OPERATING INSTRUCTIONS

TYPE 1130-A

DIGITAL TIME and FREQUENCY METER

1130-A

GENERAL RADIO COMPANY

A

OPERATING INSTRUCTIONS

TYPE 1130-A

DIGITAL TIME and FREQUENCY METER

Type 1130-0110-A
November, 1961

G E N E R A L   R A D I O   C O M P A N Y
W E S T   C O N C O R D ,   M A S S A C H U S E T T S ,   U S A

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SPECIFICATIONS

FREQUENCY MEASUREMENT

Range: Dc to 10 Mc.

Sensitivity: 0.25 volt rms for sine waves, more sensitive at low frequencies; 0.4 volt peak-to-peak for typical pulse waveforms.

Counting Interval: 1 msec to 10 sec, extendible by MULTIPLE INTERVAL switch or external connections.

Accuracy: ±1 count ± time-base oscillator accuracy

PERIOD MEASUREMENT

Range: 10 μsec to 10^7 sec (dc to 100 kc) for single-period measurement. 330 μsec to 10^7 sec (dc to 30 kc) for ten-period measurement.

Sensitivity: 0.1 volt rms for sine waves; 0.3 volt peak-to-peak for typical pulse waveforms.

Counting Interval: 1 period, 10 periods, extendible by MULTIPLE INTERVAL switch or external connections.

Counted Frequency: 10 Mc, 100 kc, 1 kc, 10 cps or External (6 volts rms sine waves, or −10 volts peak pulses, 100 cps to 10 Mc).

Accuracy: ±0.1% at 1 volt rms for single-period measurement; better for higher voltage level and good signal-to-noise ratio. ±0.01% at 1 volt rms for 10-period mesurements; better for higher voltage level and good signal-to-noise ratio.

TIME-INTERVAL MEASUREMENT

Range: 1 μsec to 10^7 sec.

Sensitivity: 0.3 volt peak-to-peak.

Counted Frequency: 10 Mc, 100 kc, 1 kc, 10 cps, or External (6 volts rms sine waves, or −10 volts peak pulses, 100 cps to 10 Mc).

Accuracy: Dependent on slope of input signals at trigger point. For steep slopes (e.g., pulses): ±1 period of frequency counted ±accuracy of frequency counted.

COUNT MEASUREMENT

Rate: Dc to 10 Mc.

Sensitivity: 0.25 volt rms for sine waves, typically 100 mv up to 3 Mc. 0.4 volt peak-to-peak for typical pulse waveforms.

Capacity: 10^8 counts.

GENERAL

Display: Neon-lamp columns — 8 digits intermittent, 4 digits continuous.

Display Time: Variable, 0.1 to 10 sec, infinite, or continuous display.

Input Impedance: 1 megohm shunted by 40 pf.

Input Attenuator: x 1 or x 10.

Check: 10 cps, 1 kc, 100 kc, or 10 Mc can be counted for 1 msec to 10 sec.

Monitor: Flashing lamp indicates lack of time-base drive signal or improper operation of frequency dividers.

Input Trigger Level: Adjustable ±10 volts.

Input Trigger Slope: Positive-going or negative-going, ac or dc coupling.

External Outputs, Front Panel: GATE signal (coincides with the counting interval); SYNC pulses (at start of internal program cycle); 10 cps to 10 Mc (except 1 Mc) standard frequencies from EXT connector, depending on settings of MEASUREMENT, FREQUENCY and TIME controls.

External Outputs, at rear: MULTIPLE-INTERVAL and RESET connections, carry output pulse; 8, four-line, binary-coded-decimal digits (1–2–4–2) ("0" = 185 volts, "1" = 65 volts — 0.5 megohm source impedance — minimum load impedance 1.8 megohms).

Time-Base Drive Required: 5 Mc, 1 volt rms into 50 ohms (supplied by 1130-P2, -P3, -P4, 1113-A, see page 79).

Power Input: 105 to 125 (or 210 to 250) volts, 50–60 cps, 400 watts.

Ambient Temperature Range: 0 to 50 C.

Tube Complement: Forty-one 5963; twenty 6922; eleven 6887; ten 5965; five 6350; three each 5915, 6AU6; one each 5651, 12AT7, 12AX7.

Accessories Supplied: Power cord, spare fuses, 4 TYPE 874-C62 Cable Connectors, TYPE 1130-47 Plug.

Accessories Available: Additional time-base units (page 79); TYPE 1132-A Data Printer (below); TYPE 1134-A Digital-To-Analog Converter (page 80); spare or replacement counting decades (page 81), TYPE 1130-P5 Servicing Accessory (page 79) for operating any one of the etched-board assemblies outside the cabinet.

Dimensions: Width 19, height 16¼, depth 19¼ inches (485 by 415 by 490 mm), over-all.

Net Weight: 85 pounds (39 kg).

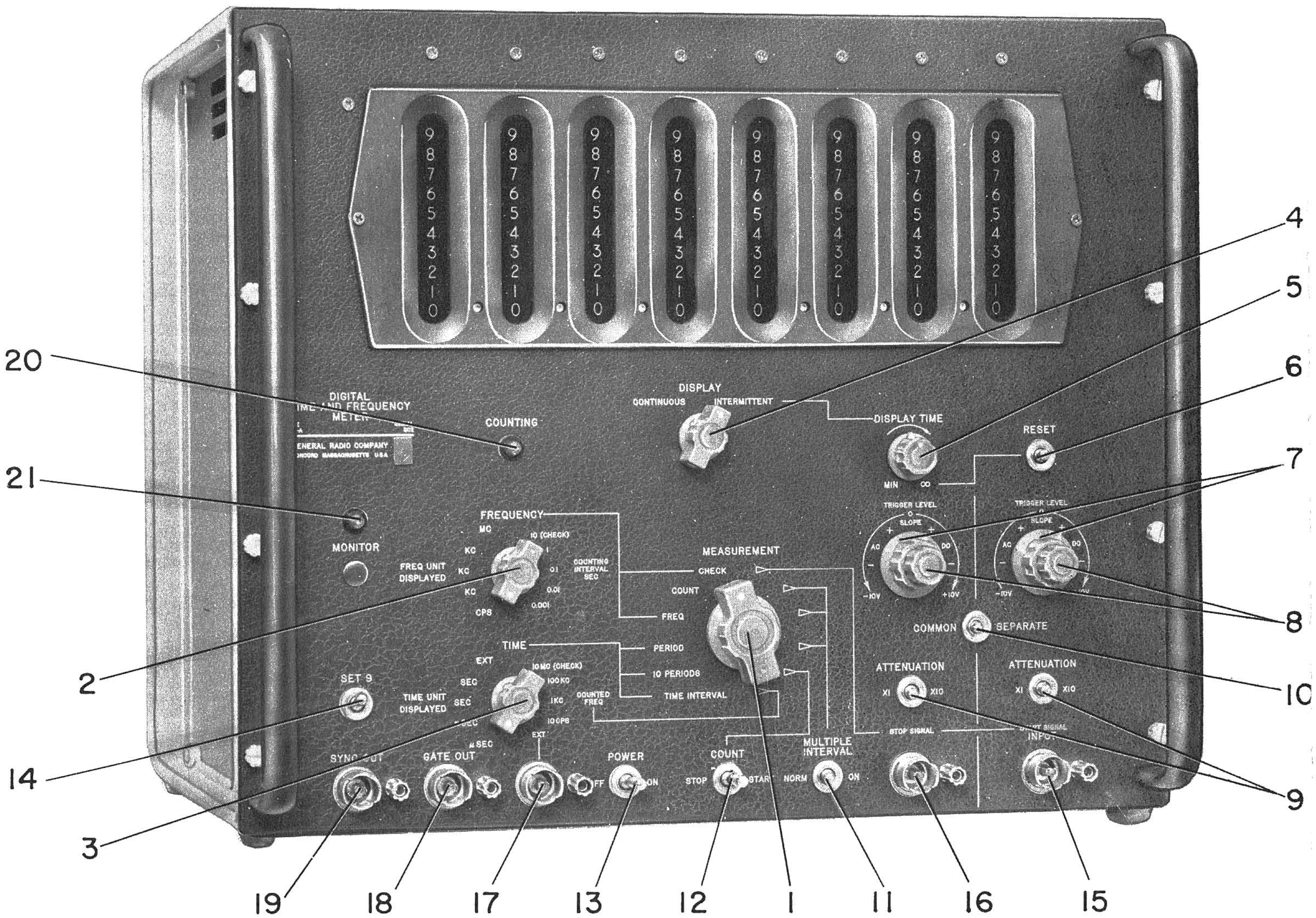


Figure 2-1. Panel view (with callouts) of the Type 1130-A Digital Time and Frequency Meter.

TYPE 1130-A
DIGITAL TIME AND FREQUENCY METER

Section 1
INTRODUCTION

1.1 PURPOSE.

The Type 1130-A Digital Time and Frequency Meter precisely measures frequency, period, and time interval. The instrument measures frequencies from dc to 10 Mc with a precision of 0.1 cps, periods from 10 μsec to 10^7 sec with a precision of 0.1 μsec, and time intervals from 1 μsec to 10^7 sec with a precision of 0.1 μsec. The Type 1130-A can also be used to count random events, measure frequency ratios, compute phase shift, and measure characteristics of pulse waveforms.

1.2 DESCRIPTION.

The Digital Time and Frequency Meter is mounted in a heavy-gauge aluminum cabinet fitted with aluminum end frames for bench use. With the end frames removed, the instrument can be mounted in a 19-inch relay rack. Special rack-mounting brackets attach both instrument and cabinet to the rack and permit either to be withdrawn independently of the other. Large front-panel handles protect the controls and simplify handling of the instrument. Cabinet ventilation is provided by a fan at the rear, which draws air into the instrument through an air filter.

1.3 DISPLAY.

The measurement presentation consists of digital neon-lamp columns. The operator can choose either an eight-digit intermittent (sequential) display or a four-digit continuous display. By proper setting of the controls, any four consecutive digits may be selected for continuous display. An illuminated decimal point is automatically positioned for each measurement and the units of measurement are clearly indicated.

1.4 ACCESSORIES SUPPLIED.

A Type CAP-22 Three-Wire Power Cord, four Type 874-C62 Cable Connectors, one 40-pin Elco plug, and spare fuses are supplied with the instrument.

Section 2
OPERATING PROCEDURE

2.1 INSTALLATION.

2.1.1 CONNECTION TO POWER SUPPLY. Connect the Type 1130-A to a source of power as indicated on the nameplate at the input socket at the rear of the instrument, using the power cord provided. While instruments are normally supplied for 115-volt operation, the power transformer can be reconnected for 230-volt service (refer to schematic diagram, Figure 4-5). When changing connections, be sure to reverse the nameplate to indicate the correct input voltage and replace the fuses.

2.1.2 TIME-BASE REFERENCE SOURCE. The Type 1130-A Digital Time and Frequency Meter operates from a time-base reference signal of 5 Mc at a level of 1 volt rms into 50 ohms. If a Type 1130-P2, -P3, or -P4 Time-Base Plug-In Unit is used, its controls can be set to operate from either an external 5-Mc source or an internal crystal oscillator. The Type 1130-P2 Time-Base Oscillator/Multiplier also allows operation from external sources of 100 kc or 1 Mc. If the drive signal is absent, the MONITOR lamp on the front panel of the instrument will flash to warn the operator. The time-base unit is plugged into the rear of the instrument and held by two panel screws.

2.2 PUTTING THE INSTRUMENT INTO OPERATION.

2.2.1 PANEL CONTROLS AND ENGRAVINGS. The panel controls and indicators are listed in the accompanying tables. To simplify the operation of the instrument, two-color engraving has been used. The white engraving indicates information of primary interest to the operator and the orange engraving indicates secondary information. For example, with the MEASUREMENT control (1, Figure 2-1) in the COUNT position, the orange dot on the double-bar knob is adjacent to an orange line which leads to the COUNT switch (12, Figure 2-1).

2.2.2 WARM-UP. To ensure long trouble-free operation, a time-delay relay is used to hold off the high voltages for about 20 seconds until the tubes have warmed up. *The instrument will not operate until the relay has switched.*

2.2.3 THERMAL CUTOUT. To prevent damage to the instrument, a thermal switch interrupts the power-line connections when the ambient temperature rises above 50 C

TABLE 1. CONTROLS.

Figure 2-1 Ref No.	Name	Type	Function
1	MEASUREMENT	6-position rotary selector switch	Selects desired measurement.
2	FREQUENCY	5-position rotary selector switch	Selects decimal-point indication and counting interval for CHECK and FREQUENCY measurements.
3	TIME	5-position rotary selector switch	Selects decimal-point indication and counted frequency for PERIOD, 10 PERIODS, and TIME INTERVAL measurements.
4	DISPLAY	2-position rotary selector switch	Selects display mode, CONTINUOUS or INTERMITTENT.
5	DISPLAY TIME	Continuous rotary control detented at maximum clockwise rotation	Adjusts display time for intermittent display.
6	RESET	Spring-return toggle switch	Resets all decimal counting units to 0 and initiates new measurement.
7	SLOPE	4-position rotary selector switch	Selects slope of input signal at which triggering will occur. Also selects ac or dc coupling.
8	TRIGGER LEVEL	Continuous rotary control concentric with SLOPE switch	Adjusts voltage level of input signal at which triggering will occur.
9	ATTENUATION	2-position toggle switch	Selects attenuation of input signal.
10	COMMON-SEPARATE	2-position toggle switch	Connects start and stop signals for common-channel time-interval measurements.
11	MULTIPLE INTERVAL	Spring-return toggle switch	Allows extension of counting interval in integral steps.
12	COUNT	2-position toggle switch	Starts and stops COUNT measurement.
13	POWER	2-position toggle switch	Turns instrument on or off.
14	SET 9	Spring-return toggle switch	Sets the four storage decades to 9 to enable full-scale adjustment of graphic recorder.

(122 F). This switch resets automatically when the instrument cools.

2.2.4 CHECK. With the MEASUREMENT control in the CHECK position, the instrument will measure an internally generated frequency determined by the position of the TIME control, with a counting interval determined by the position of the FREQUENCY control. The instrument should read the correct frequency within one count for all positions of the FREQUENCY and TIME controls. The positions of the FREQUENCY and TIME controls corresponding to a measurement of 10 Mc with a counting interval of 10 sec are labeled CHECK. These positions are chosen for check conditions because the higher the frequency measured, the greater the performance requirements of the circuits, and the longer the counting interval used, the greater the number of circuits involved.

2.3 CONTROL SETTINGS.

2.3.1 MEASUREMENT CONTROLS. The major measurement controls are shown in Figure 2-2. The centrally located MEASUREMENT control selects the type of measurement to be made.

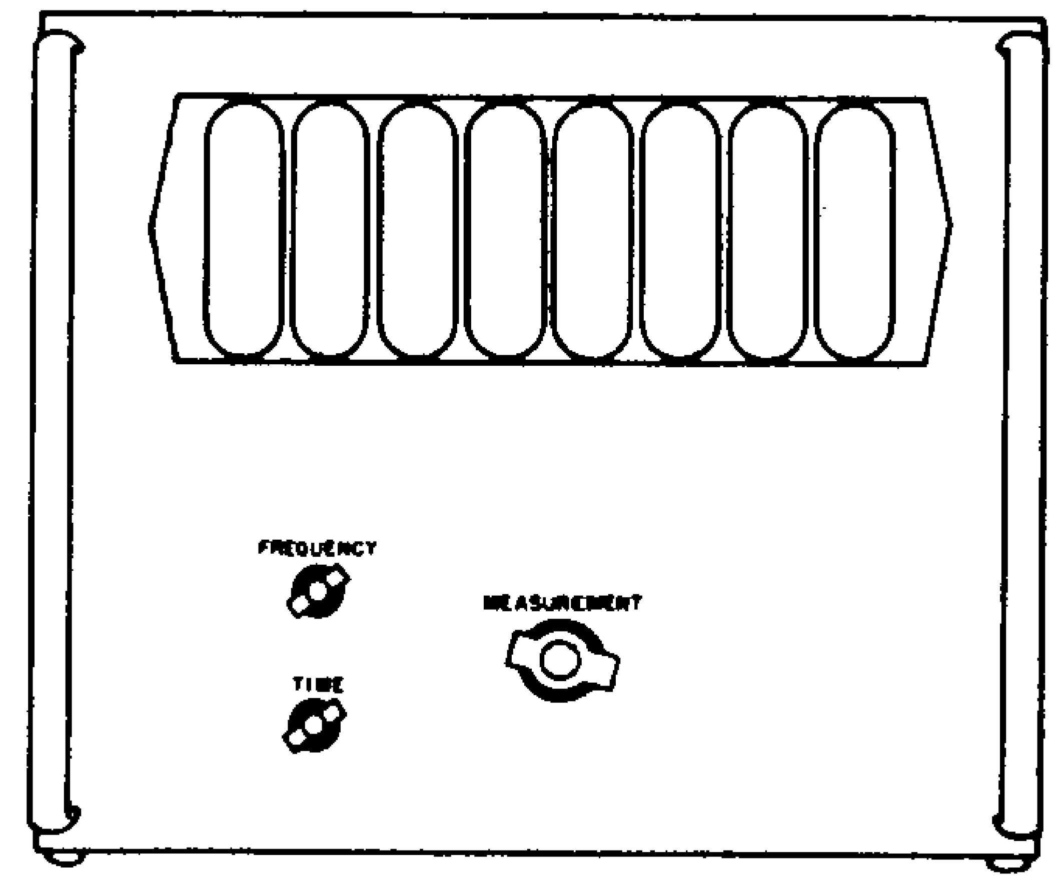


Figure 2-2. Measurement controls.

For the two frequency-measurement positions (CHECK and FREQ) the FREQUENCY control is used to select the desired counting interval, as engraved at the right of the control. As the counting interval is increased, the precision of the measurement increases and the sampling

TABLE 2. CONNECTORS.

Figure 2-1 Ref No.	Name	Type	Function
15	START SIGNAL INPUT	Type 874 Coaxial Connector	Input terminal.
16	STOP SIGNAL	Type 874 Coaxial Connector	Stop-signal input terminal for time-interval measurement.
17	EXT	Type 874 Coaxial Connector	Output terminal for standard-frequency signals; input terminal for frequency-ratio measurements.
18	GATE OUT	Type 874 Coaxial Connector	Output terminal for gate signal.
19	SYNC OUT	Type 874 Coaxial Connector	Output terminal for sync signal.
(Rear)	External Accessory Socket, SO703	40-connector Elco socket	Binary-coded decimal outputs of decimal counting units and synchronizing signals for use with Type 1132-A Data Printer and Type 1134-A Digital-to-Analog Converter, and for remote operation of the instrument.
(Rear)	External Accessory Socket, SO704	6-connector Jones-type socket	For remote multiple-interval operation and use with the Type 1130-P6 Counting Interval Multiplier.

TABLE 3. INDICATORS.

Figure 2-1 Ref No.	Name	Type	Function
20	COUNTING	Neon	Indicates opening of main gate.
21	MONITOR	Flashing Neon	Indicates lack of time-base driving signal.
22	Decimal Point	Incandescent	Indicates units displayed.

rate decreases. The decimal point is automatically positioned by the FREQUENCY control and the units of measurement are engraved at the left of this control.

For the three time-measurement positions of the MEASUREMENT control (PERIOD, 10 PERIODS, TIME INTERVAL), the TIME control is used to select the counted frequency, as engraved at the right of the control. The higher counted frequencies provide finer time-increment resolution and greater measurement precision. The decimal point is automatically positioned by the TIME control and the units of measurement are engraved at the left of this control.

2.3.2 DISPLAY CONTROLS. Figure 2-3 shows the display controls. The DISPLAY control selects the mode of measurement display. With the DISPLAY control in the CONTINUOUS position, a mask covers the four high-speed decimal counting units (decades) at the right, and the four low-speed decades at the left are converted to storage decades which display the count continuously accumulated in the high-speed decades.

With the DISPLAY control in the INTERMITTENT position, all eight decades are used for sequentially counting and displaying. The DISPLAY TIME control varies the time that the accumulated count is held for display, from a minimum of about 0.2 second to a maximum of about 10 seconds. With the control in the vertical position, the display time is about 1 second. Rotating the control against its clockwise stop (∞) activates a switch which disables the DISPLAY TIME control and holds the displayed count until the spring-return RESET switch is thrown. The RESET switch can be thrown at any time to clear all decades to 0 and initiate a new measurement.

2.3.3 INPUT CONTROLS. The function of the input circuits of the Type 1130-A Digital Time and Frequency Meter is to generate a standardized trigger pulse for each cycle of the input signal voltage. For frequency measurements these pulses are counted by the counting circuits of the instrument, and for time measurements the pulses are used to start and stop the flow of standard clock pulses into the counting circuits. The input circuits are controlled by the duplicate sets of controls

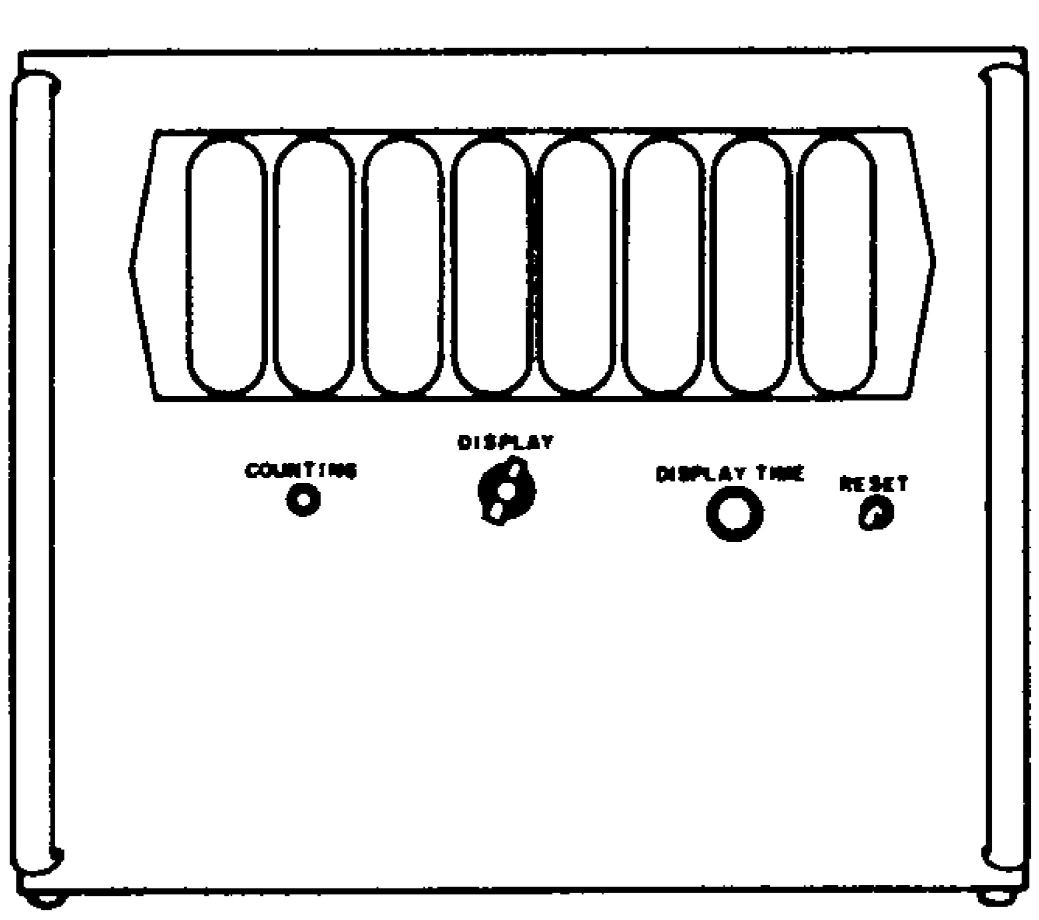


Figure 2-3. Display controls.

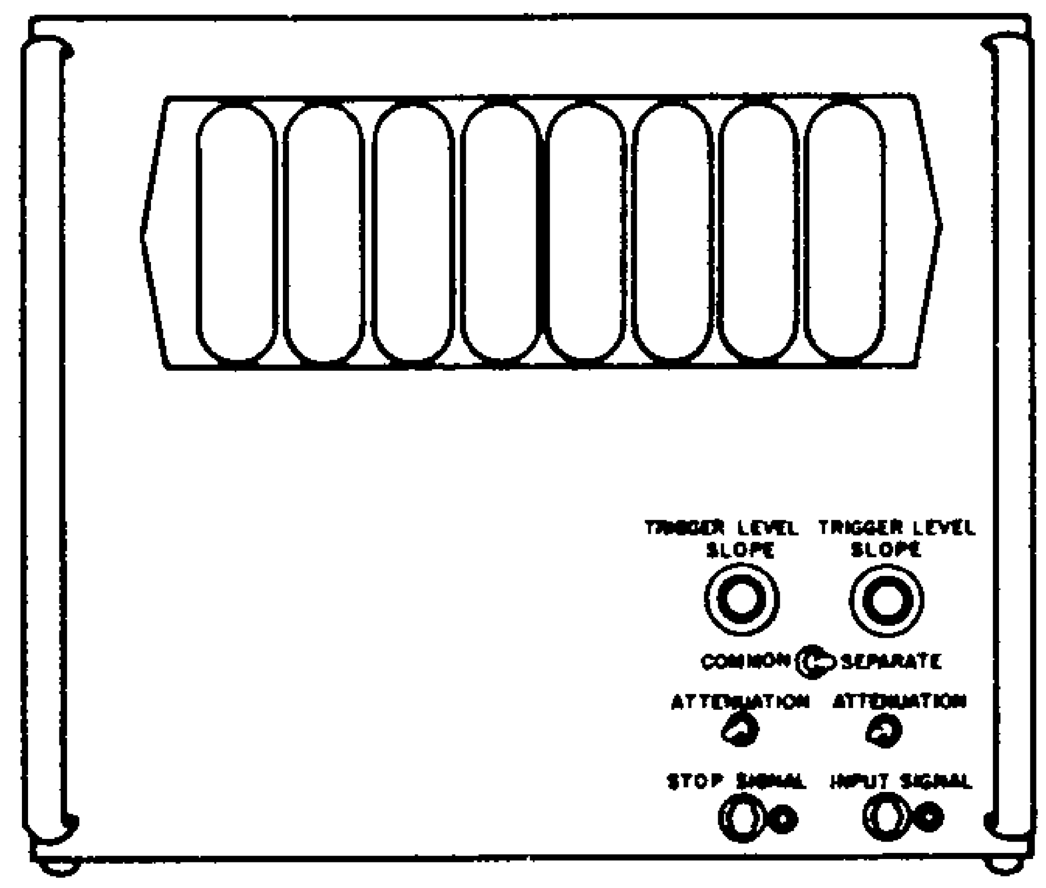


Figure 2-4. Input controls.

shown in Figure 2-4. For the COUNT, FREQUENCY, PERIOD, and 10 PERIODS positions of the MEASUREMENT control, the input signal is applied at the INPUT connector (15, Figure 2-1) and the right-hand set of input controls is used. For the TIME INTERVAL position of the MEASUREMENT control, the signal used to start the time measurement is applied at the START SIGNAL connector (15, Figure 2-1) and the right-hand controls are used to generate the start pulse. The signal used to stop the time measurement is applied at the STOP SIGNAL connector (16, Figure 2-1) and the left-hand controls are used to generate the stop pulse.

Figure 2-5 is a simplified schematic diagram illustrating the roles of the input controls.

For common-channel time-interval measurements in which both the start pulse and stop pulse are derived from different points on the same waveform, the two channels can be connected at their inputs by the COMMON-SEPARATE switch (10, Figure 2-1). The two sets of controls are still independent and conditions for starting and stopping can be adjusted independently.

The functions of the two sets of input controls are identical and the following description applies to either.

The ATTENUATION switch (9, Figure 2-1) provides either a direct connection (X1) of the input signal or a ten-to-one reduction through a voltage divider (X10). The signal from the attenuator is applied to one input terminal of a difference amplifier and a dc reference voltage set by the TRIGGER LEVEL control (8, Figure 2-1) is applied to the other terminal. The setting of the TRIGGER LEVEL control determines the point on the input waveform at which a trigger pulse is generated. For measurement of clean, sinusoidal signals, trigger pulses generated at the zero-crossings of the input signal yield maximum sensitivity. This corresponds to the vertical position of the TRIGGER LEVEL control. However, for frequency measurement of pulse waveforms in the presence of noise that causes multiple zero-crossings, and for period and time-interval measurements and the counting of random events, the triggering level should be adjusted to the cleanest or most significant region of the input waveform.

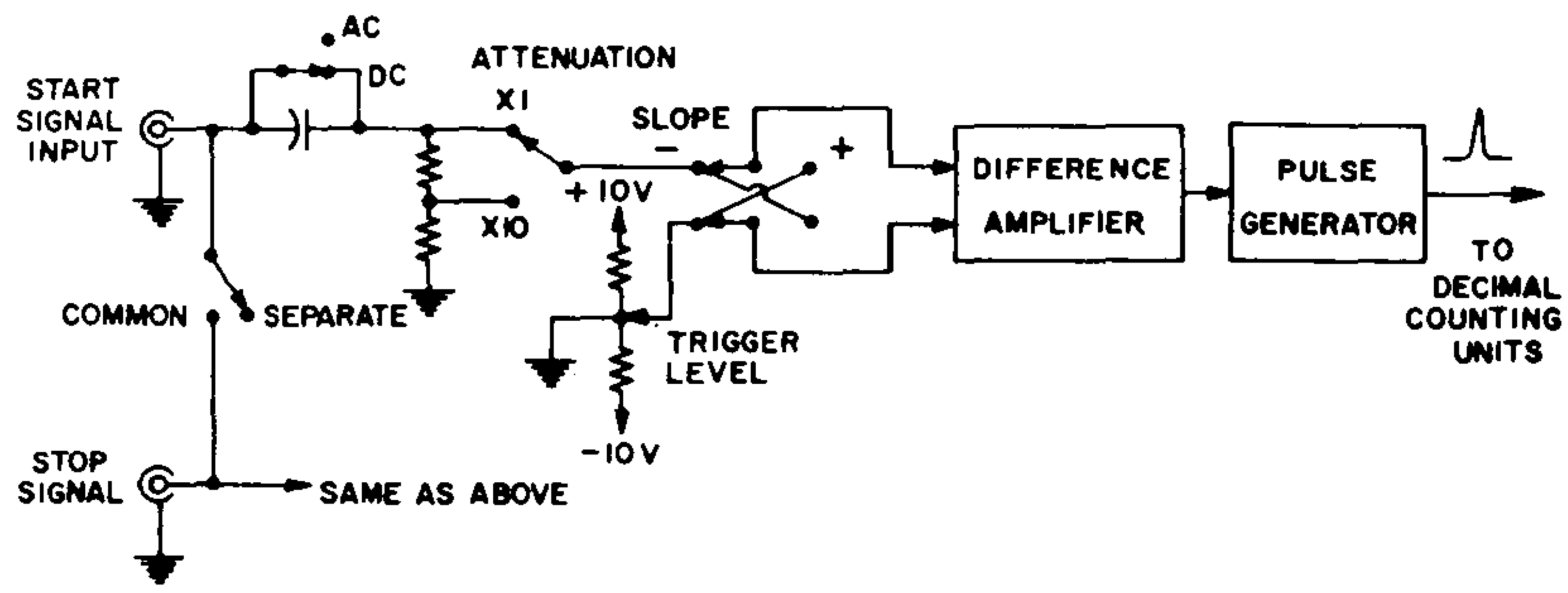


Figure 2-5. Simplified schematic of input controls.

By interchanging the connections of the input signal and reference voltage, the SLOPE control determines whether a trigger pulse is generated at a positive-going or negative-going crossing of the triggering level. With the SLOPE control in the AC position, a capacitor is connected in series with the input signal to block any dc that may be present. The input impedance of the instrument is approximately 1 megohm shunted by 40 pf for either position of the ATTENUATION switch.

The TRIGGER LEVEL control is a carbon-element potentiometer with a grounded center-tap which broadens the region of zero-reference voltage and allows a quick, noncritical return to the position of maximum sensitivity. The range of the TRIGGER LEVEL control is ±10 volts, which, in conjunction with the ATTENUATION switch, provides an effective input-triggering range of ±100 volts.

The trigger-pulse generating circuit is a Schmitt trigger circuit which must be reset by the input signal between trigger pulses. The difference in input voltage between the triggering level and the resetting level is called the "hysteresis" of the input circuits and determines the sensitivity. Figure 2-6 illustrates the effect of this hysteresis with the SLOPE control in the + position. With the SLOPE control in the − position, the triggering level and resetting level are interchanged. As indicated in Figure 2-7, the setting of the TRIGGER LEVEL control raises or lowers the triggering level and resetting level together, maintaining their fixed separation.

The minimum peak-to-peak amplitude of the input signal necessary to produce trigger pulses is equal to the hysteresis voltage. This voltage varies with frequency, ranging from about 0.1 volt at 1 Mc to about 0.7 volt at 10 Mc.

Some of the uses of the input controls are illustrated in Figure 2-7.

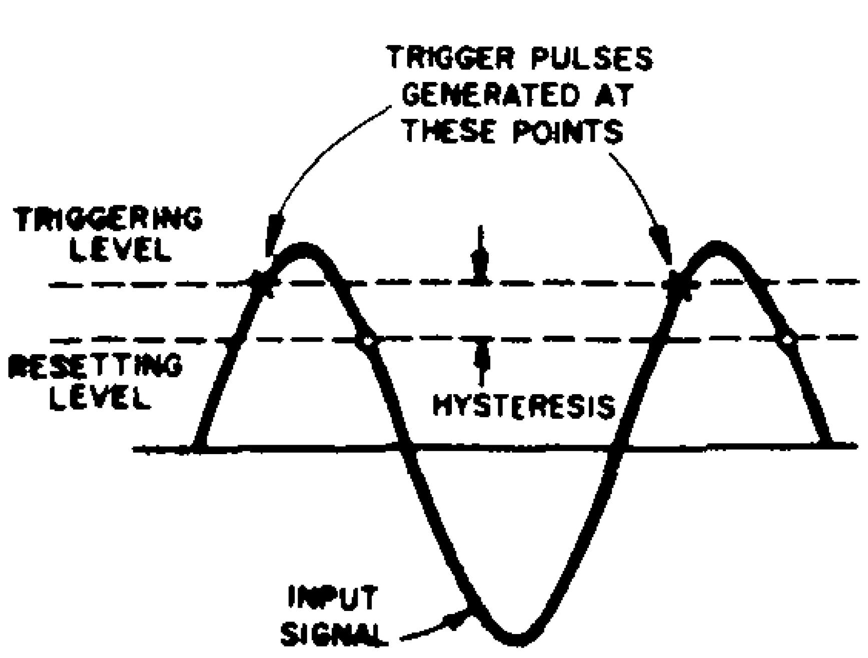


Figure 2-6. Effect of hysteresis with SLOPE control at +.

Figure 2-7. Uses of input controls.

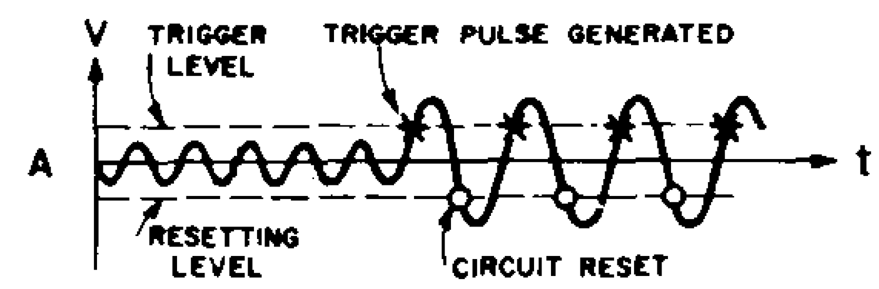


Figure 2-7a. Signal too small; must be increased.

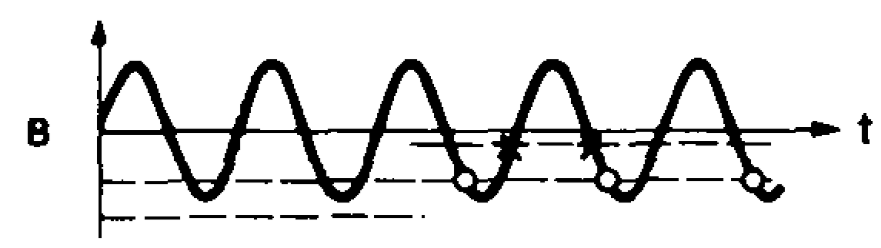


Figure 2-7b. Too large a negative offset of the TRIGGER LEVEL control. Corrected by reducing offset.

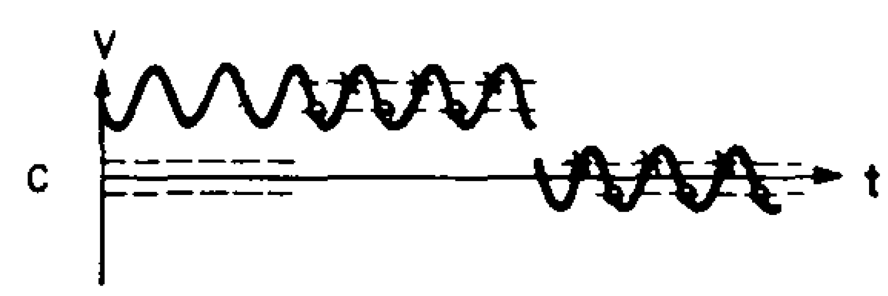


Figure 2-7c. Dc component of signal lifts ac component out of triggering region. Corrected either by raising triggering level or by setting SLOPE control to AC.

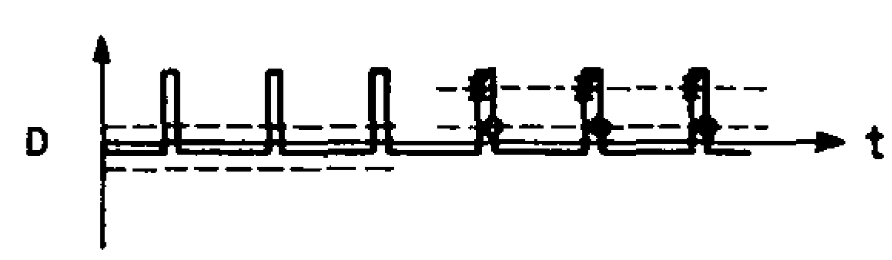


Figure 2-7d. Low duty-ratio pulse signal. Corrected by raising triggering level.

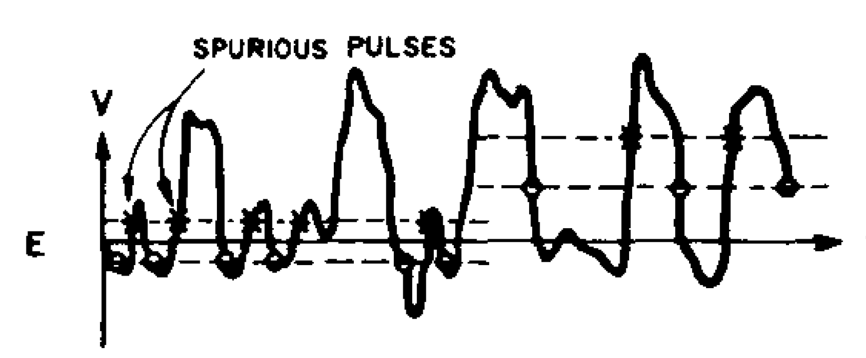


Figure 2-7e. Pulse signal with added noise. Corrected by setting triggering level to region of steepest slope. If the signal is large enough to operate the instrument when attenuated by a factor of 10, set the ATTENUATION switch to X10 to reduce the noise level to less than the hysteresis voltage and eliminate the erroneous triggering. For example, a 1-volt peak-to-peak noise level on a 10-volt pulse can cause spurious trigger pulses. When both signal and noise are attenuated by a factor of 10, the resulting 1-volt signal will reliably operate the instrument, while the resulting 0.1-volt noise level is below the triggering sensitivity.

2.4 MEASUREMENTS.

2.4.1 BASIC BLOCK DIAGRAM. The simplified block diagram of Figure 2-8 shows that the Type 1130-A Digital Time and Frequency Meter contains five basic circuit blocks: the input circuits, the time base, the main gate, the program control, and the decimal counting units. The input circuits are used to generate trigger pulses from the input signal. For frequency measurement the trigger pulses are counted for a time interval derived from the time base; for time measurement (period, 10 period, or time interval), the trigger pulses determine the time interval during which clock pulses from the time base are counted.

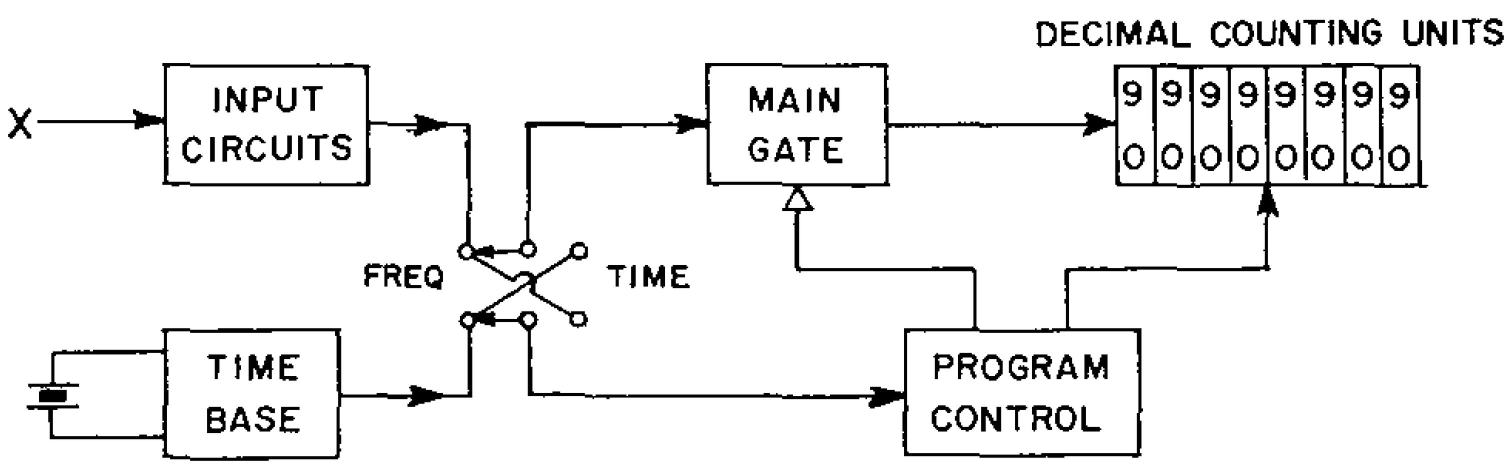


Figure 2-8. Basic block diagram.

The program control opens and closes the main gate to select the proper pulses to be counted, controls the display, and handles the resetting operations.

2.4.2 COUNT. With the MEASUREMENT control in the COUNT position, the instrument will count, or totalize, signals greater than 0.25 volt rms from dc to 10 Mc that are applied at the INPUT connector (15, Figure 2-1). (See block diagram, Figure 2-9.) The count is started and stopped by the COUNT switch (12, Figure 2-1). With the DISPLAY control (4, Figure 2-1) in the INTERMITTENT position, as is usual for this measurement, stopping the count initiates a display interval as determined by the DISPLAY TIME control (5, Figure 2-1). To retain the count, the DISPLAY TIME control should be set to the ∞ position.

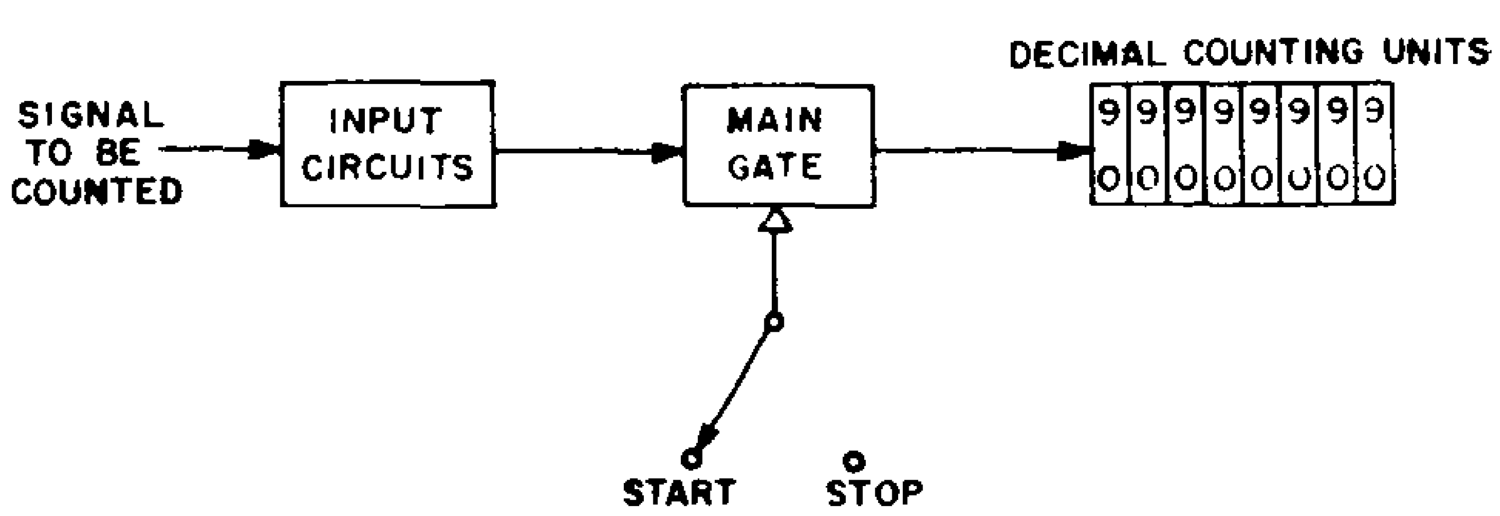


Figure 2-9. Block diagram for COUNT measurements.

2.4.3 FREQUENCY MEASUREMENTS. To measure frequency the MEASUREMENT control is set to the FREQ position. The instrument will then measure the frequency of any input signal greater than 0.25 volt rms from dc to 10 Mc that is applied at the INPUT connector (see block diagram, Figure 2-10). The precision of measurement is determined by the setting of the FREQUENCY control and the accuracy is ±1 count ± the accuracy of the 5-Mc time-base reference source. The counting interval during which the frequency is measured is adjusted from 1 msec to 10 sec in decade steps by the FREQUENCY control

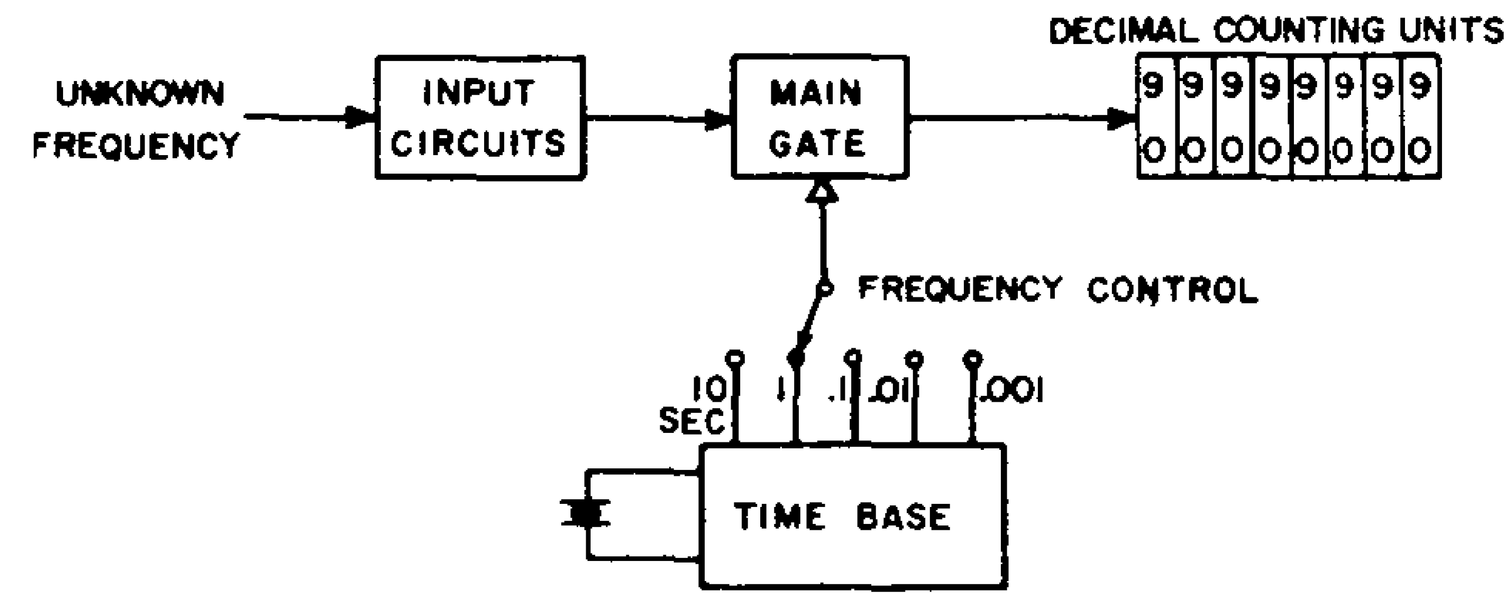


Figure 2-10. Block diagram for FREQUENCY measurements.

to adjust the value of the least significant digit from 1 kc to 0.1 cps. Either display mode may be used.

2.4.4 PERIOD MEASUREMENTS. For frequency measurements below about 1 kc, even the longest counting interval (10 sec) is not sufficient to make use of the inherent accuracy of the instrument. With a large, noise-free signal, increased accuracy can be obtained from a PERIOD or 10 PERIODS measurement. With the MEASUREMENT control in these positions the TIME control is used to adjust the precision of measurement, or the least significant digit, from 0.1 sec to 0.1 μsec. Single periods from 10 μsec to 10^7 sec (dc to 100 kc), and 10 periods from 500 μsec to 10^7 sec (dc to 20 kc) can be measured for input signals greater than 0.1 volt rms. Either display mode may be used (see block diagram, Figure 2-11).

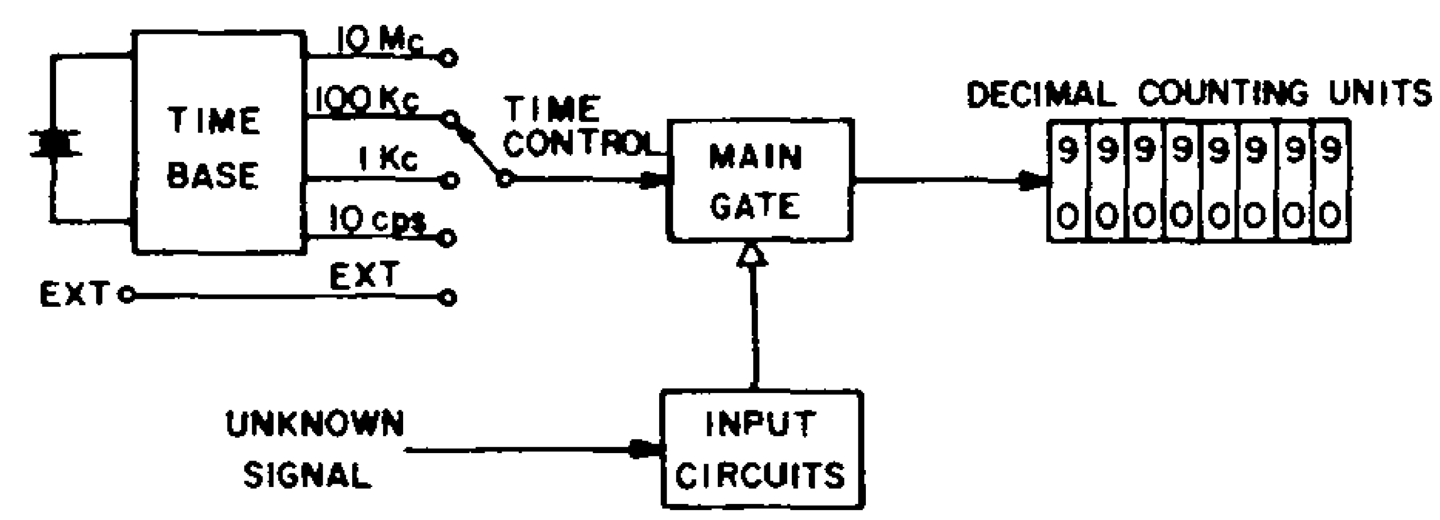


Figure 2-11. Block diagram for PERIOD measurements.

The accuracy of measurement depends on the slope and signal-to-noise ratio of the input signal at the desired triggering level. The measurement accuracy is discussed in detail in Section 2.5.

2.4.5 TIME-INTERVAL MEASUREMENTS.

2.4.5.1 Separate-Channel Time-Interval Measurements. With the MEASUREMENT control in the TIME INTERVAL

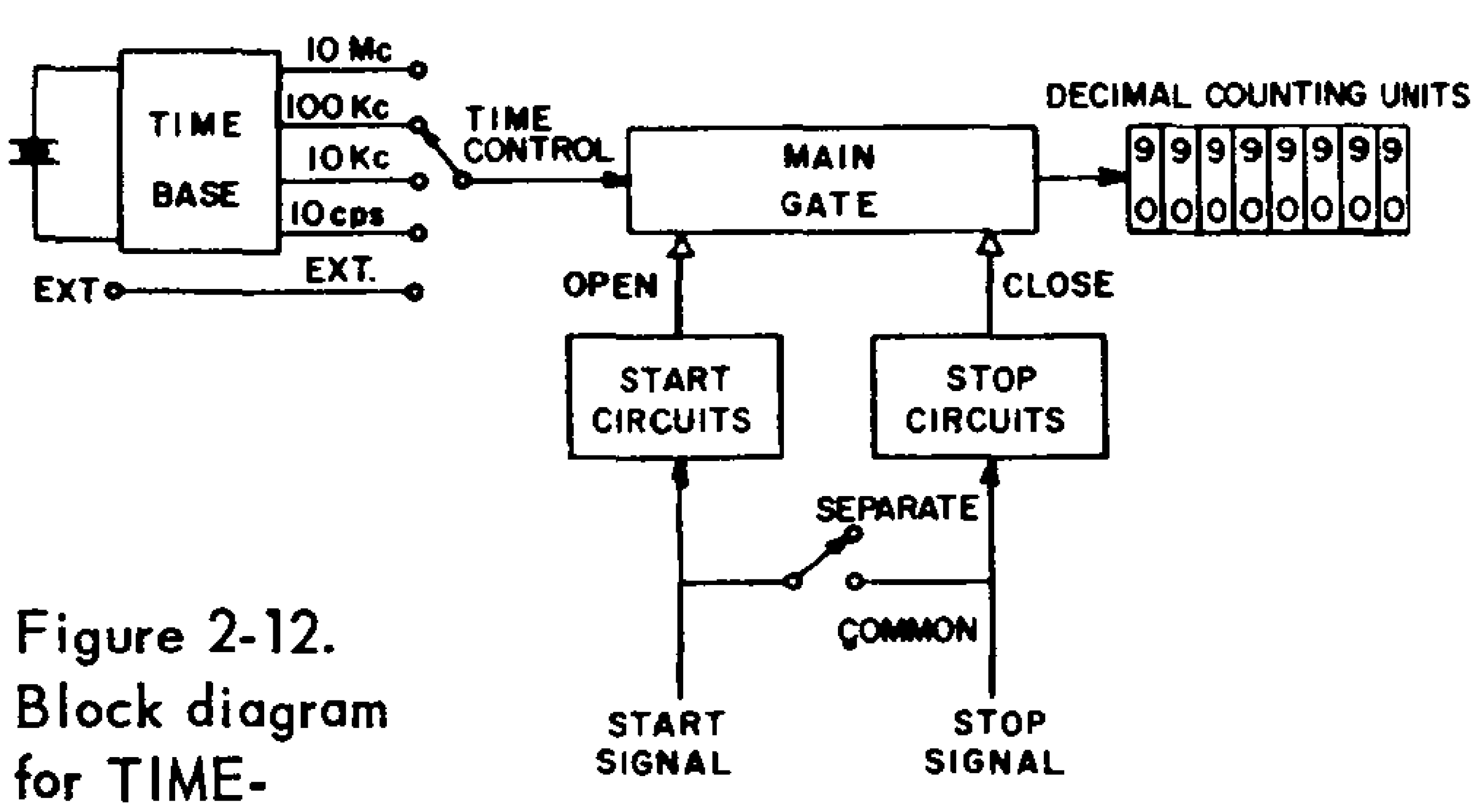


Figure 2-12. Block diagram for TIME-INTERVAL measurements.

position and the COMMON-SEPARATE switch at SEPARATE, the instrument will measure the interval between the trigger-level crossings of signals applied at the START SIGNAL connector (15, Figure 2-1) and at the STOP SIGNAL connector (16, Figure 2-1) (see block diagram Figure 2-12). The precision of measurement can be adjusted by the TIME control from 0.1 μsec to 0.1 sec, or an external frequency can be counted. The measurement range is from 1 μsec to 10^7 sec and the input sensitivity is 0.3 volt peak-to-peak. The measurement accuracy depends on the slope and signal-to-noise ratio of the signals. For input pulses with rise time comparable to one period of the counted frequency, the accuracy is ±1 period of the counted frequency ± the accuracy of the 5-Mc time-base reference source. For other signals, the accuracy is subject to the same considerations as for PERIOD measurement discussed in Section 2.5.

2.4.5.2 Common-Channel Time-Interval Measurements. With the COMMON-SEPARATE switch in the COMMON position the START SIGNAL and STOP SIGNAL connectors are connected internally so that the start and stop trigger pulses can be obtained from different regions of a single input waveform applied at either input connector (see block diagram, Figure 2-12). This type of operation is useful in measuring various characteristics of pulse waveforms such as rise time, duration, etc. Figure 2-13 shows an example of a pulse-duration measurement. With the triggering levels as shown, the interval *A* is measured. If the positive offset of the stop triggering level is reduced, the interval *B* will be measured. If the start SLOPE control is switched to - and the triggering level reduced, the interval $B - A$ can be measured.

