Errata

Title & Document Type: **2401C Integrating Digital Voltmeter Operating and Service Manual**

Manual Part Number: **02401-90681**

Revision Date: **June 1969**

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, life sciences, and chemical analysis businesses are now part of Agilent Technologies. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A. We have made no changes to this manual copy.

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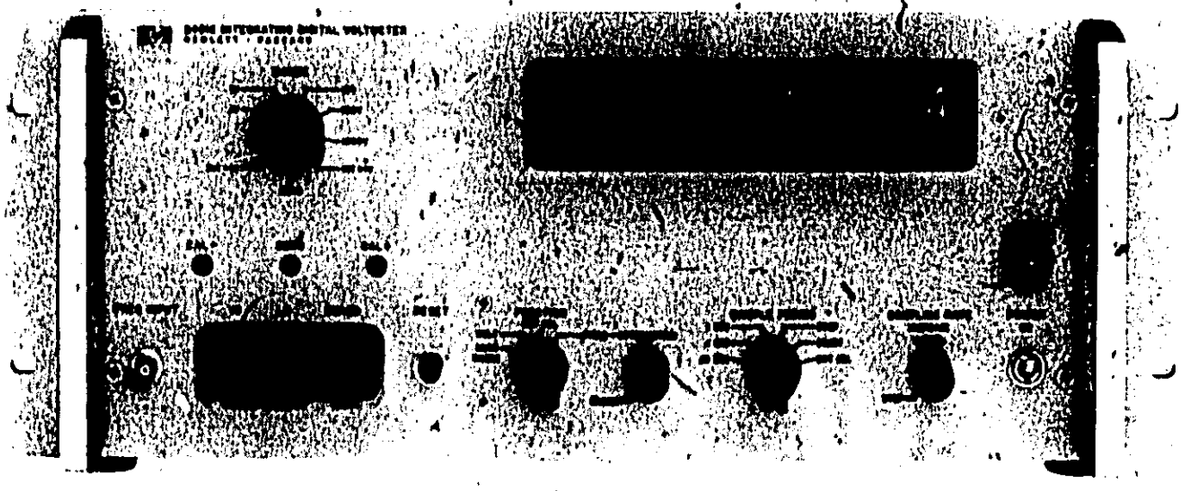
Agilent Technologies

HP 2401C

OPERATING AND SERVICE MANUAL

INTEGRATING DIGITAL VOLTMETER 2401C



HEWLETT hp PACKARD

HP 2401C

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

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

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OPERATING AND SERVICE MANUAL

(STOCK NO. 02401-9028)

MODEL HP-2401C
INTEGRATING DIGITAL VOLTMETER

(FSN 6625-999-2066)

SERIAL NUMBERS COVERED

This manual applies directly to Model 2401C Voltmeters having serial numbers prefixed 501-, 521-, 526-, 529-, 533-, 537-, 605-, 610-, 614-, 622-, 637-, 735-, 739-, 749-, 751-, and 811-. Instruments with higher prefix numbers will be covered in an Updating Manual Supplement at the rear of this manual.

OPTIONS COVERED

This manual covers instruments equipped with any of options 18, 21, 29, 30, 31, 35, and 146, as well as the standard instrument. These options were identified as M18, M21, M29, M30, M31, M35, and M146 on some older instruments but are the same as the present options. i. e., M18 is the same as option 18, M21 is the same as option 21, etc.

Microfiche No. 02401-90681

HEWLETT-PACKARD COMPANY
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GENERAL INFORMATION

QUICK REFERENCE INDEX

To locate desired data quickly, bend the handbook back to expose the index marks on the first pages of all the sections. These marks correspond to data identification marks on this page. The detailed contents of Sections 1 through 4 are listed individually just before the first page of each section.

OPTIONS

SECTION I
CONTENTS

NOTE: The contents of Sections 2 through 4 are listed just before the first page of each Section.

SECTION I
GENERAL DESCRIPTION

1.1 BASIC CAPABILITIES

The HP-2401C Integrating Digital Voltmeter is an all solid state electronic instrument which measures dc potentials up to ±1000 volts. The lowest of the instrument's five decade multiple voltage ranges is a ±0.1 volt range that permits high-resolution millivolt measurements. In addition to voltage measurements, the HP-2401C is capable of frequency measurements from 5 Hz to 300 kHz. Measurements are indicated on a direct reading 6 digit display that is accompanied by an identification display of the units being measured and input polarity.

The measurements and units are made available in 4-2'-2-1 binary-coded decimal (bcd) for recording by a digital printer or for further digital data processing. Other capabilities may be added to the standard instrument in the form of various accessories and modifications which are discussed briefly in Sections 1.4 and 1.5.

1.2 FUNCTIONAL DESCRIPTION

Basically, the HP-2401C consists of a precise input attenuator, a highly-accurate, highly-linear voltage-to-frequency converter (vfc) and a frequency counter. The vfc has separate outputs, one produced in response to positive input, the other produced in response to negative input. The frequency counter counts the pulses from the vfc for one of three specific sample periods, producing a count that is directly proportional to the average input voltage to the HP-2401C. The sample periods of the HP-2401C, .01, .1, and 1 second, are produced by decade division of the output from a 100kHz reference oscillator. The counter can be used alone for frequency measurements, as noted previously.

1.3 DESIGN FEATURES

1.3.1 Averaging of Positive and Negative Excursions

During voltage measurements, the decade counters in the HP-2401C can count either up or down under the control of special logic -- averaging the positive and negative excursions of the input algebraically. Regardless of the polarity of the input, the counters count up initially. Reversal of the input polarity switches the counters to a down count. At the down count of zero, the counters are switched to counting up and the polarity logic is switched. The count at the end of the sample period is the algebraic sum of the voltage-time integrals of the positive and negative signals tagged with the signal polarity that has the greatest voltage-time integral.

1.3.2 Noise Rejection

The HP-2401C design virtually eliminates voltage measurement errors caused by extraneous noise. This is accomplished without imposing any restrictions on the grounding of the signal source or the grounding of any interface equipment. The greatest noise rejection is achieved by using a floating and guarded vfc that eliminates common mode noise. Further noise rejection is achieved by the input averaging design of the HP-2401C. Combined, these techniques yield an effective noise rejection greater than 140 db (10 million to 1) at all frequencies, including dc.

Induced ac ground currents, usually at power line frequency, can generate a potential of several volts between the signal source ground and the voltmeter chassis ground. If not blocked these currents will cause a voltage larger than the signal to appear at the input, resulting in a completely erroneous reading. To prevent this effect, known as common-mode pickup, the HP-2401C features a shield or 'guard' that completely isolates the measuring circuit from the instrument chassis. The guard breaks the common mode loop. With the HP-2401C operated at the ground potential of the signal source, common mode rejection (defined as the ratio between the common mode signal and the spurious voltage it causes to be superimposed on the signal to be measured) exceeds 120 db at 60 Hz and 160 db at dc with a 'ground leg' impedance of 1000 ohms between the source ground and the low side of the voltmeter input. The combined effect of guarding and averaging is such that a common mode potential of 100 volts will not cause a discernible error in the HP-2401C reading.

To reduce superimposed noise, the HP-2401C, by means of active integration, reads the average value of the applied voltage over a fixed sample period. When the average value of superimposed noise is zero over the selected sample period, no error caused by superimposed noise appears in the measurement. (See Figure 3-6, a graph of noise rejection versus noise frequency for the fixed sample periods that are provided in the HP-2401C.)

1.3.3 Overranging

Overranging to 300% of full scale is permissible on every range except the 1000 volt range. This provides additional resolution and accuracy on readings that are within the overranging capability. If the instrument is accidentally overloaded beyond 300% of full scale, the input attenuator is switched automatically to the 1000 volt range. This occurs at approximately 310% of full scale. The overload condition is indicated on the units display and on the recording output. The instrument resets automatically when it starts taking the next sample. If the overload condition persists, the protective cycle and overload indication are repeated.

1.3.4 Manual Control of Display Duration and Sampling Rate

At the end of the sample period, the display and recording outputs can be held for a period that is adjustable from 200 milliseconds to 7 seconds.

At the end of this period, the HP-2401C will take a new sample. The sample-hold cycle will repeat indefinitely. The repetition rate of this cycle and the duration of the display period are set by the SAMPLING RATE control on the front panel.

1.3.5 Adaptability to Data Acquisition Systems

To facilitate its use in data acquisition systems, the HP-2401C has been designed to be completely programmable. Programming is accomplished simply by means of external contact closures to ground. The following may be programmed:

a. Measurement function (volts, frequency, or other functions added by accessories or modification of the standard instrument).

b. Voltage range.

c. Sample period.

System cabling is simplified because input, programming, and bcd output connections are made at the rear of the instrument. Data acquisition system programming of the HP-2401C can bypass the SAMPLING RATE control on the front panel. The maximum sampling rates then depend upon selection of the sample period. The .01 second sample period most frequently used for data acquisition systems permits a maximum of 50 readings per second.[1] Nine readings per second are possible when the .1 second sample period is selected. This sample period provides the optimum combination of speed, resolution, and accuracy for most measurements. The 1 second period, providing about 1 reading per second, is useful where maximum resolution is required.

1.3.6 Control of Sample Period

The input signal can be integrated over one of the fixed sample periods, or over an extended period which may be started manually or by programming. In this way analog signals from transducers can be integrated over any desired time interval, permitting totalization of flows, pressures, or other quantities.

1.3.7 Self Checking

A precision internal ±1 volt reference source is provided for checking the calibration of the HP-2401C. The internal standard is obtained from a specially aged, temperature stabilized Zener diode that is selected for less than 0.006% drift in 6 months. The provision of this internal standard permits in-place calibration, avoiding frequent unracking and transportation of the instrument to the standards laboratory.

The HP-2401C design also provides for a self check of forward counting and decimal point logic.

1.4 CAPABILITIES PROVIDED BY ACCESSORIES

1.4.1 HP-2410B AC/Ohms Converter

The HP-2410B AC/Ohms Converter adapts the HP-2401C for resistance and ac voltage measurements. This instrument makes possible resistance measurement on six decade-mulitple ranges from 0.1K ohms to 10 megohms full scale. AC voltage measurement ranges are the same as the dc ranges of the HP-2401C, except that the input cannot be allowed to exceed 750 volts peak. The HP-2401C includes the Ω, KΩ, MΩ, and AC displays which indicate the units being measured when the HP-2410B is used with the HP-2401C.

1.4.2 HP-2411A Guarded Data Amplifier

The HP-2411A Guarded Data Amplifier adapts the HP 2401C for low-level, high input impedance measurements. The HP-2411A (at + 10 gain) - HP-2401C (at .1V range) combination affords a ± 10 millivolt full scale range, with overranging to ±30 millivolts. At +10 or +1 gain, the HP-2411A input impedance is 10,000 megohms (effictive at +1 gain and HP-2401C to ± 10 volts). The HP-2411A bypasses its input directly to the HP-2401C when more than 10 volts is applied. During the time required for switchover to bypass mode, the HP-2411A will tolerate up to 300 volts overload. Correct positioning of the decimal point on the HP-2401C is controlled by decimal logic assembly A30 (supplied with the HP-2411A to be plugged into the HP-2401C.

1.5 CAPABILITIES PROVIDED BY OPTIONS

A variety of standard options to the HP-2401C are available. These are summarized briefly as follows.

18: Fits the HP-2401C with Zero-Trak C-300-S-20 slides. This facilitates calibration and servicing of rack mounted instruments.

21: Provides positive-true 8-4-2-1 bcd recording outputs instead of the 4-2-2-1 bcd recording outputs supplied by the standard instrument.

29: Allows frequency measurements to 1.2 MHz.

30: Adds period measurement capability. Full scale period of 1, 10, and 100 milliseconds may be measured.

31: Adds automatic ranging capability. The HP-2401C automatically selects the appropriate voltage measurement range on receipt of a read command signal. Maximum time from the read command to the start of the meas-

urement, allowing change from lowest to highest range or vice versa, is 34 milliseconds. The autoranger also controls the HP-2410B AC/Ohms Converter or the HP-2411A Guarded Data Amplifier when either is used with the HP-2401C.

35: Provides negative-true 8-4-2-1 bcd recording outputs instead of the 4-2'-2-1 positive-true bcd recording outputs supplied by the standard instrument.

146: Adapts HP-2401C for single-connector program input from HP computers.

1.6 PHYSICAL DESCRIPTION

The HP-2401C mounts in a standard 19-inch rack and requires 7 inches of vertical panel space. It extends to a depth of 18-3/8 inches (including the externally-mounted cooling fan). The instrument chassis is made of alodined aluminum, and the front panel is finished in light grey baked enamel with black-filled engraved titles.

1.7 SPECIFICATIONS

DC VOLTAGE MEASUREMENTS

NOISE REJECTION

Overall Effective Common Mode Rejection: (ratio of common mode signal to its effect on digital display): 140 db at all frequencies, 160 db at dc (0.1 second sample period).

Common Mode Rejection: (ratio between common mode signal and voltage it superimposes on source): 120 db at 60 Hz, 160 db at dc, with 1000 ohms between low side of source and low side of voltmeter input (resistances up to 10K permissible).

Superimposed Noise Rejection: (ratio of superimposed noise to its effect on digital display): More than 20 db at 55 Hz for 0.1 second sample period; increases 20 db per decade increase in frequency. Infinite rejection at frequencies evenly divisible by 10. (For 1 second and 0.01 second sample periods see Figure 3-6.) Combined amplitude of signal and superimposed noise can equal ±3 times full scale, for any signal amplitude.

INPUT CIRCUIT

Type: Floated and guarded signal pair. Signal pair and guard may be operated up to 500v above chassis ground.

Ranges: 5 ranges from 0.1 to 1000v full scale (see also 'Resolution' on page 1-6). 10 mv range with accessory HP-2411A Amplifier. Range selection by front panel switch or remote circuit closure to ground. See page 1-6 for specifications of optional Autoranger. Signal polarity sensed automatically.

Overranging: Overranging to 300% of full scale permissible, except on 1000v range. Attenuator switches automatically (in 3 ms) to 1000v range if overload exceeds 310%. Reset automatically by next internal or external read command signal.

Input Impedance: 10M on 10, 100, 1000v ranges. 1M on 1v range. 100K on 0.1v range. Impedance is within ±.02% of nominal value, all ranges. <150 pf all ranges.

Connectors: Front panel binding posts (3/4 inch centers) for HI, LO and GUARD. Alternate input via guarded connector on rear panel.

DC VOLTAGE MEASUREMENTS (Cont'd)

INTERNAL CALIBRATION STANDARD

A ±1 volt internal standard is provided for self calibration. This standard can be used to maintain specified accuracy for 6 months after it has been set at the factory, or at another calibration facility, to better than .002% absolute accuracy at 25°C.

▲ ABSOLUTE ACCURACY

Specification holds for all ranges, ±10% line voltage variation, and 6 months variation, assuming daily calibration against internal standard after 60-minute initial warmup.

.01% rdg ±.005% fs ±1 digit (0 to fs)
.02% rdg ±1 digit (at 2x fs)
.020% rdg ±1 digit (at 3x fs)

Temperature Coefficients:

When 2401C is calibrated against internal standard at operating temperature above or below 25°C, add:

.001% rdg per °C (10° to 40°C)
.0015% rdg per °C (40° to 50°C)

When 2401C operating temperature differs from calibrate temperature, add:

.002% rdg ±.0005% fs per °C (0.1v range)
.002% rdg ±.0002% fs per °C (other ranges)

MEASUREMENT SPEED

Fixed sample periods of 0.01, 0.1 or 1 second may be selected by front panel switch or remote circuit closure to ground. Sampling rate determined by delay between samples, adjustable at front panel from 0.2 to 7 seconds. (Max. speeds shown in Table.)

RESOLUTION

Depends on sample period selected -- see Table.

Max. resolution is 1 microvolt per digit (0.1v range, 1 second sample).

		0.1	100.0000 MV		100.0000 MV	
		1	100.0000 MV		1000.000 MV	
		10	100.0000 V		1000.000 V	
		100	100.000 V		1000.000 V	
		1000	1000.00 V		—	
		0.1	10.0000 MV		100.000 MV	
		1	10.0000 V		100.000 V	
		10	10.0000 V		100.000 V	
		100	10.000 V		100.000 V	
		1000	10.000 V		—	
		0.1	1.0000 MV		10.000 MV	
		1	1.0000 V		10.000 V	
		10	1.0000 V		100.000 V	
		100	1.0000 V		1000.00 V	
		1000	1.0000 V		—	

NOTE: POLARITY SENSED AND INDICATED AUTOMATICALLY

AUTORANGER

VOLTAGE RANGES

Automatically selects appropriate range from 5 input ranges of standard instrument (0.1v to 1000v full scale) on receipt of read command signal. Starts at range selected for previous reading, proceeds directly to higher or lower range as required. Autoranger also selects appropriate gain setting (x1 or x10) when HP 2401C is used with HP 2411A Amplifier.

RANGE CHANGE POINTS

Upranges at 110% of full scale,
Downranges at 30% of full scale.

RANGE SELECT TIME

6.0 ms (nominal) for each range change. When correct range is reached there is an encode delay of 0.7 ms before sample period commences. Max. time from receipt of read (encode) command to start of sample period, allowing autoranger to travel from lowest to highest range or vice versa, is 24 ms.

VARYING SIGNALS

Upranges if signal increases beyond 110% of full scale during sample period and starts new sample (record command at end of aborted sample period is suppressed). Does not downrange if signal decreases below 30% of full scale during sample period. This technique ensures that voltmeter will always arrive at valid reading, even in presence of very severe superimposed noise.

MODE SELECTION

Autoranging mode selected by front panel function switch or external circuit closure to ground, applied at programming input connector.

DC VOLTAGE INTEGRATION

Input signal is integrated over selected sample period. Using fixed sample period (1, 0.1 or 0.01 second) integral corresponds to average of input, readout is in volts. Alternatively, sample period may be started and stopped by front panel switch or remote signal (see External Programming) in which case display reads in millivolt-seconds or volt-seconds as appropriate.

Note: Instrument displays true integral with correct polarity, even if signal crosses through zero during sample period.

Ranges:

0 to 100.000 millivolt-seconds
1000.00 millivolt-seconds
10.0000 volt-seconds
100.000 volt-seconds
1000.00 volt-seconds

Accuracy: Same as for DC Voltage Measurement, with exception that errors given as percent of full scale must be multiplied by the integration time in seconds.

FREQUENCY MEASUREMENTS

__Range:__ 5 Hz to 300 kHz. To 1.2 MHz with Option 29.

__Gate Time:__ 0.01, 0.1, 1.0 second or manual control (front panel switch or remote signal, see External programming). 1 second gate provides 1 Hz display resolution.

__Accuracy:__ ±1 count ±time base accuracy.

__Internal Time Base:__ Stability at constant temperature (±5°C) is ±2/10^6 per week. Temperature effect is ±100/10^6 over range 10 to 50°C. (Self-check control on front panel for counting internal 10 kHz for selected gate time.)

__External Time Base:__ Rear BNC and switch provided for external frequency standard. Level required is 2v p-p into 1.2K.

__Display Time:__ Continuously variable from 0.2 to 7 seconds, or held continuously until reset either manually or by remote signal (see External programming).

__Input Sensitivity:__ 0.1 to 100v rms (front panel attenuator) or will accept pulses, 1v min. amplitude, 2 μs to 1 ms width. Internal adjustment is required for positive or negative pulse measurements.

__Impedance:__ 1 M shunted by 150 pf.

__Connector:__ BNC on front and rear panels.

PERIOD MEASUREMENTS

(Option 30)

__Ranges:__ 1, 10, and 100 periods, 5 Hz to 10 kHz.

__Display:__ Reads directly in milliseconds. (Recorder output in ms × 10^{-x}, where x is range digit recorded.)

__Resolution__ (referred to single period):

1 period	100 μs
10 periods	10 μs
100 periods	1 μs

__Accuracy:__ ±1 count ±time base accuracy, ±trigger error divided by number of periods averaged.

For time base accuracy see 'Frequency Measurements'. Trigger error for 0.1v rms sine-wave input is 0.3% for signals with 40 db signal/noise ratio. Trigger error decreases with increased signal amplitude and slope.

__Sensitivity, Impedance, Connector:__ Same as for 'Frequency Measurements'.

__Mode Selection:__ By front panel function switch or external circuit closure to ground, applied to programming input connector.

GENERAL SPECIFICATIONS

DISPLAY

6 digit Nixie readout (5 full scale digits plus overrange digit). Polarity, decimal point, function and overload condition indicated automatically. (This also applies when HP 2401C used with HP 2410B AC/Ohms Converter.) Rear switch provided to select 'Store' or 'Display' during count period.

RECORDING OUTPUTS

Binary-coded decimal outputs provided as follows:

Function:	1 digit
Data:	6 digits
Decimal point:	1 digit

(Decimal point digit indicates negative exponent, e.g. for reading of 137.58 volts, or 13758 × 10^{-2}, output is digit "2".)

Outputs will drive HP 562A Digital Recorder directly, or other devices either directly or through a Dymec coupler. Table shows printout of a special printwheel supplied with J06/5 562AR for recording function.

DATA	FUNCTION	LOGIC 4-2-2-1	HP 562A PRINTWHEEL STD.	HP 562A PRINTWHEEL SPECIAL
0	PERIOD **	0 0 0 0	0	P
1	+ VDC	0 0 0 1	1	+
2	− VDC	0 0 1 0	2	−
3	AC	0 0 1 1	3	/
4	KΩ *	0 1 1 0	4	K
5	MΩ *	0 1 1 1	5	M
6		1 1 0 0	6	>
7		1 1 0 1	7	<
8	TIME	1 1 1 0	8	T
9	OVERLOAD	1 1 1 1	9	O
		1 0 0 0	BLANK	BLANK
	VAC *	1 0 0 1	/	A

* WHEN HP 2401C USED WITH HP 2410B AC/OHMS CONVERTER
** WITH HP 2401C OPTION 30.

__BCD Outputs:__

VOLTAGE LEVELS	"0"	-25 TO -24.5V
	"1"	-2.5 TO 0V
SOURCE IMPEDANCE	DATA	100K
	FUNCTION, DEC. PT	33K
MAX. CURRENT	DATA	0.3 MA
	FUNCTION, DEC. PT	1 MA

__Record Command:__ Level '1' for record and '0' during sample period, or vice-versa. (See below.)

REFERENCE	"0"	"1"
LEVEL	-24.5 TO -21.5V	-5 TO -1V
IMPEDANCE	5000 Ω	1000 Ω
MAX. CURRENT	1 MA	15 MA

__HP 562A Recorder Reference Voltages:__

REFERENCE	"0"	"1"
LEVEL	-24.5 TO -21.5V	-5 TO -4V
IMPEDANCE	500 Ω	300 Ω
MAX. CURRENT	1 MA	0.5 MA

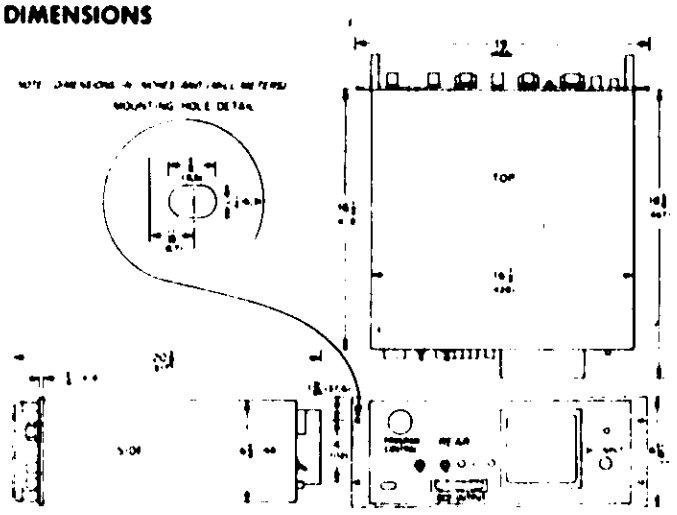
__Connector:__ Amphenol 57-40500 50-pin connector on rear panel.

FREQUENCY OUTPUT

Internal 100 kHz frequency standard is available at rear BNC. (Square wave, 0 to -1.2v, 1K source impedance.)

GENERAL SPECIFICATIONS (Cont'd)

DIMENSIONS



EXTERNAL PROGRAMMING

HP 2401C may be completely programmed by external circuit closures to ground (defined as contact closure or equivalent that raises internal circuit to -1v or more positive level and that can supply up to 70 ma). For maximum sampling speed, pulse input may be used for reset/encode command. Unless otherwise stated, all programming commands are received via rear MS3102A28-21S 37-pin connector.

Function: HP 2401C measures voltage unless closure is received on 'frequency' command line.

Range: Separate closure required to select any of the five voltage ranges. Range select time < 6 ms.

Sample Period: Separate closure required to select any of the three fixed sample periods or to activate 'manual' control. When 'manual' control is activated, closure (or -1 to +5v) on 'start/stop' line starts sample period, open circuit (or -5 to -30v) stops sample period. (Input resistance 4K.) Sample period starts/stops within 1 μs of command.

Reset (Encode): Counter portion of HP 2401C may be reset and new count started by closure on 'Counter Reset' line, or counter may be reset by -15v, 25 μs pulse (rise time < 2 μs) applied to separate rear BNC (not available with 146). Fixed delay of 12.7 ms to start of new count with closure reset, 9.7 ms with pulse reset.

Hold: Positive 1 to 12v (4.5 ma, max.) inhibits start of new count. Negative 1 to 35v permits new count. Received via recorder (bcd) output connector.

Accessory Amplifier: When used with HP 2411A Amplifier, decimal point logic card furnished with the 2411A must be installed in the 2401C.

AC/Ohms Measurements: If used with HP 2410B AC/Ohms Converter, coupling cards supplied with 2410B must be installed in the 2401C. External programming, except pulse encode command, is accomplished through 2410B.

OPERATING CONDITIONS

Ambient temperatures 10 to 50°C, relative humidity to 95% at 40°C.

POWER REQUIRED

115/230v ±10%, 50 to 60 Hz, 150 watts approx.

WEIGHT

Net wt. 48 lb (22 kg); shipping wt. 57 lb (25.7 kg).

PANEL FINISH

Light grey baked enamel, black-filled lettering.

OPTIONS

18. Rack-Mounting Slides: HP 2401C fitted with Zero-Trak C-300-S-20 slides for easy withdrawal from rack.

21. +8-4-2-1 BCD Output: Supplied instead of standard +4-2-2-1 output (same specifications). Required for compatibility with Hewlett-Packard Computers.

29. 1 MHz Frequency Range: Extends frequency measurement range to 1.2 MHz.

30. Period Measurements: Adds measurement of multiple period averages of signals to 10 kHz. Specifications on page 1-7.

31. Autoranging: Specifications on page 1-6.

35. -8-4-2-1 BCD Output: Supplied instead of standard +4-2-2-1 output (same specifications except '0' and '1' state levels reversed).

146. Programming by HP Computers: Adapts 2401C for single-connector program input from HP Computers. Provided in place of rear 'Counter Reset' BNC. Option 21 also required.

ACCESSORIES AVAILABLE

(Order by accessory or stock number.)

1. H006 5050A Digital Recorder. Check with local Hewlett-Packard sales office for appropriate options, price, and delivery.

2. J66/65 562AR Digital Recorder. Check with local Hewlett-Packard sales office for appropriate options, price, and delivery.

3. 2547A Coupler. Offers a choice of several different serial-entry output recorders, including magnetic tape, punched tape, punched cards, and typed log. Check with local Hewlett-Packard sales office for appropriate options

4. Programming Input Connector. MS3106B28-21P, 37-pin (with clamp) stock number 5060-2440

5. Recorder Output Connector: Amphenol 57-30500, stock number 1251-0086

6. Input Connector. Mates with rear guarded input connector, stock number 1251-0350 (One connector is furnished with instrument.)

7. Cover. Plugs onto front input terminals to prevent their use when rear input is in use. Accessory number 12529A

ACCESSORIES FURNISHED

1. Power Cable. Length 7-1/2 feet, plugs into rear connector. Stock number 8120-0078.

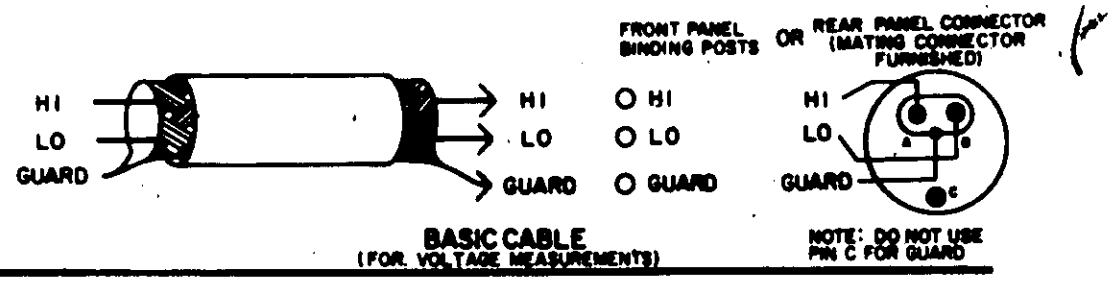
2. Input Connector. Mates with rear guarded input connector. Stock number 1250-0350.

3. Extender Boards. For servicing plug-in circuit boards. Set of five. Stock number 5060-5078.

SECTION II
CONTENTS

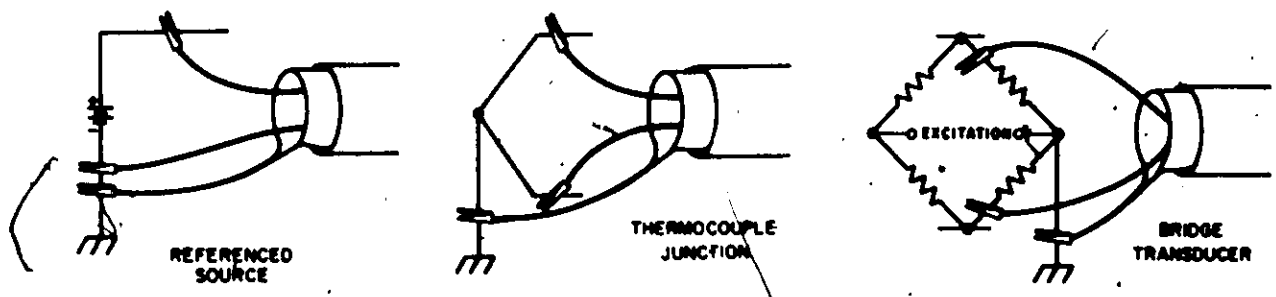
INSTALLATION

DC INPUTS

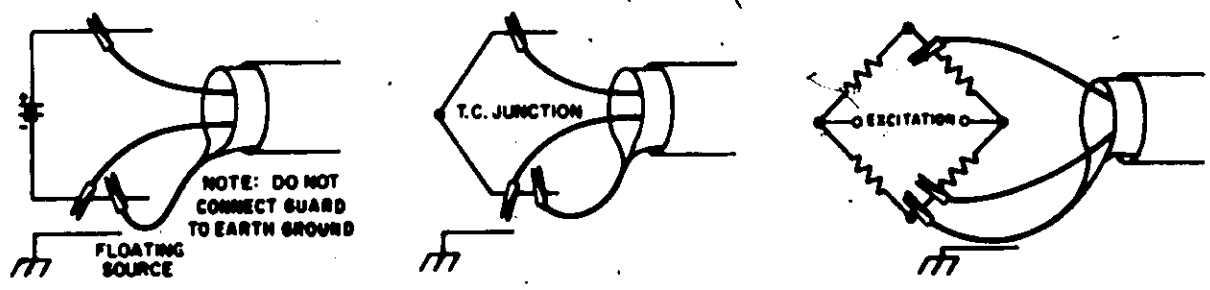


BASIC CABLE
(FOR VOLTAGE MEASUREMENTS)

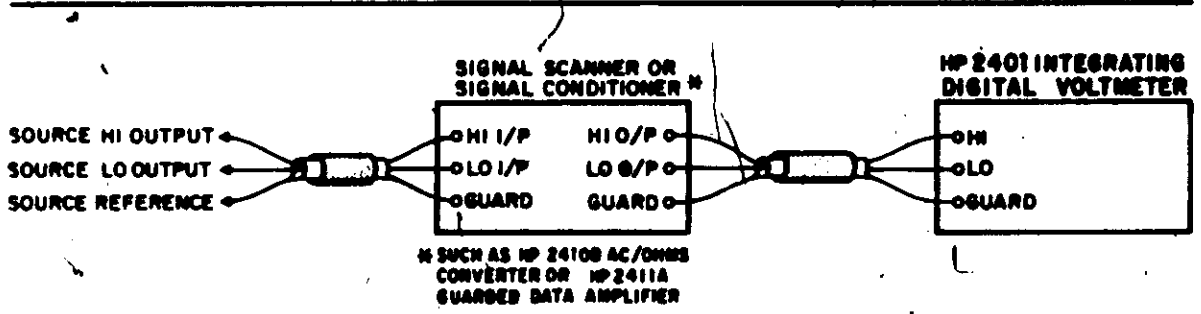
NOTE: DO NOT USE PIN C FOR GUARD



CONNECTIONS TO REFERENCED SOURCES



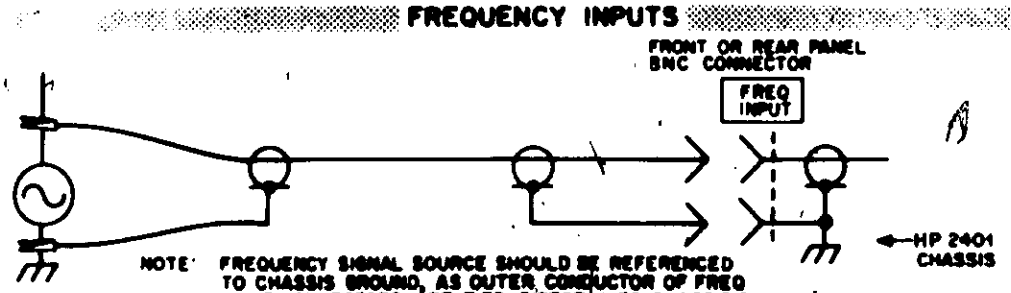
CONNECTIONS TO FLOATING SOURCES



NOTE: CONNECT GUARD TO THE SOURCE REFERENCE AND BETWEEN INSTRUMENTS AS INDICATED ABOVE. IF THE GUARD IS NOT USED, JUMPER IT TO LOW ONLY AT THE INPUT OF THE INSTRUMENT THAT IS NEAREST TO THE SOURCE AND AT NO OTHER POINT IN THE MEASUREMENT SYSTEM.

CONNECTIONS THROUGH OTHER INSTRUMENTS

FREQUENCY INPUTS



NOTE: FREQUENCY SIGNAL SOURCE SHOULD BE REFERENCED TO CHASSIS GROUND, AS OUTER CONDUCTOR OF FREQ INPUT CONNECTORS ARE TIED DIRECTLY TO CHASSIS GND. ALWAYS MEASURE AC LINE FREQUENCY THROUGH FUSES TO PREVENT DAMAGE IN CASE OF CONNECTION ERROR.

Figure 2-1. Input Signal Connections

SECTION II
INSTALLATION AND OPERATION

2.1 INSTALLATION

The HP-2401C Integrating Digital Voltmeter mounts in a standard 19-inch rack, requiring 7 inches of vertical panel space, and is also suitable for bench-top use. Depth required behind the front panel, including recommended cable clearances, is 21-3/8 inches. The HP-2401C contains its own cooling fan. No special ventilation is required unless the temperature of the instrument would otherwise be outside the range of 10-50°C or relative humidity would otherwise exceed 95 percent.

2.1.1 Line Set Switch and Power Requirements

A slide switch on the rear panel allows the HP-2401C to be set for operation from either 115 or 230-volt power, at 50 to 60 Hz, without rewiring the primary connections of the power transformer. The HP-2401C is normally supplied from the factory with the line set switch in the 115 volt position and a 2 ampere slow-blow fuse installed in the fuseholder on the front panel. Power required is approximately 150 watts.

CAUTION

Before operating the HP-2401C, make certain that the line set switch is positioned correctly. Slide this switch to expose 115 for operation from 115 volts or to expose 230 for operation from 230 volts. For 230-volt operation, replace the 2 ampere slow-blow fuse with a 1 ampere slow-blow fuse.

2.1.2 Input, Output, and Programming Connectors

HI, LO, and GUARD: Binding post terminals on the front panel. The HI and LO terminals receive the two-wire dc input voltage; the GUARD terminal (connected internally to the guard chassis) receives the reference potential of the measurement source. The signal pair and guard may be operated up to 500 volts above chassis ground. See Figure 2.1 for input signal connections.

If guarding is not used, the GUARD terminal must be connected to the LO terminal. For example, when measuring a floating dc voltage -- such as the output of a floated dc amplifier -- do not connect GUARD to the chassis ground of the amplifier; connect the GUARD terminal to the LO terminal.

CAUTION

Do not connect voltage to the HI and LO terminals when plug is connected to J31. Voltage thus applied can damage any instrument whose output is connected to the HP-2401C via J31.

DC INPUT (J31): A special guarded receptacle on the rear panel. Pins A and B connect to the HI and LO dc input lines. The oval shell connects to guard.

FREQ INPUT: Front and rear panel paralleled BNC receptacles, either of which may receive the input signal whose frequency is to be counted when the HP-2401C is used for frequency measurement.

100 Hz STD OUTPUT/INPUT (J3): Rear panel BNC receptacle that provides an output of the internal 100 kHz time base for external use, or receives a precise external time base input if desired. An associated toggle switch labelled INT-EXT selects the internal or external time base mode.

COUNTER RESET (J4): Rear panel BNC receptacle which receives an external pulse that is used to reset the counter section of the voltmeter.

PROGRAM CONTROL (J1): Rear panel MS3102A28-21S receptacle that receives the external program commands when the HP-2401C is programmed by external circuit closures to ground, as in data acquisition systems. (See Section 2.6.) Also receives program commands from a HP-2410B AC/Ohms Converter or HP-2411A Guarded Data Amplifier when either of these instruments is used with the HP-2401C. (See Sections 2.5.3 and 2.5.4.)

BCD OUTPUT (J2): Rear panel Amphenol 57-40500 receptacle that provides bcd outputs for function, data, and range, + and -bcd reference voltages, and + and -print commands. It also accepts holdoff signal and scan signal from recorder or coupler (scan signal is routed to PROGRAM CONTROL connector).

2.1.3 HP-2410B AC/Ohms Converter Coupling Cards

When the HP-2401C is used with a HP-2410B AC/Ohms Converter, the two coupling cards (printed circuit boards) supplied with the HP-2410B must be installed in the voltmeter. (If a HP-2410B/HP-2401C combination is purchased, the coupling cards are installed in the voltmeter at the factory.)

The two printed circuit boards are the HP-2410B Units Coupling (A9) and AC/Ohms Delay Gate (A23). Install HP-2410B Units Coupling Card (A9) in connector XA9; AC and Ohms Delay Gate Card (A23) in connector XA23. These locations are shown in Figures 4-3 and 4-4.

2.1.4 HP-2411A Guarded Data Amplifier Decimal Point Logic Card

When the HP-2401C is used with a HP-2411A Guarded Data Amplifier, the HP-2411A Decimal Point Logic Printed Circuit Card (A30) supplied with the HP-2411A must be installed in the voltmeter. This assures correct positioning of the decimal point when the HP-2411A is set for +10 gain. (If a HP-2401C/HP-2411A combination is purchased, A30 is installed in the voltmeter at the factory -- see Figure 4-4.) When the HP-2401C is purchased

separately, a jumper board is installed in the A30 position. HP-2411A Decimal Point Logic Card A30 replaces this jumper board in receptacle XA30.

2.2 PREOPERATIONAL CHECK AND CALIBRATION

To achieve the specified measurement accuracy, perform the following preliminary checkout and calibration procedures daily, or each time the instrument is turned on. Allow a 1-1/2 hour warmup.

2.2.1 Counter Section Check

a. Set Power switch to ON, other controls as follows:

100 KC STD (rear panel):	INT.
FUNCTION:	FREQ.
ATTENUATION:	CHECK.
SAMPLING RATE:	CW from STOP.

b. Check reading at each of the three fixed sample periods in turn; readings should be as follows (±1 count):

Sample Period:	
.01 Sec,	10.0 KC Reading
.1 Sec,	10.00 KC Reading
1.0 Sec,	10.000 KC Reading

2.2.2 ZERO Adjustment (After 1½ Hour Warmup)

a. Set Power switch to ON, note time, and set other controls as follows:

100 KC STD (rear panel):	INT.
FUNCTION:	VOLT.
RANGE:	ZERO.
SAMPLE PERIOD:	1 SEC.
SAMPLING RATE:	CW from STOP.

b. After the HP-2401C has been on for at least 1-1/2 hours, set the front panel ZERO adjustment for zero ±1 count readout on the digital display.

2.2.3 Full-Scale Adjustment (After ZERO Adjustment)

a. Set the RANGE switch to INT +1V.

b. Set the front panel CAL+ adjustment for +1000.00 MILLIVOLTS indication on the digital readout.

c. Set the RANGE switch to INT -1V.

d. Set the front panel CAL- adjustment for -1000.00 MILLIVOLTS indication on the digital readout.

2.3 LOCAL OPERATION

Operation of the HP-2401C is straightforward and can be controlled locally at the front panel per Table 2-1 or can be programmed as required for data acquisition systems use. (See Section 2.6 for programmed operation.)

2.4 FUNCTIONS OF CONTROLS

2.4.1 Front Panel Controls

FUNCTION switch: Selects the type of measurement to be made, such as VOLT for dc voltage measurements, AUTO RANGE for automatic ranging voltage measurements (with HP-2401C- 31), FREQ for frequency measurements, or PERIOD for period measurements (with HP-2401C- 30). An EXT SEL position prepares the HP-2401C to respond to function and range programming via PROGRAM CONTROL connector J1.

RANGE switch: Selects the full-scale range of .1, 1, 10, 100, or 1000 volts. INT +1V, ZERO, and INT -1V positions are also provided for daily calibration of the instrument.

SAMPLE PERIOD switch: Fixed sample periods of .01, .1, or 1 second are selected by this switch. In addition, the sample period may be started manually by switching to START position and ended by switching to STOP. An EXT SEL position allows programmed selection of a fixed sample period or programmed starting and stopping of the sample period.

SAMPLING RATE control: Adjusts the length of time that the display and recording outputs are held after the end of the sample period. The time is adjustable from 200 milliseconds to 7 seconds (approximately). When switched to STOP position, the reading is held until reset either manually or by programming. Programmed control can achieve up to 50 readings per second, as noted in Section 1.3.5.

RESET pushbutton: Resets the instrument, including the digital display, and automatically initiates another sample period if one of the three fixed sample periods is selected and the SAMPLING RATE control is in STOP position. With SAMPLE PERIOD switch at STOP, resets the instrument to zero; sample period begins when SAMPLE PERIOD switch is set to START.

ATTENUATION control: Determines the input signal attenuation when making frequency or period measurements. A switched CHECK position connects a 10 kHz signal derived from the internal time base oscillator to the counters. This is used for a confidence check of the counter section.

Power switch and Line fuse: Controls ac power to the voltmeter; 2 ampere fuse is used for operation from 115 volts, 1 ampere fuse for operation from 230 volts ac.

2.4.2 Rear Panel Controls

STORE/DISPLAY DURING COUNT switch: In the STORE position, the previous visual display is held until the end of the current sample period, at which time the display changes directly to the new reading. However, external encode commands or RESET switch triggering causes transfer of all zeros to the digital display at the start of the triggered sample. In the DISPLAY position, the actual counting is displayed during the sample period.

100 KC STD switch: Selects the source of the counter time base reference standard. The INT position of this switch selects the internal 100 kHz time base signal and connects it to the adjacent 100 KC STD INPUT/OUTPUT BNC connector J3. The EXT position selects an external signal, received via BNC connector J3, as the time base standard of the instrument.

115/230V switch: Sets the instrument for operation from available line voltage (115 or 230 vac; 2 ampere fuse is used for 115 vac operation, 1 ampere fuse for 230 vac operation).

Table 2-1. Operation Summary (Std. 30, 31 Instruments)

TURN-ON AND PRELIMINARY CONTROL SETTINGS a. Set Power switch to ON (display digits light). b. Set 100 KC STD switch to INT (EXT if external standard is to be used). c. Set SAMPLING RATE for desired display interval or to STOP for measurement triggering by RESET pushbutton or remote command. d. Select SAMPLE PERIOD that achieves the desired resolution of measurements (see Table 2-2).
VOLTAGE MEASUREMENT a. Set FUNCTION switch to VOLT (VOLT or MILLIVOLT display lights). b. Select lowest RANGE that can be used without lighting the OVERLOAD display.
AUTORANGING VOLTAGE MEASUREMENT (HP-2401C-31) a. Set FUNCTION switch to AUTO RANGE. b. Set RANGE switch to any position except INT +1V, INT -1V, or ZERO.
FREQUENCY MEASUREMENT a. Set FUNCTION switch to FREQ (KC display lights). b. Adjust ATTENUATION control clockwise about 30° past the point where consistent measurements are obtained.
PERIOD MEASUREMENT (HP-2401C-30) a. Set FUNCTION switch to PERIOD (MILLISEC display lights). b. Adjust ATTENUATION control clockwise about 30° past the point where consistent measurements are obtained.
CONNECTIONS a. Connect voltage to be measured and shield to HI, LO, and GUARD terminals per Figure 2-1. b. Connect signal whose frequency or period is to be measured to FREQ INPUT receptacle per Figure 2-1.

Table 2-2. Resolution of Measurements

Sample Period	RANGE	Full-Scale Reading	Maximum Overrange Reading	Frequency Reading	Periods Averaged*
1 SEC	.1V	100.000 MV	300.000 MV	000.000 KC	100 (1 μSec Resolution)
	1.0V	1000.00 MV	3000.00 MV		
	10.0V	10.0000 V	30.0000 V		
	100.0V	100.000 V	300.000 V		
	1000.0V	1000.00 V	-----------		
.1 SEC	.1V	100.00 MV	300.00 MV	0000.00 KC	10 (10 μSec Resolution)
	1.0V	1.0000 V	3.0000 V		
	10.0V	10.000 V	30.000 V		
	100.0V	100.00 V	300.00 V		
	1000.0V	1000.0 V	----------		
.01 SEC	.1V	100.0 MV	300.0 V	00000.0 KC	1 (100 μSec Resolution)
	1.0V	1.000 V	3.000 V		
	10.0V	10.00 V	30.00 V		
	100.0V	100.0 V	300.0 V		
	1000.0V	1000. V	----------		

*HP-2401C- 30.

2.5 SPECIAL OPERATING CAPABILITIES

2.5.1 Operation With External Time Base Reference

Accurate external 10 kHz, 1 kHz, or 100 Hz, references can be used to achieve multiplication of the fixed sample periods of the instrument by 10, 100, or 1,000. If such sample period multiplication is used, the decimal point must be shifted one, two, or three places to the left. Switchover to the external standard signal is accomplished by setting the 100 KC STD switch to EXT and connecting the standard signal to the 100 KC STD INPUT/OUTPUT receptacle at the rear of the instrument. This external signal must have 2 volt peak-to-peak amplitude across a 1.2K load.

2.5.2 Manual Control of Sample Period

Duration of the sample period (counter gate time) can be controlled manually, as follows:

a. Set the SAMPLE PERIOD switch to STOP and reset the counter by actuating the RESET pushbutton.

b. Set the SAMPLE PERIOD switch to START.

c. End the sample period by setting the SAMPLE PERIOD switch to STOP.

When a manually started and stopped sample period is used, flows, pressures, thrusts, countable events, etc., can be totalized over periods that are longer than the fixed periods selectable on the SAMPLE PERIOD switch. Average voltage or frequency may be determined by dividing the reading by the duration (in seconds) of the extended sample period.

NOTE: The counting process is always displayed while the SAMPLE PERIOD switch is in START or STOP position, regardless of the STORE/DISPLAY switch setting.

2.5.3 AC Voltage Measurements and Resistance Measurements

The HP-2410B AC/Ohms Converter makes possible ac voltage and resistance measurements with the HP-2401C. Assemblies A9 and A23, supplied with the HP-2410B, must be installed in the HP-2401C. Specified accuracy of the HP-2410B is achieved after 1 hour warmup, but it can be used 15 seconds after it is turned on.

Initial Preparation

a. Connect the HP-2410B programming cable from receptacle J8 on the rear of the HP-2410B to PROGRAM CONTROL receptacle J1 on the rear of the HP-2401C.

b. Connect the HP-2410B signal output cable from the HI, LO, and GUARD dc terminals on the terminal strip at the rear of the HP-2410B to corresponding terminals on the HP-2401C.

NOTE: To avoid unnecessary measurement errors, make certain that the guard shield is connected at only one point, the measurement reference point. If a GUARD terminal is tied to a LO terminal at the front panel of the HP-2410B, make certain that such connection is not duplicated between GUARD and LO terminals at the rear of the HP-2410B or at the front panel of the HP-2401C.

c. Turn on both instruments and set HP-2401C FUNCTION switch to EXT SEL, SAMPLE PERIOD switch to desired position, SAMPLING RATE control to STOP, and RANGE switch to 1V.

AC Voltage Measurement

a. Set HP-2410B FUNCTION switch to AC NORM for frequencies below 400 Hz or AC FAST for frequencies above 400 Hz; set HP-2410B RANGE switch to lowest range that can be used without lighting OVERLOAD indicator on HP-2401C.

b. Connect ac voltage to HI, LO, and GUARD AC/DC INPUT of HP-2410B, but do not exceed 750 volts peak input.

c. Initiate measurements by actuating the RESET pushbutton on the HP-2401C or by setting SAMPLING RATE control clockwise from STOP.

Resistance Measurement

a. Perform the HP-2410B ohms zero calibration as specified in the HP-2410B handbook.

b. Set HP-2410B FUNCTION switch to OHMS and RANGE switch to the lowest range that can be used without lighting OVERLOAD indicator on HP-2401C.

c. Connect resistance to be measured to the resistance input of the HP-2410B.

d. Initiate measurements by actuating the RESET pushbutton on the HP-2401C or by setting the SAMPLING RATE control clockwise from STOP.

2.5.4 Measurements Using the HP-2411A Guarded Data Amplifier

The HP-2411A Guarded Data Amplifier makes possible measurement of low-level inputs at a full-scale sensitivity of 10 millivolts with the HP-2401C. This instrument may also be used for extremely high input impedance measurements at +1 gain on the .1 and 1 volt ranges of the HP-2401C. Assembly A30, supplied with the HP-2411A, must be installed in the HP-2401C. To achieve specified zero drift, the HP-2411A requires a 2 hour warmup, at constant temperature, but it can be used 15 seconds after it is turned on. Proceed as follows:

a. Connect the HP-2411A programming output cable from PROGRAM OUTPUT receptacle J2 on the HP-2411A to the PROGRAM CONTROL receptacle J1 on the rear of the HP-2401C.

b. Connect the HP-2411A signal output cable from OUTPUT receptacle J5 on the HP-2411A, to the DC INPUT receptacle, J31, on the rear of the HP-2401C.

