HEWLETT PACKARD COMPANY

MODEL 523B

ELECTRONIC COUNTER

SERIAL 894 AND ABOVE

OPERATING AND SERVICING MANUAL

MANUAL CHANGES

MODEL 523B

ELECTRONIC COUNTER

Serial 894 and above:

ERRATA:

R552: Add resistor, fixed, composition, 1000 ohms ±10%, ½ W; -hp- Stock No. 23-1000, Mfr., B
Connected between terminal 2 of S401C and R547

R553, 554: Add resistor, fixed, composition, 12,000 ohms ±10%, ½ W; -hp- Stock No. 23-12K, Mfr., B
R553 is connected between R458 and junction of R456 and R457
R554 is connected between pin 19 of Z408 and R464

Serial 1494 and above:

C311: Change to capacitor, fixed, mica, 1325pf ±1%, 500 vdcw; -hp- Stock No. 0140-0155, Mfr., El Menco

C431, 433, 434, 436: Change to capacitor, fixed, mica, .001uf ±5%, 300 vdcw; -hp- Stock No. 0140-0152, Mfr., El Menco

R319, 329, 339, 350, 361: Change to resistor, fixed, composition, 10,000 ohms ±5%, ½ W; -hp- Stock No. 23-10K-5, Mfr., B

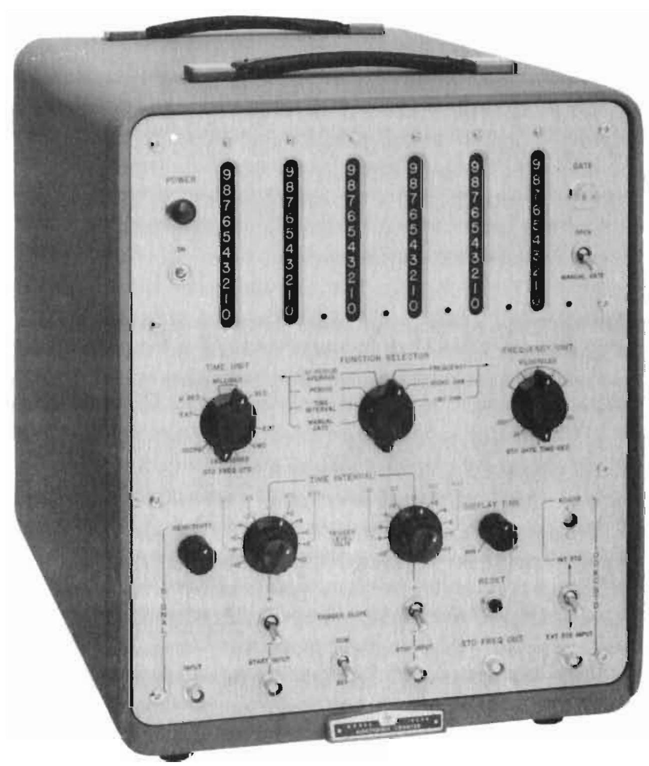
OPERATING AND SERVICING MANUAL

FOR

MODEL 523B

ELECTRONIC COUNTER

SERIAL 894 AND ABOVE



HFWLETT-PACKARD COMPANY
275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

523B002

SPECIFICATIONS

FREQUENCY MEASUREMENT

RANGE:	10 cps to 1.1 mc.
ACCURACY:	±1 count ± stability (see GENERAL).
INPUT REQUIREMENTS:	0.2 volt rms minimum.
INPUT IMPEDANCE:	Ac coupled: Approximately 1 megohm shunted by not more than 45μμf.
GATE TIME:	Approximately .001, .01, .1, 1, 10 seconds.
READS IN:	Kilocycles; decimal point automatically positioned.

PERIOD MEASUREMENT

RANGE:	.00001 cps to 10 kc.
ACCURACY:	±0.3% (for measurements of one period) ±.03% (10 period average) at 1 volt rms. Improved by greater input voltage.
INPUT REQUIREMENTS:	1 volt rms minimum; direct coupled.
INPUT IMPEDANCE:	Dc Coupled: Approximately 1 megohm shunted by not more than 100μμf, at 10 kc.
MEASUREMENT PERIOD:	1 or 10 cycles of unknown.
STANDARD FREQUENCY COUNTED:	10 cps, 1 kc, 100 kc, 1 mc, or external applied frequency.
READS IN:	Seconds, milliseconds, microseconds; decimal point automatically positioned.

TIME INTERVAL MEASUREMENTS

RANGE:	3 microseconds to 100,000 seconds (27.8 hours).
ACCURACY:	±1 count, ± stability (see GENERAL).
INPUT REQUIREMENTS:	1 volt minimum. Direct coupled input.
INPUT IMPEDANCE:	Dc coupled: Approximately 1 megohm shunted by not more than 120μμf.

SPECIFICATIONS (CONT'D.)

TIME INTERVAL MEASUREMENTS (Cont'd.)

START AND STOP:	Independent or common input.
TRIGGER SLOPE:	Positive or negative on start and/or stop input.
TRIGGER AMPLITUDE:	Continuously adjustable on both input channels from -300 to + 300 volts.
STANDARD FREQUENCY COUNTED:	10 cps, 1 kc, 100 kc, 1 mc; external.
READS IN:	Seconds, milliseconds, microseconds; decimal point automatically positioned.

GENERAL

REGISTRATION:	Six places on neon lamp decade units.
STABILITY:	2/1,000,000 per week.
DISPLAY TIME:	Variable from approximately 0.1 to 5 seconds; or infinite.
OUTPUT FREQUENCIES:	Secondary standard frequencies available at front panel 10 cps, 1 kc rectangular 100 kc and 1 mc sinewave (stability as above).
START AND STOP MARKER OUTPUTS:	Start and Stop pulse output (width approximately 5 μ sec.).
POWER SUPPLY:	115/230 volts ±10%, 50-60 cps, approximately 370 watts.
DIMENSIONS:	Cabinet Mount: 13-1/4" wide x 17" high x 21-1/8" deep. Rack Mount: 19" wide x 14" high x 19-3/8" deep behind panel.
WEIGHT:	Cabinet Mount: Net 54 lbs., shipping 81 lbs.
ACCESSORIES FURNISHED:	Two ⓗⓟ AC-16K Cable Assembly, 4 feet of RG-58/U 50 ohm coaxial cable terminated at each end with UG-88/U Type BNC male connector.
ACCESSORIES AVAILABLE:	ⓗⓟ AC-16D Cable Assembly, 44 inches of RG-58/U 50 ohm coaxial cable terminated at one end only with a UG-88/U Type BNC connector. ⓗⓟ Model 508 Tachometer Generator. Converts ⓗⓟ 523B into tachometer indicator with direct mechanical connection to equipment under test. ⓗⓟ 523B-95A, Model 560A Digital Recorder Adapter Kit for field installation.

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OPERATING NOTE
hp MODEL AC-4D-95
DECADE COUNTER

OPERATING AND SERVICING MANUAL
FOR
hp MODEL AC-4A
DECADE COUNTERS

SECTION I

GENERAL DESCRIPTION

1-1 DESCRIPTION

The Hewlett-Packard Model 523B Electronic Counter is a precision frequency-and time-measuring instrument. It measures frequencies from .00001 cycle to over 1.1 megacycle per second and time intervals from 3 microseconds to 27.8 hours, computes frequency ratios, and counts random or periodic events; the answer is instantly displayed in lighted numerals across the front panel. This direct-reading digital display permits effortless reading, and the answer is obtained without making difficult control settings. Operating controls are straight-forward and foolproof so that highly accurate measurements can be made reliably and with ease by non-technical personnel. The 523B can conveniently be checked for satisfactory circuit operation through its own indicating system. Provision is made for using an external frequency standard in place of the internal standard if a source having greater than 2 parts/million/week stability is available or if the internal frequency standard is disabled.

The 523B incorporates new features which add to reliability, stability, flexibility, ease of maintenance. Printed wiring is extensively used both in plug-in units and in the chassis. Key circuits are equipped with special indicator lights so that at a glance they can be quickly checked. If a light does not light, or acts erratically, it indicates the circuit at fault. This feature will assist service technicans greatly in making a fast trouble analysis in complicated circuits.

1-2 TYPES OF MEASUREMENTS

a. Frequency Measurements

Frequency measurements in the 523B are indicated directly in kilocycles, a lighted decimal point is automatically positioned to give a direct-reading answer for five different frequency-sampling times: 0.001, 0.01, 0.1, and 10 seconds. The longer sampling times provide more significant figures and are especially useful when reading low frequencies; the shorter sampling times provide a continuous, non-flickering display when making quick repetitive measurements of changing frequencies. Answer display time is continuously adjustable from 0.1 second (but not shorter than the gate time used) to 5 seconds, or the display can be held indefinitely.

b. Period Measurements

Period measurements (the reciprocal of frequency) are indicated in seconds, milliseconds or microseconds as selected by the operator, the decimal point being automatically positioned for the time unit selected.

It is also possible to make 10-period average measurements to obtain a 10-times increase in period measurement accuracy. Special care has been taken to assure that period measurements will always be accurately started and stopped at exactly the same voltage level on the input waveform. Period measurements are most often used for measuring low frequencies to obtain more significant figures than would be obtained by measuring frequency directly, thus making possible the measurement of frequencies as low as .0001 cps.

c. Time Measurements

Time measurements are indicated in seconds, milliseconds, or microseconds as selected by the operator, the decimal point being automatically positioned for the time unit selected. Time interval measurements can be started in a variety of ways: 1) a single pulse can be used to both start and stop the interval; 2) one pulse can start it and another stop it; 3) either the positive-going or negative-going portion of an input waveform can be used to start or stop the interval, and 4) the interval can be started and stopped at any selected voltage level from -300 volts to +300 volts. To show the exact points on an input wave that a time-interval measurement is started and stopped, the 523B produces positive output pulses that can be used to intensity-modulate an oscilloscope that views the input waveform. The start and stop points are indicated by bright dots on the waveform. The calibrated START and STOP TRIGGER LEVEL controls adjust the start and stop points to the desired voltage levels on the waveform.

d. Frequency Ratios

Frequency ratios are displayed directly when two input signals are connected to the front-panel INPUT and STD. FREQ. OUTPUT connectors. Any ratio up to 999,999 to 1 will be displayed. The measurement is repetitive and the display time is adjustable just as with frequency measurement.

e. Totalizing

Total number of events up to 999,999 are counted simply by connecting electrical impulses which correspond to events to the input connector and manually opening the MANUAL GATE toggle switch for the desired period. When the MANUAL GATE switch is closed, the total is displayed until the switch is reopened for another measurement.

SECTION II

OPERATING INSTRUCTIONS

2-1 INTRODUCTORY

This section explains how to make five basic measurements: frequency, period, time interval, totalizing and ratio. Each type of measurement is explained on a single page containing an illustration and step-by-step procedure. Detailed, supporting information for each measurement is then given later in the section. These procedures are basic uses and should be considered as a guide to making new test set-ups when meeting new and different measurement problems. The material in this section is as follows:

2-2 AIR FILTER

Inspect the air filter often when the 523B is in constant use.

The air-filter element in the 523B is a renewable type. It is located on the rear of the instrument cabinet and is removed by sliding it up and out. To renew the filter element, wash in warm water and detergent, then recoat with a special oil, such as Research Products Corp. Filter Coat No. 3.

2-3 INSTALLATION AND OPERATING PRECAUTIONS

The 523B Electronic Counter is a portable test equipment intended for bench use and requires no special installation instructions except to place the instrument so that the ventilating louvers are not obstructed. To maintain the 523B's specified stability at all times, it should remain connected to the power source during periods of non-use. The crystal oven will then remain at a constant temperature and only a five-minutes warm-up will be required to reach specified stability when the instrument is again turned on. If the 523B is disconnected from the power source and allowed to cool, 1/2 hour is required for the crystal oven to reach operating temperature and provide the specified stability. During the 1/2 hour warm-up it should be possible to obtain correct self-check answers.

When connecting a signal to be measured to the 523B input, use care to prevent hum and noise pickup by the signal source or by the input lead. Noise of significant amplitude on the input waveform can be counted in addition to the desired signal. If erratic count displays are unexpectedly obtained, observe the input signal waveform on an oscilloscope to check for unwanted signals. If the input signal contains much noise, adjust the INPUT SENSITIVITY control to the lowest sensitivity that gives a reliable count. Reliable measurements might still be made with the noise present if the adjustment makes the 523B only sensitive enough to respond to the desired signal.

When making period and time interval measurements, remember that any d-c component on the input signal waveform can affect the accuracy of the measurement and should be accounted for.

Since the self-check feature is quick and convenient, it is recommended that it be made whenever you start a measurement to establish confidence in the satisfactory operation of the 523B.

The 523B can be used on 230-volt a-c power if desired. See para. 4-4 for directions.

2-4 CONTROLS AND TERMINALS

POWER
(toggle switch)
Applies line power to the ventilating fan and power transformer for operation of the counter.

FUNCTION SELECTOR
(rotary selector switch)
Selects the type of measurement desired; SELF CHECK, FREQUENCY, PERIOD 10-PERIOD or TIME INTERVAL. Switches the Gate and Time Base Sections so that the Time Base opens and closes the Signal Gate to measure frequency or so that the input signal opens and closes the Signal Gate to count time units from the Time Base.

FREQUENCY UNIT
(rotary selector switch)
Selects one of five standard gate times (.001, .01, 0.1, 1.0 and 10 seconds) from the Time Base Section to open and close the Signal Gate when measuring frequency.

SIGNAL INPUT
(BNC connector)
Receives the input frequency to be measured. Connects to the Signal Gate Section, for application to the Counters.

SIGNAL SENSITIVITY
(potentiometer)
Adjusts the sensitivity of the counter to the input signal when measuring frequency.

TIME UNIT
(rotary selector switch)
Selects one of three time units (seconds, milliseconds or microseconds) from the Time Base Section to be fed to the counters during Time Interval and Period measurements. This switch also indicates which time unit is fed to the STD. FREQ. OUT connector.

TIME INTERVAL TRIGGER SLOPE
(toggle switch)
The left hand toggle switch determines whether the time measurement will start on a negative or a positive going voltage.

The right hand toggle switch determines whether the time measurement will stop on a negative or a positive going voltage.

TRIGGER LEVEL VOLTS
(dual control; outer control, continuous adjustment; center control, step attenuator.)
The left hand control sets the voltage level at which a time measurement will begin.

The right hand control sets the voltage level at which a time measurement is stopped.

The red controls are step attenuators which reduce the level of the input time signal by the amount indicated on the panel. The black outer controls provide continuous adjustment from 0 and ±10, between stops.

START INPUT
(BNC connector)
Receives the START timing signal when measuring time interval.

STOP INPUT
(BNC connector)
Receives the STOP timing signal when measuring time interval.

COM. SEP.
(toggle switch)
Connects the START and STOP signal inputs together so that the Time Interval measurement, can be started and stopped through a single input connection.

DISPLAY TIME
(potentiometer with switch)
Adjust the length of time the answer is displayed on the panel.

RESET
(push button)
Manually resets the counters to zero when pressed, and starts a new count when released.

MANUAL GATE
(toggle switch)
Opens the Signal Gate manually for purposes of totalizing, and at the same time removes control from the automatic Gate Control Circuit.

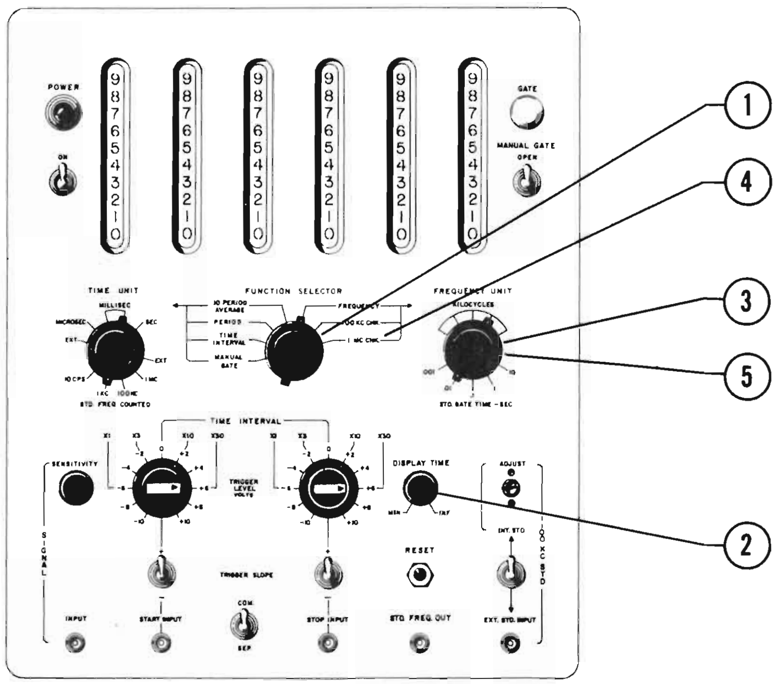
100 KC STD. EXT. INT.
(toggle switch)
Connects the input of the Time Base Section to the internal 100-kc oscillator when set to INT, and to the EXT. STD. INPUT when set to EXT.

EXT. STD. INPUT
(BNC connector)
Receives an externally-generated 100-kc standard frequency to replace the internal standard.

ADJ.
(adjustable capacitor)
Adjust the Crystal frequency of the internal 100-kc frequency standard for standardizing with WWV.

STD. FREQ. OUT
(BNC connector)
Provides the time units indicated by the TIME UNIT selector. Also serves as the input connection for an externally generated standard frequency counted when substituting for the internal standards.

2-5 HOW TO SELF CHECK THE 523B



1. Set the FUNCTION SELECTOR to the 100 KC CHK. position.

2. Adjust the DISPLAY TIME control as desired.

3. Set the FREQUENCY UNIT selector to each position and note each displayed count. These displays should agree with the table below. Check phantastron circuit adjustments in Section IV if readings do not agree with the table.

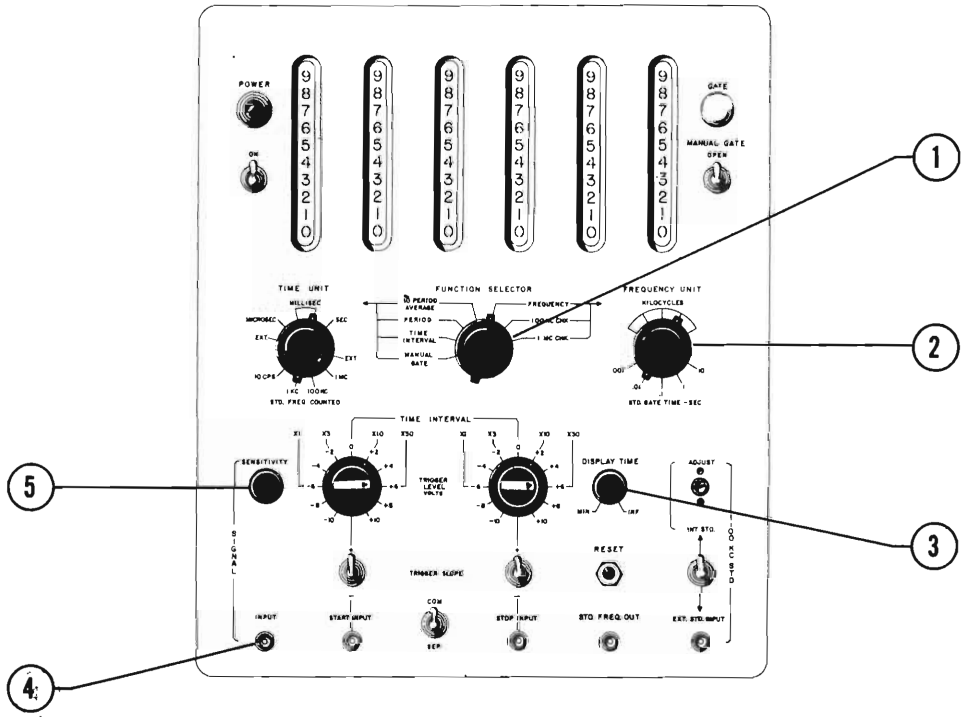
4. Set the FUNCTION SELECTOR to the 1 MC CHK. position.

5. Repeat step 3. If correct readings are obtained, the equipment can be considered to be operating properly. When checking 1 mc, a discrepancy of ±1 count in the last digit is acceptable.

Counter Displays for Self-Check Operations

GATE TIME	100 KC CHECK	1 MC CHECK
10 sec	00.0000	00.0000 ± .0001
1 sec	100.000	000.000 ± .001
0.1 sec	0100.00	1000.00 ± .01
0.01 sec	00100.0	01000.0 ± .1
0.001 sec	000100.	001000. ± 1

2-6 HOW TO MEASURE FREQUENCY



1. Set the FUNCTION SELECTOR to FREQUENCY.

2. Set the FREQUENCY UNIT selector to the STD. GATE TIME desired.

3. Set the DISPLAY TIME control for the desired display time.

4. Connect the input signal to the SIGNAL INPUT connector.

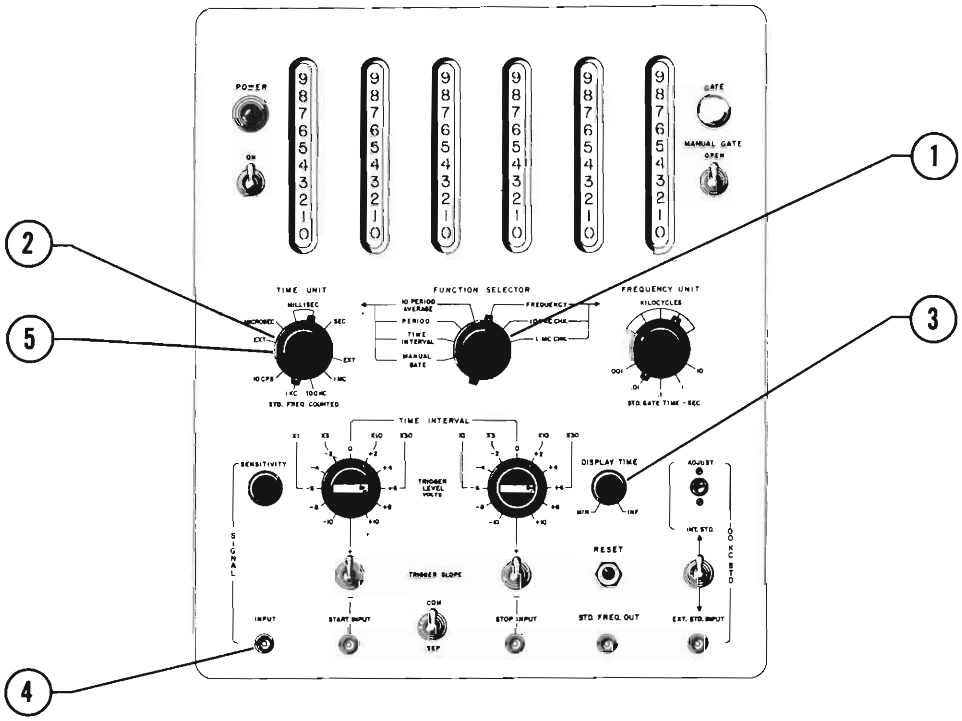
5. Set the SIGNAL SENSITIVITY control to obtain a reliable count.

6. Refer to para. 2-17 for additional information.

Reference Table for Measuring Frequency

Input Signal Level Required:	At least 0.2 volt rms.
Input Impedance:	One megohm shunted by 30 mmf.
Frequency Measurement Range:	10 cps to 1.1 MC.

2-7 HOW TO MEASURE PERIOD



1. Set the FUNCTION SELECTOR to PERIOD or 10 PERIOD AVERAGE.

2. Set the TIME UNIT selector to display the desired time units.

3. Set the DISPLAY TIME control for the desired display time.

4. Connect the input signal to the SIGNAL INPUT connector.

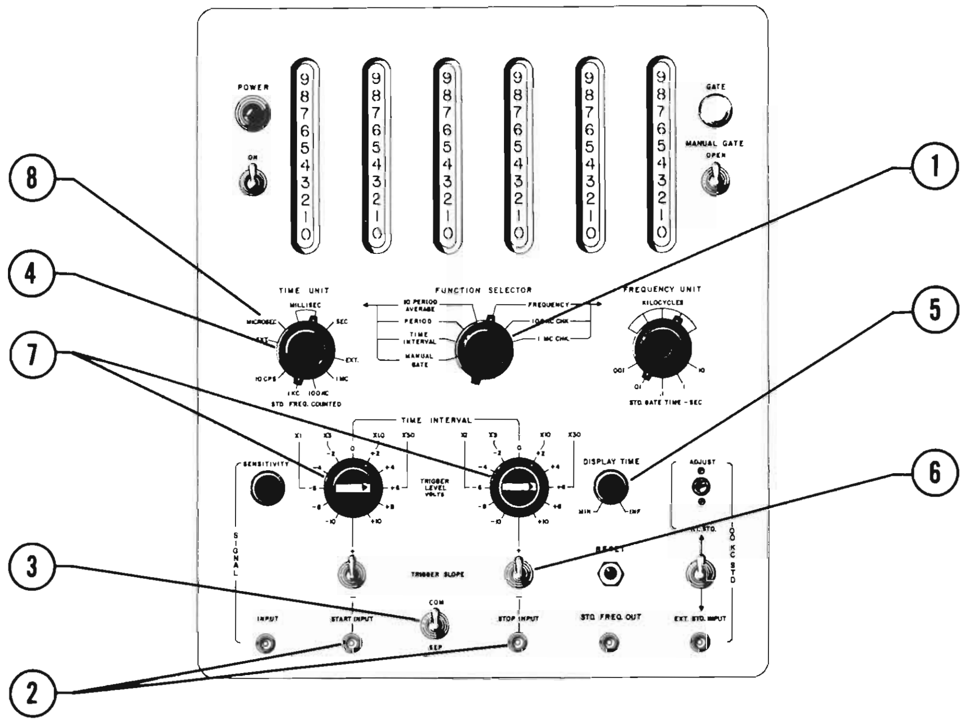
5. The period of the frequency being measured will now be indicated in the time units indicated by the TIME UNIT selector.

6. Refer to para. 2-18 for additional information.

Reference Table for Measuring Period

Input Signal Level Required:	1 volt to 200 volts rms.
Input Impedance:	1 megohm shunted by 40 mmf.
Period Measurement Range:	100 microsec. to 100,000 sec. (10 kc to .00001 cps)

2-8 HOW TO MEASURE TIME INTERVAL



1. Set the FUNCTION SELECTOR to TIME INTERVAL.

2. Connect the signal to start the time interval to the START INPUT connector. Connect the signal to stop the time interval to the STOP INPUT connector.

3. Set the SEP-COM switch to SEP. If the start and stop signals are available from a single cable, connect to either the START or STOP INPUT connectors and set the SEP-COM switch to COM.

4. Set the TIME UNIT selector to obtain a reading in the desired time units.

5. Set the DISPLAY TIME control for the desired display time.

6. Set the TRIGGER SLOPE switches so that the measurement will start on a positive-going or a negative-going slope, as desired.

7. Set the TRIGGER LEVEL controls so that the measurement will start and stop at the desired voltage levels, -300 to +300 volts.

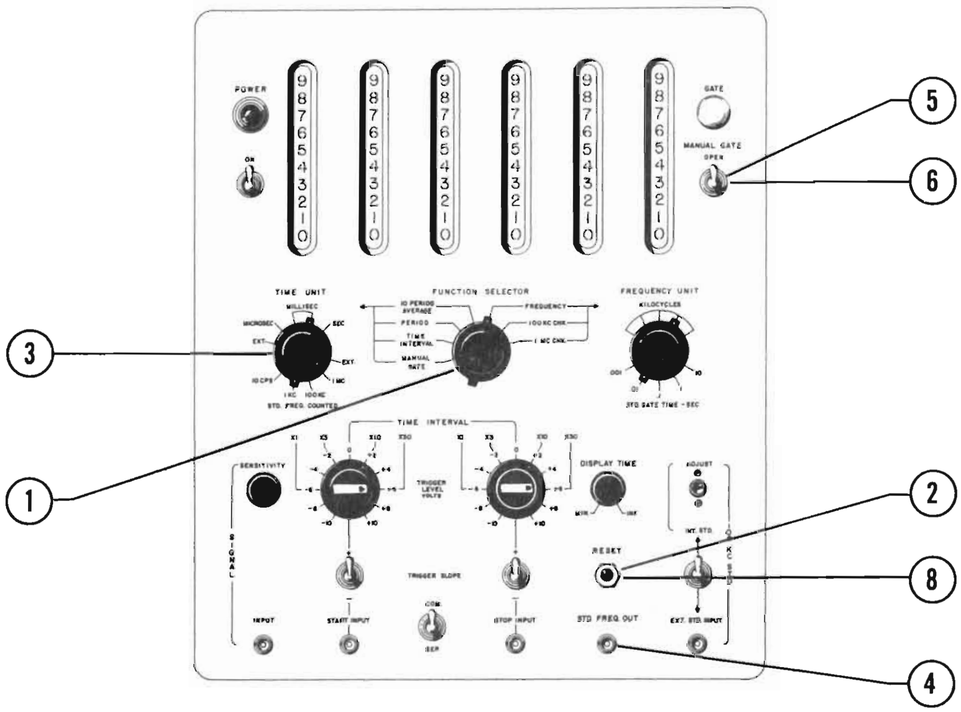
8. The measured time interval will now be displayed in the time units selected by the TIME UNIT selector.

9. Refer to para. 2-19 for additional information.

Reference Table for Measuring Time Interval

Input Signal Level Required:	±1 volt to ±300 volts peak
Input Impedance:	1 megohm shunted by 25 mmf.
Time Interval Range:	3.0 microsecs. to 100,000 secs.
Control Range for Start and Stop Channels:	Triggers on either positive- or negative-going voltages from -300 to +300 volts.

2-9 HOW TO TOTALIZE



1. Set the FUNCTION SELECTOR to MANUAL GATE.

2. Press the RESET button to set the counter display to zero.

3. Set the TIME UNIT selector to EXT.

4. Connect the input signal to the STD. FREQ. OUTPUT connector.

5. To begin the count, set the MANUAL GATE switch to OPEN.

6. To end the count, set the MANUAL GATE switch to the closed position. The total number of pulses received during the counting period will be displayed until a new count is begun.