2.4.6 SPECIAL MEASUREMENTS.

2.4.6.1 Ratio Measurements. With the MEASUREMENT control in the PERIOD or 10 PERIODS position, the instrument will count a standard frequency determined by the TIME control for an interval determined by the input signal. If the TIME control is set to the EXT position and an external frequency is applied to the EXT connector (17, Figure 2-1), the Type 1130-A will measure the number of cycles of the external frequency that occur during one or 10 periods of the input signal, thus giving the ratio of the two frequencies. The higher frequency is applied at the EXT connector and can be any signal with a frequency between 100 cps and 10 Mc and an amplitude greater than 6 volts rms. The accuracy of the measurement is determined by the same factors that govern period measurement (discussed in Section 2.5) and is limited to ±1 period of the higher frequency.

2.4.6.2 Multiple-Interval Measurement. In measurement of frequencies below about 1 kc, even the longest counting interval (10 sec) is not sufficient to make use of the inherent accuracy of the instrument. With a large, noise-free signal, increased measurement accuracy can be obtained by a period measurement. When such a signal is unavailable, however, the MULTIPLE INTERVAL switch (11, Figure 2-1) can often be used to advantage. If the instrument is measuring frequency for a certain interval, say 10 seconds, and the MULTIPLE INTERVAL switch is thrown, the instrument will continue to count beyond the end of the interval. When the switch is released, the count will stop at the end of the current interval. In this way the counting interval can be extended to 20, 30, 40 seconds and so on, increasing the precision of measurement. The switch is operative for FREQ, PERIOD, and 10 PERIODS measurement and serves as a counting-interval multiplier. The counting interval can be roughly timed by means of a watch or, with an approximate knowledge of the answer, by observation of the accumulating count.

2.4.6.3 Phase-Shift Measurement. If the instrument controls are set for a common channel TIME INTERVAL measurement (paragraph 2.4.5.1) with the start and stop TRIGGER LEVEL controls at zero and the SLOPE controls equal and two sinusoidal signals of the same frequency applied to the START SIGNAL and STOP SIGNAL connectors, the instrument will measure the time between the zero crossings of the signals. From a knowledge of this time interval and the period of the signals, the phase shift can be calculated. The MEASUREMENT control should be set to PERIOD and the phase shift calculated from the relationship:

$$\text{Phase shift in degrees} = \frac{\text{time interval}}{\text{period}} \times 360$$

2.5 ACCURACY.

2.5.1 ONE-COUNT GATING ERROR.

Because the rate of the trigger pulses that are counted by the instrument is not usually synchronous with the rate of the pulses that are opening and closing the main gate, it is possible for a trigger pulse to occur simultaneously with a gating

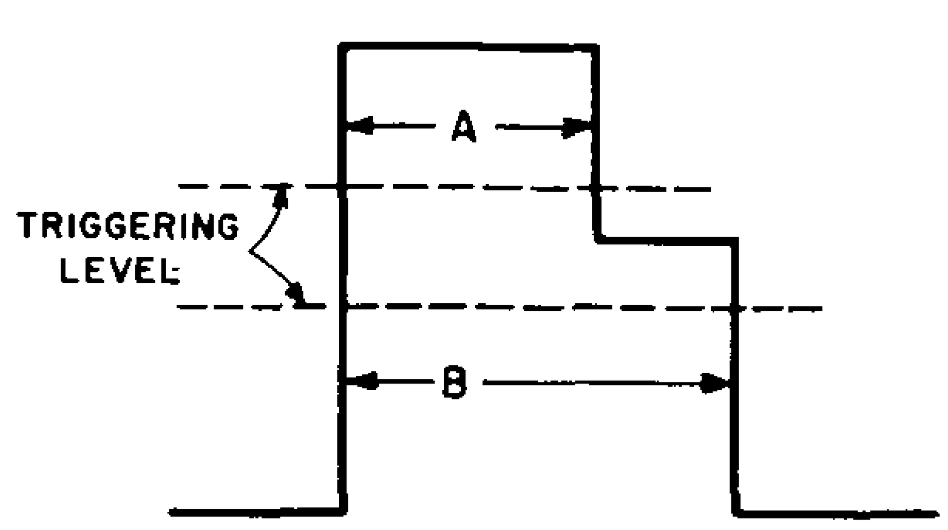


Figure 2-13. Example of pulse-duration measurement.

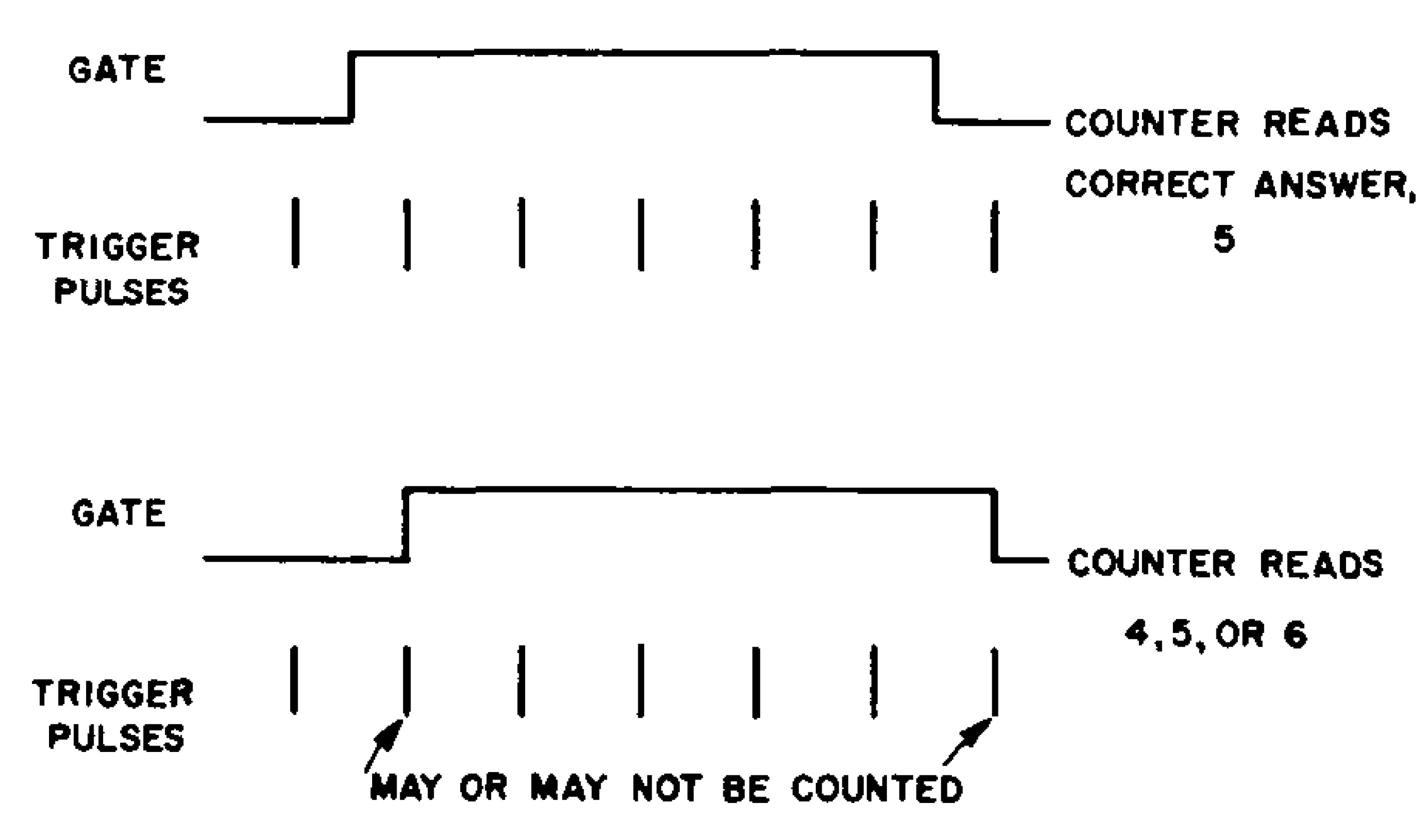


Figure 2-14. One-count gating error.

pulse and not be counted. This leads to the so-called one-count gating error, the possibility that any particular measurement may be in error by one count. Figure 2-14 shows an example of this source of error. The percentage error caused by the gating error versus frequency is plotted in Figure 2-15 for various methods of measurement.

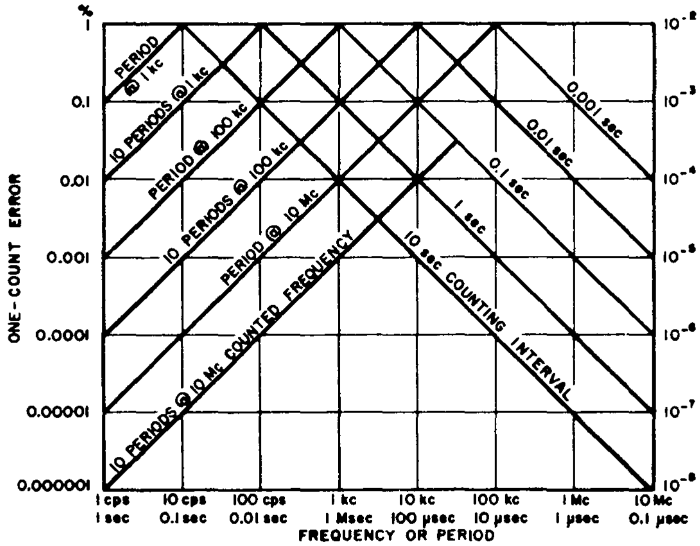


Figure 2-15. One-count error vs frequency.

This one-count gating error applies to a single measurement. In a series of measurements, such as occurs for typical uses of the Type 1130-A Digital Time and Frequency Meter, the answer is rounded off, and the one-count error disappears. For example, if the true value of the last digit is between 4 and 5, say 4.5, the reading will jump back and forth between 4 and 5. By observing the relative rate of occurrence of the two digits, the user can estimate a digit beyond the last one displayed.

2.5.2 TIME-BASE REFERENCE ACCURACY.

An additional source of error is the 5-Mc time-base reference frequency. The reference oscillator frequency of the time-base plug-in units has been adjusted to within a few parts in 10^8 of 5 Mc, but will drift with time and temperature and should be reset occasionally. A standard frequency of 10 Mc can be measured by the instrument with a counting interval of 10 sec and the time-base reference oscillator adjusted for a correct reading. Alternately, the oscillator can be adjusted to a standard frequency by Lissajou-pattern techniques or heterodyned in a radio receiver against WWV and adjusted for zero beat.

2.5.3 ERRORS IN FREQUENCY MEASUREMENT.

2.5.3.1 Amplitude-Modulation Errors. If the unknown frequency signal is amplitude-modulated, measurement errors may occur if the TRIGGER LEVEL control is offset from 0 as shown in Figure 2-16. With the control at 0, the correct frequency will be measured as long as the

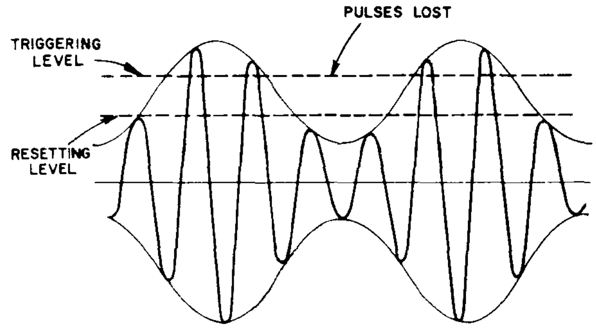


Figure 2-16. A-m error with trigger level offset.

minimum value of the signal is greater than that necessary to drive the Type 1130-A.

2.5.3.2 Frequency-Modulation Errors. The Digital Time and Frequency Meter measures the average value of an unknown frequency during the chosen counting interval, provided the frequency remains within the resolution capability of the instrument. If the unknown frequency exceeds about 11.5 Mc, counts will be missed and the measurement will be in error.

2.5.3.3 Spurious Signals and Noise. If the desired signal is accompanied by noise sufficient to cause extra transitions of the hysteresis region, false counts will be registered. This error may be combated by adjustment of the TRIGGER LEVEL control to the region of steepest slope or by attenuation of both signal and noise (refer to paragraph 2.3.3).

Occasionally it is necessary to measure the frequency of a signal in the presence of another signal of nearly equal amplitude. A capture effect exists in the Type 1130-A, similar to that encountered in frequency-modulation receivers. If the two signals are nearly equal in frequency, the instrument will measure the signal with larger amplitude if its peak-to-peak amplitude exceeds that of the other signal by the hysteresis voltage of the Type 1130-A. If the signals differ in frequency, the following relationships apply:

Type 1130-A measures higher frequency if $V_h > V_\ell + \Delta$

Type 1130-A measures lower frequency if $V_h < \frac{f_\ell}{f_h} V_\ell + K\Delta$

where V_h = peak-to-peak amplitude of higher frequency signal

V_ℓ = peak-to-peak amplitude of lower frequency signal

f_h = higher frequency

f_ℓ = lower frequency

Δ = hysteresis voltage of counter

K = a factor varying between 1 and 2

If neither condition is satisfied, the instrument will give erroneous readings. The above conditions are illustrated in Figure 2-17.

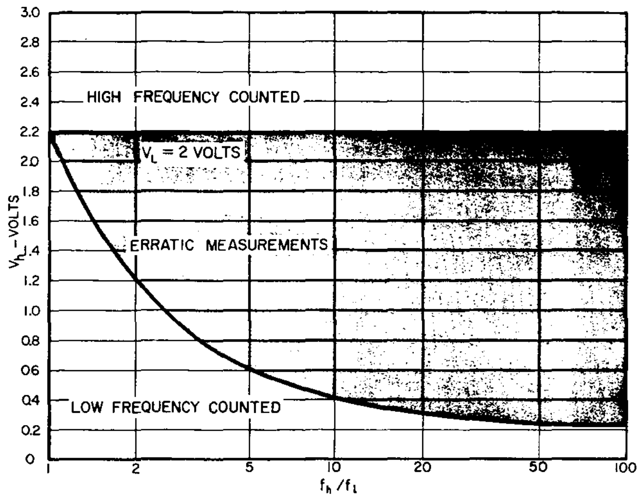


Figure 2-17. Conditions for measuring a signal in the presence of another signal of nearly equal amplitude.

2.5.4 ERRORS IN TIME MEASUREMENT.

2.5.4.1 Errors in Period Measurement. During time measurements trigger pulses generated from the input signal open and close the main gate and control the flow of time-base pulses into the decade counters. The accuracy of such a measurement depends on the time accuracy with which the triggering-level crossing of the signal can be determined. Errors in this determination may occur for several reasons: the triggering-level crossing of the signal may vary because of drift, hum pickup, noise, etc, or the triggering level itself may vary for similar reasons. Figure 2-18 illustrates the effect of uncertainty in either signal or triggering level. These uncertainties are additive and can be combined into a single "noise" voltage. For the case of sine waves triggering at zero crossings, the following relationship applies:

$$\text{Max error in \%} = \pm\frac{1}{\pi}\frac{V_n}{V_s} \times 100$$

where V_n = peak noise voltage
V_s = peak signal voltage

Stated in other terms, the fractional error caused by noise is about one third the noise-to-signal ratio. For example, a noise voltage of 3% can produce an error of about 1%.

The effective noise includes noise present in the signal and internal noise generated by the instrument. The internally generated noise depends on the impedance of the signal source and the positions of the controls. For example, measuring the period of a clean signal of 1-volt rms amplitude from a 600-ohm source will yield an accuracy of better than 0.1% (typically, .05%, leading to an effective internal noise of about 2 mv). A 10 PERIODS measurement is at least 10 times more accurate since the time error is compared with a time interval 10 times as long. A 10 PERIODS measurement of a 1-volt signal from a 600-ohm source yields an accuracy of better than .01% (typically .002%).

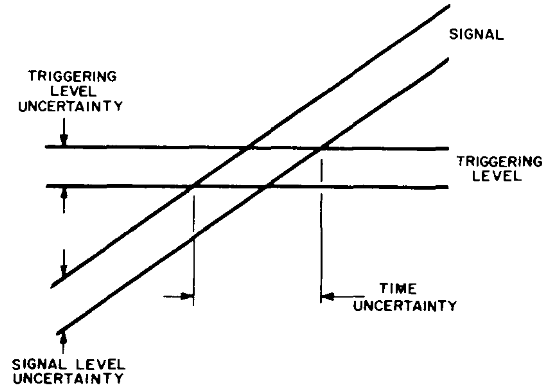


Figure 2-18. Effects of uncertainty in signal or triggering level for period measurement.

The above remarks apply to noise of a random nature. If the noise is periodic, the measurement will display a cyclic variation and it is possible to estimate the mean value of the measurement with greater accuracy than indicated by the signal-to-noise ratio.

2.5.4.2 Errors in Time-Interval Measurements. The sources of error described above apply also to time-interval measurements. Time errors caused by noise on the start and stop signals or triggering levels can be expressed as follows:

$$\Delta T = \pm\frac{1}{\pi}\frac{V_n}{V_s}\frac{1}{f}$$

where ΔT = time error
V_n = peak noise voltage
V_s = peak signal voltage
f = frequency of signal

For nonsinusoidal signals, the corresponding expression is:

$$\Delta T = \pm\frac{V_n}{s}$$

where V_n = peak noise voltage
s = slope of signal in volts/second

As the slope of the signal increases, the time error caused by noise decreases, so that, for brief pulses or voltage steps with rise time comparable to one period of the counted frequency, the measurement error is reduced to ±1 period of the counted frequency ± the error of the time-base reference.

2.6 AUXILIARY CONNECTORS.

2.6.1 EXT JACK. The EXT jack (17, Figure 2-1) is used to couple signals to the Type 1130-A Digital Time and Frequency Meter. With the MEASUREMENT control in the CHECK or FREQ position pulses will appear at the EXT jack with a repetition period 1/10 the counting interval indicated by the FREQUENCY control. For example, if the FREQUENCY control is set for a counting interval of 1 second, the pulses will occur 0.1 second apart. With the MEASUREMENT control in the PERIOD, 10 PERIODS, or TIME INTERVAL position, the pulse repetition rate will be as selected by the TIME control. These pulses are useful as time-marker signals for calibrating oscilloscopes, etc.

If the TIME control is set to EXT during a time measurement, the EXT jack becomes an input connector for external counted frequencies.

2.6.2 GATE OUT JACK. The GATE OUT jack (18, Figure 2-1) provides a positive pulse coincident with the opening of the main gate, with a duration equal to the open time of the main gate. During time measurements this waveform can be superimposed on the input-signal waveform by means of a dual-channel oscilloscope and used for precise adjustment of the TRIGGER LEVEL controls.

2.6.3 SYNC OUT JACK. The SYNC OUT jack (19, Figure 2-1) provides a positive pulse at the end of the measurement cycle when the instrument is ready to make a new measurement. This signal can be used to drive external pulse generators, delay generators, etc for calibration purposes.

2.6.4 REAR EXTERNAL ACCESSORY SOCKETS.

2.6.4.1 S0703. S0703 is the large 40-contact socket in the upper right-hand corner of the instrument. A schematic diagram of the socket is shown in Figure 2-19. The first 32 contacts are connected through series resistors to the plates of the flip-flops of the eight decimal counting units. Each group of four contacts provides a four-line binary-coded decimal digit according to the 1-2-4-2 coding of the decades, described in Section 3.2. The "0" state of a flip-flop corresponds to a voltage of +185 volts and the "1" state to a voltage of +65 volts. The minimum allowable external load impedance for these contacts is 1.8 megohms. This connector is used with the Type 1132-A Data Printer for digital printing and the Type 1134-A Digital-to-Analog Converter for graphic recording. Contact 39 provides the print-command pulse for the Type 1132-A.

For remote resetting of the Type 1130-A, the link connecting contacts 38 and 40 can be removed and an external, normally closed switch connected between these two contacts. A momentary opening of this switch will reset the instrument.

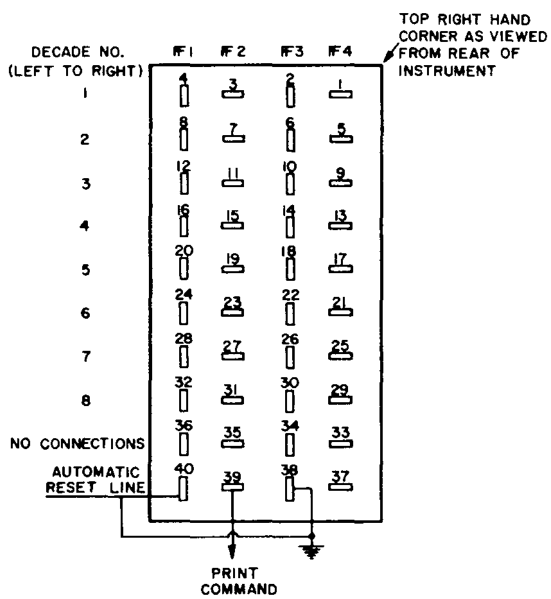


Figure 2-19. Schematic of 40-contact S0703 socket.

2.6.4.2 S0704. S0704 is the small six-contact socket located below S0703. A schematic diagram of the socket is shown in Figure 2-20. The carry output pulse of the last decade is provided at contact 2 for driving other counters to increase the register capacity of the Type 1130-A. One terminal of the MULTIPLE INTERVAL switch is connected to contact 5. An external, normally open switch with one terminal connected to contact 5 and the other terminal connected through an 18-kilohm resistor to ground (contact 3) will function as a remote MULTIPLE INTERVAL switch. The carry output pulse of the program-control decade (see Section 3.5) and the main reset pulse are connected to contacts 1 and 4, respectively, for use with external multiple-interval equipment.

The S0704 connector is used with the Type 1130-P6 Counting Interval Multiplier for automatic multiple-interval measurements.

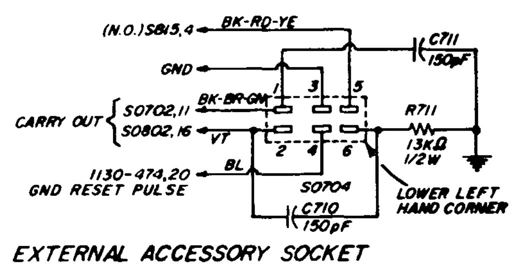


Figure 2-20. Schematic of 6-contact S0704 socket.

Section 3

PRINCIPLES OF OPERATION

3.1 GENERAL.

The simplified block diagram of Figure 3-1 shows the five basic circuit blocks of the Type 1130-A Digital Time and Frequency Meter: input circuits, time base, main gate, program control, and decimal counting units. The input circuits generate trigger pulses from the input signal. For frequency measurement these trigger pulses are counted for a time interval derived from the time base; for time measurement (PERIOD, 10 PERIODS, or TIME INTERVAL), the trigger pulses determine the time interval during which clock pulses from the time base are counted.

The program control opens and closes the main gate to select the proper pulses to be counted, controls the display, and handles the resetting operations.

The five basic circuit functions described above are performed by circuits on the etched boards listed in Table IV.

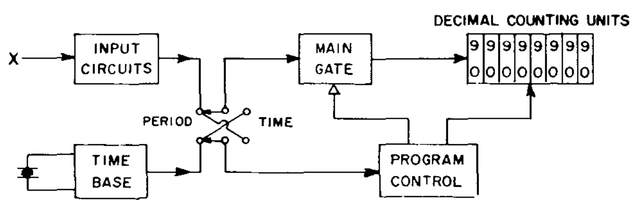


Figure 3-1. Simplified block diagram.

TABLE 4. ETCHED BOARDS.

Function	Etched Board
Input Circuits Main Gate	Type 1130-472 Input/Main-Gate Unit
Time Base	Type 1130-473 Time-Base Unit
Counting Decades	Type 1130-470 10-Mc Decade Type 1130-471 10-Mc Display Unit Type 1131-P3 1-Mc Decimal Counting Unit Type 1131-P2 100-kc Decimal Counting Unit Type 1131-P1 30-kc Decimal Counting Unit Type 1131-P4 Decimal Counting/Storage Unit
Program Control	Type 1130-474 Program-Control Unit Type 1131-P5 Transfer Unit Type 1131-P1 30-kc Decimal Counting Unit Type 1130-472 Input/Main-Gate Unit
Power Supply	Type 1130-477 Power-Supply Unit

3.2 DECIMAL COUNTING UNITS.

3.2.1 LOW-SPEED DECADES. The decimal counting units, or decades, of the Type 1130-A Digital Time and Frequency Meter are composed of bistable multivibrator circuits or "flip-flops".[1] A typical flip-flop circuit is shown in the simplified schematic diagram of Figure 3-2. If one tube of the pair is cut off, its high plate voltage is coupled to the grid of the other tube and serves to hold it on. Similarly, the low plate voltage of the on tube is coupled to the grid of the first tube and serves to hold it off. The circuit has two stable states, one tube on and the other off, and vice versa (zero state and one state). A negative pulse applied to the input terminal causes the circuit to be complemented (i.e., to reverse its state). An output pulse will be produced for every other input pulse and the circuit functions as a scale-of-two counter.

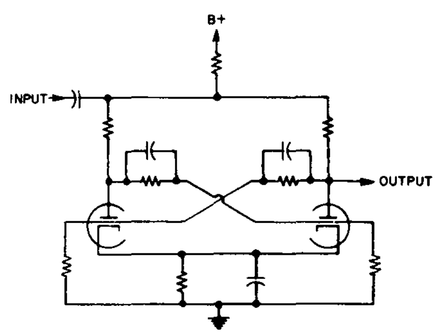


Figure 3-2. Typical flip-flop circuit.

If four flip-flops are connected in cascade so that the output of one circuit is connected to the input of the following circuit, a scale-of-16 counter is formed as shown in Figure 3-3.[2]

To obtain a decimal counting unit, six of the 16 states are eliminated by feedback pulses as shown in Figure 3-4. This feedback system results in a 1-2-4-2 coding, so-called since weighting the binary states of the flip-flops in this sequence will convert from the binary number to the corresponding decimal number. For example, the binary number 0110 corresponds to 0 +2 +4 +0 (6) in the decimal system.

[1] Jacob Millman and Herbert Taub, "Pulse and Digital Circuits," McGraw-Hill Book Co, Inc, New York, New York, (1956), page 140.

[2] Ibid, page 323.

FLIP-FLOP ELEMENTS

PULSES TO BE COUNTED → 1st 2nd 3rd 4th

DECIMAL NUMBER	STATES			
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1
11	1	1	0	1
12	0	0	1	1
13	1	0	1	1
14	0	1	1	1
15	1	1	1	1
16 = 0	0	0	0	0

Figure 3-3. Scale-of-16 counter.

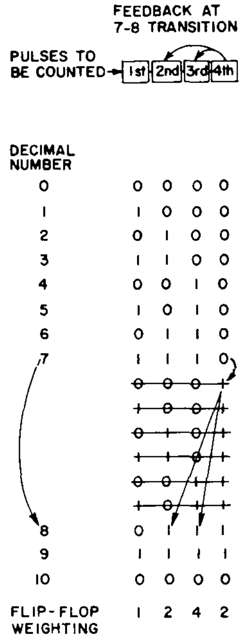


Figure 3-4. Scale-of-10 counter.

To indicate the state of a decade, the plate voltages of the flip-flops are combined to light neon lamps as shown in Figure 3-5. The circles within the blocks representing the flip-flops are the two tubes of the circuit. The shaded circles represent on tubes. The state of the first flip-flop determines whether an odd or an even lamp will be lit and the state combinations shown shaded in the table determine which lamp will be lit. The inhibit lamp lights for the counts of 8 and 9 and prevents the lighting of the 6 and 7 lamps.

3.2.2 COMBINATION COUNTING AND STORAGE DECADES. The four Type 1131-P4 Decimal Counting/Storage Units can function as normal counting decades for input frequencies in excess of 20 kc or can store binary data transferred from another decade as shown in Figure 3-6. If a flip-flop of the counting decade is in the zero state, the voltage at the upper terminal of the transfer neon lamp (V9 through V12) is +100 volts and the transfer-command voltage at the other terminal of the lamp, a negative voltage step from a level of +150 volts to a level of +50 volts, will not ionize the lamp. If the flip-flop is in the one state, however, the voltage at the upper terminal of the lamp is +200 volts and the transfer-command pulse will ionize the lamp and set the corresponding flip-flop of the storage unit to the one state. The ionizing of the transfer lamps provides the pulse to transfer the flip-flop state so that very high-valued isolating resistors can be used. Since the neon lamps have very small capacitance, the counting and storage units operate independently and no complex switching is required.

3.2.3 THE 10-MC DECADE. The cascaded time delays involved in the transition from 7 to 8 in the feedback system described above limit its use to input-pulse repetition rates up to about 1 Mc. For operation at faster rates the Type 1130-470 10-Mc decade uses a gating scheme shown in the block diagram of Figure 3-7. In this system the fourth flip-flop is a simple set-reset circuit, which controls a gate directing the carry pulses from the first flip-flop to the second. The count proceeds from 0 to 9 in normal scale-of-16 fashion. The transition from 1 to 0 in the third flip-flop at the eighth count sets the fourth flip-flop to the one state, closing the gate. The output pulse of the first flip-flop at the count of 10 is therefore prevented from triggering the second flip-flop, and instead resets the fourth flip-flop to zero, leaving all flip-flops in the zero state and reopening the gate.

In this system, only the first flip-flop operates at the high-input rate. Current-source coupling is used in this circuit to achieve maximum speed.

The decade system described results in a 1-2-4-8 code. This coding is converted to the 1-2-4-2 sequence of the lower-speed decades in a four-tube readout unit separate from the 10-Mc counting decade, the Type 1130-471 10-Mc display unit.

3.3 TIME BASE.

3.3.1 TIME-BASE DIVIDERS. The time-base unit consists of a 5-Mc amplifier (V501), a 10-Mc multiplier (V502), a 5-Mc limiter (V503), and a chain of multivibrator divider circuits[3] (see block diagram, Figure 3-8).

[3] Jacob Millman and Herbert Taub, "Pulse and Digital Circuits," McGraw-Hill Book Co, Inc, New York, New York, (1956), page 360.

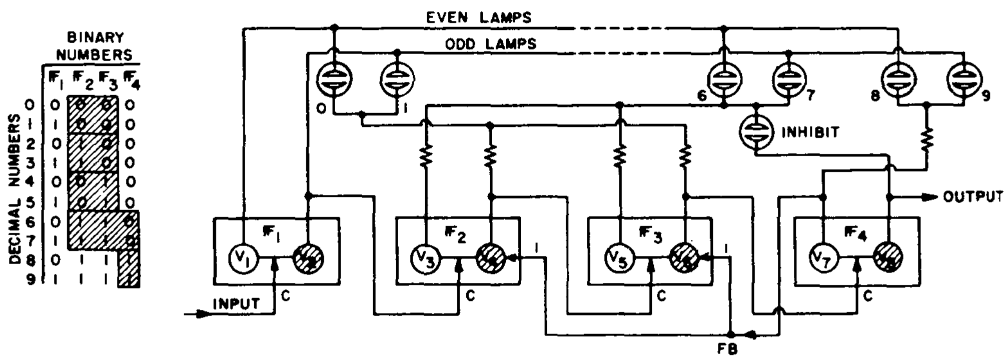


Figure 3-5. Neon-lamp Indicators.

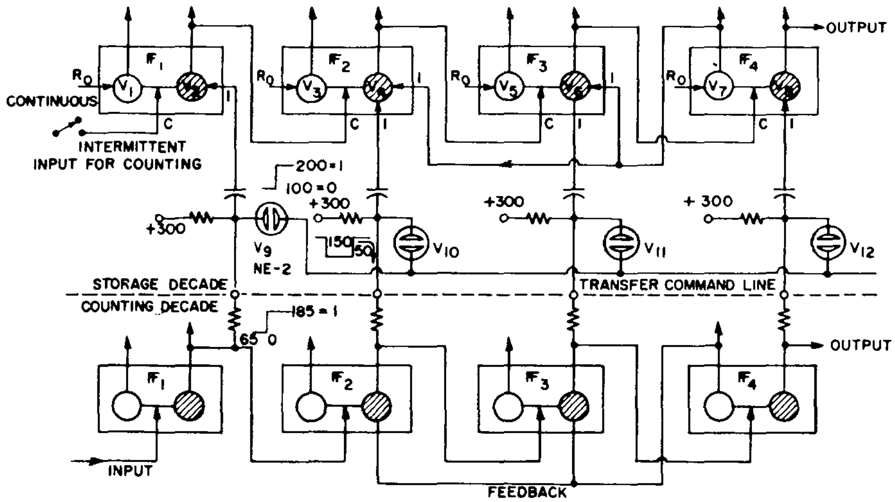
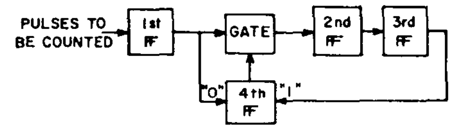


Figure 3-6. Counting/Storage decades.



FLIP-FLOP STATES

DECIMAL NUMBER	1st	2nd	3rd	4th
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	0	0	0

Figure 3-7.
10-Mc decade block diagram.

A typical multivibrator circuit and its associated waveforms are shown in Figure 3-9. The multivibrator is a relaxation oscillator with a free-running frequency about 10% lower than the desired output frequency. Synchronizing pulses from the preceding circuit are applied to the two grids to cause the oscillation cycle to end before it normally would, and thereby lock the frequency of the multivibrator at a submultiple of the synchronizing frequency. In the example shown, the grid voltages are driven positive at every fifth input pulse so that the circuit operates at a frequency one-tenth that of the input signal. In this manner, the multivibrator operates as a "count down" or frequency-divider circuit.

The multipliers with output frequencies below 1 Mc are of the "hard-bottomed" type[4] in which high-valued plate resistors minimize the effects of tube-characteristic variations. Because of the exceptional stability of these circuits, no periodic adjustments are required.

[4] R. W. Frank and F. D. Lewis, "The Type 1213-D Unit Time/Frequency Calibrator," *General Radio Experimenter*, Vol 31, No. 1, June, 1956.

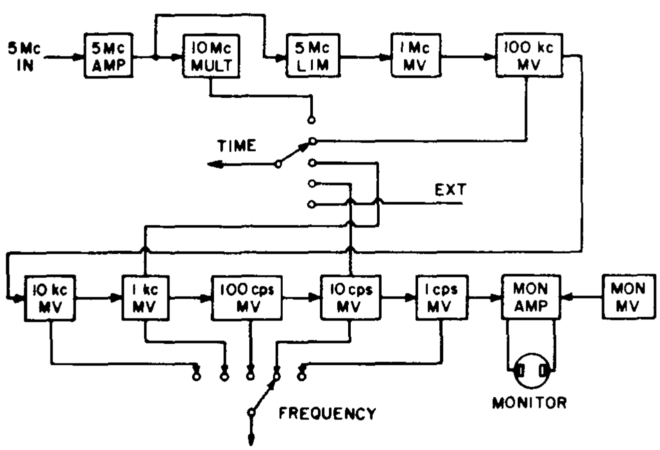


Figure 3-8. Time-base block diagram.

The 5-Mc to 1-Mc multivibrator has grid clamp diodes and a high-valued cathode resistor to ensure stable operation. Potentiometers (R513 and R512) allow factory adjustment of the free-running frequency and the duty ratio of the circuit.

3.3.2 TIME-BASE MONITOR. The 1-Mc multivibrator circuit has been adjusted so that the divider chain will operate at a frequency error of about 5% in the absence of the 5-Mc time-base reference signal. Similarly, if a failure should occur anywhere in the time base, the 1-cps multivibrator, the last divider in the chain, will be in error. Such an error, of course, will become obvious if the counter is set for CHECK operation. In addition to this, however, a monitor circuit has been provided to indicate any irregularity in the time base. The 0.5-second half period of the 1-cps divider is continuously compared with a 0.5-second interval, which is independently generated by a free-running multivibrator of design similar to the divider circuits. If the 0.5-second intervals differ by

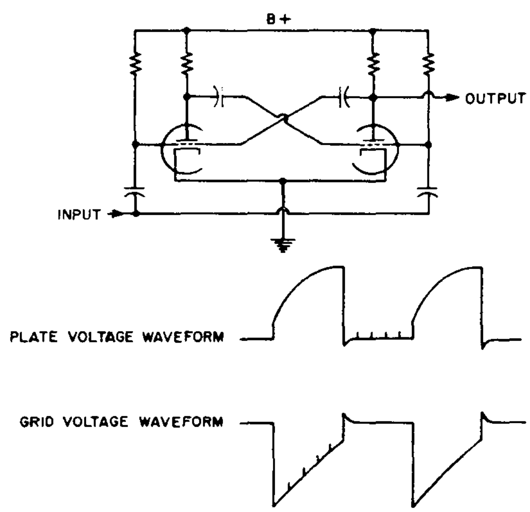


Figure 3-9. Typical multivibrator circuit.

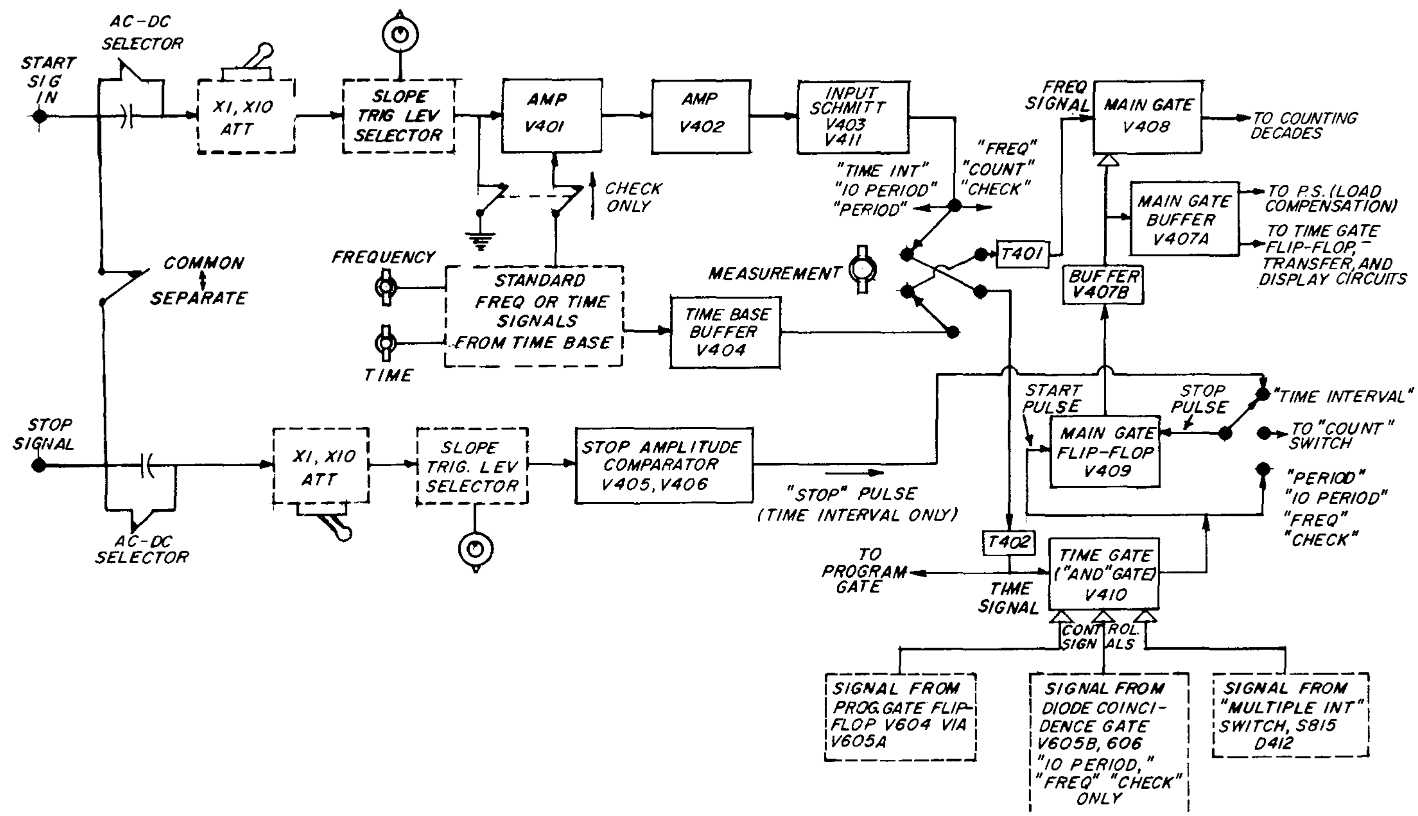


Figure 3-10. Input/Main Gate block diagram.

more than 1%, a panel light flashes to warn the operator. Thus the time base is continuously monitored even when the counter is making measurements.

The frequency of the monitor multivibrator may drift with time so that the MONITOR lamp will flash with no error in the time base. If the instrument checks correctly with the counting interval set by the FREQUENCY control at 10 sec and the counted frequency set by the TIME control at 10 Mc, the time base is correct and the potentiometer immediately below the MONITOR lamp should be adjusted to stop the flashing of the lamp.

3.4 INPUT CIRCUITS AND MAIN GATE.

Figure 3-10 is a block diagram of the circuits contained on the Type 1130-472 Input/Main-Gate Unit. The blocks enclosed by dashes indicate circuits on other etched boards.

The input (or start) signal, after passing through the ATTENUATION switch and SLOPE control, is amplified and limited in V401 and V402. A trigger pulse is generated from the amplified input signal by the Input Schmitt[5] Circuit, V403 and V411. For CHECK, COUNT, and FREQUENCY measurements the trigger pulses are applied through T401 to the main-gate circuit, V408, whose output drives the decimal counting units. The main gate is opened and closed by a control signal amplified by the buffer, V407B, from the main-gate flip-flop, V409, which is in turn controlled by signals from V410, the time gate. The time gate is driven by time-base trigger pulses generated by the time-base buffer, V404, through T402. When the time gate is opened by the various control signals from the program control, the time-base trigger pulses complement the main-gate flip-flop, causing the main gate to open and close.

For PERIOD and 10 PERIODS measurements, the input trigger pulses are applied through T402 to the time gate and control the main-gate flip-flop and main gate. The time-base trigger pulses from the time-base buffer are applied through T401 to the input of the main gate.

For TIME INTERVAL measurements, the input trigger pulses from the time gate set the main-gate flip-flop to open the main gate. The main-gate flip-flop is set to close the main gate by stop pulses generated from the stop signal by the stop-amplitude comparator, V405 and V406.

The main-gate flip-flop output is amplified by V407A, the main-gate buffer, and applied to the power-supply unit and the program control.

[5] O. H. Schmitt, "A Thermionic Trigger," *Journal of Scientific Instruments,* Vol 15, pages 24-26, January, 1938.

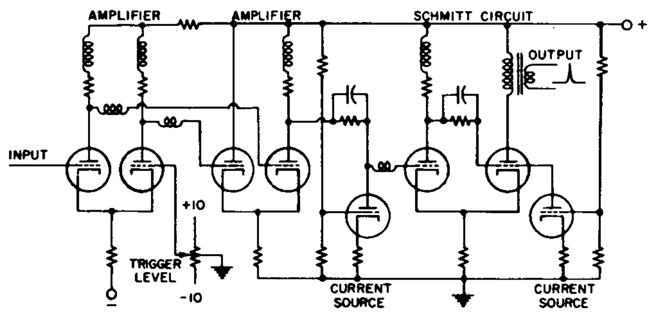


Figure 3-11. Simplified schematic.

A simplified schematic diagram of the input circuits is shown in Figure 3-11. The two triode sections of the first tube are connected as a push-pull difference-amplifier or "long-tailed pair."[6] The input signal is applied to one grid of the pair. A variable reference voltage, determined by the trigger-level control, is applied to the other grid. This reference voltage determines the point on the input-signal waveform at which a trigger pulse is generated by the input circuits. For frequency measurement of clean, sinusoidal signals, it is desirable to generate trigger pulses at the zero-crossings of the input signals to obtain maximum sensitivity. However, for frequency measurements of pulse waveforms in the presence of noise that causes multiple zero-crossings, and for period and time-interval measurements and the counting of random events, the triggering level should be set at the cleanest or most significant portion of the input waveform. The triggering-level control is a potentiometer with a grounded center-tap covering a broad region of rotation, allowing a quick, noncritical return to ground potential. The range of the reference voltage is ±10 volts, which, in conjunction with the 10:1 input attenuator, provides an effective input-triggering range of ±100 volts.

By interchanging the grid connections of the input signal and reference voltage, the slope control (not shown in Figure 3-11) determines whether a trigger pulse is generated at a positive-going or a negative-going crossing of the triggering level. The slope control can also connect a capacitor in series with the input signal to block any dc that may be present.

The first amplifier circuit also serves as a stable limiter, since the plate-voltage limits are determined by the plate-supply voltage and the plate and cathode resistors, and are essentially independent of tube characteristics. Because of the balanced nature of the circuit, operation is also essentially independent of plate-supply or filament-voltage variations. Another attribute of this circuit is its very high dynamic range, which permits measurement of signals with large amounts of amplitude modulation or lower-frequency noise – since the circuit will not be clamped by the noise or modulation peaks, but will continue to operate at true reference-level crossings.

The output of the first amplifier stage is directly coupled to the second. Both shunt and series-peaking inductors are used to obtain maximum bandwidth. The second stage of amplification is similar to the first except that the push-pull input is converted to a single-ended output. In this connection the circuit is usually referred to as a cathode-coupled clipper.[7]

The output of the second amplifier stage is directly coupled to the following circuit without attenuation by means of a triode connected as a current source.[8,9] Because of the large cathode resistor, the triode draws a constant current through the resistor connected to its plate. With a constant current in the resistor, and therefore a constant voltage across it, any variation in voltage at one terminal of the resistor is transmitted undiminished to the other terminal, but at a different dc level.

The pulse-generating circuit itself is based on the familiar Schmitt circuit[5] with another current-source-connected triode used to couple the left-hand plate to the right-hand grid. Shunt peaking alone is used in this circuit since series peaking would introduce a time delay and decrease the maximum repetition rate of the circuit. The output pulse is generated by a small toroidal transformer, wound on a ferrite core, which is connected to the right-hand plate of the Schmitt circuit.

The sensitivity (minimum voltage necessary to produce output pulses) of the circuits described is about 100 mv rms from dc to 3 Mc, rising to 250 mv rms at 10 Mc.

3.5 PROGRAM CONTROL.

3.5.1 OVER-ALL PROGRAM. The program of the Type 1130-A is controlled by circuits on the Type 1130-472 Input/Main-Gate Unit, the Type 1130-474 Program-Control Unit, the Type 1131-P1 Program-Control Decade, and the Type 1131-P5 Transfer Unit. The block diagram of Figure 3-12 and the timing diagram of Figure 3-13 illustrate the over-all operation of the program.

Assume that the sequence begins with a reset pulse from the reset generator. The reset pulse sets all the decimal counting units and the program-control decade to zero and sets the main gate flip-flop and the program gate flip-flop to zero, closing the main gate, the program

[6] G. E. Valley and H. Wallman, "Vacuum-Tube Amplifier," Radiation Laboratory Series, No. 18, McGraw-Hill Book Company, New York, New York, (1948), page 441.

[7] Jacob Millman and Herbert Taub, "Pulse and Digital Circuits," McGraw-Hill Book Co, Inc, New York, New York, 1956.

[8] Patent Pending.

[9] R. W. Frank, "An Improved Pulse Generator with 15-nsec Rise Time," *General Radio Experimenter*, Vol 33, No. 2, February, 1959.

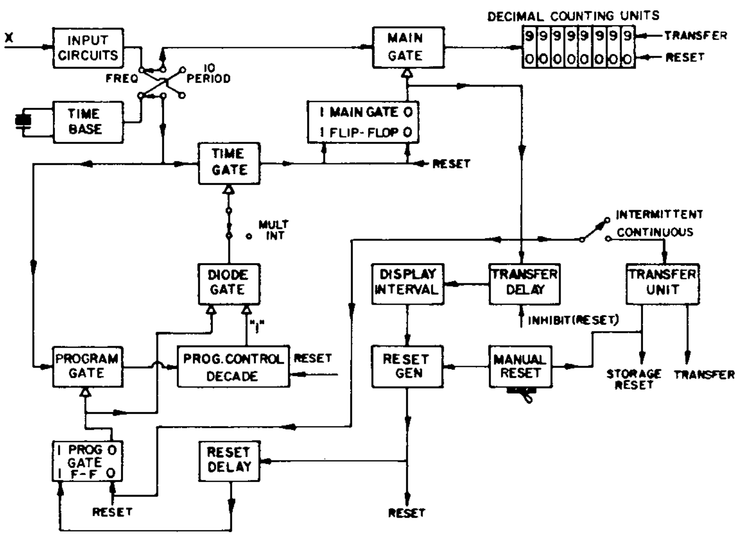


Figure 3-12. Program block diagram.

gate, the diode gate, and the time gate. Since the time gate is closed, time signals from the time base cannot activate the main-gate flip-flop and the trigger pulses from the input circuits cannot enter the decimal counting units.

The reset pulse also triggers the reset-delay generator, which produces a pulse 400 μsec later and sets the program-gate flip-flop to the "1" state, opening the program gate and partially completing the diode gate. The time gate is still closed, but pulses from the time base can pass to the program-control decade. The first time-base pulse advances the state of the decade to "1", which completes the diode gate and causes the time gate to open. The next time-base pulse, the second, passes through the time gate and complements the main-gate flip-flop to "1", which opens the main gate and allows pulses from the input circuits to enter the decimal counting units. The second time-base pulse also advances the state of the program-control decade to "2", which disables the diode gates and closes the time gate so that the following time-base pulses cannot close the main gate. The main gate remains open while the time-base pulses continue to advance the state of the program-control decade. When the decade reaches "1" again, the diode gate is again enabled and the time gate is opened, allowing the next time-base pulse, the eleventh, to pass through and complement the main-gate flip-flop to "0", closing the main gate. Pulses from the input circuit have been allowed to pass through the main gate into the decimal counting units for exactly 10 time-base pulse intervals.

The closing of the main gate at the end of the measurement interval sets the program-gate flip-flop to "0" and locks out the program gate, diode gate, and time gate so that the decimal counting units can display their accumulated count. If the intermittent display mode is used, the main gate closing also triggers the display-interval generator. At the end of the desired 0.1- to 10-second display time the reset generator is triggered, producing a reset pulse which begins the cycle again.

If the continuous display mode is used, the display interval is disabled and the main gate closing triggers the transfer unit. This unit causes the count accumulated in the four counting decades to be transferred to the four storage decades. After a brief, 1-msec delay, generated by the transfer delay, the reset generator is triggered and the cycle begins again. The measurement cycle can be stopped and started again at any point by the manual reset which is controlled by the front-panel reset switch.

For 10-period measurements, the roles of the input circuits and time base are reversed so that the main gate remains open for 10 input intervals while time-base pulses are registered in the decimal counting units.

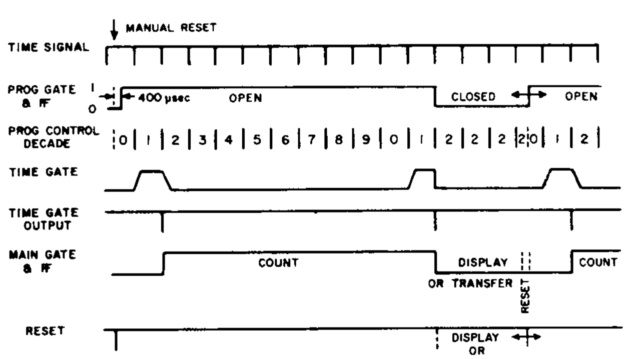


Figure 3-13. Program Timing diagram.

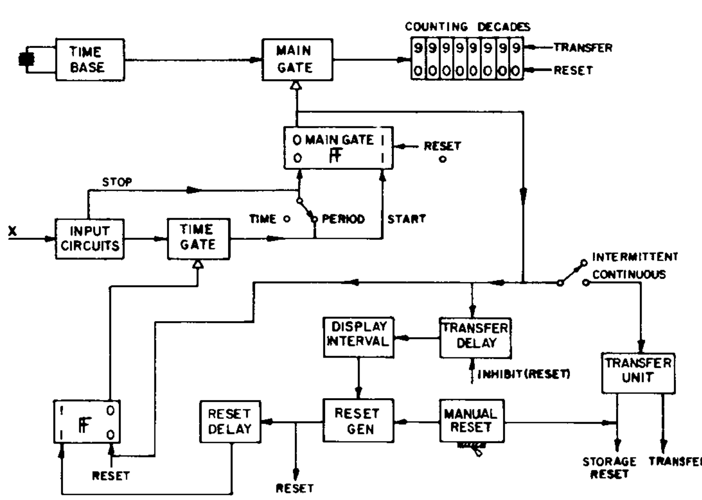


Figure 3-14. Single Period Program block diagram.

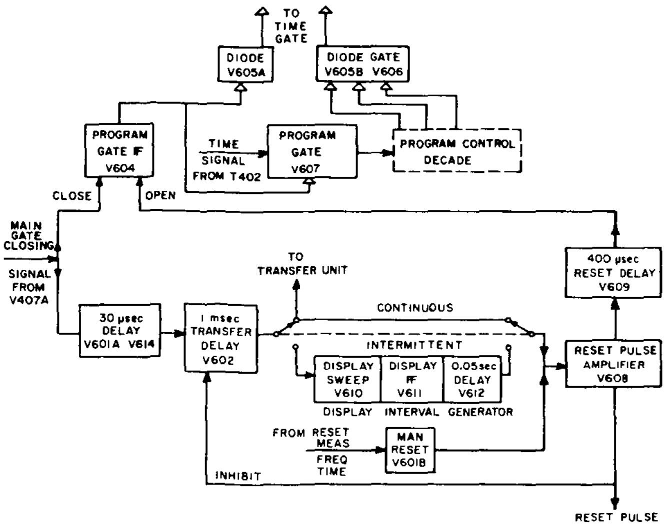


Figure 3-15. Program-Control Unit block diagram.

The use of the program-control decade in the system provides three advantages:

1. To obtain a 10-second measurement interval, the lowest speed time-base divider operates at 1 cps rather than 0.1 cps.
2. Ten-period measurements are easily made.
3. The dead time between measurements is decreased to two-tenths of a measurement interval.

For single-period and time-interval measurements, the program gate, program-control decade, and diode gate are removed from the system, and the time gate operates under the direct control of the program-gate flip-flop or the input circuits, as shown in Figure 3-14.

Figure 3-15 is a detailed block diagram of the Type 1130-474 Program Control Unit.

3.5.2 DISPLAY PROGRAM. The block diagram of Figure 3-16 shows the interconnections of the eight decimal

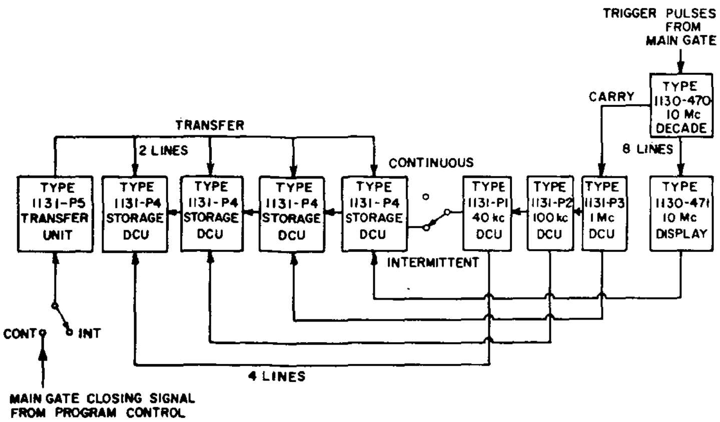


Figure 3-16. Display Program block diagram.

counting units. The four units at the right function only as counting decades. Note that the 10-Mc unit, at the far right, is a display unit only. The 10-Mc counting decade, discussed in paragraph 3.2.3, is one of the four main circuit boards in the lower part of the instrument.

The four units at the left function as both counting and storage units. With the DISPLAY control in the INTERMITTENT position, all eight decimal counting units are connected in cascade and the measurement sequence consists of alternate periods of counting and displaying. With the DISPLAY control in the CONTINUOUS position, the carry pulse between the fourth (1131-P1) and the fifth (1131-P4) decade is interrupted, breaking the eight dcu's into two groups of four. At the end of a counting interval, the closing of the main gate triggers the Type 1131-P5 transfer unit and initiates the sequence of events shown in Figure 3-17. This sequence ends 1 millisecond later when the counting decades are reset to zero. Figure 3-18 shows a block diagram of the transfer unit.

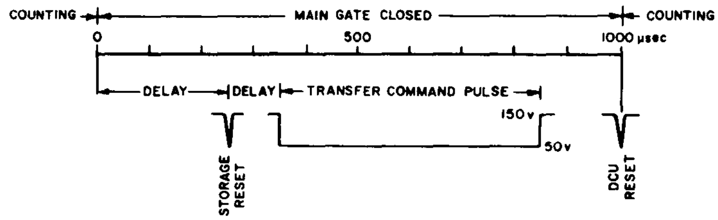


Figure 3-17. Display Program timing diagram.

During the 1-msec transfer interval:

1. After a 250-μsec delay the storage units are set to zero, erasing the data from the previous measurement.
2. A 100-μsec interval is generated to ensure equilibrium in the storage units.
3. A 500-μsec transfer-command pulse is generated. During this interval a binary "1" state in any flip-flop of of the counting decades will cause the transfer lamps (V9 through V12 of Figure 3-6) to ionize and set the corresponding flip-flop of the storage units to the "1" state.
4. 150 μsec after the termination of the transfer command pulse, the counting decades are reset to zero and a new measurement cycle begins.

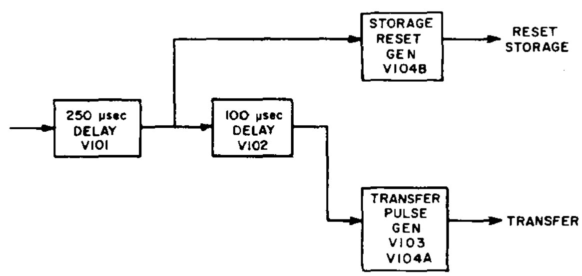


Figure 3-18. Transfer Unit block diagram.

Section 4
SERVICE AND MAINTENANCE

4.1 GENERAL.

The two-year warranty given with every General Radio instrument attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible.

In case of difficulties that cannot be eliminated by the use of these service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest district office (see back cover), requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.2 ROUTINE MAINTENANCE.

4.2.1 CLEANING THE AIR FILTER. To maintain proper cooling efficiency, the air filter should be cleaned periodically. Local air conditions determine how often this is necessary. To clean, release the air filter from its holder, rap gently to remove excess dirt, flush from dirty side with hot soapy water, rinse, and let dry.

