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MODEL
6125A

Ballantine

Ballantine

MODEL
6125A

OSCILLOSCOPE
CALIBRATOR

BALLANTINE LABORATORIES, INC.

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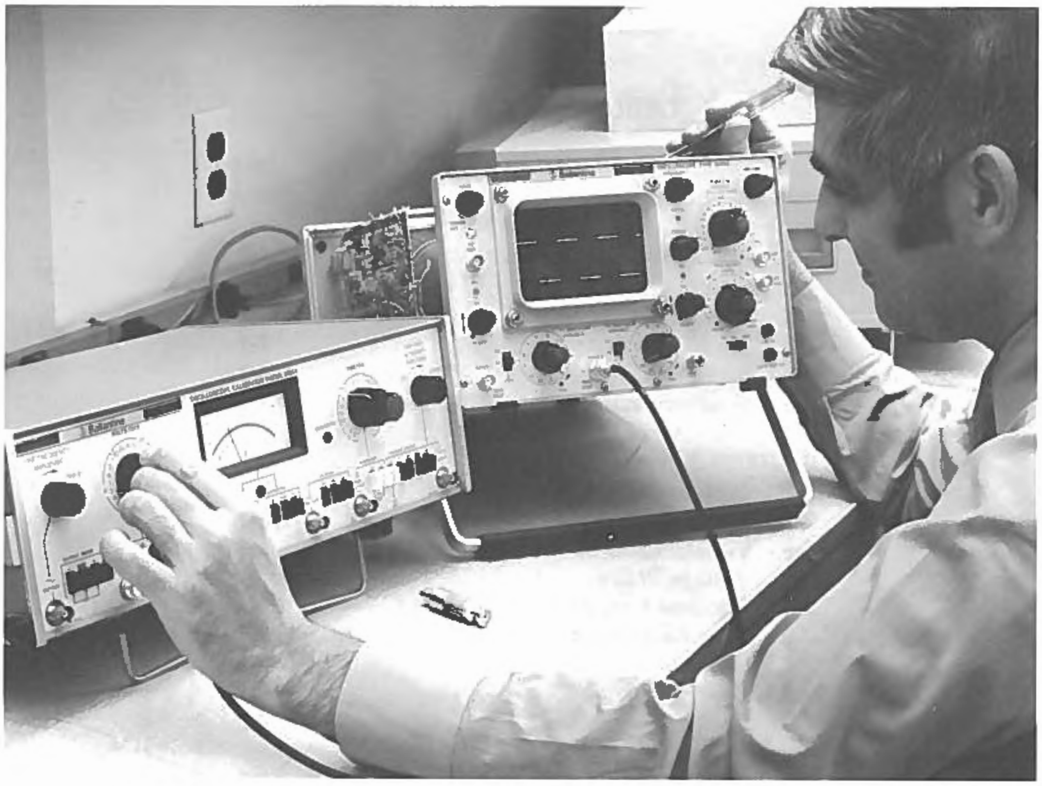
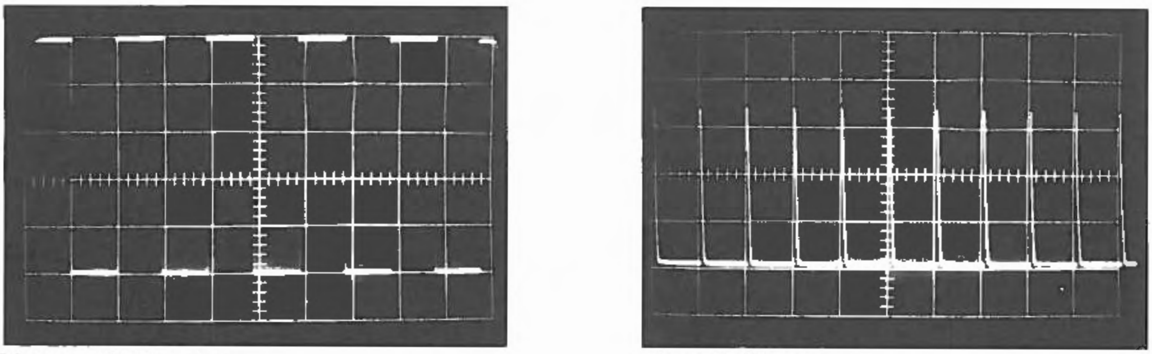
All Ballantine Laboratories, Inc. products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, except for vacuum tubes and batteries, or, in the case of certain major components listed in the instruction manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

TABLE OF CONTENTS

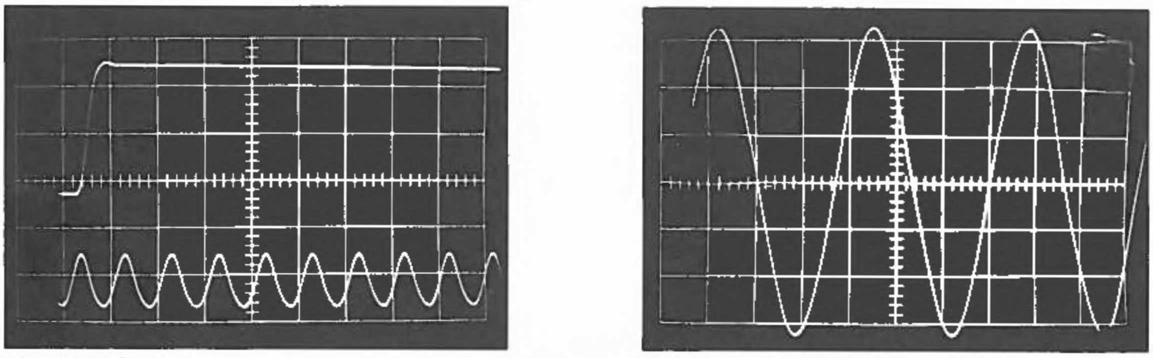


TYPICAL OPERATION



Voltage Calibrator

Time Calibrator



Risetime Calibrator

Synchronization/Trigger Check

CALIBRATION WAVEFORMS

Section 1

General Information

1-1. INTRODUCTION

The Ballantine 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 synchronization/triggering at line frequency and at seven decade frequencies.

1-2. VOLTAGE CALIBRATOR

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

The VOLTS/DIV 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 giveX 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 1 kHz square wave is crystal controlled. The voltage reference is a high quality zener diode. The amplitude accuracy is 0.25%. The waveform has fast risetimes and flat tops to permit its use in the alignment of scope input attenuators.

1-3. TIME CALIBRATION

A high quality time-mark generator provides pulses for time calibration. This section is split into two ranges, each with an output connector. The main range covers from 100 nanoseconds per division to 0.5 seconds per division in 1, 2, 5 steps. The TIME/DIV 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 deviation meter on the 6125A.

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 and jitter is normally less than 0.01% of the period.

The second range provides the faster speeds of 10, 20, 50 nanoseconds. The sinewave output has no multiplication or deviation facilities. All time calibrations are synchronized to the Risetime Calibrator whose 7 decade repetition rates may be used to trigger the scope at a constant rate when changing time calibration output frequencies. This also checks the effects of varying scope sweep repetition rates on sweep time calibration.

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 250 mV (into 50 ohms). There is sufficient adjustment to provide a display of 4 or 5 divisions on oscilloscopes of 50 mV/division without using the oscilloscope variable volts/division control. The risetime is less than 1 nanosecond with extremely flat top to permit amplifier alignment in scopes having greater than 250 MHz bandwidth.

1-5. SYNCHRONIZATION/TRIGGER CHECK

A line frequency sinewave output of variable amplitude is available for checking trigger level and trigger circuits at line frequency.

Table 1-1. Specifications

VOLTAGE CALIBRATOR

Ranges
(a) Volts/Division: 10 µV to 20 V
20 ranges in 1, 2, 5 sequence
(b) Number of division multiplier: X 3, 4, 5, 6, 8, 10
Absolute Range: 27 µV to 220 volts

Deviation ranges: ±3% and ±10%

Output Modes: AC 1 kHz ±0.01% positive going square wave (Crystal Controlled Frequency)
DC positive
DC negative
GND

Accuracy: Better than ±0.25% into open circuit

Offset: Less than ±5 µV below 50 mV. (After use on ranges above 50 mV, a five minute settling time is required to avoid thermal effects) Less than ±50 µV above 50 mV
Note: The same offset is obtained on all output modes including zero.

Ripple and Hum: Better than 0.1% +2 µV p-p

Square wave risetime: Less than 5 µs

Square wave overshoot: Less than 0.5%

Regulation (for 1 MΩ load): Varies between 0 and 0.27% depending on settling.

Deviation Accuracy: ±1% FSD ±2.5% of reading

Overload Protection: Protected against overload of short duration

Reference: High quality zener diode, (Temperature coefficient ±0.002% per °C)

Temperature Coefficient of Output (10-30°C): Better than ±0.01% per °C (±100 ppm/°C)

Line Regulation for ±10% change: ±0.02% max

Stability: ±0.10% per year (maximum)

TIME CALIBRATOR

Ranges: 10 nsec to 5 second intervals
(a) Time/Division: 10 nsec to 0.5 sec/div – 21 ranges in 1, 2, 5 sequence
(b) Multiplier (Number of Divisions): X 1, 2, 5, 10 (on 100 nsec to 0.5 secs/div only)

Deviation Ranges (for 100 nsec/div to 0.5 sec/div): ±3% and ±10%

Accuracy:
(a) Crystal controlled: ±0.01% of setting
(b) Deviation 3% range: ±0.1%
(c) Deviation 10% range: ±0.2%

Amplitude
(a) 100 nsec/div to 0.5 sec/div: 1.0 V (typical) into 50 Ω (1.4 V min into open circuit)
(b) Less than 100 nsec/div: 1.0 V p-p (typical) into 50 Ω

Pulse shape and width
(a) 100 nsec/div to 0.5 sec/div:
Spike, width at base 10% of pulse interval
(b) below 100 nsec/div:
Sinewave

RISETIME CALIBRATOR & TRIGGER OUTPUT

Amplitude: 200 mV to 250 mV continuously variable into 50 Ω (400 mV-500 mV open circuit)
Risetime: Less than 1 nsec positive going into 50 Ω
Period: 1 µsec to 1 second in 7 decade steps
Waveform: Square Wave
Overshoot: Less than 2%
Accuracy: Same as Time Calibrator

LINE FREQUENCY SYNC OUTPUT

Amplitude: Continuously variable from 0 to 1 volt peak-to-peak from 2 kΩ source max.
Waveform: Follows powerline sinewave

GENERAL INFORMATION

Power Requirements: 100/125 or 200/250 volts r.m.s., 17W, 50/60 Hz
Operating temperature: 0°C to +50°C ambient.
Storage temperature: 40°C to +70°C ambient.
Humidity: to 80% RH for full accuracy; to 95% RH operating
Dimensions: 16 3/8" wide, 5 1/4" high x 12" deep overall. (415.6 mm x 133.5 mm x 304.8 mm.)
Weight: 15 lbs 8 oz (7.08 kg.)
31 lbs (14.2 kg) shipping weight.