NOTE: To avoid unnecessary measurement errors, make certain that the guard shield is connected at only one point, the measurement reference point. Make certain that the guard shield is connected at the measurement source reference point and that the GUARD and LO terminals on the front panels of the HP-2411A and HP-2401C are not tied together.

c. Turn on both instruments and set the HP-2411A ZERO adjustment as specified in the HP-2411A handbook.

d. Set the HP-2401C FUNCTION switch to EXT SEL, SAMPLE PERIOD switch to desired sample period, and SAMPLING RATE control to STOP.

e. For maximum resolution of low-level measurements, set the HP-2411A MODE switch to +10 gain and the HP-2401C RANGE switch to .1V. This achieves a ±10 millivolt full-scale range (±30 millivolt overrange).

f. For minimum loading of the voltage being measured, set the HP-2411A MODE switch to +1 gain. The input resistance will then be 10,000 megohms for input voltages to ±10 volts. Input greater than 10 volts automatically switches the HP-2411A to bypass mode, which reduces input impedance to that of the HP-2401C.

g. Connect the dc voltage to be measured to the HI, LO, and GUARD INPUT terminals of the HP-2411A in accordance with the general principle expressed in Section 2.1.1 and Figure 2-1.

h. Initiate measurements by actuating the RESET pushbutton on the HP-2401C or by setting the SAMPLING RATE control clockwise from STOP.

2.5.5 Pulse Measurements

To measure pulses at the FREQ INPUT connectors, the input trigger circuit must be adjusted so that the hysteresis limits will be triggered by either a positive pulse or a negative pulse. Refer to Section 4.7.11 for the adjustment procedure. Refer to Section 4.7.12 to readjust for sine wave operation.

2.6 PROGRAMMED OPERATION

The measurements described in Sections 2.3 and 2.5 may be programmed and initiated by external circuit closures to ground. This feature makes the HP-2401C particularly adaptable for use in automatic data acquisition systems. The remote control lines do not interfere with the guarding properties of the measurement circuits. All programming and input connections can be made at the rear of the instrument, which simplifies cabling.

2.6.1 Control Settings

Set front panel controls of the HP-2401C as follows for fully programmed operation:

FUNCTION:	EXT SEL.
SAMPLE PERIOD:	EXT SEL.
SAMPLING RATE:	STOP (switched position) or desired rate.
RANGE:	Any position except INT -1V, INT +1V, or ZERO.

2.6.2 Programming Requirements

Refer to Table 2-3 for the pins of J1 that must be connected to program and initiate the various measurements. (An external contact closure to ground is defined as a contact closure or equivalent which raises the internal circuit to a potential that is no more negative than 1 volt at a maximum load current of 70 milliamperes.) Complete programming information must be present for each type of measurement, otherwise the input attenuator switches automatically to the 1000 volt range and the decimal point blanks. The programming required for each type of measurement is as follows:

DC Voltage Measurements: Only range and sample period must be programmed. The HP-2401C automatically measures dc voltage if the frequency measurement function is not programmed.

Autoranging Voltage Measurements (HP-2401C-31 Only): Autoranging function and sample period must be programmed; ranges must not be programmed.

Frequency Measurements: Frequency function and sample period must be programmed.

Period Measurements (HP-2401C-30 Only): Period function and sample period (number of periods averaged) must be programmed.

2.6.3 Application of Program Commands

The external contact closures are applied between the required pin(s) of J1 and pin Z. For example, to program a frequency measurement over a sample period of 1 second, external contact closures must connect pins B and R of J1 to pin Z.

Table 2-3. Program Control Connector (J1)

Connector Type: MS3102A28-21S Mating Connector: MS3106B28-21P

J1 Pin	Description	
A	Spare	
	Function	
B	Volts/Frequency (Measures volts if not programmed.)	
C*	Ohms	
D*	AC Normal	
E*	AC Fast	
F*	Spare	
	Range (Volts)	
G	0.1	
H	1	
J	10	
K	100	
L	1000	
M*	10MΩ	
	Sample Period (Sec)	Periods Averaged (W/Option M30)
N	.01	1
P	.1	10
R	1	100
S	HP-2411A +10 Gain Input to A30 (+10 Gain to HP-2411A with Option 31)	
T	Spare	
U	Spare	
V	Autorange (W/Option 31)	
W	Spare	
X	HP-2411A Sense (W/Option 31)	
Z	Chassis Ground (System Common)	
a	Manual Gate Selection	
b	Start/Stop Manual Gate (Closure to Start)	
c	Counter Reset (Closure)	
d	Overload Reset (Pulse or Closure) Input/Output**	
e	Overload Signal Output (30 Milliamperes Maximum)	
f	Period (W/Option 30)	
g	Spare	
h	Spare	
j	Spare	
k	Spare	
m	Jumpered to J2 (49) to Route Signal Scan from Printer	
p	Spare	
r	Spare	
s	Chassis Ground	

* Pins for HP-2410B use only.

**Overload reset not normally used since counter resets overload circuit. When counter section is reset, pin d provides overload reset pulse for HP-2410B and HP-2411A overload reset.

2.6.4 Initiating Measurements

Measurement may be initiated by either of two encode command inputs. One of these inputs is a contact closure between pin c of J1 and pin Z, which grounds the counter reset program line. This triggers a reset pulse after about 3 milliseconds delay, starting a new measurement cycle. The 3 millisecond delay prevents multiple reset commands caused by contact bounce when relay contact closure is used for resetting. The other input which may be used to initiate measurement is a -15 volt, 25 microsecond pulse with rise time less than 2 microseconds. This pulse, applied to COUNTER RESET receptacle J4 on the rear panel of the HP-2401C resets the digital display to all zeros and starts a new measurement cycle immediately.

2.6.5 Standard Measurement Delays

Measurement (the sample period) actually begins 9.7 milliseconds after the reset pulse has reset the time base and counting/display decades of the HP-2401C. AC Normal, AC Fast, or resistance measurements programmed through a HP-2410B AC/Ohms Converter introduce up to 550, 220, or 110 milliseconds additional delay.

2.6.6 Programmed Control of Extended Sample Periods

Program periods longer than 1 second as follows:

a. Enable extended sample period programming by connecting pin a of J1 to pin Z.

b. Start the sample period by connecting pin b of J1 from pin Z.

c. Stop the sample period by disconnecting pin b of J1 from pin Z.

d. Reset the HP-2401C as specified in Section 2.6.4 before initiating the next measurement.

Repeat steps a, b, and c of this procedure for each measurement involving an extended sample period. When extended sample period programming is no longer desired, disconnect pin a of J1 from pin Z and program the correct pin for the desired fixed sample period (.01, .1, or 1 second).

NOTEA: Alternatively, sample periods may be started by a relatively positive potential (-1 to +5 volts) and stopped by a negative potential (-5 to -30 volts) applied through J1 pin b across 4KΩ.

NOTE B: The counting process can be displayed during programmed extended sample periods only be setting the STORE/DISPLAY switch to DISPLAY position.

2.6.7 Programming Through HP-2410B or HP-2411A

When using HP-2410B or HP-2411A accessory instrument with the voltmeter, programming must be connected to the accessory instrument. See the applicable handbook for details. This is necessary for correct operation of the HP-2401C logic circuits, particularly the display and decimal point logic. The programming functions applied to the accessory instrument are routed through it to the HP-2401C via the same programming output cable that is used when making manually controlled measurements per Section 2.5.3 or 2.5.4.

Table 2-4. BCD Output Connector (J2)

Connector Type: 57-40500 Mating Connector: 57-30500

Signals and Levels	Source in HP-2401C	HP-562A Column (Columns Run 8, 7, 6, 5, 4, 3, 2, 1)	J2 PIN ASSIGNMENTS BCD Weighting Of 4-Line Outputs 1 1*	2 2*	2' 4*	4 8*
Decimal 10^{-n} Multiplier	A22 (7, 10, 9, 5)	1	1	2	26	27
Data 10^{0} Digit	A11 (7, 5, H, 4)	2	3	4	28	29
Data 10^{1} Digit	A12 (7, 5, H, 4)	3	5	6	30	31
Data 10^{2} Digit	A13 (7, 5, H, 4)	4	7	8	32	33
Data 10^{3} Digit	A14 (7, 5, H, 4)	5	9	10	34	35
Data 10^{4} Digit	A15 (7, 5, H, 4)	6	11	12	36	37
Data 10^{5} Digit	A46 (7, 5, H, 4)	7	13	14	38	39
Function For all of above: "0" = -35 to -24V "1" = -5 to -1V	A22 (19, 20, 21, 16)	8	15	16	40	41
					(1-Line Signals)	
Ground	Chassis				50	
+Ref. (-5 to -4V)	A7 (4)				25	
-Ref. (-24.5 to -21.5V)	A7 (6)				24	
+Record Command During Measurement: -35 to -24V During Display: -5 to -1V	A17 (7)				23	
-Record Command Levels same as +Record, but inverted.	A17 (11)				21	
+Hold (+1 to +12V)**	A17 (9)				22	
Scan Signal from Recorder See Printer handbook for levels.	To J1 (m)				49	

* Coding of outputs from HP-2401C-21 or 35; "0" and "1" state levels from HP-2401C-35 are reversed: "0" = -5 to -1v and "1" = -35 to -24v.

**Non-hold state is -1 to -35v.

Table 2-5. Function Codes

Function	J2 Pins / Coding	15 / 1	16 / 2	40 / 2'	41 / 4	HP562AR Printwheels Std.	4610
Period (W/ Option 30)		0	0	0	0	0	P
+VDC		1	0	0	0	1	+
-VDC		0	1	0	0	2	-
KC		1	1	0	0	3	F
KΩ (W/HP-2410B)		0	1	1	0	4	K
MΩ (W/HP-2410B)		1	1	1	0	5	M
Spare		0	0	1	1	6	>
Spare		1	0	1	1	7	<
Time		0	1	1	1	8	T
Overload		1	1	1	1	9	Q
		0	0	0	1	--- Blank ---	
VAC (W/HP-2410B)		1	0	0	1	---	A

2.6.8 Overload Resetting

Any overload condition occurring on a previous measurement is reset automatically by resetting the counters per Section 2.6.4. It is also possible to reset an overload condition without resetting the counters. This is accomplished by connecting pin d of J1 to pin Z temporarily.

2.7 RECORDING OUTPUTS

BCD voltages (ground referenced) are produced for each measured digit and for indication of measurement function (+VDC, -VDC,KC, etc.) and decimal point. These bcd outputs are available at the BCD OUTPUT connector, J2. Pin assignments of J2 are outlined in Tables 2-4 and 2-5.

Also given in Table 2-4 are the bcd output weighting and levels, record command output, and bcd reference voltages. A hold command may be applied to J2 pin 22 to inhibit the voltmeter from initiating a new measurement until the recording device has completed its cycle or has stored the data. The hold should be used only when the SAMPLING RATE control is used to initiate measurements at an unsynchronized rate. A reset command will reset the DCU's but a new measurement is not initiated until any hold-off command is removed. A voltage to J2 pin 22 that is between +1 and +12 volts (maximum load 4.5 milliamperes) inhibits the counter section of the voltmeter. A voltage to J2 pin 22 that is between -1 and -35 volts enables the counter section of the voltmeter.

The scan signal and hold command from the recording device are also routed to PROGRAM CONTROL connector J1 for systems use.

THEORY

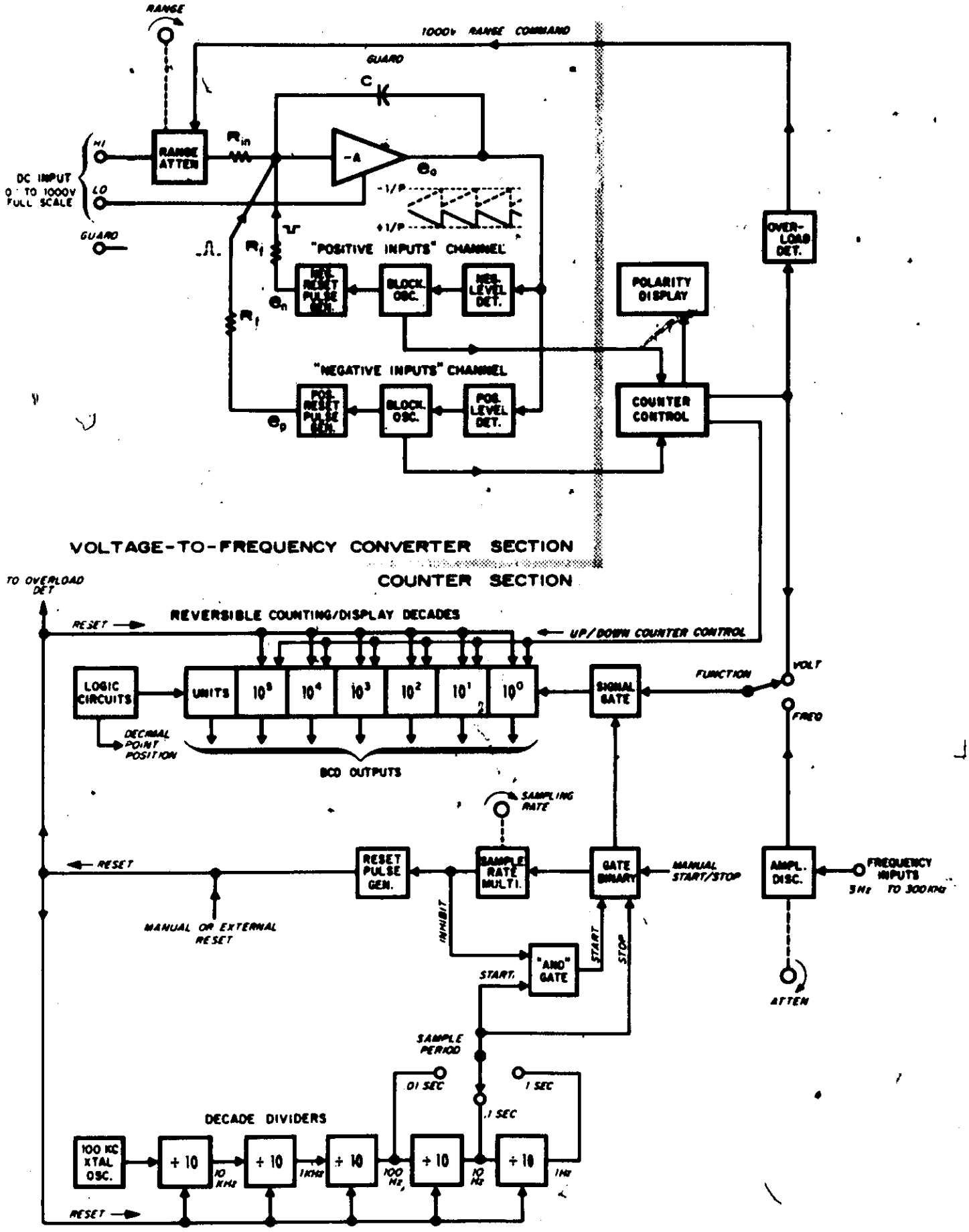


Figure 3-1. HP 2401C Digital Voltmeter Block Diagram

SECTION III
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THEORY OF OPERATION

ILLUSTRATIONS

SECTION III
THEORY OF OPERATION

3.1 GENERAL

The functional elements of the HP-2401C Integrating Digital Voltmeter are illustrated in Figure 3-1. As indicated, the HP-2401C consists principally of a voltage-to-frequency converter (vfc) and a counter. The vfc includes an input attenuator and integrating and pulse forming circuits. The vfc output is applied to the counter section and an overload detector via a counter control circuit. The counter includes a precision time base generator, decade dividers, control logic circuits, and six reversible counting and display decades.

3.1.1 Voltage Measurement

Voltage to be measured is applied via the HI-LO input terminals to the programmable input attenuator, which provides precisely calibrated attenuations for full-scale ranges of 0.1, 1, 10, 100, and 1000 volts. The GUARD terminal is provided for connecting the vfc chassis to the low side of the voltage source. Thus connected, the guard shields the input to the vfc, attenuating common-mode noise.

The output from the attenuator is transformed by the vfc to a proportional pulse rate. The integrating amplifier (-A in Figure 3-1) generates a charging current for C whose value is directly proportional to the input voltage. This current charges capacitor C to a negative or positive voltage that is inverted with respect to the voltage being measured. At a specified level, the voltage across C triggers the negative or positive inputs channel. The pulse from the triggered channel opposes the original amplifier input, discharging capacitor C. At the end of this pulse, the amplifier output current recharges capacitor C to a level that triggers one of the inputs channels. The average pulse rate thus generated is directly proportional to the average input voltage. The vfc output pulses are coupled through the counter control circuit and the signal gate to the counting/display decades when the FUNCTION switch is set to VOLT. The average vfc output rate is 100 kHz for a full-scale input. Although vfc output pulses are generated continually while an input voltage is connected to the HP-2401C, they are counted only during sample periods.

The counter control circuit receives the pulses from the positive or negative inputs channel and provides output pulses for triggering the counting/display decades in the counter section. These pulses are also applied to an overload detector. In addition, the counter control circuit provides up/down count commands to the counting/display decades and a polarity signal that lights the + or -polarity indicator of the digital display during dc voltage measurement.

During each sample period, the counting/display decades count the pulse output from the counter control circuit when the signal gate is opened and

the FUNCTION switch is set to VOLT. The decades count up during the entire sample period if the input polarity does not change. If the input polarity changes, the counter control circuit changes its count up command to a count down command. The decades then count down toward zero. If zero is reached during down counting, the counter control circuit changes its count down command to a count up command. At the same time, the polarity display is switched. At the end of the sample period, the digital display reads out the algebraic average of the applied input voltage, tagged with the correct polarity.

The overload detector always receives a pulse train output from the counter control circuit. If the pulse rate exceeds 310kHz (310% of full scale) at any time, the overload detector turns on an OVERLOAD indication on the digital display and switches the programmable attenuator to its highest range (1000V). The overload detector is reset at the start of each new sample period.

3.1.2 Frequency Measurement

A signal whose frequency is to be measured is applied to the counter gate circuits via an amplitude discriminator. The amplitude discriminator consists of an amplifier and a Schmitt Trigger. The amplitude of the amplifier output signal is set by the front panel ATTENUATION control. The Schmitt circuit shapes the amplifier output to provide a fast-rise, constant-amplitude signal for driving the 10^0 counting/display decade. During the sample period this signal is applied to the 10^0 decade through the signal gate if the FUNCTION switch is set to FREQ. Refer to Section 2.5.5 for special pulse measurement requirements.

3.1.3 Sample/Display Period Control

The sample period of the HP-2401C for voltage or frequency measurements is normally controlled by an output from the time base dividers. However, sample period can also be controlled manually to start and stop counting to provide any desired interval.

The time base dividers divide the 100kHz signal from the crystal-controlled reference oscillator by factors of 10. This produces accurate sample periods of 0.01, 0.1, and 1 second. The output from the divider that produces the selected sample period is coupled to an AND gate. When this signal is present and no inhibit is applied from the sample rate multivibrator, the gate binary flips. This opens the signal gate and allows voltage or frequency pulses to be counted. The inhibit from the sample rate multivibrator is removed at the end of the display interval. The duration of the inhibit is set by the SAMPLING RATE control on the front panel.

The pulses from the signal gate are counted during the selected sample period. This period is ended by a trigger (from one of the decade dividers) that flips the gate binary, closing the signal gate and stopping the count.

The transition of the gate binary to count inhibit state triggers the sample rate multivibrator, starting the display interval. During this interval no

new count can be started. At the end of this interval the reset generator is triggered, which causes the counting/display and divider decades to be reset. Then, after a small delay that is provided to allow circuits to stabilize, a signal from the appropriate divider decade initiates a new sample period.

3.1.4 Display Units and Decimal Control

The units readout to the left of the six-digit decimal display indicates the units being measured (e.g., VOLTS or KC). This readout position is controlled via logic networks in response to control settings or programming. These logic circuits interpret the various measurement control inputs and cause the appropriate units to be indicated on the units display. The logic circuits also interpret the control settings to determine the correct position for the decimal point indication. This assures that the display will be direct reading in the units indicated.

3.2 VOLTAGE-TO-FREQUENCY CONVERTER (A28, A31-A33)

NOTE

Unless otherwise stated, incomplete designations (C25, V1, Q8, etc.) which appear in the following discussions (Sections 3.2.1 through 3.18.3) pertain to components of the circuit assembly being described.

3.2.1 Programmable Attenuator A28 (Figure 4-29)

Programmable attenuator assembly A28 standardizes the current (1 microampere full scale) that is applied to summing point P30 of integrating amplifier A31. Thus, the vfc output with 1000 volt input on the 1000 volt range is the same as with 100 millivolt input on the .1 volt range.

Attenuation (voltage range of the HP-2401C) is controlled by relays K1 to K5 as summarized in the RANGE switch table in Figure 4-29. These relays are controlled by the RANGE switch when the FUNCTION switch is set to VOLT, or by programming when the FUNCTION switch is set to EXT SEL position. Range control is routed through attenuator coupling logic assembly A8 (discussed in Section 3.5.1).

3.2.2 Integrating Amplifier A31 (Figures 3-2, 4-29, and 4-30)

System Operation

Integrating amplifier A31 charges capacitor C25 positively or negatively at a rate that is proportional to the input current applied to its summing point, P30. This develops an output potential that is continually applied to negative and positive trigger level detectors A32 and A33. At 0.1 volt, this potential triggers one of the detectors. The polarity and which detector is triggered

are determined by the polarity of the input voltage being measured. For example, negative input voltage causes a positive-going potential that triggers negative trigger level detector A32 at +0.1 volt.

The triggering of A32 or A33 produces a constant area pulse that causes a pulsed current flow to the summing point which is greater than the input current. Amplified by A31, this current partly discharges C25. At the end of each such pulse, the input current to the amplifier again causes charging of C25 to the trigger potential. The design of the vfc is such that the average of the pulsed discharge currents is equal to the input current and proportional to the voltage being measured. Thus, the pulse rate is proportional to input voltage.

Integrating amplifier A31 consists of an operational amplifier with feedback coupled through C25. The gain of the operational amplifier is so high (-10^7 to -10^8) that the feedback (C25) and input (R_{in}) impedances determine operation.

When a dc voltage is connected to the input of the HP-2401C, a small current, proportional to the magnitude of the input, flows through R_{in} to the amplifier. The inverted and greatly amplified output from the amplifier is fed back through C25 as an opposing current. The result is an extremely high integrating amplifier input impedance. Since the currents at the summing point very nearly cancel, the summing point voltage is virtually zero. Thus, the voltage at the amplifier output is that which is developed across C25 as it is charged by the feedback current. This voltage is directly proportional to the integral of the input current. The mathematical expression for the relationship shows that for a step input voltage (e_{in}) the amplifier output (e_o) increases linearly at a rate that is determined by the constant factors R and C, as follows:

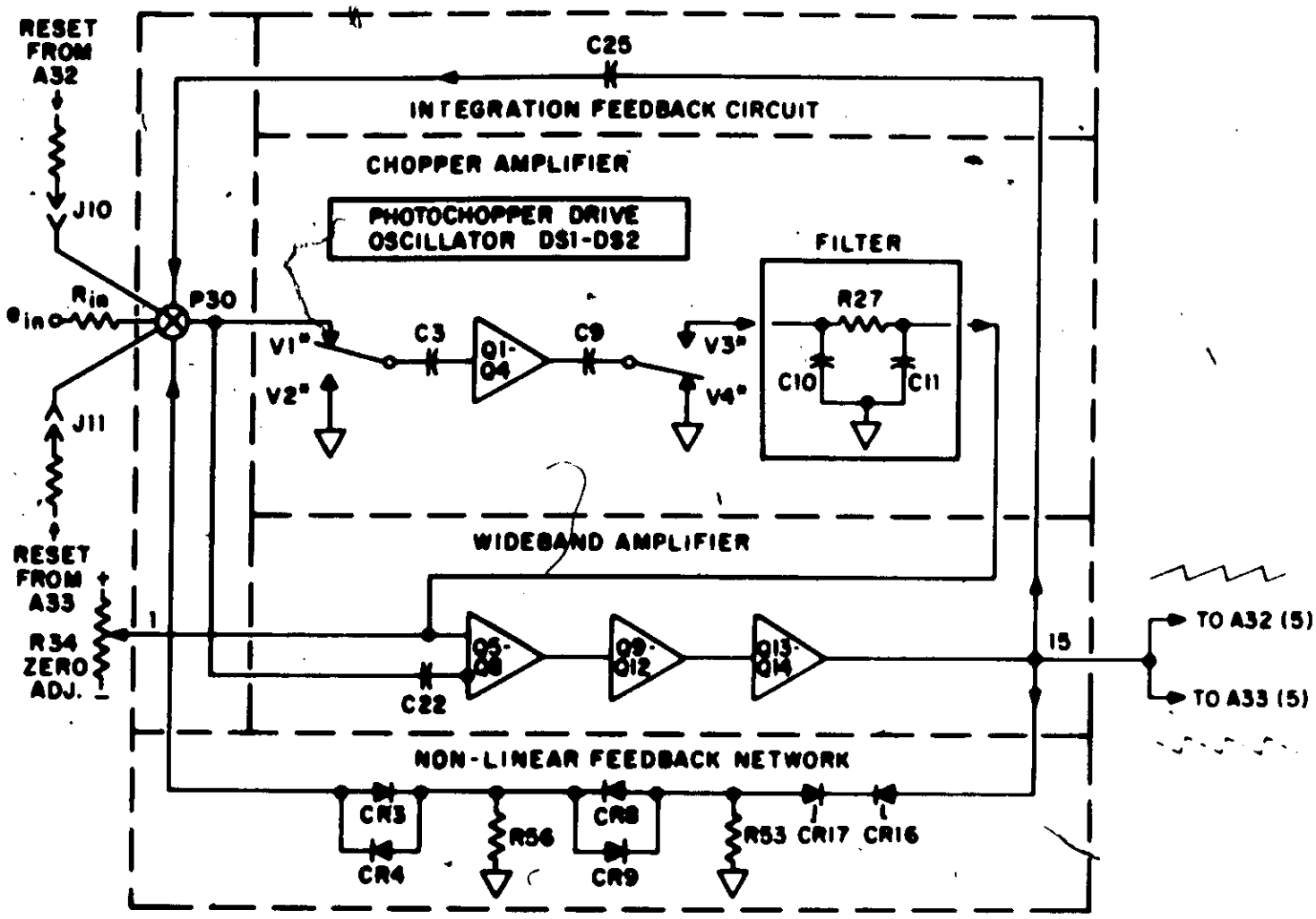
$$e_o = \frac{-1}{C} \int i_{in}\, dt = \frac{-1}{RC} \int e_{in}\, dt$$

This expression is true for both the measurement input and the reset input to the summing point. The result is the balancing of input current by pulsed reset current, as discussed in the second paragraph under Section 3.2.2.

Internal Functions

The functional elements of integrating amplifier A31 are shown in Figure 3-2. These include a chopper amplifier, a wideband amplifier, the integration feedback circuit, and a non-linear feedback network. The circuit diagram is Figure 4-30.

Chopper Amplifier -- The chopper amplifier amplifies dc and low frequency signals, after their conversion to ac by a photochopper. Because only ac is amplified, the chopper amplifier introduces no dc drift into the amplifying system. DC drift error caused by the wideband amplifier is divided by 10^4, the effective dc gain of the chopper amplifier. The resulting drift is so small that it has no effect upon the accuracy of the digital readout.



* MECHANICAL EQUIVALENTS OF PHOTORESISTORS V1-V4; THE SYNCHRONIZATION INVERTS THE OUTPUT SIGNAL

Figure 3-2. Integrating Operational Amplifier A31, Functional Diagram

The chopper amplifier input and output are modulated and de-modulated synchronously by solid-state photoresistors V1-V4 which are driven by flashes of light from the neon bulbs of a relaxation oscillator. The oscillator frequency is set by the DRIVE OSC ADJ resistor to be 240 Hz with power line voltage at 102 or 204 vac. The photochopper mechanical equivalent is shown in Figure 3-2. After filtering, the pulsed signal from demodulating photoresistors V3 and V4 is a smooth, amplified and inverted replica of the dc and low frequency components of the signal at the summing point. The output is coupled directly to one input of the wideband amplifier. The chopper amplifier output is prevented from exceeding ±0.5 volts by CR6 and CR7.

Wideband Amplifier.-- The wideband amplifier amplifies dc and low frequency signal components from the chopper amplifier and high frequency signal components coupled through C22. The high frequency signal components are connected to the inverting input of differential input stage Q5-Q8. The output from Q8 is amplified without further inversion by Q9-Q12. Complementary push-pull emitter followers Q13 and Q14 form a low-impedance, single-ended output stage that has practically equal output impedance for either output polarity. The output current charges C25 to the trigger level of A32 or A33.

Gain and response of the wideband amplifier are shaped by negative feedback from Q10 to Q9 and from Q13-Q14 to Q11. A filter network in the Q9 base circuit completes the shaping of response. Overall, the wideband amplifier amplifies input signals from dc to about 1 megacycle, with a 6 db/octave rolloff of signal gain at frequencies above 100 Hz.

Potentiometer R34, the front panel ZERO adjustment, is set to make zero input current produce zero output current from the integrating amplifier. It cancels fixed dc offset voltages existing within the integrating amplifier by applying a stable equivalent voltage of opposite polarity to the wideband amplifier dc input (the base of Q5).

Non-Linear Feedback Network -- Protection of the amplifier from severe short-term overloading is provided by a non-linear feedback network whose principal elements are voltage breakdown diodes CR16 and CR17. Whenever the amplifier output voltage exceeds the breakdown potential of CR16 or CR-17, these diodes conduct a negative feedback current that prevents saturation of the amplifier, which could cause excessive recovery time.

3.2.3 Trigger Level Detectors A32 and A33 (Figure 4-29)

A32 and A33 are voltage-sensitive pulse generators. These detectors are essentially identical, except that one responds to negative voltage and the other to positive voltage. Either of these pulse generators provides a constant voltage-time area pulse of a polarity opposite to the polarity of the input signal.

Operation of detector A33 is typical. When a positive voltage is being measured, the potential from the output of A31 increases negatively until it reaches the -0.1 volt trigger level of A33. The trigger level is set by potentiometer R27. At the trigger level, blocking oscillator Q3 is triggered through emitter follower Q6, non-inverting amplifier Q5, and emitter follower Q4. The output from Q3 is a sharp pulse that triggers binary Q1-Q2. This pulse is also transformer-coupled through the guard shield to the counter control circuit on A16.

The pulse from the blocking oscillator triggers a change of binary state, causing reversal of current in the primary of a special saturating-core transformer, T1. This produces a pulse in the secondary, which is connected for full-wave rectification. A diode within transformer T1 polarizes the output pulse. Because of the precisely controlled saturation characteristics of the T1 core, the output pulse has constant volt-time area. The output pulse is applied to summing point P30 through a resistor network. Through integrating amplifier A31 this resets the potential across C25 to a level that is below the trigger level.

If the input voltage is still present, the amplifier output continues to move toward the trigger level. Each time the trigger level is reached another reset pulse is generated, tending to keep the amplifier output constant near the trigger level, as shown in Figure 3-3.

Over any given interval the sum of the areas of the reset pulses is equal to the total integral of the input signal. By counting the number of such

pulses generated during the sample period a direct measurement of the average input voltage is obtained. For example, if each reset pulse has an area of 10 microvolt-seconds (i. e., 10 volt amplitude and 1 microsecond duration), one volt at the input will produce 100,000 output pulses per second (100,000 × 10 microvolt-seconds = 1 volt-second).

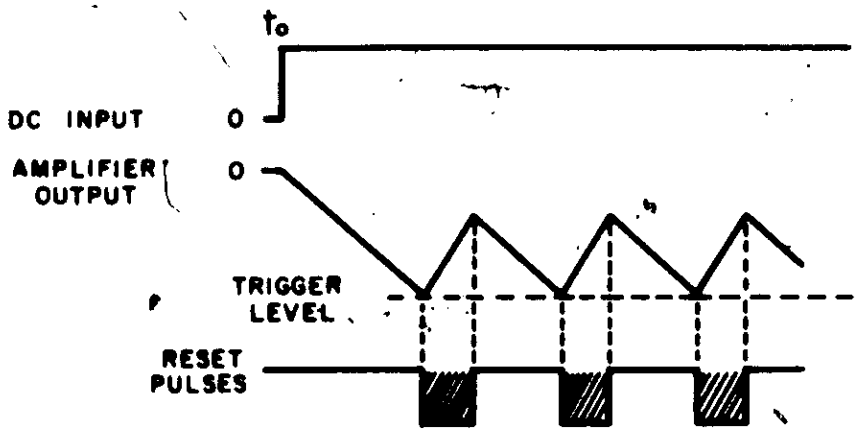


Figure 3-3. VF Converter Waveforms

3.3 COUNTER CONTROL A16 (FIGURES 4-7, 4-8 AND 4-18)

The logic on A16 generates the count direction commands for reversible decade counters A11-15 and 46 and provides the signals that light the correct polarity indicator and produce the correct BCD function output. This logic also generates delayed counter trigger pulses and undelayed rate output pulses for the overload detector, A10.

3.3.1 Derivation of Count Direction Commands

The count direction commands are derived from the positive and negative channel pulse outputs of the voltage-to-frequency converter (vfc), and the state of the zero detect line from the reversible decades. The control state memories for this logic are input polarity flip-flop Q3-4 and count polarity flip-flop Q7-8. Basically, the count up command is produced when both flip-flops are in the same state (i. e., both in positive state or both in negative state). The count down command is produced when the flip-flops are in different states (i. e., Q3-4 in positive state and Q7-8 in negative state, or vice versa).

States of the Polarity Flip-Flops

The positive state of Q3-4 is Q3 off, with its collector near -35 volts, and Q4 on, with its collector near ground. The positive state of Q7-8 is Q7 off, with its collector near -35 volts, and Q8 on, with its collector near ground. The negative states of both flip-flops are the reverse of the positive states.

The Count Up Command

The count up command consists of two outputs from A16. One of these out-

puts is an inhibit from the count down (not down) logic line. The positive state of the count down logic line closes the down count AND gates on the reversible decade counters. The other output is the negative state of the up (not up) logic line that lets the up count AND gates on the reversible decade counters remain open.

Derivation of the Count Up Command

When both flip-flops are in the same state, the negative outputs from Q3 and Q7 or from Q4 and Q8 produce a negative output from AND gate CR9-10 or from AND gate CR7-8. Either negative output is coupled through OR gate CR11-12, and AND gates CR13 and R35-36 to logic inverter Q9. The positive output from Q9 cuts off the count up logic inverter, Q13-14, which leaves the count up line negative. The positive output from Q9 is inverted and re-inverted by Q10 and Q11-12, which makes the count down line positive, inhibiting down counting as mentioned previously.

The Count Down Command

The count down command is the complement of the count up command. The positive inhibit is applied to the reversible decades along the count up logic line, closing the up count AND gates. The negative state of the count down logic line lets the down count AND gates on the reversible decades remain open.

Derivation of the Count Down Command

When flip-flops Q3-4 and Q7-8 are in different states, the negative output from Q3 is accompanied by a positive output from Q7, or vice versa, and the negative output from Q8 is accompanied by a positive output from Q4, or vice versa. Neither AND gate CR9-10 nor CR7-8 couples a negative output to OR gate CR11-12. The output of OR gate CR11-12 to logic inverter Q9 is positive. The negative output from Q9 is inverted by the count up logic inverter Q13-14, which applies a positive inhibit to the up count AND gates of the reversible decades via the up logic line. The negative output from Q9, inverted and re-inverted by Q10 and Q11-12 produces a negative down output that leaves the down count AND gates on the reversible decades open.

Typical Operating Sequence

When the first pulse during a sample period is from the positive channel, the output from Q1 triggers Q3-4 to positive state. Because the decades are all in the zero state, the negative output from zero detect emitter follower Q22 and the negative output from Q3 sets count polarity binary Q7-8 to the identical (positive) state by turning on Q8. Turn-on of Q8 cuts off Q7, which sets the +signal line positive and lights the +polarity indicator lamp through AND gate Q6. With both flip-flops in positive state, the A16 logic commands up counting as described previously.

If input voltage polarity crosses zero and becomes negative during the sample period, the first pulse from the negative channel triggers Q3-4 to negative state (Q3 on and Q4 off). Because the count is not zero, the count polarity binary remains in the positive state. The A16 logic now commands

down counting because the flip-flops are in different states. Down counting continues until the sample period ends or until a zero count is reached.

If the decades all reach a count of zero, the detection of zero, coupled through Q22, opens the count polarity binary input AND gates to the negative input from Q4. The negative output from AND gate CR3-R10 sets Q7-8 to the same (negative) state as Q3-4, by turning on Q7. This reverses the signals applied to the polarity signal lines and indicator lamps and switches the A16 logic so that up counting is commanded. The decades now accumulate an increasing count that is identified as negative.

3.3.2 Overload Output

OR gate CR15, 33 couples positive or negative channel pulses from Q1 or Q2 to overload detector A10 through pin 1 of A16.

3.3.3 Counter Output

OR gate CR26-27 couples positive or negative channel pulses from Q1 or Q2 to one-shot Q18-19. Each positive pulse from OR gate CR26-27 cuts off Q18, triggering the one-shot to its unstable state. The negative pulse from the Q18 collector is coupled through emitter follower Q20, logic assembly A19, and a differentiating circuit to the trigger input of reversible counter decade A11. The differentiated, positive-going trailing edge of the Q18 output pulse triggers decade A11 after a 1.5 microseconds delay.

Whenever zero is detected or input polarity changes, the delay of the counter trigger is extended to assure triggering after all circuit logic changes have occurred and settled. Delay is extended by reducing the turn-on bias that is applied to the base of Q18. This increases the time that Q18 remains cut off. When the Q22 and Q18 collectors are both negative Q25 is turned on through a resistance-capacitance (r-c) delay circuit. Conduction through Q25 reduces the bias voltage that is applied to Q18. As determined by the r-c delay, conduction through Q25 decreases exponentially at a rate that permits turn-on of Q18 after it has been off for about 6 microseconds. Similar r-c circuits turn on Q17 when input polarity flip-flop Q3-4 changes states. The conduction through Q17 that is timed by these circuits extends cutoff time of Q18 to about 9 microseconds.

3.3.4 Zero Detect Logic

During display periods, the zero detect logic is disabled by a ground input from A17Q8 to pin F, which closes the zero detect AND gate. During the sample period this inhibit is removed, opening the gate to the negative zero detect input from counting/display decades A11-A15 and A46. The input from these decades is negative only when all binaries are in the zero state. The negative zero detect input is coupled through Q22 to the count polarity input AND gates and the 6 microsecond delay AND gate. The disabling of the zero detect output from Q22 prevents the count polarity binary from changing states until the next measurement period.

3.3.5 Polarity Output

The state of count polarity flip-flop Q7-8 is coupled through AND gates Q5 and Q6 to the + and - lamp and signal lines (pins 7, H, and J). The positive state of Q7-8 (Q7 off, Q8 on) opens Q6, setting the + lamp and signal lines positive (near ground). The negative state of Q7-8 (Q7 on, Q8 off) opens Q5, setting the -lamp and signal lines positive. The polarity indication is inhibited by cutoff of polarity blanking amplifier Q24 when FREQ, AC, or Ω (ohms) measurement function is selected, clamping pin P of A16 to ground.

3.4 OVERLOAD DETECTOR A10 (FIGURES 4-7, 4-15 AND 4-16)

The pulse train output from the vfc is coupled through counter control assembly A16 to overload detector A10, pin 1. When the pulse rate exceeds approximately 310 kHz (310% of full scale), the overload detector generates an overload signal, causing:

a. An OVERLOAD indication on units indicator display A24;

b. Input attenuator switchover to 1000 volt range by energizing relay K5 and de-energizing previously energized range programming relays;

c. An overload signal to J1, pin e for switching the HP-2410B to 1000 volt range and to printer coupling card A22 for recording.

3.4.1 Overload Signal Memory

For serial prefix 610- and above flip-flop Q3-Q4 serves as the overload signal memory (see figure 4-15). Each negative reset pulse, inverted by Q1, resets Q3-Q4 to overload not state by cutting off Q4. Because Q3 is conducting, the overload not state cuts off overload signal driver Q5. When the output rate from the vfc exceeds the overload threshold (which can range from 305 to 320 kHz), a positive pulse from the Q2 collector cuts off Q3, setting Q3-Q4 to overload state. With Q3 cut off in overload state, -35 volts turns on overload signal driver Q5 through R20 and R25. Conduction through Q5 clamps the overload line to ground, causing all of the actions noted in Section 3.4.

For serial prefix 501- through 605-, the overload signal memory is 4-layer diode CR6 (see figure 4-16). CR6 is turned on by a positive-going pulse coupled to its anode from the collector of Q1. Once it is turned on, CR6 continues conducting, clamping the overload logic line to ground (true) until its holding current is interrupted. CR6 is cut off and the overload indication is reset when a positive pulse is applied to the CR6, cathode through C7 and R13. The positive pulse is produced by grounding J1 (d) through an external contact closure. The negative-going reset pulse, which turns on Q2, produces the same effect as grounding J1 (d). The reset pulse is generated by assembly A18 or A7 as described in Sections 3.6.4 and 3.17.1.

3.4.2 Overload Detection

For serial prefix 610- and above, the overload detector is a blocking oscillator whose feedback is switched from negative to positive by the voltage output from a frequency-to-voltage converter (fvc). The threshold at which feedback switches from negative to positive is set by means of variable resistor R3 at approximately 310 kHz; the permissible range for this threshold is 305 to 320 kHz.

When the input voltage to the Voltmeter is increased, the vfc output frequency increases. As the vfc frequency increases, current through fvc diode CR2 reduces the negative charge across C5. At input frequencies below the threshold, the voltage at the cathode of CR3 is more negative than the voltage at the cathode of CR4. Because of this, the only feedback path from the collector to the base of blocking oscillator Q2 is negative, through windings 3 and 1 of T1. At the threshold frequency, the charge across C5 makes the voltage at the CR3 cathode less negative than the voltage at the CR4 cathode. Now the feedback path from the Q2 collector to base is regenerative, through windings 3 and 2 of T1. Noise initiates the blocking oscillator action of Q2, which generates trigger pulses for the overload detector memory.

So long as the overload condition keeps the cathode of CR3 less negative than the cathode of CR4, the blocking oscillator pulses will continue to trigger the overload signal memory. This action is repeated at a rate that is determined by the time constant of R5 and C4, assuring that the switching of the attenuator to 1000 volt range is not delayed by reset. Usually only a few pulses are generated before the attenuator is switched to the 1000 volt range, removing the overload.

For serial prefix 501- through 605-, the positive overload memory trigger pulse from the collector of Q1 is developed when current flows through the No. 2 winding of transformer T1. If the vfc is not overloaded, current flows only through the No. 1 winding of

T1. The conditions which determine when the current switches from winding No. 1 to winding No. 2 are the voltage levels existing at the cathodes of CR3 and CR4. The voltage at the cathode of CR4 is set to about -25 volts by potentiometer R2. The voltage at the cathode of CR3 is determined by the frequency of the pulses arriving at pin 1. These pulses, coupled through C1 and CR2, apply a positive charge across C10. Between pulses C10 charges negatively. The voltage across C10 thus depends upon the pulse frequency. For pulse frequencies less than 310 kc the voltage across C10 is such that the cathode of CR3 is more negative than the cathode of CR4 and current flows from ground, through R5, and winding No. 1. Random thermal noise voltages developed across R5 as a result of the current flow are coupled to amplifier Q1. The output of amplifier Q1 is transformer coupled back to winding No. 1. Because of the phase relation between the primary and secondary winding No. 1, the feedback voltage is out of phase with the input, resulting in cancellation of the noise voltage.

If the input pulse frequency reaches or exceeds 310 kHz, the voltage across C10 rises to a level that makes the cathode of CR3 more positive than the cathode of CR4. At this point the current switches from winding No. 1 to winding No. 2. The random noise voltage developed across R5 is now amplified and inverted by Q1 and coupled back to winding No. 2. The feedback from the primary to secondary winding No. 2 is in phase with the amplifier input. Regeneration quickly saturates the amplifier, generating a positive pulse large enough to trigger conduction of 4-layer diode CR6. The regenerative action also increases current to the point where the transformer core saturates and no longer provides the coupling action. This stops the regenerative action. Amplifier conduction then decreases, returning to the previous unsaturated condition. After a time delay that is essentially determined by the time constant of R5 and C2, the comparison circuit is ready to cycle again. This action continues as long as the overload, producing a train of positive-going pulses from the collector of Q1. Although only one pulse is required to turn on the 4-layer diode, the series of pulses prevents removal of the overload indication by resetting until the overload condition has been corrected. Usually only a few pulses are generated before the attenuator is switched to the 1000 volt range.

3.5 ATTENUATOR COUPLING LOGIC A8 AND 1V RELAY TIMING A7

3.5.1 Attenuator Coupling Logic A8 (Figure 4-13)

The attenuator coupling logic controls range programming relays K1 through K4 of attenuator assembly A28. During normal manual operation, the RANGE switch provides a ground connection through the FUNCTION switch to the input logic line for the desired range. During external programming, the ground connection must be provided at the correct pin of PROGRAM CONNECTOR J1, from which it is routed through an EXT SEL contact of the FUNCTION switch to the input logic line. For example, a ground connection to pin 12 of A8 programs the 100 volt range. Coupled through diode CR5, this causes transistor Q8 to conduct, energizing 100 volt range relay K4, provided that no overload condition exists and that no ac or ohms measurement using a HP-2410B is being made. This example is typical of operation of the other

range programming lines, except for the 0.1 volt range. When the 0.1 volt range is selected, relays K1 and K2 are both energized.

The detection of an overload by the circuit on A10 causes pins 2 and 13 of A6 to be grounded. The grounding of pin 13 energizes 1000 volt range relay K4. The grounding of pin 2, amplified by Q3 and Q4 and connected through diodes to the bases of gating transistors Q5, Q6, Q7, and Q8, cuts off current to range programming relays K1 through K4, causing them to de-energize.

When a HP-2410B is used with the HP-2401C for ac or ohms measurements, a ground is connected to pin 4 of A6 from the HP-2410B units coupling card, A9. This signal is used to turn on Q9, energizing the 1 volt range relay K2. Amplified by Q1 and Q2, this signal disables the other range gating transistors.

3.5.2 1 Volt Relay Timing A47 (Figures 4-13 and 4-29)

The 1 volt relay timing circuit on A47 times the energizing and de-energizing of 1V range relay K2 on A26 so that it and 1000 V range relay K5 are never energized at the same time. If K2 and K5 were energized at the same time, up to 1000 volts could be applied across attenuator resistor R42. For a brief period R42 would dissipate 100 watts, sustaining damage proportional to the duration of the overload.

When K2 is not programmed, conduction through Q1 discharges capacitor C2. When K2 is programmed, C2 initially presents a low impedance path while it charges. The long time constant charging of C2 holds K2 de-energized until all other relays, including K5, have had time to de-energize.

When the attenuator is switched from 1v to 1000v range, programming of relay K2 is interrupted. The energy stored in the coil of K2 discharges across capacitor C1 and resistor R1 and relay K2 de-energizes. The energizing of K5 is delayed, by capacitor C102 (across the K5 coil) until K2 has de-energized. At the same time, capacitor C2 of A47 is disconnected from the K2 relay coil by the reversal of voltage polarities across diode CR1. It is discharged by Q1 and thus has no effect upon de-energize timing of K2.

3.6 GATE CONTROL A17 AND DISPLAY CONTROL A18 (Figures 4-7 and 4-19)

Gate and display control assemblies A17 and A18 operate together to control the gating of voltage or frequency measurement pulses to input counter decade A11. They also control the display period and the transfer of each new measurement to the digital displays of the decade counters. These functions are performed as directed by the settings of the SAMPLE PERIOD switch and the SAMPLING RATE control.

3.6.1 Measurement Phase

The measurement/display cycle of the HP-2401C is illustrated in Figure 4-28. The measurement phase (sample period) of this cycle begins when

the decade divider output selected by the SAMPLE PERIOD switch is applied to start/stop input pin 4 of gate control assembly A17 via logic assembly A21. The positive-going part of the decade divider signal cuts off A17Q1 of gate flip-flop A17Q1-Q2. This opens a clamp to -1 volt that normally inhibits triggering of the first decade counter, A11. The next positive-going excursion of the time base input signal cuts off A17Q2, turning on A17Q1, blanking counter input triggers applied to A11 pin 10, and terminating the sample period.

3.6.2 Transfer to Digital Display

The positive-going voltage from the A17Q1 collector at the end of the sample period cuts off A18Q2 of transfer one-shot A18Q1-Q2. The one-shot remains in this unstable state (A18Q2 off, A18Q1 on) for about 70 milliseconds. During this period, storage gate amplifier A18Q3 is cut off, allowing the count of the decade binaries to be transferred to the display storage circuits. At the end of this period conduction through A18Q2 turns on storage gate amplifier A18Q3, which holds the new count until the next transfer pulse is triggered.

The previously-described transfer mechanism is effective only when STORE/DISPLAY switch S7 is in STORE position. When S7 is in DISPLAY position A18Q3 is disconnected and the states of the decade counter binaries are displayed at all times, not just after transfer.

3.6.3 Variation Duration Display Phase

The negative transfer pulse from the A18Q2 collector turns on A18Q4, cutting off A18Q5 of the display timing flip-flop. (Flip-flop A18Q4-Q5 is actually a one-shot whenever the SAMPLING RATE control is not switched to STOP position.) Duration of this unstable state, determined by the time constant of A18C8 and the setting of SAMPLING RATE potentiometer R204, may range from 0.2 to 7 seconds. Conduction through A18Q4 inhibits start AND gate A17C1-R3 of gate flip-flop A17Q1-Q2, by cutting off A18CR7 and A17Q4. This prevents the start of a measurement during the display period.

An external clamp to ground from a digital recorder, programmer, or other digital data processing device may be applied to J2 (22) to hold the display and recording outputs longer than the normal period. This clamp, coupled through A17CR9 to pin 10 of A18, holds A18Q5 off until it is removed.

3.6.4 Resetting

The negative-going trailing edge of the signal from the A18Q4 collector triggers a negative reset pulse via amplifiers A18Q6-Q7. This negative pulse resets decade dividers A1-A5, decade counters A11-A15 and A46, gate flip-flop A17Q1-Q2, and the overload signal memory on overload detector A10. After resetting, the measurement phase can be initiated as described in Section 3.6.1.

Current generator A17Q7 conducts additional bias to A18Q5 during the period between resetting and the start triggering of gate flip-flop A17Q1-Q2. This assures that A18Q4-Q5 remains in the stable "measurement enable" state until it is triggered to initiate the display period.

3.6.5 Manual Control of Measurement Phase

During manual operation, the automatic measurement/display control logic is bypassed. The starting and stopping of the measurement is controlled by the START and STOP positions of the SAMPLE PERIOD switch. The START and STOP positions both apply a clamp via the manual logic line and pin 10 that holds A18Q5 cut off, inhibiting triggering by the time base input from A21, pin 24. The positive START level cuts off A17Q1, starting the measurement. A negative level produced by switching to STOP position turns on A17Q1, stopping the measurement.