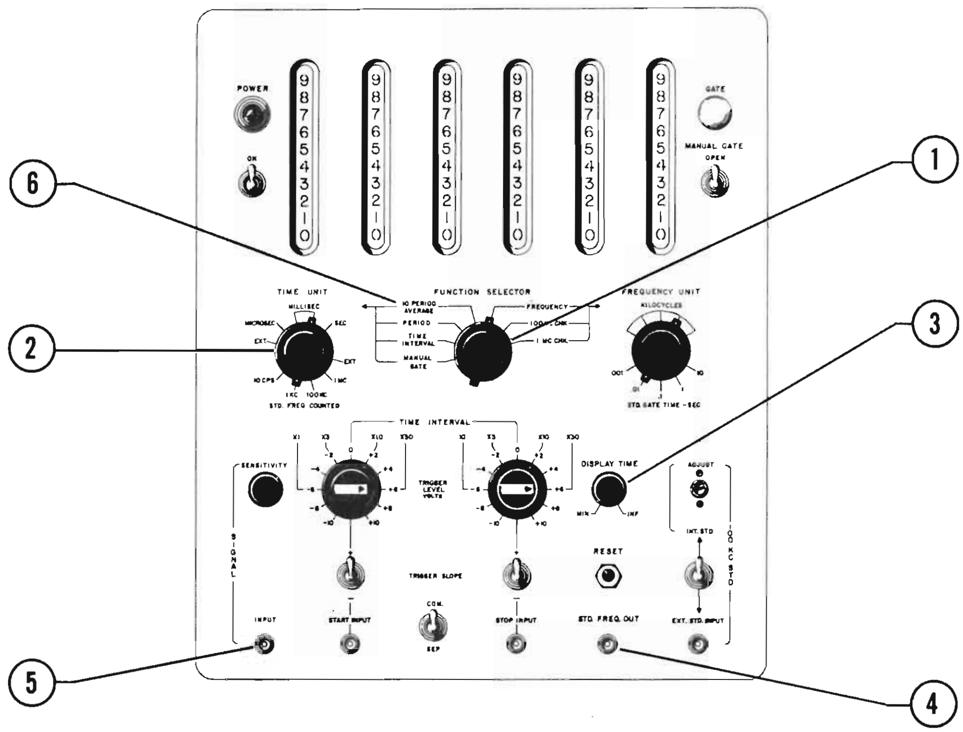
7. Clear counter by pressing RESET button.

8. Refer to para. 2-20 for additional information.

Reference Table for Totalizing

Input Signal Level Required:	Minimum: 1.0 volt peak
Input Impedance:	1 megohm shunted by 100 mmf
Counting Capacity and Rate:	999,999 after which it will recycle at up to 1.1 MC.
Resolution:	Double pulse - 0.5 microsec. Triple pulse - 0.5 microsec.

2-10 HOW TO MEASURE FREQUENCY RATIO



1. Set the FUNCTION SELECTOR to PERIOD or 10 PERIOD AVERAGE.

2. Set the TIME UNIT selector to EXT.

3. Set the DISPLAY TIME control for the desired display time.

4. Connect the higher of the two input frequencies to the STD. FREQ. OUTPUT connector.

5. Connect the lower of the two input frequencies to the SIGNAL INPUT connector.

6. The ratio of the two frequencies will be displayed in the following manner: the number of cycles of the higher input frequency per cycle of the lower input frequency is displayed when the FUNCTION SELECTOR is set to PERIOD; the number of cycles of the higher input frequency per 10 cycles of the lower frequency is displayed when the FUNCTION SELECTOR is set to 10 PERIOD.

7. Refer to para. 2-21 for additional information.

Reference Table for Ratio Measurements

	STD. FREQ. OUTPUT CHAN.	SIGNAL INPUT CHAN.
Input Signal Level Required:	1 to 10 volts rms Minimum rise time: 1 millisec.	1 to 200 volts rms Rise time: Any
Input Impedance:	1 megohm shunted by 100 mmf	1 megohm shunted by 40 mmf
Frequency Input Range:	1 MC per second to 10 cps	10 kc to .00001 cps
Ratio Measurement Range:	1:1 to 999,999:1	

2-11 HOW TO USE THE 523B AS A SECONDARY FREQUENCY STANDARD

To use the 523B as a secondary frequency standard, set the TIME UNIT selector on the front panel to the desired standard frequency, 1 mc, 100 kc, 1 kc, or 10 cps. Set the 100-KC STD. toggle switch to INT. Connect the signal output cable to the STD. FREQ. OUTPUT connector on the panel.

The output frequencies thus obtained have the waveforms shown in the schematic diagram of the Time Base Section. The use of these frequencies does not affect the operation of the counter and frequency measurements can be carried on simultaneously. When measuring period or time interval, the STD. FREQ. OUTPUT will be same as the TIME UNITS used for the measurement. Ratio measurements cannot be made at the same time since the STD. FREQ. OUTPUT connector is used for an input signal. For further information on the internal frequency standard refer to paras. 2-13 through 2-15.

2-12 HOW TO USE THE 523B WITH THE -HP- 560A DIGITAL RECORDER

To use the (hp) Model 523B with the (hp) Model 560A Digital Recorder, a kit must be installed in the counter. This kit is available for field or factory installation under (hp) Stock No. 523B-95A. With this kit installed the printer and counter may be interconnected and a permanent record made automatically of all counter indications.

2-13 THE 100-KC CRYSTAL OSCILLATOR

The internal standard frequency for the 523B is generated by a crystal-controlled oscillator in a temperature-controlled oven, and is equivalent to a secondary frequency standard. The stability of this oscillator is within 2 parts/million/week when in continuous use. This degree of stability is reached within half an hour after the instrument is first connected and turned on. If the instrument is turned off but remains connected to a power source the correct crystal-oven temperature will be maintained and only five minutes of warm up will be required to regain best stability.

To maintain the best possible accuracy, the 100-kc standard frequency should be checked weekly against WWV or a primary frequency standard, and if necessary, adjusted to bring it exactly on frequency. The typical degree of adjustment that may be required to bring the oscillator exactly on frequency is between 0.01 and 0.1 cycles, measured at 100-kc. Consequently, unless the external standard frequency and the comparing technique have accuracy and resolution sufficient to detect these small errors, no attempt to adjust the 100-kc oscillator should be made.

The following paragraphs give two procedures for comparing and adjusting the 100-kc internal standard frequency. The first and most accurate method beats a harmonic of the 523B's 100-kc standard frequency output with one of the standard frequencies broadcast by WWV, and requires a communications receiver. The second method is for use when the broadcast from WWV is not obtainable and requires a local primary or secondary frequency standard and an oscilloscope as the comparison device.

2-14 HOW TO STANDARDIZE THE CRYSTAL OSCILLATOR AGAINST WWV

Figure 2-1 shows a typical receiving set-up suitable for reception of WWV signals. Proceed as follows:

1. Turn on the 523B and allow to heat for 1/2 hour if it has been disconnected from the power source, allow 5 minutes if it has been connected to the power source and crystal oven is already at operating temperature.

2. Tune the communications receiver to the strongest WWV signal below 20 megacycles. The 10 mc signal is to be prefered since it is 100 times the crystal frequency of 100 kc and thus any error is conveniently multiplied 100 times.

3. Set the TIME UNIT switch on the 523B to 1 MC STD. FREQ. COUNTED. Set the 100 KC STANDARD switch to INT.

4. Lightly couple the 1 mc signal out of the STD. FREQ. OUT jack to the receiver antenna terminals by using two plain, unshielded leads with small capacitors in each lead (5 to 20 $\mu\mu f$). Ideally, the signal coupled in should be approximately equal in strength to WWV to get the best zero-beat indication.

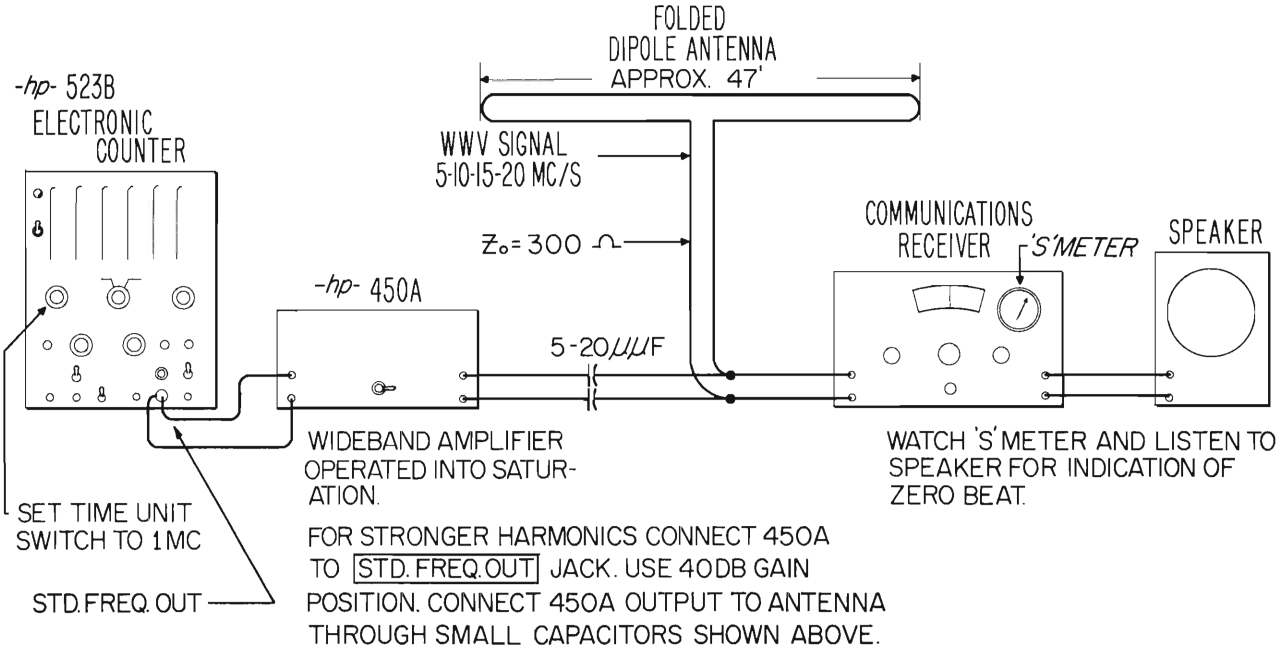


Figure 2-1 Suitable test set-up for standardizing the 523B 100KC crystal oscillator with WWV.

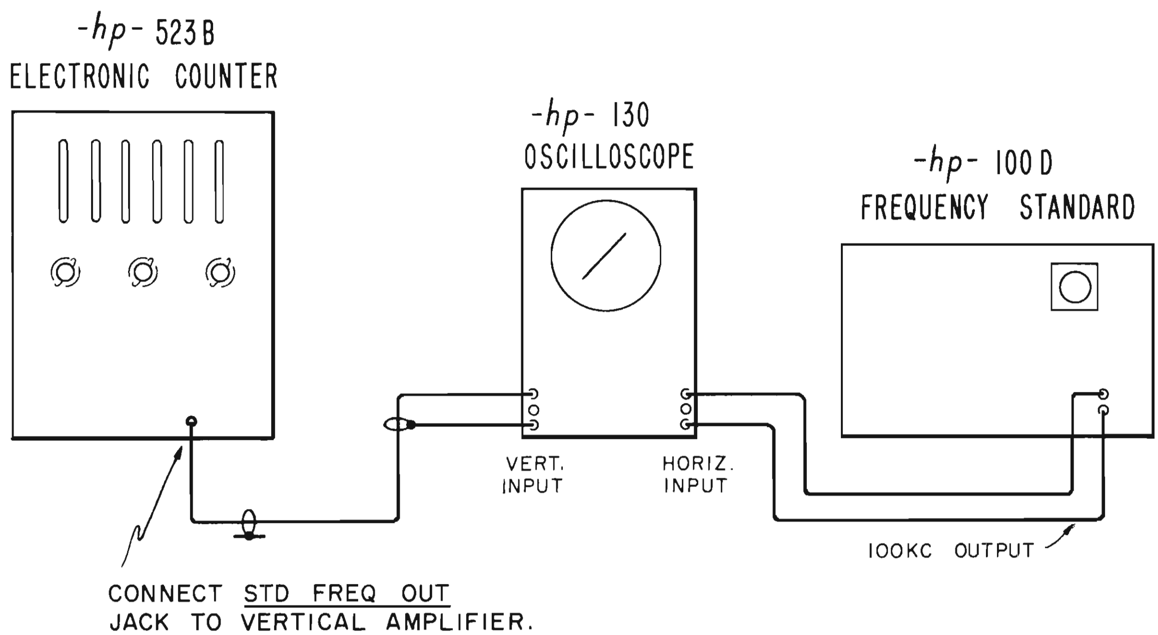


Figure 2-2 Suitable test set-up for comparing the standard frequency in the 523B electronic counter with a secondary frequency standard.

The 1 mc Standard Frequency Output from the 523B is a fairly pure sine wave. The amount of 10 mc signal component present in the output is thus quite low. If stronger 10 or 15 mc harmonics are desired, a high gain, wide band amplifier such as a ⓗ 450A operating in the 40 db gain position can be used to generate strong harmonics of 1 mc. The amplifier is rated for 10 volts output. With a 1 volt signal input the output with 40 db gain would be 100 volts. Since the amplifier is incapable of this large an output, the output waveform is severely clipped, which gives copious harmonics. When using this device, very light coupling to the receiver will give strong signals. Excessive signal strength will block the receiver and should be guarded against.

5. Listen for a beat note in the speaker. Before any adjustments are made, the beat should be within 20 cps at 10 mc. Adjust C303 INT. STD. ADJUST. As a zero-beat is approached, WWV's audio tone will begin to flutter until at exact zero-beat the tone will be constant. If the exact zero-beat is not easy to detect, an "S" meter on the receiver can be used to detect the slow beating between the two signals.

If the local crystal frequency is adjusted until the beat frequency is less than 1 cps at 10 mc/s, the error is less than 0.01 cps at 100-kc or 0.1 parts per million.

2-15 HOW TO STANDARDIZE THE CRYSTAL OSCILLATOR AGAINST A LOCAL FREQUENCY STANDARD

Refer to Fig. 2-2 and proceed as follows:

1. Turn on the 523B and allow to heat for 1/2 hour if it has been disconnected from the power source, allow 5 minutes if it has been connected to the power source, and the crystal oven is already at operating temperature.

2. Connect the STD. FREQ. OUTPUT jack on the 523B to the vertical input of an oscilloscope.

3. Connect the 100-kc output from the primary frequency standard to the horizontal input on the oscilloscope.

4. Set the TIME UNIT switch on the 523B to 100 KC STD. FREQ. COUNTED. Set the 100 KC STD. switch to INT.

5. Adjust the gain of the oscilloscope amplifiers to obtain a large clear picture similar to that illustrated.

6. Note the rate of movement of the oscilloscope pattern. If it moves at the rate of 1 revolution per second the two frequencies differ by one cycle. If it moves at the rate of 1 revolution per ten seconds the difference is 0.1 cycle, etc.

7. Adjust the locking type trimmer marked ADJ. as necessary to hold the oscilloscope trace absolutely still.

2-16 HOW TO SUBSTITUTE AN EXTERNAL FREQUENCY STANDARD FOR THE INTERNAL STANDARD IN THE 523B

An external 100-kc frequency standard can be easily substituted for the internal standard in the 523B if the internal 100-kc oscillator becomes disabled or if the external standard provides different stability characteristics as required by the operator. When using the external standard, the internal one is disconnected from the signal path but remains in operation, and can be switched back into the signal circuit without need for warming up. Thus a comparison between the accuracy provided by the internal and external standards can quickly be made by switching the INT. EXT. toggle switch from INT. to EXT. To substitute the external standard, connect it to the EXT. STD. INPUT connector on the front panel and set the INT. EXT. toggle switch to EXT.

2-17 FREQUENCY MEASUREMENT DATA

For Frequency measurement, the circuits of the 523B are connected as shown in Fig. 2-3. All electrical impulses fed to the SIGNAL INPUT connector are amplified, shaped and fed through a Signal Gate circuit to the counters. The gate circuit is made to open and close for a precision time interval (the Standard Gate Time) obtained from the Time Base Section. All impulses that pass through the open gate during this period constitute the frequency counted. One of five different standard gate times can be selected with the front-panel FREQUENCY UNIT switch; 10 seconds, 1 second, 0.1 second, 0.01 second and 0.001 second. The greatest number of significant figures, hence the greatest accuracy, is obtained by using the longest possible gate time.

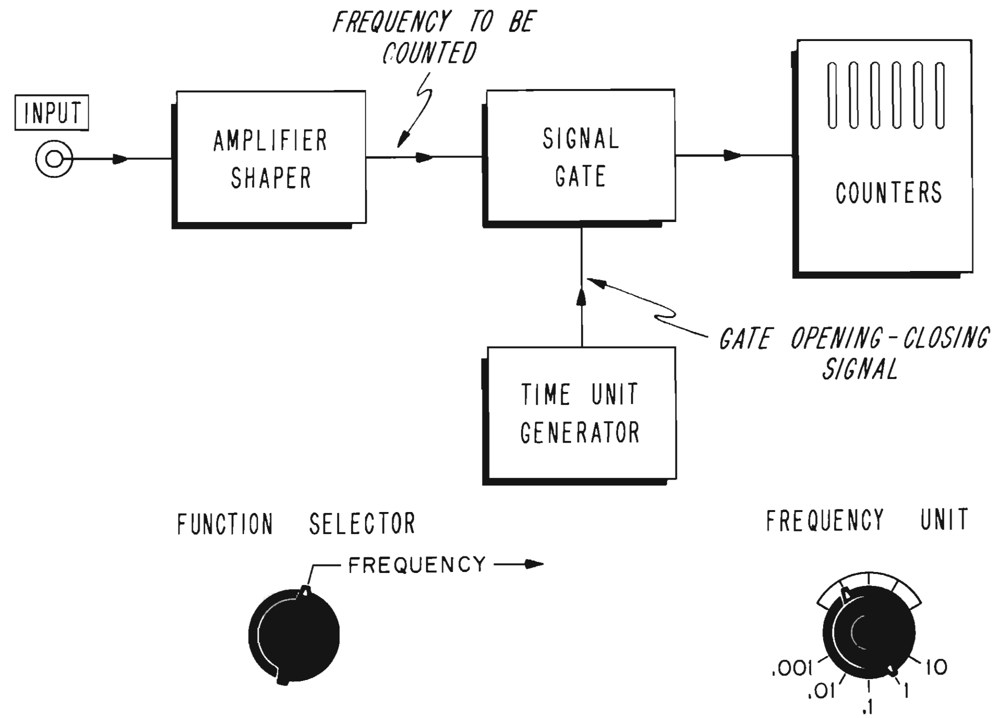


Figure 2-3 Basic diagram of the 523B Electronic Counter when measuring frequency.

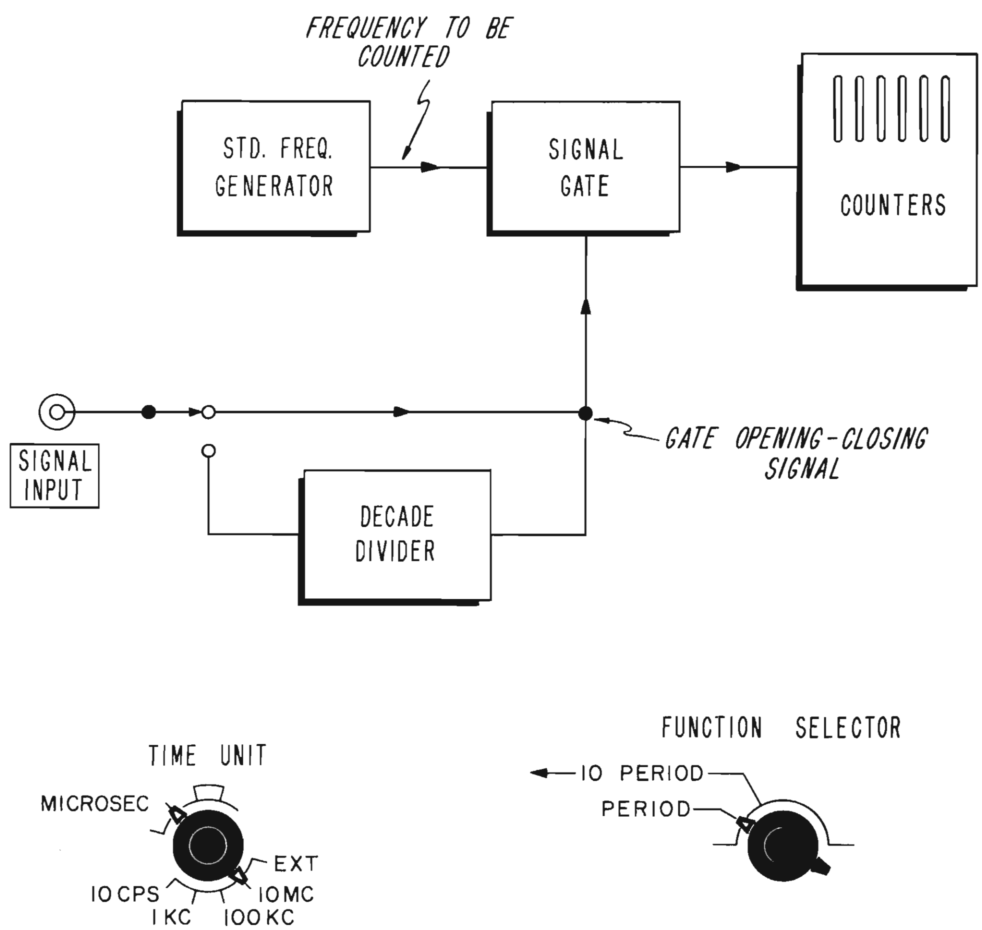


Figure 2-4 Basic diagram of the 523B Electronic Counter when measuring period.

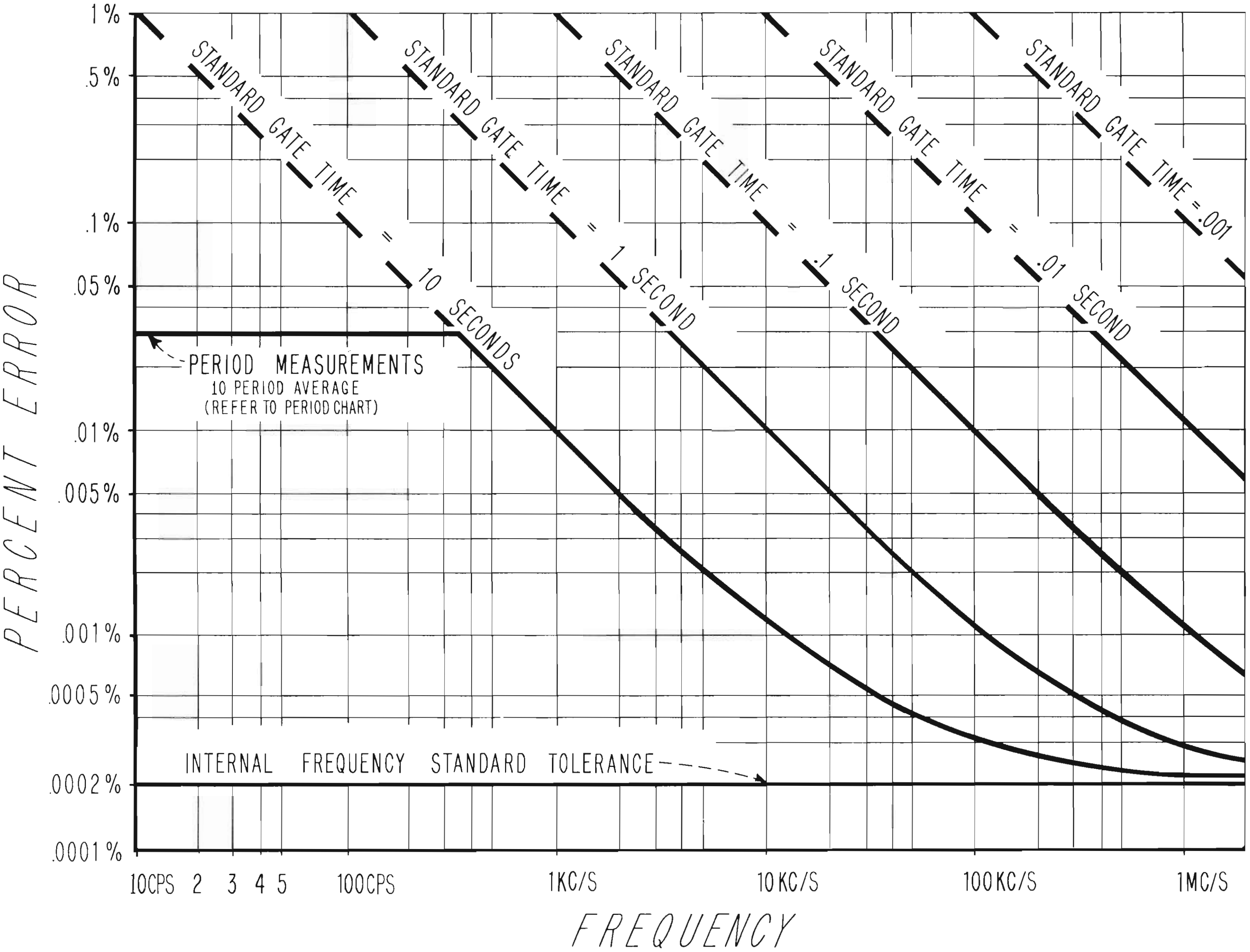


Figure 2-5 Frequency measurement accuracy of the 523B Electronic Counter

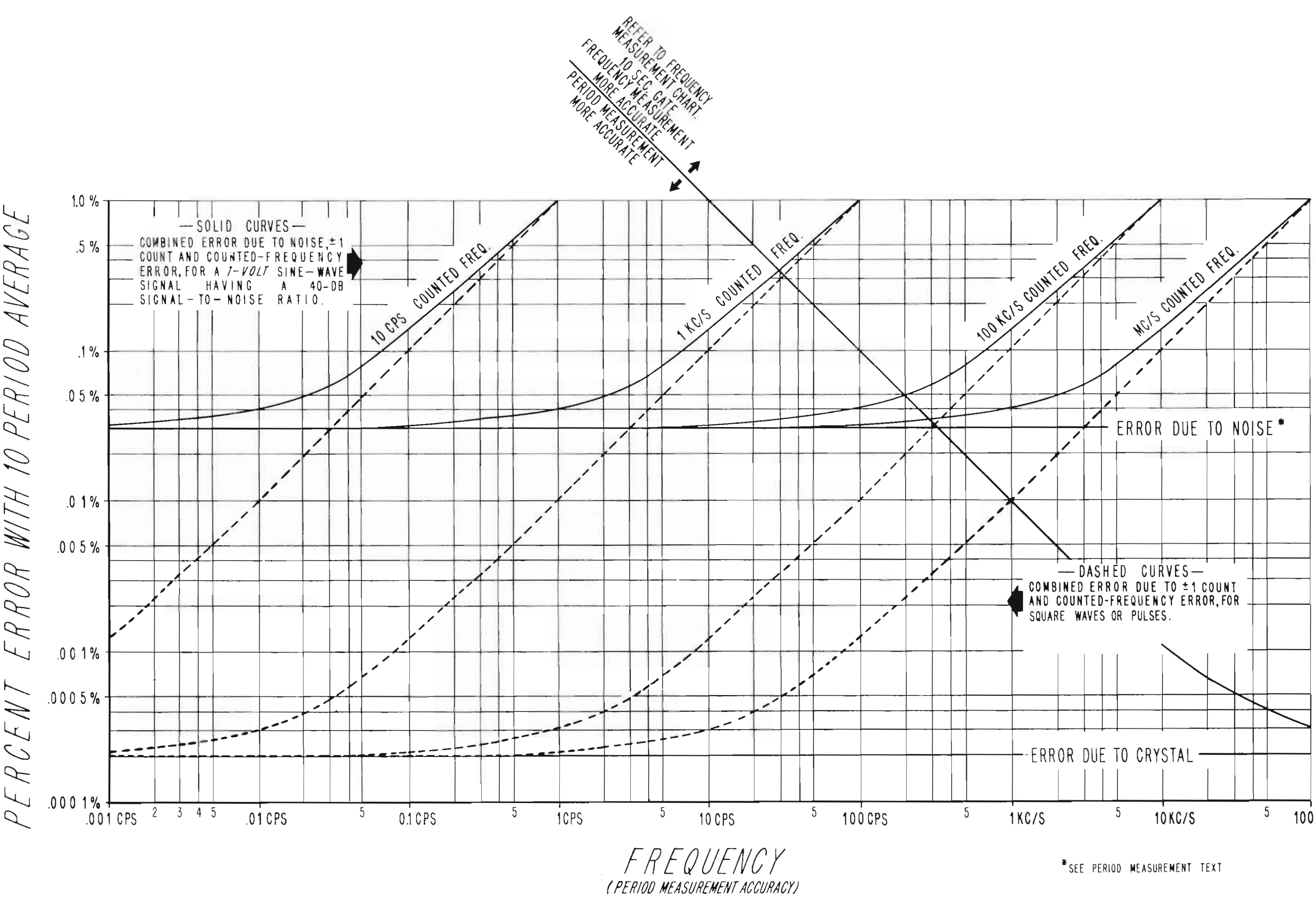
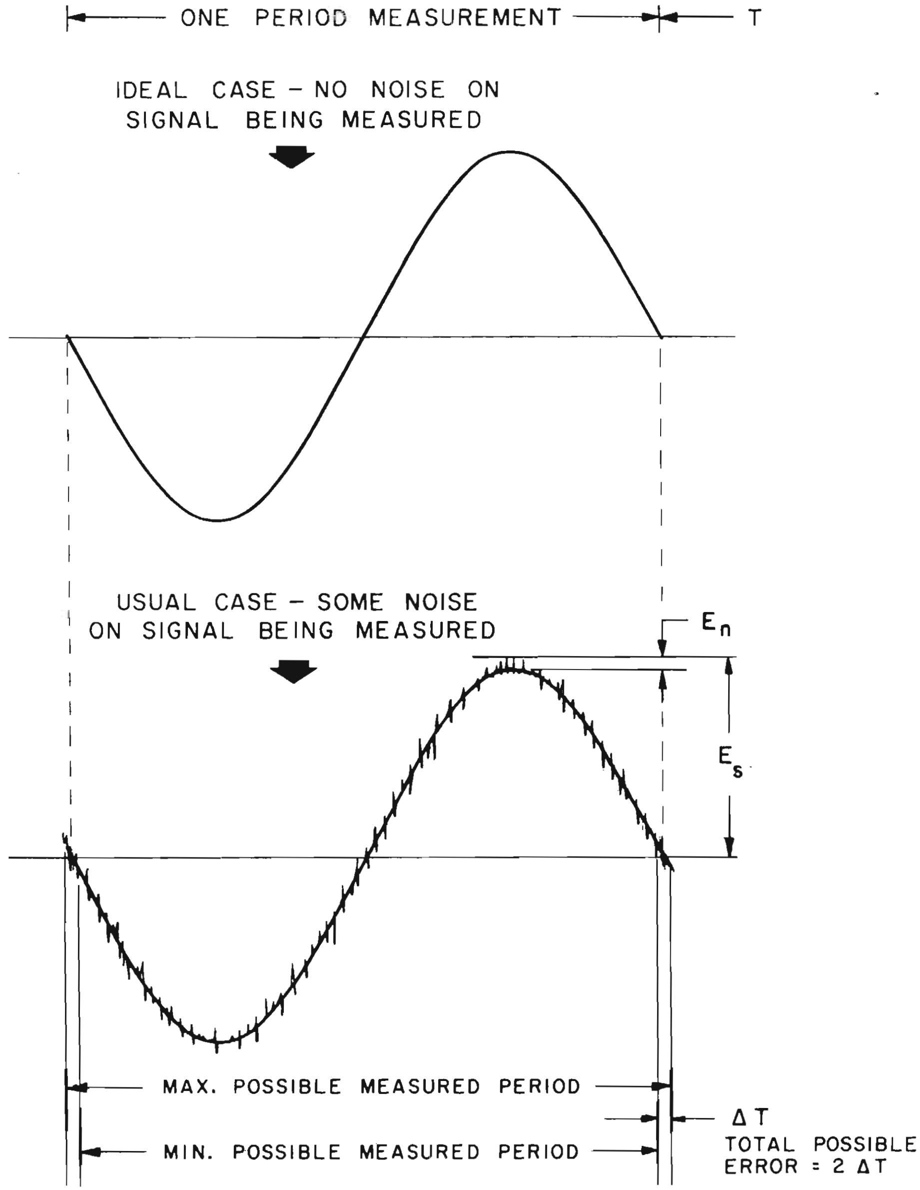


Figure 2-6 Ten-period measurement accuracy of the 523B Electronic Counter



$$\frac{\Delta T}{T} = \frac{1}{2\pi} \frac{E_n \text{ (PEAK)}}{E_s \text{ (PEAK)}}$$

$$\frac{2\Delta T}{T} = \frac{1}{\pi} \frac{E_n}{E_s} = .3\% \text{ FOR } E_n \text{ 40 DB BELOW } E_s$$

$$= .03\% \text{ FOR } E_n \text{ 60 DB BELOW } E_s$$

E_n = TOTAL NOISE INCLUDING APPROXIMATELY 5MV PEAK, FROM COUNTER INTERNAL CIRCUITRY.