4.2.2 LUBRICATING THE FAN MOTOR. For long, trouble-free operation, lubricate the fan motor at least once a year with SAE 20 or 30 premium-quality oil. Two lubricating holes, on the underside of the motor, are easily accessible with the cabinet removed (refer to paragraph 4.4) and the instrument upside down.

4.2.3 ADJUSTING THE TIME-BASE OSCILLATOR FREQUENCY.

Note: Proper self-check operation of the instrument does not indicate correct oscillator frequency, since an error in the counted frequency is exactly compensated by a similar error in the counting interval.

4.2.3.1 Adjustment by Measurement of a Standard Frequency. If a standard frequency is available, it can be measured with the counter and the oscillator frequency adjusted for a correct indication. Oscillator frequency is adjusted by means of the FREQ ADJ screw-driver control on the panel of the Time-Base Unit. Measuring a 1-Mc signal for a counting interval of 10 seconds, for instance, permits adjustment of oscillator frequency to within 1 part in 10^7 of the standard frequency. Similarly, measuring a 10-Mc standard frequency permits adjustment to within 1 part in 10^8

4.2.3.2 Adjustment to WWV. If no local frequency standard is available, the oscillator frequency can be adjusted against standard-frequency radio transmissions (such as those broadcast by the National Bureau of Standards' WWV). Proper receiving equipment is necessary, and propagation conditions must permit reception of the signal.

Tune the receiver to a standard-frequency signal at either 5 or 10 Mc and loosely couple the 5-Mc signal from the 5-Mc OUT jack of the time-base plug-in unit to the antenna input of the receiver. Tune the receiver so that a beat note can be heard, and adjust the FREQ ADJ control of the time-base plug-in unit for zero beat.

4.3 COMPOSITION OF INSTRUMENT.

4.3.1 GENERAL. The Type 1130-A Digital Time and Frequency Meter features a modular construction that greatly simplifies repair and replacement of defective units and keeps instrument "down time" to a minimum. Time-base plug-in units permit quick conversion from one frequency source to another. Every vacuum-tube circuit in the counter is on an etched board easily removable from the main structure. In many instances the user will wish to replace a defective board immediately, thus keeping the counter in operation while the defective circuit is repaired.

Components not mounted on etched boards include the power transformer, some of the power-supply rectifiers and filter capacitors, interconnection cables, plugs, sockets, some terminal boards, and front-panel switches and other controls.

4.3.2 ETCHED BOARDS. The etched boards contained in the Type 1130-A are:

Quantity	Type No.	Name
1	1130-470	10-Mc Decade
1	1130-471	10-Mc Indicating Unit
1	1130-472	Input/Main-Gate Unit
1	1130-473	Time-Base Unit
1	1130-474	Program-Control Unit
1	1130-477	Power-Supply Unit
2	1131-P1	30-kc Decimal Counting Unit
1	1131-P2	100-kc Decimal Counting Unit
1	1131-P3	1-Mc Decimal Counting Unit
4	1131-P4	Counting-Storage Decade
1	1131-P5	Transfer Unit

Figure 4-1 shows the positions of the etched boards in the instrument.

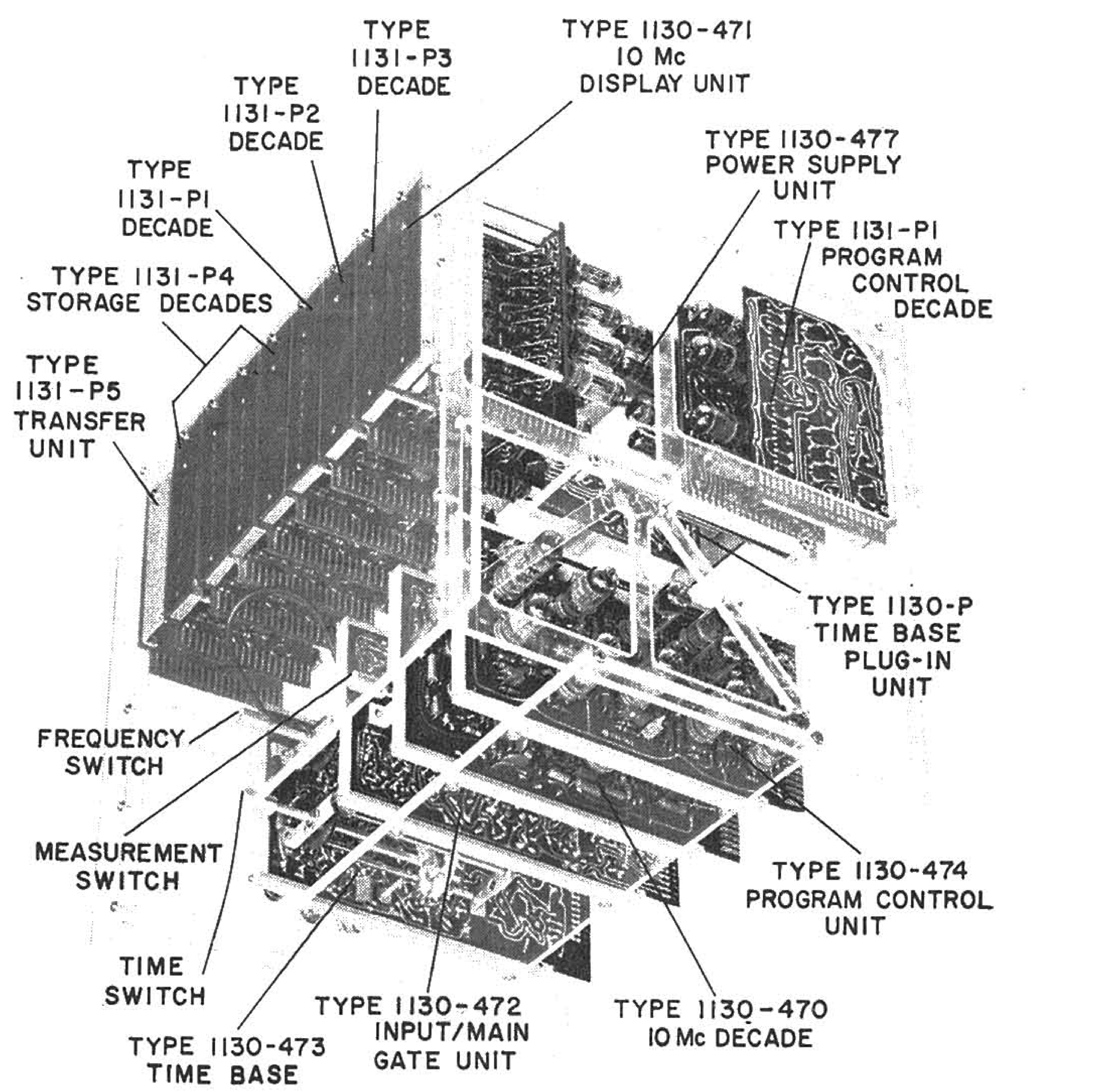


Figure 4-1. Interior view of the Type 1130-A Digital Time and Frequency Meter showing positions of the etched boards.

4.4 REMOVING THE CABINET.

If the instrument is equipped with end frames, remove the eight screws that secure them to the front panel. Roll the instrument forward onto its handles. Remove the four screws that secure the cabinet to the main structure. Lift the cabinet up and off the instrument.

If the instrument is relay-rack mounted with General Radio Type ZSU(3) Brackets, either the cabinet or the instrument can be removed from the rack independently of the other. To remove the cabinet: remove the four screws and washers on the back of the cabinet that secure it to the main structure; on each side of the cabinet remove the screw that holds it to the bracket, and pull the cabinet back off the instrument. To remove the instrument from the rack: remove the four screws on the back of the cabinet that secure it to the main structure; remove the eight panel screws that secure the instrument to the rack; and pull the instrument forward by means of the handles. Support the instrument from underneath before withdrawing it fully; the counter weighs about 85 pounds.

4.5 INTERNAL ADJUSTMENTS.

4.5.1 GENERAL. Normally, most of the factory-set adjustments will not require any attention. Those adjustments that may occasionally be necessary (as, for instance, after replacement of a tube) are listed in the table below and described in paragraph 4.5.2.

Name	Ref Number	Location	Tubes Involved	Refer to Para
+240 v Adj	R761	1130-477	V751, V752, V753	4.5.2.1
+150 v Adj	R766	1130-477	V754	4.5.2.2
-300 v Adj	R771	1130-477	V201, V202	4.5.2.4 and 4.5.2.5
Input Balance	R411	1130-472	V401	4.5.2.6
Input Schmitt	R421	1130-472	V402, V403, V411	4.5.2.7
Time-Base Buffer	R456	1130-472	V404	4.5.2.8
Stop Comparator	R471	1130-472	V405, V406	4.5.2.9
Clamp Supply	R473	1130-472	V407, V754	4.5.2.3 and 4.5.2.5
5-Mc Amp	L501	1130-473	V501	4.5.2.10
10-Mc Mult	L502	1130-473	V502	4.5.2.11
5-Mc Lim	L503	1130-473	V503	4.5.2.10
1-Mc Mv Sym	R512	1130-473	V504	4.5.2.12
1-Mc Mv Freq	R513	1130-473	V504	4.5.2.12
Input Attenuator	C802	Panel	None	4.5.2.14
Stop Attenuator	C806	Panel	None	4.5.2.14
Monitor	R818	Panel	V512	4.5.2.13

4.5.2 ADJUSTMENT PROCEDURE.

4.5.2.1 +240-Volt Adjustment, R761. The +240-volt supply is adjusted as follows:

a. Connect a dc voltmeter between ground (minus) and terminal 3 of the right-hand junction board (plus).

b. Adjust R761 for 240 volts.

4.5.2.2 +150-Volt Adjustment, R766. The +150-volt supply is adjusted as follows:

a. Set the MEASUREMENT control to COUNT, and the COUNT control to START.

b. Connect a dc voltmeter between ground (minus) and terminal 5 of the left-hand junction board (plus).

c. Adjust R766 for 150 volts.

d. Check adjustment of R473 and R771 in that order, as described below.

4.5.2.3 Clamp-Supply Adjustment, R473. (See also paragraph 4.5.2.5.) The clamping voltage is adjusted as follows:

a. Disconnect the fan by removing fan plug PL707.

b. Set the instrument on its right side.

c. Connect a dc voltmeter (20,000 ohms per volt) between TP202 (reference) and TP203, located along the bottom edge of the Type 1130-470 Board. Note the two voltages (and polarities) written on the aluminum bar supporting the Type 1130-470 Board, at the bottom center of the instrument. The one written nearest V204 (nearest rear of the instrument) concerns the adjustment of R473. The other concerns adjustment of R771 (see below). If the indicated polarity is positive, connect the positive side of the voltmeter to TP203; if the indicated polarity is negative, connect the negative voltmeter lead to TP203.

d. Set the MEASUREMENT control to CHECK, the FREQUENCY control to 10 SEC, and the TIME control to 1 kc.

e. While a count is in progress, adjust R473 for the voltage noted in step c.

f. Check the adjustment of R771.

4.5.2.4 -300-Volt Adjustment, R771. (See also paragraph 4.5.2.5.) To adjust the -300-volt supply for optimum operation of the first flip-flop in the 10-Mc decade, proceed as follows:

a. Connect the voltmeter between TP202 (reference) and TP201 on the Type 1130-470 Board, observing the polarity written nearest V201. (If the indicated polarity is positive, connect the positive side of the voltmeter to TP201.)

b. While a count is in progress (as in the adjustment of R473 above), adjust R771, on the Type 1130-477 Board (near the top right-hand rear corner of the instrument), for the voltage written nearest V201.

4.5.2.5 Alternate Clamp-Supply and -300-Volt Adjustments, R473 and R771. The voltages referred to above and recorded on the instrument are the optimum values determined during production testing of each Type 1130-A. The values are valid as long as no components other than tubes are replaced either in the pulse-forming circuits of the Type 1130-472 or in the 10-Mc Decade itself (Type 1130-470). These optimum voltages may be determined as follows:

a. Operate the Type 1130-A from a regulated (or monitored) 115-volt ac line. Connect a differential voltmeter, capable of detecting 1/10-volt increments at a 100-volt level, between ground (+) and terminal 18 of the right-hand junction board (clamp line).

b. Apply a low-frequency sine-wave signal (1 kc or less) to the START SIGNAL INPUT connector at a level of about 3 volts.

c. Set: START SIGNAL ATTENUATION switch to X10,
START SIGNAL TRIGGER LEVEL control to zero,
DISPLAY control to INTERMITTENT,
DISPLAY TIME control to MIN,
FREQUENCY control to 0.001 sec,
TIME control to 10 Mc, and
COUNT switch to START.

When the MEASUREMENT control is set alternately to CHECK and to COUNT, the instrument counts at a 10-Mc rate and 1-kc rate, respectively.

d. Set the MEASUREMENT control to COUNT, and observe the units decade. When counting properly, all 10 numerals of this decade will glow uniformly. Failure is indicated by flickering of one or more numerals.

e. Turn R473 (at rear of Type 1130-472 Board) counterclockwise as far as possible without causing failure (flicker) of the units decade. Record the clamp-line voltage (measured by the external voltmeter) to the nearest 1/10 of a volt.

f. Turn R473 clockwise as far as possible without failure, and record this clamp-line voltage.

g. The difference between the two voltages recorded above is the low-frequency clamp-range. This clamp range depends upon the setting of the -300-volt supply (R771). If the clamp range is less than 3.5 volts, adjust R771 to a new value and repeat the above. Continue until a clamp range of at least 3.5 volts is obtained. Record the two clamp voltages that define the limits of this low-frequency clamp range.

h. To determine the high-frequency clamp range, set the MEASUREMENT control to CHECK. Adjust R473 again, and record the clamp-line voltage limits within which a count of 10,000 (+1, −0) is obtained. In general, the high-frequency clamp range will not coincide exactly with the low-frequency range obtained above. The over-all clamp range is that within which correct operation is obtained at both high and low frequencies. That is, the range extends from the higher of the two minima recorded above (one for low-frequency operation, the other for high-frequency operation) to the lower of the two recorded maxima.

The over-all clamp range must be at least 3 volts. Adjust R473 to set the clamp voltage to the center of this range.

4.5.2.6 Adjustment of Input-Amplifier Balance, R411. The input-amplifier balance is adjusted as follows:

a. Set START SIGNAL SLOPE control to AC MINUS.

b. Connect terminal 106R of the START SIGNAL SLOPE switch S807 to ground by means of a clip lead. (Terminal 106R is identified by the violet wire soldered to it.)

c. Connect a dc voltmeter between pins 2 and 7 of V402.

d. Adjust R411 for 0 volts.

4.5.2.7 Adjustment of Input-Amplifier Sensitivity, R421. To adjust the input-amplifier sensitivity, first adjust R411 as described above, then proceed as follows:

a. Set the MEASUREMENT control to FREQ, the FREQUENCY control to 0.001 sec, the DISPLAY TIME control to MIN, and the START SIGNAL ATTENUATION switch to X10.

b. Apply a 10-Mc sine-wave signal to the START SIGNAL INPUT connector and monitor the signal level. If the instrument measures 10 Mc when the input level is 2.0 volts rms or less, no adjustment is required. Otherwise set the level to 2.0 volts and adjust R421 to obtain a frequency measurement of 10 Mc. R421 can be reached with a narrow-bladed 12-inch screw driver inserted through the hole near the center of the Type 1130-473 Board.

4.5.2.8 Adjustment of Time-Base Buffer Sensitivity, R456. The time-base buffer sensitivity is adjusted as follows:

a. Connect an oscilloscope with a low-capacitance probe to the test point adjacent to R456 (pin 1 of V404).

b. Set the oscilloscope to an over-all sensitivity (including probe attenuation) of 5 volts/cm.

c. Set the MEASUREMENT control to PERIOD and the TIME control to 1 kc.

d. Observe the rectangular pulse and synchronize the oscilloscope sweep to the positive-going edge of this pulse.

e. Adjust R456 for a pulse duration of 6 μsec ($\pm$1).

4.5.2.9 Adjustment of Stop-Signal Sensitivity, R471. The stop-signal sensitivity is adjusted as follows:

a. Set the MEASUREMENT control to TIME INTERVAL, the STOP SIGNAL ATTENUATION switch to X10, and the STOP SIGNAL TRIGGER LEVEL control to zero (center).

b. Connect an oscilloscope with a low-capacitance probe to terminal 407F of the MEASUREMENT switch. Terminal 407F is at the right-hand side of the center (fourth) wafer, and is identified by the straight bus connecting it to corresponding terminals of the fifth and sixth wafers. Set the oscilloscope sensitivity to 5 volts/cm (to observe a 10-volt square wave).

c. Apply a 100-kc sine-wave signal to the STOP SIGNAL INPUT connector. Increase the level of this signal until a square wave is obtained, as indicated by the oscilloscope. Simultaneously, adjust R471 and reduce the level of the input signal until maximum sensitivity is obtained.

4.5.2.10 Tuning Adjustment of 5-Mc Amplifier, L501 and L503. To adjust the tuning of the 5-Mc amplifier, loosely couple any suitable indicator (grid-drip meter, wavemeter, oscilloscope, etc) to coil L501 and adjust the coil for maximum 5-Mc signal. Then tune coil L503 in the same manner.

4.5.2.11 Tuning Adjustment of 10-Mc Multiplier, L502. The 10-Mc multiplier is adjusted as follows:

a. Set the MEASUREMENT control to PERIOD and the TIME control to 10 Mc.

b. Loosely couple any suitable indicator (grid-dip meter, wavemeter, oscilloscope, etc) to L502 and adjust for maximum 10-Mc output.

4.5.2.12 Natural-Frequency Adjustment of 1-Mc Multivibrator, R512 and R513. Connect an oscilloscope to TP2, near the center of the Type 1130-473 Board (component side). Set the oscilloscope sweep to 1 μsec/cm and the sensitivity to 1 volt/cm. The displayed pattern will be approximately as shown in Figure 4-2. This observation is to monitor the 10:1 frequency ratio between the 1-Mc multivibrator and the 100-kc multivibrator during the following adjustments. To adjust the natural frequency of the 1-Mc multivibrator, proceed as follows:

a. Apply any accurate external low-frequency signal (e.g., the line frequency) to the START SIGNAL INPUT connector.

Figure 4-2. Oscilloscope pattern used to monitor the 10/1 frequency ratio required during the natural-frequency adjustment of the 1-Mc multivibrator.

b. Set the MEASUREMENT control to PERIOD, and the TIME control to 100 kc.

c. Disable the time-base oscillator (set the TIME BASE INPUT switch at the rear of Type 1130-A to EXT and disconnect its INPUT).

d. Adjust R513 (top front corner of the Type 1130-473 Board) so that the indicated period (measured by the Type 1130-A) is 5% shorter than it is known to be, at the same time monitoring the oscilloscope pattern to ensure that the 10:1 ratio is maintained.

e. Connect the oscilloscope to TP1, near the front center of the Type 1130-473 Board. Set the oscilloscope sensitivity to 0.5 volt/cm or greater, and the sweep to 0.2 μsec/cm. The observed waveform will be approximately as shown in Figure 4-3.

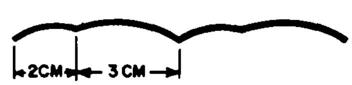


Figure 4-3. Oscilloscope pattern displayed from TP1 of the Type 1130-473 Board for natural-frequency adjustment of the 1-Mc multivibrator.

f. Adjust R512 for 2:3 duration ratio as indicated on the pattern.

g. Readjust R513 if necessary for an indicated period 5% shorter than it is known to be, as above.

4.5.2.13 Adjustment of Monitor Multivibrator, R818. The monitor is adjusted as follows:

a. Set the MEASUREMENT, TIME, and FREQUENCY controls to CHECK. The indicated count must be 100,000, 000 (+1, −0).

b. Adjust R818 (under the snap button below the MONITOR light) to the center of the range in which the lamp stops flashing.

4.5.2.14 Frequency-Compensation Adjustment for Input Attenuators, C802 and C806. The frequency-compensation for the input attenuators is adjusted as follows:

a. Set both ATTENUATION switches to X10 and the COMMON-SEPARATE switch to COMMON.

b. Apply a fast, low-frequency square wave to the START SIGNAL INPUT connector. (The CAL signal output of the oscilloscope is an adequate signal if not loaded too heavily with cable capacitance.)

c. Connect the oscilloscope, with a properly compensated low-capacitance probe, to the upper terminal of C802 (or C806).

d. Adjust C802 (or C806) for the best square-wave display (no overshoot or undershoot). These capacitors are located directly behind the ATTENUATION switches.

4.6 TROUBLE-SHOOTING PROCEDURE.

4.6.1 GENERAL. Normally, the first step in trouble-shooting the counter will be to isolate the difficulty to one of the 15 etched boards in the instrument. Then the defective board can be removed for further trouble-shooting to identify the defective circuit or component. Thus this section will first describe the procedure for locating the defective board (paragraph 4.6.2), then the removal of the board (paragraph 4.6.3), and trouble-shooting the etched board (paragraph 4.6.4). Failure of neon lamps is considered separately, in paragraph 4.6.5.

4.6.2 LOCATING A DEFECTIVE ETCHED BOARD. The following procedure should be undertaken in the sequence indicated. At the first point where observations are not as indicated, refer to Table 5 for further tests to pinpoint the defective circuit. In this way the defective etched board can be quickly located and replaced. The defective board itself can be serviced by conventional techniques from information given in following sections.

Table 6 tabulates in more detail the circuits involved in the operational tests.

TEST 1 (POWER SUPPLY)

Operation

Set: MEASUREMENT control to CHECK,
FREQUENCY control to 10 SEC,
TIME control to 10 Mc,
DISPLAY control to INTERMITTENT,
DISPLAY TIME control to the right, and
the control on the time-base plug-in unit (rear) to INT.

Apply power.

Set POWER switch ON.

Observations

1.1 Fan starts immediately.
1.2 Decimal light between units and tens DCU's goes on immediately.
1.3 After about 15 seconds, the time-delay relay gives an audible click. Simultaneously, - - -
1.4 Some (any) numeral lights in the units column. Some (any) numeral lights in the tens column. Some (any) numeral lights in each of the other six columns.
1.5 MONITOR lamp flashes on and off.
1.6 After several seconds, MONITOR stops flashing and remains off.

TEST 2A (CHECK)

Operation

Operate and release RESET switch.

Observations

2A.1 COUNTING light goes out (or is out).
2A.2 After one second or less, COUNTING light goes on. Simultaneously, - - -
2A.3 The left DCU advances sequentially from zero at the rate of one digit per second. The adjacent DCU advances sequentially at the rate of 10 digits per second. All other DCU's advance faster.
2A.4 After 10 seconds of counting, the COUNTING light goes out. Simultaneously, - - -
2A.5 Counting stops.
2A.6 Displayed count is (1)00,000,000 (±1).
2A.7 One-second markers appear at EXT TIME jack J805 (earphones or oscilloscope).

TEST 2B (CHECK)

Operation

Set TIME control to 100 kc.

Observations

2B.1 10-K's DCU (fifth from right) advances sequentially at a rate of 10 digits per second.
2B.2 100-K's DCU (sixth from right) advances sequentially one digit per second.
2B.3 When counting stops, displayed count is 1,000, 000.

TEST 2C (CHECK)

Operation

Set TIME control to 1 kc.

Observations

2C.1 100's DCU (third from right) advances sequentially 10 digits per second.

2C.2 100's DCU (fourth from right) advances sequentially one digit per second.

2C.3 Final count is 10,000.

TEST 2D (CHECK)

Operation

Set TIME control to 10 cps.

Observations

2D.1 Units DCU (at right) advances sequentially 10 digits per second.

2D.2 Tens DCU (second from right) advances sequentially one digit per second.

2D.3 Final count is 100.

TEST 2E (CHECK)

Operation

Set TIME control to 10 Mc.

Set FREQUENCY control successively to 1 sec, 0.1 sec, 0.01 sec, and 0.001 sec.

Observation

2E.1 Final counts are 10,000,000; 1,000,000; 100,000; and 10,000 respectively. A tolerance of ±1 is allowed on any of these counts.

TEST 2F (CHECK)

Operation

Set control on the time-base plug-in unit (at rear of Type 1130-A) to EXT.

Apply external 5-Mc signal (about 1 volt) to INPUT connector of time-base plug-in unit.

Set FREQUENCY control to 0.001 sec.

Operate and release RESET switch.

Observation

2F.1 Final count is 10,000 (±1).

TEST 3A (COUNT)

Operation

Set control on the time-base plug-in unit to INT.

Set MEASUREMENT control to COUNT.

Switch COUNT switch back and forth to START and STOP.

Observation

3A.1 COUNTING light goes on when (and only when) COUNT switch is at START.

TEST 3B (COUNT)

Operation

Set: COUNT switch to START,
Both ATTENUATION switches to X10, and
Both SLOPE controls to AC MINUS.

Rotate right-hand TRIGGER LEVEL control back and forth around its center position 10 times.

Observation

3B.1 Units DCU advances one digit per cycle of the TRIGGER LEVEL control, producing a final count of 10.

TEST 3C (COUNT)

Operation

Set COUNT switch to STOP.

Observation

3C.1 After a few seconds, the tens DCU resets to zero.

TEST 3D (COUNT)

Operation

Rotate right-hand TRIGGER LEVEL control back and forth several times.

Observation

3D.1 Units DCU stays at zero.

TEST 4A (PERIOD)

Operation

Set: MEASUREMENT control to PERIOD,
TIME control to 10 Mc, and
DISPLAY TIME control fully counterclockwise.

Rotate right-hand TRIGGER LEVEL control through one cycle.

Observations

4A.1 Counting light goes on.

4A.2 DCU's start to count at a 10-Mc rate (that is, left-hand DCU advances one digit per second; second from left, 10 digits per second).

TEST 4B (PERIOD)

Operation

Rotate right-hand TRIGGER LEVEL control through another cycle.

Observations

4B.1 COUNTING light goes off, and counting stops.

4B.2 DCU's reset to zero almost immediately.

TEST 4C (PERIOD)

Operation

Set DISPLAY TIME control fully clockwise, but without operating the ganged infinite display switch.

Operate and release RESET switch.

Rotate the right-hand TRIGGER LEVEL control back and forth about once per second for 10 seconds or so.

Observations

4C.1 On the first cycle, the COUNTING light goes on, and counting commences, as in 4A above.

4C.2 On the second cycle, the COUNTING light goes out, as in 4B.1, and counting stops.

4C.3 The DCU's display their final count, without resetting or advancing on succeeding cycles of the right-hand TRIGGER LEVEL control, until –

4C.4 About 10 seconds after the COUNTING light goes out, all DCU's reset to zero.

4C.5 On the next cycle of the right-hand TRIGGER LEVEL control, the COUNTING light goes on again.

TEST 4D (PERIOD)

Operation

With the COUNTING light on and DCU's counting, as in 4C.5 above, operate and release RESET switch.

Observations

4D.1 COUNTING light goes out, and units DCU resets to zero immediately.

4D.2 All other DCU's reset to zero at the same time.

TEST 4E (PERIOD)

Operation

Set TIME control successively to 100 kc, 1 kc, and 10 cps.

At each position, turn COUNTING light on by operating right-hand TRIGGER LEVEL control, as above.

Observation

4E.1 At each position, the DCU's count at the rate selected by TIME control.

4E.2 At each position, the decade that counts at 1 cps and the one just to the right of it (which counts at 10 cps) advance sequentially.

TEST 5 (10 PERIOD)

Operation

Set MEASUREMENT control to 10 PERIOD.

Rotate right-hand TRIGGER LEVEL control through 12 complete cycles.

Observations

5.1 Program-control decade advances sequentially from 0 to 9 to 0 to 2, counting the cycles of the TRIGGER LEVEL control.

Note: To observe this decade, you must first remove the instrument from the cabinet (refer to Section 4.4). The decade is at the upper right rear corner of the instrument, and its counting sequence can be observed from the rear of the instrument. This test is not necessary if observation 5.2 below is correct.

5.2 COUNTING light goes on during the second cycle of the TRIGGER LEVEL control, and stays on until the twelfth cycle.

TEST 6A (TIME INTERVAL)

Operation

Set: MEASUREMENT control to TIME INTERVAL and DISPLAY TIME control fully counterclockwise.

Rotate right-hand TRIGGER LEVEL control through several cycles.

Observation

6A.1 COUNTING light goes on during the first cycle and stays on.

TEST 6B (TIME INTERVAL)

Operation

Rotate left-hand TRIGGER LEVEL control through several cycles.

Observation

6B.1 COUNTING light goes out during the first clockwise rotation and stays out.

TEST 7A (TRANSFER & STORAGE)

Operation

Set: MEASUREMENT control to FREQ,
DISPLAY control to CONTINUOUS, and
FREQUENCY control to 1 SEC.

Operate (and hold for several seconds) SET NINE switch.

Observation

7A.1 Displayed count jumps to 9999 and stays.

TEST 7B (TRANSFER & STORAGE)

Operation

Release SET NINE switch.

Observation

7B.1 Displayed count jumps back to 0000.

4.6.3 REPLACING AN ETCHED BOARD.

4.6.3.1 Replacing a Type 1131, 1130-471, or 1130-477 Board.

a. Remove the cabinet (refer to paragraph 4.4).

b. Turn the instrument upright.

c. Remove the single screw connecting the board to the instrument and unplug the board with a gentle back-and-forth rocking motion.

When replacing any of these boards, be careful to align its plug with its socket and insert the board gradually.

4.6.3.2 Replacing the Type 1130-470 10-Mc Decade.

a. Remove the cabinet (refer to paragraph 4.4).

b. Turn the instrument upside down.

c. Remove the ventilating fan blade.

d. Unplug the cable connector at the rear of the board.

e. Disconnect the interconnecting lead.

HOW TO USE THE FOLLOWING TROUBLE-SHOOTING TABLES

Complete trouble-shooting procedures are tabulated on the following pages. Tables 5, 6-A, and 6-B are to be used in conjunction with the test procedures described in paragraph 4.6.2, pages 22 through 24.

For a complete system check-out (where you have no idea where the trouble is), start at Test 1 (POWER SUPPLY) on page 22, perform the operations in the order indicated, and make the observations as described. At the first point where an observation is not as it should be, refer to Table 5, entering the Table where the missing observations number appears in column 1. Then perform the additional tests called for in column 2. Find the results of additional tests in column 3 or column 4, and the probable defective circuit in column 5. Columns 6 and 7 indicate the component to be adjusted (if any) and the circuit board, respectively.

Tables 6-A and 6-B should be used in conjunction with each other, and are given primarily as cross references to Table 5. Table 6-A lists the circuits involved for each of the observations of paragraph 4.6.2. The circuit numbers given in column 2 refer to column 2 in Table 6-B. Numbers in parentheses refer to circuits only partially checked by the observations noted.

TABLE 5. TROUBLE-SHOOTING TABLE.

(To be used in conjunction with OPERATIONAL TESTS, paragraph 4.6.2.)

First Incorrect Observation	Additional Test Necessary	Results of Additional Tests		Probable Circuit Failure	Adjustments	Refer to Schematic and Voltage Table for
		Incorrect	Correct			
1.1	1.2	1.2	—	Fuses	—	Power Supply
		—	1.2	Fan	—	—
1.2	Continue Tests	None	All	Decimal Light	—	1130-7D
1.3	—	—	—	Time-Delay Relays	—	Power Supply
1.4	—	—	—	+300 Unreg, -150 v	—	Power Supply
1.5	—	—	—	+150 v	R766	1130-477
1.6	2A.1 to 2F	None	All	Monitor	R818	1130-473
		2A.1	—	+240 v Reg, -450 v Unreg	R761	1130-477
		2A.3 to 2A.6	2F.1	Time-Base Oscillator	—	1130-P
		2A.3, 2F.1	2B.3	V501	L501	1130-473
		2A.6, 2B.3	2A.3, 2C.3	V505 or V506	—	1130-473
		2A.6, 2B.3, 2C.3	2A.3, 2D.3	V507, V508	—	1130-473
		2A.6, 2B.3, 2C.3, 2D.3	2E complete	V510	—	1130-473
		2A.6, 2E (0.1 sec only)	2A.3, 2E (except 0.1 sec)	V509	—	1130-473
2A.1	3A to 3D, 4D.1, 4D.2	3B.1, 3C.1, 3D.1, DCU's count fast	3A.1, COUNT-INT light	V407B	—	1130-472
		4D.1	3A.1, 3B.1, 3C.1, 4D.2	D602	—	1130-474
		4D.1, 4D.2	3A.1, 3B.1, 3C.1	V601B, V615, V616	—	1130-474
		3A.1	3B.1, 3C.1, 3D.1	+300 v Reg	—	1130-477
		3A.1, 3D.1	—	V409	—	1130-472
		3C.1, 4D.1, 4D.2	—	V608	—	1130-474
2A.2	2A.3, 2A.7, 3A, 3E, 4A, 5.1, 5.2	3A.1	2 2A.3, 3B.1	+300 v Reg or V803	—	1130-477
		3A.1, 3B.1	—	V409		1130-472
		2A.7	—	V404	R456	1130-472
		4A.1	4A.1 with V605 removed	V609, V603, or V604	—	1130-474
		4A.1 with V605 removed	3A.1, 5.1	V410	—	1130-472
		4A.1 with V605 removed, 5.1	2A.7	T402, Program-Control Decade, or V607		1131-P1 or 1130-474
		5.1 with Type 1131-P1's inter-changed	4A.1	V607		1130-474
		5.2	4A.1, 5.1	V605B, V606	—	1130-474
2A.3	2B, 2C, 2D, 2E	2E	2B, 2C, 2D	V502	L502	1130-473
	3B, 4A.1	3B		V408 or T401	—	1130-472
		4A.1		V401, V402, or V403	R411, R421	1130-472
		7A.1, 7B.1		DCU that fails	—	—
2A.4	5.2	5.2		Program-Control Decade	—	1131-P1
2A.5	3A, 3B, 3D	3B, 3D	3A	Units DCU	R473, R771	1130-470, -472, -477

(Continued)

TABLE 5. TROUBLE-SHOOTING TABLE. (Cont)

(To be used in conjunction with OPERATIONAL TESTS, paragraph 4.6.2.)

First Incorrect Observation	Additional Test Necessary	Results of Additional Tests		Probable Circuit Failure	Adjustments	Refer to Schematic and Voltage Table for
		Incorrect	Correct			
2A.6	2B, 2C, 2D, 2E, 3B, 5.1, 5.2	2E	2B	Oscillating Adjustments	L502	1130-473
					R411, R421, R473	1130-472
					R771	1130-477
		2B	2C	10-k's or 100-k's DCU	—	1131-P4
		2C	2D	100's or 1-k's DCU	—	1131-P1, -P2
		2D	3B	10's DCU		1131-P3
		3B	—	Units DCU	R473, R771	1130-470
		5.1, 5.2	—	Program-Control Decade	—	1131-P1
2B.1	2B.3	—	2B.3	10-k's DCU	—	1131-P4
2B.2	2B.3	—	2B.3	100-k's DCU	—	1131-P4
2C.1	2C.3	—	2C.3	100's DCU	—	1131-P2
2C.2	2C.3	—	2C.3	1-k's DCU	—	1131-P1
2D.1	2D.3, 3B	3B	2D.3	Units DCU	—	1130-471
2D.2	2D.3	—	2D.3	10's DCU	—	1131-P3
2E.1	—	—	—	V404	R456	1130-472
2F.1	—	—	—	Time-Base Plug-In Unit	—	1130-P
3A.1	—	—	—	S814, C814, R825, R450, S403	—	1130-472
4A.2	—	—	—	Adjustments	L502	1130-473
					L502	1130-472
4B.2	4D.1, 4D.2, 7B.1	4D.1	4D.2	D602	—	1130-474
		4D.2	4D.1	D601	—	1130-474
		4D.1, 4D.2	7B.1	V610, V611, V612, V618, V619, V620	—	1130-474
		4D.1, 4D.2, 7B.1	—	V608 or	—	1130-474
				V407A	—	1130-474
4C.3		DCU's reset too soon		Display Generator	—	1130-474
4C.3		DCU's resume counting		V603, V604, V605A	—	1130-474
4C.4		Incorrect display time		Display Generator	—	1130-474
4D.1	4D.2	4D.2	—	V601B, V615, V616	—	1130-474
		—	4D.2	D602	—	1130-474
4E.1	—	—	—	Time-Base Buffer Adjustment	R456	1130-472
6B.1	—	—	—	V405, V406	—	1130-472
7A.1		All Storage DCU's	—	Transfer Unit		1131-P5
7A.1		One Storage DCU	—	DCU that failed	—	1131-P4
7B.1		All Storage DCU's		Transfer Unit		1131-P5
7B.1		One Storage DCU		DCU that failed	—	1131-P4

TABLE 6-A. CIRCUITS INVOLVED IN TROUBLE-SHOOTING TESTS of PARAGRAPH 4.6.2.

Observation No. (Section 4.6.2)	Circuits Tested (Numbers Refer to Table 6-B, Column 2)	Observation No. (Section 4.6.2)	Circuits Tested (Numbers Refer to Table 6-B, Column 2)
1.1	1	2F 1	13 thru 18, 25, 32, 37, 39 thru 43, 45, 49, 50, 56, 58, 59, 60, 75, 77, 79, 81
1.2	1, 2, etc.	3A 1	8, 45
1.3	1, 2, etc.	3B 1	26, 38, 42, 82, 83
1.4	3, 4, 5,	3C 1	44, 46, 47, (48), 49, 50
1.5	3, 9	3D 1	43
1.6	3, 6, 7, 12, 13, 15 thru 24	4A 1	26, 39, 41, 45, 54
2A 1	3, 6, 7, 8, (38), (45), (49), (51), (52)	2	12, 13, 14, 33, 42, 63, 64, 66, 67, (69), (72), (75), (77), (79), (81)
2	3, 5, 9, (22), (28), 39, 41, 45, 53, 54, 56, 58, (60)	4B 1	8, 26, 39, 41, 43, 45, 54
3	3, 4, 5, 9, (12), (13), (14), (25), 42, 63, 64, 66, 67, (69), (72), (75), (77), (79), (81)	2	44, 46, 47, (48), 49, 50, 51
4	6, 8, (22), (28), 39, 40, 41, 45, 56, 58, 59, (60)	4C 1	
5	(10), 43	2	
6	10, 12 thru 22, 25, 28, 37, 60, 63, 66, 69, 72, 75, 77, 79, 81	3	40, 55
7	(22), 28	4	44, 46 thru 51
2B 1	39, 42, 72, 73	4D 1	49, 51, 52
2	69, 70	2	49, 50, 52
3	10, (17 thru 22), 25, 28, 37, 40, 41, 43, 45, 56, 58, 59, 60, 75, 77, 79, 81	4E 1	(17), (19), (21), 26, 34, 35, 36, 39, 41, 42, 45, 54
2C 1	39, 42, 77, 78	2	69, 70, 72, 73, 75 thru 80, (81), 82, 83
2	75, 76	5 1	26, 41, 56, 60
3	11, (19 thru 22), 26, 28, 38, 40, 41, 43 thru 47, (48), 49, 50, 56, 58, 59, 60, 79, 82	2	8, 39, 40, 45, 54, 58, 59
2D 1	39, 41, 82, 83	6A 1	
2	41, 79, 80	6B 1	8, 27, 45
3	11, (21), (22), 26, 28, 38, 40, 43, 45, 49, 50, 56, 58, 59, 60	7A 1	(21), 29, 39, 42 thru 47, 58, (61), (65), (68), (71), (74), (75), (77), (79), (81), (82), (83)
2E 1	10, 12 thru 21, 25, 29 thru 32, 37, 39 thru 43, 45, 49, 50, 56, 58, 59, 60, 66, 69, 72, 75, 77, 79, 81	7B 1	(21), 29, 39, 42 thru 47, 58, (61), (65), (68), (71), (74), (75), (77), (79), (83)

TABLE 6-B. IDENTIFICATION of CIRCUITS REFERRED TO in TABLE 6-A.

Etched Board	Circuit No.	Circuit	Tubes, Components	Test Observations
	1	Fuses		1.1, 1.2, 1.3, etc.
	2	PWR XFMR Output		1.2, 1.3, etc.
	3	+300 v Unreg		1.4, 1.5, 1.6, 2A.1 – 3
	4	+225 v		1.4, 2A.3, etc.
	5	-150 v		1.4, 2A.2, 2A.3, etc.
1130-477	6	+450 v		1.6, 2A.1, 2A.4, etc.
	7	+240 v Reg	R761	1.6, 2A.1
	8	+300 v Reg		2A.1, 2A.4, 3A, 4B.1, 5.2, 6.B
	9	+150 v Reg	R766	1.5, 2A.2. 2A.3, etc.
	10	-300 v HF Count	R771	(2A.5), 2A.6, 2B.3, 2E.1
	11	-300 v LF Count	R771	2C.3, 2D.3

(Continued)

TABLE 6-B. IDENTIFICATION of CIRCUITS REFERRED TO in TABLE 6-A. (Cont)

Etched Board	Circuit No.	Circuit	Tubes, Components	Test Observations
1130-P	12	5 Mc Input Present		1.6, (2A.3), 2A.6, 2E.1, 4A.2
	13	5 Mc Amplifier	V501, L501	1.6, (2A.3), 2A.6, 2E.1, 2F.1, 4A.2
	14	10 Mc Multivibrator	V502, L502	(2A.3), 2A.6, 2E.1, 4A.2, 2F.1
	15	5 Mc Limiter	V503, L503	1.6, 2A.6, 2E.1, 2F.1
	16	1 Mc Multivibrator	V504, R512, R513	1.6, 2A.6, 2E.1, 2F.1
	17	100 kc Multivibrator	V505	1.6, 2A.6, (2B.3), 2E.1, 2F.1, (4E.1)
	18	10 kc Multivibrator	V506	1.6, 2A.6, (2B.3), 2E.1, 2F.1
1130-472	19	1 kc Multivibrator	V507	1.6, 2A.6, (2B.3), (2C.3), 2E.1, (4E.1)
	20	100 c Multivibrator	V508	1.6, 2A.6, (2B.3), (2C.3), 2E.1
	21	10 c Multivibrator	V509	1.6, 2A.6, (2B.3), (2C.3), (2D.3), 2E.1, (4E.1), (7A.1), (7B.1)
	22	1 c Multivibrator	V510	1.6, (2A.2), (2A.4), 2A.6, (2A.7), (2B.3), (2C.3), (2D.3)
	23	Monitor Amplifier	V511	1.6
	24	Monitor Multivibrator	V512, R818	1.6
	25	Start Amp-HF	V401, V402, V403,	(2A.3), 2A.6, 2B.3, 2E.1, 2F.1
	26	Start Amp-LF	R411, R421	2C.3, 2D.3, 3B.1, 4A.1, 4B.1, 4E.1, 5.1
	27	Stop Comparator	V405, V406, R471	6B.1
	28	TB Buffer, Freq, 10 sec	V404, R456	(2A.2), (2A.4), 2A.6, 2A.7, 2B.3, 2C.3, 2D.3
	29	TB Buffer, Freq, 1 sec		2E.1, 7A.1, 7B.1
	30	TB Buffer, Freq, 0.1 sec		2E.1
	31	TB Buffer, Freq, 0.01 sec		2E.1
	32	TB Buffer, Freq, 0.001 sec		2E.1
	33	TB Buffer, Period, 10 Mc		4A.2
	34	TB Buffer, Period, 100 kc		4E.1
	35	TB Buffer, Period, 1 kc		4E.1
	36	TB Buffer, Period, 10 kc		4E.1
	37	Clamp Line, HF Count	V407B, R473	2A.6, 2B.3, 2E.1, 2F.1
1130-473	38	Clamp Line, LF Count	V407B, R473	(2A.1), 2C.3, 2D.3, 3B.1
	39	Time Gate Open	V410	2A.2, 2A.4, 2B.1, 2C.1, 2D.1, 2E.1, 2F.1, 4A.1, 4B.1, 4E.1, 5.2, 7A.1, 7B.1
	40	Time Gate Closed	V410	2A.4, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 4C.3, 5.2
	41	Transformer	T402	2A.2, 2A.4, 2B.3, 2C.3, 2D.1, 2D.2, 2E.1, 2F.1, 4A.1, 4B.1, 4E.1, 5.1
	42	Main Gate Opens	V408	2A.3, 2B.1, 2C.1, 2D.1, 2E.1, 2F.1, 3B.1, 4A.2, 4E.1, 7A.1, 7B.1
	43	Main Gate Closes	V408	2A.5, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 3C.1, 3D.1, 4B.1, 7A.1, 7B.1
	44	Main Gate Buffer	V407A	2C.3, 3C.1, 4B.2, 4C.4, 7A.1, 7B.1
	45	Main Gate Flip-Flop	V409	(2A.1), 2A.2, 2A.4, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 3A.1, 4A.1, 4B.1, 4E.1, 5.2, 7A.1, 7B.1
1130-474	46	30 μsec Delay	V601A, V614	2C.3, 3C.1, 4B.2, 4C.4, 7A.1, 7B.1

(Continued)

TABLE 6-B. IDENTIFICATION of CIRCUITS REFERRED TO in TABLE 6-A. (Cont)

Etched Board	Circuit No.	Circuit	Tubes, Components	Test Observations
1130-474	47	1 Msec Transfer Delay	V602	2C.3, 3C.1, 4B.2, 4C.4, 7A.1, 7B.1
	48	Display Generator	V610, V611, V612 V618, V619, V620	(2C.3), (3C.1), (4B.2), 4C.4
	49	Reset Amplifier	V608	(2A.1), 2C.3, 2D.3, 2E.1, 2F.1, 3C.1, 4B.2, 4C.4, 4D.1, 4D.2
	50	0-v Reset Diode	D601	2C.3, 2D.3, 2E.1, 2F.1, 3C.1, 4B.2, 4D.2
	51	-150-v Reset Diode	D602	(2A.1), 4B.2, 4C.4, 4D.1
	52	Manual Reset Gen	V601B, V615, V616	(2A.1), 4D.1, 4D.2
	53	400 μsec Delay	V609	2A.2
	54	TG Control F-F - Ready	V603, V604, V605A	2A.2, 4A.1, 4B.1, 4E.1, 5.2
	55	TG Control F-F - Not Ready	V603, V604, V605A	4C.3
	56	PCD Gate Open	V607	2A.2, 2A.4, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 5.1
	57	PCD Gate Closed	V607	2A.2, 2A.4, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 5.1
	58	Diode Coinc Gate Ready	V605B, V606	2A.2, 2A.4, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 5.2 7A.1, 7B.1
	59	Diode Coinc Gate Not Ready	V605B, V606	2A.4, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 5.2
1131-P1	60	Program Control Decade		(2A.2), (2A.4), 2A.6, 2B.3, 2C.3, 2D.3, 2E.1, 2F.1, 5.1
1131-P5	61	Transfer Unit - 9		(7A.1), (7B.1)
	62	Transfer Unit - 0		
1131-P4	63	1st (From Left) DCU - Count		2A.3, 2A.6, 4A.2
	64	1st DCU - Readout		2A.3, 4A.2
	65	1st DCU - Storage		(7A.1), (7B.1)
	66	2d DCU - Count		2A.3, 2A.6, 2E.1, 4A.2
	67	2d DCU - Readout		2A.3, 4A.2
	68	2d DCU - Storage		(7A.1), (7B.1)
	69	3d DCU - Count		(2A.3), 2A.6, 2B.2, 2E.1, (4A.2), 4E.2
	70	3d DCU - Readout		2B.2, 4E.2
	71	3d DCU - Storage		(7A.1), (7B.1)
	72	4th DCU - Count		(2A.3), 2A.6, 2B.1, 2E.1, (4A.2), 4E.2
	73	4th DCU - Readout		2B.1, 4E.2
	74	4th DCU - Storage		(7A.1), (7B.1)
1131-P1	75	5th DCU - Count		(2A.3), 2A.6, 2B.3, 2C.2, 2E.1, 2F.1, (4A.2), 4E.2, (7A.1), (7B.1)
	76	5th DCU - Readout		2C.2, 4E.2
1131-P2	77	6th DCU - Count		(2A.3), 2A.6, 2B.3, 2C.1, 2E.1, 2F.1, (4A.2), 4E.2, (7A.1), (7B.1)
	78	6th DCU - Readout		2C.1, 4E.2
1131-P3	79	7th DCU - Count		(2A.3), 2A.6, 2B.3, 2C.3, 2D.2, 2E.1, 2F.1, (4A.2), 4E.2, (7A.1), (7B.1)
	80	7th DCU - Readout		2D.2, 4E.2
	81	10 Mc Decade - HF		(2A.3), 2A.6, 2B.3, 2E.1, 2F.1, (4A.2), (4E.2), (7A.1)
	82	10 Mc Decade - LF		2C.3, 2D.1, 3B.1, 4E.2, (7A.1)
1130-471	83	10 Mc Readout		2D.1, 3B.1, 4E.2, (7A.1), 7B.1)

f. Loosen the retaining thumb screw at the rear of the board and free the grounding spade lug.

g. Slide the board out of its supporting track.

4.6.3.3 Replacing the Type 1130-472 Input/Main-Gate Unit.

a. Remove the cabinet (refer to paragraph 4.4).

b. Turn the instrument upside down.

c. Remove the ventilating fan blade.

d. Unplug the cable connector at the rear of the board.

e. Disconnect the nine interconnecting leads.

f. Loosen the retaining thumb screw and remove the board.

When replacing the board, be sure the switch-coupling unit is aligned with its opposite member in the instrument.

4.6.3.4 Replacing the Type 1130-473 Time-Base Unit.

a. Remove the cabinet (refer to paragraph 4.4).

b. Turn the instrument upright.

c. Unsolder the shielded cable connected to the socket at the rear of the time-base plug-in unit housing.

d. Turn the instrument upside down.

e. Remove the ventilating fan blade.

f. Unplug the rear cable connector.

g. Disconnect the four interconnecting leads.

h. Loosen the retaining thumb screw and remove the board.

When replacing the board, be sure the switch-coupling units are properly aligned and resolder the shielded cable.

4.6.3.5 Replacing the Type 1130-474 Program-Control Unit.

a. Remove the cabinet (refer to paragraph 4.4).

b. Turn the instrument upside down.

c. Remove the ventilating fan blade.

d. Unplug the rear cable connector.

e. Disconnect the two interconnecting leads.

f. Loosen the retaining thumb screw and remove the board.

When any board is replaced, be sure to connect all interconnecting signal leads as shown in Figure 4-4 and replace the ventilating fan blade.

4.6.4 ETCHED-BOARD TROUBLE-SHOOTING. Any of the boards at the top of the instrument can be operated clear of the instrument for trouble-shooting by means of the Type 1130-P5 Accessory Unit. The four etched boards in the lower part of the instrument can be removed and reinserted into their sockets external to the structure. If necessary, the signal interconnecting leads can be extended with clip leads.

Note: When replacing a component on an etched board, be careful not to destroy the bond between board and etched wiring by excessive heat or force. Clip the defective component as close to the board as possible using diagonal cutting pliers. Remove the remaining component leads from the wiring side of the board by grasping the leads firmly and applying just enough heat to free them. Before inserting a new component, make sure that the mounting pads are clear of solder.

Power-supply test points are available at the lower rear corners of the instrument. The voltages and resistances between these test points and the chassis (ground) are tabulated in Table 7.

Note: Short circuits (resistance readings substantially lower than those tabulated) can be quickly

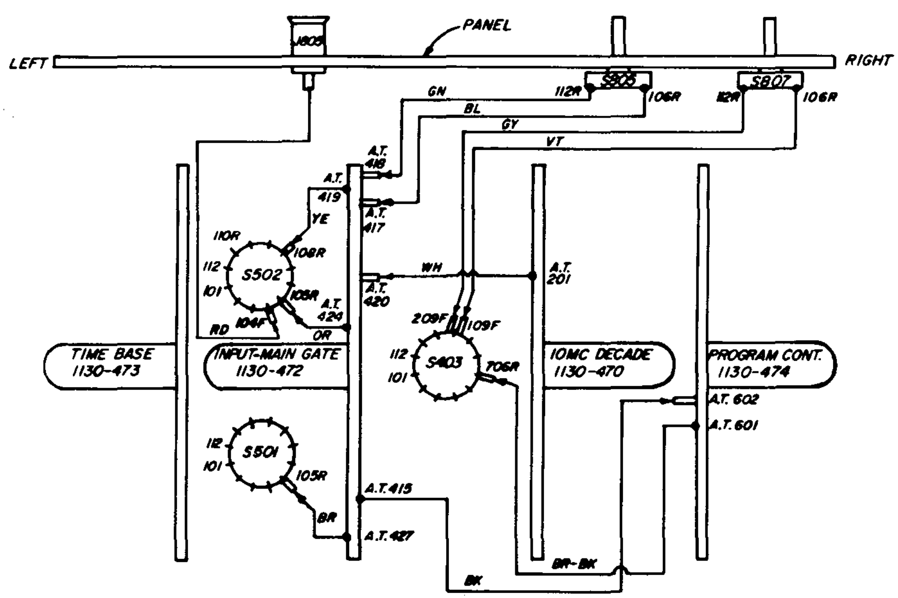


Figure 4-4. Etched board connections with interconnecting leads of the Type 1130-A, rear view.

TABLE 7. POWER SUPPLY SERVICE DATA.
(All etched boards installed.)

Test Point	Voltage to Ground	Resistance to Ground*
1130-705-2 (lower left-hand corner)		
2	+ 50 v	13 k
5	+150 v	>4 k
8	6.3 v ac	0
10	- 75 v	17 k
2 to 3	6.3 v ac	—
5 to 6	6.3 v ac	—
9 to 10	6.3 v ac	—
17 to 18	line voltage	—
19 to 20	line voltage	—
1130-705-3 (lower right-hand corner)		
1	+450 v	25 k
2	+ 65 Counting lamp on +300 Counting lamp off	200 k
3	+240	500 k
4	+300	>500 Ω
5	+225	>2 k
6	-150	>600 Ω
7	-300	20 k

* With instrument off.

localized by removal of one etched board at a time until the short circuit disappears.

Table 8 lists the various sources and loads for all the supply voltages of the instrument.

Voltage and resistance data for the various etched boards are given in the following tables on pages 32 through 53.

Etched Board	Page
Type 1130-477 Power-Supply Unit	32
Type 1130-473 Time-Base Unit	34
Type 1130-474 Program-Control Unit	36
Type 1130-472 Input/Main-Gate Unit	38
Type 1130-470 10-Mc Decade Unit	40
Type 1130-471 10-Mc Indicator Unit	43
Type 1131-P1 Decimal Counting Unit	45
Type 1131-P2 Decimal Counting Unit	47
Type 1131-P3 Decimal Counting Unit	49
Type 1131-P4 Decimal Counting Unit	51
Type 1131-P5 Transfer Unit	53

For all etched boards, the resistances are measured between the point in question and a parallel connection of all the plug connectors. This connection is easily made by insertion of a common metal strip into all the connectors.

4.6.5 NEON-LAMP FAILURES.

4.6.5.1 DCU Indicator-Lamp Failures. In trouble-shooting the DCU's one must distinguish between: (1) counting failures, in which the binary sequence of the DCU is incorrect, and the readout sequence is therefore also incorrect (the readout simply indicates the incorrect information it receives), and (2) readout failures, in which the binary sequence is correct but the readout fails to indicate correctly the information it has received. Both failures involve an incorrect readout sequence. That is, in both cases the displayed count does not progress sequentially from 0 to 9 and back to 0.

If a DCU's readout alone fails, it will still produce one carry output pulse for each 10 input pulses, and the error will not carry over into succeeding DCU's. Starting from a readout of 0 the decade will return to a readout of 0 for 10 input pulses, whatever its readout sequence may be. This is not true for counting failures.

Readout failures are of two kinds: (1) the neon lamp that should light fails to light, and, as a result, one or more of the other lamps lights (in this case the defective neon lamp is always the one that should light, but doesn't), (2) the neon lamp that should light does, but another neon lamp also goes on. This can happen at a readout of either 8 or 9 of any DCU (8 and 6, or 9 and 7 go on together). In this case the defective neon lamp is not one of the display lamps, but the readout switching lamp (V108 in the Type 1131-P1; V106 in the Type 1131-P2; V114 in the Type 1131-P3; V111 in the Type 1131-P4; V305 in the Type 1130-471).

All display lamps and the switching lamp are located behind the plastic number faceplate of the DCU. The switching lamp is at the top, above the 9.

Note: Occasional flickering of the 6 lamp when the 8 lamp lights is normal, since the switching neon lamp operates in darkness and is slow to fire after prolonged idleness. The switching lamp is idle (out) in all DCU states except 8 and 9.

4.6.5.2 Reference-Voltage Lamps (V618, V619, V755, V801, V802). Failure of the reference-voltage lamps to fire can be caused by either a defective neon lamp or defective supply voltage. All neon lamps in the Type 1130-A have at least 100 volts available for firing them. Any neon that does not fire with 90 volts or more across its terminals should be replaced. The supply voltage is defective if less than 100 volts (measured with a dc VTVM) appears across a neon lamp that should be lit.

The normal voltage drop across any neon lamp in the Type 1130-A is 50 to 60 volts when fired. Any fired lamp with more than a 60-volt drop should be replaced.

Note: All neon lamps in the Type 1130-A are operated conservatively and should operate satisfactorily for many thousands of hours. However, both the firing potential of a neon lamp and its running voltage tend to increase with age.

4.6.5.3 Trigger Generators (V613, V614, V615, V616, V620, and Feedback and Transfer Functions of Types 1131-P1 and 1131-P4). Several trigger-generating circuits in the instrument use the 15-volt step that occurs

TABLE 8. RESUME of POWER SUPPLY OUTPUTS, SOURCES, and LOADS.

