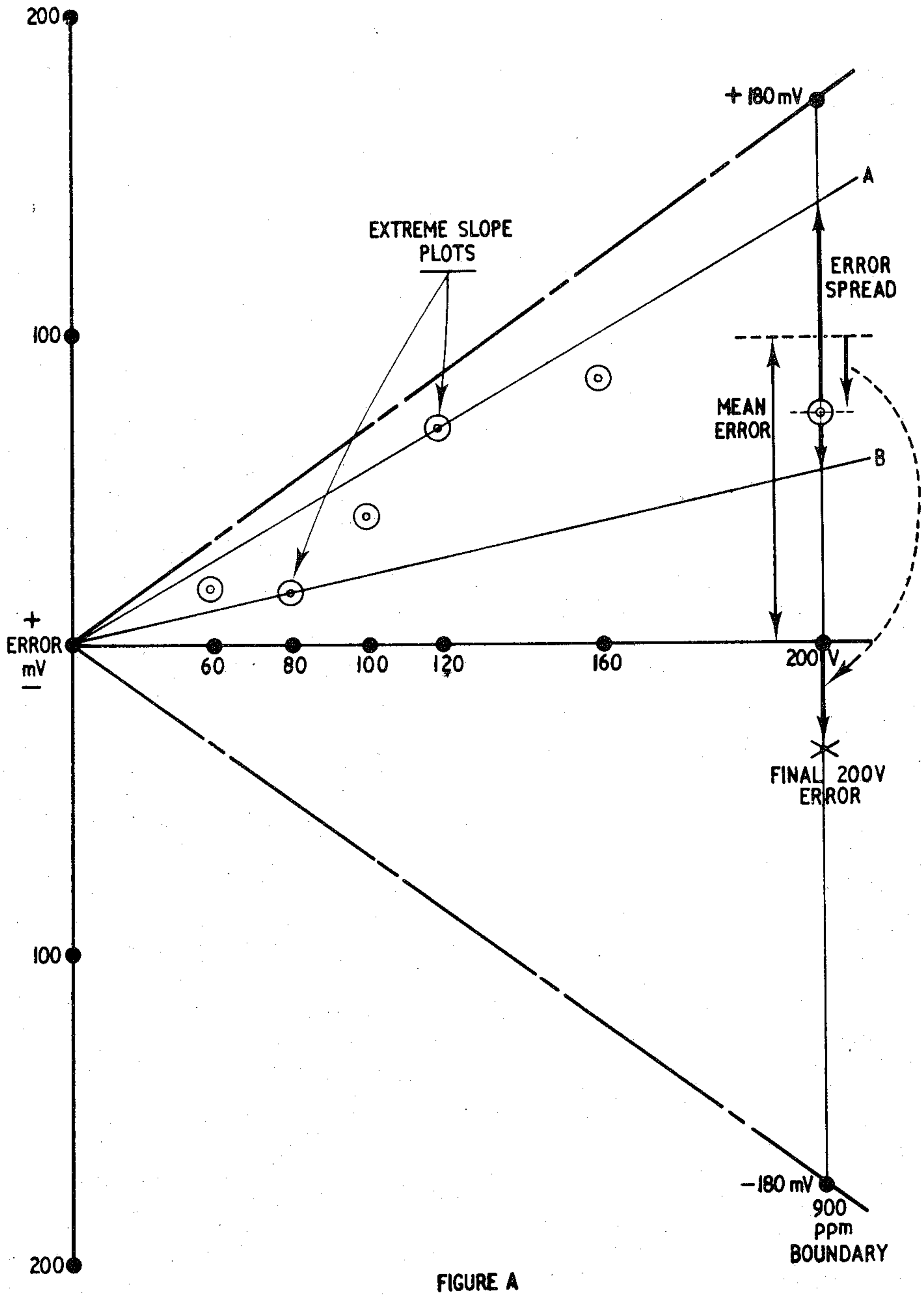

200
100
+
ERROR
mV
—
100
200
60
80
100
120
160
200 V
+ 180 mV
A
B
EXTREME SLOPE
PLOTS
ERROR
SPREAD
MEAN
ERROR
FINAL 200V
ERROR
−180 mV
900
ppm
BOUNDARY

FIGURE A

Two resistors of each group are of 10.2Ω each, while the third is a higher value, selected in calibration, to provide a total resistance of 5.05Ω.

4. If either result at sub-para 3 is outside the specification, carefully remove the group of resistors concerned and separate them. If the voltage was below 100mV, check each of the 10.2Ω resistors on a suitable bridge and change those that are outside 10.1 to 10.3Ω, then replace the group and recheck the voltage as at sub-para 3. If the result is now high, of if the original result was high, proceed as at sub-para 5 below.

5. Subtract 100 from the voltmeter reading in mV and call the result E (mV). Remove the high-value resistor of the group (leaving the two 10.2M resistors) and replace this by a resistor of value and tolerance as calculated below:

$$R \text{ (ohms)} = \frac{500}{E} \qquad \text{Tolerance } (\%) \not> \frac{5}{E}$$

Ex: If E is 1.5mV, the resistance value is $\frac{500}{1.5} = 333\Omega$ and the % tolerance $\frac{5}{1.5} = 3\frac{1}{3}\%$. A330Ω, 2% resistor would therefore be an appropriate replacement.

6. Depress the '+' MODE and the 'X2' and '5' DIVs button. Refer to the table below and check with the voltmeter, item 4, that the output at the VOLTS socket is within the limits given, at the respective VOLTS/DIV switch positions shown. Record each reading.