3.6.6 Reset-Triggered Measurement and Display

Switching the SAMPLING RATE control to STOP position converts A18Q4-Q5 to a flip-flop. The measurement-display cycle is then triggered by a positive-going reset pulse from the -35 volt regulator and reset card, A7. Through A18CR6 this pulse cuts off A18Q4, which turns on A18Q5, enabling the start triggering of gate flip-flop A17Q1-Q2 as described in Section 3.6.1. Transfer one-shot A18Q1-Q2 and display timing flip-flop A18Q4-Q5 are triggered as noted in Sections 3.6.2 and 3.6.3, except that A18Q4-Q5 continues to inhibit measurement until it is reset by a positive-going pulse from A7.

3.6.7 Record Signal Emitter Followers

Record signal emitter followers A17Q5 and A17Q6 couple the state of gate flip-flop A17Q1-Q2 to the digital recorder or other digital data processing device that may be connected to the BCD OUTPUT receptacle of the HP-2401C. During the sample period, A17Q5 clamps the -record command line to ground (positive true). A17Q6 clamps the +record command line to ground during the display period, when the bcd outputs of the HP-2401C are not changing.

3.7 100KHz OSCILLATOR AND SCHMITT TRIGGER A6 (Figures 4-7 and 4-11)

The internal time base standard for the counter section is generated by a 100kHz crystal controlled oscillator. The output of the oscillator is routed to the 100 KC STD switch, S6. The INT position of S6 connects the 100kHz oscillator output to a Schmitt trigger circuit. The output of the Schmitt trigger is a 100kHz square wave that is used to trigger the first decade divider (A1). A rear-panel BNC connector, 100 KC STD OUTPUT/INPUT, (J3), is connected via the INT position of switch S6 to the output of the Schmitt trig-

ger so that the internally generated 100kHz signal can be used externally. The EXT position of S6 connects receptacle J3 to the Schmitt trigger input. The Schmitt circuit may then be triggered by an external time base signal connected to J3.

3.8 TIME BASE DIVIDERS A1-A5 (Figures 4-7 and 4-10)

There are five identical time base dividers operating in series to divide the 100kHz time base frequency successively by ten. These dividers provide output frequencies of:

10 kHz —— Used to check operation of the counter section.
1 kHz
100 Hz
10 Hz —— Used for the standard 0.01, 0.1, 1 second sample periods.
1 Hz

Each decade divider consists of four cascaded transistorized binaries, such that the output of the first is coupled to the input of the second, and so on. Feedback networks are arranged on the binaries to provide 4-2'-2-1 binary code weighting and input-to-output division ratio of 10:1.

At the end of each counter display period the decade dividers are reset. During normal operation, when the sampling rate is determined by variable setting of the SAMPLING RATE control (i.e. 0.2 to 7 seconds), the reset pulse from the display control circuit (A18) resets the decade dividers (A1-A5) to 97033. This means that 2967 counts (or 29.67 milliseconds) are required before the outputs of the decade dividers can start another sample period. This delay allows A18C8 (the capacitor determining the 0.2 to 7 seconds display time) to discharge before the next display period starts. In the fast sampling mode of operation, when the SAMPLING RATE control is in the STOP position and resetting from A7 is used, the decade dividers are reset to 99033. This means that 967 counts (or 9.67 milliseconds) are required before the next count can start. This small delay provides attenuator switching time and settling time for the HP-2411A Guarded Data Amplifier, if used.

3.9 ATTENUATION CONTROL, INPUT AMPLIFIER, AND TRIGGER CIRCUIT A25-A27 (Figures 4-7 and 4-27 or 4-28)

When the HP-2401C is used for making direct frequency measurements, the input frequency is connected to the front or rear panel FREQ INPUT connector. It is then routed through the attenuation control circuit where the level of the input signal is adjusted by the ATTENUATION control to provide a reliable count. When the ATTENUATION control is in the CHECK position, the 10kHz frequency from the first decade divider, A1, is routed through the attenuation control circuit to be counted. The output of the attenuation control circuit is coupled through the input amplifier to the trigger circuit. The trigger circuit is a Schmitt trigger that provides a fast-rise, constant-amplitude output square wave which is routed through the counter logic on A19 to decade counter A11. The trigger circuit must be adjusted for pulse measurements (see Section 4.7.11).

3.10 REVERSIBLE 300 KHz DECADE COUNTERS A11-A15, A46 (Figures 4-7 and 4-17)

Six identical reversible decade counting units connected in series count input pulses and display the count as a six-digit number. The positive input triggers are coupled to the first counting decade, A11, through logic on A19 and a differentiating network. Gating of the triggers is controlled by A17 as described in Section 3.6.1.

3.10.1 Counting

The counting decades can count either forward or backward. The count direction is determined by the states of the count $\overline{\text{up}}$ and count $\overline{\text{down}}$ control lines from counter control assembly A16. Regardless of count direction, the feedback between the binaries is arranged to produce a count output in 1-2'-2-1 binary-coded-decimal (bcd) form. The bcd outputs from the decades are connected to the rear panel BCD OUTPUT receptacle J2.

Up Counting

The decades always count up during frequency measurements and during the first phase of voltage measurements. Up counting is enabled when the count $\overline{\text{down}}$ line is clamped to ground and the count $\overline{\text{up}}$ line is placed near negative 35 volts by the counter control logic on A16. This closes the down count AND gates and opens the up count AND gates. Positive triggers are coupled from the collectors of odd-numbered transistors (Q1, Q3, Q5, Q7) to succeeding stages. Each trigger advances the count by one. After the count reaches 9 and is then advanced to zero, the first decade generates a trigger which advances the count of the second decade, and so on through all six counting units. The waveforms associated with up counting are shown at the left of the dashed line in the Figure 4-17 waveforms diagram. The count progression is as follows:

Count	Even-Numbered Transistors On	BCD Output Table
0	NONE	0
1	Q2	1
2	Q4	2
3	Q2, Q4	1 + 2
4	Q4, Q8	2 + 2
5	Q2, Q4, Q8	1 + 2 + 2'
6	Q8, Q6	2' + 4
7	Q2, Q8, Q6	1 + 2' + 4
8	Q4, Q8, Q6	2 + 2' + 4
9	Q2, Q4, Q8, Q6	1 + 2 + 2' + 4
10	NONE	0 + a trigger to the next decade

Down Counting

The decades are commanded by the counter control logic to count down when the polarity of the input voltage reverses. The down count continues until a zero count is detected. Down counting is enabled when the count $\overline{\text{up}}$ line is clamped to ground and the count down line is placed near neg-

ative 35 volts by the counter control logic on A16. This opens the down count AND gates and closes the up count AND gates. Positive triggers are coupled from the collectors of even-numbered transistors (Q2, Q4, Q6, Q8) to succeeding stages. If the up count accumulated before reversal of the count commands is 10, it consists of zero states in the A11 decade, a 1 state in the A12 decade, and zero states in the remaining decades. The first down count trigger sets the A11 decade to the count of 9, which triggers the A12 decade to zero. The progression of the down count is the exact reverse of the up count progression.

3.10.2 Zero Detection

Decade counting units A11-A15 and A46 contain an 18-input AND gate (CR9, CR10, and CR13 of each decade) whose output is a positive-true inhibit if any of the decade binaries are in other than a zero state. All binaries in a decade are in zero state when the odd-numbered transistors (Q1, Q3, Q5, Q7) are conducting. When all binaries in the counting decades are in zero state, the zero detect line is no longer clamped to ground by conduction through an even-numbered transistor (Q2, Q4, Q8) in any of the decades. During a measurement period, removal of the clamp activates the zero detect logic of A16. In response to the detection of zero, the counter control logic commands up counting by the decades.

3.10.3 Display Section

The 4-2'-2-1 bcd output from the decade binaries is connected to neon lamps that are associated with a photoconductive translator matrix. The pattern of lighted neon lamps sets up a low-resistance path through the translator matrix that causes the correct numeral to light in the digital display tube. For example, a 5 count lights neon lamps DS1A, DS2A, DS3B, and DS4A. When decoded by the matrix, the lighted states of DS1A, DS3B, and DS4A light the 5 numeral in the display tube.

The position of STORE/DISPLAY switch S7 determines when each count is displayed. The DISPLAY position of S7 disconnects the store signal from the neon transfer line. This is used for continuous display of the binary states before, during, and after each count. The STORE position of S7 connects the store signal (a relatively low-impedance ground return) to the neon transfer line. The store signal is interrupted at the end of each count by a 70 millisecond transfer pulse that is generated on display control assembly A18. This interruption connects the binaries to the neon lamps. Restoration of the store signal at the end of the transfer pulse keeps the neon lamps on and off in the configuration established during the transfer pulse by providing a return path that is independent of the binaries.

3.10.4 Resetting and Presetting

Reversible decade counters A11-A15 and A46 are reset by a negative pulse applied to pin R. This reset pulse turns on all odd-numbered transistors (Q1, Q3, Q5, Q7), establishing the zero state.

Presetting is used for special data system applications. It involves applying a negative pulse to pins L, 6, F, and E of the various decades as required to achieve the desired initial count states. The negative preset pulse turns on the transistor(s) to which it is applied, establishing a preset count in standard 1-2-2'-4 bcd code as follows:

BCD Weighting	1	2	2'	4
Preset Pin	L	6	F	E
Transistor Turned On	Q2	Q4	Q8	Q6

3.11 UNITS/COUNTER INPUT LOGIC A19 (Figures 4-7, 4-9, and 4-20)

The units logic of A19 connects to the front-panel FUNCTION and SAMPLE PERIOD switches and provides signal outputs for lighting the units display, for decimal point logic assembly A20 and for blanking/time base selection assembly A21. The units logic is illustrated in Figures 4-9 and 4-20.

By means of positive AND gates the counter input logic determines whether the counter gate is controlled manually or by one of the standard sample periods. When voltage is to be measured, the $\overline{volt}$ signal at pin 15 of A19 is negative. This signal opens AND gate Q10 to the negative pulses that are received from the vfc via counter control assembly A16. These pulses are coupled through AND gate Q10 to units decade counter A11 through a trigger differentiating circuit. The positive triggers produced by this circuit are counted when the counter gate opens.

When the frequency of a signal is to be counted, the $\overline{freq}$ signal at pin 17 is negative. This signal opens AND gate Q11 to the positive pulses from the Schmitt trigger on A27. The output pulses from Q11 are routed to units decade counter A11 in the same manner as voltage pulses.

When opening and closing of the counter gate (flip-flop A17Q1-Q2) is manually controlled (SAMPLE PERIOD switch in START or STOP position), the $\overline{man}$ logic line is negative. This opens AND gate Q12 to the logic level on the start-stop logic line. When the SAMPLE PERIOD switch is set to START, the ground clamp output from Q12 sets A17Q1-Q2 to measurement enable state. When the SAMPLE PERIOD switch is set to STOP position, the negative-going voltage passed by the base-collector diode of Q12 turns on A17-Q1, setting A17Q1-Q2 to measurement inhibit state.

3.12 DECIMAL POINT LOGIC ASSEMBLIES A20 AND A30

3.12.1 Decimal Point Logic Assembly A20 (Figures 4-9, 4-21, and 4-32)

The decimal point lamps are controlled via a photoconductor assembly. (See Figure 4-33.) When a given decimal lamp is to light, the appropriate neon lamp (NE-1 to NE-5) in the photoconductor assembly is lighted by the decimal point logic circuits on A20. The light from the neon lamp reduces the resistance in the associated photoconductor, allowing the proper decimal lamp

in the decimal assembly to light. When an incomplete measurement program occurs, a signal from the blanking logic circuit on A21 lights NE-6, which prevents any of the other decimal lamp controlling neons (NE-1 to NE-5) from lighting. This in turn prevents lighting of any of the decimal points on the visual display. (The instrument is also switched to 1000v range resulting in a low reading when programming is incomplete.)

The decimal point logic circuitry, consisting of diode and transistor gates, translates the control settings for the various modes of operation to determine the proper decimal point position. This assures that the digital display is direct reading in volts, millivolts, or kilohertz. This logic also provides the correct decimal point placement for ac voltage measurements and resistance measurements when a HP-2410B is used with the HP-2401C.

The decimal point logic is illustrated in Figure 4-9. . . Essentially, the diode and transistor gates combine negative- and positive-true inputs to light one of the five neon lamps (NE1-NE5) in the photoconductor assembly. The positive-true input, a voltage range (0.1, 1, 10, 100, or 1000) for voltage measurements, completes an emitter ground for one or more of the transistor gates. A negative true input applied to the base of one of these transistor gates then produces a positive true collector output that lights the associated neon lamp. The negative true transistor AND gate input is assembled by a diode AND gate; it represents the removal of all positive true inputs, which are clamps to ground.

Decimal point placement is determined by the function measured (VOLT or FREQ), the voltage range (if VOLT function is selected), and the sample period. For example, when FREQ function is selected, transistor AND gates Q5, Q7, or Q9 are enabled via OR gate CR14-CR15. Selection of sample period determines which transistor AND gate opens and which neon lamp lights, as follows:

Sample Period	Transistor Gate Opened	Neon Lamp Lighted	Decimal Placement On Digital Display
.01 Sec	Q5	NE2	00000.0
0.1 Sec	Q7	NE3	0000.00
1 Sec	Q9	NE4	000.000

Only one neon lamp line can be positive at any one time; all other lines are negative. If none of the lines is positive, the output of negative AND gate CR24-CR28 is negative, indicating an incomplete program. This negative signal is coupled to logic on A21, causing the decimal point display to blank and the 1000v attenuator relay to energize.

3.12.2 HP-2411A Decimal Point Logic Card A30 (Figure 4-31)

Logic card A30 provides for correct positioning of the decimal point when the HP-240 C is used with a HP-2411A Guarded Data Amplifier. The logic shifts the decimal one place to the left, or two places to the right while lighting the MILLI portion of the MILLIVOLTS display, when the HP-2411A is set for +10 gain.

As an example of the A30 logic, assume that the HP-2401C is programmed for 1V RANGE and .01 SEC SAMPLE PERIOD. This grounds the emitters of AND gates Q9, Q10, and Q11 via the NE4 logic line and A20. When the HP-2411A is set for +1 gain, the false state (near -35 volts) of the X10 logic line turns on Q1, grounding the $\overline{X10}$ logic line and closing AND gates Q9 and Q11. AND gate Q10 is opened, lighting NE-4 on the photoconductor assembly. When the HP-2411A is set for +10 gain, Q1 is cut off and Q2 conducts. This closes Q10 and leaves Q9 and Q11 subject to the false state of the millidrive line, which turns on Q3, grounding the $\overline{\text{millidrive}}$ line and closing AND gate Q11. AND gate Q9 is opened, lighting NE-2. This decimal shift two places to the right is matched by the lighting of the MILLI portion of the MILLIVOLTS display because the grounding of the X10 line is coupled to the millidrive output line through OR diode CR1. When .1V RANGE and 1 SEC SAMPLE PERIOD are selected, the NE4 and millidrive lines are both true (near ground). When the X10 line is also true, gates Q9 and Q10 are closed and Q11 is opened, lighting NE-5. This decimal shift one place to the left converts the 000.000 MILLIVOLTS display to 00.0000 MILLIVOLTS display.

If HP-2411A Decimal Point Logic card A30 is not installed in the HP-2401C, a jumper board is installed in receptacle XA30. The connections completed by this board are shown in the upper right corner of Figure 4-31.

3.13 BLANKING LOGIC/TIME BASE SELECTION A21 (Figures 4-7, 4-9, and 4-22)

The blanking logic/time base selection circuitry combines appropriate operating logic signals to blank the decimal point lamps on the display and energize the 1000v attenuator range relay when programming is incomplete. It also selects one of the three standard time base frequencies (100 Hz, 10 Hz, or 1 Hz) to gate the counter section when using one of the standard sample periods.

If programming is incomplete, assembly A20 provides no output for lighting any of decimal neons NE1-NE5; therefore, none should be lighted. Nevertheless, additional logic is required to program the 1000v range. Logic is also provided to blank the decimal neons without programming the 1000v range.

When no decimal neon is programmed from A20, a negative signal from A20 pin 6 to A21 pin 17 and the "false" state of the freq • man logic line produce a positive output from AND transistor Q5. This output lights NE6 on the photoconductor block, inhibiting the lighting of any of NE1-NE5. This output also programs the 1000v relay logic line, setting attenuator A28 to 1000v range.

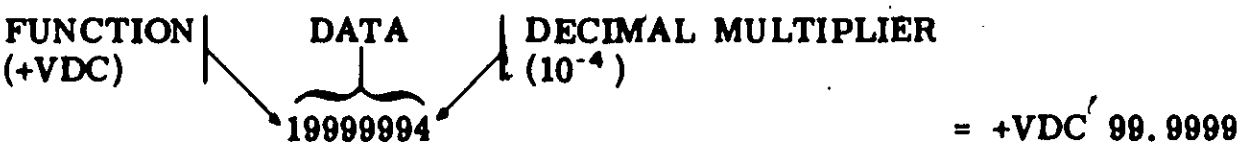
The "true" state of the freq • man logic line, coupled through diode CR6, lights NE-6. This blanks all decimal neons but does not switch A28 to 1000v range because AND transistor Q5 is cut off through CR8.

The time base selection circuitry selects one of three standard time bases by opening one of three positive AND gates connected to the time base out-

puts of the decade dividers. For example, if a .01 SEC sample period is selected, the input at pin 16 of A21 will be negative (indicated by .01 SEC). (See Figure 4-7.) This signal opens AND gate Q7. When the 100 Hz signal from the decade divider goes positive, AND gate Q7 provides a positive output. This output is coupled through a positive OR gate to the gate control circuit on A17.

3.14 PRINTER COUPLING A22 (Figures 4-9, 4-23, and 4-24)

The printer coupling circuit translates decimal position, range, and function information to appropriate bcd codes for digital recording. The decimal position is a number from 0 through 7. This number (n) stands for a negative power of ten multiplier (i.e., 10^{-4}) that indicates the position of the decimal point on the recorded measurement for the selected units. A sample digital printout follows:



Function coding is shown in Table 2-5.

The decimal position information is received from the outputs of the standard decimal point logic assembly A20, (and HP-2411A Decimal Point Logic Card A30 if installed) and then interpreted by the logic networks on A22. The decimal point logic network on A22 translates millivolt readings on the HP-2401C display to equivalent readings in volts for the recording output. For example a reading of +0001.23 MILLIVOLTS on the HP-2401C is recorded as 10001235, indicating that the function is +VDC and the decimal point is five places to the left (i.e., 0.00123).

3.15 HP-2410B AC AND OHMS GATE DELAY A23 (Figure 4-25)

The ac and ohms delay gate delays measurements as required when a HP-2410B AC/Ohms Converter is used with the HP-2401C. The delays provided differ with the type of measurement, as follows:

Type of Measurement	Delay (Milliseconds)
AC (Normal)	500-550
AC (Fast)	200-220
Ohms	100-110

The programming of a measurement using the HP-2410B cuts off Q2 through OR diode CR5, CR6, or CR7, opening AND gate Q2-CR8. Each negative reset pulse from the reset bus is then passed through the AND gate, triggering flip-flop Q3-Q4. The negative-going output from the Q4 collector is coupled through emitter follower Q1 to a resistance-capacitance (r-c) delay circuit. The negative output from the Q1 emitter allows capacitor

C1 of the r-c delay circuit to charge negatively at a rate that is determined by circuit resistance.

When the negative voltage across capacitor C1 reaches a certain level, the flip-flop is driven to its original state. The delay time required for this action is determined by the measurement function that is programmed. When ohms is programmed, resistors R1, R2, and R3 are effectively connected in parallel through diodes CR2 and CR4, thus providing the minimum delay of 100-110 milliseconds. When AC Fast is programmed R2 and R3 are in parallel, providing a longer delay of 200-220 milliseconds. When AC normal is programmed, R3 determines the longest delay, which is 500-550 milliseconds.

While the flip-flop is in the reset-triggered delay state, a negative-going pulse, coupled via non-inverting amplifier Q5, blanks the trigger input to the second time base divider, A2. The transition of Q3-Q4 to non-delay state triggers the 4-millisecond one-shot, Q6-Q7. The output pulse from the Q6 emitter prolongs the measurement delay an additional 4 milliseconds. After this delay the, time base sample gate is generated as usual.

3.16 HP-2410B UNITS COUPLING A9 (Figures 4-9 and 4-14)

The HP-2410B units coupling circuit is required when a HP-2410B AC/Ohms Converter is used. This circuit interprets the programmed range and function inputs and provides output signals to light the appropriate units and decimal on the digital display.

When the 10 megohm range is programmed by a ground connection to pin 15 of A9, the signal is coupled through A9 to light the "MΩ" lamp on the units display, and to the 10 volt logic line to position the decimal point on the digital display. At the same time, this signal is coupled through a positive OR gate to cut off transistor AND gate Q3 so that the "KΩ" lamp cannot be lighted. The blanking of the KΩ lamp is necessary, because whenever the 10 megohm line is programmed, the ohms line is also programmed. This would ordinarily allow Q3 to conduct, lighting the KΩ lamp. When the ohms line is programmed, the "VOLT", "MILLI" and polarity lamps are blanked.

The KΩ lamp will light under measurement conditions equivalent to those which light the VOLT lamp when voltage measurements are made. This requires that the 10 megohm and milli-drive lines not be programmed (i.e., negative) and that the ohms line be programmed (i.e., positive). The ohms line is always programmed for resistance measurements.

The "Ω" lamp lights when the milli-drive and ohms lines are positive and when the frequency and manual gate lines are negative. (The Ω lamp is equivalent to the MILLI and VOLTS lamps when voltage measurements are made.)

The programming of AC measurements grounds pin 8, lighting the AC lamp. The programming of either AC or ohms measurements has two additional effects. The polarity blanking amplifier, A16Q24, is cut off, blanking the polarity outputs from the counter control assembly. The positive true (ground)

state of the AC or ohms logic line is connected to the attenuator coupling logic on A8, energizing 1v range relay A28K2 and causing all other attenuator range relays to be de-energized. This is done because all measurements made with the HP-2410B must use the 1v range of the HP-2401C.

3.17 -35 VOLT REGULATOR AND RESET CIRCUIT A7 AND +6V BIAS CIRCUIT A29

3.17.1 A7 Reset Circuit (Figures 4-7 and 4-12)

The reset circuit on card A7 is designed to provide counter section reset pulses in response to pulse or contact-closure reset triggering. Pin 12 of A7, the closure input to the reset circuit, is connected to the front-panel RESET pushbutton and to pin "c" of rear-panel PROGRAM CONTROL connector J1. When pin 12 is grounded, a Schmitt trigger, Q4-Q5, is flipped after a delay of approximately 3 milliseconds. This delay is caused by an integrating network, R17-C2 which discharges toward ground when pin 12 is grounded. This network smooths out irregularities in the input signal caused by contact bounce, preventing the triggering of multiple reset signals. When the voltage across C2 reaches the emitter bias level, the Schmitt trigger is flipped as Q4 is cut off. The output of the Schmitt trigger is a fast-rising, positive-going pulse which is coupled out pin 9 to reset the display timing flip-flop on A18 to the non-display state. The Schmitt trigger output, amplified and inverted by Q7, is also coupled out pin 8 as a negative pulse to the reset buss. This pulse resets the decade counting units, the decade dividers, and the overload detector.

Pin 14 of A7 is a second input to the reset circuit that is connected to the rear panel COUNTER RESET receptacle J4. The reset circuit is designed to respond to a negative 15-volt, 25-microsecond reset pulse with a rise-time of less than 2 microseconds. The pulse reset signal is assumed to be much cleaner than a contact closure signal applied at pin 12, and therefore the pulse is simply amplified and inverted by Q6 and Q7 and coupled out pins 9 and 8 as previously mentioned.

3.17.2 A7 -35 Volt Regulator (Figure 4-12)

The -35 volt regulator provides regulated -35 vdc power for the transistorized circuits of the HP-2401C and the bcd reference level voltages that are required by an HP562A Digital Recorder. The + reference on pin 4 of A7, approximately -2 vdc, is the reference for a binary "1". The - reference on pin 6, approximately -25 vdc, is the reference for a binary "0". These reference levels are connected to rear-panel BCD OUTPUT receptacle J2.

The -35 volt regulator circuit consists of a differential amplifier, Q2-Q3, and an emitter follower, Q1. The output from Q1 is coupled externally by a chassis-mounted emitter follower, Q3, to series regulators Q1 and Q2. The series regulators are on a chassis-mounted heat sink. The regulator output is set at -35 volts by means of variable resistor R10. Differential

amplifier Q2-Q3 compares the potential tapped by R10 with that developed across resistor R6. Output voltage variations, coupled through breakdown diode CR1, amplified and inverted by Q2-Q3, and coupled by Q1 provide the negative feedback that regulates the -35 volt output. The negative feedback from the amplifiers on A7 increases or decreases conduction through the chassis-mounted series regulators enough to correct variations of output voltage almost completely.

3.17.3 A29 +6V Bias Circuit (Figure 4-12)

The +6v bias circuit on card A29 supplies regulated positive 6 vdc bias to counter control card A16 and reversible counting decades A11-A15 and A46. In addition, rectifier-filter circuits mounted on this card (A29) provide unregulated +150 vdc and -150 vdc outputs to the digital and decimal displays.

The +6 volt reference is provided by voltage breakdown diode CR3. The potential dropped across CR3 is coupled to the +6 volt bias line by emitter follower Q1.

3.18 POWER SUPPLY FILTER A36, SERIES REGULATOR A34, AND CALIBRATION STANDARD A35 (Figure 4-32)

3.18.1 Filter Board A36

Filter board A36 supplies rectified and filtered dc voltages to series regulator assembly A34 and to calibration standard assembly A35. It also provides rectified and filtered 300 vdc to the photochopper driver oscillator on A31.

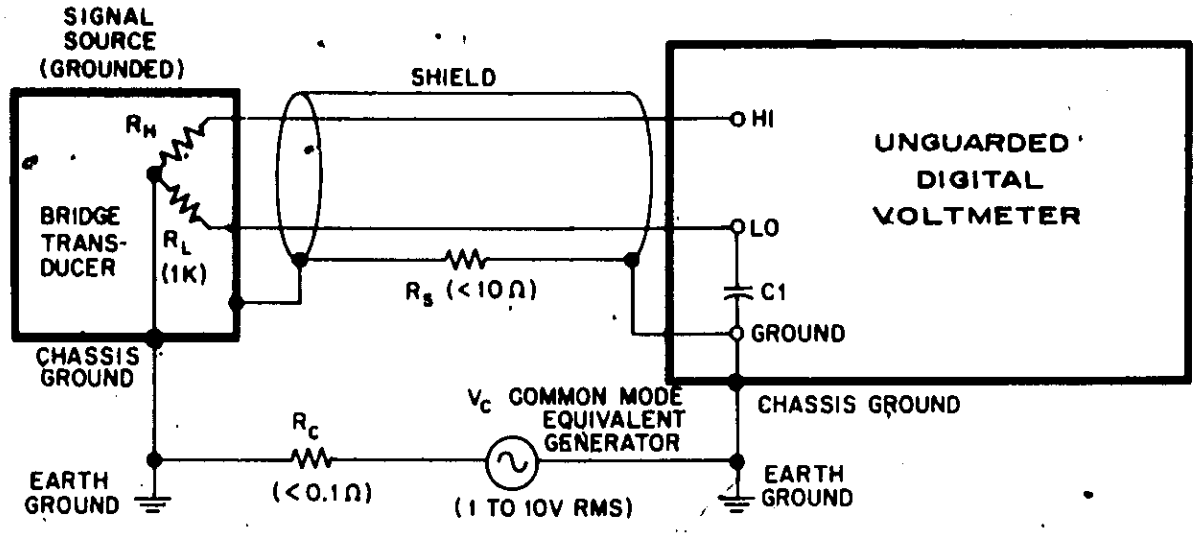
3.18.2 Series Regulator Assembly A34

The series regulator assembly contains the circuits that control the positive and negative 12.3 vdc outputs of the HP-2401C power supply. These outputs power vfc assemblies A31, A32, and A33. The series regulators perform this function in response to inputs received from calibration standard assembly A35.

3.18.3 Calibration Standard Assembly A35

The calibration standard assembly contains the calibration standard supply and amplifiers that control the positive and negative 12.3 vdc series regulators. These circuits are discussed separately in the following paragraphs.

The negative 12.3 vdc output from the power supply is set by potentiometer R9. Output voltage variations are fed back to series regulator A34Q1 through differential amplifiers Q11 and Q1-Q2 and dc amplifier A34Q2. DC amplifier A34Q2, on series regulator card A34, provides the inversion nec-

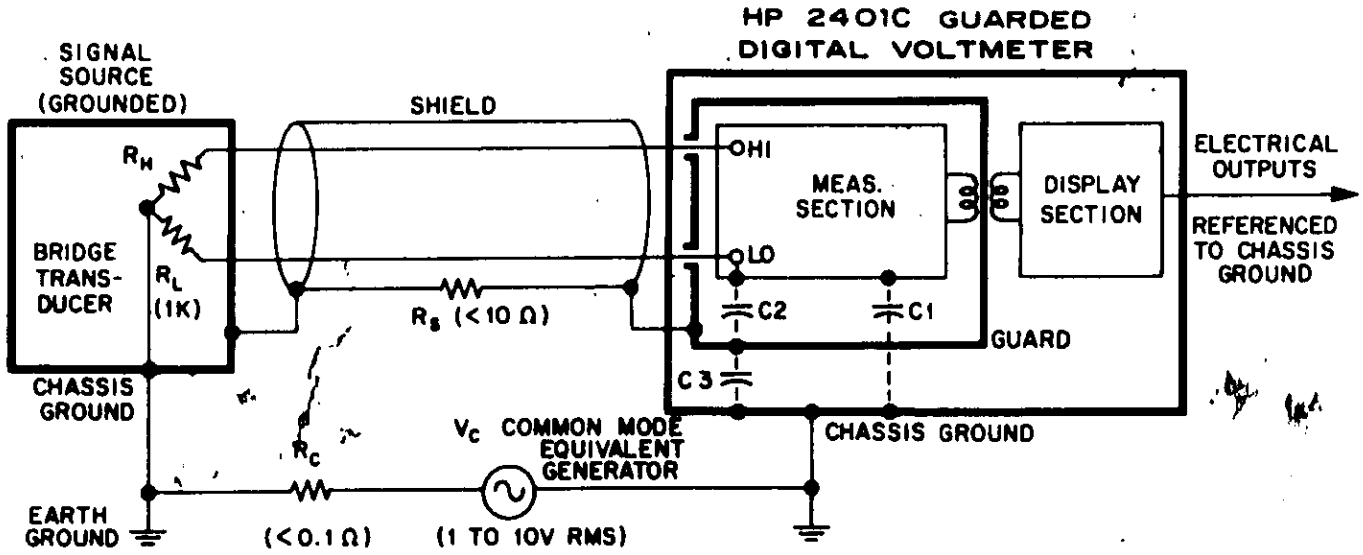


R_L = Source ground leg resistance.

R_S = Shield or ground bus resistance.

C1 = Capacitance, measuring circuit to chassis ground (typically 0.1 μf).

Figure 3-4. Typical Unguarded Input Circuit



C1 = Stray capacitance, measuring circuit to chassis (< 2.5 pf).

C2 = Stray capacitance, measuring circuit to guard (.002 μf approx.)

C3 = Stray capacitance, guard to chassis (.002 μf approx.)

Figure 3-5. HP-2401C Guarded Measurement Technique

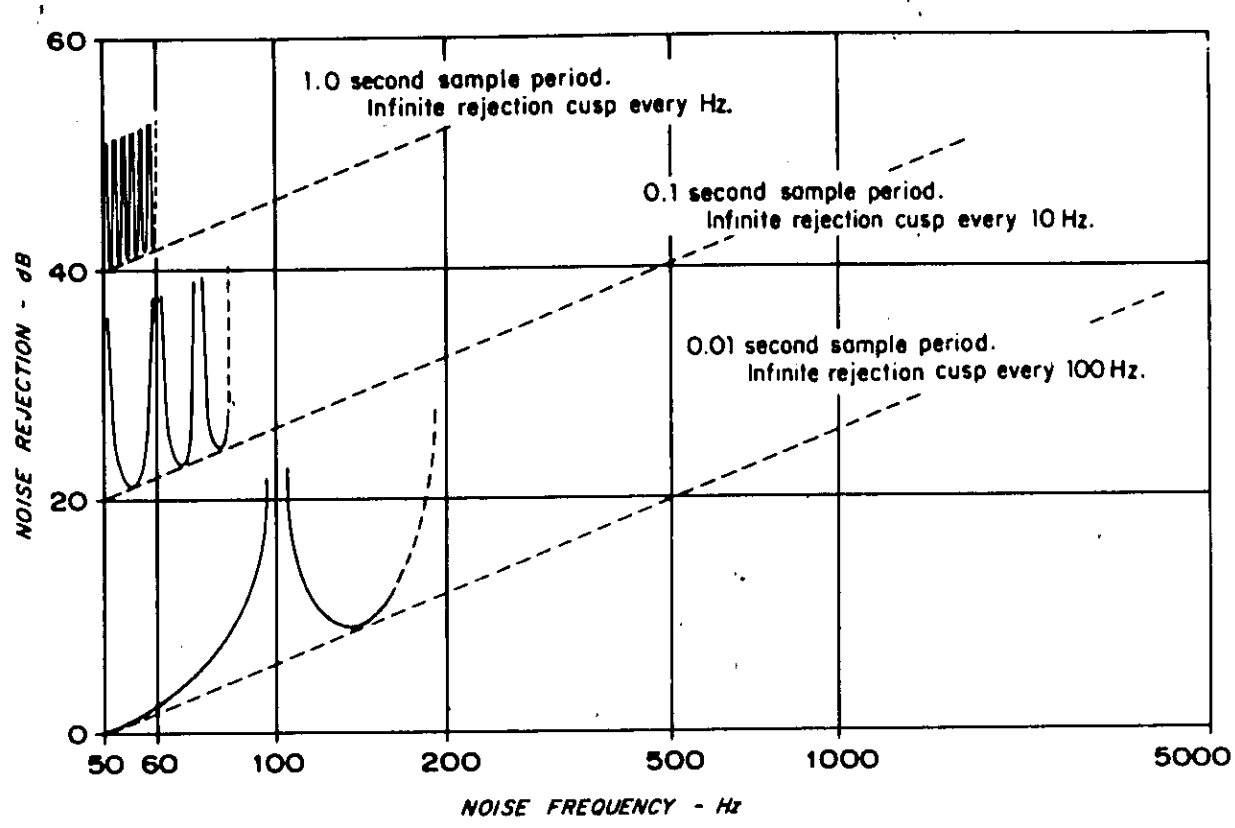


Figure 3-6. Rejection of Superimposed Noise

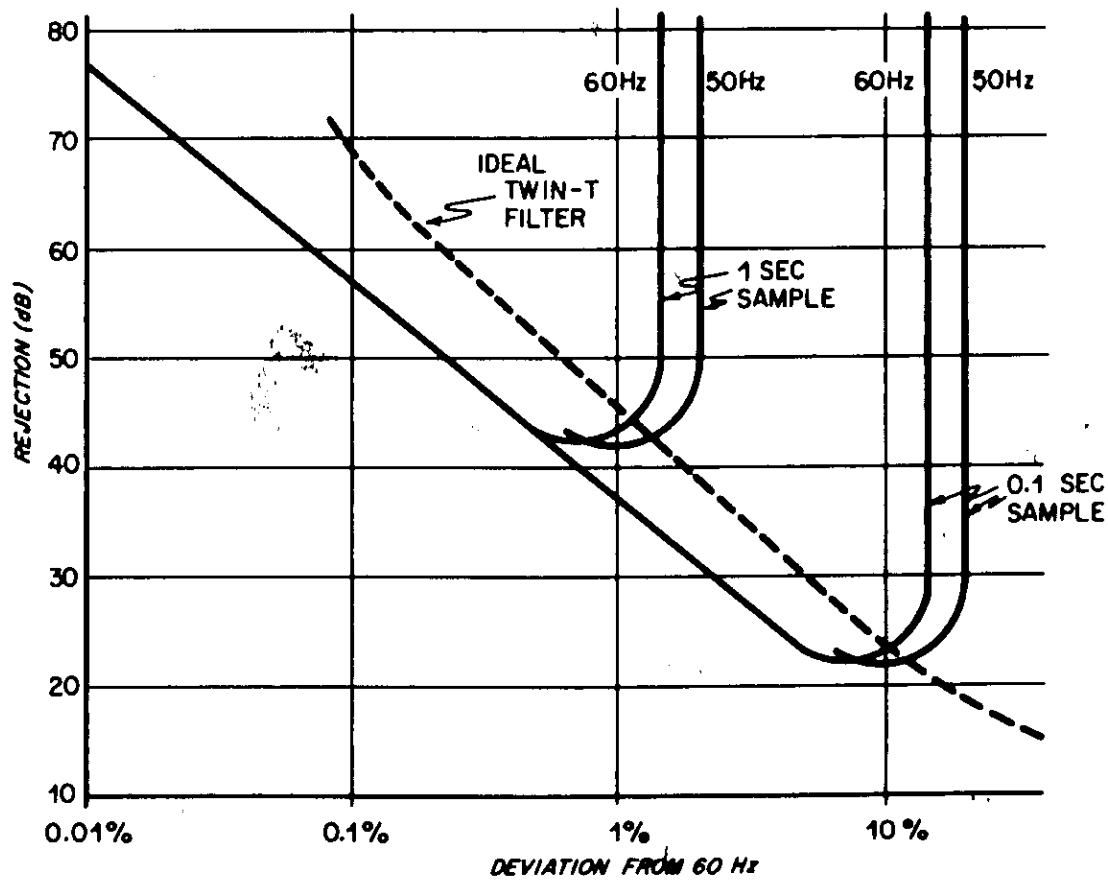


Figure 3-7. Rejection Around 60 or 50 Hz

essary for negative feedback and regulation of the negative 12.3 volt output potential. The voltage reference of the negative 12.3 volt regulator amplifier is provided by avalanche diode CR1, in the base circuit of Q10.

The positive output voltage from the power supply is set by the negative output voltage, which is used as the reference for the positive regulator amplifier. The output voltage from the positive supply is held approximately equal in magnitude to that from the negative supply by emitter follower Q9, dc amplifier Q8, and series regulator A34Q3. Equal positive and negative voltages applied across divider R25-R26 place the Q9 base-emitter near ground potential. This allows conduction through dc amplifier Q8, which biases series regulator A34Q3 to conduct the load current required from the +12.3 vdc power supply circuit. Variation of the +12.3 vdc supply output potential with respect to the negative output is amplified and inverted by Q8. Negative feedback from the Q8 collector to series regulator A34Q3 largely corrects output voltage variations. Any increase or decrease of the negative output voltage establishes a new reference that causes a corresponding increase or decrease of the +12.3 vdc output potential. The positive regulator operates to keep the Q9 base emitter near ground potential, which is the operating point of dc amplifier Q8.

The calibration standard circuit consists of voltage reference diode CR3, which is aged and selected for less than ±0.006% drift in six months. The reference potential developed across this diode is compared with the output from series regulator Q4 by differential amplifier Q6. The inverted output from the collector of Q6A is coupled without inversion through a second differential amplifier, Q3-Q5, to series regulator Q4. The negative feedback thus provided holds the series regulator output voltage constant. This output is applied across a drift-compensated voltage divider network, from which is tapped the 1 volt output of the calibration standard.

3.19 REJECTION OF COMMON MODE AND SUPERIMPOSED NOISE

3.19.1 Rejection of Common Mode Noise

Common mode voltages are those dc and ac voltages that are common to both input leads of the Digital Voltmeter. These voltages result when the signal source ground and the Digital Voltmeter ground are not at the same potential. The potential difference between the signal source and the Digital Voltmeter grounds is the common mode voltage source. Unless precautions are taken, the common mode voltage source will cause unwanted currents to flow through the signal source impedance, producing a significant error in the signal voltage measurement. The proper way to eliminate this error is to break the common mode ground loop. In the HP-2401C the ground loop is broken by a technique known as guarding, in which the input to the Digital Voltmeter is completely isolated from the chassis and its associated ground.

Figure 3-4 shows a typical unguarded circuit where the common mode voltage source is represented by V_C. The ground loop currents of concern are

those through the LO input side of the Digital Voltmeter (i.e., through R_C, R_L, C1); currents through the HI side are insignificant because of the high input impedance. With a typically large value of C1 (0.1 μf) and R_L = 1K, the common mode rejection (defined as the ratio between the common mode signal and the voltage it causes to be superimposed on the signal source) is limited to about 29 db at 60 Hz. The common mode pickup can be minimized by utilizing a shield to shunt the common mode current path, but the additional rejection obtained is negligible because of the low value of R_C with respect to the shield resistance.

Figure 3-5 shows the guarded input circuit used in the HP-2401C. In this instrument the common mode ground loop is broken by using a separate "guard" shield to isolate the analog part of the measuring circuit from the chassis. Except for a slight voltage drop in R_S, the guard operates at the potential of the signal source, resulting in a negligible current through C2 and thus a negligible current through R_L. The circulating ground current forced by V_C is now effectively shunted away from the measuring circuit and flows through R_S and C3. By utilizing the guard shield the leakage capacitance (C1) between the measuring circuit and the chassis has been reduced to less than 2.5 picofarads. Reduction of C1 to this low value yields a common mode rejection of 120 db at 60 Hz (160 db at dc) even when the value of R_L is as much as 1000 ohms.

3.19.2 Rejection of Superimposed Noise

Superimposed noise voltages are primarily those unwanted ac signals that are superimposed on the input signal, usually as a result of electromagnetic pick-up from any ac field. When this occurs, the superimposed noise is added directly to the signal to be measured. Techniques used to combat common mode noise will not eliminate this type of noise since there is no ground loop to break. The problem of superimposed noise is effectively dealt with in the HP-2401C by the process of integration, in which the input signal is integrated over a preselected sample period to obtain an average reading. If the period of the superimposed noise is such that its average value over the selected sample period is zero, no error results in the reading. For example, the fixed sample periods in the HP-2401C are multiples and submultiples of one second, and the average value of 60 Hz ac noise over a one second interval is zero. As a result the instrument provides infinite rejection at 60 Hz.

Figure 3-6 shows a graph of rejection versus noise frequency at three different fixed sample periods. Note the infinite rejection cusps such as occur at 60 Hz At other frequencies, for example at 55 Hz over a 0.1 sample period, 20 db of rejection is obtained. The rejection increases 20 db per decade (6 db per octave) increase in frequency.

Noise rejection characteristics around 60 (or 50) Hz for 1 second and .1 second sample periods are shown in Figure 3-7. As indicated, rejection is never more than 25 db poorer than that provided by an ideal Twin-T filter. With respect to the filter characteristic, rejection provided by the HP-2401C improves with increasing deviation from 60 Hz.

MAINTENANCE

SECTION IV
CONTENTS

ILLUSTRATIONS (Cont'd)

NOTE: Figures 4-10 through 4-32 are illustrations for the board assemblies and include a schematic diagram on the right-hand page and parts location diagram(s) on the facing page.

SECTION IV
MAINTENANCE

4.1 GENERAL

This section contains instructions for maintenance and servicing of the HP-2401C Integrating Digital Voltmeter. Included are instructions for in-cabinet performance checks, air filter servicing, troubleshooting, instrument cover removal, repair, and calibration. These instructions are supplemented by a list of recommended test equipment (Table 4-1), a maintenance schedule (Table 4-2), test setup, troubleshooting, logic, parts location illustrations, and schematic diagrams (Figures 4-1 through 4-34).

4.2 IN-CABINET PERFORMANCE CHECKS

The In-Cabinet Performance Checks, Table 4-3, may be used to verify specifications of the equipment. The Performance Check Test Card, which follows Table 4-3, may be used as a permanent record of the instrument's performance when filled out. Values or answers in parenthesis below or to the right of test card entry blocks specify correct reading or reading tolerance. The entry numbers on the card correspond to the checks in Table 4-3. The checks in Table 4-3 and in Section 2.2 verify correct operation of all circuits in the HP-2401C and may be used:

a. as part of an incoming inspection check of instrument specifications;
b. periodically, as specified in Table 4-2;
c. as part of a troubleshooting procedure to locate malfunctioning circuits;
d. after repairs or adjustments, before returning the instrument to regular service.

During the Performance Checks the HP-2401C should be connected to the ac line through a variable voltage device so that line voltage may be varied ±10% from nominal (115 or 230 vac) to assure that the instrument operates correctly at various supply voltages.

Table 4-1. Recommended Test Equipment (Sheet 1 of 3)

Instrument Type	Required Characteristics	Use	Recommended Model
DC Standard	0-1, 0-10, 0-100, 0-1000 vdc outputs accurate to ±0.01% stability ±0.003%.	Performance check and calibration.	HP-740A or HP-740B DC Standard Differential Voltmeter with 11054A and 110-55B Accessory Cables

Table 4-1. Recommended Test Equipment (Sheet 2 of 3)

Instrument Type	Required Characteristics	Use	Recommended Model
Standard Frequency Source	100kHz, 1 Hz outputs accurate to ±5 parts in 10^8.	Performance check and calibration of counter time base.	HP100E Frequency Standard
Oscilloscope	10-MHz bandwidth, dual-trace plug-in, calibrated time base and vertical channel, ext sync capability.	Observe waveforms and measure timing relationships during performance checks, troubleshooting, and calibration.	HP-175A Oscilloscope HP-1750A or HP-1750B Dual-Trace Amplifier HP-10003A Voltage Divider Probe (2)
DC Null Voltmeter	Low range 0-3 μv, infinite impedance at null, operation independent of ac line.	Null sensing and voltage measurements during performance checks and calibration.	HP-419A DC Null Voltmeter
Precision Volt Box	1:1, 10:1, 100:1, 200:1, 300:1, 400:1, 500:1, 600:1, 700:1, 800:1, 900:1, 1000:1 resistance ratios accurate to ±.001% at 1000 Ω/v.	Performance checks and calibration.	Julie VDH-1000 or VDN-1000 Precision Voltage Divider
Variable Line Voltage Source with Meter	Variable from 103-127 vac (or 207-253 vac).	Performance checks.	
1 Volt Calibration Standard	1 vdc output calibrated from primary standard to ±0.001% accuracy or better.	Transfer standard for performance checks and calibration.	HP-735A Transfer Standard
Isolation Transformer	50-60 cycle, 115v primary, 1:1 ratio.	Common mode noise rejection check.	
Portable Oscillator	Sine wave output from 5 Hz to 300 kHz, operation independent of ac power line.	Performance checks and calibration.	HP-204B Portable Oscillator
Test Oscillator	Sine wave output from 300 kHz to 1.2 MHz.	Performance check of M29.	HP-650A or HP-651B Test Oscillator

Table 4-1. Recommended Test Equipment (Sheet 3 of 3)

Instrument Type	Required Characteristics	Use	Recommended Model
AC Vacuum Tube Voltmeter	10, 30, 100, 300 mv ranges, measurement of rms voltage.	Performance check of superimposed noise rejection.	HP-400D VTVM
Pulse Generator	-1v, 2 μs pulse output at 1 kHz.	Performance check of frequency measurement sensitivity to pulse input.	HP-212A or HP-8003A Pulse Generator
Square Wave Generator	Square wave output from 1 Hz to 20 kHz, 27v p-p from 600Ω output.	Performance check of pulsed counter resetting from external source.	HP-211A Square Wave Generator
BNC "T" Adapter			HP-1250-0072
Electronic Counter	Time interval measurements at 10 μs resolution.	Response time and measurement speed performance checks.	HP-523C or D or 5233L Electronic Counter

Table 4-2 Maintenance Schedule

Interval	Maintenance Operation
Daily or Each Turn-On	For maximum accuracy of measurements perform preoperational check and calibration per Section 2.2.
Weekly	Verify accuracy of internal time base per check 3 of Table 4-3. If necessary, calibrate internal time base per Section 4.7.5.
Monthly*	Clean air filter per Section 4.3.
Every 6 Months	Calibrate internal 1v reference per Section 4.7.4. Perform checks 1 through 11 in Table 4-3. If necessary, calibrate overload detection per Section 4.7.3; calibrate input attenuator per Section 4.7.8.

*Shorten this interval if the instrument is operated more than 80 hours per month or if it is operated in a shop environment where no special care is taken to minimize airborne vapors and dust.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 20 Instruments (Sheet 1 of 15)

1. VOLTAGE MEASUREMENT RANGES

Full Scale Ranges: 0.1, 1, 10, [illegible], 1000V.
Overranging: To 300% of full scale except on 1000V range.
Overload Protection: HP-2401C switches to 1000V range at 310% (308-315%) of full scale.

a. Set HP-2401C Power switch to ON, other controls as follows:

FUNCTION:	VOLT.
RANGE:	1000V.
SAMPLE PERIOD:	1 SEC.
SAMPLING RATE:	Clockwise from STOP.
100 KC STD (rear panel):	INT.

b. Refer to Figure 4-1 and connect the + and - OUTPUT terminals of the DC Standard to the HI and LO terminals of the HP-2401C. Jumper the GUARD terminal to the LO terminal.

c. Turn on the DC Standard and set it to provide dc outputs as listed below; the HP-2401C readouts should be approximately as follows:

DC Standard Output (Volts)	HP-2401C Range (Volts)	Approximate HP-2401C Display	
1000	1000	+1000.00	VOLTS
100	100	+100.000	VOLTS
10	10	+10.0000	VOLTS
1	1	+1000.00	MILLIVOLTS
0.1	0.1	+100.000	MILLIVOLTS

d. Check HP-2401C overranging operation as follows:

DC Standard Output (Volts)	HP-2401C Range (Volts)	Approximate HP-2401C Display	
0.3	0.1	+300.000	MILLIVOLTS
3	1	+3000.00	MILLIVOLTS
30	10	+30.0000	VOLTS
300	100	+300.000	VOLTS

e. Increase DC Standard output voltage slowly until OVERLOAD indicator lights on HP-2401C digital display. Set HP-2401C RANGE switch to 1000V and record reading, which should be +312.5 ± 7.5 VOLTS. If incorrect, calibrate overload detection per Section 4.7.3.

2. VOLTAGE MEASUREMENT - INTEGRATION

The HP-2401C displays the true integral of the input signal with correct polarity even if the signal crosses through zero during the sample period.

a. With HP-2401C on and operating, set controls as follows:

SAMPLE PERIOD:	STOP.
STORE/DISPLAY (rear panel):	DISPLAY.
FUNCTION:	VOLT.
RANGE:	INT-1V.

b. Set HP-2401C SAMPLE PERIOD switch to START until 6-digit negative count is accumulated; then set switch to STOP.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 2 of 15)

2. c. Set HP-2401C RANGE switch to INT+1V and reset SAMPLE PERIOD switch to START. Observe counting down to zero (visible on the two most significant digits), reversal of polarity indication to +, and count up of +voltage. Set SAMPLE PERIOD switch to STOP and record observations.

NOTE
If it is desired to view this process in greater detail, apply an input voltage that is about 1/10 or 1/100 of the full scale range selected. After the initial count is accumulated, reverse this input.

