HEWLETT-PACKARD

521A/C/D/E/G

ELECTRONIC COUNTER

SERIALS PREFIXED: 032-

OPERATING AND SERVICING MANUAL

PRINTED 4/61
00150-2

MANUAL CHANGES

MODEL 521A/C/D/E/G

ELECTRONIC COUNTER

Manual printed: 4-61
For Serials Prefixed: 032-

CHANGES INSTRUCTIONS:

Place the following list of addenda, errata, and production changes in front of the title page of the above instruction manual. Incorporate all errata into the manual. To adapt the manual to a specific instrument having one of the serial number prefixes listed below, apply all addendum and/or production changes listed under the appropriate serial prefix.

ADDENDUM:

For instruments equipped with 521D-95B Digital Recorder Kit, include the following changes in the manual. New schematics are included for your convenience and should be used in place of those in the manual.

A transistorized monostable multivibrator is included as a part of the kit. The multivibrator delays (approximately 50 milliseconds) the negative print command pulse from the Electronic Counter to insure positive data entry on the 561B Digital Recorder. Schematic diagram of the transistorized multivibrator is shown on page 4. Note: The multivibrator circuit receives power from the Digital Recorder (pin 44 of J402A).

Circuit operation of the transistorized monostable multivibrator is as follows: In the steady-state condition Q1420 is cut off and Q1421 is conducting. A negative triggering pulse (negative print command signal from the counter which appears at pin 1 of V605) is applied to the base of Q1420 and Q1420 begins to conduct. A positive-going voltage is produced at the collector of Q1420 and is coupled to the base of Q1421. The base current and the collector current begin to decrease. A negative-going voltage is produced at the collector of Q1421 and is coupled through R1427 to the base of Q1420, thus increasing the conduction of Q1420. This regenerative action continues until Q1420 is driven into saturation and Q1421 is cut off. C1420 starts to discharge through R1422 and R1423 and changes the reverse bias on the base of Q1421. When the voltage at the base of Q1421 becomes slightly negative with respect to the emitter, Q1421 begins to conduct. When Q1421 conducts, Q1420 cuts off and returns to its initial steady-state condition until the next negative print command

signal occurs. The multivibrator circuit receives power (-43 volts unregulated) from the Digital Recorder via pin 44 of J402A and the return is to the common bus via pins 12, 13, and 14 of J402B.

The multivibrator provides an output pulse with an amplitude of approximately a 10-volt peak at the collector of each transistor. The two outputs in push-pull, one from Q1420 and the other from Q1421 which is 180° out-of-phase with the signal at the collector of Q1420, drive the print command circuit in the Digital Recorder via pins 48 and 49 of J402A.

When a negative print command signal from the counter is applied to the base of Q1420, producing a positive-going step at the collector of Q1420 and a negative-going step at the collector of Q1421, no print command results at this time. Approximately 50 milliseconds later, the multivibrator returns to its original state and triggers the print command circuit. Both the negative-going pulse at the collector of Q1420 and the positive-going pulse at the collector of Q1421 provide reliable triggering of the print command circuit.

TABLE OF REPLACEABLE PARTS for TRANSISTORIZED MULTIVIBRATOR

CIRCUIT REF.	DESCRIPTION	MFR.	-hp- STOCK NO.
C1420	Capacitor, fixed, electrolytic, 4uf -15% +20%, 60 vdcw	TI-TAL	0180-0008
C1421	Capacitor, fixed, electrolytic, 10uf -10% +100%, 25 vdcw	56289	0180-0059
C1422, 1423	Capacitor, fixed, ceramic, 0.01uf ±20%, 1000 vdcw	56289	0150-0012
Q1420, 1421	Transistor: 2N404	94145	1850-0062
R1420	Resistor, fixed, composition, 5,600 ohms ±5%, ¼ W	01121	0683-5625
R1421	Resistor, fixed, composition, 3,300 ohms ±5%, ¼ W	01121	0683-3325
R1422	Resistor, fixed, composition, 68,000 ohms ±5%, ¼ W. Optimum value selected at factory. Average value shown.		
R1423	Resistor, fixed, composition, 33,000 ohms ±5%, ¼ W	01121	0683-3335
R1424	Resistor, fixed, composition, 8,200 ohms ±5%, ¼ W	01121	0683-8225
R1425	Resistor, fixed, composition, 6,800 ohms ±5%, ¼ W	01121	0683-6825
R1426	Resistor, fixed, composition, 10,000 ohms ±5%, ¼ W	01121	0683-1035
R1427	Same as R1423		
R1428	Same as R1426		
R1429	Resistor, fixed, composition, 18,000 ohms ±5%, ¼ W	01121	0683-1835

CIRCUIT REF.	DESCRIPTION	MFR.	-hp- STOCK NO.
R1430	Resistor, fixed, composition, 2,200 ohms ±5%, ¼W	01121	0683-2225

ERRATA: Table of Replaceable Parts, under MISCELLANEOUS:
Add fuseholder; -hp- Stock No. 1400-0084; Mfr. 75915.

Figure 4-10,
V502: Change pin 3 to 3,4 and pin 4 to 5.

Figure 4-12,
V609: Change pin 4,5 to 4 and pin 9 to 5.

Figure 4-13,
C601: Change value to 0.27 uf.

Figure 4-14,
V502: Change pin 3 to 3,4 and pin 4 to 5.
V609: Change pin 4,5 to 4 and pin 9 to 5.

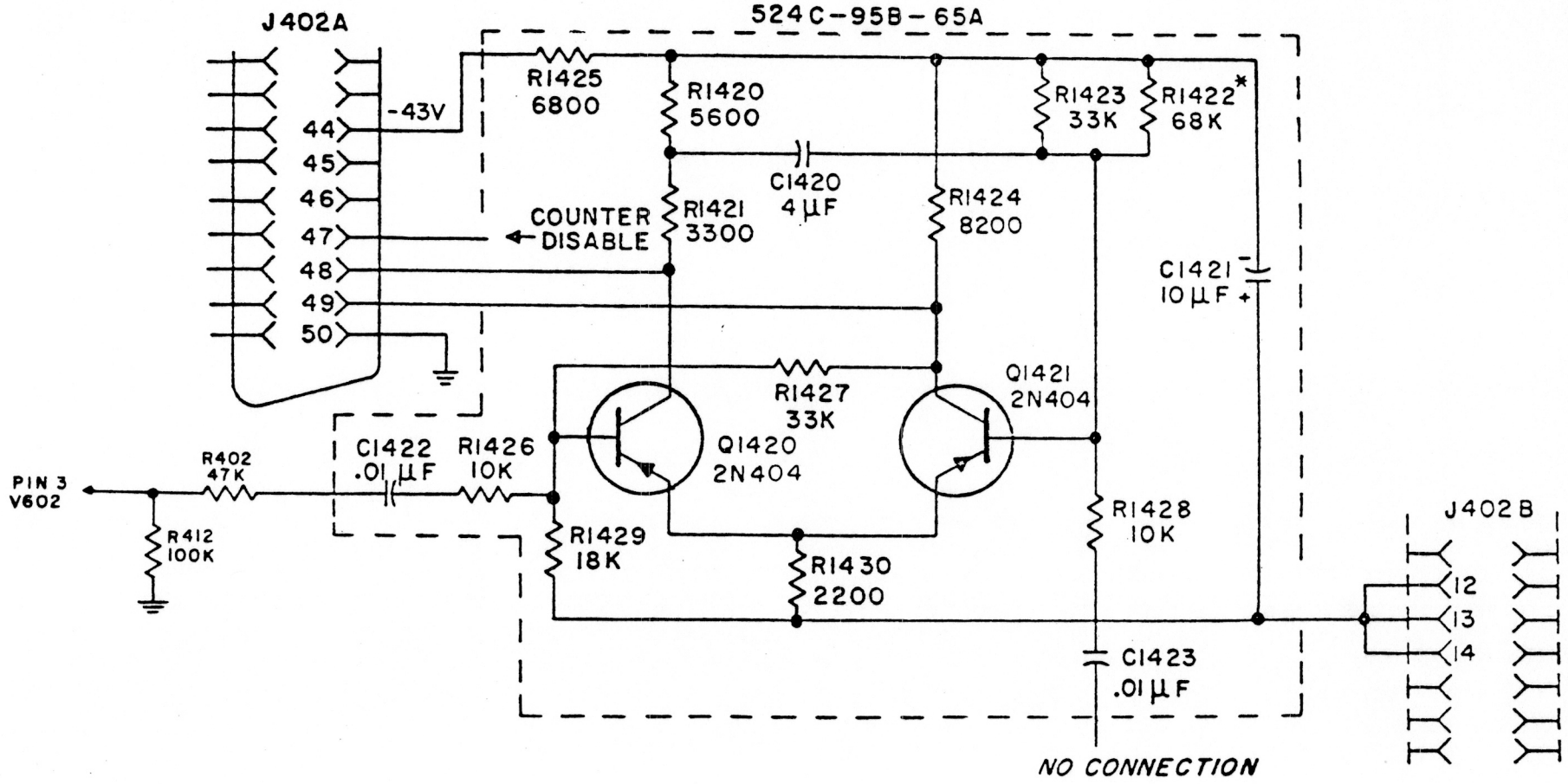
Figure 4-17,
C601: Change value to 0.27 uf.
R611: Change value to 1800 ohms.

For instruments with Serials Prefixed: 120- (Models 521C and 521E only), include the following changes:

R551: Change to resistor, fixed, wirewound, 500 ohms ±10%, 20W; -hp- Stock No. 0819-0005.

For instruments with Serials Prefixed: 217- (Model 521G only), include the following changes:

R687: Change to resistor, fixed, composition, 10M ±10%, ½W; -hp- Stock No. 0687-1061; Mfr. 01121.



PARTIAL SCHEMATIC OF 521D-95B

OPERATING AND SERVICING MANUAL

MODEL 521A/C/D/E/G
ELECTRONIC COUNTER

SERIALS PREFIXED: 032 -

SPECIFICATIONS

RANGE:	521A/C - 1 cps to 120 kc (may be increased to 220 kc by replacing the UNITS decade counter with Model AC-4C Decade Counter).
	521D/E - 1 cps to 120 kc (may be increased to 220 kc by replacing the UNITS decade counter with Model AC-4L Decade Counter).
	521G - 1 cps to 1.2 mc.
ACCURACY:	521A/D/G - ± 1 count ± accuracy of timing frequency (approximately ± 0.1% when power line used, ± 0.01% with crystal time base installed).
	521C/E - ±1 count ± 0.01%.
REGISTRATION:	521A - 4 place columnar display.
	521D - 4 place in-line digital display.
	521C/G - 5 place columnar display.
	521E - 5 place in-line digital display.
INPUT REQUIREMENTS:	0.2 volt rms minimum or output from 1P41 Phototube (or equal).
SENSITIVITY CONTROL:	Continuously adjustable sensitivity from 0.2 volt rms to 100 volts rms. 521A/C and 521D/E - 0.5 volt rms required at frequencies above 120 kc with 220 kc option. Attenuator can be used to reduce sensitivity to 100 volts rms to overcome noise.
INPUT IMPEDANCE:	Approximately 1 megohm shunted by 50 pf (.5 megohm on PHOTO connector).
GATE TIME:	521A/D/G - 1/10 and 1 second. Panel lamp indicates open gate.
	521C/E - 1/10, 1, and 10 seconds. Panel lamp indicates open gate.
MANUAL GATE:	Controlled by MANUAL GATE switch or by contact closure to EXT jack on front panel.
DISPLAY TIME:	Variable from a minimum of 1/10 second to approximately 15 seconds or may be held until manually reset.
RESET TO ZERO:	Automatic or manual.
SELF CHECK:	521A/D/G - Counts line frequency (10 kc with crystal time base installed) for selected gate time.
	521C/E - Counts 10 kc time base frequency for selected gate time.

SPECIFICATIONS (CONT'D.)

EXTERNAL STANDARD:	Can be operated from any multiple of 10 cps, 10 cps to 100 cps. 521A/D/G may be operated from time base in 521C/E.
PHOTOTUBE INPUT:	Phone jack on rear provides voltage for and receives signal from 1P41 (or equal) phototube.
ACCESSORY POWER OUTPUT:	521A/C/D/E only - 6.3 vac at 0.6 amp, + 300 vdc at 10 ma, and -150 vdc at 5 ma from AN3102-A-16S-1S receptacle (AN 3106-A-16S-1P mating plug not supplied).
POWER SUPPLY:	521A - 115/230 volts ± 10%, 50 to 60 cps, approximately 150 watts at 115-volt line. Approximately 200 watts with crystal time base installed.
	521C - 115/230 volts ± 10%, 50 to 60 cps, approximately 210 watts at 115-volt line.
	521D - 115/230 volts ± 10%, 50 to 60 cps, approximately 155 watts at 115-volt line. Approximately 205 watts with crystal time base installed.
	521E - 115/230 volts ± 10%, 50 to 60 cps, approximately 215 watts at 115-volt line.
	521G - 115/230 volts ± 10%, 50 to 60 cps, approximately 160 watts at 115-volt line. Approximately 210 watts with crystal time base installed.
SIZE:	Cabinet Mount: 9-3/4 in. wide, 15-1/4 in. high, 14-1/2 in. deep. Rack Mount: 19 in. wide, 8-3/4 in. high, 14-1/2 in. deep. (13-1/2 in. deep behind panel).
WEIGHT:	521A/D - Cabinet Mount: Net 27 lbs., shipping 39 lbs. Rack Mount: Net 25 lbs., shipping 37 lbs.
	521C/E/G - Cabinet Mount: Net 28 lbs., shipping 41 lbs. Rack Mount: Net 26 lbs., shipping 39 lbs.
ACCESSORIES PROVIDED:	hp AC-16D Cable Assembly, 44 in. RG-58/U cable terminated one end with UG - 88/U type BNC connector.
ACCESSORIES AVAILABLE:	hp Model 506A Optical Tachometer Pickup. hp Model 508A, B, C, D Tachometer Generator. hp Model AC-4C Decade Counter for 220-kc operation (521A/C). hp Model AC-4L Decade Counter for 220-kc operation (521D/E). hp 521D-95A, hp 560A Digital Recorder Adapter Kit (for all models). hp 521D-95B, hp 561B Digital Recorder Adapter Kit (521D/E only). hp 521C-59B Crystal Time Base Plug-in Unit

CONTENTS

SECTION I
GENERAL DESCRIPTION

1-1 INTRODUCTION

The 521 Series Industrial Electronic Counters count periodic and random events and display the total in a digital readout. When coupled to proper transducers, these counters can also measure speed, rpm, weight, pressure, temperature, acceleration, or any other quantity converted into appropriate electrical impulses. In addition, the counters can measure the time between the closing and opening of either a front-panel switch or a pair of external contacts.

Basically, the 521 series counters are all similar. The differences are in types of readout, readout capacity, gate times, maximum counting rate, and standard time base reference. These differences are tabulated in Table 1-1.

1-2 COOLING

The 521 series uses a forced air cooling system to maintain tolerable operating temperatures within the cabinet. The air intake and filter are located on the bottom of the instrument. The cabinet feet provide sufficient clearance for adequate ventilation. Inspect the filter regularly and clean it when dirty. See Section IV.

1-3 230 VOLT OPERATION

The 521 series is normally wired for use from a 115-volt power source. To convert it for use from a 230-volt power source, change the dual 115-volt primary windings of the power transformer from a parallel combination to a series combination. See schematic diagram for details. At the time of the change, replace the 2-ampere, slow-blow line fuse with a 1-ampere, slow-blow fuse.

1-4 POWER CABLE

The three-conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin which is added to a standard two-blade connector and grounds the instrument chassis when used with the appropriate receptacle. An adapter should be used to connect

TABLE 1-1. 521 SERIES CHARACTERISTICS

Model	Display	Readout Capacity	Gate Times (sec)	Maximum Counting Rate	Time Base Reference
521A	Number Column	4 Places (9999)	1/10,1	120 kc	Power Line
521C*	Number Column	5 Places (99,999)	1/10, 1, 10	120 kc	Crystal Time Base
521D	Digital Display Tube	4 Places (9999)	1/10, 1	120 kc	Power Line
521E*	Digital Display Tube	5 Places (99,999)	1,10, 1, 10	120 kc	Crystal Time Base
521G	Number Column	5 Places (99,999)	1/10, 1	1.2 mc	Power Line

* The crystal time base plug-in unit is a standard part in the 521C and 521E. For 521A, 521D, or 521G, crystal time base plug-in unit can be added at any time.

the NEMA plug to a standard two contact output. When the adapter is used, the ground connection terminates in a short green lead, which should be connected to a suitable ground for the protection of operating personnel.

1-5 DAMAGE IN SHIPMENT

Inspect and operate your instrument upon receipt. Section IV contains a performance check which is a good test as part of incoming quality control inspection. If there is any damage, see the "Claim for Damage in Shipment" paragraph in this manual.

1-6 DECADE COUNTER UNITS

The AC-4 Decade Counter Manual contains operating and servicing information on the plug-in decade counter units in this instrument. These counter units are common to several hp instruments and are not covered in this manual.

SECTION II
OPERATING INSTRUCTIONS

2-1 INTRODUCTION

Basic operating instructions for the 521 Series Counters are given in Figures 2-1 through 2-4. Although the instructions are for the 521D, they apply equally well to the other counters in the series. The text material in this section supplements the basic operating instructions.

2-2 ACCURACY

The accuracy of the 521 Series Counters is determined by the accuracy of the time base reference signal and the possible error of ±1 count inherent in the gate-and-counter type of instrument. The power line, an external source (any multiple of 10 cps from 10 cps to 100 cps), or the crystal time base plug-in can provide the reference signal.

The standard 521A, 521D, and 521G use the power-line frequency as the time reference. Since large commercial power systems generally hold frequency within 0.1% of 50 or 60 cps, you can assume that the readout error due to the time base reference is no more than ±1 count/kc of the input frequency. Thus, if the measured frequency is 51,200 cps, readout accuracy will be within ±51 cps ±1 count or ± 52 cps. The crystal time base provides a time base reference accurate within 0.01%. Maximum error due to the time base then becomes less than ±1 count/10 kc of the input frequency. If the measured frequency is 51,200 cps, readout accuracy will be within ± 5 cps ±1 count or ± 6 cps.

The crystal time base is a standard part of the 521C and 521E, and it is a plug-in unit which can be added to the other 521's at any time. A single crystal time base can supply a reference signal to as many as ten 521's. When the unit is installed, a 100-cps output is available at the EXT STD jack for application to other instruments.

NOTE

The TIME BASE SELECTOR switch (Figure 4-6) selects the time base reference. Set the switch to CRYSTAL to select the internal crystal time base; set it to LINE/EXT to select the power line or an external source.

2-3 FREQUENCY MEASUREMENT

A. SELECTING GATE TIME

When measuring frequency, you will generally know the approximate frequency beforehand. Table 2-1 shows gate time versus frequency range.

TABLE 2-1. GATE TIME VS FREQUENCY RANGE

Model	Frequency Range	Gate Time
521A/D	10 cps - 10 kc	1 SEC
	10 kc - 120 kc	1/10 SEC
521C/E	10 cps - 10 kc	10 SEC
	10 kc - 100 kc	1 SEC
	100 kc - 120 kc	1/10 SEC
521G	10 cps - 100 kc	1 SEC
	100 kc - 1.2 mc	1/10 SEC

If you don't know the approximate frequency, start with the 1/10-sec gate and switch to a longer gate if the frequency is low enough.

B. INTERPRETING THE READOUT

When noting the readout, be sure to take into account the gate time. On the 1/10-sec gate, the instrument counts for 1/10 sec; so the readout

indicates cycles per 1/10 sec or tens of cycles per second. On the 1-sec gate, the instrument counts for a second; so the readout indicates cycles per second. On the 10-sec gate, the instrument counts for 10 sec; so the readout indicates cycles per 10 sec or tenths of cycles per sec. Table 2-2 shows the readout for various frequencies and various gate times. The table does not take into account the time base accuracy or the inherent ± 1 count.

TABLE 2-2. READOUT EXAMPLES

Model	Input Frequency (cps)	Gate Time	Readout
521A/D	1,084	1/10 SEC	0108
		1 SEC	1084
	10,840	1/10 SEC	1084
		1 SEC	0840
	108,400	1/10 SEC	0840
		1 SEC	8400
521C/E	1,084	1/10 SEC	00108
		1 SEC	01084
		10 SEC	10840
	10,840	1/10 SEC	01084
		1 SEC	10840
		10 SEC	08400
	108,400	1/10 SEC	10840
		1 SEC	08400
		10 SEC	84000
521G	1,084	1/10 SEC	00108
		1 SEC	01084
	10,840	1/10 SEC	01084
		1 SEC	10840
	108,400	1/10 SEC	10840
		1 SEC	08400
	1,084,000	1/10 SEC	08400
		1 SEC	84000

The 521A and 521D count off scale on frequencies above 100 kc, and the 521G counts off scale on frequencies above 1 mc. However, this is no handicap because on the 1/10-sec gate the missing digit can only be 1. To be certain the instrument is counting off scale, watch the left-hand counter unit during the count (disable the readout blanking on the 521D by setting the MANUAL GATE switch to COUNT). If the left-hand unit counts to three or higher during the count and ends the count on a lower number, the instrument has counted off scale, and you must add the humdred-thousands digit (521A/D) or millions digit (521G) to the readout.