Figure 2-7 Diagram showing the possible error in the 523B Electronic Counter period measurement of a sine-wave signal containing noise.

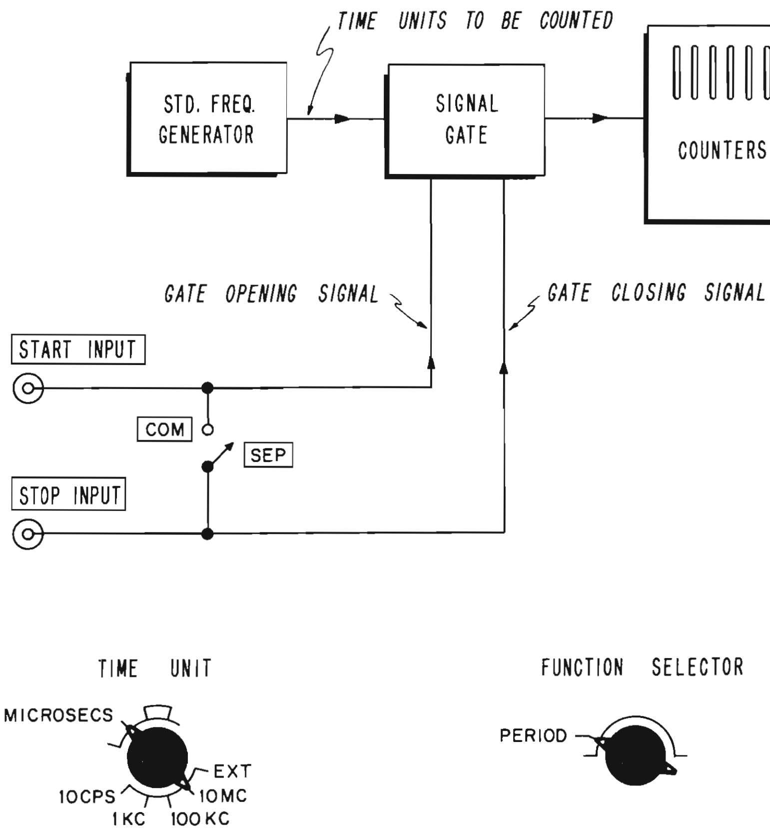


Figure 2-8 Basic diagram of the 523B Electronic Counter when measuring time interval.

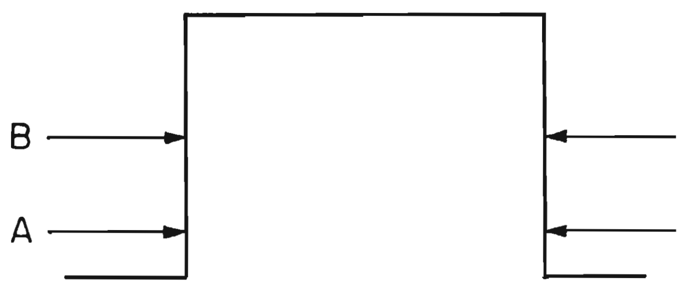


Figure 2-9 Diagram showing two possible time interval measurements on different portions of a simple waveform.

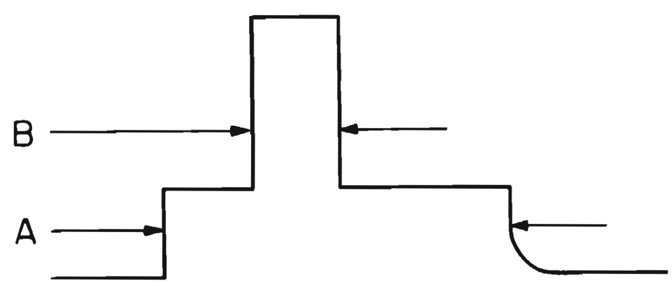


Figure 2-10 Diagram showing two possible time interval measurements on different portions of a complex waveform.

the measurement ends when the input voltage next passes the same point going in the same direction, which is at the beginning of the next cycle. The electrical impulses fed to the SIGNAL INPUT connector are shaped and fed to the Signal Gate Control Binary so that each two consecutive input impulses open and close the Signal Gate. When the gate is open, time units are fed from the Time Base Section through the Signal Gate to the counters. The Counters thus count the number of time units which pass through the gate between the time the gate is opened and closed. The time units can be either seconds, milliseconds or microseconds as selected by the TIME UNIT selector on the front panel. The greatest number of significant figures, hence the greatest accuracy, is obtained by using the smallest time units, while the millisecond and second units provide greater convenience when measuring longer periods.

The automatic display time is adjustable from approximately 0.1 to 5 seconds, except that it cannot be shorter than the standard gate time used. A continuous display of the last count can be had by setting the DISPLAY TIME control to INF. In this position an answer will be displayed until the reset button is pressed to start a new count. During period measurements, the INPUT SENSITIVITY control is inoperative and no adjustments are required.

Since ten-period measurement is intended for measuring very low frequencies, it is limited to frequencies below 10 kilocycles. Period measurement is possible above ten kilocycles but with an error increasing above 0.1% due to the inherent ±1 count ambiguity.

2-19 TIME INTERVAL MEASUREMENT DATA

For time-interval measurement, the circuits of the 523B are connected as shown in Fig. 2-8. The electrical impulses, or voltage levels that mark the beginning and the ending of the time interval to be measured are fed through the START and/or STOP INPUT connectors to amplitude discriminators and then to the Signal Gate Control Binary so that the first two consecutive impulses or voltage levels having the desired characteristics will open and close the Signal Gate. When the gate is open, time units are fed from the Time Base Section through the Signal Gate to the counters. The counters thus count the number of time units which pass through the gate between the time the gate is opened and closed. The time units can be either seconds, milliseconds or microseconds as selected by the TIME UNIT selector on the front panel. The greatest number of significant figures, hence the greatest accuracy, is obtained by using the smallest time units, microseconds. The microsecond and second time units provide greater convenience when it is desired to read the answer directly in seconds or milliseconds.

Time interval measurements can be started and stopped by signals obtained either from a single source, or from separate sources. In both cases the start and stop points are determined by the START and STOP TRIGGER LEVEL controls. To start and stop the interval from a single source, set the SEP COM toggle switch to COM. This connects the START and STOP INPUT jacks in parallel. Note that when the SEP COM switch is set to COM, the impedances of the two inputs are also in parallel, thus input impedances become one-half the value of the individual input impedances.

Using separate start and stop inputs provide an important advantage over using a common input, in that subsequent signals on the START INPUT connection cannot stop the measurement.

A time interval measurement starts when the input signal voltage crosses the selected voltage level, going in the selected direction, as determined by the calibrated START INPUT TRIGGER LEVEL control and SLOPE switches. The measurement stops when the input signal voltage crosses the selected voltage level, going in the selected direction, as determined by the calibrated STOP INPUT TRIGGER LEVEL control and SLOPE switches (the calibration of these controls is only approximate).

Making accurate time interval measurements requires more attention to the input waveform than when making frequency and period measurements. When measuring the time interval of a simple waveform such as shown in Fig. 2-9 the TRIGGER LEVEL controls can be adjusted without special precautions and the measurement will be accurate, since there is little difference if the measurement is started and stopped at either a or b or a combination of a and b. However, if a waveform such as shown in Fig. 2-10 starts and stops the measurement, care must be taken to measure the time between the desired points on the waveform, a, for example, and not the time between b which may be only a fraction of a volt higher or lower than the time at a.

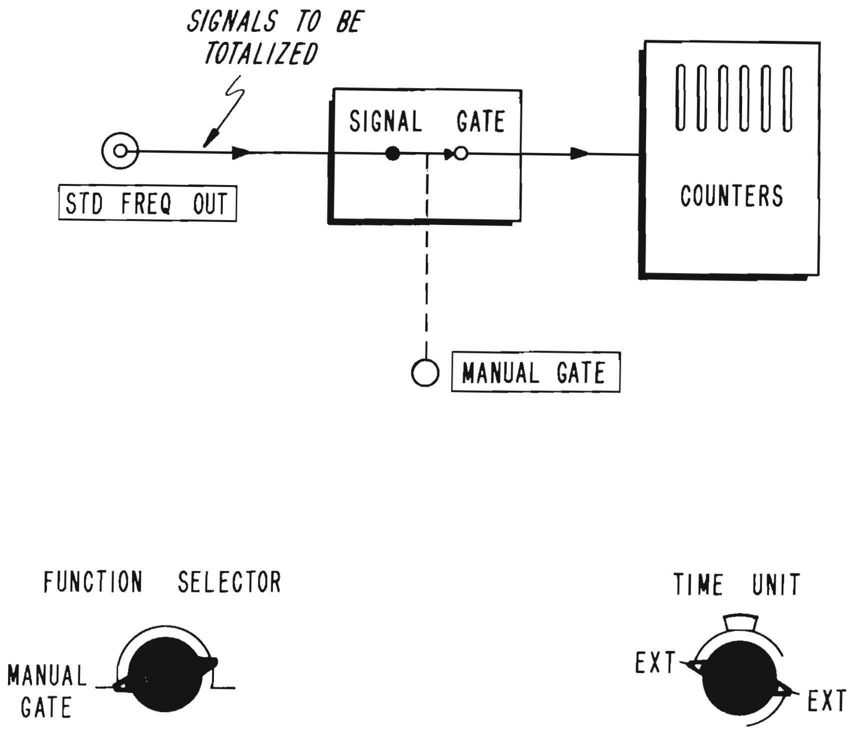


Figure 2-11 Basic diagram of the 523B Electronic Counter when totalizing.

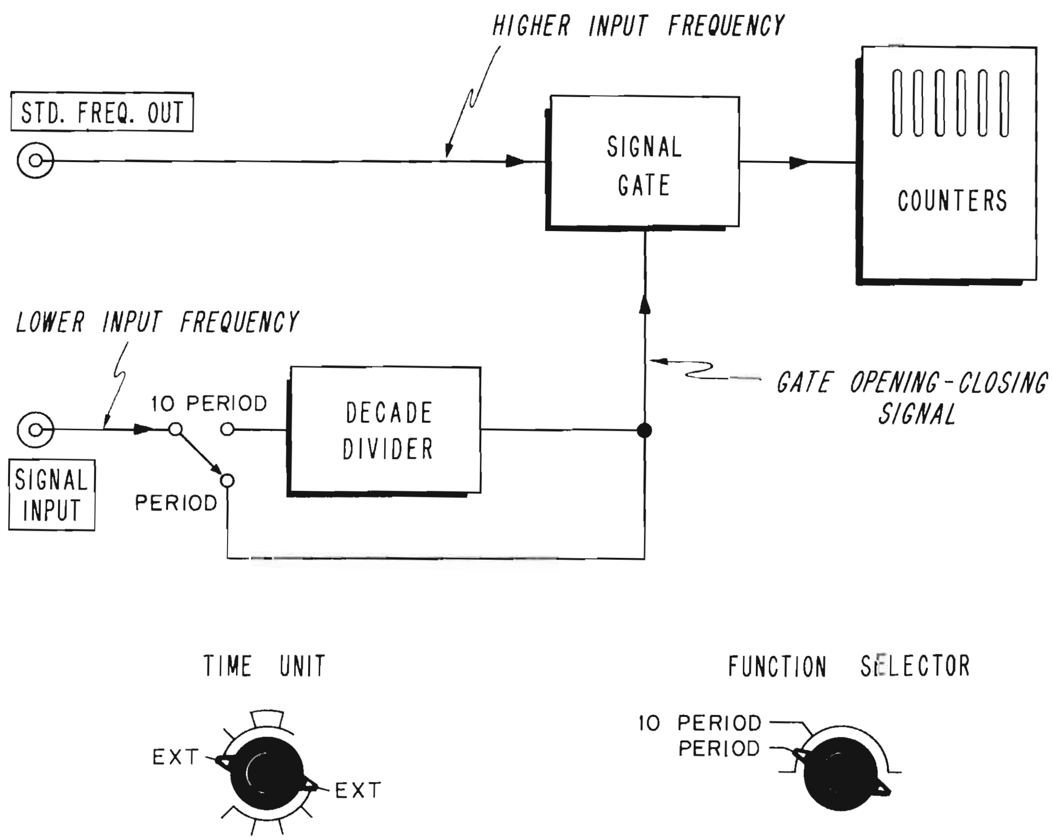


Figure 2-12 Basic diagram of the 523B Electronic Counter when measuring ratios.

If there is substantial noise or spurious signals on the input waveform, the threshold voltage may be reached prematurely by a spurious voltage, and the measurement will be inaccurate. To completely eliminate such errors, view the input waveform on an oscilloscope and intensity modulate the oscilloscope with the pulses obtained from the Start and Stop Pulse Output connectors on the rear of the 523B. These pulses will produce bright spots on the input waveform scope trace at the exact points where the measurement is started and stopped. The threshold controls can then be adjusted to accurately position the start and stop points anywhere on the input waveform.

If time interval measurements must be made without an oscilloscope, set the threshold controls near zero for a preliminary measurement. Then, while increasing the voltage level indicated by the TRIGGER LEVEL controls, watch for a change in the displayed length of the time interval. If there is a sudden jump in the length, there is a jump in the waveform, and it must be determined where on the waveform the measurement is to be terminated.

The automatic display time is adjustable from approximately 0.1 to 5 seconds, except that it cannot be shorter than the standard gate time used. A continuous display of the last count can be had by setting the DISPLAY TIME control to INF. In this position an answer will be displayed until the reset button is pressed to start a new count.

The highest possible accuracy during time-interval measurement is determined primarily by the ability to accurately establish the start and stop voltages on a given input waveform. When the start and stop points are established exactly, time-interval measurement accuracy is determined by Δ E rate at the start and stop points on the input waveform, the accuracy of the internal frequency standard, and by a possible ±1 count error in the right hand digit. When the start and stop points can be easily established, time-interval measurement accuracy is determined by the rate of ΔE at the start and stop points on the input waveform, by the accuracy of the internal frequency standard and by a possible ±1 count error in the right hand digit. The internal frequency standard largely affects long-time measurements and the ±1 count error largely affects short-time measurements. The rate of rise or decay of the input waveform that starts and stops the measurement can affect all measurements; signals having a faster rise time or higher amplitude will decrease errors of this sort.

2-20 TOTALIZING DATA

For totalizing measurements, the circuits of the 523B are connected as shown in Fig. 2-11.

All electrical impulses fed to the STD. FREQ. OUTPUT connector are amplified, shaped, and fed through the Signal Gate to the counters. The gate circuit is opened and closed manually by the operator with the MANUAL GATE toggle switch. Each input impulse simply sets the displayed number forward by one number. This continues as long as the MANUAL GATE switch is open. When the switch is closed, the total of the impulses received will remain displayed until the reset button is pressed. During a count, the input impulses can stop for any period of time, and the total up to that time will be displayed until the next impulse is received. If a new count is to be begun, the reset button must be pressed to remove the stored total from a previous count. If another count is begun without pressing the reset button, the second count will simply be added to the first.

2-21 RATIO MEASUREMENT DATA

For frequency ratio measurements, the circuits of the 523B are connected as shown in Fig. 2-12

The lower of the input frequencies (fy) is fed through the SIGNAL GATE INPUT connector to the Signal Gate Control Binary; with the time unit switch set on EXT, the higher input frequency (fx) is fed to the STD. FREQ. OUTPUT connector and through the Signal Gate to the counters. One period of the lower frequency thus opens and closes the Signal Gate and during this period a number of cycles of the higher frequency will be fed through the gate to the counters. The number of cycles of the higher (fx) frequency per one cycle of the lower frequency (fy) is then displayed:

$$\frac{\text{No. of cycles of (fx)}}{\text{per one cycle of (fy)}}$$

It is also possible to measure the number of cycles of the higher frequency (fx) per ten cycles of the lower frequency (fy):

$$\frac{\text{No. of cycles of (fx)}}{\text{per ten cycles of (fy)}}$$

and thus obtain one more significant figure and up to ten times better accuracy. The length of display will depend upon the setting of the DISPLAY TIME control, but cannot be shorter than the period of the frequency applied to the SIGNAL INPUT connector.

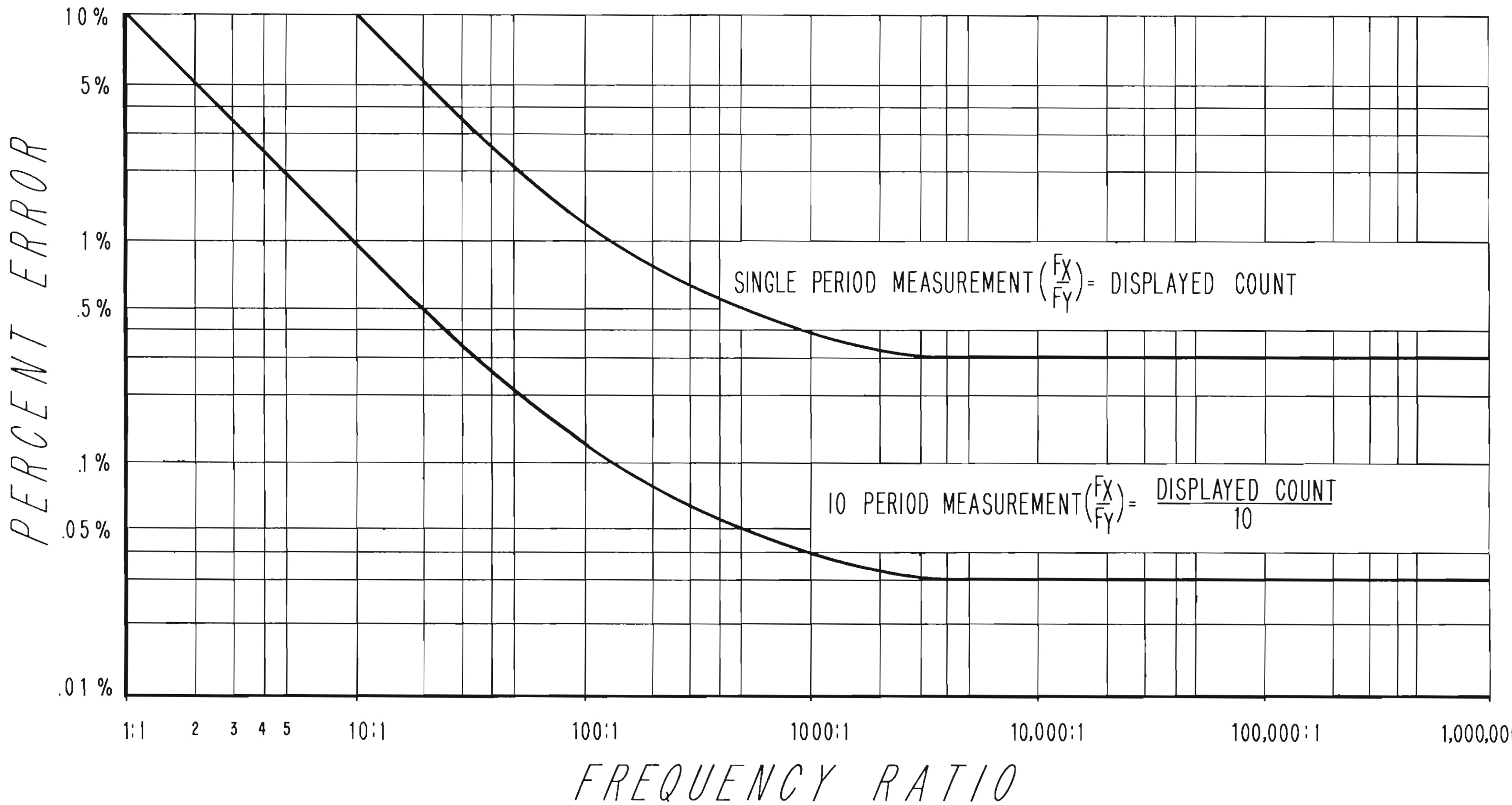


Figure 2-13 Accuracy obtainable as a function of frequency ratio for both single period and 10 period measurements.

The automatic display time is adjustable from approximately 0.1 to 5 seconds, except that it cannot be shorter than the standard gate time used. A continuous display of the last count can be had by setting the DISPLAY TIME control to INF., in this position an answer will be displayed until the reset button is pressed to start a new count.

The highest possible accuracy in ratio measurement is determined at high ratios by the triggering consistency obtained with the lower frequency applied to the SIGNAL INPUT connector. The larger this signal is, the more accurate will be the triggering. The highest possible accuracy at low ratios is determined by a possible error of ±1 count in the right hand digit.

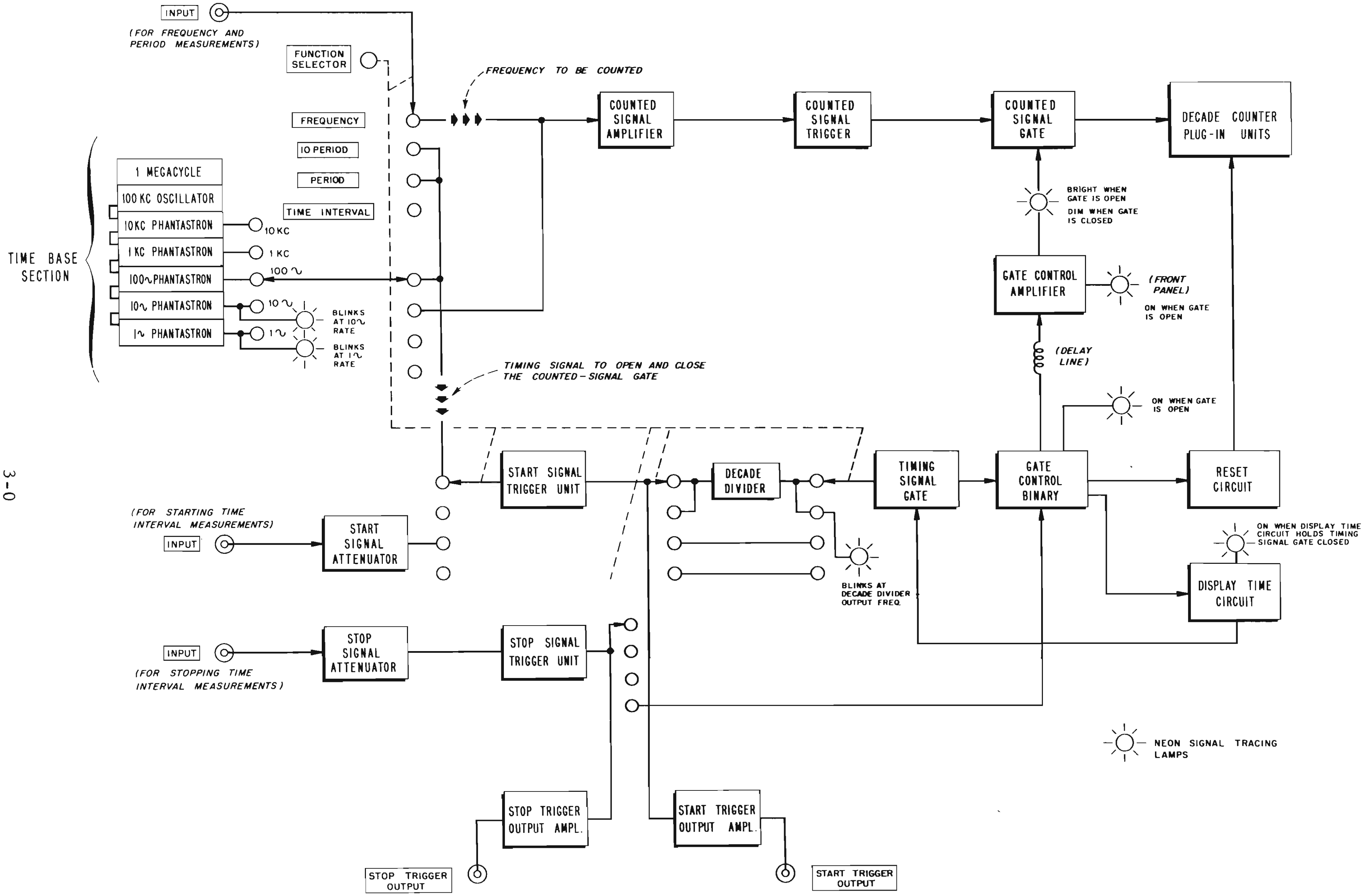


Figure 3-1 Block diagram of the 523B Electronic Counter

SECTION III

THEORY OF OPERATION

3-1 INTRODUCTORY

This section describes the electrical operation of the circuits of the 523B Electronic Counter. First the overall operation of the instrument is explained with reference to the block diagram in Figure 3-1, then the operation of important circuits is described in detail, to be of value both when trouble shooting and operating the instrument. All circuit references are to the block diagram in this section and to the schematic diagrams at the rear of the manual. The material in this section is as follows:

3-2 THEORY OF OPERATION - GENERAL

The 523B Electronic Counter consists of the circuit sections shown in the block diagram in Figure 3-1. The block diagram shows the circuit layout used for frequency measurement; the variations in this circuit layout used with other types of measurements are shown in Figure 2-3 to 2-11. The overall operation of the 523B is described first, and is followed by more detailed explanations of important circuits.

a. A signal applied to the 523B INPUT connector is fed through an amplifier and shaper to the Counted Signal Gate. The essential part of the signal, the frequency, goes through the shaper unchanged, but since this waveform is used to operate the counters, it must be changed to a fast-rise, constant-amplitude pulse to assure consistant operation of the counter circuits.

b. The Counted Signal Gate V406 conducts the input signal to the indicating counters while a measurement is being made, and blocks the input signal while the answer is being displayed. While the signal gate V406 is open, it acts as a normal amplifier; when closed it acts as an open circuit to the input signal.

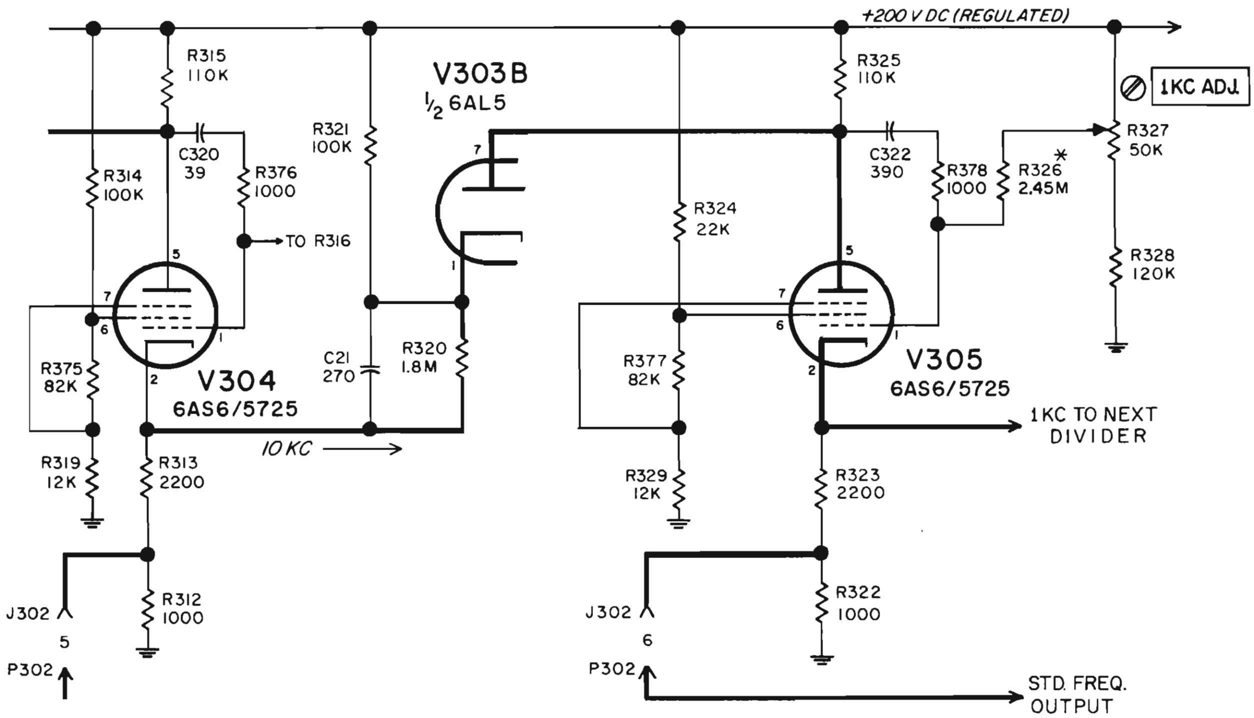
c. The Signal Gate is opened and closed by precision signals initiated in the Time Base Section which actuate the Gate Control Binary and produce a large, fast on-off pulse to operate the Signal Gate. The first signal from the Time Base Section causes the Gate Control Binary to open the Signal Gate; the second signal from the Time Base causes the Gate Control Binary to close the Signal Gate. So long as signals come from the Time Base, the Signal Gate will continue to be opened and closed.

d. Timing Signal Gate CR413 conducts the timing signals from the Time Base to the Gate Control Binary while a measurement is being made, and blocks the timing signals while the answer is being displayed.

e. The Timing Signal Gate is opened and closed by signals from the Display Time Circuit. The Display Time Circuit either opens and closes the Timing Signal Gate automatically at regular intervals, or manually by the front-panel RESET button. When set for automatic operation, the Display Time Circuit is operated by signals from the Gate Control Binary; when the Control Binary closes the Signal Gate, the Display Time Circuit closes the Timing Signal Gate for the time selected by the DISPLAY TIME control so the next timing signal will not reopen the Signal Gate and start another count before the desired display time has been completed. When the display time is over, the Display Time Circuit opens the Timing Signal Gate, and the next timing signal opens the Signal Gate to start another measurement.

f. Whenever the Gate Control Binary opens the Signal Gate to start a new measurement, it first operates the Reset Circuit to return the counters to zero, so the new count will begin at zero instead of being added to the

PHANTASTRON FREQUENCY DIVIDER



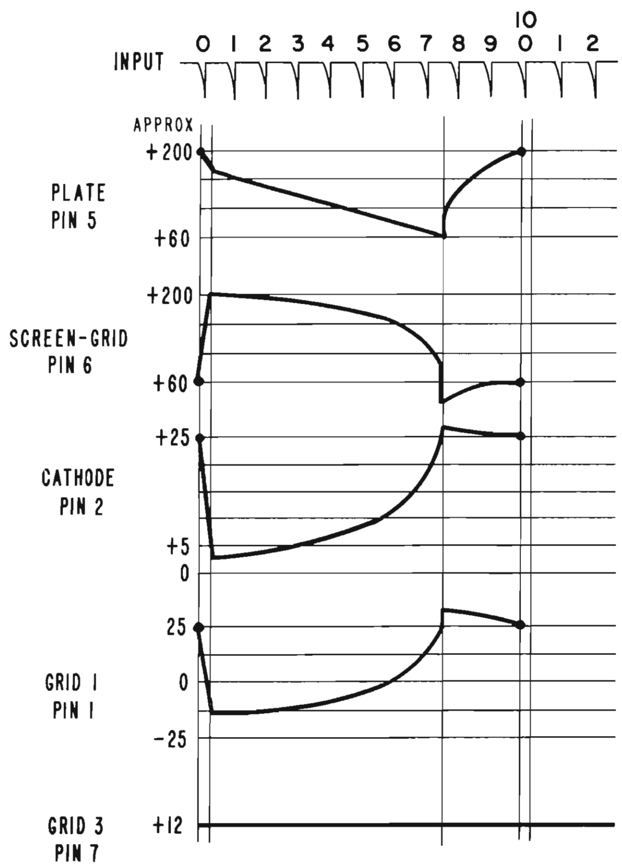


Figure 3-2 Phantastron Frequency Divider

previous count. The Reset Circuit, upon receiving a negative pulse from the Gate Control Binary, generates a large, fast positive pulse which is applied to the reset circuit of each of the counters.

g. The signal to be counted is fed to six indicating plug-in counting units connected in cascade. The output of the first unit connects to the input of the second, and so on. Each cycle of the input signal advances the count of the first (units) counter by one numeral. Each time the number on the first counter is advanced from 9 to 0 it puts out a pulse which advances the count on the second (tens) counter by one number, and so on through all six units. When the Signal Gate is closed, the counter units display the number of the last cycle received. Thus, the number of cycles displayd after opening the Signal Gate for exactly 1 second indicates the frequency directly in cps.