Output	AC			DC			Loads
	Source	Volts	Amp	Source	Volts	Ma	
"G" Heaters (one side grounded) BR-GN (Gnd) BR-GY-GY	T701, 16-17	6.5	5	—	—	—	V203, V401, V405, V411, V501 to V512; RE701, RE702; P801 to P806; V101 in Type 1130-P2 or Type 1130-P3
"N" Heaters (centered on −75 v) BR-YE BR-BL-BL	T701, 14-15	6.5	2.5	1130-477, 1	−75	—	V201, V202, V204, V205, V206, V207, V407, and V409
"H" Heaters (set on +150 v) RD-BL (+150) BR-RD	T701, 12-13	6.5	2.5	1130-477, 7	+150	—	V402, V403, V404, V406, V410, V605, V606, V607, V753, V754
S2-S3 Heaters (set on +50 v) BR (+50 v) BR-GN-GN	T701, 22-23	6.5	10	1130-477, 15	+50	—	All tubes on Types 1131-P4, 1131-P5; V601, V602, V603, V604, V608, V609, V610, V611, V612, V408
S1-S2 Heaters (set on +50 v) BR (+50 v) BR-OR	T701, 8-9	6.5	10	1130-477, 15	+50	—	All tubes on Types 1130-471, 1131-P1, 1131-P2, 1131-P3; Also V752 Also V201, V202, V203 on Type 1130-P2 Also to Power Transformer of Type 1130-P4
+300 v Unreg RD	T701, 20-21	256	0.6	RX701, RX702, RX705, RX706 plus filter	+300	—	Type 1131-P1(2): 24 ma (12 ma each) Type 1131-P2: 20 ma Type 1131-P4(4): 48 ma (12 ma each) Type 1131-P5: 18 ma Type 1130-472: 74 or 88 (Counting) Type 1130-474: 22.5 ma Mult in Type 1130-P2: 18 ma
+225 Unreg RD-GY	—	—	—	+300 v Unreg via R704	+225	58	Type 1130-471: 12 ma Type 1131-P3: 46 ma via Type 1130-477
+450 Unreg (+150 added to +300) RD-YE-YE	T701, 10-11 T701, 10-11	71	0.15	+300 v Unreg plus RX751, RX752 and filter	+450	28	+240 Reg and +300 Gated supplies via Type 1130-477
+240 Reg RD-BK-BR	—	—	—	+450 v Unreg via V751, V752A, V753A	+240	8.5	Oscillator in Types 1130-P2, -P3, or -P4, via SO-705, 2
+300 Gated (+60 added to +240 Reg) RD-YE	—	—	—	+240 Reg, and +450 Unreg via V752B, V753B, V755	0 or +300	—	Panel COUNTING lamp V803
−150 Unreg RD-BK	T701, 26-27	72	0.5	RX703, RX704 plus filter	−150	—	Type 1130-470: 55 or 65 (Counting) Type 1130-471: 12 ma Type 1130-472: 55 ma Type 1130-474: 10 ma −300 v Unreg
−300 v Unreg (−170 added to −150 Unreg) RD-GN	T701, 29-30	61 v	0.1	−150 Unreg plus RX753, RX754 and filter	−300	—	Type 1130-470: 8.3 ma S814 2 (Panel COUNT switch)
+150	—	—	—	+300 Unreg via V754	+150	—	Type 1130-470: 15 or 17 (Counting) Type 1130-472: −7.3 or +26 ma Type 1130-473: 32 ma

in the voltage across a neon lamp when it ionizes. Defects that can cause failure in such trigger generators are:

(1) Absence of a trigger pulse. This indicates that the neon lamp is not firing. Either the lamp is defective or the applied voltage is too low.

(2) Low-amplitude trigger pulse. This indicates that the firing potential and the operating potential are too nearly equal. Replace the lamp.

(3) Trigger pulse occurs too late. The neon lamp is slow to fire after potential has been applied. This effect is aggravated by darkness and by low duty ratio (low-frequency operation). Since this failure is a random effect (most apt to happen just after the instrument is turned on), it is difficult to trace. It should be suspected in any of the failures described below:

(a) Whenever a manual reset is required for no apparent reason (that is, no switching changes are made and the instrument stops cycling occasionally), suspect V614 of the Type 1130-474 Board.

If DCU should display	But does display	Suspect
Any odd number	One less than it should	V105
9	7	V108
7	3	V107
6	2	V107
5	1	V107
7	5	V106
6	4	V106
3	1	V106

(b) If incorrect counts are occasionally displayed for CONTINUOUS operation but not for INTERMITTENT operation, suspect the lamp in the Type 1131-P4 Decimal Counting Unit which registers the incorrect count, as indicated in the table below, left.

(c) In INTERMITTENT operation, if any one of the five low-frequency DCU's (at the left-hand side of the display) occasionally exhibits either of the following incorrect counting sequences, suspect the feedback neon lamp indicated:

Counting Sequence	Suspect: Type 1131-P4	Suspect: Type 1131-P1
0-1-2-3-4-5-6-7-2-3-4	V110	V106
0-1-2-3-4-5-6-7-4-5-6	V109	V105

4.6.6 FEEDBACK FAILURES IN THE DECIMAL COUNTING UNITS. If a feedback failure occurs in any of the decimal units except the 10-Mc decade, the following behavior will be noted with the MEASUREMENT control set to CHECK:

a. All digits to the right of the defective DCU are correct.

b. The count displayed to the left of the defective DCU will be one or two counts too low.

c. The defective DCU will display an even number or a pair of even numbers instead of zero. The possible displays are: 0, 2, 4, 6, 8, 2 and 8, or 4 and 8.

d. On successive counts the defective DCU is likely to display another incorrect even number.

The cause of failure in the defective DCU may be (1) either the second or third flip-flop tube, (2) either of the two feedback neon lamps in the Types 1131-P1 and 1131-P4, or (3) either of the two feedback diodes (6887) in the Types 1131-P2 and 1131-P3.

TYPE 1130-A DIGITAL TIME AND FREQUENCY METER

PARTS LISTS AND SCHEMATICS

On the following pages appear parts lists, schematic diagrams, voltage and resistance tables, and etched-board layouts, which should prove helpful in trouble-shooting. These data are arranged by circuit as follows:

NOTES FOR PARTS LISTS

Type designations for resistors and capacitors are as follows:

COC - Capacitor, ceramic	COT - Capacitor, trimmer
COE - Capacitor, electrolytic	COW - Capacitor, wax
COL - Capacitor, oil	POSC - Potentiometer, composition
COM - Capacitor, mica	REC - Resistor, composition
COP - Capacitor, plastic	REF - Resistor, film
REPO - Resistor, power	

All resistances are in ohms, unless otherwise indicated by k (kilohms) or M (megohms).

All capacitances are in picofarads, unless otherwise indicated by μf (microfarads).

NOTE FOR SERVICE TABLES

For all etched boards, the resistances are measured between the point in question and a parallel connection of all the plug connectors. This connection is easily made by insertion of a common metal strip into all the connectors.

RESISTORS

R701	18	± 5%	10 w	REPO-44(180B)
R702	4.3 k	± 5%	10 w	REPO-44(432B)
R703	56	± 5%	10 w	REPO-44(560B)
R704	1.3 k	± 5%	10 w	REPO-44(132B)
R705	4.7	± 5%	10 w	REPO-44(047B)
R706	200	± 5%	10 w	REPO-44(201B)
R707	100	± 5%	1/2 w	REC-20BF(101B)
R708	100	± 5%	1/2 w	REC-20BF(101B)
R709	12 k	± 5%	1 w	REC-30BF(123B)
R710	13 k	± 5%	1/2 w	REC-20BF(133B)
R711	13 k	± 5%	1/2 w	REC-20BF(133B)
R751	10	± 5%	1/2 w	REC-20BF(100B)
R752	510	± 5%	1/2 w	REC-20BF(511B)
R753	33 k	± 5%	2 w	REC-41BF(333B)
R754	100 k	± 5%	2 w	REC-41BF(104B)
R755	750 k	± 5%	1/2 w	REC-20BF(754B)
R756	220 k	± 5%	1/2 w	REC-20BF(224B)
R757	680 k	± 5%	1/2 w	REC-20BF(684B)
R758	82 k	± 5%	2 w	REC-41BF(823B)
R759	16 k	± 5%	1/2 w	REC-20BF(163B)
R760	360 k	± 5%	1/2 w	REC-20BF(364B)
R761	50 k	±20%		POSC-22(503D)
R762	180 k	± 5%	1/2 w	REC-20BF(184B)
R763	240 k	± 5%	1 w	REC-30BF(244B)
R764	1.2 k	± 5%	1/2 w	REC-20BF(122B)
R765	130 k	± 5%	1/2 w	REC-20BF(134B)
R766	25 k	±20%		POSC-22(253D)
R767	180 k	± 5%	1/2 w	REC-20BF(184B)
R768	240 k	± 5%	1/2 w	REC-20BF(244B)
R769	10	± 5%	1/2 w	REC-20BF(100B)
R771	1 k	±20%		POSC-22(102D)
R772	33 k	± 5%	2 w	REC-41BF(333B)
R773	33 k	± 5%	1/2 w	REC-20BF(333B)
R774	33 k	± 5%	1/2 w	REC-20BF(333B)

CAPACITORS

C701	.01 µf	±10%	600 dcwv	COL-71(103C)
C702	.01 µf	±10%	600 dcwv	COL-71(103C)
C703A	50 µf			
C703B	25 µf		450 dcwv	COE-10
C703C	25 µf			
C704A	50 µf			
C704B	25 µf		450 dcwv	COE-10
C704C	25 µf			
C705A	50 µf			
C705B	25 µf		450 dcwv	COE-10
C705C	75 µf			

CAPACITORS (Cont)

C706A	150 µf			
C706B	75 µf		150 dcwv	COE-38
C706C	30 µf			
C707A	150 µf		150 dcwv	COE-38
C707B	75 µf			
C708A	90 µf			
C708B	30 µf		300 dcwv	COE-52
C708C	30 µf			
C709	1 µf	±10%	200 dcwv	COW-16(105C)
C710	150	±10%	500 dcwv	COM-15B(151C)
C711	150	±10%	500 dcwv	COM-15B(151C)
C751	16 µf		150 dcwv	COE-4
C752	16 µf		150 dcwv	COE-4
C753	20 µf		250 dcwv	1130-48
C754	.01 µf	±20%	500 dcwv	COC-62(103D)
C755	16 µf		150 dcwv	COE-4
C756	16 µf		150 dcwv	COE-4
C757	20 µf		250 dcwv	1130-48
C758	.01 µf	±20%	500 dcwv	COC-62(103D)

FUSES

115 v:		
F701	5 a	FUF-1
F702	5 a	FUF-1
F703		FUC-15
230 v:		
F701	2.5 a	FUF-1
F702	2.5 a	FUF-1
F703		FUC-15

MOTOR

MO-701 MOD-31

PLUGS

PL701	CDPP-10
PL707	CDMP-1275-2

RELAYS

RE701	1130-45
RE702	1130-44

RECTIFIERS

RX701	1N1695
RX702	1N1695
RX703	1N1695
RX704	1N1695

RECTIFIERS (Cont)

RX705	1N1695
RX706	1N1695
RX751	1N1695
RX752	1N1695
RX753	1N1695
RX754	1N1695

SOCKETS

SO701	CDMS-33, 20
SO702	CDMS-33, 20
SO703	1130-46
SO704	CDMS-1262-6
SO705	CDMS-33, 7
SO706	CDMS-33, 7
SO707	CDMS-1262-2

TRANSFORMER

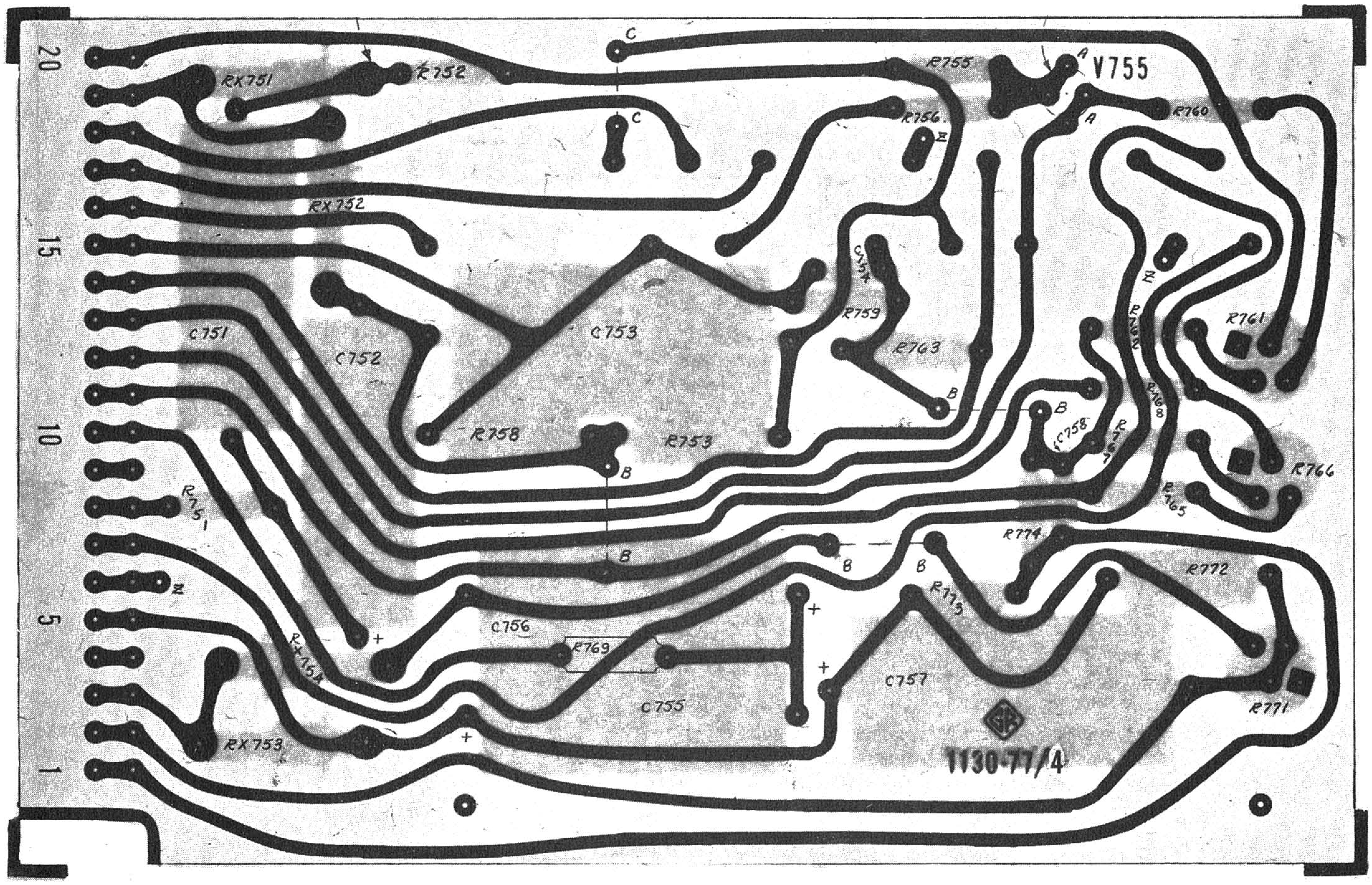
T701 565-420

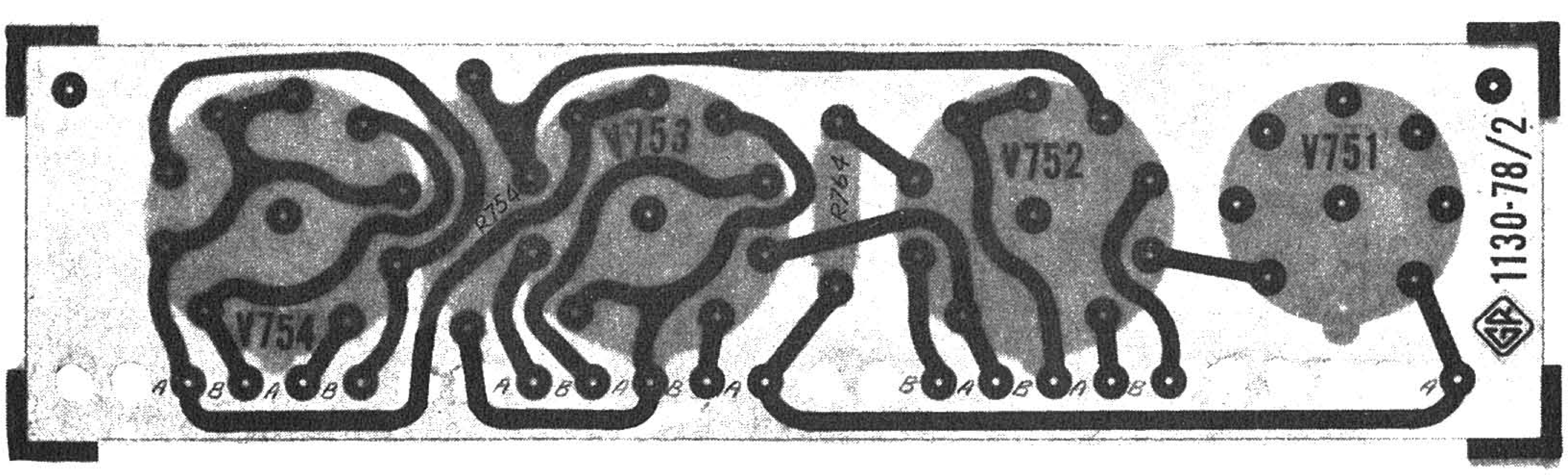
TUBES

V751	5651
V752	5965
V753	6350
V754	6350
V755	NE2

Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V751	1	+87	∞
(5651)	7	0	0
V752	1	+10(+300)	970 k
(5965)	2	+1(−11)	0
	3	+1(0)	1.2 k
	4, 5, 9	+50 ±6.3 v ac	0
	6	+230	100 k
	7	+83	135 k
	8	+87	∞
V753	1	+450	0
(6350)	2	+240	0
V753	3	+230	100 k
(6350)	4, 5, 9	+150 ±6.3 v ac	0
	6	+450	0
	7	+60(+300)	0
	8	+10(+300)	970 k
V754	1, 6	+300	0
(6350)	2, 7	+150	0
	3, 8	+140	64 k
	4, 5, 9	+150 ±6.3 v ac	0
V755	1	+300	750 k
(NE-2)	2	+240	0

Note: Voltages are measured with Main Gate open and (in parentheses) closed.


1130-77/4


V754
V753
V752
V751
1130-78/2

T701
1130-477
+450V
TO LJ19
+240V REG
TO 1130-473 & 1130-P'S
+300V REG
MAIN GATE SIG.
PL701
20 YE +450V
19 GY T701, 10
18 BR-OR S1
17 GN 1130-472, 2
16 BK GND
15 BR S2 (+50V)
14 RD-YE +300V REG (BLANKED)
13 RD-BK-BR +240V REG
12 OR-VT 1130-472, 11
11 RD +300V
10 BR-YE-BL T701, 30
8 BR-OR-YE T701, 11
7 OR-GY H1 (+150V)
6 BR-RD H2
5 RD-BK -150V
3 BR-YE-GN T701, 29
2 RD-GN -300V
1 BR-OR-GN (-75V)
+225 (58 MA) TO 1130-471 & 1131-P3
+300V
TO 1130-472, 474, AND ALL 1131-P1, P2, P3, P4
MAIN GATE BUFFER SIG.
+150V
TO 1130-470, 472, 473
-150V
TO 1130-470, 471, 472, 474
-300V
TO 1130-470 & S814 #2
-75V
+240V ADJ
-300V ADJ
POWER
OFF
S813
INPUT 115/230V 50-60C
NOTE FOR T701:
FOR 115V OPERATION CONNECT
1 TO 3 AND 2 TO 4, F701, F702 = 5 AMP
FOR 230V OPERATION CONNECT
2 TO 3, F701, F702 = 2.5 AMP

RESISTORS

R501	100 k	± 5%	1/2 w	REC-20BF(104B)
R502	100 k	± 5%	1/2 w	REC-20BF(104B)
R503	100 k	± 5%	1/2 w	REC-20BF(104B)
R504	100 k	± 5%	1/2 w	REC-20BF(104B)
R505				
R506	100 k	± 5%	1/2 w	REC-20BF(104B)
R507	68 k	± 5%	1/2 w	REC-20BF(683B)
R508	20 k	± 5%	1/2 w	REC-20BF(203B)
R509	3.9 k	± 5%	1/2 w	REC-20BF(392B)
R510	51 k	± 5%	1/2 w	REC-20BF(513B)
R511	33 k	± 5%	1/2 w	REC-20BF(333B)
R512	10 k	±20%		POSC-22(103D)
R513	25 k	±20%		POSC-22(253D)
R514	5.1 k	± 5%	1/2 w	REC-20BF(512B)
R515	5.1 k	± 5%	1/2 w	REC-20BF(512B)
R516	5.1 k	± 5%	1 w	REC-30BF(512B)
R517	1 k	± 5%	1/2 w	REC-20BF(102B)
R518	340 k	± 1%	1/4 w	REF-65(344A)
R519	330 k	± 1%	1/4 w	REF-65(334A)
R520	20 k	± 5%	1/2 w	REC-20BF(203B)
R521	20 k	± 5%	1/2 w	REC-20BF(203B)
R522				
R523	1 M	± 1%	1/8 w	REF-60(105A)
R524	1 M	± 1%	1/8 w	REF-60(105A)
R525				
R526	180 k	± 5%	1/2 w	REC-20BF(184B)
R527	180 k	± 5%	1/2 w	REC-20BF(184B)
R528				
R529	1 M	± 1%	1/8 w	REF-60(105A)
R530	1 M	± 1%	1/8 w	REF-60(105A)
R531				
R532	180 k	± 5%	1/2 w	REC-20BF(184B)
R533				
R534				
R535	1 M	± 1%	1/8 w	REF-60(105A)
R536	1 M	± 1%	1/8 w	REF-60(105A)
R537				
R538	180 k	± 5%	1/2 w	REC-20BF(184B)
R539	180 k	± 5%	1/2 w	REC-20BF(184B)
R540				
R541	1 M	± 1%	1/8 w	REF-60(105A)
R542	1 M	± 1%	1/8 w	REF-60(105A)
R543				
R544	180 k	± 5%	1/2 w	REC-20BF(184B)
R545				
R546				
R547	1 M	± 1%	1/8 w	REF-60(105A)
R548	1 M	± 1%	1/8 w	REF-60(105A)
R549				
R550	180 k	± 5%	1/2 w	REC-20BF(184B)
R551	180 k	± 5%	1/2 w	REC-20BF(184B)
R552				
R553	180 k	± 5%	1/2 w	REC-20BF(184B)
R554	1.5 M	± 5%	1/2 w	REC-20BF(155B)
R555	180 k	± 5%	1/2 w	REC-20BF(184B)
R556	1.5 M	± 5%	1/2 w	REC-20BF(155B)
R557	1 M	± 5%	1/2 w	REC-20BF(105B)
R558	62 k	± 5%	1/2 w	REC-20BF(623B)
R559	62 k	± 5%	1/2 w	REC-20BF(623B)
R560	1 M	± 5%	1/2 w	REC-20BF(105B)
R561	1.3 M	± 1%	1/8 w	REF-60(135A)
R562	180 k	± 5%	1/2 w	REC-20BF(184B)
R563	180 k	± 5%	1/2 w	REC-20BF(184B)
R564	1 M	± 1%	1/8 w	REF-60(105A)
R565	91 k	± 5%	1/2 w	REC-20BF(913B)
R566	30 k	± 5%	1/2 w	REC-20BF(303B)
R567	30 k	± 5%	1/2 w	REC-20BF(303B)
R568	100 k	± 5%	1/2 w	REC-20BF(104B)
R827	10 k	± 5%	1/2 w	REC-20BF(103B)

CAPACITORS

C501	.01 µf	±20%	500 dcwv	COC-62(103D)
C502	470	±20%	500 dcwv	COC-60(471D)
C503	.001 µf	±20%	500 dcwv	COC-60(102D)
C504	10	± 5%	500 dcwv	COM-15C(100B)

CAPACITORS (Cont)

C505	470	±20%	500 dcwv	COC-60(471D)
C506	.001 µf	±20%	500 dcwv	COC-60(102D)
C507	30	± 5%	500 dcwv	COM-15C(300B)
C508				
C509	470	±20%	500 dcwv	COC-60(471D)
C510	.001 µf	±20%	500 dcwv	COC-60(102D)
C511	22	±10%	500 dcwv	COM-15B(220C)
C512	10	± 5%	500 dcwv	COC-1(100B)
C513	.01 µf	±20%	500 dcwv	COC-62(103D)
C514	470	± 5%	500 dcwv	COM-15D(471B)
C515	.001 µf	±20%	500 dcwv	COC-60(102D)
C516	47	± 5%	500 dcwv	COM-15D(470B)
C517	47	± 5%	500 dcwv	COM-15D(470B)
C518	18	± 5%	500 dcwv	COM-15C(180B)
C519	.01 µf	±20%	500 dcwv	COC-62(103D)
C520	15	± 5%	500 dcwv	COM-15C(150B)
C521	.01 µf	±20%	500 dcwv	COC-62(103D)
C522	30	± 1%	500 dcwv	COM-15E(300A)
C523	30	± 1%	500 dcwv	COM-15E(300A)
C524	5.6	± 5%	500 dcwv	COC-1(056B)
C525	4.3	± 5%	500 dcwv	COC-1(043B)
C526	10	± 5%	500 dcwv	COM-15C(100B)
C527	100	± 1%	500 dcwv	COM-15E(101A)
C528	100	± 1%	500 dcwv	COM-15E(101A)
C529	.01 µf	±20%	500 dcwv	COC-62(103D)
C530	3	± 5%	500 dcwv	COC-1(030B)
C531	3.6	± 5%	500 dcwv	COC-1(036B)
C532	10	± 5%	500 dcwv	COM-15C(100B)
C533	.001 µf	± 1%	500 dcwv	COM-20E(102A)
C534	.001 µf	± 1%	500 dcwv	COM-20E(102A)
C535	3.6	± 5%	500 dcwv	COC-1(036B)
C536	3.3	± 5%	500 dcwv	COC-1(033B)
C537	10	± 5%	500 dcwv	COM-15C(100B)
C538	.01 µf	± 1%	300 dcwv	COM-35E(103A)
C539	.01 µf	± 1%	300 dcwv	COM-35E(103A)
C540	3.9	± 5%	500 dcwv	COC-1(039B)
C541	2.4	± 5%	500 dcwv	COC-1(024B)
C542	.01 µf	±20%	500 dcwv	COC-62(103D)
C543	10	± 5%	500 dcwv	COM-15C(100B)
C544	0.1 µf	± 1%	200 dcwv	COP-24(104A)
C545	0.1 µf	± 1%	200 dcwv	COP-24(104A)
C546	4.3	± 5%	500 dcwv	COC-1(043B)
C547	2.2	± 5%	500 dcwv	COC-1(022B)
C548	10	± 5%	500 dcwv	COM-15C(100B)
C549	1 µf	± 1%	200 dcwv	COP-24(105A)
C550	1 µf	± 1%	200 dcwv	COP-24(105A)
C551	10	± 5%	500 dcwv	COM-15C(100B)
C552	10	± 5%	500 dcwv	COM-15C(100B)
C553	0.01 µf	±20%	500 dcwv	COC-62(104D)
C554	10	± 5%	500 dcwv	COC-1(100B)
C555	1 µf	± 1%	200 dcwv	COP-24(105A)
C556	1 µf	± 1%	200 dcwv	COP-24(105A)
C557	.01 µf	±20%	500 dcwv	COC-62(103D)

DIODES

CR501	1N191	CR503	1N628
CR502	1N191	CR504	1N628

INDUCTORS

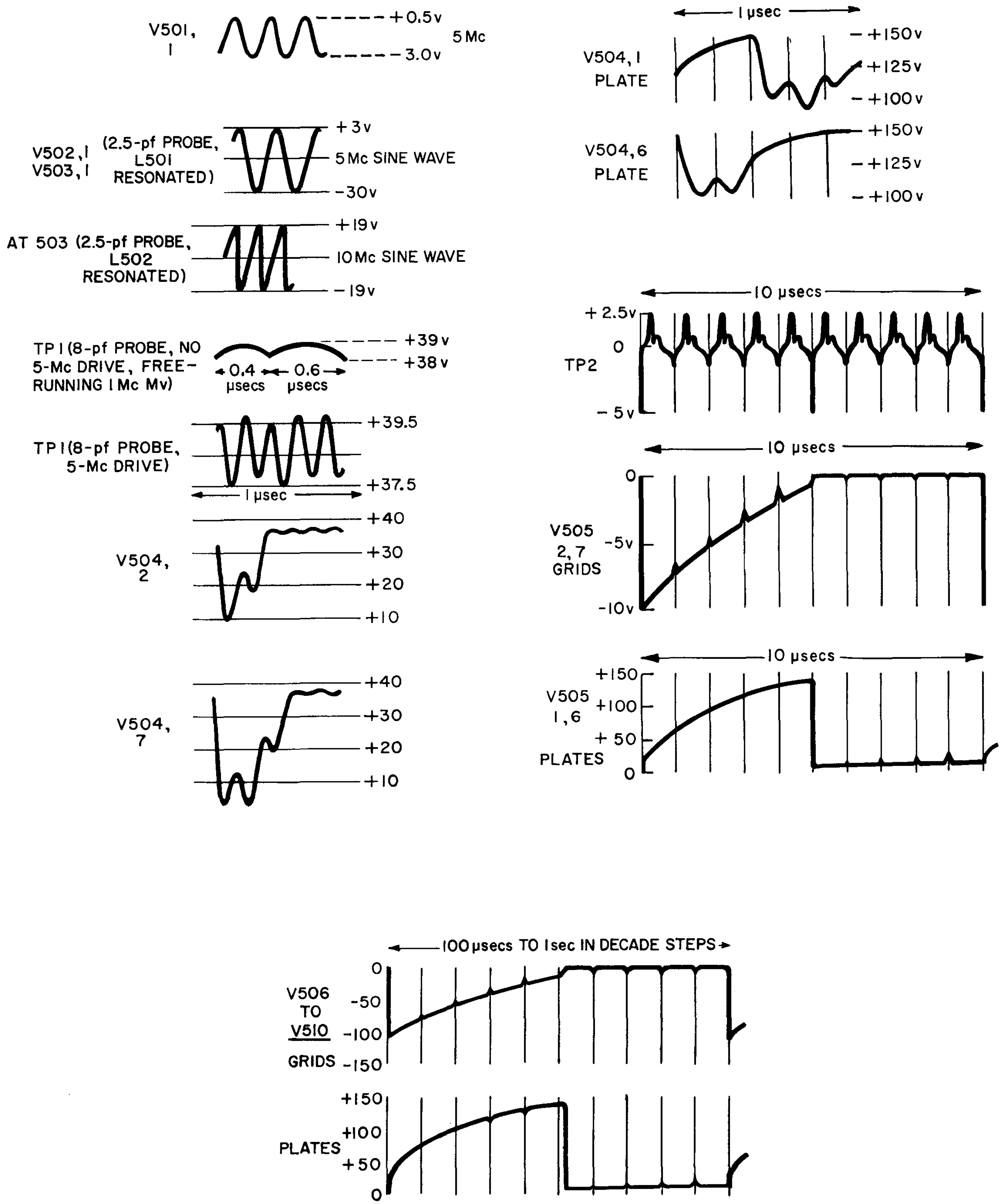
L501	22-29.5 µh		CHA-59-7
L502			1130-206
L503	22-29.5 µh		CHA-59-7
L504	560 µh	±10%	CHM-6
L505	560 µh	±10%	CHM-6

SWITCHES

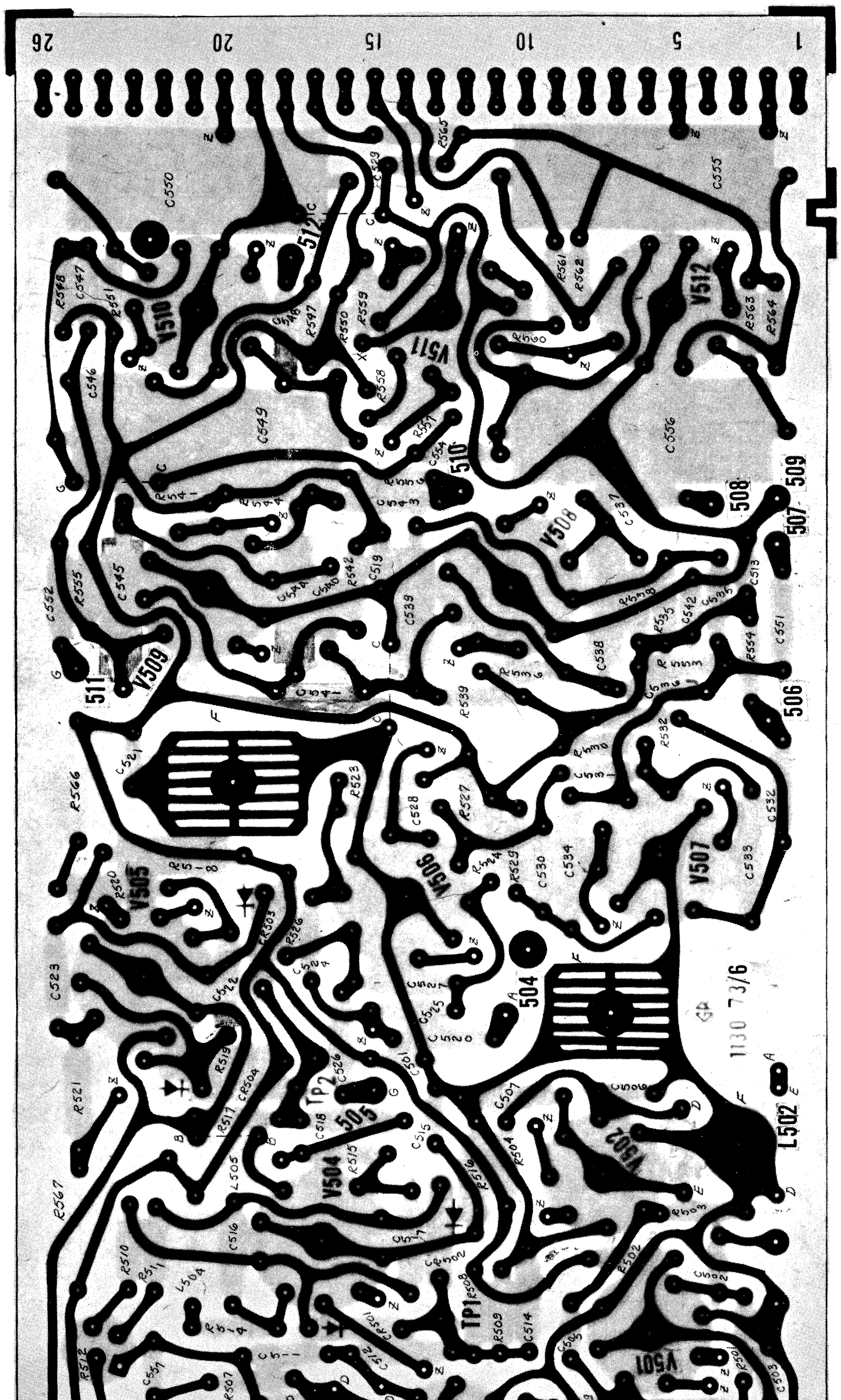
S501	SWRW-205	S502	SWRW-206

TUBES

V501	6AU6	V507	5963
V502	6AU6	V508	5963
V503	6AU6	V509	5963
V504	6922	V510	5963
V505	6922	V511	5963
V506	5963	V512	5963


V501, 1
+0.5v
3.0v
5 Mc
V502, 1
V503, 1
(2.5-pf PROBE, L501 RESONATED)
+3v
5 Mc SINE WAVE
-30v
AT 503 (2.5-pf PROBE, L502 RESONATED)
+19v
10 Mc SINE WAVE
-19v
TP1 (8-pf PROBE, NO 5-Mc DRIVE, FREE-RUNNING 1 Mc Mv)
+39v
+38v
0.4 μsecs
0.6 μsecs
TP1 (8-pf PROBE, 5-Mc DRIVE)
+39.5
+37.5
1 μsec
V504, 2
+40
+30
+20
+10
V504, 7
+40
+30
+20
+10
1 μsec
V504, 1 PLATE
+150v
+125v
+100v
V504, 6 PLATE
+150v
+125v
+100v
10 μsecs
TP2
+2.5v
0
-5v
10 μsecs
V505 2, 7 GRIDS
0
-5v
-10v
10 μsecs
V505 1, 6 PLATES
+150
+100
+50
0
100 μsecs TO 1 sec IN DECADE STEPS
V506 TO V510 GRIDS
0
-50
-100
-150
PLATES
+150
+100
+50
0

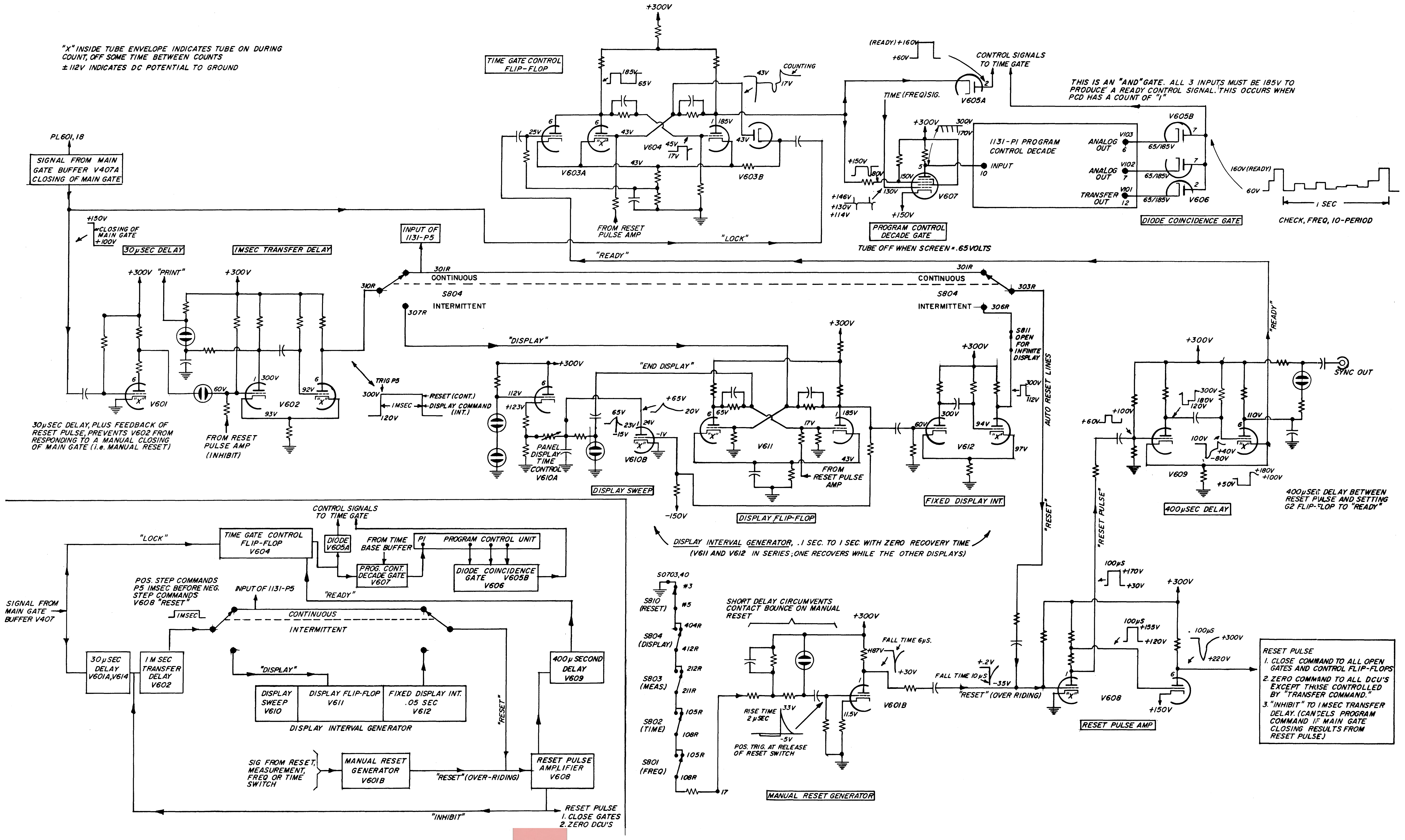
Tube (Type)	Pin	Volts to Ground	Res to Shorted PL501	Ohmmeter Data
V501	1	-1	100 k	
(6AU6)	2, 7	0	0	
	3	6.3 v ac	0	
	4	0	0	
	5	+32	100 k	
	6	+32	100 k	
V502	1	-9	100 k	
(6AU6)	2, 7	0	0	
	3	6.3 v ac	0	
	4	0	0	
	5	+40	100 k	
	6	+40	100 k	
V503	1	-9	100 k	
(6AU6)	2, 7	0	0	
	3	6.3 v ac	0	
	4	0	0	
	5	+53	68 k	
	6	+53	68 k	
V504	1	+133	5.1 k	
(6922)	2	+28.5	approx. 50 k	x 1000(-)
			5.3 k	x 1000(+)
	3, 8	+34	5.1 k	
	4	6.3 v ac	0	
	5	0	0	
	6	+133	5.1 k	
	7	+28.5	approx. 50 k	x 1000(-)
			5.3 k	x 1000(+)
V505	1	+42	47 k	
(6922)	2	-17	approx. 10 k	x 1000(-)
			approx. 175 k	x 1000(+)
	3, 8	0	0	
	4	0	0	
	5	6.3 v ac	0	
	6	+42	47 k	
	7	-17	approx. 10 k	x 1000(-)
			approx. 175 k	x 1000 (+)
V506	1	+48	180 k	
(5963)	2	-18	1 M	
	3, 8	0	0	
	4, 5	6.3 v ac	0	
	6	+48	180 k	
	7	-18	1 M	
	9	0	0	
V507, V508,	1	+55	180 k	
V509	2	-34	1 M	
(5963)	3, 8	0	0	
	4, 5	0	0	
	6	+55	180 k	
	7	-34	1 M	
	9	6.3 v ac	0	
V510	1	+55 Average	180 k	
(5963)	2	-33 Average	1 M	
	3, 8	0	0	
	4, 5	6.3 v ac	0	
	6	+55 Average	180 k	
	7	-33 Average	1 M	
	9	0	0	
V511	1	+90 Average	0	
(5963)	2	-25 Average	2 M	
	3, 8	0	0	
	4, 5	6.3 v ac	0	
	6	+90 Average	0	
	7	-25 Average	2.4 M	
	9	0	0	
V512	1, 6	+55 Average	271 k	
(5963)	2	-33 Average	1.4 M	
	3, 8	0	0	
	4, 5	6.3 v ac	0	
	7	-33 Average	1.09 M	
	9	0	0	



NOTES:

1. SWITCH SHOWN IN COUNTERCLOCKWISE POSITION
2. CONTACT NUMBERING OF SWITCH EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN THE INSTRUCTION BOOK FOR VOLTAGES APPEARING ON THE DIAGRAM AND ALSO FOR THE D-C RESISTANCE OF IRON CORED INDUCTORS
4. RESISTORS 1/2 WATT UNLESS OTHERWISE SPECIFIED
5. RESISTANCE IN OHMS UNLESS OTHERWISE SPECIFIED K=1000 OHMS M=1MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICRO-MICROFARADS (PICOFARADS). LESS THAN ONE MICROFARADS UNLESS OTHERWISE SPECIFIED
7. ⊘ SCREWDRIVER ADJUSTMENTS

ANCHOR TERMINALS USED: A.T. 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513
TEST POINTS USED: TP1, TP2



TYPE 1130-474 PROGRAM-CONTROL UNIT

RESISTORS

R601	10 M	± 5%	1/2 w	REC-20BF(106B)
R602	2 M	± 5%	1/2 w	REC-20BF(205B)
R603	75 k	± 5%	1/2 w	REC-20BF(753B)
R604	300 k	± 5%	1/2 w	REC-20BF(304B)
R605	300 k	± 5%	1/2 w	REC-20BF(304B)
R606	1 M	± 1%	1/4 w	REF-65(105A)
R607	267 k	± 1%	1/8 w	REF-60(2673A)
R608	130 k	± 5%	1/2 w	REC-20BF(134B)
R609	62 k	± 5%	1/2 w	REC-20BF(623B)
R610	6.2 M	± 5%	1/2 w	REC-20BF(625B)
R611	120 k	± 5%	1 w	REC-30BF(124B)
R612	6.8 k	± 5%	1/2 w	REC-20BF(682B)
R613	68 k	± 5%	1 w	REC-30BF(683B)
R614	240 k	± 5%	1/2 w	REC-20BF(244B)
R615	100 k	± 5%	1/2 w	REC-20BF(104B)
R616	24 k	± 5%	1 w	REC-30BF(243B)
R617	8.2 k	± 5%	1/2 w	REC-20BF(822B)
R618	11 k	± 5%	1/2 w	REC-20BF(113B)
R619	240 k	± 5%	1/2 w	REC-20BF(244B)
R620	100 k	± 5%	1/2 w	REC-20BF(104B)
R621	68 k	± 5%	1 w	REC-30BF(683B)
R622	6.8 k	± 5%	1/2 w	REC-20BF(682B)
R623	1.2 M	± 5%	1/2 w	REC-20BF(125B)
R624	7.5 M	± 5%	1/2 w	REC-20BF(755B)
R625	47 k	± 5%	1/2 w	REC-20BF(473B)
R626	680 k	± 5%	1/2 w	REC-20BF(684B)
R627	6.8 M	± 5%	1/2 w	REC-20BF(685B)
R628	91 k	± 5%	1/2 w	REC-20BF(913B)
R629	470 k	± 5%	1/2 w	REC-20BF(474B)
R630	120 k	± 5%	1/2 w	REC-20BF(124B)
R631	13 k	± 5%	1/2 w	REC-20BF(133B)
R632	470 k	± 5%	1/2 w	REC-20BF(474B)
R633	470 k	± 5%	1/2 w	REC-20BF(474B)
R634	2.4 M	± 5%	1/2 w	REC-20BF(245B)
R635	15 k	± 5%	2 w	REC-41BF(153B)
R636	15 k	± 5%	2 w	REC-41BF(153B)
R637	12 k	± 5%	2 w	REC-41BF(123B)
R638	2 k	± 5%	2 w	REC-41BF(202B)
R639	2 k	± 5%	2 w	REC-41BF(202B)
R640	560 k	± 5%	1/2 w	REC-20BF(564B)
R641	1 M	± 1%	1/4 w	REF-65(105A)
R642	267 k	± 1%	1/8 w	REF-60(2673A)
R643	120 k	± 5%	1/2 w	REC-20BF(124B)
R644	62 k	± 5%	1/2 w	REC-20BF(623B)
R645	2.7 M	± 5%	1/2 w	REC-20BF(275B)
R646	130 k	± 5%	1 w	REC-30BF(134B)
R647	510 k	± 5%	1/2 w	REC-20BF(514B)
R648	510 k	± 5%	1/2 w	REC-20BF(514B)
R649	910 k	± 5%	1/2 w	REC-20BF(914B)
R650	30 k	± 5%	1 w	REC-30BF(303B)
R651	390 k	± 5%	1/2 w	REC-20BF(394B)
R652	68 k	± 5%	1/2 w	REC-20BF(683B)
R653	2.2 M	± 5%	1/2 w	REC-20BF(225B)
R654	68 k	± 5%	1 w	REC-30BF(683B)
R655	240 k	± 5%	1/2 w	REC-20BF(244B)
R656	100 k	± 5%	1/2 w	REC-20BF(104B)
R657	24 k	± 5%	1 w	REC-30BF(243B)
R658	20 k	± 5%	1/2 w	REC-20BF(203B)
R659	240 k	± 5%	1/2 w	REC-20BF(244B)
R660	100 k	± 5%	1/2 w	REC-20BF(104B)
R661	68 k	± 5%	1 w	REC-30BF(683B)
R662	1.8 M	± 5%	1/2 w	REC-20BF(185B)
R663	1 M	± 1%	1/4 w	REF-65(105A)

RESISTORS (Cont)

R664	267 k	± 1%	1/8 w	REF-60(2673A)
R665	120 k	± 5%	1/2 w	REC-20BF(124B)
R666	62 k	± 5%	1/2 w	REC-20BF(623B)
R667	3.9 M	± 5%	1/2 w	REC-20BF(395B)
R668	120 k	± 5%	1 w	REC-30BF(124B)
R709	12 k	± 5%	1 w	REC-30BF(123B)
R814	3 k	± 5%	1/2 w	REC-20BF(302B)
R817	15 k	± 5%	2 w	REC-41BF(153B)
R819	5 M	±20%	part of 1130-43	
R826	1 k	± 5%	1/2 w	REC-20BF(102B)

CAPACITORS

C601	100	± 5%	500 dcwv	COM-15D(101B)
C602	220	± 5%	500 dcwv	COM-15D(221B)
C603	680	± 5%	300 dcwv	COM-20D(681B)
C604	100	± 5%	500 dcwv	COM-15D(101B)
C605	68	± 5%	500 dcwv	COM-15D(680B)
C606	.01 μf	±20%	500 dcwv	COC-62(103D)
C607	.01 μf	±20%	500 dcwv	COC-62(103D)
C608	68	± 5%	500 dcwv	COM-15D(680B)
C609	47	± 5%	500 dcwv	COM-15D(470B)
C610	.022 μf	±10%	400 dcwv	COW-25(222C)
C611	.001 μf	± 5%	300 dcwv	COM-20D(102B)
C612	220	± 5%	500 dcwv	COM-15D(221B)
C613	150	± 5%	500 dcwv	COM-15D(151B)
C614	0.1 μf	±10%	400 dcwv	COW-25(104C)
C615	.022 μf	±10%	600 dcwv	COL-71(222C)
C616	.01 μf	±20%	500 dcwv	COC-62(103D)
C617	680	± 5%	300 dcwv	COM-20D(681B)
C618	.001 μf	± 5%	300 dcwv	COM-20D(102B)
C619	220	± 5%	500 dcwv	COM-15D(221B)
C620	220	± 5%	500 dcwv	COM-15D(221B)
C621	68	± 5%	500 dcwv	COM-15D(680B)
C622	.01 μf	±20%	500 dcwv	COC-62(103D)
C623	47	± 5%	500 dcwv	COM-15D(470B)
C624	68	± 5%	500 dcwv	COM-15D(680B)
C625	47	± 5%	500 dcwv	COM-15D(470B)
C626	.047	±10%	400 dcwv	COW-25(473C)
C627	.0047 μf	±20%	500 dcwv	COC-62(472D)
C809	2.2 μf	±10%	200 dcwv	COW-16(224C)
C813	.01 μf	±20%	500 dcwv	COC-62(103D)

DIODES

D601	1N453
D602	1N450

JACKS

J801	BP-5
J802	BP-5

SWITCHES

S804	SWRW-222
S810	SWT-11A
S811	part of 1130-43
S812	SWT-10

TUBES

V601	5963
V602	5963
V603	5963
V604	5963

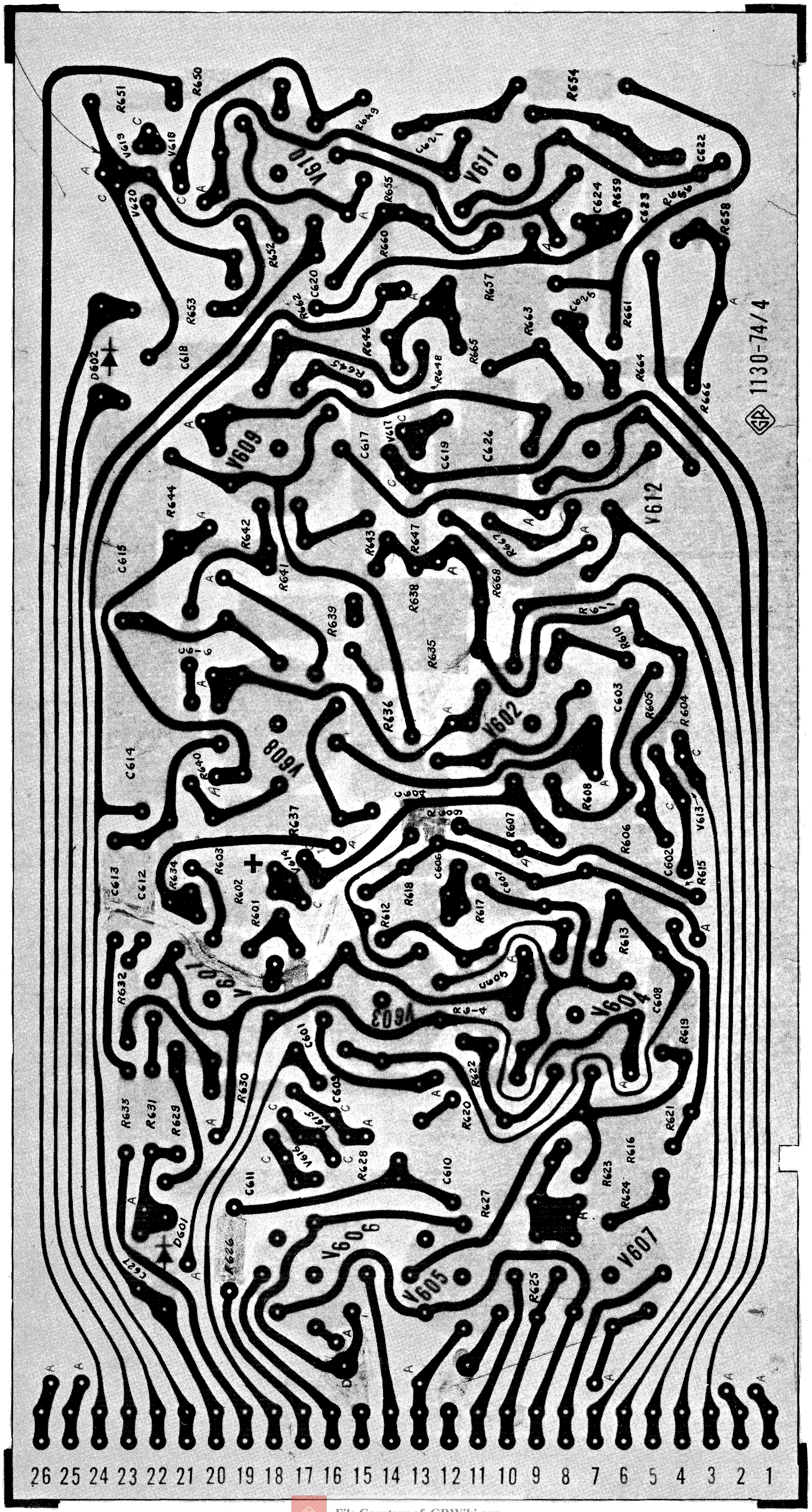
TUBES (Cont)

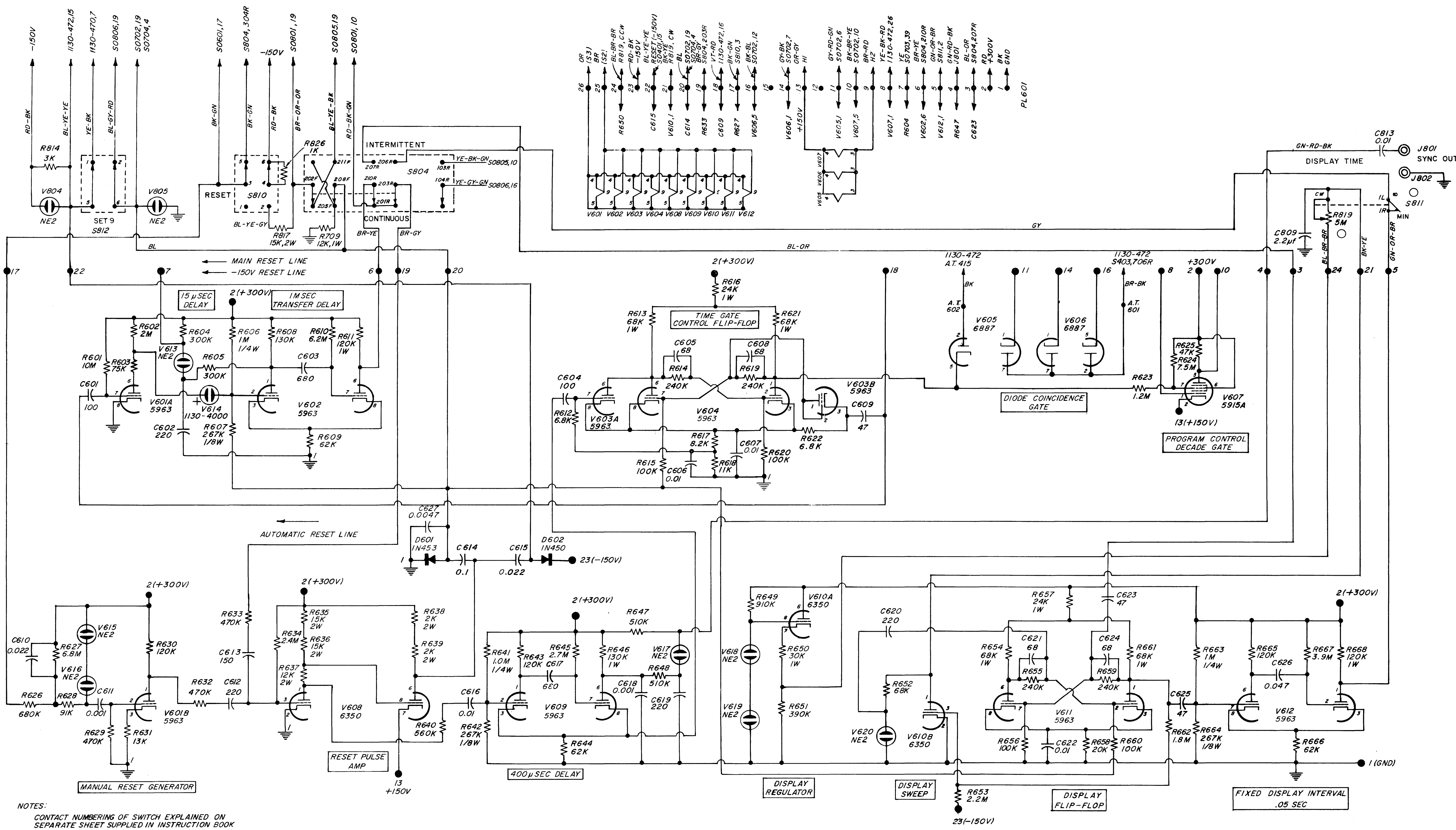
V605	6887
V606	6887
V607	5915A
V608	6350
V609	5963
V610	6350
V611	5963
V612	5963
V613	NE2
V614	1130-4000
V615	NE2
V616	NE2
V617	NE2
V618	NE2
V619	NE2
V620	NE2
V804	NE2
V805	NE2