Note: *All accuracies specified at 23°C ±1°C with full compensation for output loading and referenced to a standard traceable to NBS with uncertainty of ±0.01%.*

OPERATIONAL HINTS

1. Always press in one of the four black TRIGGER PERIOD pushbuttons (1,10,100,1S) when using the fast rise output.

2. Always set DEVIATION pushbutton to OFF when using the H.F. TIME OUT.

3. Only load VOLTS/DIV output with a high impedance to avoid loading errors. See Section 2 of this manual for maximum loading within the accuracy specification.

4. Always press in one of the three DIV pushbuttons (2,3,5) for the VOLTS/DIV MULTIPLIER.

5. Always press in one of the OUTPUT MODE pushbuttons in the VOLTS/DIV circuit.

6. Always ground the power cord ground pin on the calibrator and the instrument under test. This is especially important to avoid noise interference on low VOLTS/DIV ranges due to the off ground circuitry used to avoid ground loops in VOLTS/DIV output circuitry.

Section 2

Operation

NOTE: *Set the voltage selector plug on the rear panel to the supply voltage range expected from the powerline.*

2-1. OUTPUT CONNECTIONS

Five output BNC connectors are provided.

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

Volts — Provides an accurate DC voltage, positive or negative or zero. Also provides a 1 kHz square wave positive going output for amplitude and attenuator calibration of the Y amplifier.

Time Calibration Outputs — Two output connectors provide normal or H.F.. The normal connector provides for outputs from 100 ns 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 graticule.

The H.F. range provides the faster speeds of 10, 20 and 50 ns. The H.F. output is a sinewave. No multiplier or deviation facilities are provided on the H.F. ranges.

Risetime Output — Provides an output square wave with a risetime less than 1 ns into 50 ohms. The amplitude is continuously variable over the range 200 to 250 mV. Frequency is variable from 1 Hz to 1 MHz in seven decade steps.

2-2. PUSHBUTTONS

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

Four pushbuttons 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".

2-3. VOLTAGE CALIBRATION

The VOLTS output provides an accurate DC voltage either positive or negative or zero. The VOLTS/DIV control provides from 10 µvolts to 20 volts per division in 20 steps of 1, 2, 5 sequence.

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

1. Select the required range on the VOLTS/DIV switch to match the voltage range setting of the oscilloscope.
2. Using the mode pushbuttons select the required mode:
   negative DC
   zero
   positive DC
   positive going square wave
3. 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.
4. For a calibrated output press the Deviation 'Off' button.
5. 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.

Adjust the display on the CRT to align with the graticule by rotating the Deviation Control (concentric with the VOLTS/DIV switch.)

Read the percentage error directly off the meter.

2-4. VOLTAGE ERRORS

Loading

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

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

← Before operating this instrument, refer to the Operational Hints

DC Offset

At Volts/division settings of 50 mV and above the output attenuator dissipates sufficient heat to produce thermoelectric 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 50 mV/division, or greater before using the low voltage outputs if maximum specified accuracy is required.

Use the GND mode of the 6125A voltage output to provide the zero reference for the oscilloscope. Do not use the switch on the oscilloscope itself. This eliminates any remaining thermal effect in the attenuator resistors of the calibrator or in the interconnections to the oscilloscope.

Warm-up

The drift to be expected during the first 20 minutes is approximately ±0.2% and is therefore of no significance for normal operation.

2-5. 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. (maximum oscilloscope sensitivity)

The 6125A Fast-rise output provides 0.25 volts into 50 Ω, or 0.5 volts unterminated, and will, therefore, produce 5 divisions of deflection on oscilloscopes having sensitivities of 50 mV or even 100 mV per division. Unterminated operation is not recommended.

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, 50 Ω wideband co-axial attenuators (GR874 Series) should be used. A feed thru 50 ohm termination such as the Ballantine 12630A is recommended for use at the input of oscilloscopes having bandwidths greater than 1 MHz.

Cable Matching

The impedance of the interconnecting cable should be 50 Ω ±2%. Cable length should be kept as short as possible since long cables (above four feet) will degrade the risetime.

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

Another effect of a proper termination is to reduce the source impedance to the oscilloscope. This results in a more accurate scope amplifier calibration.

In practice the effect on the shape of response due to a terminating resistance on oscilloscopes of bandwidths up to 50 MHz is not normally noticeable. The 6125A risetime calibrator is usable with oscilloscopes having bandwidths beyond 250 MHz.

Display Perturbations

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

This may be verified by (a) if other fast-rise sources are available, and checking that perburtations are independent of source, or (b) if other oscilloscopes or channels are available, check that applying the 6125A Fast risetime to various channels does alter the perturbations.

Measurement Accuracy

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

The 1 nsec going edge will increase the observed risetime of a 50 MHz oscilloscope (7 nsec 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: —

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

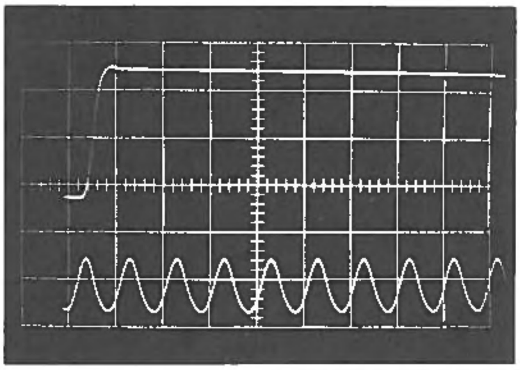
The error due to taking the source risetime to be 1 nanosec when it differs from this by 10% is negligible ($< 1\%$) for oscilloscopes up to 150 MHz, and approximately 5% for oscilloscopes having 250 MHz bandwidth.

NOTE: *Always calibrate the time base of the oscilloscope in the region where risetime measurements are made to assure accuracy. Risetime checks are usually made on the fastest sweep range and the operater must correct for beginning trace non-linearity and magnifier errors which often account for 8 to 10% timing error. Risetimes should be measured some 50 or more nanoseconds from the beginning of the visible scope trace and near screen center for best results.*

Measurement

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

Select the desired repetition period, for example 1 μsec 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:

$$\text{Bandwidth in MHz} = \frac{350}{\text{True risetime, in nanoseconds}} = \frac{350}{\sqrt{(\text{observed risetime})^2\ (\text{source risetime})^2}}$$

of a scope having a Gaussian response amplifier (minimal overshoot).

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

2-6. TIME CALIBRATION

1. Connect the TIME output to the oscilloscope voltage input by a co-axial lead (preferably 50 Ω) with BNC terminations. The use of a 50 Ω ffedthru termination (Ballantine 12630A) at the scope into is recommended.

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. Rotate the 'Deviation' 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 Deviation meter.

2-7. 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 1 V peak-to-peak into 50 Ω-

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 the the 10 μsec period. Varying the trigger rate will test scope time calibration accuracy and jitter for signals of varied repetition rates.

2-8. LINE FREQUENCY OUTPUT

A sinewave of amplitudes variable from 0 to 1 V peak-to-peak from a 20 kΩ max. source impedance is provided at this output.

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

2-9. 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.

Varying the trigger frequency to the external trigger input of the scope will check the scope performance, jitter factor and time calibration accuracy when signals of varying repetition rates are displayed on the scope.

The trigger rate should always be the same or lower than the observed frequency to avoid the appearance of an unwanted base line on the scope. Keeping trigger repetion rate high will give the brightest display on the scope.

As a operator convenience, the scope to be calibrated may be triggered externally at a fixed rate (i.e. 1 ms). This avoids the need to adjust scope triggering as high calibration ranges are checked. (a special help on older scopes or those having poor trigger performance)

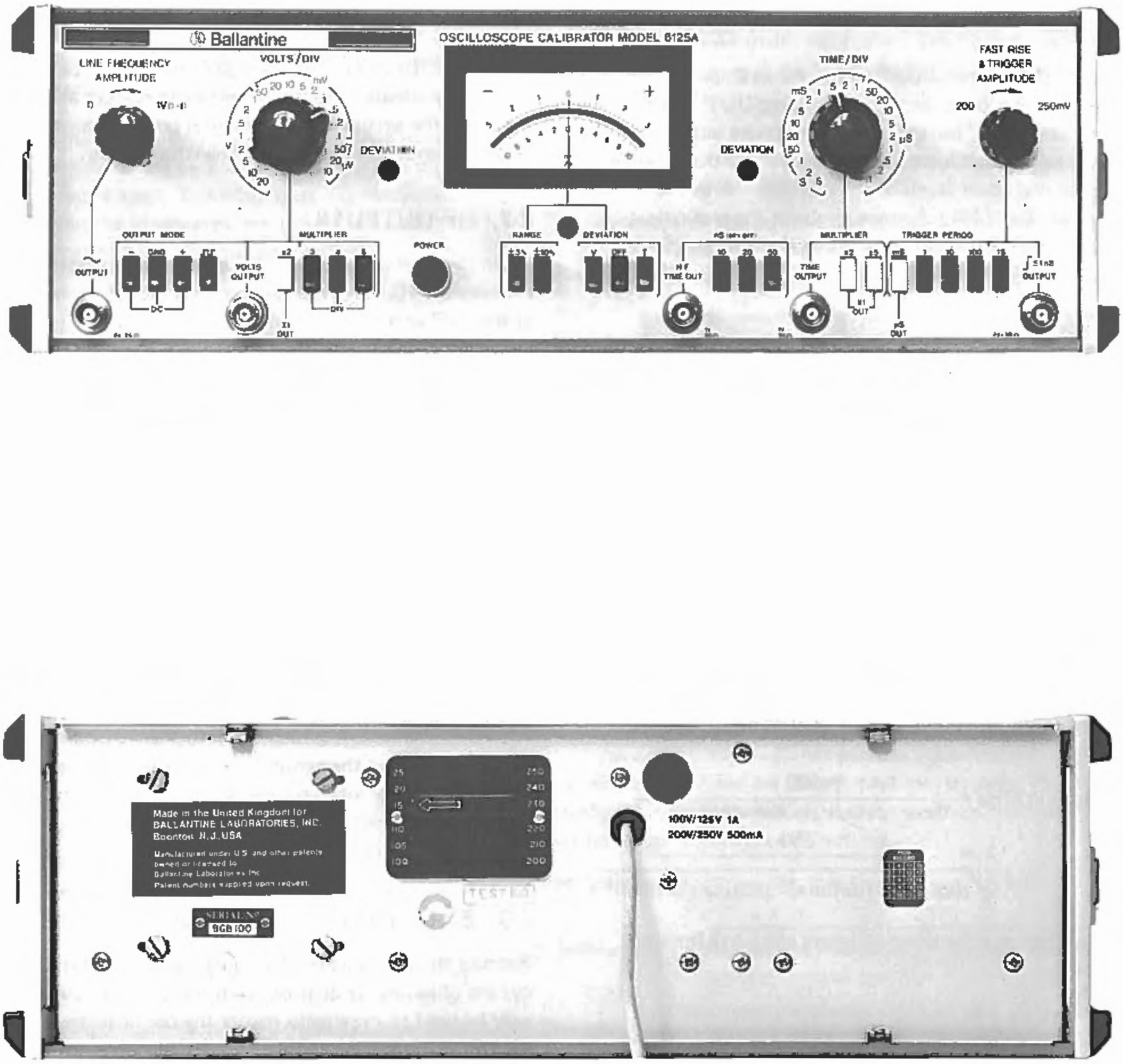


Figure 2-1. 6125A Front and Rear Views

Section 3

Principles of Operation

3-1. VOLTAGE FUNCTIONS

TR104A and TR104B are the two halves of a differential amplifier which sense the difference in potentials between the negative end of the reference zener D113 and the virtual ground point of the reference divider. (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 divider is supplied from the positive end of the reference diode D113. The output voltage is determined by the ration of the resistance on either side of the virtual ground point. Resistors selected by the MULTIPLIER/DIV switch S102, fix the ratios so that for settings of 3, 4, 5, 6, 8 and 10 DIV the voltage at collector TR 107 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 ground point for positive or negative deviation respectively. The DEVIATION control RV101 connected via switch S702 enable the current in the lower leg 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 regulated DC line to the output. TR108 forms a switch which enables the output to be modulated by a 1 kHz 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 connector from the DC blocking capacitor built into the input circuit of the oscilloscope under test. 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.