VOLTS/DIV setting	20	10	5	1	0.5	0.1	50mV
Voltmeter range	100V* dc	10V dc	10V dc	1V dc	1V dc	100mV dc	100mV dc
Output limits	200V ±20mV	100V ±100mV	50V ±50mV	10V ±10mV	5V ±5mV	1V ±1mV	0.5V ±500μV
Measured valve							

*To make this test first proceed as at sub-para 5.13.1., 5.13.2

and 5.13.3. (REGULATION) omitting the T-junction. Put the CALIBRATOR switch of the oscilloscope to '+100V DC and note the (negative) reading of the voltmeter after this has stabilised. Add this voltmeter reading to that obtained in the test to obtain type 192 output voltage.

5.16 OPTIMUM REFERENCE SETTING (Test Gear items 1, 2, 4 and 5)

1. Prepare a table as shown below:

Depress DIVs buttons:	Nominal voltage (V)	Initial errors (mV)	Error spread (mV)	Mean error (mV)	Final 200V error (mV)
X2 and 5	200				
X2 and 4	160				
X2 and 3	100				
5	100				
4	80				
3	60				

2. Connect the type 192 and oscilloscope as at sub-para 5.13.1, 5.13.2 and 5.13.3., omitting the T-junction. Depress the OFF DEVIATION button.

3. Depress the 'X2' and '5' DIVs buttons and measure the type 192 output voltage as at sub-para 5.13.4. Re-adjust RV4 on the '100' board for 200V ±20mV if outside these limits. Subtract 200 from the figure obtained, append the appropriate positive or negative sign and enter the result in the first line of the third column in the table.

4. Depress the type 192 '0' MODE button. Switch off the oscilloscope calibrator then remove the oscilloscope from the meter circuit.

5. With the voltmeter initially set to its 100V range, depress the '+' MODE button of the type 192.

6. Measure the outputs at each of the other DIVs setting listed and subtract the corresponding nominal voltage. Enter each difference with its appropriate sign, in the third column of the table.

7. Plot a graph of mV error against nominal voltage, as shown in Fig A (at the end of this section). Rule two lines, A and B, from the 0 volt origin through these plots which give lines of the greatest and least slope.

8. Draw a perpendicular at the 200 volt point of the horizontal axis and measure the distance (in mV) between the intersection of this with lines A and B. Record the value found on the first line of the 'error spread' column of the table.

9. Mark the centre point between the two intersections and record its value in the fifth column of the table (Mean Error).

10. Change the sign of the mean error and add it to the initial 200V error. Record this value in the sixth column of the table (Final 200V error).

11. Repeat sub-para 2 and 3, but adjust RV4 to give an output voltage equal to the final 200V error value recorded at sub-para 10.

5.17 SQUARE WAVE ZERO LEVEL (Test Gear items 1, 2, 3, 4, 14, 15 and 16)

1. Depress the '+' MODE, the 'X2' and '5' DIVs and the 'OFF' DEVIATION buttons and adjust the VOLTS/DIV control to '20V'. Switch the type 192 off.

2. Wire the outer terminals of potentiometer, item 15 in series with the switch, item 14, across the battery, item 16. Set the multimeter, item 3 to its 1.2 volt d.c. range and connect it across the positive outer terminal and the slider of the potentiometer. Put the switch on, adjust the potentiometer for 1 volt output, then put the switch off again.

3. Connect the positive end of the potentiometer to test point TP1 (adjacent to the 'R31' legend on board 100) and its slider to test point TP2 (to the right of TP1 looking from the front). Put the potentiometer switch on, re-adjust for a reading of 1 ±0.02V on the voltmeter, then switch off again.

4. Switch on the type 192, set the multimeter, item 4, to its 1000V range and connect it to the VOLTS socket. Verify that the output is 200V when the battery switch is 'off' and approximately 0 volts when it is on. Leave the battery switch on.

5. Set the voltmeter, item 4 to its 1 volt d.c. range and adjust RV5 on board 100 until the voltmeter reads 0±5mV. Momentarily connect the 2.2MΩ resistor between one fixing screw of TR7 and the negative end of D16, both on board 100, and verify that the output voltage does not rise to more than 50mV.

6. Switch off the type 192 and disconnect the potentiometer leads therefrom before changing any front-panel settings.

5.18 VOLTAGE SQUARE WAVE (Test Gear items 1, 2 and 5)

1. Depress the '+' MODE, the 'X2' and '5' DIVs and the 'OFF' DEVIATION buttons. Set the VOLTS/DIV control to '10V'.

2. Adjust oscilloscope, item 5, for 20V/cm d.c. coupled and 1mSec/cm. Connect its input to the type 192 VOLTS socket. A square wave display 5cm high and 1mSec wide should be obtained.

3. Reduce the type 192 VOLTS/DIV control setting to '50mV' and reset the oscilloscope for 0.1V/cm. Adjust the oscilloscope time/cm so as to display the leading edge of the square wave. Note the risetime between 10% and 90% of maximum amplitude; this must be less than 5μSec. Note the overshoot on the waveform: this must not exceed 0.5% of maximum amplitude.

4. Reduce the VOLTS/DIV control setting to '20mV' and adjust the oscilloscope for a display similar to that obtained at sub-para 3 above. Adjust the capacitor C11 on board 100 (attenuator trimmer located on rear wafer of VOLTS/DIV control) to eliminate any roll-up, or overshoot.

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

5.19 RIPPLE (Test Gear item 1, 2 and 5)

1. Set the variac input to the type 192 to 216±1V. Depress the '+' MODE, the 'X2' and '5' DIVS and the 'OFF' DEVIATION buttons. Set the VOLTS/DIV control to '20V'.