Tube (Type)	Pin	Res to Shorted PL601
V601 (5963)	1	120 k
	2	470 k
	3	13 k
	4, 5, 9	0
	6	2 M
	7	10 M
	8	0
V602 (5963)	1	130 k
	2	210 k
	3	62 k
	4, 5, 9	0
	6	0
	7	6.2 M
	8	62 k
V603 (5963)	1	80 k
	2	80 k
	3	26 k
	4, 5, 9	0
	6	75 k
	7	17.8 k
	8	19.2 k
V604 (5963)	1	72 k
	2	78 k
	3, 8	19.2 k
	4, 5, 9	0
	6	72 k
	7	78 k
V605 (6887)	1	0
	2	OPEN
	3, 4	0
	5	72 k
	7	OPEN

Tube (Type)	Pin	Res to Shunted PL601
V606 (6887)	1	0
	2	OPEN
	3, 4	0
	5	0
	7	OPEN
V607 (5915)	1	0
	2	0
	3, 4	0
	5	0
	6, 7	0
V608 (6350)	1	42 k
	2	0
	3	2.4 M
	4, 5, 9	0
	6	4 k
	7	0
	8	30 k
V609 (5963)	1	120 k
	2	210 k
	3, 8	62 k
	4, 5, 9	0
	6	130 k
	7	2.7 M
V610 (6350)	1	0
	2	0
	3	2.2 M
	4, 5, 9	0
	6	0
	7	30 k
	8	910 k
V611 (5963)	1	75 k
	2	80 k

Tube (Type)	Pin	Res to Shorted PL601
V611 (5963) (Cont)	3, 8	20 k
	4, 5, 9	0
	6	75 k
	7	80 k
V612 (5963)	1	0
	2	3.9 M
	3, 8	62 k
	4, 5, 9	0
	6	120 k
	7	210 k
V613 (NE-2)	1	0
	2	430 k
V614 (1130-4000)	1	2 M
	2	210 k
V615 (NE-2)	1	0
	2	OPEN
V616 (NE-2)	1	OPEN
	2	700 k
V617 (NE-2)	1	0
	2	640 k
V618 (NE-2)	1	910 k
	2	OPEN
V619 (NE-2)	1	OPEN
	2	0
V620 (NE-2)	1	68 k
	2	0

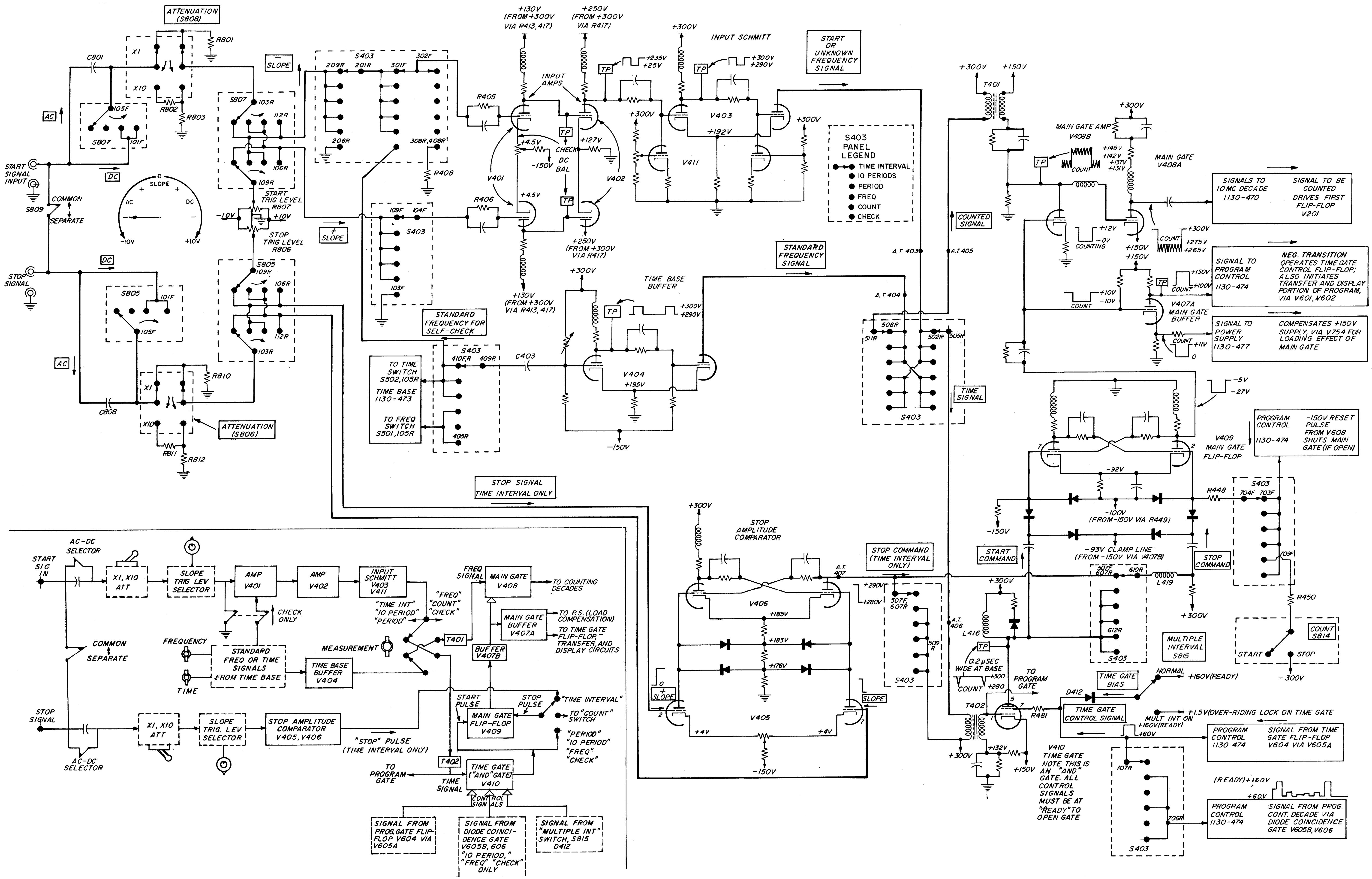

1130-74/4
26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1



NOTES:

CONTACT NUMBERING OF SWITCH EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK

REFER TO SERVICE NOTES IN THE INSTRUCTION BOOK FOR VOLTAGES APPEARING ON THE DIAGRAM


ATTENUATION (S808)
R801
C801
X1
X10
R802
R803
S807
105F
101F
AC
DC
START SIGNAL INPUT
S809
COMMON
SEPARATE
SLOPE
-10V
+10V
STOP SIGNAL
S805
ATTENUATION (S806)
C808
R810
R811
R812
START TRIG LEVEL R807
STOP TRIG LEVEL R806
- SLOPE
+ SLOPE
S403
209R
201R
301F
302F
206R
308R,408R
R408
109F
104F
103F
103R
112R
106R
109R
105F
STANDARD FREQUENCY FOR SELF-CHECK
TO TIME SWITCH S502,105R
TIME BASE 1130-473
TO FREQ SWITCH S501,105R
410F,R
409R
405R
C403
+130V (FROM +300V VIA R413,417)
+250V (FROM +300V VIA R417)
INPUT AMPS
R405
R406
V401
V402
TP
CHECK
DC BAL
+4.5V
-150V
+127V
+250V (FROM +300V VIA R417)
+130V (FROM +300V VIA R413, 417)
+300V
INPUT SCHMITT
+235V
+25V
+300V
+290V
V403
+192V
V411
START OR UNKNOWN FREQUENCY SIGNAL
S403 PANEL LEGEND
TIME INTERVAL
10 PERIODS
PERIOD
FREQ
COUNT
CHECK
STANDARD FREQUENCY SIGNAL
TIME BASE BUFFER
V404
+195V
-150V
STOP SIGNAL TIME INTERVAL ONLY
A.T. 403
A.T. 405
A.T. 404
COUNTED SIGNAL
TIME SIGNAL
508R
511R
502R
505R
T401
+150V
MAIN GATE AMP V408B
+148V
+142V
+137V
+131V
MAIN GATE V408A
COUNTING
SIGNALS TO 10 MC DECADE 1130-470
SIGNAL TO BE COUNTED DRIVES FIRST FLIP-FLOP V201
+275V
+265V
SIGNAL TO PROGRAM CONTROL 1130-474
NEG. TRANSITION OPERATES TIME GATE CONTROL FLIP-FLOP; ALSO INITIATES TRANSFER AND DISPLAY PORTION OF PROGRAM, VIA V601, V602
V407A MAIN GATE BUFFER
SIGNAL TO POWER SUPPLY 1130-477
COMPENSATES +150V SUPPLY, VIA V754 FOR LOADING EFFECT OF MAIN GATE
-5V
-27V
V409 MAIN GATE FLIP-FLOP
PROGRAM CONTROL 1130-474
-150V RESET PULSE FROM V608 SHUTS MAIN GATE (IF OPEN)
-92V
R448
704F
703F
-100V (FROM -150V VIA R449)
-93V CLAMP LINE (FROM -150V VIA V407B)
START COMMAND
STOP COMMAND
709F
R450
COUNT S814
START
STOP
-300V
STOP AMPLITUDE COMPARATOR
V406
+185V
+183V
+176V
V405
+4V
-150V
STOP COMMAND (TIME INTERVAL ONLY)
A.T. 407
+290V
+280V
507F, 607R
509R
A.T. 406
L416
607F
610R
L419
612R
MULTIPLE INTERVAL S815
0.2 µSEC WIDE AT BASE
TO PROGRAM GATE
TIME GATE BIAS
NORMAL
+160V(READY)
D412
T402
R481
TIME GATE CONTROL SIGNAL
MULT INT ON
+1.5V(OVER-RIDING LOCK ON TIME GATE
PROGRAM CONTROL 1130-474
SIGNAL FROM TIME GATE FLIP-FLOP V604 VIA V605A
+132V
V410 TIME GATE NOTE: THIS IS AN "AND" GATE. ALL CONTROL SIGNALS MUST BE AT "READY" TO OPEN GATE
707R
706R
(READY)+160V
+60V
SIGNAL FROM PROG. CONT. DECADE VIA DIODE COINCIDENCE GATE V605B,V606
START SIG IN
AC-DC SELECTOR
X1, X10 ATT
SLOPE TRIG LEV SELECTOR
AMP V401
AMP V402
INPUT SCHMITT V403 V411
FREQ SIGNAL
MAIN GATE V408
TO COUNTING DECADES
CHECK ONLY
"FREQ" "COUNT" "CHECK"
"TIME INT" "10 PERIOD" "PERIOD"
T401
MAIN GATE BUFFER V407A
TO P.S. (LOAD COMPENSATION)
TO TIME GATE FLIP-FLOP TRANSFER AND DISPLAY CIRCUITS
FREQUENCY
STANDARD FREQ OR TIME SIGNALS FROM TIME BASE
TIME BASE BUFFER V404
MEASUREMENT
BUFFER V407B
TIME
START PULSE
STOP PULSE
MAIN GATE FLIP-FLOP V409
"TIME INTERVAL"
TO "COUNT" SWITCH
"PERIOD" "10 PERIOD" "FREQ" "CHECK"
STOP SIGNAL
STOP AMPLITUDE COMPARATOR V405, V406
"STOP" PULSE (TIME INTERVAL ONLY)
T402
TO PROGRAM GATE
TIME SIGNAL
TIME GATE ("AND" GATE) V410
CONTROL SIGNALS
SIGNAL FROM PROG.GATE FLIP-FLOP V604 VIA V605A
SIGNAL FROM DIODE COINCIDENCE GATE V605B, 606 "10 PERIOD," "FREQ" "CHECK" ONLY
SIGNAL FROM "MULTIPLE INT" SWITCH, S815 D412

RESISTORS

R401	100	± 5%	1/2 w	REC-20BF(101B)
R402	100	± 5%	1/2 w	REC-20BF(101B)
R403	100	± 5%	1/2 w	REC-20BF(101B)
R404	100	± 5%	1/2 w	REC-20BF(101B)
R405	100 k	± 5%	1/2 w	REC-20BF(104B)
R406	100 k	± 5%	1/2 w	REC-20BF(104B)
R407	15 k	± 5%	5 w	REPO-43(153B)
R408	100 k	± 5%	1/2 w	REC-20BF(104B)
R409	1.3 k	± 5%	1/2 w	REC-20BF(132B)
R410	1.3 k	± 5%	1/2 w	REC-20BF(132B)
R411	100	±20%		POSC-22(101D)
R412	15 k	± 5%	5 w	REPO-43(153B)
R413	11 k	± 5%	5 w	REPO-43(113B)
R414	10 k	± 5%	1/2 w	REC-20BF(103B)
R415	10 k	± 5%	1/2 w	REC-20BF(103B)
R416	1.3 k	± 5%	1/2 w	REC-20BF(132B)
R417	2.2 k	± 5%	5 w	REPO-43(222B)
R418	270 k	± 5%	1/2 w	REC-20BF(274B)
R419	100 k	± 5%	1/2 w	REC-20BF(104B)
R420	200 k	± 5%	1/2 w	REC-20BF(204B)
R421	50 k	±20%		POSC-22(503D)
R422	75 k	± 5%	1/2 w	REC-20BF(753B)
R423	100 k	± 5%	1/2 w	REC-20BF(104B)
R424	10 k	± 5%	1/2 w	REC-20BF(103B)
R425	680	± 5%	1/2 w	REC-20BF(681B)
R426	200 k	± 5%	1/2 w	REC-20BF(204B)
R427	16 k	± 5%	5 w	REPO-43(163B)
R428	100 k	± 5%	1/2 w	REC-20BF(104B)
R429	240 k	± 5%	1/2 w	REC-20BF(244B)
R430	240 k	± 5%	1/2 w	REC-20BF(244B)
R431	100 k	± 5%	1/2 w	REC-20BF(104B)
R432	820	± 5%	1/2 w	REC-20BF(821B)
R433	150 k	± 5%	1/2 w	REC-20BF(154B)
R434	1.1 k	± 5%	1/2 w	REC-20BF(112B)
R435	30 k	± 5%	1 w	REC-30BF(303B)
R436	1.2 k	± 5%	1/2 w	REC-20BF(122B)
R437	16 k	± 5%	1/2 w	REC-20BF(163B)
R438	2.32 k	± 1%	1/2 w	REF-70(2321A)
R439	1 k	± 1%	1/4 w	REF-65(102A)
R440	220 k	± 5%	1/2 w	REC-20BF(224B)
R441	1.3 k	± 1%	1/4 w	REF-65(132A)
R442	33.2 k	± 1%	1/2 w	REF-70(3322A)
R443	33.2 k	± 1%	1/2 w	REF-70(3322A)
R444	100	± 5%	1/2 w	REC-20BF(101B)
R445	100	± 5%	1/2 w	REC-20BF(101B)
R446	560	± 5%	1/2 w	REC-20BF(561B)
R447	20 k	± 1%	1/4 w	REF-65(203A)
R448	20 k	± 1%	1/4 w	REF-65(203A)
R449	4.99 k	± 1%	1/2 w	REF-70(4991A)
R450	33 k	± 5%	1 w	REC-30BF(333B)
R451	5.1 k	± 5%	1 w	REC-30BF(512B)
R452	150 k	± 5%	1/2 w	REC-20BF(154B)
R453	1.2 k	± 5%	1/2 w	REC-20BF(122B)
R454	100 k	± 5%	1/2 w	REC-20BF(104B)
R455	130 k	± 5%	1/2 w	REC-20BF(134B)
R456	50 k	±20%		POSC-22(503D)
R457	910	± 5%	1/2 w	REC-20BF(911B)
R458	100 k	± 5%	1/2 w	REC-20BF(104B)
R459	16 k	± 5%	5 w	REPO-43(163B)
R460	200 k	± 5%	1/2 w	REC-20BF(204B)
R461	150 k	± 5%	1/2 w	REC-20BF(154B)
R462	13 k	± 5%	5 w	REPO-43(133B)
R463	470	± 5%	1/2 w	REC-20BF(471B)
R464	18.2 k	± 1%	1 w	REF-75(1822A)
R465	18.2 k	± 1%	1 w	REF-75(1822A)
R466	1.5 k	± 5%	1 w	REC-30(152B)
R467	100	± 5%	1/2 w	REC-20BF(101B)
R468	120	± 5%	1/2 w	REC-20BF(121B)
R469	100	± 5%	1/2 w	REC-20BF(101B)
R470	330	± 5%	1/2 w	REC-20BF(331B)
R471	100	±20%		POSC-22(101D)
R472	91 k	± 5%	1/2 w	REC-20BF(913B)
R473	10 k	±20%		POSC-22(103D)
R474	47 k	± 5%	1/2 w	REC-20BF(473B)
R475	3.3 k	± 5%	2 w	REC-41BF(332B)
R476	150 k	± 5%	1/2 w	REC-20BF(154B)
R477	15 k	± 5%	1/2 w	REC-20BF(153B)
R478	330	± 5%	1/2 w	REC-20BF(331B)
R479	8.2 k	± 5%	1/2 w	REC-20BF(822B)
R480	2.2 M	± 5%	1/2 w	REC-20BF(225B)
R481	100 k	± 5%	1/2 w	REC-20BF(104B)
R482	4.7 k	± 5%	1/2 w	REC-20BF(472B)
R483	4.7 k	± 5%	1/2 w	REC-20BF(472B)
R484	100	± 5%	1/2 w	REC-20BF(101B)
R485	1.5 M	± 5%	1/2 w	REC-20BF(155B)
R486	160 k	± 5%	1/2 w	REC-20BF(164B)
R487	12 k	± 5%	5 w	REPO-43(123B)
R488	300 k	± 5%	1/2 w	REC-20BF(304B)
R489	220 k	± 5%	1/2 w	REC-20BF(224B)
R490	1.5 k	± 5%	1/2 w	REC-30BF(152B)
R491	4.7 k	± 5%	1/2 w	REC-20BF(472B)
R492	100 k	± 5%	1/2 w	REC-20BF(104B)
R801	1 M	± 5%	1/2 w	REC-20BF(105B)
R802	910 k	± 5%	1/2 w	REC-20BF(914B)
R803	100 k	± 5%	1/2 w	REC-20BF(104B)
R804	620 k	± 5%	1/2 w	REC-20BF(624B)
R805	510 k	± 5%	1/2 w	REC-20BF(514B)
R806	500 k	±10%		1130-42(504C)
R807	500 k	±10%		1130-42(504C)
R808	510 k	± 5%	1/2 w	REC-20BF(514B)
R809	620 k	± 5%	1/2 w	REC-20BF(624B)
R810	1 M	± 5%	1/2 w	REC-20BF(105B)

RESISTORS (Cont)

R811	910 k	± 5%	1/2 w	REC-20BF(914B)
R812	100 k	± 5%	1/2 w	REC-20BF(104B)
R813	7.5 M	± 5%	1/2 w	REC-20BF(755B)
R821	910 k	± 5%	1/2 w	REC-20BF(914B)
R822	10 M	± 5%	1/2 w	REC-20BF(106B)
R823	18 k	± 5%	1/2 w	REC-20BF(183B)
R825	1.2 k	± 5%	1/2 w	REC-20BF(122B)

CAPACITORS

C401	.01 µf	±20%	500 dcwv	COC-62(103D)
C402	.01 µf	±20%	500 dcwv	COC-62(103D)
C403	.01 µf	±20%	500 dcwv	COC-62(103D)
C404	.01 µf	±20%	500 dcwv	COC-62(103D)
C405	.01 µf	±20%	500 dcwv	COC-62(103D)
C406	.01 µf	±20%	500 dcwv	COC-62(103D)
C407	.01 µf	±20%	500 dcwv	COC-62(103D)
C408	560	± 5%	300 dcwv	COM-20D(561B)
C409	.01 µf	±20%	500 dcwv	COC-62(103D)
C410	22	± 5%	500 dcwv	COM-15C(220B)
C411	22	± 5%	500 dcwv	COM-15C(220B)
C412	.01 µf	±20%	500 dcwv	COC-62(103D)
C413	.01 µf	±20%	500 dcwv	COC-62(103D)
C414	33	± 5%	500 dcwv	COM-15C(330B)
C415	47	± 5%	500 dcwv	COM-15D(470B)
C416	220	± 5%	500 dcwv	COM-15C(221B)
C417	18	± 5%	500 dcwv	COM-15C(180B)
C418	100	± 5%	500 dcwv	COM-15D(101B)
C419	.01 µf	±20%	500 dcwv	COC-62(103D)
C420	15	± 5%	500 dcwv	COM-15C(150B)
C421	10	± 5%	500 dcwv	COM-15C(100B)
C422	10	± 5%	500 dcwv	COM-15C(100B)
C423	.01 µf	±20%	500 dcwv	COC-62(103D)
C424	.01 µf	±20%	500 dcwv	COC-62(103D)
C425	.0022 µf	±20%	500 dcwv	COC-61(221D)
C426	.01 µf	±20%	500 dcwv	COC-62(103D)
C427	.01 µf	±20%	500 dcwv	COC-62(103D)
C428	.01 µf	±20%	500 dcwv	COC-62(103D)
C429	.01 µf	±20%	500 dcwv	COC-62(103D)
C430	.01 µf	±20%	500 dcwv	COC-62(103D)
C431	.01 µf	±20%	500 dcwv	COC-62(103D)
C432	.0022 µf	±20%	500 dcwv	COC-61(221D)
C433	.001 µf	±20%	500 dcwv	COC-60(102D)
C434	.01 µf	±20%	500 dcwv	COC-62(103D)
C435	5.6	± 5%	500 dcwv	COC-1(056B)
C801	.01 µf	±20%	500 dcwv	COC-62(103D)
C802	5-20			COT-18
C804	0.1 µf	+80-20%	50 dcwv	COC-63-3(104D)
C805	0.1 µf	+80-20%	50 dcwv	COC-63-3(104D)
C806	5-20			COT-18
C807	220	± 5%	500 dcwv	COM-15D(221B)
C808	.01 µf	±20%	500 dcwv	COC-62(103D)
C810	.01 µf	±20%	500 dcwv	COC-62(103D)
C811	5.1	± 5%	500 dcwv	COC-1(051B)
C814	.01 µf	±20%	500 dcwv	COC-62(103D)

DIODES

D401	1N191	D405	1N191	D409	1N191
D402	1N191	D406	1N191	D410	1N191
D403	1N191	D407	1N191	D411	1N191
D404	1N191	D408	1N191	D412	1N1695

INDUCTORS

L401	10 µh	±10%	CHM-1
L402	10 µh	±10%	CHM-1
L403	10 µh	±10%	CHM-1
L404	10 µh	±10%	CHM-1
L405	10 µh	±10%	CHM-1
L406	3.3 µh	±10%	CHM-1
L407	12 µh	±10%	CHM-1
L408	10 µh	±10%	CHM-1
L409	10 µh	±10%	CHM-1
L410	47 µh	±10%	CHM-3
L411	47 µh	±10%	CHM-3
L412			
L413			
L414	1 µh	±10%	CHM-1
L416	82 µh	±10%	CHM-3
L417	10 µh	±10%	CHM-1
L419	56 µh	±10%	CHM-3

JACKS

J803	BP-5	J808	874-6990
J804	BP-5	J809	874-4514
J807	874-4514	J810	874-6990

SWITCHES

S403	SWRW-2150	S808	SWT-335
S805	SWRW-223	S809	SWT-323
S806	SWT-335	S814	SWT-333
S807	SWRW-223	S815	SWT-9

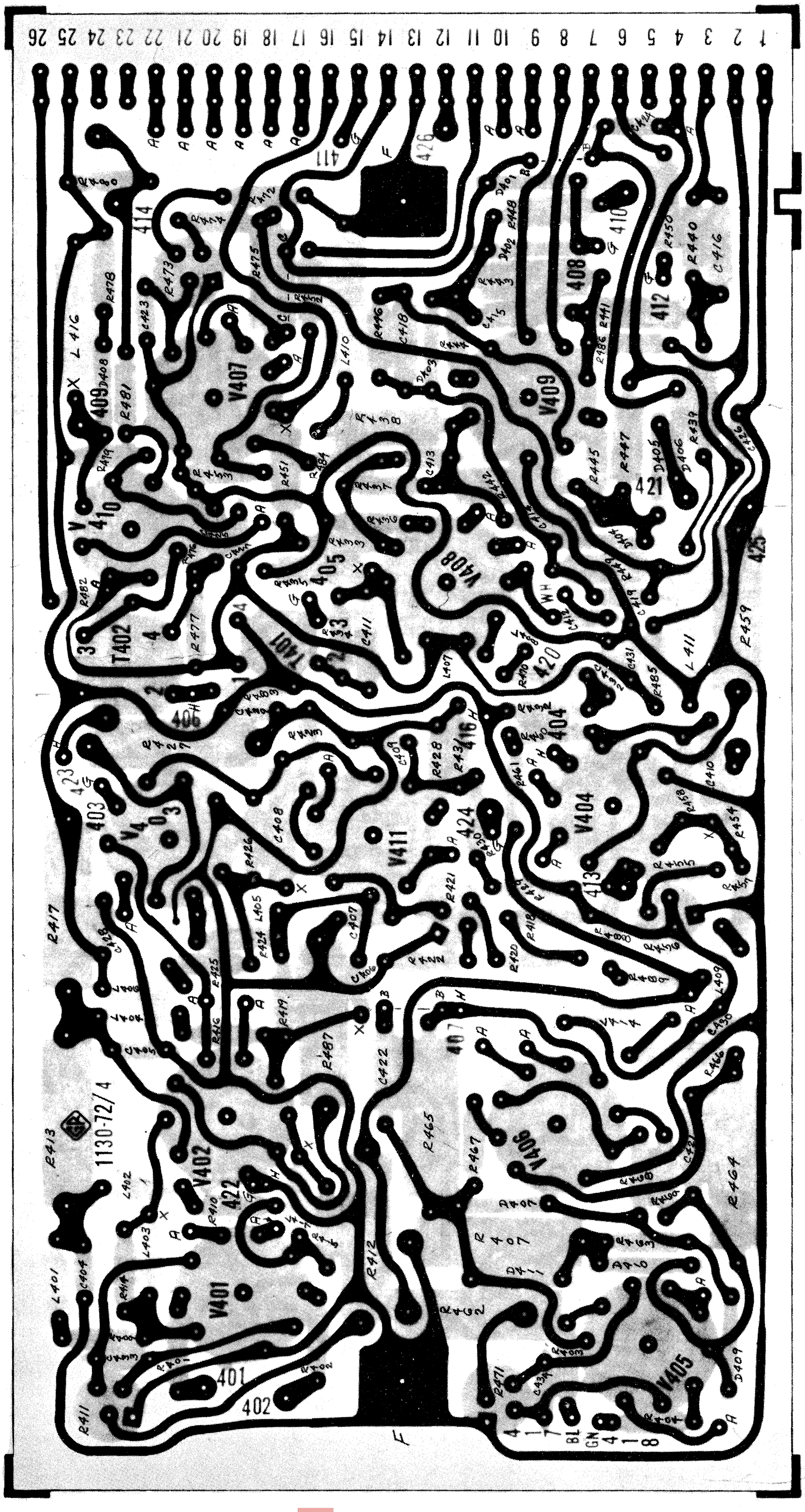
TRANSFORMERS

T401	1130-401	T402	1130-402

TUBES

V401	6922	V408	6922
V402	6922	V409	6922
V403	6922	V410	5915
V404	6922	V411	12AX7
V405	5965	V801	NE2
V406	6922	V802	NE2
V407	6922		

Tube (Type)	Pin	S403	Res to Shorted PL401	Ohmmeter Data
V401 (6922)	1		14.5 k	
	2	CHECK	100 k	
	3		15 k	
	4, 5		0	
	6		14.5 k	
	7	CHECK	200 k	
	8		15 k	
V402 (6922)	1		2.2 k	
	2		14.5 k	
	3, 8		12 k	
	4, 5		0	
	6		3.5 k	
	7		14.5 k	
V403 (6922)	1		680	
	2		103 k	
	3, 8		16 k	
	4, 5		0	
	6	CHECK	<1	
	6	PERIOD	5	
	7		200 k	
V404 (6922)	1		910	
	2		115 k	
	3, 8		18 k	
	4, 5		0	
	6	CHECK	5	
	6	PERIOD	<1	
	7		78 k	
V405 (5965)	1	TIME INT	8.5 k	
	2		Open	
	3, 8		13 k	
	4, 5, 9		0	
	6	TIME INT	8.5 k	
	7		Open	
V406 (6922)	1		1.4 k	
	2	TIME INT	8.5 k	
	3, 8	TIME INT	8.6 k	
	4, 5	0		
	6	TIME INT	1.4 k	
	7	TIME INT	8.5 k	
V407 (6922)	1		0	
	2		34 k	
	3		0	
	4, 5		0	
	6		0	
	7		16.5 k	
	8		1.2 k	
V408 (6922)	1		1.1 k	
	2		16.5 k	
	3		1.2 k	
	4, 5		0	
	6		0	
	7		16.6 k	
	8		0	
V409 (6922)	1, 6		2.2 k	
	2, 7	CHECK	4.8 k	x 1000 (+)
	2, 7	CHECK	5.2 k	x 1000 (–)
	3, 8		3.9 k	x 1000 (+)
	3, 8		5.3 k	x 1000 (–)
	4, 5		0	
V410 (5915)	1		3.6 k	
	2		0	
	3, 4		0	
	5		2	
	6		8.2 k	
V411 (12AX7)	1		200 k	
	2		83 k	
	3		100 k	
	4, 5, 9		0	
	6		103 k	
	7		100 k	
	8		100 k	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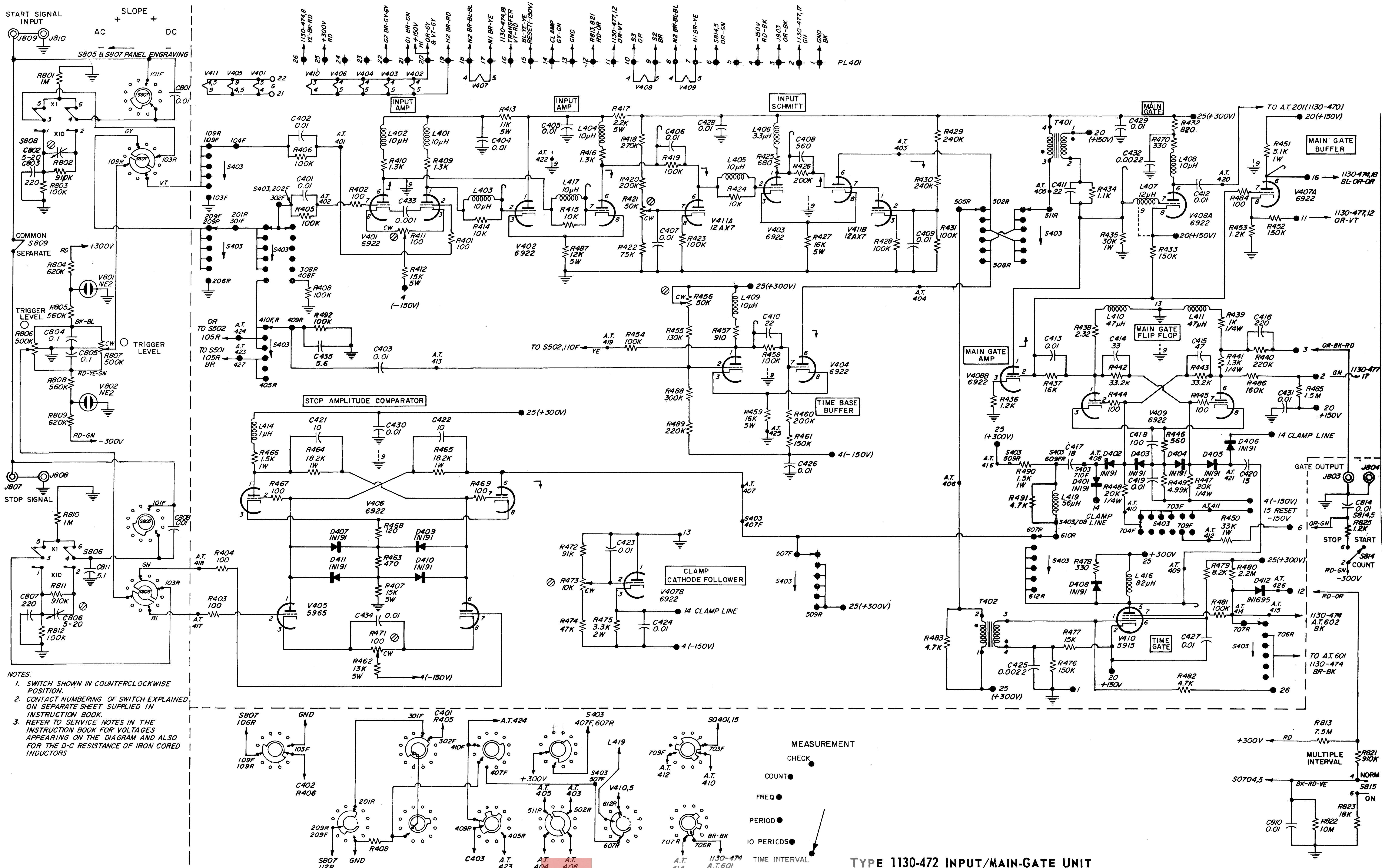


NOTES:
1. SWITCH SHOWN IN COUNTERCLOCKWISE POSITION.
2. CONTACT NUMBERING OF SWITCH EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN THE INSTRUCTION BOOK FOR VOLTAGES APPEARING ON THE DIAGRAM AND ALSO FOR THE D-C RESISTANCE OF IRON CORED INDUCTORS

TYPE 1130-472 INPUT/MAIN-GATE UNIT

RESISTORS

R201	51 k	± 5%	1/2 w	REC-20BF(513B)
R202	680	± 5%	1/2 w	REC-20BF(681B)
R203	30.1 k	± 1%	1/2 w	REF-70(3012A)
R204	100	± 5%	1/2 w	REC-20BF(101B)
R205	30.1 k	± 1%	1/2 w	REF-70(3012A)
R206	100	± 5%	1/2 w	REC-20BF(101B)
R207	680	± 5%	1/2 w	REC-20BF(681B)
R208	51 k	± 5%	1/2 w	REC-20BF(513B)
R209	430	± 5%	1/2 w	REC-20BF(431B)
R210	3.3 k	± 5%	1 w	REC-30BF(332B)
R211	100 k	± 1%	1/8 w	REF-60(104A)
R212	154 k	± 1%	1/8 w	REF-60(1543A)
R213	29.4 k	± 1%	1/2 w	REF-70(2942A)
R214	29.4 k	± 1%	1/2 w	REF-70(2942A)
R215	154 k	± 1%	1/8 w	REF-60(1543A)
R216	100 k	± 1%	1/8 w	REF-60(104A)
R217	390	± 5%	1/2 w	REC-20BF(391B)
R218	150 k	± 5%	1/2 w	REC-20BF(154B)
R219	4.3 k	± 5%	1/2 w	REC-20BF(432B)
R220	30 k	± 5%	1/2 w	REC-20BF(303B)
R221	330	± 5%	1/2 w	REC-20BF(331B)
R222	360 k	± 5%	1/2 w	REC-20BF(364B)
R223	8.2 k	± 5%	1/2 w	REC-20BF(822B)
R224	100 k	± 5%	1/2 w	REC-20BF(104B)
R225	100 k	± 5%	1/2 w	REC-20BF(104B)
R226	2.32 k	± 1%	1/4 w	REF-65(2321A)
R227	33.2 k	± 1%	1/2 w	REF-70(3322A)
R228	100	± 5%	1/2 w	REC-20BF(101B)
R229	33.2 k	± 1%	1/2 w	REF-70(3322A)
R230	100	± 5%	1/2 w	REC-20BF(101B)
R231	2.32 k	± 1%	1/4 w	REF-65(2321A)
R232	110 k	± 5%	1/2 w	REC-20BF(114B)
R233	910 k	± 5%	1/2 w	REC-20BF(914B)
R234	110 k	± 5%	1/2 w	REC-20BF(114B)
R235	560	± 5%	1/2 w	REC-20BF(561B)
R236	2 k	± 5%	1/2 w	REC-20BF(202B)
R237	20 k	± 1%	1/4 w	REF-65(203A)
R238	5.11 k	± 1%	1/2 w	REF-70(5111A)
R239	20 k	± 1%	1/4 w	REF-65(203A)
R240	100 k	± 5%	1/2 w	REC-20BF(104B)
R241	100 k	± 5%	1/2 w	REC-20BF(104B)
R242	2.32 k	± 1%	1/4 w	REF-65(2321A)
R243	33.2 k	± 1%	1/2 w	REF-70(3322A)
R244	100	± 5%	1/2 w	REC-20BF(101B)
R245	33.2 k	± 1%	1/2 w	REF-70(3322A)
R246	100	± 5%	1/2 w	REC-20BF(101B)
R247	2.32 k	± 1%	1/4 w	REF-65(2321A)
R248	110 k	± 5%	1/2 w	REC-20BF(114B)
R249	110 k	± 5%	1/2 w	REC-20BF(114B)
R250	910 k	± 5%	1/2 w	REC-20BF(914B)
R251	560	± 5%	1/2 w	REC-20BF(561B)
R252	2.2 k	± 5%	1/2 w	REC-20BF(222B)
R253	20 k	± 1%	1/4 w	REF-65(203A)
R254	5.11 k	± 1%	1/2 w	REF-70(511A)
R255	20 k	± 1%	1/4 w	REF-65(203A)
R256	51 k	± 5%	1/2 w	REC-20BF(513B)
R257	2.32 k	± 1%	1/4 w	REF-65(2321A)
R258	33.2 k	± 1%	1/2 w	REF-70(3322A)
R259	100	± 5%	1/2 w	REC-20BF(101B)
R260	33.2 k	± 1%	1/2 w	REF-70(3322A)
R261	100	± 5%	1/2 w	REC-20BF(101B)
R262	2.32 k	± 1%	1/4 w	REF-65(2321A)
R263	160 k	± 5%	1/2 w	REC-20BF(164B)
R264	51 k	± 5%	1/2 w	REC-20BF(513B)
R265	560	± 5%	1/2 w	REC-20BF(561B)
R266	2.2 k	± 5%	1/2 w	REC-20BF(222B)
R267	20 k	± 1%	1/4 w	REF-65(203A)
R268	5.11 k	± 1%	1/2 w	REF-70(5111A)
R269	20 k	± 1%	1/4 w	REF-65(203A)
R270	2.2 k	± 5%	1/2 w	REC-20BF(222B)
R271	510	± 5%	1/2 w	REC-20BF(511B)
R272	150 k	± 5%	1/2 w	REC-20BF(154B)
R273	5.6 k	± 5%	1/2 w	REC-20BF(562B)
R274	1.5 k	± 5%	1/2 w	REC-20BF(152B)

RESISTORS (Cont)

R275	1200	± 5%	1/2 w	REC-20BF(122B)
R276	10 k	± 5%	1/2 w	REC-20BF(103B)
R277	10 k	± 5%	1/2 w	REC-20BF(103B)
R278	10 k	± 5%	1/2 w	REC-20BF(103B)
R279	56	± 5%	1/2 w	REC-20BF(560B)

CAPACITORS

C201	100	± 5%	500 dcwv	COM-15D(101B)
C202	100	± 5%	500 dcwv	COM-15D(101B)
C203	100	± 5%	500 dcwv	COM-15D(101B)
C204	.01 µf	±20%	500 dcwv	COC-62(103D)
C205	.01 µf	±20%	500 dcwv	COC-62(103D)
C206	.01 µf	±20%	500 dcwv	COC-62(103D)
C207	.001 µf	±20%	500 dcwv	COC-60(102D)
C208	68	± 5%	500 dcwv	COM-15C(680B)
C209	.022 µf	±20%	500 dcwv	COC-63(222D)
C210	39	± 5%	500 dcwv	COM-15C(390B)
C211	47	±20%	500 dcwv	COC-60(470D)
C212	100	± 5%	500 dcwv	COC-63-2(101B)
C213	15	± 5%	500 dcwv	COM-15C(150B)
C214	15	± 5%	500 dcwv	COM-15C(150B)
C215	100	± 5%	500 dcwv	COM-15D(101B)
C216	.01 µf	±20%	500 dcwv	COC-62(103D)
C217	22	± 5%	500 dcwv	COM-15C(220B)
C218	15	± 5%	500 dcwv	COM-15C(150B)
C219	27	± 5%	500 dcwv	COM-15C(270B)
C220	100	± 5%	500 dcwv	COM-15D(101B)
C221	.01 µf	±20%	500 dcwv	COC-62(103D)
C222	27	± 5%	500 dcwv	COM-15C(270B)
C223	39	± 5%	500 dcwv	COM-15D(390B)
C224	100	± 5%	500 dcwv	COM-15D(101B)
C225	.01 µf	±20%	500 dcwv	COC-62(103D)
C226	39	± 5%	500 dcwv	COM-15C(390B)
C227	20	± 5%	500 dcwv	COM-15C(200B)
C228	.01 µf	±20%	500 dcwv	COC-62(103D)
C229	470	± 5%	500 dcwv	COM-15D(471B)
C230	.01 µf	±20%	500 dcwv	COC-62(103D)
C231	.01 µf	±20%	500 dcwv	COC-62(103D)
C232	.022 µf	±20%	500 dcwv	COC-63(222D)
C233	2.2	±10%	500 dcwv	COC-1(022C)
C234	22	± 5%	500 dcwv	COM-15C(220B)

DIODES

D201	1N191	D208	1N191	D215	1N191
D202	1N191	D209	1N191	D216	1N191
D203	1N191	D210	1N191	D217	1N191
D204	1N191	D211	1N191	D218	1N191
D205	1N191	D212	1N191	D219	1N191
D206	1N191	D213	1N191	D220	1N191
D207	1N191	D214	1N191	D221	1N191

INDUCTORS

L201	15 µh	±10%	CHM-1
L202	22 µh	±10%	CHM-1
L203	4.7 µh	±10%	CHM-1
L204	27 µh	±10%	CHM-2
L205	22 µh	±10%	CHM-1
L206	22 µh	±10%	CHM-1
L207	22 µh	±10%	CHM-1
L208	22 µh	±10%	CHM-1
L210	33 µh	±10%	CHM-2
L211	22 µh	±10%	CHM-1
L212	39 µh	±10%	CHM-2
L213	3.3 µh	±10%	CHM-1
L214	1000 µh	±10%	CHM-6

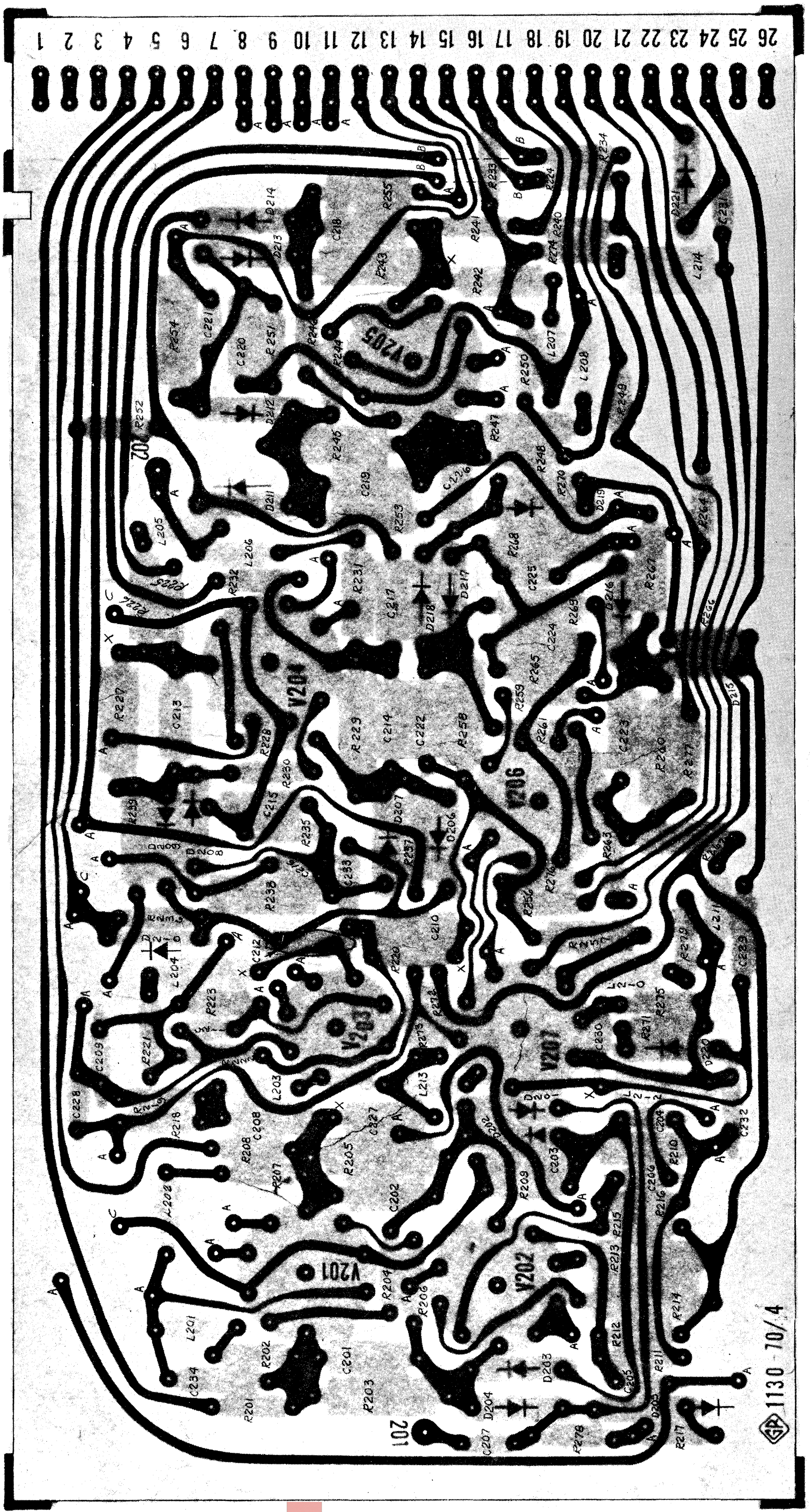
TUBES

V201	6922
V202	12AT7
V203	5915
V204	6922
V205	6922
V206	6922
V207	6922

Tube (Type)	Pin	Volts to Ground	Res to Shorted PL201	Ohmmeter Data
V201 (6922)	1	-2(-12)	640	
	2	-103(-98)	5.3 k	x 1000 (+)
			5.1 k	x 1000 (-)
	3, 8	-97	3.8 k	x 1000 (+)
			3.2 k	x 1000 (-)
	4, 5	-75 ±6.3 v ac	0	
	6	-12(-2)	640	
	7	-98(-103)	5.3 k	x 1000 (+)
			5.1 k	x 1000 (-)
V202 (12AT7)	1	-103(-98)	5.2 k	x 1000 (+)
			5.0 k	x 1000 (-)
	2	-209	61 k	
	3	-211	29.4 k	
	4, 5, 9	-75 ±6.3 v ac		
	6	-98(-103)	5.2 k	x 1000 (+)
			5.0 k	x 1000 (-)
	7	-209	61 k	
	8	-211	29.4 k	
V203 (5915)	1	-4.3	4.2 k	
	2	0	0	

Tube (Type)	Pin	Volts to Ground	Res to Shorted PL201	Ohmmeter Data
V203 (5915) (Cont)	3	6.3 v ac	0	
	4	0		
	5	+149	330	
	6	+88	8.2 k	
	7	0(-14)	29 k	
V204, V205, V206 (6922)	1	-6(-30)	2.2 k	
	2	-103(-98)	5.2 k	x 1000 (+)
			3.7 k	x 1000 (-)
	3, 8	-97.5	5.3 k	x 1000 (+)
			3.6 k	x 1000 (-)
	4, 5	-75 ±6.3 v ac	0	
	6	-30(-6)	2.2 k	
	7	-98(-103)	5.2 k	x 1000 (+)
			3.7 k	x 1000 (-)
V207 (6922)	1	0	0	
	2	-156	5.4 k	
	3	-150	0	
	4, 5	-75 ±6.3 v ac	0	
	6	+140	1.5 k	
	7	-0.7(-0.2)	0	
	8	+3.0	560	

Notes: Driven by 1-cps signal.
Resistance measured with Weston Model 980 (20,000 Ω/v) on ranges as specified.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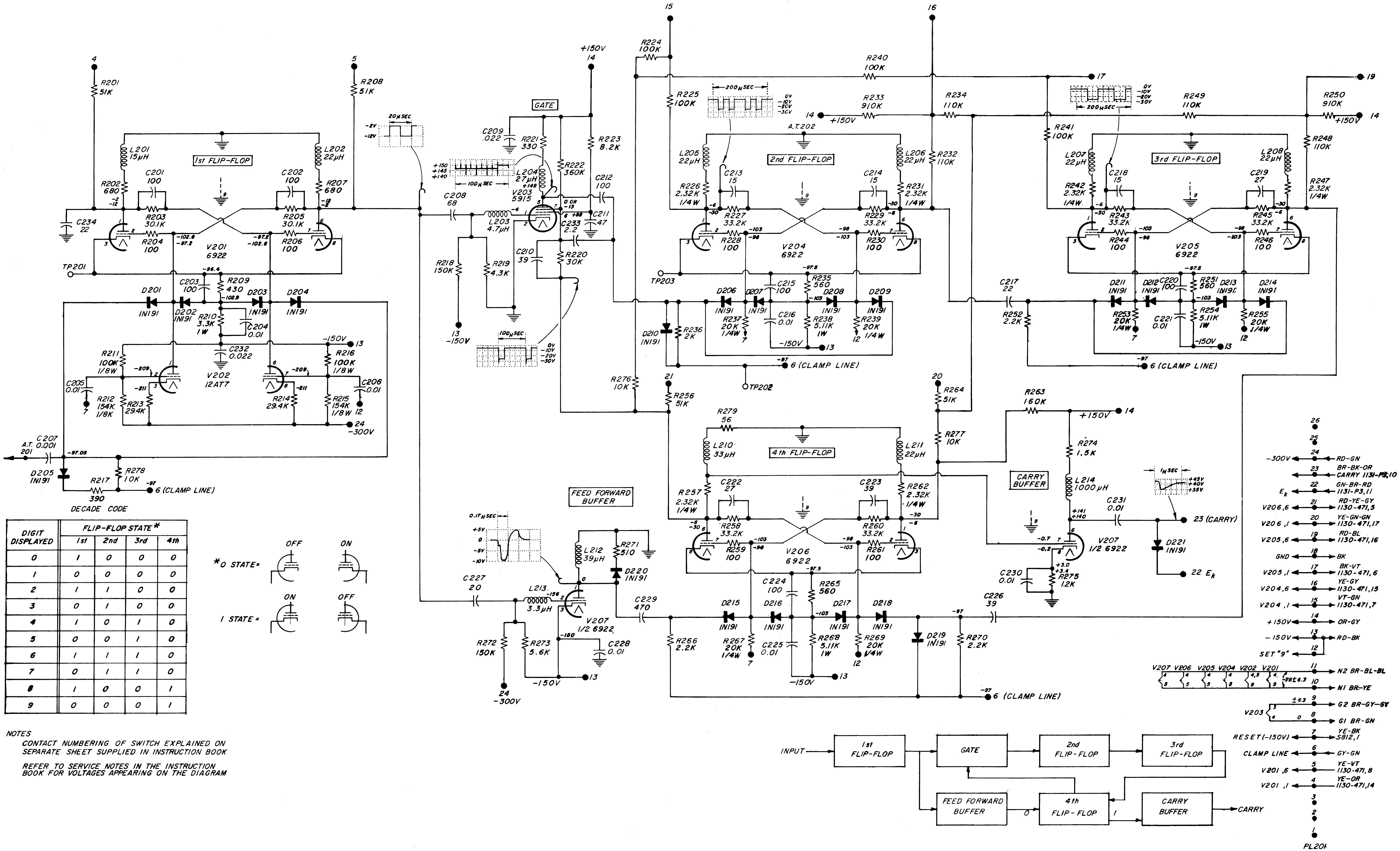


DIGIT DISPLAYED	FLIP-FLOP STATE* 1st	2nd	3rd	4th
0	1	0	0	0
1	0	0	0	0
2	1	1	0	0
3	0	1	0	0
4	1	0	1	0
5	0	0	1	0
6	1	1	1	0
7	0	1	1	0
8	1	0	0	1
9	0	0	0	1

NOTES

CONTACT NUMBERING OF SWITCH EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK

REFER TO SERVICE NOTES IN THE INSTRUCTION BOOK FOR VOLTAGES APPEARING ON THE DIAGRAM

RESISTORS

R301	33 k	± 5%	1/2 w	REC-20BF(333B)
R302	33 k	± 5%	1/2 w	REC-20BF(333B)
R303	33 k	± 5%	1/2 w	REC-20BF(333B)
R304	33 k	± 5%	1/2 w	REC-20BF(333B)
R305	75 k	± 5%	1 w	REC-30BF(753B)
R306	75 k	± 5%	1 w	REC-30BF(753B)
R307	75 k	± 5%	1 w	REC-30BF(753B)
R308	75 k	± 5%	1 w	REC-30BF(753B)
R309	68 k	± 5%	1 w	REC-30BF(683B)
R310	33 k	± 5%	1/2 w	REC-20BF(333B)
R311	33 k	± 5%	1/2 w	REC-20BF(333B)
R312	330 k	± 5%	1/2 w	REC-20BF(334B)
R313	330 k	± 5%	1/2 w	REC-20BF(334B)
R314	470 k	± 5%	1/2 w	REC-20BF(474B)
R315	470 k	± 5%	1/2 w	REC-20BF(474B)
R316	470 k	± 5%	1/2 w	REC-20BF(474B)
R317	470 k	± 5%	1/2 w	REC-20BF(474B)
R318	430 k	± 5%	1/2 w	REC-20BF(434B)
R319	390 k	± 5%	1/2 w	REC-20BF(394B)
R320	68 k	± 5%	1 w	REC-30BF(683B)
R321	62 k	± 5%	1 w	REC-30BF(623B)
R322	62 k	± 5%	1 w	REC-30BF(623B)
R323	62 k	± 5%	1 w	REC-30BF(623B)
R324	470 k	± 5%	1/2 w	REC-20BF(474B)
R325	470 k	± 5%	1/2 w	REC-20BF(474B)
R326	470 k	± 5%	1/2 w	REC-20BF(474B)

RESISTORS (Cont)

R327	470 k	± 5%	1/2 w	REC-20BF(474B)
R328	180 k	± 5%	1/2 w	REC-20BF(184B)
R329	180 k	± 5%	1/2 w	REC-20BF(184B)
R330	390 k	± 5%	1/2 w	REC-20BF(394B)
R331	390 k	± 5%	1/2 w	REC-20BF(394B)
R332	390 k	± 5%	1/2 w	REC-20BF(394B)
R333	390 k	± 5%	1/2 w	REC-20BF(394B)
R334	390 k	± 5%	1/2 w	REC-20BF(394B)
R335	390 k	± 5%	1/2 w	REC-20BF(394B)
R336	390 k	± 5%	1/2 w	REC-20BF(394B)
R337	390 k	± 5%	1/2 w	REC-20BF(394B)
R338	51 k	± 5%	1/2 w	REC-20BF(513B)
R339	430 k	± 5%	1/2 w	REC-20BF(434B)
R340	910 k	± 5%	1/2 w	REC-20BF(914B)
R341	470 k	± 5%	1/2 w	REC-20BF(474B)
R342	470 k	± 5%	1/2 w	REC-20BF(474B)
R343	470 k	± 5%	1/2 w	REC-20BF(474B)
R344	470 k	± 5%	1/2 w	REC-20BF(474B)
R345	62 k	± 5%	1 w	REC-30BF(623B)

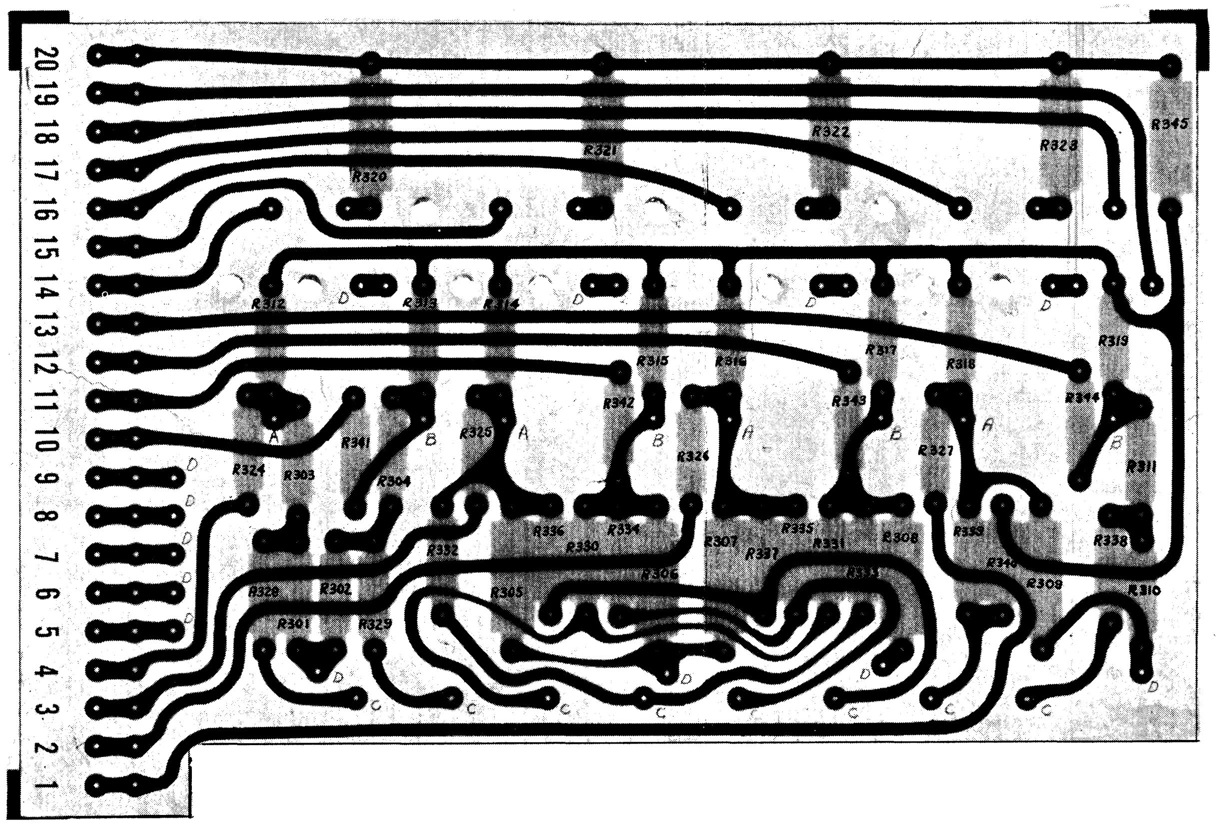
TUBES

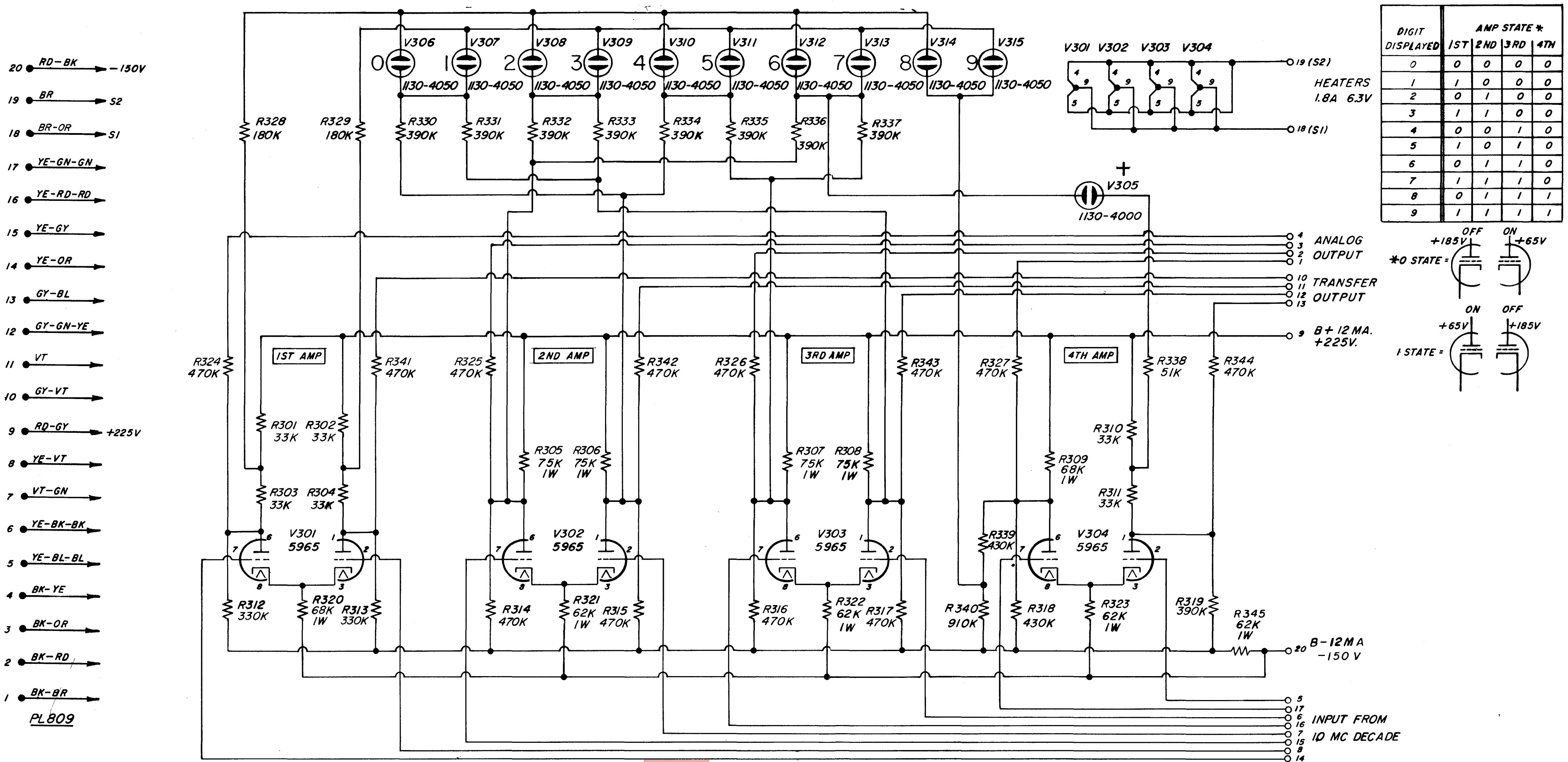
V301	5965	V306	1130-4050	V311	1130-4050
V302	5965	V307	1130-4050	V312	1130-4050
V303	5965	V308	1130-4050	V313	1130-4050
V304	5965	V309	1130-4050	V314	1130-4050
V305	1130-4000	V310	1130-4050	V315	1130-4050

Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V301 (5965)	1	75(175)	49 k
	2	0(-10)	0
	3, 8	+1	68 k
	4, 5, 9	50 ±6.3 v ac	0
	6	175(75)	49 k
	7	-10(0)	0
V302, V303 (5965)	1	60(180)	50 k
	2	0(-10)	0
	3, 8	+1	62 k
	4, 5, 9	50 ±6.3 v ac	0
	6	180(60)	50 k
	7	-10(0)	0
V304 (5965)	1	60(180)	51 k
	2	0(-10)	0
	3, 8	+1	62 k
	4, 5, 9	50 ±6.3 v ac	0
	6	180(60)	51 k
	7	-10(0)	0
V305 (1130-4000)	1	135(200)	220 k
	2	173(113)	80 k

Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V306 (1130-4050)	1	160(145)	200 k
	2	105(173)	220 k
V307 (1130-4050)	1	145(160)	200 k
	2	105(173)	220 k
V308, V310 (1130-4050)	1	160(145)	200 k
	2	113	220 k
V309, V311 (1130-4050)	1	145(160)	200 k
	2	113	220 k
V312 (1130-4050)	1	160(145)	200 k
	2	173(113)	220 k
V313 (1130-4050)	1	145(160)	200 k
	2	173(113)	220 k
V314 (1130-4050)	1	160(145)	200 k
	2	113(105)	320 k
V315 (1130-4050)	1	145(160)	200 k
	2	113(105)	320 k

Note: Voltages are measured with the decade in the "0" state and (in parentheses) in the "9" state.