(a) Positive DC level.

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

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

(d) GND — Zero output voltage obtained by shorting the input end of the attenuator to circuit ground.

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

NOTE: *When using the amplitude calibrator use only ONE cable between the 6125A and the scope or voltmeter under test. Any other ground connection will cause small zero offset errors.*

3-2. TIME FUNCTIONS

Multivibrator TR430, TR440 with center frequency of 20 MHz (50 nsec period) is the variable master oscillator providing signal frequencies via the frequency 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 1 MHz crystal oscillator X740.) When time deviation is switched off, power is supplied to the 100 MHz crystal oscillator X411, TR410, which then locks the multivibrator to 20 MHz.

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 DC 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 on the master oscillator 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. This ensures the best safe locking range for synchronization with the 10 nsec sinewave supplied to the base of TR430.

The 20 MHz multivibrator is synchronized on each half cycle, i.e. every 2 1/2 cycles of incoming 100 MHz signal. This technique doubles the safe locking range compared with conventional methods of synchronization.

Time Output

The 20 MHz signal from the variable master oscillator is AC coupled to the type D flip-flop X510, to which feedback is applied so that it divides by two, providing 10 MHz, or 0.1 μsec period. X520 then divides this signal by 5, giving a 0.5 μsec period. The next six stages, X530 to X580 each divide by two and five in series, providing the output 1, 5, 10, 50 μsec and down to 0.5 sec.

These signals are brought out at 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 6125A, 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 TR460 provides the low impedance necessary to drive the capacitance of a coaxial cable. R647 provides matching for a 50 Ω cable.

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 DC output proportional to their frequency.

Type D flip-flop X710a subtracts the variable frequency, (nominally 1 μsec period), of X530 from the fixed 1 MHz 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 1 MHz.

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 1 MHz, and whose prf is the difference frequency.

Assume the 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 +5 V 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 AC component so that negligible voltage drop occurs and only the DC component of this pulsed current passes through the meter.

Thus:

Meter Current ∝ pulse width x prf.

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

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

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

∝ Percentage period deviation

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

At very 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. No matter how ragged the edges of the difference frequency squarewave, there can be only one pulse per cycle of the difference frequency.

1 MHz Crystal Oscillator

This circuit provides a nominally symmetrical output without overdriving the crystal. This reduces the risk of the crystal operating at an overtone.

Both positive and negative inputs of X740 are biased at 0 V. 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 DC drop across R742 because only the small input bias current is passed. The quiescent output voltage is therefore +1.4 V which matches the logic threshold voltage. This also ensures that the oscillator is self starting.

3-3. HIGH FREQUENCY OUTPUTS

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

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

3-4. 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 configuration 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, which also has a 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.

3-5. POWER SUPPLIES

Both supplies are regulated. The +5 V is referenced to the −10 V supply.

RV961 provides the major part of the bias current for zener diode D962 from the stabilized −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.

3-6. LINE FREQUENCY OUTPUT

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

Section 4

Maintenance and Calibration

4-1. GENERAL

This section should be read in conjuntion with the Operating Instructions contained in previous sections.

Before attempting to trace a fault or effect a repair read Section 3.

This section together with Section 3 is intended to provide the user with sufficient information to allow most repairs and to allow calibration of the instrument after servicing.

4-2. MECHANICAL DETAILS

To remove the top cover loosen the two screws on the rear upper surface 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 acces 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.

4-3. TEST EQUIPMENT REQUIRED

1. Variac, 5 amps, 115 volt or 230 volt nominal
2. Multimeter, Simpson Type 260 with leads
3. Oscilloscope — 15 MHz Dual Trace, 5 mV, Ballantine 1066A
4. Oscilloscope Test Probe — Attenuation 10:1 and 1:1 — Ballantine 10600A
5. DC Differential voltmeter, Fluke 895A
6. BNC to BNC cable. 4 ft length 50 Ω ±2%, Ballantine 12249A
7. True RMS Voltmeter. Ballantine 323 Series
8. BNC Female to Banana plug type adapter. Ballantine 12617A
9. Low voltage DC supply 1V DC
10. 2.2 MΩ resistor ±2% insultated body with stiff insulated leads.
11. 1 MΩ resistor ±2% wired across a BNC Female plug and fully insulated. Use with Ballantine 12620A. A BNC female to binding post adapter.
12. BNC "T" Connector. Ballantine 12619A.
13. Digital Frequency Counter 5 Hz to beyond 100 MHz. Ballantine 5700A.
14. Oscilloscope — 150 MHz Teletronix 454 or equivalent.
15. Oscilloscope — Sampling type < 350 psec risetime. HP Type 1810A or equiv. Use optional.
16. BNC to Alligator clips cable 4 ft. length. Ballantine 12250A.
17. Termination, Feedthru 50 Ω BNC. Ballantine 12630A.

4-4. TIME CALIBRATION

Power Supplies

1. Set power line voltage selector on the rear of the instrument 115 (230) volts.

Note: *Use (230) volt setting when the instrument will normally be used on 230 volts supply.*

2. Apply 103 (205) volts measured with Ballantine 323. Use the Variac (1) to adjust line voltage.
3. Switch Power On; check that pilot lamp lights.
4. Select "Deviation Off". Operating mode.
5. Adjust RV951 to give +5.00 V at RT940 collector. Measure with Fluke 895A Voltmeter (5)
6. Read ripple at same point. 1.0 mV max. — Use Ballantine 323 (7)
7. Read voltage at TR980 collector. −10 V ±0.5 V. Measure with Fluke 895A Voltmeter (5)
8. Read ripple at same point. 1.5 mV max. Measure with Ballantine 323 (7)
9. Reset power line voltage to 115 V (230) volts with the Variac (1)

4-5. TIME OUTPUTS
(Using the 15 MHz Oscilloscope)

1. Connect the instrument to the oscilloscope using the 50 Ω BNC lead with T-connector at oscilloscope. Switch 6125A Time/Div to 0.1 μsec and select X5 divs.

   Switch oscilloscope to 1 V/cm and 0.1 μsec/cm. "DEVIATION" control knob on the Time/Div Switch.

2. Select Deviation 'T'. Turn "DEVIATION" control knob on the Time/Div switch fully counter-clockwise. Set 'BAL' RV430 midway. Adust '—LIM' RV343 to give about 4.4 cms between pips.
3. Turn "Deviation" fully clockwise. Adjust '—LIM' RV472 to give about 5.6 cms between pips.
4. Adjust "Deviation" until the meter reads approximately zero. Adjust oscilloscope horizontal control so that the three pips roughly line up with the graticule ends and center line.
5. Switch the Time/Divs controls on the 6125A calibrator and the scope counter 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 reset while switching by observing that the deviation meter needle remains at zero.
6. Return both switches to 0.1 μsec. Press the X2 Divs button. Check that the spacing becomes 10 cm. Release both X2 and X5. Check that the spacing is now 1 cm on screen.
7. In this test the amplitude of marker pips at all settings of the 6125A Time/Div switch must be between 1.5 and 2.5 V. Rotate the 6125A Time/Div switch three steps to 1 μsec, so that the spacing is 10 cm. Then rotate both switches two steps to 5 μsec on the 6125A.

   Rotate both switches a further 10 steps to 10 msec on the 6125A. Check that the base width is 1 cm ±30% in each case. (The spacing of marker pips should remain at 10 cm).
8. Add 50 Ω termination at the oscilloscope. (Ballantine 12630A) Check that the amplitude is reduced by a factor of two.

4-6. FAST RISE SQUAREWAVES
(Using 15 MHz Oscilloscope)

1. Connect the 6125A to the oscilloscope using the 50 Ω BNC lead terminated in 50 Ω. Set oscilloscope to 50 mV/cm. (Be sure that the oscilloscope is correctly calibrated).
2. Select 1 μsec period by releasing the 'mS' button and depressing the '1' button. Set oscilloscope to 0.1 μsec. Observe the squarewave 10 cm period. The amplitude must be variable over the range 0.180 to 0.275 volts.
3. Switch oscilloscope Time/cm 3 steps each time, selecting 10 μ, 100 μ, 1 m, 10 m, 100 m and 1 Sec in turn. Check that period remains at 10 cm.

4-7. TIME DEVIATION
(Use the Digital Counter)

1. Check meter zero with Power Off and Time Deviation selected.
2. Switch Power on, select ±3% range on the 6125A deviation meter.

   Set Deviation to —2.5% either by:adjusting Deviation control, measuring the period in μsecs of the Fast-Rise output on the 6125A set at 10 msec. The counter reads 9750 μsec (10,000 μsec less 2 1/2%.

   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%. Counter reads 10250 μsec.
4. Select 10% meter range, set Deviation to —8% and adjust the meter to this value by adjusting —10% potentiometer RV710. Counter reads 9200 μsec.
5. Set Deviation to +8% and adjust meter to this value by adjusting the +10% range potentiometer RV711. Counter reads 10800 μsec.
6. Select 3% range, check —2.5% and +2.5% points.

   Readjust if necessary.

4-8. HF OUTPUTS
(Using the 150 MHz Oscilloscope)

1. Select Time Deviation ±10% range. Adjust BAL potentiometer (RV 430) to give the most —ve meter reading.
2. Set the oscilloscope to 200 mV/Div, and 10 nsec/cm. Connect the 6125A HF output to the scope input, using the 50 Ω BNC cable and the 50 Ω feedthru termination.
3. Select Deviation Off and HF output to 10 nsecs. Starting from minimum capacitance point, adjust C415 clockwise to give a sinewave of maximum amplitude 10 nsec. 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 mid scale.
5. Select 20 nsecs. Adjust C425 to center of safe range. TAKE CARE to avoid damaging the transistors by overload thru excessive detuning.
6. Select 50 nsecs. Adjust LOCK to keep the needle at center of the scale. Adjust C455 to give nearly maximum amplitude where waveform has minimum destortion.