The crystal time base increases 521 accuracy to five places. By utilizing the two available gate times on the 521A and 521D, you can obtain a five-place readout from these instruments on frequencies above 10 kc. Refer to Table 2-2. With an input frequency of 10,840, a measurement on the 1/10-sec gate produces a readout of 1084, supplying the first figures of the frequency. A second measurement, on the 1-sec gate, produces a readout of 0840, supply the last figures of the frequency. By combining the two readings, you obtain the five-place reading of 10,840.

2-4 PHOTOTUBE INPUT

The PHOTO input jack on the rear of the instrument parallels the front-panel INPUT connector and has the same input-signal requirements. It simultaneously supplies +70 to +90 volts bias to and receives a signal from a phototube such as a 1P41. With phototube connected to PHOTO jack, and the phototube-counter system in operation, adjust the system for optimum performance by 1) connecting voltmeter ac probe to counter INPUT connector and 2) positioning phototube and light source for highest voltmeter reading.

2-5 OPERATING INSTRUCTIONS

Basic operating instructions are given on the following pages. If the instrument has been out of operation, self check it (Figure 2-1) prior to making a specific measurement. By so doing you check nearly all circuits of the instrument.

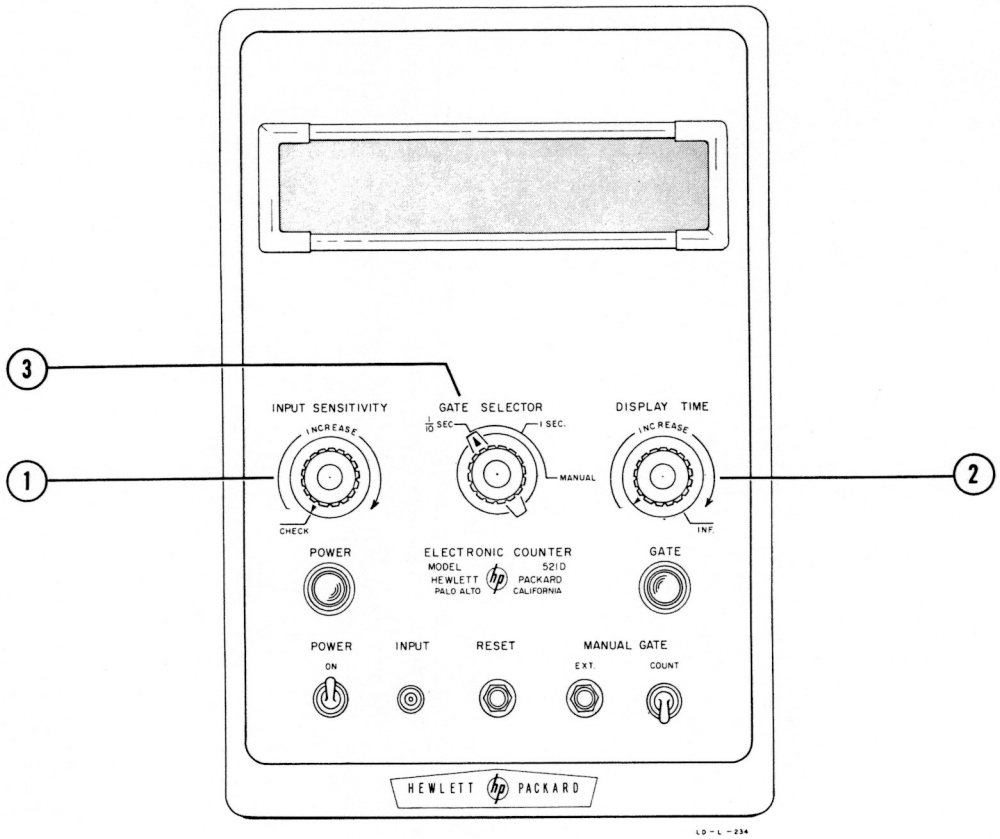
Fig. 2-1 Procedure for Self Check

Fig. 2-2 Procedure for Frequency Measurement

Fig. 2-3 Procedure for Totalizing

Fig. 2-4 Procedure for Time Interval Measurement.

PROCEDURE FOR SELF CHECK



1. Set INPUT SENSITIVITY control to CHECK.

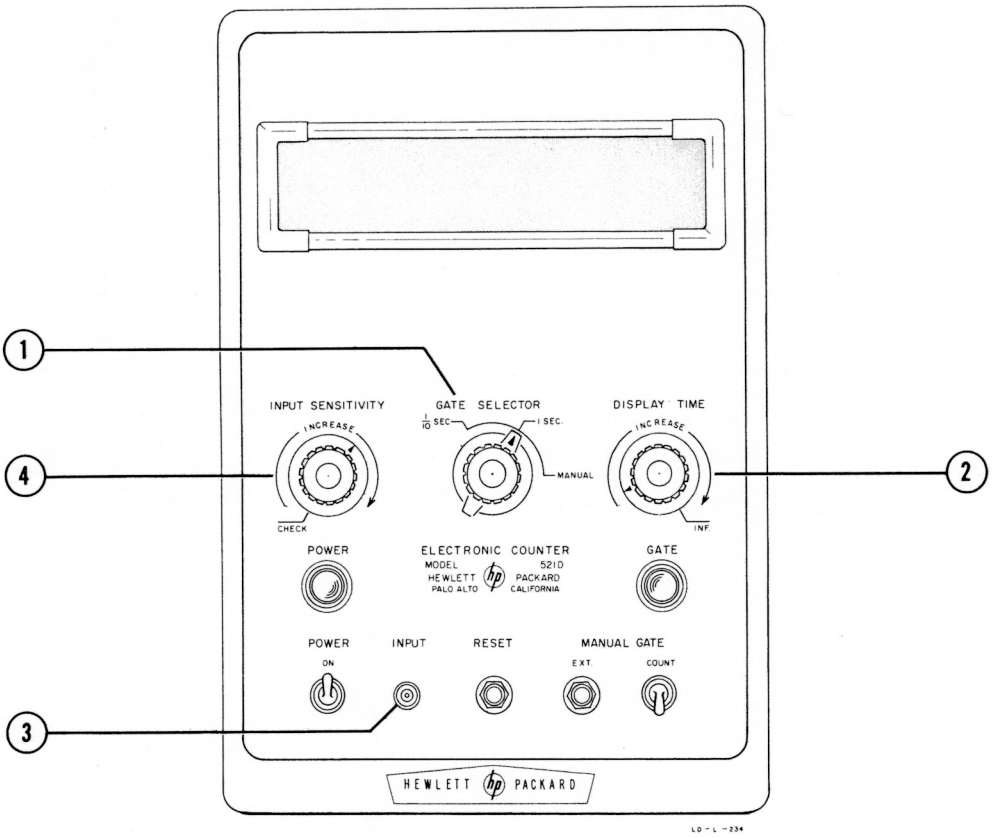
2. Set DISPLAY TIME control for minimum display time.

3. Note reading on display system for each setting of GATE SELECTOR switch listed in table. If readings are as indicated on table, consider instrument to be operating properly. If readings are incorrect, time base may need adjustment (Paragraph 4-7 and/or 4-11).

Figure 2-1

	Gate Time	50 cps line	60 cps line	Crystal Time Base
521 A/D	1/10 SEC	0005	0006	1000 ±1
	1 SEC	0050	0060	0000 ±1
521 C/E	1/10 SEC	00005	00006	01000 ±1
	1 1 SEC	00050	00060	10000 ±1
	10 SEC	00500	00600	00000 ±1
521 G	1/10 SEC	00005	00006	01000±1
	1 SEC	00050	00060	10000±1

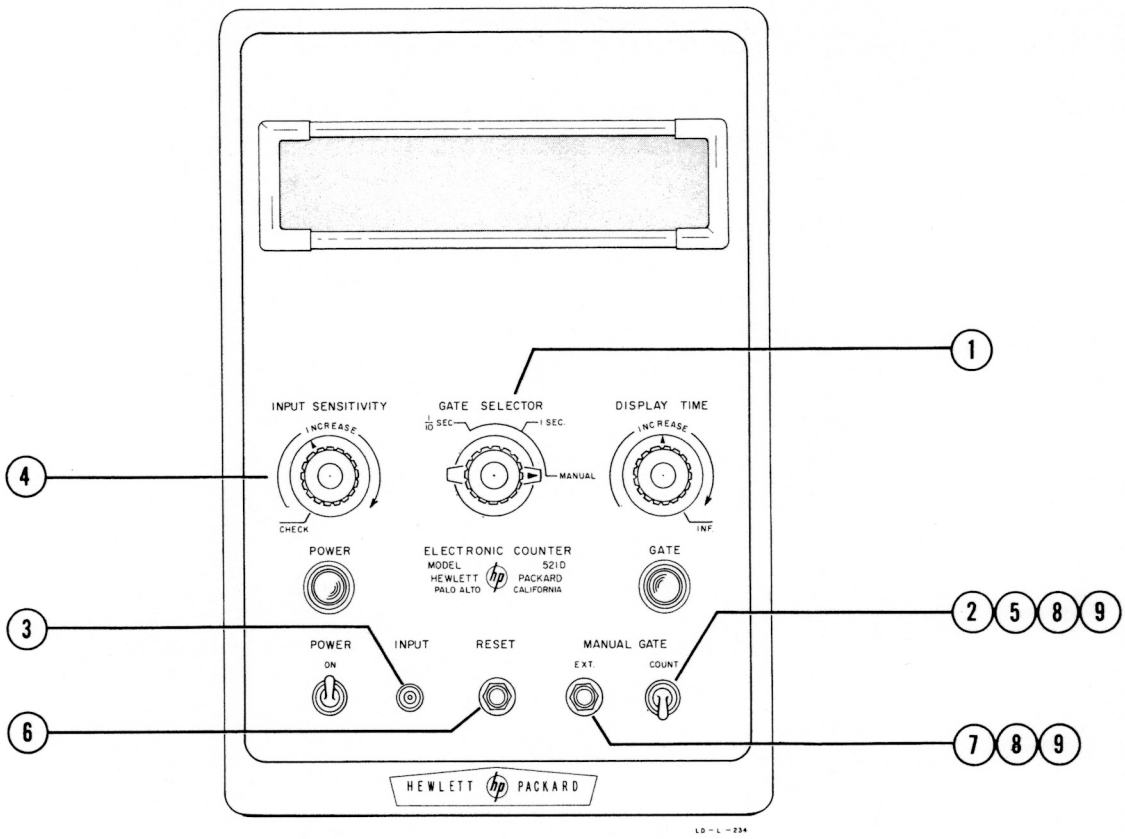
PROCEDURE FOR FREQUENCY MEASUREMENT



1. Set GATE SELECTOR to desired gate time.
2. Set DISPLAY TIME control for desired display time.
3. Connect frequency to be measured to INPUT connector.
4. Adjust INPUT SENSITIVITY control to point slightly above lowest level that gives consistent counting.
5. Read frequency placing decimal point as required by setting of GATE SELECTOR switch.

Figure 2-2

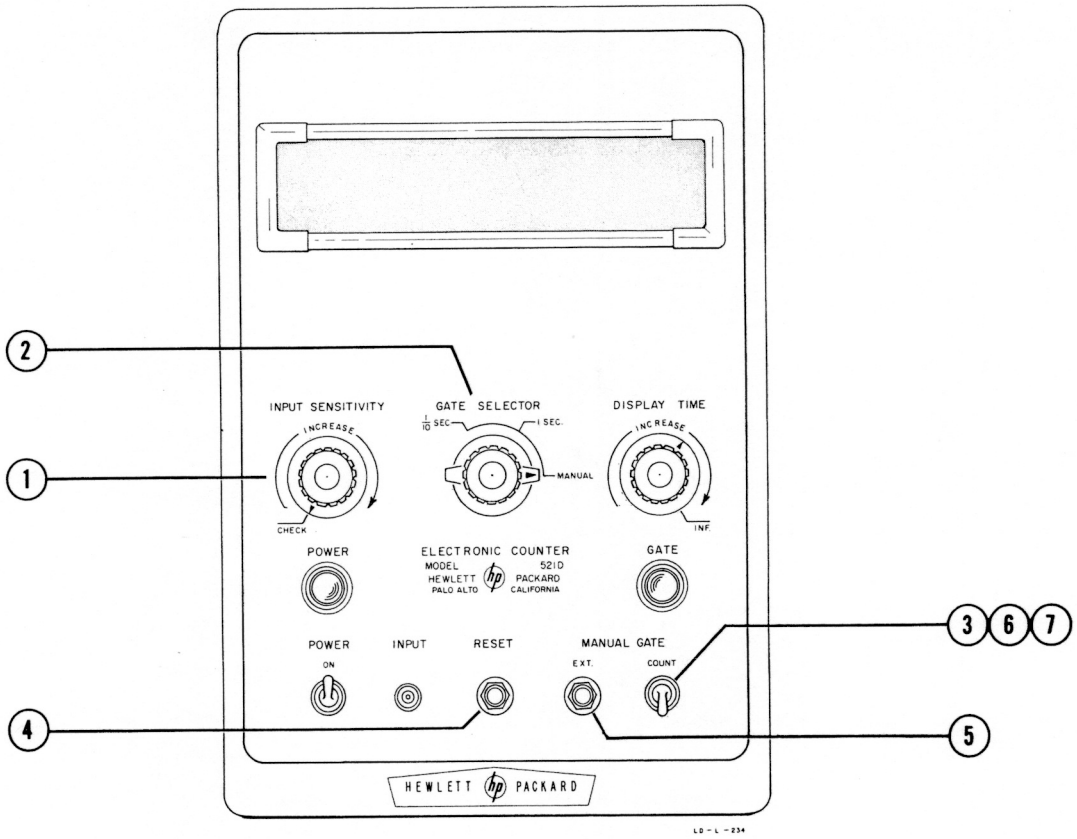
PROCEDURE FOR TOTALIZING



1. Set GATE SELECTOR to MANUAL.
2. Set MANUAL GATE switch to COUNT.
3. Connect signal to be totalized to INPUT connector.
4. Set INPUT SENSITIVITY control to point slightly above lowest level that gives consistent counting.
5. Set MANUAL GATE switch to down position.
6. Press RESET switch to zero counters.
7. If external switching device is to be used, connect it to EXT connector.
8. Start count by setting MANUAL GATE switch to COUNT or by closing external switching device.
9. End count by setting MANUAL GATE switch to down position or opening external switching device.
10. Read displayed total.

Figure 2-3

PROCEDURE FOR TIME INTERVAL MEASUREMENT



1. Set INPUT SENSITIVITY control to CHECK.

   Note - If timing signal is from external source, connect it to INPUT connector, set DISPLAY TIME control for minimum display time, set GATE SELECTOR to 1/10 SEC, and set INPUT SENSITIVITY control to point slightly above lowest level that gives consistent reading.

2. Set GATE SELECTOR to MANUAL.

3. Set MANUAL GATE switch to down position.

4. Press RESET switch to zero counters.

5. If external switching device is used, connect it to EXT. connector.

6. Set MANUAL GATE switch to COUNT or close external switching device to start measurement.

7. Set MANUAL GATE switch to down position or open external switching device to end measurement.

8. To convert displayed reading to seconds, multiply displayed reading by period (1/frequency) of timing signal.

Figure 2-4

SECTION III
CIRCUIT DESCRIPTION

3-1 INTRODUCTION

The 521 counter is basically a totalizing instrument; it counts applied impulses and displays the accumulated total. Cascaded decade counter units do the counting. Other circuits give the displayed totals meaning in terms of frequency (by accurately controlling the counting time) or in terms of time (by applying a known frequency to the counter units). Still other circuits 1) shape the input waveform to allow a variety of waveforms to register on the counter units, 2) return the counter units to zero prior to each new count, 3) control for the time the count is displayed, and 4) (521D and 521E only) blank the readout during count time.

Figure 3-1 is a block diagram of the 521A, 521D, and 521G. The 521C and 521E have two additional circuits, a 0.1 cps phantastron and a reset amplifier, which are discussed below.

3-2 COUNTING CIRCUITS

The INPUT and PHOTO connectors are parallel input connectors; however, the PHOTO connector supplies bias to 1P41 or equivalent phototubes as well as receives input signals. The INPUT SENSITIVITY control connects either the input signal or a check signal to an amplitude discriminator. The check signal is supplied by the power line, a crystal time base plug-in unit, or an external source and can be used to check instrument operation or to measure time.

The amplitude discriminator is a plug-in unit which consists of an amplifier followed by a bistable multivibrator (a Schmitt trigger in the 521G). It generates the fast-rise signal required to drive the counter units through signal gate V601. The signal gate opens and closes the signal path to the counter units. The counter units totalize the output of the signal gate and display the total when the signal gate is closed.

3-3 TIMING CIRCUITS

The crystal time base plug-in unit, the power line, or an external standard can provide the reference signal for the timing circuits. The crystal time base consists of a free-running multivibrator followed by three phantastrons in series. A crystal maintains the output of the multivibrator very close to 100 kc, and this signal triggers the 10 kc phantastron. The 10 kc phantastron, in turn triggers the 1-kc phantastron, which triggers the 100 cps phantastron. The output of the 100-cps phantastron is the reference signal for the timing circuits. (The check signal supplied by the crystal time base to the counting circuits is a 10-kc signal from the 10-kc phantastron.)

Schmitt trigger V501 shapes the reference signal into a form suitable for triggering 10-cps phantastron V502A/V503, which in turn triggers 1-cps phantastron V502B/V504. (The 521C and 521E have an additional phantastron, 0.1-cps phantastron V502C/V509, which is triggered by the 1-cps phantastron.)

The GATE SELECTOR switch determines whether a phantastron or the manual controls actuate the counter control circuits. With the switch set to MANUAL, signal gate V601 is open as long as the MANUAL GATE switch is set to COUNT or an external, low-resistance switching device such as a relay completes the circuit through the EXT jack.

3-4 COUNTER CONTROL CIRCUITS

With the GATE SELECTOR switch set to a specific gate time, the counter units are controlled automatically. The first negative-going signal through time base gate V603A triggers delay multivibrator V604. The delay multivibrator immediately triggers reset thyratron V606, which sets the counter units to zero. After a 45-μsec delay, the delay multivibrator triggers gate control binary V605. The gate control binary: 1) opens the signal gate

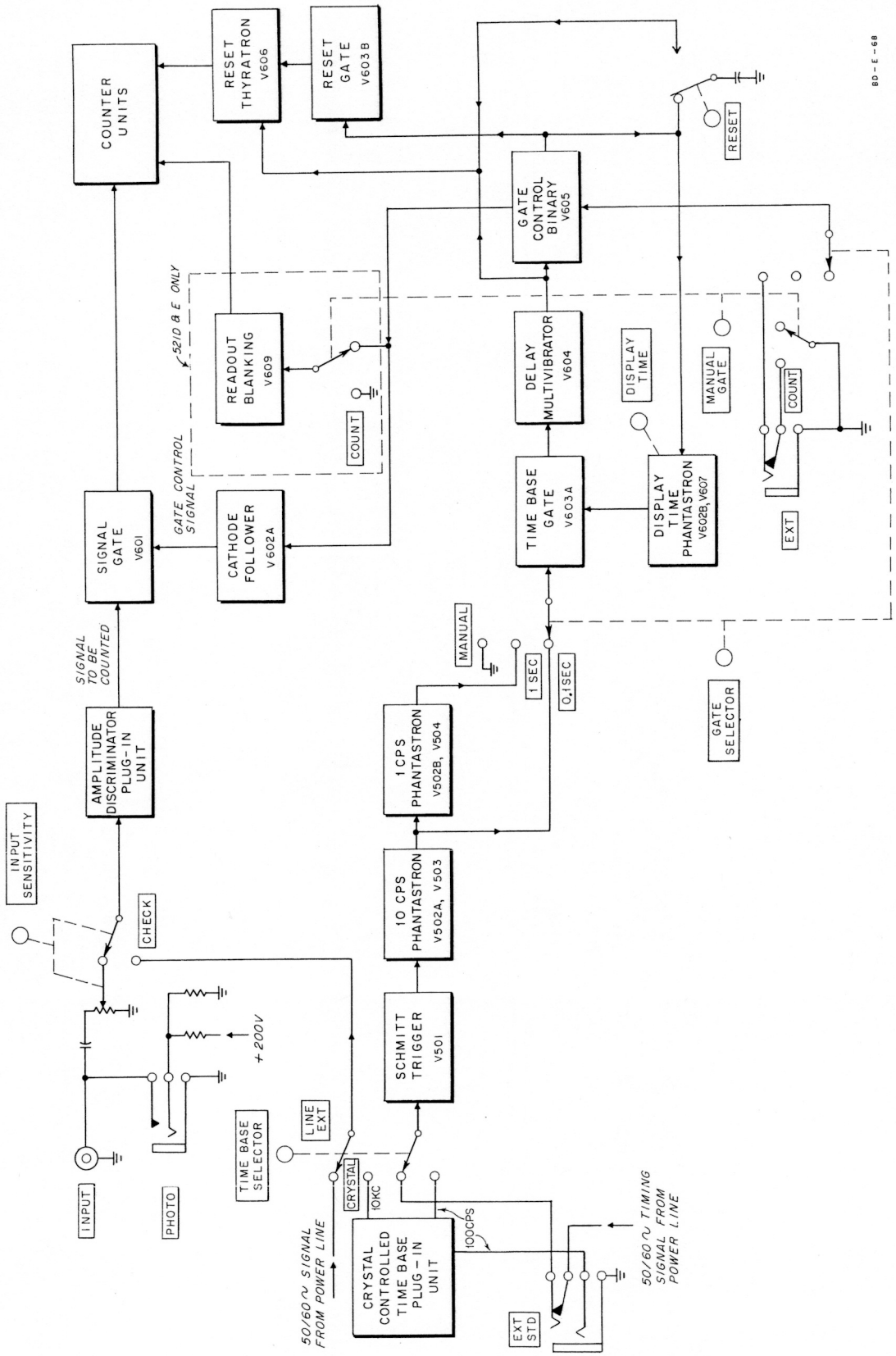


Figure 3 - 1. Block Diagram

through cathode follower V602A, 2) opens reset gate V603B which essentially grounds signals applied to the reset thyratron, and 3) (521D and 521E only) blanks the readout through the readout blanking circuit, V609. (The MANUAL GATE switch prevents readout blanking when set to COUNT.)

