## 524C/D ELECTRONIC COUNTER

### OPERATING AND SERVICE MANUAL



#### CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

#### WARRANTY AND ASSISTANCE

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#### OPERATING AND SERVICE MANUAL

# MODELS 524C/524D ELECTRONIC COUNTERS

MODEL 524C--SERIALS PREFIXED 234-AND SERIAL NUMBERS 141-04326 TO 141-04725

MODEL 524D-SERIALS PREFIXED 141-

This manual applies directly to the standard \$\overline{\pi}\$ Model 524C and 524D Electronic Counters listed above.

MODEL 524C--SERIAL NUMBERS 141-04325 AND BELOW MODEL 524C AND 524D--SERIALS PREFIXED 116-, 042-, 029-, 018-, 004-, 429-, OR 249-; OR SERIAL NUMBER 447 AND BELOW.

Table 6-1 lists the changes required to make this manual apply to these older instruments.

#### OPTIONS 01 AND 02

These currently available options are described in Section VI,

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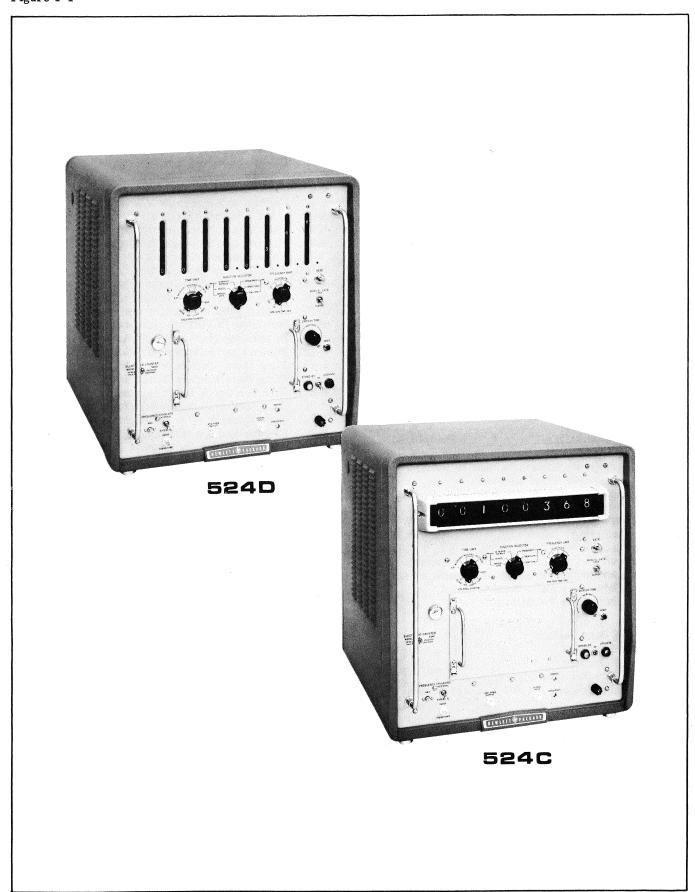


Figure 1-1. Model 524C and 524D Electronic Counters

### SECTION I GENERAL DESCRIPTION

#### 1-1. INTRODUCTION.

The Models 524C and 524D Electronic Counters are precision counters which can measure frequencies to 10.1 megacycles and display the readings in digital form on an eight-place indicating system. In addition to making direct frequency measurements, the counters can measure period, frequency ratio, and total events. The counters can also count random events such as encountered in nuclear work. A self-check feature enables an operator to verify instrument operation for most types of measurements.

The internal oscillator of the 524C and 524D is stable within 5 parts in  $10^8$  per week. Thus these counters are good secondary frequency standards and in many cases can replace more elaborate installations.

To increase the range of measurement of Model 524C and 524D Electronic Counters, seven accessory plug-in units are presently available. These plug-in units, their functions and specifications, are shown in figures 1-4 through 1-10. (If earlier-type plug-ins are to be used with the counters described in this manual, see paragraph 1-9 for a small modification which should be made.) In addition to the plug-ins, the Model 540B Transfer Oscillator also is available as a companion instrument. The transfer oscillator extends the frequency range of a Model 524C or 524D equipped with a 525B or 525C Frequency Converter to at least 12.4 gigacycles.



Figure 1-2. Model 540B Transfer Oscillator

The Models 524C and 524D are identical except for type of readout. The 524C uses eight in-line digital display tubes behind a light filter, and can blank the readout during count time. The 524D uses eight numbered masks, illuminating one number in each mask; the readout is visible at all times.

The text and illustrations throughout this manual refer primarily to the 524D. However, they apply equally well to the 524C except where specifically noted.

The text and illustrations throughout this manual refer primarily to the 524D. However, they apply equally well to the 524C except where specifically noted.

The text and schematic diagrams included in this manual cover all circuits except the AC-4 Decade Counter plug-in units. The AC-4 Decade Counter units are covered in a separate Operating and Servicing Manual.

#### 1-2. BASIC OPERATING PRINCIPLES.

A. MEASURING FREQUENCY. Figure 1-2 shows the basic circuit arrangement of the Model 524D Electronic Counter. For frequency measurement the signal is fed through a Signal Gate to a series of digital type counters. A precision time interval obtained from the Time Base Section opens and closes the Signal Gate for an extremely accurate period of time, for example, 1 second. The counters count the number of cycles entering through the gate during the 1-second interval and then display the total. The answer is read directly as the number of kilocycles occurring during the 1-second interval. The period of time the Signal Gate remains open is set by the FREQUENCY UNIT switch. For each position of the FREQUENCY UNIT switch the illuminated decimal point is automatically positioned so that the answer is always read directly in kilocycles per second. The answer is automatically displayed for a period of time determined by gate time or the setting of the DISPLAY TIME control on the front panel, whichever is greater.

B. MEASURED PERIOD. To measure period or time interval the 524D reverses the application of the two signals as shown by the dotted line in figure 1-2. The period or time interval to be measured is connected to open and close the Signal Gate while one of the standard frequencies from the Time Base Section is passed through the Signal Gate to the counters. When measuring period, one cycle of the incoming signal opens the gate, the next cycle closes it. The number of cycles of the standard frequency from the Time Base

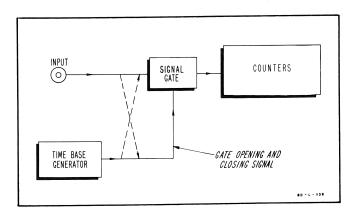


Figure 1-3. Basic Diagram of 524D

Section I
Paragraphs 1-3 to 1-9

that occurred during the period are then indicated on the counters. The standard frequencies obtained from the Time Base have been selected so that the answer to the measured period will always be displayed in direct-reading units of time: seconds, milliseconds, or microseconds.

Provision is also made in the circuit to permit measurement of the average of 10 periods of the unknown frequency. Higher accuracy can thus be obtained than with period measurements.

#### 1-3. ACCESSORIES FURNISHED OR AVAILABLE.

One 4-foot AC-16K Cable Assembly is supplied with each 524D ordered, except that when the 526B Time Interval Unit is part of the order, two identical 4-foot video cords are supplied.

Two special connector cables are required for completing the necessary electrical connections to a plug-in unit when it has to be removed from the main instrument for tests and adjustments. Special 13-1/2 inch long test cables for this purpose, equipped with pairs of 8- or 16-connector Amphenol type plugs, are available from the factory. Specify \$\infty\$ 524B-16Q (8 contact) and hp 524B-16P (16 contact) when ordering.

#### 1-4. COOLING SYSTEM.

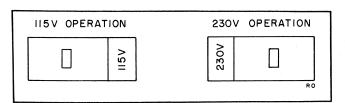
The 524D uses a forced-air cooling system. Air intake and filter are located at the rear of the instrument. For adequate ventilation, allow at least 3 inches clearance about the filter and cabinet louvers. Keep the filter clean. Inspect the element regularly and if filter is dirty, clean it. See paragraph 4-4.

The instrument is provided with an internal thermal cutout (TC201) to prevent overheating. See figure 4-13 for location. If normal air flow is restricted by a dirty air filter or inadequate ventilation around the cabinet, TC201 will be activated. Excessively high ambient temperature will also activate TC201.

Remove cause of excessive temperature, allow instrument to cool, and reset TC201. A plug button in the side of the cabinet can be removed to reset TC201.

#### 1-5. 230-VOLT OPERATION.

A switch located on the instrument rear converts the Model 524C/D for use from either a 115-volt or 230-volt, 50-60 cps power source. The switch changes the connections of the dual primary windings of the power transformers and the dual primary windings of the crystal oven heater transformer from parallel combinations to series combinations, or vice versa. Switch positions are marked 115 and 230.



To convert the instrument from a 115-volt operation to 230-volt operation, or vice versa, proceed as follows:

- a. Remove air filter from rear cover.
- b. Insert a screwdriver into the switch slot and slide the slot until the marking indicates the desired line voltage.
  - c. Remove screwdriver and re-install air filter.
- d. Replace the line fuse. A 6.25 amperes slow-blow fuse should be used for 115-volt operation; a 3.2 amperes slow-blow fuse should be used for 230-volt operation.

#### **CAUTION**

Be sure the 115/230V switch is set at the proper position before applying power to the instrument. Incorrect setting of the switch can result in damage to the instrument.

#### 1-6. POWER CABLE.

To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate recepacle, grounds the instrument. The offset pin on the power cable three-prong connector is the ground wire.

To preserve the protection feature when operating instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to ground.

#### 1-7. UNPACKING AND INSPECTION...

If shipping carton is damaged, ask that carrier's agent be present when instrument is unpacked. Inspect instrument for damage (scratches, dents, broken knobs, etc.). If instrument is damaged or fails Performance Check (Paragraph 4-5), notify carrier and nearest Hewlett-Packard sales and service office immediately. (Sales and service offices are listed at the back of this manual.) Retain shipping carton and padding material for carrier's inspection. The sales and service office will arrange for repair or replacement of instrument without waiting for claim against carrier to be settled.

#### 1-8. DECADE COUNTER INFORMATION.

The plug-in Decade Counter Units (Z1200 through Z1206) are described in a separate manual, "AC-4 DECADE COUNTERS" Operating and Service Manual (supplied).

#### 1-9. PLUG-IN MODIFICATIONS.

Early units of the p Model 525 and 526 series Plug-ins had a 100K ohm resistor connected between pins 1 and 5 of P101, the 8-contact connector that mates with J202, the forward connector in the Counter Plug-in opening. For maximum sensitivity this resistor should be replaced with a 22K ohm  $\pm 10\%$ , 1/2 Watt resistor p Part 0687-2231). The 22K resistor value is standard in later Plug-in units.

#### Table 1-1. Specifications

Basic Unit for Frequency Measurements, 0 cps to 10.1 mc

FREQUENCY MEASUREMENT (without plug-in units)

Range:

10 cps to 10.1 mc

Gate Time:

0.001, 0.01, 0.1, 1, 10 seconds or manual control

Accuracy:

±1 count ± time base accuracy

Reads In:

Kilocycles; decimal point automatically positioned

PERIOD MEASUREMENT (without plug-in units)

Range:

0 cps to 100 kc

Gate Time:

1 or 10 cycles of unknown

Accuracy:

±1 count ±time base accuracy ±trigger error\*

\*Trigger error =  $\frac{\pm 0.3\% \text{ of period}}{\text{periods av.}}$ 

for signals with 40 db signal

to noise ratio

Reads In:

Seconds, milliseconds, or microseconds; decimal point automatically

positioned

Standard Frequency Counted:

10 cps, 1 kc, 100 kc, or 10 mc, or externally applied frequency

**GENERAL** 

Registration:

524C, 8 places in-line; 524D, 8 places (99, 999, 999 maximum display)

Stability:

 $\pm 5$  parts in  $10^8$  per week;  $\pm 3$  parts in  $10^8$  short term. External 100 kc

or 1 mc primary standard may be used

Display Time:

Variable 0.1 to 10 seconds but not less than gate time; display can be

held indefinitely

Output Frequencies:

Secondary standard frequencies available at front panel; 10 cps, 1 kc

rectangular; 100 kc positive pulse; 10 mc sine wave (stability as above)

Crystal Oven:

Temperature monitored by dial thermometer

Self Check:

Panel control provides automatic count of internal standard 100 kc and

10 mc frequencies to assure accuracy of gate and proper operation of

counter.

Input Voltage:

1 volt rms minimum/1.5 volt peak. Rise time 0.2 sec (or faster)

Input Impedance:

Approximately 1 megohm, 40 pf shunt capacitance

External Standard:

100 kc or 1 mc signal from external primary standard can be applied to unit for highest accuracy. 2 volts rms required. Input impedance,

nominal: 56K, 40 pf shunt

Connectors:

BNC Type

Power Supply:

115/230 volts  $\pm 10\%$ , 50-60 cps, approximately 600 watts

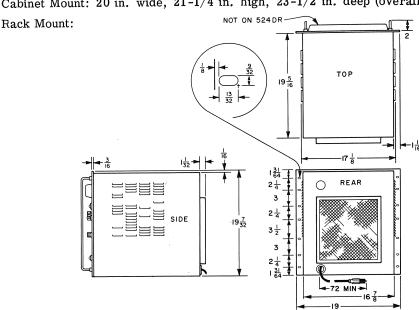
524CR/DR

Table 1-1. Specifications (Cont'd)



Dimensions:

Cabinet Mount: 20 in. wide, 21-1/4 in. high, 23-1/2 in. deep (overall)



Weight:

Cabinet Mount: Net 118 lbs (53 Kg). Shipping 153 lbs (69 Kg)

Rack Mount: Net 108 lbs (49 Kg). Shipping 153 lbs (69 Kg)

Accessory Furnished:

₱ 10503A Cable Assembly, 48 in. RG-58/U cable, terminated each end with UG-88/U BNC male connectors.

Complementary Equipment: (for 524C and 524D)

- m Model 540B Transfer Oscillator (cabinet)
- Model P932A Harmonic Mixer
- model 560A Digital Recorder (cabinet, 8 operating columns). Requires 524D-95A Kit or Option 01
- Model 562A Digital Recorder (8 columns operation, depends on Options or modification, see Section VI).

(for 524C):

Model 561B Digital Recorder (cabinet, 11 operating columns) Requires 524C-95B Kit or Option 02.

Accessories Available: (for 524C and 524D)

- 69 524D-95A Model 560A Digital Recorder Kit for field installation
- @ 524C-95E Model 562A Digital Recorder Kit for field installation

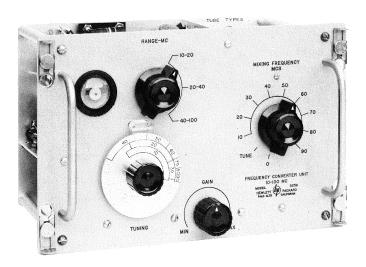
Test Cable Set to interconnect  $\Phi$  524 and 525/526 units during test and adjustment of auxiliary units: specify \$\phi\$ 524B-16P, 16-conductor cable and \$\oplus 524B-16Q\$, 8-conductor cable

(for 524C/CR only):

- ₱ 524C-95B, Model 561B Digital Recorder Kit for field installation; with 6-foot cable, 562A-16C
- ⊕ K05-524C Remote Indicator (requires 524C-95B Kit and K07-524C) cable)
- @ K07-524C Cable for remote indicator; 100 feet maximum

Options: (see Section VI for details)

- 01: Single-line voltage coded decimal output (staircase) for operating ₱ 560A Digital Recorder; consists of ₱ 524D-95A Kit installed and tested at factory. Output connector is MS 3102A-22-14S
- 02 (for 524C/CR only): 10-line decimal code output for operating @ 561B Digital Recorder or @ K05-524C Remote Indicator; consists of Amphenol 57-20500



The Model 525A Frequency Converter Unit increases the frequency range of a 524C/D from 10.1 mc to 100 mc

#### SPECIFICATIONS when plugged into 6 524C/D:

Range: As amplifier, 10 cps to 10.1 mc. As converter, 10.1 mc to 100 mc

Accuracy: Retains accuracy of 524 counter

Registration: 8 places; first place indicated on converter selector switch labeled

0, 10, 20 ... 90; next 7 indicated by counter

Resolution: 0.1 cycle to 1000 cycles, depending on gate time

Input Voltage: 0.1 volt to 10 volts rms, 10 cps to 10 mc; 10 mv to 1 volt rms, 10 mc

to 100 mc

Input Impedance: Approximately 1 megohm shunted by 40 pf, 10 cps to 10 mc; approxi-

mately 50 ohms, 10 mc to 100 mc

Level Control: Tuning eye aids frequency selection; indicates correct voltage level

adjustment

Weight: Net 5 lbs (2 Kg). Shipping 8 lbs (4 Kg).

Accessory Available: 

10504A Transit Case, with carrying handle

Figure 1-4. Model 525A Frequency Converter Unit



The Model 525B Frequency Converter Unit enables a  $524\,C/D$  to measure frequencies between 100 mc and 220 mc

#### 

Range:

100 mc to 220 mc

Accuracy:

Retains accuracy of 524 counter

Registration:

9 places; first two places indicated on converter selector switch

labeled 100, 110, 120 ... 210, next 7 indicated by counter

Resolution:

0.1 cycle to 1000 cycles, depending on gate time

Input Voltage:

0.2 volt rms minimum

Tuning Indicator:

Tuning eye aids frequency selection, indicates correct voltage

Input Impedance:

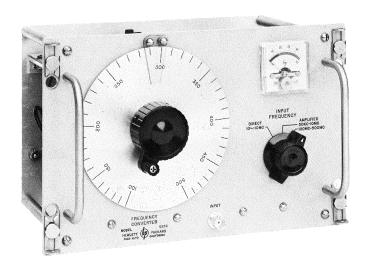
Approximately 50 ohms

Weight:

Net 5 lbs (2 Kg). Shipping 8 lbs (4 Kg).

Accessory Available:

10504A Transit Case, with carrying handle



The Model 525C Frequency Converter Unit enables a 524C/D to measure frequencies between 100 mc and 510 mc

#### SPECIFICATIONS when plugged into @ 524C/D

Range:

As converter for counter, 100 mc to 510 mc. As amplifier for counter

50 kc to 10.1 mc. Direct connection for 0 to 10.1 mc

Accuracy:

Retains accuracy of 524 counter

Registration:

9 places; first 2 places indicated on converter dial, next 7 displayed

by counter

Resolution:

0.1 cycle to 1000 cycles, depending on gate time

Input Voltage:

20 mv rms minimum, 50 kc to 10.1 mc; 100 mv rms minimum, 100 mc

to 510 mc

Maximum Input:

2 volts rms from 50 kc to 10.1 mc and 100 mc to 510 mc

Input Impedance:

Approximately 700 ohms, 50 kc to 10.1 mc; approximately 50 ohms,

100 mc to 510 mc

Level Indicator:

Meter aids frequency selection; indicates usable voltage level

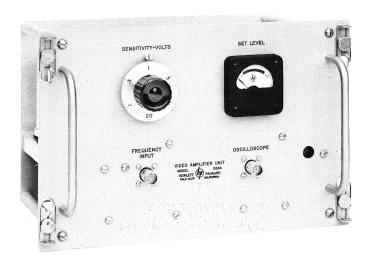
Weight:

Net 6-1/2 lbs (3 Kg). Shipping 11 lbs (5 Kg).

Accessory Available:

@ 10504A Transit Case, with carrying handle

Figure 1-6. Model 525C Frequency Converter Unit



The Model 526A Video Amplifier Unit increases the sensitivity of a 524C/D to 10 mv in the range from 10 cps to 10.1 mc

#### SPECIFICATIONS when plugged into @ 524C/D

Range: 10 cps to 10.1 mc

Accuracy: Retains accuracy of 524 counter

Minimum Input Voltage: Approximately 10 mv rms

Level Control: Meter indicates input signal level, correct voltage adjustment

Output Terminal: BNC connector provides 10 times input voltage from 93-ohm source on

the most sensitive range. Allows oscilloscope monitoring of input signal

without loading circuit

Reads In: Same as basic 524 counter

Accessory Furnished: Supplied with 10504A probe assembly which increases input im-

pedance to 10 megohms shunted by 15 pf: maximum sensitivity using

probe is 0.1 volt rms

Accessory Available: \$\ointileq 10504A\$ Transit Case, with carrying handle

Weight: Net 5 lbs (2 Kg). Shipping 7 lbs (3 Kg).

Figure 1-7. Model 526A Video Amplifier Unit



The Model 526B Time Interval Unit enables a 524C/D to measure time intervals from 1 microsecond to  $10^7$  seconds

#### SPECIFICATIONS when plugged into @ 524C/D

Range: 1 use

1 usec to 10<sup>7</sup> seconds

Accuracy:

±1 period of standard frequency counted, ±time base accuracy

Registration:

On 524 counter

Input Voltage:

1 volt peak minimum, direct-coupled input

Input Impedance:

Approximately 1 megohm, 40 pf shunt

Start Stop:

Independent or common channels

Trigger Slope:

Positive or negative on start and/or stop channels

Trigger Amplitude:

Both channels continuously adjustable from -192 to +192 volts

Standard

Frequency Counted:

10 cps, 1 or 100 kc; 10 mc from hp 524 or externally applied frequency

Reads In:

Seconds, milliseconds or microseconds; decimal point automatically

positioned

Accessory Furnished:

10503A Cable Assembly, 42 in. RG-58/U cable terminated on one

end with UG-88/U BNC connector

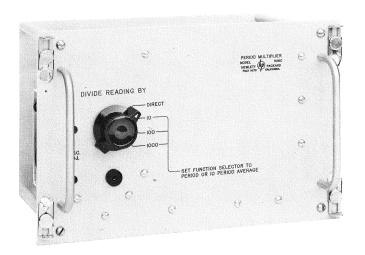
Accessory Available:

10504A Transit Case, with carrying handle

Weight:

Net 5 lbs (2 Kg). Shipping 7 lbs (3 Kg).

Figure 1-8. Model 526B Time Interval Unit



The Model 526C Period Multiplier Unit extends the period measurement range of a 524C/D up to 10,000 periods of the unknown frequency

#### SPECIFICATIONS when plugged into \$\oplus 524C/D\$

Range:

0 to 100 kc

Gate Time:

1, 10, 100, 1000, and 10,000 cycles of the unknown frequency

Accuracy:

±1 count, ± time base accuracy ± trigger error

Standard

Frequency Counted:

10 cps, 1 kc, 100 kc, 10 mc or externally applied frequency

Reads In:

Seconds, milliseconds, microseconds

Input Voltage:

1.0 volt rms minimum

Input Impedance:

1 megohm, 40 pf shunt

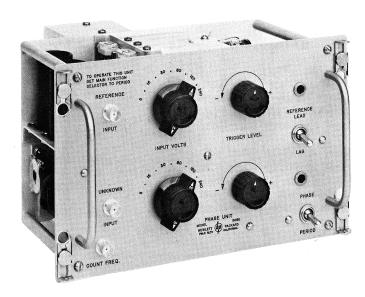
Weight:

Net 5 lbs (2 Kg). Shipping 7 lbs (3 Kg).

Accessory Available:

10504A Transit Case, with carrying handle

Figure 1-9. Model 526C Period Multiplier Unit



The Model 526D Phase Unit enables a 524C/D to measure phase angle with resolution approaching ±0.1°

#### SPECIFICATIONS when plugged into @ 524C/D

Phase angle, 0 - 3600 lead or lag Range:

Frequency Range: 1 cps to 20 kc

> Reads In: Time units with maximum resolution of  $0.1~\mu$ second for full frequency

range. For frequencies 396-404 cps, a 3600-times frequency multi-

plier provides direct reading in tenths of degrees.

Accuracy:

 $\pm\,[\,0.5\,^\circ\,+\,(F_p/F_c\,+F_p\,x\,10^6)\,\,x\,360\,^\circ\,]$  where  $F_p$  is frequency of phase-measured signal, and  $F_c$  is counted frequency ... assuming noise 65 db below signal and negligible counted frequency error. S/N ratio influnences accuracy; accuracy diminishes somewhat below 350 cps when ac coupled; for highest accuracy both inputs should be coupled in same mode, ac or  $\mbox{dc.}$ 

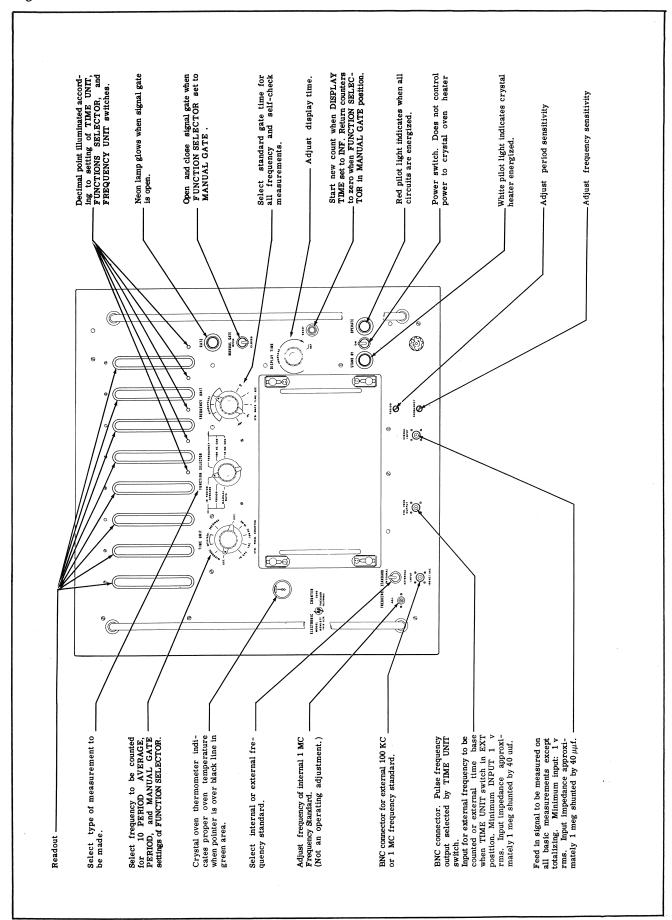
For example, a 400-cps measurement, using the 3600 times frequency multiplier, accuracy would be:  $\pm 0.1^{\circ} \pm (400/1.44 \times 10^{6}) 360^{\circ}$ , or ±0.20. For a 1000 cps phase angle measurement, counting 10 mc, would have a maximum error of  $\pm 0.1^{\circ} \pm (1000/10^{7}) 360^{\circ}$ , or  $\pm 0.136^{\circ}$ 

5 to 120 volts, rms. Usable to 240 volts rms Input Voltage:

Input Impedance: Approximately 1 megohm, 70 pf shunt

> Weight: Net 5 lbs (2 Kg). Shipping 10 lbs (5 Kg).





### SECTION II OPERATING INSTRUCTIONS

#### 2-1. OSCILLATOR ACCURACY.

The internal oscillator of the 524D is set within 5 parts in  $10^8$  of 1 mc at the factory. To check the accuracy of the oscillator in the field, use a standard at least this accurate. To check the drift of the oscillator, use a standard at least ten times more stable than the 524D oscillator. If such a standard is not available, do not attempt to adjust the 524D oscillator.

Signals broadcasted by stations WWV and WWVH are often used as frequency standards. The accuracy of the signals at the transmitter is within 1 part in  $10^8$ . However, atmospheric conditions produce Doppler shifts, limiting the accuracy for short-period comparisons to about 3 parts in  $10^7$ . To approach the accuracy of the signal at the transmitter, comparisons should be made over a period of at least 24 hours with special comparison equipment. Complete details for checking and adjusting the 524D oscillator are given in the maintenance section (section IV).

#### 2-2. CRYSTAL STABILITY.

If the temperature of an oscillator crystal changes, there are mechanical stresses set up within the crystal which affect its resonant frequency. Returning the crystal to its original temperature does not immediately remove these stresses and return the crystal to its original stability. The 524D oscillator may require as much as a week to return to rated stability (5 parts in  $10^8$  per week) after the crystal oven has been allowed to cool. Operating the crystal helps remove the stresses so it is desirable to run the oscillator during part of the recovery period. (The oscillator runs only when the power switch is ON.)

To maintain oscillator stability, KEEP THE INSTRU-MENT CONNECTED TO THE POWER SOURCE AT ALL TIMES. With the instrument in stand-by (power switch in the OFF position), the crystal oven remains in operation and keeps the crystal at its operating temperature.

#### CAUTION

After connecting the instrument to a power source, watch the crystal oven thermometer. If the pointer overshoots the green area, DISCONNECT THE COUNTER FROM THE POWER SOURCE IMMEDIATELY. See section IV for oven replacement.

#### 2-3. FREQUENCY MEASUREMENTS.

The accuracy of frequency measurements is determined by an internal oscillator (to use an external oscillator, see paragraph 2-8), and by a possible error of ±1 count that is inherent in the gate and counter type of instrument. The accuracy of frequency measurements is shown graphically as part of the

Procedure for Frequency Measurement. At low frequencies, greater accuracy can be obtained by measuring the period of the signal than by measuring the frequency directly. See figure 2-6.

The basic 524D measures frequencies up to 10.1 mc. The block diagram, figure 2-2, shows the circuit arrangement of the basic counter when measuring frequencies in this range. To measure frequencies up to 510 mc, one of three frequency converter units is This arrangement is shown in the block diagram, figure 2-3. The 525A Frequency Converter Unit\* is used for frequency measurements up to 100 mc, the 525B Frequency Converter Unit is used between 100 mc and 220 mc and the 525C Frequency Converter Unit is used between 100 mc and 510 mc. In these frequency converters the input signal is mixed with a harmonic of 10 mc so that the difference between the signal and the harmonic is not more than 10.1 mc. The difference frequency is counted and displayed by adding the count displayed by the counter to the known 10-mc harmonic.

All three frequency converters have tuning systems to indicate the correct mixing frequency. However, if the mixing frequency is within 1 mc of the unknown frequency, there is a possibility of ambiguity, for you may not know whether to add or subtract the displayed reading from the mixing frequency. In such cases, make additional measurements using the two adjacent mixing frequencies to determine the unknown frequency. When making the final measurement choose a mixing frequency which is at least 100 kc away from the unknown.

\*If plug-in is an earlier model, see paragraph 1-9.

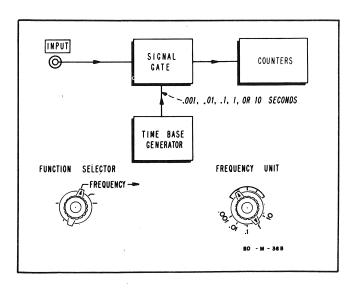


Figure 2-2. Block Diagram, Frequency Measurements below 10 Megacycles

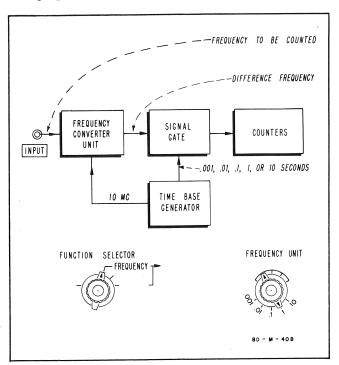


Figure 2-3. Block Diagram of 524D, Frequency Measurements above 10 Megacycles

When measuring frequency, the 524D will count sine waves, rectangular waves, and positive pulses. To measure the frequency of negative pulses, you must adjust the FREQUENCY sensitivity control (R211). The FREQUENCY sensitivity control is a screwdriver adjustment located on the front panel. To make the adjustment, proceed as follows:

- 1) Set the FUNCTION SELECTOR to FREQUENCY.
- 2) Set the FREQUENCY UNIT switch to .001.
- 3) Set the DISPLAY TIME control for minimum display time.
- 4) Connect a signal which contains only negative pulses to the SIGNAL INPUT connector.
- 5) Adjust the FREQUENCY sensitivity control clockwise until the counter starts to count the signal. Set the control slightly beyond this point. This completes the adjustment. To return the control to its normal setting, see paragraph 4-12.

#### 2-4. PERIOD MEASUREMENTS.

The 524D is also arranged so that it can directly measure the period of the frequency to be measured. When set for period measurements, the time base and the signal input circuits are interchanged from their frequency measurement positions, as shown in figure 2.4. With the circuits so connected, the counters count the output of the time base for the period of the unknown input signal. Thus the standard frequencies generated in the time base are used as units of time to measure the unknown period in terms of microseconds, milliseconds, or seconds.

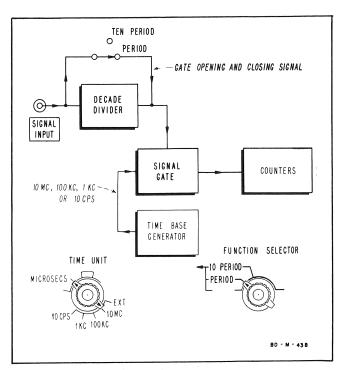
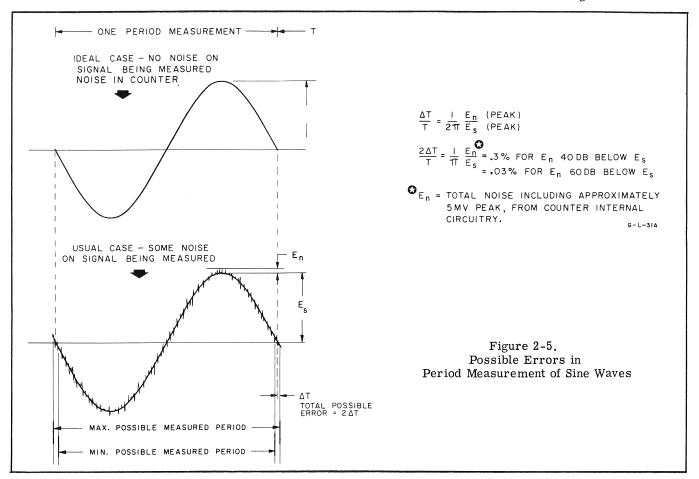


Figure 2-4. Block Diagram of 524D, Period Measurements

The accuracy of period measurements is largely determined by the accuracy with which triggering occurs at the same point on consecutive cycles of signal voltages having a slow rate-of-rise. Figure 2-5 shows the error in triggering for a single period measurement of a sine wave. Note that as the signal-to-noise ratio improves, the triggering accuracy also improves. Averaged over ten periods, the single-period error is reduced by a factor of ten. If you use the 526C Period Multiplier Unit, the error is reduced an additional factor of ten for each factor of ten you extend measurement. The accuracy of triggering is considerably improved when the waveforms being measured have a fast rise time. For example, you can obtain a significant reduction in error if you apply square waves instead of sine waves to the input.

Figure 2-6 graphically shows the ultimate accuracy of the 524D, with and without the 526C Period Multiplier Unit, over the range from 0.001 cps to 10 mc. The section of the graph between 10 cps and 100 kc is of particular interest because frequency and period measurements overlap in this region. For the more accurate type of measurement in this region, you must consider waveform and signal-to-noise ratio. For example, if you want to measure a 2-kc, 1-volt rms sine wave having a 40-db signal-to-noise ratio, a direct frequency measurement is more accurate. However, if the signal is a 2-kc square wave, a ten-period average measurement is more accurate because you can neglect the limitation due to noise.

In order to follow the slowest-changing waveforms, the period measurement input circuits are direct-coupled and are adjusted to trigger at the zero-volt crossing of a negative-going voltage. Thus, any dc



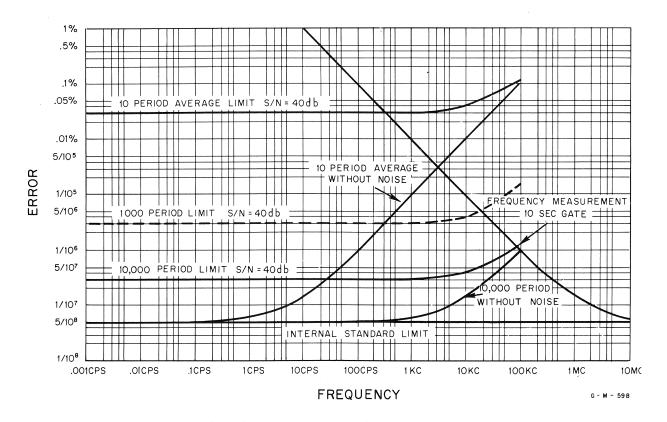


Figure 2-6. Model 524D Accuracy

Section II
Paragraphs 2-5 to 2-6

component in the input signal will shift the triggering level so that the maximum slope no longer occurs at the zero-volt level, resulting in a loss of accuracy. A large dc component may result in no triggering at all. You can measure period using an external generator in place of the time base generator. This procedure comes under the heading of ratio measurements, which are covered in the following paragraph.