3. INTERNAL TIME BASE

Frequency: 100 kHz.
Stability: Aging Rate $<\pm 2$ parts in 10^6 per week.
Temperature $<\pm 100$ parts in 10^6 over range of 10-50°C.

a. Turn on HP-2401C, the Frequency Standard, and the Oscilloscope; note time.

b. Set 100 KC STD switch on rear of HP-2401C to INT position.

c. Connect a BNC cable from the 100 KC STD OUTPUT/INPUT receptacle, J3, on the rear of the HP-2401C to a vertical input of the Oscilloscope.

d. Synchronize the Oscilloscope externally from the 1 cps output of the Frequency Standard.

e. Set Oscilloscope for display of the 1.2V p-p, 100 kHz square wave time base output from the HP-2401C at 1 μSEC/CM sweep rate.

f. After the HP-2401C has been operating for at least an hour, observe square wave display on Oscilloscope to determine degree of drift, if any. Left drift is -, right drift is +.

g. The horizontal drift of the square wave in CM/SEC is the difference between the Standard Frequency and the Counter time base frequency in parts in 10^6. Determine this difference and record it on the Performance Check Test Card.

NOTE A
Temperature must be within ±5°C of the temperature at which internal time base oscillator was calibrated. If a record of the temperature and date of last calibration is not available, the frequency offset should not be considered drift or aging rate of the 100 kHz crystal.

NOTE B
If drift of the internal time base is greater than ±2 parts in 10^6, recalibrate per Section 4.7.5.

h. Check long term stability by repeating the procedure of steps a through g one week later.

i. If a precisely controlled temperature chamber is available, check temperature stability by repeating the procedure of steps a through g after the HP-2401C has been on and operating at 10°C for at least 1-1/2 hours, but use 10 μSEC/CM sweep rate. Repeat after 1-1/2 hour warmup at 50°C. The horizontal drift of the square wave in CM/SEC is the difference between the standard frequency and the Counter time base in 10 parts in 10^6. Determine frequency difference, which should be no greater than ±100 parts in 10^6.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 3 of 15)

4. INTERNAL CALIBRATION SOURCE

Voltage:	1V ±.002% (after factory adjustment).
Drift:	<±.006% in six months.
Temperature Coefficient:	10-40°C ±.001% per °C. 40-50°C ±.0015% per °C.

a. Set DC Standard for 1V output.

b. Zero the HP-2401C per the procedure in Section 2.2.2.

c. Connect the DC Standard, DC Null Voltmeter, 1V Calibration Standard, Precision Volt Box, and HP-2401C as shown in Figure 4-1(A). Operate the DC Null Voltmeter from its internal batteries; do not connect it to the ac line.

d. Set the DC Standard output voltage to produce a null on the most sensitive range of the DC Null Voltmeter.

e. Set the HP-2401C to 1V RANGE and set the CAL+ adjustment for +1000.00 MILLIVOLTS indication on the digital readout.

f. Reverse the connections of leads 2 and 4 to the HP-2401C HI and LO terminals and set the CAL- adjustment for -1000.00 MILLIVOLTS indication on the digital readout.

g. Set the HP-2401C RANGE switch to INT-1V and record the digital readout. This reading should be -1000.00 ±0.10 MILLIVOLTS (maximum drift of ±0.006%, ±0.002% initial calibration, ±0.001% accuracy of external standard, ±1 digit).

NOTE A
If reading is not within ±0.10 mv of 1000 MILLIVOLTS, recalibrate the internal standard per Section 4.7.4 and repeat steps a through g.

NOTE B
Immediately after calibration, at the calibration temperature, the digital readout should be within ±0.03 mv of -1000.00 MILLIVOLTS (initial calibration to ±0.002% ±1 digit.

h. Check long term stability by repeating the procedure of steps a through g monthly for six months.

NOTE
If a precisely controlled temperature chamber is available, the temperature coefficient of the internal calibration source may be checked per the procedure of steps i through l.

i. Hold the HP-2401C on and operating at 40°C (±1°) for at least 1-1/2 hours.

j. Repeat steps a through d, above, to obtain a 1V ±0.001% external standard.

k. Read voltage of external standard on 1V range; then read voltage from internal calibration source on corresponding INT 1V range and subtract the difference in readings. This difference should be no greater than ±0.17 mv.

l. Repeat the procedure of steps i through k, above, after 1-1/2 hour warmup at 50°C and at 10°C. The 50°C difference should be no greater than ±0.30 mv; the 10°C difference should be no greater than ±0.17 mv.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 4 of 15)

5. VOLTAGE MEASUREMENT - FULL SCALE ACCURACY

At 25°C:	±.01% rdg ±.005% fs ±1 digit (1).
Temperature Coefficients:	10-40°C, ±.001% rdg per °C (2).
	40-50°C, ±.0015% rdg per °C
	0.1V range, ±.002% rdg ±.0005% fs per °C
	Other ranges, ±.002% rdg ±.0002% fs per °C

(1) Holds for all ranges at 25°C, assuming daily calibration against internal standard, calibration of internal standard every six months, line voltage variation no greater than ±10%.

(2) When calibrated against internal standard at operating temperature.

(3) Over the range of 10-50°C when calibrated against internal standard at 25°C.

a. After 1-1/2 hour warmup at 25°C with instrument zeroed per Section 2.2.2 and controls set as specified below, set the CAL- adjustment for -1000.00 MILLIVOLT reading on the HP-2401C digital display.

100 KC STD (rear panel):	INT.
FUNCTION:	VOLT.
RANGE:	INT-1V.
SAMPLE PERIOD:	1 SEC.
SAMPLING RATE:	Clockwise from STOP.

b. Set the HP-2401C RANGE switch to INT+1V and set the CAL+ adjustment for +1000.00 MILLIVOLT reading on the digital display.

c. Set the HP-2401C to 1V RANGE and set the DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter (connections are as shown in Figure 4-1 (A), except for leads 2 and 4 to the HP-2401C, which are reversed, as at the end of check 4).

NOTE A
All voltage reading tolerances noted in this check include the potential inaccuracy of the external voltage standard (±0.001% for 1V, ±0.002% for other voltages).

NOTE B
If any range is out of tolerance at 25°C ambient, calibrate per Section 4.7.8.

d. Record the next readout. This reading should be within ±0.17 mv of -1000.00 MILLIVOLTS.

e. Connect leads 2 and 4 exactly as shown in Figure 4-1(A) and record the next readout. This reading should be within ±0.17 mv of +1000.00 MILLIVOLTS.

f. Change connections to those shown for .1V check in Figure 4-1(B) and set the HP-2401C RANGE switch to .1V. Record the next digital readout. This reading should be within ±0.018 mv of ±099.108 MILLIVOLTS.

NOTE
The 100K input impedance of the HP-2401C on the .1V RANGE loads the output of the Precision Volt Box so that the input voltage is +99.108 mv. The accuracy tolerances total ±18 μv for this reading, scale, and digits, including the ±0.002% tolerance of the voltage source.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 5 of 15)

5. g. Change connections to those shown for 10V check in Figure 4-1(B). Set the HP-2401C RANGE switch to 10V and set the DC Standard to exactly 10V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.

h. Record the next reading. This reading should be within ±0.0018v of +10.000 VOLTS.

i. Change connections to those shown for 100V check in Figure 4-1(B). Set the HP-2401C RANGE switch to 100V and set the DC Standard to exactly 100V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.

j. Record the next reading. This reading should be within ±0.018v of +100.000 VOLTS.

k. Change connections to those shown for 1000V check; set the HP-2401C RANGE switch to 1000V and set the DC Standard to exactly 1000V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.

l. Record the next reading. This reading should be within ±0.18v of +1000.00 VOLTS.

NOTE
If a precisely controlled temperature chamber is available, the voltage measurement temperature coefficient may be checked per the procedure of steps m through o.

m. Hold the HP-2401C on and operating at 40°C (±1°) for 1-1/2 hours.

n. Repeat steps c through e, and determine the difference between the readings for 1V input at 25°C and 40°C, which should not be greater than ±0.35 mv.

o. Repeat steps c through e after 1-1/2 hour warmup at 50°C and after 1-1/2 hour warmup at 10°C. The 50°C difference should be no greater than ±0.57 mv; the 10°C difference should be no greater than ±0.35 mv.

6. VOLTAGE MEASUREMENT - LINEARITY

At Less Than Full Scale:	±.01% rdg ±.005% fs ±1 digit.
At 3 Times Full Scale:	±.025% rdg ±1 digit.
At 2 Times Full Scale:	±.02% rdg ±1 digit.

With ambient temperature at 25°C, line voltage variation no greater than ±10%.

a. After 1-1/2 hour warmup at 25°C and with instrument zeroed and calibrated per Sections 2.2.2 and 2.2.3, set controls as specified below.

100 KC STD (rear panel):	INT.
FUNCTION:	VOLT.
RANGE:	1000V.
SAMPLE PERIOD:	1 SEC.
SAMPLING RATE:	Clockwise from STOP.

b. Connect the DC Standard, DC Null Voltmeter, 1V Calibration Standard, Precision Volt Box, and HP-2401C for 10% fs interval linearity checks as shown in Figure 4-1(A) and (B) and set the DC Standard for 900V output.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 6 of 15)

6. c. In turn, connect lead from HI input terminal of the HP-2401C to each of the terminals of the Precision Volt Box that are listed following this step and reset output from the DC Standard for a precise null reading on the most sensitive range of the DC Null Voltmeter. At each point, record the reading.

Precision Volt Box Terminal	% Full Scale	Reading (Volts)	Tolerance (Volts)
900:1	90	+0900.00	±0.17
800:1	80	+0800.00	±0.16
700:1	70	+0700.00	±0.14
600:1	60	+0600.00	±0.13
500:1	50	+0500.00	±0.12
400:1	40	+0400.00	±0.11
300:1	30	+0300.00	±0.10
200:1	20	+0200.00	±0.08
100:1	10	+0100.00	±0.07

NOTE
All voltage reading tolerances noted in this check include the potential inaccuracy of the external voltage standard (±0.002%).

d. Set the DC Standard for output of approximately 3 vdc and change connections to those shown in Figure 4-1(B) for 3X check.

e. Set the DC Standard output to exactly 3 vdc, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter.

f. Set the HP-2401C RANGE switch to 1V and record the next reading. This reading should be within ±0.82 mv of +3000.00 MILLIVOLTS.

g. Reverse the connections to the HI and LO terminals of the HP-2401C and record the next reading, which should be -3000.00 ±0.82 MILLIVOLTS.

h. Change connections to those shown in Figure 4-1(B) for 2X check.

i. Set the DC Standard to exactly 2V, as indicated by a null reading on the most sensitive range of the DC Null Voltmeter. Record the next reading. This reading should be within ±0.45 mv of -2000.00 MILLIVOLTS.

j. Reverse the connections to the HI and LO terminals of the HP-2401C and record the next reading, which should be +2000.00 ±0.45 MILLIVOLTS.

7. VOLTAGE MEASUREMENT - REJECTION OF COMMON MODE NOISE

140 db.

a. With the HP-2401C on and operating, connect only the equipment shown in Figure 4-1(C). Set variable voltage transformer for minimum output voltage.

b. On the HP-2401C, select .1V RANGE and 1 SEC SAMPLE PERIOD. Set SAMPLING RATE control fully clockwise and record the next reading.

c. Increase output voltage from the variable transformer to maximum, or until the reading on the HP-2401C changes more than ±2 digits. Determine and record rms voltage across secondary of the isolation transformer.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 7 of 15)

7. d. Repeat the procedure of steps a through c for .1 and .01 SEC SAMPLE PERIOD. The common mode line frequency signal required to produce the specified change in reading should be greater than 100V rms at each sample period.

8. VOLTAGE MEASUREMENT - REJECTION OF SUPERIMPOSED NOISE

At 55 Hz, 0.1 Sec Sample Period: >20 db.
At 550 Hz, 0.1 Sec Sample Period: >40 db.

(Increases 20 db per decade increase in frequency.)

a. With HP-2401C on and operating, connect test equipment as shown in Figure 4-1(D).

b. Set controls of the HP-2401C as follows:

FUNCTION:	FREQ.
SAMPLE PERIOD:	1 SEC.
SAMPLING RATE:	Fully clockwise.
ATTENUATION:	Fully clockwise.

c. Turn on the Portable Oscillator and set it to provide 0.055 kHz output, as counted by the HP-2401C.

d. On the HP-2401C reset controls as follows:

FUNCTION:	VOLT.
RANGE:	10V.
SAMPLE PERIOD:	.1 SEC.

e. Set the Portable Oscillator for minimum output amplitude and note the reading displayed by the HP-2401C.

f. Slowly increase the Portable Oscillator output amplitude until the 10 mv digit (second from right) changes.

g. Determine and record the rms output from the transformer secondary. More than 100 MV rms (20 db greater than the second, 10 mv digit) should be required to produce the specified change in the HP-2401C reading.

h. Repeat steps a through c, above, but set the Portable Oscillator to provide 0.550 kHz output as counted by the HP-2401C.

i. Repeat steps d through g, above. More than 1V rms (40 db greater than the 10mv digit) should be required to produce the specified change in the HP-2401C reading.

NOTE
If desired, a similar technique can be used to verify the noise rejection of the HP-2401C for other sample periods and other frequencies. See Figure 3-6 for superimposed noise rejection characteristics with respect to noise frequency and sample period.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 8 of 15)

9. FREQUENCY MEASUREMENT RANGE - 5 Hz TO 300 KHz (TO 1.2MHz WITH OPTION 29

a. Set HP-2401C Power switch to ON, other controls as follows:

100 KC STD (rear panel):	INT.
FUNCTION:	FREQ.
SAMPLE PERIOD:	.1 SEC.
SAMPLING RATE:	Clockwise from STOP.
ATTENUATION:	Fully clockwise.

b. Connect output of Portable Oscillator to HP-2401C FREQ INPUT and to an Oscilloscope with a BNC "T" connector.

c. While holding Oscillator output amplitude constant at 0.1V rms (0.28V p-p), vary the output frequency downward from 100kHz to determine the lowest frequency that is counted reliably. This frequency should be 5 Hz or lower. Then increase Oscillator frequency to determine highest frequency that is counted reliably. This frequency should be 300kHz or higher. Record lowest and highest frequencies.

NOTE:
For high end testing of HP-2401C-29 instruments, substitute a Test Oscillator for the Portable Oscillator and increase frequency from 300 kHz with amplitude set at 0.5V rms (1.4V p-p) to determine and record the highest frequency that is counted reliably. This frequency should be 1200kHz or higher.

10. FREQUENCY MEASUREMENT - SENSITIVITY

Sine Wave Input:	Std. HP-2401C, 0.1V rms (max.) at 300 kHz.
	HP-2401C-29 0.5V rms (max.) at 1 MHz.
Pulse Input (Std. or Option 29):	Polarity, negative or positive.
	Minimum peak amplitude, 1V (max.).
	Minimum duration, 2 μs (max.),

a. With HP-2401C on and operating and its controls set as follows, increase amplitude of 300 kHz Oscillator output from zero until consistent measurement is obtained.

100 KC STD (rear panel):	INT.
FUNCTION:	FREQ.
SAMPLE PERIOD:	.1 SEC
SAMPLING RATE:	Clockwise from STOP.
ATTENUATION:	Fully clockwise.

b. Determine and record the rms output voltage from the Oscillator (use AC VTVM); the voltage should be no greater than 0.1v rms.

c. Check 1 MHz sensitivity of Option 29 instrument with the Test Oscillator set for 999.999 kHz output. Increase Oscillator output from zero until consistent measurement is obtained. Then determine and record the output voltage, which should be no greater than 0.5v rms.

NOTE: Perform steps d through f only if trigger circuit has been adjusted for pulse operation according to Section 4.7.11.

d. Connect output of Pulse Generator to HP-2401C FREQ INPUT and to input of Oscilloscope with a BNC "T" connector. Set Pulse Generator for negative 1v, 2 μs pulse with 1 kHz repetition rate.

e. Increase pulse amplitude from minimum until consistent measurement is obtained. Record the peak amplitude, which should be no greater than 1v.

f. Set pulse amplitude at 1v and increase pulse duration from minimum until consistent measurement is obtained. Record the duration, which should be no greater than 2 μs.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 9 of 15)

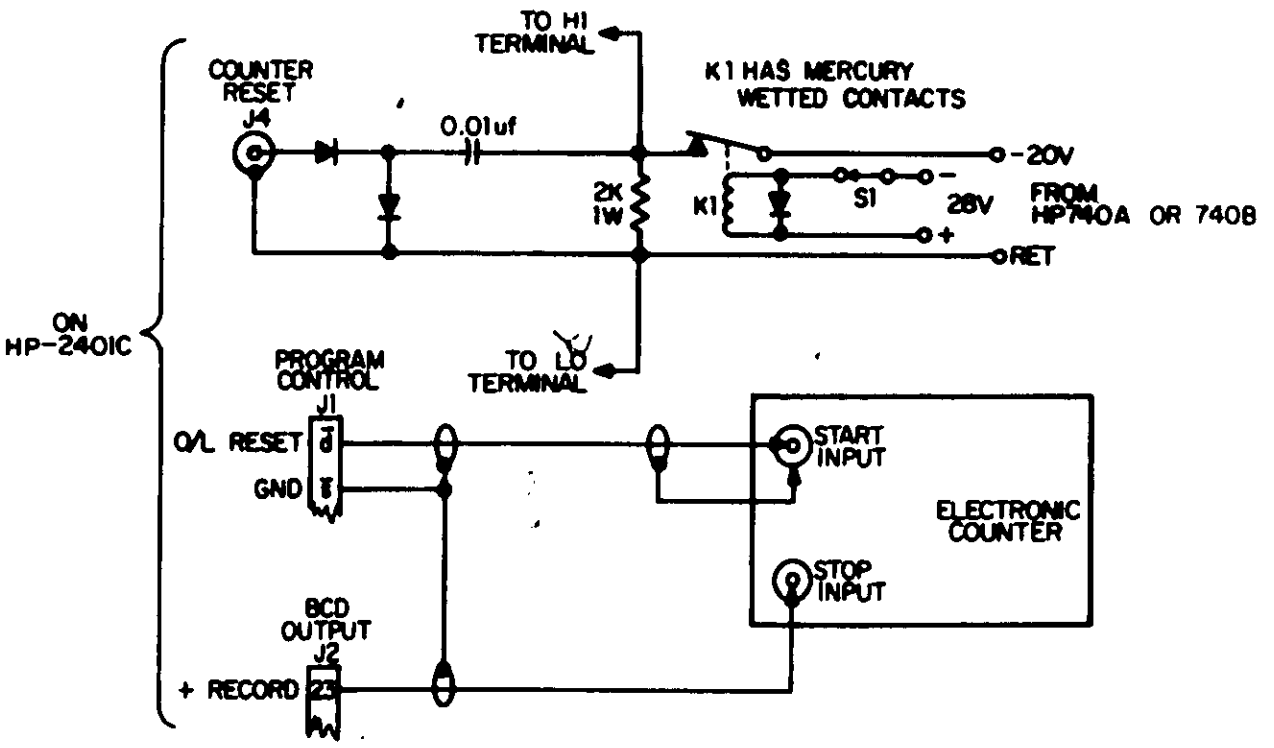
11. RESPONSE TIME AND MEASUREMENT RATE

Response time and selected sample period determine maximum measurement rate for data system applications, as follows:

Response Time (MS)	+	Sample Period (Sec)	=	Measurement Time (MS)	Approximate Measurement Rate (Readings/Sec)
9.67		0.01		19.67	50
9.67		0.1		109.67	9
9.67		1.0		1009.67	1

a. Connect test equipment as indicated in the sketch. Close S1 to energize K1. Set DC Standard for 20V output. With HP-2401C on and operating, set controls as follows:

FUNCTION: VOLT.
RANGE: 10V.
SAMPLE PERIOD: 1 SEC.
SAMPLING RATE: Clockwise from STOP.
100 KC STD (rear panel): INT.



b. Set the Electronic Counter for time interval measurement in ms, started by positive-going input and stopped by negative-going input. Time interval readings on the Electronic Counter should be 29.67 ms ±0.02 ms. Voltage readings on the HP-2401C should be approximately -20.0000 VOLTS. Record voltage reading, then set the HP-2401C SAMPLING RATE control to STOP.

c. Open S1 to de-energize K1, disconnecting the 20V input to the HP-2401C. Then reset the HP-2401C and the Electronic Counter. The HP-2401C should now read 0V ±1 count.

d. Close S1 to energize K1, connecting the -20V. Then record the reading on the Electronic Counter and the difference between this voltage reading on the HP-2401C and that previously recorded. The Counter reading should be 9.67 ms ±0.02 ms, and the voltage reading on the HP-2401C should be within ±0.0002 VOLTS of that recorded in step b.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 10 of 15)

11. e. Set the Electronic Counter for time interval measurement stopped by positive-going input and repeat steps c and d at .01 SEC, .1 SEC, and 1 SEC sample periods. Record the Electronic Counter readings, which should be as follows (±0.02 ms):

Sample Period (Sec)	Time Interval Reading (MS)
.01	19.67
.1	109.67
1.	1009.67

12. TIME BASE - OUTPUT (Rear Panel)

100kHz square wave.
Negative 1.2v p-p.
1K output impedance.

a. With HP-2401C on and operating and 100 KC STD switch set to INT, connect Oscilloscope to rear panel 100 KC STD OUTPUT/INPUT receptacle, J3.

b. Oscilloscope should display a 100kHz square wave, negative-going to 1.2v. Record the signal amplitude.

c. The output impedance is determined by a fixed value 1K resistor (R15), which can be seen in the assembly A6 circuit diagram, Figure 4-11.

13. TIME BASE - EXTERNAL INPUT (Rear Panel)

2v p-p maximum into 1.2K.

a. With the HP-2401C on and operating, set controls as follows:

100 KC STD (rear panel):	EXT.
FUNCTION:	FREQ.
SAMPLE PERIOD:	1 SEC.
SAMPLING RATE:	Clockwise from STOP.
ATTENUATION:	Fully clockwise.

b. Connect 100 kHz 2v p-p output, from the Portable Oscillator to the HP-2401C FREQ INPUT and 100 KC STD OUTPUT/INPUT receptacle with a BNC "T" connector.

c. Increase Oscillator output amplitude from minimum to the point where consistent measurement is obtained.

d. Determine and record the p-p amplitude of the Oscillator output. Amplitude should be no greater than 2v p-p.

e. The input impedance is determined by a fixed value 1.2K resistor (R6), which can be seen in the assembly A6 circuit diagram, Figure 4-11.

14. RECORDING OUTPUTS - BCD DATA

6 digits.
4-line 4-2'-2-1 code.
"0" state level, -35 to -24.5v; "1" state level -2.5 to 0v.
Source impedance 100K.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 11 of 15)

14. a. With the HP-2401C on and operating, set controls as follows:

100 KC STD (rear panel): INT.
SAMPLE PERIOD: START.
ATTENUATION: CHECK.

b. Connect a 10 pf, 10X attenuation, 10M probe to one channel of the Oscilloscope.

c. With the probe, verify "0" and "1" state levels for each data digit at the following pins of J2. These levels will be represented by a 22 to 35v p-p square wave. (The square wave frequency differs at each pin of J2.) Record a yes on the test card for each correct 4-line digital output.

Digit	Decade
10^0	A11
10^1	A12
10^2	A13
10^3	A14
10^4	A15
10^5	A46

J2 Pins:				
	3	4	28	29
	5	6	30	31
	7	8	32	33
	9	10	34	35
	11	12	36	37
	13	14	38	39

d. The source impedance is determined by fixed value 100K resistors, which can be seen in the assembly A11-15, 46 circuit diagram, Figure 4-17.

15. RECORDING OUTPUTS - BCD FUNCTION

1 digit.
4-line 4-2'-2-1 code.
"0" state level, -35 to -24.5v; "1" state level -2.5 to 0v.
Source impedance 33K.

a. With the HP-2401C on and operating, set as specified below to determine and record dc function levels at the following pins of J2:

Control Settings	Function	J2 Pins:	41	40	16	15
		Code:	4	2'	2	1
VOLTS, INT+1V	+VDC		0	0	0	1
VOLTS, INT-1V	-VDC		0	0	1	0
FREQ	KC		0	0	1	1
EXT SEL, 1V	KΩ (W/HP-2410B)		0	1	1	0
EXT SEL, 1V	MΩ (W/HP-2410B)		0	1	1	1
VOLTS, 1V*	OVERLOAD		1	1	1	1
EXT SEL, 1V	VAC (W/HP-2410B)		1	0	0	1

*With dc input sufficient to produce OVERLOAD indication.

b. The source impedance is determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram, Figure 4-23 or 4-24.

16. RECORDING OUTPUTS - BCD DECIMAL POINT

1 digit.
4-line 4-2'-2-1 code.
"0" state level -35 to -24.5v; "1" state level -2.5 to 0v.
Source impedance 33K.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 12 of 15)

16. a. With the HP-2401C on and operating, set FUNCTION switch to VOLT, other controls as specified below; determine and record dc decimal levels at the following pins of J2; short-circuit HI, LO, and GUARD terminals to assure all zeros reading.

Range (Volts)	Sample Period (Sec)	Decimal Position	J2 Pins: 27	26	2	1	
			Code: 4	2'	2	1	
1000	.01	000000.V	0	0	0	0	(10^{-0})
1000	.1	00000.0V	0	0	0	1	(10^{-1})
100	.1	0000.00V	0	0	1	0	(10^{-2})
10	.1	000.000V	0	0	1	1	(10^{-3})
1	.1	00.0000V	0	1	1	0	(10^{-4})
.1	.1	0000.00MV	0	1	1	1	(10^{-5})
.1	1.0	000.000MV	1	1	0	0	(10^{-6})
.1	1.0	00.0000MV*	1	1	0	1	(10^{-7})

*With HP-2411A Guarded Data Amplifier operated at +10 gain(10 MILLIVOLTS full scale); FUNCTION switch set to EXT SEL position; HP-2411A Decimal Point Logic Card A30 installed.

b. Set HP-2401C FUNCTION switch to FREQ, ATTENUATION control just clockwise from switched CHECK position, other controls as specified below; use DC Null Voltmeter to check decimal levels at the following pins of J2:

Sample Period (Sec)	Decimal Position	J2 Pins: 27	26	2	1	
		Code: 4	2'	2	1	
.01	00000.0KC	0	0	0	1	(10^{-1})
.1	0000.00KC	0	0	1	0	(10^{-2})
1.	000.000KC	0	0	1	1	(10^{-3})
STOP	000000	1	0	0	1	

c. The source impedances are determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram, Figure 4-23 or 4-24.

17. RECORDING OUTPUTS - REFERENCE LEVELS

"0" State Level: -24.5 to -21.5v, source impedahce 800Ω.
"1" State Level: -5 to -4v, source impedance 380Ω.

a. With the HP-2401C on and operating (FUNCTION: VOLT; RANGE: 10V), connect HP-2401C LO terminal to J2, pin 50 and connect HI terminal to J2 pins as specified below and record readings.

HI Terminal to J2 Pin	Reference Measured	Tolerance of Reading Range
25	+ ("1" Level)	- 4.00 to - 5.00V
24	- ("0" Level)	-24.50 to -21.50V

b. The source impedances are determined by fixed value 1.2K, 2.0K, and 470Ω resistors (A7R13-R15) which are shown in the A7 and A29 circuit diagram, Figure 4-12.

18. RECORDING OUTPUTS - RECORD COMMANDS

"0" State Level: -24.5 to -21.5v, source impedance 5K.
"1" State Level: -5 to -1v, source impedance 1K.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 20 Instruments (Sheet 13 of 15)

18. a. With the HP-2401C on and operating, set controls as follows:

SAMPLE PERIOD:	.01 SEC.
SAMPLING RATE:	Fully clockwise.
100 KC STD (rear panel):	INT.

b. Connect Oscilloscope to pins 21 and 23 to verify "0" and "1" state levels. The Oscilloscope will display the switching between these levels as a square wave with 20.5 to 29.5v p-p amplitude. Record p-p signal amplitudes.

c. The "1" state source impedance is determined by fixed value 1K resistors R6 and R7, which are shown in the A17 and A16 circuit diagram, Figure 4-19, connected to pins 11 and 17 of A17. The "0" state source impedance is determined by fixed value 3.9K resistors (A17R18 and A17R21), which are also shown in Figure 4-19.

19. EXTERNAL PROGRAMMING - HOLD OFF INPUT

Hold State:	+1 to +12v at 4.5 ma.
Non-Hold State:	-1 to -35v.

a. With HP-2401C on and operating, set controls as follows:

100 KC STD (rear panel):	INT.
FUNCTION:	VOLT.
RANGE:	INT+1V.
STORE/DISPLAY (rear panel):	DISPLAY.
SAMPLE PERIOD:	.01 SEC.
SAMPLING RATE:	Fully clockwise.

b. Connect a voltage source that can be varied continuously from -2v dc to +2v dc to J1, pin p (or J2, pin 22), and connect return to J1, pin Z (or J2, pin 50). Set source for -2v dc output.

c. Slowly adjust source for more positive (less negative) output until the HP-2401C measurement-display cycle stops. Then measure and record the hold-off voltage while the voltage source is still connected to the HP-2401C.

20. EXTERNAL PROGRAMMING - FUNCTION INPUT

Input Requirement:	External contact closure to ground or clamp that holds input pin at -1V dc or more positive while supplying 70 ma.
Function:	With no programming, VOLTS. Programmable functions, FREQ and with HP-2410B Units Coupling Card A9 installed, Ω, AC Normal, and AC Fast.

a. With HP-2401C on and operating, set controls as follows:

FUNCTION:	EXT SEL.
SAMPLE PERIOD:	1 SEC.
RANGE:	1V.

b. Record lighted HP-2401C units display which should be VOLTS.

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 14 of 15)

20. c. Connect a jumper from J1, pin Z, to each of the following other J1 pins in turn, recording HP-2401C units display lighted at each test.

Jumper J1 Pin Z to Pin	Units Readout
B	KC
C	Ω
D	AC
E	AC

21. EXTERNAL PROGRAMMING - SAMPLE PERIOD

Input Requirement: External contact closure to ground or clamp that holds input pin at -1V dc or more positive while supplying 70 ma.

Programmable Periods: .01, .1, 1 SEC.

a. With HP-2401C on and operating, set controls as follows:

FUNCTION:	VOLT.
SAMPLING RATE:	Clockwise from STOP.
SAMPLE PERIOD:	EXT SEL.
RANGE:	INT+1V.

b. Connect a jumper from J1, pin Z, to each of the following other J1 pins in turn, recording digital readout at each test.

Jumper J1 Pin Z to Pin	Digital Readout	Programmed Sample Period (Sec)
N	+001.000V	.01
P	+01.0000V	.1
R	+1000.00MV	1.

22. EXTERNAL PROGRAMMING - RANGE INPUT

Input Requirement: External contact closure to ground or clamp that holds input pin at -1V dc or more positive while supplying 70 ma.

Programmable Ranges: .1, 1, 10, 100, 1000V.
.01V w/HP-2411A Decimal Point Logic Card A30 installed.
10M w/HP-2410B Unit Coupling Card A9 installed.

a. With the HP-2401C on and operating and controls set as specified below, connect a jumper between the HI and LO terminals.

FUNCTION:	EXT SEL.
SAMPLE PERIOD:	1 SEC.
RANGE:	1V.

b. Connect a jumper from J1, pin A, to each of the following other J1 pins in turn, recording digital readout at each test. Then, disconnect jumper from HI and LO terminals.

Jumper J1 Pin Z to Pin(s)		Approximate Digital Readout	Programmed Range
G		000.000MV	0.1V
H		0000.00MV	1. V
J		00.0000V	10. V
K		000.000V	100. V
L		0000.00V	1000. V
G and S	W/A30	00.0000MV	0.1V and +10 Gain
G and C	W/A9	000.000Ω	0.1V and Ω
H and C	W/A9	0.00000KΩ	1. V and Ω
J and C	W/A9	00.0000KΩ	10. V and Ω
K and C	W/A9	000.000KΩ	100. V and Ω
L and C	W/A9	0000.00KΩ (1MΩ)	1000. V and Ω
M	W/A9	00.0000MΩ (10MΩ)	10 MΩ

Table 4-3. In-Cabinet Performance Checks Std & Opt. 29 Instruments (Sheet 15 of 15)

23. EXTERNAL PROGRAMMING - SAMPLE PERIOD START/STOP

Start/Stop Enabling:	By contact closure to ground or clamp that holds input pin at -1v dc or more positive.
Sample Period Start:	By contact closure to ground or -1 to +5v dc level.
Sample Period Stop:	By opening contact closure or -5 to -30v dc level.

a. With the HP-2401C on and operating, set controls as follows:

STORE/DISPLAY (rear panel):	DISPLAY.
100 KC STD (rear panel):	INT.
FUNCTION:	VOLT.
SAMPLING RATE:	Clockwise from STOP.
SAMPLE PERIOD:	EXT SEL.
RANGE:	INT+1V.

b. Connect jumpers from J1, pin Z, to pins a and b of J1; record (start) on the test card if counting starts.

c. Disconnect the jumper from pin b of J1 and record (stop) on the test card if counting stops. Then disconnect jumper from pin a.

24. EXTERNAL PROGRAMMING - RESET

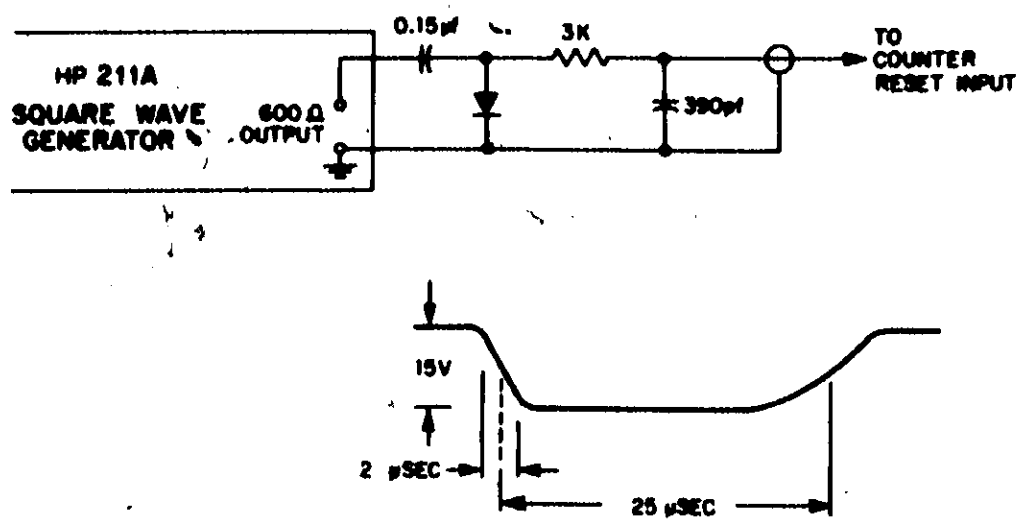
Counter Reset Line:	External contact closure to ground or clamp that holds input pin between 0 and -1v dc.
Counter Reset Input:	Negative 15v, 25 μs pulse with rise time <2 μs to J4 on rear panel.

a. With HP-2401C on and operating, set SAMPLE PERIOD to .01 SEC and SAMPLING RATE to STOP; leave other controls set as specified in step a of check 23.

b. Connect a jumper from pin Z to pin c of J1 and observe HP-2401C digital display. Record yes on test card if counting is triggered for one sample period.

c. Disconnect jumper. Record no on test card if counting is not triggered.

d. Connect Square Wave Generator 600Ω output to COUNTER RESET receptacle on rear of HP-2401C through a pulse shaping network as shown below.



e. While monitoring output of pulse shaping network with an Oscilloscope, set Square Wave Generator for 15V p-p at 20 kHz output frequency, then for 1 Hz output frequency.

f. Record a yes on the test card if counting is triggered about once a second.

PERFORMANCE CHECK

HP-2401C PERFORMANCE CHECK TEST CARD

SER ____ - ____ DATE _____

DESCRIPTION	CHECK RESULTS
1. VOLTAGE MEASUREMENT RANGES	
.1, 1, 10, 100, 1000V readings correct?	[ ]
.3, 3, 30, 300V readings correct?	[ ] (yes)
Reading of overload voltage	[ ] VOLTS (305-320v)
2. VOLTAGE MEASUREMENT - INTEGRATION	
Polarity reversal reverses count?	[ ]
Polarity symbol changes at zero?	[ ]
Forward counting resumes at zero?	[ ] (yes)
3. INTERNAL TIME BASE	
Frequency Offset From 100 kHz:	
At start of test	[ ] parts in 10^6
1 week later	[ ] parts in 10^6
Aging rate difference	[ ] parts in 10^6 (± 2 parts in 10^6)

(At 25 ±5°C ambient temperature.)

NOTE

Because considerable time and a precisely-controlled temperature chamber are required, it is anticipated that few users of the HP-2401C will check the effects of temperature upon the time base, the internal calibration standard, and voltage measurements. For this reason, no spaces are provided for entering temperature test results in any of the checks. However, procedures are presented in Table 4.3 of the handbook for those users who desire to check the effect of temperature upon the performance of the instrument.

SER ____ - ____ DATE ____

DESCRIPTION	CHECK RESULTS
4. INTERNAL CALIBRATION SOURCE	
Voltage:	
At start of test	MV
1 month later	MV
2 months later	MV
3 months later	MV
4 months later	MV
5 months later	MV
6 months later	MV
	(1000 ±0.10 mv)
	At 25°C ambient; quoted tolerance includes potential inaccuracy (±0.01%) of external standard.
5. VOLTAGE MEASUREMENT - FULL SCALE ACCURACY	
Input Measured, Volts:	
-1	MV (-1000 ±0.17 mv)
+1	MV (+1000 ±0.17 mv)
0.099108	MV (+099.108 ±0.18 mv)
10	VOLTS (+10 ±0.0018v)
100	VOLTS (+100 ±0.018v)
1000	VOLTS (+1000 ±0.18v)
	At 25°C ambient; the quoted tolerance includes potential inaccuracy (±0.001% for 1v, ±0.002% for other voltages) of external standard.

SER ____ - ____ DATE ____

DESCRIPTION		CHECK RESULTS
6. VOLTAGE MEASUREMENT - LINEARITY		
Input Measured, Volts*:	Range, Volts:	
+900	1000	____ VOLTS (+900 ±0.17v)*
+800	1000	____ VOLTS (+800 ±0.16v)*
+700	1000	____ VOLTS (+700 ±0.14v)*
+600	1000	____ VOLTS (+600 ±0.13v)*
+500	1000	____ VOLTS (+500 ±0.12v)*
+400	1000	____ VOLTS (+400 ±0.11v)*
+300	1000	____ VOLTS (+300 ±0.10v)*
+200	1000	____ VOLTS (+200 ±0.08v)*
+100	1000	____ VOLTS (+100 ±0.07v)*
+3	1	____ MV (+3000 ±0.82 mv)*
-3	1	____ MV (-3000 ±0.82 mv)*
-2	1	____ MV (-2000 ±0.45 mv)*
+2	1	____ MV (+2000 ±0.45 mv)*

*At 25°C ambient; quoted tolerance includes potential inaccuracy (±0.002%) of external standard.

HP-2401C PERFORMANCE CHECK TEST CARD

SER. ____ - ____ DATE ____

DESCRIPTION	CHECK RESULTS
7. VOLTAGE MEASUREMENT - REJECTION OF COMMON MODE NOISE	
Reading of divider input without noise	____ MV
AC common mode signal required to change reading more than ±2 digits:	
1.0 sec sample period	____ v rms
0.1 sec sample period	____ v rms
.01 sec sample period	____ v rms
	(>100v rms)
8. VOLTAGE MEASUREMENT - REJECTION OF SUPERIMPOSED NOISE	
55 Hz signal required to affect 10 MV digit	____ mv rms
	(>100 mv rms)
550 Hz signal required to affect 10 MV digit	____ v rms
	(>1v rms)
(10V range, 0.1 sec sample period.)	
9. FREQUENCY MEASUREMENT RANGE	
Lowest frequency of the range	____ KC
	(<000.005 kHz)
Highest frequency of the range	____ KC
	(> 300.000 kHz-Std)
	(>1200.000 kHz-Option 29)
10. FREQUENCY MEASUREMENT - SENSITIVITY	
Minimum signal to trigger at 300 kHz (or 1200 kHz for Option 29)	____ v rms
	(0.1v rms, max., 300 kHz)
	(0.5v rms, max., 1200 kHz-Option 29)
Minimum trigger pulse amplitude (duration constant at 2 μs)	____ v peak
	(-1v, max.)
Minimum trigger pulse duration (amplitude constant at -1v peak	____ μs
	(2 μs, max.)

HP-2401C PERFORMANCE CHECK TEST CARD

SER ____ - ____ DATE ____

DESCRIPTION	CHECK RESULTS
11. RESPONSE TIME AND MEASUREMENT SPEED	
Reading of steady 20V input	[ ] VOLTS
Difference between previous reading and reading from step input (same voltage)	[ ] VOLTS (±0.0002v, max.)
Response time to start of measurement	[ ] ms (9.67 ±0.02 ms)
Total Measurement Times:	
.01 sec sample period	[ ] ms (19.67 ±0.02 ms)
0.1 sec sample period	[ ] ms (109.67 ±0.02 ms)
1.0 sec sample period	[ ] ms (1009.67 ±0.02 ms)
12. TIME BASE OUTPUT (Rear Panel)	
Amplitude	[ ] v p-p (1.25 ±0.1v p-p)
13. TIME BASE EXTERNAL INPUT (Rear Panel)	
Minimum amplitude required to trigger time base	[ ] v p-p (2v p-p, max.)
14. RECORDING OUTPUTS - BCD DATA	
Decade: Outputs Correct At J2 Pins:	
10^0 (A11) 3 4 28 29?	[ ]
10^1 (A12) 5 6 30 31?	[ ]
10^2 (A13) 7 8 32 33?	[ ]
10^3 (A14) 9 10 34 35?	[ ]
10^4 (A15) 11 12 36 37?	[ ]
10^5 (A46) 13 14 38 39?	[ ] (yes)

HP-2401C PERFORMANCE CHECK TEST CARD

SER ____ - ____ DATE ____

DESCRIPTION	CHECK RESULTS

15. RECORDING OUTPUTS - BCD FUNCTION

Function:	Outputs Correct At J2 Pins 41	40	16	15	
+VDC	0	0	0	1	?
-VDC	0	0	1	0	?
KC	0	0	1	1	?
KΩ	0	1	1	0	?
MΩ	0	1	1	1	?
OVERLOAD	1	1	1	1	?
VAC	1	0	0	1	?

(yes)

16. RECORDING OUTPUTS - BCD DECIMAL POINT

Display:	Outputs Correct at J2 Pins 27	26	2	1	
000000.V	0	0	0	0	?
00000.0V	0	0	0	1	?
0000.00V	0	0	1	0	?
000.000V	0	0	1	1	?
00.0000V	0	1	1	0	?
0000.00MV	0	1	1	1	?
000.000MV	1	1	0	0	?
00.0000MV	1	1	0	1	?

(yes)

Note: "0" = -35 to -24.5v dc; "1" = -2.5 to 0v dc.

17. RECORDING OUTPUTS - REFERENCE LEVELS

"1" state reference at J2, pin 25 ____ v dc

(-5 to -4v dc)

"0" state reference at J2, pin 24 ____ v dc

(-24.5 to -21.5v dc)

DESCRIPTION	CHECK RESULTS
18. RECORDING OUTPUTS - RECORD COMMANDS	
-Record amplitude at J2, pin 21	____ v p-p
+Record amplitude at J2, pin 23	____ v p-p
	(20.5 to 29.5v p-p)
19. EXTERNAL PROGRAMMING - HOLDOFF	
Hold-off voltage	____ v dc
	(between - & +1v dc)
20. EXTERNAL PROGRAMMING - FUNCTION	
J1 Pin Z Connected To Pin / Programmed Function: None — VDC; B — FREQ; C — OHMS; D — VAC; E — VAC	UNITS READOUT: ____ VOLTS; ____ KC; ____ Ω; ____ AC VOLTS; ____ AC VOLTS
21. EXTERNAL PROGRAMMING - SAMPLE PERIOD	
J1 Pin Z Connected To Pin / Programmed Sample Period / Digital Readout: N — .01 Sec — +001.000V ?; P — 0.1 Sec — +01.0000V ?; R — 1.0 Sec — +1000.00MV ?	____ ____ ____ (yes)

DESCRIPTION	CHECK RESULTS

22. EXTERNAL PROGRAMMING - RANGE

J1 Pin Z Connected To Pin(s)	Programmed Range	Digital Readout	
G	.1V	000.000MV	?
H	1V	0000.00MV	?
J	10V	00.0000V	?
K	100V	000.000V	?
L	1000V	0000.00V	?
G and B*	.01V	00.0000MV	?
G and C**	100Ω	000.000Ω	?
H and C**	1KΩ	0.00000KΩ	?
J and C**	10KΩ	00.0000KΩ	?
K and C**	100KΩ	000.000KΩ	?
L and C**	1000KΩ	0000.00KΩ	?
M**	10MΩ	00.0000MΩ	?

(yes)

* W/HP-2411A and assembly A30.
**W/HP-2410B and assembly A9.

23. EXTERNAL PROGRAMMING - START/STOP

J1 pin Z connected to a and b starts measurement ? (yes)

J1 pin Z connected to pin a only stops measurement ? (yes)

24. EXTERNAL PROGRAMMING - RESET

Connecting J1 pin Z to pin c triggers measurement? (yes)

Disconnecting J1 pin c triggers measurement? (yes)

Pulse triggers measurement? (yes)

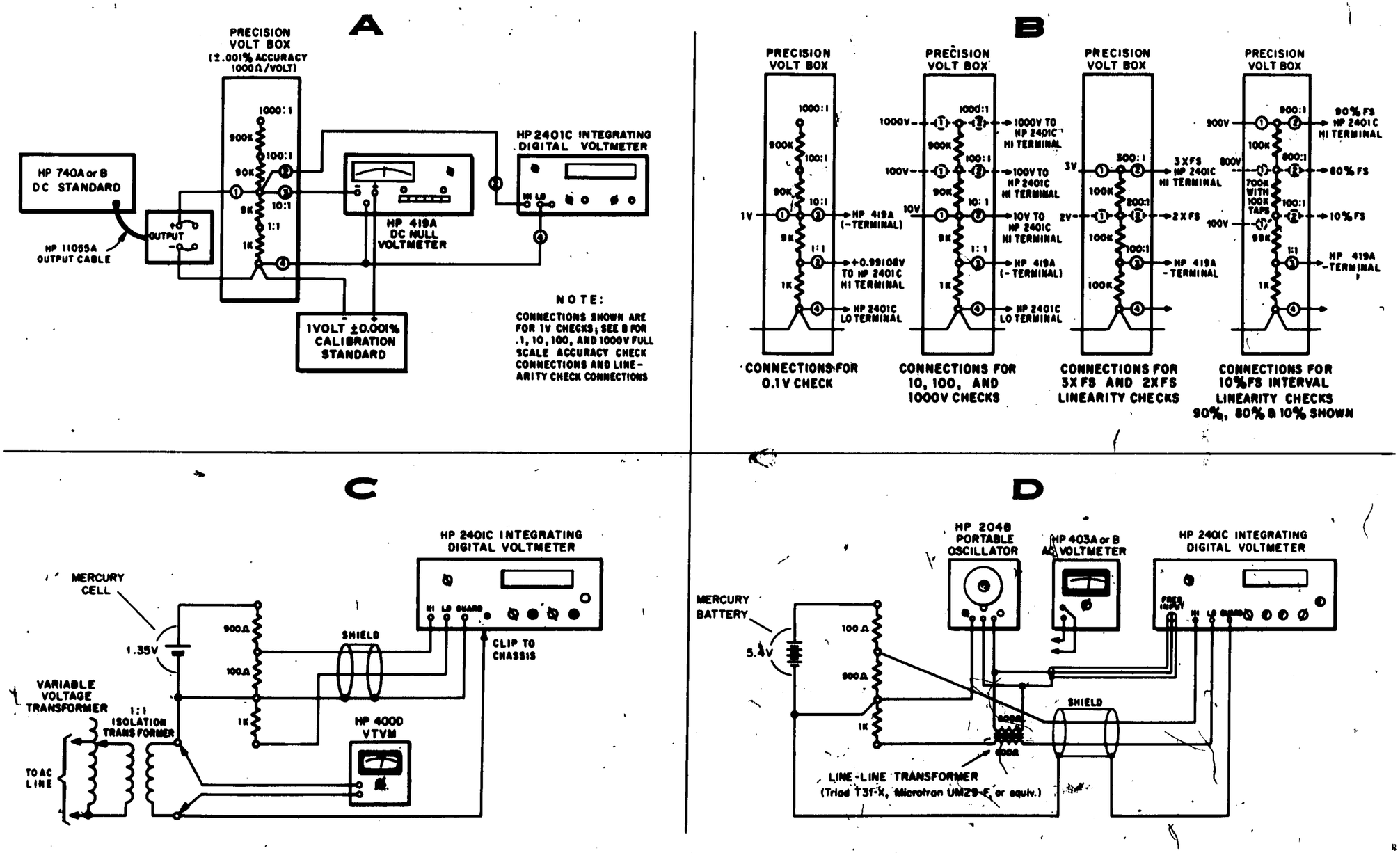


Figure 4-1. Performance Check Setups

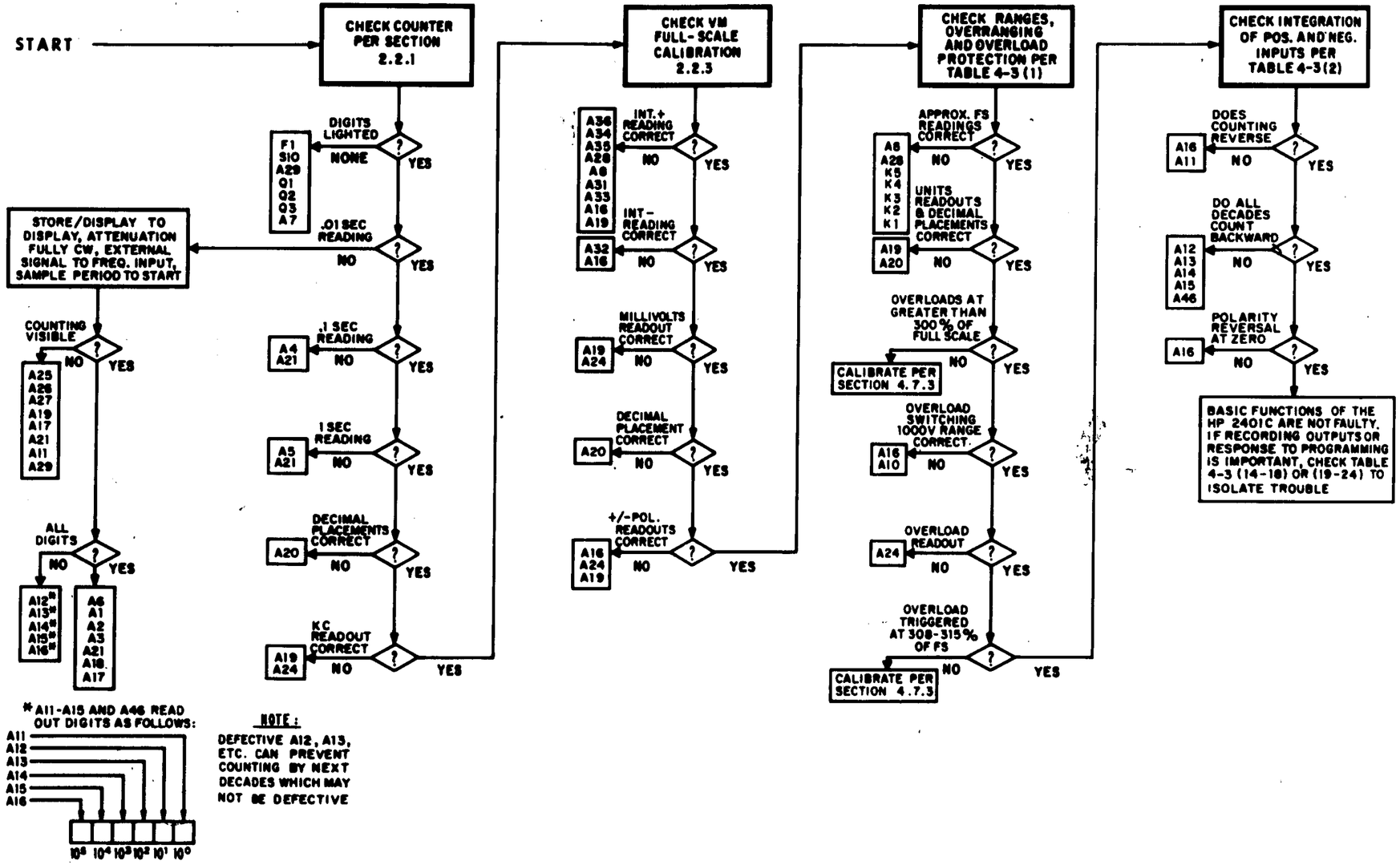


Figure 4-2. Troubleshooting

4.3 AIR FILTER

Inspect the air filter (center of rear panel) regularly and clean it before it becomes dirty enough to restrict air flow. Proceed as follows:

a. Remove filter-housing assembly (unlock the two quarter-turn fasteners and slide housing to rear).

b. Wash filter in warm water and detergent.

c. Remove cleaning solution from filter-housing assembly by shaking. Allow the assembly to dry completely before securing it to the rear panel.