3-3 TIME BASE SECTION

The Time Base Section, located on the etched-circuit boards along the right-hand side of the instrument supplies standard frequencies of 1 megacycle, 100, 10 and 1 kilocycles, 100 and 10 cycles per second. The Time Base consists of a crystal-controlled, 100-kc oscillator, a X10 frequency multiplier and a series of five 10 to 1 frequency dividers, and a plug-in decade divider. The Decade Divider divides the phantastron frequencies from the time base by 10 during frequency measurements and the input signal by 10 during 10 PERIOD average measurement. The same high accuracy obtained from the crystal oscillator is also obtained with all the multiplied and divided frequencies when the circuits are in correct adjustment.

The operation of the crystal oscillator and multiplier is described in detail in par. 3-4, the operation of the 10 to 1 phantastron frequency dividers is described in par. 3-5 and the operation of the decade frequency divider is described in par. 3-6.

3-4 CRYSTAL OSCILLATOR AND FREQUENCY MULTIPLIER

The internal frequency standard for the 523B is a crystal-controlled, 100-kc, Meacham Bridge Oscillator. The bridge is the tuned circuit which provides a positive-feedback signal at the resonant frequency. The positive feedback is fed to the amplifier tube grid, is amplified and transformer coupled back to the bridge circuit.

Crystal Y301 in series with a 10,000-ohm resistor R302 forms one half the bridge circuit; low-resistance electric lamp I301 and 100-ohm variable resistor R303 constitute the other half of the bridge. Off resonance, the high impedance of the crystal balances the bridge and there is no output from the bridge. At resonance, the low impedance of the crystal unbalances the bridge and developes an in-phase signal which is fed to the Amplifier V301A. Lamp I301 in the opposite side of the bridge automatically controls the level of the output signal developed across the bridge. As the oscillation build up, the increasing current through the lamp raises the resistance of the lamp. the increase in lamp resistance tends to rebalance the bridge and reduce the signal level from the bridge. The output amplitude finds a stable level determined by the lamps resistance vs temperature characteristic. Subsequently if the output level tends to decrease, the decreasing current lowers the resistance of the lamp, which further unbalances the bridge to produce more output. The output is thus held relatively constant. Potentiometer R303 is adjusted at the factory to set the level of the output from the bridge, and thus from the oscillator, and requires no further adjustment. The signal from the crystal oscillator is coupled through 100-kc Amplifier V301B to a chain of 10 to 1 phantastron frequency dividers to the FUNCTION SELECTOR switch and to Frequency Multiplier V302A. To obtain multiplication, the plate circuit of V302A is double tuned to 1 megacycle by coils L302 and L303. Double tuning is used to minimize the 100-kc component in the output. The output signal is taken from a tap on the second tuning coil to minimize detuning which would otherwise occur due to loading of the tuned circuits.

3-5 PHANTASTRON FREQUENCY DIVIDER

The five standard gate times, .001, .01, 1.0 and 10 sec, and two frequency units, milliseconds and seconds are obtained by dividing the 100-kc crystal controlled frequency in steps of 10. Five 10:1 phantastron frequency dividers connected in cascade so that each divides the output of the previous one to produce standard frequencies of 10kc, 1 kc, 100 cps and 10 cps. The operation of each divider is the same; only the value of one capacitor in each subsequent divider circuit is changed to obtain a ten-times longer time constant. The shapes of the output waveforms from the dividers are similar, large unsymmetrical positive pulses.

Division in a phantastron circuit is accomplished by adjusting the time constant of the circuit so that one period of phantastron operation lasts nine cycles of the input frequency, actually a division of time. During the period of operation the phantastron is not affected by subsequent input cycles. After the period of operation, the phantastron is returned to its original state, ready to be triggered by the next input cycle. Consequently the phantastron puts out one pulse for each ten cycles of input frequency; but note that it divides by 10 only at the one frequency - at other frequencies, if not readjusted, it divides by another factor, always producing pulses having practically the same period, regardless of the input frequency.

To prevent any of the nine intermediate input cycles from prematurely operating the phantastron, the input signal is fed through a diode gate (V303B in Fig. 3-2) which blocks input cycles during the phantastron cycle. The blocking is accomplished by connecting the plate of the diode gate to the plate of the phantastron, and biasing the cathode of the diode gate a few volts below +200 vdc. When the phantastron plate voltage, and thus the diode plate voltage, is high, the diode gate is open and the input signal is passed to the phantastron. When the phantastron is triggered by an input signal, its plate voltage drops and cuts off the diode, thus closing the gate. The plate voltage remains down (and the gate closed) during nine periods of the input frequency. at the end of its cycle, the phantastron plate voltage rises, the diode gate is opened and the next (10th) cycle triggers the phantastron.

The switching action in the phantastron circuit is as follows:

Refer to Fig. 3-2. Phantastron tube V305 is a special pentode in which the suppressor grid is tightly wound and can be used as a second control grid for the plate current, but not for the screen current. This feature makes it possible to switch the cathode current from plate to screen and vise versa. In this circuit the initial stable state has current going to the screen, 0 volts between control grid and cathode, and the cathode is about 25 volts positive. The suppressor grid, being returned to ground, is thus negative, thus blocking current to the plate such that cathode current goes to the screen grid.

When a negative input pulse is applied to the phantastron control grid, the cathode voltage drops, the negative bias on the suppressor is instantaneously removed and the cathode current switches to the plate. Current continues to the plate until the charge on C322 discharges through the series resistor R 326, the control grid voltage returns in a positive direction, cathode voltage following, until the suppressor to cathode bias is again negative and the plate current cut off. Actually the voltage on the suppressor is maintained constant by voltage divider R324, 377 and 329, while the control-grid and cathode voltage move together as in a cathode follower to affect the shift in suppressor-grid bias. This shift in bias is held by the time constant of timing capacitor C322 and its series resistor R378, the positive charge curve being applied to the control grid of the tube.

3-6 DECADE DIVIDER PLUG-IN UNIT

This unit is required primarily for dividing input frequencies by ten during 10 PERIOD AVERAGE measurement. It is also used during frequency measurement to divide the STD. GATE TIME timing signals from the Time Base so that STD. GATE TIMES from 0.001 to 10 seconds can be obtained from the standard frequencies of 10 kilocycles per second to 1 cycle per second obtained from the phantastron dividers. This unit, unlike the phantastron divider, is not sensitive to its operating frequency and will divide by ten at any frequency up to approximately 10 kilocycles. The operation of the decade divider is described below.

The Decade Divider consists of four cascaded binaries (bistable multivibrator) each triggered by the previous binary. Consequently, the cycles fed to the input are divided by two in the first binary (since the first pulse switches the binary to the opposite state and a second input cycle is required to return it to the original state) and again by two in the second binary (to make a total division by four) and so on, with an expected total division of sixteen at the output of forth binary. At this point the desired division of ten is obtained by two feedback loops which supply pulses to the appropriate binaries so that they will be equivalent to six input cycles. On the ninth input cycle, the two feedback circuits apply triggering voltages to the inputs of the second and third binaries. These binary are thus set to the states they would be in had the additional six cycles been received at the input. Consequently, when the tenth input cycle is received a final output pulse is produced. This action is very similar to the action of the AC-4A Decade Counter without its indicating lights and in general, the voltages and waveforms are the same.

3-7 TRIGGER PLUG-IN UNITS

Two Trigger Plug-In Units and a similar trigger circuit on the Gate Section etched board develope the fast-rise pulses required to operate subsequent binary-type circuits at a certain voltage level on various input waveforms. For example: a sine wave applied to the input connector for frequency measurement must be converted into constant-amplitude, fast-rise pulses to operate the indicating counter units reliably. Input signals for period measurements must be converted into constant-amplitude, fast-rise pulses for precise opening and closing of the Input Signal Gate. The essential part of the Trigger Unit, a Schmitt Trigger, produces a large, sharp output pulse regardless of the shape of the signal that triggers it. In addition, the trigger can be adjusted so that it will produce the output pulse when the input signal voltage reaches a certain level or polarity. Each Schmitt Trigger is preceeded by a differential amplifier so that a substantial trigger operating voltage is assured. The operation of the Schmitt Trigger is described below.

A Schmitt Trigger consists of two amplifiers (twin-triode tube), having both d-c plate—to-cathode coupling from A triode to B triode. The circuit has two stable states; A side fully conducting, B side cut off; B side fully conducting, A side cut off. The change-over from one state to the other is very rapid, producing fast rise and decay times from each side of the circuit, either of which can be used for triggering subsequent circuits.

The d-c voltage level applied to the A-side grid determines which state the circuit will be in. If the grid voltage is made more positive than a certain established level, A side will conduct and B side will not; if more negative than that same level, A side will cutoff and B side will conduct. Each time the A-side grid voltage crosses this threshold in the opposite direction, the circuit changes state. In practice, the threshold voltage is slightly more positive when moving the grid in a positive direction, and slightly more negative when moving the grid in a negative direction. The range between the two different voltage levels is the husteresis of the circuit. The manner in which the circuit changes state is described below.

If A side is cutoff and B side is conducting, and the A side grid voltage is gradually made more positive, a grid voltage will be reached that will cause A side to conduct. When A side begins to conduct its plate voltage drops, which in turn drops the grid voltage of B side, and cuts B side off. As B side cuts off its cathode voltage goes more negative. Since the cathodes are dirct coupled, this constitutes positive feedback and further drives A side into conduction until plate saturation is reached. This action is very rapid and when completed, the Schmitt Trigger is in the opposite stable state. It will remain in this state unitl the voltage level of the A-side grid is moved negatively until the lower histeresis limit is crossed and A side is cutoff. The above process is then repeated in the opposite direction.

3-8 INPUT SIGNAL STABILIZED AMPLIFIER

The Input Signal after passing through the video amplifier is applied to V403 which is a d-c coupled stabilized amplifier. Due to the common cathode bias resistor (R417), any changes in d-c output voltage due to changing filament voltage or supply voltage, etc. are reduced by a factor approximately equal to the stage gain.

The d-c level on the second section of the tube is set by the FREQ. SENS. control R418, which is part of a bias divider from the -115 volt supply to the positive voltage on the plate of the first section of the amplifier. Adjustment of this control shifts the bias on the grid of the second section of the amplifier which in turn changes the quiescent d-c voltage level on the input grid of the Schmitt Trigger. Changes in the d-c bias voltage level on the trigger affect its threshold sensitivity. Because this amplifier is able to maintain a stable d-c output level with changing filament voltage and tube aging, the counter sensitivity will remain constant over long periods.

3-9 INPUT SIGNAL AUTOMATIC NOISE FILTER

(located at input to Stabilized Amplifier V403)

Low frequency signals are coupled from the video amplifier through C405 to the grid of

V403 and are amplified in the two halves of the d-c stabilized amplifier and applied to the Schmitt Trigger through R426. The signal from V404 is coupled back through R416 and C406. Negative signals are shunted to ground by CR403. CR401 is biased in the non-conducting condition approximately 5 volts by current flow from the -115V supply through resistors R414, R415, CR402 and CR403 to ground. On positive signals CR402 conducts and C408 charges to some positive potential, offsetting the 5V bias. This positive potential is tied to the anode of CR401 which biases it in the forward, conducting direction. This in effect grounds C407 which is a bypass for high frequency noise which may be present on the signal, thus removing it from the counter input system.

High frequency signals are fed through the first stage of the stabilized amplifier V403 and into the grid of the second half through C410, which bypasses the resistors R422 and R423. The output from the amplifier is fed into the Schmitt Trigger through C412 which is a bypass around R426.

The output voltage fed back from the plate of Schmitt Trigger V404 through R416 and C406 is shunted to ground by C409 so the diode circuits are inoperative and high frequency signals are not attenuated.

3-10 INPUT SIGNAL GATE

The Input Signal Gate serves as a precision switch to the input signal to be counted, and which can be opened and closed completely within a few tenths of a microsecond. Signal Gate Tube V406 is a type 6AS6 tube which is designed for gating purposes. The suppressor grid is closely wound and serves as a second control grid. By lowering the suppressor grid voltage, plate current can be cut off. When driven beyond cutoff (-19 volts), any signal at the control grid does not appear in the plate circuit and the gate is closed. When the voltage on the suppressor grid is 0 volts with respect to the cathode, the tube functions as an ordinary amplifier, the control-grid signal appears in the plate circuit amplified and the gate is open.

The plate circuit of the Signal Gate is coupled to the input of the first decade counter.

3-11 SIGNAL GATE CONTROL BINARY

The Gate Control Binary, V408 and V409, opens and closes the Signal Gate by raising and lowering the suppressor-grid voltage on the Gate tube. In addition, the Control Binary starts the Reset Circuit just before it opens the Signal Gate, and also starts the Display Time Circuit each time it closes the Signal Gate. The Gate Control Binary is actuated either by precision timing signals obtained from the Time Base Section during FREQUENCY measurement, or by a signal from the SIGNAL INPUT connector for PERIOD and 10 PERIOD measurements, or by the front panel manual RESET button.

The Gate Control Binary is a bistable multivibrator designed to be triggered by negative pulses applied to the grids of both halves of the binary; positive pulses are blocked by crystal diodes CR409 and CR413. Each subsequent negative pulse automatically shifts conduction from one side of the binary to the other. When ready to start a count, the first negative pulse from the Time Base Section cuts off V409 and shifts conduction to V408 causing its plate voltage to drop. This negative voltage is coupled through Cathode Follower V407B and the delay line, is inverted in Amplifier V407 and opens the Input Signal Gate. The next negative pulse cuts off V408 and shifts conduction to V409, raises the plate voltage and closes the Input Signal Gate. Signals applied to V409 can only open the Signal Gate, while signals applied to V408 can only close the Signal Gate.

V409 is preceeded by a diode gate, CR413 which, if biased to cutoff by the Display Time Circuit, blocks incoming timing signals and a new count cannot be started. Diode clamps CR410 and 411 at the grid of V408, and CR412 and 414 at the grid of V409, clamp the grids to the negative and positive clamp voltages so the grids can be driven only as far as necessary to accomplish the desired action, and thus obtain a very fast recovery time for the circuit. Clamp CR418 clamps the bias from the Display Time Circuit to the positive clamp voltage.

3-12 DISPLAY TIME CIRCUITS

The Display Time Circuit determines how long an answer will be displayed before the next count is begun. Display time is obtained by blocking signals from the Time Base Section to the Gate Control Binary. This is done by closing the Timing Signal Gate, i.e., by biasing crystal diode CR413 so that the timing signals cannot pass through it. The display circuits action is begun when the Gate Control Binary closes the Input Signal Gate and fires the Display Time Thyratron. Display Thyratron V411 starts the display time by discharging C454 and switching Schmitt Trigger V412 so it produces a positive output voltage and closes the Timing Signal Gate. The display-holding action continues until C454 recharges sufficiently to raise the grid-bias voltage on pin 7 of V412 and retrigger V412 to produce a negative output voltage, and open the Timing Signal Gate. This action permits signals from the Time Base Section to again operate the Gate Control Binary to open the Signal Gate and start a new measurement.

3-13 RESET CIRCUITS

The Reset Circuit resets the displayed count to zero immediately before each new count is started. A reset signal is obtained from the Gate Control Binary just before it opens the Input Signal Gate, the signal to the Input Signal Gate being delayed slightly to give the Reset Circuit a chance to operate and the counters time to return to 0 before the Signal Gate opens. Thus each time a new count is started, it will begin from a count of 000000.

The reset pulse is obtained from Blocking Oscillator V410B which is triggered by the output from the Gate Control Binary during repetitive-measurement operation, and from the front-panel MANUAL RESET push button during manually reset operation. The reset pulse is positive in polarity and coupled to each plug-in counter unit through the common reset lead. The reset pulse is applied to the grid of each of the four binaries in the AC-4A and AC-4D-95 counters to switch each binary to the state that ultimately produces a displayed count of 0.

3-14 POWER SUPPLY

The power supply consists of two separate but interdependent, regulated power supplies, the -115-volt supply and the +200-volt supply; each has its own high-voltage winding and rectifier. The -115-volt supply has its own reference voltage (V206); whereas the +200-volt supply uses the output of the -115-volt supply for its reference, consequently the -115-volt supply must be correctly set before the +200-volt supply can be adjusted properly.

The operation of both regulated supplies is the same; only the operation of the -115-volt supply is described as follows:

The -115-volt regulated power supply consists of 4 tubes and their associated components. A full wave rectifier, V203, a series regulator, V204, a control tube, V205, and a reference tube, V206, make up the supply.

If the -115-volt output tends to change, a portion of the change is coupled through voltage divider R216, R217 and R218 to the grid of V205. V204 amplifies the difference between the voltage reference and the new output voltage, inverts it and applies it to V204. If the -115-volt tends to go positive, the grid of amplifier V204 will be made more positive, the grid of series regulator V204 will be made more negative and will instantly counteract the tendency of the output voltage to change. The output voltage is thus held very constant. Ripple and noise in the output are cancelled in the same manner as a change in d-c level.

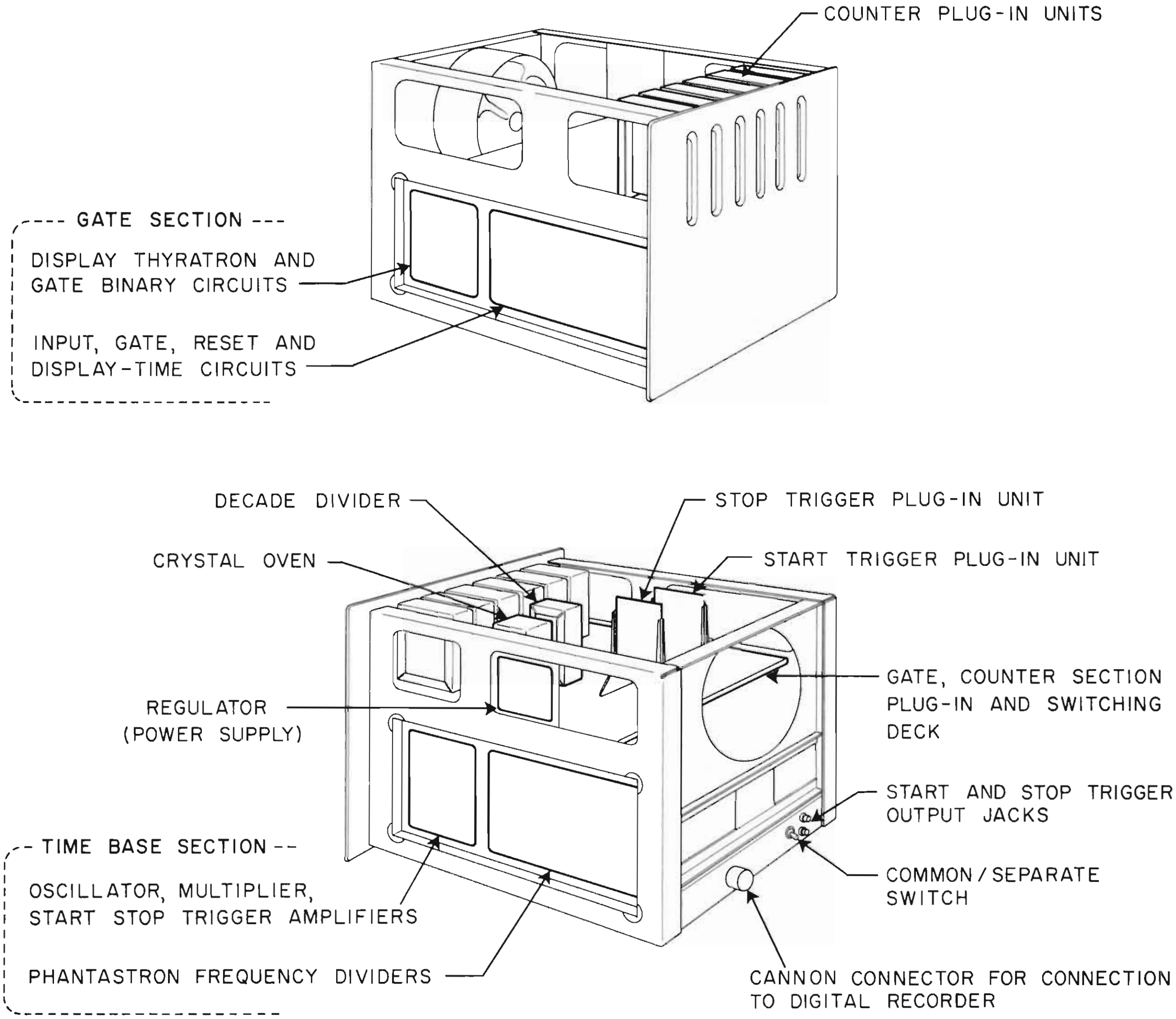


Figure 4-1 Major section location diagram for the 523B Electronic Counter

SECTION IV

MAINTENANCE INSTRUCTIONS

4-1 INTRODUCTORY

This section contains instructions for adjusting and servicing the 523B Electronic Counter. The 523B is constructed so that each of the major circuit sections is physically located in a well defined area as shown in Figure 4-1. The Material in this section is divided as the circuit sections, each section having a complete set of adjustment instructions, and at the rear of the manual, a schematic and a voltage-resistance diagram. The AC-4A, AC-4D-95 Decade Counter Plug-In Units are described in their own manual which is included at the end of this manual. The material in this section is as follows:

4-2 REPLACING THE AIR FILTER

Inspect the air-filter element often when the 523B is in constant use.

The air-filter element in the 523B is a renewable type. It is located on the rear of the instrument cabinet and is removed by sliding up and out. To renew the filter element, wash in warm water and detergent, then recoat with the special oil supplied with the instrument for this purpose.

4-3 REMOVING THE INSTRUMENT CABINET

The 523B chassis and panel are removed from the cabinet by removing the four retainer screws on the rear of the cabinet and sliding the chassis forward out of the cabinet.

4-4 CONNECTING THE 523B FOR USE ON 230-VOLT POWER LINES

The 523B is normally shipped from the factory with the dual primary windings of each power transformer connected in parallel for use on 115 volt a-c lines. The windings can be connected for use on 230 volt lines with addition of one extra part.

Experience has found that the initial magnetizing current to the main transformer T201 can be as high as 160 amperes, depending on what part of the a-c cycle the instrument was on when the switch was shut off, and what part of the cycle when the switch is turned on. It has been found that this high current will often blow the main fuse needlessly, even though it is a slow blow type, when operation on 230 volts is desired. The addition of a thermistor between the terminals A4 and A5 instead of a jumper wire, limits peak current when starting. The thermistor has a cold resistance of 10 ohms and a hot resistance of about 0.25 ohms.

No thermistor is needed on the smaller T202.

The conversion of T201 to 230 volt operation consists of removing the jumper wires from T201 A1 and A4, A2 and A5. Install a thermistor, Carboloy #D-754 (hp Stock No. 211-73) between terminals A4 and A5.

WARNING

The thermistor is a glass-like material and will break very easily if struck or if the leads are over stressed next to the thermistor body.

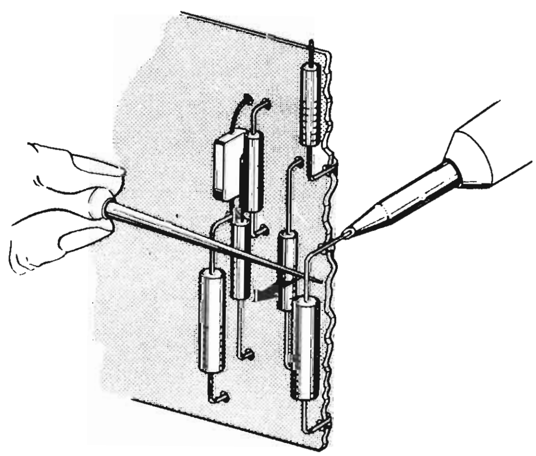
SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

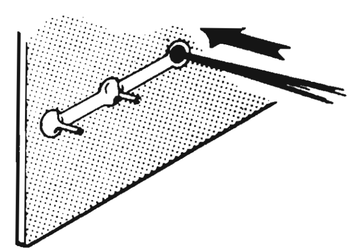
Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or laquer.

A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

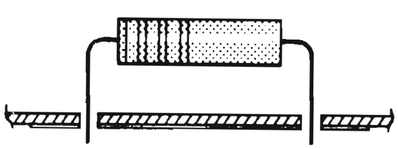
When replacing tube sockets it will be necessary to lift each pin slightly, working around the socket several times until it is free.



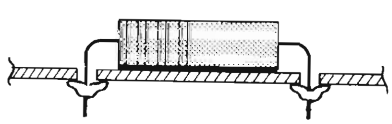
1. Apply heat sparingly to lead of part to be replaced. Remove part from card as iron heats the lead.



2. Using a small awl, carefully clean inside of hole left by old part.



3. Bend clean tinned leads on new part and carefully insert through holes on board.



4. Hold part against board and solder leads. Avoid overheating the board.

Fig. 4-2

To connect T202 for 230 volt operation, remove the wire jumpers from between the top two terminals and between the bottom two terminals; then connect the two center terminals together. The input connections to both transformers remain unchanged. Phasing of the windings is automatically correct.

Replace the 5 ampere slow blow fuse with a 2.5 ampere slow blow fuse.

4-5 SERVICING ETCHED CIRCUITS

Figure 4-2 illustrates how to replace electrical parts on etched-circuit boards.

When servicing etched circuits, DO NOT push or pull wires in such a way as to raise the deposited wiring from the board.

When soldering leads on the etched board, use a 50-watt iron or smaller. Apply heat sparingly to the leads on the part to be replaced, not to the wiring on the board.

Before installing new parts, clean holes to receive new part without forcing. Have leads tinned and if necessary fluxed to receive solder quickly with a minimum of heat and without residue.

4-6 TUBE REPLACEMENT CHART

The following chart lists all the tubes in the 523B with their functions and adjustments required following replacement. None of the tubes in the 523B are specially selected at the factory and require no selection when replaced other than to be sure that the replacement tube is a good one. When replacing tubes to locate troubles, if replacement affects no improvement, return old tube to original position. Indiscriminate replacement of tubes hinders rather than helping with systematic trouble localization.

4-7 ISOLATING TROUBLES TO MAJOR SECTIONS USING THE TROUBLE LIGHTS

In all cases of trouble shooting begin by measuring the power supply voltages shown in Figure 4-3.

The 523B is equipped with neon indicator lamps at strategic points throughout the circuits. These lamps indicate whether or not the previous circuits are operating. The following table lists the circuits which contain the lights and describe the indication of satisfactory operation. Observe the lights in the order given. When marginal unsatisfactory operation is suspected, see paragraph below.

4-8 CHECKING FOR MARGINAL OPERATION

The operation of some electrical circuits in electronic equipment vary over the specified frequency range of the equipment and over the range of line voltages that can occur. At the extremes of both of these ranges there is a greater change for marginal operation. Many cases of marginal operation of the 523B can be easily detected with a variable voltage power transformer and proper use of the self check features.

Since all critical circuits in the 523B operate from regulated supplies, the only thing that is different at high or low supply voltage is the filament voltage on the tubes. If the power supply tubes are weak, the regulated voltages will change at high or low line. If any of the counter circuitry has weak tubes the circuits involved may fail to operate normally at low or high line voltage.

Needless to say, the first thing to check when trouble is suspected, are the power supply voltages and the regulation with line voltage change.

Areas of trouble can be determined by adjusting the counter for 100 kc self check. With the line voltage reduced to 103 volts, start with the shortest gate time (0.001 sec.) and see if the counter is reading correctly. Switch to succeeding slower gate times and check for proper operation. If any position fails to read properly, that particular phantastron is not dividing properly.

The tests should be repeated with a 127 volt supply voltage and then repeat the whole routine using the 1 mc check position. Failure to count high frequencies probably is due to trouble in the input or counter sections.