#### 2-5. RATIO MEASUREMENTS.

The 524D can be used to measure the ratio of two frequencies. The higher frequency is passed through the signal gate to the counters and is counted for a period of time determined by either one period or ten periods of the lower frequency, which controls the opening and closing of the gate. See figure 2-7.

Ratio measurement accuracy is determined by the same factors as period measurement accuracy: consistency of triggering by the lower input frequency and the inherent error of  $\pm 1$  count of the higher frequency. The error due to inconsistent triggering is explained in paragraph 2-4. You can use the 526C Period Multiplier Unit to reduce the error by extending the number of periods of the lower frequency over which the measurement is made. For each factor of ten the measurement is extended, the error is decreased by a factor of ten.

The accuracy of ratio measurements by the basic counter is shown graphically as part of the Procedure for Ratio Measurement, figure 2-15.

Although the time base generator is not used during ratio measurements, you cannot make ratio measurements if the time base generator is not operating. The

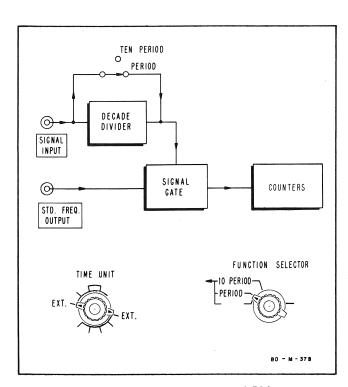


Figure 2-7. Block Diagram of 524D, Ratio Measurements

524D has a hold-off circuit which disables the signal gate if the time base generator fails. To measure ratios, be sure to (1) set the FREQUENCY STANDARD switch to INTERNAL or (2) apply a signal to the 100 KC/1 MC INPUT connector if the FREQUENCY STANDARD switch is set to EXTERNAL.

#### 2-6. TIME INTERVAL MEASUREMENT.

To make time interval measurements you must install the 526D Time Interval Unit. Time interval measurements are similar to period measurements except that the points on the signal waveform or waveforms at which the measurement starts and stops are adjustable. The adjustable threshold feature allows you to make measurements from one part of the same waveform or to use separate waveforms as start and stop signals.

As in the case of period measurements, the input signals control the opening and closing of the gate while the standard frequencies are passed to the counters, as indicated in figure 2-8. Thus the accurate frequencies generated in the time base are used as units of time to measure the unknown interval in terms of microseconds, milliseconds, or seconds.

The threshold-selecting controls adjust the start and stop channels so that they will be actuated only by signals of predetermined polarity, amplitude and slope. Time interval measurements begin when the start signal crosses the selected start threshold value in the selected direction and end when the stop signal crosses

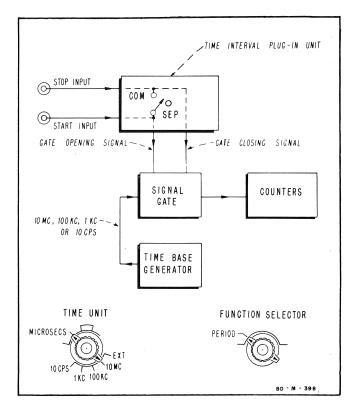


Figure 2-8. Block Diagram of 524D, Time Interval Measurements

the selected stop threshold value in the selected direction. The threshold controls are only approximately calibrated, and in some applications you will have to take special precautions in order to obtain the desired interval.

If you use an uncomplicated waveform as the start and/or stop isgnal, the setting of the threshold controls is not critical. For example, if you use a sharp pulse like that shown in figure 2-9, there will be little difference whether the measurement begins at point A or B.

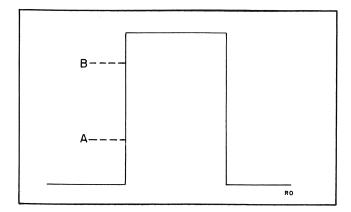


Figure 2-9. Simple Waveform Showing Two Possible Voltage Levels at which a Time Interval Measurement may be Started

If you use a more complex waveform like that shown in figure 2-10 to measure the interval "X", set the threshold controls near zero as a preliminary adjustment. As you adjust first the start and then the stop threshold controls, you will notice definite changes in the measured time interval. Thus you know that the start and stop thresholds are above the step and that the indicated time interval is actually "X".

It is highly desirable to examine both start and stop signals on a dc coupled oscilloscope such as an hp Model 130 or 150 before you attempt a measurement. In this way you can determine that no spurious signals exist, and you will know how carefully you must set the threshold controls.

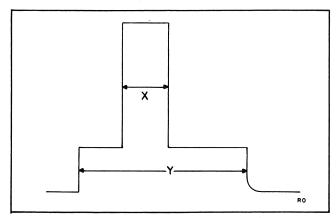


Figure 2-10. Two Possible Time Interval Measurements of a Single Complex Waveform

The input circuits in the Time Interval Unit are direct coupled. You can sometimes simplify the setting of the threshold controls by eliminating the dc component of the start and/or stop signals by using blocking capacitors. However, to avoid drawing grid current and the resulting dc shift in the input stages, be sure that the signals applied to the input circuits do not exceed ten times the settings of the coarse threshold controls. Either limit the input voltage or use direct coupling.

#### 2-7. TOTALIZING.

You can use the 524Das a high-speedtotalizer capable of counting at a maximum rate of 10.1 million events per second. Figure 2-11 shows the basic circuit arrangement. As such, the instrument will accept sine waves, 1.0 volt rms minimum, and positive pulses. 1.5 volts peak minimum with a rise time of 0.2 second or less. To enable the instrument to register negative pulses, refer to paragraph 2-3.

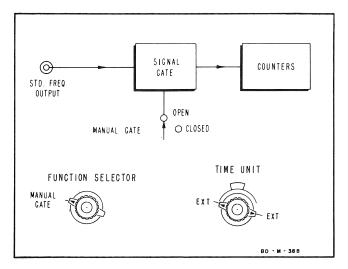


Figure 2-11. Block Diagram of 524D, Totalizing

#### 2-8. PHASE MEASUREMENTS.

With a 526D Phase Unit plugged into the counter, the phase angle between two signals of identical frequency, in the range from 1 cps to 20 kc, may be measured. The Phase Unit is useful for investigating, at various points in a circuit, the phase a signal has with respect to the phase it had at the input. Connect the reference signal to the REFERENCE INPUT, and the signal whose phase is under investigation to the UNKNOWN INPUT. If the frequency of the signal is 400 cps ±4 cps, phase angle is read directly in tenths of a degree. For a signal of some other frequency in the rated range, the information is read in time units, with resolution up to 0.1 usecond. For all phase measurements, set the Phase Unit PHASE/PERIOD switch to PHASE, the REFERENCE LEAD/LAG switch to the type of measurement desired, and the counter FUNCTION SELEC-TOR to PERIOD.

In general, circuit action for a phase measurement is similar to that for a time interval measurement. Trigger circuits in the Phase Unit supply the pulses which open and close the signal gate in the counter. For signals other than 400 cps  $\pm 4$  cps, the counter supplies the frequency counted, and the counter TIME UNIT switch should be set to MICROSEC or MILLISEC, depending on resolution required. Arrangement of the circuits will be similar to that shown in figure 2-8 for time interval measurements.

When the input is 400 cps  $\pm 4$  cps, the count frequency is supplied by the Phase Unit, and thus the counter TIME UNIT switch must be set to EXT. The count frequency is supplied to the counter through a cable from the Phase Unit COUNT FREQ connector to the counter STD FREQ OUTPUT connector. To obtain this frequency, the Phase Unit takes a portion of the 400-cps signal and puts it through a 3600-times-multiplier. By using a count frequency which is 3600 times the input frequency, phase angle can be read directly in tenths of a degree. The count frequency (approximately 1.44 mc) is only as accurate as the input signal and cannot be used as a standard for 1.44 mc.

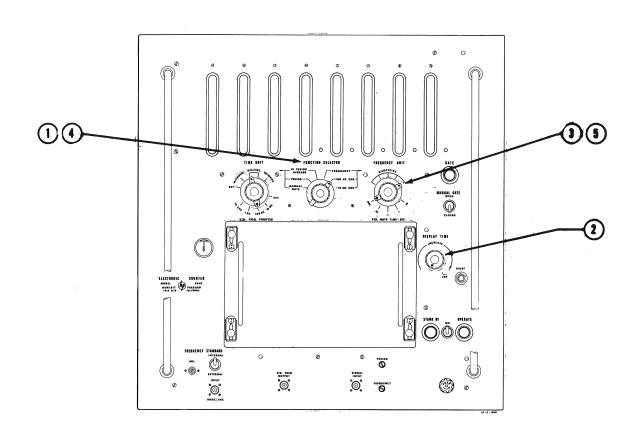
#### 2-9. USING AN EXTERNAL STANDARD.

If a 1-mc or 100-kc primary frequency standard of greater accuracy than the internal oscillator of the 524D is available, you can substitute the primary standard for the internal oscillator as follows:

Set the INTERNAL-EXTERNAL switch to EXTERNAL and connect the 1-mc or 100-kc standard to the 1 MC/100 KC INPUT connector. A 2-volt rms signal is required.

#### 2-10. OPERATING PROCEDURES.

Figures 2-12 through 2-16 give specific operating procedures for the 524D. If the instrument has not been operated for sometime, self-check it as directed in figure 2-12 prior to making any specific measurement. In so doing, you check almost all circuits of the instrument.

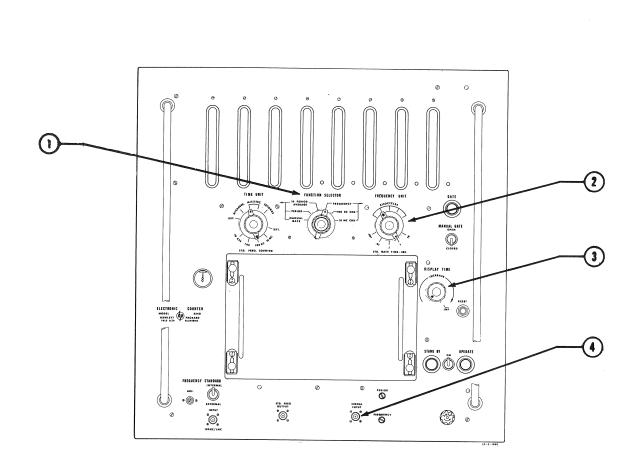


- 1. Set FUNCTION SELECTOR to 100 KC CHK.
- 2. Adjust DISPLAY TIME control for minimum display time (CCW).
- Note treading on display system for each position of FREQUENCY UNIT switch. These readings should agree with the table below. Check phantastron circuit adjustments if readings do not agree with the table.
- 4. Set FUNCTION SELECTOR to 10 MC CHK.
- 5. Repeat step 3. When checking 10 mc, note that a discrepancy of  $\pm 1$  count in the last digit is acceptable because of inherent error due to the counting system.

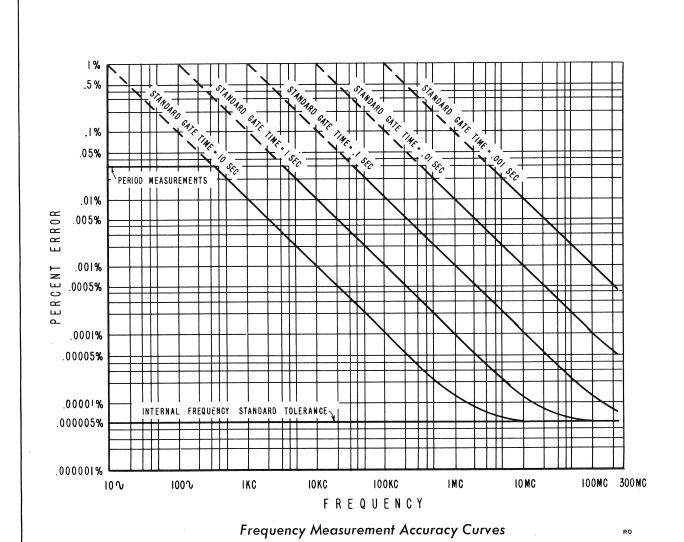
 If the readings are correct, you can consider the instrument to be operating properly. If the readings are incorrect, repair the instrument before proceeding with any measurements.

### Correct Counter Readings for Self-Check Operation

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- 1. Set FUNCTION SELECTOR to FREQUENCY.
- 2. Set FREQUENCY UNIT switch to desired gate time.
- 3. Set DISPLAY TIME control to desired display time (usually minimum).
- Connect the signal to SIGNAL INPUT connector.
- 5. Read the frequency in kilocycles.



REFERENCE TABLE FOR FREQUENCY MEASUREMENTS

Input Signal:

1 volt rms minimum.

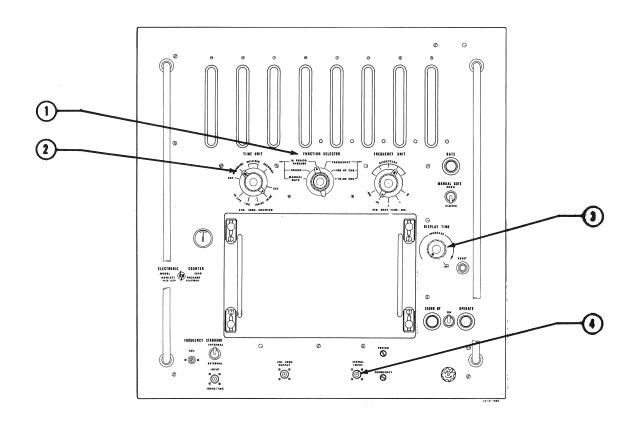
Input Impedance:

Approximately 1 megohm shunted by 40 pf.

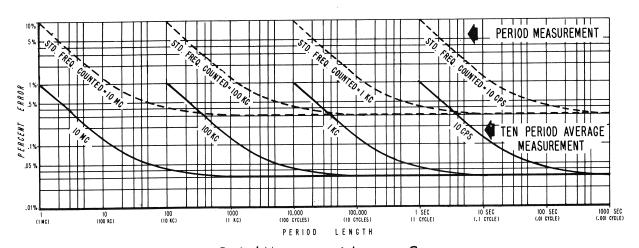
Accuracy:

 $\pm 0.000005\% \pm 1$  cps/gate time in seconds.

Figure 2-13. Procedure for Frequency Measurement (Sheet 2 of 2)



- 1. Set FUNCTION SELECTOR to PERIOD or 10 PERIOD AVERAGE.
- 2. Set TIME UNIT switch to desired time unit (usually to obtain highest possible count).
- 3. Set DISPLAY TIME control for desired display time (usually minimum).
- 4. Connect the signal to SIGNAL INPUT connector.
- 5. Read the period in units selected by the setting of the TIME UNIT switch.



Period Measurement Accuracy Curves
(SIGNAL = SINE WAVE WITH 40DB SIGNAL-TO-NOISE RATIO)

#### REFERENCE TABLE FOR PERIOD MEASUREMENT

Input Signal:

Minimum: 1 volt rms. Maximum: 200 volts rms.

(No dc component)

Input Impedance:

Approximately 1 megohm shunted by 40 pf.

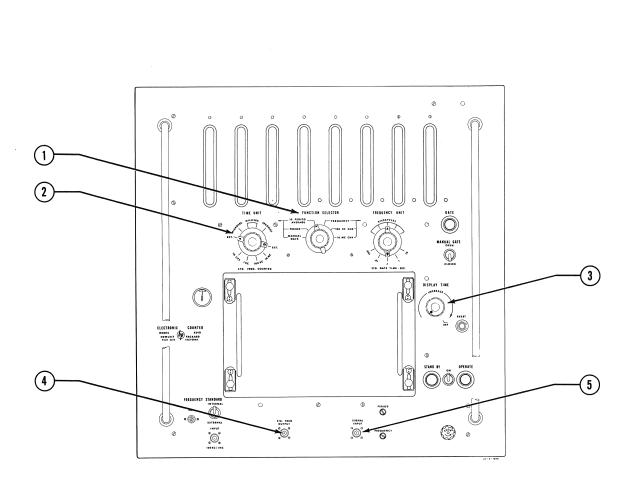
Measurement Range:

0 cps to 100 kc.

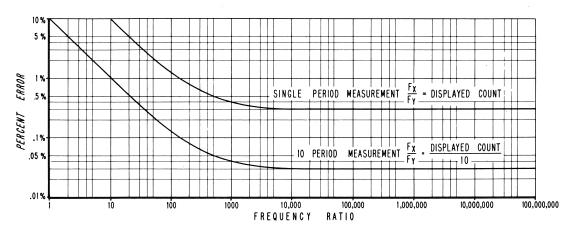
Accuracy:

 $\pm 0.03\% \pm 1$  sec/std. frequency counted in cps.

Figure 2-14. Procedure for Period Measurement (Sheet 2 of 2)



- 1. Set FUNCTION SELECTOR to PERIOD or 10 PERIOD AVERAGE.
- 2. Set TIME UNIT switch to EXT.
- 3. Set DISPLAY TIME control for desired display time (usually minimum).
- 4. Connect higher frequency to STD, FREO, OUTPUT connector.
- 5. Connect lower frequency to SIGNAL INPUT connector.
- 6. Read the ratio (FUNCTION SELECTOR set to PERIOD) or 10 times the ratio (FUNCTION SELECTOR set to 10 PERIOD AVERAGE).

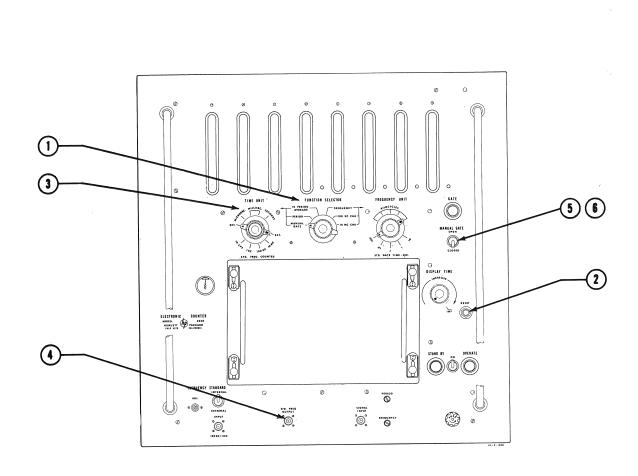


Ratio Measurement Accuracy Curves (LOWER FREQUENCY = 1 VOLT RMS SINE WAVE)

#### REFERENCE TABLE FOR RATIO MEASUREMENTS

	Higher Frequency	Lower Frequency	
Required Input Signal:	Minimum: 1.5 volts peak. Maximum: 10 volts peak.	Minimum: 1.5 volts peak.  Maximum: 280 volts peak.  (No dc component)	
Input Impedance: 1 megohm shunted by 100 pf.		1 megohm shunted by 40 pf.	
Range:	10 cps to 10.1 mc.	0 cps to 100 kc.	
Accuracy:	± 0.03% ±100%/total co	ount.	

Figure 2-15. Procedure for Ratio Measurement (Sheet 2 of 2)



- 1. Set FUNCTION SELECTOR to MANUAL GATE.
- 2. Press RESET button to clear counter.
- 3. Set TIME UNIT switch to EXT.
- 4. Connect signal to be counted to STD, FREQ. OUTPUT. If signal consists of negative pulses, see paragraph 2-3.
- 5. To begin count, set MANUAL GATE switch to OPEN.

- 6. To end count, set MANUAL GATE switch to CLOSED.
- 7. Read the total number of pulses received.

#### Reference Table for Totalizing

Input Signal:

Minimum: 1.5 volts peak Maximum: 10 volts peak

Rise Time: 0.2 sec or less

Input Impedance: 1 megohm shunted by 100 pf.

Counting Capacity: 99,999,999.

Figure 2-16. Procedure for Totalizing

## SECTION III CIRCUIT OPERATION

#### 3-1. INTRODUCTION.

The Model 524D Electronic Counter consists of a time base section, gate section, and eight cascaded counter units. The time base section generates accurate reference frequencies for frequency and period measurements. The gate section opens and closes the signal path to the counter units, controls display time, and resets the counter units to zero. In the 524C, the gate section can also blank the readout during count time. The counter units totalize signals applied to them and display the total on the front panel.

#### 3-2. TIME BASE SECTION,

A 1-mc oscillator, V901, is the time base reference. See figure 3-1. Amplifier V902 drives an agc (automatic gain control) circuit, CR901 and CR902, and one input grid of mixer V903. The agc circuit varies oscillator bias to maintain oscillator output at a constant amplitude. Mixer V903 mixes the 1-mc output of the amplifier and the 900-kc output of a X9 filter, T901 and C912, to produce a 100-kc signal. This signal

drives blocking oscillator V236A. The blocking oscillator pulses the X9 filter, which rings at 900 kc.

The mixer, blocking oscillator, and X9 filter form a regenerative divider, which is not self starting. To start it, a relaxation oscillator, VR1001 and VR1002, periodically triggers the blocking oscillator, and the blocking oscillator pulses the X9 filter. After a few tries, the regenerative divider starts, and rectifier V235A cuts off the relaxation oscillator. The rectifier also controls the voltage applied to a hold-off circuit, VR201 and VR202, in the gate section.

An external 1-mc or 100-kc signal may be used as the time base reference. If the external signal is 100 kc, the mixer operates as an amplifier, and the X9 filter is not active.

The Mixer provides a 100-kc check signal and drives a 10-mc multiplier. The 10-mc multiplier provides a 10-mc check signal and drives the harmonic generators in the 525A and 525B Frequency Converter plug-in units. The output of the blocking oscillator passes

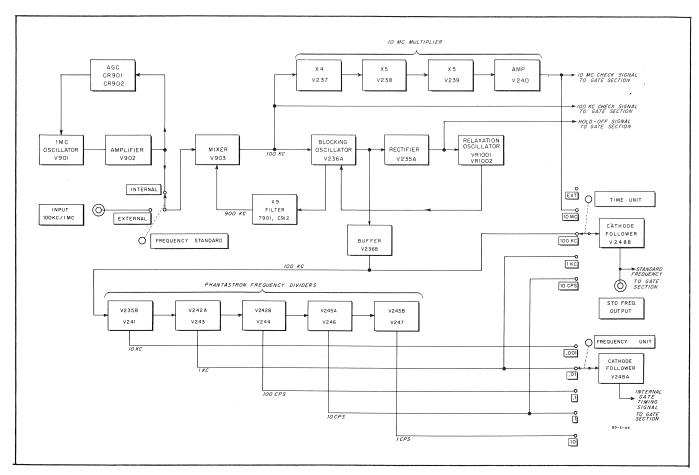


Figure 3-1. Time Base Section

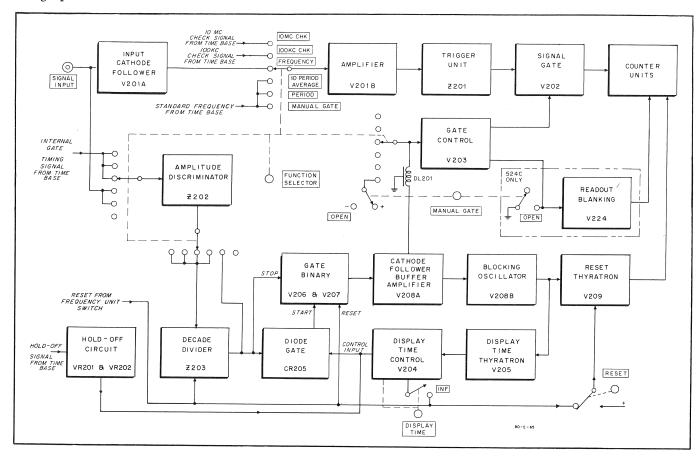


Figure 3-2. Gate Section

through buffer V236B to five phantastron frequency dividers, V235B and V241 through V247. These phantastrons provide the signals used by the gate control circuits to time the signal gate during frequency measurements.

Four frequencies are available for measuring period and time. The available frequencies are 10 cps, 1 kc, 100 kc and 10 mc. An external frequency connected to the STD FREQ OUT connector can also be used.

#### 3-3. GATE SECTION.

The FUNCTION SELECTOR switch (figure 2-3) determines the type of operation. All signals to be counted are applied to trigger unit Z201, a stabilized amplifier followed by a Schmitt trigger. The trigger unit shapes the signal to provide the fast-rise, constant-amplitude waveform required to drive the units counter. Signal gate V202 opens and closes the signal path.

Gate-timing signals for frequency and period measurements are applied to amplitude discriminator Z202. Like trigger unit Z201, the amplitude discriminator is a stablized amplifier followed by a Schmitt trigger, and it provides a fast-rise, constant-amplitude signal to drive the circuit that follows: decade divider Z203 or the gate binary, V206 and V207.

Decade divider Z203 divides its input by ten. The divider consists of four cascaded binaries (bi-stable multivibrators) with feedback from the fourth binary to the second and third binaries to provide the inputoutput ratio of 10:1.

The gate binary, V206 and V207, controls signal gate V202 through cathode follower buffer amplifier V208A, delay line DL201, and gate control V203. (In the 524C, the gate binary also controls readout blanking circuit V224, which blanks the readout while the signal gate is open.) When a start pulse causes the gate binary to open the signal gate, the gate binary triggers blocking oscillator V208B through the cathode follower buffer amplifier. The blocking oscillator fires reset thryratron V209 and display time thyratron V205. Delay line DL201 delays the opening of the signal gate long enough for the reset thyratron to generate the positive pulse which sets the counter units to zero. The display time thyratron triggers display time control V204, a Schmitt trigger, which closes diode gate CR205. The diode gate remains closed for a time determined by the front-panel DISPLAY TIME control. A stop pulse causes the gate binary to close the signal gate, but succeeding start pulses are blocked until display time control V204 reopens the diode gate. Hold-off circuit VR201 and VR202 also closes the diode gate if there is no signal out of mixer V903 (figure 3-1).

The RESET switch provides manual reset control. When pressed, the RESET switch fires reset thyratron V209, and when released, it sets the decade divider to a count of eight. If the DISPLAY TIME control is set to INF, the RESET switch also causes display time control V204 to open the diode gate. When switched from one setting to another, the FREQUENCY UNIT switch (figure 3-1) sets the decade divider to a count of eight and the gate binary to its gate-closed position.

A MANUAL GATE switch controls the signal gate when the FUNCTION SELECTOR is set to MANUAL GATE. If set to OPEN, the MANUAL GATE switch prevents readout blanking in the 524C regardless of FUNCTION SELECTOR setting.

#### 3-4. UNITS COUNTER.

The units counter (figure 3-3) has two sections: a counting section and a readout section. The counting section consists of four binaries (V210-V213 and V215-V218), a coincidence network (CR231-CR233), and feedback gate V214. The readout system consists of four readout amplifiers (V1200-V1203) and the readout itself.

The binaries of the counting section have two stable conditions (either half conducting and the other half cut off) and remain in either condition until actuated by a trigger pulse. The trigger pulse causes the triggered binary to reverse its condition; the previously conducting half cuts off and the previously cutoff half conducts. The binaries quickly change from one condition to the other. Thus, the output of one half is a positive voltage step, and the output of the other half is a negative voltage step. Circuit components between the first and second binaries, second and third binaries, and first binary and feedback gate differentiate the voltage steps into pulses. However, except for the positive reset pulse, only negative pulses can trigger the binaries.

The reset pulse from reset thyratron V209 (figure 3-2) sets the counting section to its zero position, in which the tubes marked "c" (figure 3-3) conduct. Figure 3-4 shows output waveforms of one half of each binary, the coincidence network, and the feedback gate for a succession of negative pulses from the signal gate. The coincidence network opens feedback gate V214 only when both V212 and V216 are non-conducting. Starting from the zero or reset position, the counting section operates as shown in table 3-1.

The binaries position the four readout amplifiers, which drive the readout. In the 524D the readout consists of ten neon lamps behind a numbered mask; in the 524C the readout consists of ten neon lamps, ten photoconductors, and a digital display tube. A sum of the voltages from three different readout binary

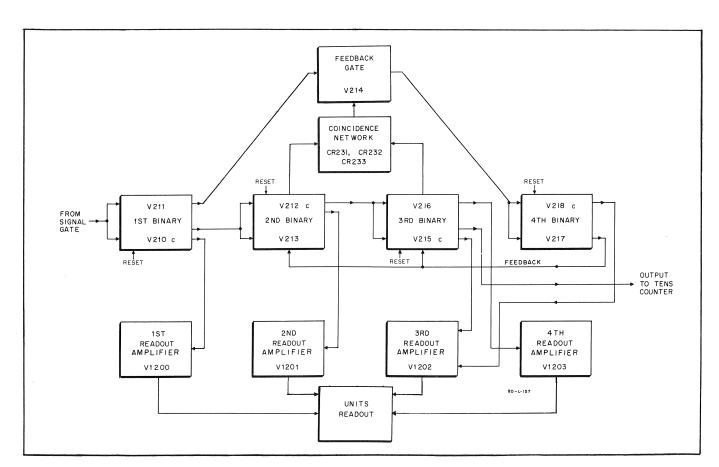


Figure 3-3. Units Counter

halves is applied to each neon lamp. For a given number, only one of the ten possible sums is large enough to light a lamp. In the 524D the lighted lamp illuminates a number on the mask. In the 524C the

lighted lamp illuminates a photo-conductor which causes one number of the digital display tube to light. In either case the number lighted corresponds to the number stored in the positions of the four binaries.

Table 3-1. Units Counter Operating Sequence

Pulse	Operation
Number	Operation
1	1st binary: negative pulse from signal gate causes V210 to cut off and V211 to conduct
2	1st binary: negative pulse from signal gate causes V210 to conduct and V211 to cut off.
	2nd binary: negative pulse from V210 causes V212 to cut off and V213 to conduct.
	Coincidence network: coincidence network opens feedback gate, for both V212 and V216 are cut off.
3	1st binary: negative pulse from signal gate causes V210 to cut off and V211 to conduct.
4	1st binary: negative pulse from signal gate causes V210 to conduct and V211 to cut off.
	Feedback gate: feedback gate amplifies and inverts posi- tive pulse from V211.
	4th binary: negative pulse from feedback gate causes V217 to conduct and V218 to cut off.
	2nd and 3rd binaries: feedback from V217 keeps V212 and V216 cut off, V213 and V215 conducting. Negative pulse from V210 to 2nd binary has no effect.
5	1st binary: negative pulse from signal gate causes V210 to cut off and V211 to conduct.
6	1st binary: negative pulse from signal gate causes V210 to conduct and V211 to cut off.
	Feedback gate: feedback gate amplifies and inverts posi- tive pulse from V211.

Pulse Number	Operation
(cont'd)	4th binary: negative pulse from feedback gate causes V217 to cut off and V218 to conduct. When V217 is cut off, it removes the feedback from the 2nd and 3rd binaries.
	2nd binary: negative pulse from V210 causes V212 to conduct and V213 to cut off.
	3rd binary: negative pulse from V212 causes V215 to cut off and V216 to conduct.
	Coincidence network: coincidence network closes feedback gate.
7	1st binary: negative pulse from signal gate causes V210 to cut off and V211 to conduct.
8	1st binary: negative pulse from signal gate causes V210 to conduct and V211 to cut off.
	2nd binary: negative pulse from V210 causes V212 to cut off and V213 to conduct.
9	1st binary: negative pulse from signal gate causes V210 to cut off and V211 to conduct.
10	1st binary: negative pulse from signal gate causes V210 to conduct and V211 to cut off.
	2nd binary: negative pulse from V210 causes V212 to conduct and V213 to cut off.
	3rd binary: negative pulse from V212 causes V215 to conduct and V216 to cut off.
	The counting section is again in its zero or reset position.

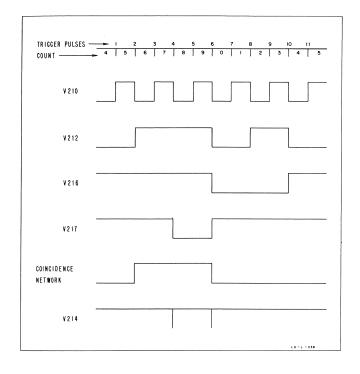


Figure 3-4. Unit Counter Waveforms

# 3-5. SCHMITT TRIGGER.

The Schmitt trigger (figure 3-5) is a type of bi-stable multivibrator. It is used where fast-rise waveforms are needed for reliable circuit operation.

If the input voltage is such that section A is cut off, section B is conducting. As the input voltage becomes

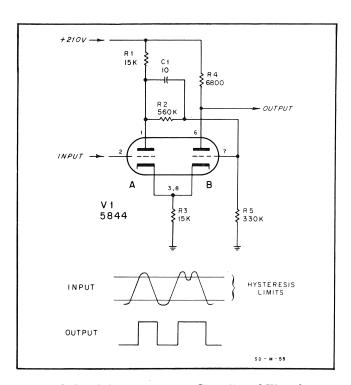


Figure 3-5. Schmitt Trigger Circuit and Waveforms

more positive, it will eventually reach a predetermined level at which the circuit changes state. Section A conducts and section B is quickly cut off. If the input voltage then goes in a negative direction, the common cathode potential decreases and the section B grid goes in a positive direction. When the input voltage reaches a second predetermined level, section B conducts and section A is quickly cut off. Thus, the output is a voltage step, either positive or negative depending upon the slope of the input. In the 524D, components in the following circuits 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.

The phantastron frequency divider is shown in figure 3-6. The heart of this phantastron is the 6AS6/5725, 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 25 volts 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 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

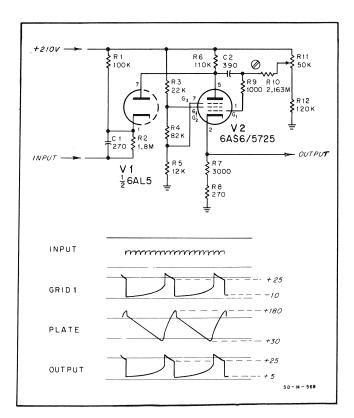


Figure 3-6. Phantastron Circuit and Waveforms

Section III Paragraph 3-6 cont'd

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 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 potential to cut off plate current. As C2 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 V2 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 adjustment of the required time over narrow limits. In the 524D, each phantastron is adjusted to respond to every tenth input trigger to provide the required 10:1 division ratio.

# SECTION IV MAINTENANCE

#### 4-1. INTRODUCTION.

This section contains information on the maintenance and repair of the 524D Electronic Counter. 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 instrument are given at the front of this manual.

To facilitate servicing, make up the test connector shown in figure 4-1. With the connector plugged into J202, the 8-pin connector inside the front panel opening, the instrument can perform all its basic functions, and you still have access to all controls, plug-in units, etc., located within the opening. You can substitute the blank plug-in panel or a front-panel plug-in unit for the test connector. If you use the 525A Frequency Converter Unit, remember that its video amplifier is in use for frequency measurements below 10 mc.

A separate AC-4 Decade Counter manual contains operating and servicing information on the plug-in counter units.

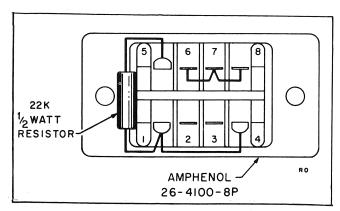


Figure 4-1. Test Connector for Servicing

# 4-2. PERIODIC CHECKS.

For good performance from your instrument, check the following items as indicated:

Air filter element (paragraph 4-4) . . . . . . . . . . . . . . . . . weekly

#### 4-3. TEST EQUIPMENT

The following test equipment is recommended for testing and servicing the 524D:

- 1) Volt-ohmmeter such as the Simpson 260 or Triplett 630A for general circuit testing and checking crystal diodes.
- 2) AC-DC vacuum tube voltmeter accurate within 3% of full scale. On dc, the instrument should have at least 100 megohms input resistance, and on ac, it should have at least 1 megohm input impedance at 10 mc. Recommended hp equipment: \$\phi\$ 410BVacuum Tube Voltmeter.
- 3) Signal source which can provide a sinewave signal at least 2 volts rms over the range from 10 cps to 10 mc. Recommended hp equipment: \$\oplus\$ 605A Test Oscillator.
- 4) Oscilloscope with a bandwidth of dc to 10 mc and a minimum sensitivity of 0.5 volt/cm. Recommended hp equipment: 150A Oscilloscope with 152B Dual Trace Amplifier and AC-21A or AC-21C Oscilloscope Probe.
- 5) Variable autotransformer to vary line voltage between 103, 115, and 127 volts. Transformer must have at least a 7-1/2 ampere capacity, and the output voltage must be monitored by a meter accurate within 1 volt.