DECADE CODE

DIGIT DISPLAYED	AMP STATE * 1ST	2ND	3RD	4TH
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	1	1	1
9	1	1	1	1

RESISTORS

R101	22 k	± 5%	1 w	REC-30BF(223B)
R102	27 k	± 5%	1 w	REC-30BF(273B)
R103	27 k	± 5%	1 w	REC-30BF(273B)
R104	30 k	± 5%	1 w	REC-30BF(303B)
R105	33 k	± 5%	1/2 w	REC-20BF(333B)
R106	33 k	± 5%	1/2 w	REC-20BF(333B)
R107	33 k	± 5%	1/2 w	REC-20BF(333B)
R108	33 k	± 5%	1/2 w	REC-20BF(333B)
R109	75 k	± 5%	1 w	REC-30BF(753B)
R110	75 k	± 5%	1 w	REC-30BF(753B)
R111	75 k	± 5%	1 w	REC-30BF(753B)
R112	75 k	± 5%	1 w	REC-30BF(753B)
R113	91 k	± 5%	1 w	REC-30BF(913B)
R114	82 k	± 5%	1 w	REC-30BF(823B)
R115	240 k	± 5%	1/2 w	REC-20BF(244B)
R116	240 k	± 5%	1/2 w	REC-20BF(244B)
R117	360 k	± 5%	1/2 w	REC-20BF(364B)
R118	360 k	± 5%	1/2 w	REC-20BF(364B)
R119	360 k	± 5%	1/2 w	REC-20BF(364B)
R120	360 k	± 5%	1/2 w	REC-20BF(364B)
R121	300 k	± 5%	1/2 w	REC-20BF(304B)
R122	470 k	± 5%	1/2 w	REC-20BF(474B)
R123	100 k	± 5%	1/2 w	REC-20BF(104B)
R124	100 k	± 5%	1/2 w	REC-20BF(104B)
R125	150 k	± 5%	1/2 w	REC-20BF(154B)
R126	150 k	± 5%	1/2 w	REC-20BF(154B)
R127	150 k	± 5%	1/2 w	REC-20BF(154B)
R128	150 k	± 5%	1/2 w	REC-20BF(154B)
R129	120 k	± 5%	1/2 w	REC-20BF(124B)
R130	200 k	± 5%	1/2 w	REC-20BF(204B)
R131	20 k	± 5%	1/2 w	REC-20BF(203B)
R132	20 k	± 5%	1/2 w	REC-20BF(203B)
R133	20 k	± 5%	1/2 w	REC-20BF(203B)
R134	20 k	± 5%	1/2 w	REC-20BF(203B)
R135	470 k	± 5%	1/2 w	REC-20BF(474B)
R136	470 k	± 5%	1/2 w	REC-20BF(474B)
R137	470 k	± 5%	1/2 w	REC-20BF(474B)
R138	470 k	± 5%	1/2 w	REC-20BF(474B)
R139	180 k	± 5%	1/2 w	REC-20BF(184B)
R140	180 k	± 5%	1/2 w	REC-20BF(184B)
R141	390 k	± 5%	1/2 w	REC-20BF(394B)
R142	390 k	± 5%	1/2 w	REC-20BF(394B)
R143	390 k	± 5%	1/2 w	REC-20BF(394B)
R144	390 k	± 5%	1/2 w	REC-20BF(394B)

RESISTORS (Cont)

R145	390 k	± 5%	1/2 w	REC-20BF(394B)
R146	390 k	± 5%	1/2 w	REC-20BF(394B)
R147	390 k	± 5%	1/2 w	REC-20BF(394B)
R148	390 k	± 5%	1/2 w	REC-20BF(394B)
R149	390 k	± 5%	1/2 w	REC-20BF(394B)
R150	200 k	± 5%	1/2 w	REC-20BF(204B)
R151	430 k	± 5%	1/2 w	REC-20BF(434B)
R152	910 k	± 5%	1/2 w	REC-20BF(914B)
R153	510 k	± 5%	1/2 w	REC-20BF(514B)
R154	510 k	± 5%	1/2 w	REC-20BF(514B)
R155	470 k	± 5%	1/2 w	REC-20BF(474B)
R156	470 k	± 5%	1/2 w	REC-20BF(474B)
R157	470 k	± 5%	1/2 w	REC-20BF(474B)
R158	470 k	± 5%	1/2 w	REC-20BF(474B)
R159	820 k	± 5%	1/2 w	REC-20BF(824B)

CAPACITORS

C101	68	± 5%	500 dcwv	COM-15D(680B)
C102	68	± 5%	500 dcwv	COM-15D(680B)
C103	68	± 5%	500 dcwv	COM-15D(680B)
C104	68	± 5%	500 dcwv	COM-15D(680B)
C105	100	± 5%	500 dcwv	COM-15D(101B)
C106	100	± 5%	500 dcwv	COM-15D(101B)
C107	150	± 5%	500 dcwv	COM-15D(151B)
C108	150	± 5%	500 dcwv	COM-15D(151B)
C109	47	± 5%	500 dcwv	COM-15D(470B)
C110	68	± 5%	500 dcwv	COM-15D(680B)
C111	.01 μf	±20%	500 dcwv	COC-62(103D)
C112	.01 μf	±20%	500 dcwv	COC-62(103D)
C113	.01 μf	±20%	500 dcwv	COC-62(103D)
C114	.01 μf	±20%	500 dcwv	COC-62(103D)
C115	150	± 5%	500 dcwv	COM-15D(151B)
C116	150	± 5%	500 dcwv	COM-15D(151B)
C117	150	± 5%	500 dcwv	COM-15D(151B)
C118	150	± 5%	500 dcwv	COM-15D(151B)
C119	0.0022 μf	±20%	500 dcwv	COC-61(222D)

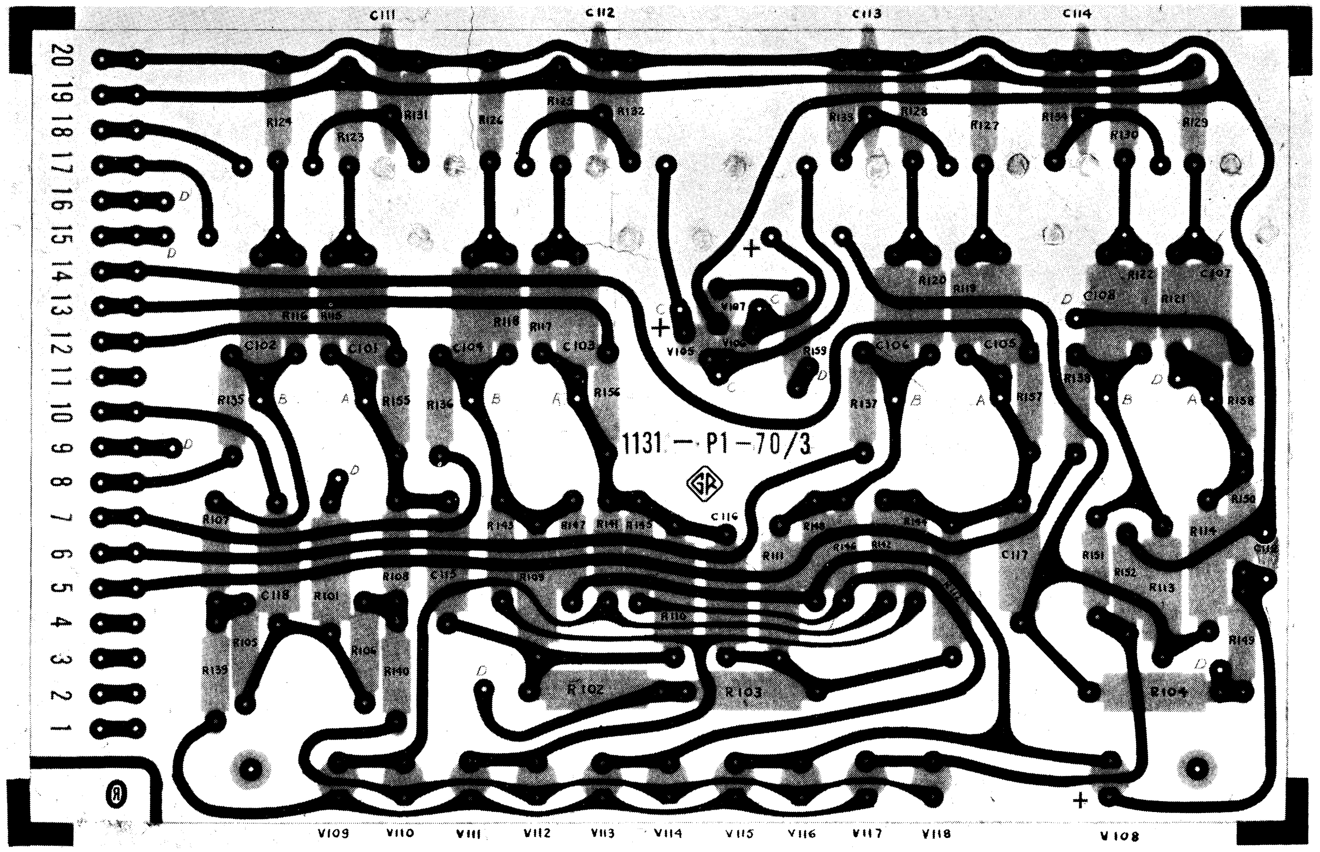
TUBES

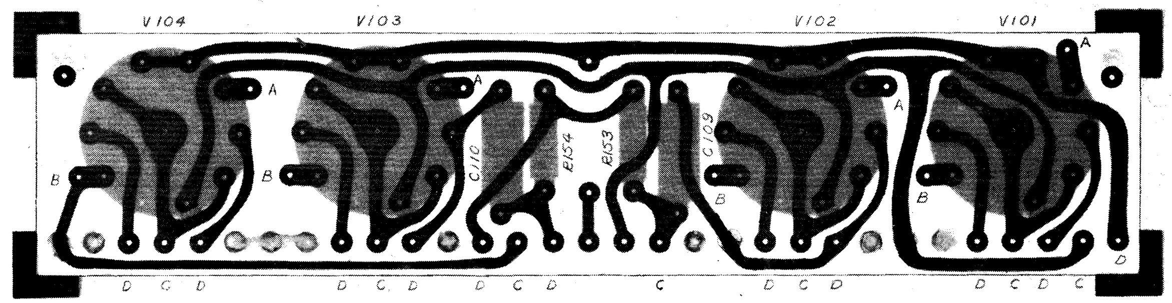
V101	5963	V107	NE2	V113	1130-4050
V102	5963	V108	1130-4000	V114	1130-4050
V103	5963	V109	1130-4050	V115	1130-4050
V104	5963	V110	1130-4050	V116	1130-4050
V105	1130-4000	V111	1130-4050	V117	1130-4050
V106	1130-4000	V112	1130-4050	V118	1130-4050

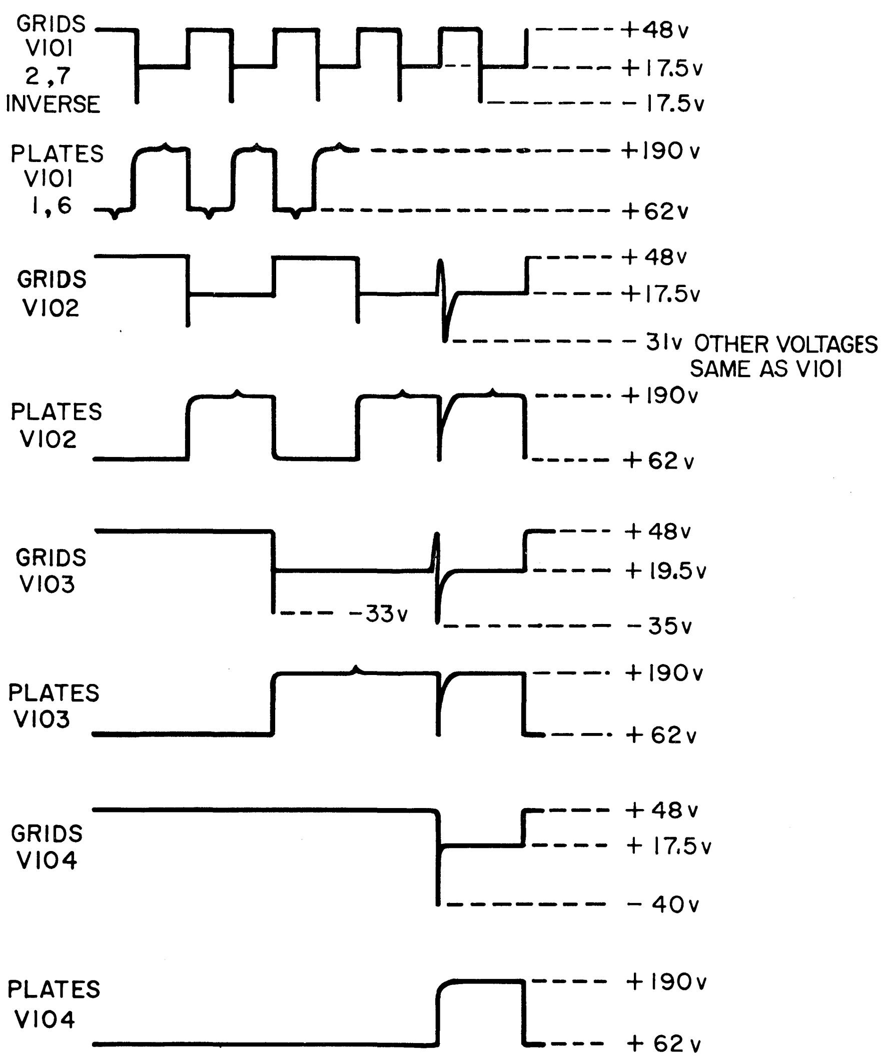
Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V101 (5963)	1	185(65)	58 k
	2	20(48)	73 k
	3, 8	48	20 k
	4, 5, 9	50 ±6.3 v ac	0
	6	65(185)	58 k
	7	48(20)	73 k
V102, V103 (5963)	1	185(65)	58 k
	2	20(48)	108 k
	3, 8	48	20 k
	4, 5, 9	50 ±6.3 v ac	0
	6	65(185)	58 k
	7	48(20)	108 k
V104 (5963)	1	185(65)	75 k
	2	20(48)	82 k
	3, 8	48	20 k
	4, 5, 9	50 ±6.3 v ac	0
	6	65(185)	0
	7	48(20)	180 k
V105, V106 (1130-4000)	1	225(120)	540 k
	2	185(65)	75 k
V107 (NE-2)	1	55	820 k
	2	0	0
V108 (1130-4000)	1	188(130)	225 k
	2	152(185)	130 k

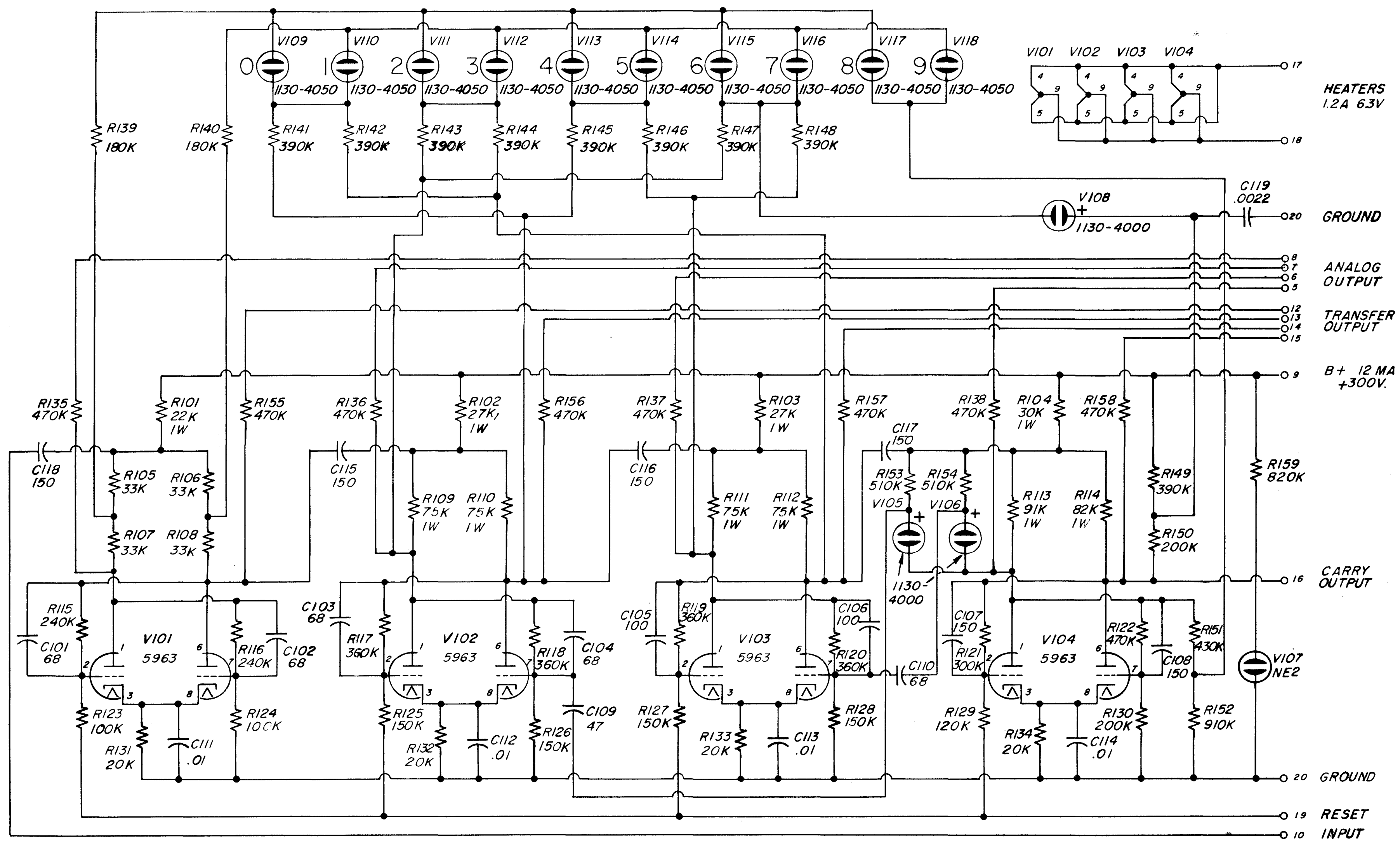
Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V109 (1130-4050)	1	165(150)	225 k
	2	110(185)	225 k
V110 (1130-4050)	1	150(165)	225 k
	2	110(185)	225 k
V111 (1130-4050)	1	165(150)	225 k
	2	125(125)	225 k
V112 (1130-4050)	1	150(165)	225 k
	2	125(125)	225 k
V113 (1130-4050)	1	165(150)	225 k
	2	125(125)	225 k
V114 (1130-4050)	1	150(165)	225 k
	2	125(125)	225 k
V115 (1130-4050)	1	165(150)	225 k
	2	185(130)	225 k
V116 (1130-4050)	1	150(165)	225 k
	2	185(130)	225 k
V117 (1130-4050)	1	165(150)	225 k
	2	125(110)	320 k
V118 (1130-4050)	1	150(165)	225 k
	2	125(110)	320 k

Note: Voltages are measured with the decade in the "0" state and (in parentheses) in the "9" state.


1131-P1-70/3




GRIDS V101 2,7 INVERSE
+48v
+17.5v
-17.5v
PLATES V101 1,6
+190v
+62v
GRIDS V102
+48v
+17.5v
-31v OTHER VOLTAGES SAME AS V101
PLATES V102
+190v
+62v
GRIDS V103
+48v
+19.5v
-33v
-35v
PLATES V103
+190v
+62v
GRIDS V104
+48v
+17.5v
-40v
PLATES V104
+190v
+62v


HEATERS 1.2A 63V
GROUND
ANALOG OUTPUT
TRANSFER OUTPUT
B+ 12 MA +300V.
CARRY OUTPUT
GROUND
RESET
INPUT

RESISTORS

R101	13 k	± 5%	1 w	REC-30BF(133B)
R102	16 k	± 5%	1 w	REC-30BF(163B)
R103	16 k	± 5%	1 w	REC-30BF(163B)
R104	16 k	± 5%	1 w	REC-30BF(163B)
R105	20 k	± 5%	1 w	REC-30BF(203B)
R106	20 k	± 5%	1 w	REC-30BF(203B)
R107	20 k	± 5%	1 w	REC-30BF(203B)
R108	20 k	± 5%	1 w	REC-30BF(203B)
R109	43 k	± 5%	2 w	REC-41BF(433B)
R110	43 k	± 5%	2 w	REC-41BF(433B)
R111	43 k	± 5%	2 w	REC-41BF(433B)
R112	43 k	± 5%	2 w	REC-41BF(433B)
R113	43 k	± 5%	2 w	REC-41BF(433B)
R114	43 k	± 5%	2 w	REC-41BF(433B)
R115	150 k	± 5%	1/2 w	REC-20BF(154B)
R116	150 k	± 5%	1/2 w	REC-20BF(154B)
R117	200 k	± 5%	1/2 w	REC-20BF(204B)
R118	200 k	± 5%	1/2 w	REC-20BF(204B)
R119	200 k	± 5%	1/2 w	REC-20BF(204B)
R120	200 k	± 5%	1/2 w	REC-20BF(204B)
R121	160 k	± 5%	1/2 w	REC-20BF(164B)
R122	160 k	± 5%	1/2 w	REC-20BF(164B)
R123	43 k	± 5%	1/2 w	REC-20BF(433B)
R124	43 k	± 5%	1/2 w	REC-20BF(433B)
R125	51 k	± 5%	1/2 w	REC-20BF(513B)
R126	56 k	± 5%	1/2 w	REC-20BF(563B)
R127	56 k	± 5%	1/2 w	REC-20BF(563B)
R128	56 k	± 5%	1/2 w	REC-20BF(563B)
R129	47 k	± 5%	1/2 w	REC-20BF(473B)
R130	47 k	± 5%	1/2 w	REC-20BF(473B)
R131	8.2 k	± 5%	1/2 w	REC-20BF(822B)
R132	8.2 k	± 5%	1/2 w	REC-20BF(822B)
R133	8.2 k	± 5%	1/2 w	REC-20BF(822B)
R134	8.2 k	± 5%	1/2 w	REC-20BF(822B)
R135	470 k	± 5%	1/2 w	REC-20BF(474B)
R136	470 k	± 5%	1/2 w	REC-20BF(474B)
R137	470 k	± 5%	1/2 w	REC-20BF(474B)
R138	470 k	± 5%	1/2 w	REC-20BF(474B)
R139	180 k	± 5%	1/2 w	REC-20BF(184B)
R140	180 k	± 5%	1/2 w	REC-20BF(184B)
R141	390 k	± 5%	1/2 w	REC-20BF(394B)
R142	390 k	± 5%	1/2 w	REC-20BF(394B)

RESISTORS (Cont)

R143	390 k	± 5%	1/2 w	REC-20BF(394B)
R144	390 k	± 5%	1/2 w	REC-20BF(394B)
R145	390 k	± 5%	1/2 w	REC-20BF(394B)
R146	390 k	± 5%	1/2 w	REC-20BF(394B)
R147	390 k	± 5%	1/2 w	REC-20BF(394B)
R148	390 k	± 5%	1/2 w	REC-20BF(394B)
R149	390 k	± 5%	1/2 w	REC-20BF(394B)
R150	200 k	± 5%	1/2 w	REC-20BF(204B)
R151	200 k	± 5%	1/2 w	REC-20BF(204B)
R152	470 k	± 5%	1/2 w	REC-20BF(474B)
R153	180 k	± 5%	1/2 w	REC-20BF(184B)
R154	180 k	± 5%	1/2 w	REC-20BF(184B)
R155	470 k	± 5%	1/2 w	REC-20BF(474B)
R156	470 k	± 5%	1/2 w	REC-20BF(474B)
R157	470 k	± 5%	1/2 w	REC-20BF(474B)

CAPACITORS

C101	68	± 5%	500 dcwv	COM-15D(680B)
C102	68	± 5%	500 dcwv	COM-15D(680B)
C103	68	± 5%	500 dcwv	COM-15D(680B)
C104	68	± 5%	500 dcwv	COM-15D(680B)
C105	68	± 5%	500 dcwv	COM-15D(680B)
C106	68	± 5%	500 dcwv	COM-15D(680B)
C107	150	± 5%	500 dcwv	COM-15D(151B)
C108	150	± 5%	500 dcwv	COM-15D(151B)
C109	47	± 5%	500 dcwv	COM-15D(470B)
C110	68	± 5%	500 dcwv	COM-15D(680B)
C111	.01 µf	±20%	500 dcwv	COC-62(103D)
C112	.01 µf	±20%	500 dcwv	COC-62(103D)
C113	.01 µf	±20%	500 dcwv	COC-62(103D)
C114	.01 µf	±20%	500 dcwv	COC-62(103D)
C115	150	± 5%	500 dcwv	COM-15D(151B)
C116	150	± 5%	500 dcwv	COM-15D(151B)
C117	150	± 5%	500 dcwv	COM-15D(151B)
C118	0.0022 µf	±20%	500 dcwv	COC-61(222D)

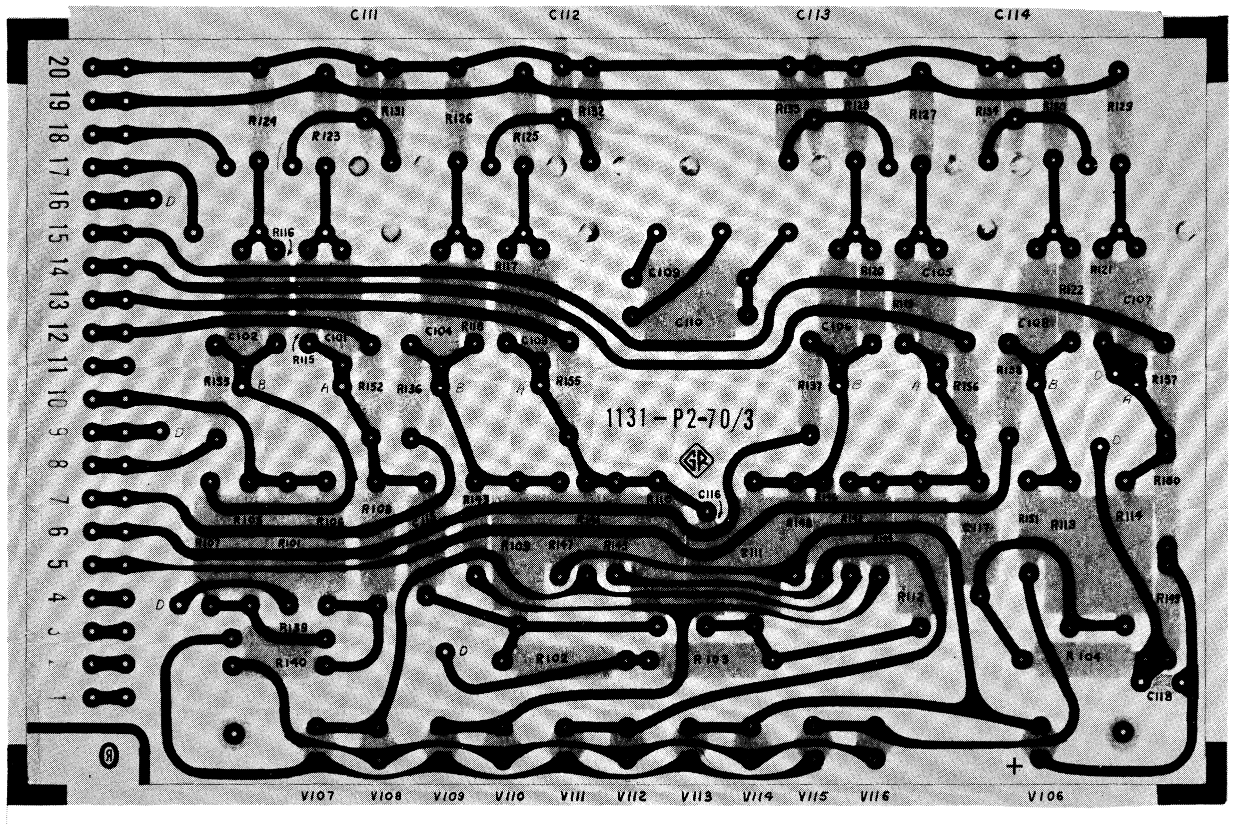
TUBES

V101	5965	V107	1130-4050	V112	1130-4050
V102	5965	V108	1130-4050	V113	1130-4050
V103	5965	V109	1130-4050	V114	1130-4050
V104	5965	V110	1130-4050	V115	1130-4050
V105	6887	V111	1130-4050	V116	1130-4050
V106	1130-4000				

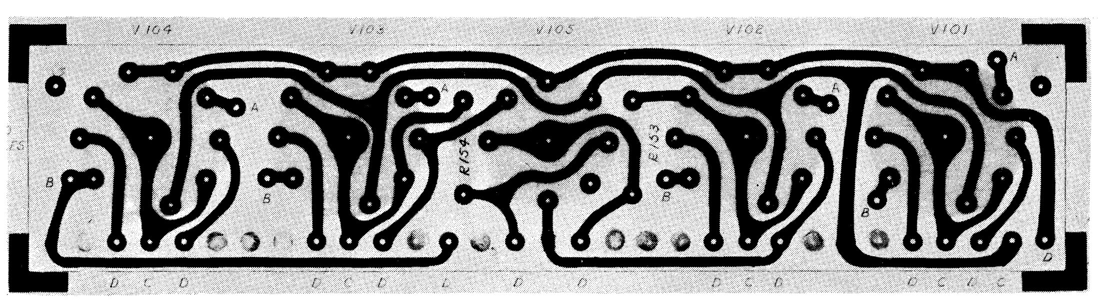
Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V101 (5965)	1	185(60)	31 k
	2	13(34)	35 k
	3, 8	34	8.2 k
	4, 5, 9	50 ±6.3 v ac	0
	6	60(185)	31 k
	7	34(13)	35 k
V102, V103 (5965)	1	same as V101	39 k
	2		43 k
	3, 8		8.2 k
	4, 5, 9		0
	6		39 k
	7		43 k
V104 (5965)	1	same as V101	39 k
	2		36 k
	3, 8		8.2 k
	4, 5, 9		0
	6		0
	7		39 k
V105 (6887)	1	34	188 k
	2	34(13)	43 k
	3, 4	50 ±6.3 v ac	0
	5	34	188 k
	7	34(13)	43 k

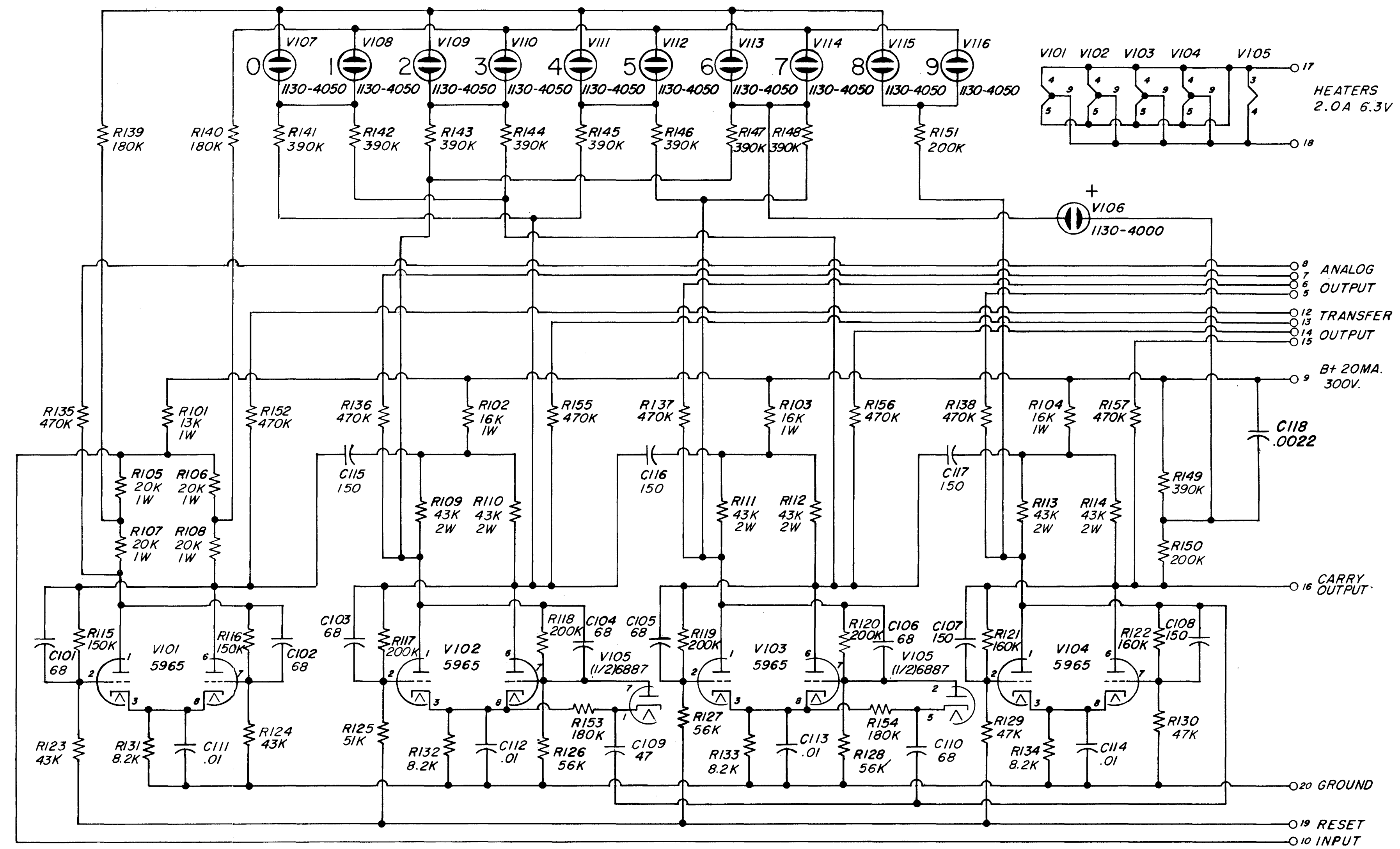
Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V106 (1130-4000)	1	185(125)	215 k
	2	142(178)	130 k
V107 (1130-4050)	1	163(145)	200 k
	2	110(185)	215 k
V108 (1130-4050)	1	145(163)	200 k
	2	110(185)	215 k
V109, V111 (1130-4050)	1	163(145)	200 k
	2	124	215 k
V110, V112 (1130-4050)	1	145(163)	200 k
	2	124	215 k
V113 (1130-4050)	1	163(145)	200 k
	2	185(124)	215 k
V114 (1130-4050)	1	145(163)	200 k
	2	185(124)	215 k
V115 (1130-4050)	1	163(145)	200 k
	2	185(108)	240 k
V116 (1130-4050)	1	145(163)	200 k
	2	185(108)	240 k

Note: Voltages are measured with the decade in the "0" state and (in parentheses) in the "9" state.



C111
C112
C113
C114
1131 – P2-70/3
V107
V108
V109
V110
V111
V112
V113
V114
V115
V116
V106





V107
V108
V109
V110
V111
V112
V113
V114
V115
V116
1130-4050
V106
1130-4000
V101
V102
V103
V104
V105
HEATERS
2.0A 6.3V
ANALOG
OUTPUT
TRANSFER
OUTPUT
B+ 20MA.
300V.
C118
.0022
CARRY
OUTPUT
GROUND
RESET
INPUT
V101
5965
V102
5965
V103
5965
V104
5965
V105
(1/2)6887

RESISTORS

R101	11 k	± 5%	2 w	REC-41BF(113B)
R102	11 k	± 5%	2 w	REC-41BF(113B)
R103	11 k	± 5%	2 w	REC-41BF(113B)
R104	11 k	± 5%	2 w	REC-41BF(113B)
R105	12 k	± 5%	2 w	REC-41BF(123B)
R106	12 k	± 5%	2 w	REC-41BF(123B)
R107	11 k	± 5%	2 w	REC-41BF(113B)
R108	11 k	± 5%	2 w	REC-41BF(113B)
R109	12 k	± 5%	2 w	REC-41BF(123B)
R110	12 k	± 5%	2 w	REC-41BF(123B)
R111	11 k	± 5%	2 w	REC-41BF(113B)
R112	11 k	± 5%	2 w	REC-41BF(113B)
R113	12 k	± 5%	2 w	REC-41BF(123B)
R114	11 k	± 5%	2 w	REC-41BF(113B)
R115	11 k	± 5%	2 w	REC-41BF(113B)
R116	11 k	± 5%	2 w	REC-41BF(113B)
R117	82 k	± 5%	1 w	REC-30BF(823B)
R118	82 k	± 5%	1 w	REC-30BF(823B)
R119	91 k	± 5%	1 w	REC-30BF(913B)
R120	91 k	± 5%	1 w	REC-30BF(913B)
R121	91 k	± 5%	1 w	REC-30BF(913B)
R122	91 k	± 5%	1 w	REC-30BF(913B)
R123	82 k	± 5%	1 w	REC-30BF(823B)
R124	82 k	± 5%	1 w	REC-30BF(823B)
R125	33 k	± 5%	1/2 w	REC-20BF(333B)
R126	33 k	± 5%	1/2 w	REC-20BF(333B)
R127	36 k	± 5%	1/2 w	REC-20BF(363B)
R128	36 k	± 5%	1/2 w	REC-20BF(363B)
R129	36 k	± 5%	1/2 w	REC-20BF(363B)
R130	36 k	± 5%	1/2 w	REC-20BF(363B)
R131	33 k	± 5%	1/2 w	REC-20BF(333B)
R132	33 k	± 5%	1/2 w	REC-20BF(333B)
R133	2.7 k	± 5%	1/2 w	REC-20BF(272B)
R134	3.6 k	± 5%	1/2 w	REC-20BF(362B)
R135	2.7 k	± 5%	1/2 w	REC-20BF(272B)
R136	3.6 k	± 5%	1/2 w	REC-20BF(362B)
R137	2.7 k	± 5%	1/2 w	REC-20BF(272B)
R138	3.6 k	± 5%	1/2 w	REC-20BF(362B)
R139	2.7 k	± 5%	1/2 w	REC-20BF(272B)
R140	3.6 k	± 5%	1/2 w	REC-20BF(362B)
R141	470 k	± 5%	1/2 w	REC-20BF(474B)
R142	470 k	± 5%	1/2 w	REC-20BF(474B)
R143	470 k	± 5%	1/2 w	REC-20BF(474B)
R144	470 k	± 5%	1/2 w	REC-20BF(474B)
R145	180 k	± 5%	1/2 w	REC-20BF(184B)
R146	180 k	± 5%	1/2 w	REC-20BF(184B)
R147	390 k	± 5%	1/2 w	REC-20BF(394B)
R148	390 k	± 5%	1/2 w	REC-20BF(394B)
R149	390 k	± 5%	1/2 w	REC-20BF(394B)
R150	390 k	± 5%	1/2 w	REC-20BF(394B)
R151	390 k	± 5%	1/2 w	REC-20BF(394B)
R152	390 k	± 5%	1/2 w	REC-20BF(394B)
R153	390 k	± 5%	1/2 w	REC-20BF(394B)
R154	390 k	± 5%	1/2 w	REC-20BF(394B)

RESISTORS (Cont)

R155	200 k	± 5%	1/2 w	REC-20BF(204B)
R156	56 k	± 5%	1/2 w	REC-20BF(563B)
R157	470 k	± 5%	1/2 w	REC-20BF(474B)
R158	470 k	± 5%	1/2 w	REC-20BF(474B)
R159	470 k	± 5%	1/2 w	REC-20BF(474B)
R160	470 k	± 5%	1/2 w	REC-20BF(474B)
R161	3.3 k	± 5%	1/2 w	REC-20BF(332B)
R162	3.3 k	± 5%	1/2 w	REC-20BF(332B)
R163	6.8 k	± 5%	1/2 w	REC-20BF(682B)
R164	3.3 k	± 5%	1/2 w	REC-20BF(332B)
R165	3.3 k	± 5%	1/2 w	REC-20BF(332B)
R166	470 k	± 5%	1/2 w	REC-20BF(474B)
R167	82 k	± 5%	1/2 w	REC-20BF(823B)
R168	33 k	± 5%	1/2 w	REC-20BF(333B)
R169	220 k	± 5%	1/2 w	REC-20BF(224B)
R170	8.2 k	± 5%	2 w	REC-41BF(822B)

CAPACITORS

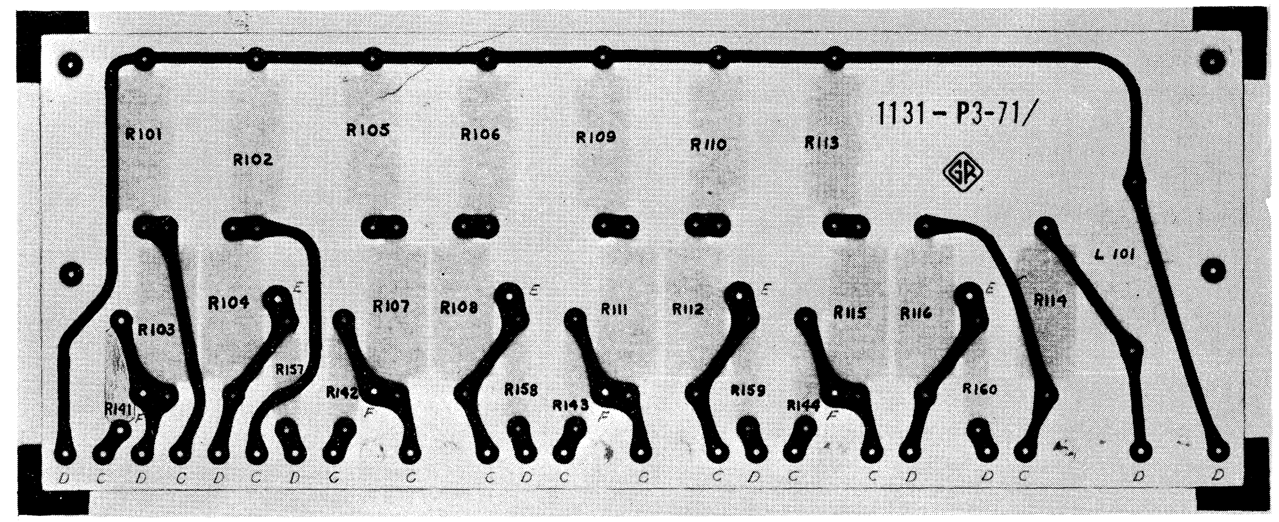
C101	22	± 5%	500 dcwv	COM-15C(220B)
C102	33	± 5%	500 dcwv	COM-15C(330B)
C103	33	± 5%	500 dcwv	COM-15C(330B)
C104	47	± 5%	500 dcwv	COM-15D(470B)
C105	33	± 5%	500 dcwv	COM-15C(330B)
C106	47	± 5%	500 dcwv	COM-15D(470B)
C107	68	± 5%	500 dcwv	COM-15D(680B)
C108	100	± 5%	500 dcwv	COM-15D(101B)
C109	33	± 5%	500 dcwv	COM-15C(330B)
C110	68	± 5%	500 dcwv	COM-15D(680B)
C111	.0047 μf	±20%	500 dcwv	COC-62(472D)
C112	.0047 μf	±20%	500 dcwv	COC-62(472D)
C113	.0047 μf	±20%	500 dcwv	COC-62(472D)
C114	.0047 μf	±20%	500 dcwv	COC-62(472D)
C115	.0047 μf	±20%	500 dcwv	COC-62(472D)
C116	.0047 μf	±20%	500 dcwv	COC-62(472D)
C117	.0047 μf	±20%	500 dcwv	COC-62(472D)
C118	.0047 μf	±20%	500 dcwv	COC-62(472D)
C119	100	± 5%	500 dcwv	COM-15D(101B)
C120	.0047 μf	±20%	500 dcwv	COC-62(472D)
C121	22	± 5%	500 dcwv	COM-15C(220B)
C122	22	± 5%	500 dcwv	COM-15C(220B)
C123	22	± 5%	500 dcwv	COM-15C(220B)

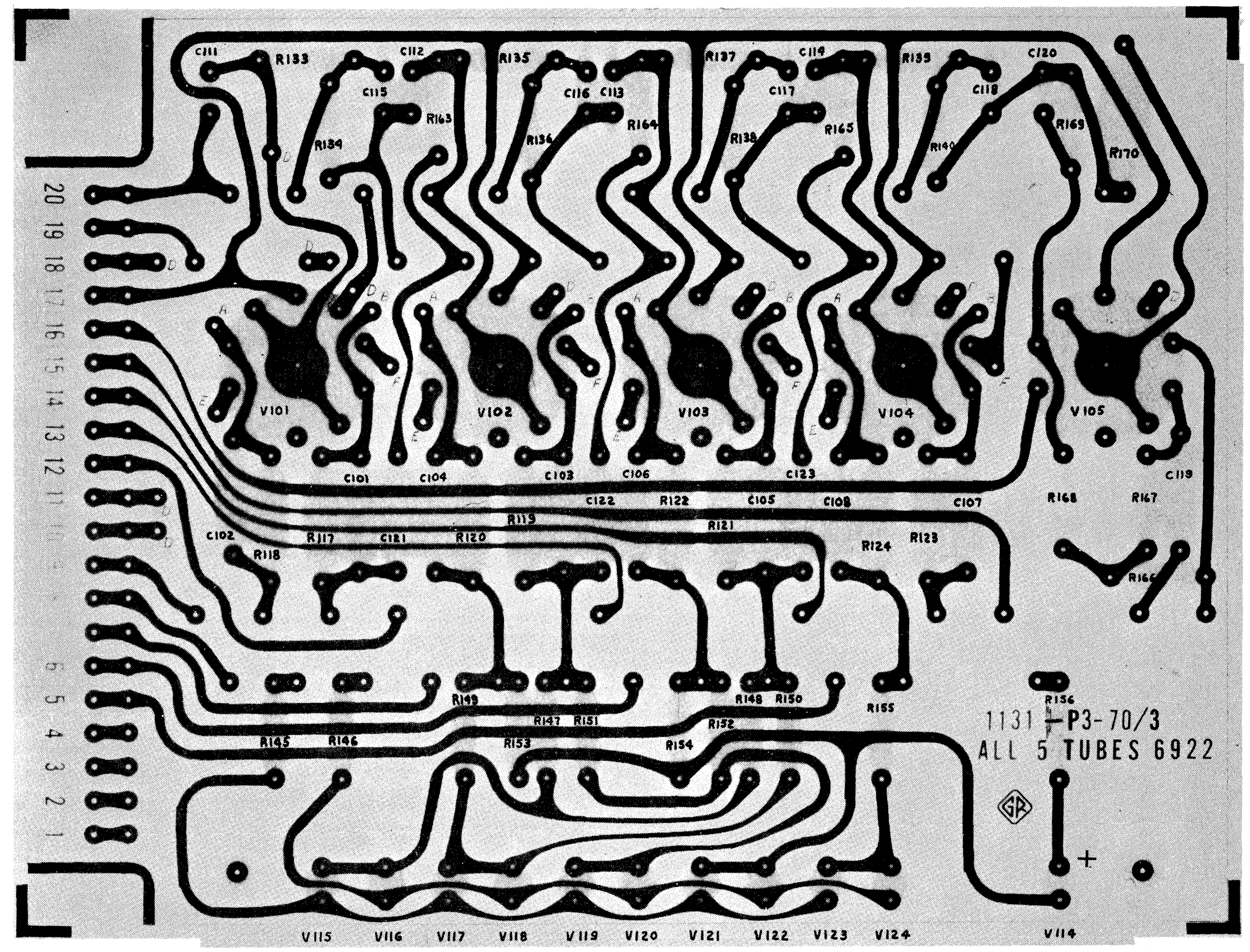
INDUCTOR

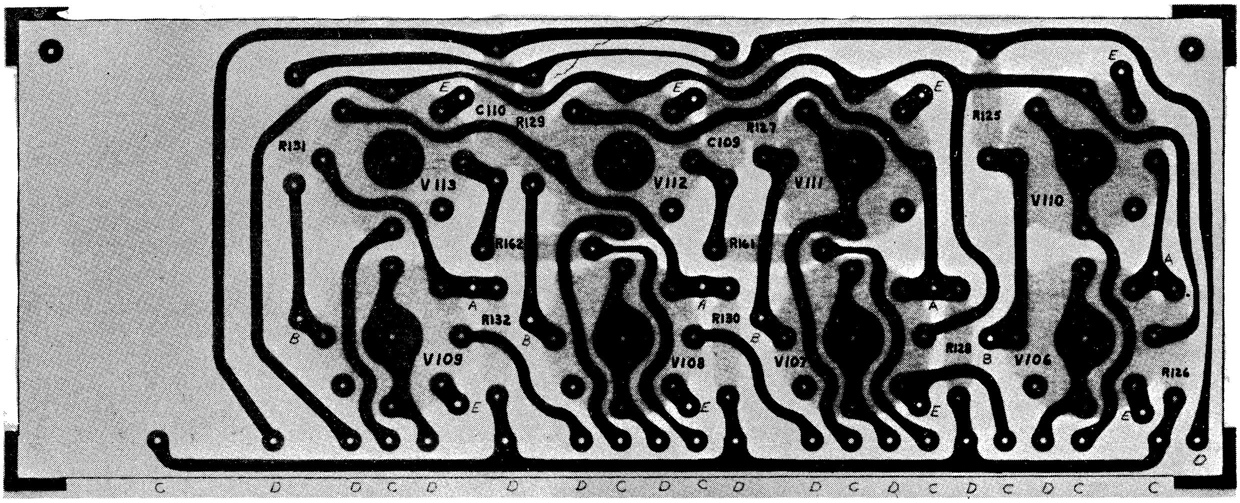
L101	10 mh	±10%	CHM-7

TUBES

V101	6922	V109	6887	V117	1130-4050
V102	6922	V110	6887	V118	1130-4050
V103	6922	V111	6887	V119	1130-4050
V104	6922	V112	6887	V120	1130-4050
V105	6922	V113	6887	V121	1130-4050
V106	6887	V114	1130-4000	V122	1130-4050
V107	6887	V115	1130-4050	V123	1130-4050
V108	6887	V116	1130-4050	V124	1130-4050



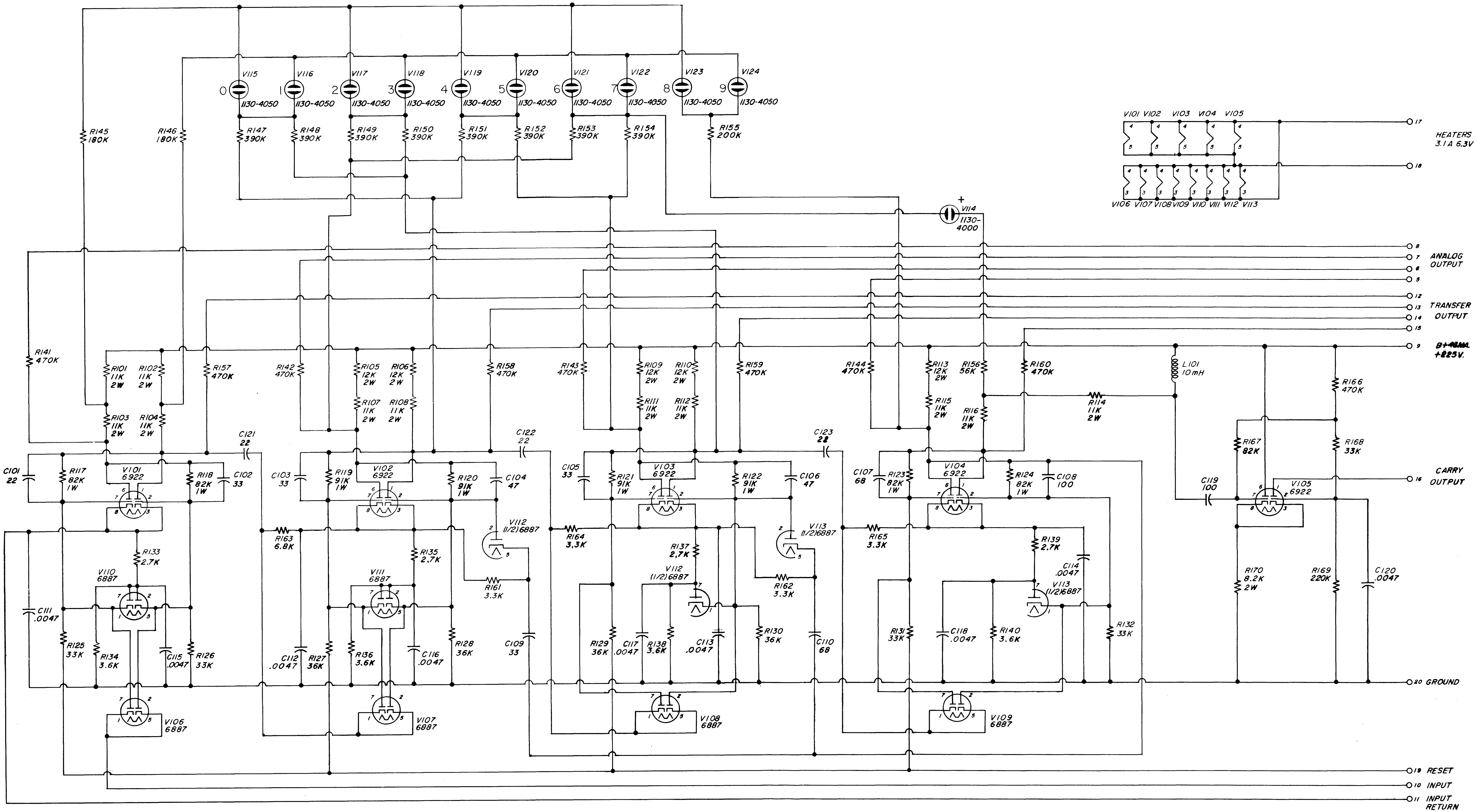




Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V101	1	65(185)	18 k
(6922)	2	43(25)	25 k
	3, 8	43	0
	4, 5	50 ±6.3 v ac	0
	6	185(65)	18 k
	7	25(43)	25 k
V102	1	same as V101	17.5 k
(6922)	2		28 k
	3, 8		6.3 k
	4, 5		0
	6		17.5 k
	7		28 k
V103	1	65(185)	same as V102
(6922)	2	43(25)	
	3, 8	43	
	4, 5	50 ±6.3 v ac	
	6	185(65)	
	7	18(43)	
V104	1	same as V103	18 k
(6922)	2		25.8 k
	3, 8		6.3 k
	4, 5		0
	6		18 k
	7		25.8 k
V105	1	225	0
(6922)	2	65	153 k
	3, 8	82	8.2 k
	4, 5	50 ±6.3 v ac	0
	6	225	0
	7	75	230 k
V106	1, 5	43	0
(6887)	2	43(25)	25 k
	3, 4	50 ±6.3 v ac	0
	7	25(43)	25 k
V107	1, 5	same as V106	13.1 k
(6887)	2		28 k
	3, 4		0
	7		28 k
V108	1, 5	43	9.6 k
(6887)	2	43(25)	28 k
	3, 4	50 ±6.3 v ac	0
	7	18(43)	28 k

Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V109	1, 5	43	
(6887)	2	43(25)	
	3, 4	50 ±6.3 v ac	
	7	18(43)	
V110	1	25(43)	25 k
(6887)	2, 7	25	1.5 k
	3, 4	50 ±6.3 v ac	0
	5	43(25)	25 k
V111	1	same as V110	28 k
(6887)	2, 7		3.6 k
	3, 4		0
	5		28 k
V112	1	43(25)	28 k
(6887)	2	43(25)	28 k
	3, 4	50 ±6.3 v ac	0
	5	43	9.6 k
	7	25	3.6 k
V113	1	same as V112	25.8 k
(6887)	2		28 k
	3, 4		0
	5		9.6 k
	7		3.6 k
V114	1	170(115)	200 k
(1130-4000)	2	135(170)	67 k
V115	1	155(135)	190 k
(1130-4050)	2	100(170)	200 k
V116	1	135(155)	190 k
(1130-4050)	2	100(170)	200 k
V117, V119	1	155(135)	190 k
(1130-4050)	2	115	200 k
V118, V120	1	135(155)	190 k
(1130-4050)	2	115	200 k
V121	1	155(135)	190 k
(1130-4050)	2	170(115)	200 k
V122	1	135(155)	190 k
(1130-4050)	2	170(115)	200 k
V123	1	155(135)	190 k
(1130-4050)	2	170(98)	220 k
V124	1	135(155)	190 k
(1130-4050)	2	170(98)	220 k

Note: Voltages are measured with the decade in the "0" state and (in parentheses) in the "9" state.