7. Choose the best position of the BAL potentiometer (RV450) to allow the maximum counter-clockwise rotation of LOCK with the meter needle remaining locked at mid scale. Go back and forth several times to arrive at best overall compromise.
   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 center of this range.
8. Select Time Deviation 10% range. Turn 'Deviation' control fully counter-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 'Deviation' 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 'Deviation' 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 centered for 10, 20 and 50 nsec outputs both with the oscilloscope connected and with the lead disconnected at the 6125A HF output connector.

4-9. FAST-RISETIME (Using 150 MHz oscilloscope or sampling oscilloscope)

1. Connect 6125A output to oscilloscope input terminated in 50 Ω- Set 1 μsec period, and sensitivity of 50 mV/cm on the oscilloscope.

Note: *The sampling scope is preferred for step 2 since its <350 psec while the 150 MHz scope is 2.3 nsec.*

2. Adjust 6125A Fast Rise amplitude control to give exactly 5 cm display on the oscilloscope. Measure the risetime of the positive edge over center 4 cm (10 to 90%). Allow for the oscilloscope risetime which should be known. Use the formula:

$$\text{Input Risetime} = \sqrt{(\text{Observed Risetime})^2 - (\text{Scope Risetime})^2}$$

to give true risetime. Record this. Limits: 1 nsec max.

Note: *This test (3) is optional and should only be made if performance is in doubt and a sampling scope is available.*

3. Set the sampling oscilloscope to 2 nsec/cm and 5 mV/cm. Measure overshoot on positive edge. Each cm of deflection on the scope now represents 2% of the 250 μV p-p fastrise signal. Limits: 2% max. Check that the overshoot remains less than 1 cm for any position of the 6125A amplitude control.

4-10. VOLTS CALIBRATION

4-11. RESISTANCES (Using Multimeter ohms X100 range)

1. Switch Power Off.
2. Measure resistance across outer insulated band of VOLTS output connector (i.e. from chassis to connector shell) Limits 100 Ω ± 20%.
3. Measure resistance across normal inner to outer of VOLTS connector. This should be 220 Ω at 10 μV setting of volts/div switch increasing on each range to 3.2 kΩ at 10 mV/Div. (Allow for multimeter error).

4-12. SUPPLY and SHORTED OUTPUT (Using Multimeter and True RMS Voltmeter)

1. Set Power line voltage selector on rear of 6125A to 115 (230) volts.
2. Switch multimeter to 250 V DC range. Apply 115 V ±1 V power to the 6125A thru variac (1) and measure its amplitude with Ballantine 323 (7).

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

Output voltage to be +170 to +230 V at voltage output BNC connector of 6125A.

3. Switch multimeter to current DC 100 mA range thus shorting output. Limits 31 to 37 mA.

CAUTION

Do not short output continuously. Only 2-5 seconds required to make the measurement.

4. Switch back to multimeter 250 V DC and check that the voltage returns to 170 to +230 volts.

5. Select: Mode GND

Record the voltages across:

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

(All contacts to the capacitors are +ve to left hand end of instrument).

4-13. REGULATION
(Using DC Differential Voltmeter)

1. Supply the unit with 115 (230) ±1 V r.m.s. from variac (1) using the Ballantine 323 (7) to monitor the voltage.
2. Select: Mode + (positive).
3. Monitor the VOLTAGE output via BNC Tee Connector, BNC lead and adaptor (8) with Fluke set to 200 V and 100 mV full scale. Adjust RV104 to center the fluke meter ±20 mV. RECORD voltage.
4. Reduce the variac output so that the Ballantine 323 (7) reads 103 (206) volts ± 1 V. RECORD change in output voltage of 6125A:

   Limit: 40 mV max.

5. Reset the variac for a power input voltage of 115 (240) volts.
6. Connect the 1 MΩ termination (11) onto the T connector at the VOLTS output BNC of the 6125A. RECORD the change in output voltage.

   Limit: 0.1 V max.

4-14. VOLTAGE DEVIATION
(Use Differential Voltmeter)

1. Select: Deviation Volts.
2. Select the ±10% deviation range and adjust the voltage output of the 6125A using the DEVIATION control, to 220 V ±40 mV measured on the Fluke meter (5).
3. Adjust RV102 so that the deviation meter needle reads Full Scale on the +10% scale readjusting the DEVIATION control if found necessary to maintain 220 V ±40 mV.
4. Turn the deviation control counter clockwise 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 $E_D \div 2$ determined in paragraph 4 above.
6. Readjust RV102 to obtain −10% on scale (FSD).

7. Turn the DEVIATION control clockwise to that the meter reads +10% (FSD). Measure the output voltage and verify that the voltage is 220 V $\pm E_D \div 2$ ±100 mV 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 100 mV.*
8. Select ±3% voltage deviation range and adjust the deviation control so that the instrument meter reads +3% (Full Scale) on the 3% scale.
9. Adjust RV103 so that the voltage output indicated on Fluke meter (5) reads 206 V ±20 mV.
10. Turn the DEVIATION control anti-clockwise so that the meter reads −3% (FSD). Measure the voltage and calculate the deviation from 194.00 V. Let the voltage be V_D. This Deviation voltage should not exceed 0.2 volts.

    NOTE: *Tests 11 and 12 are not necessary if* $V_D < 40$ *mV.*
11. Readjust RV103 to bring the output voltage nearer to 194.00 volts by shifting by an amount $V_D \div 2$.
12. Turn the DEVIATION control clockwise so that the meter reads +3% (FSD). Measure the output voltage and verify that it is approximately 206 $\pm V_D \div 2$ ±40 mV (that is 206.12 to 205.88 volts).

4-15. ATTENUATOR RATIOS
(Using DC Differential Voltmeter)

1. Select: Deviation Off.
   RECORD output voltage at VOLTS output BNC connector. Readjust RV104 to give 200 V ±20 mV.
2. Taking care not to touch any high voltages on the voltage attenuator, connect Fluke 895A (5) via flexible leads (6) across R146 and R147 in turn and note the two voltage readings.

   NOTE: *When replacing Attenuator resistors follow the follow following selection procedure: 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 millivolts (mV).*

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

	Measured Voltage	Resistor Required	Resistor Tolerance
R146	$V_m = 100\,\text{mV} + E$	$500/_E$ ohms	$\pm 5/_E$ ohms
R147	$V_m = 100\,\text{mV} + E$	$500/_E$ ohms	$\pm 5/_E$ ohms

   where E and V_m *are in mV.*

   Switch the instrument off when soldering resistors.

3. RECORD the voltage across R146 and R147 and verify that they are 0.1 V ±100 µV after a period of 5 minutes with the instrument ON.
4. Connect Fluke 895A (5) to the VOLTAGE output connector 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 Shown on the chart below:

Mode	Divs	Volts/Div	Voltage Measured	Output Tolerance Limits
+	10	20		200 V ±20 mV
+	10	10		100 V ±100 mV
+	10	5		50 V ±50 mV
+	10	2		20 V ±20 mV
+	10	1		10 V ±10 mV
+	10	0.5		5 V ±5 mV
+	10	0.2		2 V ±2 mV
+	10	0.1		1 V ±1 mV
+	10	50 mV		0.5 V ±500 μV

6. Select 20 mV/Div with VOLTS/DIV switch and adjust the output voltage to 0.2 volts ±20 μV by RV106.
7. Select: Mode – and 20 V/Div. Verify that the voltage is –200 V ±20 mV.

4-16. OPTIMUM REFERENCE SETTING (Using DC Differential Voltmeter Fluke 895A).

1. Select: Volts/Div 20
   Mode + (positive).
2. RECORD the errors for all DIV settings in the following table under "Initial Errors, mV".
3. Plot a graph of error against nominal voltage as shown in Figure 4-1
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 center point between the two intersections. RECORD the value under "Mean Error, mV".
7. Change sign of Mean Error and add to initial 200 V error. RECORD under "Final 200 V Error".
8. Select: DIV 10. (5 DIV X2)

   Adjust 200 V error to "Final error".

4-17. SQUARE WAVE ZERO LEVEL (Using DC Differential Voltmeter)

1. Select the following controls:

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

2. Connect a low voltage DC supply set at 1 V ±0.02 V across emitter TR108 and junction of R130 to R131 making the positive connection to the junction of the of the resistors. Two pins TP1 and TP2 are provided for connecting the wires. Check the low voltage using Fluke meter (5).
3. Monitor the VOLTAGE output with Fluke meter (5) and switch the instrument ON.
4. Switch on the low voltage DC supply and verify that the voltage output changes from 200 V to approximately 0 V.
5. Set RV105 to obtain zero volts ±5 mV on the Fluke meter (5).
6. Place 2.2 mΩ resistor (1) momentarily across collector and emitter of TR107 and verify that the output voltage does not rise to more than +0.05 volts. Measure with Fluke meter (5).
7. Switch off the instrument and disconnect the low voltage DC supply before changing any front panel settings.

DIVISION MULTIPLIER SETTING ERRORS

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

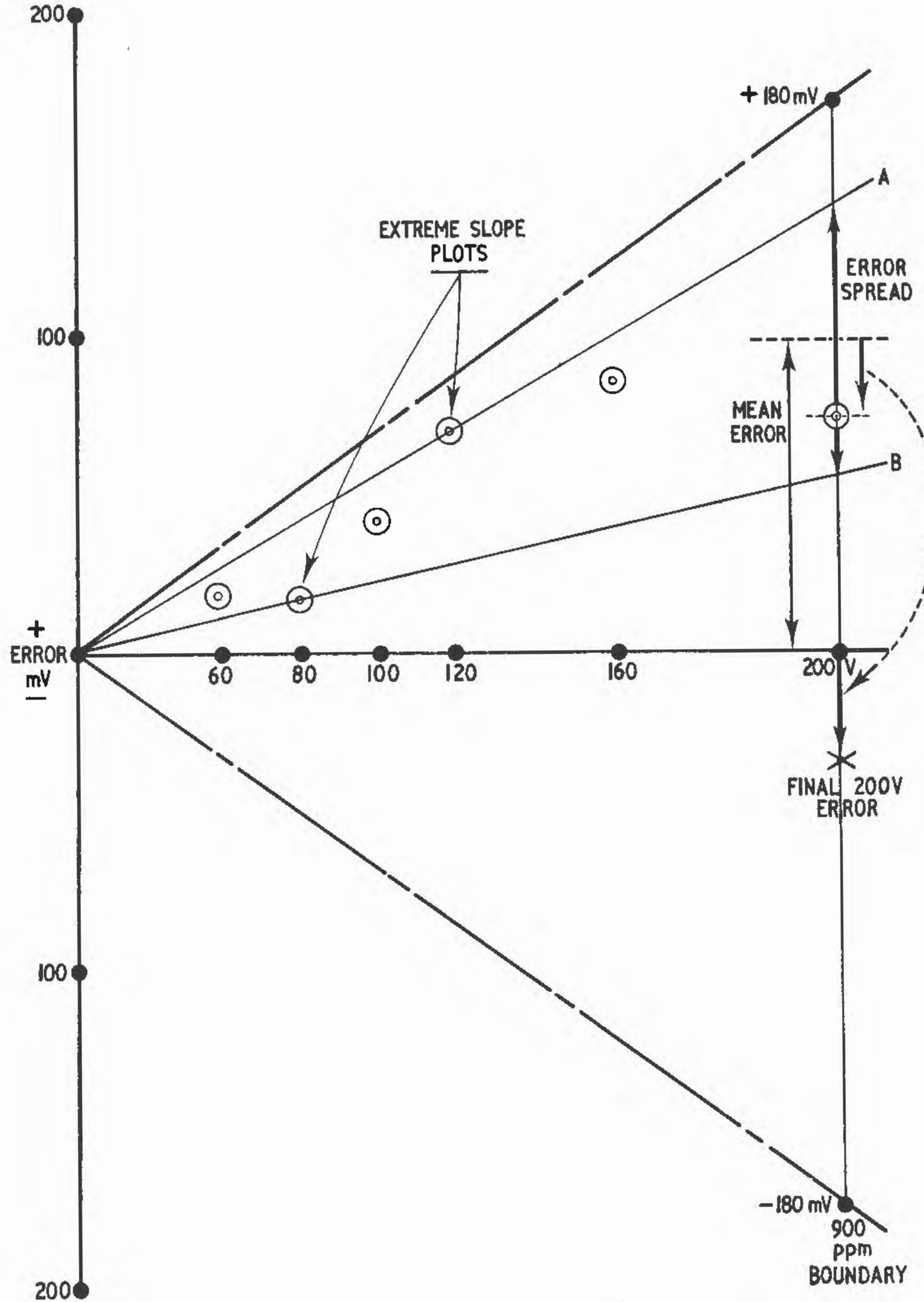


Figure 4-1. Error Vs. Nominal Voltage

4-18. VOLTAGE SQUARE WAVE
(Using 15 MHz Oscilloscope)