The next negative-going signal through the time base gate also triggers the delay multivibrator. Again, a trigger is immediately applied to the reset thyratron, but the reset gate holds the thyratron off. After a 45-μsec delay, the delay multivibrator triggers the gate control multivibrator, which now closes the signal gate to end the totalizing process, closes the reset gate, and (521D and 521E only) lights the readout through the readout blanking circuit. In addition, the gate control binary triggers display time phantastron V602B/V607, which then closes the time base gate to prevent another measurement for a time determined by the DISPLAY TIME control. The minimum display time equals the gate time.

The 521C and 521E have an additional control circuit, reset amplifier V608, which shortens the minimum display time on the 10-second gate to about 2 seconds. When the display time phantastron reopens time base gate V603A, the display time phantastron also triggers the reset amplifier. The reset amplifier is a mono-stable multivibrator which has a short recovery time. When triggered, the reset amplifier resets the 0.1-cps phantastron and so cuts short the normal 10-second cycle.

The RESET switch is active only during display time, when reset gate V603B is closed. When pressed, the RESET switch triggers reset thyratron V606; when released, it resets the display time phantastron to open time base gate V603 and triggers reset amplifier V608 to reset the 0.1-cps phantastron.

3-5 SCHMITT TRIGGER

The Schmitt trigger (Figure 3-2) is a type of a bistable multivibrator. It is used where fast-rising waveforms are needed for reliable circuit operation. If the input voltage is such that section A is cut off, section B conducts. As the input voltage becomes more positive, it will eventually reach a predetermined level(χ) at which the circuit changes stage. Section A conducts and section B is quickly cut off. If the input voltage then goes in a negative direction, the common cathode

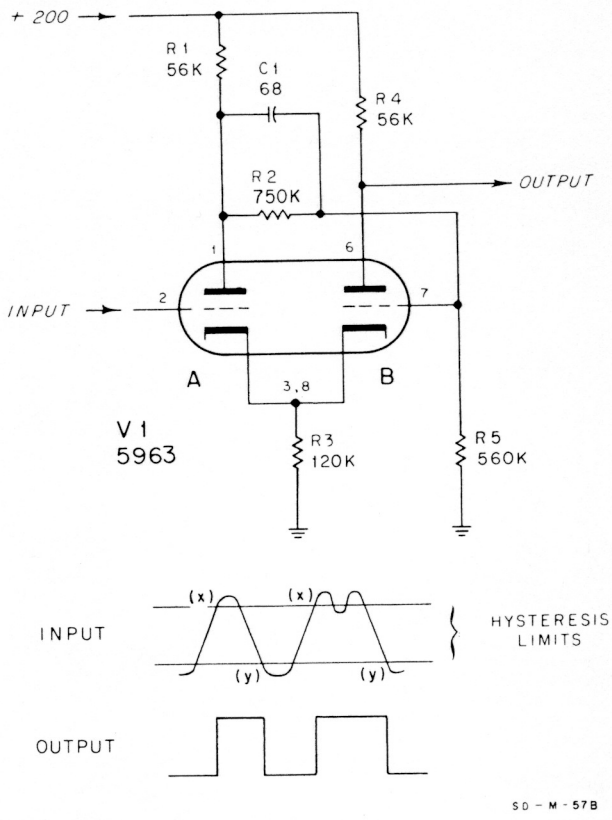


Figure 3-2. Schmitt Trigger Circuit and Waveform

potential decreases and section B grid goes in a positive direction. When the input voltage reaches a second predetermined level (Y), section B conducts and section A is quickly cut off. Thus the Schmitt trigger output is a voltage step, either positive or negative depending upon the slope polarity of the input. In this instrument, components following the Schmitt trigger differentiate the voltage step into a sharp trigger pulse.

The input voltage levels at which a Schmitt trigger switches are the hysteresis limits. Note that there is no output if the input fails to cross both limits.

3-6 PHANTASTRON

A phantastron frequency divider is shown in Figure 3-3. The heart of this phantastron is the 5915, a special tube with two control grids, G1 and G3. Grid G1 controls total cathode current, and G3 controls the division of current between G2 and the plate. Initially, G1 and the cathode are about 25v

positive, and G3 is sufficiently negative with respect to the cathode to hold plate current to zero. The cathode current flows mainly to G2; some flows to G1.

A negative trigger applied to the input is coupled through the C1, V1, and C2 to G1 of V2. The negative pulse on G1 reduces cathode current and thus reduces cathode potential. If the pulse is large enough, the potential difference between G3 and the cathode decreases to the point where plate current flows. When plate current starts flowing, plate potential decreases; this decrease is coupled through C2 to G1, further decreasing cathode potential and increasing plate current. Grid G1 quickly reaches a voltage level where any further decrease also decreases plate current; here G1 potential stops dropping. As C2 discharges, G1 potential rises, increasing cathode current. Most of the increasing cathode current goes to the plate, decreasing plate potential further. The plate signal, coupled to G1 slows the rise of G1 caused by the discharge of C2. Eventually plate potential approaches cathode potential, and plate current stops increasing. Now G1 potential increases more rapidly. Cathode potential follows G1 potential and becomes sufficiently positive with respect to G3 to cut off plate current. As C1 recharges, the circuit returns to its initial condition.

The cathode of V1 is biased very close to the supply voltage; thus V1 is open and blocks the input signal as long as the plate voltage of the 5915 tube is below its initial value.

The time required for the phantastron to complete a cycle is determined primarily by the values of C2 and R10. Potentiometer R11 permits some adjustment of the cycle time.

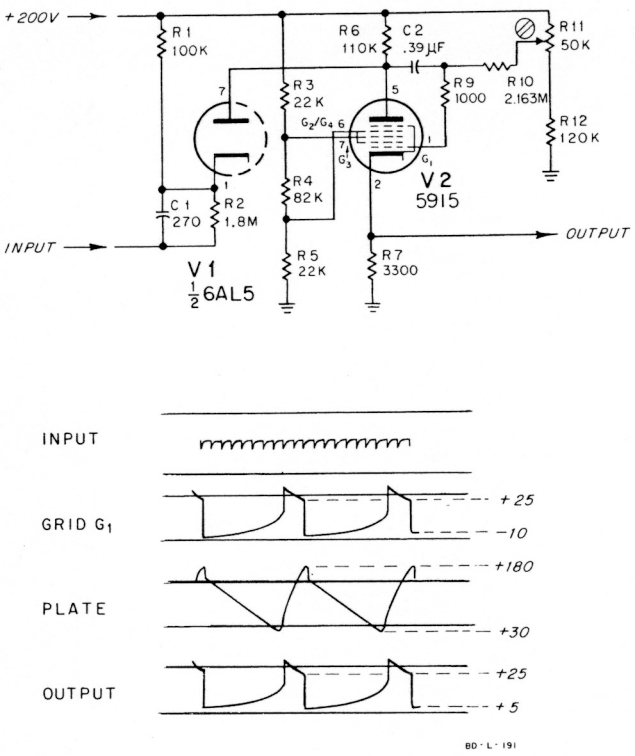


Figure 3-3. Phantastron Frequency Divider Circuit and Waveform

SECTION IV
MAINTENANCE

4-1 INTRODUCTION

This section contains maintenance and servicing information for the 521 Series. Included is a performance check to verify proper instrument operation. The check can be made with the instrument in its cabinet and is a good test as part of routine maintenance or incoming quality control inspection.

Adjustment procedures cover all possible adjustments within the instrument. The test data included in these procedures are not specifications. Specifications for the instruments are given at the front of this manual.

A separate AC-4 Decade Counter Manual contains operating and servicing information on the plug-in counter units. This manual contains no information on these units.

4-2 AIR FILTER SERVICE

Inspect the air filter regularly, and never let it get dirty enough to restrict air flow. The element itself is re-usable and can be cleaned as follows:

1) Snap element out of recess in cabinet bottom and wash it in warm water and detergent.

2) Dry element and coat it with light film of filter oil. We recommend Filter Coat No. 3 by Research Products Corporation. This adhesive is available in "Handi-Koter" sprayer cans at most heating supply stores or from your Hewlett-Packard Representative.

4-3 TEST EQUIPMENT

To test and service the 521 series we recommend the following test equipment:

1) A dc voltmeter with an input resistance of at least 100 megohms. You can use a voltmeter with 20,000 ohms/volt sensitivity, but some readings will be in error due to the low voltmeter resistance. Recommended hp equipment: 410B Vacuum Tube Voltmeter or 412A DC Vacuum Tube Voltmeter.

2) An ac voltmeter which can measure voltages as low as 0.2 volt rms from 10 cps to 120 kc (1.2 mc for 521G). Recommended hp equipment: 400D Vacuum Tube Voltmeter.

3) A test oscillator which can supply a sine-wave signal at least 0.2 volts rms from 10 cps to 120 kc (1.2 mc for 521G). Recommended hp equipment: 200 CD Wide Range Oscillator (650A Test Oscillator for 521G).

4) An oscilloscope whose bandwidth is at least 10 cps to 120 kc (1.2 mc for 521G) and which has at least 0.5 v/cm sensitivity. Recommended hp equipment: 120A Oscilloscope (150A Oscilloscope for 521G).

5). Variable power transformer for varying line voltage between 103, 115, and 127 volts. The transformer should have a monitor voltmeter accurate within 1 volt and should have a capacity of at least 3 amps.

6) Wide-range ohmmeter. Recommended hp equipment, 410B Vacuum Tube Voltmeter or 412A DC Vacuum Tube Voltmeter.

7) Either of the following instrument sets for checking frequency of the crystal time base oscillator:

a. Primary or secondary frequency standard. Recommended hp equipment: 100E Frequency Standard.

b. Communications receiver capable of receiving the 5, 10, and 15 mc transmissions of WWV, and an amplifier to provide adequate harmonics from a time-base signal for comparison with WWV. Recommended hp amplifier: 450A Amplifier.

4-4 PERFORMANCE CHECK

You can check instrument performance without removing the cabinet. Proceed as follows:

A. SELF CHECK

1) Set line voltage to 115 volts, turn instrument on, and allow five-minute warm up.

2) Self check instrument as directed in Figure 2-2. If instrument does not check properly, check phantastron adjustments (paragraph 4-7) and/or crystal time base phantastron adjustments (paragraph 4-11A).

B. SENSITIVITY AND TOP FREQUENCY CHECK

1) Set:
GATE SELECTOR - - - - - - - - - 1/10 SEC
INPUT SENSITIVITY - - - - - minimum (cw)
DISPLAY TIME - - - - - - minimum (ccw)

2) Connect output of test oscillator to INPUT connector of 521's and monitor oscillator output with voltmeter. See Figure 4-1.

3) Adjust oscillator output to about 1 kc at 0.2 v rms; counter should consistently indicate input frequency

4) Adjust oscillator output to about 120 kc (1.2 mc for 521G) at 0.2 volts rms; counter should consistently indicate input frequency.

5) If sensitivity is low, check amplitude discriminator sensitivity adjustment (paragraph 4-8).

C. MANUAL GATE CHECK

1) Set:
GATE SELECTOR - - - - - MANUAL GATE
INPUT SENSITIVITY - - - - - - - - - CHECK

2) Set MANUAL GATE switch to COUNT. GATE light should light and counter should count continuously.

3) Set MANUAL GATE switch to down position. GATE light should go out and counter should stop counting.

D. DISPLAY TIME AND MANUAL RESET CHECK

1) Set:
GATE SELECTOR - - - - - - - - - 1/10 SEC
INPUT SENSITIVITY - - - - - - - - - CHECK

2) Rotate DISPLAY TIME control from its counterclockwise position to its clockwise position but

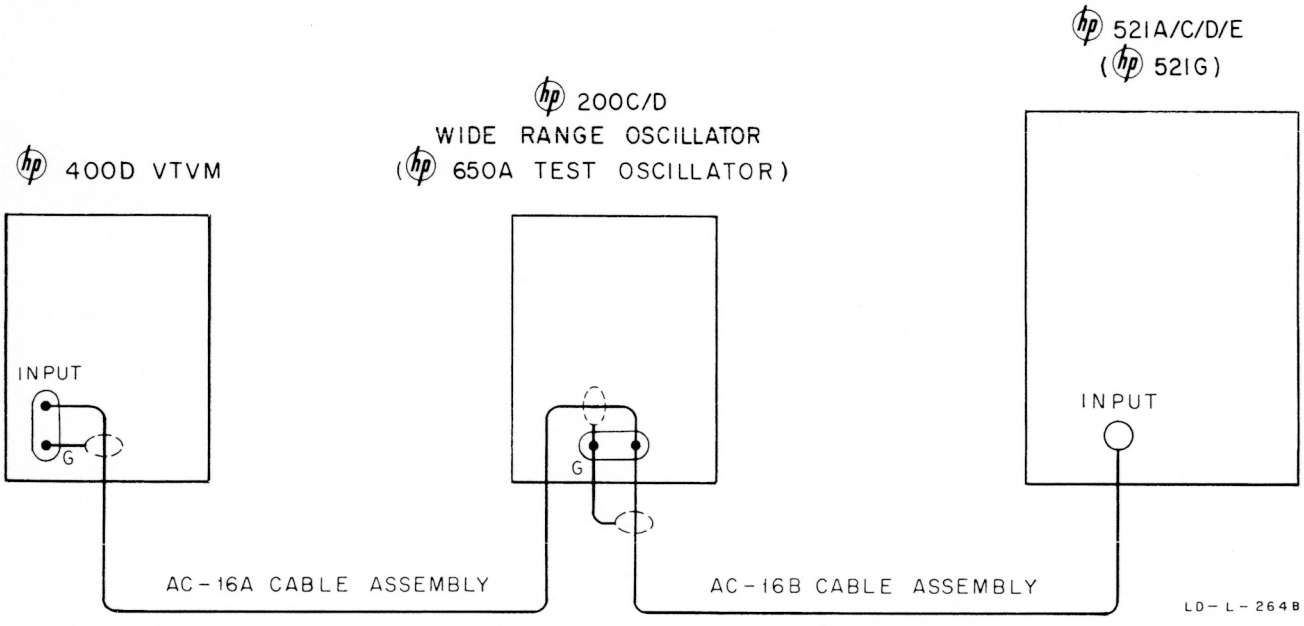


Figure 4-1. Equipment Setup for Sensitivity and Top Frequency Check

do not switch to INF. Display time should increase from 1/10 sec to about 15 sec.

3) Set DISPLAY TIME control to INF. Readout should remain indefinitely.

4) Press and release RESET switch. Readout should return to zero when you press the switch, and counter should start another count when you release the switch.

Repeat entire procedure at line voltages of 103 and 127 volts.

4-5 CABINET REMOVAL

1) Remove two retaining screws on rear of cabinet.

2) Slide instrument forward out of cabinet. Bezel remains on cabinet.

4-6 POWER SUPPLY

Check power supply voltages and regulation prior to making other adjustments and as a first trouble-shooting step. If the output of the + 200-volt supply is essentially correct, it should not be adjusted unless you intend to check the other adjustments in the instrument. If you do adjust the + 200-volt supply, use a voltmeter accurate within 3% of full scale.

Proceed as follows:

1) Remove cabinet, turn instrument on, and allow five-minute warm up.

2) Connect voltmeter between pin 2 of V508 (-105 volts) and ground and vary line voltage between 103 and 127 volts. Check V508 if voltage varies more than 2%.

3) Set line voltage to 115 volts.

4) Connect voltmeter between pin 3 of V505 and ground and adjust R548 (+ 200 V ADJ) until meter reads + 200 volts.

5) Vary line voltage between 103 and 127 volts. Check V505 and V507 if voltage varies more than 2%.

4-7 PHANTASTRON FREQUENCY DIVIDER ADJUSTMENT

Failure of the 521's to self check properly may indicate improper adjustment of the phantastron frequency dividers. Adjustment potentiometers are located on the rear chassis. Proceed as follows:

1) If crystal time base plug-in unit is installed remove cabinet and set TIME BASE switch to LINE-EXT.

2) Turn instrument on and allow five-minute warm up.

3) Set:

INPUT SENSITIVITY - - - - - - - - CHECK
DISPLAY TIME - - - - - - minimum (ccw)

NOTE

When adjusting phantastrons, turn potentiometers clockwise until counter miscounts. Continue slightly past this point and then turn potentiometer counterclockwise until counter just begins to give correct count. Note shaft position; this is the clockwise limit. Repeat procedure in counterclockwise direction and note shaft position. This is the counterclockwise limit. Set potentiometer midway between these limits. Check phantastrons for correct count with line voltage set at 103 and 127 volts. Allow counter to operate at each extreme voltage for at least one minute. Improper operation indicates incorrect control setting or a weak tube. (Be sure power supply regulation is good too.)

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4) Set GATE SELECTOR to 1/10 SEC and adjust .1 SEC potentiometer to give readout of power line frequency (for 60 cycles the readout is 0006 on 521A/D, 00006 on 521C/E/G).

5) Set GATE SELECTOR to 1 SEC and adjust 1 SEC potentiometer to give readout of power line frequency (for 60 cycles the readout is 0060 on 521A/D, 00060 on 521C/E/G).

6) (521C/E) Set GATE SELECTOR to 10 SEC and adjust 10 SEC potentiometer to give readout of power line frequency (for 60 cycles the readout is 00600).

7) Return TIME BASE switch to its original setting.

4-8 AMPLITUDE DISCRIMINATOR BIAS ADJUSTMENT FOR 521A/C/D/E

Adjust amplitude discriminator bias if you replace any discriminator component or if instrument sensitivity is low. Two procedures follow. The second is simpler, but requires an oscilloscope in addition to the oscillator and ac voltmeter required in procedure 1.

PROCEDURE 1:

1) Remove cabinet, turn instrument on, and allow five-minute warm up.

2) Set:
GATE SELECTOR - - - - - - - - - - .1 SEC
INPUT SENSITIVITY - - - - - maximum (cw)

3) Apply signal approximately 1 kc at 3 volts rms to INPUT connector.

4) If instrument does not consistently indicate input frequency, rotate R606, Disc Bias Adjust, fully counterclockwise.

5) Adjust Amplifier Balance R2 on top of plug-in unit to center of range that produces consistent indication of input signal frequency.

6) Decrease input signal voltage to 0.6 volt rms and rotate R606, clockwise until stable count just begins.

7) Reduce input signal voltage to 0.1 volt rms and repeat steps 5 and 6. After final adjustment of R606, check to be sure instrument does not count on input signal voltage less than 0.1 volt rms.

PROCEDURE 2:

1) Remove cabinet, turn instrument on, and allow five-minute warm up.

2) Set:
GATE SELECTOR - - - - - - - - - - .1 SEC
INPUT SENSITIVITY - - - - maximum (cw)

3) Connect oscilloscope probe over insulation on either output (usually blue) lead in Amplitude Discriminator plug-in unit. Do not make direct electrical connection to either plate of output tube.

4) Connect signal about 1 kc to INPUT connector.

5) Adjust signal amplitude to get indication on oscilloscope. Waveform is a differentiated square wave.

6) Adjust R2 on top of plug-in unit to make waveform symmetrical.

7) Reduce input signal voltage to 0.1 volt.

8) Adjust R606, Disc Bias Adjust until waveform appears on oscilloscope; then readjust R606 until waveform almost disappears.

9) Adjust R2 to make waveform symmetrical.

10) Repeat steps 8 and 9 until waveform is symmetrical and any counterclockwise rotation of R606 causes waveform to disappear.

4-9 AMPLITUDE DISCRIMINATOR BIAS ADJUSTMENT FOR 521G

Adjust amplitude discriminator sensitivity if you replace any discriminator component or if instrument sensitivity is low.

1) Remove cabinet, turn instrument on, and allow five-minute warm up.

2) Set GATE SELECTOR to .1 SEC, DISPLAY TIME control to minimum (counterclockwise), and INPUT SENSITIVITY control to maximum (clockwise).

3) Apply signal approximately 1 kc at 3 volt rms to INPUTconnector.

4) Adjust R604, Disc Bias Adjust until counter consistently indicates input frequency.

5) Gradually reduce input signal amplitude and readjust R604 as necessary to maintain consistent counter operation. Counter should operate properly with input amplitude as low as 0.1 volt rms.

4-10 SCHMITT TRIGGER SENSITIVITY ADJUSTMENT

1) Remove cabinet, turn instrument on, and allow five-minute warm up.