CAUTION

DO NOT APPLY ANY COATING COMPOUND TO THE FILTER.

4.4 TROUBLESHOOTING

When trouble is suspected it can often be isolated rapidly to a specific assembly or group of assemblies by performing a series of brief checks, such as those diagrammed in Figure 4-2. From start, and before the instrument's cover is removed, the counter is checked, with various aspects of the check results diagrammed as diamond-shaped decision points. The decision point "yes" outputs form a main sequence that leads to and through the voltmeter (VM) full-scale calibration check, the range-overranging-overload check, and the integration check. "No" outputs point leftward toward checks off the main sequence or toward the component(s) that could cause an incorrect check result at the decision point.

After the initial check has isolated the trouble area, remove the instrument cover per Section 4-5 to permit completion of troubleshooting and repair. This next stage of troubleshooting may be greatly simplified by substituting for each suspected assembly in turn a spare assembly that is known to be operating correctly. Component assembly locations in the HP-2401C are indexed in Table 4-4 and illustrated in Figures 4-3 and 4-4. When the faulty assembly is found, trouble may then be traced to the defective component, or the faulty assembly may be shipped to your Hewlett-Packard field office for repair

If spare assemblies are not available for troubleshooting by substitution, the trouble must be located by signal tracing with oscilloscope and voltmeter. This procedure is also used to locate defective components on a faulty assembly. The HP-2401C overall logic diagram, Figures 4-7 through 4-9 and the wiring diagram, Figure 4-34, are provided to assist the signal tracing process. Equally useful are the detailed parts placement illustrations, circuit diagrams, and circuit descriptions for each assembly that are indexed in Table 4-4, with the assembly locations. For easy access to assembly circuits during operation, use the printed circuit assembly extension card provided with your instrument.

4.5 INSTRUMENT COVER REMOVAL AND ACCESS TO ASSEMBLIES

To remove the top wraparound cover, unscrew the six screws from the lower right and lower left sides of the instrument. The top cover may then be lifted from the instrument.

WARNING

DISCONNECT ANY HIGH POTENTIAL (MORE THAN 50 VOLTS) FROM THE HIGH, LO, AND GUARD TERMINALS TO ELIMINATE SHOCK HAZARD AT THE VFC CHASSIS AND SHIELD PLATES.

Remove the upper shield plate from the vfc by pulling up on the white plastic fasteners. All components shown in Figure 4-3(A) should now be visible. For access to components shown in Figure 4-3(B) pull up on white plastic fasteners at corners of the integrating amplifier card rack.

With the instrument upside down, unscrew the seven attaching screws and remove the bottom cover. The lower vfc shield plate is removed in the same manner as the upper shield. For access to the precision resistors in A28, remove both attaching screws and the cover. These operations expose the components shown in Figure 4-4(A). For access to the components shown in Figure 4-4(B), release the swing chassis fasteners and open the swing chassis.

When replacing plug-in printed circuit assemblies and other components, make certain they are installed in the correct place. Reverse the procedure used to gain access to assemblies when troubleshooting, repair, and calibration of the HP-2401C are completed.

4.6 REPAIR

4.6.1 Assemblies That Should Not Be Repaired In The Field

Satisfactory repair of certain assemblies is difficult to achieve without special training and/or special equipment. Consequently, it is recommended that these assemblies be returned to your Hewlett-Packard field office for repair. The assemblies which should receive this treatment are as follows:

a. Integrating Operational Amplifier A31.
b. Trigger Level Detector A32 or A33 -- if R1, R2, R5, R6 or T1 must be replaced.
c. Reversible Decade Counter A11-A15, or A46 -- if photoconductor plate V1 must be replaced.

4.6.2 Replacement of Components on Printed Circuit Assemblies

Component lead holes in the printed circuit boards have plated walls to assure good electrical contact on the opposite sides of the board. Apply heat sparingly and work carefully to avoid damage to this plating.

The following replacement procedure is recommended:

a. Remove defective component.

b. Melt solder in component lead holes, using clean dry soldering iron to remove excess solder. Clean holes with a toothpick or woooden splinter. Do not use a metal tool for cleaning because it may damage the through-hole plating.

c. Shape leads of new component to match those of component being replaced and insert leads into the lead holes. Make certain diodes and capacitors are oriented correctly, then solder the component in place, using heat and solder sparingly.

d. Repair any breaks in through-hole plating (indicated by separation of the round conductor pad on either side of the board) by pressing the conductor pads against the board and soldering component lead to pads on both sides of the board.

CAUTION

Use only rosin-core solder or rosin flux for soldering components of the HP-2401C. Use of other fluxes for soldering can cause erratic and unsatisfactory performance.

4.6.3 Post-Repair Cleanup

Failure to clean a printed circuit board or other assembly after repair can be a prime cause of substandard performance. Performance of attenuator A28, integrating amplifier A31, and trigger level detectors A32 and A33 is particularly susceptible to lowering of leakage resistance and electrolytic effects caused by soldering flux, spattered solder, bits of wire, finger marks, etc. It is partly because of this susceptibility that factory repair of A31, A32, and A33 is strongly recommended.

When cleaning, it is most important to keep in mind that solvents can damage certain parts if not used carefully. The photoconductors in that photochopper assembly on A31, the photodecoder on the counting/display decades, and other plastic encased parts are definitely subject to damage from solvents. For this reason, any cleaning solvent should be selected carefully and applied sparingly. Particularly to be avoided is the total immersion of any assembly in a solvent bath of any sort. The best way to clean a repaired assembly is with Isopropyl Alcohol or with a rosin solvent, such as Dupont TE-35 Freon (HP stock number 8500-0275). The solvent should be applied with a cotton-tipped swab, such as a Q-tip, that is used to scrub-clean the repaired area. All solvent should then be wiped off with a dry swab.

4.7 CALIBRATION

For normal day-to-day operation of the HP-2401C only the zero and full-scale calibration adjustments specified in Sections 2.2.2 and 2.2.3 are required. The calibration adjustments given in this section should be accomplished at the intervals specified in Table 4-2, or to correct power supply output voltages or substandard performance.

The instrument should be calibrated only if correct test equipment, operating within its calibration period, is used. The instrument should be given a 1-1/2 hour warmup at operating temperature before any adjustment is made.

4.7.1 Adjustment of -12.3V Power Supply Output

With the DC Standard Differential Voltmeter measure the potential across filter capacitor C32. If the potential is not within ±0.002 volts of 12.3 volts, adjust A35R9 for exactly 12.3 volts across C32. (See Figure 4-3(B) for locations.) Tap circuit board A35 to verify stability of the setting; if necessary, reset A35R9 for 12.3 volt output.

4.7.2 Adjustment of -35V Power Supply Output

With the DC Standard Differential Voltmeter measure the potential across filter capacitor C10. If the potential is not within ±0.15 volts of 35 volts, adjust A7R10 for exactly 35 volts across C10. (See Figures 4-3(A) and 4-4(B) for locations.)

4.7.3 Calibration of Overload Detection

Calibrate Overload Detection whenever the OVERLOAD indicator is lighted by an overrange input that is less than 305% of full scale or greater than 320% of full scale. (See performance check 1, Table 4-3.) Proceed as follows:

a. On any range but the 0.1v range, apply a negative dc input voltage that is 312.5% of full scale on the next lower range. (For example, apply -31.25% vdc to the HP-2401C set for 100v range.)

b. Select next lower range and check for OVERLOAD indication.

c. If OVERLOAD indicator does not light, slowly adjust A10R2 counterclockwise to make it light. (See Figure 4-3 for location of adjustments.)

d. If OVERLOAD indicator lights in step b, set A10R2 clockwise until it no longer lights, then perform step c.

e. Repeat steps a-d with positive input voltage, but set A16R86 for correct response instead of A10R2.

4.7.4 Calibration of Internal 1V Reference Standard

Whenever the internal reference reading obtained from performance check 4 of Table 4-3 is not within ±0.10 millivolts of 1000.00 MILLIVOLTS, set A35R21 to obtain a reading of 1000 ±0.02 MILLIVOLTS. Tap circuit board A35 to verify mechanical stability of the setting; if necessary, reset A35-

R21 for correct output from the internal reference standard. (See Figure 4-3B for location of A35R21.)

4.7.5 Calibration of Internal Time Base

Whenever the horizontal drift of the internal reference square wave, determined in performance check 3 of Table 4-3, exceeds 2 centimeters in 1 second, set capacitor C4 for minimum drift. Improve brightness of oscilloscope display by synchronizing from 100 kHz output of Frequency Standard. (See Figure 4-3(A) for location of C4.)

4.7.6 Coarse Full-Scale Calibration Adjustments (Figure 4-4A)

Perform these adjustments only after replacement of printed circuit assembly A31, A32, or A33 or parts on any of these assemblies. Gain access to adjustments per Section 4.5 (leaving A28 shield in place) and proceed as follows:

a. Zero the instrument per Section 2.2.2.

b. Set the RANGE switch to INT+1V and mechanically center the front panel CAL+ adjustment.

c. Set A33R4, the +FULL SCALE CAL ADJustment, for reading of +1000.00 ±0.20 MILLIVOLTS. Tap plug-in assembly A33 to check mechanical stability of the setting; if necessary, reset A33R4 for correct reading.

d. Repeat steps b and c with the RANGE switch at INT-1V and the CAL- adjustment centered. Set A32R4 for reading of -1000.00 ±0.20 MILLIVOLTS.

e. Complete normal full-scale calibration of the HP-2401C per Section 2.2.3.

4.7.7 + And - Trigger Level Adjustments

Perform either or both of these adjustments after replacement of printed circuit assembly A32 or A33 or parts on either of these assemblies. With top and bottom of the instrument both accessible as shown in Figures 4-3(A) and 4-4(A), proceed as follows:

a. Set the RANGE switch to INT+1V.

b. With oscilloscope, monitor waveform at A31(15); ground oscilloscope probe at A31(P29). See Figure 4-3(A) for locations of A31(15) and (P29).

c. Set A33R27 for a maximum negative peak amplitude of -0.1v.

NOTE

See Figure 4-4(A) for locations of A33R27 and A32R27.

d. Set the RANGE switch to INT-1V.

e. Set A32R27 for a maximum positive peak of +0.1v.

4.7.8 Input Attenuator Calibration

Calibration of the input attenuator requires the equipment and setup used for performance check 5 in Table 4-3. Gain access to adjustments as specified in Section 4.5, but do not remove the A28 cover shield. Proceed as follows (see Figures 4-1(A) and (B), and 4-4(A):

a. Zero the HP-2401C using the procedure in Section 2.2.2.

b. Connect the DC Standard, DC Null Voltmeter, 1 Volt Calibration Standard, Precision Volt Box, and HP-2401C as shown in Figures 4-1(A) and (B) for 0.1V check.

NOTE

Operate the DC Null Voltmeter from its internal batteries; do not connect it to the ac line.

c. Set the DC Standard output voltage to produce a null on the most sensitive range of the DC Null Voltmeter.

d. On the HP-2401C, set the RANGE switch to .1V and the CAL+ adjustment for +00.100 MILLIVOLTS reading.

NOTE

The 100K input impedance of the HP-2401C on the .1V RANGE loads the output of the Precision Volt Box so that the input voltage is +00.100 millivolts.

e. Change HP-2401C connection to that shown in Figure 4-1(A) for 1V check.

f. Set HP-2401C RANGE switch to 1V and set the 1V calibration adjustment (marked on A28 cover) for +1000.00 MILLIVOLTS reading.

g. Change connections to those shown in Figure 4-1(B) for 10V check and set DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter.

h. Set RANGE switch to 10V and set the 10V calibration adjustment for +10.0000 VOLTS reading.

i. Change connections to those shown in Figure 4-1(B) for 100V check and set DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter.

j. Set RANGE switch to 100V and set the 100V calibration adjustment for +100.000 VOLTS reading.

k. Change connections to those shown in Figure 4-1(B) for 1000V check and set DC Standard to produce a null on the most sensitive range of the DC Null Voltmeter.

l. Set RANGE switch to 1000V and set the 1000V calibration adjustment for +1000.00 VOLTS reading.

4.7.9 Overrange Linearity Adjustment (See Figure 4-3A)

The negative and positive overrange linearity adjustments of the HP-2401C are A32R32 and A33R32. These adjustments are set at the factory to provide overrange accuracy better than that specified for the instrument and should not be reset unless improved overranging linearity is absolutely necessary. An adjustable dc standard capable of supplying a suitable range of positive or negative voltages that are known accurately to ±0.002% or better is required. If such a standard is available, overranging linearity can be optimized by the following general procedure:

a. After 1-1/2 hour warmup, zero the HP-2401C per Section 2.2.2. Perform the full-scale adjustments in Section 2.2.3, but use the 1V RANGE and +1.00000 and -1.00000 volt inputs from the dc standard.

b. Before touching A32R32 or A33R32, make a complete plot from full scale to three times full scale, at 0.1 full scale or shorter intervals, of the high or low deviation of HP-2401C readings from the known voltages supplied by the dc standard. Plot both positive and negative inputs.

c. If the linearity characteristic plotted in step b is unacceptable, adjust A32R32 or A33R32 to correct it. When capacitor C6 (Figure 4-29) is next to R32, clockwise adjustment of R32 compensates for low readings. If an inductor is in the C6 position, clockwise adjustment of R32 compensates for high readings.

d. Repeat steps b and c, until acceptable linearity is achieved. Then reset course full scale calibration adjustments as specified in Section 4.7.6.

4.7.10 Photochopper Drive Oscillator Adjustment

The DRIVE OSC ADJ resistor sets the frequency of the photochopper drive oscillator. On instruments with Serial Prefix 501-, this adjustment is located on the base of the swing chassis card rack as shown in the inset on Figure 4-3 (B). On instruments with Serial Prefix 521- and above, this adjustment is located on assembly A31 (see Figure 4-30). The frequency should be 240 ± 5Hz when line voltage to the HP-2401C is at 102 or 204 vac. The frequency may be counted through a high impedance probe at either terminal of A31C27 when the drive oscillator cover is removed as shown in Figure 4-30.

Table 4-4. Component Locations and Theory Index (Sheet 1 of 2)

Reference Designation(s)	Component Name or Purpose	REFERENCES Location(s) Figure	Details Figure(s)	Circuit Description Section	Page
Assemblies					
A1-A5	Decade Divider	4-3	4-10	3.8	3-16
A6	100 kHz Oscillator & Schmitt Trigger	4-3	4-11	3.7	3-15
A7	-35V Regulator & Reset	4-3	4-12	3.17	3-24
A8	Attenuator Coupling Logic	4-3	4-13	3.5.1	3-12
A9*	HP-2410B Units Coupling	4-3	4-14	3.16	3-23
A10	Overload Detector	4-3	4-15 & 4-16	3.4	3-10
A11-A15, A46	Reversible 4'2'-2-1 Decade Counter	4-3	4-17	3.10	3-17
A16	Counter Control	4-3	4-18	3.3	3-7
A17	Gate Control	4-3	4-19	3.6	3-13
A18	Display Control	4-3	4-19	3.6	3-13
A19	Units/Counter Input Logic	4-4	4-20	3.11	3-19
A20	Decimal Point Logic	4-4	4-21	3.12.1	3-19
A21	Blanking Logic/Time Base Selection	4-4	4-22	3-13	3-21
A22	Printer Coupling Logic	4-4	4-23 & 4-24	3.14	3-22
A23*	HP-2410B AC & Ohms Delay Gate	4-4	4-25	3.15	3-22
A24	Units Indicator	4-3	4-26		
A25	Sensitivity (ATTENUATION) Control	4-4	4-27 & 4-28	3.9	3-16
A26	Input Amplifier	4-3	4-27 & 4-28	3.9	3-16
A27	Trigger Circuit	4-3	4-27 & 4-28	3.9	3-16
A28	Attenuator	4-4	4-29	3.2.1	3-3
A29	+6V Bias Circuit	4-3	4-12	3.17.3	3-25
A30**	HP-2411A Decimal Point Logic	4-4	4-31	3.12.2	3-20
A31	Integrating Operational Amplifier	4-3	4-30	3.2.2	3-3
A32	Negative Trigger Level Detector	4-4	4-29	3.2.3	3-6
A33	Positive Trigger Level Detector	4-4	4-29	3.2.3	3-6
A34	Series Regulator	4-3	4-32	3.16.2	3-25
A35	Calibration Standard & Power Supply Amplifier	4-3	4-32	3.16.3	3 25
A36	Filter Board	4-4	4-32	3.16.1	3-25
A47	1V Relay Timing	4-4	4-13	3.5.2	3-13

*Supplied with the HP-2410B.

**Supplied with the HP-2411A (a jumper board is installed in the A30 position if the HP-2401C is ordered by itself).

Table 4-4. Component Location and Theory Index (Sheet 2 of 2)

Reference Designation(s)	Component Name or Purpose	REFERENCES Location(s) Figure	Details Figure(s)
Capacitors			
C1	+150V filter	4-4	4-12
C2	Filtering at input to -35V series regulators	4-3	4-12
C3	Counter trigger differentiating	4-4	4-15, 16, 20
C4	100kHz oscillator trimmer	4-3, 4	4-11
C5	100kHz oscillator padder	4-4	4-11
C7	-35V regulator output filter	4-4	4-15, 16, 20
C33, C34	+ & -12.3V regulator output filter	4-3	4-32
A28C101, A28C102	Attenuator relay switching delay	4-4	4-13
C202	Coupling for reset-triggered measurement display cycle	4-4	4-19
Diodes			
CR2, CR3	-35V power supply rectifier	4-3	4-12
A28CR101, A28CR103-A28CR105	Attenuator relay surge suppression	4-4	4-13
Relays			
A28K1-A28K5	Attenuator control	4-4	4-13 & 20
Inductors			
L1	-35V supply filter	4-3	4-12
Plugs			
P1/FL1	AC line input receptacle & noise filter	4-5	4-12
Transistors			
Q1-Q3	-35V supply series regulator	4-3	4-12
Resistors			
R1	Current limiting	4-4	4-12
R2	-35V rectifier filter output load	4-4	4-12
R3	Series regulator Q3 emitter load	4-4	4-12
R4	10 kHz check attenuator	4-4	4-27 & 28
R5	Capacitor C1 discharge	4-4	4-12
R6, R7	+ & -record command source	4-4	4-19
R8, R9	Counter trigger differentiating	4-4	4-15, 16, 20
R48	Attenuator resistor, .1V range	4-3	4-29
R49	Part of cal+/zero divider network	4-4	4-29
R50	Part of cal+/zero divider network	4-3	4-29
R61, R62	+ & -channel output transformer (T5, T4) load	4-3	4-29
A28R101, A28R102	Attenuator relay delay	4-4	4-13
A28R105-A28R107			
R202-R204	SAMPLE RATE control network	4-4	4-19
Switches			
S1	RANGE	4-3	4-13 & 29
S2	FUNCTION	4-4	4-13, 20 & 21
S3	SAMPLE PERIOD	4-4	4-19, 20 & 22
S5	SAMPLING RATE	4-4	4-19
Transformers			
T1	Power for -35, +6, ±150V power supplies	4-3	4-12
T2	Power for ±12.3V power supply & 1V Calibration Standard	4-4	4-32
T4, T5	+ & -channel output	4-3	4-29
Crystals			
Y1	100kHz for time base oscillator A6	4-3	4-11

4.7.11 Adjustment For Pulse Measurement (Figures 4-27 or 4-28)

Optimum adjustment for pulse measurement will differ from the factory-set optimum sine wave adjustment. Use this adjustment only for pulse measurements. Input Trigger A27 may be adjusted for either positive or negative pulse measurements at frequencies between 5 Hz and 300 kHz (1.2 MHz with Option 29).

a. Connect output of Pulse Generator to HP 2401C FREQ INPUT connector.

b. Set Pulse Generator for positive or negative 1 volt, 2 μsec pulse, with 300 kHz repetition rate.

c. Adjust A27R2(A27R3 if applicable) for a steady 300 kHz display.

4.7.12 Readjustment For Sine Wave Measurement (Figures 4-27 or 4-28)

If the instrument was adjusted for pulse measurements, it must be readjusted for sine wave measurement. This adjustment is to factory tolerances and must be made to assure that the instrument will operate within stated specifications. Proceed as follows:

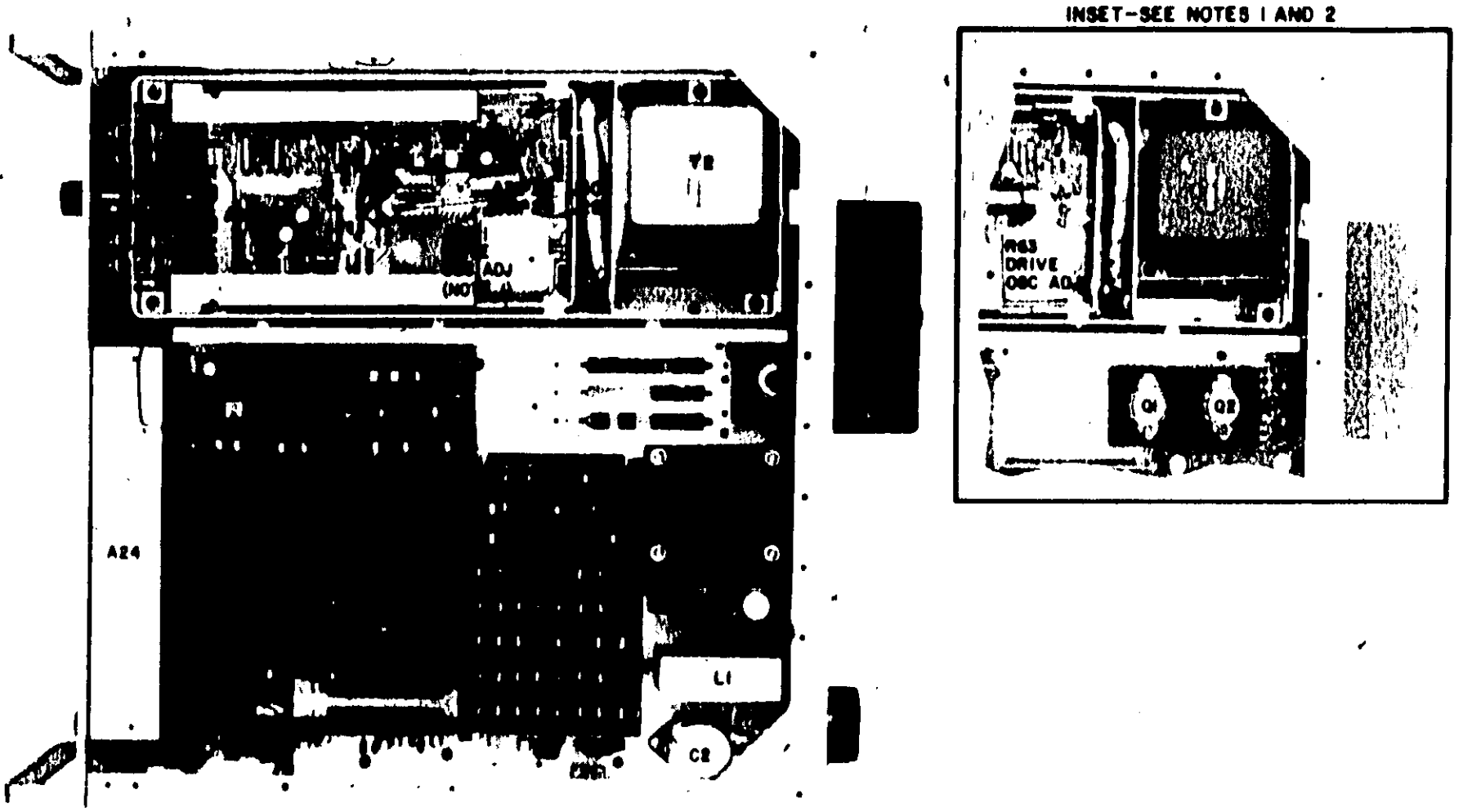
a. Set Portable Oscillator for 300 kHz and adjust output to zero. Connect the Portable Oscillator output connection to the HP 2401C FREQ INPUT connector and to ac vtvm.

b. Adjust Portable Oscillator for 50 millivolt output.

c. Adjust A27R2(A27R3 if applicable) for a steady 300 kHz display.

d. Slowly reduce the Portable Oscillator output. The display should disappear completely before the output reaches 40 millivolts.

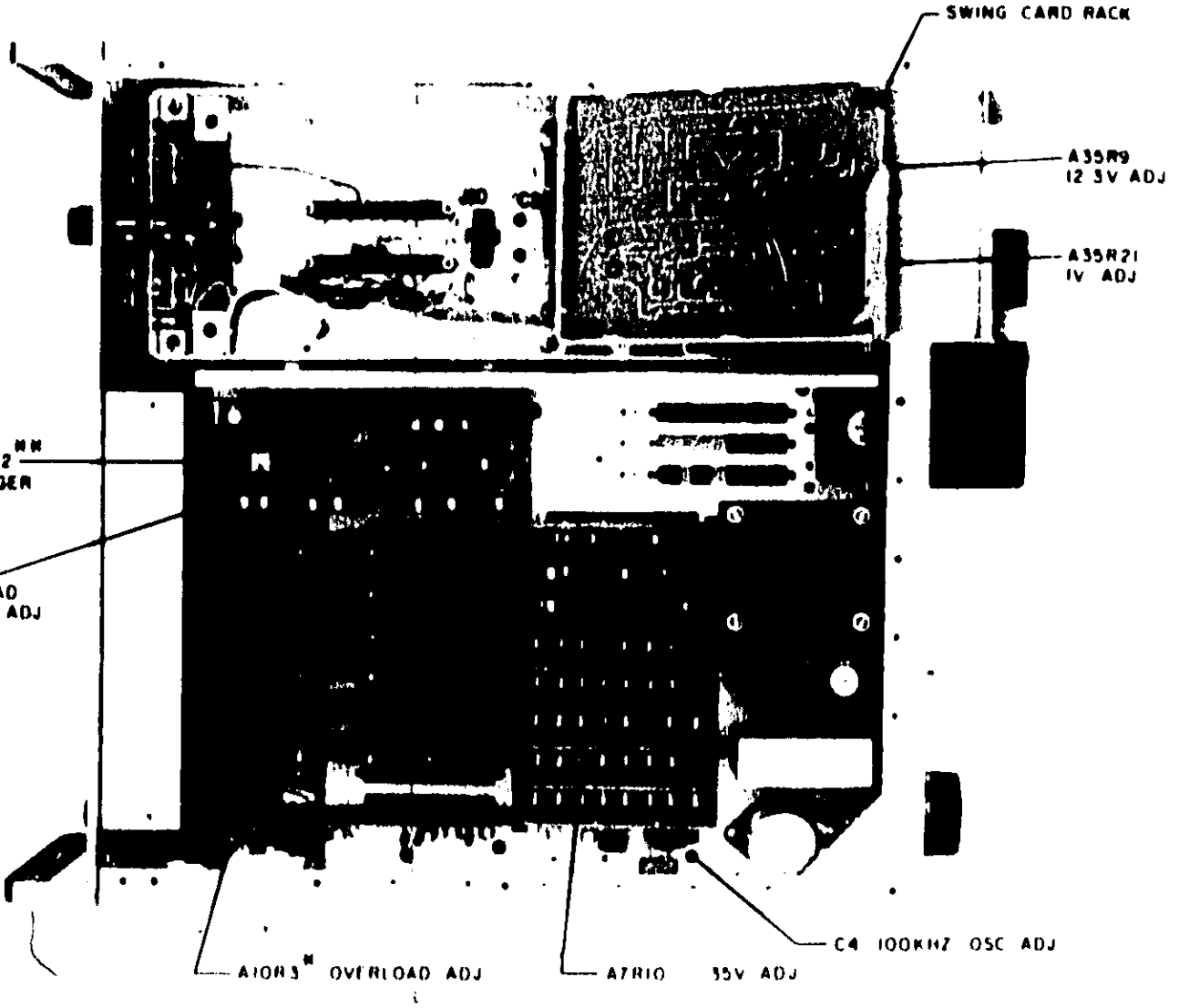
e. If the requirements of step d are not met, increase the Portable Oscillator output (100 millivolts maximum) and repeat steps c and d until the requirements of 40-millivolt dropout are met.



NOTES 1 SEE INSET FOR LOCATION OF DRIVE OSC ADJ ON SERIAL PREFIX 501-
2 SEE INSET FOR TRANSISTOR LOCATION ON SERIAL PREFIX 501- THRU 610-
3 A9 SUPPLIED WITH HP 2410B AC/OHMS CONVERTER

View A

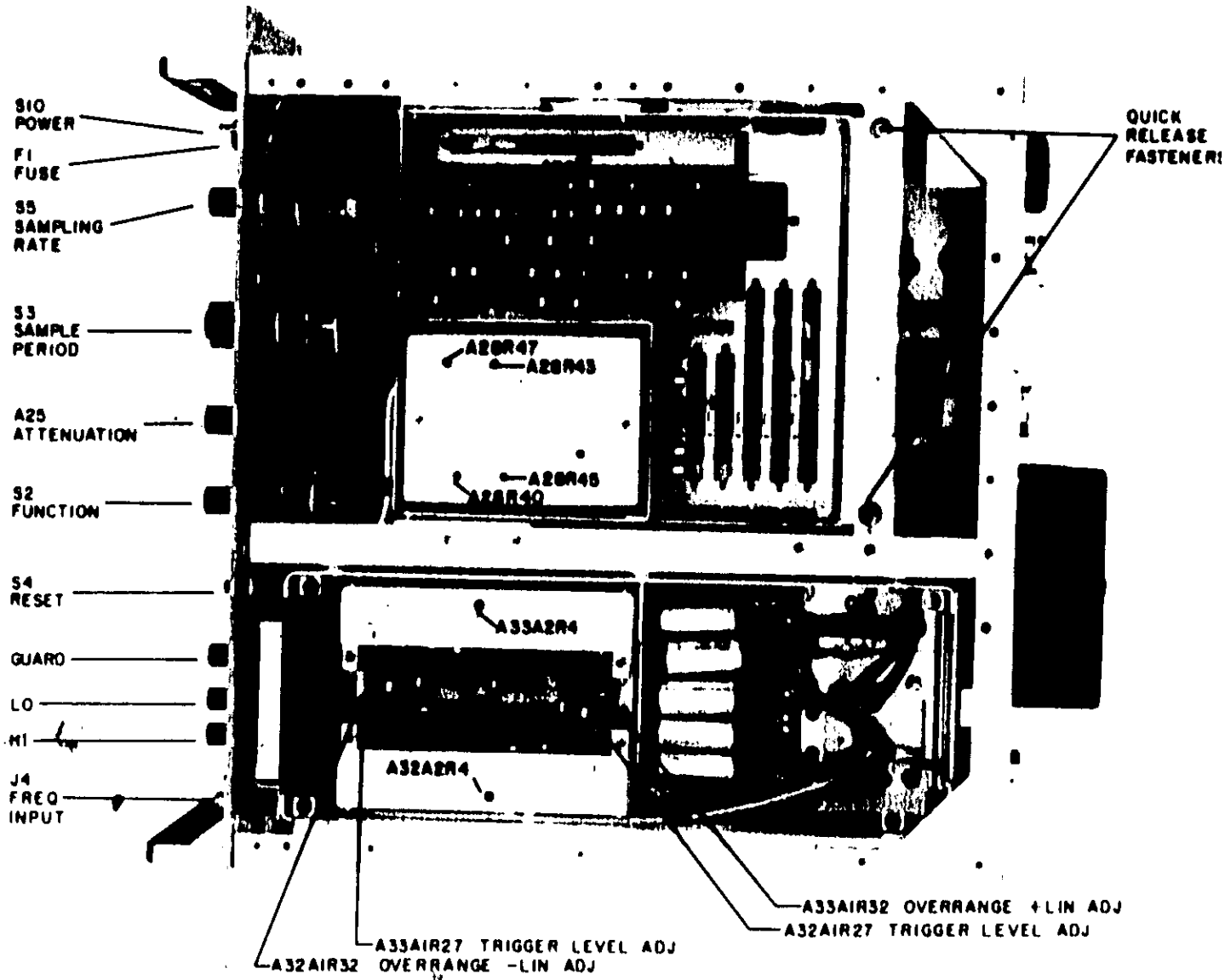
(See parts list beginning on page 5-42.)



M A10R2 ON SERIAL PREFIX 501 THRU 605
NN A27R3 FOR BOARD STOCK NO 5060-5016

View B
(See parts list beginning on page 5-42.)

Figure 4-3. Top Internal View

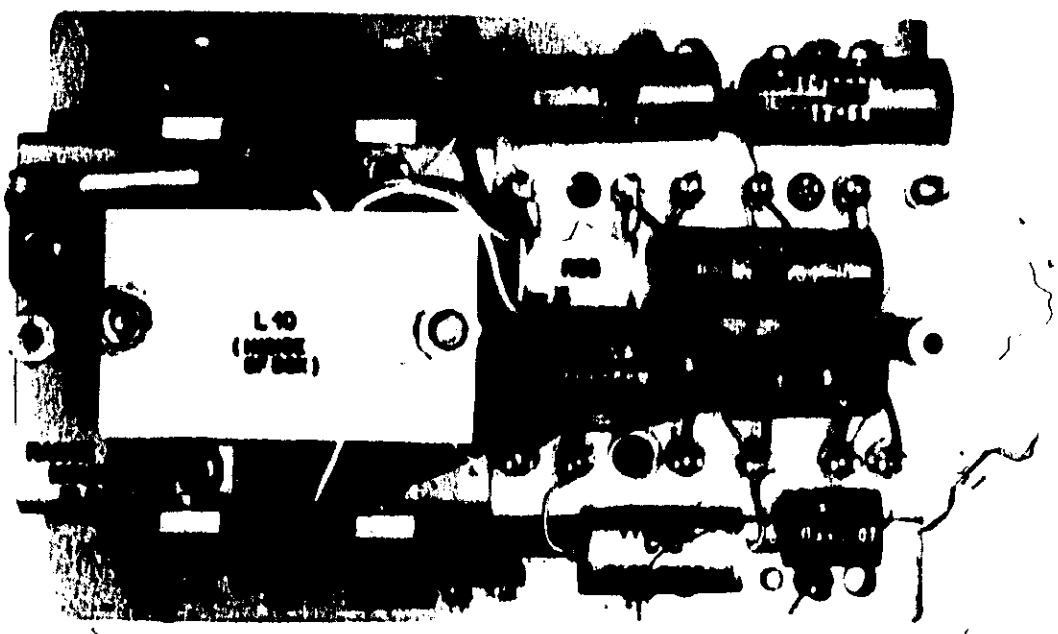


* SUPPLIED WITH HP 2411A GUARDED DATA AMPLIFIER. JUMPER BOARD INSTALLED HERE IF HP 2401C IS ORDERED BY ITSELF

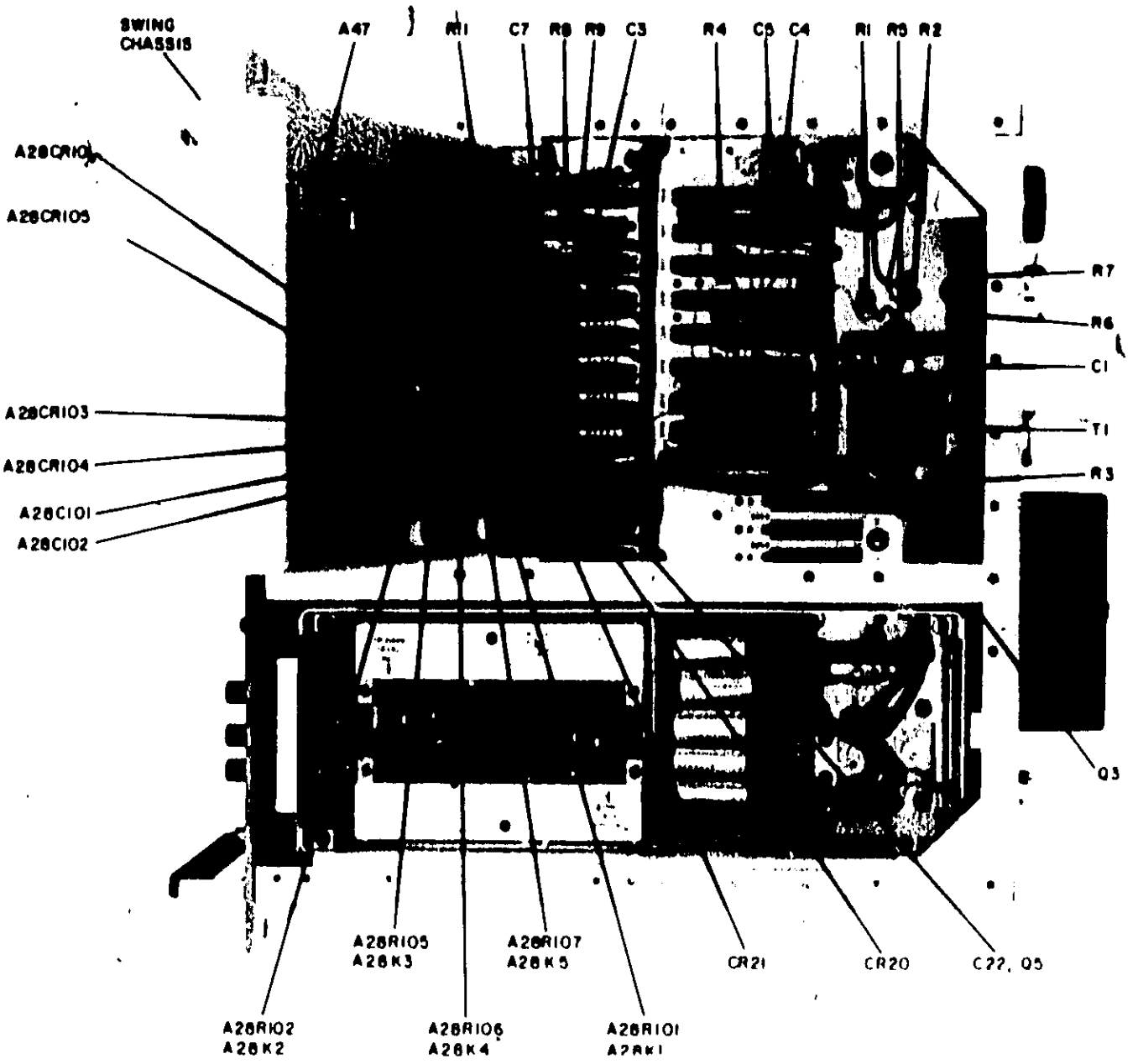
** SUPPLIED WITH HP 2410B AC/OHMS CONVERTER

View A

(See parts list beginning on page 5-42.)



(A28) Attenuator Assembly
(See parts list beginning on page 5-46.)



View B

Figure 4-4. Bottom Internal View

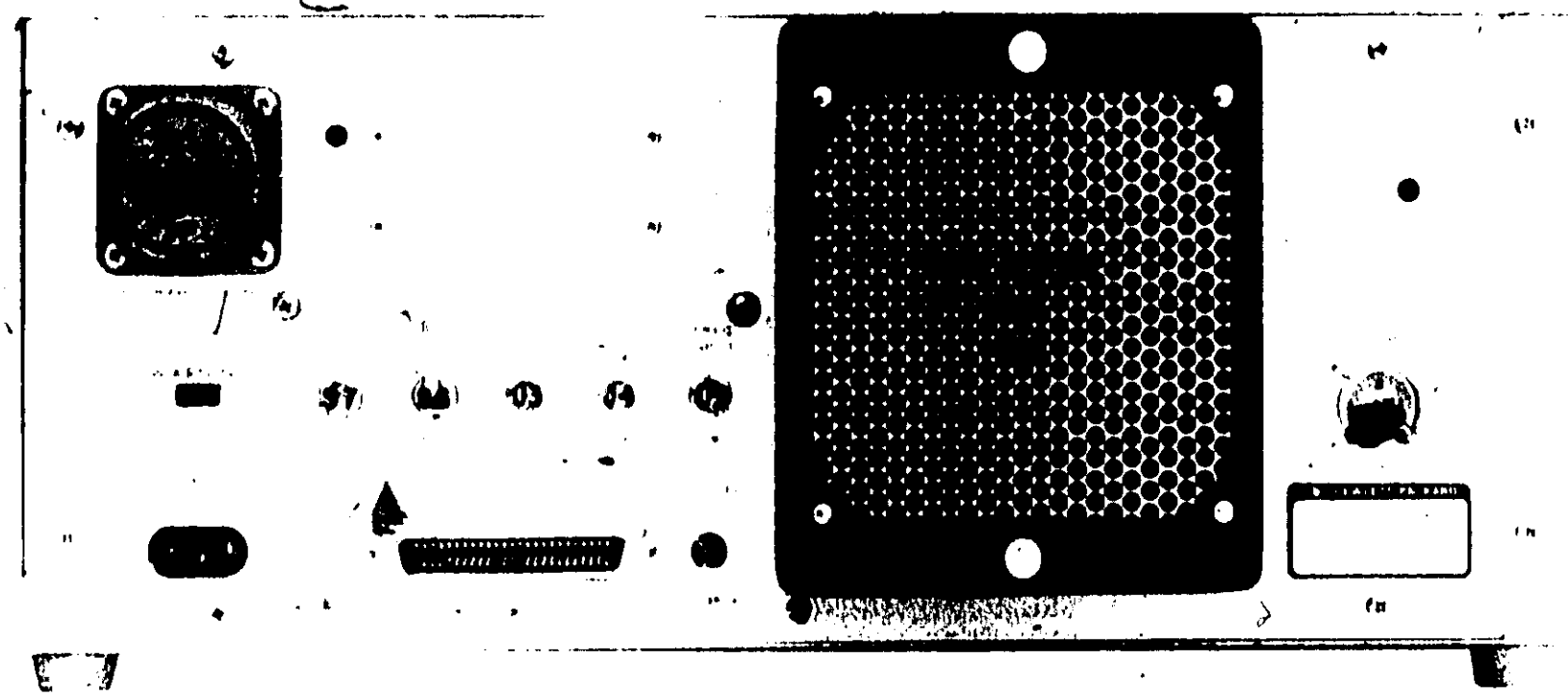
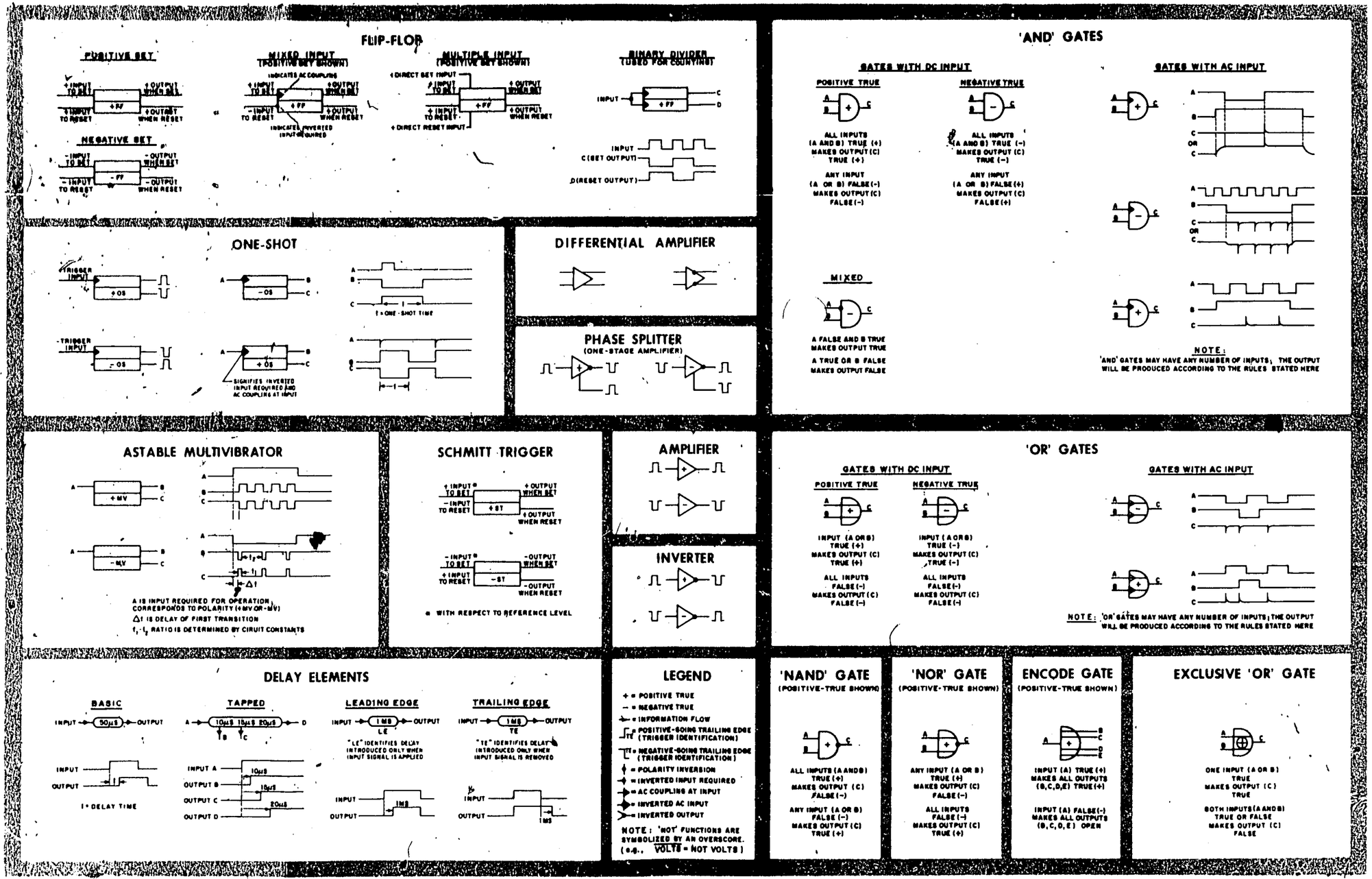


Figure 4-5. Rear Panel View

(See parts list beginning on page 5-42.)

KEY TO LOGIC SYMBOLOGY



NOTE: THIS IS A SUMMARY OF DETAILED DESCRIPTION FROM LOGIC SYMBOLOGY. A PUBLICATION AVAILABLE THROUGH HEWLETT-PACKARD SALES AND SERVICE OFFICES.