# 4-4. AIR FILTER.

Inspect the air-filter element periodically. Never let it get dirty enough to restrict air flow. The element is renewable; clean it as often as necessary. Proceed as follows:

- 1) Remove element.
- 2) Clean element in detergent and water.
- 3) Dry element thoroughly.
- 4) Coat element with light film of filter oil. We recommend No. 3 Filter Coat from Research Products Company. This adhesive is available in "Handi-Koter" sprayer cans at most heating supply stores or from your Hewlett-Packard sales office.

# 4-5. PERFORMANCE CHECK.

The following tests check overall instrument performance. You can make the tests with the instrument in its cabinet. Set line voltage at 115 volts, and proceed as follows:

#### A. SELF CHECK.

- 1) With line at 115 volts, turn instrument on, and allow five-minute warmup.
- 2) Self check instrument as instructed in figure 2-12.

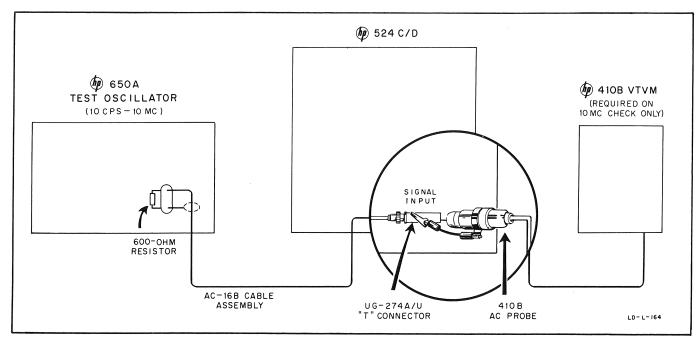


Figure 4-2. Equipment Setup for Performance Check

- B. FREQUENCY SENSITIVITY CHECK.
- 2) Connect output of test oscillator to SIGNAL INPUT of counter (see figure 4-2).
- 3) Adjust test oscillator output to about 10 cps at 1 volt rms; counter should consistently indicate input frequency.
- 4) Adjust test oscillator output to about 100 kc at 1 volt rms; counter should consistently indicate input frequency.
- 5) Adjust test oscillator output to about 10 mc at 1 volt rms -- measure signal amplitude at SIGNAL INPUT connector (figure 4-2); counter should consistently indicate input frequency. If counter sensitivity is low, check frequency sensitivity adjustment, paragraph 4-12.
- 6) Repeat steps 3 through 5 with line voltage of 103 and 127 volts.
- C. PERIOD SENSITIVITY CHECK.
- 2) Connect output of test oscillator to SIGNAL INPUT of counter.
- 3) Adjust test oscillator output to about 1 kc at 1 volt rms; counter should consistently indicate signal period  $\pm 0.3\%$ . If sensitivity is low, check period sensitivity adjustment, paragraph 4-13.

4) Repeat steps 2 and 3 with line voltages of 103 and 127 volts.

# 4-6. STANDARDIZING THE OSCILLATOR.

A. CHECKING OSCILLATOR FREQUENCY. The procedure below may be used to check the frequency of the 524C/D1 Mc internal oscillator. Hewlett-Packard Application Note 52 "FREQUENCY AND TIME STANDARDS" describes other methods for determining oscillator frequency, involving either phase comparison with WWV or use of Lissajous patterns on an oscilloscope. The Application Note also presents a more detailed discussion of the problems and techniques of frequency measurement than is given here.

NBS station WWV frequency transmissions are accurate to within 1 part in  $10^8$ , and usually 3 parts in  $10^9$ . However, Doppler shifts caused by atmospheric conditions can cause changes in the received frequency at points beyond the range of the ground wave, often reducing accuracy by more than a factor of 10. Comparisons of the 524C/D oscillator against the received WWV frequency should be made for several consecutive days before making any adjustment in oscillator frequency. By doing this (1) much of the Doppler effect is averaged out, (2) results obtained on days when there has been excessive Doppler shift may be eliminated, (3) direction and rate of oscillator drift may be determined, and (4) oscillator frequency may be determined within 2 or 3 parts in  $10^8$ .

Use the 20-mc transmission from WWV. WWVH does not duplicate this transmission and thus does not interfere, and at this frequency any error in the 524D oscillator frequency is multiplied 20 times. You can use other transmissions from WWV if you have a good directional antenna or if location permits; however at 15 mc you may have to amplify the 524D output to get

sufficient harmonics. Minimum Doppler effects usually occur when noon or midnight is midway between WWV and the receiving station; make your comparison at either of these times. For additional information on WWV, see the Proceedings of the IRE or contact the Radio Standards Division, National Bureau of Standards at Boulder, Colorado.

The setup for checking 524D oscillator accuracy is shown in figure 4-3. To better understand the procedure, consider the following:

 $f_{o}$  = WWV carrier frequency at the receiver

 $f_s$  = WWV sideband frequency at the receiver (WWV modulates on upper sideband only)

 $M = WWV modulation frequency = f_S - f_O$ 

 $f_1 = 524D$  output frequency (2nd harmonic of 10-mc signal)

e = error frequency of 524D harmonic =  $f_1 - f_0$ .

When the signals  $f_0$ ,  $f_s$ , and  $f_1$  are applied at the receiver input (antenna terminal), the reciever output contains the following signals:

- 1)  $M = f_S f_O$ , which is a constant (440 or 600 cps), 2)  $e = f_1 f_O$ , the unknown, and
- 3)  $M-e = f_S f_1$ .

The signal e is a very low frequency and is eliminated from the receiver output by the receiver's bandpass. so it cannot be determined directly; in this application e is determined by finding the difference between M and M-e. The low frequency of e means that M and M-e are close in frequency, and could be hard to tell apart; the effect of M at the receiver output is reduced by making the level of M-elarge with respect to the level of M so the receiver output consists mostly of M-e with very little M or e signal. The M-elevel is raised by making  $f_1$  large compared to  $f_0$  at the receiver input. If you apply M-e to the vertical input of an oscilloscope and synchronize the sweep from an external audio oscillator, you can determine M-e by measuring the audio oscillator output frequency required to stop the pattern on the oscilloscope. The 524D itself can measure this frequency. (For good results, the audio oscillator should drift less than 0.1 cycle per second.) Each tenth cycle difference between audio-oscillator frequency and Mcorresponds to a 524D oscillator error of about 5 parts in 10<sup>9</sup> compared to fo.

# Proceed as follows:

1) Turn 524D on. Allow 24 hours warmup if instrument has been disconnected from power source; allow 1/2 hour warmup if it has been connected to power source but turned off.

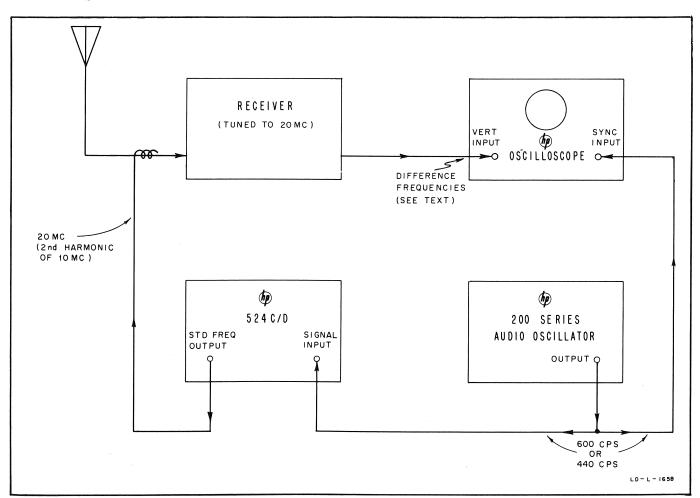


Figure 4-3. Equipment Setup for Checking Oscillator against WWV

Section IV Paragraph 4-6 cont'd

- 2) Set 524D controls:
   FUNCTION SELECTOR
   FREQUENCY

   FREQUENCY UNIT
   10

   TIME UNIT
   10 MC

   DISPLAY TIME
   minimum (ccs)

   FREQUENCY STANDARD
   INTERNAL
- 3) Tune communications receiver to 20-mc WWV signal.
- 4) Connect plain unshielded wire to 524D STD FREQ OUTPUT connector; couple other end to receiver antenna lead. Be sure signal coupled from the 524D is stronger than the WWV signal but not strong enough to block the receiver. If harmonics of 524D 10-mc signal are not strong enough, connect a crystal diode between ground and the unshielded wire at the STD FREQ OUTPUT connector.
- 5) Connect receiver output to vertical input of oscilloscope. Any Hewlett-Packard oscilloscope will do.
- 6) Connect test oscillator output to 524D SIGNAL INPUT connector and to sync input of oscilloscope. (Any hp 200 series audio oscillator will do with the 650A Test Oscillator.) Adjust oscillator output frequency to either WWV audio signal: 440 or 600 cps, and adjust output amplitude to maximum.
- 7) While WWV transmits its audio tone, adjust test oscillator output frequency to stop pattern on oscilloscope or to point where pattern drifts as much to the left as it does to the right.
- 8) Measure audio oscillator frequency on 524D. Watch oscilloscope during count time to be sure pattern does not start drifting excessively. Try to keep drift rate less than 0.1 cps per 10 seconds.
- 9) Note counted frequency and repeat comparison several times over 15- or 20-minute period. This frequency is M-e. Determine e (error frequency of 524D harmonic) by subtracting counted frequency from M (WWV audio signal). If e is negative, 524D oscillator frequency is low; if e is positive, oscillator frequency is high.
- 10) Repeat comparison daily for five or six days and plot each day's results. From the data, determine 524D oscillator error and decide if oscillator needs adjusting.
- B. ADJUSTING THE OSCILLATOR. Three procedures follow. Use the first if you must set the 524D oscillator against WWV; use the second if you have a local oscillator with short-term stability no worse than 1 part in  $10^8$ ; and use the third if you have a local primary standard.

# Procedure 1: Setting 524D oscillator against WWV.

- 1) Make a comparison as indicated above. If reading does not fall into expected pattern, atmospheric conditions are poor. Do not attempt to adjust oscillator on such a day.
- 2) Set FUNCTION SELECTOR to PERIOD.
- 3) Set audio oscillator to obtain counter reading of 1666.67 usec (600 cps) or 2272.73 usec (440 cps) according to WWV audio signal you are using.

- 4) Set STANDARD FREQUENCY ADJ C914 (frequency adjustment range: 4 parts in 10<sup>7</sup>) to stop oscilloscope pattern. C914 is located on front panel next to FREQUENCY STANDARD switch. Continue to monitor audio oscillator frequency on counter to be sure it does not change while you set C914.
- 5) If C914 does not have sufficient range to set oscillator on frequency, adjust C915 (frequency adjustment range: 4 parts in 107). See figure 4-15 for location of C915.
- 6) If you cannot set oscillator on frequency with both C914 and C915, adjust C918 (frequency adjustment range: 6 to 11 parts in 10<sup>6</sup>), located inside crystal oven. The crystal oven has an access hole in its base for adjusting C918. Prior to adjusting C918, set C914 and C915 to maximum capacitance if oscillator frequency drift is down or to minimum capacitance if oscillator drift is up; thus you will have plenty of adjustment range at the front panel for future adjustment.

# NOTE

Use an insulated screwdriver to adjust C918. Insert and remove screwdriver carefully; there are fine wires within the oven easily broken by a carelessly handled screwdriver.

<u>Procedure 2</u>: Setting 524D oscillator against a local oscillator.

- 1) From daily plots, determine how much counter oscillator frequency must be shifted.
- 2) Set TIME UNIT switch to 10 MC.
- 3) Connect signal from STD FREQ OUTPUT connector to vertical input of oscilloscope.
- 4) Connect signal from local oscillator to sync input of oscilloscope.
- 5) Adjust oscilloscope to show several complete cycles.
- 6) Adjust frequency of local oscillator to stop pattern on oscilloscope.
- 7) To increase 524D oscillator frequency, adjust FREQUENCY STANDARD ADJ C914 to make oscilloscope pattern drift to left; to decrease frequency, adjust C914 to make pattern drift to right. Adjust drift rate one cycle per second for frequency change of 1 part per 10<sup>7</sup>, one cycle per 10 seconds for frequency change of 1 part per 10<sup>8</sup>.
- 8) If C914 does not have sufficient range to set 524D oscillator on frequency, see steps 5 and 6 of procedure 1.

<u>Procedure 3</u>: Setting 524D against local primary standard.

- 1) Set 524D TIME UNIT switch to 10 MC.
- 2) Connect signal from STD FREQ OUTPUT connector to vertical input of oscilloscope.
- 3) Connect signal from local primary standard to sync input of oscilloscope.

- 4) Adjust oscilloscope to show several complete cycles.
- 5) Adjust STANDARD FREQUENCY ADJ C914 to stop pattern on oscilloscope.
- 6) If C914 does not have sufficient range to stop pattern, see steps 5 and 6 of procedure 1.

# 4-7. CABINET REMOVAL/OPERATION WITH CABINET REMOVED.

- A. CABINET REMOVAL.
  Refer to figure 4-4, and proceed as follows:
- 1) Remove four retaining screws from cabinet rear.
- 2) Carefully pull off rear cover; unplug fan connector.
- 3) Set instrument on rear framework.
- 4) Unscrew setscrews near front feet about seven turns and remove cap screw which mount rear feet.
- 5) Lift cabinet upward; tip it to one side to allow inside rear lips to clear front panel. To replace cabinet, reverse procedure.
- B. CABINET REMOVAL, RACK MODEL. Refer to figure 4-5, and proceed as follows:
- 1) Place instrument face down.
- 2) Remove four retainer screws from rear of cabinet.
- 3) Lift cabinet upward. Fan connector will come free as you remove cabinet. When replacing cabinet, re-

move filter element, reach in through fan and plug in fan connector before securing retainer screws.

C. OPERATION WITH CABINET REMOVED. The 524D can be safely operated outside of the cabinet at normal room temperature without component damage. However, thermal cutout (TC201) may be activated by heat conducted through the chassis. To prevent this from happening a fan can be directed at the corner of the instrument on which TC201 is mounted (see figure 4-13).

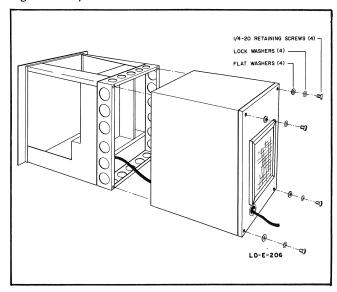


Figure 4-5. Cabinet Removal (rack mount)

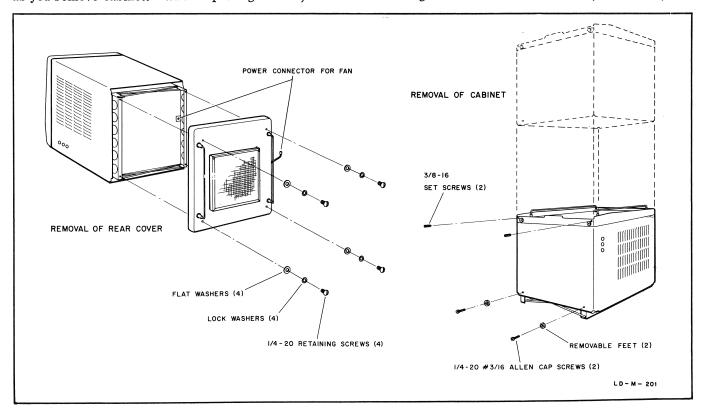


Figure 4-4. Cabinet Removal (cabinet model)

# 4-8. POWER SUPPLIES.

The power supplies in this instrument are extremely stable. Check them for output voltage and regulation prior to making adjustments elsewhere in the instrument and as a first troubleshooting step, but avoid unnecessary adjustment. If the voltages are essentially correct and the supplies regulate properly, there is no reason to adjust them.

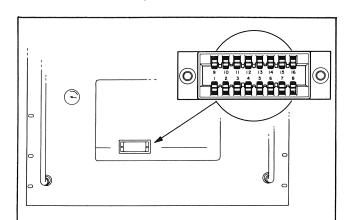
#### CAUTION

BE CAREFUL WHEN MEASURING POWER SUP-PLY VOLTAGES. SHOULD YOU SHORT THEM TOGETHER OR TO GROUND, YOU MAY RUIN A LARGE NUMBER OF CRYSTAL DIODES.

Do not operate this instrument for more than a few minutes with improper power-supply voltages. If you discover a faulty supply or more than 50 volts between the +70 volt and +90 volt supplies, turn the instrument off immediately and troubleshoot.

You can measure all voltages at J201 (see figure 4-6) or at the power supply itself (see figure 4-12). The output of the unregulated +300 volt supply measures about 50 volts high at the power supply, since dropping resistor R536 is located outside the power supply area. The regulated voltages normally vary less than 2% when line voltage varies between 103 and 127 volts.

When you do adjust the supply voltages, use a meter accurate within 3%. Adjust the -195 volt supply first, for it is independent of the other supplies. Adjust the +210 volt supply second, for it depends only upon the -195 volt supply. Adjust the +70 volt and +90 volt supplies last; they depend upon both the -195 volt and +210 volt supplies.



	Contact	Voltage	Resistance*				
	5	-195	5000 ₽				
	11	+300 (unregulated)	2200 Ω				
	3	+210	1400 ♀				
	10	+90	900 ₽				
	9	+70	700 Ω				
*1	*May vary ±10% from value shown						

Figure 4-6. Power Supply Voltage at J201

# 4-9. ADJUSTING OSCILLATOR AMPLIFIER.

Adjust L901 whenever you replace V901, V902 or any other component of the oscillator or amplifier circuit. Proceed as follows:

- 1) Connect dc probe of vacuum tube voltmeter to agc line on oscillator printed circuit board. It is marked on the board.
- 2) Adjust L901 for maximum negative voltage -- about 3 or 4 volts -- on voltmeter.

# 4-10. ADJUSTING 1 MC - 100 KC DIVIDER.

Adjust 1 mc - 100 kc divider circuits whenever you replace V903 or any other divider component. Two procedures follow. Use procedure A if divider operates and just needs peaking; use procedure B if divider requires alignment.

Procedure A: Peaking 1 mc - 100 kc Divider.

- 1) Set FREQUENCY STANDARD switch to INT.
- 2) Connect oscilloscope probe to pin 1 of V237.
- 3) Adjust L211 and T901 for maximum 100-kc signal on oscilloscope.

Procedure B: Aligning 1 mc - 100 kc Divider.

- 1) Set FREQUENCY STANDARD switch to EXT.
- 2) Connect accurate 100-kc, 3-volt rms signal to 100 KC/1 MC INPUT connector.
- 3) Connect oscilloscope probe to pin 5 of V903.
- 4) Adjust L211 for maximum 100-kc signal on oscilloscope.
- 5) Connect oscilloscope probe to pin 3 of V236.
- 6) Adjust T901 for maximum 900-kc signal on oscilloscope (see waveform 5 of table 4-3, paragraph 4-18).
- 7) Set FREQUENCY STANDARD switch to INT.
- 8) Connect oscilloscope probe to pin 1 of V237.
- 9) Adjust L211 and T901 for maximum 100-kc signal on oscilloscope.

# 4-11. ADJUSTING THE PHANTASTRONS.

A phantastron needs adjusting if 100-kc self-check yields counts of 80, 90, 110 or 120 kc on one gate time, and correct counts on all shorter gate times. The adjustment potentiometers are located just inside and above the front-panel opening. Proceed as follows:

- 1) Remove front-panel plug-in unit.
- 3) Adjust 0.001 potentiometer R444 to center of range which yields consistent count of 00000100.
- 4) Set FREQUENCY UNIT switch to .01 SEC.
- 5) Adjust 0.1 potentiometer R453 to center of range which yields consistent count of 0000100.0.

- 6) Set FREQUENCY UNIT switch to .1 SEC.
- 7) Adjust 0.1 potentiometer R462 to center of range which yields consistent count of 000100.00.
- 8) Set FREQUENCY UNIT switch to 1 SEC.
- 9) Adjust 1 potentiometer R471 to center of range which yields consistent count of 00100.000.
- 10) Set FREQUENCY UNIT switch to 10 SEC.
- 11) Adjust 10 potentiometer R480 to center of range which yields consistent count of 0100.0000.

# 4-12. ADJUSTING FREQUENCY SENSITIVITY.

FREQUENCY sensitivity potentiometer R211 is properly set when the no-signal voltage on input grid pin 1 of Schmitt trigger V1102 is very close to but more positive than the upper hysteresis limit. Two procedures follow. The second is more accurate, but the first requires no test equipment.

# Procedure A:

- 1) Set:
- 2) Turn FREQUENCY sensitivity potentiometer R211 clockwise until counting stops.
- 3) Turn R211 counterclockwise until counter just counts at 100 kc rate.
- 4) Turn R211 about 5 degrees more counterclockwise.

# Procedure B:

- 1) Set:
- 2) Connect test oscillator output to SIGNAL INPUT connector.
- 3) Adjust test oscillator output to about 100 kc at 0.4 volt rms.
- 4) Adjust FREQUENCY potentiometer R211 to a point where any counterclockwise rotation of R211 causes counter to stop counting.

# 4-13. ADJUSTING PERIOD SENSITIVITY.

PERIOD sensitivity potentiometer R248 is properly set when the no-signal voltage on input grid pin 5 of Schmitt trigger V702 is midway between the hysteresis limits. Proceed as follows:

- 1) Set:

- 2) Connect test oscillator output to SIGNAL INPUT connector.
- 3) Adjust test oscillator output to about 1 kc at 2 v rms.
- 4) If counter does not operate consistently, adjust PERIOD sensitivity potentiometer R248 to obtain consistent operation. The potentiometer is located on the front panel.
- 5) Gradually reduce signal voltage to approximately 0.3 volt rms; adjust R248 as necessary to maintain consistent operation.

# 4-14. ADJUSTING THE 10-MC MULTIPLIER.

Two procedures follow. If multiplier output is low (less than 4 or 5 volts peak-to-peak at the junction of C316 and C386 with nothing plugged into J201) follow procedure A. If multiplier output is off frequency, follow procedure B. Coils L212 through L217 have locknuts; loosen them before attempting to adjust the coils.

Procedure A: Peaking the 10-mc Multiplier.

- 1) Connect oscilloscope to pin 1 of V238. Use a high-impedance probe.
- 2) Adjust L211 for maximum 400-kc signal on oscilloscope.
- 3) Loosely couple oscilloscope to grid pin 1 of V239 by clamping probe jaws on insulated section of the green lead.
- 4) Adjust L212, L213, L214, and L215 for maximum 2-mc signal on oscilloscope (there may be some 10-mc signal superimposed on the 2-mc signal). Tighten locknuts on the four coils without reducing signal amplitude.
- 5) Connect oscilloscope probe directly to plate pin 5 of V240.
- 6) Adjust L216 and L217 for maximum 10-mc signal on oscilloscope. Tighten locknuts on these two coils without reducing signal amplitude.
- 7) Connect oscilloscope probe to junction of C316 and C386. See figure 4-12.
- 8) Adjust L218 for maximum 10-mc signal on oscilloscope.

Procedure B: Aligning the 10-mc Multiplier.

- 1) Connect oscilloscope to pin 1 of V238. Use a high-impedance probe.
- 2) Adjust L211 for maximum indication on oscilloscope.
- 3) Adjust oscilloscope sweep speed to 1 usec/cm.
- 4) Adjust L212 and L213 to obtain four complete sine waves (400 kc) on oscilloscope.
- 5) Adjust oscilloscope sweep speed to 0.2 usec/cm.

- 6) Connect oscilloscope probe directly to grid pin 1 of V239.
- 7) Adjust L214 and L215 to obtain four complete sine waves (2 mc).
- 8) Loosely couple oscilloscope probe to pin 1 of V239. Clip jaws over insulation of green wire.
- 9) Readjust L213, L214, and L215 for maximum 2-mc signal on oscilloscope.
- 10) Tighten locknuts for L212, L213, L214, and L215 without decreasing signal.
- 11) Adjust oscilloscope sweep speed to 0.1 usec/cm.
- 12) Connect probe directly to plate pin 5 of V240.
- 13) Adjust L216 and L217 for ten complete sine waves (10 mc) on oscilloscope. Tighten locknuts on these two coils without reducing signal amplitude.
- 14) Connect probe to junction of C316 and C386. See figure 4-12.
- 15) Adjust L218 for maximum 10-mc signal. Normal signal with nothing plugged into J201 is a sine wave 4 to 5 volts peak-to-peak.

# 4-15. ADJUSTING GATE LENGTH.

Adjust gate length whenever the 10-mc self check yields readings consistently one to three counts in error. GATE LENGTH potentiometer is located on a bracket about 5 inches behind the upper edge of the front-panel opening. Proceed as follows:

- 1) Allow five-minute warmup before making adjustment. If possible, have blank panel or front-panel plug-in unit in place during warmup to insure that instrument reaches normal operating temperature.
- 2) Set:

   FUNCTION SELECTOR
   10 MC CHK

   FREQUENCY UNIT
   1

   DISPLAY TIME
   minimum (ccw)
- 3) Turn instrument off, remove front-panel plug-in unit, and turn instrument on again.
- 4) Adjust GATE LENGTH potentiometer R224 to center of range which yields reading of 10000.000.

# 4-16. ADJUSTING 10-MC DRIVE.

A tuned voltage divider applies the 10-mc signal to frequency converter plug-in units. The divider consists of C316, L224 and frequency converter input capacitance, adjusted to 22 pf at the factory. C316 and L224 are adjusted at the factory to resonate with 22-pf capacitance and should not need adjustment in the field. If you must check their adjustment, proceed as follows:

- 1) Remove front-panel plug-in unit and insert test plug (see figure 4-7) into J201.
- 2) Turn instrument on and allow 15-minute warmup.
- 3) Connect ac probe of vacuum tube voltmeter to pin 8 of J201; use 100- or 300-volt range. Voltmeter input impedance must be greater than 1 megohm at 10 mc.
- 4) Adjust L224 for maximum reading on voltmeter (voltmeter input capacitance detunes circuit). If reading is between 85 and 100 volts, proceed to step 11.
- 5) If reading is below 85 volts or above 100 volts, check 10-mc multiplier adjustment, paragraph 4-14.
- 6) If reading is still below 85 volts or above 100 volts, slightly adjust C316 starting about 45 degrees from maximum capacitance -- the two solder droplets are closest together at maximum capacitance.
- 7) Connect oscilloscope probe to junction of C316 and C386.
- 8) Adjust L218 for maximum signal on oscilloscope.
- 9) Disconnect oscilloscope and adjust L224 for maximum reading on voltmeter.
- 10) Repeat steps 6 through 9 until reading at pin 8 of J201 is between 85 and 100 volts.
- 11) Loosely couple voltmeter probe to 10-mc drive circuit by placing probe close to J201. Place probe close enough to get good indication on 10-volt range of voltmeter.
- 12) Readjust L224 for maximum reading on voltmeter.

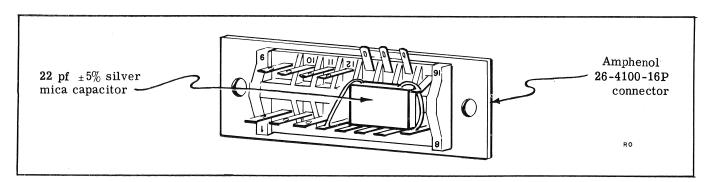


Figure 4-7. Test Connector for Adjusting 10-mc Drive

# 4-17. TUBE AND DIODE REPLACEMENT.

In many cases of instrument malfunction, the cause is a weak or defective tube. Adjustments made in an attempt to compensate for such tubes may complicate the repair problem. Locate the faulty circuit (see paragraph 4-18) and check the tube in that circuit before changing any of the internal adjustments.

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. If circuit condition (burned resistors, etc.) indicates that the original tube might have been shorted or otherwise mechanically defective, test the tube on a "tube tester" before returning it to the circuit.

You can use any tube with corresponding standard EIA characteristics for replacement. Where variations in tube characteristics may affect circuit performances, an adjustment is provided. Following the replacement of a tube listed in table 4-1, check the indicated adjustment. For tube locations see figure 4-8.

There are holes in the bottom of the cabinet-model cabinet which allow you to loosen the retainer screws on the amplitude discriminator, decade divider, and trigger plug-in units without removing the cabinet. Thus you can remove these units or any tube through the front-panel opening with the cabinet in place.

The crystal diodes used in the 524D have fast switching characteristics, and high back resistance at high temperatures. To check diodes (forward resistance, 600 ohms or less; back resistance, 500,000 ohms or more), use an ohmmeter of the multimeter type such as Simpson 260 or Triplett 630A. Checking diodes in this manner does not detect certain dynamic troubles but reveals most others. If necessary, check diodes by replacement.

Whenever possible, use diodes from Hewlett-Packard for replacement. If you use ordinary high-speed diodes for replacement, check back resistance at 150°F (at least 75,000 ohms).

# 4-18. TROUBLESHOOTING.

A. TROUBLESHOOTING PROCEDURE. The following is a systematic procedure for locating trouble in the 524D. For specific notes on the gate binary and units counter, see B and C of this paragraph.

Study the block diagrams in section III. This counter is logical in its operation. Many troubles can be traced to a specific circuit by systematic checks made at the front panel.

1) Check power supplies (paragraph 4-8). Proceed to step 2 only if power supplies operate properly.

- 2) Self-check instrument (figure 2-12). By so doing you check a maximum number of circuits and will save time if the trouble is external to the counter. Also, if the trouble is in the 10-mc multiplier or any phantastron but the 10-kc phantastron, self-check procedure shows it. Self-check procedure checks instrument operation but not sensitivity; if instrument self-checks properly, check performance (paragraph 4-5). If instrument does not self-check, proceed to step 3.
- 3) Check instrument reactions to specific front-panel control settings and compare reactions with those of table 4-2. When you have isolated the trouble to as few circuits as possible, proceed to step 4.
- 4) Compare waveforms throughout suspected circuits with those of table 4-3 to isolate the trouble as near as possible to the faulty component. If necessary, proceed to step 5.
- 5) Check tubes, voltages, and resistances within malfunctioning circuits to locate the faulty component. Voltage/resistance diagrams are included with the schematic diagrams. Should you have to replace a part on a printed circuit board, see figure 4-16. If you replace a part in any of the circuits listed in table 4-1, check the indicated adjustment.
- B. TROUBLESHOOTING GATE BINARY. If the gate binary does not operate properly, be sure that display time control V204 is not holding diode gate CR205 closed, and that the driving signal is adequate. Check tubes by substitution. If new tubes do not correct instrument operation, return the original tubes and check voltages and resistances.

Check +210 volt-to-plate, plate-to-grid, and grid-to-bias networks by removing binary tubes V206 and V207 and all crystal diodes (CR203, CR204, CR205, CR206, CR207, CR209, CR210 and CR211) except CR208 and CR212. Plate-pin voltages and grid-pin voltages should agree within 0.4 volt. If not, check resistances and replace any faulty components. Check crystal diodes as directed in paragraph 4-17.

#### C. TROUBLESHOOTING UNITS COUNTER.

If trouble occurs in units counter section, check waveforms throughout the section while applying a 1-mc signal to counter. Compare observed waveforms with those of table 4-3. Remember that one faulty binary can affect waveforms in all binaries. Figure 4-9 shows some incorrect waveforms in the first binary and indicates some possible faults. The principles implied in figure 4-9 apply equally well to the other three binaries.

The coincidence network of the units counter, shown in figure 4-10, is important in the operation of the feedback circuit. If either tube driving the network is weak, its plate voltage may be affected by the plate

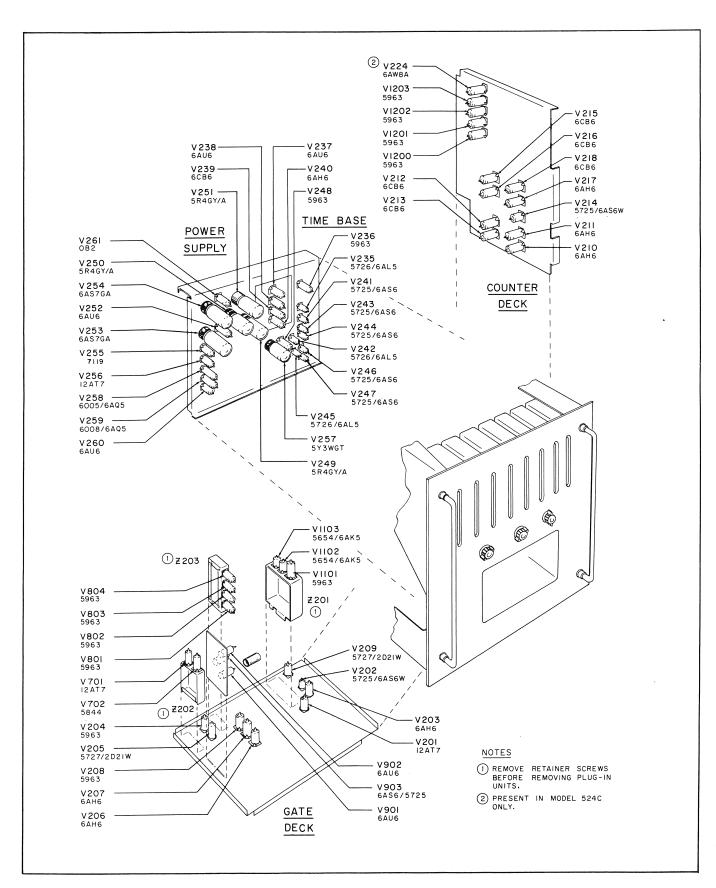


Figure 4-8. Tube Locations

Table 4-1. Adjustments Necessitated by Tube Replacement

Tube	e No. and Type	Function	Adjustment
V203	6AH6	Gate Control Tube	Gate length paragraph 4-15
V208	5963	Cathode Follower Buffer Amplifier	Gate length paragraph 4-15
V235	57 <b>26/6A</b> L5W	Rectifier/Coupling Diode	Phantastrons paragraph 4-11
V237	6AU6WA	X4 Multiplier	10-mc Multiplier paragraph 4-14
V238	6AU6WA	X5 Multiplier	10-mc Multiplier paragraph 4-14
V239	6CB6	X5 Multiplier	10-mc Multiplier paragraph 4-14
V240	6AH6	10 MC Amplifier	10-mc Multiplier paragraph 4-14
V241	5725/6AS6W	1st Phantastron	Phantastrons paragraph 4-11
V242	5726/6AL5W	Coupling Diode	Phantastrons paragraph 4-11
V243	5725/6AS6W	2nd Phantastron	Phantastrons paragraph 4-11
V244	5725/6AS6W	3rd Phantastron	Phantastrons paragraph 4-11
V245	5726/6AL5W	Coupling Diode	Phantastrons paragraph 4-11
V246	5725/6AS6W	4th Phantastron	Phantastrons paragraph 4-11
V247	5725/6AS6W	5th Phantastron	Phantastrons paragraph 4-11
V252	6AU6WA	Control Tube	Power supplies paragraph 4-8
V253 V254	6080WA/ 6AS7GA	Series Regulator	Power supplies paragraph 4-8
V255	7119	Series Regulator	Power supplies paragraph 4-8
V256	12AT7	Control Tube	Power supplies paragraph 4-8
V258 V259	6005/6AQ5W	Series Regulator	Power supplies paragraph 4-8
V260	6AU6WA	Control Tube	Power supplies paragraph 4-8
V261	OB <b>2</b> WA	Reference Tube	Power supplies paragraph 4-8
V701	12AT7	Stabilized Amplifier	Period sensitivity paragraph 4-13
V702	5844	Schmitt Trigger	Period sensitivity paragraph 4-13
V90 <b>2</b>	6AU6WA	Amplifier	Oscillator amplifier paragraph 4-9
V903	5725/6AS6W	Mixer	1 mc - 100 kc divider paragraph 4-10
V1101	5963	Stabilized Amplifier	Frequency sensitivity paragraph 4-12
V1102 V1103	5654	Schmitt Trigger	Frequency sensitivity paragraph 4-12

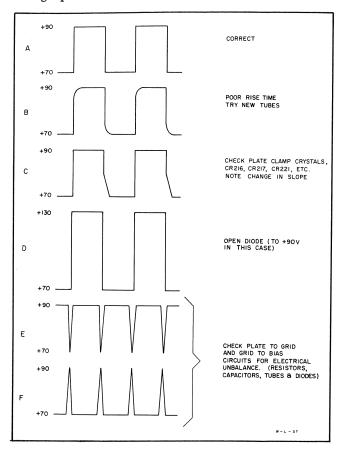


Figure 4-9. Correct and Incorrect Waveforms in 1st Binary of Units Counter

voltage of the other tube. Diodes with low back resistance can also affect plate voltages by connecting the tube plates together through a low resistance.