The 10-cycle to 1-mc performance check is a rigorous test of the overall operation of the 523B Counter and requires a signal generator providing a 0.2-volt output signal from 10 cycles to 1.1 megacycle and a variable line transformer. Proceed as follows:

1. Set the line transformer to obtain 115 volts output.

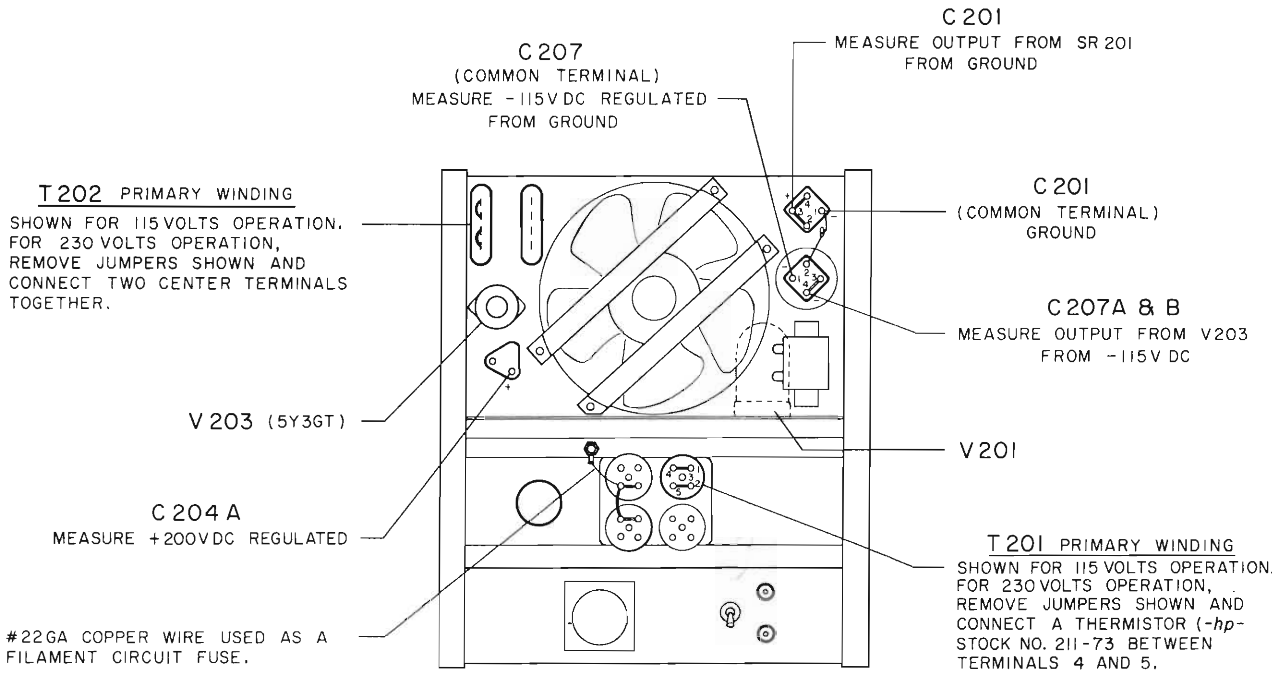
TUBE REPLACEMENT CHART

Ref.	Type	Function	Checks or Adjustments
		AC-4A	
V1	5963	Bi-stable multivibrator	No adjustment required
V2	5963	" "	" "
V3	5963	" "	" "
V4	5963	" "	" "
		DECADE DIVIDER	
V1	5963	Bi-stable multivibrator	No adjustment required
V2	5963	" "	" "
V3	5963	" "	" "
V4	5963	" "	" "
		AC-4D-95	
V1	6211	Bi-stable multivibrator	No adjustment required
V2	6211	" "	" "
V3	6211	" "	" "
V4	6211	" "	" "
		POWER SUPPLY	
V201	6080	Series Regulator	Adjust R210 see para 4-9
V202	6AU6	Voltage Control Tube	Adjust R210 see para 4-9
V203	5Y3	Rectifier	No adjustment required
V204	6216	Series Regulator	Adjust R217 see para 4-9
V205	6AU6	Voltage Control Tube	Adjust R217 see para 4-9
V206	5651	Voltage Regulator Reference Tube	Adjust R217 see para 4-9
		TIME BASE SECTION	
V301	6AW8	Oscillator-Amplifier	Adjust R303 see para 4-10. Check Oscillator frequency see paras 2-14 and 2-15.
V302	12AT7	X10 Multiplier-Cathode Follower	Adjust L302 see para 4-10
V303	6AL5	Coupling Diodes	No adjustment required
V304	6AS6/5725	Frequency Divider	Adjust R317 see para 4-10B
V305	6AS6/5725	Frequency Divider	Adjust R327 see para 4-10B
V306	6AS6/5725	Frequency Divider	Adjust R337 see para 4-10B
V307	6AS6/5725	Frequency Divider	Adjust R348 see para 4-10B
V308	6AS6/5725	Frequency Divider	Adjust R359 see para 4-10B
V309	6BC7	Coupling Diodes	No adjustment required
V310	12AT7	Amplifier-Amplifier	No adjustment required
		GATE SECTION	
V401	5963	Amplifier-Regulator	No adjustment required
V402	6CB6	Amplifier	No adjustment required
V403	5963	Stabilized Amplifier	Adjust R418 see para 4-11
V404	6CB6	Schmitt Trigger	Adjust R418 see para 4-11
V405	6CB6	Schmitt Trigger	Adjust R418 see para 4-11
V406	6AS6/5725	Signal Gate	Adjust R504 see para 4-11C
V407	5963	Gate Control Amplifier - Cathode Follower	Adjust R504 see para 4-11C
V408	6485	Gate Control Binary	Adjust R504 see para 4-11C
V409	6485		
V410	6AN8	Amplifier-Blocking Oscillator	No adjustment required
V411	2D21	Display Thyratron	No adjustment required
V412	5963	Schmitt Trigger	No adjustment required
		TRIGGER PLUG-IN UNIT	
V601	5963	Stabilized Amplifier	Adjust R458 and 460 or 464 see para 4-11B
V602	6CB6	Schmitt Trigger	Adjust R459 and 460 or 464 see para 4-11B
V603	6CB6	Schmitt Trigger	Adjust R458 and 460 or 464 see para 4-11B

LOCATING TROUBLES WITH THE TROUBLE SHOOTING INDICATOR LIGHTS

(see complete block diagram in figure 3-1)

1302	Lights 10 times/sec	Indicates that the 100-kc standard signal is correctly divided down to 10 cps and the all standard frequencies except 1 cps are being provided by the Time Base Section.
1303	Lights 1 time/sec	Indicates, in addition to above, that 1 cps standard frequency is provided by the Time Base Section.
1401	Lights at the rate indicated by the STD. GATE TIME selector, with the FUNCTION SELECTOR set to FREQUENCY or CHECK position.	Indicates that STD. CATE TIME signals are being fed to the SIGNAL GATE Control Binary, and should be opening and closing the Signal Gate. Indicates satisfactory operation of the Decade Divider Plug-In unit.
1402	Lights when the Gate Control Binary opens the Signal Gate.	Indicates operation of the Gate Control Binary which should be opening and closing the Signal Gate.
1405	Lights when the display circuit holds the Timing Signal Gate closed. The Gate Control Binary cannot be operated when this light is on.	Indicates the operation of the display time circuits.
1404	Lights brightly when the Signal Gate is open and dimly when the Signal Gate is closed.	Indicates that the Signal Gate is receiving the gate-opening and gate-closing signals from the Gate Control Binary.
1403 (front panel)	Lights when the Signal Gate is open (During the count) and is unlighted when the Signal Gate is closed (during the display)	Same as 1404.



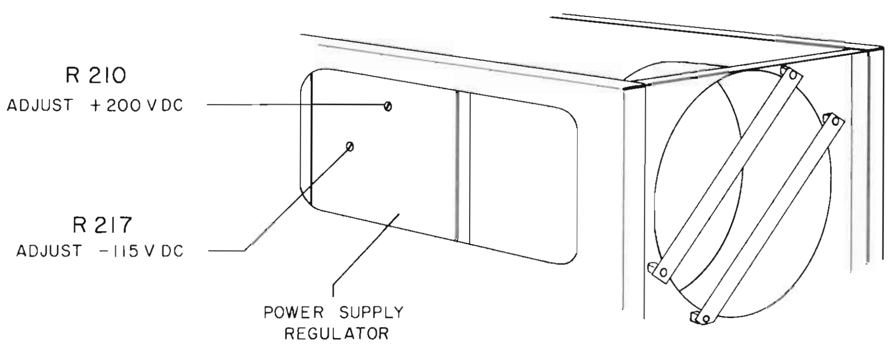


Figure 4-3 Diagram showing location of adjustments in the Power Supply Section

2. Turn the 523B on and allow to heat for 15 minutes.

3. Set the 523B controls as follows:

FUNCTION SELECTOR -- FREQUENCY
FREQUENCY UNIT -- .01
DISPLAY TIME -- Minimum (counterclockwise)

4. Connect a signal generator to the SIGNAL INPUT and set for 0.2 volts rms output and frequency at 10 cps. Increase the frequency in discrete steps, and allow the counter to count at least twice on each frequency. As the frequency is increased from 10 cps to 1.1 megacycles, the indicated readings on the counters should exhibit the following characteristics:

The lighted numerals should increase smoothly without instability or hiatus, i.e.: the indications should progress smoothly one digit at a time with no tendency to pause on one number or skip numbers.

The units counter should increase one number at a time. Any tendency to hesitate on a number or skip numbers is an indication of trouble in the AC-4D-95 Decade Counter Plug-In Unit.

The tens counter should increase 1 count each time the units counter goes from 9 to 0. Any tendency to hesitate on a number or to skip numbers is an indication of trouble in the AC-4D-95 Decade Counter Plug-In Unit, or the AC-4A Decade Counter Plug-In Unit.

The hundreds counter should increase 1 count each time the tens counter goes from 9 to 0. Any tendency to hesitate on a number or to skip numbers is an indication of trouble in the Decade Counter Plug-In Unit.

Note the count progression in the thousands, ten-thousands and hundred-thousands AC-4A Decade Counters as in steps 1, 2 and 3.

5. Repeat the above checks at line voltages of 103 and 127 volts and with a signal input voltage of 1 volt.

This check is a valuable means of detecting marginal functioning of components before actual failure has occured.

4-9 ADJUSTING THE POWER SUPPLY

The complete power supply has two adjustments. These adjustments set the two regulated voltages to -115 and +200 volts dc. The -115 volt supply is independent and must be set first.

The +200-volt supply depends upon the setting of the -115-volt supply and should be adjusted only when the -115-volt supply is known to be correctly set. There is a third regulated voltage (+180 volts, not adjustable) which should be measured when testing the power supply. This voltage is obtained at pin 8 of V401B on the front of the Gate Section etched-circuit board. When adjusting the supplies, first measure the unregulated supply voltages to be sure that adequate operating voltages are available for the regulators. To measure and adjust the power supplies, refer to Fig. 4-3 and proceed as follows:

a. Remove 523B cabinet, turn on, and allow counter to warm-up with line voltage set at 115 volts.

b. Test dc output voltages from SR201 and V203 rectifiers. See Figure 4-3. Output of SR201 should be 320 volts between chassis and capacitor C201 terminal. Output of V203 should be 200 volts between -115 volt regulated supply and capacitor C207A/B terminal when measured with a voltmeter isolated from power-line ground and 523B chassis. If these voltages are more than 10% low with 115 volt line, replace rectifiers.

c. Measure the -115 volt d-c output to ground. If necessary adjust R217 to obtain exactly 115 volts.

d. If possible, vary the line voltage from 103 to 127 volts while measuring the -115 vdc regulated. The regulated voltage should remain constant.

e. Measure the +200 volt d-c output to ground. If necessary adjust R210 to obtain exactly 200 volts.

f. If possible, vary the line voltage from 103 to 127 volts while measuring the +200 vdc regulated. The regulated voltage should remain constant.

4-10 ADJUSTING THE TIME BASE SECTION

The Time Base Section has three separate circuit sections: the 100-kc standard oscillator and amplifier; the X10 frequency multiplier; the chain of five 10:1 frequency dividers. Each section has independent adjustments,

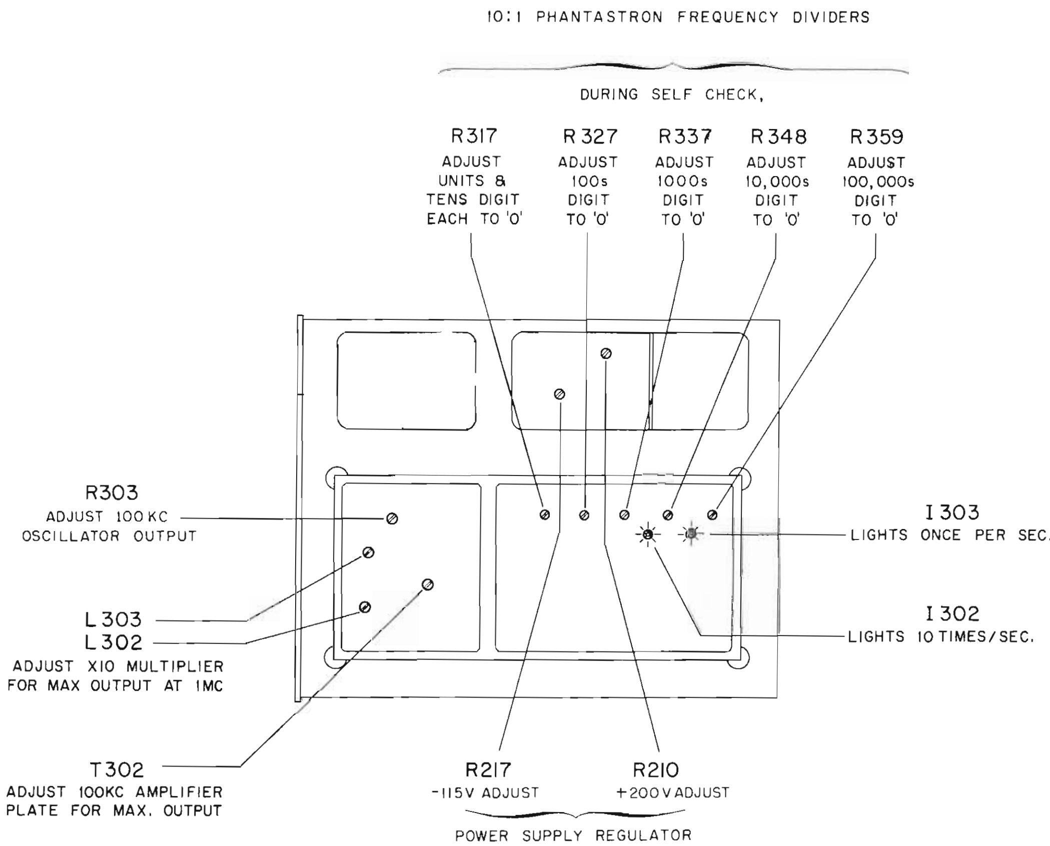


Figure 4-4 Diagram showing location of adjustments in the Time Gate Section

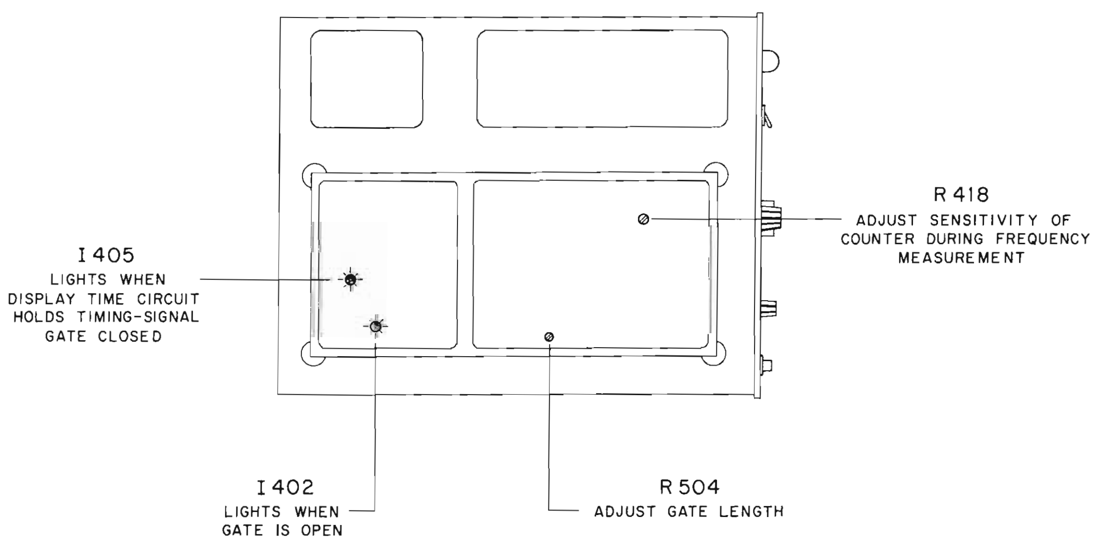


Figure 4-5 Diagram showing location of adjustments in the Gate Section

however the X10 frequency multiplier is adjusted in the same manner as the oscillator so both are handled in a single procedure. The frequency dividers are covered in a separate procedure, as follows:

4-10A 100-kc Osilator, Amplifier and X10 Multiplier Adjustments

4-10B ÷ Frequency Divider Adjustments

4-10A 100-KC OSCILLATOR AND AMPLIFIER ADJUSTMENTS

The internal 100-kc frequency standard has three adjustments: frequency; oscillator amplitude; amplifier tuning for maximum output. Frequency adjustment is described in para. 2-14 and 2-15; oscillator amplitude adjustment and amplifier tuning are independent adjustments described in one procedure below. To adjust the oscillator amplitude, then the 1-mc multiplier output, refer to Fig. 4-4 and proceed as follows:

a. Remove the 523B from the instrument cabinet, turn on and allow to warm up for 30 minutes.

b. Connect an oscilloscope having less then 15 μμf input capacitance and greater than 100K ohms input resistance to pin 9 of V301.

c. If necessary, adjust Bridge Balance R303 to obtain a 30-volt peak-to-peak, 100-kc sinewave.

d. To adjust the 100-kc amplifier, connect the oscilloscope to the STD. FREQ. OUTPUT connector; set the TIME UNIT selector to 100 kc.

e. Adjust T302 with a non-metallic alignment tool to maximize the 100-kc scope presentation.

f. To adjust the 1-mc Multiplier, connect the oscilloscope to the STD. FREQ. OUTPUT connector; set the TIME UNIT selector to 1 MC.

g. Adjust L302 and L303 alternately to obtain the highest 1-mc signal amplitude.

4-10B FREQUENCY DIVIDER ADJUSTMENTS

The Time Base Section contains a series of five 10:1 frequency dividers to obtain frequencies of 10 kc, 1 kc, 100 cycles, 10 cycles and 1 cycle from the standard frequency of 100 kc. Each of these dividers has an adjustment potentiometer which can change the division ratio from approximately 9:1 to 11:1, and which must be set to the center of the adjustment range over which the division ratio is 10:1. Since each subsequent frequency divider depends upon the correct adjustment of the previous divider, the 10-kc divider must be adjusted first, the 1-kc second, and so on. These adjustments can be made by using the instrument's self-check feature when the instrument is operating properly. To check the output of the dividers independently, measure the frequency of each divider's output at position 7 of S302 (see schematic diagram of Time Base Section) and switch the STD. GATE TIME selector to each of the standard gate time to obtain each divided frequency. Each standard gate time should be accurate to within .0002%. The frequency dividers, when dividing by ten, provide the full accuracy of the 100-kc standard; division accuracy can be destroyed only by setting to an incorrect division ratio. To adjust the 10:1 frequency dividers refer to Fig. 4-4 and proceed as follows:

a. Remove the 523B from the cabinet, turn on and allow to warm up for 15 minutes.

b. Set the FUNCTION SELECTOR to 100 KC CHECK position, set the STD. GATE TIME selector to the .001 position.

c. If necessary, adjust R317 to obtain a displayed count of 100 in the three right-hand digits.

d. Set the STD. GATE TIME selector to .01 position.

e. If necessary, adjust R327 to obtain a displayed count of 100.0 in the four right-hand digits.

f. Set the STD. GATE TIME selector to the .1 position.

g. If necessary, adjust R337 to obtain a displayed count of 100.00 in the five right-hand digits.

h. Set the STD. GATE TIME selector to the 1. position.

i. If necessary, adjust R348 to obtain a displayed count of 100.000.

j. Set the STD. GATE TIME selector to the 10 SEC position.

k. If necessary, adjust R359 to obtain a displayed count of 00.0000.

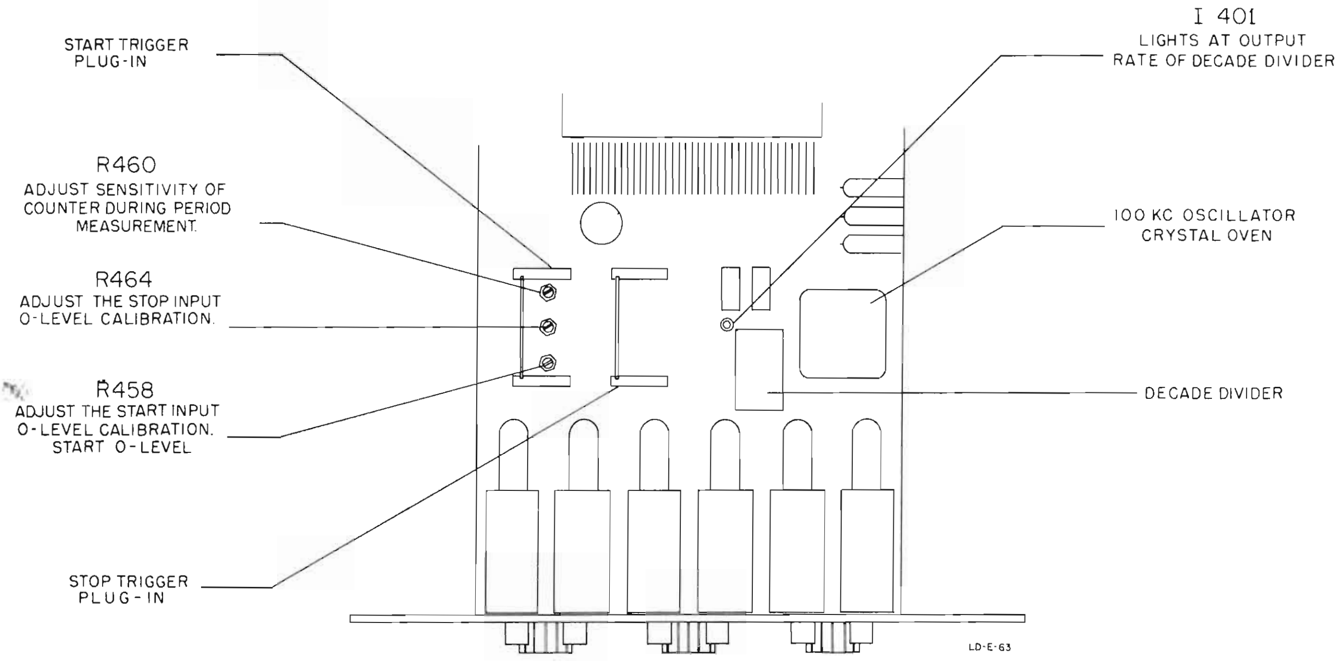


Figure 4-6 Diagram showing location of adjustments in the Trigger Plug-in Units.

4-11 ADJUSTING THE GATE SECTION

The Gate Section contains four separate sensitivity adjustments and a very limited "gate-length" adjustment, as follows:

4-11A Period and Frequency Sensitivity Adjustments
4-11B Time Interval Sensitivity Adjustments (Start & Stop channels)
4-11C Gate Length Adjustment

4-11A PERIOD AND FREQUENCY SENSITIVITY ADJUSTMENTS

The sensitivity of the 523B to incoming signals must be set for both Period and Frequency measurements, however the Period sensitivity adjustment must be correctly set before the instrument can be used for frequency measurement. To adjust the Period and Frequency sensitivity, refer to Fig. 4-5 and proceed as follows:

a. Remove the 523B from the cabinet, turn on and allow to warm up for 15 minutes.

b. Set the FUNCTION SELECTOR to PERIOD; set the TIME UNIT selector to 1 MC.

c. Connect a signal generator to the SIGNAL INPUT connector; set generator to 1 kc.

d. Reduce signal generator output amplitude to lowest level that provides a reliable count.

e. Reduce signal generator output until the displayed count becomes erratic or unreliable. Adjust the Period Sensitivity potentiometer R460 to obtain a reliable count for the lowest possible input signal level.

f. To adjust the Frequency sensitivity set the FUNCTION SELECTOR to FREQUENCY; set the STD. GATE TIME selector to .1 SEC position; set the INPUT SENSITIVITY control to the maximum clockwise position.

g. Connect the signal generator to the SIGNAL INPUT connector and set for 100 kc, 0.1 volt rms output.

h. Adjust the Frequency Sensitivity potentiometer R418 so that the 523B just stops counting as it is turned clockwise. This is the point of correct adjustment.

4-11B TIME INTERVAL ZERO LEVEL CALIBRATION ADJUSTMENTS

Both the START and STOP input channels used in time-interval measurement have an adjustment to position the front-panel TRIGGER LEVEL VOLTS controls. The adjustment shifts the trigger voltage level of the Schmitt trigger for each channel. Since any trigger circuit has some small hysteresis (about 1 volt in the 523B) the trigger point for positive-going input signals is slightly different from the trigger point for negative-going input signals. In the following procedure, these two trigger points will be spaced approximately equidistant and very close to 0 volts when the front panel TRIGGER LEVEL VOLTS control is set to 0. To calibrate the zero-level position of each TRIGGER LEVEL VOLTS control refer to Fig. 4-6 and proceed as follows:

a. Remove the 523B from the cabinet, turn on and allow to warm up for 15 minutes.

b. Set the FUNCTION SELECTOR to TIME INTERVAL; set both the START and STOP TRIGGER LEVEL VOLTS controls to 0; set the COM-SEP toggle switch to COM.

c. On the rear of the instrument chassis, set the COM-SEP toggle switch to SEP.

d. Connect a signal generator supplying 1 kilocycle at approximately 1 volt rms to the START INPUT connector.

e. Connect an oscilloscope to the START TRIGGER OUTPUT connector on the rear of the instrument.

f. While viewing the START TRIGGER OUTPUT pip on the oscilloscope, simultaneously adjust R458, the Start Zero Level adjustment potentiometer and the signal input level to obtain a pip at the lowest possible input voltage.

g. Repeat set f with the scope connected to the STOP TRIGGER OUTPUT and adjusting R464, the Stop Zero Level adjustment potentiometer.

4-11C GATE LENGTH ADJUSTMENT

The Gate Length Adjustment potentiometer adjusts the on-off ratio of the pulse which opens and closes the Signal Gate. In turn, this affects a very small change in the length of time the Signal gate is opened by the pulse.

This adjustment corrects for small differences in pulse amplitude and width which may occur due to small differences in V407, V408, V409, and I404. The adjustment is made by setting the amplitude of the pulse which opens and closes the Signal Gate to about -16 volts; 0 volts when the gate is open, about -16 volts when the gate is closed. To adjust the Gate Length, refer to Fig. 4-5 and proceed as follows:

a. Remove instrument cabinet, turn on, and allow 523B to warm-up for at least 15 minutes with line voltage set to 115 volts.

b. Set FUNCTION SELECTOR to 1 MC CHK and FREQUENCY UNIT selector to 0.001 SEC.

c. Connect a dc vtvm between V406 pin 7 and chassis to measure bias voltage.

d. Turn Gate Length Adjustment R549 to get a +1 count and then in the reverse direction to get a -1 count. Record both voltmeter readings.

e. Set R549 for a voltage midway between the two measurements. This voltage will normally be about -16 volts.

f. Check all gate lengths at line voltages of 103 and 127 volts. If you get a consistent +1 or a -1 count, make a compromise adjustment of R549.

4-12 TROUBLE SHOOTING FROM FRONT PANEL INDICATIONS

ERRATIC INCORRECT COUNT

A. ONE DECADE

Feed in a stable 10 cps 0.2v rms test signal. Use the one or ten second gate. Raise the frequency in small steps and note the count. If the count is accurate to some point and then becomes erratic, the last decade associated with the count is defective. Replace all its tubes.

B. ALL TO THE LEFT OF ONE DECADE

The first decade to the left of the one giving the correct consistent count is defective. Replace tubes in that decade.

C. ALL DECADES

Trouble can be:

1. Gate tube V406.

2. Gate tube amplifier V407.

3. Gate Binary V408, V409.

4. Plug-in trigger circuits.

NO COUNT

A. ONE DECADE

Defective unit. Try exchanging with another decade (if an AC-4A). Replace all tubes in suspected decade with new, good ones.

B. ALL DECADES

1. Gate Lamp Flashing.

a. Large input signal counts ok.

b. Small signal (0.2 volt) no count. Check for weak V401, V402, V403, V404, V405.

2. No flashing Gate Lamp.

a. Flashing Time Base Neon (I302, I303). Start trigger defective. Try reversing start trigger with stop trigger as a check.

b. No flashing time base (I303) check: V301, V302, V303, V304, V306, V307, V309.

Note: Check to see that I401 next to the decade divider is flashing normally. This lamp is connected into the divider at a point which causes it to be lighted for 2/10 of the gate time in use, i.e.: the lamp glows for 2 seconds out of 10 seconds when on 10 second gate length time.

If the front panel Gate Light is out but the gate binary light I402 is flashing at a normal rate, check V407.

If I405 is on constantly, the display thyratron circuit is "hung up". Check V411.

The above trouble shooting notes will in many cases locate the cause of trouble with a minimum of equipment and effort. However, if the trouble is not located by the above symptoms, a thorough check of the proper operation of all circuits in each section of the counter will have to be made. For this purpose, a high frequency oscilloscope equipped with a 10 megohm low capacity probe is needed. An excellent oscilloscope of this type is the hp 150A equipped with an AC-21A 10:1 divider probe. Voltage and resistance measurements should be made with an accurate, sensitive, voltohmmeter. The hp 410B with 122 megohms input impedance is ideal for this purpose.

Schematic and Voltage-Resistance Diagrams have typical values measured on a standard unit in operating condition. Important wave-forms at key points are also shown.

SCHEMATIC DIAGRAM NOTES

1. Heavy solid line shows main signal path; heavy dashed line shows control, secondary signal, or feedback path.

2. Heavy box indicates front-panel engraving; light box indicates chassis marking.

3. Arrows on potentiometers indicate clockwise rotation as viewed from the round shaft end, counterclockwise from the rectangular shaft end.

4. Resistance values in ohms, inductance in microhenries, and capacitance in micromicrofarads unless otherwise specified.

5. Rotary switch schematics are electrical representations; for exact switching details refer to the switch assembly drawings.