2) Set:
INPUT SENSITIVITY - - - - - - - - CHECK
GATE SELECTOR - - - - - - - - 1/10 SEC
TIME BASE SELECTOR - - - - - LINE EXT

3) Connect test oscillator to EXT STD connector or rear of 521's.

4) Adjust oscillator frequency to any integral multiple of 10 cps from 10 cps to 100 cps and adjust oscillator output amplitude to about 5 v rms.

5) Adjust R507, Sens Adjust until counter consistently indicates line frequency.

6) Reduce oscillator output amplitude in small steps, and readjust 507 to maintain correct count. Counter should operate properly with oscillator output reduced to 1 or 2 volts rms.

4-11 CRYSTAL CONTROLLED TIME BASE ADJUSTMENTS

A. PHANTASTRON FREQUENCY DIVIDER ADJUSTMENT

Improper frequency divider adjustment in crystal controlled time base plug-in unit may produce counts such as 9900, 8900, 0100, 0900, etc. when instrument is self checked. Adjust frequency dividers as follows:

1) Remove instrument cabinet, turn on, and allow five-minute warm up.

2) Set TIME BASE SELECTOR to LINE-EXT.

3) Self check instrument as directed in Figure 2-2. If necessary, adjust phantastron frequency dividers as directed in paragraph 4-7.

4) Set:
INPUT SENSITIVITY - - - - - maximum (cw)
GATE SELECTOR - - - - - - - - - 1/10 SEC
DISPLAY TIME - - - - - - minimum (ccw)

5) Connect wire lead from pin 2 of V52 (10-kc phantastron) in time base plug-in to INPUT connector.

6) Set R67, 10-kc adjust, to center of range which yields count of 1000.

7) Set GATE SELECTOR to 1 SEC.

8) Move wire lead to pin 2 of V54 (1-kc phantastron) in plug-in unit.

9) Set R28, 1-kc adjust, to center of range which yields count of 1000.

10) Move wire lead to 100-cps output, pin 8, of plug-in socket.

11) Set R89, 100-cps adjust, to center of range which yields count of 0100.

12) Remove wire lead.

13) Set:
TIME BASE SELECTOR - - - - - CRYSTAL
GATE SELECTOR - - - - - - - - 1/10 SEC
INPUT SENSITIVITY - - - - - - - - CHECK

14) Set .1 SEC phantastron potentiometer on rear of instrument to center of range which yields count of 1000. See NOTE of paragraph 4-7.

B. ADJUSTING OSCILLATOR FREQUENCY

Two procedures follow. If a local standard is available, use Procedure 1; if not, use Procedure 2.

PROCEDURE 1:

Setting oscillator frequency against local standard.

1) Remove instrument cabinet, turn on, and allow five-minute warm up.

2) Connect 100-kc output from frequency standard such as hp Model 100E to 521 INPUT connector. See Figure 4-2.

3) Set:
GATE SELECTOR - - - - - - - - - - 1 SEC
DISPLAY TIME - - - - - - - minimum (ccw)
INPUT SENSITIVITY to obtain consistent count

4) Adjust C51, Freq. Adj., (Figure 4-5) to give readout of 0000±1 (521A/D) or 00000±1 (521C/E/G).

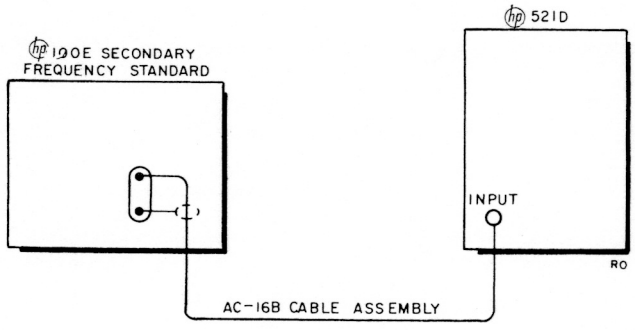


Figure 4-2. Equipment Setup for Setting Crystal Time Base Oscillator Against a Local Standard

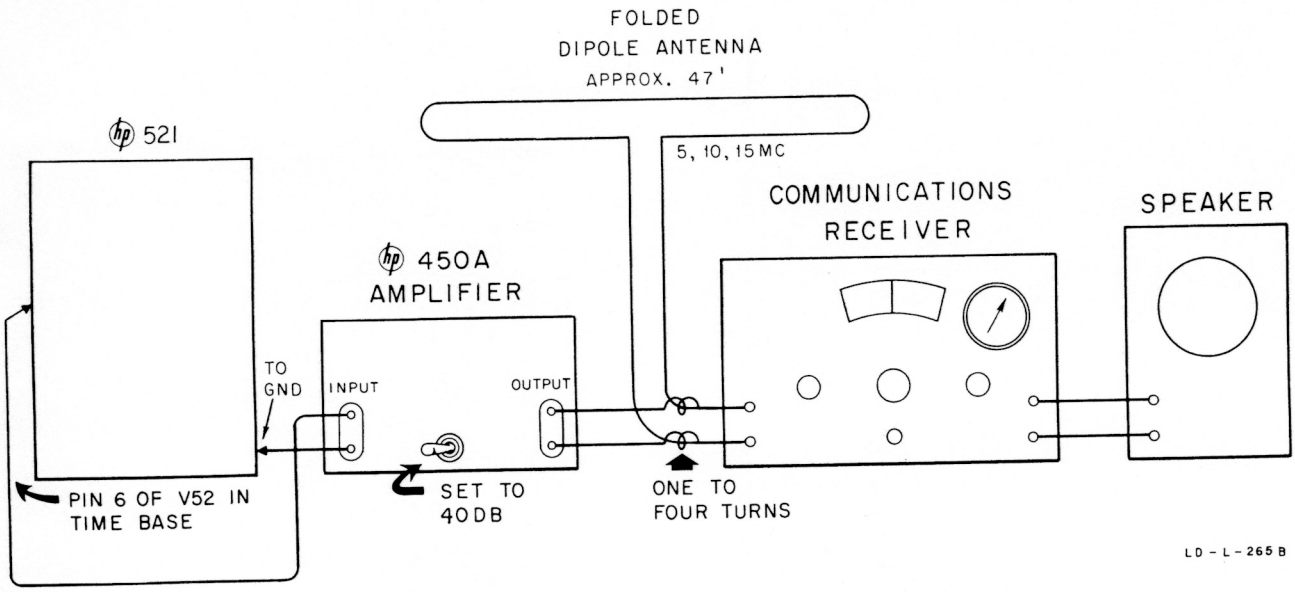


Figure 4-3. Equipment Setup for Setting Crystal Time Base Oscillator Against WWV

PROCEDURE 2:

Setting Oscillator Frequency Against WWV.

1) Remove instrument cabinet and connect equipment as shown in Figure 4-3.

2) Turn on equipment and allow five minute warm up.

3) Tune communications receiver to best WWV signal below 20 mc and listen for beat note. If necessary adjust coupling of amplifier to antenna; coupling should be such that harmonic coupled to receiver is slightly weaker than WWV signal.

4) Adjust C51, Frequency Adjust (see Figure 4-5) for lowest beat note. WWV broad casts audio tones three minutes out of every five; adjust C51 during two-minute intervals between audio tones when only the carrier is present. If you use the 10-mc transmission from WWV, oscillator frequency is within 0.01% of 100 kc when beat note is less than 1 kc.

If C51 does not provide enough adjustment range to set the oscillator frequency at 100 kc, change the values of C51 and/or C52. One of the three following combinations will do: C51 and C52 both 27 $\mu\mu$f; C51 and C52 both 39 $\mu\mu$f; or C51, 39 $\mu\mu$f and C52, 27 $\mu\mu$f. If none of these combinations work, try another crystal.

4-12 TUBE REPLACEMENT

In many cases of instrument malfunction, the cause is a weak or defective tube. Before adjusting any of the internal controls, locate the trouble as nearly as possible (see paragraph 4-13) and check the tubes in the suspected circuits. Adjusting an internal control to compensate for a defective tube may complicate the repair problem.

The best tube checker is the circuit in which a tube must operate. Therefore check a tube by substitution and return the original tube if a new one does not restore proper circuit operation. However, should circuit condition (burned resistor, etc.) indicate that the original tube might be shorted or otherwise mechanically defective, test it on a "tube checker" before returning it to the circuit.

You can use any tube with corresponding standard EIA characteristics as a replacement. Where variations in tube characteristics affect circuit operation, an adjustment is provided. If you replace any of the tubes listed in Table 4-1, check the indicated adjustment.

4-13 TROUBLE SHOOTING

The following is a systematic procedure for locating trouble:

1) Check power supply voltages and regulation (paragraph 4-6). Proceed to step 2 only if the power supply operates properly.

2) Self check instrument as instructed in Fig. 2-1. By so doing you check nearly all circuits and will save time if trouble is external to the counter. Self check procedure checks circuits for operation but not for sensitivity; if instrument self checks properly, check performance (paragraph 4-4). Proceed to step 3 if instrument does not self check.

3) Check instrument reaction to various front-panel control settings (see Table 4-2). When you have located the trouble as nearly as possible, proceed to step 4.

4) Check suspected circuits. Approximate waveforms and voltages are shown throughout the schematic diagrams. If you change parts in any circuit listed in Table 4-1, check the indicated adjustment. Figure 4-4 gives instructions for servicing etched circuit boards.

TABLE 4-1. TUBE REPLACEMENT/ADJUSTMENT

Tube No. and Type		Function	Adjustment
V501	5963	Schmitt trigger	Schmitt trigger sensitivity (para. 4-10)
V503	5915	10-cps phantastron	Phantastrons (para. 4-7)
V504	5915	1-cps phantastron	Phantastrons (para. 4-7)
V505	6AV5	Series regulator	Power supply (para. 4-6)
V506	5U4G	Rectifier	Power supply (para. 4-6)
V507	6CB6	Control tube	Power supply (para. 4-6)
V508	OB2	Reference tube	Power supply (para. 4-6)
V509	5915 (521C/E)	0.1-cps phantastron	Phantastrons (para. 4-7)
		AMPLITUDE DISCRIMINATOR (521A/C/D/E)	
V1	5963	Amplifier	Amplitude discriminator sens. (para. 4-8)
V2	5963	Multivibrator	Amplitude discriminator sens. (para. 4-8)
		AMPLITUDE DISCRIMINATOR (521G)	
V301	6922	Amplifier	Amplitude discriminator sens. (para. 4-9)
V302	5965	Schmitt trigger	Amplitude discriminator sens. (para. 4-9)
		CRYSTAL TIME BASE	
V51	5963	Oscillator	Crystal oscillator frequency (para. 4-11B)
V52	5915	10-kc phantastron	Crystal time base phantastrons (para. 4-11A)
V54	5915	1-kc phantastron	Crystal time base phantastrons (para. 4-11A)
V55	5915	100-cps phantastron	Crystal base phantastrons (para. 4-11A)

TABLE 4-2. TROUBLE-SHOOTING AID

Control Settings	Counter Reaction	Faulty Circuit
INPUT SENSITIVITY to CHECK GATE SELECTOR to MANUAL MANUAL GATE switch to COUNT	Counter does not count; GATE light off Counter does not count; GATE light on	V605 V602A Amplitude discriminator, V601 Units counter
INPUT SENSITIVITY to CHECK DISPLAY TIME control to minimum (ccw)	GATE light flashes with GATE SELECTOR set to 1 SEC, stays off with GATE SELECTOR set to 10 SEC (521C/E only) GATE light flashes with GATE SELECTOR set to 1/10 SEC, stays off with GATE SELECTOR set to 1 SEC GATE light stays off with gate selector set to 1/10 SEC	V502C V509 V504 V502B No timing signal, V501, V502, V503 V603, V604, V607
GATE SELECTOR to 10 SEC (521C/E only) DISPLAY TIME to minimum (ccw)	Display time 10 sec long	V608
	GATE light lighted at all times Readout blank at all times Counter units cannot be reset to zero.	V605, V602A V609 V606

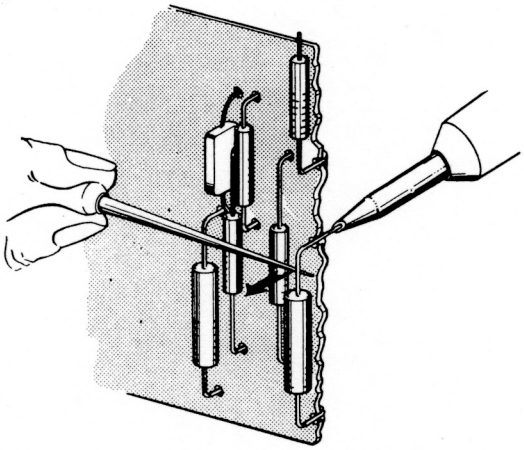
SERVICING ETCHED CIRCUIT BOARDS

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.

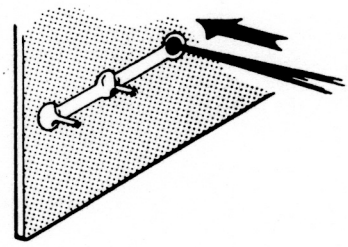
Use only high quality rosin core solder when repairing etched circuit boards. **NEVER USE PASTE FLUX.** After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

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

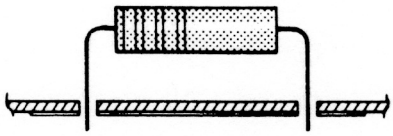
When replacing tube sockets it will be necessary to lift each pin slightly, working around the socket several times until it is free.



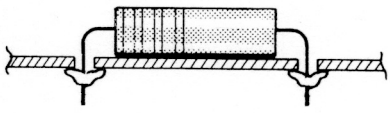
1. Apply heat sparingly to lead of part to be replaced. Remove part from card as iron heats the lead.



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.

Figure 4-4

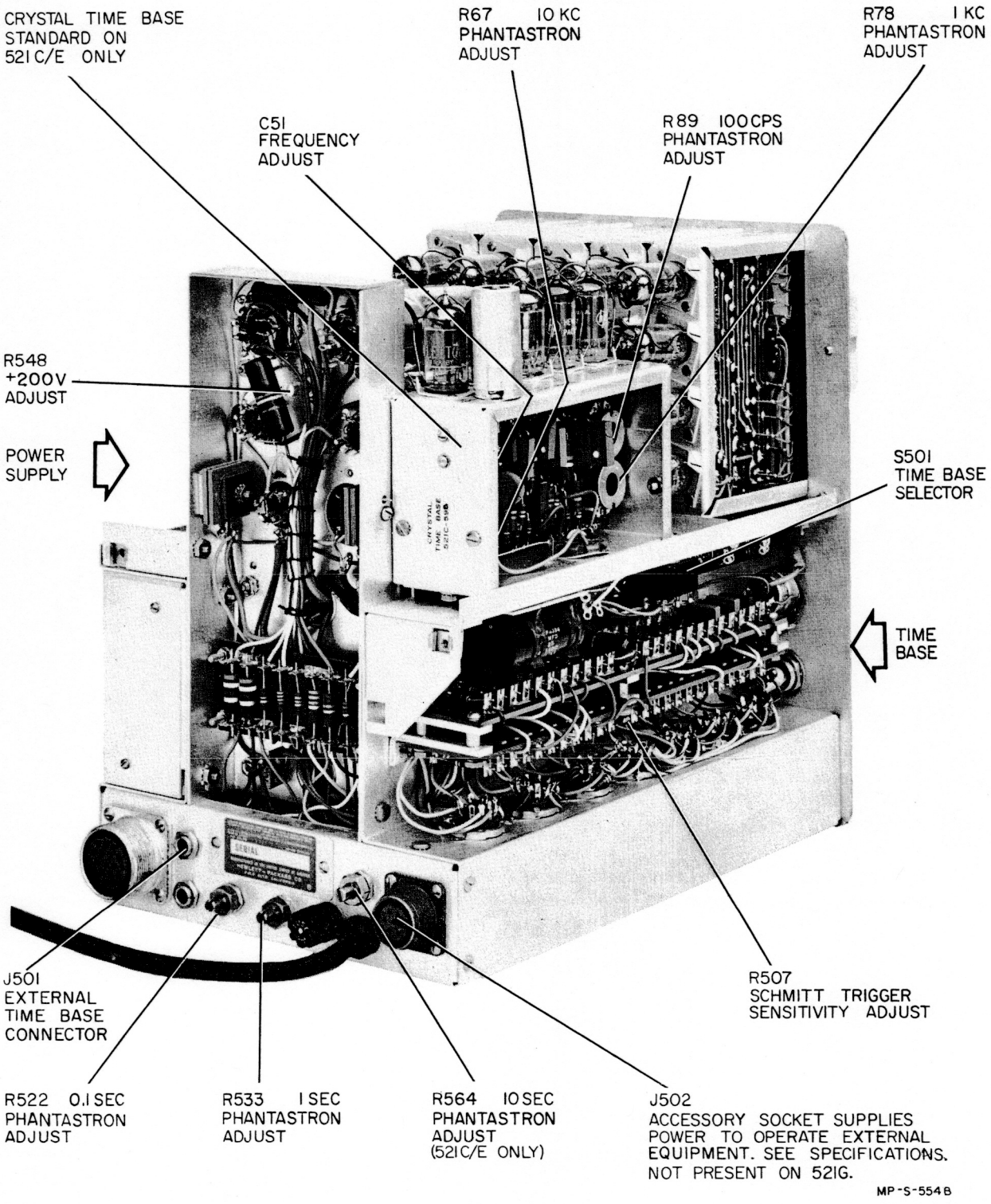


Figure 4-5. Right Rear Internal View of 521E

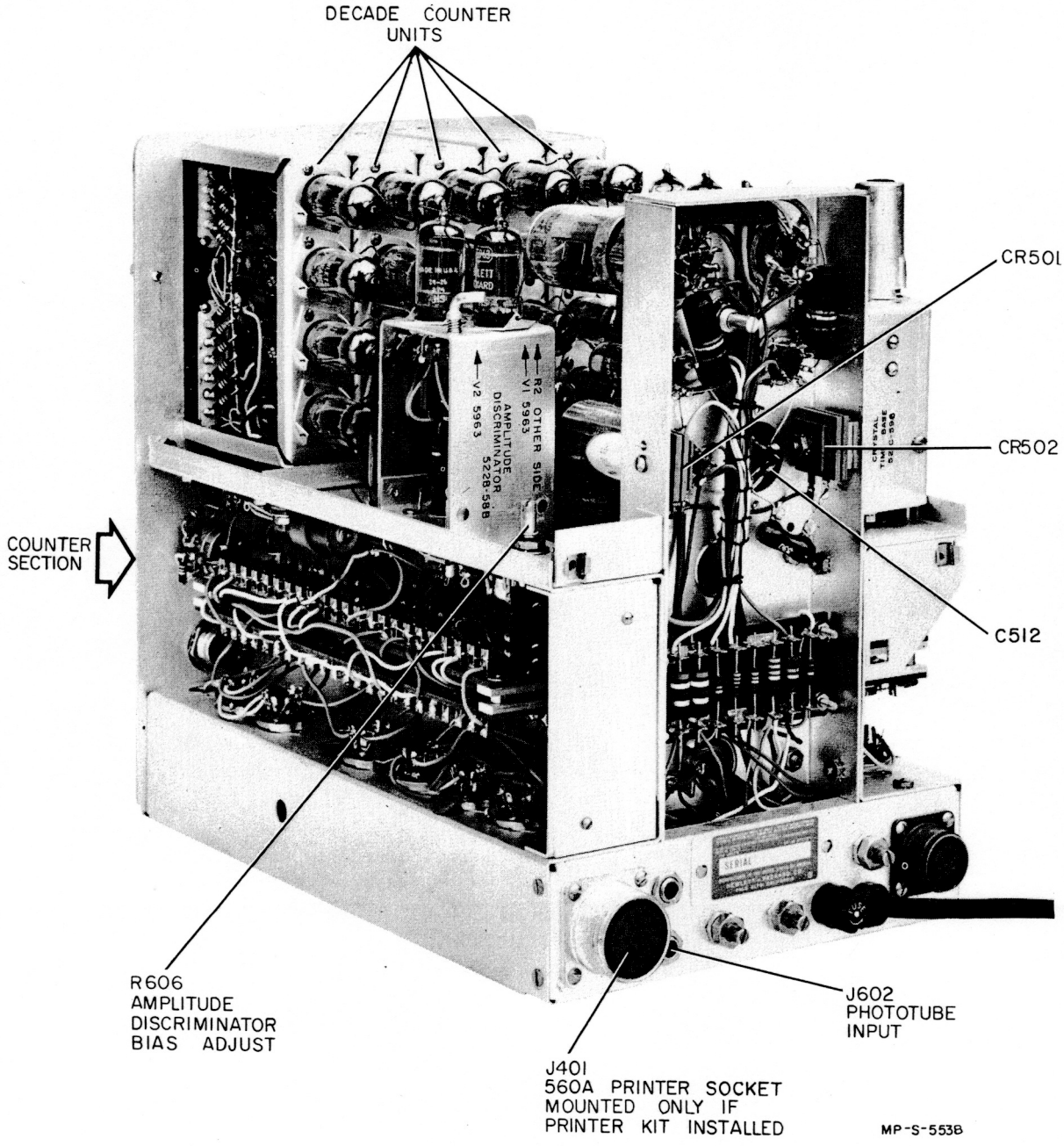
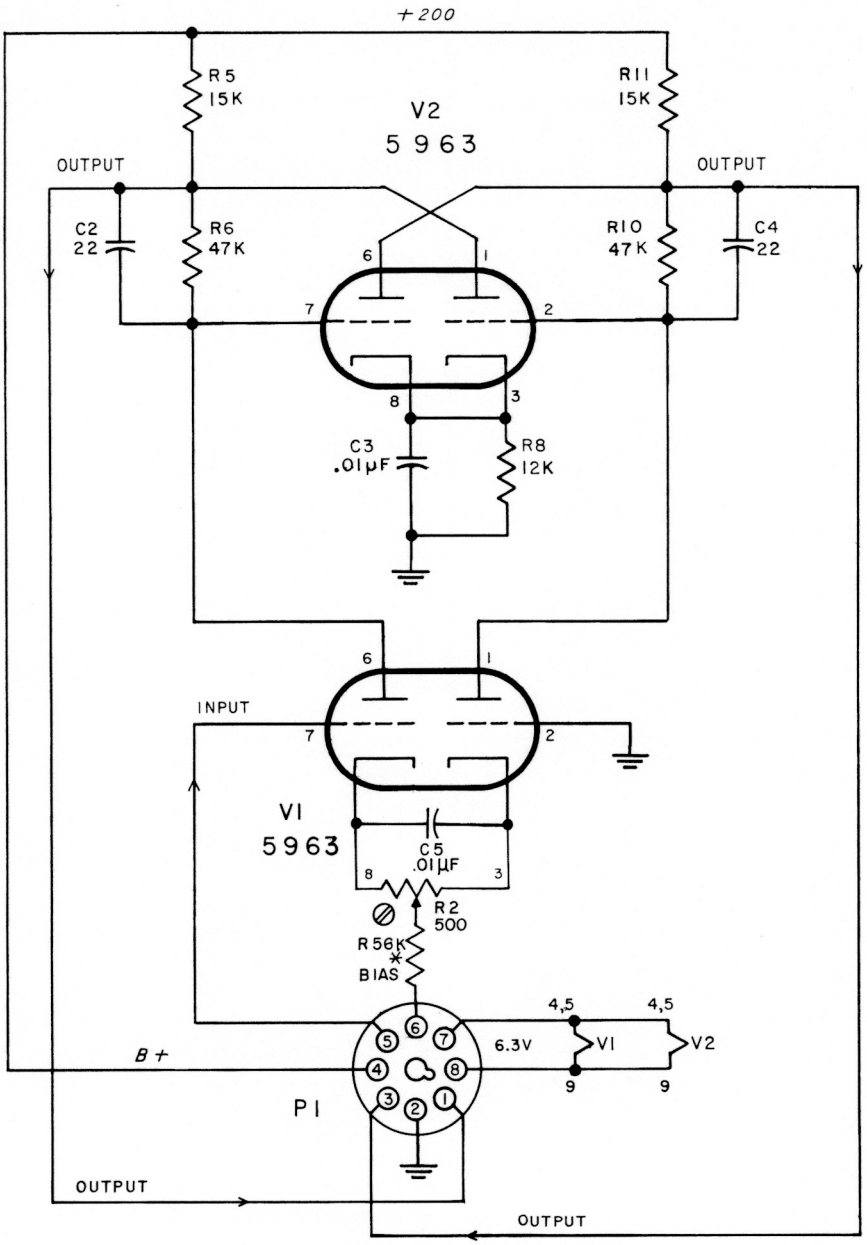