2. Adjust oscilloscope, item 5, for 0.1V/cm a.c coupled and 10mSec/cm. Connect its input to the type 192 VOLTS socket.

3. Adjust the position of the oscilloscope display to exhibit any ripple on the waveform and verify that this is less than 0.2V p/p.

4. Reset the variac to 240±1V.

5.20 LINE FREQUENCY (Test Gear items 1, 2 and 5)

Monitor the LINE FREQUENCY output socket using oscilloscope, item 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.

6. Parts list

Reference must be made to the relevant I.P.C. when demanding spares.

Where supplies of a component from a particular manufacturer are not obtainable, exact equivalents from a different supplier may be fitted. These changes in no way affect the performance of the instrument.

VOLTS CIRCUIT

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	C1309 90
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	GR00724
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	1/2	Morganite S	C130939
R110	57.6k	1.0	1/8	Welwyn 4033 100ppm	GR00990
R111	2.2k	2.0	1/2	Mullard MR30	GRO01019
R112	39k	2.0	1/2	Mullard MR30	GRO01025
R113	2.7k	2.0	1/2	Mullard MR30	GRO01020
R114	2.2k	2.0	1/2	Mullard MR30	GR01019
R115	18k	2.0	1/2	Mullard MR30	GRO 0987
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 15ppm	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				
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	2N4240	GV01518
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 V	TOL %	RATING V	MANUFACTURER OR STYLE	BRADLEY REF NO.
C171	1000p	-20 +80	500	Erie Feed Thro 361-K2600	GC22166
C172	1000p	-20 +80	500	Erie Feed Thro 361-K2600	GC22166
C173	1000p	-20 +80	500	Erie Feed Thro 361-K2600	GC22166
C174	1000p	-20 +80	500	Erie Feed Thro 361-K2600	GC22166
C175	1000p	-20 +80	500	Erie Feed Thro 361-K2600	GC22166
C180	270p	5	500	Mullard 42722701 J	GC92116

DIODES

CIRCUIT REF	VALUE V	TOL %	RATING V	MANUFACTURER OR STYLE	BRADLEY REF NO.
D101				IR 10D4	GV01136
D102				IR 10D4	GV01136
D103				IR 10D4	GV01136
D104				IR 10D4	GV01136
D105				IR 10D4	GV01136
D106				IR 10D4	GV01136
D107				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

*Alternative 1N 4577

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	Electrosil TR5	GR07888
R854	150	10	0.25	Morganite XL	GR01129
R855	150	10	0.25	Morganite XL	GR01129
R856	470	2	0.5	Mullard MR39	GR00638
R857	82	2	0.5	Mullard MR30	GR00624
R858	100	2	0.4	Mullard MR25	GR00560
R859	100	2	0.4	Mullard MR25	GR00575
*R831	150	2			

* 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	1k	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)	GR07584

TRANSISTORS

CIRCUIT REF	VALUE Ω	TOL %	RATING W	MANUFACTURER OR STYLE	BRADLEY REF. NO.
TR410				Mullard BSX20	GVO 1356
TR420				Mullard BSX20	GVO 1356
TR430				Mullard BSX20	GVO 1356
TR440				Mullard BSX20	GVO 1356
TR450				Mullard BSX20	GVO 1356

TRANSISTORS (Cont'd)

CIRCUIT REF	MANUFACTURER OR STYLE	BRADLEY REF. NO.
TR630	Mullard BSX20	GVO 1356
TR640	Mullard BSX20	GVO 1356
TR810	Mullard BSX20	GVO 1356
TR820	Mullard BSX20	GVO 1356
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	-10 +50	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	STC PMA	GC22072
C944	330	-10 +50	16	Mullard 017-55331	GC26089
C984	200μ	-10 +50	10	Mullard C426BC/D200	GC20222
C991	800μ	-10 +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	Motorola MV1652	MV1652
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
D732	Mullard BAX13	BAX13
D740	Mullard BZY88-C3V3	BZY88-C3V3
D822	Mullard BZX13	BAX13
D823	Mullard BZX13	BZX13
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	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 SN7472 N	GV00817
X610			Texas Instrument SN7490N	GV00815
X710			Texas Instrument SN7474N	GV00815
X720			Texas Instrument SN7474N	GV01513
X730			Texas Instrument SN15844N	GV01465
X740			Texas Instrument SN72702N	GV01514
XL411	100MHz	0-50°C	STC 4203/AT-5	GV00651
XL747	1MHz	-20+70°C	STC 4026/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