Although the high-speed binaries of the units counter do the counting, they do not directly drive the readout. Thus, if the units counter divides its input by

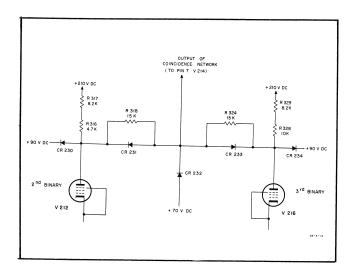


Figure 4-10. Coincidence Network

ten but the display count does not follow the correct sequence, the readout section may be at fault.

# D. COMPONENT TERMINAL BOARD INDEX.

Table 4-4 is a listing of all components mounted on terminal boards. The listing includes components used in the 560A printer kit. For terminal-board locations, see figures 4-12 through 4-15.

# 4-19. REMOVING CRYSTAL OVEN ASSEMBLY.

To replace any part of crystal oven assembly Z235, you should replace the whole assembly. The crystal and thermostat are matched and so should not be replaced separately. Replacement oven assemblies are supplied with complete replacement instructions.

#### Proceed as follows:

1) Remove instrument cabinet and set instrument on rear framework.

#### CAUTION

Unplug instrument from power source. Power switch does not remove power from crystal oven heater.

- 2) Remove thermometer. Nut and flat washer hold it from behind front panel. With nut unscrewed (use 2/8 inch open-end wrench) thermometer easily slides out of oven.
- 3) Disconnect all external leads at base of crystal oven.
- 4) Remove screws holding ADJ capacitor C914 to front panel and move C914 away from oven base.
- 5) Remove six screws holding oven to chassis and remove oven from instrument. To install replacement oven assembly, reverse above procedure.

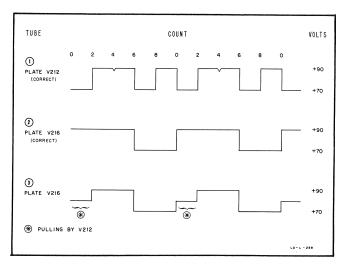


Figure 4-11. Correct and Incorrect Waveforms in Coincidence Network

Table 4-2. Troubleshooting Aid (Sheet 1 of 2)

Counter Controls	Normal Counter Reaction	Circuits Checked
(No external signal applied)	VR1001 and VR1002 (figure 4-12) flash on and off with FREQUENCY STANDARD switch at EXT; flash a few seconds and then stay off when FREQUENCY STANDARD switch is switched to INT	1-mc oscillator V901 Amplifier V902 1-mc - 100-kc divider V235A, V236A, V903
FUNCTION SELECTOR to MANUAL GATE TIME UNIT switch to 100 KC	GATE light on when MANUAL GATE switch set to OPEN, off when MANUAL GATE switch set to down position	Gate control V203 MANUAL GATE switch S202 GATE light DS201
FUNCTION SELECTOR to MANUAL GATE TIME UNIT switch to 100 KC MANUAL GATE switch to OPEN	Counter counts continuously	Buffer V236B Cathode follower V248B Input amplifier V201B Trigger unit Z201 Signal gate V202 Counter units
FUNCTION SELECTOR to MANUAL GATE TIME UNIT switch to 1 KC MANUAL GATE switch to OPEN	Counter counts continuously	10-kc phantastron V235B, V241 1-kc phantastron V242A, V243
FUNCTION SELECTOR to MANUAL GATE TIME UNIT switch to 10 CPS MANUAL GATE switch to OPEN	Counter counts continuously	100-cps phantastron V242B, V244 10-cps phantastron V245A, V246
FUNCTION SELECTOR to MANUAL GATE TIME UNIT switch to 100 KC MANUAL GATE switch to OPEN, then down position Press RESET switch	Readout returns to zero	Reset thyratron V209
FUNCTION SELECTOR to 100 KC CHK  FREQUENCY UNIT switch to 1  DISPLAY TIME control to minimum (ccw)  MANUAL GATE switch to down position	Counter counts for 1 sec, displays for 1 sec; 524C blanks readout during count time	Cathode follower V248A Amplitude discriminator Z202 Decade divider Z203 Gate binary V206, V207 Cathode follower buffer amplifier V208A Readout blanking V224 Display time control V205

Table 4-2. Troubleshooting Aid (Sheet 2 of 2)

Counter Controls	Normal Counter Reaction	Circuits Checked
FUNCTION SELECTOR to 100 KC CHK  FREQUENCY UNIT switch to 10  DISPLAY TIME control to minimum (ccw)	Counter counts for 10 sec, displays for 10 sec	1-cps phantastron V245B, V247
FUNCTION SELECTOR to 10 MC CHK  FREQUENCY UNIT switch to 1  DISPLAY TIME control to minimum (ccw)	Counter counts for 1 sec, displays for 1 sec; readout is 10000.000 ±.001	10-mc multiplier V237, V238, V239, V240
FUNCTION SELECTOR to 100 KC CHK  FREQUENCY UNIT switch to 1  DISPLAY TIME control to maximum (cw) but not to INF	Counter counts for 1 sec, displays for about 10 sec	Display time thyratron V205 Display time control V205

Table 4-3. Typical Waveforms (Sheet 1 of 14)

The following waveforms were observed on a 10-mc oscilloscope such as @ Model 150A with a 10:1 probe such as the @ AC-21A. Actual vertical sensitivity in volts/cm is shown with each waveform. To set oscilloscope vertical sensitivity, divide the value shown on each waveform by 10. This will compensate for the 10:1 division in the probe. Set the oscilloscope for ac coupling and sync as given beside each waveform. DC voltage levels (when important) are given in parentheses by each waveform. Sweep time is given below each waveform in microseconds unless otherwise noted in milliseconds (MS) or seconds (S).

Set the counter FREQUENCY STANDARD switch to INTERNAL and the DISPLAY TIME control fully counterclockwise (minimum); other counter control positions or test conditions are given with each waveform. Use an external signal source only when specified and disconnect this source when not required.

NOTE: THE WAVEFORMS SHOWN ARE TYPICAL FOR ANY 524C/D COUNTER. THE OVERALL WAVEFORM OBTAINED AT A GIVEN TEST POINT SHOULD BE SIMILAR BUT NOT NECESSARILY IDENTICAL TO THE ONE GIVEN IN THIS TABLE. THERE WILL ALSO BE SOME VARIATION IN PEAK-TO-PEAK AMPLITUDE.

Waveform Number	Counter Control	Oscilloscope Sweep Speed	Typical
and Test Point	Position	and Sync Setting	Indication
1 Pin 5 V901		0.2 usec/cm +INT Sync.	+.5 0 5

Table 4-3. Typical Waveforms (Sheet 2 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
2 Pin 5 V902	- <del>-</del> -	0.2 us/cm +INT Sync.	+5
3 Pin 1 V903	- <del>-</del> -	0.2 us/cm +INT Sync.	+5 0 -5 0 1 2
4 Pin 5 V903		2 us/cm +INT Sync.	+50 0 -50 0 10 20
5 Pin 3 V236	 	2 us/cm +INT Sync.	+.5 5 5 0 10 20
6 Pin 7 V236	 	2 us/cm +INT Sync	+100
7 Pin 1 V235	<del></del>	20 us/cm -INT Sync.	+ 20 0 - 20 0 100 200
8 Pin 2 V241		20 us/cm -INT Sync.	+10

Table 4-3. Typical Waveforms (Sheet 3 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
9 Pin 1 V242		20 us/cm -INT Sync.	+10 0 -10 0 100 200
10 Pin 2 V243	, <del></del>	0.2 ms/cm -INT Sync.	+10 0 -10 0 1 MS 2
11 Pin 5 V242	<sup>-</sup>	0.2 ms/cm -INT Sync.	+10 0 -10 0 1 MS 2
12 Pin 2 V244		2 ms/cm -INT Sync.	+10 0 -10 0 IOMS 20
13 Pin 1 V245	 	2 ms/cm -INT Sync.	+10 0 -10 0 IOMS 20
14 Pin 2 V246	- <del></del>	20 ms/cm -INT Sync.	+10 0 -10 0 100MS 200
15 Pin 5 V245		20 ms/cm -INT Sync.	+10 0 -10 0 100MS 200

Table 4-3. Typical Waveforms (Sheet 4 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
16 Pin 2 V247		0.2 s/cm -INT Sync	+10 0 -10 0 1s 2
17 Pin 3 V248	FREQUENCY UNIT to .01 SEC	0.2 ms/cm -INT Sync.	+10 0 -10 0 IMS 2
18 Pin 1 V237	<b></b>	2 us/cm +INT Sync.	+2 0 -2 0 10 20
19 Pin 5 V237		1 us/cm +INT Sync.	+20 0 -20 0 5 10
20 Pin 1 V238		1 us/cm +INT Sync.	+10 0 -10 0 5 10
21 Pin 5 V238		0.2 us/cm +INT Sync.	+10
22 Pin 1 V239		0.2 us/cm +INT Sync.	+10

Table 4-3. Typical Waveforms (Sheet 5 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
23 Pin 5 V239	<b></b>	0.1 us/cm +INT Sync.	+2 0 -2 0 0 .5
24 Pin 1 V240	<b></b> -	0.1 us/cm +INT Sync	+2 0 -2 0 .5
25 Pin 5 V240		0.1 us/cm +INT Sync.	+10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
26 Junction C316 and C386		0.1 us/cm +INT Sync.	+2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
27 STD. FREQ OUTPUT connector	TIME FREQUENCY to 10 CPS	10 ms/cm -INT Sync.	+.5 0 5 0 50 MS 100
28 STD. FREQ OUTPUT connector	TIME UNIT to 1 KC	0.2 ms/cm -INT Sync.	+.5 0 5 0 IMS 2
29 STD. FREQ OUTPUT connector	TIME UNIT to 100 KC	2 us/cm -INT Sync.	+5

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Table 4-3. Typical Waveforms (Sheet 6 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
30 STD, FREQ OUTPUT connector	TIME UNIT to 10 MC	0.1 us/cm -INT Sync.	+ 2 0 - 2 0 0 .5
31 Pin 5 Z202	FUNCTION SELECTOR to 100 KC CHK FREQUENCY UNIT to .001	20 us/cm -INT Sync. (Dc level must be zero)	+.5 (0)0 5 0 100 200
32 Pin 3 Z202	SAME as Waveform 31	_INT Sync	+ 20 0 - 20 - 1MS 2
33 Pin 2 Z203	SAME as Waveform 31	-INT Sync	+20 0 -20 
34 Junction of C225 and S201C	SAME as for Waveform	0.2 ms/cm -INT Sync.	+5 0 -5 0 IMS 2
35 Pin 5 V207 (Junction of CR207 and CR208)	FUNCTION SELECTOR to 100 KC CHK FREQUENCY UNIT to .001 Remove V205 to make dis- play time equal gate time	-INT Sync.	GATE GATE OPEN CLOSED  +90) +5 0 -5 +70) IMS 2
36 Pin 8 V208	SAME as Waveform 35	0.2 ms/cm -INT Sync.	15 0 -5 0 IMS 2

Table 4-3. Typical Waveforms (Sheet 7 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
37 Junction of R219 and R220	SAME as Waveform 35	0.2 ms/cm -INT Sync.	+5 0 -5 0 IMS 2
38 Pin 5 V203 (Junction of CR201 & CR202)	SAME as Waveform 35	0,2 ms/cm +INT Sync.	(+90) +5 0 -5 (+70) 0 IMS 2
39 Pin 5 V202	SAME as Waveform 35	0.2 ms/cm +INT Sync.	+20 0 -20 -1 IMS 2
40 Pin 5 V202	SAME as Waveform 35	0.2 ms/cm +INT Sync. Sweep expanded X10 to show pulses	+ 20 0 - 20 0 0,1MS 0.2
41 Pin 6 V208	SAME as Waveform 35	0.2 ms/cm +INT Sync.	+20 0 -20 -20 1MS 2
42 Pin 2 V208	SAME as Waveform <b>3</b> 5	0.2 ms/cm +INT Sync	+20 -20 -1MS 2
43 Pin 1 V209	SAME as Waveform 35	0.2 ms/cm +INT Sync	+50 0 -50 0 IMS 2

Table 4-3. Typical Waveforms (Sheet 8 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
44 Pin 2 V209	SAME as Waveform 35	0.2 ms/cm +INT Sync.	+50 0 -50 -1MS 2
45 Cathode CR214 (white lead)	SAME as Waveform 35	0.2 ms/cm +INT Sync.	+2 0 -2 -1 HS 2
46 Pin 1 V205	FUNCTION SELECTOR to 100 KC CHK FREQUENCY UNIT to .001	20 ms/cm +INT Sync. (period varies with dis- play Time Control)	+50 0 -50 0 100MS 200
47 Pin 6 V205	SAME as for Waveform 46	20 ms/cm +INT Sync. (period varies with Dis- play Time control)	+50 0 -50 0 100 MS 200
48a Pin 1 V204	SAME as for Waveform 46	10 ms/cm -INT Syn. (period varies with Dis- play Time control)	+ 20 0 - 20 - 50 MS 100
48b Pin 1 V204	SAME as for Waveform 46	Sweep ex- panded X10 -INT Sync.	+20 0 -20 -20 
49 Pin 2 V201	FUNCTION SELECTOR to FREQUENCY FREQUENCY UNIT to . 001 Plug test connector into J20 Connect 100-kc, 2-volts rm sine wave to SIGNAL INPUT	s	+2 0 -2 0 10 20

Table 4-3. Typical Waveforms (Sheet 9 of 14)

Waveform Number and Test Point	Counter Control	Oscilloscope Sweep Speed	Typical
and Test Point	Position	and Sync Setting	Indication
50 Pin 7 V201	SAME as Waveform 49	2 us/cm +EXT Sync. from signal source	+2 0 -2 0 10 20
51 Pin 6 V201	SAME as Waveform 49	2 us/cm +EXT Sync. from signal source	+2 0 -2 0 10 20
52 Pin 1 Z201	SAME as Waveform 49	2 us/cm +EXT Sync. from signal source	+5 0 -5 0 10 20
53 Pin 1 V202	SAME as Waveform 49	2 us/cm +EXT Sync. from signal source	+5
54 Pin 5 V202	FUNCTION SELECTOR to FREQUENCY FREQUENCY UNIT to 1 Plug test connector into J202 Connect 100-kc, 2-volts rms sine wave to SIGNAL INPUT	2 us/cm +EXT Sync. from signal source. Gating causes wave- form to disappear during display time.	0 10 20
55 Junction CR215 and CR219	FUNCTION SELECTOR to MANUAL GATE MANUAL GATE switch to OPEN TIME UNIT switch to EXT.	1 us/cm +EXT Sync. *	+10
56a Pin 5 V210	Connect 1-mc, 2-volts rms signal to STD FREQ OUTPUT connector  SAME as for Waveform 55	+EXT Sync.* (+7)	0)+10

Table 4-3. Typical Waveforms (Sheet 10 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
56b Pin 5 V210	SAME as for Waveform 55	0.1 us/cm (+90) +5	.5,
57 Pin 5 V211	SAME as for Waveform 55	1 us/cm +EXT Sync. * (+90)+10 (+70)-10 TIME (µSEC) 0	5 10
58 Junction CR223 and CR228	SAME as for Waveform 55	1 us/cm +EXT Sync.*	5 10
59 Pin 5 V212	SAME as for Waveform 55	1 us/cm +EXT Sync.* (+90)+10 (+70)-10	6 0 2 4
60 Pin 5 V213	SAME as for Waveform 55	1 us/cm +EXT Sync.* (+90)+10 (+70)-10	6 0 2 4
61 Junction CR231, CR232 and CR233	SAME as for Waveform 55	1 us/cm +EXT Sync.* (+90)+10 (+70)-10	5 10
62 Pin 5 V214	SAME as for Waveform 55	1 us/cm +10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	8 0 4 +++++++++++++++++++++++++++++++++++

Table 4-3. Typical Waveforms (Sheet 11 of 14)

Vaveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication	
		COUN	T 4 8 0 4	
63	SAME as Waveform 55	1 us/cm	+10	
Junction		+EXT Sync.*	0 <del>-+++1-</del>	
CR242 and			-10	
CR246		TIME (µSEC	) 0 5 10	
		TIME (#320	,	
			4 8 0 4	
64	SAME as Waveform 55	1 us/cm	» <del></del>	
Pin 5		+EXT Sync. *	))+10	
V218			D)-10	
			0 5 (	
			4 8 0 4	
65	SAME as Waveform 55	1 us/cm	) up	
Pin 5		+EXT Sync.*	)+10	
V217		•	»)-10  <del>  </del>	
			+	
			0 5 10	
66	SAME as Waveform 55	1 us/cm	4 6 8 0 2 4	
	SAME as waveform 55	· ·	+10	
Junction CR235 and		+EXT Sync.*	10-11-1-11	
CR237 and CR237			-10	
010101			+	
			0 5 10	
67	SAME as Waveform 55	1 us/cm	4 0 4	
	ZIIII US WAVEIGIII US	/+0/	0)+10	
Pin 5 V215		-EXT Sync.*	0)-10	
V213		(+//	))-10	
			0 5 10	
			4 0 4	
68	SAME as Waveform 55	1 us/cm (+90)	1+10	
	and the country of		0	
Pin 5 V216		+EXT Sync. * (+70)		
4 E T C	·			
And the second s			0 5 10	
69	FUNCTION SELECTOR	0.2 us/cm		
Junction	to MANUAL GATE	+EXT Sync.*	+10 = = = = = = = = = = = = = = = = = = =	
CR215 and	MANUAL GATE switch to	Dync.	+10 +10 +10 +10 +10 +10 +10 +10 +10 +10	
CR219	OPEN		-10	
	TIME UNIT switch to 10 MC		+	
		1 - 1 - p.	0 1 2	

Table 4-3. Typical Waveforms (Sheet 12 of 14)

aveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication		
70	SAME as Waveform 69	0.2 us/cm	+		
Pin 5 V210		+EXI Sync.	0)+10		
V210		(+7	0 1 2		
71	SAME as Waveform 69	0.2 us/cm	+		
Junction		+EXT Sync.*	+5		
CR223 and CR228			0 1 2		
72	SAME as Waveform 69	0.2 us/cm			
Pin 5		+EXT Sync. * (+9	10)+10 mmm		
V212			0)-10		
73	SAME as Waveform 69	0.2 us/cm	+		
Junction		+EXT Sync.*	0)+10		
R231, CR232		(+7	0)-10		
74	SAME as Waveform 69	0.2 us/cm	+		
Pin 5 V214		+EXT Sync.*	-10		
			0 1 2		
75	SAME as Waveform 69	0.2 us/cm	1		
Junction CR242 and CR246		+EXT Sync.*	10		
			0 2		
76	SAME as Waveform 69	0.2 us/cm	00)+10		
Pin 5		FVT Sync *	0)_0		
V218	e e e		~′-10		
			0 1 2		

Table 4-3. Typical Waveforms (Sheet 13 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication
77 Junction CR235 and CR237	SAME as Waveform 69	0.2 us/cm +INT Sync.*	+10
78 Pin 5 V215	SAME as Waveform 69	INT Sunc *	0)+10
79 Pin 6 V1200	FUNCTION SELECTOR to MANUAL GATE MANUAL GATE switch to OPEN TIME UNIT switch to 1 KC	COUNT 1 ms/cm +EXT Sync.*  TIME (µSEC)	+50
80 Pin 6 V1201	SAME as Waveform 79	1 ms/cm +EXT Sync.*	+50 -50 0 5MS 10
81 Pin 6 V1202	SAME as Waveform 79	1 ms/cm +EXT Sync.*	4 8 0 4 +50 0 -50 0 5 MS 10
82 Pin 6 V1203	SAME as Waveform 79	1 ms/cm +EXT Sync.*	+50 -50 -50 -5MS IO
83 Pin 6 V801 (In Z203)	FUNCTION SELECTOR to 100 KC CHK FREQUENCY UNIT switch to .01	1 ms/cm -EXT Sync.**	+20 0 -20 0 5MS 10

<sup>\*</sup>EXT sync taken from junction of R328 and R329 (V216 plate load) with an unshielded wire.

<sup>\*\*</sup>EXT sync taken from V804 pin 6 with an unshielded wire.

Table 4-3. Typical Waveforms (Sheet 14 of 14)

Waveform Number and Test Point	Counter Control Position	Oscilloscope Sweep Speed and Sync Setting	Typical Indication		
84 Pin 6 V802 (In Z203)	SAME as for Waveform 83	1 ms/cm -EXT Sync.**	+20 0 -20 0 5MS 10		
85 Pin 6 V803 (In Z203)	SAME as for Waveform 83	1 ms/cm -EXT Sync.**	+20 0 -20 -20 5M\$ TO		
86 Pin 6 V804 (In Z203)	SAME as for Waveform 83	1 ms/cm -EXT Sync.**	+20 0 -20 0 5MS 10		
87 Pin 7 V701 (In Z202)	SAME as for Waveform 83	0.2 ms/cm -INT Sync.	+2 0 -2 0 IMS 2		
88 Pin 6 V701 (In Z202)	SAME as for Waveform 83	0.2 ms/cm -INT Sync.	+10 0 -10 1 MS 2		
89 Pin 1 V1101 (In Z201)	FUNCTION SELECTOR to 100 KC CHK	5 us/cm +INT Sync.	+10 0 -10 0 25 50		
90 Pin 5 V1102 (In Z201)	SAME as for Waveform 89	5 us/cm +INT Sync.	+10		

Table 4-4. Component-Terminal Board Index (Sheet 1 of 2)

Circuit Symbol	Terminal Board	Circuit Symbol	Terminal Board	Circuit Symbol	Terminal Board	Circuit Symbol	Terminal Board
C204	<b>TB16</b>	C327	TB21	CR234	TB 9	R231	TB15
C205	4	C333	20	CR235	9 9	R232	13
C214	15	C345	22	CR236	9	R233	15
C217	5	C346	22	CR237	9	R235	15
C219	19	C361	13	CR238	9	R236	15
C225	13	C362	13	CR239	9	R238	5
C227	13	C363	14	CR240	9	R239	5
C228	13		16	CR241	9	R240	5 5
		C364			9		
C229	15	C365	13	CR242	9	R241	5
C230	13	C371	13	CR243	9	R243	6
C231	13	C387	15	CR244	9	R244	5
C233	16	C919	13	CR245	9	R249	15
C234	16	C1002	20	CR246	9	R251	13
C235	16	C1003	20	CR247	9 9	R252	13
C236	18	C1004	20		0	R253	13
C237	17	C1004 C1005	20 20	CR248	9	R254	13
				CR260	9	R254 R255	
C238	19	C1401	4	CR1401	16		13
1.2.1		C1402	16	CR1402	1401	R256	13
C239	14	C1403	1401	CR1403	16		
C240	8	C1404	16			R257	13
C241	6			F202	23	R258	13
C242	6	CR201	19			R259	13
C243	8	CR202	19	L201	17	R260	13
C244	9	CR203	14	L202	17	R261	13
		CR204	14	L203	18	R262	13
C245	10	CR205	14	L203	19	10-0-	
C247	12	CR206	14			R263	13
		CR200	14	L205	19	R264	13
C248	12	GD00F			_		
C249	10	CR207	14	L208	9	R265	15
C250	8	CR208	14	L226	9	R266	13
C251	8	CR209	14	L227	· 9	R267	13
		CR210	14	L1401	16	R268	13
C252	. 8	CR211	14				
C253	10	CR212	14	R205	4	R269	13
C254	10			R206	17	R270	13
C255	11	CR213	16	R207	17	R271	16
C256	11	CR214	17	R208	17	R272	16
C257	10	CR215	9	R212	19	R273	16
<u></u>	-0	CR216	9	R213	18	R274	16
C258	8	CR217	9	16210	10		
C259	12	CR218	9	R214	19	R275	16
C260	12	CRZIO	<b>ט</b>			R276	16
		GD010	^	R215	19	R277	
C261	8	CR219	9	R216	17		18
C264	1	CR220	9	R217	17	R280	19
C284	7	CR221	9	R218	19	R281	13
		CR222	9	R219	19	R282	5
C286	7	CR223	9				
C290	15	CR224	9	R220	19	R283	17
C291	15	CR225	9	R221	19	R285	5
C318	20			R222	19	R287	4
C319	20	CR226	9	R223	19	R288	15
C320	20	CR227	9	R225	19	R290	9
		CR228	<u>,</u> , , , , , , , , , , , , , , , , , ,	1020	10		= '
C321	20	CR229	9	R226	19	R291	7
- U41	20	CR229 CR230	9			R292	8
	40			R227	19		
C322	กา	CIDOOI					
C322 C323	21	CR231	9	R228	17	R293	8
C322	21 21 21	CR231 CR232 CR233	9 9 9	R228 R229 R230	17 13 13	R295 R296	8 7 7

Table 4-4. Component-Terminal Board Index (Sheet 2 of 2)

Circuit	Terminal	Circuit	Terminal	Circuit	Terminal	Circuit	Terminal
Symbol	Board	Symbol	Board	Symbol	Board	Symbol	Board
						71004	
R297, R2	298 TB6	R411	TB7	R523	TB23	R1224	TB2
R299	7	R412	7	R525	23	R1225	2
R300	8	R413	7	R526	23	R1226	1
R301	8	R414	7	R527	22	R1227	1
		R433	20	R528	22	R1228	1
R303	8			R530	13	R1229	2
	_	R435	20	Rosu	13	R1229	4
R304	8	İ				-1000	
R305	7	R436	20	R540	9	R1230	2
R306	9	R437	20	R541	9	R1231	1
R307	10	R438	20	R551	19	R1232	1
R308	10	R439	20	R552	19	R1233	2 3
R309	10	R440	20	R553	1	R1234	3
Rous	10				i l	R1236	3
		R443	20	R554	. 1	111230	J
R310	10				_	D1000	•
R311	12	R445	20	R555	1	R1238	2
R312	12	R446	20	R919	13	R1239	2
R313	10	R447	20	R920	13	R1240	1
R314	10	R448	20	R1001	20	R1241	1
R315	10	R449	20	R1002	20	R1242	1
K315	10					R1243	ī
		R452	20	R1003	20	R1243	
R316	11						_
R317	11	R454	21	R1004	20	R1244	1
R318	10	R455	21	R1006	20	R1245	1
R319	7	R456	21	R1007	20	R1246	2 2
R320	7	R457	21	R1008	20	R1247	2
	7	R458	21	R1009	20	R1248	3
R321	•						3
		R461	21	R1011	20	R1249	3
R322	7	R463	21				
R323	7			R1012	21	R1251	3
R324	10	R464	21	R1014	21	R1253	3
R325	10	R465	21	R1015	21	R1254	2
R326	10	R466	21	R1017	21	R1255	1
				R1018	21	R1256	î
R327	10	R467	21				
		R470	21	R1020	21	R1401	4
R328	11	R472	21		· ·	R1402	1401
R329	11	R473	21	R1021	21		
R330	11			R1025	20	R1403	4
R331	11	R474	21	R1200	1	R1404	1401
	11	R475	21	R1201	2	R1405	16
R332				R1201		R1406	1401
R333	10	R476	21		1		1401
		R479	21	R1203	1	R1407	
R334	10	R495	23		Ì	R1408	16
R335	1	R496	22	R1204	3	R1412	16
R336	11	R497	22	R1205	3		
R337	8	1	•	R1207	3	VR201	15
		R498	22	R1208	3	VR202	15
R338	8				2	VR203	1
R339	8	R499	22	R1210			20
		R502	23	R1211	2	VR1001	40
R340	7	R503	23	1			
R342	12	R505	23	R1212	1	VR1002	20
R343	12	R506	23	R1213	1	VR1201	1
R344	8	R510	22	R1214	1	VR1202	1
		1,010	~ ~	R1215	$\stackrel{1}{2}$	VR1203	1
R345	8	2511	0.0				î
		R511	23	R1216	1	VR1204	1
		R513	23				4
R346	8	R514	23	R1217	1	VR1205	1
R347	7	R517	22	R1218	3	VR1401	4
R348	7	R520	23	R1219	3	VR1402	4
	•	11040			- 1		1401
R407	7	R521	23	R1221	3	VR1403	1401

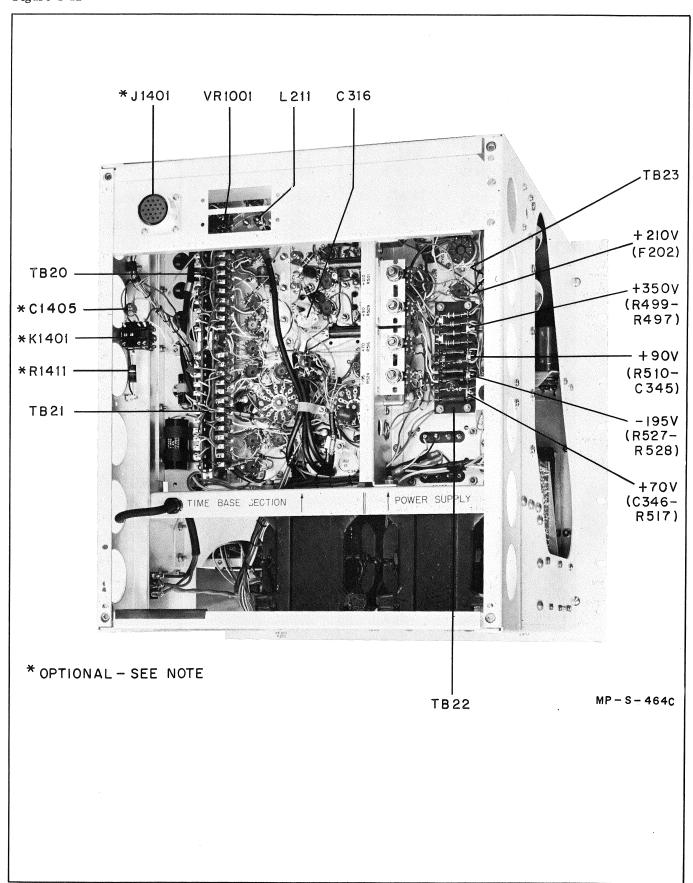


Figure 4-12. Rear View of Counter Chassis. Note: 1400 series components are present only if 560A or 561B printer kit is installed.

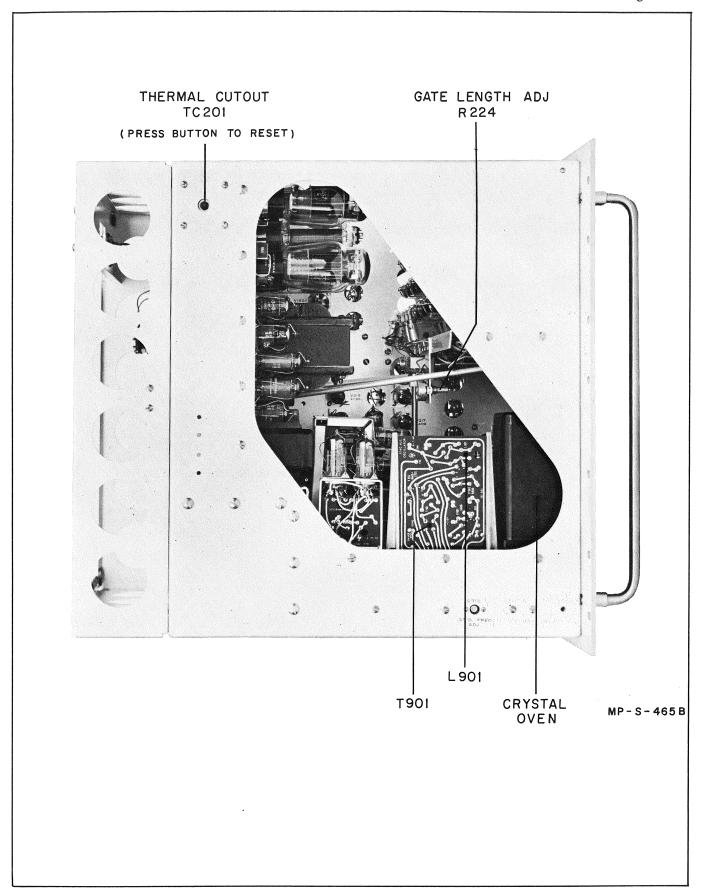


Figure 4-13. Left Side View of Counter Chassis

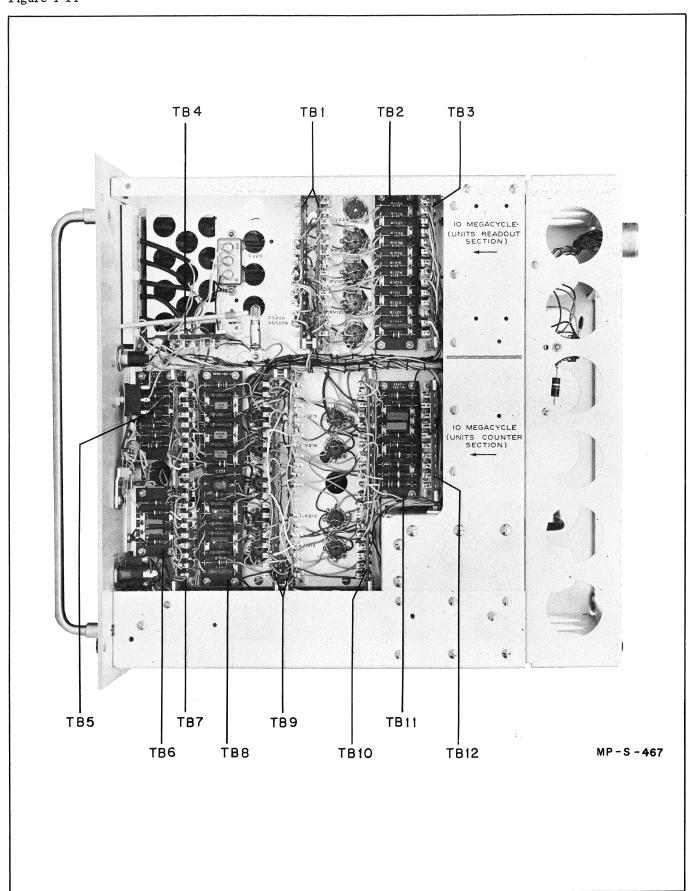


Figure 4-14. Right Side View of Counter Chassis

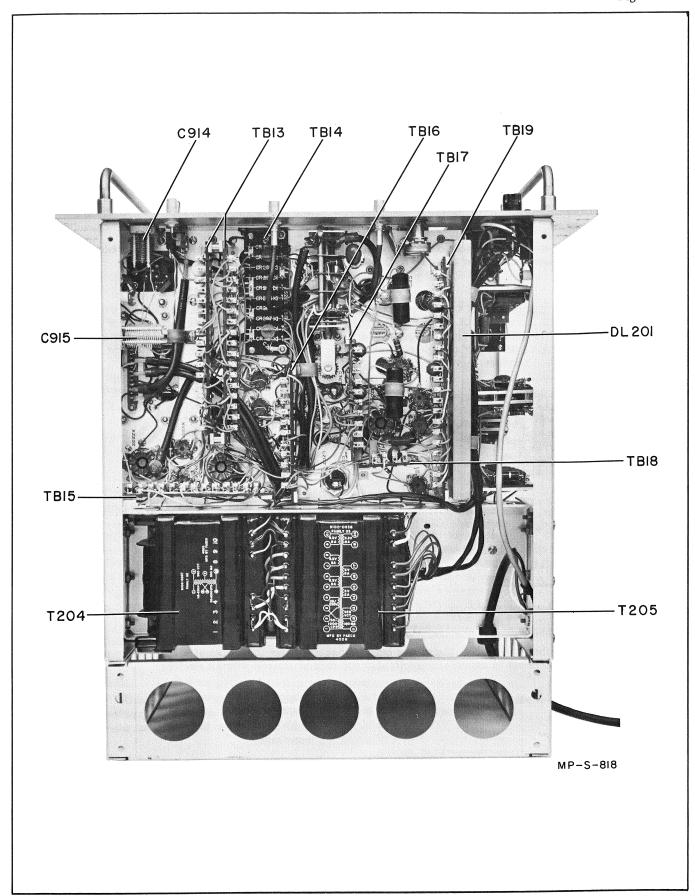


Figure 4-15. Bottom View of Counter Chassis

# 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.

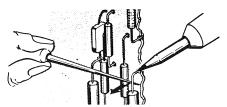
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

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.

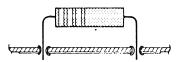
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

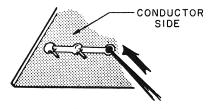
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



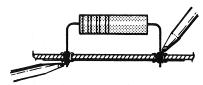
3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.



2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.