1. Select the following controls on the 6125A:

MODE	+
DIVS	10
VOLTS/DIV	10
DEVIATION	OFF

2. Monitor the VOLTAGE output with the oscilloscope (3) set to 20 V/div 1 ms/div via coaxial cable (6). The oscilloscope should be DC coupled.

   A square wave of 5 divisions amplitude and 1 division period should be displayed.
3. Reduce the calibrator VOLTS/DIV switch setting to 50 mV/div and the oscilloscope to 0.1 V/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 5 μS with overshoot less than 0.5%.
4. Reduce the VOLTS/DIV switch setting to 20 mV/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.

4-19. RIPPLE (Using 15 MHz Oscilloscope)

1. Set the variac to give 103 (216) volts ± 1 V with rear panel power line voltage selected for 115 (240) volts.
2. Select the following controls:

MODE	+
DIVS	10
VOLTS/DIV	20
DEVIATION	OFF

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

   Verify that the ripple is less than 0.2 V peak-to-peak.
4. Reset the variac at 115 (240) volts ±1 V.

4-20. LINE FREQUENCY AMPLITUDE
(Using 15 MHz Oscilloscope)

Monitor the LINE FREQUENCY output connector using oscilloscope (3) set to 0.5 V/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.

4-21. FAULT FINDING

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).

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 1 MHz signal on the right hand side of R744 has a 50-50 mark to space ration ±5%. If not change the value of R745 until it does. If the needle reverses, or stops at the center, the fault is 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.

Circuit Diagrams and Parts List

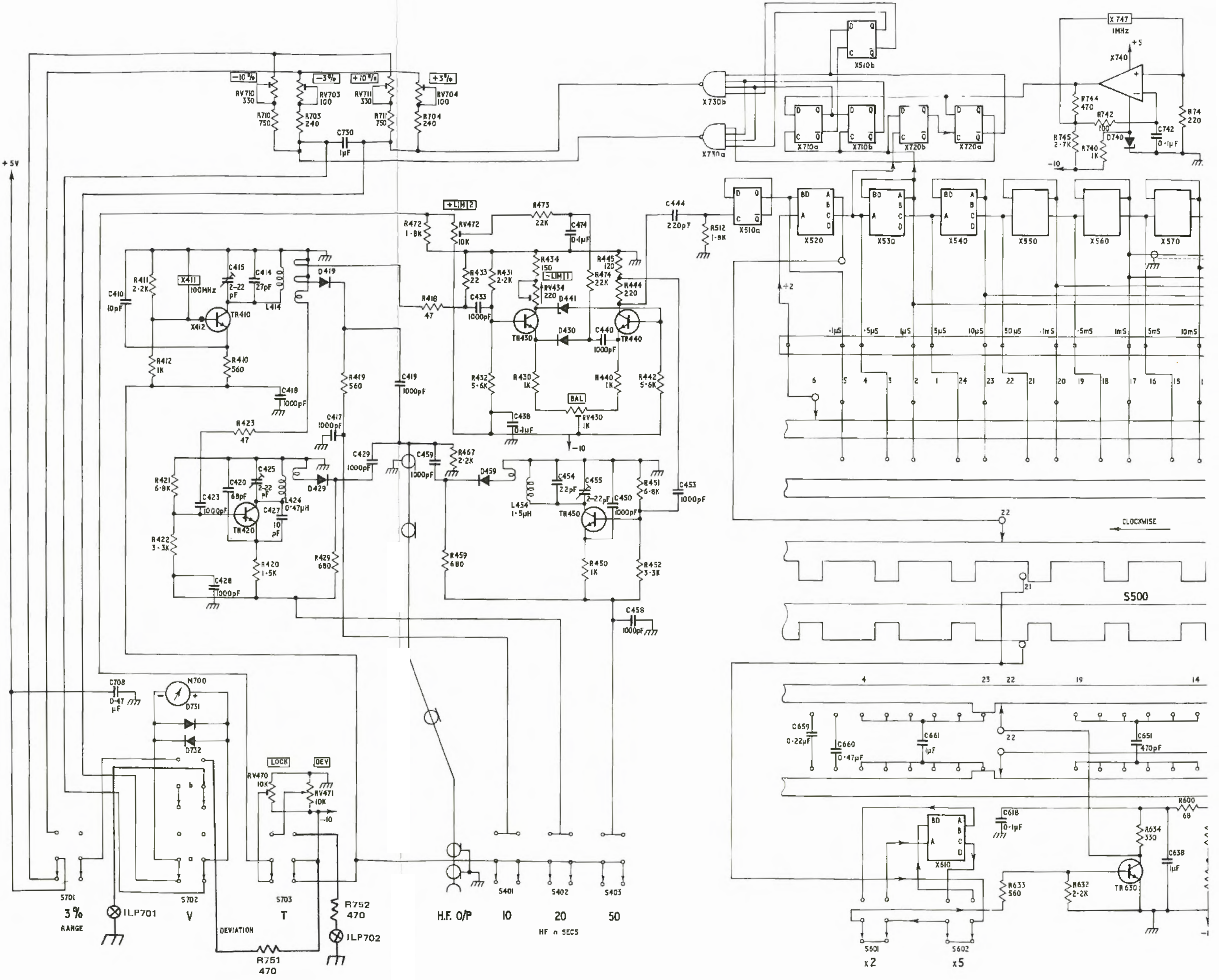
PARTS LIST (FIGURES 5-1, 5-2, 5-3)

REF. DESIG.	PART NO.	DESCRIPTION
R410,R419 R633	12-12272-0A	560 250 MW 1%
R411,R431 R467,R632 R641,R642	12-12333-0A	2200 250 MW 1%
R823,R952	12-12333-0A	2200 250 MW 1%
R412,R430, R440,R450 R740	12-12300-0A	1000 250 MW 1%
R418,R423, R640,R647	12-12165-0A	47 250 MW 1%
R420,R911	12-12317-0A	1500 250 MW 1%
R421,R451	12-12380-0A	6800 250 MW 1%
R422,R452 R974	12-12350-0A	3300 250 MW 1%
R429,R459 R924	12-12280-0A	680 250 MW 1%
R432,R442	12-12372-0A	5600 250 MW 1%
R433	12-12133-0A	22 250 MW 1%
R434,R844, R854,R855	12-12217-0A	150 250 MW 1%
R831*	12-12217-0A	150 250 MW 1%
R444,R741, R830,R806, R807	12-12233-0A	220 250 MW 1%
R445,R801, R802,R803, R804,R805	12-12208-0A	120 250 MW 1%
R472,R512, R951,R964	12-12325-0A	1800 250 MW 1%
R473,R474, R963	12-12322-0A	22 K 250 MW 1%
R600,R635	12-12480-0A	68 250 MW 1%
R634	12-12250-0A	330 250 MW 1%
R643	12-12142-0A	27 250 MW 1%
R703,R704	12-12237-0A	240 250 MW 1%
R710,R711	12-12284-0A	750 250 MW 1%
R742,R824 R850,R858 R859	12-12200-0A	100 250 MW 1%
R744,R856	12-12265-0A	470 250 MW 1%
R745,R950	12-12342-0A	2700 250 MW 1%
R813,R832 R934	12-12257-0A	390 250 MW 1%
R814,R961	12-12288-0A	820 250 MW 1%
R822	12-12417-0A	15 K 250 MW 1%
R834	12-12150-0A	33 250 MW 1%
R851	12-12308-0A	1200 250 MW 1%
R852	12-12268-0A	510 250 MW 1%
R857	12-12188-0A	82 250 MW 1%
R910	12-12329-0A	2000 250 MW 1%
R912	12-12346-0A	3000 250 MW 1%
R901	12-126470-0A	1.5 2.5 W 5% TRW (IRC) Type PW 3
R991	12-126480-0A	2.7 2.5 W 5% TRW (IRC) Type PW 3
RV430,RV951	09-10022-0A	1000 1/2 W 10% Helipot Series 72P Cermet
RV434	09-10023-0A	220 1/2 W 10% Helipot Series 72P Cermet
RV470,RV472	09-10024-0A	10 K 1/2W 10% Helipot Series 72P Cermet
RV471	09-10025-0A	10 K 1/2 W 10% Allen Bradley AB/45 Long Spindle
RV703,RV704	09-10026-0A	100 3/4 W 10% Helipot Series 72P Cermet
RV710,RV711	09-10027-0A	330 3/4 W 10% Helipot Series 72P Cermet
RV800	09-10028-0A	10 K 1/2 W 20%, Allen Bradley AB/45 LOG