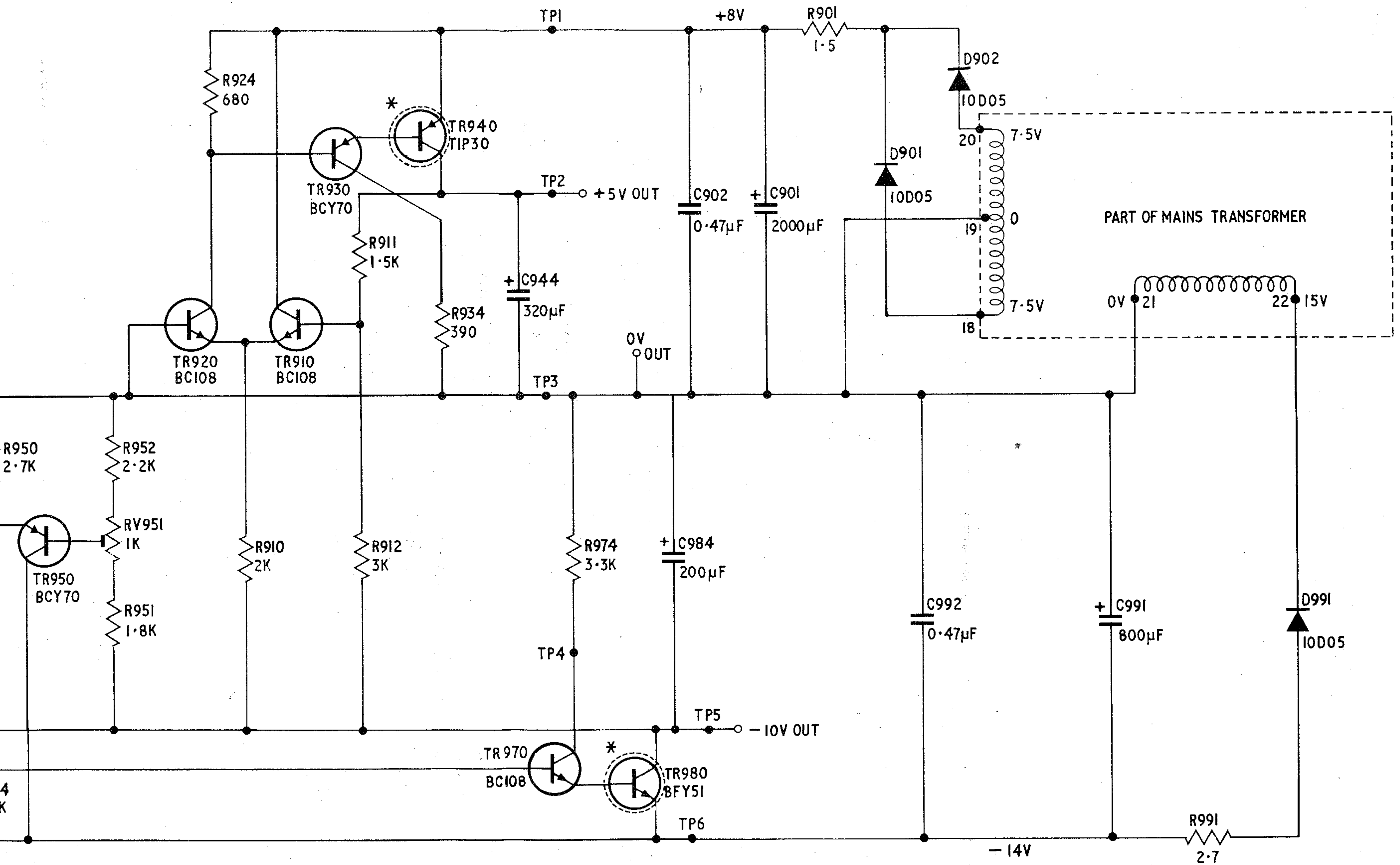
VOLTS CIRCUIT (ADDITIONAL ITEMS)