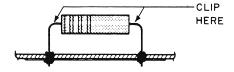


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

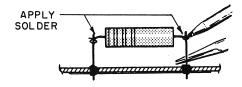


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 4-16. Servicing Etched Circuit Boards

## **VOLTAGE AND RESISTANCE DIAGRAM NOTES -**

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

H = heater K = cathode

G or G1 = grid closest to cathode
G2 = 2nd grid from cathode
G3 = 3rd grid from cathode

Hm = heater mid-tap
Is = internal shield

P = plate

NC = no external connection to socket

The letter subscript to tube-element designators indicates the section of a multiplesection tube.

- 2. DC voltages shown were measured with a voltmeter having an input resistance greater than 100 megohms.
- 3. Voltage values shown are for guidance; values may vary from those shown due to tube aging or normal differences between instruments. Resistance values may vary considerably from those shown when the circuit includes potentiometers, crystal diodes, or electrolytic capacitors.
- 4. Voltage measured at the terminal is shown above the line, resistance below the line; measurements made with an electronic multimeter, from terminal to chassis ground unless otherwise noted.
- 5. A solid line between socket terminals indicates a connection external to the tube between the terminals; a dotted line between terminals indicates a connection inside the tube. Voltage and resistance are given at only one of the two joined terminals.

00021-2

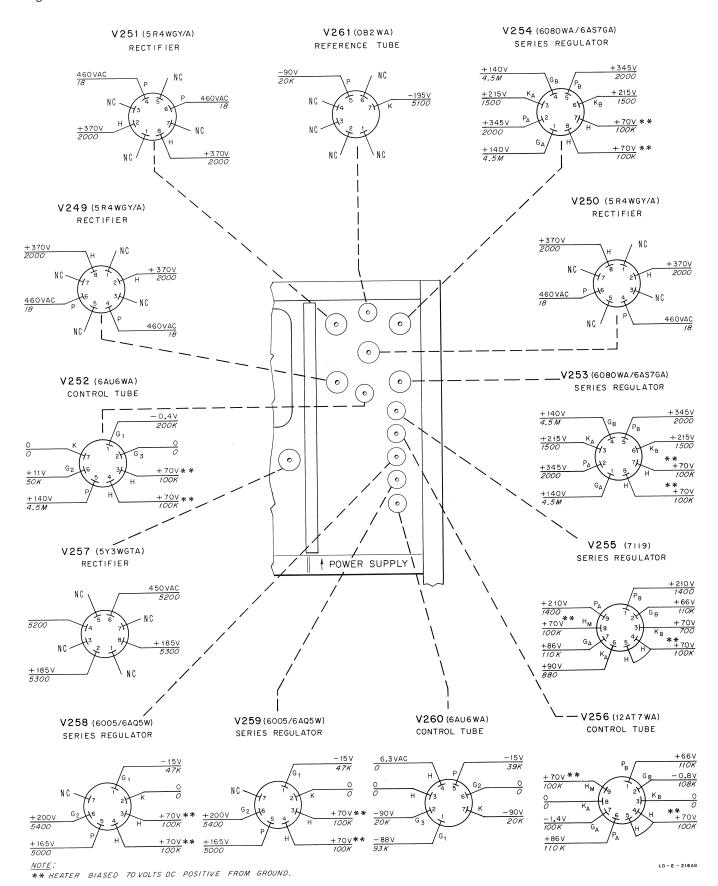


Figure 4-17. Power Supply

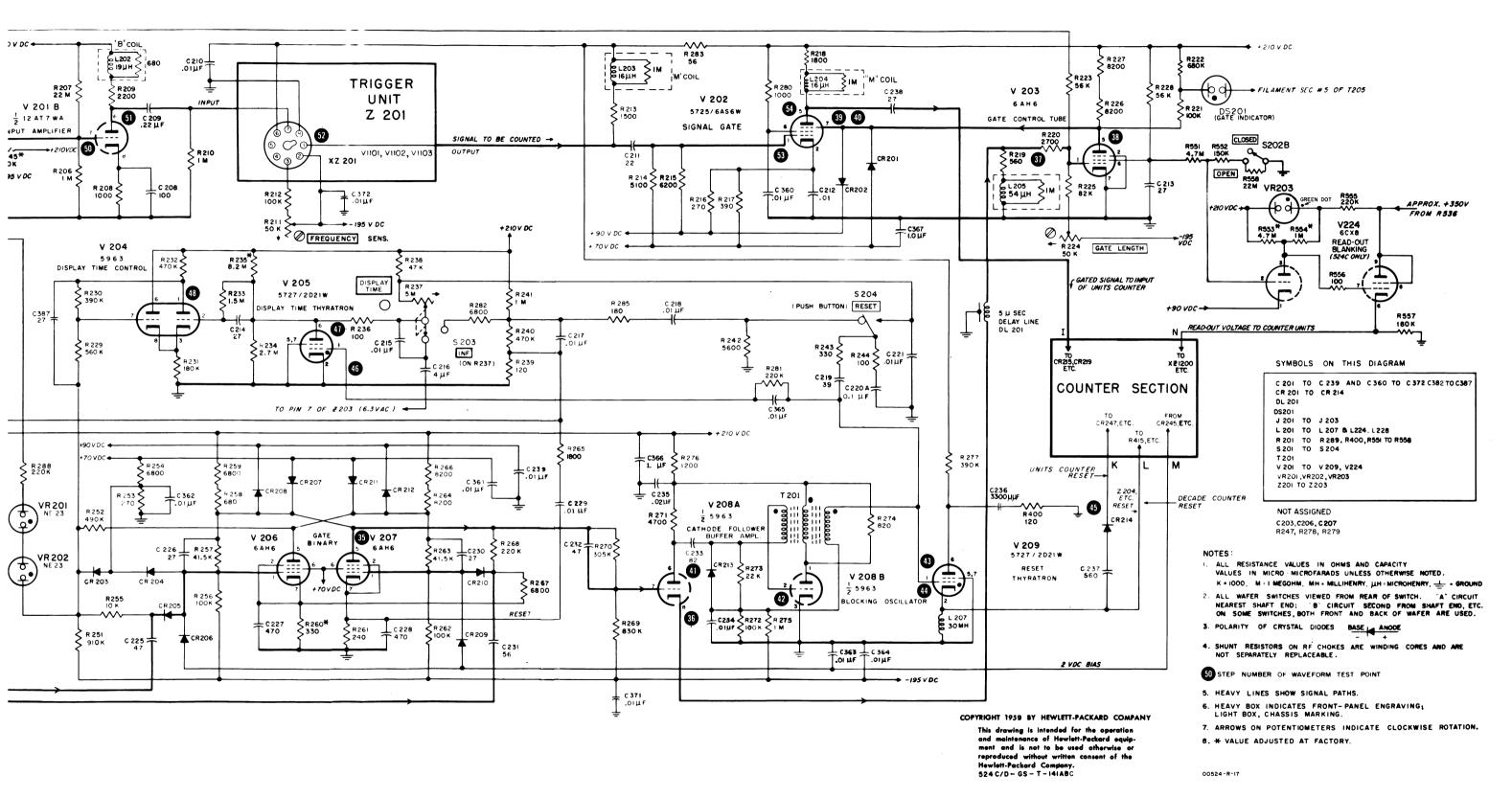
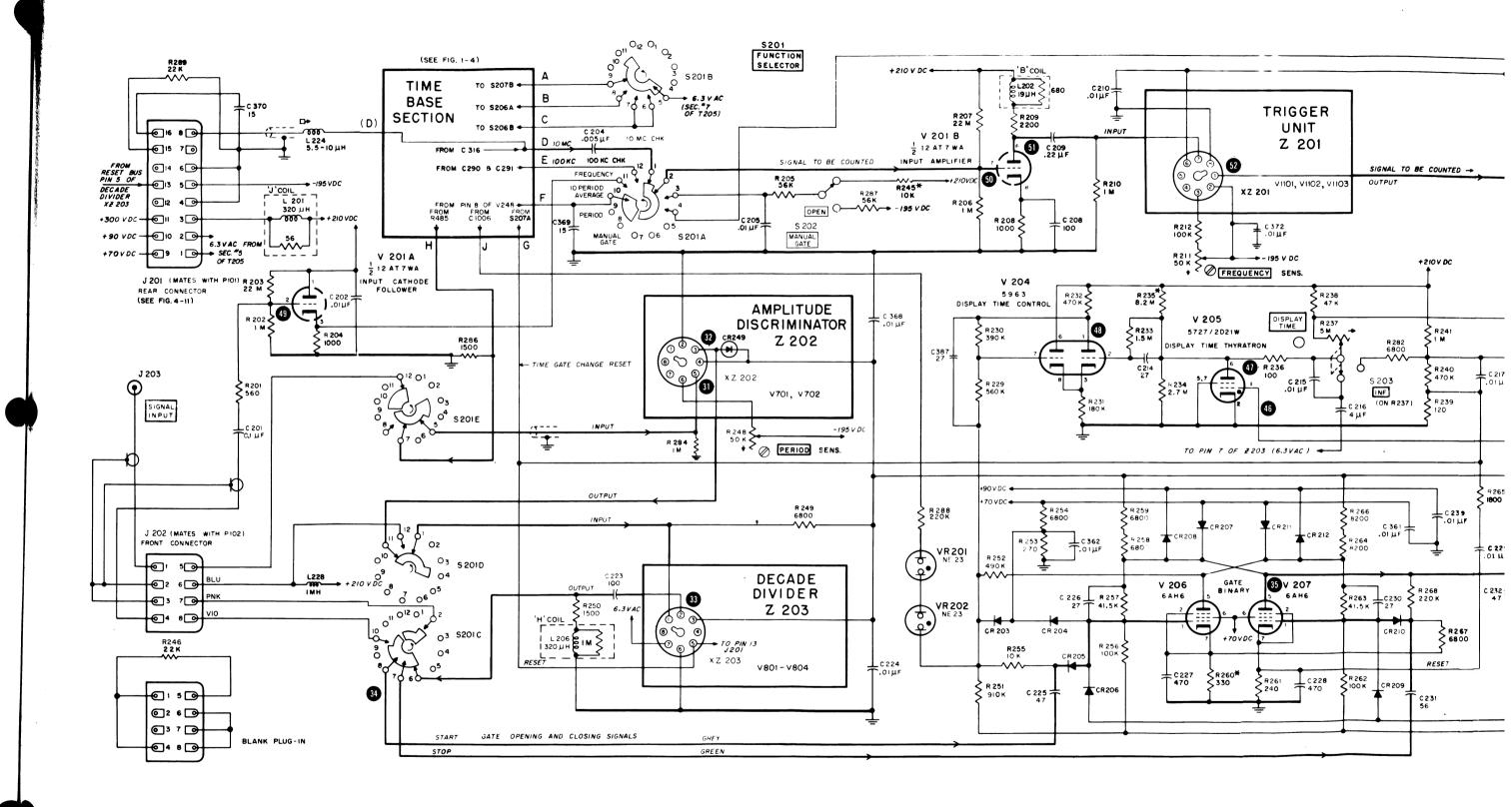


Figure 4-22. Gate Section



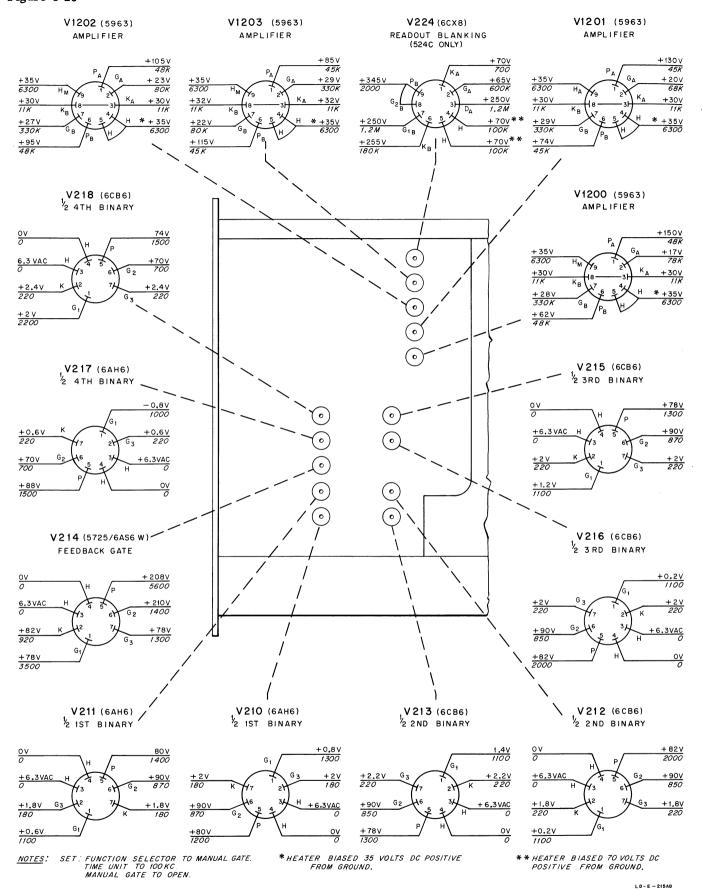


Figure 4-23. Units Counter

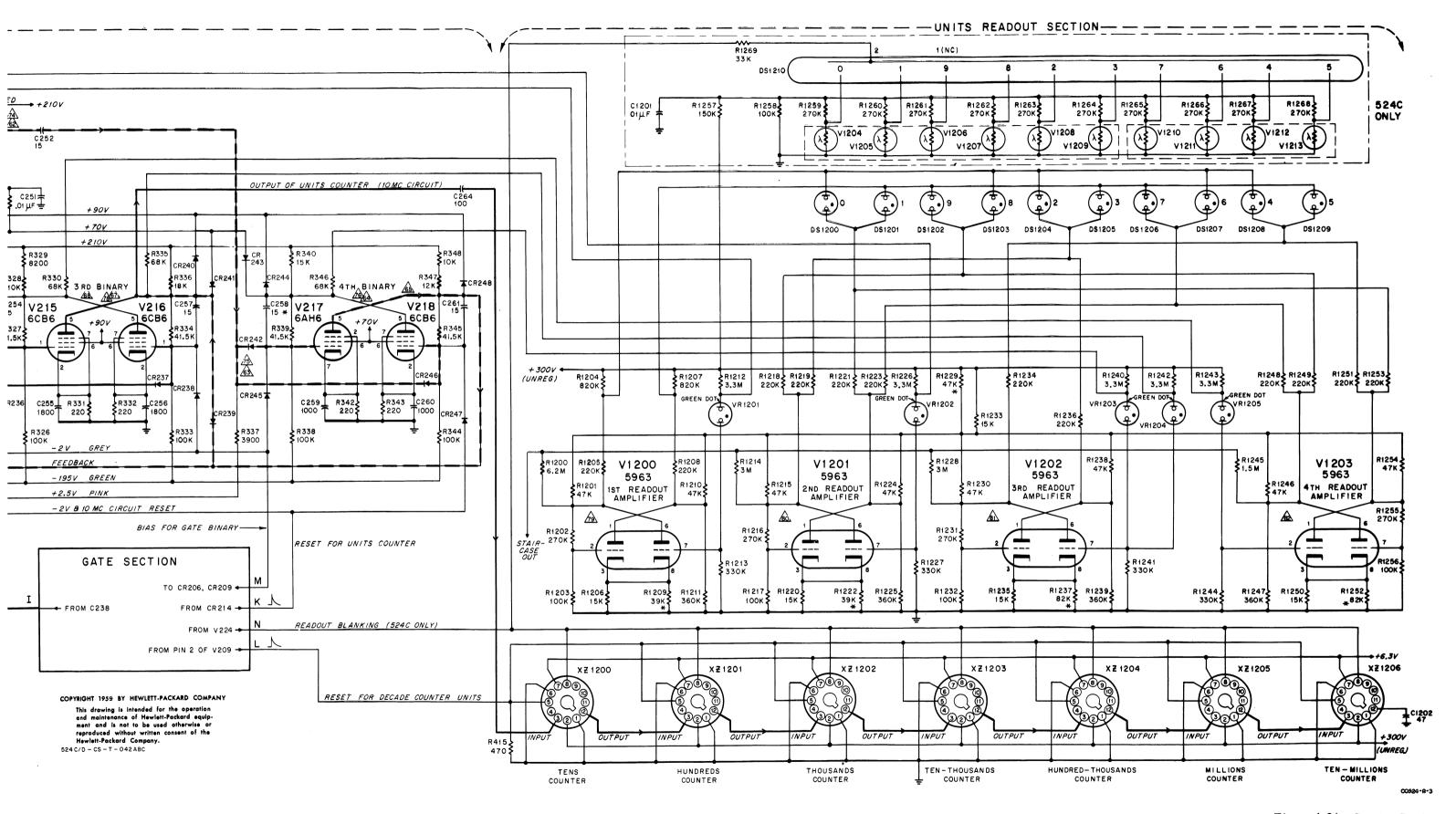
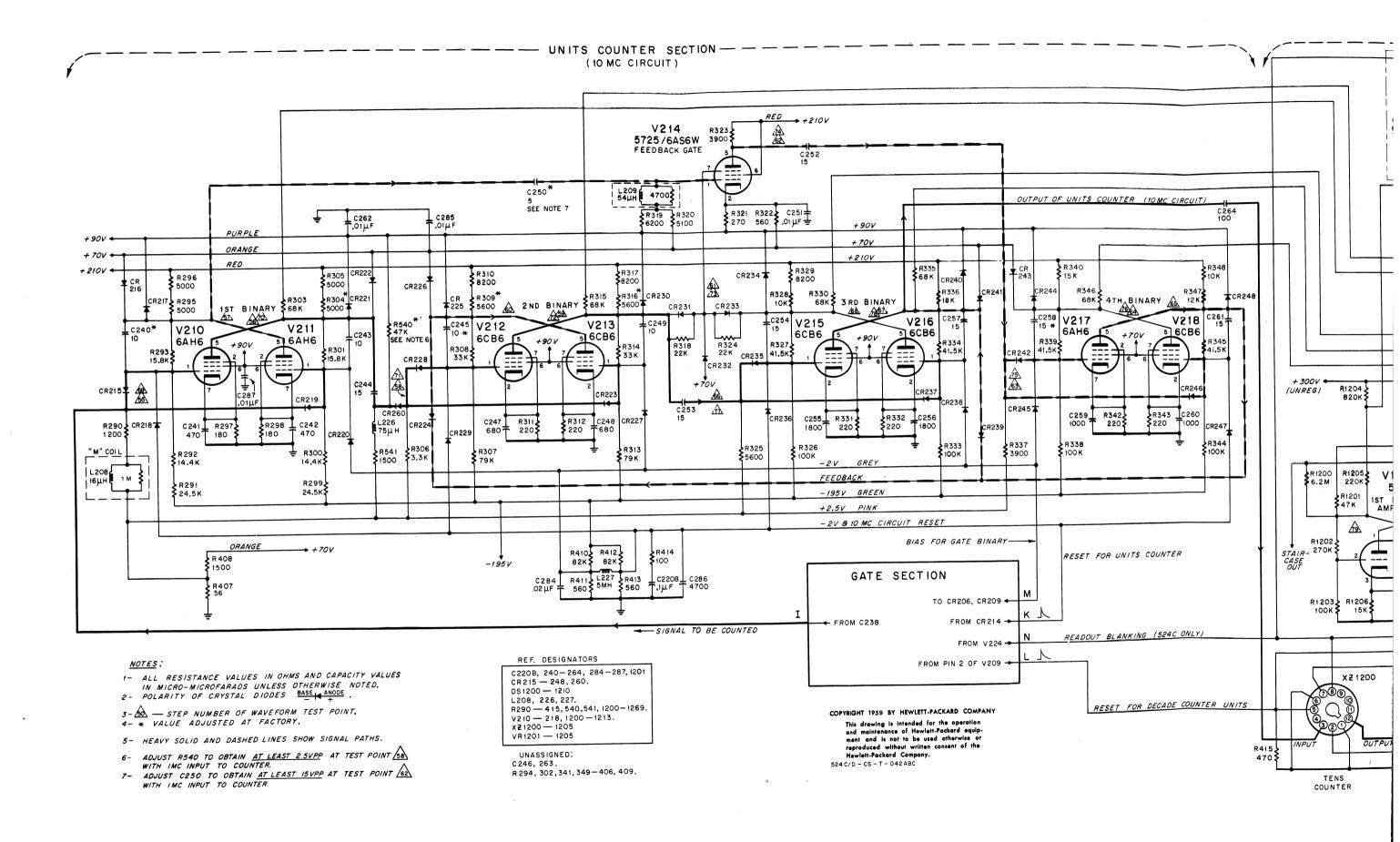
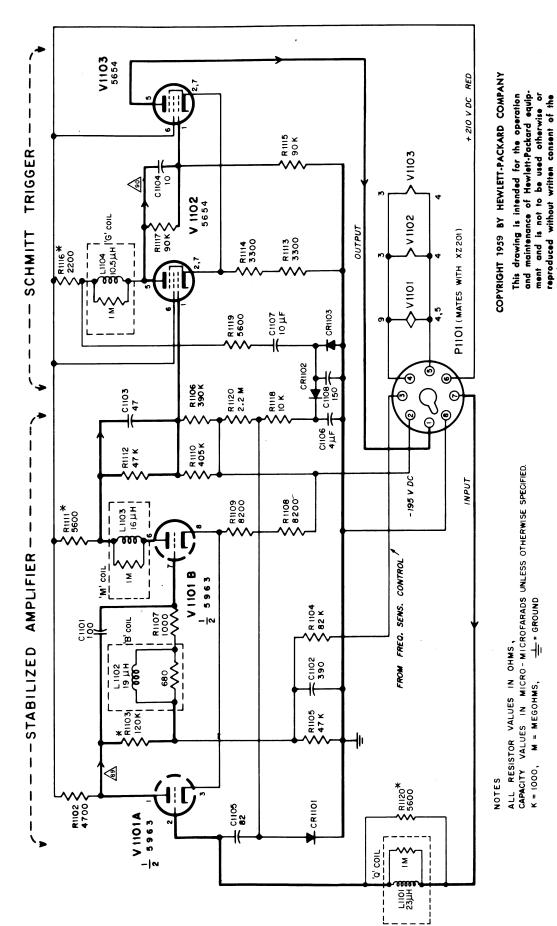


Figure 4-24. Counter Section

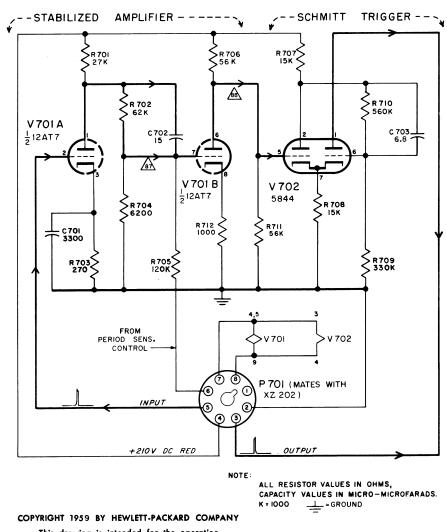




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524C/D- TRIG UNIT - T042A This drawing is intended for the operation

Figure 4-26. Trigger Unit Z201

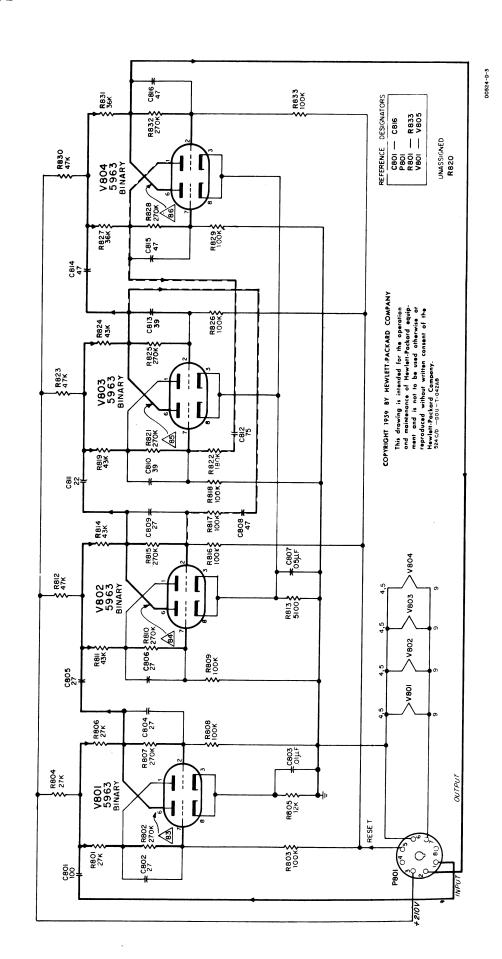


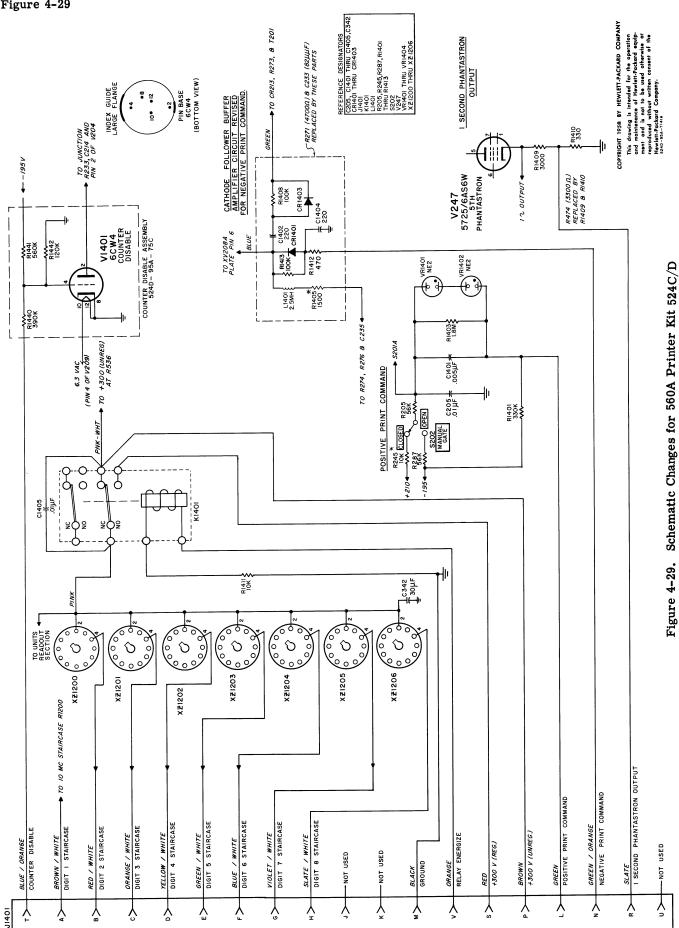
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524 C/D - AMPL DISC - T0042A

Figure 4-27. Amplitude Discriminator Z202







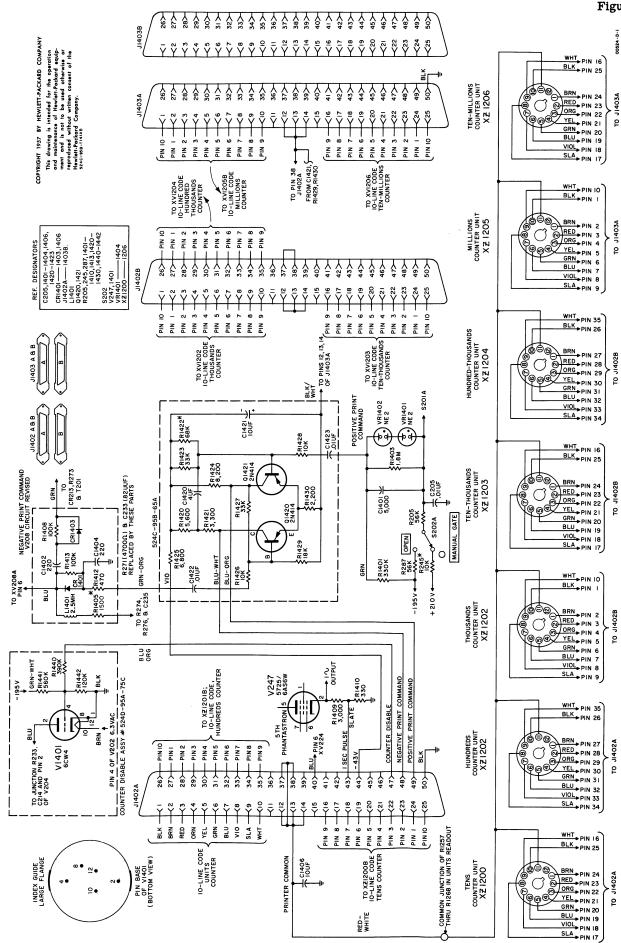


Figure 4-30. Schematic Changes for 561B Printer Kit (524C only)

Figure 4-31. Schematic Changes for 562A Printer Kit Installed In 524C Counter

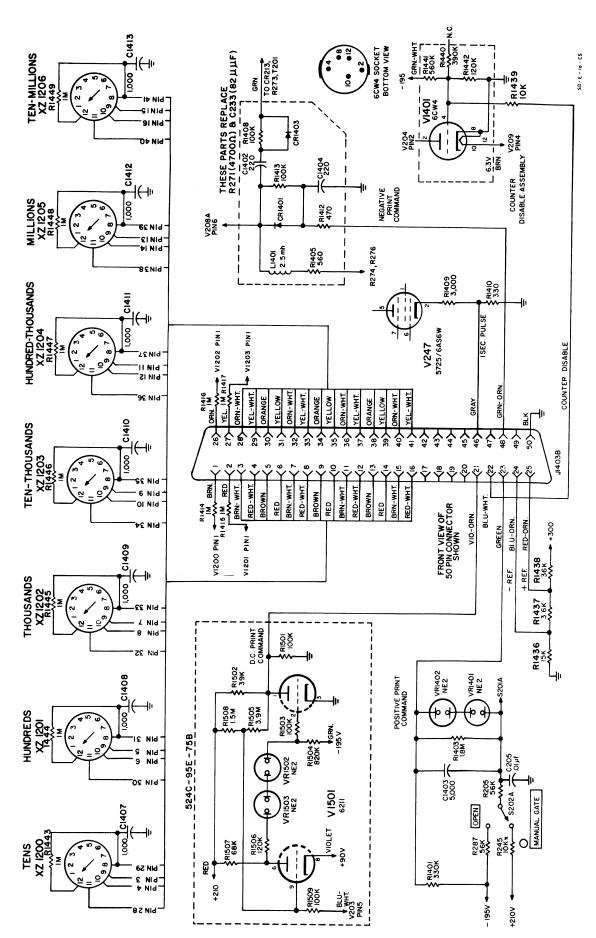


Figure 4-32. Schematic Changes for 562A Printer Kit Installed in 524D Counter

## SECTION V REPLACEABLE PARTS

## 5-1. INTRODUCTION.

This section contains information for ordering replacement parts for the 524C and 524D Electronic Counters.

Tables 5-1 through 5-7 lists replaceable parts in alphanumerical 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. Parts descriptions are arranged as follows:

Table 5-1. Replaceable Parts, 524C/D
Table 5-2. Trigger Unit Plug-In Assembly
Table 5-3. Amplitude Discriminator
Table 5-4. Decade Divider Plug-In Unit
Table 5-5. 524C-95B Digital Recorder Kit
Table 5-6. 524D-95A Digital Recorder Kit
Table 5-7. 524C-95E Digital Recorder Kit

Each table includes the following information:

- 1) Reference designator
- 2) Full description of the part

- 3) Manufacturer of the part in a five-digit code; see list of manufacturers, Table 5-8.
- 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 obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identifyparts by their Hewlett-Packard stock numbers.

To obtain a part that is not listed, include:

- 1) Instrument model number
- 2) Instrument serial number
- 3) Description of the part
- 4) Function and location of the part

Table 5-1. Replaceable Parts, 524C/D (Sheet 1 of 30)

		<del></del>			 l	<del></del>
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
B201	Motor, fan, 1/60 hp, 110 v 50/60 cps	24466	3140-0001	1		
	Blade, fan, 4 blades, 10'' dia	24466	3160-0006	1		
C201	Capacitor: fixed, paper, 0.1 uf ±5%, 600 vdcw	56289	0160-0022	1		
C202	Capacitor: fixed, ceramic, $0.01\mathrm{uf}\pm20\%$ , $1000\mathrm{vdcw}$	71590	0150-0012 524C- 524D-	38 37		
C203	Not assigned					
C204	Capacitor: fixed, ceramic, 0.005 uf , 500 vdcw	96095	0150-0014	2		
C205	Same as C202					
C206	Not assigned					
C207	Capacitor: fixed, ceramic, 0.05 uf ±20%, 400 vdcw	05729	0150-0052	1		

Table 5-1. Replaceable Parts, 524C/D (Sheet 2 of 30)

<b></b>	Table 5-1. Replaceable Par	rts, 524C/D	(Sheet 2 of 30)		
Ckt Ref.	Description	Mfr *	₩ Stock No.	TQ*	
C208	Capacitor: fixed, mica, 100 pf ±10%, 500 vdcw	76433	0140-0054	4	
C209	Capacitor: fixed, paper 0.22 uf ±10%, 400 vdcw	56289	0160-0018	2	
C210	Same as C202				
C211	Capacitor: fixed, mica, 22 pf ±10%, 500 vdcw	00853	0140-0026	2	
C212	Same as C202				
C213, 214	Capacitor: fixed, mica, 27 pf ±10%, 500 vdcw	00853	0140-0005	6	
C215	Same as C202				
C216	Capacitor: fixed, paper, 4 uf ±10%, 600 vdcw	72758	0160-0077	1	
C217, 218	Same as C202				
C219	Capacitor: fixed, mica, 39 pf ±10%, 500 vdcw	00853	0140-0021	1	
C220A, 220B	Capacitor: fixed, paper, 2 sections 0.1 uf +20% -10%/sec., 1000 vdcw	00853	0160-0089	1	
C221	Same as C202				
C222	Not assigned				
C223	Same as C208				
C224	Same as C202				
C225	Capacitor: fixed, mica, 47 pf ±10%, 500 vdcw	76433	0140-0032	2	
C226	Same as C213				
C227, 228	Capacitor: fixed, mica, 470 pf ±10%, 500 vdcw	00853	0140-0027	5	
C229	Same as C202				
C230	Same as C213				
C231	Capacitor: fixed, mica, 56 pf ±10%, 500 vdcw	76433	0140-0014	1	
C232	Same as C225				
C233	Capacitor: fixed, mica, 82 pf ±10%, 500 vdcw	00853	0140-0006	1	

<sup>\*</sup> See introduction to this section

Table 5-1. Replaceable Parts, 524C/D (Sheet 3 of 30)

Ckt Ref.	Table 5-1. Replaceable Part  Description	Mfr *	⊕ Stock No.	TQ*	-	
C234						
	Same as C202					
C235	Capacitor: fixed, ceramic, 0.02 uf +80% - 20%	71418	0150-0024	3		
C236	Capacitor: fixed, mica, 3300 pf ±10%, 500 vdcw	76433	0140-0029	1		
C237	Capacitor: fixed, mica, 560 pf ±10%, 500 vdcw	76433	0140-0044	1		
C238	Same as C213					
C239	Same as C202					
C240	Capacitor: fixed, mica, 15pf ±10%, 500 vdcw Optimum value selected at factory. Average value shown.	00853	0140-0004	9		
C241, 242	Same as C227					
C243	Capacitor: fixed, mica, 10 pf $\pm 10\%$ , 500 vdcw	00853	0140-0002	3		
C244	Same as C240					
C245	Same as C243					
C246	Not assigned					
C247, 248	Capacitor: fixed, mica, 680 pf ±10%, 500 vdcw	76433	0140-0007	2		
C249	Same as C243					
C250	Capacitor: fixed, ceramic, 5 pf ±0.5 pf, 500 vdcw Optimum value selected at factory. Average value shown.	72982	0150-0008	1	·	
C251	Same as C202				l	
C252	Capacitor: fixed, mica, 15 pf ±5%, 500 vdcw	00853	0140-0101	1		
C253, 254	Same as C240					
C255, 256	Capacitor: fixed, mica, 1800 pf ±10%, 500 vdcw	00853	0140-0020	2		
C257, 258	Same as C240 Optimum value selected at factory. Average value shown.					
C259, 260	Capacitor: fixed, mica, 1000 pf ±10%, 500 vdcw	76433	0140-0003	3		

Table 5-1. Replaceable Parts, 524C/D (Sheet 4 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
C261	Same as C240	·				
C262	Same as C202					
C263	Not assigned					
C264	Same as C208					
C265 thru C283	Not assigned					
C284	Same as C235			-		
C285	Same as C202					,
C286	Capacitor: fixed, mica, 4700 pf ±10%, 500 vdcw	76433	0140-0017	1		
C287	Same as C202					
C288, 289	Not assigned					
C290	Same as C227					
C291	Same as C211					
C292 thru C300	Not assigned					
C301	Capacitor: fixed, titanium dioxide, 1 pf ±10%, 500 vdcw	82142	0150-0029	1		
C302	Not assigned					
C303, 304	Same as C202					
C305	Capacitor: fixed, mica, 220 pf ±5%, 500 vdcw	76433	0140-0083	4		
C306	Capacitor: fixed, titanium dioxide, 1.5 pf ±20%, 500 vdcw	78488	0150-0011	3		
C307	Same as C305				,	
C308	Same as C202					!
C309	Capacitor: fixed, mica, 62 pf ±5%, 500 vdcw	00656	0140-0064	2		
C310	Same as C306					
C311	Same as C309					
C312, 313	Same as C305					
!						