6. Relays shown in condition prevailing during normal instrument operation.

VOLTAGE AND RESISTANCE DIAGRAM NOTES

1. Each tube socket terminal is numbered and lettered to indicate the tube element and pin number, as follows:

* = no tube element	P = plate
H = heater	T = target (plate)
K = cathode	R = reflector or repeller
G = control grid	A = anode (plate)
Sc = screen grid	S = spade
Sp = suppressor grid	Sh = shield
	NC = no external connection to socket

   The numerical subscript to tube-element designators indicates the section of a multiple-section tube; the letter subscript to tube-element designators indicates the functional difference between like elements in the same tube section.

   A socket terminal with an asterisk may be used as a tie point and may have a voltage and resistance shown.

2. Voltages values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit contains potentiometers, crystal diodes, or electrolytic capacitors.

3. Voltage measured at the terminal is shown above the line, resistance below the line; measurements made with an electronic multimeter, from terminal to chassis ground unless otherwise noted.

4. A solid line between socket terminals indicates a connection external to the tube between the terminals; a dotted line between terminals indicates a connection inside the tube. Voltage and resistance are given at only one of the two joined terminals.

POWER SUPPLY

VOLTAGE - RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)

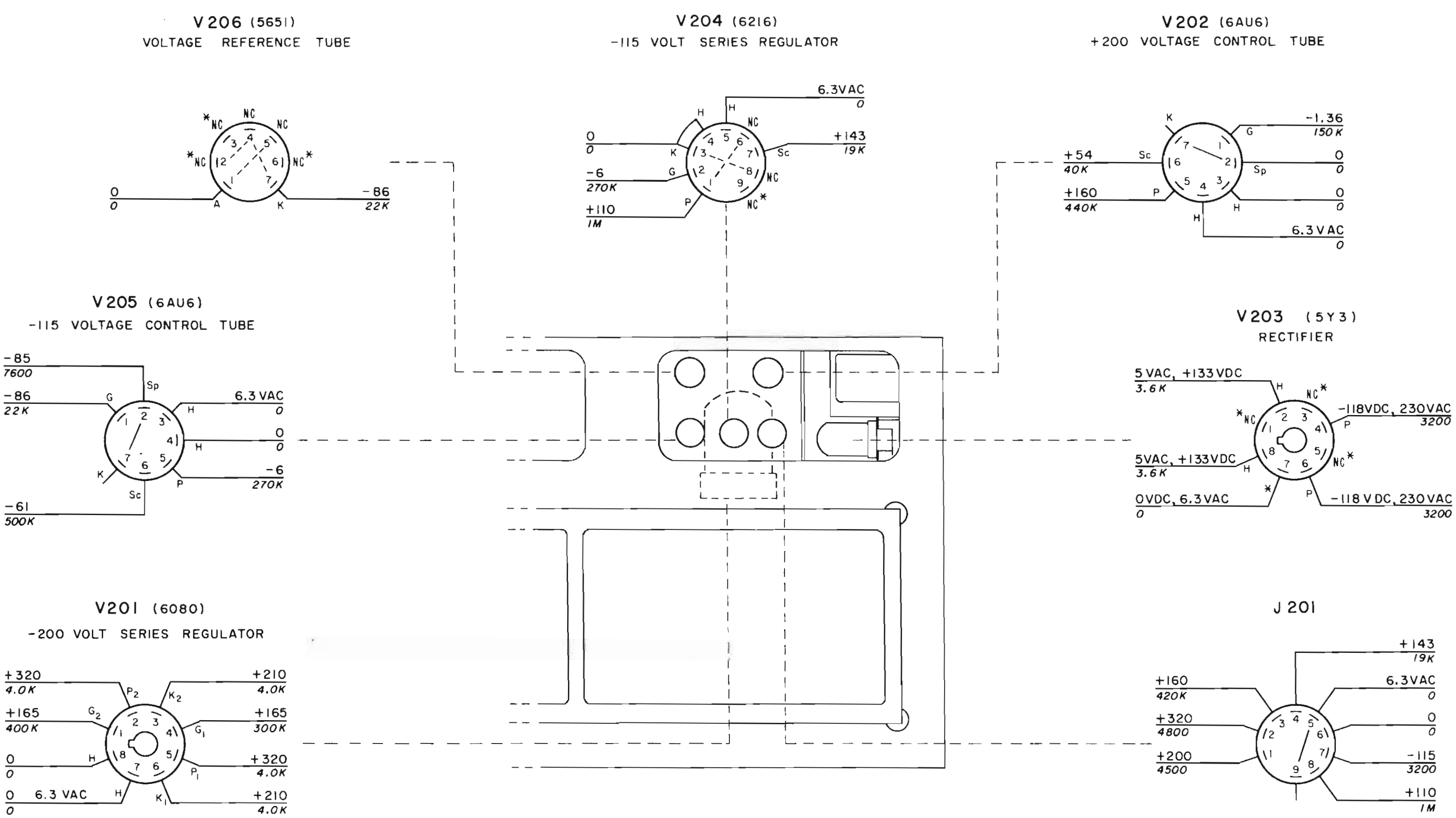
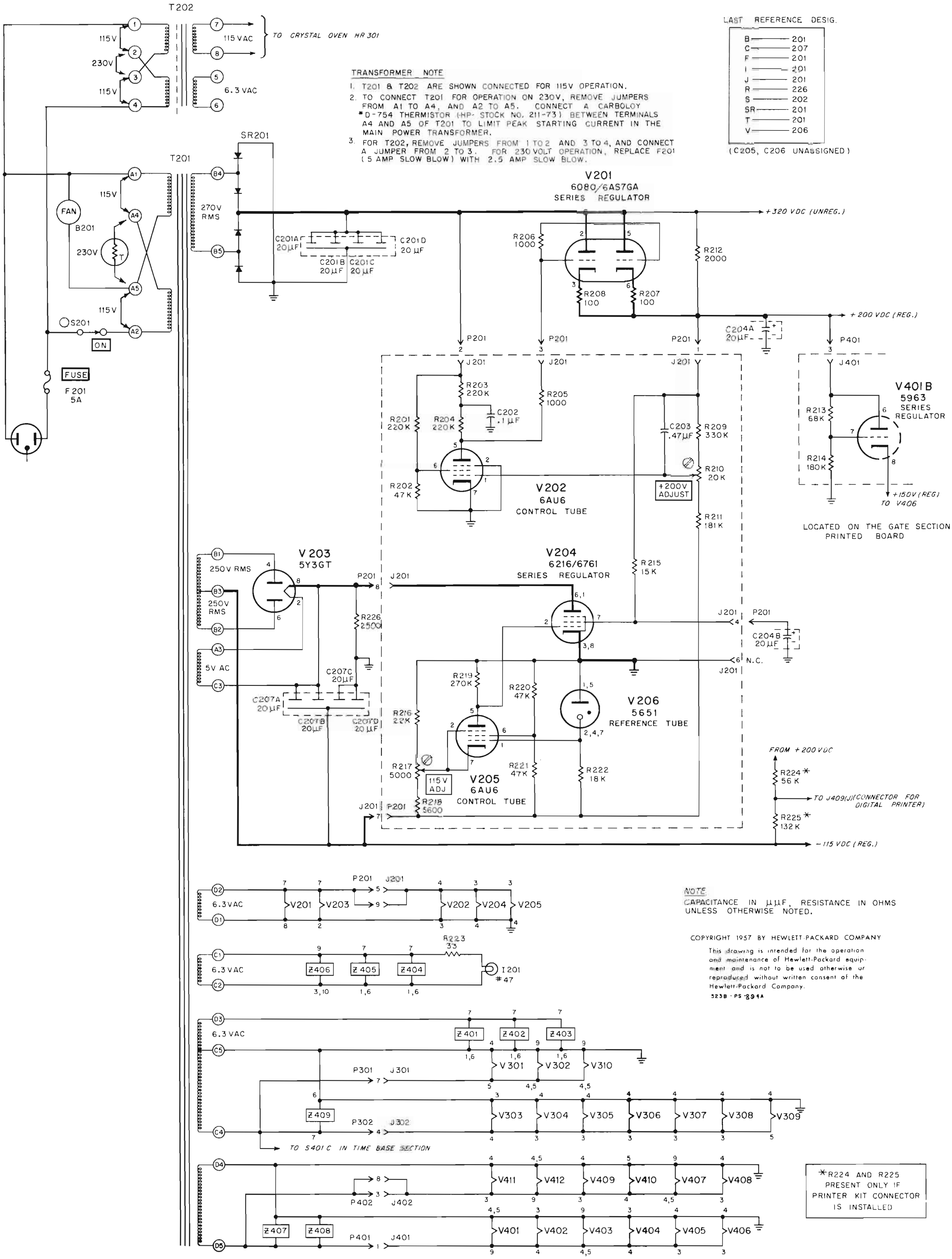


FIGURE 4-7



T202
115 VAC
TO CRYSTAL OVEN HR 301
6.3 VAC
115V
230V
115V
TRANSFORMER NOTE
1. T201 & T202 ARE SHOWN CONNECTED FOR 115V OPERATION.
2. TO CONNECT T201 FOR OPERATION ON 230V, REMOVE JUMPERS FROM A1 TO A4, AND A2 TO A5. CONNECT A CARBOLOY *D-754 THERMISTOR (HP- STOCK NO. 211-73) BETWEEN TERMINALS A4 AND A5 OF T201 TO LIMIT PEAK STARTING CURRENT IN THE MAIN POWER TRANSFORMER.
3. FOR T202, REMOVE JUMPERS FROM 1 TO 2 AND 3 TO 4, AND CONNECT A JUMPER FROM 2 TO 3. FOR 230 VOLT OPERATION, REPLACE F201 (5 AMP SLOW BLOW) WITH 2.5 AMP SLOW BLOW.
LAST REFERENCE DESIG.
B — 201
C — 207
F — 201
I — 201
J — 201
R — 226
S — 202
SR — 201
T — 201
V — 206
(C205, C206 UNASSIGNED)
SR201
T201
FAN
B201
230V
S201
ON
FUSE
F201 5A
270V RMS
C201A 20µF
C201B 20µF
C201C 20µF
C201D 20µF
V201
6080/6AS7GA
SERIES REGULATOR
+320 VDC (UNREG.)
R206 1000
R212 2000
R208 100
R207 100
+200 VDC (REG.)
C204A 20µF
P201
J201
P401
J401
R203 220K
C202 .1µF
R205 1000
R201 220K
R204 220K
C203 .47µF
R209 330K
R210 20K
+200V ADJUST
R202 47K
V202
6AU6
CONTROL TUBE
R211 181K
V401B
5963
SERIES REGULATOR
R213 68K
R214 180K
+150V (REG) TO V406
LOCATED ON THE GATE SECTION PRINTED BOARD
V203
5Y3GT
250V RMS
250V RMS
5V AC
R226 2500
C207A 20µF
C207B 20µF
C207C 20µF
C207D 20µF
V204
6216/6761
SERIES REGULATOR
R215 15K
C204B 20µF
N.C.
R219 270K
R220 47K
V206
5651
REFERENCE TUBE
R216 22K
R217 5000
115V ADJ
R218 5600
V205
6AU6
CONTROL TUBE
R221 47K
R222 18K
FROM +200VDC
R224* 56K
TO J409(J)(CONNECTOR FOR DIGITAL PRINTER)
R225* 132K
-115 VDC (REG.)
6.3VAC
V201 V203 V202 V204 V205
R223 33
Z406 Z405 Z404
I201 #47
Z401 Z402 Z403
V301 V302 V310
P301 J301
Z409
V303 V304 V305 V306 V307 V308 V309
P302 J302
TO S401C IN TIME BASE SECTION
V411 V412 V409 V410 V407 V408
P402 J402
Z407 Z408
V401 V402 V403 V404 V405 V406
NOTE
CAPACITANCE IN µµF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED.
*R224 AND R225 PRESENT ONLY IF PRINTER KIT CONNECTOR IS INSTALLED
523B-PS-894A

TIME BASE SECTION (OSCILLATOR, MULTIPLIER, TRIGGER AMPLIFIER PORTION)

VOLTAGE - RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)

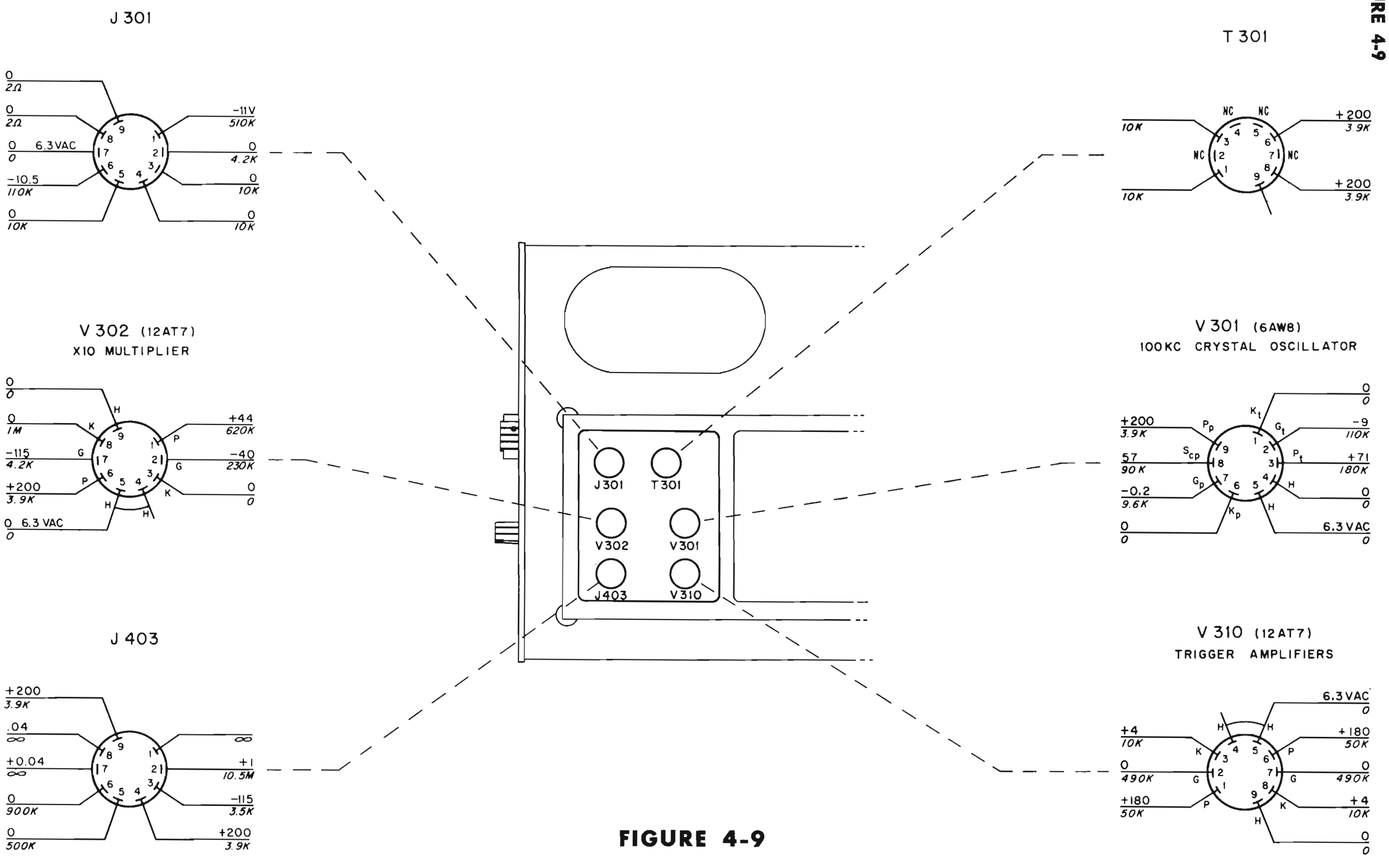
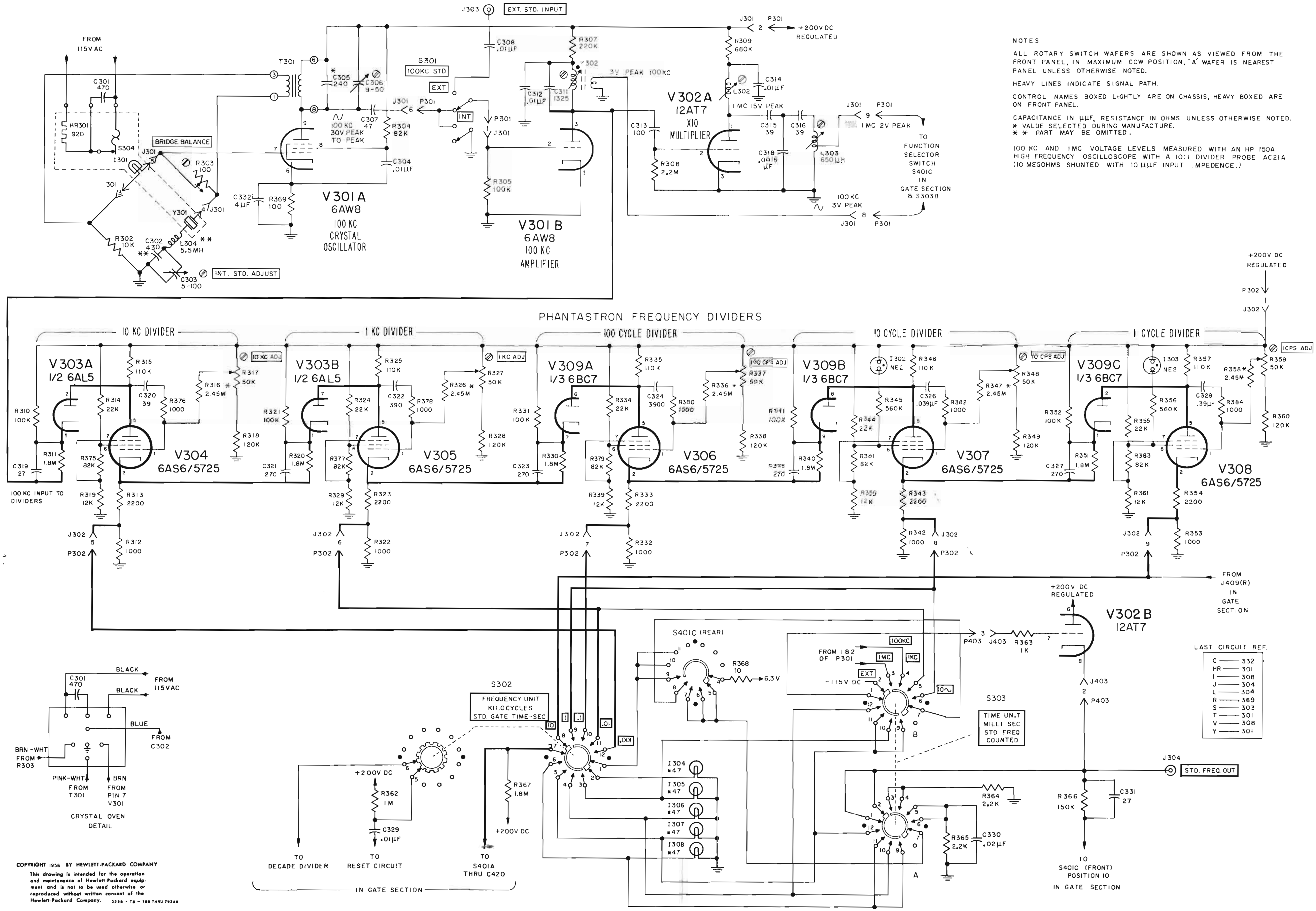


FIGURE 4-9



NOTES

ALL ROTARY SWITCH WAFERS ARE SHOWN AS VIEWED FROM THE FRONT PANEL, IN MAXIMUM CCW POSITION, "A" WAFER IS NEAREST PANEL UNLESS OTHERWISE NOTED.

HEAVY LINES INDICATE SIGNAL PATH.

CONTROL NAMES BOXED LIGHTLY ARE ON CHASSIS, HEAVY BOXED ARE ON FRONT PANEL.

CAPACITANCE IN $\mu\mu F$, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED.
* VALUE SELECTED DURING MANUFACTURE.
** PART MAY BE OMITTED.

100 KC AND 1MC VOLTAGE LEVELS MEASURED WITH AN HP 150A HIGH FREQUENCY OSCILLOSCOPE WITH A 10:1 DIVIDER PROBE AC21A (10 MEGOHMS SHUNTED WITH 10 $\mu\mu F$ INPUT IMPEDENCE.)

LAST CIRCUIT REF.

C	332
HR	301
I	308
J	304
L	304
R	369
S	303
T	301
V	308
Y	301

5238 - T8 - 788 THRU 793A8

DECADE DIVIDER PLUG-IN UNIT

VOLTAGE AND RESISTANCE DIAGRAM

NOTE: WHEN TWO VOLTAGES ARE SHOWN, THE FIRST IS THE MINIMUM AND THE LAST IS THE MAXIMUM VALUE OF A NORMALLY FLUCTUATING VOLTAGE.

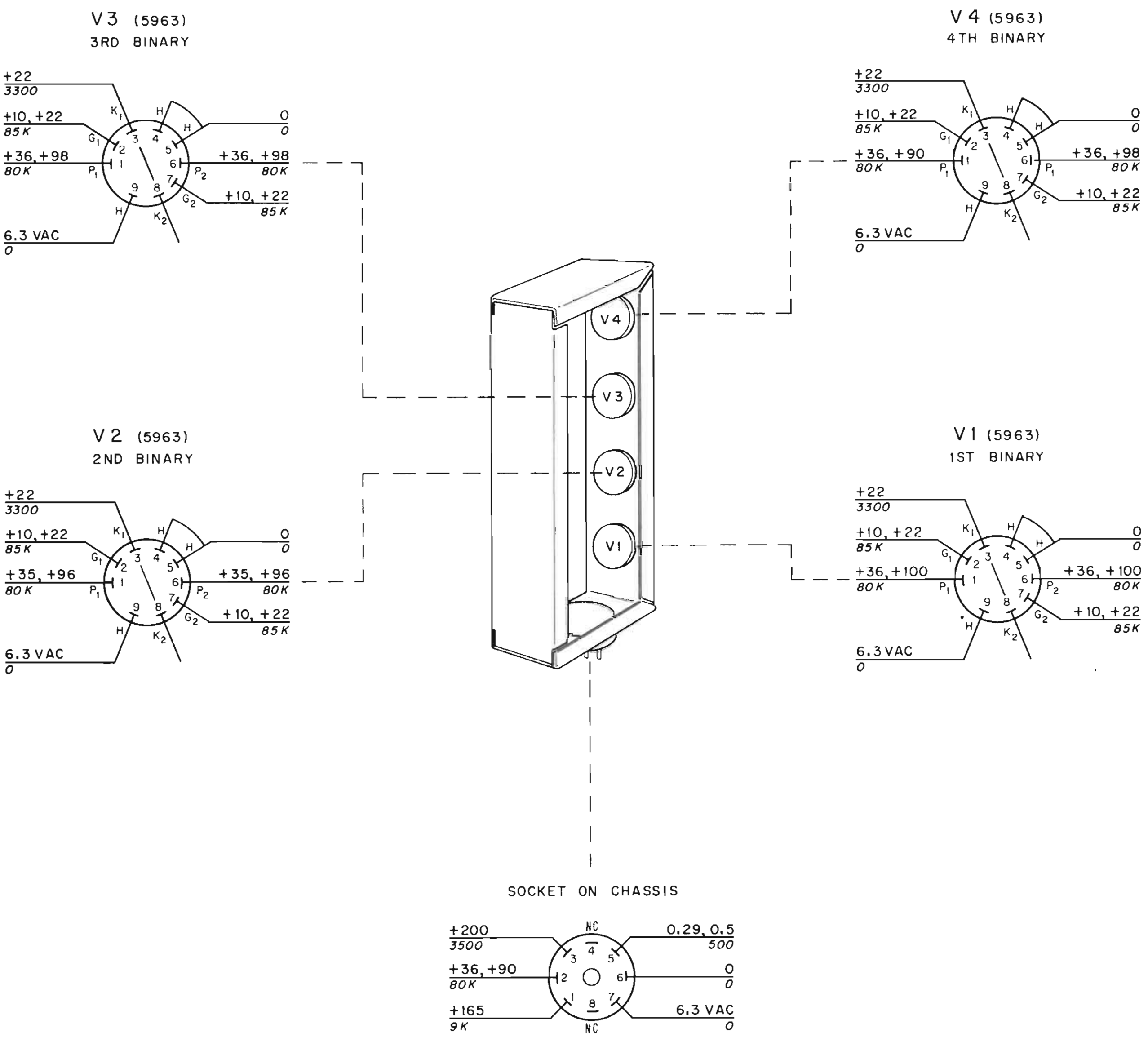
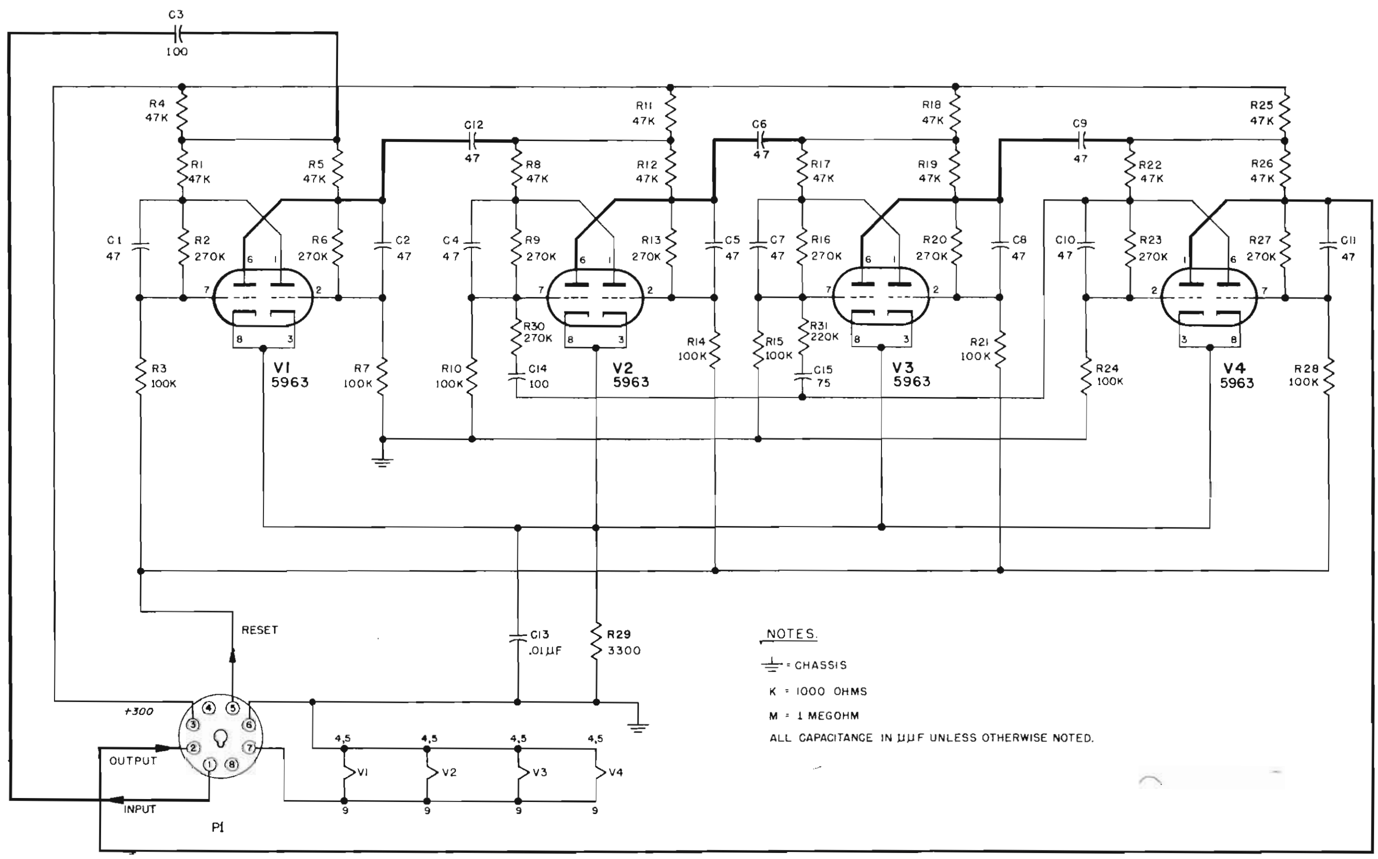


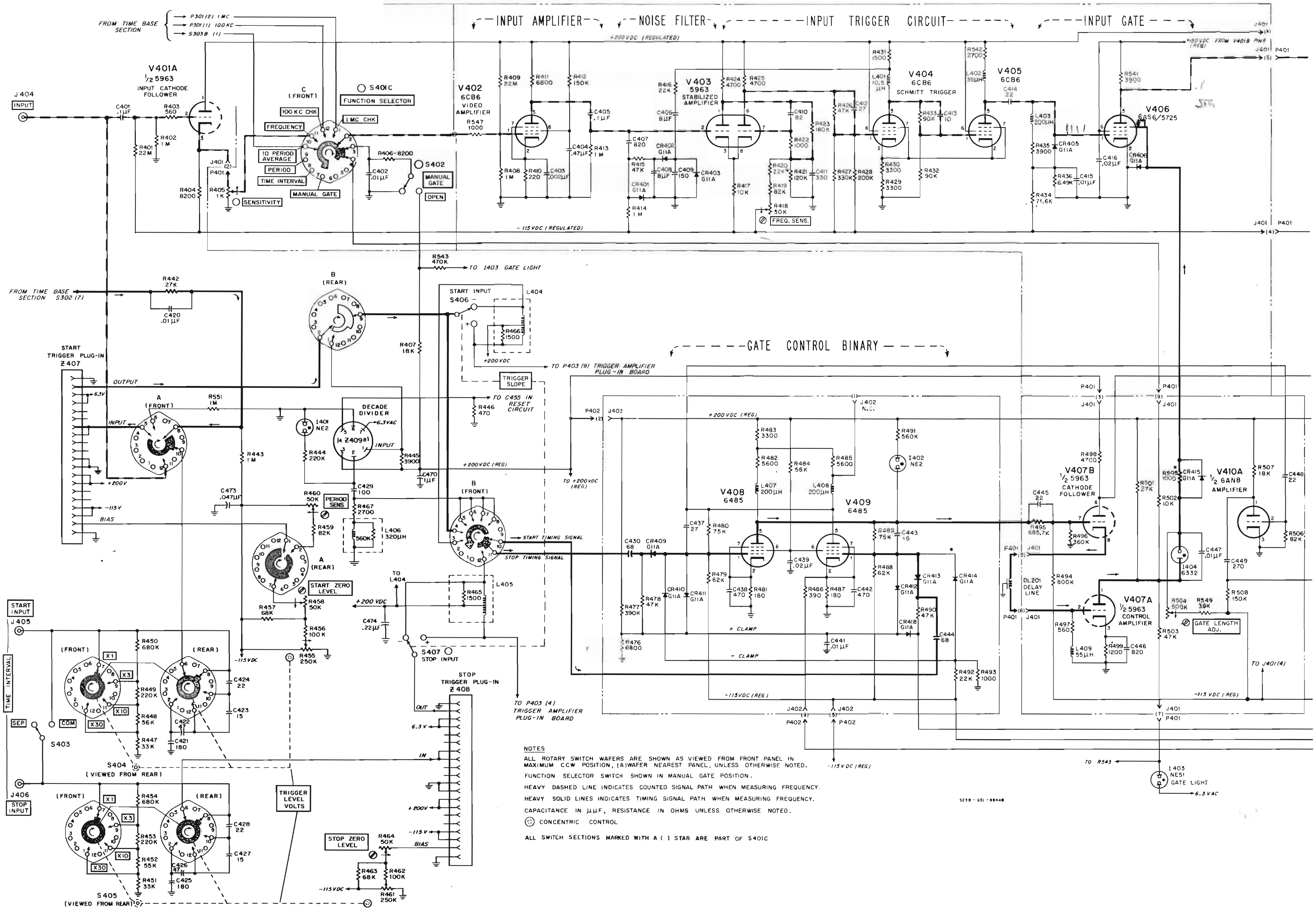
FIGURE 4-11



DECADE DIVIDER UNIT

STOCK NO. 524B-4A

FIGURE 4-12



NOTES

ALL ROTARY SWITCH WAFERS ARE SHOWN AS VIEWED FROM FRONT PANEL IN MAXIMUM CCW POSITION, (A)WAFER NEAREST PANEL, UNLESS OTHERWISE NOTED.