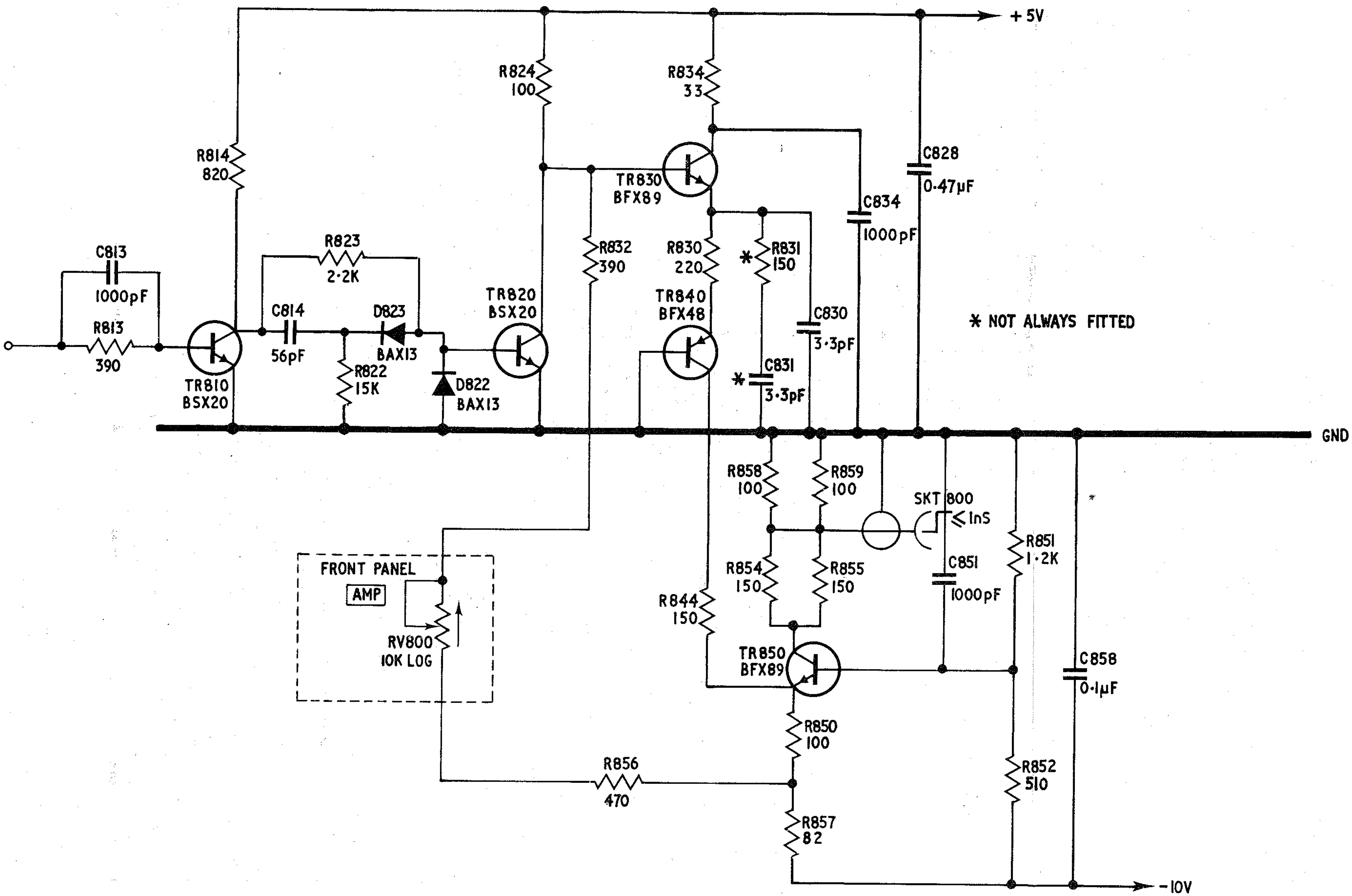
SWITCHES

CIRCUIT REF	VALUE	RATING	MANUFACTURER OR STYLE	BRADLEY REF. NO.
S101		250V 3A	Mains Toggle DPD. T. MST205N Waycom	GS01422
S102			VOLTS/DIV Push Button Isostat	A129993
S103			MODE Push Button Isostat	A129992
S104			VOLTS/DIV Rotary Wafer Switch	C147614

SWITCHES (Cont'd)

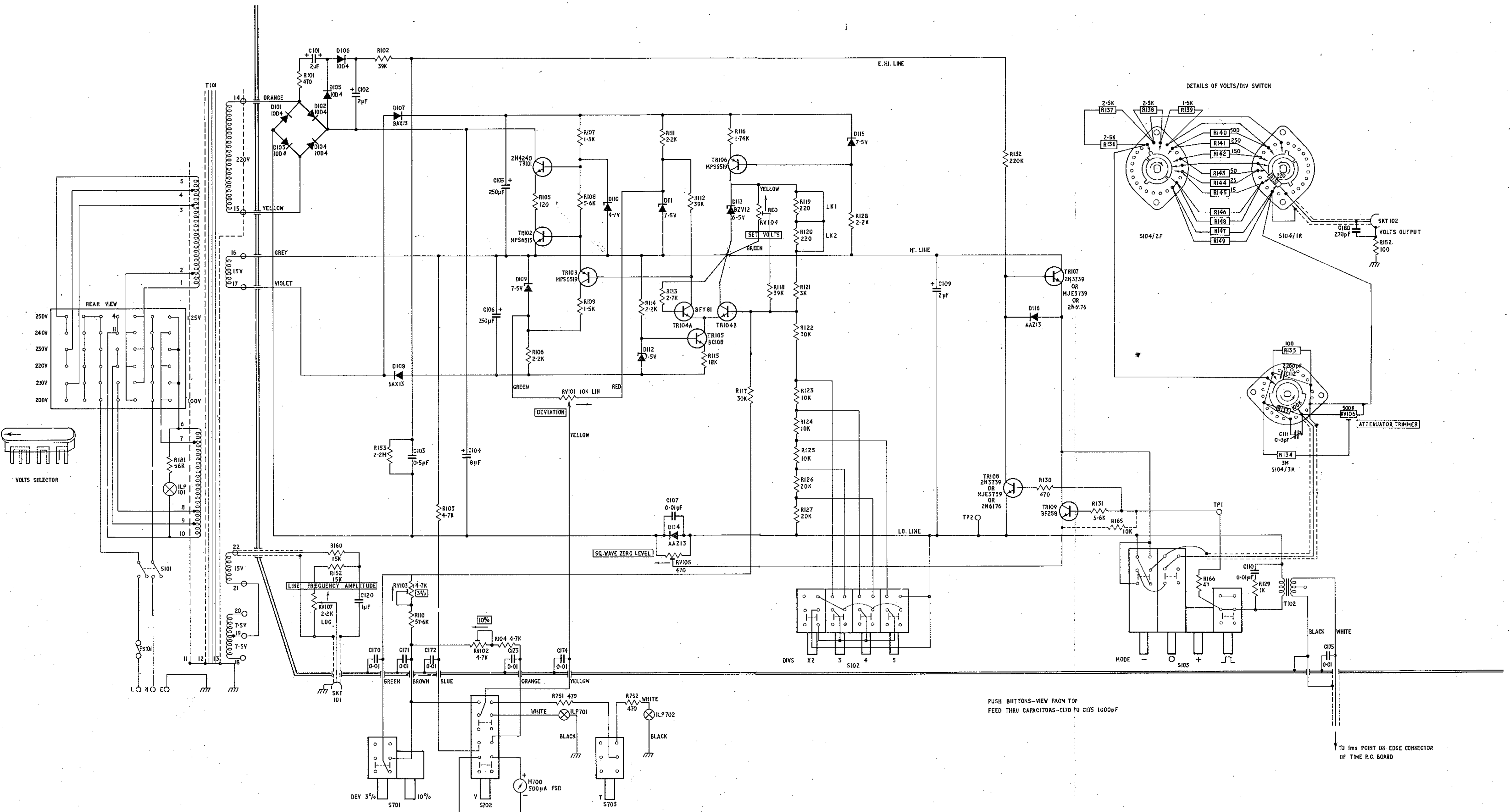
CIRCUIT REF	VALUE	RATING	MANUFACTURER OR STYLE	BRADLEY REF. NO.
S401				
S402			HF O/P 10, 20, 50nSec Isostat	C129995
S403				
S500			TIME/DIVISION Rotary Wafer Switch	C147615
S701			Range. 3, 10% Deviation Isostat	
S702			Deviation: Volts & Time	A129975
S703				
S601				
S602				
S801				
S802			x2 + x5, Period	A129996
S803				
S804				
BNC SOCKETS				
SKT101			UG657/U	GP01584
SKT102				
INDICATOR LAMPS				
ILP101	12V	0.1A	BOSS Industrial SM/A/1/79/ TAMB	GV01485
ILP701			HP 5082-4440 Solid State lamp Orange	GV01710
ILP702			HP 5082-4440 Solid State lamp Orange	GV01710
TRANSFORMERS				
T101			Mains Transformer with Input Selector Panel	C129988
T102			Radiospares Driver Transformer	GT13160
MISCELLANEOUS				
FS	200/250	500mA	Fuse Belling Lee L1055	GV17105
Part of T101			McMurdo Voltage Selector B279002/A	B130104
	Power cable (3 core moulded)		Belling Lee L1949	GP60523
	Plug Fixed		Belling Lee L1950	GP60524