Table 5-1. Replaceable Parts, 524C/D (Sheet 5 of 30)

	Table 5-1. Replaceable Parts, 524C/D (Sheet 5 of 30)									
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*						
C314	Same as C306									
C315	Capacitor: fixed, mica, 100 pf ±5%, 500 vdcw	76433	0140-0041	4						
C316	Capacitor: variable, ceramic, 7-45 pf, 500 vdcw	72982	0130-0001	1						
C317	Same as C209									
C318	Same as C202									
C319	Capacitor: fixed, mica, 270 pf ±10%, 500 vdcw	76433	0140-0015	5						
C320	Capacitor: fixed, mica, 39 pf ±2%, 500 vdcw	76433	0140-0116	1						
C321	Same as C319									
C322	Capacitor: fixed, mica, 390 pf ±2%, 500 vdcw	76433	0140-0114	1						
C323	Same as C319	1								
C324	Capacitor: fixed, mica, 3900 pf ±2%, 500 vdcw	76433	0140-0115	1						
C325	Same as C319									
C326	Capacitor: fixed, plastic, 0.039 uf ±2%, 400 vdcw	02777	0170-0032	1						
C327	Same as C319									
C328	Capacitor: fixed, plastic, 0.39 uf ±2%, 400 vdcw	02777	0170-0031	1						
C329, 330	Not assigned									
C331	Capacitor: fixed, mica, 180 pf ±10%, 500 vdcw	00853	0140-0023	1						
C332	Capacitor: fixed, paper, 0.01 uf ±20%, 400 vdcw	56289	0160-0054	1						
C333	Capacitor: fixed, mica, 1000 pf ±1%, 500 vdcw	00853	0140-0099	1						
C334 thru C336	Not assigned									
C337	Same as C202									
C338, 339	Not assigned									

Table 5-1. Replaceable Parts, 524C/D (Sheet 6 of 30)

Ckt Ref.	Description	Mfr *	₩ Stock No.	TQ*		
C340	Capacitor: See Crystal Oven Assembly Z235.					
C341, 342	Capacitor: fixed, electrolytic, 30 uf, 450 vdcw	56289	0180-0014	3		
C343A 343B	Capacitor: fixed, paper, 2 sections, 0.25 uf +20% -10%/sec., 600 vdcw	00656	0160-0080	2		
C344	Capacitor: fixed, paper, 0.5 uf ±10%, 600 vdcw	00656	0160-0087	1		
C345, 346	Same as C202					
C347	Same as C341					
C348A, 348B	Same as C343					
C349	Capacitor: fixed, electrolytic, 50 uf, 300 vdcw	56289	0180-0015	1		
C350 thru C353	Not assigned					
C354	Same as C204					
C355 thru C359	Not assigned					
C360 thru C365	Same as C202		, ,			
C366, 367	Capacitor: fixed, paper, 1 uf ±10%, 600 vdcw	24446	0160-0079	2		
C368	Same as C202					
C369, 370	Same as C240					
C371, 372	Same as C202					
C373 thru C384	Not assigned					
C385	Same as C202					
C386	Capacitor: fixed, ceramic, 1500 pf ±20%, 500 vdcw	72982	0150-0020	1		
C387	Same as C213					

Table 5-1. Replaceable Parts, 524C/D (Sheet 7 of 30)

	Table 5-1. Replaceable Par	Τ	<u>,                                      </u>	т —	Γ	T	1
Ckt Ref.	Description	Mfr *	₩ Stock No.	TQ*		ļ	
C388 thru C700	Not assigned						
C701 thru C799	See Table 5-3						
C800	Not assigned						
C801 thru C900	Capacitors: See Table 5-4						
C901	Same as C202						
C902	Capacitor: fixed, mylar, 0.1 uf ±20%, 600 vdcw	09134	0170-0022	3			
C903	Same as C315						
C904	Capacitor: fixed, mica, $110 \text{ pf } \pm 5\%$ , $500 \text{ vdcw}$	76433	0140-0036	2			
C905	Same as C202		*				
C906	Same as C315						
C907	Capacitor: fixed, mica, 47 pf ±5%, 500 vdcw	76433	0140-0039	2			
C908	Same as C315						
C909, 910	Same as C202						
C911	Capacitor: fixed, mica, 470 pf ±5%, 300 vdcw	72136	0140-0149	2			
C912	Same as C904						
C913	Same as C911						
C914	Capacitor: variable, air, 6-100.5 pf	80486	0121-0013	1			
C915	Capacitor: variable, air, 7.5-102.7 pf	84970	0121-0008	1			÷
C916 thru C918	Capacitors: See Crystal Oven Assembly Z235						
C919	Same as C902						

Table 5-1. Replaceable Parts, 524C/D (Sheet 8 of 30)

	Table 5-1. Replaceable 1			r		
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
C920	Same as C208					
C921	Capacitor: See Crystal Oven Assembly Z235					
C922 thru C1000	Not assigned					
C1001	Capacitor: fixed, paper 0.1 uf ±10%, 400 vdcw	56289	0160-0013	1		
C1002	Same as C235					
C1003	Same as C259					
C1004	Capacitor: fixed, ceramic, 75 pf ±5%, 500 vdcw	72982	0150-0016	1		
C1005	Capacitor: fixed, mica, 560 pf ±10%, 500 vdcw	00853	0140-0044	1		
C1006	Same as C902					
C1007 thru C1100	Not assigned					
C1101 thru C1108	Capacitors: See Table 5-2					
C1109 thru C1200	Not assigned					
C1201 <sup>1</sup>	Same as C202					
C1202	Same as C907					
C1203 thru C1400	Not assigned					
C1401 thru C1499	Capacitors: Digital Recorder Kit (see Table 5-5, 5-6, or 5-7)					
CR201 thru CR249	Diode; germanium: type HD2135	73293	1910-0011	52		
CR250 thru CR259	Not assigned					
CR260	Same as CR201					
	1 Used in 524C only.					

Table 5-1. Replaceable Parts, 524C/D (Sheet 9 of 30)

	Table 5-1. Replaceable Par	r	<u> </u>	Г	<u> </u>	T	Ι
Ckt Ref.	Description	Mfr *	₩ Stock No.	TQ*	<u> </u>		
CR261 thru CR900	Not assigned					:	
CR901, 902	Same as CR201						
CR903 thru CR1100	Not assigned						
CR1101 thru CR1200	See Table 5-2					:	H. T.
CR1201 thru CR1400	Not assigned						
CR1401 thru CR1500	See Table 5-5, 5-6, or 5-7						
DL201	Delay line	98734	9190-0001	1			
DS201	Lamp, neon: 1/25 W, NE51	24455	2140-0006	1			·
DS202 thru DS208	Lamp, incandescent: 6-8 v, 0.15 amp, #47	93519	2140-0009	7			
DS209 thru DS1000	Not assigned						
DS1001, 1002	Lamp, neon: 1/25 W, NE23	24455	2140-0013	6			
DS1003 thru DS1199	Not assigned						,
DS1200 thru DS1209	Lamp, neon: aged and selected;	28480	2140-0082	10			
DS1210 <sup>1</sup>	Tube, electron: digital indicator	83594	1970-0002	1		,	:
F201	Fuse, cartridge: 6.25 amps slow-blow (for 110 v operation)	71400	2110-0023	1			
	Fuse, cartridge: 3.2 amps slow-blow (for 230 v operation only)	71400	2110-0013				
	Used in 524C only.		2	-			

Table 5-1. Replaceable Parts, 524C/D (Sheet 10 of 30)

r	Table 5-1. Replaceable Pal	1	1	-, 	Τ	· · · · · · · · · · · · · · · · · · ·
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
F202	Fuse, cartridge: 0.5 amps, slow-blow	71400	2110-0008	1		
HR201	Heater, for Crystal Oven Assembly, (not separately replaceable) See Z235					
J201	Connector, female: 16 contacts	02660	1251-0007	1		
J202	Connector, female: 8 contacts	02660	1251-0009	1		
J203	Connector, female: BNC (SIGNAL INPUT)	91737	1250-0075	2		
J204	Connector, male: 2 contacts	71785	1251-0018	1		
J205	Same as J203 (STD. FREQ. OUTPUT)					
J206 thru J900	Not assigned					
J901	Connector, female: BNC (INPUT 100KC/1MC)	91737	1250-0118	1		
J902	Connector, female: 15 contacts	95238	1251-0088	1		
J903 thru J1400	Not assigned					
J1401 thru J1403	Connectors: Digital Recorder Kit see Table 5-5, 5-6, or 5-7					
L201	Inductor: fixed; 320 uh wound on 56 ohms resistor	28480	524B-60J	1		
L202	Inductor: fixed; 19 uh wound on 680 ohms resistor	28480	524B-60B	1		
L203, 204	Inductor: fixed; 16 uh wound on 1 megohm resistor	28480	524B-60M	3		
L205	Inductor: fixed; 54 uh wound on 1 megohm resistor	28480	524B-60E	1		
L206	Inductor: fixed; 320 uh wound on 1 megohm resistor	28480	524B-60H	2		
L207	Inductor: fixed; 30 mh	28480	9130-0001	1		
L208	Same as L203					
L209	Inductor: fixed, 54 uh wound on 4700 ohms resistor	28480	524B-60R	1		
L210	Not assigned					
L211	Inductor: variable, 5 mh nominal, ±5%	98405	9140-0016	1		
			·		<del></del>	

Table 5-1. Replaceable Parts, 524C/D (Sheet 11 of 30)

	Table 5-1. Replaceable Pa	arts, 524C/	D (Sheet 11 of a	00)		
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
L212, 213	Inductor: variable, 600 uh nominal, ±5%	09250	9140-0013	2		
L214, 215	Inductor: variable, nominal 100 uh, ±5%	98405	9140-0009	2		
L216, 217	Inductor: fixed; 4 uh	98405	9140-0011	2		
L218	Inductor: variable, 5.5-10.5 uh	98405	9140-0015	1		
L219	Inductor, filter: 6 h, 0.5 amp	98734	9110-0015	1		
L220	Not assigned					
L221	Inductor, filter: 6 h, 90 ma	98734	9110-0010	1		
L222	Inductor: 4.8 uh wound on 1 megohm resistor	28480	524B-60F	1		
L223	Not assigned					
L224	Inductor, variable: 5.5-10 uh	28480	524B-60N	1		
L225	Same as L206					
L226	Inductor, fixed: 75 uh	99848	9140-0031	1		
L227	Inductor, fixed: 5 mh	99848	9140-0037	1		
L228	Inductor, fixed: 1 mh	99848	9140-0053	1		
L229 thru L900	Not assigned					
L901	Inductor, variable: 600 uh	28480	524C-60B	1		
L902 thru L1100	Not assigned					
L1101 thru L1200	See Table 5-2				·	
L1201 thru L1400	Not assigned					
L1401	See Table 5-5, 5-6, or 5-7					
P201	Cord, power	70903	8120-0015	1		
P202, 203	Not assigned					
P204	Connector, male: 2 blade	71785	1251-0018	1		

Table 5-1. Replaceable Parts, 524C/D (Sheet 12 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*			
P205 thru P901	Not assigned						
P902	Part of Oscillator Circuit board						
R201	Resistor: fixed, composition, 560 ohms ±10%, 1 W	01121	0690-5611	3			
R202	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W	01121	0687-1051 524C- 524D-	9 8	·		
R203	Resistor: fixed, composition, 22 megohms ±10%, 1/2 W	01121	0687-2261 524C- 524D-	3 2		_	
R204	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121	0687-1021	14			
R205	Resistor: fixed, composition, 56,000 ohms ±10%, 1/2 W	01121	0687-5631	3			
R206	Same as R202						
R207	Same as R203						
R208	Resistor: fixed, composition, 1000 ohms ±10%, 1 W	01121	0690-1021	3			
R209	Resistor: fixed, composition, 2200 ohms ±10%, 1/2 W	01121	0687-2221	1			
R210	Same as R202						
R211	Resistor: variable, composition, linear taper, 50,000 ohms ±20%	71590	2100-0013	3			
R212	Resistor: fixed, composition, 100,000 ohms ±10%, 1 W	01121	0690-1041	10			
R213	Resistor: fixed, composition, 1500 ohms ±10%, 1 W	01121	0690-1521	3			
R214	Resistor: fixed, composition, 5100 ohms ±5%, 1 W	01121	0689-5125	2			
R215	Resistor: fixed, composition, 6200 ohms ±5%, 1 W	01121	0689-6225	2			
R216	Resistor: fixed, composition 270 ohms ±5%, 1 W	01121	0689-2715	2			
R217	Resistor: fixed, composition, 390 ohms ±5%, 1 W	01121	0689-3915	1			
R218	Resistor: fixed, composition 1800 ohms ±10%, 1 W	01121	0690-1821	2			

Table 5-1. Replaceable Parts, 524C/D (Sheet 13 of 30)

	Table 5-1. Replaceable P	arts, 524C/	D (Sneet 13 of a	30)	T	Ţ	· · · · · · · · · · · · · · · · · · ·
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*			
R219	Resistor: fixed, composition, 560 ohms ±5%, 1 W	01121	0689-5615	2			
R220	Resistor: fixed, composition, 2700 ohms ±10%, 1 W	01121	0690-2721	1			
R221	Same as R212						
R222	Resistor: fixed, composition, 680, 000 ohms ±10%, 1 W	01121	0690-6841	1			
R223	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W	01121	0690-5631	3			
<b>R224</b>	Same as R211						
R225	Resistor: fixed, composition, 82,000 ohms ±10%, 1 W Optimum value selected at factory. Average value shown.	01121	0690-8231	2			
R226, 227	Resistor: fixed, composition, 8200 ohms ±10%, 2 W	01121	0693-8221	4			
R228	Same as R223						
R229	Resistor: fixed, composition, 560, 000 ohms ±5%, 1/2 W	01121	0686-5645	1			
R230	Resistor: fixed, composition, 390, 000 ohms ±5%, 1/2 W	01121	0686-3945	1			
R231	Resistor: fixed, composition, 180,000 ohms ±10%, 1 W	01121	0690-1841	1			
R232	Resistor: fixed, composition, 470, 000 ohms ±5%, 1/2 W	01121	0686-4745	2			
R233	Resistor: fixed, composition, 1.5 megohms ±10%, 1 W	01121	0690-1551	2			
R234	Resistor: fixed, composition, 2.7 megohms ±10%, 1 W	01121	0690-2751	1			
R235	Resistor: fixed, composition, 10 megohms ±10%, 1 W Optimum value selected at factory. Average value shown.	01121	0690-1061	1			
R236	Resistor: fixed, composition, 100 ohms ±10%, 1 W	01121	0690-1011	3			
R237	Resistor: variable, composition, 5 megohms; includes S203	11237	2100-0066	1			
R238	Resistor: fixed, composition, 47,000 ohms ±10%, 1 W	01121	0690-4731	5			
R239	Resistor: fixed, composition, 120 ohms ±10%, 1 W	01121	0690-1211	1			
		L					<u> </u>

Table 5-1. Replaceable Parts, 524C/D (Sheet 14 of 30)

	Table 5-1. Replaceable Pa	T	Γ	· T	1	<u> </u>
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R240	Same as R232					
R241	Resistor: fixed, composition, 1 megohm ±5%, 1/2 W	01121	0686-1055	1		
R242	Resistor: fixed, composition, 5600 ohms ±10%, 1/2 W	01121	0687-5621	1		
R243	Resistor: fixed, composition, 330 ohms ±10%, 1 W	01121	0690-3311	2		
R244	Same as R236					
R245	Resistor: fixed, composition, 10,000 ohms ±10%, 1/2 W Optimum value selected at factory. Average value shown.	01121	0687-1031	1	·	
R246	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121	0687-2231			
R247 R248	Not assigned Same as R211					
R249	Resistor: fixed, composition, 6800 ohms ±10%, 2 W	01121	0693-6821	2		
R250	Same as R213					
R251	Resistor: fixed, composition, 910, 000 ohms ±5%, 1/2 W	01121	0686-9145	1		
R252	Resistor: fixed, deposited carbon, 490, 000 ohms ±1%, 1 W	19701	0730-0092	1		
R253	Resistor: fixed, composition, 270 ohms ±10%, 1 W	01121	0690-2711	3		
R254	Same as R249					
R255	Resistor: fixed, composition, 10,000 ohms $\pm 10\%$ , 1 W	01121	0690-1031	3		
R256	Resistor: fixed, deposited carbon, 100, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0069	6		
R257	Resistor: fixed, deposited carbon, 41,500 ohms $\pm 1\%$ , 1 W	19701	0730-0050	6		
R258, 259	Resistor: fixed, composition, 6800 ohms ±5%, 2 W	01121	0692-6825	2		
R260	Same as R243 Optimum value selected at factory. Average value shown.					
R261	Resistor: fixed, composition, 240 ohms ±5%, 1 W	01121	0689-2415	1		
R262	Same as R256					
R263	Same as R257					

Table 5-1. Replaceable Parts, 524C/D (Sheet 15 of 30)

	Table 5-1. Replaceable Pa	Т	(Sheet 15 of 5)	) 	 <del></del>
Ckt Ref.	Description	Mfr *	® Stock No.	TQ*	
R264	Resistor: fixed, composition, 8200 ohms ±5%, 2 W	01121	0692-8225	2	
R265	Same as R218				
R266	Same as R264				
R267	Resistor: fixed, composition, 6800 ohms ±10%, 1 W	01121	0690-6821	2	
R268	Resistor: fixed, composition, 220, 000 ohms ±10%, 1 W	01121	0690-2241	3	
R269	Resistor: fixed, deposited carbon, 830, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0102	1	
R270	Resistor: fixed, deposited carbon, 305, 000 ohms ±1%, 1 W	19701	0730-0084	1	
R271	Resistor: fixed, composition, 4700 ohms ±10%, 1 W (Not used in instrument equipped with Digital Recorder Kit)	01121	0690-4721	1	
R272	Same as R212				
R273	Resistor: fixed, composition, 22,000 ohms $\pm 10\%$ , 1 W	01121	0690-2231	1	
R274	Resistor: fixed, composition, 820 ohms ±10%, 1 W	01121	0690-8211	1	
R275	Resistor: fixed, composition, 1 megohm ±10%, 1 W	01121	0690-1051	2	
R276	Resistor: fixed, composition, 1200 ohms ±10%, 1 W	01121	0690-1221	3	
R277	Resistor: fixed, composition, 390,000 ohms ±10%, 1 W	01121	0690-3941	1	
R278, 279	Not assigned				
R280	Same as R208				
R281	Same as R268				
R282	Same as R267				
R283	Resistor: fixed, composition, 56 ohms ±5%, 1 W	01121	0689-5605	2	
R284	Same as R202				
R285	Resistor: fixed, composition, 180 ohms ±10%, 1 W	01121	0690-1811	3	
R286	Resistor: fixed, composition, 1500 ohms ±10%, 1/2 W	01121	0687-1521	2	

Table 5-1. Replaceable Parts, 524C/D (Sheet 16 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*	
R287	Same as R205				
R288	Resistor: fixed, composition, 220,000 ohms ±10%, 1/2 W	01121	0687-2241 524C- 524D-	5 4	
R289	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	01121	0687-2231	4	
R290	Same as R276				
R291	Resistor: fixed, deposited carbon, 24,500 ohms ±1%, 1 W	19701	0730-0040	2	
R292	Resistor: fixed, deposited carbon, 14,400 ohms ±1%, 1 W	19701	0730-0034	2	
R293	Resistor: fixed, deposited carbon, 15,800 ohms ±1%, 1 W	19701	0730-0036	2	
R294	Not assigned				
R295, 296	Resistor: fixed, metal film 5000 ohms ±5%, 3 W	07115	0767-0004	4	
R297 298	Same as R285		,		
R299	Same as R291				
R300	Same as R292				
R301	Same as R293				
R302	Not assigned				
R303	Resistor: fixed, composition, 68,000 ohms ±10%, 1 W	01121	0690-6831	4	
R304, 305	Same as R295 R304-Optimum value selected at factory. Average value shown.				
R306	Resistor: fixed, composition 3300 ohms ±10%, 1 W	01121	0690-3321	4	
R307	Resistor: fixed, deposited carbon, 79,000 ohms ±1%, 1 W	19701	0730-0061	2	
R308	Resistor: fixed, deposited carbon, 33,000 ohms ±1%, 1 W	19701	0730-0048	2	
R309	Resistor: fixed, composition, 5600 ohms ±10%, 2 W Optimum value selected at factory. Average value shown.	01121	0693-5621	2	
R310	Same as R226				
:					

Table 5-1. Replaceable Parts, 524C/D (Sheet 17 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R311, 312	Resistor: fixed, composition, 220 ohms ±10%, 1 W	01121	0690-2211	6		
R313	Same as R307					
R314	Same as R308					
R315	Same as R 303					
R316	Same as R309					
R317	Same as R226					
R318	Same as R289					
R319	Same as R215					
R320	Same as R214					
R321	Same as R216					
R322	Same as R219					·
R323	Resistor: fixed, composition, 3900 ohms ±10%, 1 W	01121	0690-3921	3		
R324	Same as R289				'	
R325	Resistor: fixed, composition, 5600 ohms ±10%, 1 W	01121	0690-5621	1		
R326	Same as R256					
R327	Same as R257					
R328	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W	01121	0693-1031	1		
R329	Resistor: fixed, composition, 8200 ohms ±10%, 1 W	01121	0690-8221	1		
R330	Same as R303					
R331, 332	Same as R311					
R333	Same as R256					
R334	Same as R257					
R335	Resistor: fixed, composition, 68,000 ohms ±10%, 1/2 W	01121	0687-6831	1		
R336	Resistor; fixed, composition, 18,000 ohms ±10%, 2 W	01121	0693-1831	1		
R337	Same as R323					
R338	Same as R256					

Table 5-1. Replaceable Parts, 524C/D (Sheet 18 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*	
R339	Same as R257				
R340	Resistor: fixed, metal film, 15,000 ohms $\pm 5\%$ , 3 W	07115	0767-0010	2	
R341	Not assigned				
R213 R342	Same as R311				
R344	Same as R256				
R345	Same as R257				
R346	Same as R303				
R347	Resistor: fixed, composition, 12,000 ohms ±10%, 1 W	01121	0690-1231	4	
R348	Same as R255				
R349 thru R399	Not assigned				
R400	Resistor: fixed, composition, 120 ohms ±10%, 1/2 W	01121	0687-1211	1	
R401 thru R406	Not assigned				
R407	Same as R283				
R408	Resistor: fixed, wirewound, 1500 ohms ±10%, 20 W	35434	0819-0016	1	
R409	Not assigned				
R410	Same as R225				
R411	Same as R201				
R412	Same as R 225				
R413	Same as R201				
R414	Same as R236				
R415	Resistor: fixed, composition, 470 ohms ±10%, 1 W	01121	0690-4711	1	
R416 thru R426	Not assigned				
R427	Resistor: fixed, composition, 470,000 ohms ±10%, 1 W	01121	0690-4741	1	

Table 5-1. Replaceable Parts, 524C/D (Sheet 19 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R428 thru R430	Resistor: fixed, composition, 470, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-4741	5		
R431	Resistor: fixed, composition 33,000 ohms ±10%, 1 W	01121	0690-3331	2		
R432	Resistor: fixed, composition, 390 ohms ±10%, 1 W	01121	0690-3911	1		
R433	Same as R275					
R434	Resistor: fixed, composition, 220 ohms $\pm 10\%$ , $1/2$ W	01121	0687-2211	1		
R435	Resistor: fixed, composition, 1.8 megohms ±10%, 1/2 W	01121	0687-1851	5		
R436	Same as R213					
R437	Same as R212					
R438	Resistor: fixed, composition, 22,000 ohms $\pm 10\%$ , 2 W	01121	0693-2231	5		
R439	Resistor: fixed, composition, 110,000 ohms $\pm 5\%$ , 1 W	01121	0689-1145	5		
R440	Same as R306					
R441	Not assigned					
R442	Resistor: fixed, composition, 120, 000 ohms $\pm 10\%$ , 1 W	01121	0690-1241	5		
R443	Resistor: fixed, deposited carbon 2.163 megohms $\pm 1\%$ , 1 W Optimum value selected at factory. Average value shown.	19701	0730-0113	5		
R444	Resistor: variable, composition 50,000 ohms $\pm 10\%$	01121	2100-0028	5		
R445	Same as R212					
R446	Same as R435					
R447	Same as R438					
R448	Same as R439					-
R449	Resistor: fixed, composition, 3000 ohms ±5%, 1 W	01121	0689-3025	2		
R450	Not assigned					
R451	Same as R442					
R452	Same as R443					
R453	Same as R444					
R454	Same as R212					
R455	Same as R435					
R456	Same as R438					
R457	Same as R439					
R458	Same as R306					

Table 5-1. Replaceable Parts, 524C/D (Sheet 20 of 30)

	Table 5-1. Replaceable Par			TQ*	1	
Ckt Ref.	Description	Mfr *	⊕ Stock No.	16/		 
R459	Not assigned					
R460	Same as R442		·			
R461	Same as R443					
R462	Same as R444			}		
R463	Same as R212					
R464	Same as R435					
R465	Same as R438		:			
R466	Same as R439					
R467	Same as R449					
R468	Not assigned					
R469	Same as R442					
R470	Same as R443					
R471	Same as R444					
R472	Same as R212					
R473	Same as R435					
R474	Same as R306					
R475	Same as R438					
R476	Same as R439					
R477	Not assigned			İ		
R478	Same as R442					
R479	Same as R443					
R480	Same as R444					
R481	Resistor: fixed, composition, 470 ohms $\pm 10\%$ , $1/2$ W	01121	0687-4711	1		
R482, 483	Same as R253					
R484	Same as R276					
R485	Resistor: fixed, composition 18,000 ohms ±10%, 1 W	01121	0690-1831	2		
R486	Same as R202					
R487	Resistor: fixed, composition, 150, 000 ohms ±10%, 1 W	01121	0690-1541	1		
R488	Same as R202					
R489	Resistor: fixed, composition, 1.2 megohms $\pm 10\%$ , $1/2$ W	01121	0687-1251	1		
R490 thru R492	Not assigned					
R493	Resistor: fixed, wirewound, 5000 ohms ±10%, 20 W	35434	0819-0003	1		
R494	Same as R204					
R495	Same as R323					
R496	Same as R238					

Table 5-1. Replaceable Parts, 524C/D (Sheet 21 of 30)

Clat Dos	Table 5-1. Replaceable Par	T	<u> </u>	·	I	T	
Ckt Ref.	Description	Mfr *	₩ Stock No.	TQ*			<del> </del>
R497	Same as R233						
R498	Resistor: fixed, composition, 3.9 megohms ±10%, 1 W	01121	0690-3951	1			
R499	Same as R268						
R500	Same as R204						
R501	Resistor: variable, composition, linear taper, 20,000 ohms ±20%, 1/3 W	11237	2100-0161	4			
R502	Resistor: fixed, deposited carbon 405, 000 ohms ±1%, 1 W	19701	0730-0088	1			
R503	Resistor: fixed, composition, 100 ohms ±10%, 2 W	01121	0693-1011	4			
R504	Same as R204						
R505	Same as R212						
R506	Same as R503						
R507 508	Same as R204						
R509	Same as R501						
R510	Resistor: fixed, deposited carbon, 144, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0074	1			
R511	Same as R503						
R512	Same as R204						
R513	Same as R503				:		
R514	Same as R212						
R515	Same as R204						
R516	Same as R501						
R517	Resistor: fixed, deposited carbon, 132, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0073	1			
R518, 519	Resistor: fixed, wirewound, 400 ohms $\pm 5\%$ , 40 W	12697	0818-0011	3			
R520	Same as R485						
R521	Same as R208						
R522	Resistor: fixed, composition, 39,000 ohms $\pm 10\%$ , 1 W	01121	0690-3931	1			
R523	Resistor: fixed, deposited carbon, 181, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0077	1			
R524	Same as R501						
R525	Resistor: fixed, deposited carbon, 160, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0075	1			
R526	Resistor: fixed, deposited carbon, 370, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0087	2			
R527	Resistor: fixed, deposited carbon, 316, 000 ohms $\pm 1\%$ , 1 W	19701	0730-0085	1			
R528	Same as R526				•		
R529, 530	Same as R347						
				1			

Table 5-1. Replaceable Parts, 524C/D (Sheet 22 of 30)

	Table 5-1. Replaceable Part	S, 0240/D	(blieet 22 of 50	, 	 r	1
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R531	Not assigned					
R532	Resistor: fixed, wirewound, 3500 ohms $\pm 10\%$ , 20 W	35434	0819-0013	1		
R533	Same as R223					
R534	Resistor: fixed, composition, 47 ohms, ±10%, 1 W	01121	0690-4701	1		
R535	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W	01121	0687-1011 524C 524D	3 2		
R536	Same as R518					
R537	Not assigned					
R538	Resistor: fixed, composition, 100,000 ohms ±10%, 1/2 W	01121	0687-1041 524C 524D	3 2		
R539	Resistor: see crystal oven assembly (Z235)					
R540	Resistor: fixed, composition, 47,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-4731	2		
R541	Same as R286					
R542 thru R550	Not assigned					
R551 <sup>1</sup>	Resistor: fixed, composition, 4.7 megohms ±10%, 1/2 W	01121	0687-4751	2		
R552 <sup>1</sup>	Resistor: fixed, composition, 150, 000 ohms	01121	0687-1541	2		
R553 <sup>1</sup>	Same as R551 $\pm 10\%$ , 1/2w Optimum value selected at factory. Average value shown.					
R554 <sup>1</sup>	Same as R202 Optimum value selected at factory. Average value shown.					
R555 <sup>1</sup>	Same as R288					
R556 <sup>1</sup>	Same as R535					
R557 <sup>1</sup>	Resistor: fixed, composition,	01121	0687-1841	1		
R558 <sup>1</sup>	Same as R203					
R559 thru R700	Not assigned					
R701 thru R799	See Table 5-3					
R800	Not assigned					
R801 thru R900	See Table 5-4					
	1 Used in 524C only.					

Table 5-1. Replaceable Parts, 524C/D (Sheet 23 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R901	Same as R347					
R902	Same as R238					
R903	Resistor: fixed, composition, 15,000 ohms ±10%, 1 W	01121	0690-1531	2		
R904	Resistor: fixed, composition, 47 ohms ±10%, 1/2 W	01121	0687-4701	4		
R905	Same as R288					
R906	Same as R904					
R907	Same as R903					
R908	Same as R428					
R909	Resistor: fixed, composition, 18,000 ohms ±10%, 1/2 W	01121	0687-1831	1		
R910	Resistor: fixed, composition, 180 ohms ±10%, 1/2 W	01121	0687-1811	1		
R911	Same as R204					
R912	Same as R288					
R913	Same as R238					
R914	Same as R904					
R915	Resistor: fixed, composition, 39, 000 ohms	01121	0687-3931	3		
R916	Same as R205 $\pm 10\%$ , $1/2$ W					
R917 918	Capacitors: see crystal oven assembly Z235					
R919	Same as R540					
R920	Same as R202					
R921	Resistor: fixed, composition, 4700 ohms $\pm 10\%$ , $1/2$ W	01121	0687-4721			
R922	Same as R904					
R923 thru R1000	Not assigned					
R1001	Same as R289					
R1002	Resistor: fixed, composition, 47,000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-4735	1		
R1003	Resistor: fixed, composition, 620, 000 ohms $\pm 5\%$ , 1 W	01121	0689-6245	1		
R1004	Resistor: fixed, composition, 10 megohms $\pm 10\%$ , $1/2$ W	01121	0687-1061	1		
R1005	Resistor: fixed composition, 390, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-3941	1		
R1006	Resistor: fixed, composition, 2200 ohms $\pm 10\%$ , 1 W	01121	0690-2221	1		
R1007	Same as R431					
R1008	Resistor: fixed, composition, 82,000 ohms ±5%, 1 W	01121	0689-8235	5		
R1009	Resistor: fixed, composition, 12,000 ohms $\pm 5\%$ , 1 W	01121	0686-1235	5		

Table 5-1. Replaceable Parts, 524C/D (Sheet 24 of 30)

G1 - 5 -	Table 5-1. Replaceable Par	<u>-                                    </u>	<u></u>	T	Ţ		T
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*	<b> </b>	<b></b>	
R1010	Same as R204						
R1011	Same as R1008						
R1012	Same as R1009						
R1013	Same as R204						
R1014	Same as R1008						
R1015 R1016	Same as R1009						
R1017	Same as R204			İ			
R1018	Same as R1008 Same as R1009						
R1019	Same as R204						
R1020	Same as R1008						
R1021	Same as R1009						
R1022	Same as R204	į					
R1023	Resistor: fixed, composition, 390 ohms ±10%, 1/2 W	01121	0687-3911	1			
R1024	Same as R288						
R1025	Same as R535						
R1026 thru R1101	Not assigned						
R1102 thru R1199	See Table 5-2						
R1200	Resistor: fixed, composition, 6.2 megohms ±5%, 1/2 W	01121	0686-6255	1			
R1201	Resistor: fixed, composition, 47,000 ohms $\pm 5\%$ , $1/2$ W	75042	0698-0005	8	-		
R1202	Resistor: fixed, composition, 270, 000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-2745	4			
R1203	Resistor: fixed, composition, 100, 000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-1045	4			
R1204	Resistor: fixed, composition, 820, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-8241	2			
R1205	Resistor: fixed, composition, 220, 000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-2245	12			
R1206	Resistor: fixed, composition, $15,000 \text{ ohms}, \pm 5\%, 1/2 \text{ W}$	01121	0686-1535	4			
R1207	Same as R1204						
R1208	Same as R1205						
R1209	Same as R915 Optimum value selected at factory. Average value shown.						
R1210	Same as R1201						
R1211	Resistor: fixed, composition, 360, 000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-3645	4			

<sup>\*</sup> See introduction to this section

Table 5-1. Replaceable Parts, 524C/D (Sheet 25 of 30)

	Table 5-1. Replaceable Parts, 5	524C/D (Sne	eet 25 of 30)		-	
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R1212	Resistor: fixed, composition, 3.3 megohms ±10%, 1/2 W	01121	0687-3351	5		
R1213	Resistor: fixed, composition, 330, 000 ohms, ±10%, 1/2 W	01121	0687-3341	4		
R1214	Resistor: fixed, deposited carbon, 3 megohms $\pm 1\%$ , $1/2$ W	19701	0727-0292	2		
R1215	Same as R1201					
R1216	Same as R1202					
R1217	Same as R1203					
R1218, 1219	Same as R1205					
R1220	Same as R1206					
R1221	Same as R1205			-		
R1222	Same as R.915 Optimum value selected at factory. Average value shown.					
R1223	Same as R1205					
R1224	Same as R1201					
R1225	Same as R1211		·			
R1226	Same as R1212			ļ		
R1227	Same as R1213					
R1128 R1229	Same as R1214 Same as R238 Optimum value selected at factory. Average value shown.					
R1230	Same as R1201					
R1231	Same as R1202					
R1232	Same as R1203				·	
R1233	Same as R340				-	
R1234	Same as R1205					
R1235	Same as R1206					
R1236	Same as R1205					
R1237	Resistor: fixed, composition, 82,000 ohms ±10%, 1/2 W Optimum value selected at factory	01121	0687-8231	2		
R1238	Same as R1201					
R1239	Same as R1211		·			
R1240	Same as R1212					
R1241	Same as R1213					
R1242, 1243	Same as R1212					
R1244	Same as R1213			ľ		
R1245	Resistor: fixed, deposited carbon, 1.5 megohms ±1%, 1/2 W	19701	0727-0282	1		
R1246	Same as R1201					

Table 5-1. Replaceable Parts, 524C/D (Sheet 26 of 30)

7	Table 5-1. Replaceable Part	<u> </u>				
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R1247	Same as R1211					
R1248, 1249	Same as R1205					
R1250	Same as R1206					
R1251	Same as R1205					
R1252	Same as R1237 Optimum value selected at factory. Average value shown.					
R1253	Same as R1205					
R1254	Same as R1201					
R1255	Same as R1202					
R1256	Same as R1203				, ÷	
R1257 <sup>1</sup>	Same as R552					
R1258 <sup>1</sup>	Same as R538					
R1259 thru R1268 <sup>1</sup>	Resistor: fixed, composition, 270, 000 ohms ±10%, 1/4 W	01121	0684-2741	10		
R1269 <sup>1</sup>	Resistor: fixed, composition, 33,000 ohms ±10%, 1/2 W	01121	0687-3331	1		
R1270 thru R1400	Not assigned					
R1401 thru R1509	See Table 5-5, 5-6, or 5-7					
S201	Switch; rotary; 6 positions, 3 sections, Function Switch assembly: includes C223, L206, L228, R250, and R286	76854 28480	3100-0089 524C-19A	1		
S202	Switch, toggle: DPDT	04009	3101-0005	4		,
S202 S203	Switch: SPST, part of R237. Not separately replaceable	01000	0101 0000			
S204	Switch, push: SPDT	82389	3101-0004	1		
S205	Same as S202					
S206	Switch; rotary: 5 positions, 2 sections, Time Unit Switch assembly: includes	76854	3100-0031	1		
	L222, R482, and R483.	28480	524B-19T-1			
S207	Switch, rotary: 5 positions, one section Frequency Selector Switch assembly	76854 28480	3100-0087 524B-19T-2	1 6		
S208	Same as S202					
S209	Switch: part of Crystal Oven Assembly (Z235). Not separately replaceable					
S210	Switch, slide, 4PDT	42190	3101-0034	1		
S211 thru S900	Not assigned					
	1 <sub>Used in 524C only</sub> .					