HEATERS 3.1A 6.3V
ANALOG OUTPUT
TRANSFER OUTPUT
CARRY OUTPUT
GROUND
RESET
INPUT
INPUT RETURN
V101 6922
V102 6922
V103 6922
V104 6922
V105 6922
V106 6887
V107 6887
V108 6887
V109 6887
V110 6887
V111 6887
V112 (1/2)6887
V113 (1/2)6887
V114 1130-4000
V115 1130-4050
V116 1130-4050
V117 1130-4050
V118 1130-4050
V119 1130-4050
V120 1130-4050
V121 1130-4050
V122 1130-4050
V123 1130-4050
V124 1130-4050
L101 10 mH

RESISTORS

R101	22 k	± 5%	1 w	REC-30BF(223B)
R102	27 k	± 5%	1 w	REC-30BF(273B)
R103	27 k	± 5%	1 w	REC-30BF(273B)
R104	30 k	± 5%	1 w	REC-30BF(303B)
R105	33 k	± 5%	1/2 w	REC-20BF(333B)
R106	33 k	± 5%	1/2 w	REC-20BF(333B)
R107	33 k	± 5%	1/2 w	REC-20BF(333B)
R108	33 k	± 5%	1/2 w	REC-20BF(333B)
R109	75 k	± 5%	1 w	REC-30BF(753B)
R110	75 k	± 5%	1 w	REC-30BF(753B)
R111	75 k	± 5%	1 w	REC-30BF(753B)
R112	75 k	± 5%	1 w	REC-30BF(753B)
R113	91 k	± 5%	1 w	REC-30BF(913B)
R114	82 k	± 5%	1 w	REC-30BF(823B)
R115	240 k	± 5%	1/2 w	REC-20BF(244B)
R116	240 k	± 5%	1/2 w	REC-20BF(244B)
R117	360 k	± 5%	1/2 w	REC-20BF(364B)
R118	360 k	± 5%	1/2 w	REC-20BF(364B)
R119	360 k	± 5%	1/2 w	REC-20BF(364B)
R120	360 k	± 5%	1/2 w	REC-20BF(364B)
R121	300 k	± 5%	1/2 w	REC-20BF(304B)
R122	470 k	± 5%	1/2 w	REC-20BF(474B)
R123	100 k	± 5%	1/2 w	REC-20BF(104B)
R124	100 k	± 5%	1/2 w	REC-20BF(104B)
R125	150 k	± 5%	1/2 w	REC-20BF(154B)
R126	150 k	± 5%	1/2 w	REC-20BF(154B)
R127	150 k	± 5%	1/2 w	REC-20BF(154B)
R128	100 k	± 5%	1/2 w	REC-20BF(104B)
R129	110 k	± 5%	1/2 w	REC-20BF(114B)
R130	200 k	± 5%	1/2 w	REC-20BF(204B)
R131	20 k	± 5%	1/2 w	REC-20BF(203B)
R132	20 k	± 5%	1/2 w	REC-20BF(203B)
R133	20 k	± 5%	1/2 w	REC-20BF(203B)
R134	20 k	± 5%	1/2 w	REC-20BF(203B)
R135	470 k	± 5%	1/2 w	REC-20BF(474B)
R136	470 k	± 5%	1/2 w	REC-20BF(474B)
R137	470 k	± 5%	1/2 w	REC-20BF(474B)
R138	470 k	± 5%	1/2 w	REC-20BF(474B)
R139	180 k	± 5%	1/2 w	REC-20BF(184B)
R140	180 k	± 5%	1/2 w	REC-20BF(184B)
R141	390 k	± 5%	1/2 w	REC-20BF(394B)
R142	390 k	± 5%	1/2 w	REC-20BF(394B)
R143	390 k	± 5%	1/2 w	REC-20BF(394B)
R144	390 k	± 5%	1/2 w	REC-20BF(394B)
R145	390 k	± 5%	1/2 w	REC-20BF(394B)
R146	390 k	± 5%	1/2 w	REC-20BF(394B)
R147	390 k	± 5%	1/2 w	REC-20BF(394B)
R148	390 k	± 5%	1/2 w	REC-20BF(394B)
R149	390 k	± 5%	1/2 w	REC-20BF(394B)
R150	200 k	± 5%	1/2 w	REC-20BF(204B)
R151	430 k	± 5%	1/2 w	REC-20BF(434B)
R152	910 k	± 5%	1/2 w	REC-20BF(914B)
R153	510 k	± 5%	1/2 w	REC-20BF(514B)
R154	510 k	± 5%	1/2 w	REC-20BF(514B)

RESISTORS (Cont)

R155	5.1 M	± 5%	1/2 w	REC-20BF(515B)
R156	5.1 M	± 5%	1/2 w	REC-20BF(515B)
R157	5.1 M	± 5%	1/2 w	REC-20BF(515B)
R158	5.1 M	± 5%	1/2 w	REC-20BF(515B)
R159	510 k	± 5%	1/2 w	REC-20BF(514B)
R160	510 k	± 5%	1/2 w	REC-20BF(514B)
R161	510 k	± 5%	1/2 w	REC-20BF(514B)
R162	510 k	± 5%	1/2 w	REC-20BF(514B)
R163	22	± 5%	1 w	REC-30BF(220B)

CAPACITORS

C101	100	± 5%	500 dcwv	COM-15D(101B)
C102	100	± 5%	500 dcwv	COM-15D(101B)
C103	100	± 5%	500 dcwv	COM-15D(101B)
C104	100	± 5%	500 dcwv	COM-15D(101B)
C105	150	± 5%	500 dcwv	COM-15D(151B)
C106	150	± 5%	500 dcwv	COM-15D(151B)
C107	220	± 5%	500 dcwv	COM-15D(221B)
C108	220	± 5%	500 dcwv	COM-15D(221B)
C109	68	± 5%	500 dcwv	COM-15D(680B)
C110	100	± 5%	500 dcwv	COM-15D(101B)
C111	.01 µf	±20%	500 dcwv	COC-62(103D)
C112	.01 µf	±20%	500 dcwv	COC-62(103D)
C113	.01 µf	±20%	500 dcwv	COC-62(103D)
C114	.01 µf	±20%	500 dcwv	COC-62(103D)
C115	220	± 5%	500 dcwv	COM-15D(221B)
C116	220	± 5%	500 dcwv	COM-15D(221B)
C117	220	± 5%	500 dcwv	COM-15D(221B)
C118	220	± 5%	500 dcwv	COM-15D(221B)
C119	.01 µf	±20%	500 dcwv	COC-62(103D)
C120	.01 µf	±20%	500 dcwv	COC-62(103D)
C121	.01 µf	±20%	500 dcwv	COC-62(103D)
C122	.01 µf	±20%	500 dcwv	COC-62(103D)
C123	33	± 5%	500 dcwv	COM-15C(330B)
C124	22	± 5%	500 dcwv	COM-15C(220B)
C125	22	± 5%	500 dcwv	COM-15C(220B)
C126	22	± 5%	500 dcwv	COM-15C(220B)
C127	220	± 5%	500 dcwv	COM-15D(221B)
C128	220	± 5%	500 dcwv	COM-15D(221B)
C129	220	± 5%	500 dcwv	COM-15D(221B)
C130	220	± 5%	500 dcwv	COM-15D(221B)
C131	0.0022 µf	±20%	500 dcwv	COC-61(222D)

PILOT LIGHT

P101 2LAP-5 Mazda

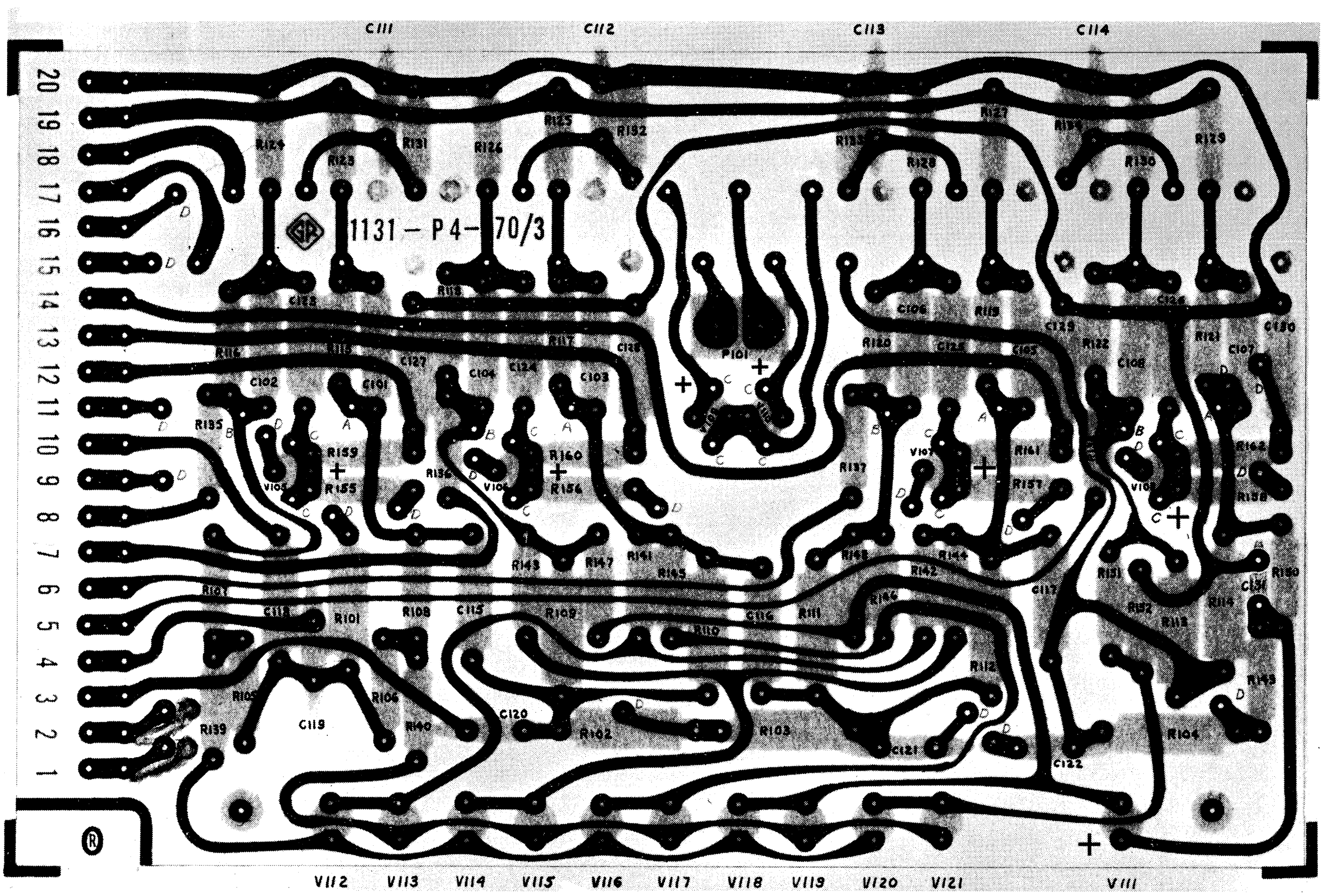
TUBES

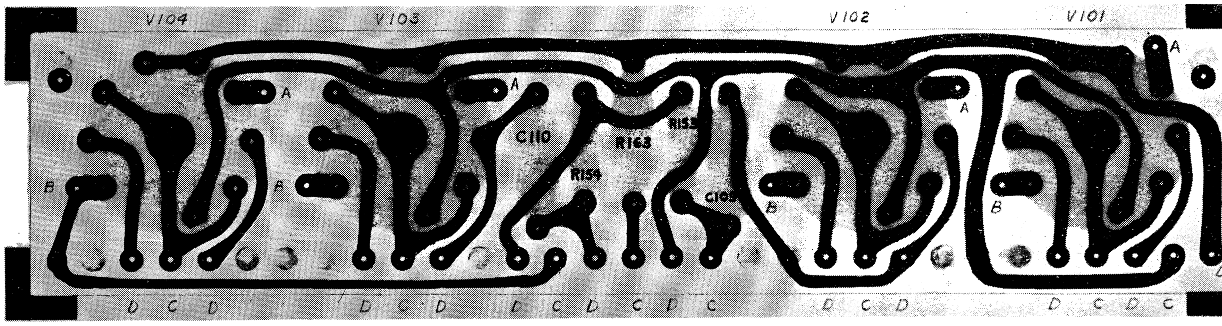
V101	5963	V108	1130-4000	V115	1130-4050
V102	5963	V109	1130-4000	V116	1130-4050
V103	5963	V110	1130-4000	V117	1130-4050
V104	5963	V111	1130-4000	V118	1130-4050
V105	1130-4000	V112	1130-4050	V119	1130-4050
V106	1130-4000	V113	1130-4050	V120	1130-4050
V107	1130-4000	V114	1130-4050	V121	1130-4050

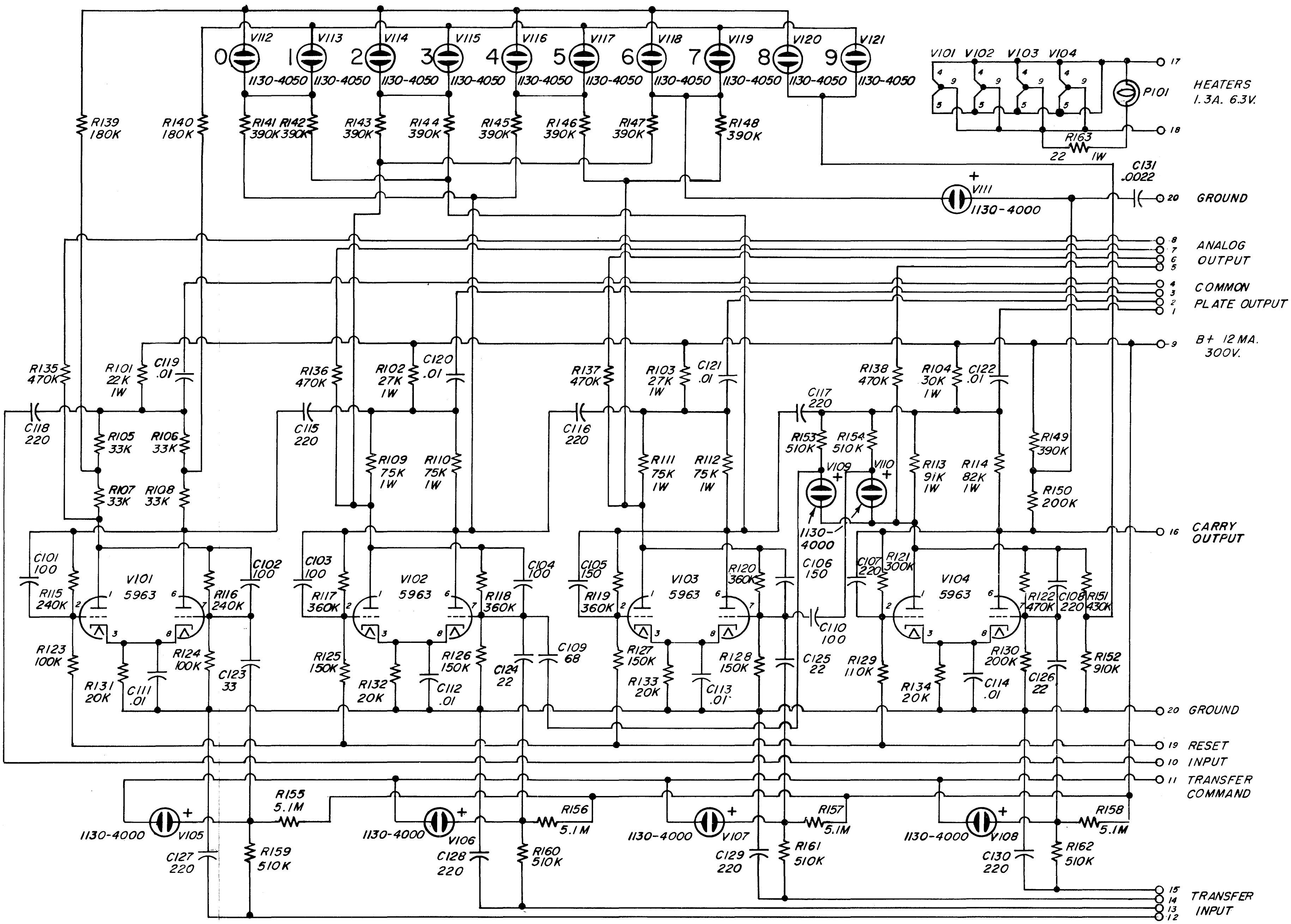
Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V101 (5963)	1	190(68)	58 k
	2	21(48)	76 k
	3, 8	48	20 k
	4, 5, 9	50 ±6.3 v ac	0
	6	68(190)	67 k
	7	48(21)	76 k
V102, V103 (5963)	1	same as V101	60 k
	2		110 k
	3, 8		20 k
	4, 5, 9		0
	6		69 k
	7		110 k
V104 (5963)	1	same as V101	73 k
	2		86 k
	3, 8		20 k
	4, 5, 9		0
	6		0
	7		145 k
V105, V106 V107, V108 (1130-4000)	1	160	0
	2	87(195)	460 k

Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V109, V110 (1130-4000)	1	230(123)	540 k
	2	190(68)	73 k
V111 (1130-4000)	1	195(136)	225 k
	2	155(190)	130 k
V112 (1130-4050)	1	170(155)	215 k
	2	115(195)	225 k
V113 (1130-4050)	1	155(170)	215 k
	2	115(195)	225 k
V114, V116 (1130-4050)	1	170(155)	
	2	130	
V115, V117 (1130-4050)	1	155(170)	
	2	130	
V118 (1130-4050)	1	170(155)	
	2	195(136)	
V119 (1130-4050)	1	155(170)	
	2	195(136)	
V120 (1130-4050)	1	170(155)	
	2	130(115)	
V121 (1130-4050)	1	155(170)	
	2	130(115)	

Note: Voltages are measured with the decade in the "0" state and (in parentheses) in the "9" state.




V104
V103
V102
V101
C110
R163
R153
R154
C105


V112
V113
V114
V115
V116
V117
V118
V119
V120
V121
1130-4050
HEATERS
1.3A. 6.3V.
P101
R163
22 1W
C131
.0022
V111
1130-4000
GROUND
ANALOG
OUTPUT
COMMON
PLATE OUTPUT
B+ 12 MA.
300V.
CARRY
OUTPUT
V101
5963
V102
5963
V103
5963
V104
5963
V109
V110
GROUND
RESET
INPUT
TRANSFER
COMMAND
V105
V106
V107
V108
TRANSFER
INPUT

RESISTORS

R101	1 M	± 1%	1/4 w	REF-65(105A)
R102	120 k	± 5%	1/2 w	REC-20BF(124B)
R103	1.3 M	± 5%	1/2 w	REC-20BF(135B)
R104	120 k	± 5%	1/2 w	REC-20BF(124B)
R105	1 M	± 1%	1/4 w	REF-65(105A)
R106	62 k	± 5%	1/2 w	REC-20BF(623B)
R107	62 k	± 5%	1/2 w	REC-20BF(623B)
R108	2 M	± 5%	1/2 w	REC-20BF(205B)
R109	56 k	± 5%	1/2 w	REC-20BF(563B)
R110	68 k	± 5%	1/2 w	REC-20BF(683B)
R111	10 M	± 5%	1/2 w	REC-20BF(106B)
R112	300 k	± 5%	1/2 w	REC-20BF(304B)
R113	3.6 M	± 5%	1/2 w	REC-20BF(365B)
R114	470 k	± 5%	1/2 w	REC-20BF(474B)
R115	100 k	± 5%	2 w	REC-41BF(104B)
R116	6.8 k	± 5%	1/2 w	REC-20BF(682B)
R117	4.7 k	± 5%	1/2 w	REC-20BF(472B)
R118	267 k	± 1%	1/8 w	REF-60(2673A)
R119	62 k	± 5%	1/2 w	REC-20BF(623B)
R120	267 k	± 1%	1/8 w	REF-60(2673A)
R121	62 k	± 5%	1/2 w	REC-20BF(623B)
R122	43 k	± 5%	1/2 w	REC-20BF(433B)
R123	240 k	± 5%	1/2 w	REC-20BF(244B)

RESISTORS (Cont)

R124	470 k	± 5%	1/2 w	REC-20BF(474B)
R125	30 k	± 5%	2 w	REC-41BF(303B)
R126	30 k	± 5%	2 w	REC-41BF(303B)
R127	470 k	± 5%	1/2 w	REC-20BF(474B)
R128	11 k	± 5%	1/2 w	REC-20BF(113B)
R129	360 k	± 5%	1/2 w	REC-20BF(364B)

CAPACITORS

C101	100	± 5%	500 dcwv	COM-15D(101B)
C102	.001 μf	± 5%	500 dcwv	COM-20D(102B)
C103	47	± 5%	500 dcwv	COM-15D(470B)
C104	220	± 5%	500 dcwv	COM-15D(221B)
C105	220	± 5%	500 dcwv	COM-15D(221B)
C106	47	± 5%	500 dcwv	COM-15D(470B)
C107	.01 μf	±10%	400 dcwv	COW-25(103C)
C108	.01 μf	±20%	500 dcwv	COC-62(103D)
C109	.01 μf	±20%	500 dcwv	COC-62(103D)
C110	.047 μf	±10%	100 dcwv	COW-17(473C)

DIODES

D101 1N448

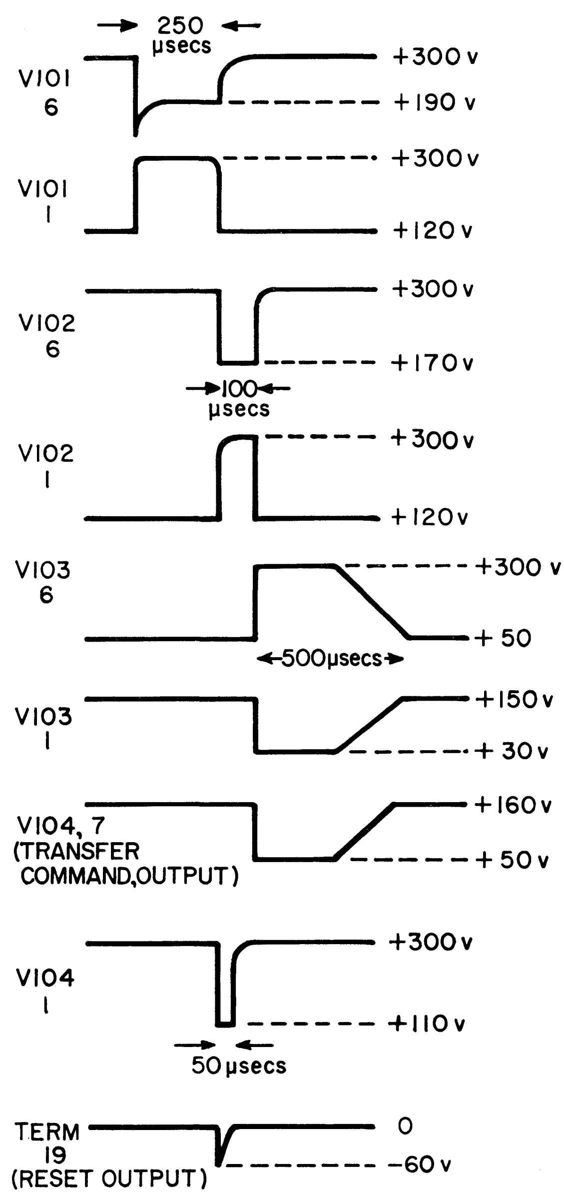
TUBES

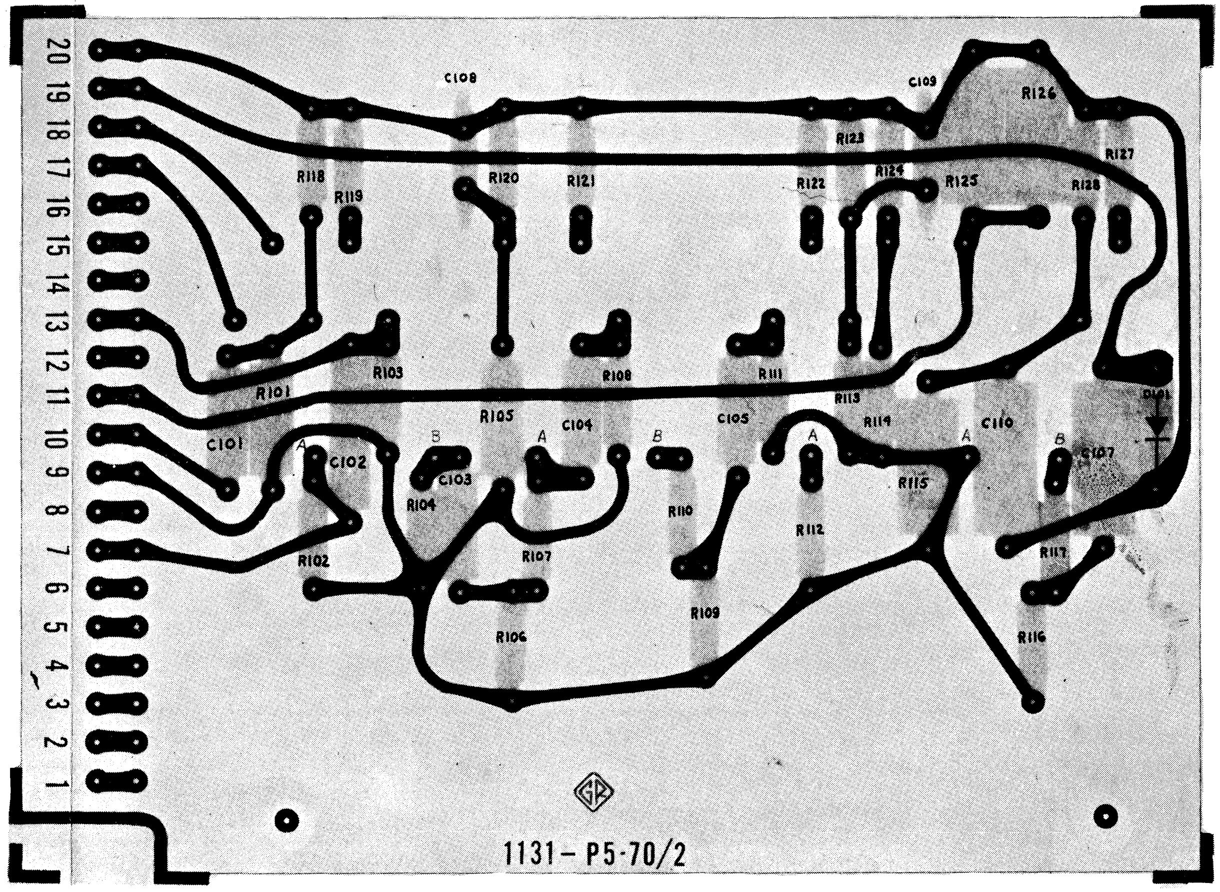
V101	5963	V103	5963
V102	5963	V104	6350

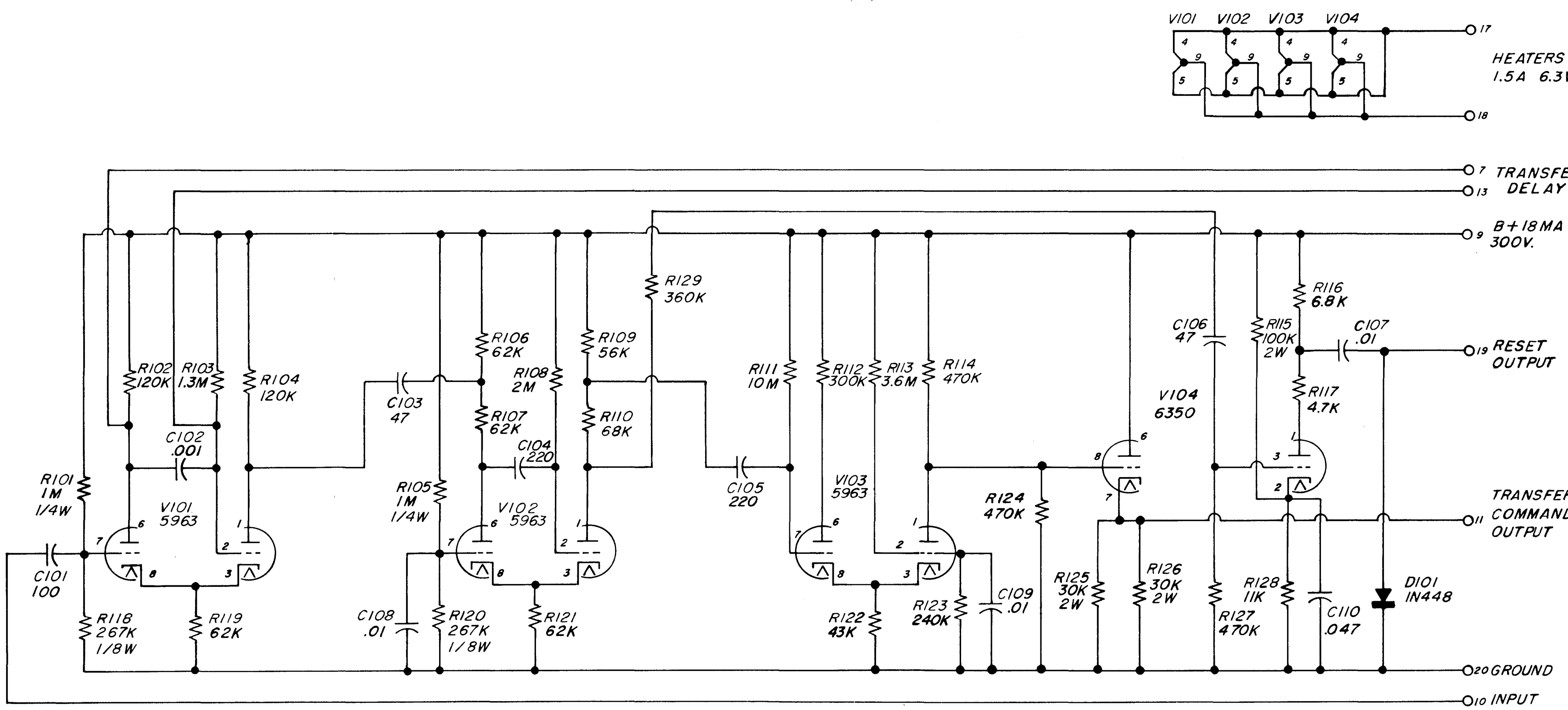
Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V101	1	120	120 k
(5963)	2	100	0
	3, 8	100	62 k
	4, 5, 9	50 ±6.3 v ac	0
	6	300	0
	7	70	210 k
V102	1	120	124 k
(5963)	2	100	2 M
	3, 8	100	62 k
	4, 5, 9	50 ±6.3 v ac	0
	6	300	124 k
	7	70	210 k

Tube (Type)	Pin	Volts to Ground	Res to Shorted Plug
V103	1	150	235 k
(5963)	2	25	133 k
	3, 8	40	43 k
	4, 5, 9	50 ±6.3 v ac	0
	6	50	300 k
	7	40	10 M
V104	1	300	11.5 k
(6350)	2	30	10 k
	3	0	470 k
	4, 5, 9	50 ±6.3 v ac	0
	6	300	0
	7	+160	15 k
	8	+150	235 k

Note: Voltages are measured with the decade in the "0" state and (in parentheses) in the "9" state.







TYPE 1131-P5 TRANSFER UNIT

RESISTOR

R820	5.1	± 5%	1 w	REC-30BF(051B)

PILOT LAMPS

P801	2LAP-6	P804	2LAP-6	P806	2LAP-6
P802	2LAP-6	P805	2LAP-6	V806	2LAP-5
P803	2LAP-6				

SWITCHES

S801	SWRW-219	S803	SWRW-221
S802	SWRW-220	S804	SWRW-222

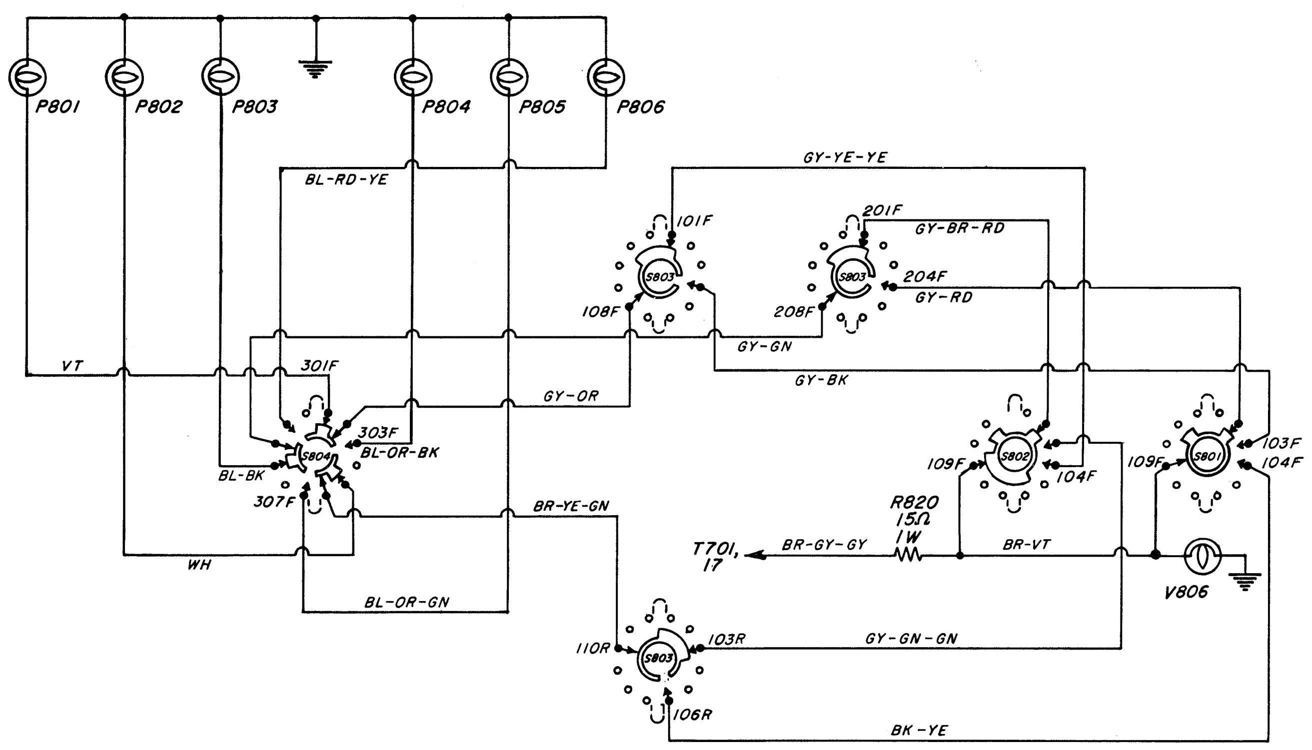
RESISTORS

R816	100 k	± 5%	1/2 w	REC-20BF(104B)
R817	15 k	± 5%	2 w	REC-41BF(153B)
R826	1 k	± 5%	1/2 w	REC-20BF(102B)

SWITCHES

S801	SWRW-219	S803	SWRW-221	S810	SWT-11A
S802	SWRW-220	S804	SWRW-222		

Decimal Point Switching



Switching Table

DECIMAL POINT	P801	P802	P803	P804	P805	P806

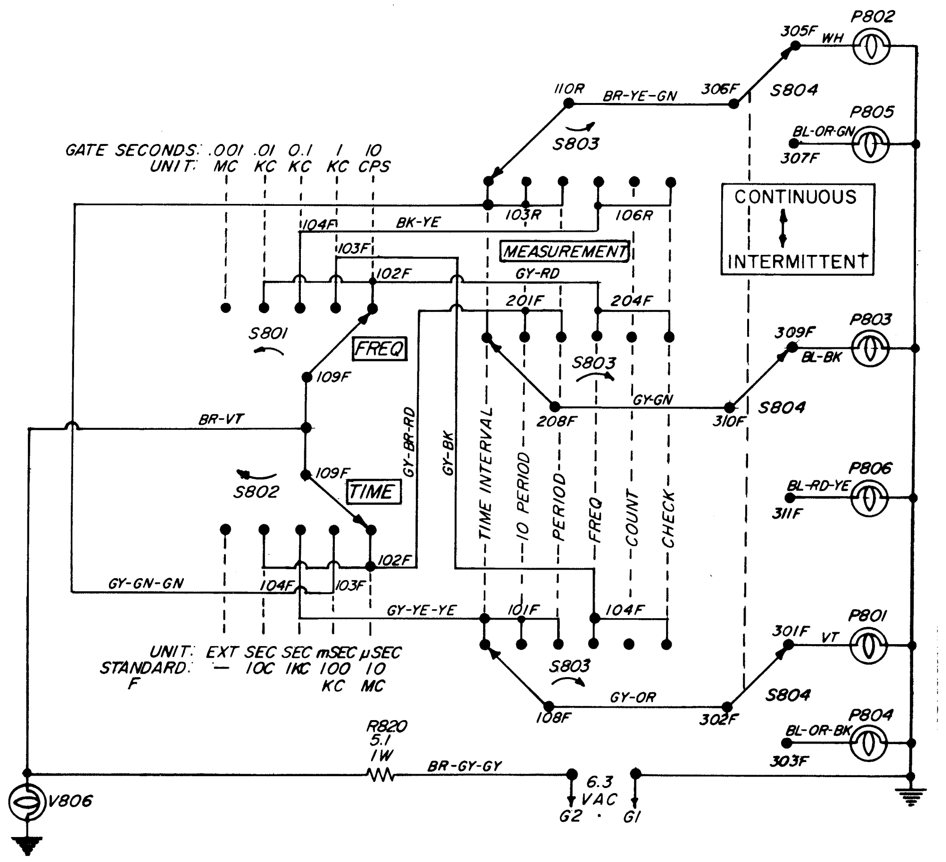
CHECK
COUNT–NONE
FREQ.

MEASUREMENT SWITCH S803

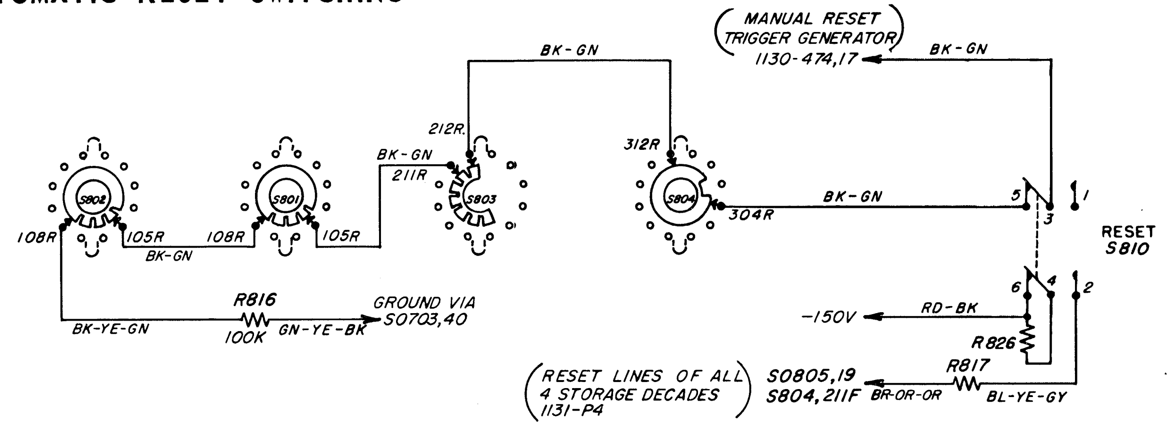
PERIOD
10 PERIOD
TIME INTERVAL

FREQUENCY SWITCH S801		DISPLAY SWITCH S804	
COUNTING INTERVAL SEC	FREQ. UNIT DISPLAYED	CONTINUOUS	INTERMITTENT
10	CPS	P803	P806
1	KC	P801	P804
0.1	KC	P802	P805
0.01	KC	P803	P806
0.001	KC	P801	P804

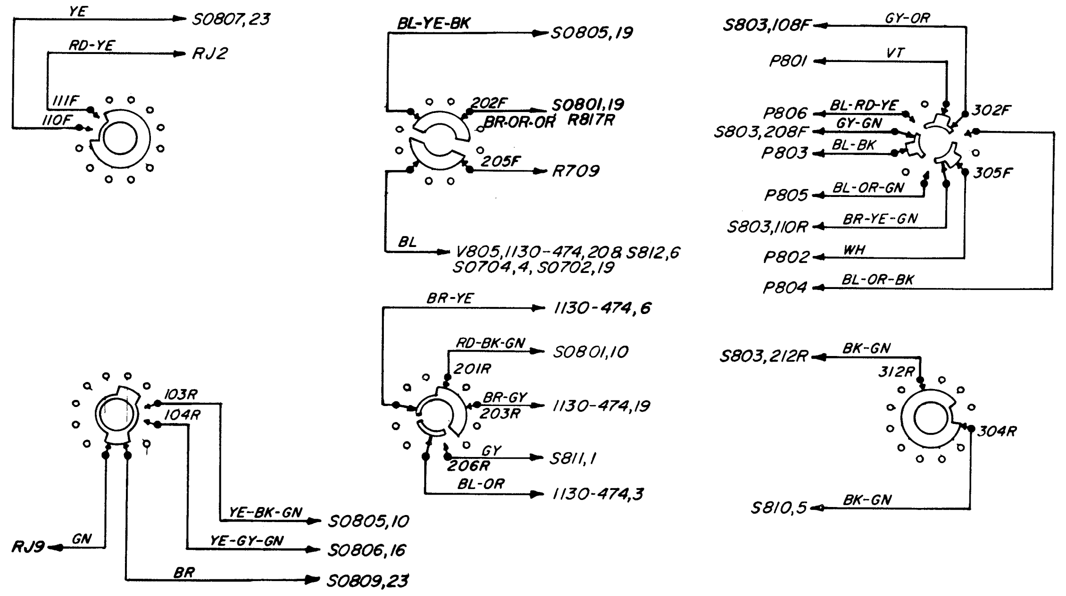
TIME SWITCH S802		DISPLAY SWITCH S804	
COUNTED FREQ	TIME UNIT DISPLAYED	CONTINUOUS	INTERMITTENT
10 MC	μ SEC	P803	P806
100 KC	m SEC	P802	P805
1 KC	SEC	P801	P804
10 CPS	SEC	P803	P806
EXT	EXT	NONE	NONE

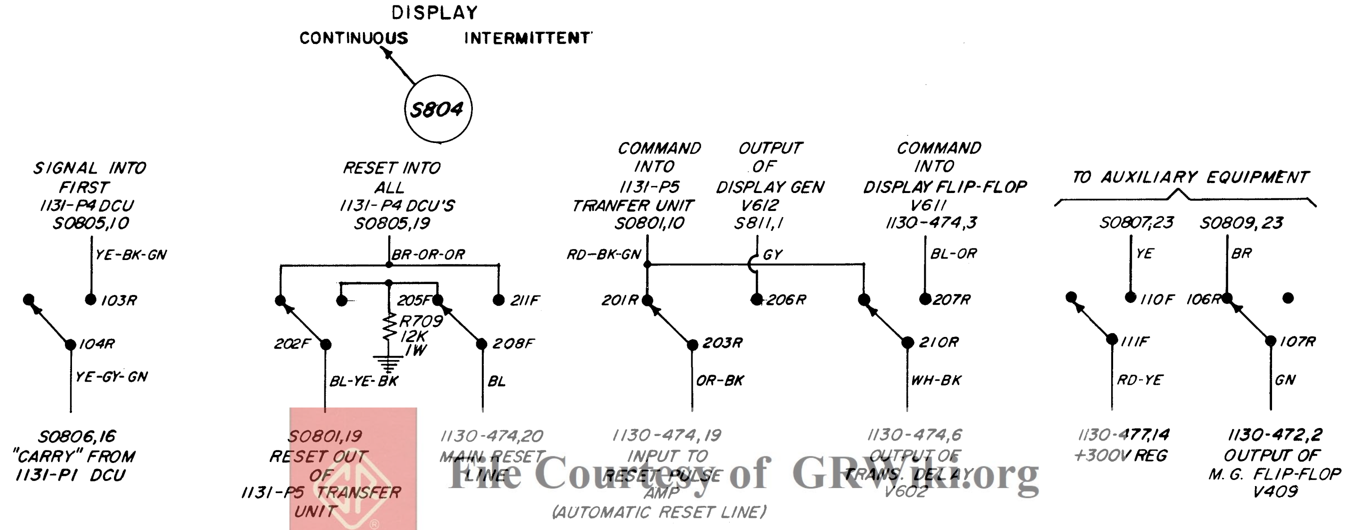


Automatic Reset Switching

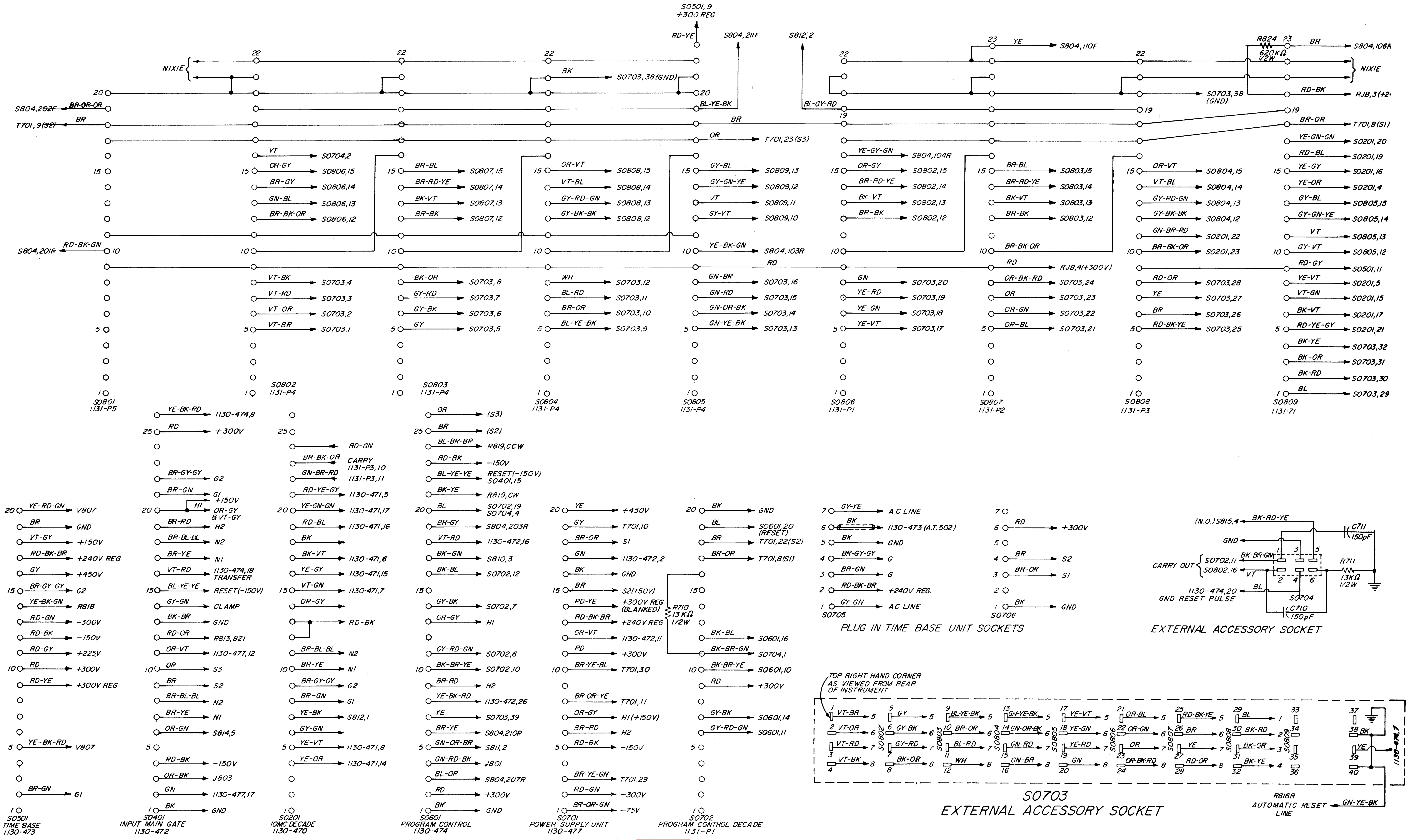


Display Switch





FOR "RESET" SECTION OF S804, SEE DIAGRAM 1130-6D



SOCKET CONNECTIONS

Type 1130-P
Time-Base Plug-In Units

TABLE OF CONTENTS

SPECIFICATIONS

TYPE 1130-P1 COUPLING UNIT

For use with external 5-Mc oscillator only. Input requirements are 1 volt rms into 50 ohms. This unit provides an inexpensive means of using a highly stable oscillator, such as the Type 1113-A Standard-Frequency Oscillator, as a time base for the counter.

TYPE 1130-P2 TIME-BASE OSCILLATOR/MULTIPLIER

This unit contains an internal 5-Mc crystal oscillator and also can be used with external frequency input of 5 Mc, 1 Mc, or 100 kc.

External Drive Requirements:

5 Mc – 1 volt rms into 50 ohms
1 Mc – 2 volts rms into 1 kilohm
100 kc – 1 volt rms into 100 kilohms.

Internal Oscillator: Same as in Type 1130-P3.

Tube Complement: Two 6X8; one each 5965, 6U8.

TYPE 1130-P3 TIME-BASE OSCILLATOR

For use with external 5-Mc standard-frequency oscillator or with internal crystal oscillator. External drive requirements are the same as for Type 1130-P4.

Internal Oscillator: 5-Mc crystal oscillator operating at room temperature.

Stability:

Long-Term Drift: Less than 10×10^{-6} in 6 months.

Short Term: Less than 2×10^{-7} per week.
Less than 1×10^{-8} per minute.

Temperature Coefficient: Less than 2×10^{-7} per degree Centigrade.

Tube Complement: One 6U8.

TYPE 1130-P4 PRECISION TIME-BASE OSCILLATOR

This unit contains an accurate and stable crystal oscillator, but can also be used to couple to an external 5-Mc standard-frequency oscillator.

External Drive Requirements: 5 Mc: 1 volt rms into 50 ohms.

Internal Oscillator: A vacuum-sealed 5-Mc crystal and solid-state circuit in a constant-temperature, proportional-control oven. Operates directly from the power line connection of the Type 1130-A Digital Time and Frequency Meter.

Long-Term Drift: Less than 3×10^{-8} per week after 60 days of operation.

Typical Drift: After one year of operation, typically less than 1×10^{-8} per week. Fluctuations over any 24-hour period are less than 5×10^{-9}.

Short-Term Stability: Less than 1×10^{-9} per minute (one-second sampling time.

Temperature Coefficient: Less than 3×10^{-10} per degree C from 0 to 50 C.

Line-Voltage Effects: Less than 2×10^{-9} for ±10% voltage change.

Power Input: 7 watts.

APPENDIX 1

Type 1130-P Time-Base Plug-In Units

Introduction

1.1 PURPOSE.

The Type 1130-P Time-Base Plug-In Units are used to provide the 5-Mc reference signal for the time-base circuits of the Type 1130-A Digital Time and Frequency Meter, and the 5-Mc reference signal for the Type 1133-A Frequency Converter and Video Amplifier.

1.2 DESCRIPTION.

There are four time-base plug-in units (Figure A-1). The Type 1130-P1 Coupling Unit can be used only with external sources of 5 Mc, such as the Type 1113-A Standard-Frequency Oscillator. The Type 1130-P2 Time-Base Oscillator/Multiplier can be used with external sources of 100 kc, 1 Mc, or 5 Mc, or it can operate from its own 5-Mc quartz-crystal oscillator. The Type 1130-P3 Time-Base Oscillator can operate from an external 5-Mc source or from its own 5-Mc quartz-crystal oscillator. The Type 1130-P4 Precision Time-Base Oscillator can operate from an external 5-Mc source or from its own 5-Mc quartz-crystal oscillator of exceptional stability.

The oscillators of the Types 1130-P2 and -P3 use a room-temperature quartz crystal with a low temperature coefficient. The oscillator of the Type 1130-P4 uses a vacuum-sealed crystal held at constant temperature in a proportional-control oven.

Each unit is housed in a rugged package for insertion in the Type 1130-A Digital Time and Frequency Meter.

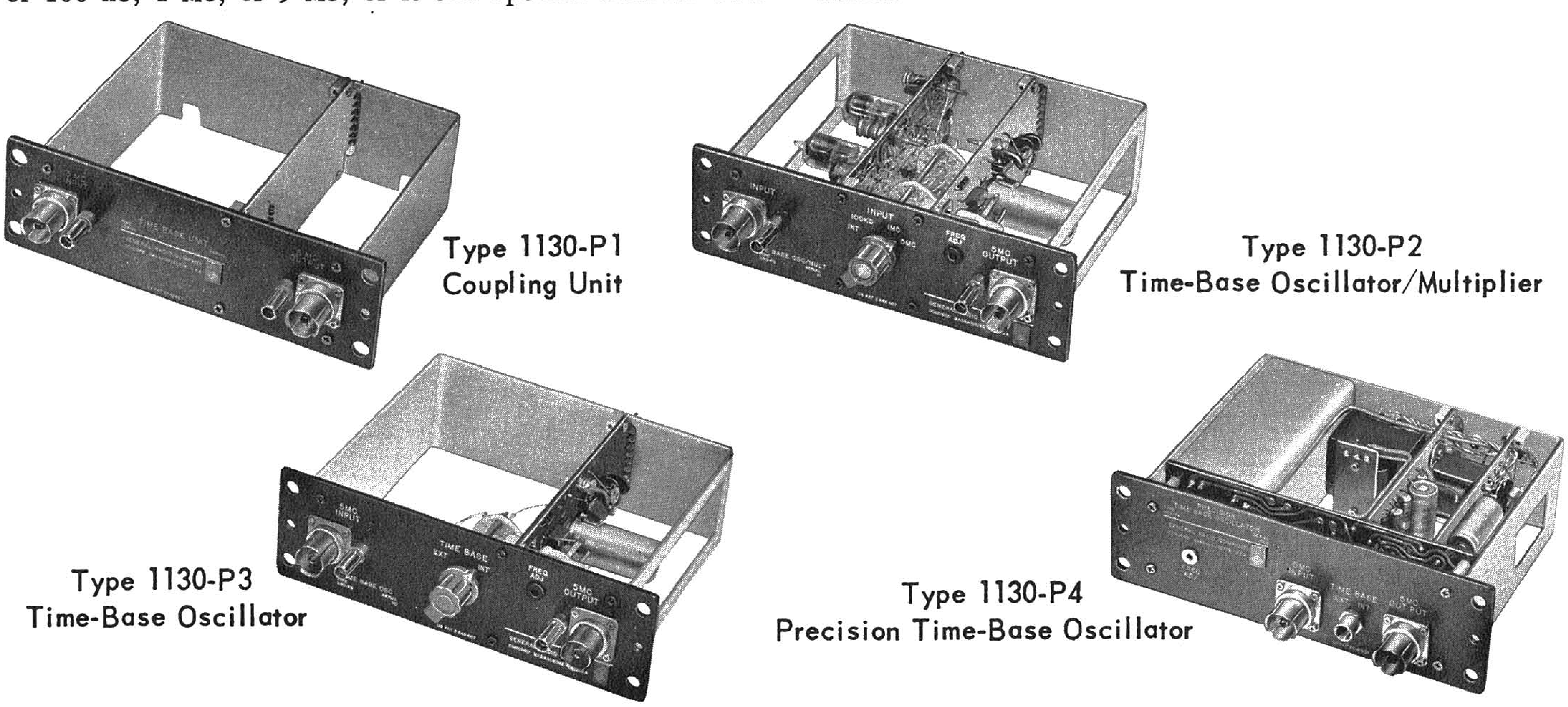


Figure A-1. Time-base units for the Type 1130-A Digital Time and Frequency Meter.