Figure 4-6. Key to Logic Symbology

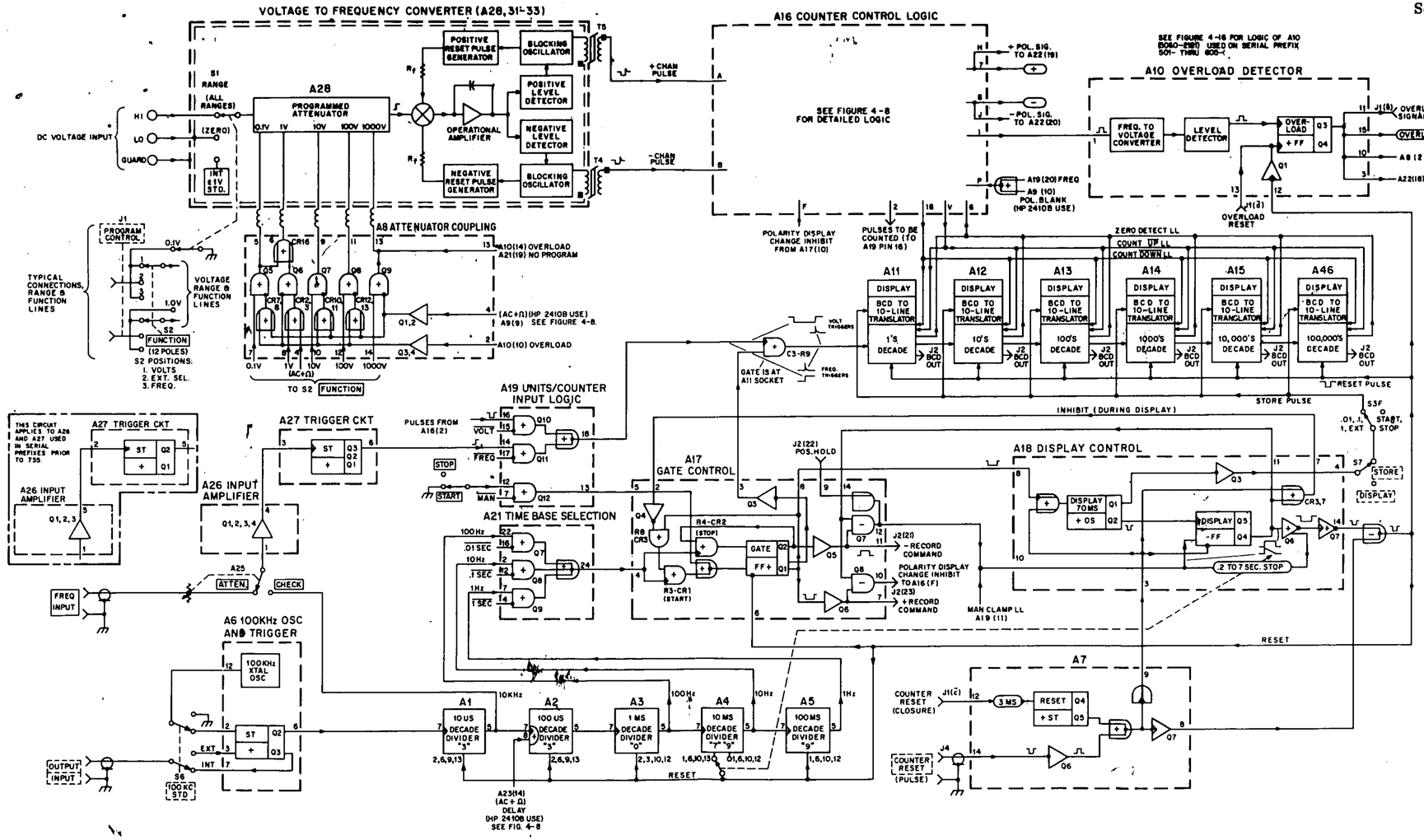
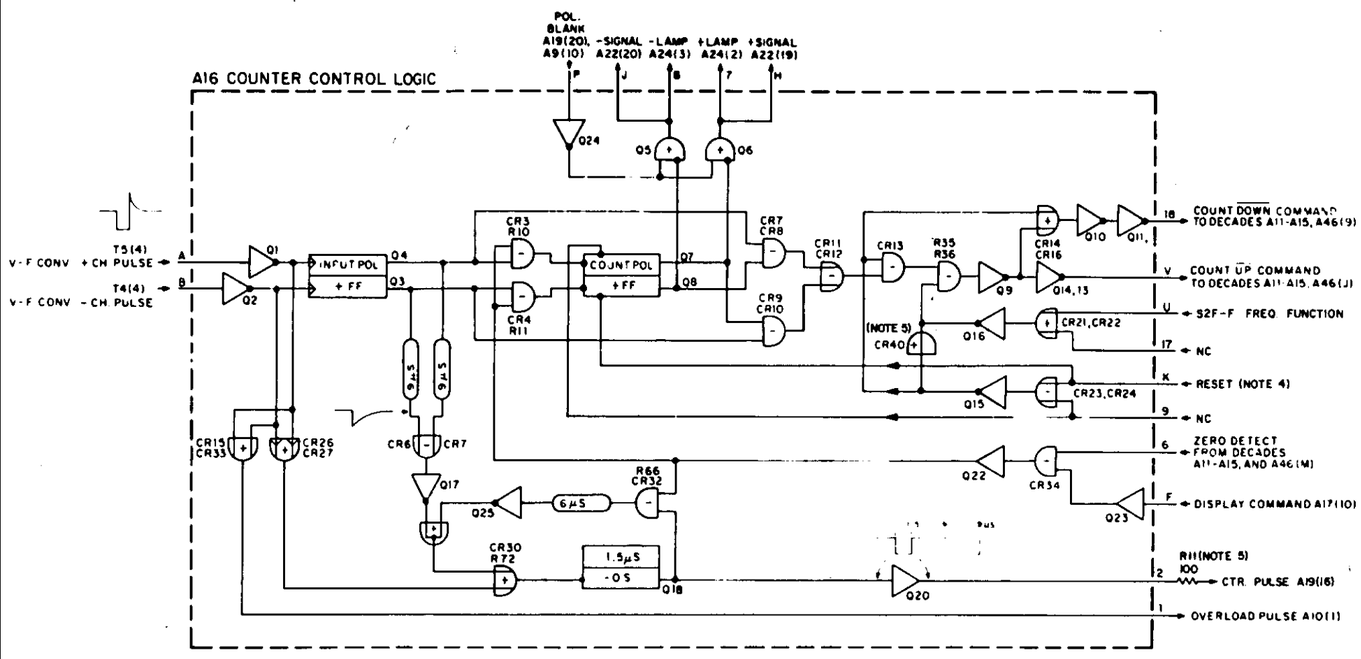
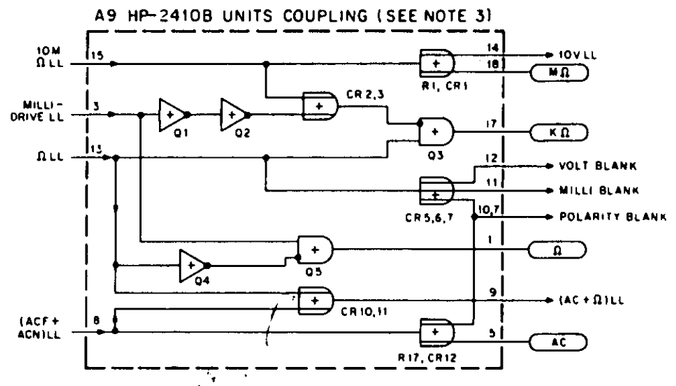
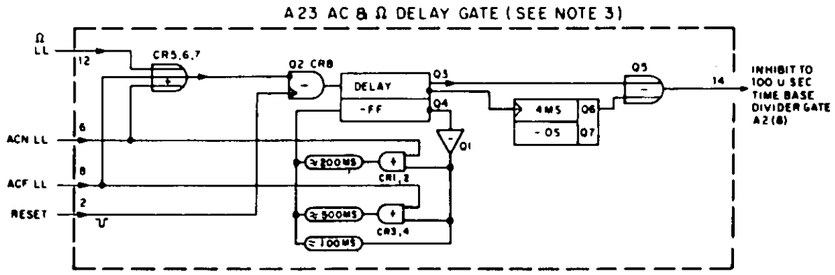


Figure 4-7. Overall Logic Diagram V to F Converter and Counter

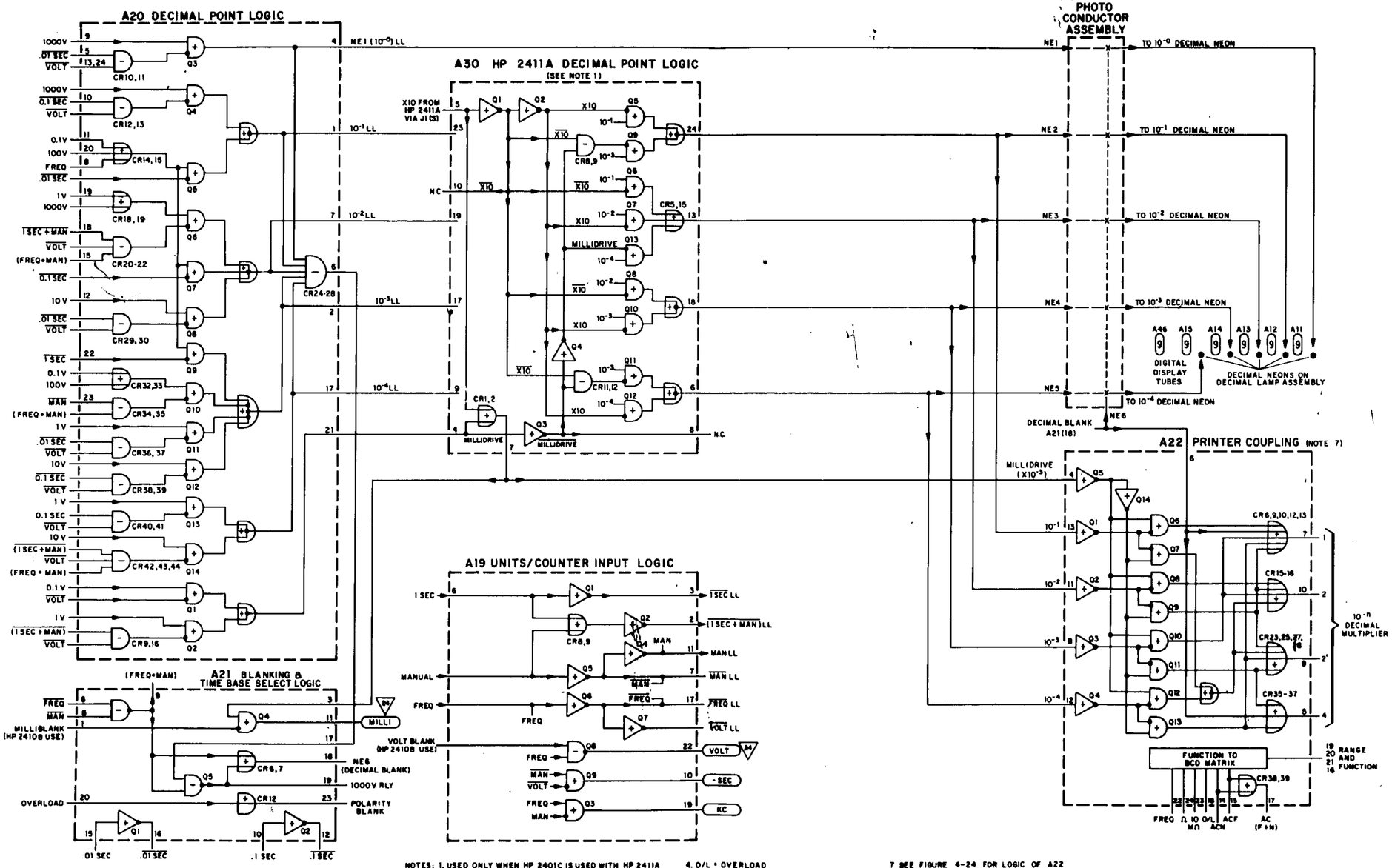






NOTES:
1. LL = LOGIC LINES
2. ACF = AC FAST, ACN = AC NORMAL, O/L = OVERLOAD
3. USED ONLY WHEN HP 2401C IS USED WITH HP 2410B AC/OHMS CONVERTER
4. NO CONNECTION FOR SERIAL PREFIX 501- THRU 537
5. CR40 AND R11 FIRST USED ON SERIAL PREFIX 606-

Figure 4-8. Overall Logic Diagram Counter Control and HP 2410B Coupling



NOTES: 1. USED ONLY WHEN HP 2401C IS USED WITH HP 2411A GUARDED DATA AMPLIFIER. OTHERWISE A JUMPER BOARD CONNECTS A30 PIN 23 TO 24, 19 TO 13, 17 TO 18, 9 TO 6, AND 4 TO 7.

2. LL = LOGIC LINES

3. ACF = AC FAST; ACN = AC NORMAL (APPLICABLE WHEN HP 2401C IS USED WITH HP 2410B AC/OHMS CONVERTER.

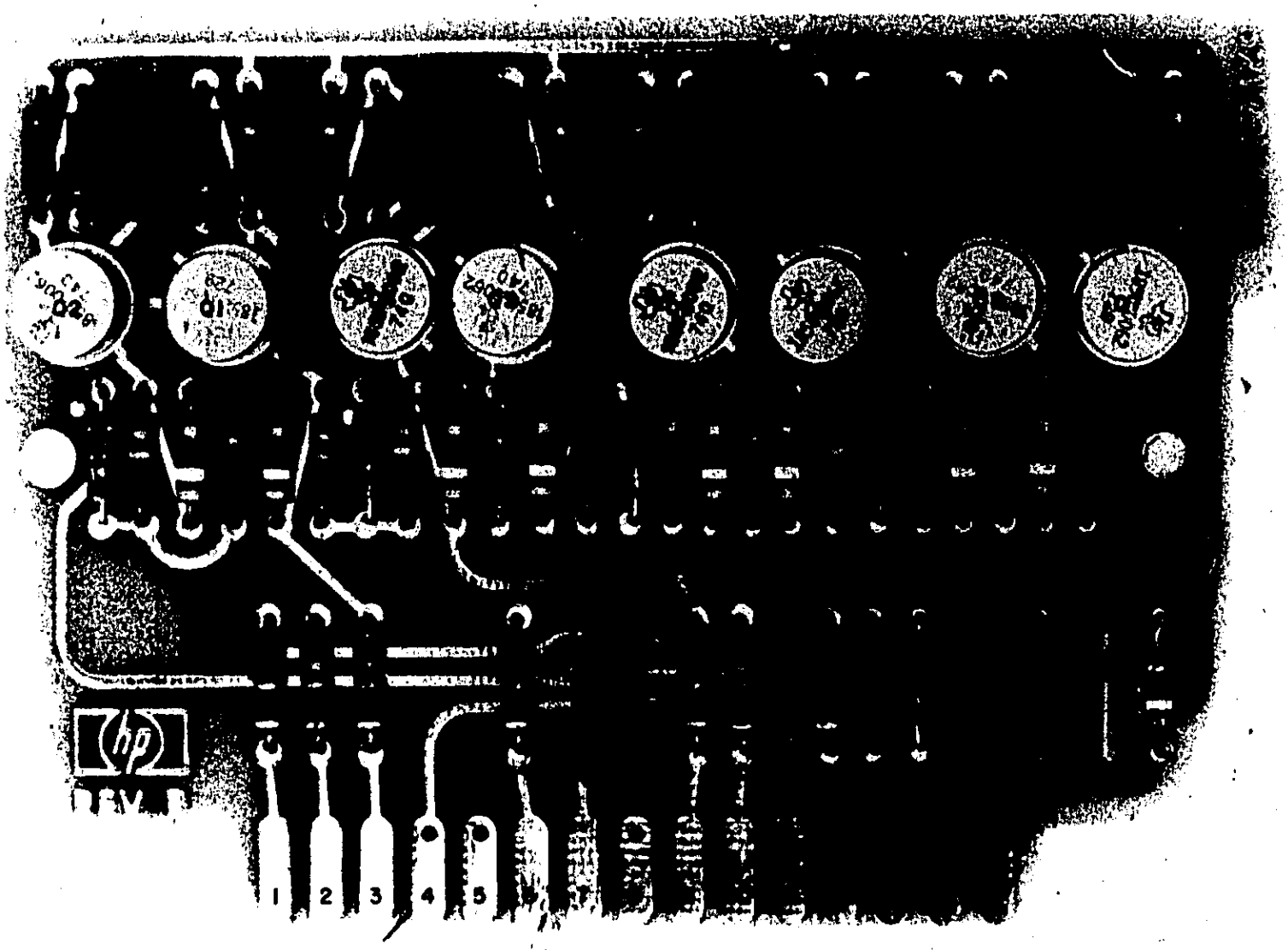
4. O/L = OVERLOAD

5. SEE LOGIC SYMBOLOGY EXPLANATION FOR TRANSLATION OF UNFAMILIAR SYMBOLS.

6. IDENTIFIES UNITS INDICATORS OF ASSEMBLY A24.

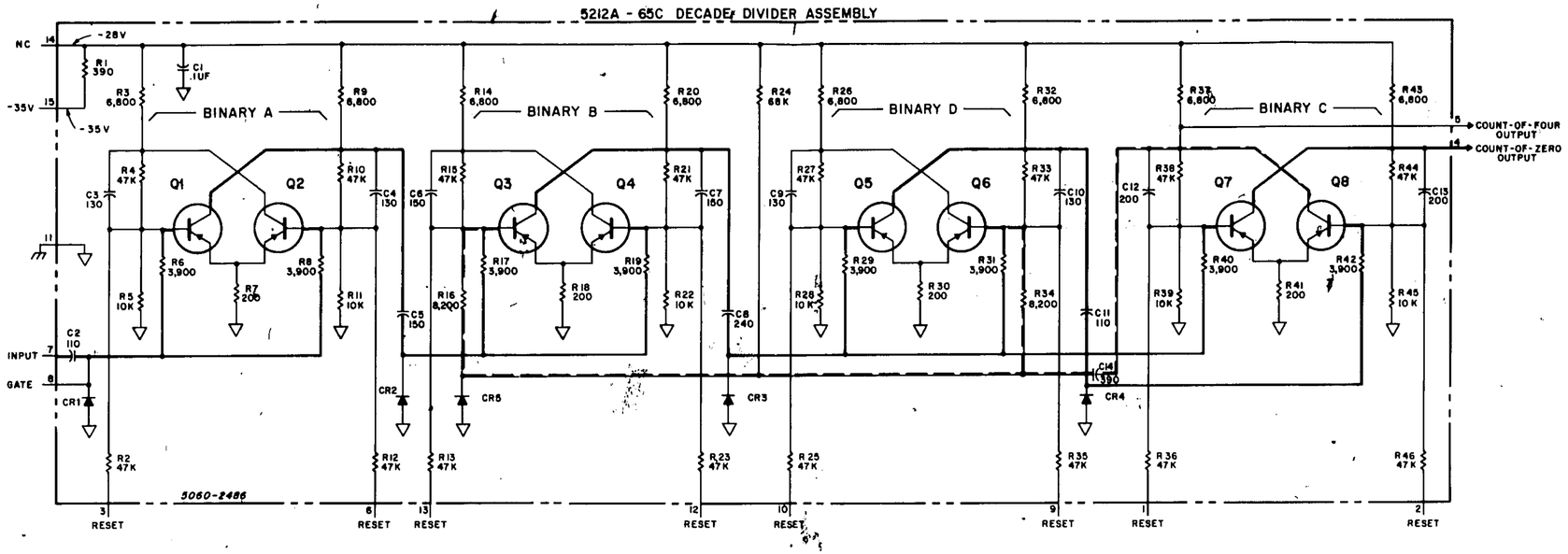
7 SEE FIGURE 4-24 FOR LOGIC OF A22 (5060-2111) USED ON SERIAL PREFIX 501- THRU 533-

Figure 4-9. Overall Logic Diagram Decimal Point and Control



Stock No. 5212A-65C

(A1-A5) Decade Divider
(See parts list beginning on page 5-4.)

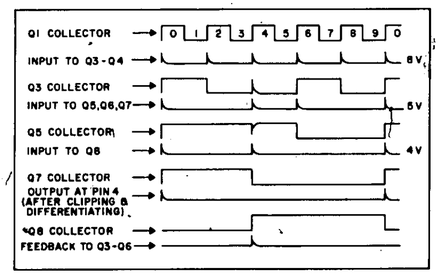


NOTES

1. TYPICAL CIRCUITRY EXTERNAL TO DECADE DIVIDER ASSY IS SHOWN; FOR EXACT CONNECTION AND REFERENCE DESIGNATIONS OF EXTERNAL COMPONENTS, REFER TO OVERALL LOGIC DIAGRAM.
2. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS AND CAPACITANCE IN PICOFARADS
3. ⏚ = CHASSIS GROUND
4. ▽ = CIRCUIT COMMON

D5060-2486

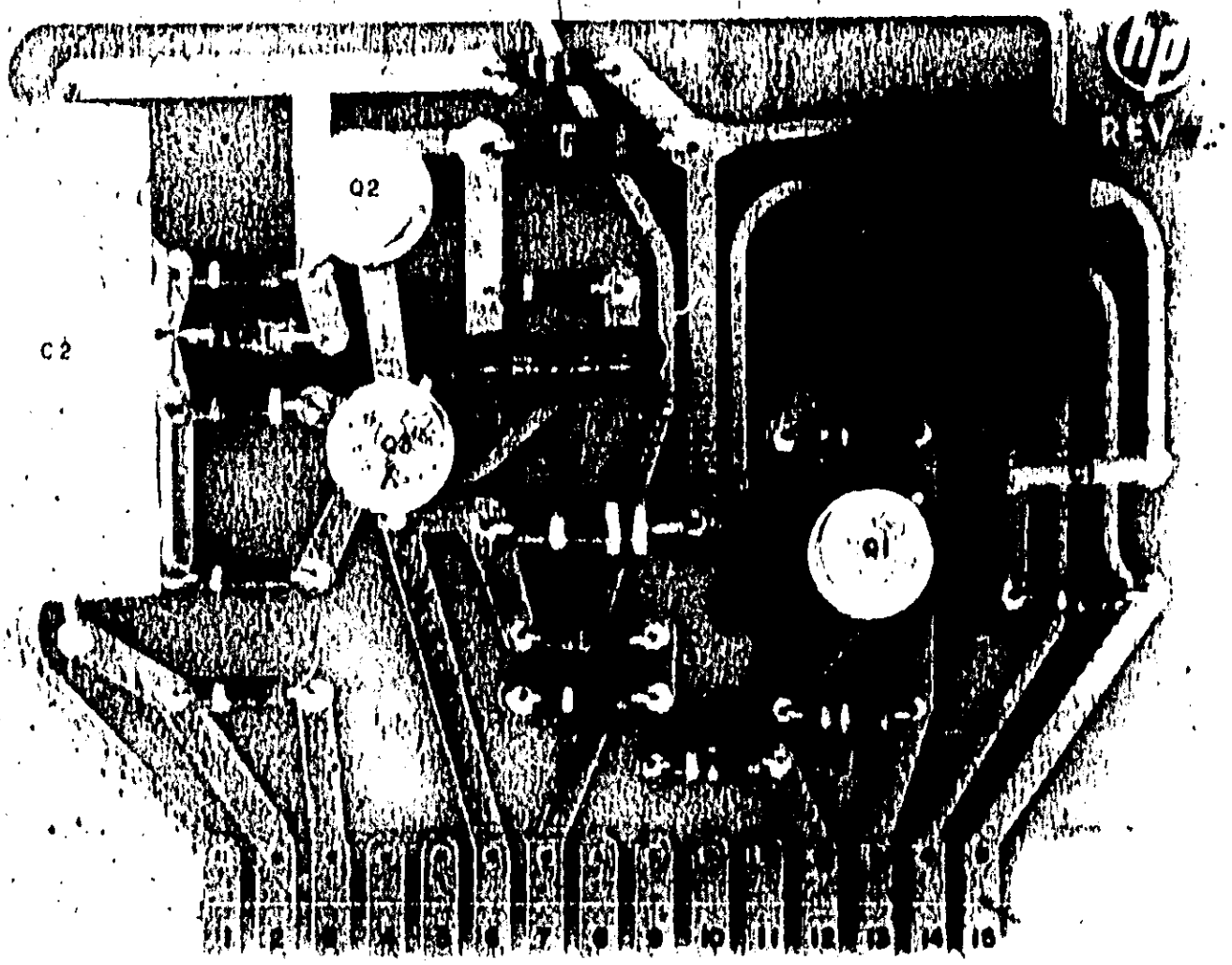
WAVEFORMS



RESET WIRING

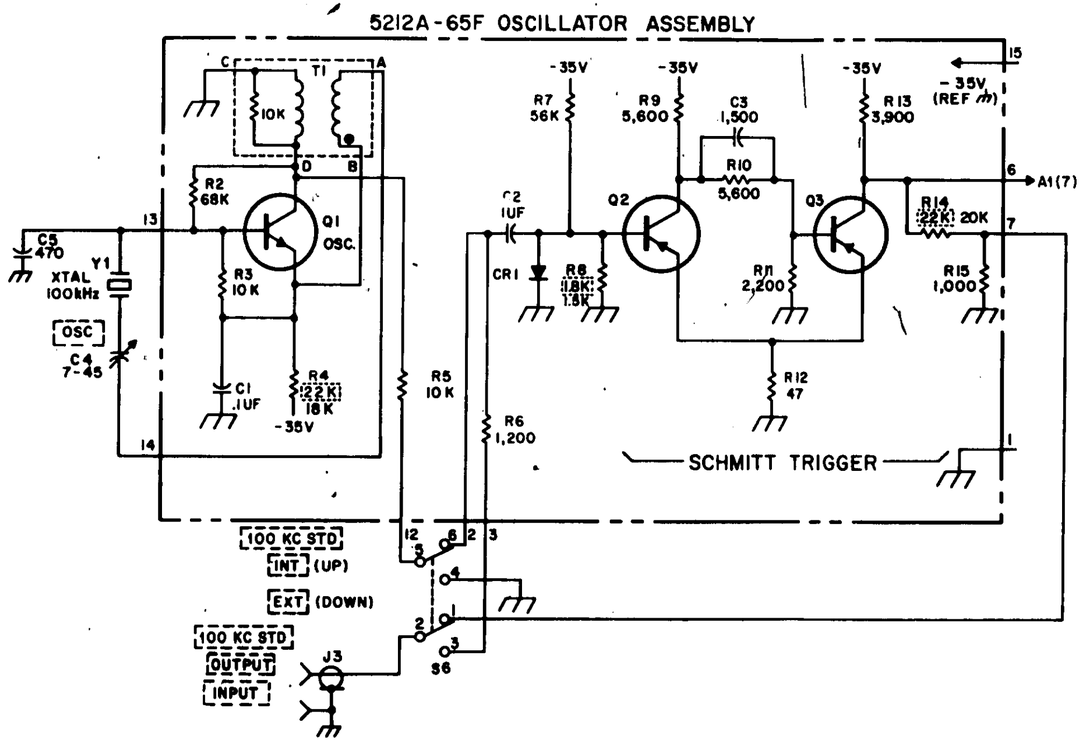
RESET NUMERAL	RESET PULSE (NEGATIVE) PIN CONNECTIONS			
0	3	13	10	1
1	6	13	10	1
2	3	12	10	1
3	6	12	10	1
4	3	12	10	2
5	6	12	10	2
6	3	13	9	2
7	6	13	9	2
8	3	12	9	2
9	6	12	9	2

Figure 4-10. Decade Divider (A1-A5)



Stock No. 5212A-65F

(A6) 100 KHz Oscillator and Schmitt Trigger
(See parts list beginning on page 5-5.)

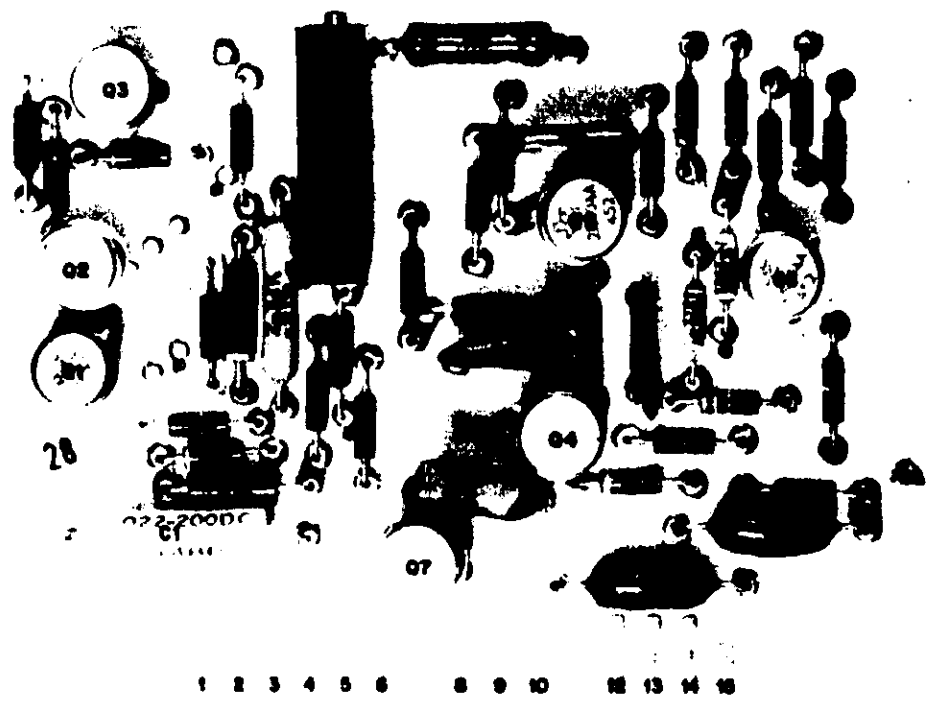


05060-2488

NOTES

1. ⏚ = CHASSIS GROUND
2. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS AND CAPACITANCE IN PICOFARADS
3. RESISTANCE VALUES WITHIN DOTTED LINES APPLY TO SER. PREFIX 501- THRU 614-.

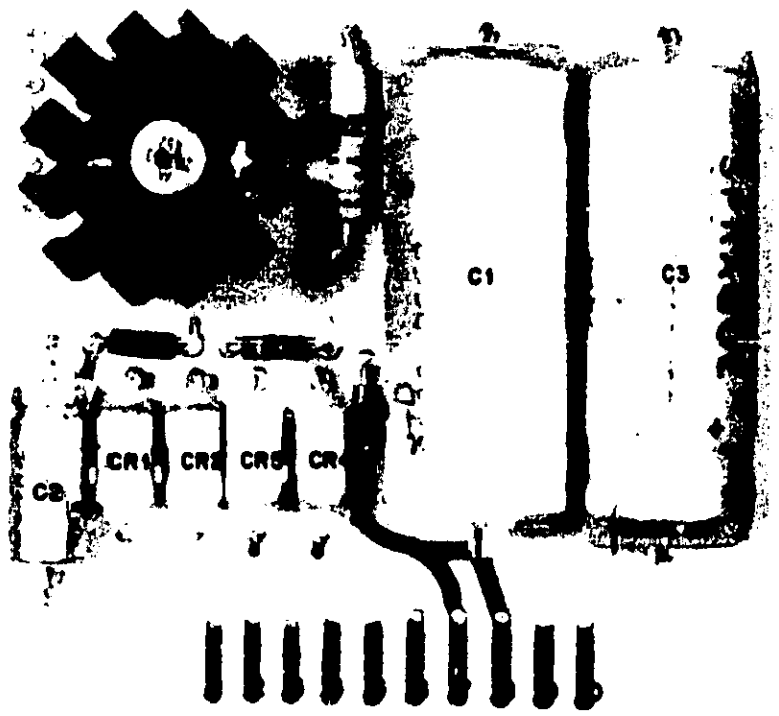
Figure 4-11. 100KHz Oscillator and Schmitt Trigger (A6)



*SEE SCHEMATIC DIAGRAM FOR R1, R2, AND W1 USAGE.

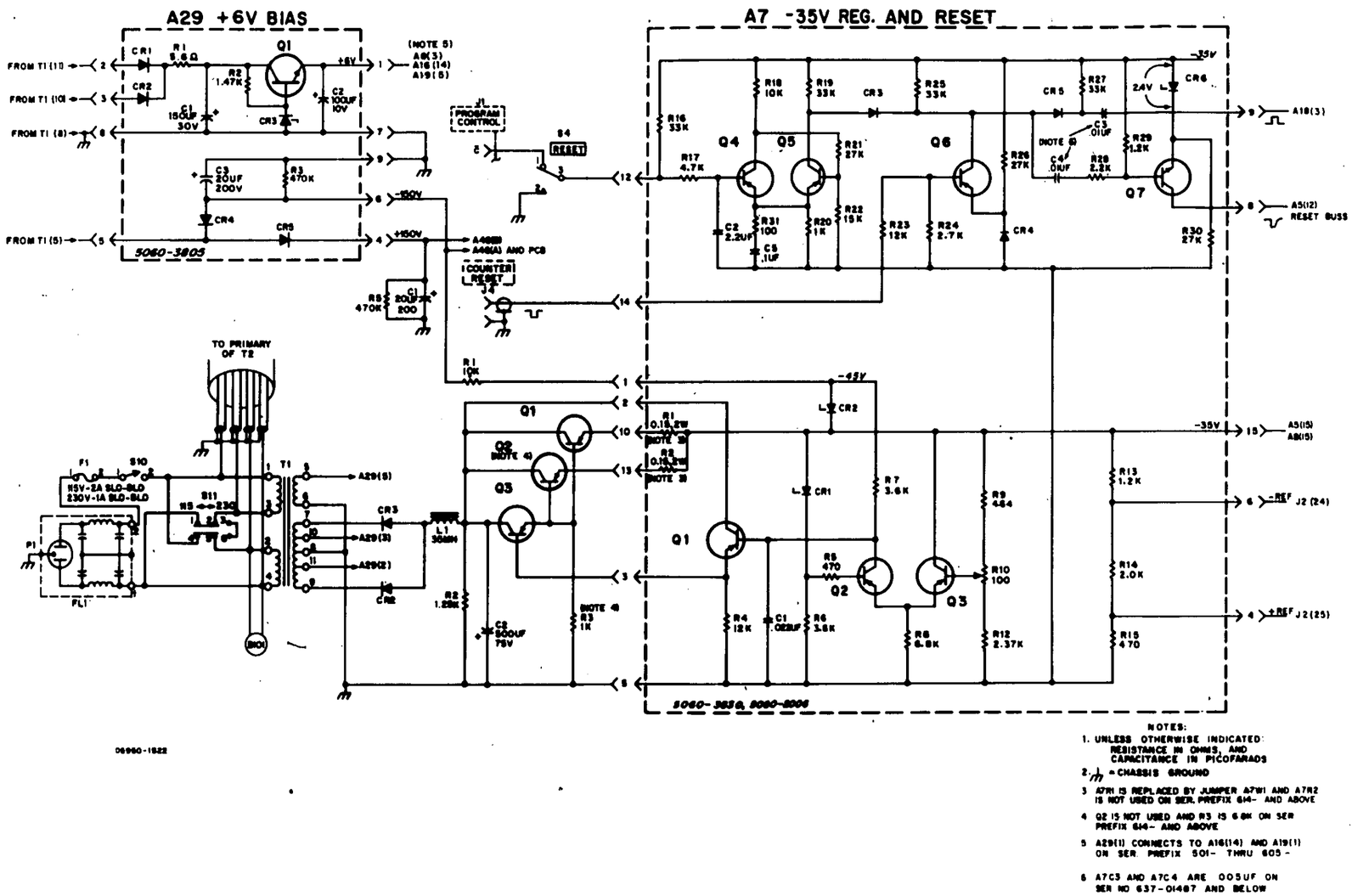
Stock No. 5060-2006 (Serial Prefix 614 and above)
Stock No. 5060-3830 (Serial Prefix 501 thru 610)

(A7) -35V Regulator and Reset
(See parts list beginning on page 5-6.)



Stock No. 5060-3805

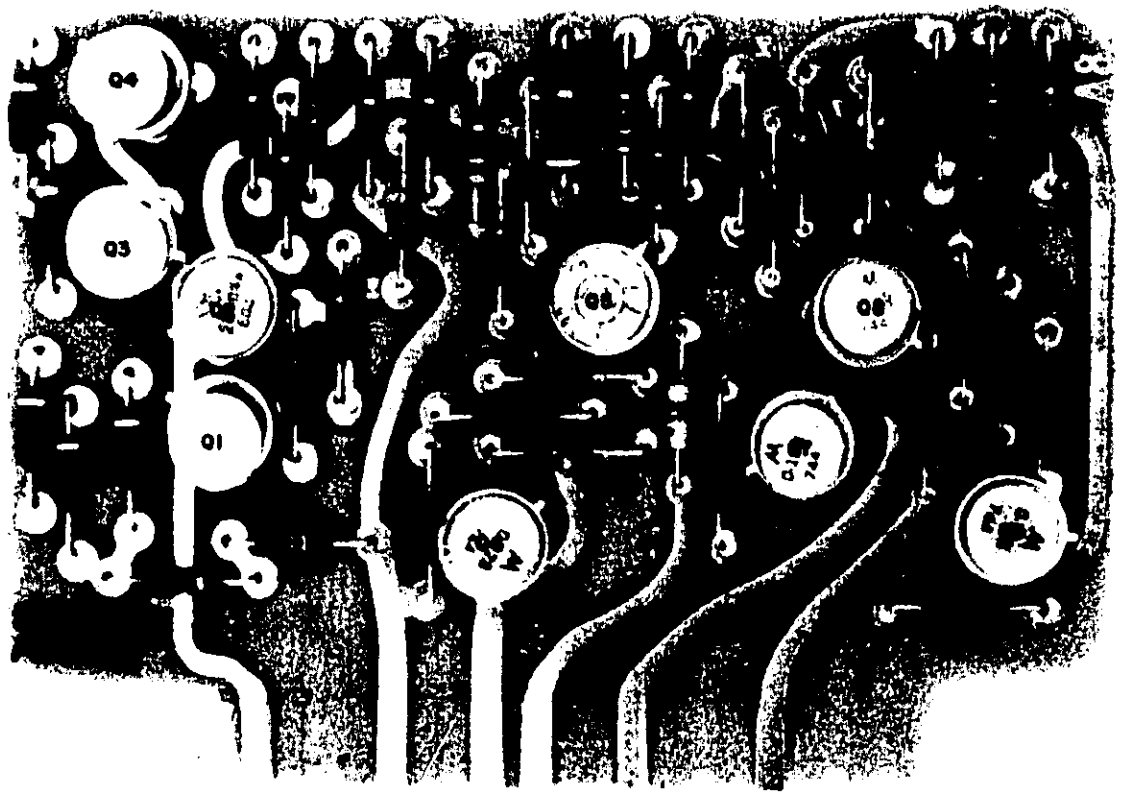
(A29) +6V Bias
(See parts list beginning on page 5-32.)



NOTES:

1. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS, AND CAPACITANCE IN PICOFARADS
2. ⏚ = CHASSIS GROUND
3. A7R1 IS REPLACED BY JUMPER A7W1 AND A7R2 IS NOT USED ON SER. PREFIX 614- AND ABOVE
4. Q2 IS NOT USED AND R3 IS 6.8K ON SER PREFIX 614- AND ABOVE
5. A29(1) CONNECTS TO A16(14) AND A19(1) ON SER. PREFIX 501- THRU 605-
6. A7C3 AND A7C4 ARE .005UF ON SER NO 637-01487 AND BELOW

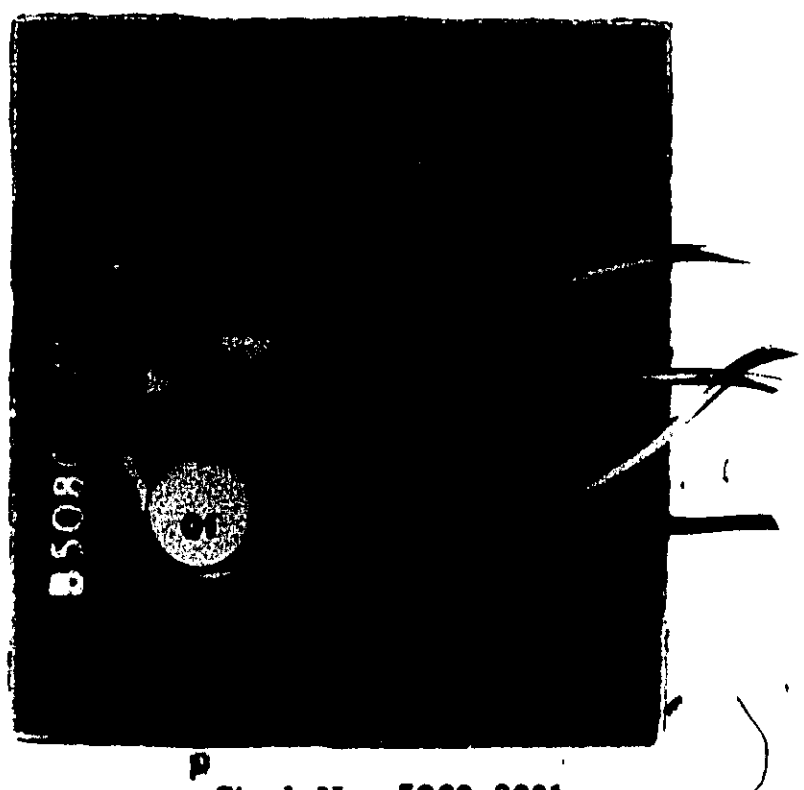
Figure 4-12. -35V Regulator and Reset (A7) and +6V Bias (A29)



*CR17 USED ONLY ON SERIAL PREFIX 610- AND ABOVE

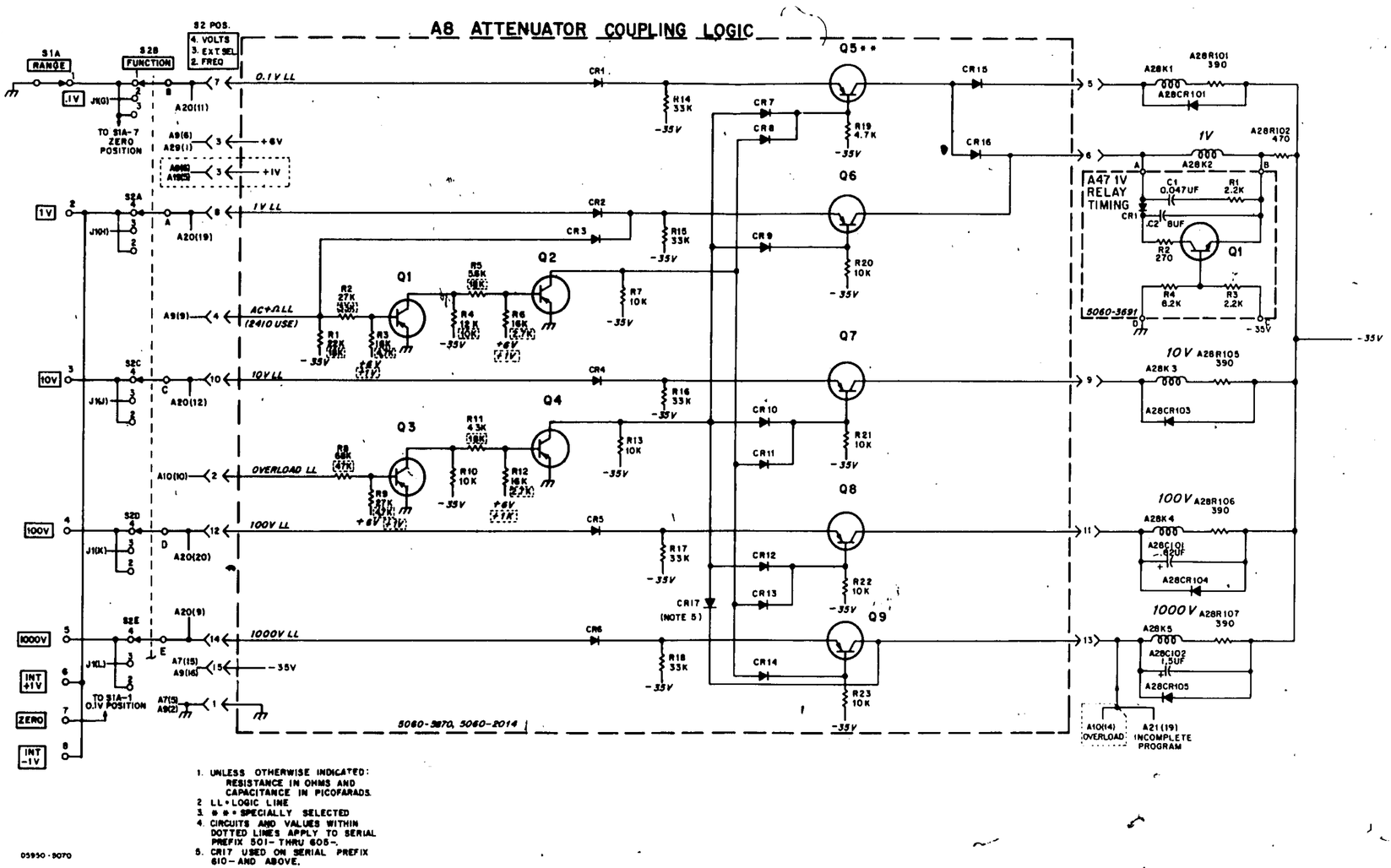
Stock No. 5060-2014 (Serial Prefix 501 thru 605)
Stock No. 5060-5870 (Serial Prefix 610 and above)

(A8) Attenuator Coupling Logic Assembly
(See parts list beginning on page 5-7.)



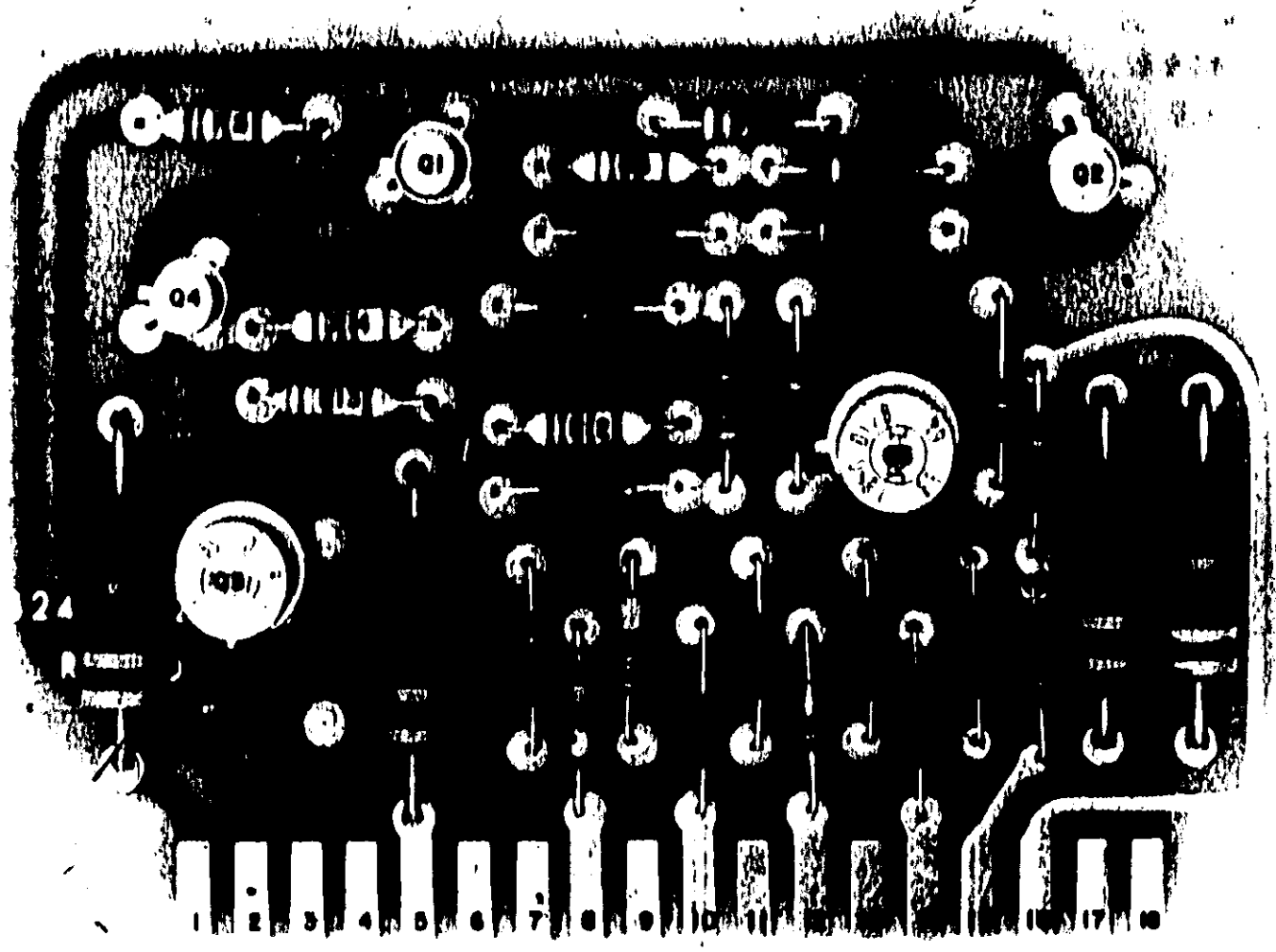
Stock No. 5060-3691

(A47) IV Relay Timing Assembly
(See parts list beginning on page 5-42.)



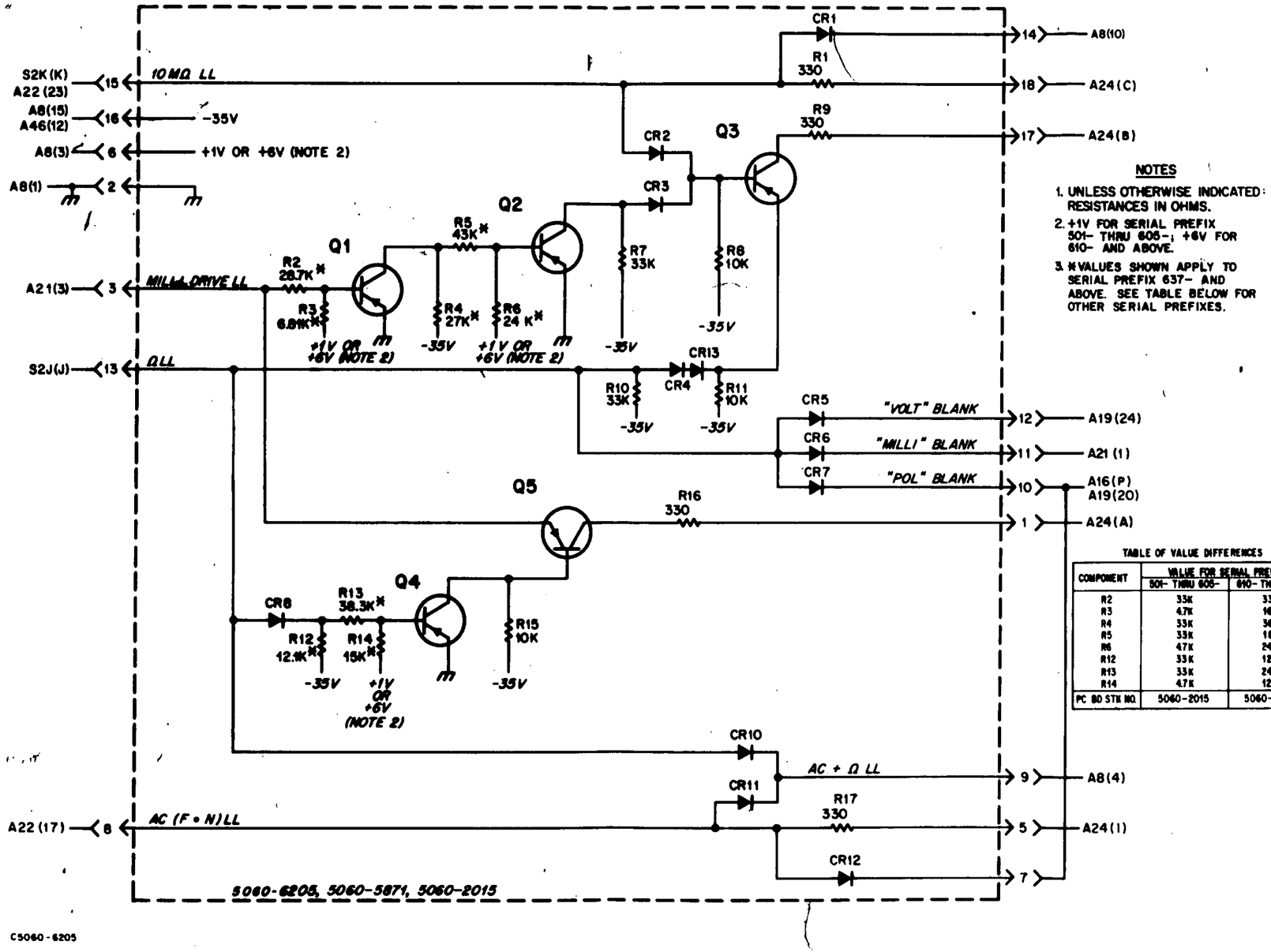
1. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS AND CAPACITANCE IN PICOFARADS.
2. LL=LOGIC LINE
3. ⊕ = SPECIALLY SELECTED
4. CIRCUITS AND VALUES WITHIN DOTTED LINES APPLY TO SERIAL PREFIX 501- THRU 605-.
5. CR17 USED ON SERIAL PREFIX 610- AND ABOVE.

Figure 4-13. Attenuator Coupling (A8) and IV Relay Timing (A47)



Stock No. 5060-2015 (For Serial Prefix 501 thru 605)
Stock No. 5060-5871 (For Serial Prefix 610 thru 622)
Stock No. 5060-6205 (For Serial Prefix 637 and above)

(A9) HP 2410B Units Coupling
(See parts list beginning on page 5-8.)