FUNCTION SELECTOR SWITCH SHOWN IN MANUAL GATE POSITION.

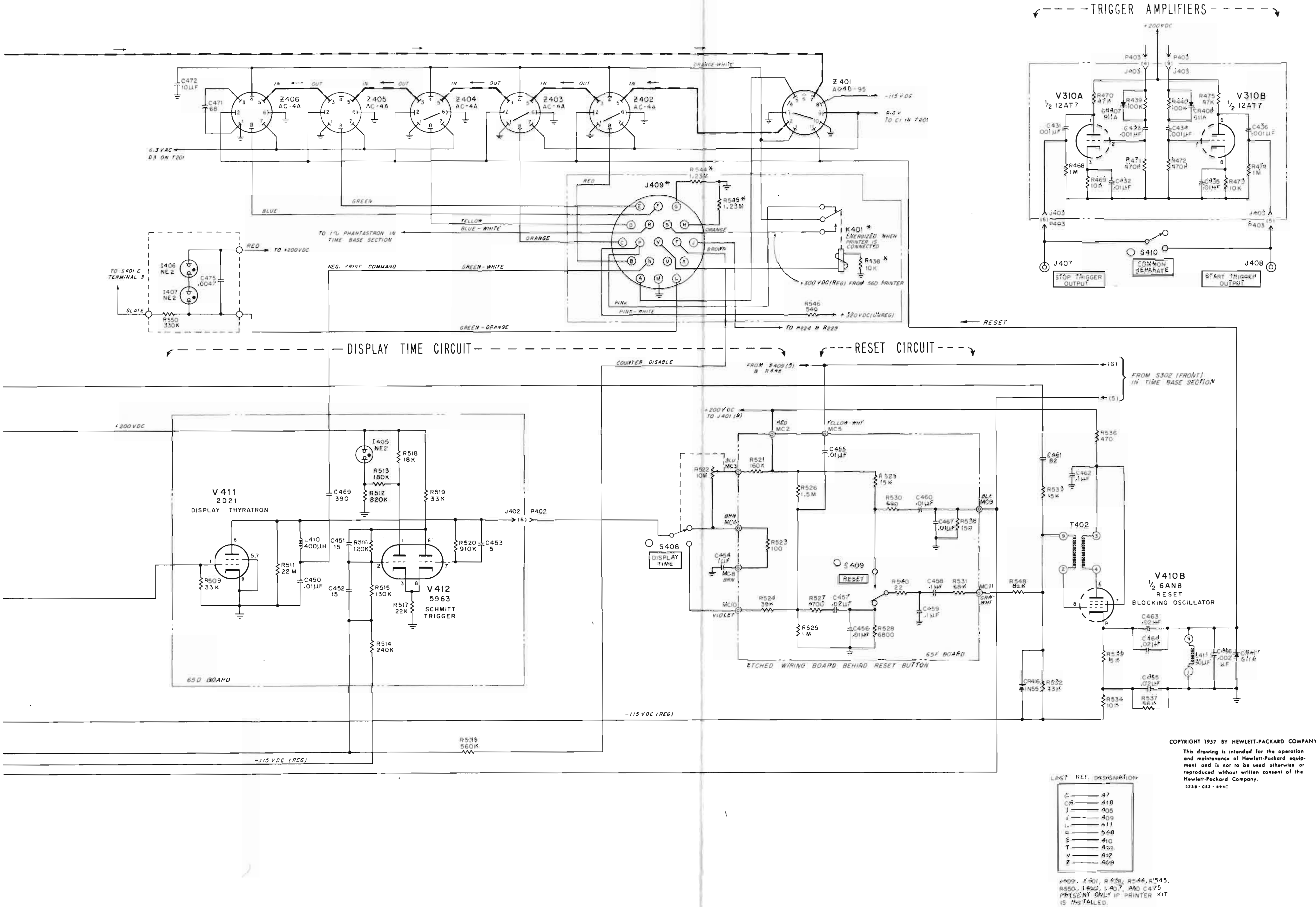
HEAVY DASHED LINE INDICATES COUNTED SIGNAL PATH WHEN MEASURING FREQUENCY.

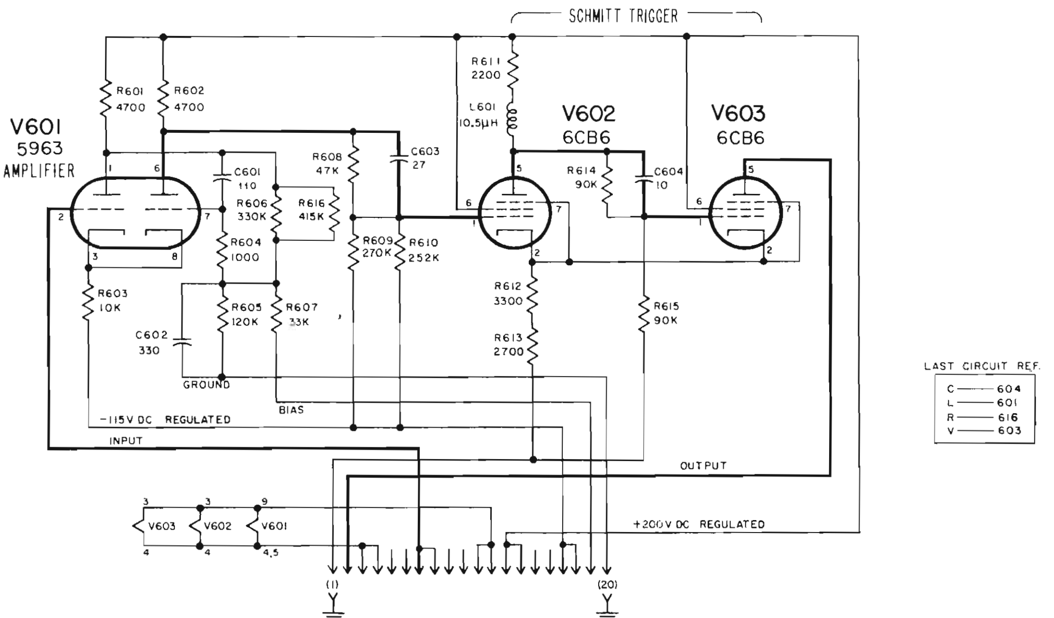
HEAVY SOLID LINES INDICATES TIMING SIGNAL PATH WHEN MEASURING FREQUENCY.

CAPACITANCE IN µµF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED.

⊙ CONCENTRIC CONTROL

ALL SWITCH SECTIONS MARKED WITH A (*) STAR ARE PART OF S401C


TRIGGER AMPLIFIERS
V310A
1/2 12AT7
V310B
1/2 12AT7
J407
STOP TRIGGER OUTPUT
S410
COMMON SEPARATE
J408
START TRIGGER OUTPUT
Z406 AC-4A
Z405 AC-4A
Z404 AC-4A
Z403 AC-4A
Z402 AC-4A
Z401 AC40-95
J409*
K401* ENERGIZED WHEN PRINTER IS CONNECTED
TO 1/2 PHANTASTRON IN TIME BASE SECTION
NEG. PRINT COMMAND
COUNTER DISABLE
RESET
DISPLAY TIME CIRCUIT
RESET CIRCUIT
V411
2D21
DISPLAY THYRATRON
V412
5963
SCHMITT TRIGGER
650 BOARD
S408
DISPLAY TIME
S409
RESET
ETCHED WIRING BOARD BEHIND RESET BUTTON
65F BOARD
FROM S302 (FRONT) IN TIME BASE SECTION
T402
V410B
1/2 6AN8
RESET
BLOCKING OSCILLATOR
+200 VDC
-115 VDC (REG)
LAST REF. DESIGNATION
J409, K401, R438, R544, R545, R550, I406, I407, AND C475 PRESENT ONLY IF PRINTER KIT IS INSTALLED.



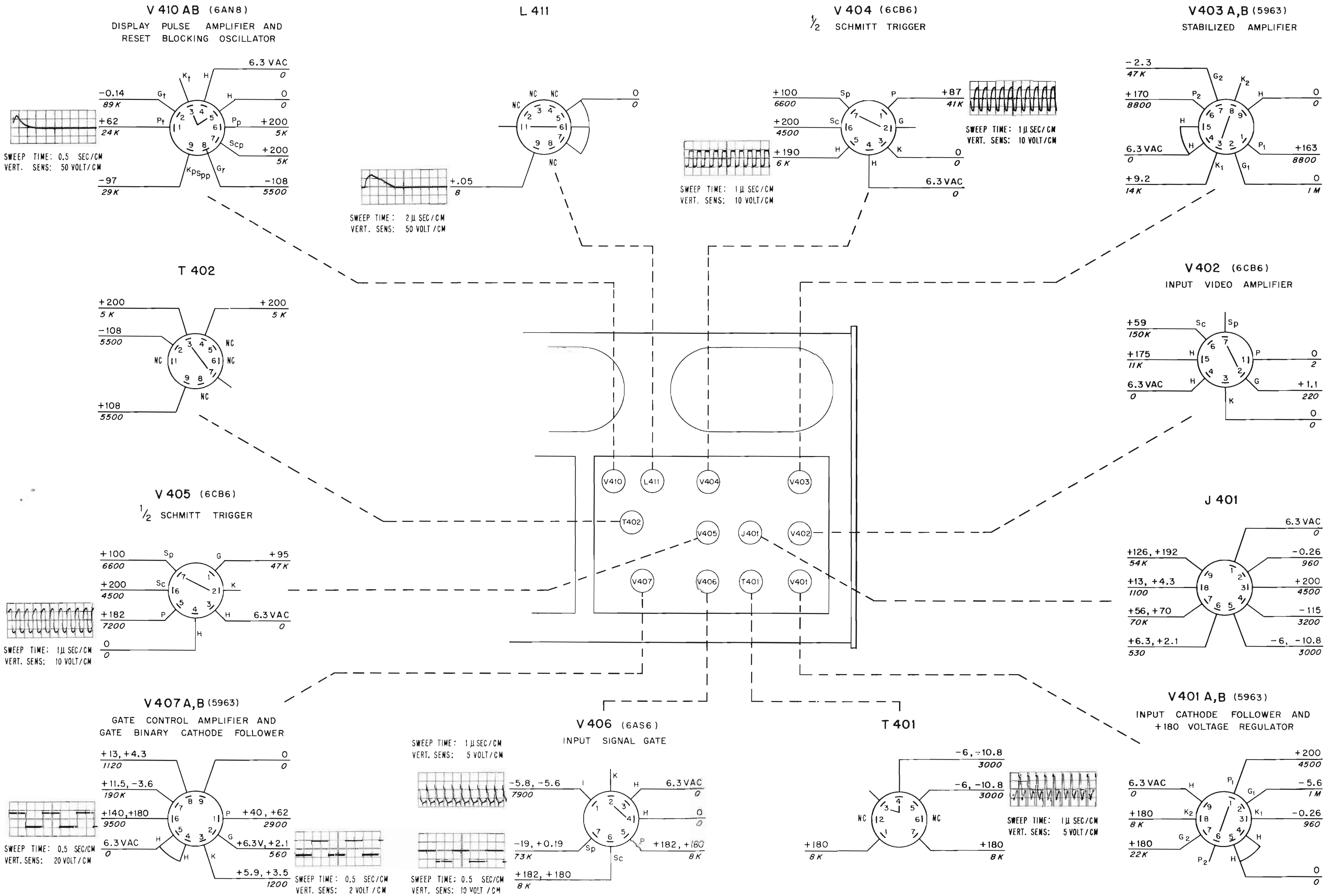
P601
(INTEGRAL PART OF ETCHED CIRCUIT BOARD.
VIEWED FROM ETCHED SIDE.)

FIGURE 4-14

INPUT AMPLIFIER AND INPUT SIGNAL GATE CIRCUITS

VOLTAGE AND RESISTANCE DIAGRAM (VIEWED FROM OUTSIDE)

NOTE: WHEN TWO VOLTAGES ARE SHOWN THE FIRST IS FOR GATE CLOSED, THE SECOND IS FOR GATE OPEN.



SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Readily available standard-components have been used in this instrument, whenever possible. However, special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. ⓗⓟ Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed give complete description, function, and location of part.

If there are any corrections for the Table of Replaceable Parts they will be listed on an Instruction Manual Change sheet at the front of this manual.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		hp STOCK NO.	#			
Z409	DECADE DIVIDER UNIT ASSEMBLY	HP*	524B-4A	1			
C1, 2	Capacitor: fixed, mica, 47 $\mu\mu$f ±5%, 300 vdcw	V*	14-74	13			
C3	Capacitor: fixed, mica, 100 $\mu\mu$f ±5%, 300 vdcw	V*	14-76	2			
C4 thru C12	Same as C1						
C13	Capacitor: fixed, ceramic, .01 μf, tol. -0% +100%, 1000 vdcw	CC*	15-43	13			
C14	Same as C3						
C15	Capacitor: fixed, mica, 75 $\mu\mu$f ±5%, 300 vdcw	V*	14-75	1			
P1	Connector, male: octal	HH*	125-31	1			
R1	Resistor: fixed, composition, 47,000 ohms ±5%, 1/2 W	B*	23-47K-5	9			
R2	Resistor: fixed, composition, 270,000 ohms ±5%, 1/2 W	B*	23-270K-5	8			
R3	Resistor: fixed, composition, 100,000 ohms ±5%, 1/2 W	B*	23-100K-5	8			
R4	Resistor: fixed, composition, 47,000 ohms ±10%, 1 W	B*	24-47K(C)	4			
R5	Same as R1						
R6	Same as R2						
R7	Same as R3						
R8	Same as R1						
R9	Same as R2						
R10	Same as R3						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	#			
	DECADE DIVIDER UNIT ASSEMBLY (Cont'd)					
R11	Same as R4					
R12	Same as R1					
R13	Same as R2					
R14, 15	Same as R3					
R16	Same as R2					
R17	Same as R1					
R18	Same as R4					
R19	Same as R1					
R20	Same as R2					
R21	Same as R3					
R22	Same as R1					
R23	Same as R2					
R24	Same as R3					
R25	Same as R4					
R26	Same as R1					
R27	Same as R2					
R28	Same as R3					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
	DECADE DIVIDER UNIT ASSEMBLY (Cont'd)					
R29	Resistor: fixed, composition, 3300 ohms ±10%, 1 W B*	24-3300(C)	1			
R30	Resistor: fixed, composition, 270,000 ohms ±10%, 1/2 W B*	23-270K	3			
R31	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W B*	23-220K	8			
V1, 2, 3, 4	Tube, electron: 5963 ZZ*	212-5963	10			
	POWER SUPPLY					
B201	Motor, fan L. Scruggs Co.	314-29	1			
C201 ABCD	Capacitor: fixed, electrolytic, 4 sections, 20 μf/sect., 450 vdcw CC*	18-42HP	2			
C202	Capacitor: fixed, paper, 0.1 μf ±10%, 400 vdcw A*	16-98	4			
C203	Capacitor: fixed, paper, 0.47 μf ±10%, 400 vdcw A*	16-99	2			
C204	Capacitor: fixed, electrolytic, 2 sections, 20 μf/sect., 450 vdcw A*	18-22	1			
C205, 206	These circuit references not assigned					
C207	Same as C201					
F201	Fuse, cartridge: 5 amp, slo-blo (115 V operation) E*	211-75	1			
	Fuse, cartridge: 2.5 amp, slo-blo (230 V operation) E*	211-48	1			
I201	Lamp, incandescent: 6-8V, .15 amp, #47 N*	211-47	6			
J201	Connector, female HP*	G-76D	6			
P201	Plug, 9 pin miniature, male, short HP*	150A-95F	4			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	(hp) STOCK NO.	#			
	POWER SUPPLY (Cont'd)					
R201	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W B*	23-220K	7			
R202	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W B*	23-47K	9			
R203, 204	Same as R201					
R205, 206	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W B*	23-1000	8			
R207, 208	Resistor: fixed, composition, 100 ohms ±10%, 1 W B*	24-100	2			
R209	Resistor: fixed, deposited carbon, 330,000 ohms ±1%, 1 W NN*	31-330K	1			
R210	Resistor: variable, composition, linear taper, 20,000 ohms ±20% BO*	210-141	1			
R211	Resistor: fixed, deposited carbon, 181,000 ohms ±1%, 1 W NN*	31-181K	1			
R212	Resistor: fixed, wirewound, 2000 ohms ±5%, 30 W AS*	27-26	1			
R213	Resistor: fixed, composition, 68,000 ohms ±5%, 1/2 W B*	23-68K-5	1			
R214	Resistor: fixed, composition, 180,000 ohms ±10%, 1/2 W B*	23-180K	2			
R215	Resistor: fixed, composition, 15,000 ohms ±10%, 1 W B*	24-15K	1			
R216	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W B*	24-22K	1			
R217	Resistor: variable, composition, 5000 ohms ±20%, 1/2 W BO*	210-122	1			
R218	Resistor: fixed, composition, 5600 ohms ±10%, 1 W B*	24-5600	1			
R219	Resistor: fixed, composition, 270,000 ohms ±10%, 1/2 W B*	23-270K	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	POWER SUPPLY (Cont'd)						
R220, 221	Same as R202						
R222	Resistor: fixed, composition, 18,000 ohms ±10%, 1/2 W	B*	23-18K	3			
R223	Resistor: fixed, composition, 33 ohms ±10%, 1 W	B*	24-33	1			
R224	Resistor: fixed, deposited carbon, 56,000 ohms ±1%, 1 W (present only if Printer Modification Kit is used)	NN*	31-56K	1			
R225	Resistor: fixed, deposited carbon, 132,000 ohms ±1%, 1 W (present only if Printer Modification Kit is used)	NN*	31-132K	1			
R226	Resistor: fixed, wirewound, 2500 ohms ±10%, 20 W	S*	27-2	1			
S201	Switch, toggle: SPST	D*	310-11	3			
S202	Switch, push: SPST	D*	310-75	1			
SR201	Rectifier, selenium: metallic	N*	211-15	1			
T201	Transformer, power	HP*	910-151	1			
T202	Transformer, power	HP*	910-159	1			
V201	Tube, electron: 6AS7GA	ZZ*	212-6AS7 GA	1			
V202	Tube, electron: 6AU6	ZZ*	212-6AU6	2			
V203	Tube, electron: 5Y3GT	ZZ*	212-5Y3GT	1			
V204	Tube, electron: 6216 or 6761	HP*	212-6216	1			
V205	Same as V202						
V206	Tube, electron: 5651	ZZ*	212-5651	1			
V401B	Tube, electron: 5963	ZZ*	212-5963	5			
	Thermistor: #D-754, for 230 volt operation only	Carboloy	211-73	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
	TIME BASE					
C301	Capacitor: fixed, mica, 470 $\mu\mu f$ ±10%, 500 vdcw V*	14-62	3			
C302	Capacitor: fixed, silver mica, 430 $\mu\mu f$ ±5%, 500 vdcw Electrical value adjusted at factory (part may be omitted) A*	15-28	1			
C303	Capacitor: variable, air, 7.5 $\mu\mu f$ to 102.7 $\mu\mu f$ All Star	12-11	1			
C304	Capacitor: fixed, mylar, .01 μf ±5%, 400 vdcw CW*	16-101	5			
C305	Capacitor: fixed, silver mica, 240 $\mu\mu f$ ±5%, 500 vdcw Electrical value adjusted at factory Z*	15-105	1			
C306	Capacitor: variable, ceramic, trimmer, 9-50 $\mu\mu f$, N750 temp. coeff. L*	13-36	1			
C307	Capacitor: fixed, mica, 47 $\mu\mu f$ ±10%, 500 vdcw V*	14-67	1			
C308	Capacitor: fixed, ceramic, .01 μf, tol. -0%, +100%, 1000 vdcw CC*	15-43	11			
C309, 310	These circuit references not assigned					
C311	Capacitor: fixed, silver mica, 1325 $\mu\mu f$ ±1% J*	15-120	1			
C312	Same as C304					
C313	Capacitor: fixed, mica, 100 $\mu\mu f$ ±10%, 500 vdcw V*	14-100	2			
C314	Same as C304					
C315, 316	Capacitor: fixed, mica, 39 $\mu\mu f$ ±5%, 300 vdcw V*	14-70	2			
C317	This circuit reference not assigned					
C318	Capacitor: fixed, paper, .0015 μf ±10%, 600 vdcw CC*	16-32	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	(hp) STOCK NO.	#			
	TIME BASE (Cont'd)					
C319	Capacitor: fixed, mica, 27 $\mu\mu$f ±10%, 500 vdcw V*	14-17	1			
C320	Capacitor: fixed, silver mica, 39 $\mu\mu$f ±2%, 500 vdcw V*	15-164	1			
C321	Capacitor: fixed, mica, 270 $\mu\mu$f ±10%, 500 vdcw V*	14-42	4			
C322	Capacitor: fixed, silver mica, 390 $\mu\mu$f ±2%, 500 vdcw V*	15-162	1			
C323	Same as C321					
C324	Capacitor: fixed, silver mica, 3900 $\mu\mu$f ±2%, 500 vdcw V*	15-163	1			
C325	Same as C321					
C326	Capacitor: fixed, polystyrene, .039 μf ±2%, 400 vdcw P*	16-128	1			
C327	Same as C321					
C328	Capacitor: fixed, polystyrene, .39 μf ±2%, 400 vdcw P*	16-127	1			
C329	Same as C308					
C330	Capacitor: fixed, ceramic disc, .02 μf, tol. -0% +100%, 600 vdcw Radio Materials Corp.	15-85	8			
C331	Capacitor: fixed, mica, 27 $\mu\mu$f ±5%, 300 vdcw Z*	14-78	1			
C332	Capacitor: fixed, electrolytic, 4 μf , 19 vdcw CC*	18-37	1			
I301	Lamp, miniature telephone type N*	211-71	1			
I302, 303	Lamp, neon: aged, NE2 HP*	AC-4A-9	4			
I304 thru I308	Same as I201					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	TIME BASE (Cont'd)						
J301, 302	Same as J201						
J303, 304	Connector, BNC	LL*	125-9	5			
L302	Coil, R. F., 2 mh	HP*	523B-60A	1			
L303	Coil, R. F., 650 μh	HP*	523B-60E	1			
L304	Coil, R. F., 5. 5 mh	CG*	48-3	1			
P301	Same as P201						
R302	Resistor: fixed, wirewound, 10,000 ohms ±1%, 5 W	AC*	26-46	1			
R303	Resistor: variable, composition, 100 ohms ±30%, 1/3 W	BO*	210-154	1			
R304	Resistor: fixed, composition, 82,000 ohms ±10%, 1 W	B*	24-82K	1			
R305	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W	B*	23-100K	10			
R306	This circuit reference not assigned						
R307	Same as R201						
R308	Resistor: fixed, composition, 2. 2 megohms ±10%, 1/2 W	B*	23-2. 2M	1			
R309	Resistor: fixed, composition, 680,000 ohms ±10%, 1/2 W	B*	23-680K	3			
R310	Same as R305						
R311	Resistor: fixed, composition, 1. 8 megohms ±10%, 1/2 W	B*	23-1. 8M	6			
R312	Resistor: fixed, composition, 1000 ohms ±5%, 1/2 W	B*	23-1000-5	5			
R313	Resistor: fixed, composition, 2200 ohms ±5%, 1/2 W	B*	23-2200-5	5			
R314	Resistor: fixed, composition, 22,000 ohms ±10%, 2 W	B*	25-22K	5			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	TIME BASE (Cont'd)						
R315	Resistor: fixed, composition, 110,000 ohms ±5%, 1 W	B*	24-110K-5	5			
R316	Resistor: fixed, deposited carbon, 2.4 megohms ±1%, 1 W Electrical value adjusted at factory	NN*	31-2.4M	5			
R317	Resistor: variable, composition, 50,000 ohms ±20%, 1/2 W	BO*	210-124	6			
R318	Resistor: fixed, composition, 120,000 ohms ±10%, 1/2 W	B*	23-120K	8			
R319	Resistor: fixed, composition, 12,000 ohms ±5%, 1/2 W	B*	23-12K-5	8			
R320	Same as R311						
R321	Same as R305						
R322	Same as R312						
R323	Same as R313						
R324	Same as R314						
R325	Same as R315						
R326	Same as R316						
R327	Same as R317						
R328	Same as R318						
R329	Same as R319						
R330	Same as R311						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
	TIME BASE (Cont'd)					
R331	Same as R305					
R332	Same as R312					
R333	Same as R313					
R334	Same as R314					
R335	Same as R315					
R336	Same as R316					
R337	Same as R317					
R338	Same as R318					
R339	Same as R319					
R340	Same as R311					
R341	Same as R305					
R342	Same as R312					
R343	Same as R313					
R344	Same as R314					
R345	Resistor: fixed, composition, 560, 000 ohms ±10%, 1/2 W B*	23-560K	4			
R346	Same as R315					
R347	Same as R316					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
	TIME BASE (Cont'd)					
R348	Same as R317					
R349	Same as R318					
R350	Same as R319					
R351	Same as R311					
R352	Same as R305					
R353	Same as R312					
R354	Same as R313					
R355	Same as R314					
R356	Same as R345					
R357	Same as R315					
R358	Same as R316					
R359	Same as R317					
R360	Same as R318					
R361	Same as R319					
R362	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W B*	23-1M	10			
R363	Same as R205					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	(hp) STOCK NO.	#			
	TIME BASE (Cont'd)					
R364, 365	Resistor: fixed, composition, 2200 ohms ±10%, 1 W B*	24-2200	3			
R366	Resistor: fixed, composition, 150,000 ohms ±10%, 1/2 W B*	23-150K	1			
R367	Same as R311					
R368	Resistor: fixed, composition, 10 ohms ±10%, 1/2 W B*	23-10	1			
R369	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W B*	23-100	2			
R370 thru R374	These circuit references not assigned					
R375	Resistor: fixed, composition, 82,000 ohms ±5%, 1/2 W B*	23-82K-5	5			
R376	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W B*	23-1000	5			
R377	Same as R375					
R378	Same as R376					
R379	Same as R375					
R380	Same as R376					
R381	Same as R375					
R382	Same as R376					
R383	Same as R375					
R384	Same as R376					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
	TIME BASE (Cont'd)						
S301	Switch, toggle: DPDT	D*	310-54	1			
S302	Switch, assembly: selector	HP*	523B-19C	1			
	Switch, rotary: frequency unit (less components)	W*	310-126				
S303	Switch, rotary: time unit	W*	310-39	1			
S304	Switch, thermostatic	AC*	310-129	1			
T301	Transformer, oscillator	HP*	523B-60C	1			
T302	Transformer, pulse	HP*	523B-60B	1			
V301	Tube, electron: 6AW8	ZZ*	212-6AW8	1			
V302	Tube, electron: 12AT7	ZZ*	212-12AT7	2			
V303	Tube, electron: 6AL5	ZZ*	212-6AL5	1			
V304 thru V308	Tube, electron: 5725	ZZ*	212-5725	5			
V309	Tube, electron: 6BC7	ZZ*	212-6BC7	1			
V310	Same as V302						
Y301	Crystal: frequency determining, 100 kc	HP*	G-69B-2B	1			