REF. DESIG.	PART NO.	DESCRIPTION
C410,C427	07-02222-0A	Cap 10 pF 0.5% @ 750 V
C414	07-02272-0A	Cap 27 pF 5% @ 750 V
C415,C455, C425	07-10027-0A	Cap 2-22 pF 10% 50 V Mullard Type 808
C417,C418, C419,C428, C429	07-10028-0A	Cap 1000 pF 10% @ 1 kV Elmenco CCD-102
C433,C440, C450,C453, C458	07-10028-0A	Cap 1000 pF 10% @ 1 kV Elmenco CCD-102
C459,C652, C813,C834, C851	07-10018-0A	Cap 1000 pF 10% @ 1 kV Elmenco CCD-102
C420	07-10029-0A	Cap 68 pF 10% @ 1 kV Elmenco CCD-680
C423	07-10030-0A	Cap 39 pF 10% @ 1 kV Elmenco CCD-390
C438,C474, C658,C742, C858,C618	07-10031-0A	Cap 0.1 µF 20% @ 100 V Elmenco 1 MD 2104
C444	07-10032-0A	Cap 220 pF 10% @ 1 kV Elmenco CCD-221
C454	07-10033-0A	Cap 22 pF 10% @ 1 kV Elmenco CCD-220
C568,C638, C661,C730	07-10026-0A	Cap 1.0 µF 10% @ 100 V Elmenco 1 MD-5-105
C653	07-10036-0A	Cap 2000 pF 10% @ 1 kV Elmenco CCD-202
C654	07-10037-0A	Cap 4700 pF 10% @ 1 kV Elmenco CCD-472
C651	07-10035-0A	Cap 470 pF 10% @ 1 KV Elmenco CCD-471
C656,C659	07-10034-0A	Cap 0.022 µF 10% @ 100 V Elmenco 1 MDF-1-223
C657	07-10035-0A	Cap 0.047 µF 10% @ 100 V Elmenco 1 MDF-2-473
C660,C708, C828,C902, C992	07-10039-0A	Cap 0.47 µF 10% @ 100 V Elmenco 1 MDF-4-474
C814	07-10040-0A	Cap 56 pF 10% @ 1 kV Elmenco CCD-560
C830,C831	07-10041-0A	Cap 3.3 pF 0.5 pF @ 750 V
C901	07-10042-0A	Cap 2000 pF @ 10 V Mullard C 431 BR/D2000
TR410,TR420, TR430,TR440, TR450,TR630	10-100010-0A	Transistor 2N2369
TR640,TR810 TR820	10-100010-0A	Transistor 2N2369
TR830,TR850	10-08055-0A	Transistor 2N918
TR840	10-10017-0A	Transistor 2N3250
TR910,TR920, TR970	10-10014-0A	Transistor 2N3709
TR930,TR950, TR960	10-10018-0A	Transistor 2N4060
TR940	10-10019-0A	Transistor TIP30 Texas Instru.
TR980	10-10020-0A	Transistor 2N2297

PARTS LIST (FIGURES 5-1, 5-2, 5-3)

REF. DESIG.	PART NO.	DESCRIPTION
CR419	05-10015-0A	Diode IN4244
CR429,CR459, CR640,CR641, CR642	05-0792-0A	Diode IN4148
CR731,CR732, CR822,CR823, CR961	05-07920-0A	Diode IN4148
CR430	05-10016-0A	Diode MV1648 Motorola
CR441,CR740	05-10017-0A	Diode IN746A
CR901,CR902, CR991	05-10018-0A	Diode 10D05 International Rectifier
CR962	05-10010-0A	Diode IN752A
IC510,IC710, IC720	24-10002-0A	IC SN7474N Texas Inst.
IC520,IC530, IC540,IC550, IC560,IC570, IC610,IC580	24-10003-0A	IC SN7490N Texas Inst.
IC590	24-10004-0A	IC SN7472N Texas Inst.
IC730	24-10005-0A	IC SN15844N Texas Inst.
IC740	24-10006-0A	IC SN72702N Texas Inst.
XL411	04-10001-0A	Xtal 100 MHz 0.1% 0-50°C STC 4203/AT-5
XL747	04-10002-0A	Xtal 1.0 MHz 0.1% –20 +70 STC 4046/AT
M700	18-10004-0A	METER - Sifam. 500 µA F.S.D. C 128720 "RB"
L414	03-10001-0A	Coil Bradley Reference A 129918
L424	03-10002-0A	Coil 0.47 µH
L454	03-10003-0A	Coil 1.5 µH
X412	46-10001-0A	Ferrite bead Mullard FX 1242 Ref A 10355
SW101	25-10005-0A	Illuminated Pushbutton power SW Marco Oak
SW102	25-10006-0A	Pushbutton switch Bradley Ref A129993
SW103	25-10007-0A	Pushbutton switch Bradley Ref A129992
SW104	25-10008-0A	Rotary Wafer Switch Bradley Ref C129990
SW401,SW402, SW403	25-10009-0A	Pushbutton switches Bradley Ref C129995
SW701,SW702, SW703	25-10010-0A	Pushbutton switches Bradley Ref A129975
SW601,SW602, SW801,SW802, SW803,SW804, SW805	25-10011-0A	Pushbutton switches Bradley Ref A129996
ILP101	16-10001-0A	Lamp 12 V 0.1 Amp ITT SGF 1361-D-RD-12
T101	20-10001-0A	Power Trans. Ref Brad. C 129988
T102	20-10002-0A	Driver Trans. Ref Brad. GT 13160
L1	03-10004-0A	500 mA suppressor Ref Brad GT 20276
F1	19-10001-0A	Fuse 500 mA/250 V Belling Lee L-1055



+5V
−10%
−3%
+10%
+3%
RV710 330
R710 750
RV703 100
R703 240
RV711 330
R711 750
RV704 100
R704 240
C730 1μF
X730b
X730a
X510b
X710a
X710b
X720b
X720a
X747 1MHz
+5
X740
R744 470
R742 100
R745 2·7K
R740 1K
D740
C742 0·1μF
R74 220
−10
C444 220pF
R512 1·8K
X510a
X520
X530
X540
X550
X560
X570
BD A B C D
÷2
·1μS
·5μS
1μS
5μS
10μS
50μS
·1mS
·5mS
1mS
5mS
10mS
6 5 4 3 2 1 24 23 22 21 20 19 18 17 16 15
22
21
CLOCKWISE
S500
4 23 22 19 14
C659 0·22μF
C660 0·47μF
C661 1μF
C651 470pF
22
C618 0·1μF
X610
R634 330
R600 68
C638 1μF
R633 560
R632 2·2K
TR630
S601
S602
x2
x5
+LIM2
R472 1·8K
RV472 10K
R473 22K
C474 0·1μF
R434 150
−LIM1
RV434 220
R445 120
R474 22K
R444 220
R433 22
R431 2·2K
C433 1000pF
R418 47
D441
D430
C440 1000pF
TR430
TR440
R432 5·6K
R430 1K
R440 1K
R442 5·6K
BAL
RV430 1K
C438 0·1μF
−10
C415 2−22 pF
C414 27pF
L414
X411 100MHz
R411 2·2K
C410 10pF
X412
TR410
D419
R412 1K
R410 560
C418 1000pF
R419 560
C419 1000pF
R423 47
C417 1000pF
C429 1000pF
C459 1000pF
R467 2·2K
D459
D429
R421 6·8K
C423 1000pF
C420 68pF
C425 2−22 pF
L424 0·47μH
C427 10 pF
TR420
R422 3·3K
R420 1·5K
C428 1000pF
R429 680
C454 22pF
C455 2−22pF
C450 1000pF
R451 6·8K
C453 1000pF
L454 1·5μH
TR450
R459 680
R450 1K
R452 3·3K
C458 1000pF
C708 0·47 μF
M700
D731
D732
b
a
LOCK
DEV
RV470 10K
RV471 10K
−10
S701
3%
RANGE
ILP701
S702
V
DEVIATION
R751 470
S703
T
R752 470
ILP702
H.F. O/P
S401
S402
S403
10
20
50
HF n SECS

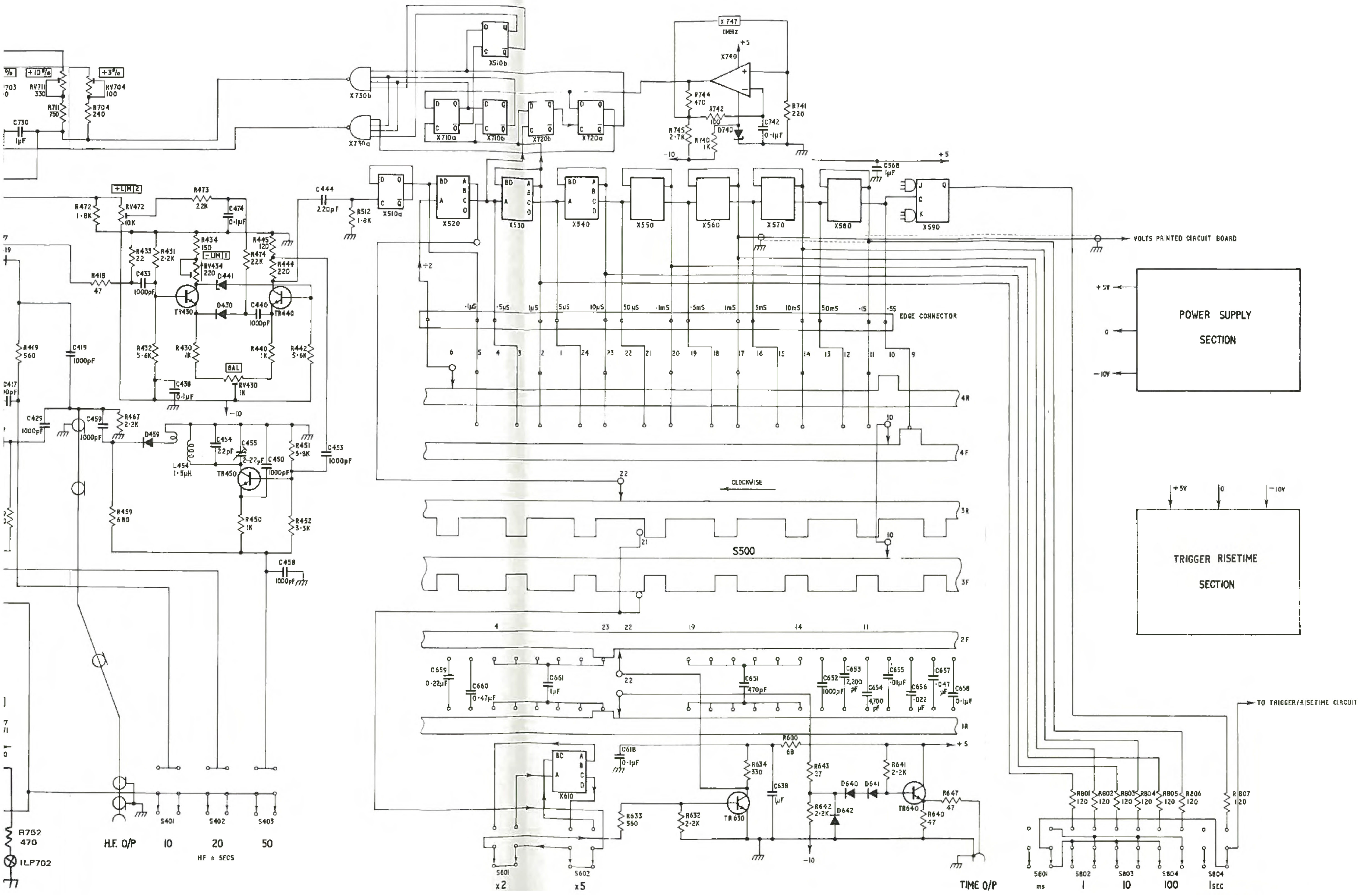
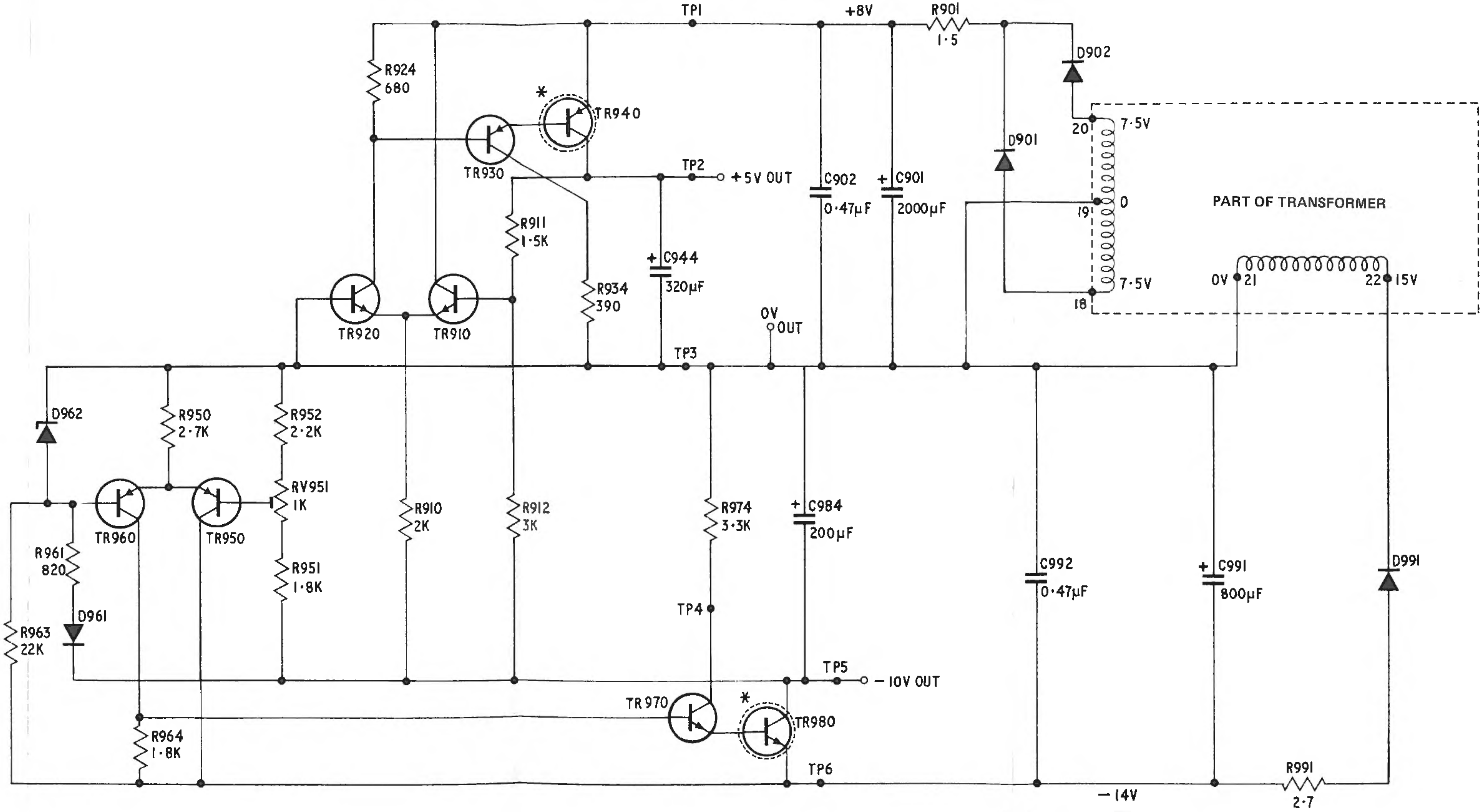