Figure 4-6. Left Rear Internal View of 521E

SCHEMATIC DIAGRAM NOTES

1. Heavy solid and dashed lines show signal paths.
2. Resistance values are in ohms, capacitance values in micromicrofarads, and inductance values in micromicrohenries unless otherwise specified.
3. Voltages shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. DC voltages were measured with a voltmeter having an input resistance greater than 100 megohms and are shown with respect to chassis ground.
4. Relay is shown de-energized.
5. *indicates value adjusted at the factory; average value is shown.



522B-
521A/C- AD- 2533A
521 1682A
T-032A

Figure 4-7. Amplitude Discriminator for Models 521A/C/D/E

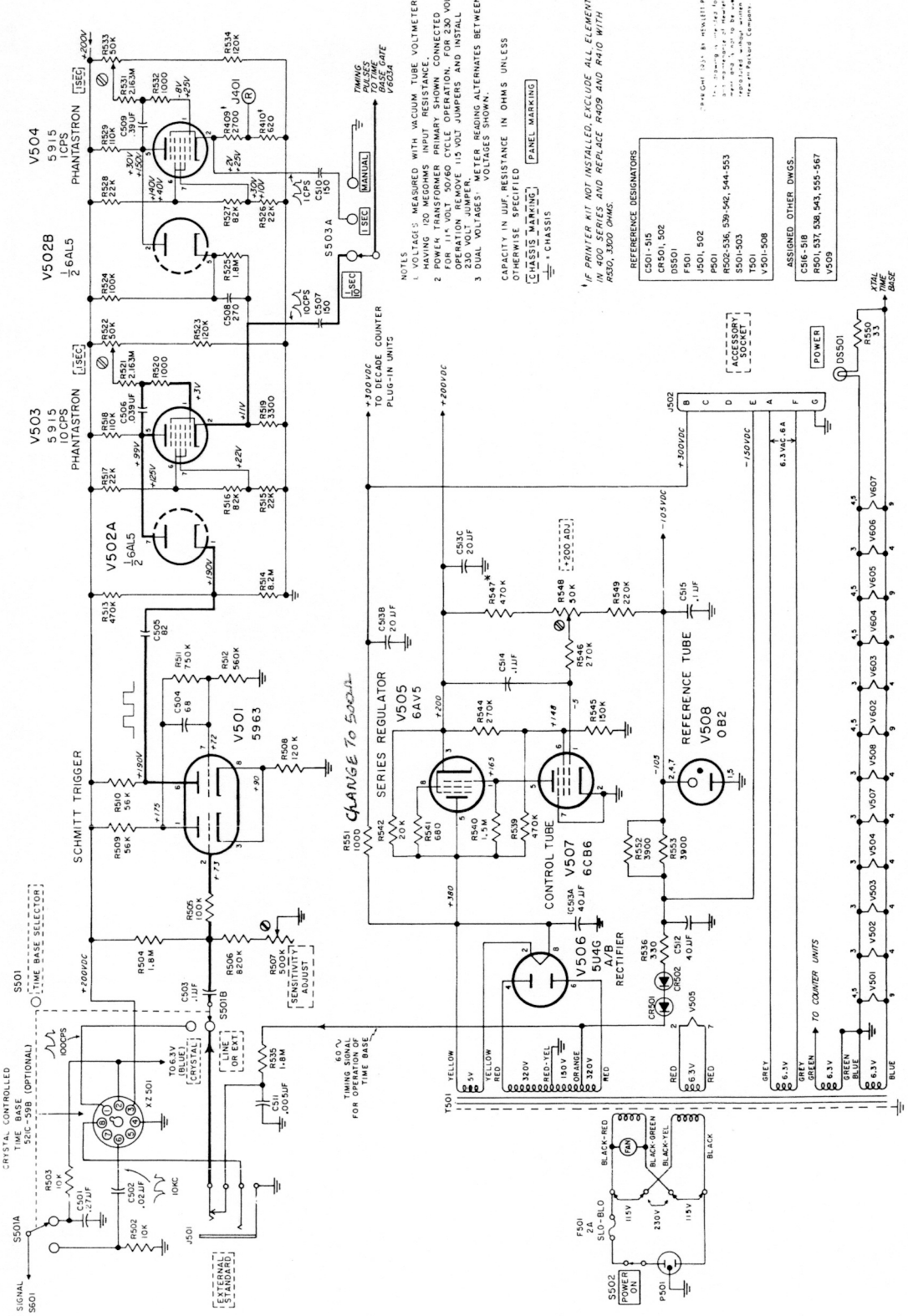
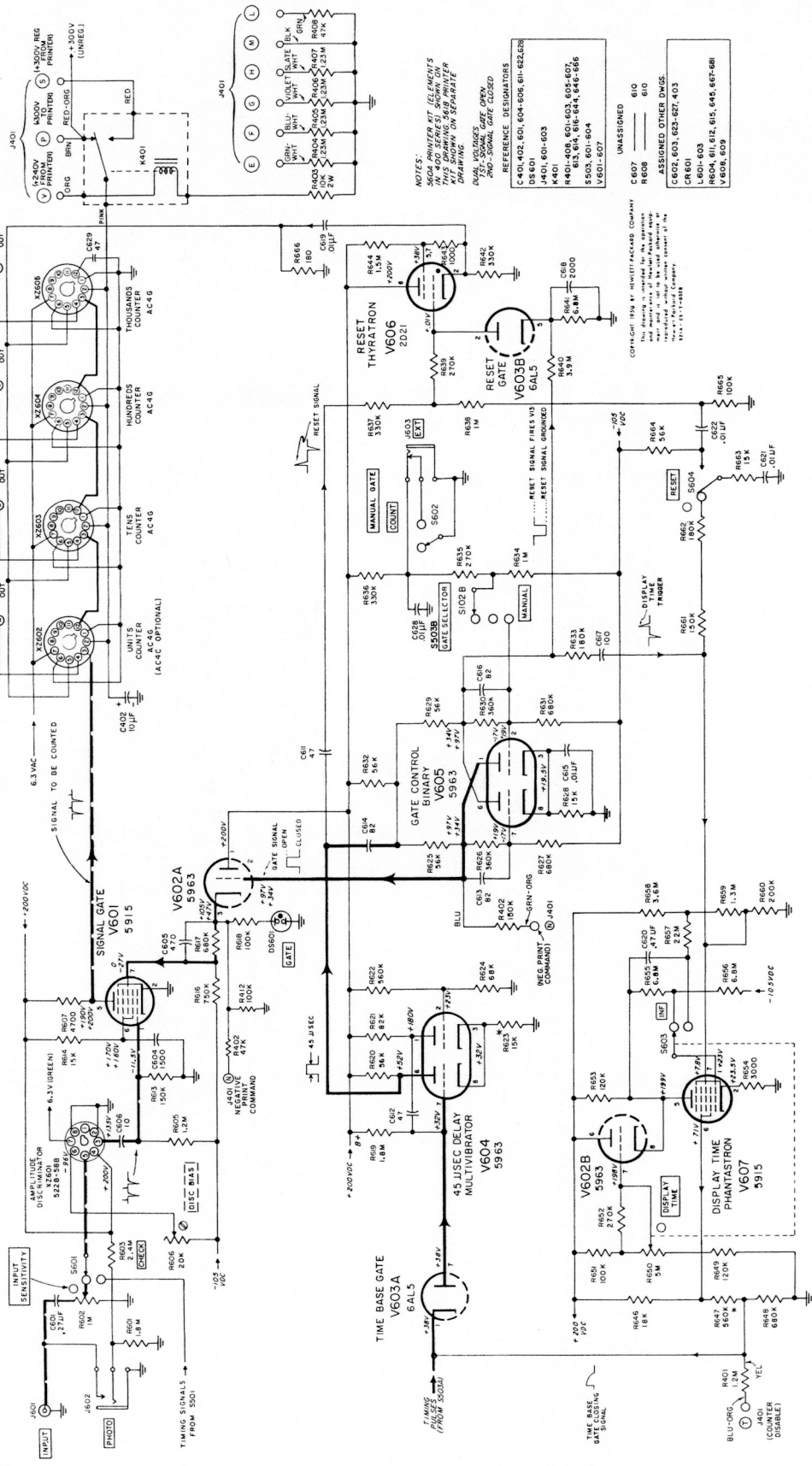


Figure 4-8. Model 521A Time Base/Power Supply Sections



00150-2

Figure 4-9. Model 521A Counter Section

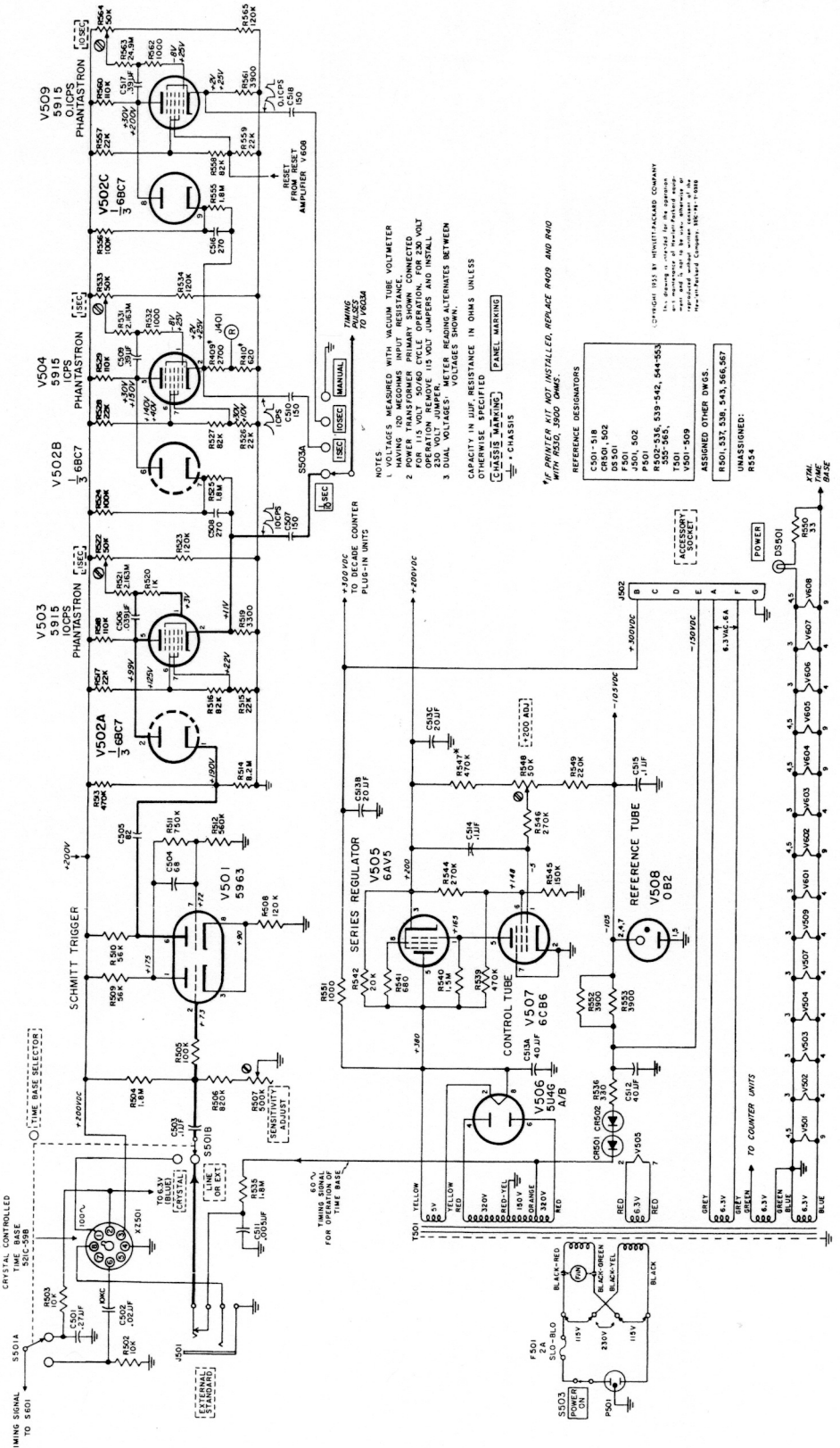
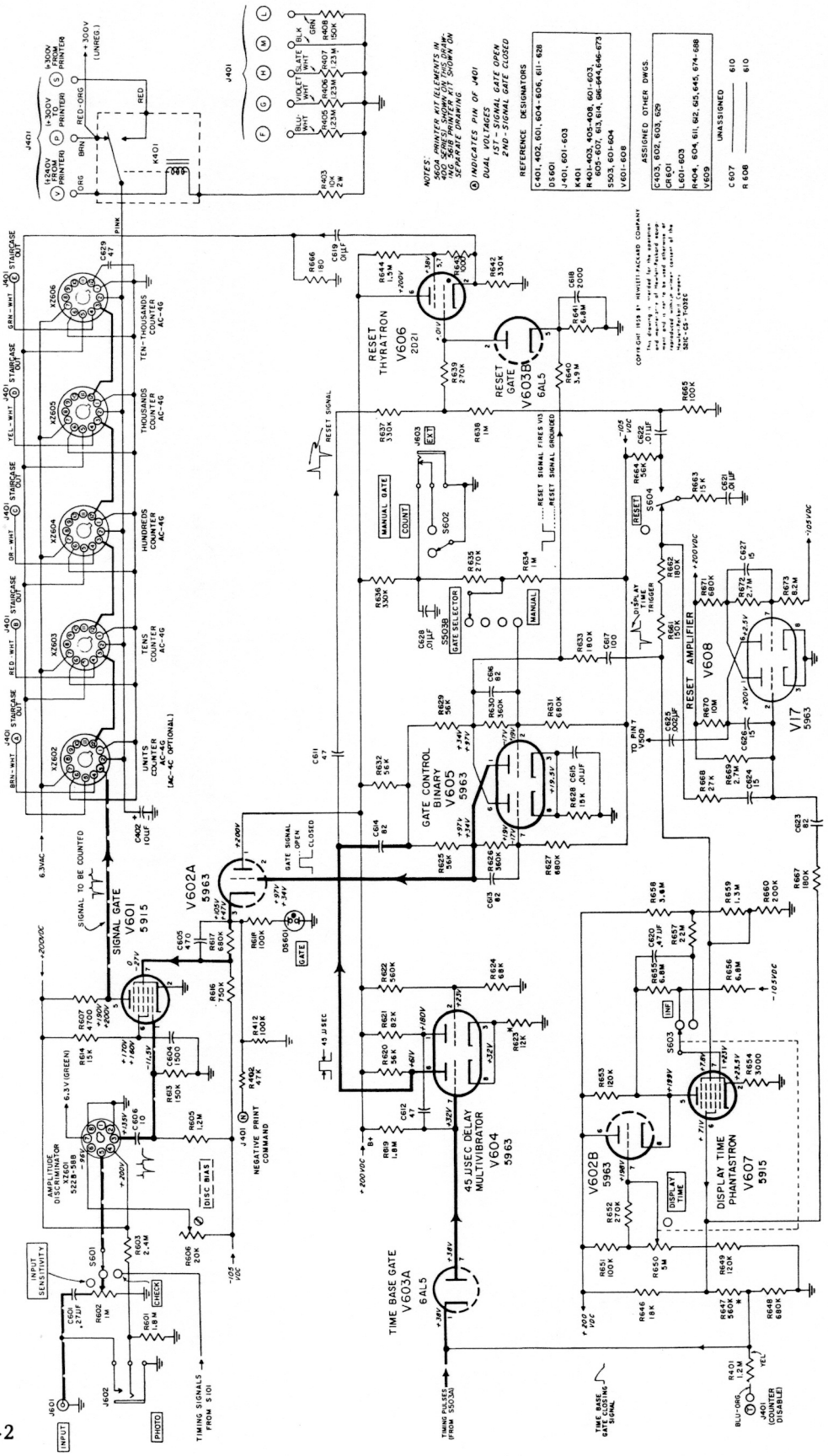