	GATE SECTION						
C401	Same as C202						
C402	Same as C308						
C403	Capacitor: fixed, ceramic, 2000 $\mu\mu$f $\pm$20%, 1000 vdcw	Radio Materials Corp.	15-80	2			
C404	Same as C203						
C405	Same as C202						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	(hp) STOCK NO.	#			
	GATE SECTION (Cont'd)					
C406	Capacitor: fixed, electrolytic, 8 μf, 350 vdcw CC*	18-56	1			
C407	Capacitor: fixed, mica, 820 $\mu\mu$f ±10%, 500 vdcw V*	14-28	2			
C408	Capacitor: fixed, electrolytic, 8 μf, tol. -15%, +20%, 30 vdcw AH*	18-17	1			
C409	Capacitor: fixed, mica, 150 $\mu\mu$f ±10%, 500 vdcw V*	14-150	1			
C410	Capacitor: fixed, mica, 82 $\mu\mu$f ±10%, 500 vdcw V*	14-19	2			
C411	Capacitor: fixed, mica, 330 $\mu\mu$f ±10%, 500 vdcw Z*	14-79	2			
C412	Capacitor: fixed, mica, 27 $\mu\mu$f ±10%, 500 vdcw V*	14-17	3			
C413	Capacitor: fixed, mica, 10 $\mu\mu$f ±10%, 500 vdcw V*	14-10	2			
C414	Capacitor: fixed, mica, 22 $\mu\mu$f ±10%, 500 vdcw Z*	14-61	3			
C415	Same as C308					
C416	Same as C330					
C417, 418, 419	These circuit references not assigned					
C420	Same as C308					
C421	Capacitor: fixed, mica, 180 $\mu\mu$f ±10%, 500 vdcw Z*	14-51	2			
C422	Capacitor: fixed, mica, 47 $\mu\mu$f ±5%, 300 vdcw V*	14-74	2			
C423	Capacitor: fixed, mica, 15 $\mu\mu$f ±10%, 500 vdcw V*	14-15	5			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		(hp) STOCK NO.	#			
	GATE SECTION (Cont'd)						
C424	Capacitor: fixed, mica, 22 $\mu\mu$f $\pm$5%, 300 vdcw	V*	14-69	2			
C425	Same as C421						
C426	Same as C422						
C427	Same as C423						
C428	Same as C424						
C429	Same as C313						
C430	Capacitor: fixed, mica, 68 $\mu\mu$f $\pm$10%, 500 vdcw	Z*	14-60	3			
C431	Capacitor: fixed, mica, 1000 $\mu\mu$f $\pm$5%, 500 vdcw	J*	15-114	4			
C432	Same as C304						
C433, 434	Same as C431						
C435	Same as C304						
C436	Same as C431						
C437	Same as C412						
C438	Same as C301						
C439	Same as C330						
C440	This circuit reference not assigned						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	GATE SECTION (Cont'd)						
C441	Same as C308						
C442	Same as C301						
C443	Same as C423						
C444	Same as C430						
C445	Same as C414						
C446	Same as C407						
C447	Same as C308						
C448	Same as C414						
C449	Capacitor: fixed, mica, 270 $\mu\mu$f ±10%, 500 vdcw	Z*	14-42	1			
C450	Same as C308						
C451, 452	Same as C423						
C453	Capacitor: fixed, mica, 5 $\mu\mu$f ±20%, 500 vdcw	Z*	14-5	1			
C454	Capacitor: fixed, paper, 1 μf ±10%, 600 vdcw	Z*	17-12	2			
C455, 456	Same as C308						
C457	Same as C330						
C458	Capacitor: fixed, paper, 0.1 μf ±20%, 400 vdcw	CC*	16-96	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	GATE SECTION (Cont'd)						
C459	Capacitor: fixed, paper, 0.1 μf ±10%, 400 vdcw	CC*	16-35	1			
C460	Same as C308						
C461	Same as C410						
C462	Same as C202						
C463, 464, 465	Same as C330						
C466	Same as C403						
C467	Same as C308						
C468	Same as C330						
C469	Capacitor: fixed, mica, 390 μμf ±5%, 300 vdcw	V*	14-72	1			
C470	Same as C454						
C471	Same as C430						
C472	Capacitor: fixed, electrolytic, 10 μf ±50%, 450 vdcw	X*	18-10	1			
C473	Capacitor: fixed, paper, .047 μf ±10%, 600 vdcw	CC*	16-15	1			
C474	Capacitor: fixed, paper, .22 μf ±10%, 400 vdcw	CC*	16-48	1			
C475	Capacitor: fixed, tubular, .0047 μf ±10%, 600 vdcw	CC*	16-25	1			
CR401, 402, 403	Rectifier, crystal diode, G11A	BU*	212-G11A	16			
CR404	This circuit reference not assigned						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		STOCK NO.	#			
	GATE SECTION (Cont'd)						
CR405 thru CR415	Same as CR401						
CR416	Rectifier, crystal diode, 1N55	BN*	212-1N55	1			
CR417, CR418	Same as CR401						
DL201	Delay line: 5 microseconds	HP*	524B-60C	1			
I401	Lamp, neon: 1/25 W, NE2	N*	211-43	3			
I402	Same as I302						
I403	Lamp, neon: NE51	N*	211-27	1			
I404	Tube, electron: 6332	Landsdale Tube Co.	212-6332	1			
I405	Same as I302						
I406, 407	Same as I401 (used only if Printer Modification Kit is installed)						
J401, 402, 403	Same as J201						
J404, 405, 406	Same as J303						
J407, 408	Connector, receptacle: UG-1094/U	LL*	125-UG-1094/U	2			
J409	Socket, female: 19 contact (used only if Printer Modification Kit is installed)	HH*	125-93	1			
K401	Relay, armature: 110 V dc, DPDT (used only if Printer Modification Kit is installed)	CT*	49-32	1			
L401	Coil, choke: 10.5 μh	CG*	48-54	2			
L402	Coil, R. F., 35 μh	CG*	48-42	1			
L403	Coil, R. F., 200 μh	CG*	48-34	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		STOCK NO.	#			
	GATE SECTION (Cont'd)						
L404, 405	Transformer, pulse	HP*	524B-60H	1			
L406	Coil, R. F., 320 μh	HP*	524B-60H	1			
L407, 408	Coil, R. F., 200 μh	CG*	48-34	2			
L409	Coil, R. F., 55 μh	CG*	48-38	1			
L410	Coil, R. F., 400 μh	CG*	48-35	1			
L411	Coil, choke: 30 mh	HP*	913-8	1			
P401, 402, 403	Same as P201						
R401	Resistor: fixed, composition, 22 megohms ±10%, 1/2 W	B*	23-22M	3			
R402	Same as R362						
R403	Resistor: fixed, composition, 560 ohms ±10%, 1/2 W	B*	23-560	1			
R404	Resistor: fixed, composition, 8200 ohms ±10%, 2 W	B*	25-8200	1			
R405	Resistor: variable, composition, linear taper, 1000 ohms ±10%	B*	210-32	1			
R406	Resistor: fixed, composition, 8200 ohms ±10%, 1/2 W	B*	23-8200	1			
R407	Same as R222						
R408	Same as R362						
R409	Same as R401						
R410	Resistor: fixed, composition, 220 ohms ±10%, 1/2 W	B*	23-220	1			
R411	Same as R319						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
	GATE SECTION (Cont'd)					
R412	Resistor: fixed, composition, 150,000 ohms ±10%, 1/2 W B*	23-150K	1			
R413, 414	Same as R362					
R415	Same as R202					
R416	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W B*	23-22K	2			
R417	Resistor: fixed, metal film, 10,000 ohms ±5%, 4 W AB*	334-10K	2			
R418	Same as R317					
R419	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W B*	23-82K	4			
R420	Same as R416 Electrical value adjusted at factory					
R421	Same as R318					
R422	Same as R205					
R423	Resistor: fixed, composition, 180,000 ohms ±10%, 1 W B*	24-180K	1			
R424, 425	Resistor: fixed, composition, 4700 ohms ±10%, 2 W B*	25-4700	4			
R426	Resistor: fixed, composition, 47,000 ohms ±5%, 1/2 W B*	23-47K-5	1			
R427	Resistor: fixed, composition, 330,000 ohms ±10%, 1/2 W B*	23-330K	2			
R428	Resistor: fixed, deposited carbon, 200,000 ohms ±1%, 1/2 W NN*	33-200K	1			
R429, 430	Resistor: fixed, composition, 3300 ohms ±10%, 2 W B*	25-3300	3			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	GATE SECTION (Cont'd)						
R431	Resistor: fixed, composition, 1500 ohms ±10%, 1 W	B*	24-1500	1			
R432, 433	Resistor: fixed, deposited carbon, 90,000 ohms ±1%, 1/2 W	NN*	33-90K	2			
R434	Resistor: fixed, deposited carbon, 71,560 ohms ± 1%, 1/2 W	NN*	33-71.56K	1			
R435	Resistor: fixed, composition, 3900 ohms ±10%, 1/2 W	B*	23-3900	1			
R436	Resistor: fixed, deposited carbon, 6.49K ohms ±1%, 1/2 W	NN*	33-6.49K	1			
R437	This circuit reference not assigned						
R438	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W (used only when Printer Modification Kit is installed)	B*	25-10K	1			
R439	This circuit reference not assigned						
R440, 441	Same as R305						
R442	Resistor: fixed, composition, 27,000 ohms ±10%, 1/2 W	B*	23-27K	1			
R443	Same as R362						
R444	Same as R201						
R445	Resistor: fixed, composition, 3900 ohms ±10%, 1 W	B*	24-3900	1			
R446	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	B*	23-470	2			
R447	Resistor: fixed, composition, 33,000 ohms ±10%, 1/2 W	B*	23-33K	6			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗ STOCK NO.	#			
	GATE SECTION (Cont'd)					
R448	Resistor: fixed, composition, 56,000 ohms ±10%, 1/2 W B*	23-56K	4			
R449	Same as R201					
R450	Same as R309					
R451	Same as R447					
R452	Same as R448					
R453	Same as R201					
R454	Same as R309					
R455	See S404					
R456	Same as R305					
R457	Resistor: fixed, composition, 68,000 ohms ±10%, 1/2 W B*	23-68K	3			
R458	Resistor: variable, composition, linear taper, 50,000 ohms ±20% I*	210-18	3			
R459	Same as R419					
R460	Same as R458					
R461	See S405					
R462	Same as R305					
R463	Same as R457					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
\# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
	GATE SECTION (Cont'd)						
R464	Same as R458						
R465, 466	Resistor: fixed, composition, 1500 ohms ±10%, 1/2 W	B*	23-1500	2			
R467	Resistor: fixed, composition, 2700 ohms ±10%, 1/2 W	B*	23-2700	1			
R468	Same as R362						
R469	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W	B*	23-10K	4			
R470	Resistor: fixed, composition, 470,000 ohms ±10%, 1 W	B*	24-470K	2			
R471, 472	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W	B*	23-470K	4			
R473	Same as R469						
R474	Same as R362						
R475	Same as R470						
R476	Same as R319						
R477	Resistor: fixed, composition, 390,000 ohms 10%, 1/2 W	B*	23-390K	1			
R478	Same as R202						
R479	Resistor: fixed, deposited carbon, 62,000 ohms ±1%, 1 W	NN*	31-62K	2			
R480	Resistor: fixed, deposited carbon, 75,000 ohms ±1%, 1 W	NN*	31-75K	2			
R481	Resistor: fixed, composition, 180 ohms ±10%, 1/2 W	B*	23-180	2			
R482	Resistor: fixed, composition, 5600 ohms ±10%, 2 W	B*	25-5600	2			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		STOCK NO.	#			
	GATE SECTION (Cont'd)						
R483	Resistor: fixed, composition, 3300 ohms ±10%, 1 W	B*	24-3300	1			
R484	Same as R448						
R485	Same as R482						
R486	Resistor: fixed, composition, 390 ohms ±10%, 1/2 W	B*	23-390	1			
R487	Same as R481						
R488	Same as R479						
R489	Same as R480						
R490	Same as R202						
R491	Same as R345						
R492	Resistor: fixed, composition, 22,000 ohms ±10%, 1 W	B*	24-22K	2			
R493	Same as R205						
R494	Resistor: fixed, deposited carbon, 800,000 ohms ±1%, 1 W	NN*	31-800K	1			
R495	Resistor: fixed, deposited carbon, 683,700 ohms ±1%, 1 W	NN*	31-683.7K	1			
R496	Resistor: fixed, composition, 360,000 ohms ±5%, 1/2 W	B*	23-360K-5	1			
R497	Resistor: fixed, composition, 560 ohms ±10%, 1 W	B*	24-560	1			
R498	Resistor: fixed, composition, 4700 ohms ±10%, 1 W	B*	24-4700	1			
R499	Resistor: fixed, composition, 1200 ohms ±10%, 1/2 W	B*	23-1200	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
	GATE SECTION (Cont'd)					
R500	This circuit reference not assigned					
R501	Resistor: fixed, composition, 33,000 ohms ±5%, 1 W B*	24-33K -5(C)	1			
R502	Same as R469					
R503	Same as R202					
R504	Resistor: variable, composition, linear taper, 500,000 ohms ±30%, 1/4 W BO*	210-146	1			
R505	Same as R205 Electrical value adjusted at factory					
R506	Same as R419					
R507	Resistor: fixed, composition, 18,000 ohms ±10%, 1 W B*	24-18K	1			
R508	Resistor: fixed, composition, 150,000 ohms ±10%, 1/2 W B*	23-150K	1			
R509	Same as R447					
R510	This circuit reference not assigned					
R511	Same as R401					
R512	Resistor: fixed, composition, 820,000 ohms ±10%, 1/2 W B*	23-820K	1			
R513	Same as R214					
R514	Resistor: fixed, composition, 240,000 ohms ±5%, 1/2 W B*	23-240K-5	1			
R515	Resistor: fixed, composition, 130,000 ohms ±5%, 1/2 W B*	23-130K-5	1			
R516	Same as R318					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗⓟ STOCK NO.	#			
	GATE SECTION (Cont'd)					
R517	Same as R492					
R518	Same as R222					
R519	Same as R447					
R520	Resistor: fixed, composition, 910,000 ohms ±5%, 1/2 W B*	23-910K-5	1			
R521	Resistor: fixed, composition, 160,000 ohms ±5%, 1/2 W B*	23-160K-5	1			
R522	Resistor: variable, composition, 10 megohms (part of S408) BO*	210-204	1			
R523	Same as R369					
R524	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W B*	23-39K	2			
R525	Same as R362					
R526	Resistor: fixed, composition, 1.5 megohms ±10%, 1/2 W B*	23-1.5M	1			
R527	Resistor: fixed, composition, 4700 ohms ±10%, 1/2 W B*	23-4700	1			
R528	Same as R319					
R529	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W B*	23-15K	3			
R530	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W B*	23-680	1			
R531	Same as R457					
R532	Same as R447					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗ STOCK NO.	#			
	GATE SECTION (Cont'd)					
R533	Same as R529					
R534	Same as R469					
R535	Same as R529					
R536	Same as R446					
R537	Same as R448					
R538	Resistor: fixed, composition, 150 ohms ±10%, 1/2 W B*	23-150	1			
R539	Same as R345					
R540	Resistor: fixed, composition, 22 ohms ±10%, 1/2 W B*	23-22	1			
R541	This circuit reference not assigned					
R542	Resistor: fixed, composition, 2700 ohms ±10%, 1 W B*	24-2700	1			
R543	Same as R471					
R544, 545	Resistor: fixed, deposited carbon, 1. 23 megohms ±1%, 1 W (presented only when the Printer Modification Kit is installed) NN*	31-1. 23M	2			
R546	Resistor: fixed, wirewound, 540 ohms ±1%, 5 W AC*	26-42	1			
R547	Same as R205					
R548	Same as R419					
R549	Same as R524					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		hp STOCK NO.	#			
	GATE SECTION (Cont'd)						
R550	Resistor: fixed, composition, 330,000 ohms ±10%, 1/2 W	B*	23-330K	1			
R551	Same as R362						
S401	Switch, rotary: function selector	W*	310-176	1			
S402	Switch, toggle: SPST	D*	310-12	3			
S403	Same as S201						
S404, 405	Switch, attenuator: (less components)	W*	310-177				
	Switch, attenuator: (includes R455, R461)	HP*	523B-19A	2			
S406, 407	Same as S402						
S408	Part of R522						
S409	Switch, push: SPDT	KK*	310-53	1			
S410	Same as S201						
T402	Transformer, pulse	HP*	913-9	1			
V401	Same as V401B						
V402	Tube, electron: 6CB6	ZZ*	212-6CB6	5			
V403	Same as V401B						
V404, 405	Same as V402						
V406	Tube, electron: 6AS6/5725	ZZ*	212-6AS6/5725	1			
V407	Same as V401B						
V408, 409	Tube, electron: 6485	ZZ*	212-6485	2			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗ STOCK NO.	#			
	GATE SECTION (Cont'd)						
V410	Tube, electron: 6AN8	ZZ*	212-6AN8	1			
V411	Tube, electron: 2D21	ZZ*	212-2D21	1			
V412	Same as V401B						
XZ401	Socket, tube: 11 pin	HH*	120-55	1			
XZ402 thru XZ406	These circuit references not assigned						
XZ407, 408	Connector, female: 20 contact (printed circuit)	H*	125-75	1			
Z401	AC-4D-95 Decade Counter (complete)	HP*	AC-4D-95	1			
Z402	This circuit reference not assigned						
Z403 thru Z406	AC-4A Decade Counter (complete)	HP*	AC-4A	4			
Z407, 408	Trigger Plug-In Unit (complete)	HP*	523B-58A	2			
Z409	Decade Divider Unit (complete)	HP*	524B-4A	1			

Z407, 408	TRIGGER PLUG-IN UNIT ASSEMBLY	HP*	523B-58A	2			
C601	Capacitor: fixed, mica, 110 $\mu\mu f \pm 5\%$, 300 vdcw	V*	14-71	1			
C602	Same as C411						
C603	Same as C412						
C604	Same as C413						
L601	Same as L401						
R601, 602	Same as R424						

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	#			
	TRIGGER PLUG-IN UNIT ASSEMBLY (Cont'd)					
R603	Same as R417					
R604	Same as R205					
R605	Same as R318					
R606	Same as R427					
R607	Same as R447					
R608	Same as R202					
R609	Same as R201					
R610	Resistor: fixed, deposited carbon, 252,000 ohms ±1%, 1/2 W NN*	33-252K	1			
R611	Same as R364					
R612	Same as R429					
R613	Resistor: fixed, composition, 2700 ohms ±10%, 2 W B*	25-2700	1			
R614, 615	Resistor: fixed, deposited carbon, 90,000 ohms ±1%, 1/2 W NN*	33-90K	2			
R616	Resistor: fixed, composition, 415,000 ohms ±1%, 1 W NN*	31-415K	1			
V601	Same as V401B					
V602, 603	Same as V402					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
	MISCELLANEOUS						
	Crystal Oven Top Assembly	HP*	G-69B-2A	1			
	Crystal Oven base	HP*	G-69C-1	1			
	Fan blade	BD*	314-30	1			
	Filter, air	Research Prod.	314-40	1			
	Holder, fuse	T*	140-16	1			
	Holder, lamp, decimal point indicator	AD*	145-10	5			
	Jewel, red, for POWER pilot lamp	II*	145-22	1			
	Knob: SENSITIVITY, DISPLAY TIME	HP*	G-74D	2			
	Knob: TIME INTERVAL	HP*	G-74L	2			
	Knob: FUNCTION SELECTOR	HP*	G-74N	1			
	Knob: TIME UNIT, FREQUENCY UNIT	HP*	G-74P	2			
	Knob: TIME INTERVAL (red)	HP*	G-74AT	2			
	Power Cord	Elec. Cords	812-56	1			
	Pilot Light Assembly, red jewel	II*	145-2	1			
	Pilot Light Assembly, clear jewel	II*	145-6	1			
	Printer Modification Kit modified 523B for use with ⓗⓟ Model 560A Digital Recorder	HP*	523B-95A	1			
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* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

OPERATING NOTES

HEWLETT-PACKARD COMPANY • 275 PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U. S. A.
CABLE "HEWPACK" TELEPHONE DAVENPORT 5-4451

MODEL AC-4D-95

DECADE COUNTER

For use in MODEL 523B

HEWLETT-PACKARD COMPANY
275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U. S. A.

SPECIFICATIONS

COUNTING RATE:	1.1 mc.
DOUBLE-PULSE RESOLUTION:	0.7 usec.
INPUT VOLTAGE:	20 volt negative pulse 0.2µsec rise time.
OUTPUT VOLTAGE:	80 volts peak, at low frequencies.
RESET:	To Zero, apply positive 40v pulse 5 to 6µsec wide.
STAIRCASE OUTPUT VOLTAGE:	+135V at count of zero. +55v at count of nine. 10 steps.
POWER SUPPLY:	Power provided by Model 523B Electronic Counter.

SECTION I

GENERAL DESCRIPTION

1-1 GENERAL

The Model AC-4D-95 is a plug-in electronic counter that counts at rates up to 1.1 megacycles per second. The number of the last pulse counted is displayed in a column of numerals from "0" to "9" on the front panel by illuminating the correct numeral in the number column with a neon lamp.

An output pulse is produced each time the registered count steps from "9" to "0"; that is, for every ten input pulses, a single output pulse is produced.

A second output signal, the "Staircase" output, is provided by the AC-4D-95 for external indicating devices. This output signal consists of approximately ten equal steps of voltage, one step for each count indicated in the number column.

The AC-4D-95 uses etched circuits which provide good production uniformity and very low capacity wiring. This results in a very stable fast counting unit. The open-frame construction lowers operating temperatures and simplifies parts' inspection and servicing. The unit plugs into an eleven-pin socket and is secured by a single mounting screw at the top of the number column.

SECTION II

THEORY OF OPERATION

2-1 GENERAL

The AC-4D-95 Decade Counter plug-in unit consists of four bistable multivibrators (binaries) and a bank of 10 neon lighted numerals on the front panel. As the binaries sense the input pulses, certain combinations of voltages are set up between halves of the binaries which light the appropriate neon lamp for each pulse.

The state of the first binary determines whether an odd or even numbered lamp will be lighted by applying one necessary voltage to the even lamps, or to the odd lamps. The other voltage is obtained as the difference-voltage existing across two specific halves of two different binaries. As subsequent input pulses are received the difference- voltage lighting the lamps procedes from one pair of binaries to the next, lighting subsequent lamps.

The four binaries are connected in cascade so the output from the first is fed to the input of the second, and so on Each binary is designed to respond only to negative-going input pulses. Each binary produces alternately positive and negative output pulses for a series of negative input pulses. Since the next binary senses only the negative pulses, the effect is to divide by two.

With four such binaries, 16 input pulses would be required to obtain one negative output pulse (overall division would be 16). However, by the use of two feedback loops 6 extra "counts" are added within the unit so that only 10 input pulses are required to obtain one negative output pulse to make the total division 10. The feedback circuits used in counters are not to be confused with feedback circuits used in amplifier design. Counter feedback circuits are used only to apply a pulse from one of the binaries in a chain to another in the same chain. If the feedback pulse is of the correct polarity, it will trigger the binary, producing the same result as additional pulses at the input.

SECTION III

MAINTENANCE

3-1 GENERAL

The majority of failures in counter units can be remedied by tube replacement. Replace tubes one at a time, and if there is no improvement in the operation of the circuit, return the original tube to its socket.

If the faulty component is not a tube, its location can usually be narrowed down to a single stage by observing the operation of the unit with a known input. The reset action, final indicated count, staircase output, and signal output can be individually checked.

NOTE

It is important that the replacement parts be made by the manufacturer indicated in the Table of Replaceable Parts because parts made by other manufacturers will behave differently with changing temperature and may result in unstable operation.

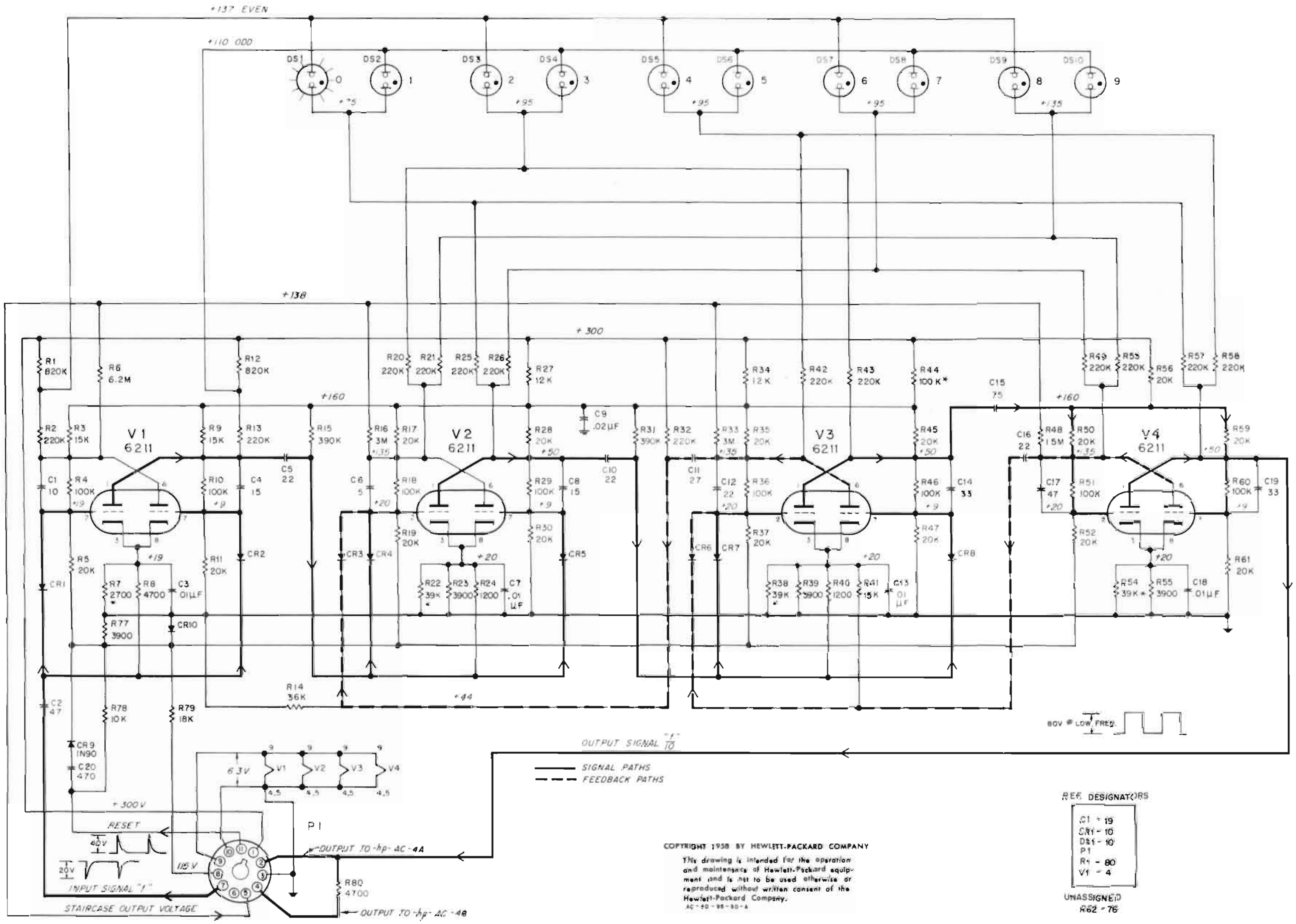

Figure 4-1. Model AC-4D-95 Decade Counter Schematic Diagram

SECTION V

TABLE OF REPLACEABLE PARTS

NOTE

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual.

When ordering parts from the factory always include the following information:

Instrument model number
Serial number
-hp- stock number of part
Description of part

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ⓗ STOCK NO.	#			
C1	Capacitor: fixed, ceramic, 10 $\mu\mu$f $\pm$0. 5 $\mu\mu$f, 500 vdcw K*	15-30	1			
C2	Capacitor: fixed, mica, 47 $\mu\mu$f $\pm$5%, 300 vdcw V*	14-74	2			
C3	Capacitor: fixed, ceramic, .01 μf, tol. -0% +100%, 1000 vdcw CC*	15-43	4			
C4	Capacitor: fixed, mica, 15 $\mu\mu$f $\pm$10%, 500 vdcw V*	14-15	2			
C5	Capacitor: fixed, mica, 22 $\mu\mu$f $\pm$5%, 500 vdcw V*	14-69	4			
C6	Capacitor: fixed, mica, 5 $\mu\mu$f $\pm$20%, 300 vdcw V*	14-68	1			
C7	Same as C3					
C8	Same as C4					
C9	Capacitor: fixed, ceramic disc, .02 μf, tol. -0% +100%, 600 vdcw Radio Materials Corp.	15-85	1			
C10	Same as C5					
C11	Capacitor: fixed, mica, 27 $\mu\mu$f $\pm$5%, 300 vdcw V*	14-78	1			
C12	Same as C5					
C13	Same as C3					
C14	Capacitor: fixed, mica, 33 $\mu\mu$f $\pm$5%, 300 vdcw V*	15-136	2			
C15	Capacitor: fixed, mica, 75 $\mu\mu$f $\pm$5%, 300 vdcw V*	14-75	1			
C16	Same as C5					
C17	Same as C2					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
C18	Same as C3						
C19	Same as C14						
C20	Capacitor: fixed, mica, 470 $\mu\mu f$ ±10%, 500 vdcw	V*	14-62	1			
CR1 thru CR8	Rectifier, crystal	BU*	212-G11A	8			
CR9, 10	Crystal, diode	BU*	212-1N90	2			
DS1 thru DS10	Neons, paired	HP*	AC-4A-8	5			
P1	Connector, male: 11 pin	HH*	125-85	1			
R1	Resistor: fixed, composition, 820,000 ohms ±10%, 1/2 W	B*	23-820K	2			
R2	Resistor: fixed, composition, 220,000 ohms ±5%, 1/2 W	B*	23-220K-5	13			
R3	Resistor: fixed, metal film, 15,000 ohms ±5%, 3 W	AB*	333-15K-5	2			
R4	Resistor: fixed, composition, 100,000 ohms ±5%, 1/2 W	B*	23-100K-5	8			
R5	Resistor: fixed, composition, 20,000 ohms ±5%, 1/2 W	B*	23-20K-5	8			
R6	Resistor: fixed, composition, 6.2 megohms ±5%, 1/2 W	B*	23-6.2M-5	1			
R7	Resistor: fixed, composition, 2700 ohms ±5%, 1/2 W Electrical value adjusted at factory	B*	23-2700-5	1			
R8	Resistor: fixed, composition, 4700 ohms ±10%, 1/2 W	B*	23-4700	2			
R9	Same as R3						
R10	Same as R4						

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R11	Same as R5						
R12	Same as R1						
R13	Same as R2						
R14	Resistor: fixed, composition, 36,000 ohms ±5%, 1/2 W	B*	23-36K-5	1			
R15	Resistor: fixed, composition, 390,000 ohms ±10%, 1/2 W	B*	23-390K	2			
R16	Resistor: fixed, deposited carbon, 3 megohms ±1%, 1/2 W	NN*	33-3M	2			
R17	Resistor: fixed, metal film, 20,000 ohms ±5%, 3 W	AB*	333-20K-5	7			
R18	Same as R4						
R19	Same as R5						
R20, 21	Same as R2						
R22	Resistor: fixed, composition, 39,000 ohms ±10%, 1/2 W	B*	23-39K	3			
R23	Resistor: fixed, composition, 3900 ohms ±5%, 1/2 W	B*	23-3900-5	4			
R24	Resistor: fixed, composition, 1200 ohms ±10%, 1/2 W	B*	23-1200	2			
R25, 26	Same as R2						
R27	Resistor: fixed, metal film, 12,000 ohms ±5%, 3 W	AB*	333-12K-5	2			
R28	Same as R17						
R29	Same as R4						

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	#			
R30	Same as R5					
R31	Same as R15					
R32	Same as R2					
R33	Same as R16					
R34	Same as R27					
R35	Same as R17					
R36	Same as R4					
R37	Same as R5					
R38	Same as R22					
R39	Same as R23					
R40	Same as R24					
R41	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W B*	23-15K	1			
R42, 43	Same as R2					
R44	Resistor: fixed, composition, 100,000 ohms ±10%, 1 W B*	24-100K	1			
R45	Same as R17					
R46	Same as R4					
R47	Same as R5					

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	hp STOCK NO.	#			
R48	Resistor: fixed, deposited carbon, 1.5 megohms ±1%, 1/2 W NN*	33-1.5M	1			
R49	Same as R2					
R50	Same as R17					
R51	Same as R4					
R52	Same as R5					
R53	Same as R2					
R54	Same as R22					
R55	Same as R23					
R56	Same as R17					
R57, 58	Same as R2					
R59	Same as R17					
R60	Same as R4					
R61	Same as R5					
R62 thru R76	These circuit references not assigned					
R77	Same as R23					
R78	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W B*	23-10K	1			
R79	Resistor: fixed, composition, 18,000 ohms ±10%, 2 W B*	25-18K	1			

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
 # Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		ⓗⓟ STOCK NO.	#			
R80	Same as R8						
V1 thru V4	Tube, electron: 6211	ZZ*	212-6211	4			
	<u>MISCELLANEOUS</u>						
	Clamp, tube	Univ. Metal Prod.	140-12	4			
	Plate, numeral	HP*	AC-4A-6	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
# Total quantity used in the instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

275 PAGE MILL ROAD PALO ALTO. CALIF. U.S.A.

CABLE "HEWPACK"