FIGURE 5-1. CALIBRATOR TIME CIRCUIT



* TRANSISTORS MOUNTED WITH HEAT SINKS

FIGURE 5-2. TIMING CIRCUIT POWER SUPPLY

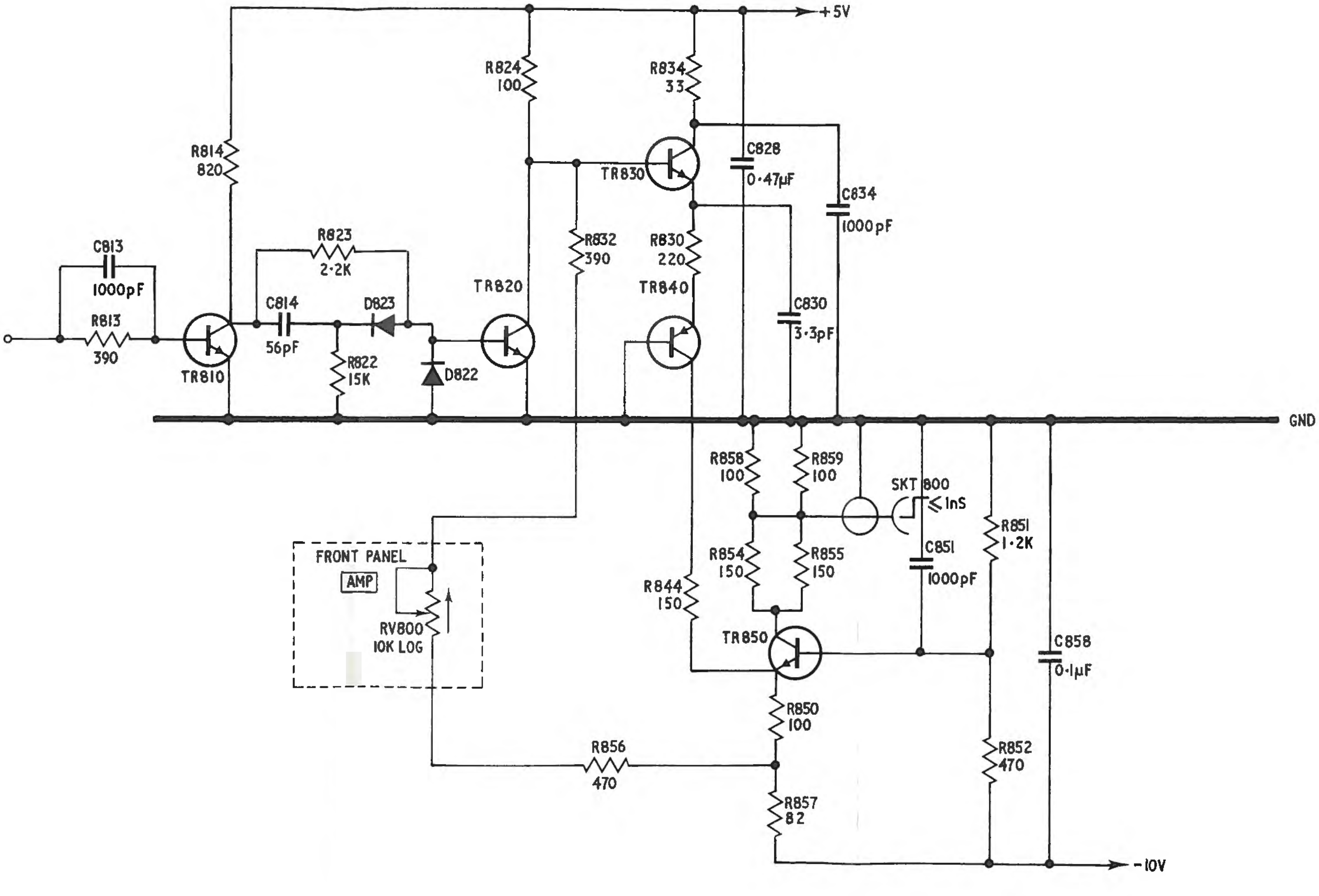
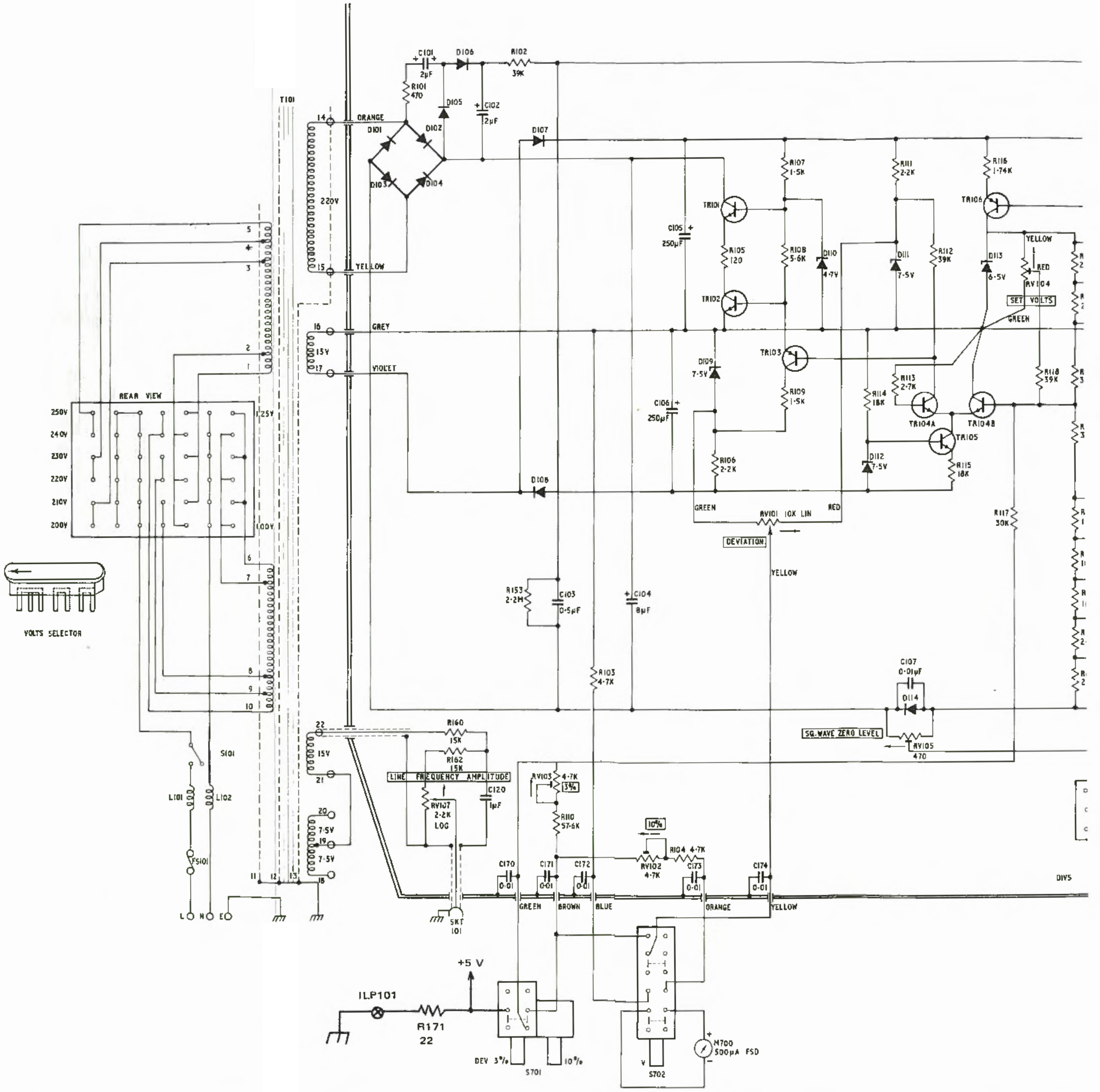