Figure 4-10. Model 521C Time Base/Power Supply Sections



00150-2

Figure 4-11. Model 521C Counter Section

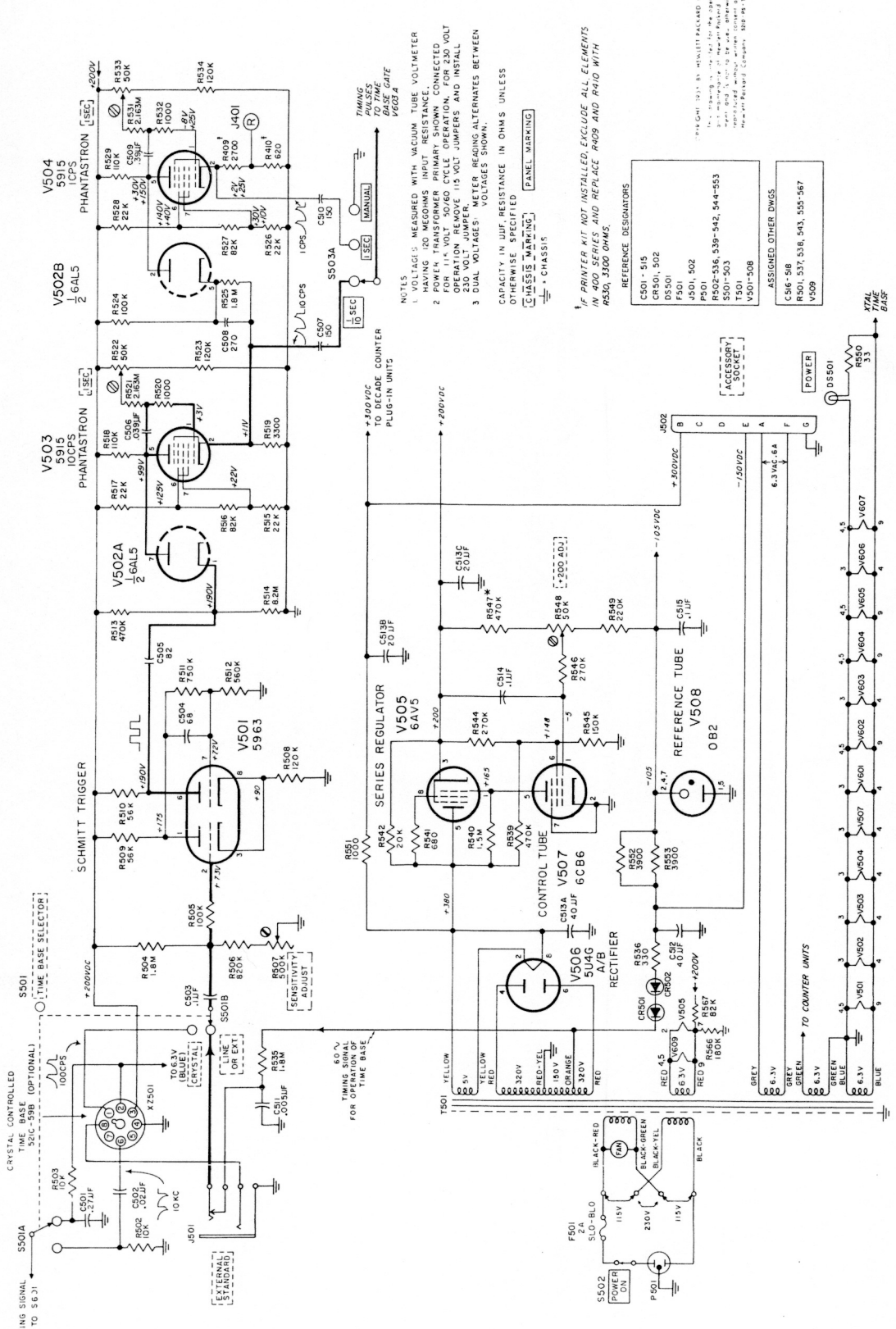


Figure 4-12. Model 521D Time Base/Power Supply Sections

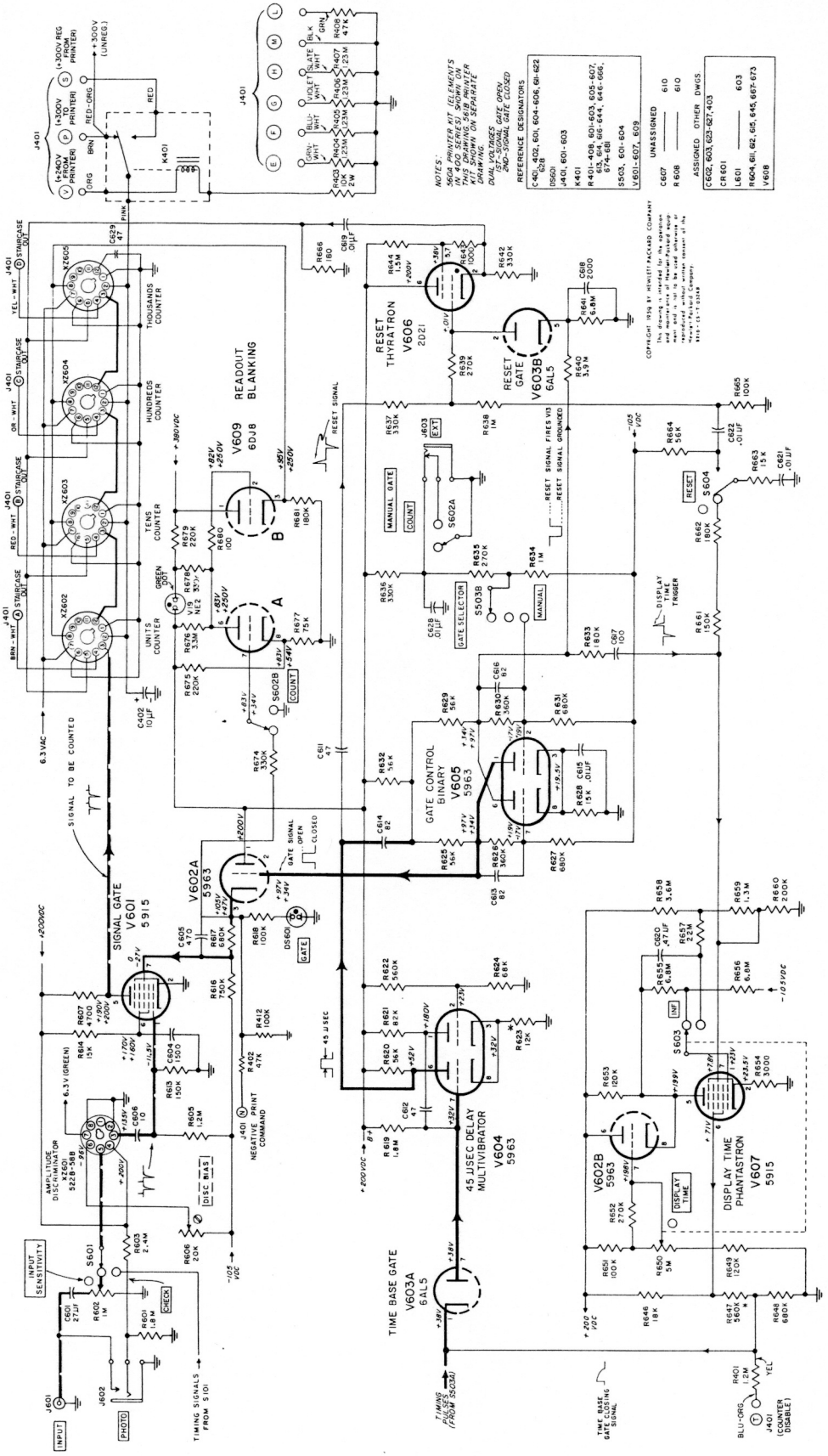


Figure 4-13. Model 521D Counter Section

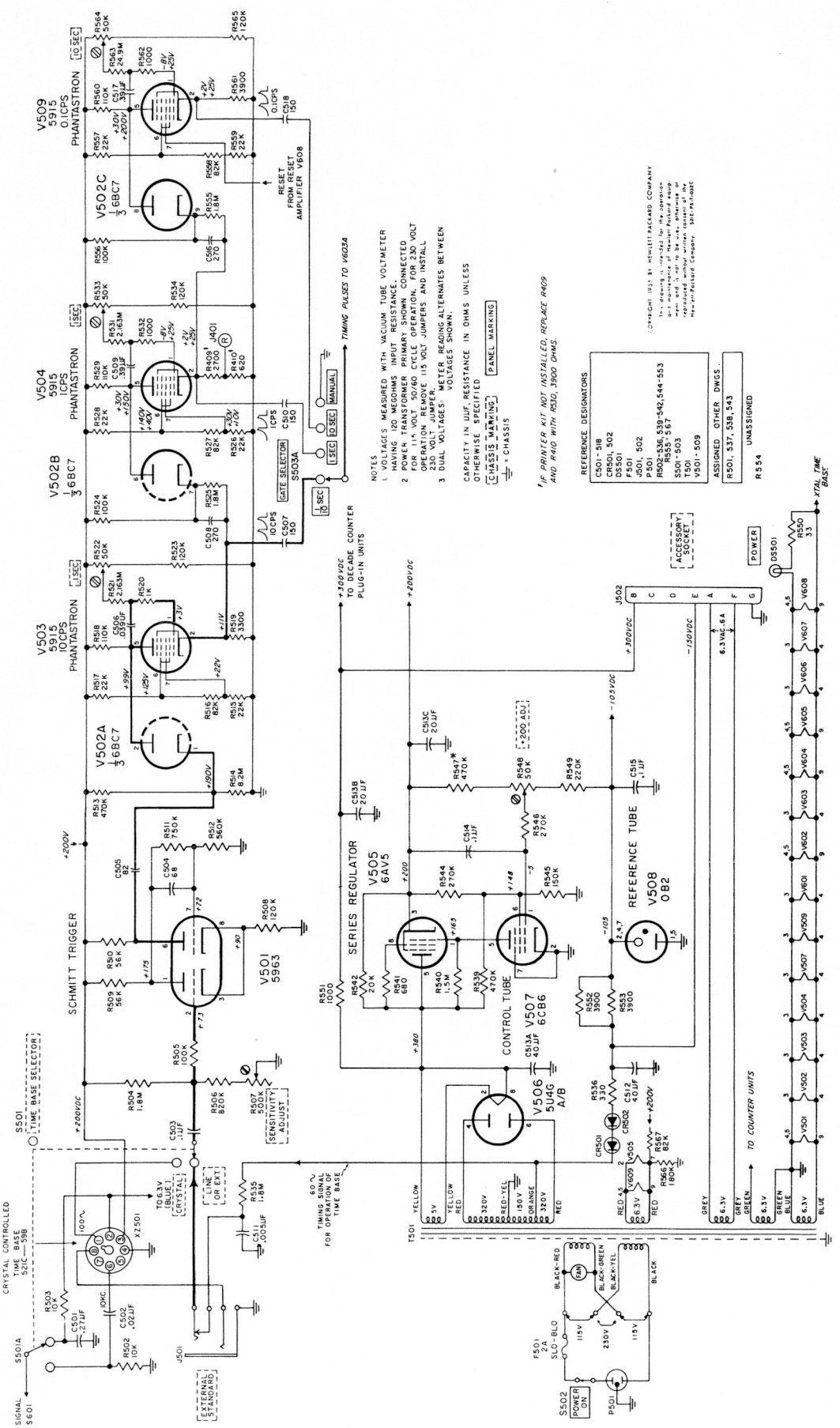


Figure 4-14. Model 521E Time Base/Power Supply Sections

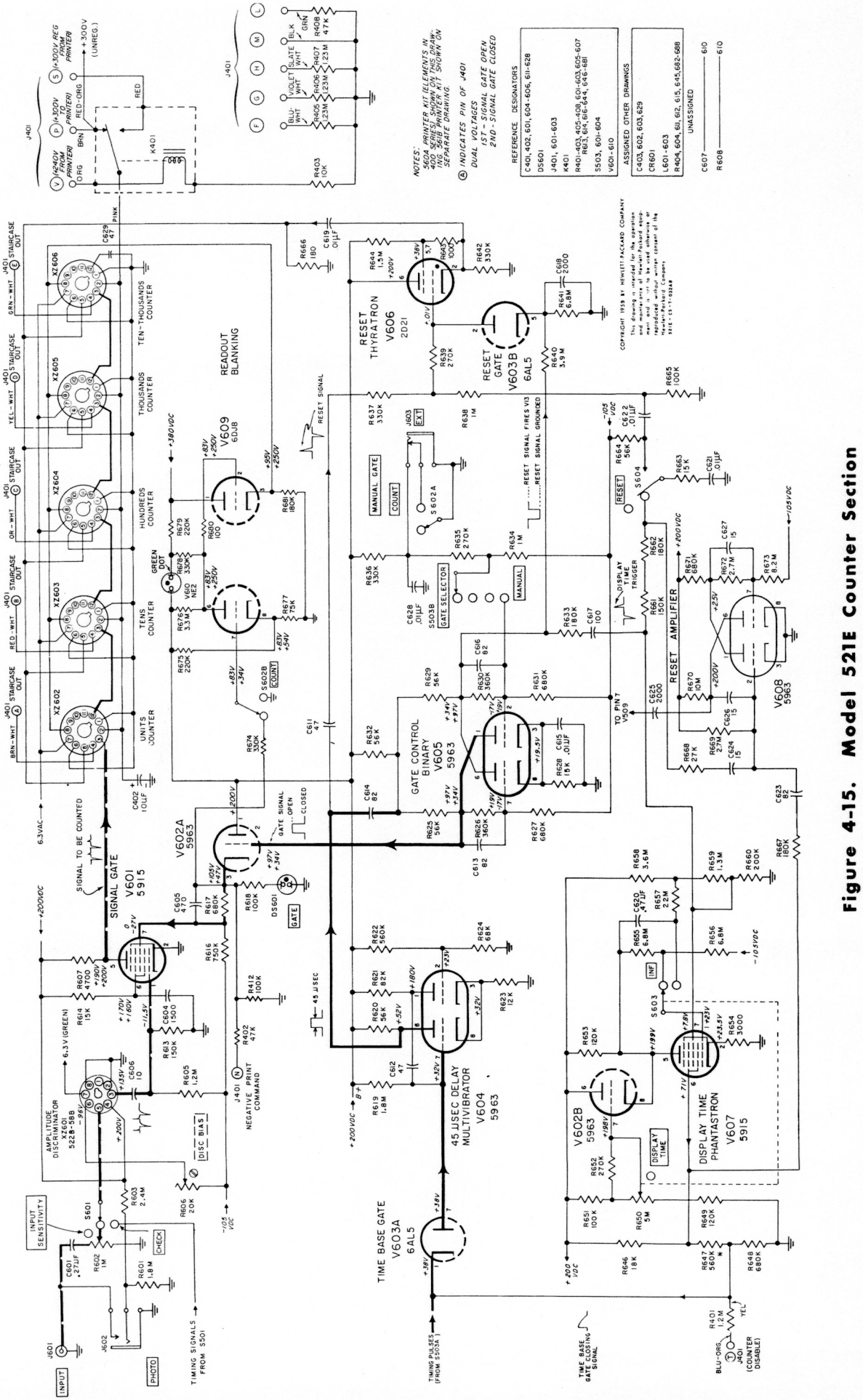


Figure 4-15. Model 521E Counter Section

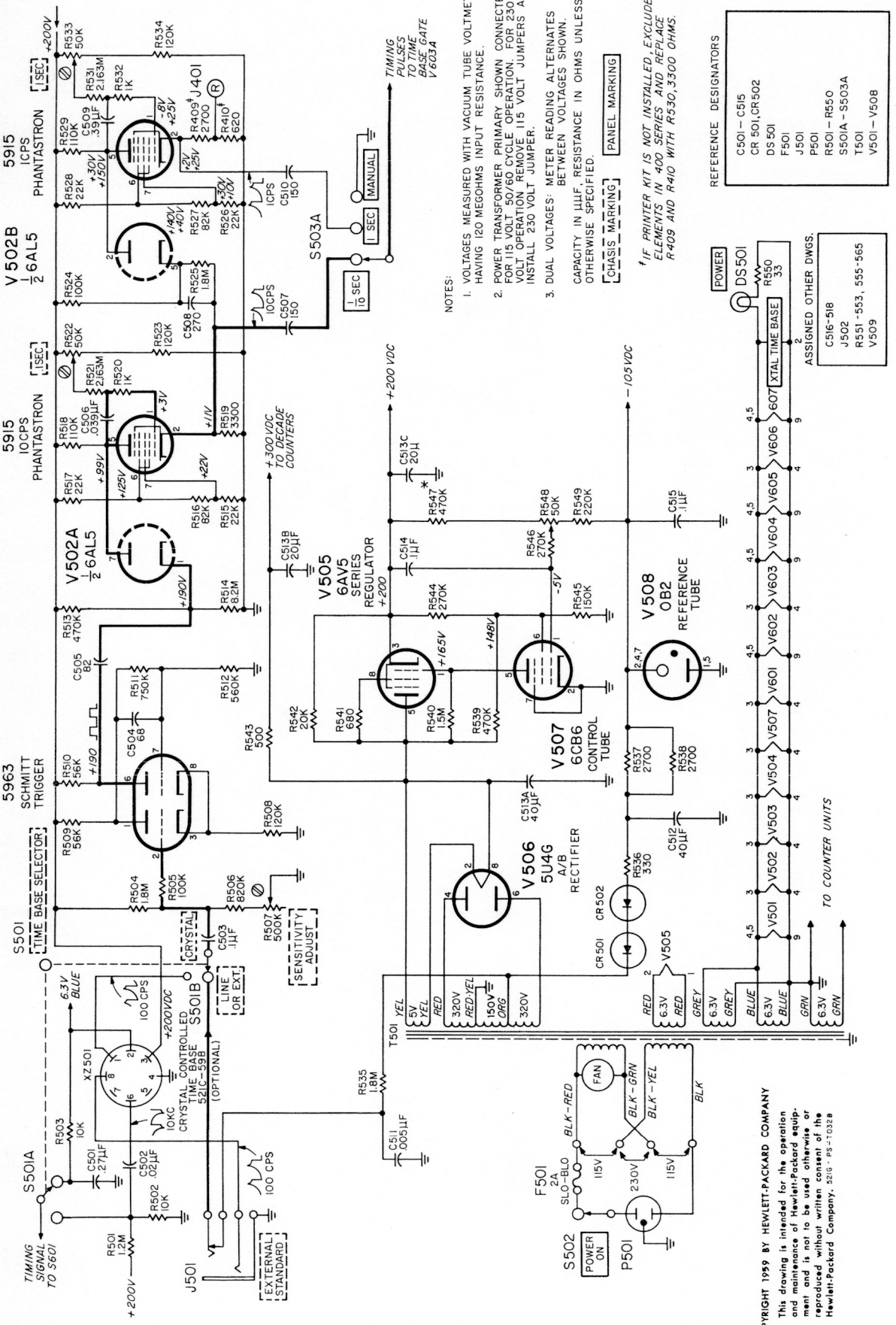


Figure 4-16. Model 521G Time Base/Power Supply Sections

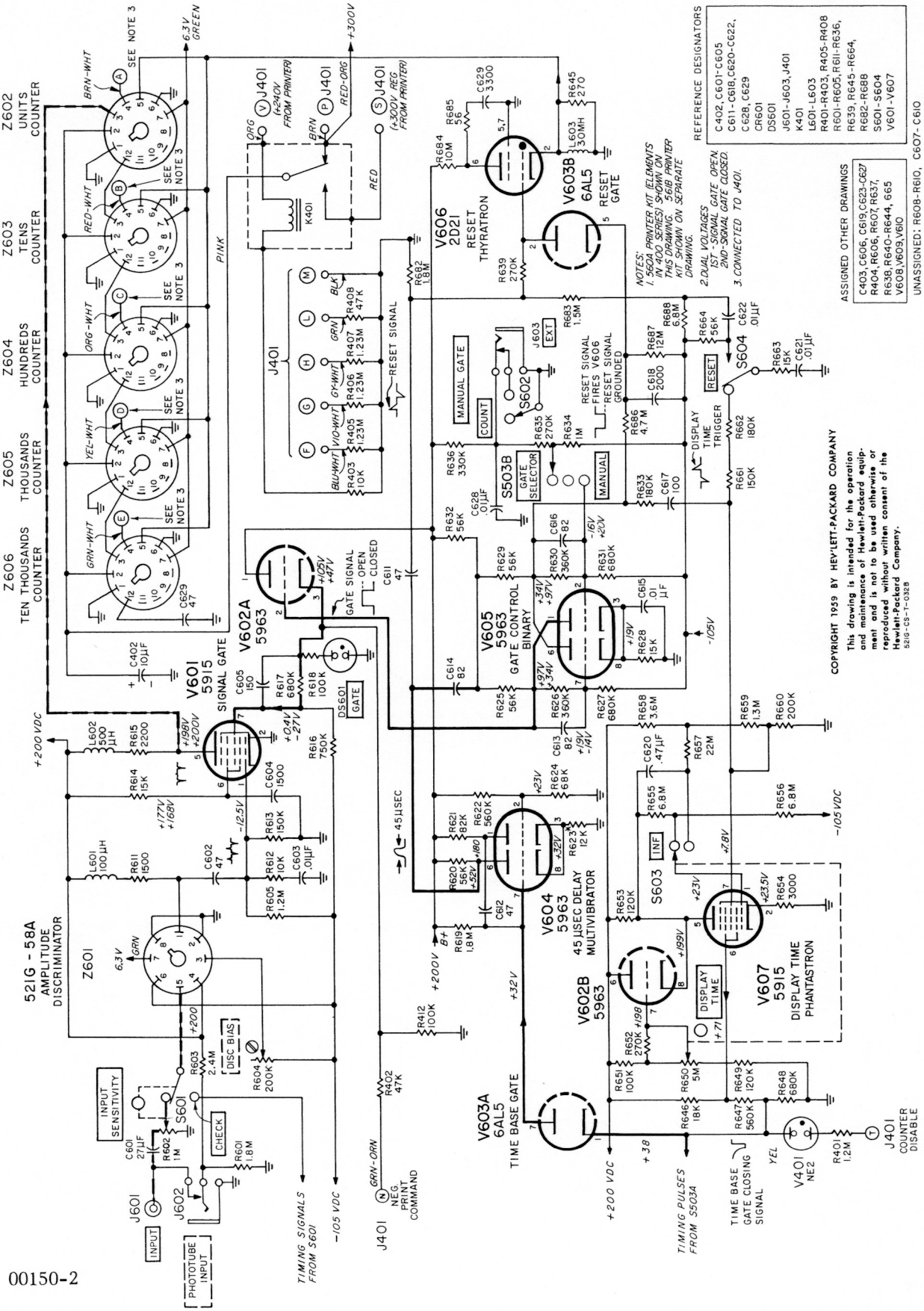
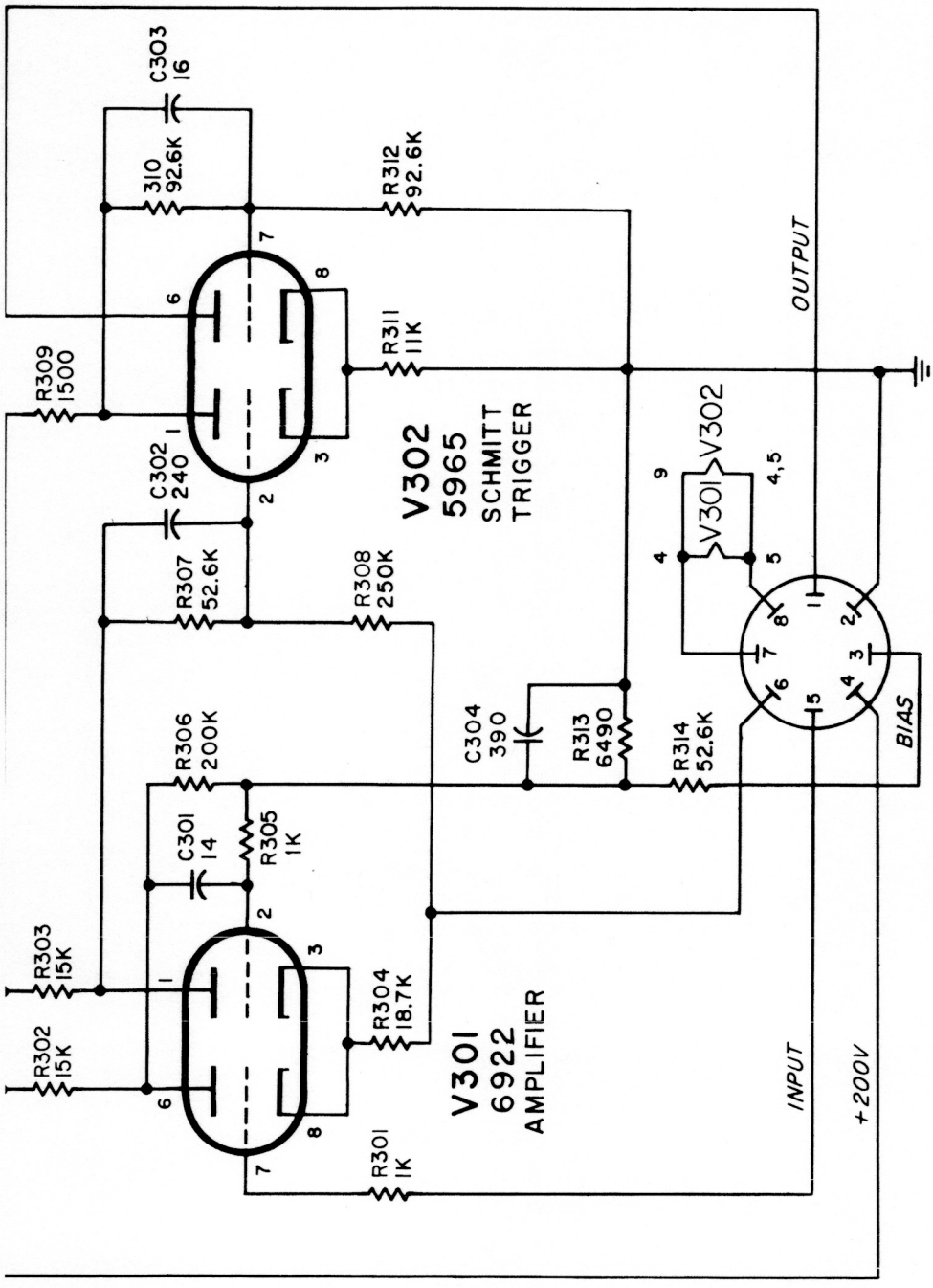