Table 5-1. Replaceable Parts, 524C/D (Sheet 27 of 30)

	Table 5-1. Replaceable P	arts, 524C/L	Sheet 27 of 30	)) <del></del>		
Ckt Ref.	Description	Mfr *	® Stock No.	TQ*		
S901	Same as S202					
T201 202	Transformer, pulse	98734	9130-0002	2		
T203	Not assigned					
T204	Transformer, power	98734	9100-0037	1		
T205	Transformer, power	98734	9100-0038	1		
T206	Transformer, power	98734	9100-0081	1		
T207 thru T900	Not assigned					
T901	Transformer, RF	28480	524C-60A	1		
TC201	Switch, thermostat, thermal cut-out 130°F	13396	3103-0001	1		
V201	Tube, electron: 12AT7	80131	1932-0027	3		
V202	Tube, electron: 5725	33173	1923-0064	8		
V203	Tube, electron: 6AH6	80131	1923-0063	7		
V204	Tube, electron: 5963	80131	1932-0008	4		
V205	Tube, electron: 2D21	80131	1941-0005	2		
V206, 207	Same as V203					
V208	Same as V204					
V209	Same as V205				.	
V210, 211	Same as V203					
V212 213	Tube, electron: 6CB6A	80131	1923-0062	6		
V214	Same as V202					
V215, 216	Same as V212					
V217	Same as V203					
V218	Same as V212					
V219 thru V223	Not assigned					
V224 <sup>1</sup>	Tube, electron: 6CX8	80131	1933-0006	1		
V225 thru V233	Not assigned				-	
V234	Tube, electron: 6AU6	80131	1923-0021	7		
V235	Tube, electron: 6AL5	80131	1930-0013	3		
V236	Same as V204					
	1 Used in 524C only.					

Table 5-1. Replaceable Parts, 524C/D (Sheet 28 of 30)

Table 5-1. Replaceable Parts, 524C/D (Sheet 28 of 30)										
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*						
V237 238	Same as V234									
V239	Same as V212									
V240	Same as V203									
V241	Same as V202		:							
V242	Same as V235									
V243, 244	Same as V202									
V245	Same as V235									
V246, 247	Same as V202									
V248	Same as V204									
V249 thru V251	Tube, electron: 5R4GY	80131	1930-0007	3						
V252	Same as V234									
V253, 254	Tube, electron: 6AS7GA or 6080WA	80131	1932-0018	2						
V255	Tube, electron: 7119	80131	1932-0016	1						
V256	Same as V201									
V257	Tube, electron: 5Y3GT	80131	1930-0010	1						
V258, 259	Tube, electron: 6AQ5 or 6005	80131	1923-0018	2						
V260	Same as V234									
V261	Tube, electron: 0B2	80131	1940-0007	1						
V262 thru V700	Not assigned									
V701 thru V800	See Table 5-3									
V801 thru V900	See Table 5-4									
V901, 902	Same as V234									
V903	Same as V202									
V904 thru V1100	Not assigned									
V1101 thru V1199	See Table 5-2									
V1200 thru V1203	Same as V204									
			j							

Table 5-1. Replaceable Parts, 524C/D (Sheet 29 of 30)

	Table 5-1. Replaceable Par	18, 524C/D	(Sheet 29 of 30	) <del></del>	·	•	
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*			
V1204 thru	Assembly photoconductor plate: 6 units	28480	1990-0016	1			
V1209 V1210 thru	Assembly photoconductor plate: 4 units	28480	1990-0015				
V1213 V1401 V1501 VR201,	See Table 5-5, 5-6, or 5-7 See Table 5-7	-					
202 VR203	Same as DS1001 Lamp, neon: aged and selected green code	28480	2140-0084				
VR204 thru VR1000	Not assigned						
VR1001, 1002	Same as DS1001						
VR1003 thru VR1200	Not assigned						
VR1201	-						
thru VR1205	Same as VR203						
VR1206 thru VR1400	Not assigned						
VR1401, 1402	See Table 5-5, 5-6, or 5-7						
VR1501, 1502	See Table 5-7						
XZ201 thru XZ203	Socket, octal base	71785	1200-0005	3			
XZ204 thru XZ1199	Not assigned						
XZ1200 thru XZ1206	Socket, tube: 12 pins	02660	1200-0038	7			
Y901	Crystal, quartz: part of Crystal Oven Assembly (Z235). Not separately replaceable.						
Z201	See Table 5-2 for components	28480	524B-58C				
Z202	See Table 5-3 for components	28480	524C-58A				
Z203	See Table 5-4 for components	28480	523D-4A				
Z204 thru Z234	Not assigned						
Z235	Assembly, crystal oven: includes: C340, C916 thru C918, C921, HR201, S209, R539, R917, R918, Y901 and thermometer	28480	524D-95B	1			
Z236 thru Z1199	Not assigned						

Table 5-1. Replaceable Parts, 524C/D (Sheet 30 of 30)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
Z1200	Counter, decade, plug-in unit (524C only, AC-4J) (524D only, AC-4E)	28480 28480	5080-0013 5080-0011	1 1		
Z1201 thru Z1206	Counter, decade, plug-in unit (524C only, AC-4K) (524D only, AC-4G)	28480 28480	5080-0014 5080-0012	6 6		
	MISCELLANEOUS					
	Assembly, 10-mc readout (unit, readout for 524C) include: C1201, R1257 thru R1269	28489	524C-75A	1		
	Neon Lamp block with digital tube socket (Unit, readout for 524-C)	28480	5040-0016			
	Assembly, 10-mc readout (unit, readout for 524D) includes: DS1200 thru DS1209 and numeral plate	28480	524D-75A	1		
	Board, molded lamp (unit, readout for 524D)	28480	5040-0015			
	Plate, numeral	28480	5040-0014			
	Filter, air Filter, light (524C only) Fuseholder	82866 28480 75915	3150-0001 1000-0009 1400-0084	1 1 1		
	Knob: Display Time	28480	0370-0029	1		
	Knob: Function Selector	28480	0370-0035	1		
	Knob: Time Unit, Frequency Unit	28480	0370-0036	2		
	Lampholder	72765	1450-0009	5		
	Oil, soluble; for air filter; 1-pint can with spray dispenser	82866	3150-0002			
	Socket, for V238	82893	1200-0027	1		
:						
				1		

Table 5-2. Trigger Unit Plug-In Assembly (Sheet 1 of 2)

Table 5-2. Trigger Unit Plug-In Assembly (Sheet 1 of 2)									
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*					
Z201	Includes the following:	28480	524B-58C						
C1102	Capacitor: fixed, mica, 390 pf ±10%, 500 vdcw	00853	0140-0030	1					
C1103	Capacitor: fixed, mica, 47 pf ±10%, 500 vdcw	76433	0140-0032	1					
C1104	Capacitor: fixed, ceramic, 10 pf $\pm$ 0.5 pf, 500 vdcw	04222	0150-0009	1					
C1105	Capacitor: fixed, mica, 82 pf ±10%, 500 vdcw	00853	0140-0006	1					
C1106	Capacitor: fixed, electrolytic, 4 uf, 10 vdcw	56289	0180-0022	1					
C1107	Capacitor: fixed, electrolytic, 10 uf, 300 vdcw	56289	0180-0021	1					
C1108	Capacitor: fixed, mica, 150 pf ±10%, 500 vdcw	76433	0140-0055	1					
CR1101 thru CR1103	Diode; germanium: type HD2135-5	73293	1910-0011	3					
L1101	Reactor: 23 uh, wound on 1 megohm resistor	28480	524B-60Q	1					
L1102	Inductor, fixed: 19 uh wound on 680 ohms resistor	28480	524B-60B	1					
L1103	Inductor, fixed: 16 uh wound on 1 megohm resistor	28480	524B-60M	1					
L1104	Inductor, fixed: 10.5 uh wound on 1 megohm resistor	28480	524B-60G	1					
P1101	Connector, male: 8 pin	02660	1251-0026	1					
R1102	Resistor: fixed, composition, 4700 ohms ±10%, 2 W	01121	0693-4721	1					
R1103	Resistor: fixed, composition, 180, 000 ohms ±10%, 1 W Optimum value selected at factory. Average value shown.	01121	0690-1841	1		·			
R1104	Resistor: fixed, composition, 82,000 ohms ±5%, 1/2 W	01121	0686-8235	1					
R1105	Resistor: fixed, composition, 47,000 ohms ±10%, 1 W	01121	0690-4731	1					
R1106	Resistor: fixed, composition, 390, 000 ohms ±10%, 1/2 W	01121	0687-3941	1					
R1107	Resistor: fixed, composition, 1000 ohms ±10%, 1/2 W	01121	0687-1021	1			-		
R1108, 1109	Resistor: fixed, composition, 8200 ohms ±5%, 2 W	01121	0692-8225	2		:			
R1110	Resistor: fixed, deposited carbon, 405, 000 ohms ±1%, 1 W	19701	0730-0088	1					
R1111	Resistor: fixed, composition 5600 ohms ±10%, 2 W Optimum value selected at factory. Average value shown.	01121	0693-5621	1					

Table 5-2. Trigger Unit Plug-In Assembly (Sheet 2 of 2)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*	
R1112	Resistor: fixed, composition, 47,000 ohms ±10%, 1/2 W	01121	0687-4731	1	
R1113, 1114	Resistor: fixed, composition, 3300 ohms ±10%, 2 W	01121	0693-3321	2	
R1115	Resistor: fixed, deposited carbon, 90,000 ohms $\pm 1\%$ , $1/2$ W	19701	0727-0203	2	
R1116	Resistor: fixed, composition 2200 ohms ±10%, 1 W Optimum value selected at factory. Average value shown.	01121	0690-2221	1	
R1117	Same as R1115				
R1118	Resistor: fixed, composition, 10,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1031	1	
R1119	Resistor: fixed, composition, 5600 ohms $\pm 10\%$ , $1/2$ W	01121	0687-5621	1	
R1120	Resistor: fixed, composition, 5600 ohms ±10%, 1/2 W Optimum value selected at factory. Average value shown.	01121	0687-5621		
V1101	Tube, electron: 5963	80131	1932-0008	1	
V1102, 1103	Tube, electron: 5654	80131	1923-0001	2	

Table 5-3. Amplitude Discriminator (Sheet 1 of 2)

Ckt. Ref.	Description	Mfr.*		TQ*	
Z202	Includes the following:	28480	524C-58A		
C701	Capacitor: fixed, paper, $0.0033 \text{ uf } \pm 10\%$ , $600 \text{ vdcw}$	56289	0160-0008	1	
C702	Capacitor: fixed, mica, 15 pf ±10%, 500 vdcw	00853	0140-0004	1	
C703	Capacitor: fixed, titonium dioxide 6.8 pf $\pm .5$ %, 500 vdcw	82142	0150-0043	1	
C704 thru C799	Not assigned				
P701	Connector, male: for octal base	02660	1251-0026	1	
R701	Resistor: fixed, composition, 27,000 ohms $\pm 10\%$ , 1 W	01121	0690-2731	1	
R702	Resistor: fixed, composition, 62,000 ohms ±5%, 1 W	01121	0689-6235	1	
R703	Resistor: fixed, composition, 270 ohms $\pm 10\%$ , $1/2$ W	01121	0687-2711	1	
R704	Resistor: fixed, composition, 6200 ohms ±5%, 1/2 W	01121	0686-6225	1	

<sup>\*</sup> See introduction to this section

Table 5-3. Amplitude Discriminator (Sheet 2 of 2)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*	
R705	Resistor: fixed, composition, 120, 000 ohms ±10%, 1 W	01121	0690-1241	1	
R706	Resistor: fixed, composition, 56,000 ohms ±10%, 1 W	01121	0690-5631	1	
R707, 708	Resistor: fixed, composition, 15,000 ohms ±10%, 1 W	01121	0690-1531	2	
R709	Resistor: fixed, composition, 330, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-3341	1	
R710	Resistor: fixed, composition, 560, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-5641	1	
R711	Resistor: fixed, composition, 56,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-5631	1	
R712	Resistor: fixed, composition, 1000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1021	1	
R713 thru R799	Not assigned				
V701	Tube, electron: 12AT7	80131	1932-0027		
V702	Tube, electron: 5844	80131	1932-0007	1	

Table 5-4. Decade Divider Plug-In Unit (Sheet 1 of 3)

Ckt. Ref.	Description	Mfr.*		TQ*		
Z203	Includes the following:	28480	523D-4A		4	
C801	Capacitor: fixed, mica, 100 pf ±5%, 500 vdcw	76433	0140-0041	1		
C802	Capacitor: fixed, mica, 27 pf ± 5 %, 500 vdcw	76433	0140-0042	5		
C803	Capacitor: fixed, titonium dioxide, 3.3 pf ±10%, 500 vdcw	82142	0150-0022	1		
C804 thru C806	Same as C802					
C807	Capacitor: fixed, ceramic, 0.05 uf ±20%, 400 vdcw	05729	0150-0052	1		
C808	Capacitor: fixed, mica, 47 pf ±5%, 500 vdcw	76433	0140-0039	4		
C809	Same as C802					
C810	Capacitor: fixed, mica, 39 pf ±5%, 500 vdcw	76433	0140-0035	2		
C811	Capacitor: fixed, mica, 22 pf ± 5%, 500 vdcw	00853	0140-0034	1		
C812	Capacitor: fixed, mica, 75 pf ±5%, 500 vdcw	00853	0140-0040	1		

<sup>\*</sup> See introduction to this section

Table 5-4. Decade Divider Plug-In Unit (Sheet 2 of 3)

CI-4 D C	Table 5-4. Decade Divider	Т	1	T	1
Ckt Ref.	Description	Mfr *	® Stock No.	TQ*	 -
C813	Same as C810				
C814 thru	Same as C808				
C816					
P801	Connector, male, for octal base	02660	1251-0026		
R801	Resistor: fixed, composition 27,000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-2735	2	
R802	Resistor: fixed, composition 270,000 ohms ±5%, 1/2 W	01121	0686-2745	8	
R803	Resistor: fixed, composition 100,000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-1045	9	
R804	Resistor: fixed, composition 27,000 ohms $\pm 10\%$ , 1 W	01121	0690-2731	1	
R805	Resistor: fixed, composition 12,000 ohms $\pm 5\%$ , $1/2$ W	01121	0686-1235	1	
R806	Same as R801				
R807	Same as R802				
R808, 809	Same as R803				
R810	Same as R802				
R811	Resistor: fixed, composition, $43,000 \text{ ohms } \pm 5\%, 1/2 \text{ W}$	01121	0686-4335	4	
R812	Resistor: fixed, composition, 47,000 ohms ±10%, 1 W	01121	0690-4731	3	
R813	Resistor: fixed, composition 5,100 ohms ±5%, 1 W	01121	0689-5125	1	
R814	Same as R811				
R815	Same as R802				
R816 thru R818	Same as R803				
R819	Same as R811			İ	
R820	Not assigned				
R821	Same as R802				
R822	Resistor: fixed, composition 180, 000 ohms ±10%, 1/2 W	01121	0687-1841	1	
R823	Same as R812				
R824	Same as R811				
R825	Same as R802				
R826	Same as R803				
R827	Resistor: fixed, composition 36,000 ohms ±5%, 1/2 W	01121	0686-3635	2	
R828	Same as R802				

<sup>\*</sup> See introduction to this section

Table 5-4. Decade Divider Plug-In Unit (Sheet 3 of 3)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
R829	Same as R803					
R830	Same as R812					
R831	Same as R827					
R832	Same as R802				ĺ	
R833	Same as R803					
R834 thru R900	Not assigned					
V801 thru V804	Tube: electron 5963	80131	1932-0008	4		

Table 5-5. 524C-95B Digital Recorder Kit for 561B (Sheet 1 of 2)

Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*		
C1401	Capacitor: fixed, ceramic 0.005 uf, 500 vdcw	96095	0150-0014	1		
C1402	Capacitor: fixed, mica 220 pf, $\pm 10\%$ , 500 vdcw	00853	0140-0031	2		
C1403	Not assigned					
C1404	Same as C1402					
C1405	Not assigned					
C1406	Capacitor: fixed, electrolytic, 10 uf $\pm 50\%$ , 450 vdcw	37942	0180-0005	1		
C1407 thru C1419	Not assigned					
C1420	Capacitor: fixed, electrolytic 4 uf -15%, +20%, 60 vdcw	10411	0180-0008	1		
C1421	Capacitor: fixed, electrolytic 10 uf -10%, +100%, 25 vdcw	56289	0180-0059	1		
C1422, C1423	Capacitor: fixed, ceramic $0.01 \text{ uf } \pm 20\%$ , $1000 \text{ vdcw}$	71590	0150-0012	2		
CR1401	Diode, germanium	08792	1910-0015	2		
CR1402	Not assigned					
CR1403	Same as CR1401					
J1401 ·	Not assigned					
J1402A, B 1403A,	Connector; female: 50 contacts	02660	1251-0101	3		
L1401	Inductor: fixed, 2.5 mh	98405	9110-0034	1		
Q1420, 1421	Transistor: 2N404	02735	1850-0062	2		
R1401	Resistor: fixed, composition 330,000 ohms ±10%, 1/2 W	01121	0687-3341	1		
R1402	Not assigned					

Table 5-5. 524C-95B Digital Recorder Kit (Sheet 2 of 2)

	Table 5-5. 524C-95B Digital	Trecorder 1	1	'' 	r	1	1
Ckt Ref.	Description	Mfr *	⊕ Stock No.	TQ*			
R1403	Resistor: fixed, composition 1.8 megohms $\pm 10\%$ , $1/2W$	01121	0687-1851	1			
R1404	Not assigned						
R1405	Resistor: fixed, composition, 1500 ohms $\pm 10\%$ , 1/2 W. Optimum value selected at factory. Average value shown	01121	0687-1521	1			
R1406,1407	Not assigned						
R1408	Resistor: fixed, composition $100,000$ ohms $\pm 10\%$ , $1/2$ W	01121	0687-1041	2			
R1409	Resistor: fixed, composition 3000 ohms ±5%, 1 W	01121	0689-3025	1			
R1410	Resistor: fixed, composition 330 ohms, $\pm 10\%$ , $1/2$ W	01121	0687-3311	1			
R1411	Not assigned						
R1412	Resistor: fixed, composition 470 ohms $\pm 10\%$ , $1/2$ W	01121	0687-4711	1			
R1413	Same as R1408						
R1414 thru R1419	Not assigned						
R1420	Resistor: fixed, composition 5600 ohms $\pm 5\%$ , $1/4$ W	01121	0683-5625	1			
R1421	Resistor: fixed, composition 3300 ohms $\pm 5\%$ , $1/4$ W	01121	0683-3325	1			
R1422	Resistor: fixed, composition 68,000 ohms ±5%, 1/4 W. Optimum value selected at factory. Average value shown.	01121	0683-6835	1			
R1423	Resistor: fixed, composition $33,000$ ohms $\pm 5\%$ , $1/4$ W	01121	0683-3335	2			
R1424	Resistor: fixed, composition 8200 ohms $\pm 5\%$ , $1/4$ W	01121	0683-8225	1			
R1425	Resistor: fixed, composition 6800 ohms $\pm 5\%$ , $1/4$ W	01121	0683-6825	1			
R1426	Resistor: fixed, composition 10,000 ohms $\pm 5\%$ , $1/4$ W	01121	0683-1035	2			
R1427	Same as R1423						
R1428	Same as R1426						
R1429	Resistor: fixed, composition 18,000 ohms $\pm 5\%$ , $1/4W$	01121	0683-1835	1			
R1430	Resistor: fixed, composition 2200 ohms $\pm 5\%$ , $1/4$ W	01121	0683-2225	1			
R1431 thru R1439	Not assigned						
R1440	Resistor: fixed, composition 390,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-3941	1			
R1441	Resistor: fixed, composition $560,000$ ohms $\pm 10\%$ , $1/2$ W	01121	0687-5641	1			
R1442	Resistor: fixed, composition 120,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1241	1			
V1401	Tube: electron, 6CW4 (Nuvistor)	86684	1921-0013	1			
VR1401, VR1402	Lamp, neon: NE 2	24455	2140-0008	2			

Table 5-6. 524D-95A Digital Recorder Kit for 560A (Sheet 1 of 1)

	Table 5-6. 524D-95A Digita	T Trecorder	121t 101 300A (L	1	1 01 1)	γ	<del> </del>
Ckt Ref.	Description	Mfr *	₩ Stock No.	TQ*			
C1401	Capacitor: fixed, ceramic, 0.005 uf, 500 vdcw	96095	0150-0014	1			
C1402	Capacitor: fixed, mica, 220 pf ±10%, 500 vdcw	00853	0140-0031	2			
C1403	Not assigned					İ	
C1404	Same as C1402						
C1405	Capacitor: fixed, ceramic 0.01 uf ±20%, 1000 vdcw	71590	0150-0012	1			
CR1401	Diode, crystal	98925	1910-0016	2			
CR1402	Not assigned						
CR1403	Same as CR1401						
J1401	Connector, female: 19 contacts, chassis mounting, type AN-3102A-14S	71468	1251-0056	1			
K1401	Relay: DPDT, 110 vdc	77342	0490-0017	1		1	
L1401	Inductor: fixed, 2.5 mh	98405	9110-0034	1			
R1401	Resistor: fixed, composition, 330, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-3341	1			
R1402	Not assigned						
R1403	Resistor: fixed, composition, 1.8 megohms $\pm 10\%$ , $1/2$ W	01121	0687-1851	1			
R1404	Not assigned						
R1405	Resistor: fixed, composition, 1500 ohms ±10%, 1/2 W Optimum value selected at factory. Average value shown.	01121	0687-1521	1			
R1406,1407	_						
R1408	Resistor: fixed, composition, 100, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1041	1			
R1409	Resistor: fixed, composition, 3000 ohms ±5%, 1 W	01121	0689-3025	1			
R1410	Resistor: fixed, composition, 330 ohms $\pm 10\%$ , $1/2$ W	01121	0687-3311	1			
R1411	Resistor: fixed, composition, 10,000 ohms ±10%, 2 W	01121	0693-1031	1			
R1412	Resistor: fixed, composition, 470 ohms ±10%, 1/2 W	01121	0687-4711	1			
R1413	Resistor: fixed, composition, 100,000 ohms, $\pm 10\%$ , $1/2$ W	01121	0687-1041	1			
R1414 thru R1439	Not assigned						
R1440	Resistor: fixed, composition, 390, 000 ohms ±10%, 1/2 W	01121	0687-3941	1			
R1441	Resistor: fixed, composition, 560, 000 ohms ±10%, 1/2 W	01121	0687-5641	1			
R1442	Resistor: fixed, composition, 120, 000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1241	1			
V1401	Tube, electron: 6CW4 (nuvistor)	86684	1921-0013	1			
VR1401, 1402	Lamp, neon glow, 1/25 W, type NE2	24455	2140-0008	2	!		

Table 5-7. 524C-95E Digital Recorder Kit for 562A (sheet 2 of 3)

·	Table 5-7. 524C-95E Digital Reco	Tuel Int 10	1 00271 (Sincet 2	<del>(10)</del>	 γ	·
Ckt.	Description	Mfr.*	∅ Stock No.	TQ*		
R1437	Resistor: fixed, composition 3600 ohms $\pm 5\%$ , $1/2$ W	01121	0686-3625	1		
R1438	Resistor: fixed, composition $36,000 \text{ ohms } \pm 5\%, 2 \text{ W}$	01121	0692-2635	1		
R1439	Resistor: fixed, composition 10,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1031	1		
R1440	Resistor: fixed, composition 39,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-3941	1		
R1441	Resistor: fixed, composition 560,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-5641	1		
R1442	Resistor: fixed, composition 120,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1241	1		
R1443 thru R1449	Same as R1414 (see Z1200 thru Z1206)					
R1450 thru R1500	Not assigned					
R1501	Resistor: fixed, composition 100,000 ohms $\pm 10\%$ , 1 W	01121	0690-1041	1		
R1502	Resistor: fixed, composition 39,000 ohms $\pm 10\%$ , 1 W	01121	0690-3931	1		
R1503	Resistor: fixed, composition 100,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1041	2		
R1504	Resistor: fixed, composition $820,000$ ohms $\pm 10\%$ , 1 W	01121	0690-8241	1		
R1505	Resistor: fixed, composition 3.9 megohms $\pm 10\%$ , 1 W	01121	0690-3951	1		
R1506	Resistor: fixed, composition 120,000 ohms $\pm 10\%$ , 1 W	01121	0690-1241	1		
R1507	Resistor: fixed, composition $68,000 \text{ ohms } \pm 10\%, 1 \text{ W}$	01121	0690-6831	1		
R1508	Resistor: fixed, composition 1.5 megohms ±10%, 1 W	01121	0690-1551	1		
R1509	Same as R1503					
V1401	Tube, electron: 6CW4 (nuvistor)	86684	1921-0013	1		
V1501	Tube, electron: 6211	24455	1932-0012	1		
VR1401, 1402	Lamp, neon glow, 1/25 W	24455	2140-0008	4		
VR1403, thru VR1500	Not assigned					
VR1501, 1502	Same as VR1401					
Z1200 (524C)	Counte: decade, plug-in unit.Standard unit modified for this application by installation of four 1.0 megohm resistors ( Stock No. 0686-1055)		For direct replacement order H01-5080- 0013			/

Table 5-7. 524C-95E Digital Recorder Kit for 562A (sheet 1 of 3)

	Table 5-1. 524C-95E Digital Rec	T	T	<del></del>	<u> </u>	I	T
Ckt.	Description	Mfr. *	Stock No.	TQ*			
C1401	Capacitor: fixed, ceramic 0.005 $\mu$ f, 500 vdcw	96095	0150-0014	1			
C1402	Capacitor: fixed, mica 220 pf, ±10%, 500 vdcw	00853	0140-0031	2			
C1403	Not assigned						
C1404	Same as C1402						
C1405, 1406	Not assigned						
C1407 thru C1413	Capacitor: fixed, ceramic 1000 pf, ±5%, 500 vdcw	28480	0140-0018	7			
CR1401	Diode, crystal	98925	1910-0016	2			
CR1402	Not assigned						
CR1403	Same as CR1401				'		
J1403B	Connector; female: 50 contacts	02660	1251-0101	1	:		
L1401	Inductor: fixed, 2.5 mh	98405	9110-0034	1			
R1401	Resistor: fixed, composition 330,000 ohms ±10%, 1/2 W	01121	0687-3341	1			
R1402	Not assigned						
R1403	Resistor: fixed, composition 1.8 megohms ±10%, 1/2 W	01121	0687-1851	1			1
R1404	Not assigned						
R1405	Resistor: fixed, composition 560 ohms, ±10%, 1/2 W NOTE: This resistor will be 1500* ohms if 560A or 561B adapter kit is installed (see Table 5-5 or 5-6).	01121	0687-5611	1			
R1406, 1407	Not assigned						
R1408	Resistor: fixed composition 100,000 ohms $\pm 10\%$ , $1/2$ W	01121	0687-1041	2		i	
R1409	Resistor: fixed composition 3000 ohms $\pm 5\%$ , 1 W	01121	0689-3025	1			
R1410	Resistor: fixed, composition 330 ohms $\pm 10\%$ , $1/2$ W	01121	0687-3311	1			
R1411	Not assigned						
R1412	Resistor: fixed, composition 470 ohms $\pm 10\%$ , $1/2$ W	01121	0687-4711	1			
R1413	Same as R1408						
R1414 thru R1417	Resistor: fixed, composition 1.0 megohms, $\pm 10\%$ , $1/2$ W	01121	0686-1055	32		·	
R1418 thru R1435	Not assigned						/
R1436	Resistor: fixed, composition 15,000 ohms ±10%, 1 W	01121	0690-1531	1			

Table 5-7. 524C-95E Digital Recorder Kit for 562A (sheet 3 of 3)

	Table 5-7. 524C-95E Digital Record				1	
Ckt.	Description	Mfr.*	⊕ Stock No.	TQ*		
Z1200 (524D)	Same as Z1200 (524C), except only three resistors installed in plug-in unit; fourth resistor is R1443		For direct replacement order H01-5080- 0011			
Z1200 thru Z1206 (524C)	Same description as Z1200 (524C)		For direct replacement order H01-5080- 0014			
Z1201 thru Z1206 (524D)	Same description as Z1200 (524D), except fourth resistor is R1444 thru R1449		For direct replacement order H01-5080- 0012			
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### Table 5-8. Code List of Manufacturers

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.

	suppire	is not appearing in the		abooks.			
Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer Address
00000	U.S.A. Common	Any supplier of U.S.	05729	Metro-Tel Corp.	Westbury, N.Y.	12881	Metex Electronics Corp. Clark, N.J.
00136	McCoy Electronics	Mount Holly Springs, Pa.		Stewart Engineering Co.	Santa Cruz, Calif.		Delta Semiconductor Inc. Newport Beach, Calif.
00213	Sage Electronics Corp.	Rochester, N.Y.	05820	Wakefield Engineering Inc.	Wakefield, Mass.	12954	Dickson Electronics Corp. Scottsdale, Arizona
-	Cemco Inc.	Danielson, Conn.		Bassick Co., The	Bridgeport, Conn.		Thermolloy Dallas, Texas
	Humidial	Colton, Calif.		Raychem Corp.	Redwood City, Calif.		Telefunken (GmbH) Hanover, Germany
	Microtron Co., Inc.	Valley Stream, N.Y.		Bausch and Lomb Optical C		13835	Midland-Wright Div. of Pacific Industries, Inc.
003/3	Garlock Inc., Electronics Products D	iv. Camden, N.J.		E. T. A. Products Co. of A		14000	Kansas City, Kansas Sem-Tech Newbury Park, Calif.
00656	Aerovox Corp.	New Bedford, Mass.	06340	Amatom Electronic Hardwar	New Rochelle, N.Y.		Calif. Resistor Corp. Santa Monica, Calif.
	Amp. Inc.	Harrisburg, Pa.	06555	Beede Electrical Instrument			American Components, Inc. Conshohocken, Pa.
	Aircraft Radio Corp.	Boonton, N.J.	00000	Boode Electives (national	Penacook, N.H.		ITT Semiconductor, A Div. of Int. Telephone
00815	Northern Engineering Lab		06666	General Devices Co., Inc.	Indianapolis, Ind.		& Telegraph Corp. West Palm Beach, Fla.
		Burlington, Wis.	06751	Semcor Div. Components In	c. Phoenix, Ariz.		Hewlett-Packard Company Loveland, Colo.
00853	Sangamo Electric Co P		06812	Torrington Mfg. Co., West			Cornell Dublier Electric Corp. Newark, N. J.
	0 5	Pickens, S.C.			Van Nuys, Calif.		Corning Glass Works Corning, N.Y.
	Goe Engineering Co.	Los Angeles, Calif.		Varian Assoc. Eimac Div.	San Carlos, Calif.		Electro Cube Inc. So. Pasadena, Calif.
	Carl E. Holmes Corp. Microlab Inc.	Los Angeles, Calif. Livingston, N.J.		Kelvin Electric Co.	Van Nuys, Calif.		Williams Mfg. Co. San Jose, Calif. Webster Electronics Co. New York, N.Y.
	Alden Products Co.	Brockton, Mass.		Digitran Co. Transistor Electronics Corn	Pasadena, Calif. Minneapolis, Minn.		Adjustable Bushing Co. N. Hollywood, Calif.
	Allen Bradley Co.	Milwaukee, Wis.		Westinghouse Electric Corp			Micron Electronics
	Litton Industries, Inc.	Beverly Hills, Calif.	0,100	Electronic Tube Div.	Elmira, N.Y.		Garden City, Long Island, N.Y.
	TRW Semiconductors, Inc		07149	Filmohm Corp.	New York, N.Y.	15566	Amprobe Inst. Corp. Lynbrook, N.Y.
01295	Texas Instruments, Inc.,		07233	Cinch-Graphik Co.	City of Industry, Calif.	15772	Twentieth Century Coil Spring Co.
	Transistor Products Di		07261	Avnet Corp.	Culver City, Calif.		Santa Clara, Calif.
	The Alliance Mfg. Co.	Alliance, Ohio	07263	Fairchild Camera & Inst. C	•		Amelco Inc. Mt. View, Calif.
	Pacific Relays, Inc. Amerock Corp.	Van Nuys, Calif. Rockford, III.	07200	Semiconductor Div.	Mountain View, Calif.	15909	Daven Div. Thomas A. Edison Ind.
	Pulse Engineering Co.	Santa Clara, Calif.		Minnesota Rubber Co.	Minneapolis, Minn. Monterey Park, Calif.	16027	McGraw-Edison Co. Long Island City, N.Y. Spruce Pine Mica Co. Spruce Pine, N.C.
	Ferroxcube Corp. of Amer			Birtcher Corp., The Technical Wire Products Inc			Omni-Spectra Inc. Spruce Pine, N.C.  Detroit, III.
	Cole Rubber and Plastics			Continental Device Corp.	Hawthorne, Calif.		Computer Diode Corp. Lodi, N.J.
	Amphenol-Borg Electronic			Raytheon Mfg. Co.,			Ideal Prec. Meter Co., Inc.
02735	Radio Corp. of America,			Semiconductor Div.	Mountain View, Calif.		De Jur Meter Div. Brooklyn, N.Y.
	and Materials Div.	Somerville, N.J.	07966	Shockley Semi-Conductor La		16758	Delco Radio Div. of G.M. Corp. Kokomo, Inc.
02771	Vocaline Co. of America,				Palo Alto, Calif.		Thermonetics Inc. Canoga Park, Calif.
02777	Hopkins Engineering Co.	Old Saybrook, Conn. San Fernando, Calif.	07980	Hewlett-Packard Co., Boon			Tranex Company Mountain View, Calif.
03508	G. E. Semiconductor Prod		00146	II C Engineering Co	Rockaway, N.J.		Hamlin Metal Products Corp. Akron, Ohio
	Apex Machine & Tool Co.			U.S. Engineering Co. Blinn, Delbert Co.	Los Angeles, Calif. Pomona, Calif.		Angstrohm Prec. Inc. No. Hollywood, Calif. Power Design Pacific Inc. Palo Alto, Calif.
	Eldema Corp.	Compton, Calif.		Burgess Battery Co.	romona, Gairr.		Power Design Pacific Inc. Palo Alto, Calif. Ty-Car Mfg. Co., Inc. Holliston, Mass.
03877	Transitron Electric Corp.	Wakefield, Mass.	00000		Falls, Ontario, Canada		TRW Elect. Comp. Div. Des Plaines, III.
	Pyrofilm Resistor Co., Ir	nc. Cedar Knolls, N.J.	08664	Bristol Co., The	Waterbury, Conn.		Curtis Instrument, Inc. Mt. Kisco, N.Y.
03954	Singer Co., Diehl Div.			Sloan Company	Sun Valley, Calif.	18873	E.I. DuPont and Co., Inc. Wilmington, Del.
04000	Finderne Plant	Sumerville, N.J.	08718	ITT Cannon Electric Inc., F			Durant Mfg. Co. Milwaukee, Wis.
04009	Arrow, Hart and Hegeman	Hartford, Conn.	00700	00051	Phoenix, Arizona	19315	Bendix Corp., The
04013	Taurus Corp.	Lambertville, N.J.	08/92	CBS Electronics Semiconduc		10500	Eclipse-Poineer Div. Teterboro, N.J.
	Hi-Q Division of Aerovox	Myrtle Beach, S.C.		Operations, Div of C.B.S	Lowell, Mass.	19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co. West Orange, N.J.
	Precision Paper Tube Co		08984	Mel-Rain	Indianapolis, Ind.	19644	McGraw-Edison Co. West Orange, N.J.  LRC Electronics Horseheads, N.Y.
04404	Dymec Division of Hewle			Babcock Relays Div.	Costa Mesa, Calif.		Electra Mfg. Co. Independence, Kansas
		Palo Alto, Calif.		Texas Capacitor Co.	Houston, Texas		General Atronics Corp. Philadelphia, Pa.
04651	Sylvania Electric Product			Atohm Electronics	Sun Valley, Calif.		Executone, Inc. Long Island City, N.Y.
0.4712	Device Div.	Mountain View, Calif.		Electro Assemblies, Inc.	Chicago, III.		Fafnir Bearing Co., The New Britain, Conn.
04/13	Motorola, Inc., Semicond	Phoenix, Arizona	09569	Mallory Battery Co. of			Fansteel Metallurgical Corp. N. Chicago, III.
04732	Filtron Co., Inc. Western		10214	Canada, Ltd. To General Transistor Western	ronto, Ontario, Canada		British Radio Electronics Ltd. Washington, D.C.
01702		Culver City, Calif.	10214	General Hallsistor Western	Los Angeles, Calif.	24455	G. E. Lamp Division
04773	Automatic Electric Co.	Northlake, III.	10411	Ti-Tal, Inc.	Berkeley, Calif.	24655	Nela Park, Cleveland, Ohio General Radio Co. West Concord, Mass.
04796	Sequoia Wire Co.	Redwood City, Calif.		Carborundum Co.	Niagara Falls, N.Y.		General Radio Co. West Concord, Mass. Gries Reproducer Corp. New Rochelle, N.Y.
	Precision Coil Spring Co.			CTS of Berne, Inc.	Berne, Ind.		Grobet File Co. of America, Inc.
	P.M. Motor Company	Westchester, III.	11237	Chicago Telephone of Califo	rnia, Inc.		Carlstadt, N.J.
05006	Twentieth Century Plastic				So. Pasadena, Calif.	26992	Hamilton Watch Co. Lancaster, Pa.
05277	Wastinghouse Floatric Co	Los Angeles, Calif.		Bay State Electronics Corp.	Waltham, Mass.		Hewlett-Packard Co. Palo Alto, Calif.
03211	Westinghouse Electric Co Semi-Conductor Dept.	Youngwood, Pa.		Teledyne Inc., Microwave D			G. E. Receiving Tube Dept. Owensboro, Ky.
05347	Ultronix, Inc.	San Mateo, Calif.		Duncan Electronics Inc. General Instrument Corp., S	Costa Mesa, Calif.		Lectrohm Inc. Chicago, III.
	Illumitronic Engineering (		11/11	Div., Products Group	emiconductor Newark, N.J.	36196	Stanwyck Coil Products Ltd.
	Cosmo Plastic		11717	Imperial Electronic, Inc.	Buena Park, Calif.	37042	Hawkesbury, Ontario, Canada
	(c o Electrical Spec. C			Melabs, Inc.	Palo Alto, Calif.		P.R. Mallory & Co. Inc. Indianapolis, Ind. Mechanical Industries Prod. Co. Akron, Ohio
	Barber Colman Co.	Rockford, III.		Philadelphia Handle Co.	Camden, N.J.		Miniature Precision Bearings, Inc. Keene, N.H.
05728	Tiffen Optical Co.	Table I am Into I M M	12697	Clarostat Mfg. Co.	Dover, N.H.		Muter Co. Chicago, III.
	Roslyn He	ights, Long Island, N.Y.	12859	Nippon Electric Co., Ltd.	Tokyo, Japan		C. A. Norgren Co. Englewood, Colo.