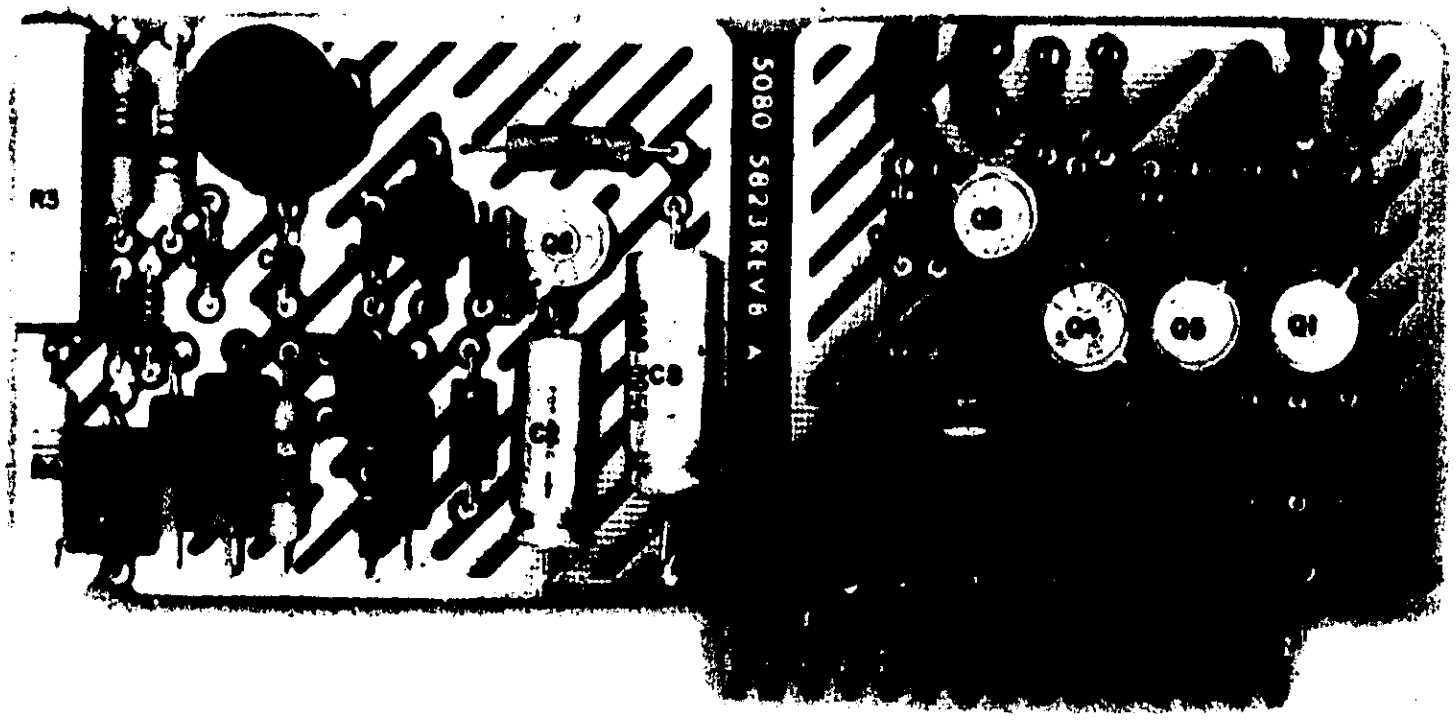
NOTES

1. UNLESS OTHERWISE INDICATED: RESISTANCES IN OHMS.
2. +1V FOR SERIAL PREFIX 501- THRU 605-; +6V FOR 610- AND ABOVE.
3. *VALUES SHOWN APPLY TO SERIAL PREFIX 637- AND ABOVE. SEE TABLE BELOW FOR OTHER SERIAL PREFIXES.

TABLE OF VALUE DIFFERENCES

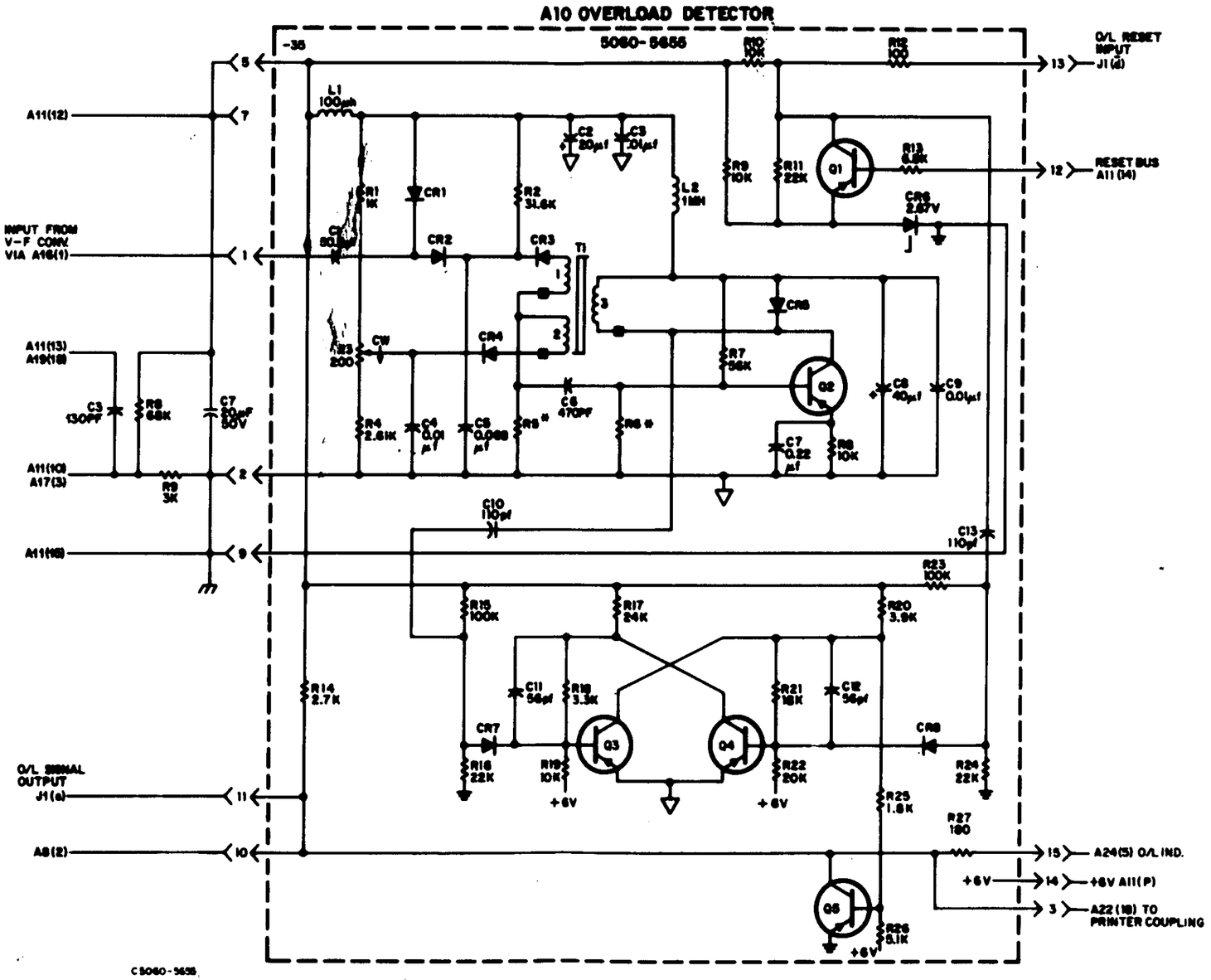
COMPONENT	VALUE FOR SERIAL PREFIX	
	501- THRU 605-	610- THRU 622-
R2	33K	33K
R3	4.7K	16K
R4	33K	36K
R5	33K	18K
R6	4.7K	24K
R12	33K	12K
R13	33K	24K
R14	4.7K	12K
PC BD STK NO.	5060-2015	5060-5871

Figure 4-14. HP 2410B Units Coupling (A9)



Stock No. 5060-5655 (Serial Prefix 610 and above)

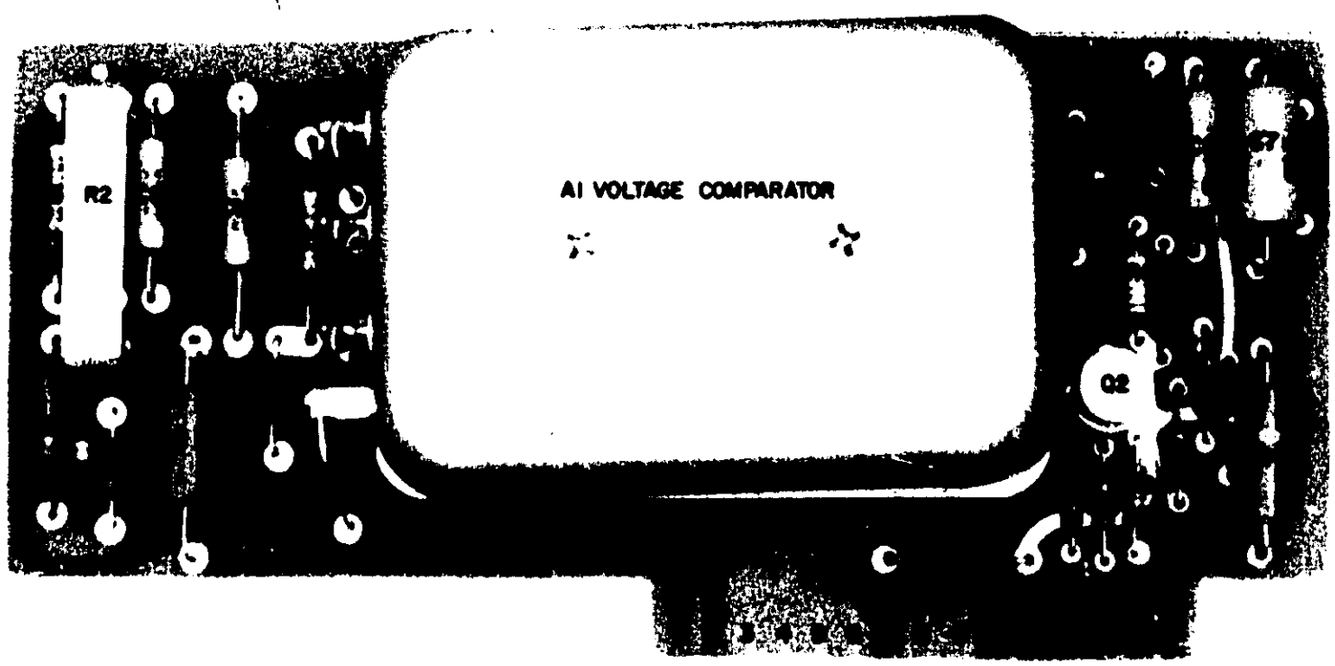
(A10) Overload Detector
(See parts list beginning on page 5-11.)



C5060-5656

NOTES: 1. UNLESS OTHERWISE NOTED:
RESISTANCE IN OHMS
2. * = FACTORY SELECTED.
3. ▽ = CIRCUIT COMMON (ANALOG)
4. ⏚ = CHASSIS GROUND
5. ⏚ = CIRCUIT COMMON (DIGITAL)

Figure 4-15. Overload Detector (A10) - For Serial Prefix 610 and above



Stock No. 5060-2181 (Serial Prefix 501 thru 605)

(A10) Overload Detector
(See parts list beginning on page 5-10.)

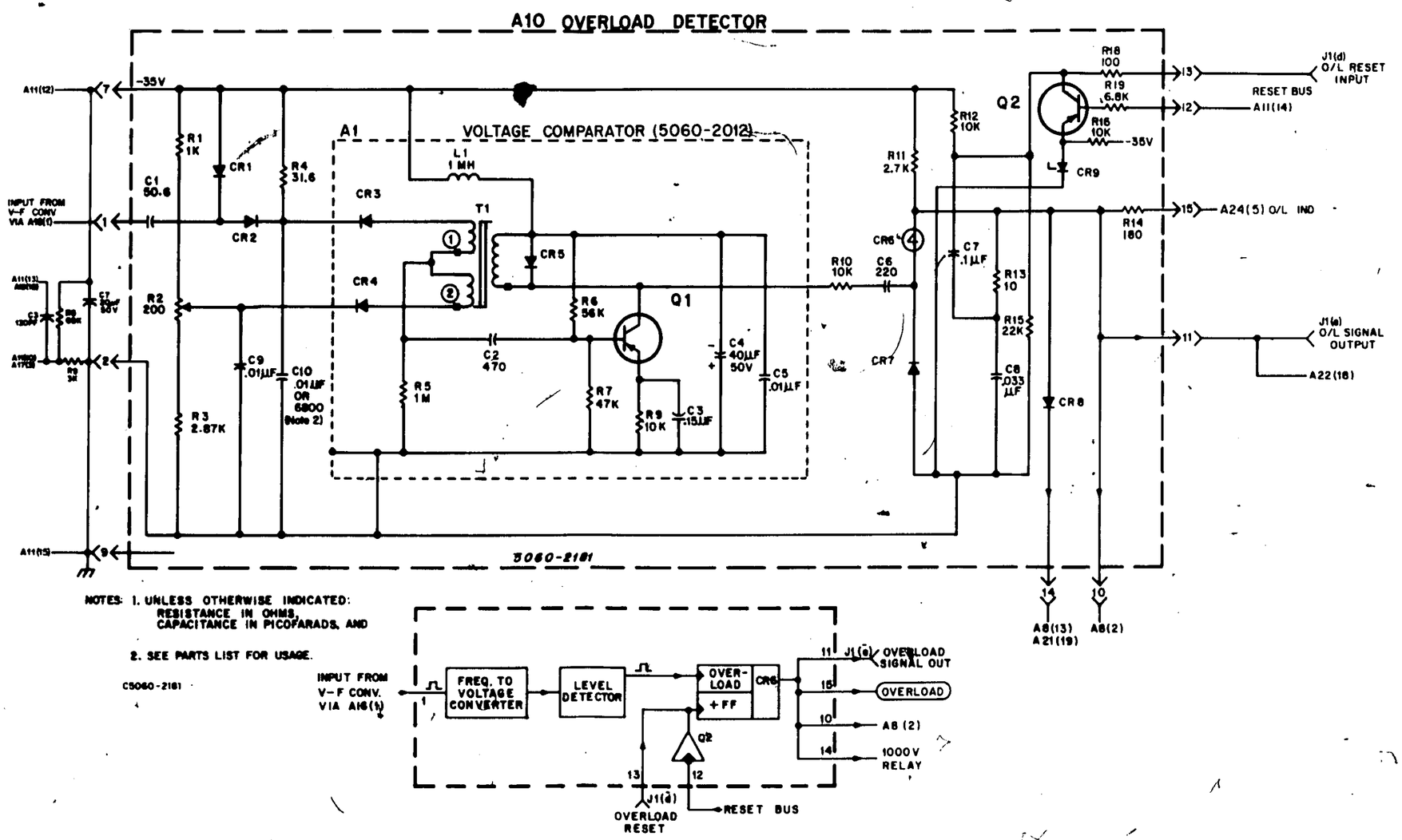
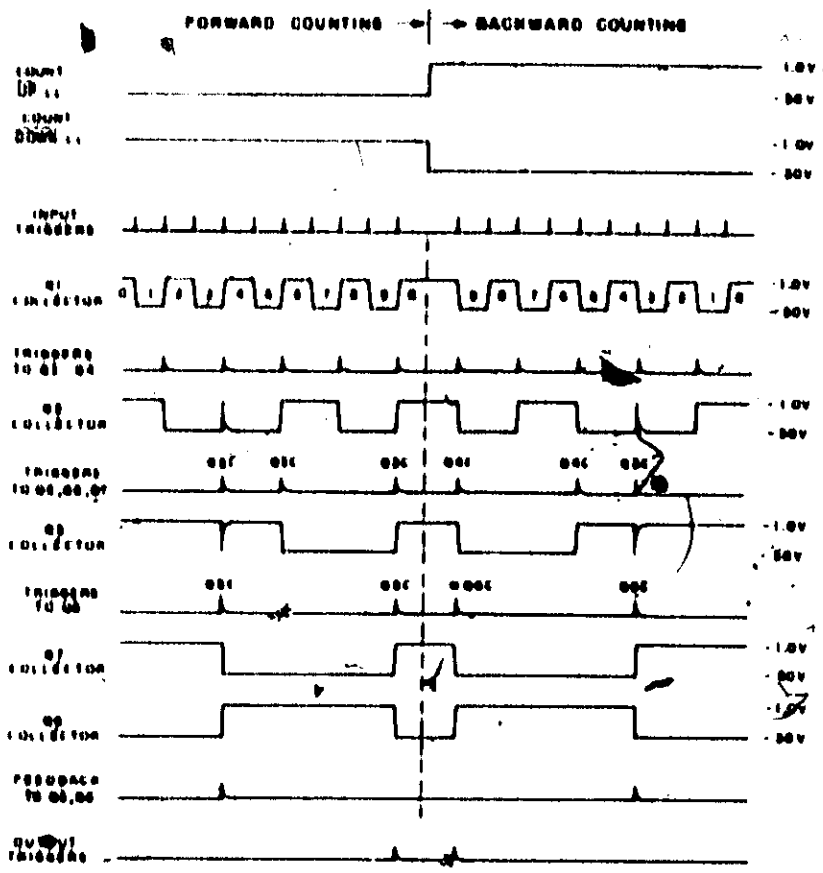
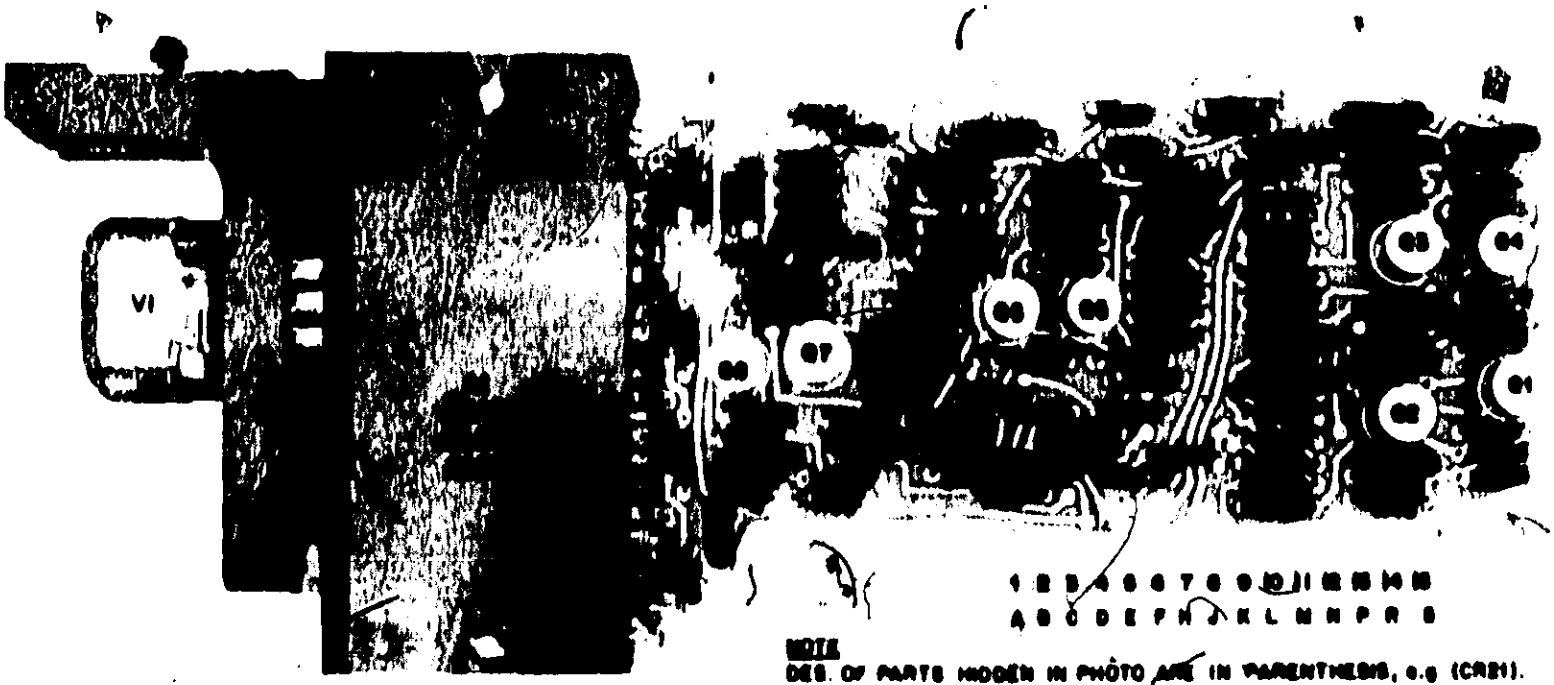


Figure 4-16. Overload Detector (A10) - For Serial Prefix 501 thru 605



REVERSIBLE DECADE WAVEFORMS



NOTE
DES. OF PARTS HIDDEN IN PHOTO ARE IN PARENTHESIS, e.g. (CR21).
LETTERED PINS ARE ON OPPOSITE SIDE OF BOARD.

Stock No. 5060-3781

(A11-A15, A46) Reversible +4-2'-2-1 Decade Counter
(See parts list beginning on page 5-13.)

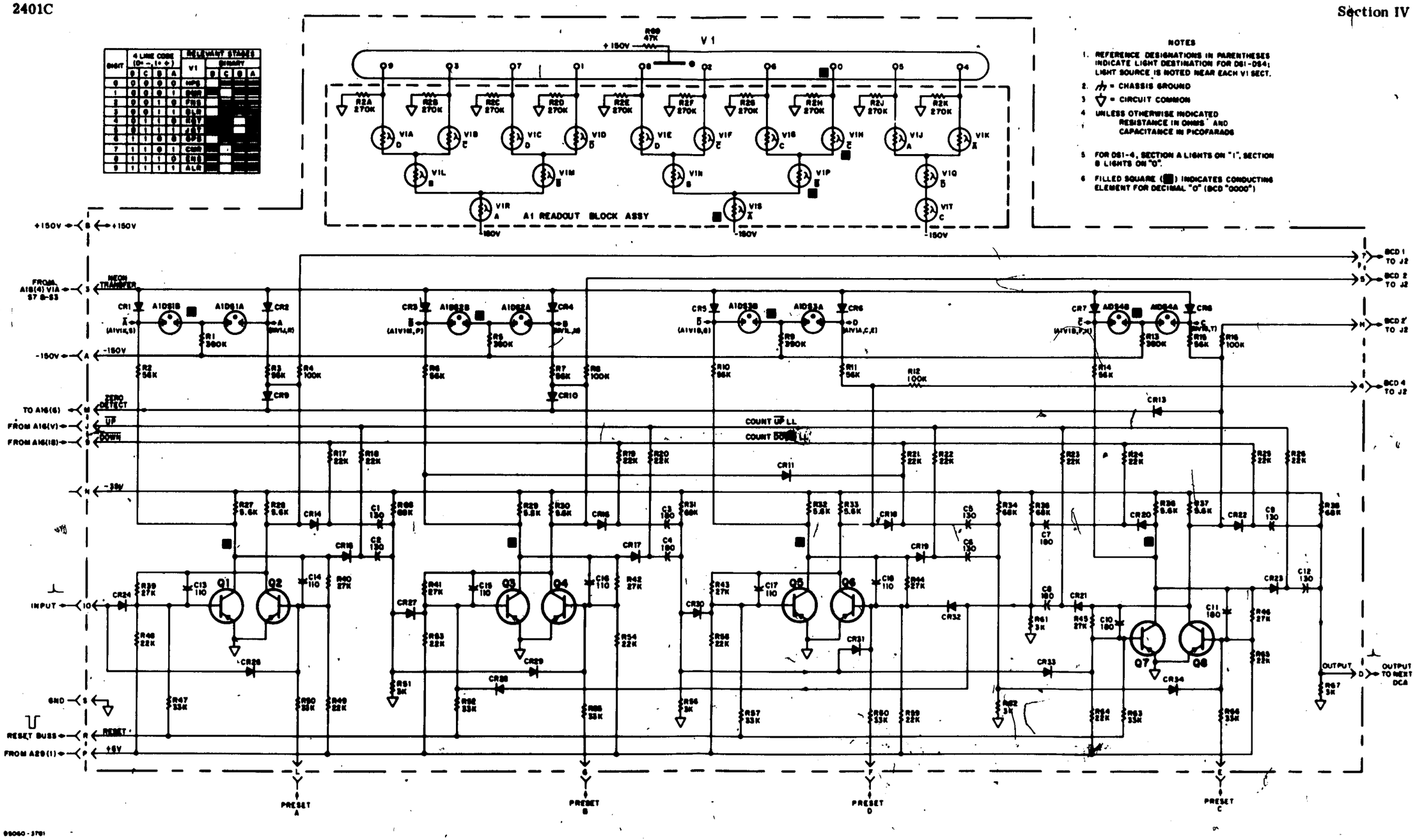
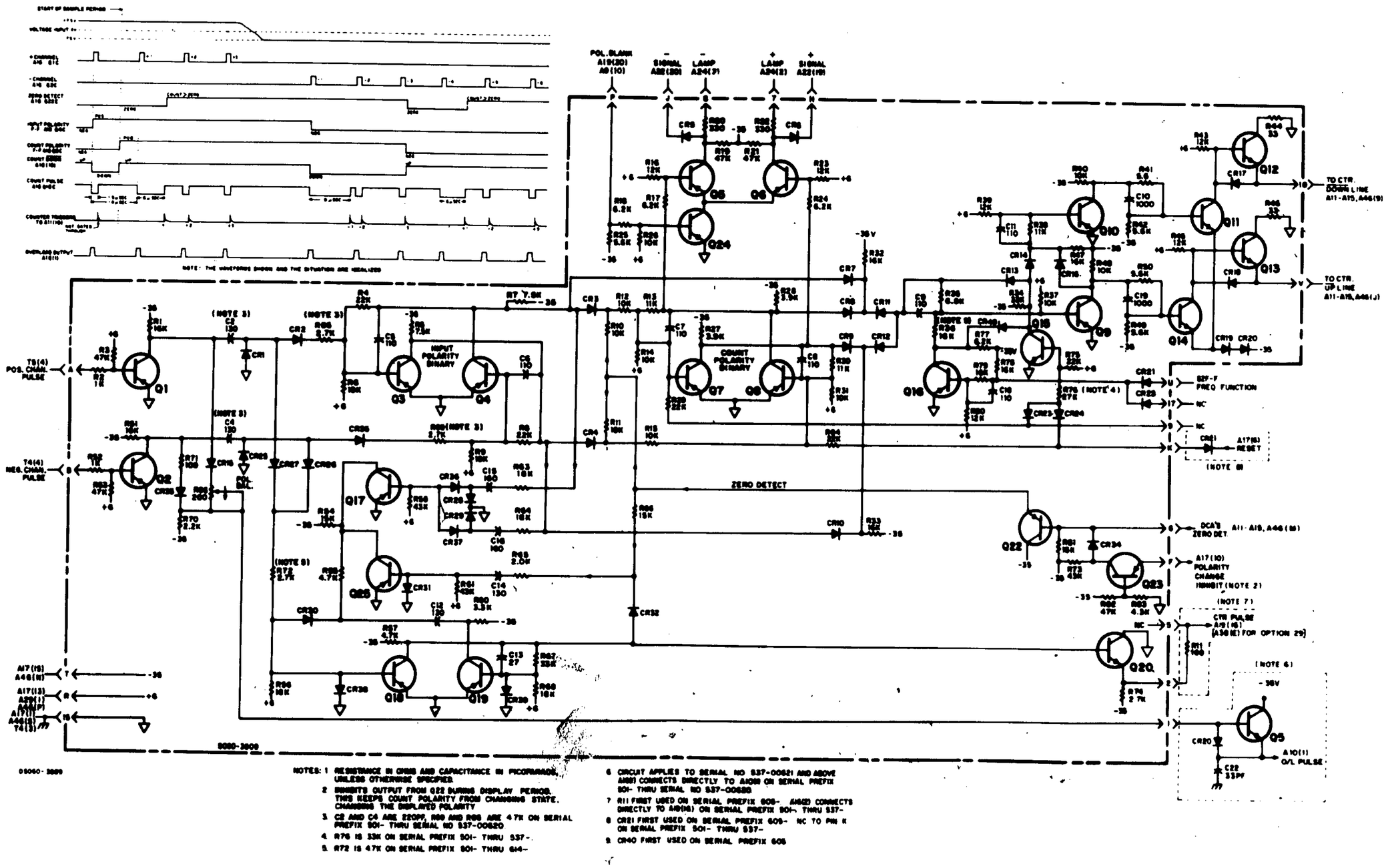


Figure 4-17. Reversible +4-2'-2-1 Decade Counter (A11-A15, A46)

* CR38 IS UNDER Q18 AND CR39 IS UNDER Q19.

Stock No. 5060-3809

(A16) Counter Control
(See parts list beginning on page 5-15.)



NOTES: 1. RESISTANCE IN OHMS AND CAPACITANCE IN PICOFARADS, UNLESS OTHERWISE SPECIFIED.

2. INHIBITS OUTPUT FROM Q22 DURING DISPLAY PERIOD. THIS KEEPS COUNT POLARITY FROM CHANGING STATE, CHANGING THE DISPLAYED POLARITY.

3. C2 AND C4 ARE 220PF, R66 AND R68 ARE 4.7K ON SERIAL PREFIX 501- THRU SERIAL NO 537-00620.

4. R76 IS 33K ON SERIAL PREFIX 501- THRU 537-.

5. R72 IS 47K ON SERIAL PREFIX 501- THRU 644-.

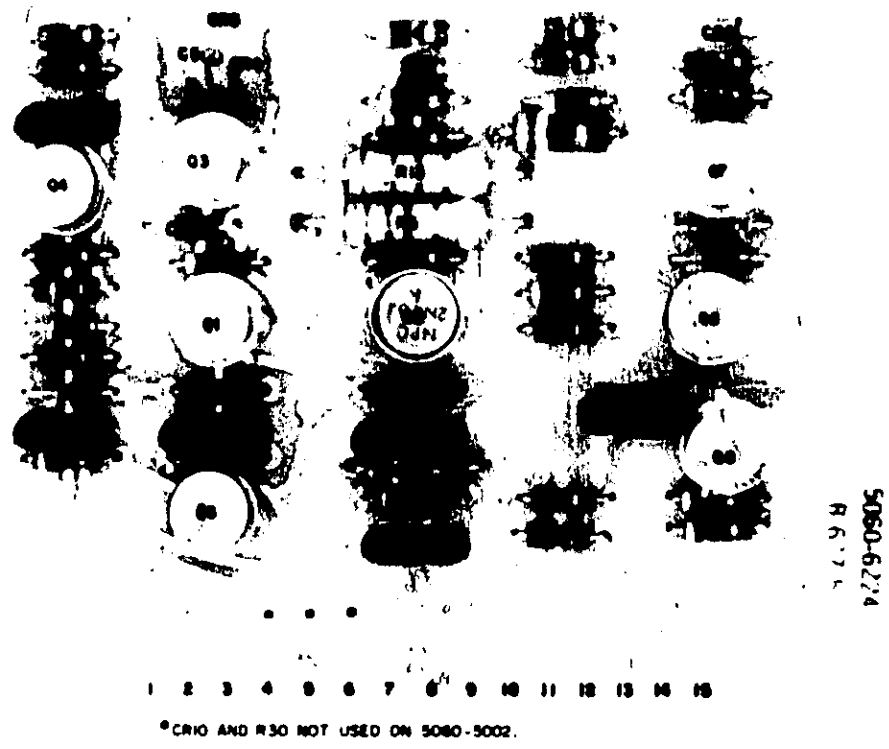
6. CIRCUIT APPLIES TO SERIAL NO 537-00621 AND ABOVE AND CONNECTS DIRECTLY TO A46B9 ON SERIAL PREFIX 501- THRU SERIAL NO 537-00688.

7. R11 FIRST USED ON SERIAL PREFIX 608- A46(E) CONNECTS DIRECTLY TO A46(H8) ON SERIAL PREFIX 501- THRU 537-.

8. CR21 FIRST USED ON SERIAL PREFIX 608- NC TO PIN K ON SERIAL PREFIX 501- THRU 537-.

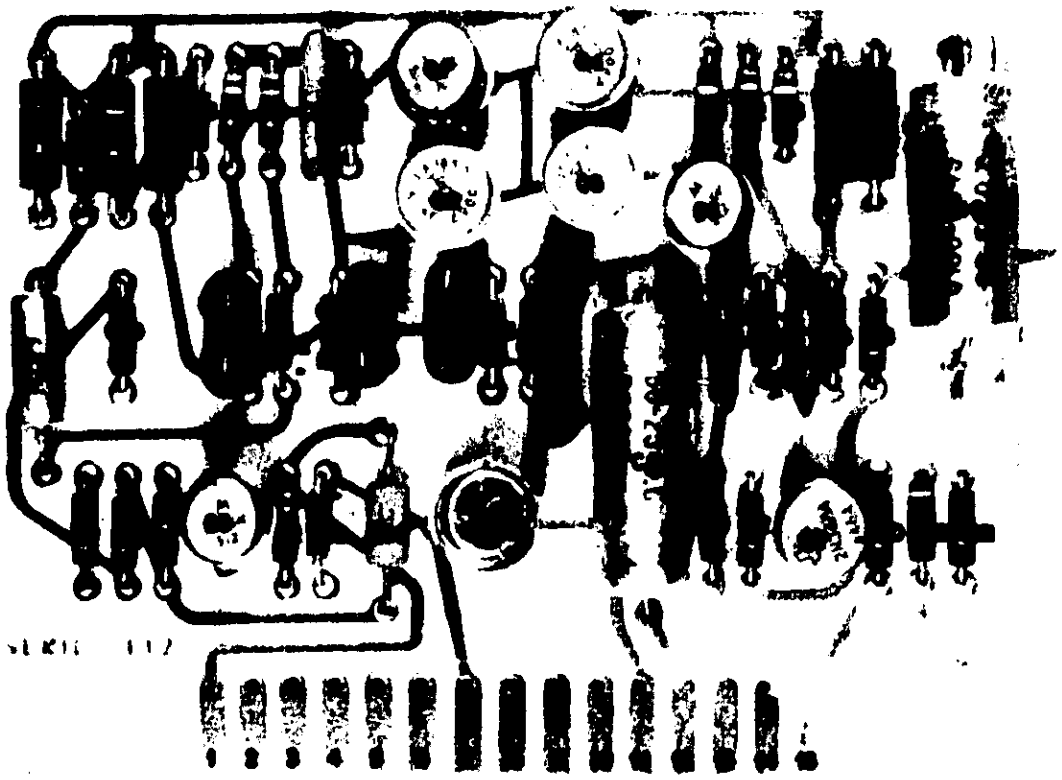
9. CR40 FIRST USED ON SERIAL PREFIX 608.

Figure 4-18. Counter Control (A16)



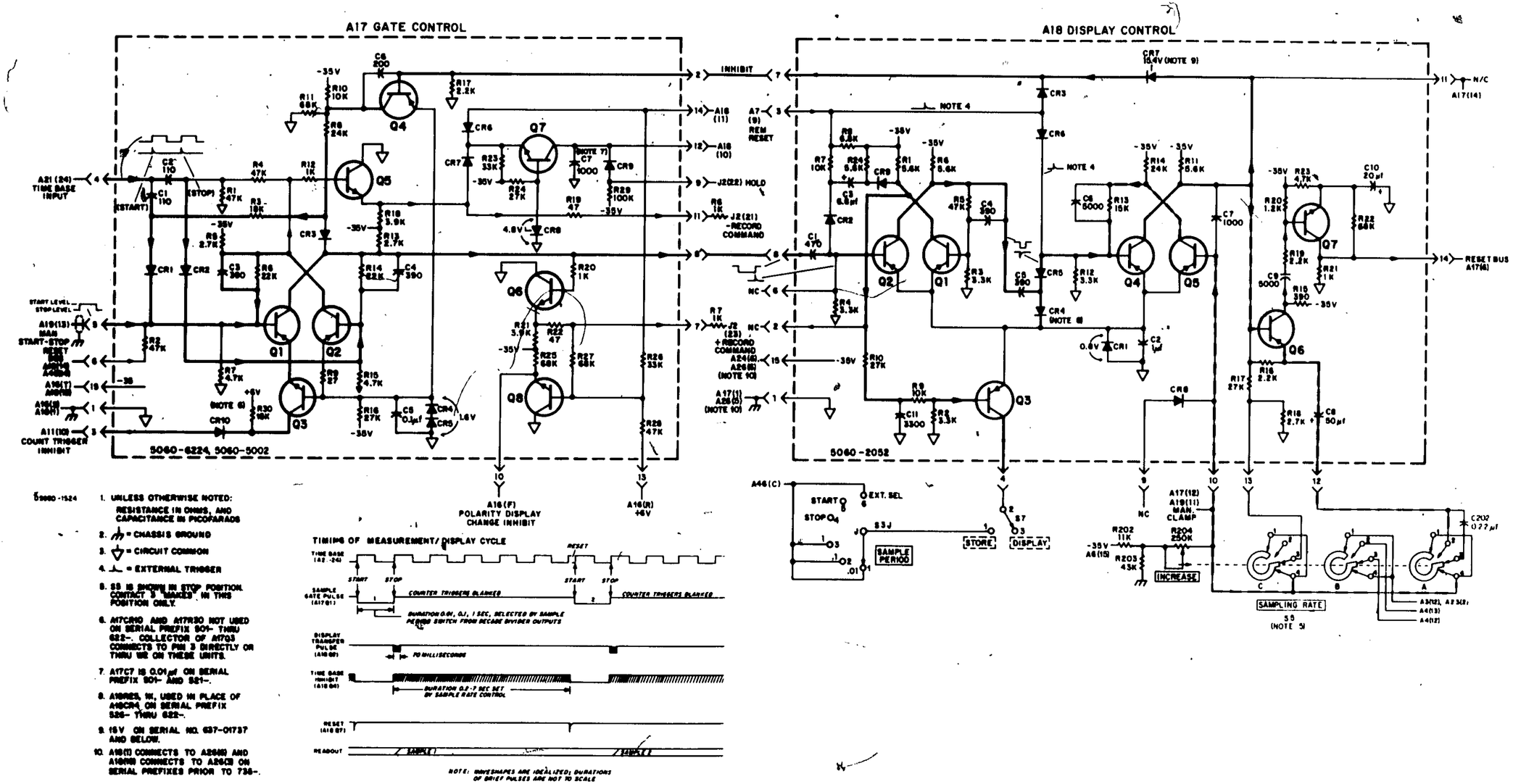
Stock No. 5060-5002 (Serial Prefix 501 thru 622)
Stock No. 5060-6224 (Serial Prefix 637 and above)

(A17) Gate and Display Control
(See parts list beginning on page 5-17.)



Stock No. 5060-2052

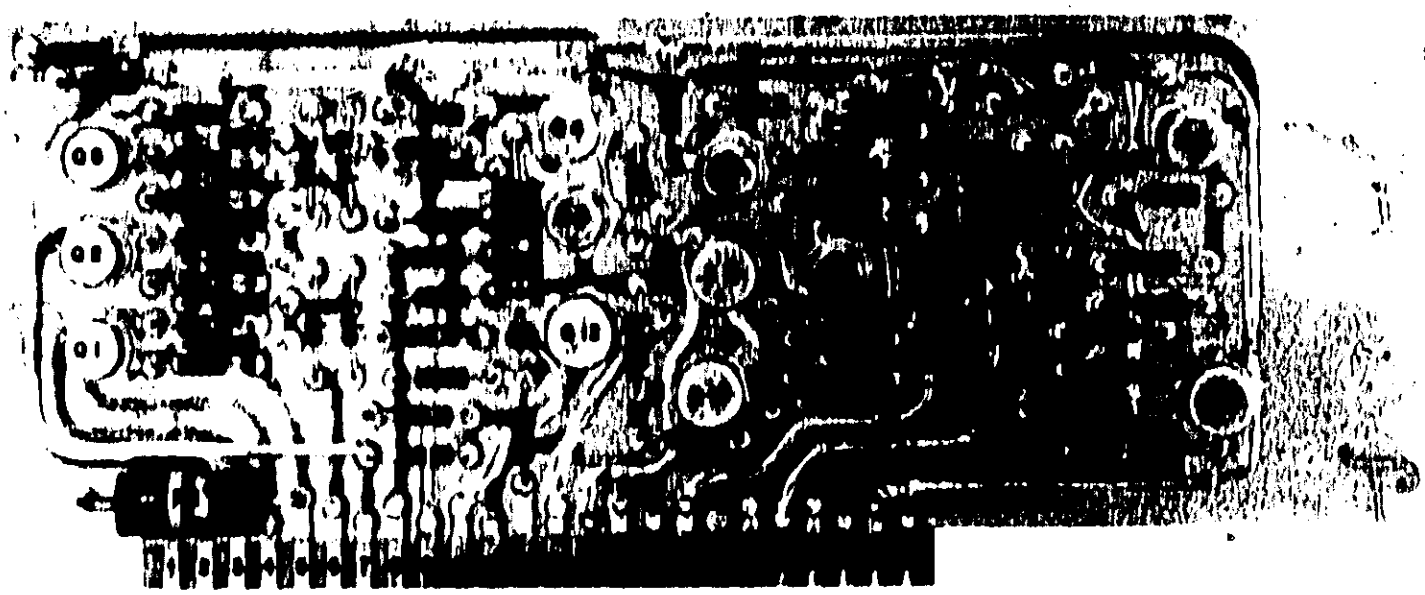
(A18) Gate and Display Control
(See parts list beginning on page 5-19.)



5060-1524

1. UNLESS OTHERWISE NOTED: RESISTANCE IN OHMS, AND CAPACITANCE IN PICOFARADS
2. = CHASSIS GROUND
3. = CIRCUIT COMMON
4. = EXTERNAL TRIGGER
5. SS IS SHOWN IN STOP POSITION. CONTACT 3 "MAKES" IN THIS POSITION ONLY.
6. A17CR10 AND A17R30 NOT USED ON SERIAL PREFIX 901- THRU 922-. COLLECTOR OF A1Q3 CONNECTS TO PIN 3 DIRECTLY OR THRU 10E ON THESE UNITS.
7. A17C7 IS 0.01 μf ON SERIAL PREFIX 901- AND 921-.
8. A18R65, 1K, USED IN PLACE OF A18CR4 ON SERIAL PREFIX 526- THRU 622-.
9. 15 V ON SERIAL NO. 637-01737 AND BELOW.
10. A19(1) CONNECTS TO A26(6) AND A19(9) CONNECTS TO A26(3) ON SERIAL PREFIXES PRIOR TO 736-.

Figure 4-19. Gate and Display Control (A17 and A18)



* CR1, CR2, AND R1 USED ONLY ON SERIAL PREFIX 501- THRU 605-

Stock No. 5060-3820 (Serial Prefix 501 thru 605)
Stock No. 5060-5872 (Serial Prefix 610 and above)

(A19) Units/Counter Input Logic
(See parts list beginning on page 5-20.)

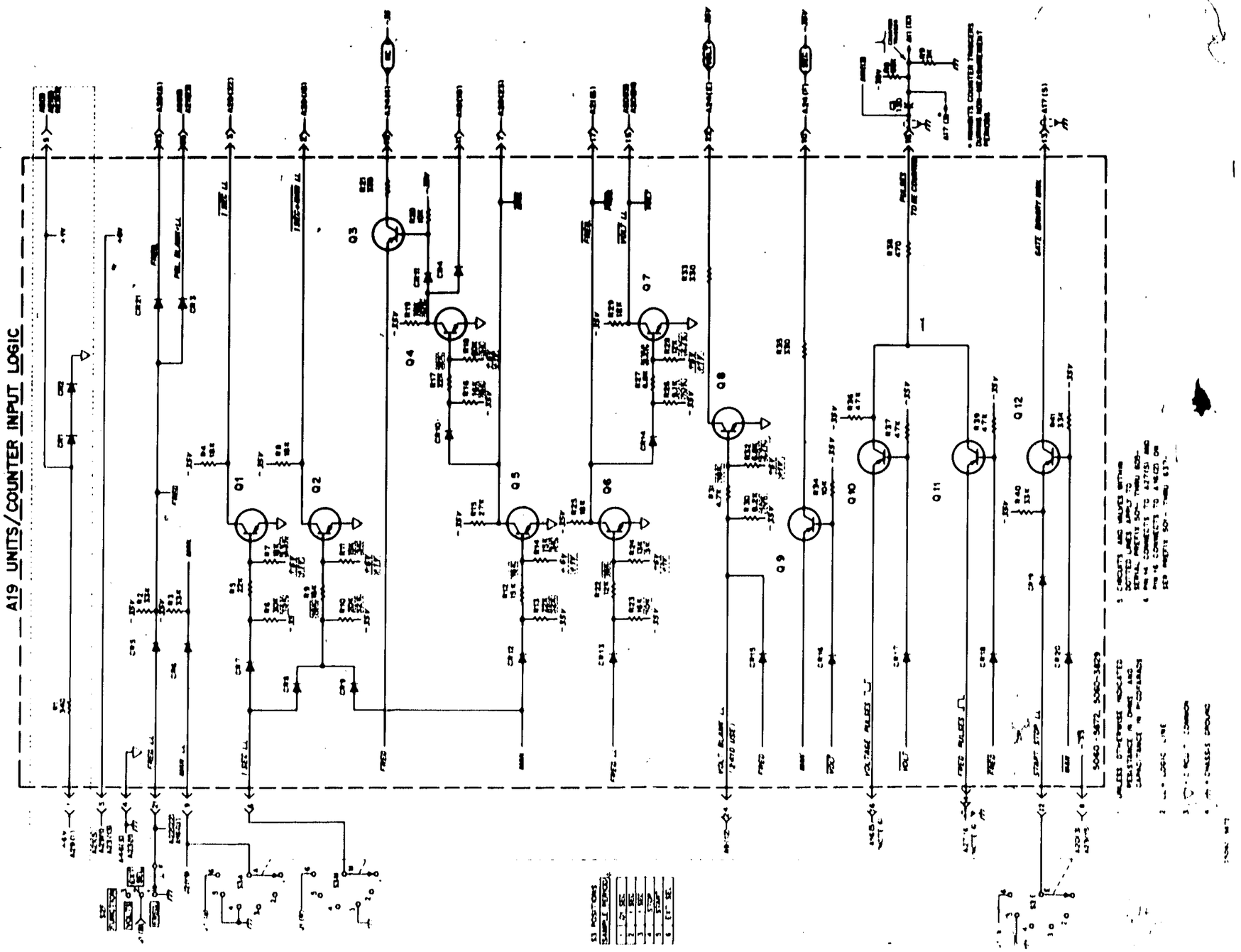
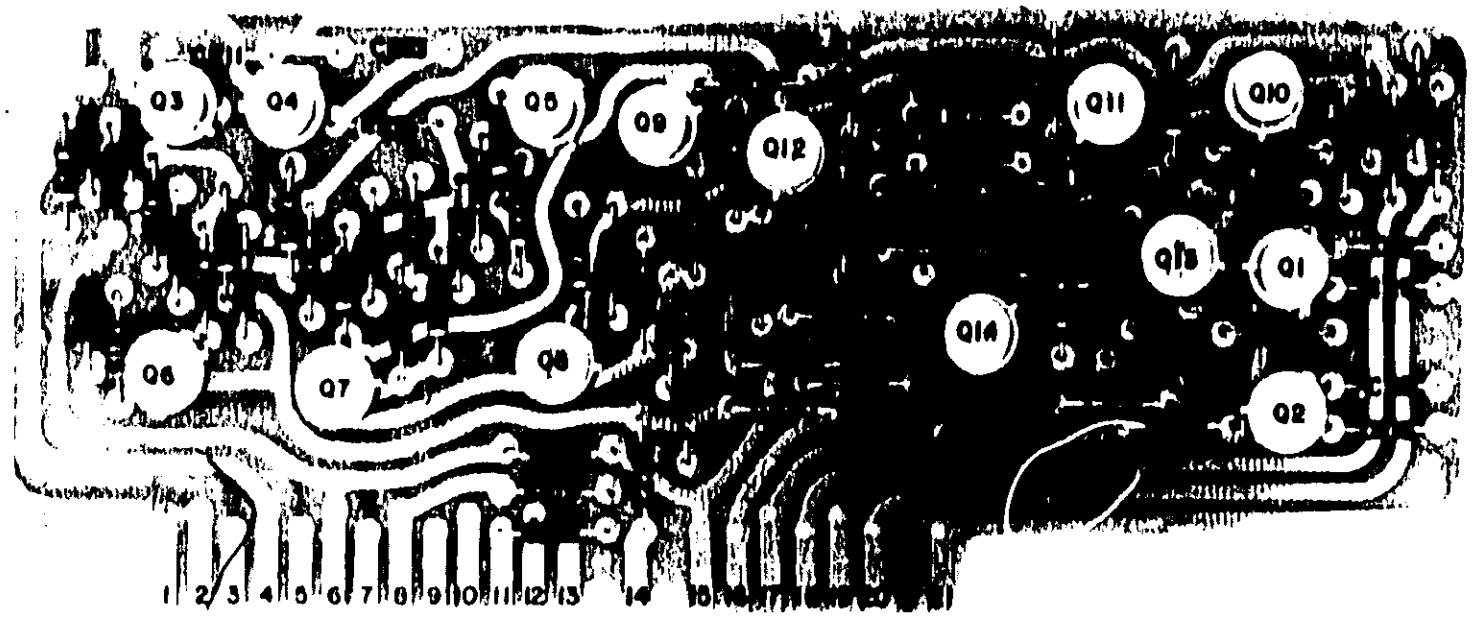


Figure 4-20. Units/Counter Input Logic (A19)



Stock No. 5060-2009

(A20) Decimal Point Logic
(See parts list beginning on page 5-22.)