TP1
+8V
R901
1·5
D902
10D05
R924
680
TR940
TIP30
TR930
BCY70
TP2
+5V OUT
C902
0·47µF
C901
2000µF
D901
10D05
20
7·5V
19
0
PART OF MAINS TRANSFORMER
18
7·5V
0V 21
22 15V
R911
1·5K
C944
320µF
R934
390
TR920
BC108
TR910
BC108
0V
OUT
TP3
R950
2·7K
R952
2·2K
RV951
1K
TR950
BCY70
R951
1·8K
R910
2K
R912
3K
R974
3·3K
C984
200µF
C992
0·47µF
C991
800µF
D991
10D05
TP4
TP5
-10V OUT
TR970
BC108
TR980
BFY51
TP6
-14V
R991
2·7



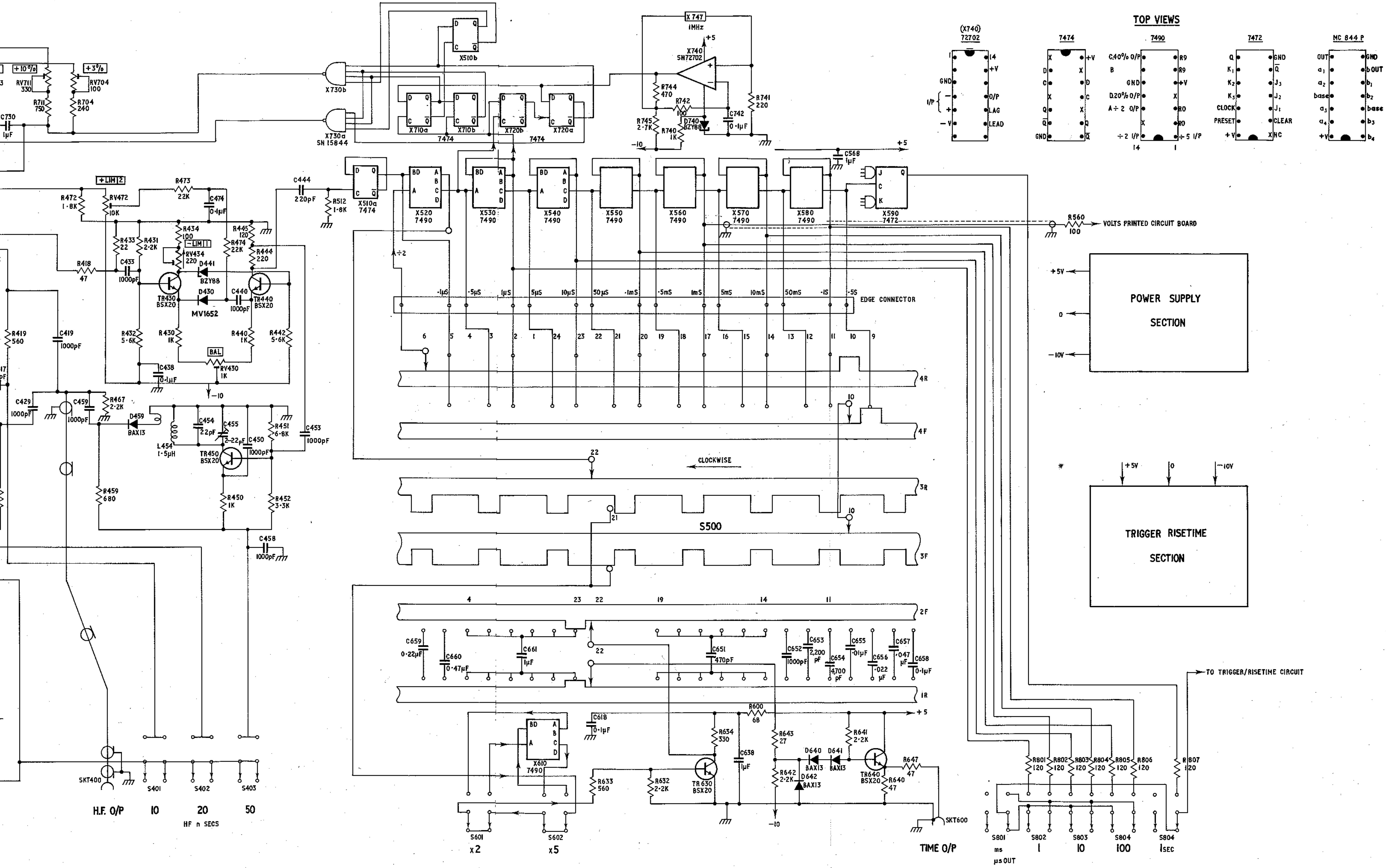
TRIGGER/RISETIME CIRCUIT

FIG. 2



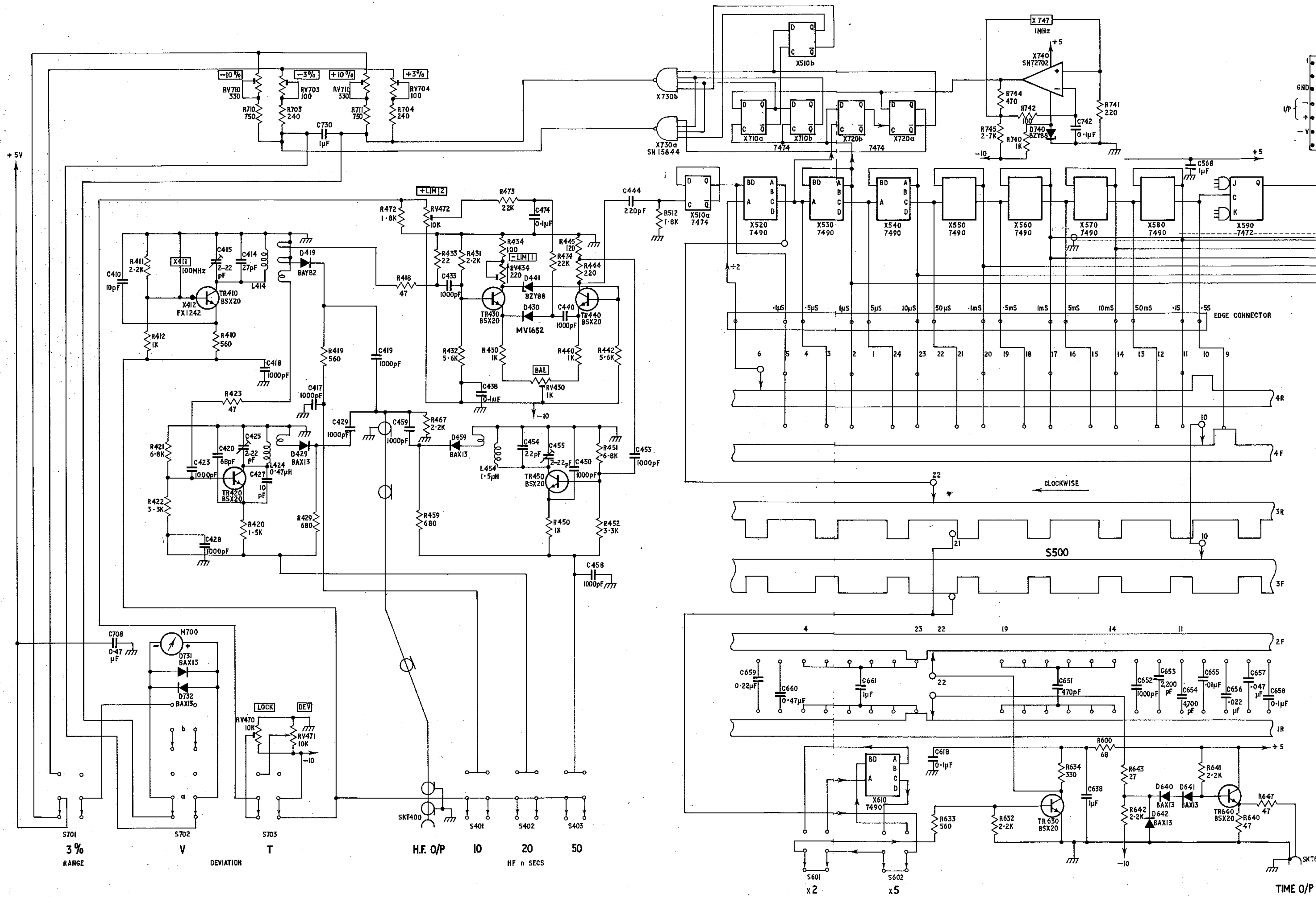
192 OSCILLOSCOPE CALIBRATOR VOLTS CIRCUIT