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### Table 5-8. Code List of Manufacturers (Cont'd)

6 1		Code	W 6 . All	Code No.	Manufacturer Address
Code No.	Manufacturer Address	No.	Manufacturer Address		
AACEE	Ohmita Mfa Ca Chaldia III		Robert M. Hadley Co. Los Angeles, Calif.		Mepco Division of Sessions Clock Co.  Morristown, N.J.
	Ohmite Mfg. Co. Skokie, III. Penn Eng. & Mfg. Corp. Doylestown, Pa.		Erie Technological Products, Inc. Erie, Pa Hansen Mfg. Co., Inc. Princeton, Ind.	80120	Schnitzer Alloy Products Co. Elizabeth, N.J.
	Polaroid Corp. Cambridge, Mass.		H.M. Harper Co. Chicago, III.	80130	Times Telephoto Equipment New York, N.Y.
	Precision Thermometer & Inst. Co.		Helipot Div. of Beckman Inst., Inc.	80131	Electronic Industries Association. Any brand
	Southampton, Pa.		Fullerton, Calif.	00007	Tube meeting EIA Standards-Washington, DC.
	Microwave & Power Tube Div. Waltham, Mass.	73293	Hughes Products Division of Hughes	80207	Unimax Switch, Div. Maxon Electronics Corp. Wallingford, Conn.
	Rowan Controller Co. Westminster, Md.	72445	Aircraft Co. Newport Beach, Calif.	80223	United Transformer Corp. New York, N.Y.
	Sanborn Company Waltham, Mass. Shallcross Mfg. Co. Selma, N.C.	/3445	Amperex Electronic Co., Div. of North American Phillips Co., Inc. Hicksville, N.Y.		Oxford Electric Corp. Chicago, III.
	Simpson Electric Co. Chicago, III.	73506	Bradley Semiconductor Corp. New Haven, Conn.	80294	Bourns Inc. Riverside, Calif.
	Sonotone Corp. Elmsford, N.Y.		Carling Electric, Inc. Hartford, Conn.	80411	Acro Div. of Robertshaw Controls Co.
55938	Raytheon Co. Commercial Apparatus &		George K. Garrett Co., Div. MSL	00400	Columbus, Ohio
	Systems Div. So. Norwalk, Conn.		Industries Inc. Philadelphia, Pa.		All Star Products Inc. Defiance, Ohio Avery Adhesive Label Corp. Monrovia, Calif.
	Spaulding Fibre Co., Inc. Tonawanda, N.Y.		Federal Screw Products Inc. Chicago, III.		Hammarlund Co., Inc. New York, N.Y.
	Sprague Electric Co. North Adams, Mass. Telex, Inc. St. Paul, Minn.		Fischer Special Mfg. Co. Cincinnati, Ohio General Industries Co., The Elyria, Ohio		Stevens, Arnold, Co., Inc. Boston, Mass.
	Thomas & Betts Co. Elizabeth, N.J.		Goshen Stamping & Tool Co. Goshen, Ind.	81030	International Instruments Inc. Orange, Conn.
	Triplett Electrical Inst. Co. Bluffton, Ohio		JFD Electronics Corp. Brooklyn, N.Y.		Grayhill Co. LaGrange, III.
	Union Switch and Signal, Div. of	73905	Jennings Radio Mfg. Corp. San Jose, Calif.		Triad Transformer Corp. Venice, Calif.
	Westinghouse Air Brake Co. Pittsburgh, Pa.		Signalite Inc. Neptune, N.J.	81312	Winchester Elec. Div. Litton Ind., Inc. Oakville, Conn.
	Universal Electric Co. Owosso, Mich.		J. H. Winns, and Sons Winchester, Mass.	81349	Military Specification
	Ward-Leonard Electric Co. Mt. Vernon, N.Y.		Industrial Condenser Corp. Chicago, III.		International Rectifier Corp. El Segundo, Calif.
	Western Electric Co., Inc. New York, N.Y. Weston Inst. Inc. Weston-Newark Newark, N.J.	74000	R.F. Products Division of Amphenol-Borg Electronics Corp. Danbury, Conn.		Airpax Electronics, Inc. Cambridge, Mass.
	Wittek Mfg. Co. Chicago, III.	74970	E. F. Johnson Co. Waseca, Minn.	81860	Barry Controls, Div. Barry Wright Corp.
	Revere Wollansak Div. Minn. Mining &		International Resistance Co. Philadelphia, Pa.		Watertown, Mass.
	Mfg. Co. St. Paul, Minn.		CTS Knights Inc. Sandwich, III.		Carter Precision Electric Co. Skokie, III.  Sperti Faraday Inc., Copper Hewitt
	Allen Mfg. Co. Hartford, Conn.		Kulka Electric Corporation Mt. Vernon, N. Y.	02047	Electric Div. Hoboken, N.J.
/0318	Allmetal Screw Product Co., Inc.		Lenz Electric Mfg. Co. Chicago, III. Littlefuse, Inc. Des Plaines, III.	82142	Jeffers Electronics Division of Speer
70485	Garden City, N.Y. Atlantic India Rubber Works, Inc. Chicago, III.		Lord Mfg. Co. Erie, Pa.		Carbon Co. Du Bois, Pa.
	Amperite Co., Inc. Union City, N.J.		C. W. Marwedel San Francisco, Calif.	82170	Fairchild Camera & Inst. Corp.,
	Belden Mfg. Co. Chicago, III.	76487	James Millen Mfg. Co., Inc. Malden, Mass.	02200	Defense Prod. Division Clifton, N.J. Maguire Industries, Inc. Greenwich, Conn.
	Bird Electronic Corp. Cleveland, Ohio		J.W. Miller Co. Los Angeles, Calif.		Sylvania Electric Prod. Inc.
	Birnbach Radio Co. New York, N.Y.	76530	Cinch-Monadnock, Div. of United Carr	02213	Electronic Tube Division Emporium, Pa.
71041	Boston Gear Works Div. of Murray Co.	76545	Fastener Corp. San Leandro, Calif. Mueller Electric Co. Cleveland, Ohio	82376	Astron Corp. East Newark, Harrison, N, J,
71218	of Texas Quincy, Mass. Bud Radio, Inc. Willoughby, Ohio		National Union Newark, N.J.		Switchcraft, Inc. Chicago, III.
	Camloc Fastener Corp. Paramus, N. J.		Oak Manufacturing Co. Crystal Lake, III.	82647	Metals & Controls Inc. Spencer Products
	Cardwell Condenser Corp.	77068	Bendix Corp., The	82768	Attleboro, Mass.  Phillips-Advance Control Co.  Joliet, III.
	Lindenhurst L.I., N.Y.	77075	Bendix Pacific Div. N. Hollywood, Calif.		Research Products Corp. Madison, Wis.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.		Pacific Metals Co. San Francisco, Calif. Phanostran Instrument and Electronic Co.		Rotron Mfg. Co., Inc. Woodstock, N.Y.
71/36	St. Louis, Mo. Chicago Condenser Corp. Chicago, III.	11221	South Pasadena, Calif.		Vector Electronic Co. Glendale, Calif.
	Calif. Spring Co., Inc. Pico-Rivera, Calif.	77252	Philadelphia Steel and Wire Corp.		Western Washer Mfg. Co. Los Angeles, Calif.
	CTS Corp. Elkhart, Ind.		Philadelphia, Pa.		Carr Fastener Co. Cambridge, Mass.  New Hampshire Ball Bearing, Inc.
71468	ITT Cannon Electric Inc. Los Angeles, Calif.	77342	American Machine & Foundry Co. Potter	03000	Peterborough, N.H.
71471	Cinema Plant, Hi-Q Div. Aerovox Corp.	77620	& Brumfield Div. Princeton, Ind.	83125	General Instrument Corp., Capacitor Div.
71402	Burbank, Calif.		TRW Electronic Components Div. Camden, N.J. General Instrument Corp., Rectifier Div.		Darlington, S.C.
	C. P. Clare & Co. Chicago, III. Centralab Div. of Globe Union Inc.	. , , , , ,	Brooklyn, N.Y.		ITT Wire and Cable Div. Los Angeles, Calif.
	Milwaukee, Wis.	77764	Resistance Products Co. Harrisburg, Pa.		Victory Engineering Corp.  Springfield, N.J.  Pad Bank, N. J.
71616	Commercial Plastics Co. Chicago, III.		Rubbercraft Corp. of Calif. Torrance, Calif.		Bendix Corp. Red Bank Div. Red Bank, N.J. Hubbell Corp. Mundelein, III.
	Cornish Wire Co., The New York, N.Y.	78189	Shakeproof Division of Illinois Tool Works		Smith, Herman H., Inc. Brooklyn, N.Y.
	Coto Coil Co., Inc. Providence, R.I.	70202	Elgin, III. Signal Indicator Corp. New York, N.Y.		Central Screw Co. Chicago, III.
	Chicago Miniature Lamp Works Chicago, III.		Signal Indicator Corp. New York, N.Y. Struthers-Dunn Inc. Pitman, N.J.	83501	Gavitt Wire and Cable Co.
/1/33	A.O. Smith Corp., Crowley Div. West Orange, N.J.		Thompson-Bremer & Co. Chicago, III.		Div. of Amerace Corp. Brookfield, Mass.
71785	Cinch Mfg. Co., Howard B. Jones Div.		Tilley Mfg. Co. San Francisco, Calif.	83594	Burroughs Corp. Electronic Tube Div. Plainfield, N.J.
	Chicago, III.		Stackpole Carbon Co. St. Marys, Pa.	83740	Union Carbide Corp. Consumer Prod. Div.
71984	Dow Corning Corp. Midland, Mich.		Standard Thomson Corp. Waltham, Mass.	007 40	New York, N.Y.
	Electro Motive Mfg. Co., Inc. Willimantic, Conn.		Tinnerman Products, Inc. Cleveland, Ohio	83777	Model Eng. and Mfg., Inc. Huntington, Ind.
72354	John E. Fast Co., Div. Victoreen Instr. Co.		Transformer Engineers San Gabriel, Calif. Ucinite Co. Newtonville, Mass.	83821	Loyd Scruggs Co. Festus, Mo.
72610	Chicago, III. Dialight Corp. Brooklyn, N.Y.		Waldes Kohinoor Inc. Long Island City, N.Y.		Aeronautical Inst. & Radio Co. Lodi, N.J.
	Indiana General Corp., Electronics Div.		Veeder Root, Inc. Hartford, Conn.		Arco Electronics Inc. Great Neck, N.Y.
. 2000	Keasby, N.J.		Wenco Mfg. Co. Chicago, III.		A.J. Glesener Co., Inc. San Francisco, Calif. TRW Capacitor Div. Ogallala, Neb.
72699	General Instrument Corp., Cap. Div. Newark, N.J.	79727	Continental-Wirt Electronics Corp.		Sarkes Tarzian, Inc.  Bloomington, Ind.
	Drake Mfg. Co. Chicago, III.	70062	Philadelphia, Pa. Zierick Mfg. Corp. New Rochelle, N.Y.		Boonton Molding Company Boonton, N.J.
	Hugh H. Eby Inc. Philadelphia, Pa.	, ,,,,,	Z. S. S. M. H. G. W. H. H. H. H. H. H. H. H. H. H. H. H. H.		
12928	Gudeman Co. Chicago, III.				

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### Table 5-8. Code List of Manufacturers (Cont'd)

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
				General Cable Corp.	Bayonne, N.J.	98376	Zero Mfg. Co.	Burbank, Calif.
	A.B. Boyd Co.	San Francisco, Calif.	94144	Raytheon Co., Comp. Div.	, Ind.	98731	General Mills Inc., Electron	ics Div.
	R.M. Bracamonte & Co.	San Francisco, Calif.		Comp. Operations	Quincy, Mass.			Minneapolis, Minn.
	Koiled Kords, Inc.	Hamden, Conn.	94148	Scientific Electronics Produ	ucts, Inc.	98734	Paeco Div. of Hewlett-Pack	ard Co.
	Seamless Rubber Co.	Chicago, III.		_	Loveland, Colo.			Palo Alto, Calif.
86197	Clifton Precision Products			Tung-Sol Electric, Inc.	Newark, N.J.	98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
00570		Clifton Heights, Pa.	94197	Curtiss-Wright Corp. Electro	onics Div.	98978	International Electronic Res	earch Corp.
	Precision Rubber Products				East Paterson, N.J.			Burbank, Calif.
86684	Radio Corp. of America, E			South Chester Corp.	Chester, Pa.	99109	Columbia Technical Corp.	New York, N.Y.
07004	Comp. & Devices Div.	Harrison, N.J.	94310	Tru-Ohm Products Memcor C	Components Div.	99313	Varian Associates	Palo Alto, Calif.
	Marco Industries	Anaheim, Calif.			Huntington, Ind.		Atlee Corp.	Winchester, Mass.
8/216	Philco Corporation (Lansda			Wire Cloth Products, Inc.	Bellwood, III.	99515	Marshall Ind. Elect. Product	s Div.
07472	Waster Eile of Olive B	Lansdale, Pa.	94682	Worcester Pressed Aluminum	•			San Marino, Calif.
8/4/3	Western Fibrous Glass Proc				Worcester, Mass.	99707	Control Switch Division, Cor	itrols Co.
0.7.0.4	V W-t 0 D	San Francisco, Calif.		Magnecraft Electric Co.	Chicago, III.		of America	El Segundo, Calif.
	Van Waters & Rogers Inc.	San Francisco, Calif.	95023	George A. Philbrick Resear	* *		Delevan Electronics Corp.	East Aurora, N.Y.
	Tower Mfg. Corp.	Providence, R.I.			Boston, Mass.		Wilco Corporation	Indianapolis, Ind.
	Cutler-Hammer, Inc. Gould-National Batteries, I	Lincoln, III.		Allies Products Corp.	Miami, Fla.	99934		Boston, Mass.
	Federal Telephone & Radio	'		Continental Connector Corp.	,	99942	Hoffman Electronics Corp.	
	General Mills, Inc.			Leecraft Mfg. Co., Inc.	Long Island, N.Y.		Semiconductor Div.	El Monte, Calif.
	Graybar Electric Co.	Buffalo, N.Y.		Lerco Electronics, Inc.	Burbank, Calif.	99957	Technology Instrument Corp.	of Calif.
	United Transformer Co.	Oakland, Calif.		National Coil Co.	Sheridan, Wyo.			Newbury Park, Calif.
		Chicago, III.		Vitramon, Inc.	Bridgeport, Conn.			
30173	US Rubber Co., Consumer I Prod. Div.			Gordos Corp.	Bloomfield, N.J.			
00070	Bearing Engineering Co.	Passaic, N.J.		Methode Mfg. Co.	Chicago, III.			
	Connor Spring Mfg. Co.	San Francisco, Calif.		Dage Electric Co., Inc.	Franklin, Ind.			
	Miller Dial & Nameplate Co	San Francisco, Calif.		Siemon Mfg. Co.	Wayne, III.		OLLOWING HP VENDORS HA	
	Radio Materials Co.			Weckesser Co.	Chicago, III.		IED IN THE LATEST SUPPL	
	Augat Inc.	Chicago, III.		Huggins Laboratories	Sunnyvale, Calif.		AL SUPPLY CODE FOR MAN	NUFACTURERS
	Dale Electronics, Inc.	Attleboro, Mass.		Hi-Q Div. of Aerovox Corp.	Olean, N.Y.	HANDE	100K.	
	Elco Corp.	Columbus, Nebr. Willow Grove, Pa.		Thordarson-Meissner Inc.	Mt. Carmel, III.			
	Gremar Mfg. Co., Inc.	Wakefield, Mass.		Solar Manufacturing Co.	Los Angeles, Calif.			
	K F Development Co.	Redwood City, Calif.		Carlton Screw Co.	Chicago, III.	0000F	Malco Tool and Die	Los Angeles, Calif.
	Honeywell Inc., Micro Swite			Microwave Associates, Inc.	Burlington, Mass.	M0000	Western Coil Div. of Autom	
31323	noneywen mc., with Swith			Excel Transformer Co.	Oakland, Calif.	00007		Redwood City, Calif.
01061	Nahm-Bros. Spring Co.	Freeport, III.		Industrial Retaining Ring Co	• ,	0000Z	Willow Leather Products Co	
	Tru-Connector Corp.	Oakland, Calif. Peabody, Mass.		Automatic & Precision Mfg.	Englewood, N.J.	000AA	British Radio Electronics L	
	Elgeet Optical Co. Inc.	Rochester, N.Y.		Reon Resistor Corp.	Yonkers, N.Y.			Washington, D.C.
	Universal Industries, Inc.		9/983	Litton System Inc., Adler-We		000AB	ETA	England
	Tensolite Insulated Wire Co		00141	Commun. Div.	New Rochelle, N.Y.	000BB	Precision Instrument Compo	
32007	Tensonite insulated wife Co	Tarrytown, N.Y.		R-Troncis, Inc.	Jamaica, N.Y.		511 5 5 5	Van Nuys, Calif.
03333	Sylvania Electric Prod. Inc.		98139	Rubber Teck, Inc.	Gardena, Calif.	000MM	Rubber Eng. & Developmen	,,
33332	Semiconductor Div.	Woburn, Mass.	98220	Hewlett-Packard Co., Mosel		000NN	A ''N'' D Mfg. Co.	San Jose, Calif.
93369	Robbins and Myers, Inc.	New York, N.Y.	00270	Microdot Inc	Pasadena, Calif.	000QQ	Cooltron	Oakland, Calif.
	Stevens Mfg. Co., Inc.	Mansfield, Ohio		Microdot, Inc.	So. Pasadena, Calif.	000WW	California Eastern Lab.	Burlington, Calif.
	G. V. Controls	Livingston, N.J.	30731	Sealectro Corp.	Mamaroneck, N.Y.	000YY	S.K. Smith Co.	Los Angeles, Calif.
33323	3. 1. 30111013	LIVINGSTON, N.J.						

From: FSC. Handbook Supplements
H4-1 Dated JULY 1965
H4-2 Dated NOV. 1962



# SECTION VI MANUAL CHANGES AND OPTIONS

### 6-1. MANUAL CHANGES.

This manual applies directly to standard Model  $524 \, \mathrm{C/D}$  Electronic Counters with serial prefixes or serial numbers listed below:

524C--Serials prefixed 234-Serials number 141-04326 to 141-03725 524D--Serials prefixed 141-

To relate this manual to an older instrument, look for its serial prefix or serial number in Table 6-1 and make the changes listed.

As changes are made in the Model 524C or 524D, newer instruments may have serial prefix numbers not listed in this manual. The manuals for these instruments will be supplied with an additional "Manual Changes" sheet containing the required information; contact the nearest Hewlett-Packard sales and service office if this change sheet is missing.

### 6-2. OPTIONS.

The Model 524C/D Counters require circuit modifications if they are to be used to operate Digital Recorders or other complementary equipment. These modifications may be ordered as options, installed and tested at the factory when the instrument is built, or in kit form for field installation. The modifications are such that they do not interfere with each other, although there is some duplication or circuitry; a Counter may have 1, 2, or 3 modifications installed but can operate only one other unit at a time. Modifications required to operate complementary equipment are listed in Table 6-2 by number and by reference to the Figure and parts list Table in this manual that show the changes made.

Other instrument modifications are available on special order; manuals for these instruments include an insert describing the modification, in addition to any possible "Manual Changes" sheet. Contact the nearest Hewlett-Packard sales and service office if either of these sheets are missing from the manual for a special instrument. Be sure to refer to the instrument by its full specification number, name, and serial number (example: E11-524C Electronic Counter, serial number 141-).

Table 6-1. Backdating

Serial prefix/serial number	Make Changes		
141-04325 and below (524C only) 116-	1 1, 2		
116-03825 and below 042	1, 2, 3 1, 2, 3, 4		
042-02425 and below (524C only)	1, 2, 3, 4, 5		
029 -	1 thru 6		
018 - 009 -	1 thru 7 1 thru 8		
004-	1 thru 9		
001 -	1 thru 10		
429 -	1 thru 11		
249-	1 thru 12		
Serial number only (no prefix) 447 and below (except 446 thru 436, 431, 427, 424, 422, 419, 417, 407,			
405, 403)	1 thru 13		
350 and below	1 thru 14		
150 and below	1 thru 15		
148, 135, 127 and below	1 thru 16		

CHANGE 1:	These instruments were supplied with a 561B-16A 100-conductor cable instead of the 562A-16C 50-conductor cable for connection to @ Model 561B Digital Recorders. A 100-conductor cable which can accommodate 6 columns of information is furnished with each Model 561B Digital Recorder. The 562A-16C cable is a satisfactory replacement for the 100-conductor cable supplied with the older Counters, since less than 50 conductors are required to accommodate the additional 2 columns of information that cannot be carried by the cable furnished with the Digital Recorder.
CHANGE 2:	Replace Paragraph 1-5 with the text below: "The 524C/D is normally shipped from the factory wired for use from a 115-volt power source. To convert the instrument for use from a 230-volt power source, change the dual 115-volt primary windings of the three power transformers, T204, T205, and T206 from parallel to series connection. See power supply schematic diagram for details. At the time of conversion, remove R534 from STANDBY lamp DS207 and replace the existing line fuse with a 3.2-amp slow-blow fuse."  Change Power Supply schematic diagram, Figure 4-18, as shown in Figure 6-1.

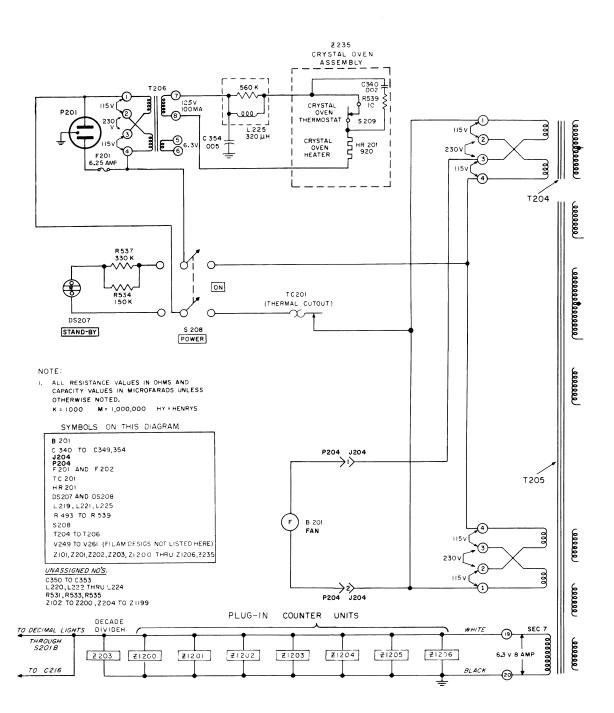


Figure 6-1. Power Supply Schematic Changes

CHANGE 2:	
(Cont'd)	Change Table 5-1 as follows: Change DS202 thru DS208 to DS202 thru DS206. Change DS207 description to "Same as DS201". Add DS208; "Same as DS202". R534; Resistor: fixed, composition, 150K ohms $\pm 10\%$ , $1/2$ W, $\oplus$ Stock No. 0687-1541, TQ and RS = 1. R537; Resistor: fixed, composition, 330K ohms $\pm 10\%$ , $1/2$ W, $\oplus$ Stock No. 0687-3341, TQ and RS = 1. Delete S210.
CHANGE 3:	Delete R1413.
CHANGE 4:	R915 is Resistor: fixed, composition, 100K ohm ±10%, 1/2 W,  Stock No. 0687-1041. R916 is Resistor: fixed, composition, 56K ohm ±10%, 1/2 W,  Stock No. 0687-5631. Recommended replacement parts for R915 and R916 are those listed in Table 5-1. When these parts are used, the mixer circuit (V903) gain is reduced, making it less susceptible to noise pulses from the oven circuit.
CHANGE 5:	R407 is Resistor: fixed, composition, 39 ohms $\pm 5\%$ , 1 W, $\oplus$ Stock No. 0689-3905. R408 is Resistor: fixed, wirewound, 1000 ohms $\pm 10\%$ , 20 W, $\oplus$ Stock No. 0819-0006. R532 is Resistor: fixed, wirewound, 4500 ohms $\pm 5\%$ , 40 W, $\oplus$ Stock No. 0818-0012.
	Recommended replacement values for R407, R408, and R532 are those listed in Table 5-1. These new values reduce the load on 70-volt series regulator V255, increasing its life.
CHANGE 6:	Replace Figure 4-29 with Figure 6-2. Replace Figure 4-30 with Figure 6-3.
	The older type Disable Circuit was not adequate when the Model 570A or 571B Digital Clock was used to control the 524C/D Counters; also, the Model 561B Digital Recorder would not function correctly with the old circuit. The new circuit overcomes these problems.
CHANGE 7:	Delete C1202.
CHANGE 8:	Delete CR249. Delete L228.  Add R246; Resistor, fixed, composition, 1500 ohms ±10%, 1/2 W, Mfr. 01121, \$\overline{\phi}\$ Stock  No. 0687-1521. This resistor is connected between the +210-volt buss and pin 6 of J202.  Delete R489.
CHANGE 9:	C807 is Capacitor: fixed, ceramic, 0.01 $\mu$ f -0%+100%, 1000 vdcw, Mfr. 56289, @ Stock No. 0150-0012. R813 is Resistor: fixed, composition, 4700 ohms ±10%, 1 W, Mfr. 01121, @ Stock No. 0690-4721.
CHANGE 10:	C703 is Capacitor: fixed, mica, 10 $\mu\mu$ f ±10%, 500 vdcw, @ Stock No. 0140-0002. Recommended replacement value is listed in Table 5-1. The newer value extends the PERIOD and 10 PERIOD ranges from 10 kc to 100 kc.
CHANGE 11:	Delete L209. R318 and R324 are Resistor: fixed, composition, 15,000 ohms ±10%, 1 W, @ Stock No. 0690-1531.
CHANGE 12:	C333 is Capacitor: fixed, mica, 470 $\mu\mu$ f ±10%, 500 vdcw, @ Stock No. 0140-0014. R265 is Resistor: fixed, composition, 2200 ohms ±10%, 1 W, @ Stock No. 0690-2221. Delete R558.

00021-4

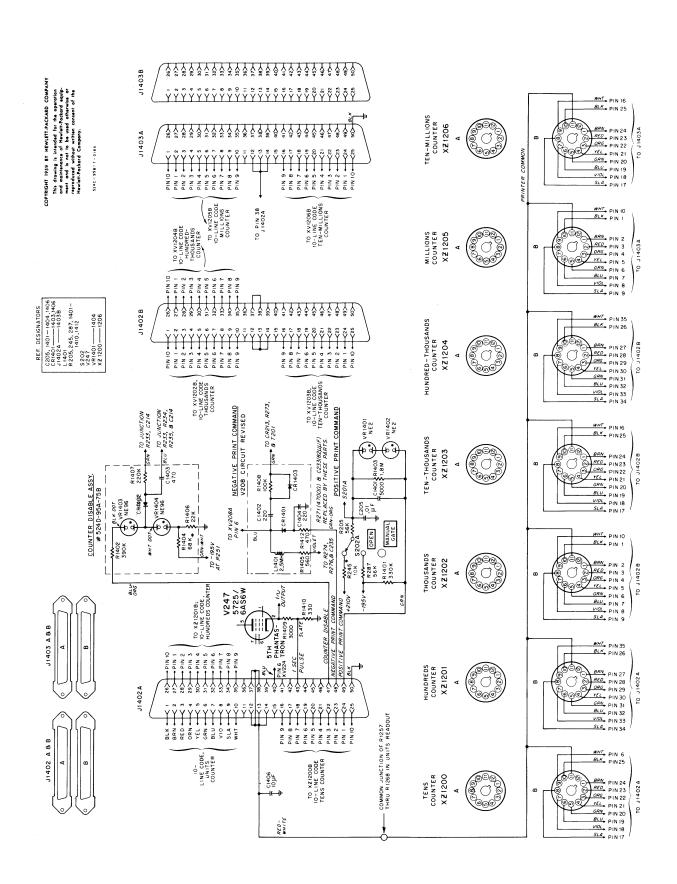


Figure 6-2. Schematic Changes for 560A Printer Kit

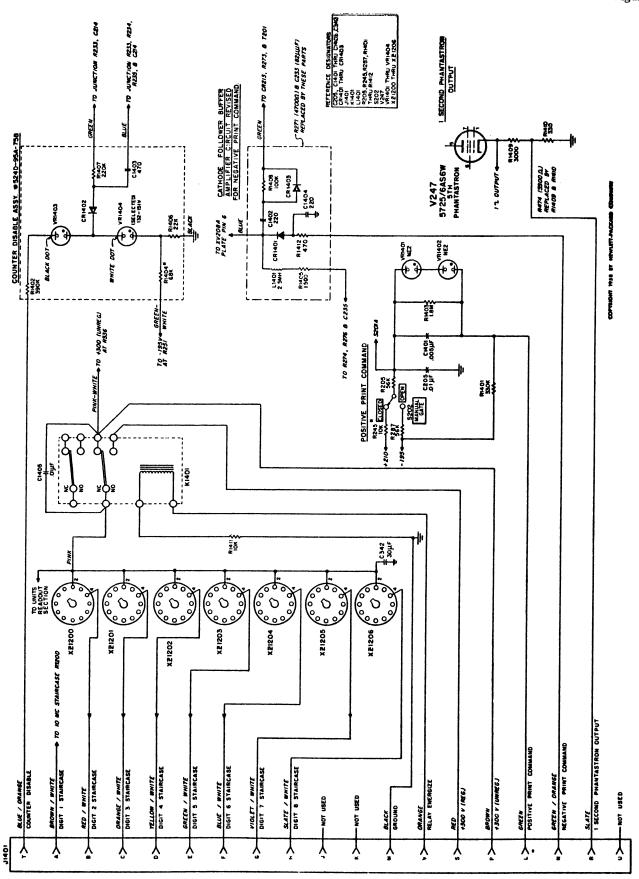


Figure 6-3. Schematic Changes for 561B Printer Kit

CHANGE 13:	Change connections to Power Transformer T204 as follows: Section 4, terminal 8 is grounded, and there is no connection between terminal 7 and the +70- volt buss. V224 filaments are connected across section 5. V248 filaments are connected across section 6. V260 filaments are connected across section 4. The connections shown in the current schematic diagram raise V224 filament from +35 to +70-volt level and balance filament winding loads. Delete R538. R400 is Resistor: fixed, composition, 180 ohms ±10%, 1/2 W, \$\phi\$ Stock No. 0687-1811. R1212, R1226, R1240, R1242, and R1243 are "Same as R435".
CHANGE 14:	Delete CR260, L226, L227, R540, R541. Connect C244 to junction of CR223 and CR228 (CR260 anode). L209 is "Same as L205".
CHANGE 15:	C918 (Part of Crystal Oven Assembly Z235, not separately replaceable) is a fixed value, factory selected part.  On Time Base Section schematic, Figure 4-20, delete connection between 10 Mc line and S206A.  Add C329; Capacitor: fixed, titanium dioxide dielectric, 2.2 $\mu\mu f \pm 10\%$ , 500 vdcw, $\Phi$ Stock No. 0150-0015, and C330 (description "Same as C231") in series between V240 terminal 5 and ground. The junction of C329 and C330 is connected to S206A terminal 9.
CHANGE 16:	Change C291 value to 10 $\mu\mu$ f, and description to "Same as C240". Delete R1025.

Table 6-2. Modifications for Complementary Equipment

To Operate	Required Modification			
	Installed and tested at factory	For field installation	See Figure	Parts List Table
560A Digital Recorder	Option 01	524D-95A Digital Recorder (Staircase) Adapter Kit	Figure 4-29	Table 5-6
561B Digital Recorder or K05-524C Remote Indicator	Option 02 (*) (*)	524C-95B Digital Recorder (Ten-line) Adapter Kit	Figure 4-30	Table 5-5
562A Digital Recorder or 580A/581A Digital-to-Analog Converter	H80-524C or H80-524D	524C-95E Digital Recorder (BCD +1224) Adapter Kit	Figure 4-31 (for 524C) Figure 4-32 (for 524D)	Table 5-7

<sup>(\*)</sup> Ten-line output available from 524C only.

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