FIGURE 5-3. TRIGGER/RISETIME CIRCUIT

PARTS LIST (FIGURE 5-4)

REF. DESIG.	PART NO.	DESCRIPTION
R101,R130	12-12265-0A	470 1/4 W 1%
R102	12-12457-0A	39 K 1/4 W 1%
R103,R104	12-12365-0A	4.7 K 1/4 W 1%
R105	12-12208-0A	120 1/2 W 1%
R106	12-12333-0A	2.2 K 1/4 W 1%
R107,R109	12-12317-0A	1.5 K 1/4 W 1%
R108	12-12372-0A	5.6 K 1/2 W 1%
R110	12-12473-0A	57.6 K 1/4 W 1%
R111	12-12333-0A	2.2 K 1/4 W 1%
R112	12-12457-0A	39 K 1/2 W 1%
R113	12-12342-0A	2.7 K 1/2 W 1%
R114,R115	12-12425-0A	18 K 1/2 W 1%
R116	12-12323-0A	1.74 K 1/4 W 1%
R117	12-12446-0A	30 K 1/4 W 1%
R118	12-12457-0A	39 K 1/4 W 1%
R119,R120 R151	12-12233-0A	220 1/4 W 1%
R121	12-12630-0A	3 K 1/8 W 0.5%
R122	12-12631-0A	30 K 0.4 W 0.02%
R123,R124 R125	12-12632-0A	10 K 0.1% 1/8 W
R126, R127	12-12633-0A	20 K 1/8 W 0.1%
R128	12-12425-0A	18 K 1/2 W 1%
R129	12-12300-0A	1 K 1/4 W 1%
R131	12-12372-0A	5.6 K 1/4 W 1%
R132	12-12634-0A	220 K 1 W 1%
R133	12-12635-0A	100 K 1 W 0.25%
R134	12-12636-0A	3 M 1/4 W 1%
R135	12-12637-0A	100 1/8 W 0.1%
R136,R137, R138	12-12638-0A	2.5 K 1.2 W 0.02%
R139	12-12639-0A	1.5 K 1 W 0.02%
R140	12-12640-0A	500 1/4 W 0.1%
R141	12-12641-0A	250 1/8 W 0.1%
R142	12-12642-0A	150 1/8 W 0.1%
R143	12-12643-0A	50 1/8 W 0.1%
R144	12-12644-0A	25 0.4 W 0.1%
R145	12-12645-0A	15 0.4 W 0.1%
R146,R147	12-12646-0A	5.05 1/8 W, 1%
R148,R149		Factory Selected Value 1/2 W 1 %
R151	12-12233-0A	220 1/4 W 1%
R152	12-12200-0A	100 1/2 W 1%
R153	12-12629-0A	2.2 M 1/4 W 1%
R160,R162	12-12417-0A	15 K 1/2 W 1%

REF. DESIG.	PART NO.	DESCRIPTION
RV101	09-10016-0A	10 K 1/2 W Allen Bradley C45 LIN LAW
RV102,RV103	09-10017-0A	5 K 1/2 W 10% Helipot Series 72 Cermet
RV104	09-10018-0A	50 K 3/4 W 10% Helipot Series 78L Cermet
RV105	09-10019-0A	500 1/2 W 10% Helipot Series 72 Cermet
RV106	09-10020-0A	500 K 1/4 W 10% Helipot Series 78L Cermet
RV107	09-10021-0A	2.2 K 1/2 W 20% Allen Bradley C45 LOG LAW
C101,C102, C109	07-10020-0A	Cap Electrolytic 2 µF @ 350 V
C103	07-10021-0A	Cap 0.5 µF @ 600 V 20%
C104	07-10022-0A	Cap Electrolytic 8 µF @ 350 V
C105	07-07829-0A	Cap Electrolytic 250 µF @ 25 V
C107,C110	07-10023-0A	Cap 0.01 µF @ 25 V
C111	07-10024-0A	Cap Trimmer 0-3 pF @ 500 V
C112	07-10025-0A	Cap 2200 pF @ 200 V 20%
C120	07-10026-0A	Cap 1 µF @ 100 V
C170,C171, C172,C173, C174,C175	07-02583-0A	Cap Feed through 1000 pF −20 +80
TR101	10-10003-0A	Transistor RCA 40374
TR102	10-10005-0A	Transistor Motorola 6515
TR103,TR106	10-10009-0A	Transistor Motorola 6519
TR104	10-10013-0A	Transistor 2N2643
TR105	10-10014-0A	Transistor 2N3709
TR107,TR108	10-10015-0A	Transistor 2N3739 Motorola
TR109	10-10016-0A	Transistor 2N5058 Texas Inst.
CR101,CR102, CR103,CR104, CR105	05-10019-0A	Diode 10 D4 International Rect.
CR106	05-10019-0A	Diode 10 D4 International Rect.
CR108,CR117	05-07920-0A	Diode IN4148
CR109,CR111, CR112,CR115	05-10007-0A	Diode Type IN755A
CR110	05-10010-0A	Diode Type IN750A
CR113	05-10000-0A	Diode Zener Type IN753B Dickson
CR114,CR116	05-10014-0A	Diode Type AAZ13 Mullard, Ref AAZ13


C101
2µF
D106
R102
39K
R101
470
D105
C102
2µF
T101
14
ORANGE
D101
D102
D103
D104
220V
15
YELLOW
D107
R107
1·5K
R111
2·2K
R116
1·74K
TR101
TR106
C105
250µF
R105
120
R108
5·6K
D110
4·7V
D111
7·5V
R112
39K
D113
6·5V
YELLOW
RED
RV104
SET VOLTS
GREEN
TR102
16
GREY
15V
17
VIOLET
TR103
D109
7·5V
R113
2·7K
R114
18K
R118
39K
R109
1·5K
C106
250µF
TR104A
TR104B
TR105
R106
2·2K
D112
7·5V
R115
18K
D108
5
4
3
2
1
REAR VIEW
250V
240V
230V
220V
210V
200V
1.25V
1.00V
6
7
8
9
10
GREEN
RV101 10K LIN
RED
DEVIATION
YELLOW
R117
30K
VOLTS SELECTOR
R153
2·2M
C103
0·5µF
C104
8µF
R103
4·7K
C107
0·01µF
D114
SQ. WAVE ZERO LEVEL
RV105
470
22
R160
15K
R162
15K
15V
21
LINE FREQUENCY AMPLITUDE
C120
1µF
RV107
2·2K
LOG
RV103
4·7K
3%
R110
57·6K
10%
R104 4·7K
RV102
4·7K
20
7·5V
19
7·5V
18
S101
L101
L102
FS101
11
12
13
C170
0·01
C171
0·01
C172
0·01
C173
0·01
C174
0·01
DIV5
L
N
E
SKT
101
GREEN
BROWN
BLUE
ORANGE
YELLOW
+5 V
ILP101
R171
22
DEV 3%
10%
S701
V
S702
M700
500µA FSD

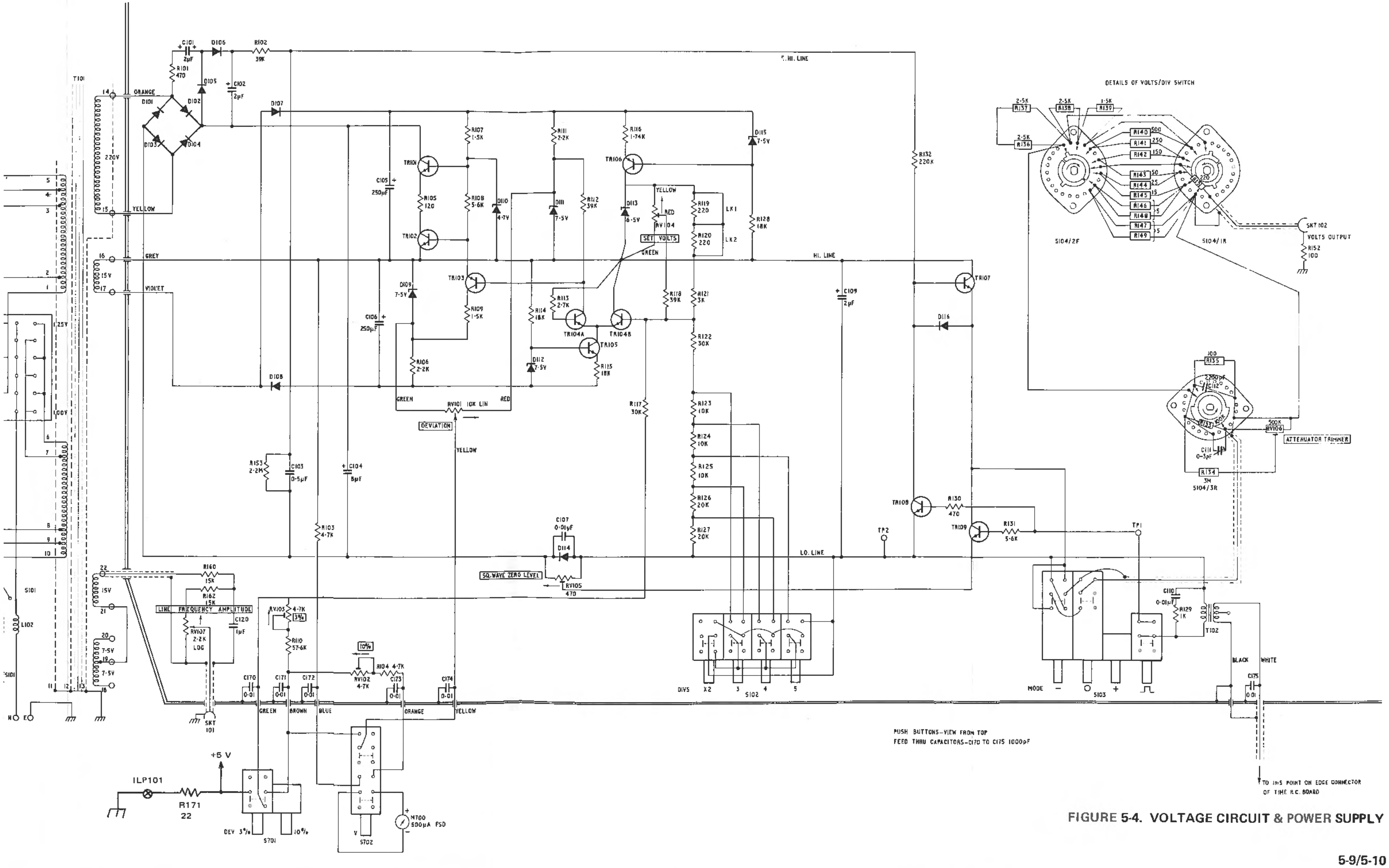


FIGURE 5-4. VOLTAGE CIRCUIT & POWER SUPPLY