APPENDIX 1

Operating Procedure

2.1 INSTALLATION.

The Type 1130-P units plug into the rear of the Type 1130-A Digital Time and Frequency Meter and fasten with two panel screws. The Type 1130-P4 unit can operate independently, however, if a source of 115 (or 230) volts, 50 to 60 cps, is connected to the proper terminals as indicated on the schematic diagram.

While instruments are normally supplied for 115-volt operation, the power transformer can be reconnected for 230-volt operation. When changing connections, be sure to reverse the metal plate so that it will read 230 volts, and also replace the 0.2-ampere line fuses with fuses rated at 0.1 ampere.

2.2 OPERATION.

To operate the time-base unit from an external source, connect the external reference signal to the INPUT connector and set the INPUT or TIME BASE control to EXT.

To operate the time-base unit from the internal 5-Mc oscillator, set the INPUT or TIME BASE control to INT. For maximum accuracy the units should be warmed up thoroughly (about two hours). The Type 1130-P4 is connected to operate at the proper temperature as long as the Type 1130-A is connected to a source of power.

2.3 ADJUSTMENT OF INTERNAL-OSCILLATOR FREQUENCY.

Refer to paragraph 4.2.3 of the Operating Instructions for the Type 1130-A.

Principles of Operation

3.1 TYPE 1130-P2 TIME-BASE OSCILLATOR.

Figure A-2 is a block diagram of the Type 1130-P2 Oscillator/Multiplier. The unit contains two etched boards: the Type 1130-P2-270 Multiplier Board and the Type 1130-P3-270 Oscillator Board. When the internal crystal oscillator is used, the plate-supply voltage for the multiplier board is disconnected. When external sources are used, the internal oscillator circuit is disabled.

The multiplier unit will accept either 100-kc or 1-Mc signals. Input signals of 5 Mc are switched directly

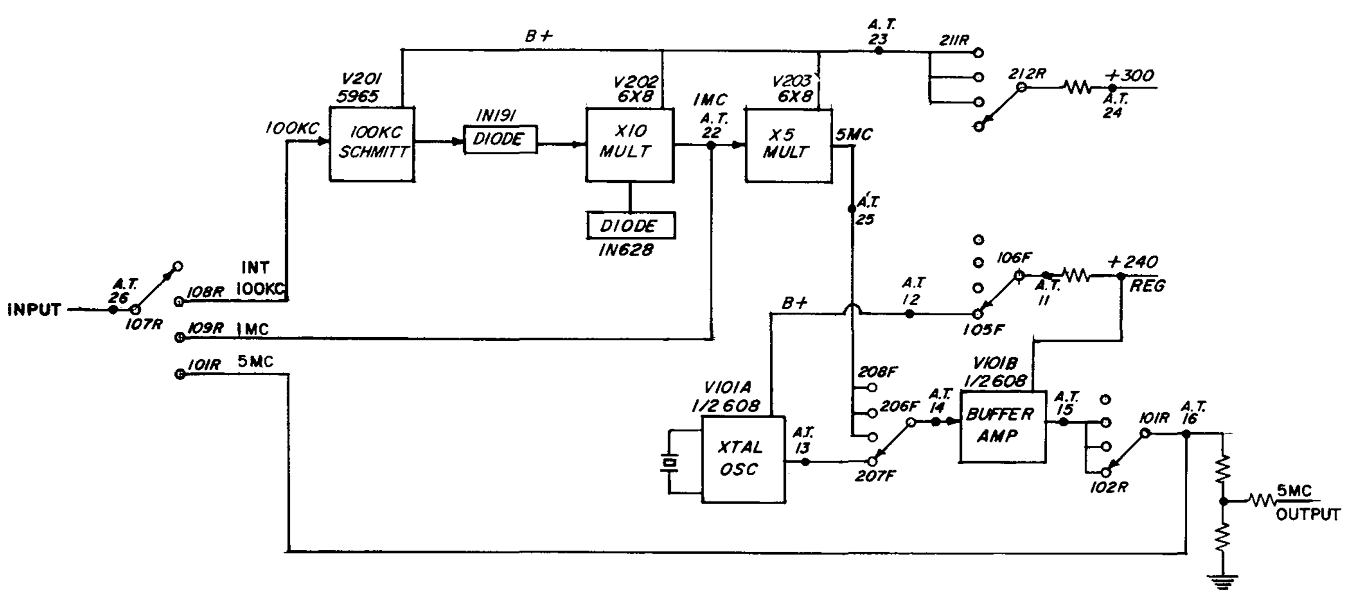


Figure A-2. Block diagram of the Type 1130-P2 Oscillator/Multiplier.

APPENDIX 1

to the output. Trigger pulses are generated from a 100-kc input signal by the 100-kc Schmitt circuit. The trigger pulses activate the X10 multiplier circuit, a monostable multivibrator adjusted to produce rectangular pulses of exactly 4.5-μsec duration. The resulting duty ratio of 0.45 maximizes the 10th-harmonic component (1 Mc) and minimizes the 9th and 11th harmonics. The 1-Mc component is filtered and applied to the X5 multiplier, a Schmitt circuit which produces square waves. The strong 5-Mc harmonic component is filtered and applied to the tuned buffer amplifier.

The internal crystal oscillator board is identical to that of the Type 1130-P3 Time-Base Oscillator described below.

3.2 TYPE 1130-P3 TIME-BASE OSCILLATOR.

On the Type 1130-P3-270 Oscillator Board of the Type 1130-P3 Time-Base Oscillator, a Type 6U8 triode-pentode is used. The triode is connected as a Pierce oscillator and the pentode as a tuned-plate amplifier. A 5-Mc fundamental-mode AT-cut quartz crystal with a very low temperature coefficient is used in the oscillator circuit to ensure high accuracy over a wide range of operating temperature. Figure A-3 shows the frequency-vs-temperature characteristic of a typical oscillator.

3.3 TYPE 1130-P4 PRECISION TIME-BASE OSCILLATOR.

Figure A-4 is a block diagram of the Type 1130-P4 Precision Time-Base Oscillator. A 5-Mc fundamental-mode AT-cut quartz crystal in a vacuum-sealed mounting is used in a modified Pierce oscillator circuit. The amplitude of oscillation is limited at a low level by a pair of crystal diodes and is amplified by a three-stage amplifier.

The crystal and oscillator circuit are housed in a proportional-control-type oven to obtain constant operating temperature (about 70 C) and maximum stability. A temperature-sensitive bridge circuit provides an error signal which is amplified by a four-stage amplifier. The output of the amplifier drives a push-pull synchronous detector which controls the current in the oven heater.

The power supply is self-contained and operates from 115 (or 230) volts, 50 to 60 cps. Two supplies regulated by Zener diodes are used: -20 volts for the oven control circuit and 5-Mc output amplifier, and -6 volts for the oscillator and low-level amplifier circuits.

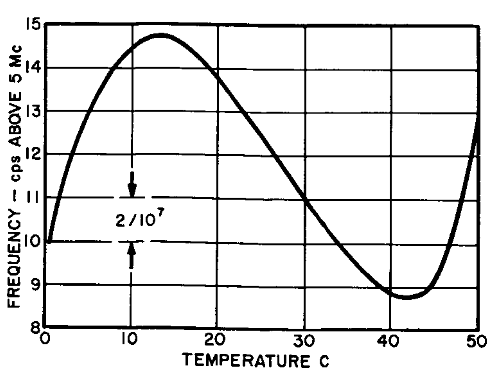


Figure A-3. Frequency-vs-temperature characteristic of a typical Type 1130-P3 Time-Base Oscillator.

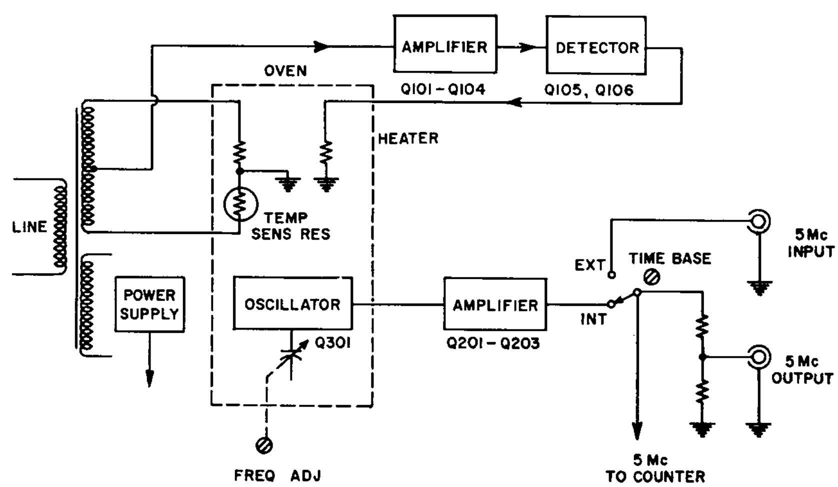


Figure A-4. Block diagram of the Type 1130-P4 Precision Time-Base Oscillator.

APPENDIX 1

Service and Maintenance

4.1 INTERNAL ADJUSTMENTS.

4.1.1 GENERAL. Normally, most of the factory-set adjustments will not require any attention. Those adjustments that may occasionally be necessary (as, for instance, after replacement of a tube or transistor) are listed in the table below and described in paragraph 4.1.2.

4.1.2 ADJUSTMENT PROCEDURE.

Note: Adjustments must be made in the order given.

4.1.2.1 Tuning Adjustment of 5-Mc Amplifier, L101. To adjust L101:

a. Set the selector switch on the Type 1130-P2 or -P3 to INT.

b. Connect an oscilloscope or VTVM to the 5 MC OUTPUT connector.

c. Adjust L101 for maximum output (at least 0.65 volt rms, open circuit).

4.1.2.2 Sensitivity Adjustment of 5-Mc Multiplier, R219. To adjust R219:

a. With a low-capacitance probe (8 pf or less), connect an oscilloscope to the body of C213, the small disk capacitor directly behind V203.

b. Set the selector switch to 1 Mc.

c. Set the oscilloscope sweep to 0.5 μsec/cm and the vertical sensitivity to about 5 volts/cm.

d. Apply an accurate 1-Mc signal of 5.6 volts peak-to-peak or 2 volts rms to the INPUT connector.

e. Adjust R219 for a symmetrical 1-Mc square-wave display on the oscilloscope.

4.1.2.3 Preliminary Tuning Adjustment of 5-Mc Multiplier, L204. To adjust L204:

a. As in paragraph 4.1.2,2, set the selector switch to 1 Mc, apply a 1-Mc signal to the INPUT connector, and set the oscilloscope sweep to 0.5 μsec/cm and vertical sensitivity to 5 volts/cm.

b. Connect the oscilloscope probe to the 5 MC OUTPUT connector.

c. Adjust L204 for maximum amplitude of the 5-Mc display.

4.1.2.4 Preliminary Tuning Adjustment of 1-Mc Multiplier, L201. To adjust L201:

a. As in paragraph 4.1.2.2, set the selector switch to 1 Mc and the oscilloscope sweep to 0.5 μsec/cm.

b. Connect the oscilloscope probe to the unused terminal at the top of L201.

c. Set the oscilloscope sensitivity to maximum.

d. Increase the 1-Mc input signal until a measurable 1-Mc display appears.

e. Adjust L201 for maximum amplitude of this display.

4.1.2.5 Sensitivity Adjustment of 100-kc Schmitt circuit, R202. To adjust R202:

a. Set the selector switch of the Type 1130-P2 to 100 kc.

b. With a low-capacitance probe (8 pf or less), connect an oscilloscope to anchor terminal 22, below and to the rear of L202 on the circuit side of the multiplier board.

c. Set the oscilloscope sensitivity to 1 volt/cm and the sweep to 5 μsec/cm.

Name	Time-Base Unit	Ref Number	Refer to Paragraph
5-Mc Amplifier Tuning	1130-P2 1130-P3	L101	4.1.2.1
5-Mc Multiplier Sensitivity	1130-P2	R219	4.1.2.2
5-Mc Multiplier Tuning	1130-P2	L204	4.1.2.3, 4.1.2.9
1-Mc Multiplier Tuning	1130-P2	L201	4.1.2.4, 4.1.2.7
100-kc Schmitt Circuit Sensitivity	1130-P2	R202	4.1.2.5
1-Mc Multiplier Duty Ratio	1130-P2	R212	4.1.2.6
1-Mc Filter Tuning	1130-P2	L202	4.1.2.8
RF Amplifier Tuning	1130-P4	C205	4.1.2.10
RF Amplifier Tuning	1130-P4	C211	4.1.2.10

APPENDIX 1

d. Apply an accurate 100-kc signal of 2.0 volts peak-to-peak to the INPUT terminal.

e. Adjust R202 to obtain a 1-Mc output display on the oscilloscope.

4.1.2.6 Duty-Ratio Adjustment of 1-Mc Multiplier, R212. To adjust R212:

a. As in paragraph 4.1.2.5, set the selector switch to 100 kc and apply a 100-kc signal to the INPUT connector of the Type 1130-P2. Set the oscilloscope sensitivity to 1 volt/cm and the sweep to 5 μsec/cm and connect the probe to anchor terminal 22.

b. Adjust R212 for maximum 1-Mc output. If more than one maximum occurs, select the one nearest center.

4.1.2.7 Final Tuning Adjustment of 1-Mc Multiplier, L201. To adjust L201:

a. As in paragraph 4.1.2.5, set the selector switch to 100 kc and apply a 100-kc signal to the INPUT connector of the Type 1130-P2. Set the oscilloscope sensitivity to 1 volt/cm and the sweep to 5 μsec/cm and connect the probe to anchor terminal 22.

b. Adjust L201 for maximum 1-Mc output (tunes sharply).

4.1.2.8 Tuning Adjustment of 1-Mc Filter, L202. To adjust L202:

a. As in paragraph 4.1.2.5, set the selector switch to 100 kc and apply a 100-kc signal to the INPUT connector of the Type 1130-P2. Set the oscilloscope sensitivity to 1 volt/cm and the sweep to 5 μsec/cm and connect the probe to anchor terminal 22.

b. Adjust L202 for maximum 1-Mc output (tunes broadly).

4.1.2.9 Final Tuning Adjustment of 5-Mc Multiplier, L204. To adjust L204:

a. As in paragraph 4.1.2.5, set the selector switch to 100 kc and apply a 100-kc signal to the INPUT connector of the Type 1130-P2. Set the oscilloscope sensitivity to 1 volt/cm and the sweep to 5 μsec/cm.

b. Connect the oscilloscope probe to the 5 MC OUTPUT connector of the Type 1130-P2.

c. Adjust L204 for minimum ripple of the displayed 5-Mc signal. If the ripple exceeds 5 percent, a very slight readjustment of R212, L201, L202, L204, or L101 will reduce it. (Five-percent ripple is tolerable.)

4.1.2.10 Tuning Adjustment of 1130-P4 RF Amplifier, C205 and C211. Adjust C205 and C211 for maximum 5-Mc output.

4.2 VOLTAGE MEASUREMENTS.

Table 1 gives the normal voltage measurements from tube pins to ground in the Type 1130-P2 or -P3. Table 2 gives the normal voltage measurements from from transistor terminals to ground in the Type 1130-P4. A deviation of 10 percent from any of these values is not necessarily abnormal.

PARTS LISTS AND SCHEMATICS

On the following pages appear parts lists, schematic diagrams, voltage and resistance tables, and etched-board layouts, which should prove helpful in trouble-shooting. These data are arranged by circuit as follows:

NOTES FOR PARTS LISTS - Refer to page 31.

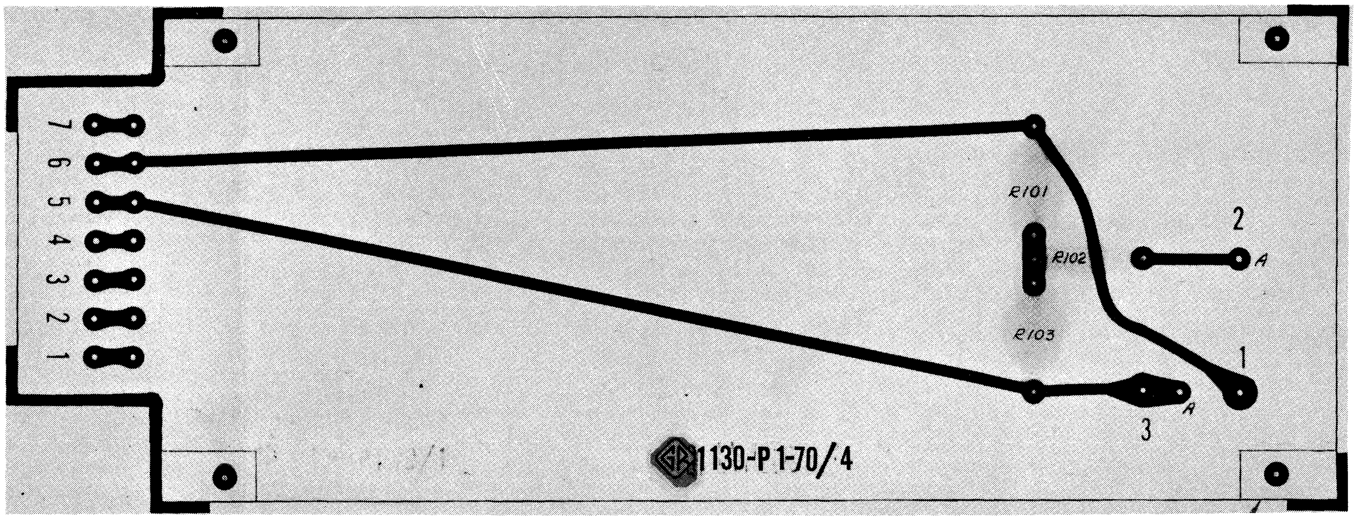
NOTE FOR SERVICE TABLES - Refer to page 31.

RESISTORS

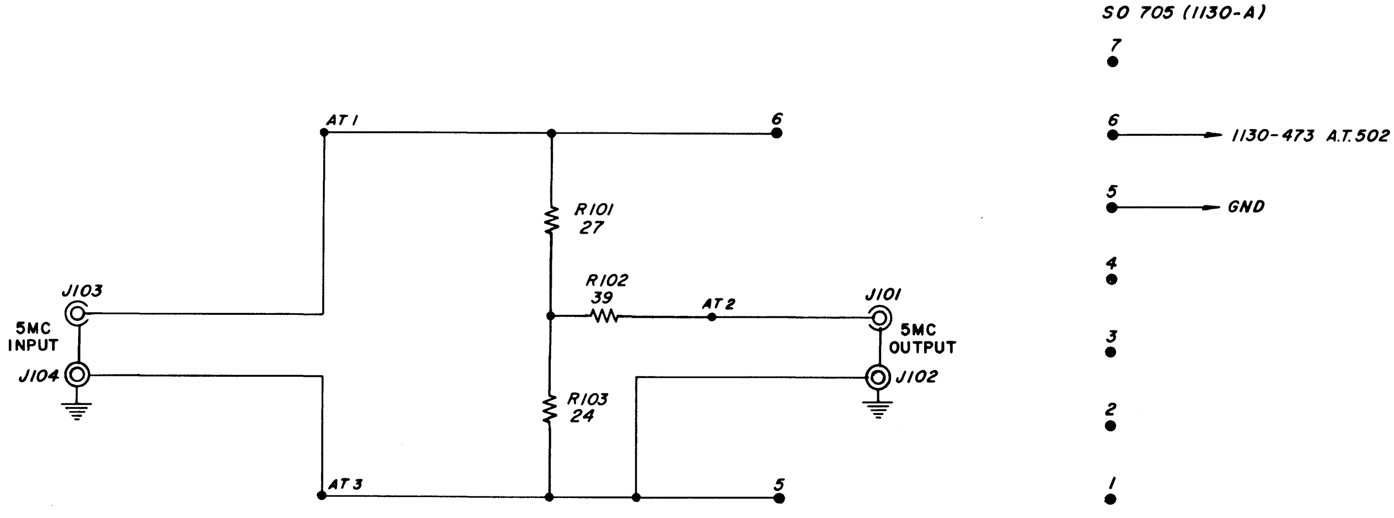
R101	27	± 5%	1/2 w	REC-20BF(270B)
R102	39	± 5%	1/2 w	REC-20BF(390B)
R103	24	± 5%	1/2 w	REC-20BF(240B)

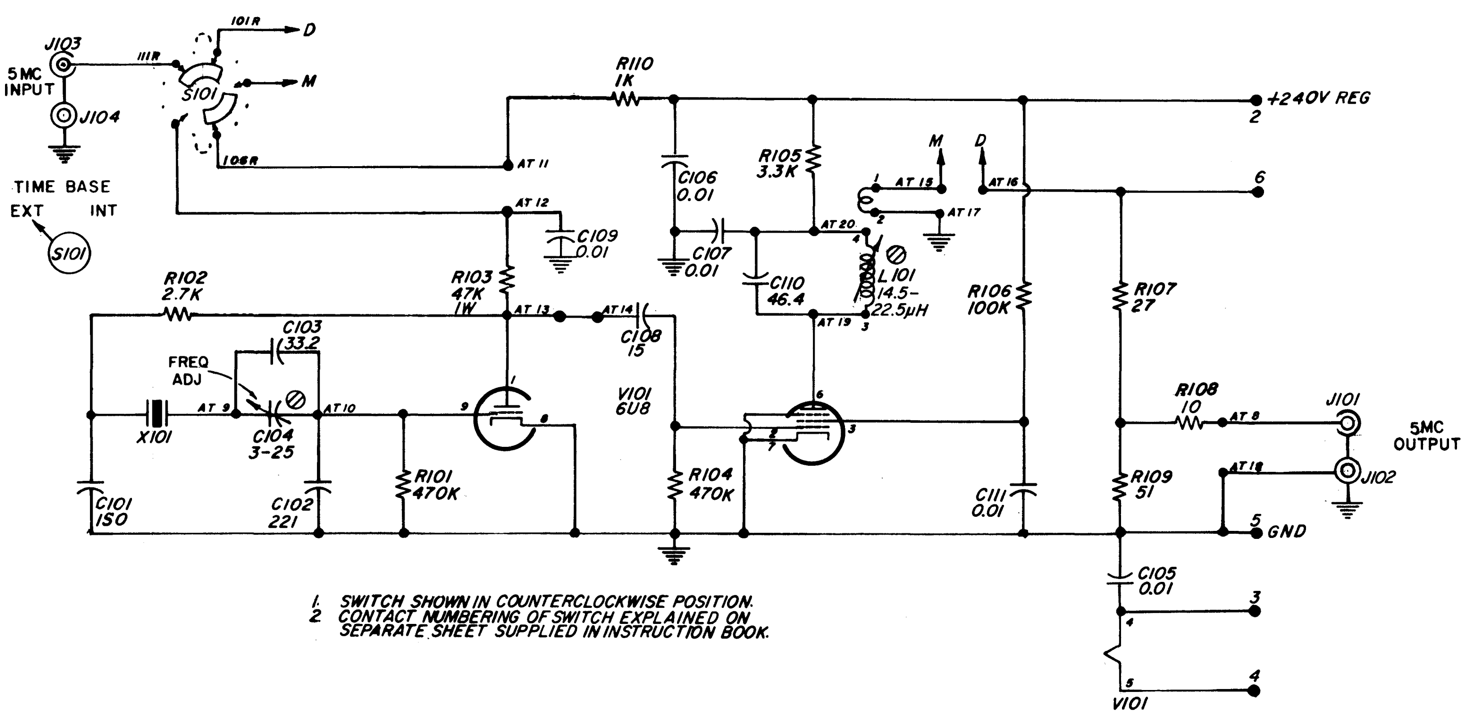
JACKS

J101	874-404	J103	874-404
J102	BP-10, 11/16	J104	BP-10, 11/16



Note: Etched board, parts list, and service data for the Type 1130-P3 are included with the Type 1130-P2 on pages 66 and 67.





1. SWITCH SHOWN IN COUNTERCLOCKWISE POSITION.
2. CONTACT NUMBERING OF SWITCH EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.

TYPE 1130-P1 COUPLING UNIT
TYPE 1130-P3 TIME-BASE OSCILLATOR (Schematic only)

Type 1130-P2 Time-Base Oscillator/Multiplier

RESISTORS

R201	390 k	± 5%	1/2 w	REC-20BF(394B)
R202	100 k	±20%		POSC-22(104D)
R203	82 k	± 5%	1/2 w	REC-20BF(823B)
R204	10 k	± 5%	1 w	REC-30BF(103B)
R205	10 k	± 5%	1/2 w	REC-20BF(103B)
R206	200 k	± 5%	1/2 w	REC-20BF(204B)
R207	13 k	± 5%	1 w	REC-30BF(133B)
R208	56 k	± 5%	1/2 w	REC-20BF(563B)
R209	15 k	± 5%	1/2 w	REC-20BF(153B)
R210	39 k	± 5%	1 w	REC-30BF(393B)
R211	240 k	± 5%	1/2 w	REC-20BF(244B)
R212	100 k	±20%		POSC-22(104D)
R213	39 k	± 5%	2 w	REC-41BF(393B)
R214	1 M	± 5%	1/2 w	REC-20BF(105B)
R215	62 k	± 5%	1 w	REC-30BF(623B)
R216	4.3 k	± 5%	1/2 w	REC-20BF(432B)
R217	33 k	± 5%	1 w	REC-30BF(333B)
R218	200 k	± 5%	1/2 w	REC-20BF(204B)
R219	100 k	±20%		POSC-22(104D)
R220	300 k	± 5%	1/2 w	REC-20BF(304B)
R221	3 k	± 5%	1/2 w	REC-20BF(302B)
R222	220 k	± 5%	1/2 w	REC-20BF(224B)
R223	36 k	± 5%	2 w	REC-41BF(363B)
R224	1 M	± 5%	1/2 w	REC-20BF(105B)
R225	300 k	± 5%	1/2 w	REC-20BF(304B)
R226	300	± 5%	1/2 w	REC-20BF(301B)

CAPACITORS

C201	10	± 5%	500 dcwv	COC-60-2(100B)
C202	33	± 5%	500 dcwv	COC-60-2(330B)
C203	.01 μf	±20%	500 dcwv	COC-62(103D)

CAPACITORS (Cont)

C204	62	± 5%	500 dcwv	COC-63-2(620B)
C205	.01 μf	±20%	500 dcwv	COC-62(103D)
C206	62	± 5%	500 dcwv	COC-63-2(620B)
C207	2.7	± 5%	500 dcwv	COC-1(027B)
C208	.01 μf	±20%	500 dcwv	COC-62(103D)
C209	.01 μf	±20%	500 dcwv	COC-62(103D)
C210	.01 μf	±20%	500 dcwv	COC-62(103D)
C211	18	± 5%	500 dcwv	COC-61-2(180B)
C212	100	± 5%	500 dcwv	COC-63-2(101B)
C213	100	± 5%	500 dcwv	COC-60-2(101B)
C214	33	± 5%	500 dcwv	COC-62-2(330B)
C215	.01 μf	±20%	500 dcwv	COC-62(103D)
C216	33	± 5%	500 dcwv	COC-62-2(330B)
C217	.01 μf	±20%	500 dcwv	COC-62(103D)
C218	.01 μf	±20%	500 dcwv	COC-62(103D)
C219	.01 μf	±20%	500 dcwv	COC-62(103D)

DIODES

D201	1N191	D202	1N628

INDUCTORS

L201	305-520 μh		CHA-59-12
L202	515-830 μh		CHA-59-13
L203	56 μh	±10%	CHM-3
L204	29-55.5 μh		

JACKS

J201 | J202

SWITCH

S201 SWRW-230

TUBES

V201	5965	V203	6X8
V202	6X8	V101	6U8

Type 1130-P3 Time-Base Oscillator

RESISTORS

R101	470 k	± 5%	1/2 w	REC-20BF(474B)
R102	2.7 k	± 5%	1/2 w	REC-20BF(272B)
R103	47 k	± 5%	1 w	REC-30BF(473B)
R104	470 k	± 5%	1/2 w	REC-20BF(474B)
R105	3.3 k	± 5%	1/2 w	REC-20BF(332B)
R106	100 k	± 5%	1/2 w	REC-20BF(104B)
R107	27	± 5%	1/2 w	REC-20BF(270B)
R108	10	± 5%	1/2 w	REC-20BF(100B)
R109	51	± 5%	1/2 w	REC-20BF(510B)
R110	1 k	± 5%	1/2 w	REC-20BF(102B)

CAPACITORS

C101	150	± 1%	500 dcwv	COM-22F(151A)
C102	221	± 1%	500 dcwv	COM-22F(2210A)
C103	33.2	± 2%	500 dcwv	COM-22E(0332
C104	3-25		500 dcwv	COA-1

CAPACITORS (Cont)

C105	.01 μf	±20%	500 dcwv	COC-62(103D)
C106	.01 μf	±20%	500 dcwv	COC-62(103D)
C107	.01 μf	±20%	500 dcwv	COC-62(103D)
C108	15		500 dcwv	COC-21(150
C109	.01 μf	±20%	500 dcwv	COC-62(103D)
C110	46.4		500 dcwv	COM-22E(0464
C111	.10 μf	±20%	500 dcwv	COC-62(103D)

CRYSTAL

X101 1213-D-44

INDUCTOR

L101 CHA-59-6

JACKS

J101
J102

JACKS (Cont)

J103
J104

SWITCH

S101 SWRW-232

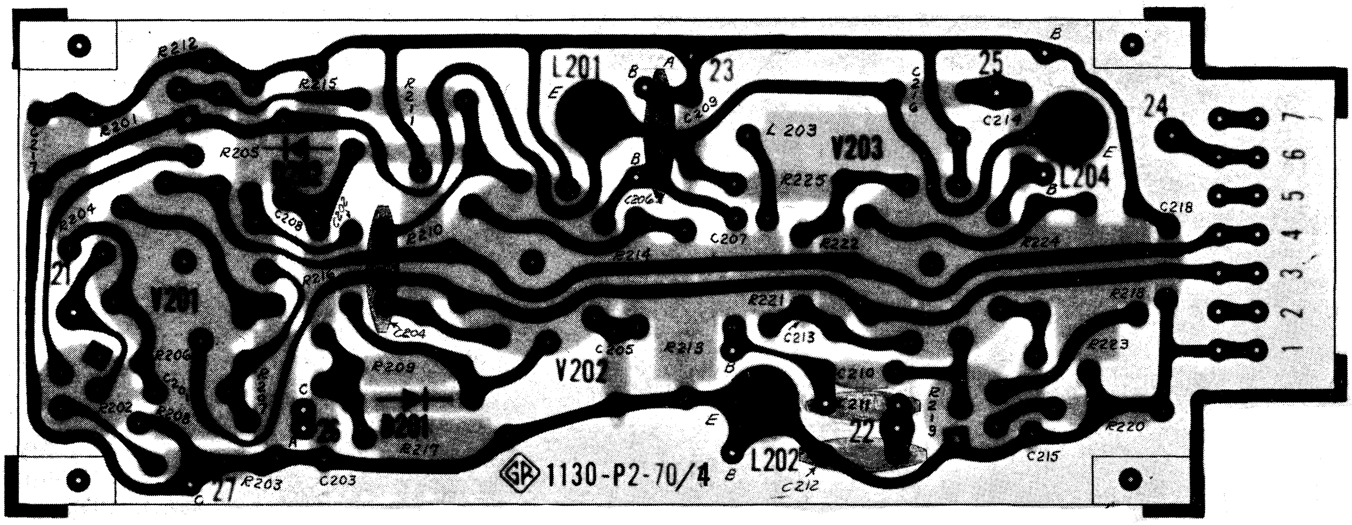
TUBE

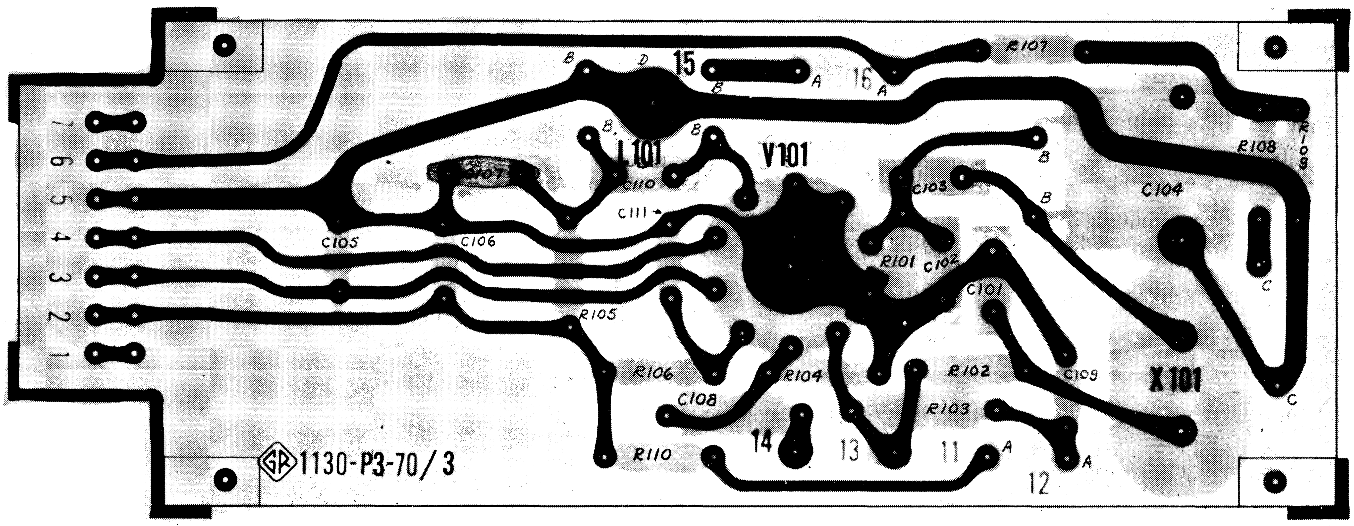
V101 6U8

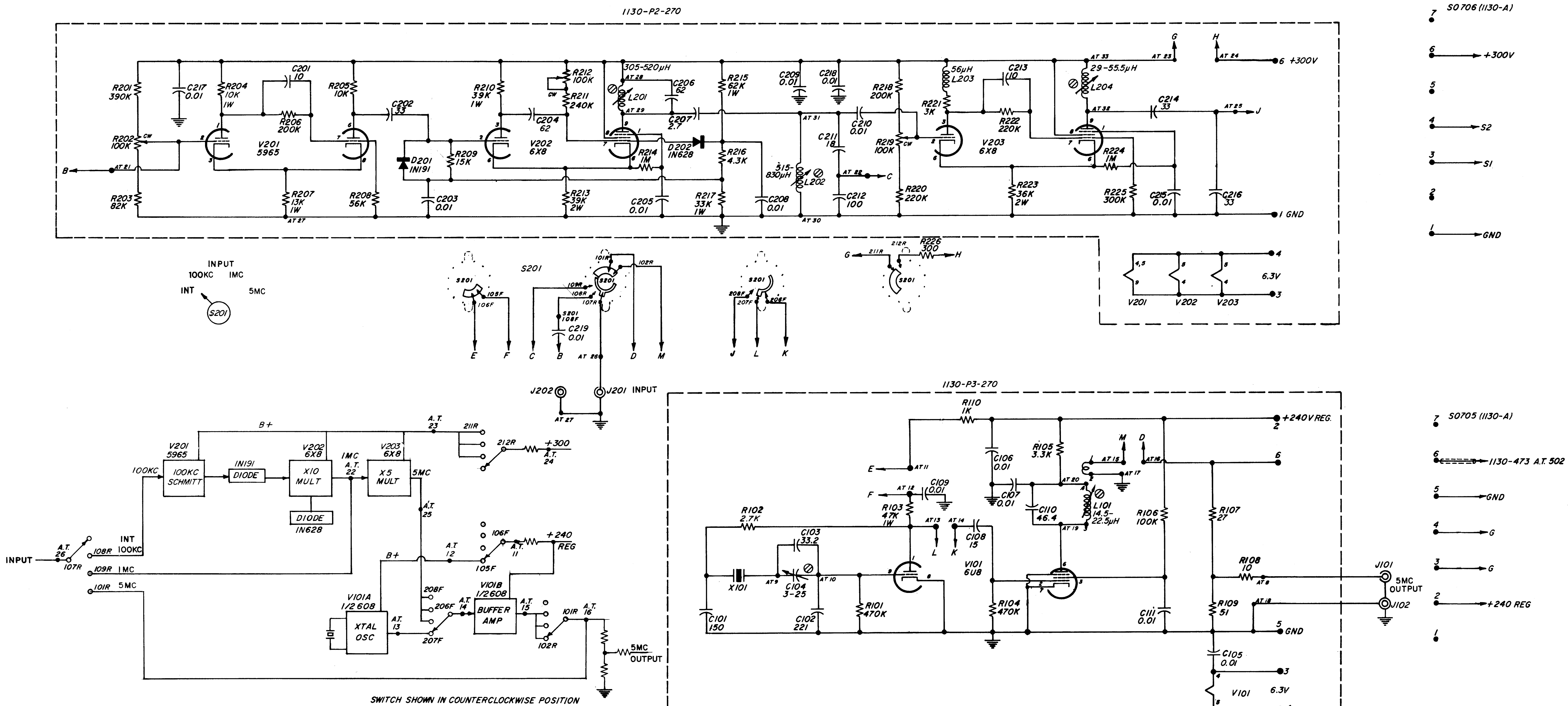
Tube (Type)	Pin	Element	DC Volts to Ground	Res to Shorted Plug
V101 (6U8)	1	P_1	+50	48 k
	2	G_2	-2.8	470 k
	3	S_2	+90	100 k
	4	H	0	0
	5	H	6.3 v ac	0
	6	P_2	+220	3.3 k
	7	K_2	0	0
	8	K_1	0	0
	9	G_1	-1.8	470 k
V201 (5965)	1	P_1	+280 or +235	9600
	2	G_1	+58	100 k
	3, 8	K_{12}	+62 or +66	13 k
	4, 5, 9	H	+50	0
	6	P_2	+240 or +290	10 k
	7	G_2	+62 or +53	44 k
V202 (6X8)	1	Sup	+130	1 M
	2	G_1	+110	37 k or 22 k*
	3	P_1	+290	39 k
	4, 5	H	+50	0
	6	K_{12}	+130	39 k
	7	G_2	+125	290 k or 22 k*
	8	S	+290	0
	9	P_2	+290	10
V203 (6X8)	1	Sup	+160	1 M
	2	G_1	+160	130 k
	3	P_1	+280	3 k
	4, 5	H	+50	0
	6	K_{12}	+160	36 k
	7	G_2	+160	130 k
	8	S	+290	0
	9	P_2	+290	3

Notes: V101 voltages are measured while the Time Base is oscillating.
Voltages for V201, V202, and V203 are measured with no input signal.
Resistances are measured with all terminals of PL705 and PL706 shorted together.
* Res depends on ohmmeter polarity.

TYPES 1130-P2 and 1130-P3


1130-P2-70/4
V201
V202
V203
L201
L202
L204
D201


1130-P3-70/3
V101
L101
X101



TYPE 1130-P2 TIME-BASE OSCILLATOR/MULTIPLIER

RESISTORS

R101	2.7 k	± 5%	1/2 w	REC-20BF(272B)
R102	10 k	± 5%	1/2 w	REC-20BF(103B)
R103	5.1 k	± 5%	1/2 w	REC-20BF(512B)
R104	4.7 k	± 5%	1/2 w	REC-20BF(472B)
R105	2 k	± 5%	1/2 w	REC-20BF(202B)
R106	10 k	± 5%	1/2 w	REC-20BF(103B)
R107	10 k	± 5%	1/2 w	REC-20BF(103B)
R108	4.7 k	± 5%	1/2 w	REC-20BF(472B)
R109	12 k	± 5%	1/2 w	REC-20BF(123B)
R110	6.2 k	± 5%	1/2 w	REC-20BF(622B)
R111	1.3 k	± 5%	1/2 w	REC-20BF(132B)
R112	100 k	± 5%	1/2 w	REC-20BF(104B)
R113	36	± 5%	1/2 w	REC-20BF(360B)
R201	2.2 k	± 5%	1/2 w	REC-20BF(222B)
R202	3 k	± 5%	1/2 w	REC-20BF(302B)
R203	2 k	± 5%	1/2 w	REC-20BF(202B)
R204	6.2 k	± 5%	1/2 w	REC-20BF(622B)
R205	1.5 k	± 5%	1/2 w	REC-20BF(152B)
R206	1 k	± 5%	1/2 w	REC-20BF(102B)
R207	2.4 k	± 5%	1/2 w	REC-20BF(242B)
R208	10 k	± 5%	1/2 w	REC-20BF(103B)
R209	4.7 k	± 5%	1/2 w	REC-20BF(472B)
R210	2.2 k	± 5%	1/2 w	REC-20BF(222B)
R211	1 k	± 5%	1/2 w	REC-20BF(102B)
R212	6.2 k	± 5%	1/2 w	REC-20BF(622B)
R213	1.5 k	± 5%	1/2 w	REC-20BF(152B)
R214	820	± 5%	1/2 w	REC-20BF(821B)
R215	62	± 5%	1/2 w	REC-20BF(620B)
R216	24	± 5%	1/2 w	REC-20BF(240B)
R217	47	± 5%	1/2 w	REC-20BF(470B)
R301	560	± 5%	1/2 w	REC-20BF(561B)
R302	part of 1130-2422			
R303	part of 1130-2422			
R304	part of 1130-2422			
R305	1130-2120			
R501	1.8 k	± 5%	1/2 w	REC-20BF(182B)
R502	1.3 k	± 5%	1/2 w	REC-20BF(132B)

C101	47 μf	±20%	6 v	COE-61(476D)
C102	40 μf		3 dcwv	COE-54
C103	40 μf		3 dcwv	COE-54
C104	200 μf		10 dcwv	COE-6
C105	1 μf	±20%	35 v	COE-60
C106	40 μf		3 dcwv	COE-54
C107	40 μf		3 dcwv	COE-54
C108	1 μf	±20%	35 v	COE-60
C109	.027 μf	± 5%	100 v	COP-24(273B)
C201	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C202	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C203	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C204	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C205	8-50			COT-29-4
C206	47	± 5%	500 dcwv	COC-62-2(470B)
C207	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C208	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C209	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C210	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)
C211	8-50			COT-29-4
C212	47	± 5%	500 dcwv	COC-62-2(470B)
C213	.01 μf	+80-20%	50 dcwv	COC-61-3(103D)

CAPACITORS (Cont)

C301	.01 μf	+80-20%	50 dcwv	COC-61-3(103
C302	402	± 1%	500 dcwv	COM-5F(4020A)
C303	.6-20			1130-41-2
C304	18	± 5%	500 dcwv	COC-61-2(180B)
C305	.0029 μf	± 1%	500 dcwv	COM-5F(292A)
C306	.01 μf	+80-20%		COC-61-3(103D
C307	.0012 μf	± 5%	500 dcwv	COM-5D(122B)
C308			500 dcwv	COM-15
C501	100 μf		25 dcwv	COE-35
C502	50 μf		50 dcwv	COE-34

CRYSTAL

X301 1130-4030

DIODES

CR101	SG-22
CR301	1N118
CR302	1N118
CR501	1N1692
CR502	1N1692
CR503	1N1692
CR504	1N1692
CR505	SV127
CR506	SV144

FUSES

115 v		
F501	.2	FUF-1
F502	.2	FUF-1
230 v		
F501	.1	FUF-1
F502	.1	FUF-1

INDUCTORS

L201	22 μh	±10%	CHM-1
L301	22 μh	±10%	CHM-1

JACKS

J201	874-404
J202	874-404

SWITCH

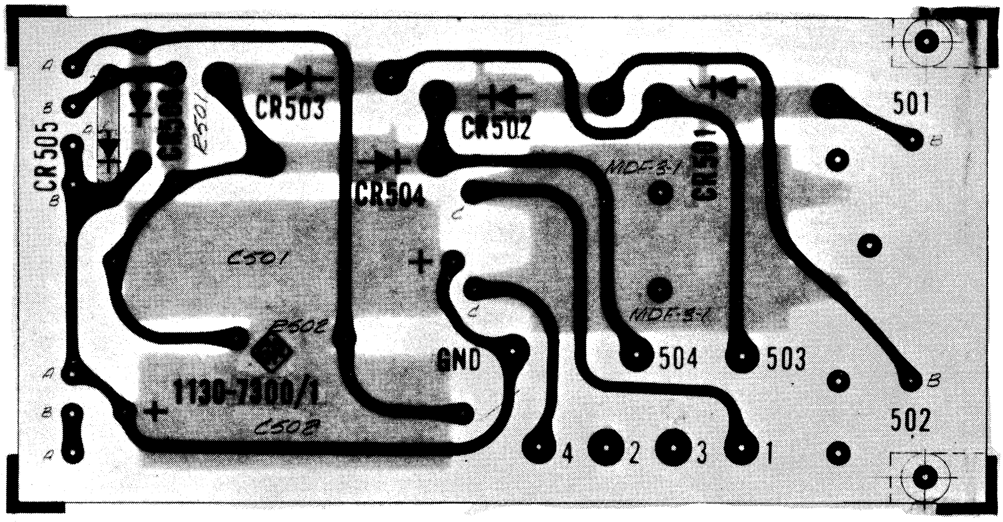
S201 SWRW-266

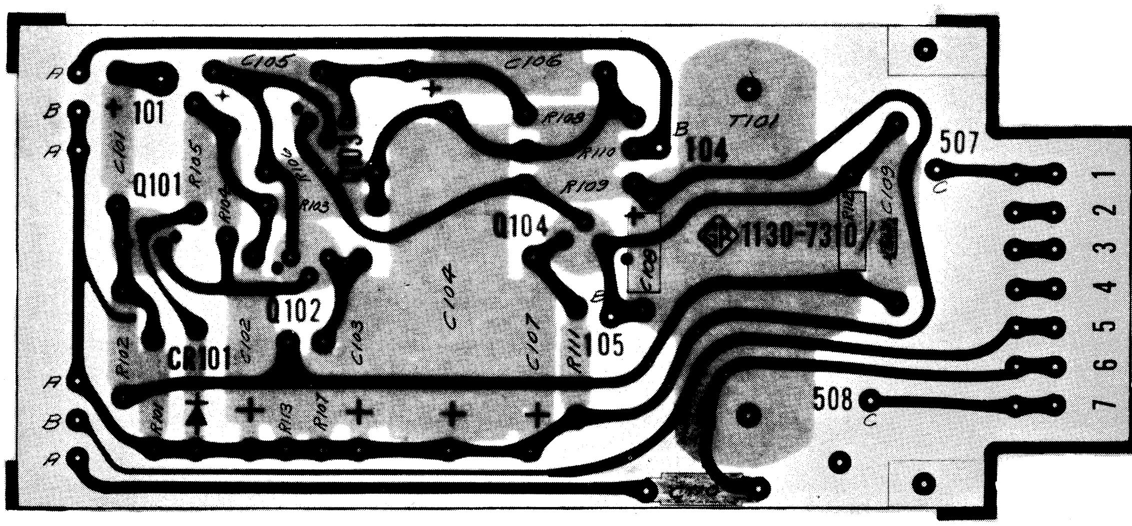
TRANSFORMERS

T101	746-4370
T201	1130-2410
T202	1130-2410
T501	0745-4220

TRANSISTORS

Q101	2N520A
Q102	2N520A
Q103	2N445A, BR
Q104	2N1374
Q105	2N1138
Q106	2N1138
Q201	2N1396
Q202	2N1396
Q203	2N1396
Q301	2N706



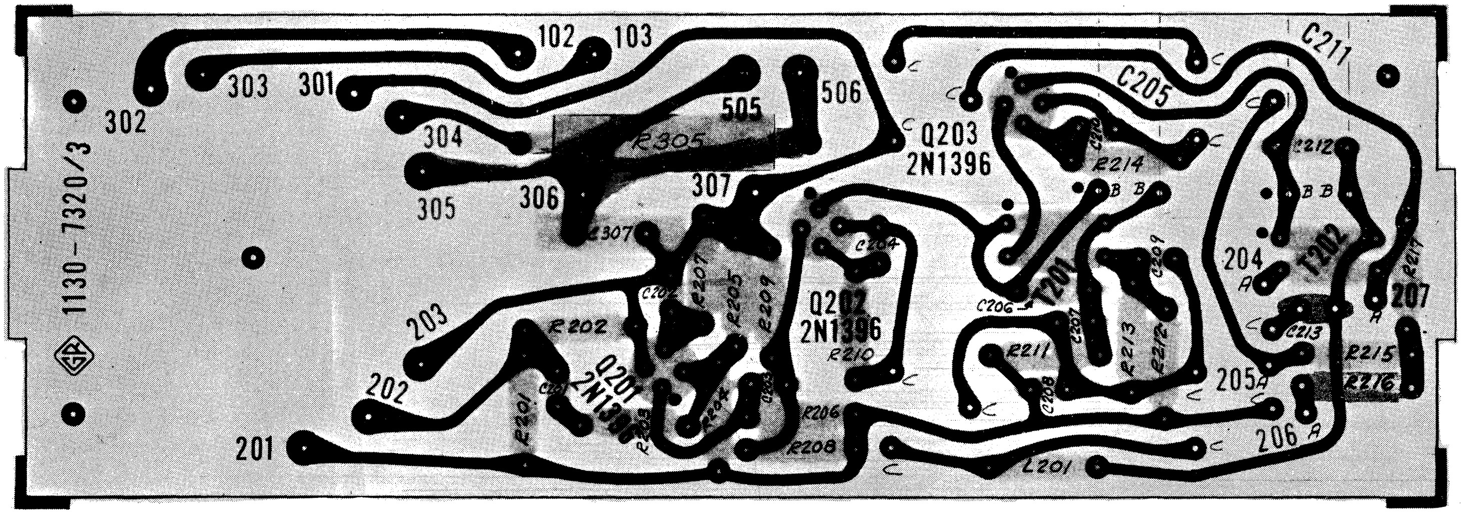


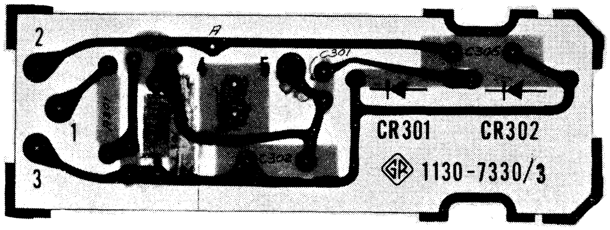
Transistors (Type)	DC VOLTS		
	Emitter	Base	Collector
Q101 (2N520A)	-0.42	-0.52	-1.5
Q102 (2N520A)	-1.3	-1.5	-7.5
Q103 (2N445A,BR)	-7.6	-7.5	-3.0
Q104 (2N1374)	-2.5	-3.0	-18.5
Q201 (2N1396)	-0.9	-1.1	-5.6
Q202 (2N1396)	-1.6	-1.8	-5.1
Q203 (2N1396)	-1.1	-1.3	-20.0

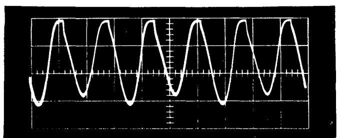
Anchor Terminals	DC Volts to Ground
104	-20
105	-18.5
201	-6.0
202	-3.4
203	0

Note:

Voltages are measured with a VTVM which has a 1 MΩ resistor in series with the probe tip.

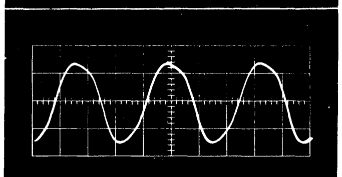






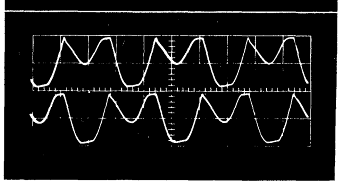
ANCHOR TERMINAL NO. 102

Sweep: 5 μsec/cm
Sensitivity: 5 volts/cm



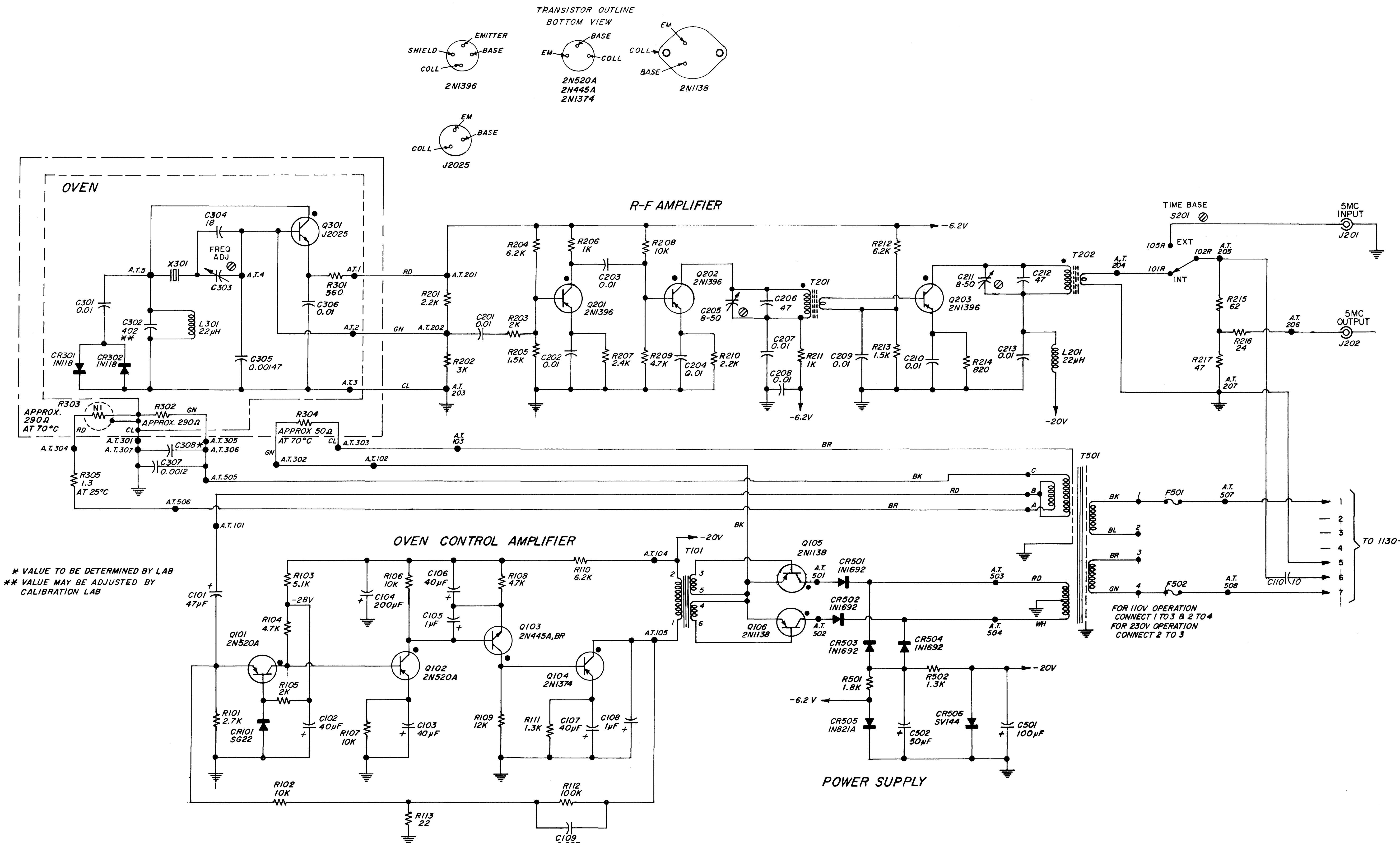
ANCHOR TERMINAL NO. 105

Sweep: 5 μsec/cm
Sensitivity: 1 volt/cm



ANCHOR TERMINALS NO. 501 *(Top)*, NO. 502 *(Bottom)*

Sweep: 5 μsec/cm
Sensitivity: 20 volts/cm


TRANSISTOR OUTLINE
BOTTOM VIEW
SHIELD
EMITTER
BASE
COLL
2N1396
EM
BASE
COLL
2N520A
2N445A
2N1374
EM
COLL
BASE
2N1138
EM
BASE
COLL
J2025
OVEN
R-F AMPLIFIER
OVEN CONTROL AMPLIFIER
POWER SUPPLY
TIME BASE
S201
EXT
INT
5MC
INPUT
J201
5MC
OUTPUT
J202
FREQ
ADJ
X301
Q301
J2025
Q201
2N1396
Q202
2N1396
Q203
2N1396
T201
T202
T501
T101
Q101
2N520A
Q102
2N520A
Q103
2N445A,BR
Q104
2N1374
Q105
2N1138
Q106
2N1138
R303
APPROX.
290Ω
AT 70°C
R302
APPROX. 290Ω
R304
APPROX 50Ω
AT 70°C
R305
1.3
AT 25°C
C308 *
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FOR 230V OPERATION
CONNECT 2 TO 3
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** VALUE MAY BE ADJUSTED BY
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