FIG.3



192 OSCILLOSCOPE CALIBRATOR TIME CIRCUIT

FIG. 4



-10%
-3%
+10%
+3%
RV710 330
RV703 100
RV711 330
RV704 100
R710 750
R703 240
R711 750
R704 240
C730 1µF
+5V
X730b
X730a SN 15844
X510b
X710a
X710b
X720b
X720a
7474
X747 1MHz
X740 SN72702
R744 470
R742 100
D740 BZY88
C742 0·1µF
R741 220
R745 2·7K
R740 1K
C568 1µF
+LIM 2
R473 22K
C474 0·1µF
R472 1·8K
RV472 10K
C444 220pF
R512 1·8K
X510a 7474
X520 7490
X530 7490
X540 7490
X550 7490
X560 7490
X570 7490
X580 7490
X590 7472
X411 100MHz
C415 2-22 pF
C414 27pF
L414
D419 BAY82
R411 2·2K
C410 10pF
X412 FX1242
TR410 BSX20
R412 1K
R410 560
C418 1000pF
R418 47
R433 22
R431 2·2K
C433 1000pF
R434 100
-LIM 1
RV434 220
D441 BZY88
R474 22K
R445 120
R444 220
TR430 BSX20
D430 MV1652
C440 1000pF
TR440 BSX20
R419 560
C419 1000pF
R432 5·6K
R430 1K
R440 1K
R442 5·6K
BAL
RV430 1K
C438 0·1µF
-10
R423 47
C417 1000pF
C429 1000pF
C459 1000pF
R467 2·2K
D459 BAX13
R421 6·8K
C420 68pF
C425 2-22 pF
D429 BAX13
L424 0·47µH
C423 1000pF
C427 10 pF
TR420 BSX20
R422 3·3K
R420 1·5K
R429 680
C428 1000pF
L454 1·5µH
C454 22pF
C455 2-22pF
C450 1000pF
R451 6·8K
C453 1000pF
TR450 BSX20
R459 680
R450 1K
R452 3·3K
C458 1000pF
÷2
·1µS ·5µS 1µS 5µS 10µS 50µS ·1mS ·5mS 1mS 5mS 10mS 50mS ·1S ·5S
EDGE CONNECTOR
4R
4F
CLOCKWISE
3R
S500
3F
2F
1R
C708 0·47 µF
M700
D731 BAX13
D732 BAX13
LOCK
DEV
RV470 10K
RV471 10K
C659 0·22µF
C660 0·47µF
C661 1µF
C651 470pF
C652 1000pF
C653 2,200 pF
C654 4700 pF
C655 ·01µF
C656 ·022 µF
C657 ·047 µF
C658 0·1µF
R600 68
C618 0·1µF
X610 7490
R634 330
C638 1µF
R643 27
D640 BAX13
D641 BAX13
R641 2·2K
R647 47
R642 2·2K
D642 BAX13
TR640 BSX20
R640 47
R633 560
R632 2·2K
TR630 BSX20
+5
SKT400
S701
S702
S703
S401
S402
S403
3%
RANGE
V
DEVIATION
T
H.F. O/P
10
20
50
HF n SECS
S601
S602
x2
x5
TIME O/P

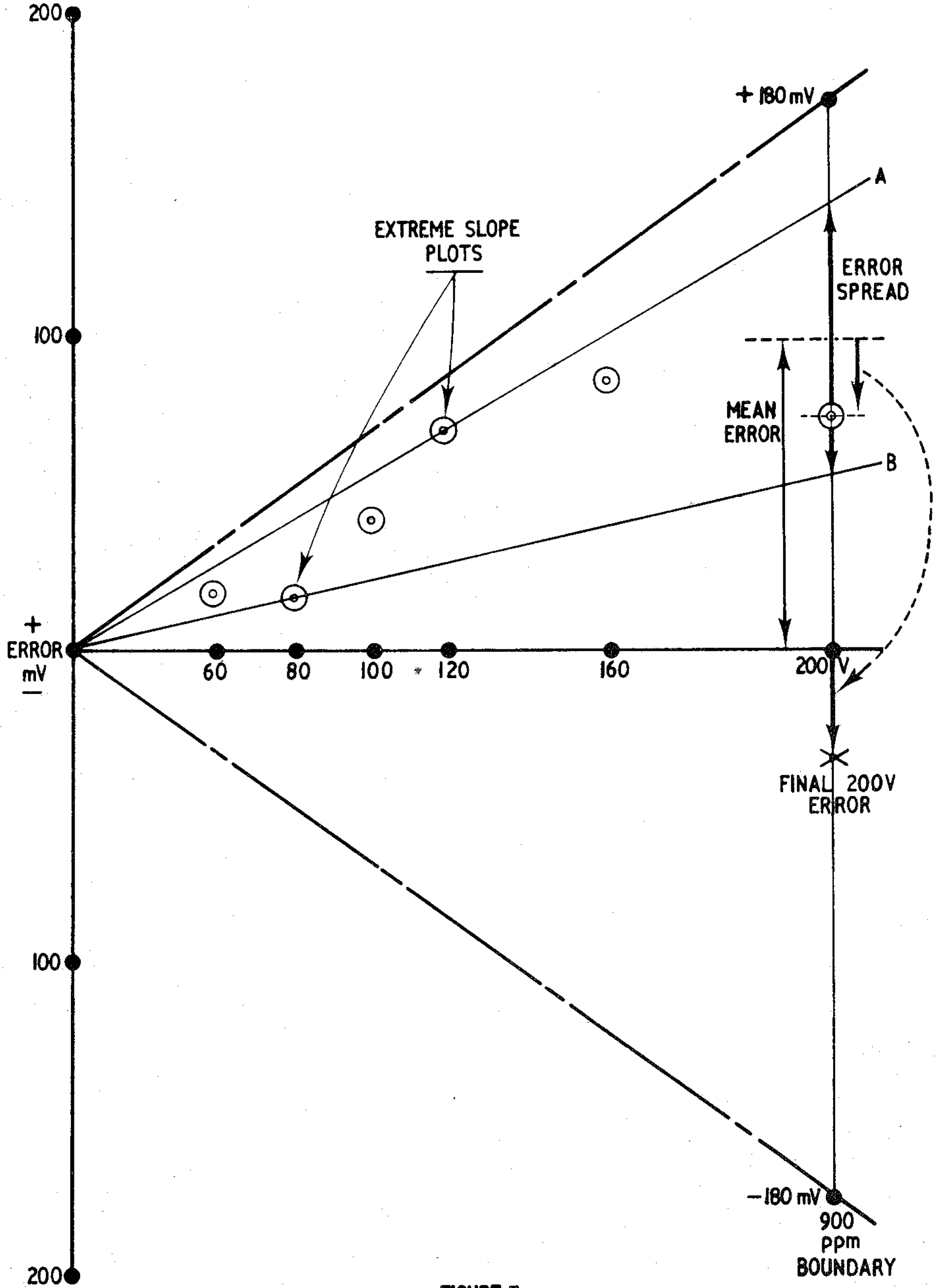


FIGURE 5.

OPTIMUM REFERENCE SETTING