Figure 4-17. Model 521G Counter Section



REFERENCE DESIGNATORS

C301 – C304
R301 – R314
V301, V302

521G-58A INPUT DISCRIMINATOR

gure 4-18. Amplitude Discriminator for Model 521G

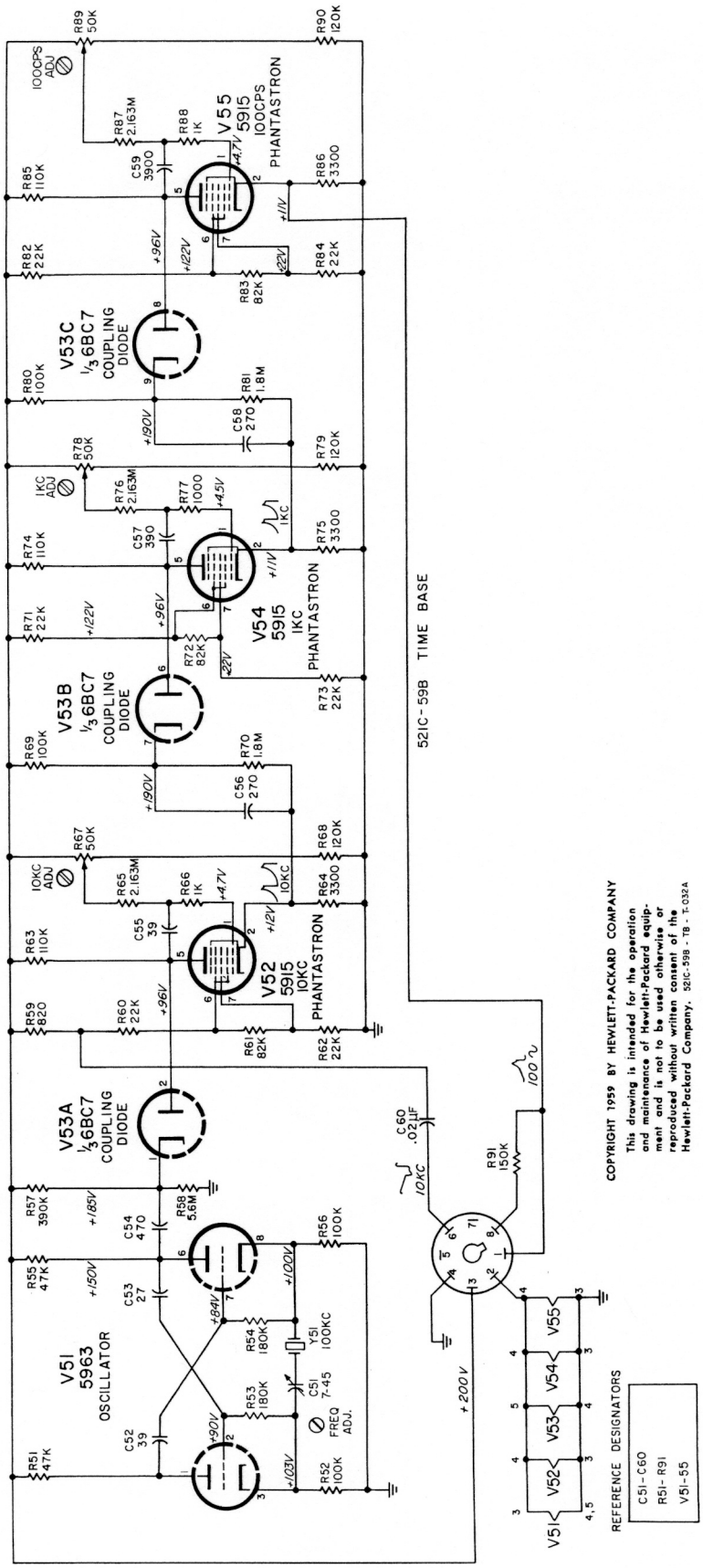


Figure 4-19. Crystal Time Base

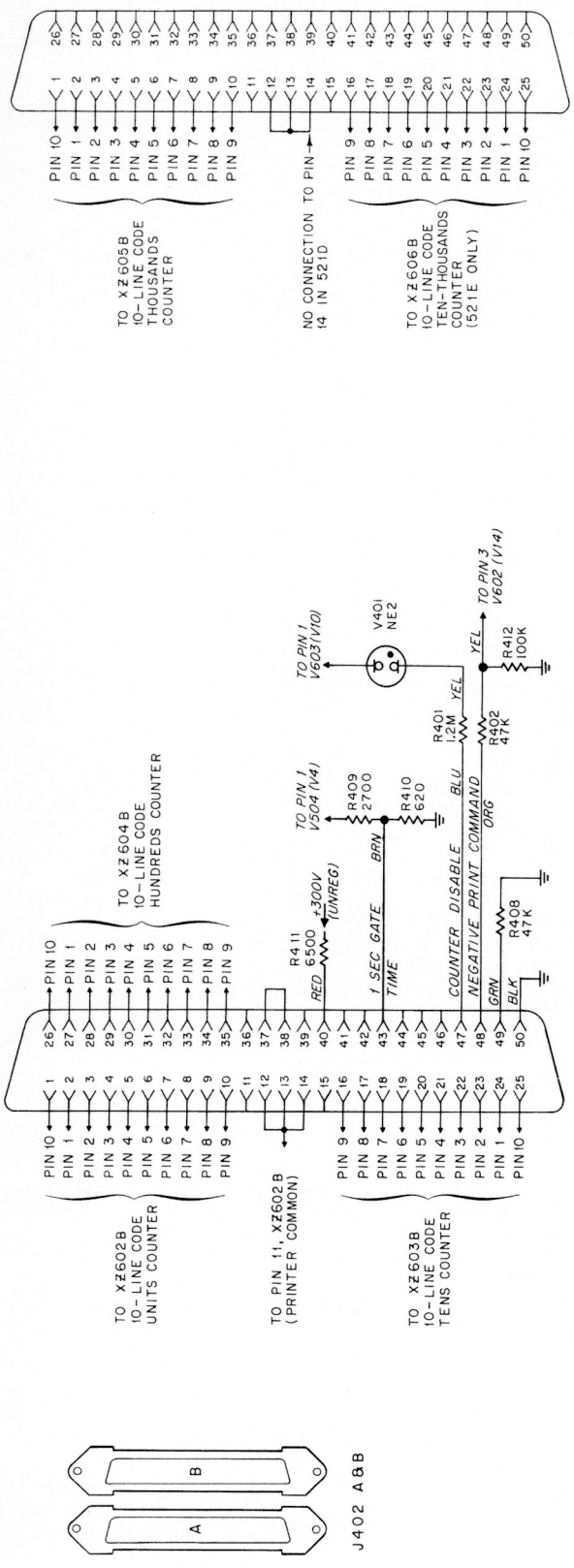


Figure 4-20. 561B Printer Kit

00150-2

SECTION V
TABLE OF REPLACEABLE PARTS

5-1 INTRODUCTION

This section contains information for ordering replacement parts for the Models 521A/C/D/E/G Electronic Counter.

Table 5-1 lists replaceable parts in alpha-numerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

1) Reference designator

2) Full description of the part

3) Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

4) Hewlett-Packard stock number

5) Total quantity used in the instrument (TQ col).

6) Recommended spare quantity for complete maintenance during one year of isolated service (RS col).

5-2 ORDERING INFORMATION

To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales office or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

Specify the following information for each part:

1) Model and complete serial number of instrument.

2) Hewlett-Packard stock number

3) Circuit reference designator

4) Description

To order a part not listed in table 5-1, give a complete description of the part and include its function and location.

Table 5-1. Replaceable Parts (Sheet 1 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
C1	Not assigned							
C2	Capacitor: fixed, mica, 22 pf ±5%, 500 vdcw	76433	0140-0034	2	2	2	0	
C3	Capacitor: fixed, ceramic, 0.01 μf ±20%, 1000 vdcw	56289	0150-0012	7	7	7	2	
C4	Same as C2							
C5	Same as C3							
C6 thru C50	Not assigned							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 2 of 22)

Ckt Ref	Description	Mfr *	ⓗp Stock No.	A/D	C/E	G	RS	
C51	Capacitor: variable, ceramic, 7-45 pf, 500 vdcw	72982	0130-0001	1	1	1	0	
C52	Capacitor: fixed, mica, 39 pf ±5%, 500 vdcw	76433	0140-0035	1	1	1	0	
C53	Capacitor: fixed, mica, 27 pf ±5%, 500 vdcw	00853	0140-0042	1	1	1	0	
C54	Capacitor: fixed, mica, 470 pf ±10%, 500 vdcw	76433	0140-0027	1	1	1	0	
C55	Capacitor: fixed, mica, 39 pf ±2%, 500 vdcw	76433	0140-0116	1	1	1	0	
C56	Capacitor: fixed, mica, 270 pf ±10%, 500 vdcw	00853	0140-0015	3	4	3	1	
C57	Capacitor: fixed, mica, 390 pf ±2%, 500 vdcw	76433	0140-0114	1	1	1	0	
C58	Same as C56							
C59	Capacitor: fixed, mica, 3900 pf ±2%, 500 vdcw	76433	0140-0015	1	1	1	0	
C60	Capacitor: fixed, ceramic, 0.02 μf ±10%, 600 vdcw	91418	0150-0024	2	2	2	0	
C61 thru C300	Not assigned							
C301	Capacitor: fixed, ceramic, 14 pf ±3%, 500 vdcw	72982	0150-0056	1	1	1	0	
C302	Capacitor: fixed, mica, 240 pf ±5%, 500 vdcw	00853	0140-0092	1	1	1	0	
C303	Capacitor: fixed, ceramic, 16 pf ±3%, 500 vdcw	72982	0150-0057	1	1	1	0	
C304	Capacitor: fixed, mica, 390 pf ±5%, 500 vdcw	76433	0140-0037	1	1	1	0	
C305 thru C401	Not assigned							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 3 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
C402	Capacitor: fixed, electrolytic, 10 μf ±50%, 450 vdcw (561A kit only)	37942	0180-0005	2	2	2	0	
C403	Same as C402 (561B kit only)							
C404 thru C500	Not assigned							
C501	Capacitor: fixed, paper, 0.27 μf ±10%, 200 vdcw	56289	0160-0039	1	1	1	1	
C502	Same as C60							
C503	Capacitor: fixed, paper, 0.1 μf ±10%, 400 vdcw	56289	0160-0013	3	3	3	1	
C504	Capacitor: fixed, mica, 68 pf ±10%, 500 vdcw	76433	0140-0025	1	1	1	1	
C505	Capacitor: fixed, mica, 82 pf ±10%, 500 vdcw	76433	0140-0006	4	5	4	1	
C506	Capacitor: fixed, polystyrene, 0.039 μf ±2%, 400 vdcw	02777	0170-0032	1	1	1	1	
C507	Capacitor: fixed, mica, 150 pf ±10%, 500 vdcw	76433	0140-0055	2	3	3	1	
C508	Same as C56							
C509	Capacitor: fixed, polystyrene, 0.39 μf ±2%, 400 vdcw	02777	0170-0031	1	2	1	1	
C510	Same as C507							
C511	Capacitor: fixed, ceramic, 0.005 μf, 500 vdcw	04222	0150-0014	1	1	1	1	
C512	Capacitor: fixed, electrolytic, 40 μf, 450 vdcw	56289	0180-0024	1	1	1	1	
C513	Capacitor: fixed, electrolytic, 4 sections, 20 μf/sect., 450 vdcw	56289	0180-0025	1	1	1	1	
C514, 515	Same as C503							
C516	Same as C56 (521C/E only)							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 4 of 22)

Ckt Ref	Description	Mfr *	hp Stock No.	A/D	C/E	G	RS	
C517	Same as C509 (521C/E only)							
C518	Same as C507 (521C/E only)							
C519 thru C600	Not assigned							
C601	Capacitor: fixed, paper, 0.27 μf -15% +20%, 600 vdcw	00853	0160-0041	1	1	1	1	
C602	Capacitor: fixed, mica, 47 pf ±10%, 500 vdcw (521G only)	76433	0140-0032	2	2	3	1	
C603	Same as C3 (521G only)							
C604	Capacitor: fixed, paper, 1500 pf ±10%, 600 vdcw	00853	0160-0012	1	1	1	1	
C605	Capacitor: fixed, mica, 470 pf ±10%, 500 vdcw (521A/C/D/E only)	76433	0140-0027	1	1		1	
C605	Same as C507 (521G only)							
C606	Capacitor: fixed, mica, 10 pf ±10%, 500 vdcw (521A/C/D/E only)	76433	0140-0002	1	1		1	
C607 thru C610	Not assigned							
C611, 612	Same as C602							
C613, 614	Same as C505							
C615	Same as C3							
C616	Same as C505							
C617	Capacitor: fixed, mica, 100 pf ±10%, 500 vdcw	00853	0140-0054	1	1	1	1	
C618	Capacitor: fixed, ceramic, 2000 pf ±20%, 1000 vdcw	91418	0150-0023	1	1	1	1	
C619	Same as C3 (521A/C/D/E only)							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 5 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
C620	Capacitor: fixed, paper, 0.47 μf ±10%, 200 vdcw	56289	0160-0015	1	1	1	1	
C621, 622	Same as C3							
C623	Same as C505 (521C/E only)							
C624	Capacitor: fixed, mica, 15 pf ±10%, 500 vdcw (521C/E only)	76433	0140-0004		3		1	
C625	Capacitor: fixed, mica, 2000 pf ±5%, 500 vdcw (521C/E only)	00853	0140-0086		1		1	
C626, 627	Same as C624 (521C/E only)							
C628	Same as C3							
C629	Capacitor: fixed, mica, 47 pf ±5%, 500 vdcw	76433	0140-0039	1	1	1	1	
CR1 thru CR500	Not assigned							
CR501, 502	Rectifier, metallic	81483	1880-0003	2	2	2	2	
DS1 thru DS500	Not assigned							
DS501	Lamp, incandescent: 6-8V, .15 amp, #47	24455	2140-0009	1	1	1	1	
DS502 thru DS600	Not assigned							
DS601	Lamp, neon: NE51, 1/25 W, 65 VAC, 90 vdcw	24455	2140-0006	1	1	1	1	
F1 thru F500	Not assigned							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 6 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
F501	Fuse, cartridge:							
	2 amp, 125V (115V operation)	71400	2110-0006	1	1	1	10	
	1 amp, 250V (230V operation)		2110-0007	1	1	1	0	
J1 thru J400	Not assigned							
J401	Connector, female: 19 pin (560A kit only)	02660	1251-0056	1	1	1	0	
J402A, 402B	Connector, female: 50 pin (561B kit only)	02660	1251-0101	2	2	2	0	
J403 thru J500	Not assigned							
J501	Jack, telephone: 3 plug	82389	1251-0070	1	1	1	1	
J502	Connector, female: 7 pin (521A/C/D/E only)	71468	1251-0047	1	1		1	
J503 thru J600	Not assigned							
J601	Connector, BNC: (rack only)	91737	1250-0001	1	1	1	0	
	(cabinet only)		1250-0083	1	1	1	1	
J602	Jack, telephone: NO	82389	1251-0072	1	1	1	1	
J603	Jack, telephone: NC	82389	1251-0066	1	1	1	1	
K1 thru K400	Not assigned							
K401	Relay, armature: DPDT (560A kit only)	77342	0490-0017	1	1	1	0	
L1 thru L600	Not assigned							
L601	Inductor, fixed: 100 μh (521G only)	99848	9140-0029			1	1	
L602	Inductor, fixed: 500 μh (521G only)	99848	9140-0022			1	1	
L603	Choke, pulse: 30 mh (521G only)	28480	9130-0001			1	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 7 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
P1	Connector, male: octal	02660	1251-0026	3	3	3	0	
P2 thru P50	Not assigned							
P51	Same as P1							
P52 thru P300	Not assigned							
P301	Same as P1							
P302 thru P500	Not assigned							
P501	Power cord	70903	8120-0015	1	1	1	1	
R1	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W Optimum value selected at factory Average value shown	01121	0690-5631	1	1	1	0	
R2	Resistor: variable, wirewound, linear taper, 500 ohms ±30%, 1/10 W	01121	2100-0078	1	1	1	0	
R3, 4	Not assigned							
R5	Resistor: fixed, composition, 15,000 ohms ±10%, 1 W	01121	0690-1531	2	2	2	0	
R6	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W	01121	0687-4731	6	6	6	0	
R7	Not assigned							
R8	Resistor: fixed, composition, 12,000 ohms ±10%, 1 W	01121	0690-1231	1	1	1	0	
R9	Not assigned							
R10	Same as R6							
R11	Same as R5							
R12 thru R50	Not assigned							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 8 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
R51	Same as R6							
R52	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W	01121	0687-1041	10	11	10	2	
R53, 54	Resistor: fixed, composition, 180,000 ohms ±10%, 1/2 W	01121	0687-1841	A=4 D=6	C=5 E=7	4	1	
R55	Same as R6							
R56	Same as R52							
R57	Resistor: fixed, composition, 390,000 ohms ±10%, 1/2 W	01121	0687-3941	1	1	1	0	
R58	Resistor: fixed, composition, 5.6 megohms ±10%, 1/2 W	01121	0687-5651	1	1	1	0	
R59	Resistor: fixed, composition, 820 ohms ±10%, 1/2 W	01121	0687-8211	1	1	1	0	
R60	Resistor: fixed, composition, 22,000 ohms ±10%, 2 W	01121	0693-2231	5	6	5	1	
R61	Resistor: fixed, composition, 82,000 ohms ±5%, 1/2 W	01121	0686-8235	5	6	5	1	
R62	Resistor: fixed, composition, 22,000 ohms ±5%, 1/2 W	01121	0686-2235	5	6	5	1	
R63	Resistor: fixed, composition, 110,000 ohms ±5%, 1 W	01121	0689-1145	5	6	5	1	
R64	Resistor: fixed, composition, 3300 ohms ±5%, 1/2 W	01121	0686-3325	5	5	5	1	
R65	Resistor: fixed, deposited carbon, 2.163 megohms ±1%, 1 W	19701	0730-0113	5	5	5	1	
R66	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121	0687-1021	7	8	6	1	
R67	Resistor: variable, composition, 50,000 ohms ±20%, 1/3 W	71450	2100-0084	3	3	3	1	
R68	Resistor: fixed, composition, 120,000 ohms ±10%, 1/2 W	01121	0687-1241	8	9	8	2	
R69	Same as R52							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 9 of 22)

Ckt Ref	Description	Mfr *	ⓗ Stock No.	A/D	C/E	G	RS	
R70	Resistor: fixed, composition, 1.8 megohms ±10%, 1/2 W	01121	0687-1851	6	7	7	1	
R71	Same as R60							
R72	Same as R61							
R73	Same as R62							
R74	Same as R63							
R75	Same as R64							
R76	Same as R65							
R77	Same as R66							
R78	Same as R67							
R79	Same as R68							
R80	Same as R52							
R81	Same as R70							
R82	Same as R60							
R83	Same as R61							
R84	Same as R62							
R85	Same as R63							
R86	Same as R64							
R87	Same as R65							
R88	Same as R66							
R89	Same as R67							
R90	Same as R68							
R91	Resistor: fixed, composition, 150,000 ohms ±10%, 1/2 W	01121	0687-1541	3	3	3	1	
R92 thru R300	Not assigned							
R301	Same as R66							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 10 of 22)

Ckt Ref	Description	Mfr *	ⓗ Stock No.	A/D	C/E	G	RS	
R302, 303	Resistor: fixed, metal film, 15,000 ohms ±5%, 3 W	07115	0767-0010	2	2	2	0	
R304	Resistor: fixed, metal film, 18,700 ohms ±2%, 1 W	19701	0760-0003	1	1	1	0	
R305	Resistor: fixed, composition, 1000 ohms ±5%, 1/2 W	01121	0686-1025	1	1	1	0	
R306	Resistor: fixed, deposited carbon, 200,000 ohms ±1%, 1 W	19701	0727-0221	1	1	1	0	
R307	Resistor: fixed, deposited carbon, 52,600 ohms ±1%, 1/2 W	19701	0727-0196	2	2	2	0	
R308	Resistor: fixed, deposited carbon, 250,000 ohms ±1%, 1/2 W	19701	0727-0226	1	1	1	0	
R309	Resistor: fixed, composition, 1500 ohms ±5%, 1/2 W	01121	0686-1525	1	1	1	0	
R310	Resistor: fixed, deposited carbon, 92,600 ohms ±1%, 1/2 W	19701	0727-0205	2	2	2	0	
R311	Resistor: fixed, composition, 11,000 ohms ±5%, 2 W	01121	0692-1135	1	1	1	0	
R312	Same as R310							
R313	Resistor: fixed, deposited carbon, 6490 ohms ±1%, 1/2 W	19701	0727-0143	1	1	1	0	
R314	Same as R307							
R315 thru R400	Not assigned							
R401	Resistor: fixed, composition, 1.2 megohms ±10%, 1 W	01121	0690-1251	1	1	1	0	
R402	Same as R6							
R403	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W (560A kit only)	01121	0693-1031	1	1	1	0	
R404 thru R407	Resistor: fixed, deposited carbon, 1.23 megohms ±1%, 1/2 W (560A kit only)	19701	0730-0108	4	4	4	0	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 11 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
R408	Same as R6							
R409	Resistor: fixed, composition, 2700 ohms ±5%, 1/2 W	01121	0686-2725	1	1	1	0	
R410	Resistor: fixed, composition, 620 ohms ±5%, 1/2 W	01121	0686-6215	1	1	1	0	
R411	Resistor: fixed, metal film, 6500 ohms ±5%, 3 W (561B kit only)	07115	0767-0006	1	1	1	0	
R412	Same as R52							
R413 thru R500	Not assigned							
R501	Resistor: fixed, composition, 1.2 megohms ±10%, 1/2 W (521G only)	01121	0687-1251	1	1	2	1	
R502, 503	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W	01121	0687-1031	2	2	3	1	
R504	Same as R70							
R505	Same as R52							
R506	Resistor: fixed, composition, 820,000 ohms ±10%, 1/2 W	01121	0687-8241	1	1	1	1	
R507	Resistor: variable, composition, linear taper, 500,000 ohms ±20%	71590	2100-0015	1	1	1	1	
R508	Same as R68							
R509	Resistor: fixed, composition, 56,000 ohms ±5%, 1/2 W	01121	0686-5635	1	1	1	1	
R510	Resistor: fixed, composition, 56,000 ohms ±10%, 1/2 W	01121	0687-5631	4	4	4	1	
R511	Resistor: fixed, composition, 750,000 ohms ±5%, 1/2 W	01121	0686-7545	1	1	1	1	
R512	Resistor: fixed, composition, 560,000 ohms ±5%, 1/2 W	01121	0686-5645	1	1	1	1	
R513	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W	01121	0687-4741	2	2	2	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 12 of 22)

Ckt Ref	Description	Mfr *	ⓗ Stock No.	A/D	C/E	G	RS	
R514	Resistor: fixed, composition, 8.2 megohms± 10%, 1/2 W	01121	0687-8251	1	2	1	1	
R515	Same as R62							
R516	Same as R61							
R517	Same as R60							
R518	Same as R63							
R519	Same as R64							
R520	Same as R66							
R521	Same as R65							
R522	Resistor: variable, composition, 50,000 ohms ±10%	01121	2100-0028	2	3	2	1	
R523	Same as R68							
R524	Same as R52							
R525	Same as R70							
R526	Same as R62							
R527	Same as R61							
R528	Same as R60							
R529	Same as R63							
R530	Same as R64							
R531	Same as R65							
R532	Same as R66							
R533	Same as R522							
R534	Same as R68							
R535	Same as R70							
R536	Resistor: fixed, wirewound, 330 ohms ±10%, 5 W	35434	0813-0011	1	1	1	1	
R537, 538	Resistor: fixed, composition, 2700 ohms ±10%, 2 W (521G only)	01121	0693-2721			2	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 13 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
R539	Resistor: fixed, composition, 470,000 ohms ±10%, 1 W	01121	0690-4741	1	1	1	1	
R540	Resistor: fixed, composition, 1.5 megohms ±10%, 1/2 W	01121	0687-1551	2	2	2	1	
R541	Resistor: fixed, composition, 680 ohms ±10%, 1/2 W	01121	0687-6811	1	1	1	1	
R542	Resistor: fixed, metal film, 20,000 ohms ±10%, 4 W	07115	0771-0004	1	1	1	1	
R543	Resistor: fixed, wirewound, 500 ohms ±10%, 20 W (521G only)	35434	0819-0005			1	1	
R544	Resistor: fixed, composition, 270,000 ohms ±10%, 1/2 W	01121	0687-2741	5	5	5	2	
R545	Resistor: fixed, composition, 150,000 ohms ±10%, 1 W	01121	0690-1541	1	1	1	1	
R546	Same as R544							
R547	Same as R513 Optimum value selected at factory Average value shown							
R548	Resistor: variable, composition, 50,000 ohms ±20%	01121	2100-0013	1	1	1	1	
R549	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W	01121	0687-2241	A=1 D=3	C=1 E=3	1	1	
R550	Resistor: fixed, composition, 33 ohms ±10%, 1 W	01121	0690-3301	1	1	1	1	
R551	Resistor: fixed, wirewound, 1000 ohms ±10%, 20 W	35434	0819-0006	1	1	1	1	
R552, 553	Resistor: fixed, composition, 3900 ohms ±10%, 2 W	01121	0693-3921	2	2	2	1	
R554	Not assigned							
R555	Same as R70 (521C/E only)							
R556	Same as R52 (521C/E only)							
R557	Same as R60 (521C/E only)							

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 14 of 22)

Ckt Ref	Description	Mfr *	ⓗp Stock No.	A/D	C/E	G	RS	
R558	Same as R61 (521C/E only)							
R559	Same as R62 (521C/E only)							
R560	Same as R63 (521C/E only)							
R561	Resistor: fixed, composition, 3900 ohms ±5%, 1/2 W (521C/E only)	01121	0686-3925		1		1	
R562	Same as R66 (521C/E only)							
R563	Resistor: fixed, composition, 24.9 megohms ±1%, 1 W (521C/E only)	19701	0730-0148		1		1	
R564	Same as R522 (521C/E only)							
R565	Same as R68 (521C/E only)							
R566	Same as R53 (521D/E only)							
R567	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W (521D/E only)	01121	0687-8231	D=1	E=1		1	
R568 thru R600	Not assigned							
R601	Resistor: fixed, composition, 1.8 megohms ±5%, 1/2 W	01121	0686-1855	1	1	1	1	
R602	Resistor: variable, composition, 1 megohm ±30%, (includes S601)	71590	2100-0132	1	1	1	1	
R603	Resistor: fixed, composition, 2.4 megohms ±5%, 1/2 W	01121	0686-2455	1	1	1	1	
R604	Resistor: variable, composition, 200,000 ohms ±20% (521G only)	01121	2100-0014			1	1	
R605	Same as R501							
R606	Resistor: variable, composition, 20,000 ohms ±20% (521A/C/D/E only)	12697	2100-0012	1	1		1	
R607	Resistor: fixed, composition, 4700 ohms ±10%, 1 W (521A/C/D/E only)	01121	0690-4721	1	1		1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 15 of 22)

Ckt Ref	Description	Mfr *	Stock No.	A/D	C/E	G	RS	
R608 thru R610	Not assigned							
R611	Resistor: fixed, composition, 1800 ohms ±10%, 1/2 W (521G only)	01121	0687-1821			1	1	
R612	Same as R502 (521G only)							
R613	Same as R91							
R614	Resistor: fixed, composition, 15,000 ohms ±10%, 2 W	01121	0693-1531	1	1	1	1	
R615	Resistor: fixed, composition, 2200 ohms ±10%, 1/2 W (521G only)	01121	0687-2221			1	1	
R616	Resistor: fixed, composition, 750,000 ohms ±5%, 1/2 W	01121	0686-7545	1	1	1	1	
R617	Resistor: fixed, composition, 680,000 ohms ±5%, 1/2 W	01121	0686-6845	3	3	3	1	
R618	Same as R52							
R619	Same as R70							
R620	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W	01121	0690-5631	2	2	2	1	
R621	Resistor: fixed, composition, 82,000 ohms ±10%, 1 W	01121	0690-8231	1	1	1	1	
R622	Resistor: fixed, composition, 560,000 ohms ±10%, 1/2 W	01121	0687-5641	2	2	2	1	
R623	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W Optimum value selected at factory Average value shown	01121	0687-1531	1	1	1	1	
R624	Resistor: fixed, composition, 68,000 ohms ±10%, 1/2 W	01121	0687-6831	1	1	1	1	
R625	Same as R510							
R626	Resistor: fixed, composition, 360,000 ohms ±5%, 1/2 W	01121	0686-3645	2	2	2	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 16 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
R627	Same as R617							
R628	Resistor: fixed, composition, 15,000 ohms ±10%, 1/2 W	01121	0687-1531	2	2	2	1	
R629	Same as R510							
R630	Same as R626							
R631	Same as R617							
R632	Same as R620							
R633	Same as R53							
R634	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W	01121	0687-1051	2	2	1	1	
R635	Same as R544							
R636	Resistor: fixed, composition, 330,000 ohms ±10%, 1/2 W	01121	0687-3341	A=3 D=5	C=3 E=5	1	1	
R637	Same as R636 (521A/C/D/E only)							
R638	Same as R634 (521A/C/D/E only)							
R639	Same as R544							
R640	Resistor: fixed, composition, 3.9 megohms ±10%, 1/2 W (521A/C/D/E only)	01121	0687-3951	1	1		1	
R641	Resistor: fixed, composition, 6.8 megohms ±10%, 1/2 W (521A/C/D/E only)	01121	0687-6851	3	3	3	1	
R642	Same as R636 (521A/C/D/E only)							
R643	Same as R66 (521A/C/D/E only)							
R644	Same as R540 (521A/C/D/E only)							
R645	Resistor: fixed, composition, 270 ohms ±10%, 1 W (521G only)	01121	0687-2711			1	1	
R646	Resistor: fixed, composition, 18,000 ohms ±10%, 2 W	01121	0693-1831	1	1	1	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 17 of 22)

Ckt Ref	Description	Mfr *	ⓗp Stock No.	A/D	C/E	G	RS	
R647	Same as R622 Optimum value selected at factory Average value shown							
R648	Resistor: fixed, composition, 680,000 ohms ±10%, 1/2 W	01121	0687-6841	1	2	1	1	
R649	Same as R68							
R650	Resistor: variable, composition, 5 megohms (includes S603)	71450	2100-0066	1	1	1	1	
R651	Same as R52							
R652	Same as R544							
R653	Same as R68							
R654	Resistor: fixed, composition, 3000 ohms ±5%, 1 W	01121	0689-3025	1	1	1	1	
R655, 656	Same as R641							
R657	Resistor: fixed, composition, 22 megohms ±10%, 1/2 W	01121	0687-2261	1	1	1	1	
R658	Resistor: fixed, composition, 3.6 megohms ±5%, 1/2 W	01121	0686-3655	1	1	1	1	
R659	Resistor: fixed, composition, 1.3 megohms ±5%, 1/2 W	01121	0686-1355	1	1	1	1	
R660	Resistor: fixed, composition, 200,000 ohms ±5%, 1/2 W	01121	0686-2045	1	1	1	1	
R661	Same as R91							
R662	Same as R53							
R663	Same as R628							
R664	Same as R510							
R665	Same as R52							
R666	Resistor: fixed, composition, 180 ohms ±10%, 1/2 W (521A/C/D/E only)	01121	0687-1811	1	1		1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 18 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
R667	Same as R53 (521C/E only)							
R668	Resistor: fixed, composition, 27,000 ohms ±10%, 1/2 W (521C/E only)	01121	0687-2731		1		1	
R669	Resistor: fixed, composition, 2.7 megohms ±10%, 1/2 W (521C/E only)	01121	0687-2751		2		1	
R670	Resistor: fixed, composition, 10 megohms ±10%, 1/2 W (521C/E only)	01121	0687-1061		1	1	1	
R671	Same as R648 (512C/E only)							
R672	Same as R669 (512C/E only)							
R673	Same as R514 (521C/E only)							
R674	Same as R636 (521D/E only)							
R675	Same as R549 (521D/E only)							
R676	Resistor: fixed, composition, 3.3 megohms ±10%, 1/2 W (521D/E only)	01121	0687-3351	D=1	E=1		1	
R677	Resistor: fixed, composition, 75,000 ohms ±5%, 1/2 W (521D/E only)	01121	0686-7535	D=1	E=1		1	
R678	Same as R636 (521D/E only)							
R679	Same as R549 (521D/E only)							
R680	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W (521D/E only)	01121	0687-1011	D=1	E=1		1	
R681	Same as R53 (521D/E only)							
R682	Same as R70 (521G only)							
R683	Same as R540 (521G only)							
R684	Same as R670 (521G only)							
R685	Resistor: fixed, composition, 56 ohms ±10%, 1/2 W (521G only)	01121	0687-5601			1	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 19 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
R686	Resistor: fixed, composition, 4.7 megohms ±10%, 1/2 W (521G only)	01121	0687-4751			1	1	
R687	Resistor: fixed, composition, 12 megohms ±10%, 1/2 W (521G only)	01121	0687-1261			1	1	
R688	Same as R641 (521G only)							
S1 thru S500	Not assigned							
S501	Switch, toggle: DPDT	04009	3101-0005	2	2	2	1	
S502	Switch, toggle: SPST, 3 amp, 250V	04009	3101-0001	1	1	1	1	
S503	Switch, rotary: 4 pole, 3 position (521A/D/G only)	76854	3100-0109	1		1	1	
S503	Switch, rotary: (521C/E only)	76854	3100-0146				1	
S504 thru S600	Not assigned							
S601	Part of R602							
S602	Same as S501							
S603	Part of R650							
S604	Switch, push button: SPDT	82389	3101-0014	1	1	1	1	
T1 thru T500	Not assigned							
T501	Transformer, power	28480	9100-0061	1	1	1	1	
V1, 2	Tube, electron: 5963	80131	1932-0008	7	8	7	4	
V3 thru V50	Not assigned							
V51	Same as V1							
V52	Tube, electron: 5915	80131	1924-0001	3	3	3	0	
V53	Tube, electron: 6BC7	80131	1939-0002	1	2	1	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 20 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
V54, 55	Same as V52							
V56 thru V300	Not assigned							
V301	Tube, electron: 6922	80131	1932-0015	1	1	1	0	
V302	Tube, electron: 5965	80131	1932-0009	1	1	1	0	
V303 thru V400	Not assigned							
V401	Lamp, neon: NE2	24455	2140-0008	1	1	1	0	
V402 thru V500	Not assigned							
V501	Same as V1							
V502	Tube, electron: 6AL5 (521A/D/G only)	80131	1930-0013	1		1	1	
V502	Same as V53 (521C/E only)							
V503, 504	Tube, electron: 5915	80131	1924-0001	4	5	4	4	
V505	Tube, electron: 6AV5GA	80131	1923-0023	1	1	1	1	
V506	Tube, electron: 5U4GA/B	80131	1930-0008	1	1	1	1	
V507	Tube, electron: 6BC6	80131	1923-0028	1	1	1	1	
V508	Tube, electron: OB2	80131	1940-0007	1	1	1	1	
V509	Same as V503 (521C/E only)							
V510 thru V600	Not assigned							
V601	Same as V503							
V602	Same as V1							
V603	Tube, electron: 6AL5	80131	1930-0013	1	1	1	1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 21 of 22)

Ckt Ref	Description	Mfr *	℗ Stock No.	A/D	C/E	G	RS	
V604, 605	Same as V1							
V606	Tube, electron: 2D21	80131	1941-0005	1	1	1	1	
V607	Same as V503							
V608	Same as V1 (521C/E only)							
V609	Tube, electron: 6DJ8 (521D/E only)	80131	1932-0022	D=1	E=1		1	
V610	Lamp, neon: aged and selected, green code (521D/E only)	28480	G-84D	D=1	E=1		1	
XF1 thru XF500	Not assigned							
XF501	Holder, fuse: extractor post type	75915	1400-0084	1	1	1	1	
Y1 thru Y50	Not assigned							
Y51	Crystal unit, quartz	28480	0410-0021	1	1	1	0	
Z1 thru Z500	Not assigned							
Z501	Crystal Time Base (521C/E only)	28480	521C-59B		1		1	
Z502 thru Z600	Not assigned							
Z601	Amplitude Discriminator (521A/C/D/E only)	28480	522B-58B	1	1		1	
Z601	Amplitude Discriminator (521G only)	28480	521G-58A			1	1	
Z602 thru Z606	Decade Counter Unit (521A/C only)	28480	AC-4G	A=4	C=5		1	
Z602 thru Z606	Decade Counter Unit (521D/E only)	28480	AC-4K	D=4	E=5		1	

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 22 of 22)

Ckt Ref	Description	Mfr *	ℌ Stock No.	A/D	C/E	G	RS	
Z602	Decade Counter Unit (521G only)	28480	AC-4E			1	1	
Z603 thru Z605	Decade Counter Unit (521G only)	28480	AC-4G			4	1	
	MISCELLANEOUS							
	Air filter (rack) (cabinet)	28480 28480	3150-0004 3150-0006	1	1	1	1	
	Blade, fan: CW	06812	3160-0011	1	1	1	1	
	Knob: INPUT SENSITIVITY, DISPLAY TIME	28480	G-74K	2	2	2	0	
	Knob: GATE SELECTOR	28480	G-74N	1	1	1	0	
	Motor: AC	73793	3140-0010	1	1	1	1	
	Oil, for air filter	28480	3150-0002	1	1	1	1	
	Socket: 9 pin	71785	1200-0008	5	5	5	1	
	Socket: 7 pin min.	91662	1200-0009	9	9	9	1	
	Socket: octal	02660	1200-0020	4	4	4	1	
	Socket: 12 pin	02660	1200-0038	8	8	8	1	

* See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04404	Dymec Inc.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
10646	Carborundum Co.	Niagara Falls, N.Y.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	Chicago Telephone Supply Co.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78790	Transformer Engineers	Pasadena, Calif.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80130	Times Facsimile Corp.	New York, N.Y.

From: F.S.C. Handbook Supplements
H4-1 Dated July 1960
H4-2 Dated Oct. 1960

00015-4
Revised 15 March 1961

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Spencer Thermostat, Div. of Texas Instruments, Inc.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div.	Newton, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics, Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000A	Amp, Inc.	Hawthorne, Calif.
0000B	Chicago Telephone of Calif.	S. Pasadena, Calif.
0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000D	Connex Corp.	Oakland, Calif.
0000E	Fisher Switches, Inc.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000G	Microwave Engineering Co.	Palo Alto, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000J	Ti Tal, Inc.	Berkeley, Calif.
0000K	Transitron Electronic Sales Corp.	Wakefield, Mass.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000R	Metro Cap. Div., Metropolitan Telecommunications Corp.	Brooklyn, N.Y.
0000S	Moulton Electronics	San Carlos, Calif.

00015-4
Revised 15 March 1961

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H4-1 Dated July 1960
H4-2 Dated Oct. 1960

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"