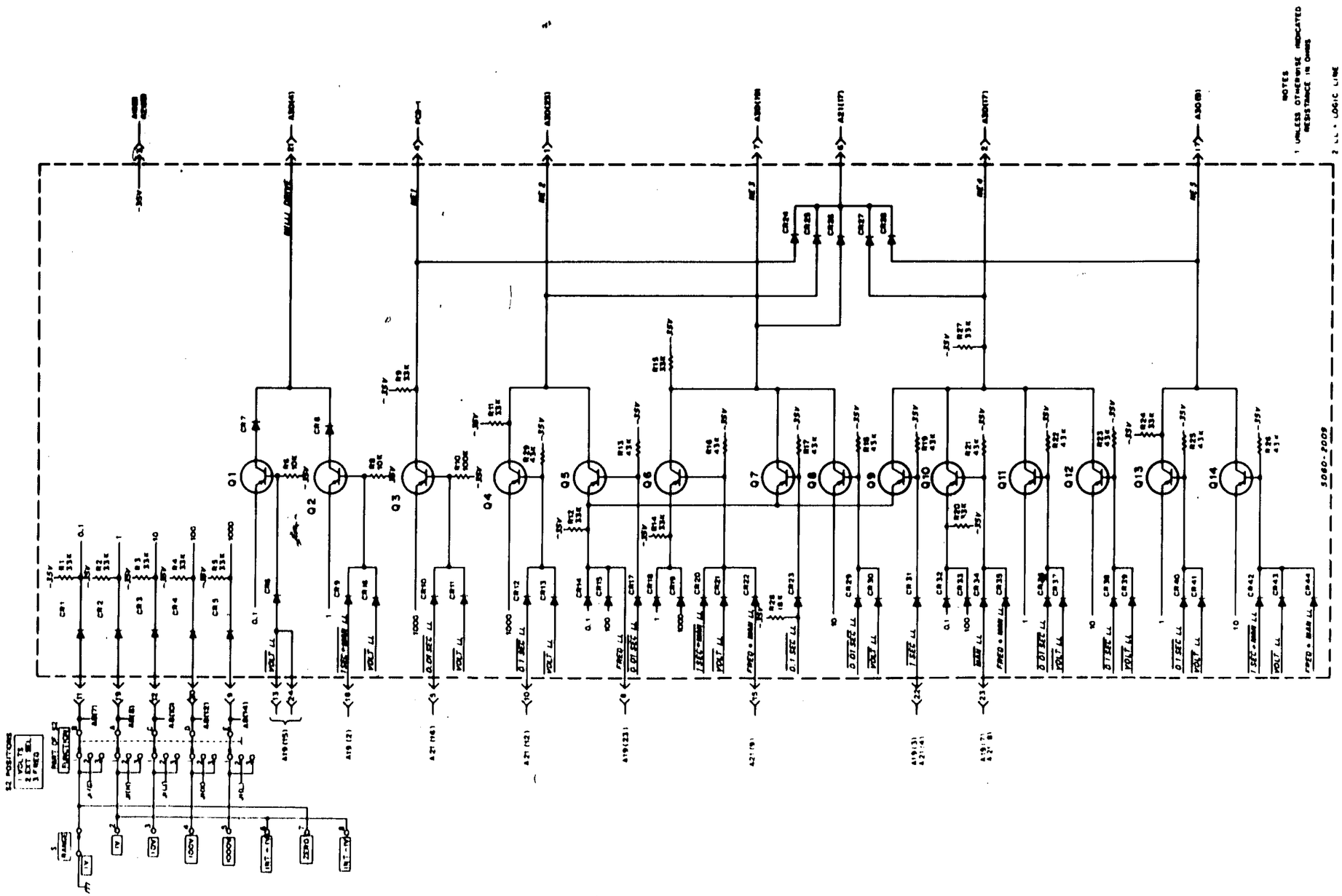
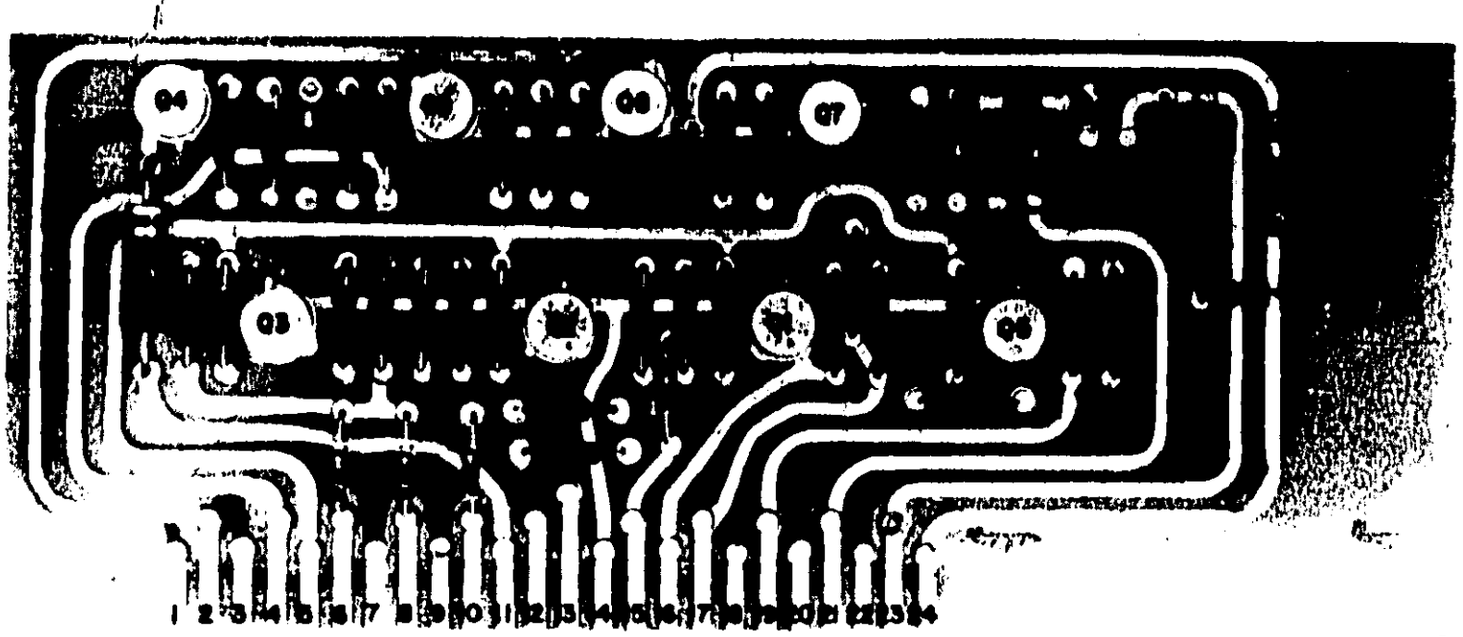
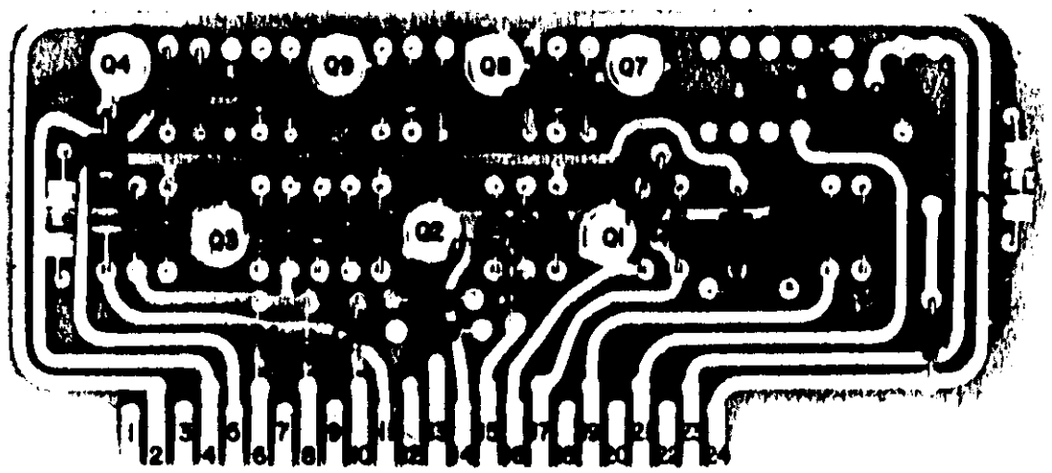


Figure 4-21. Decimal Point Logic (A20)



* CR12 NOT USED ON SERIAL PREFIX 501 AND 521.

Stock No. 5060-2010 (Serial Prefix 501 thru 605)



Stock No. 5060-5873 (Serial Prefix 610 and above)

(A21) Blanking Logic/Time Base Selection
(See parts list beginning on page 5-23.)

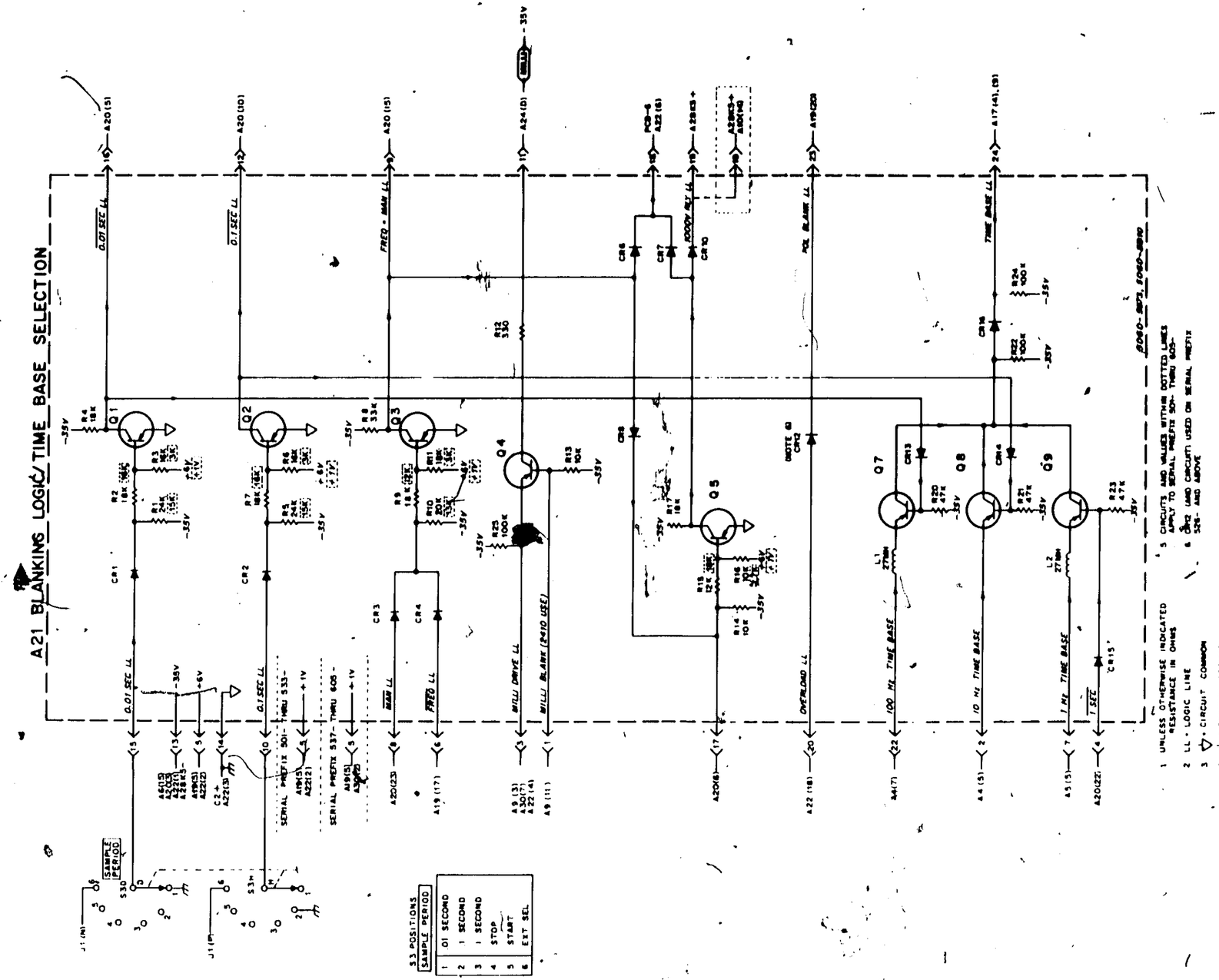
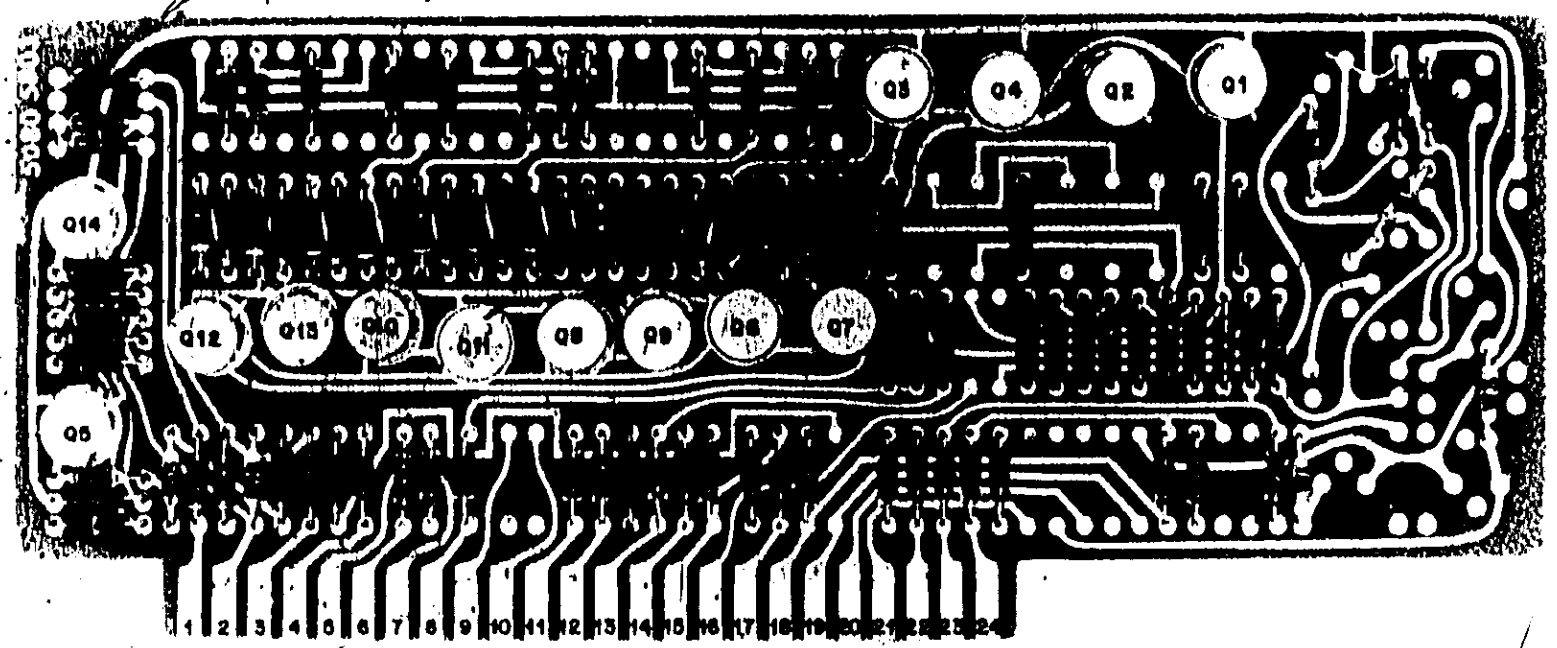
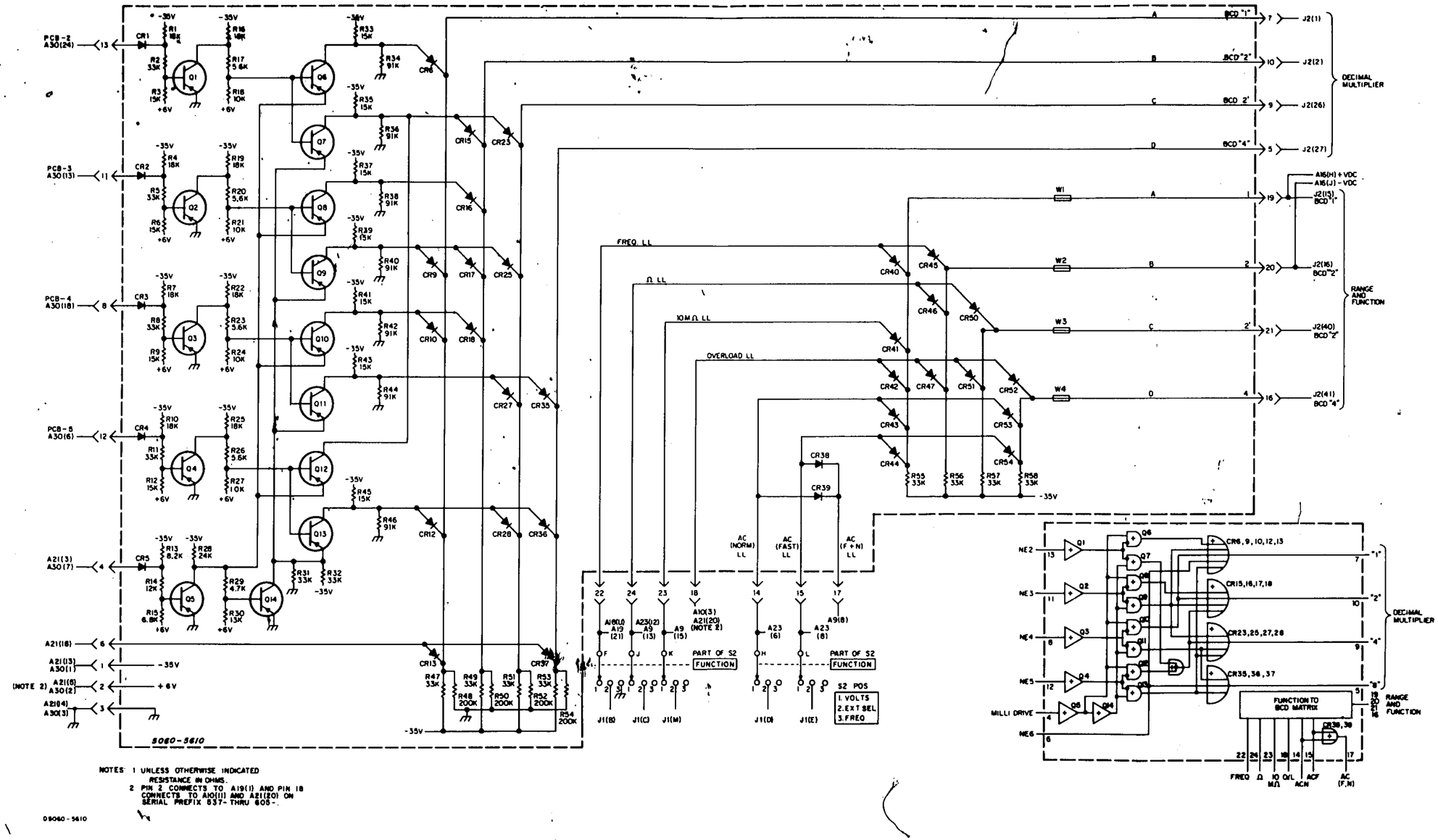


Figure 4-22. Blanking Logic/Time Base Selection (A21)



Stock No. 5060-5610 (Serial Prefix 537 and above)

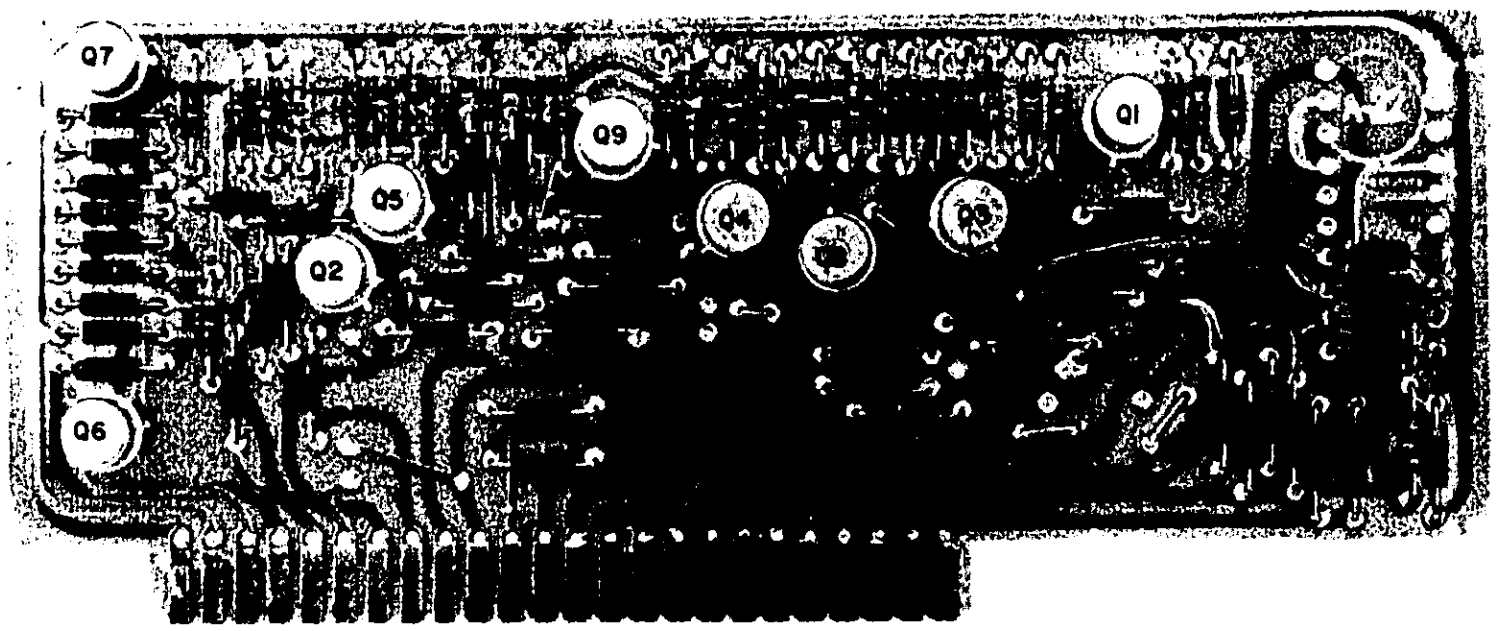
(A22) Printer Coupling
(See parts list beginning on page 5-26.)



NOTES: 1 UNLESS OTHERWISE INDICATED RESISTANCE IN OHMS.
2 PIN 2 CONNECTS TO A19(1) AND PIN 18 CONNECTS TO A10(1) AND A21(20) ON SERIAL PREFIX 537- THRU 605-.

05060-5610

Figure 4-23. Printer Coupling (A22) For Serial Prefix 537 and above



Stock No. 5060-2111 (Serial Prefix 501 thru 533)

(A22) Printer Coupling
(See parts list beginning on page 5-24.)

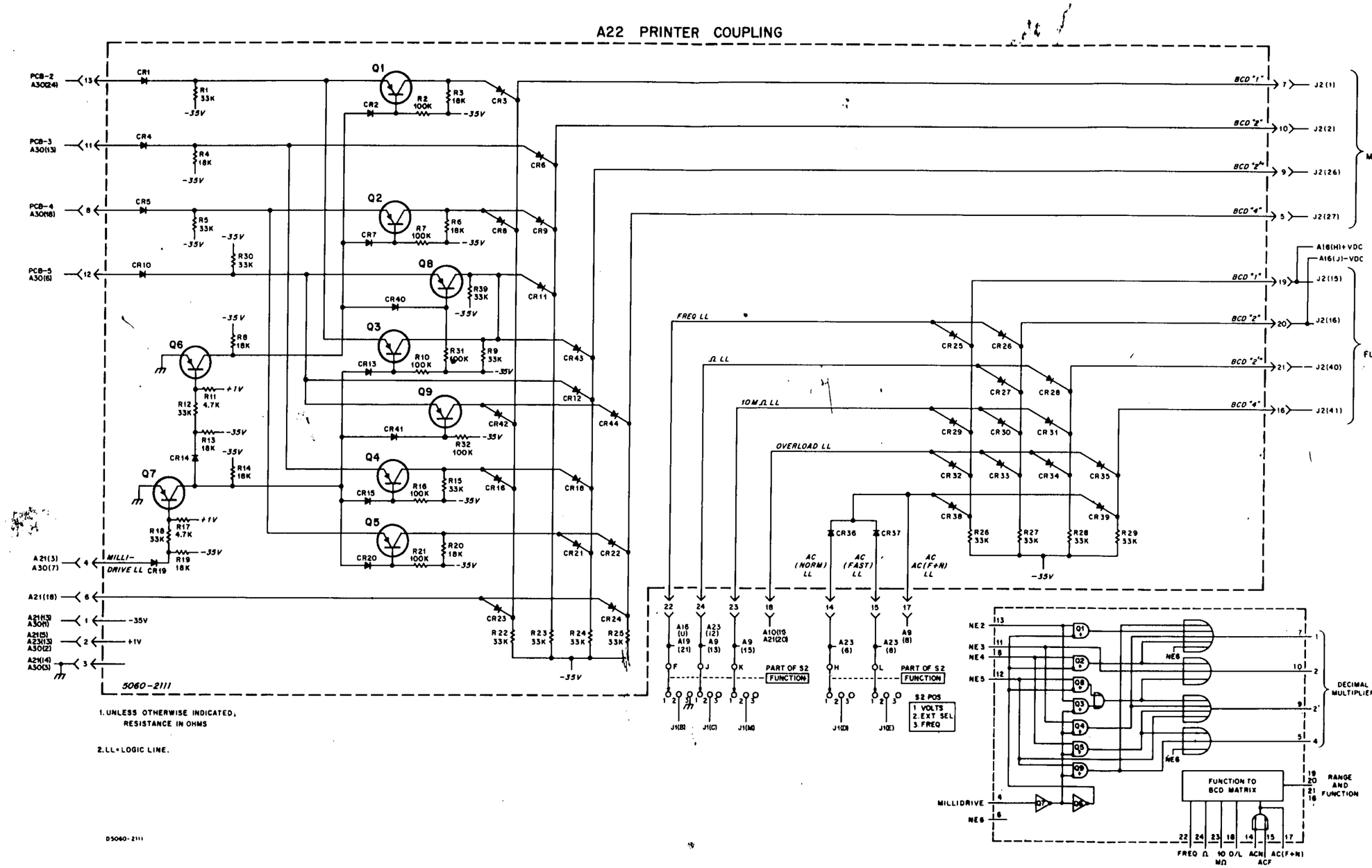
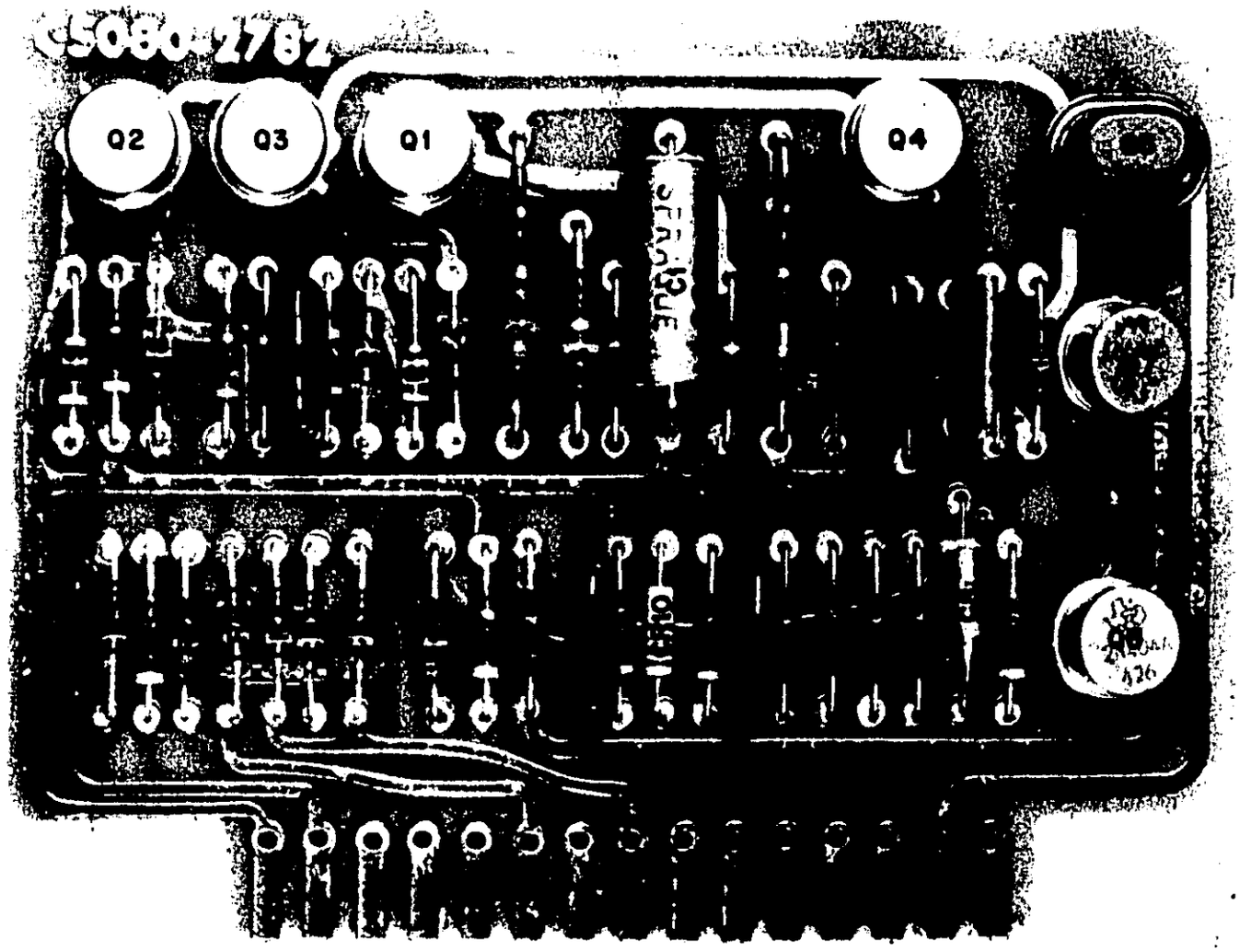
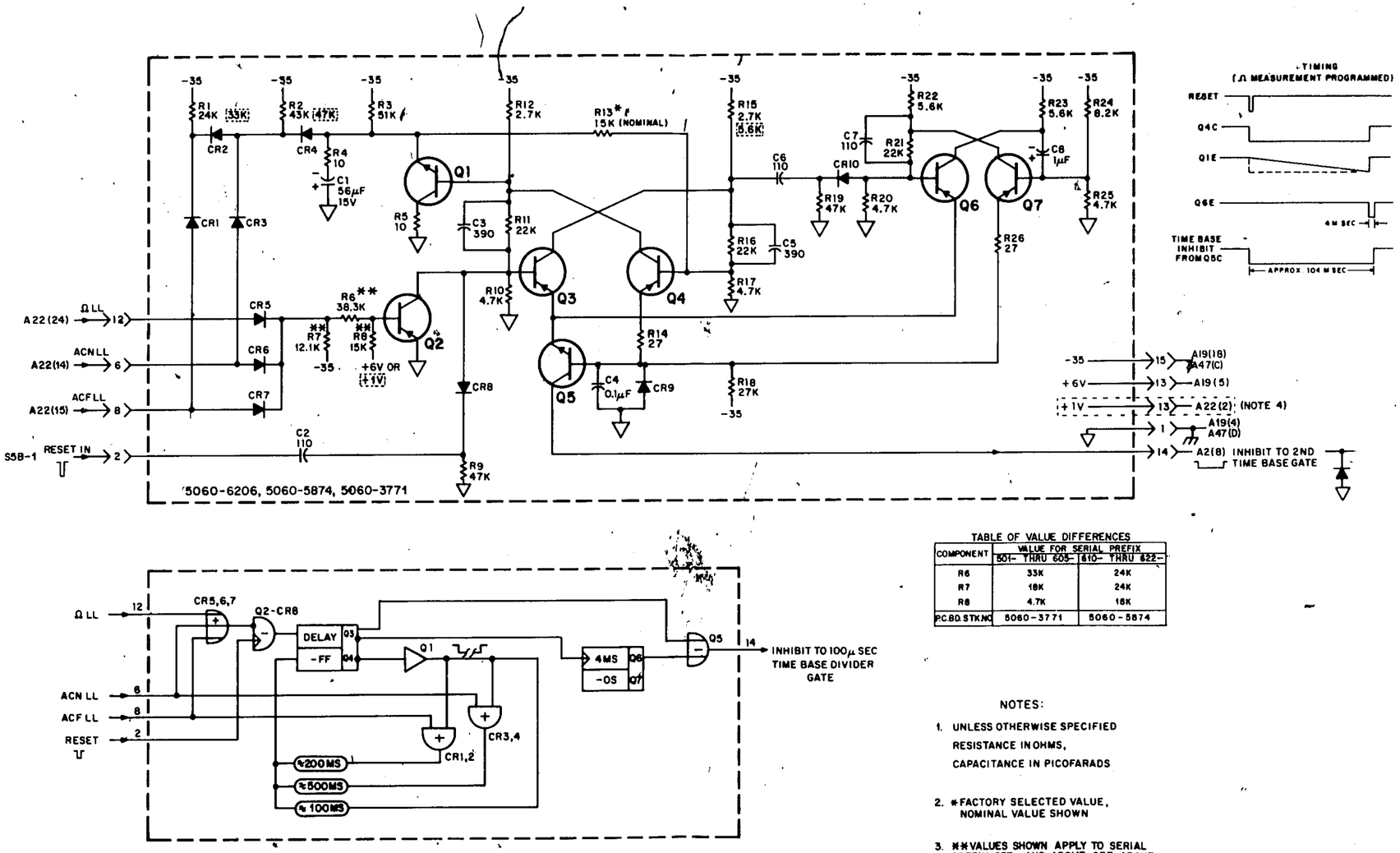


Figure 4-24. Printer Coupling (A22) For Serial Prefix 501 thru 533



Stock No. 5060-3771 (Serial Prefix 501 thru 605)
Stock No. 5060-5874 (Serial Prefix 610 thru 622)
Stock No. 5060-6206 (Serial Prefix 637 and above)

(A23) HP 2410B AC and Ohms Delay Gate
(See parts list beginning on page 5-28.)



05060-6206

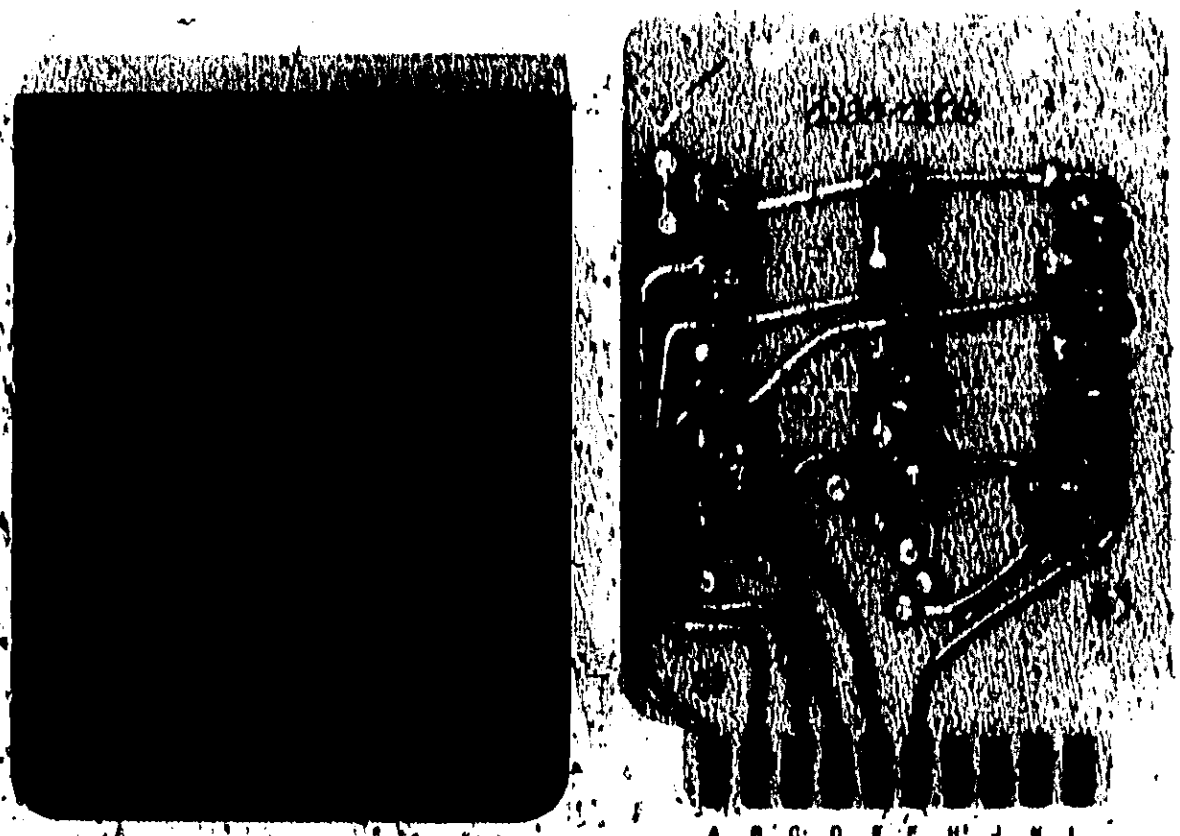
TABLE OF VALUE DIFFERENCES

COMPONENT	VALUE FOR SERIAL PREFIX	
	501- THRU 605-	610- THRU 622-
R6	33K	24K
R7	18K	24K
R8	4.7K	15K
P.C.BD. STK.NO.	5060-3771	5060-5874

NOTES:

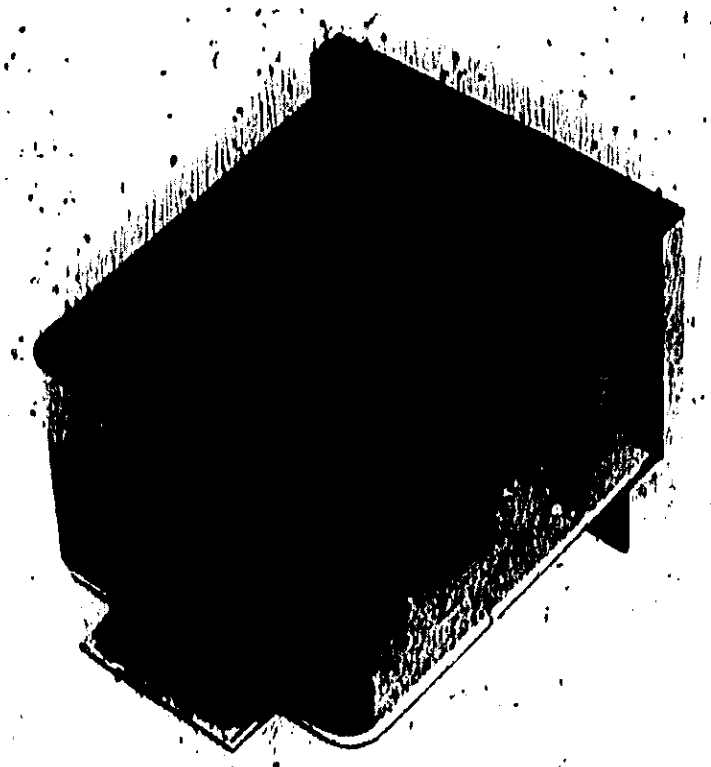
1. UNLESS OTHERWISE SPECIFIED RESISTANCE IN OHMS, CAPACITANCE IN PICOFARADS
2. *FACTORY SELECTED VALUE, NOMINAL VALUE SHOWN
3. **VALUES SHOWN APPLY TO SERIAL PREFIX 637- AND ABOVE. SEE ABOVE TABLE FOR OTHER SERIAL PREFIXES.
4. VALUES AND CIRCUITS WITHIN DOTTED LINES APPLY TO SERIAL PREFIX 501- THRU 605-.

Figure 4-25. HP 2410B AC and Ohms Delay Gate (A23)



NOTE: LETTERED PINS ARE ON OPPOSITE SIDE OF BOARD.

DISASSEMBLED VIEW



ASSEMBLED VIEW

Stock No. 5060-3818

(A24) Units Indicator

(See parts list beginning on page 5-20.)

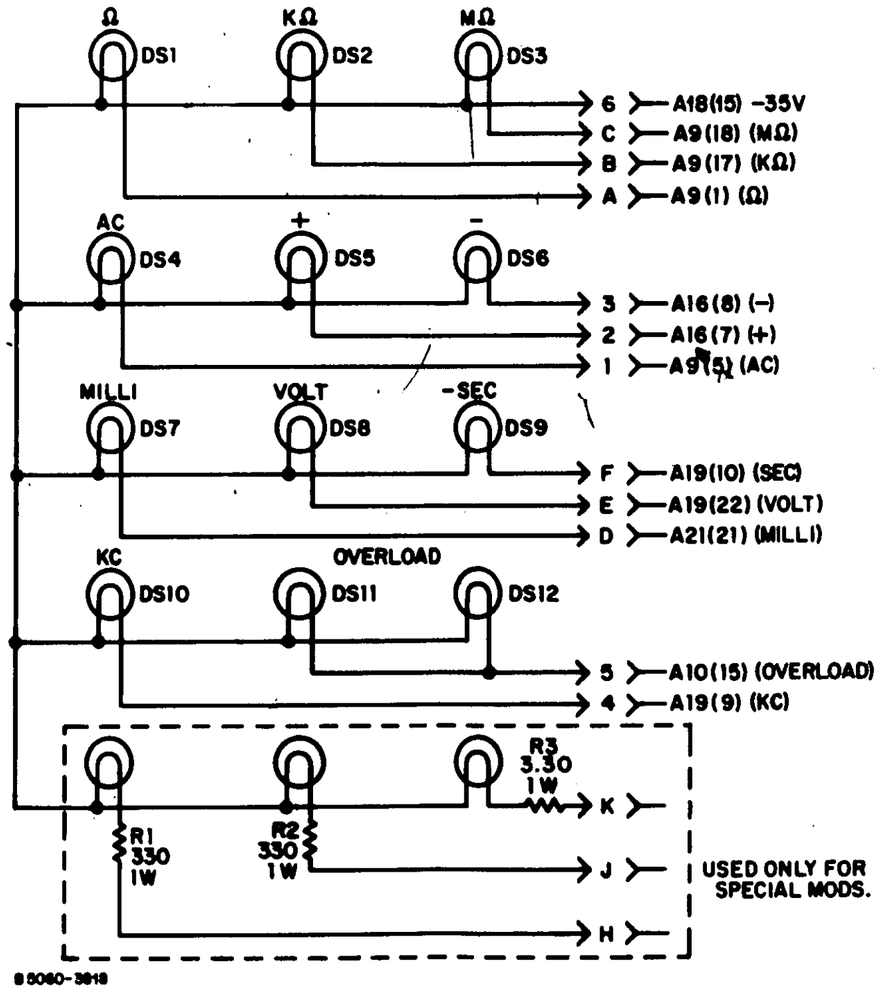
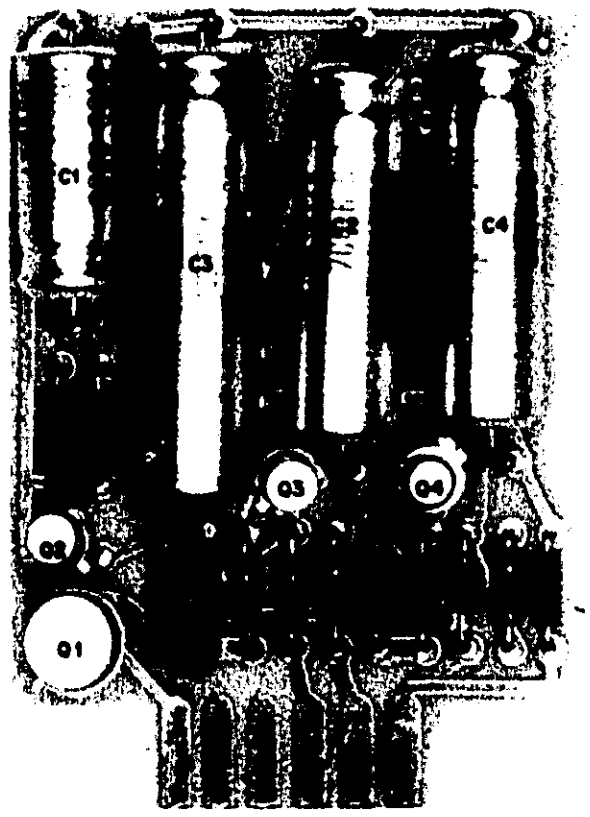


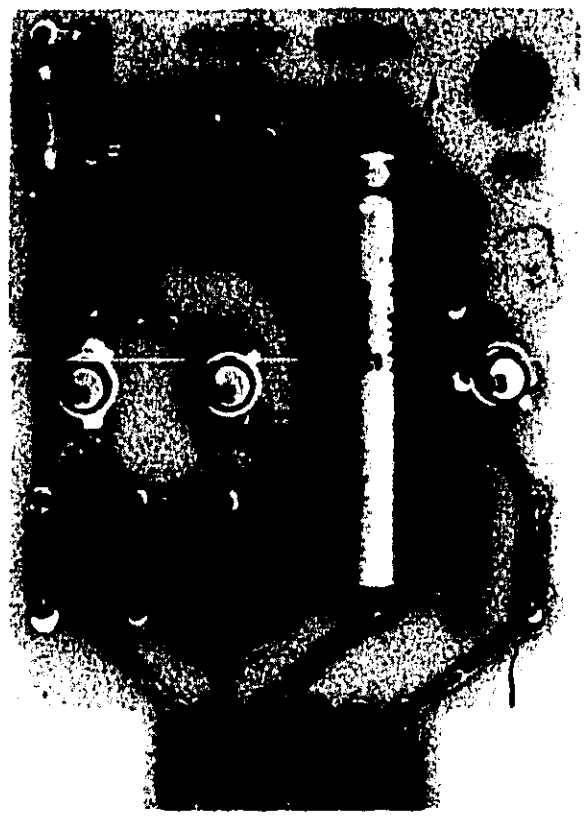
Figure 4-26. Units Indicator (A24)

NOTE:
A25 not illustrated.



Stock No. 05232-6007 (Serial Prefix 735 and above)

(A26) Input Amplifier
(See parts list beginning on page 5-30.)



Stock No. 05232-6006 (Serial Prefix 735 and above)

(A27) Trigger
(See parts list beginning on page 5-31.)

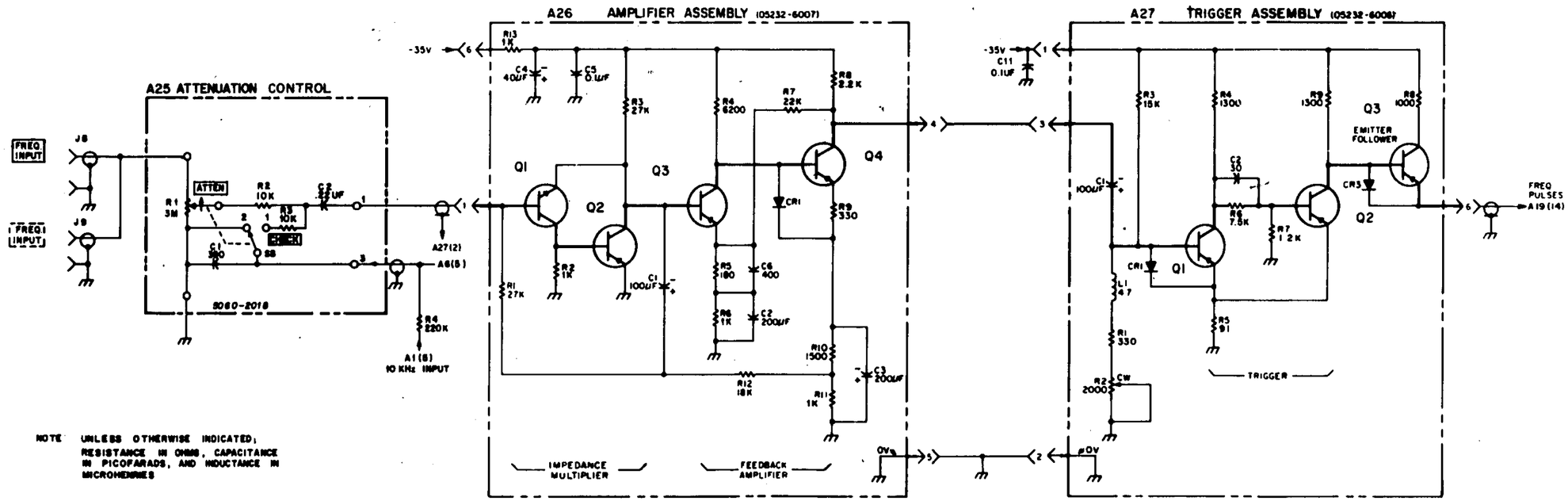
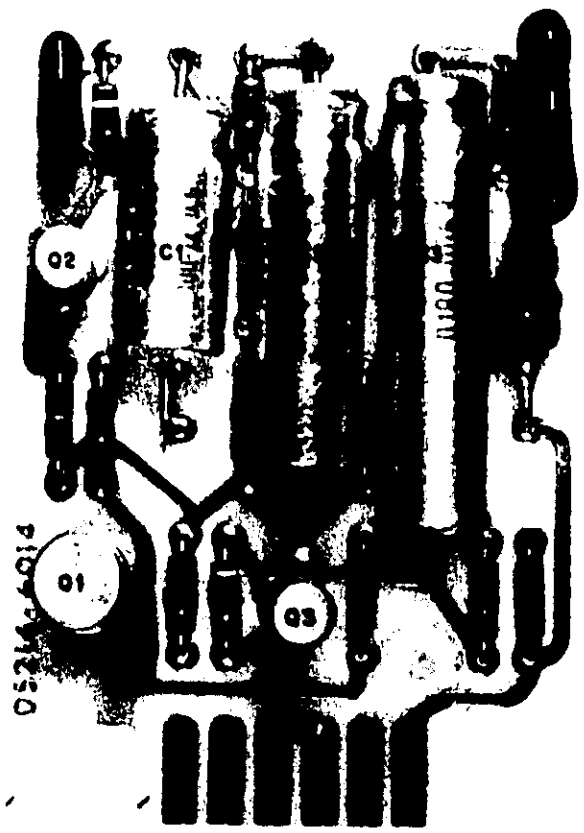


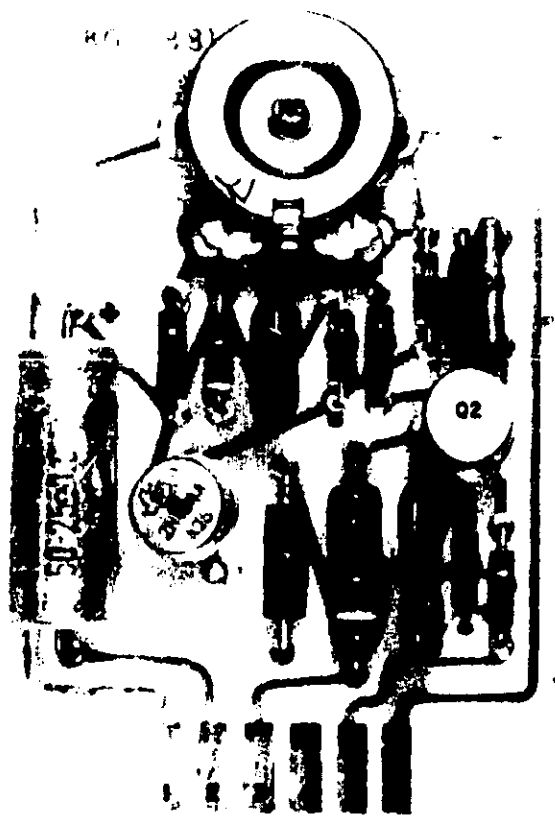
Figure 4-27. Attenuation Control (A25), Input Amplifier (A26), and Trigger (A27) For Serial Prefix 735 and above

NOTE:
A25 not illustrated.



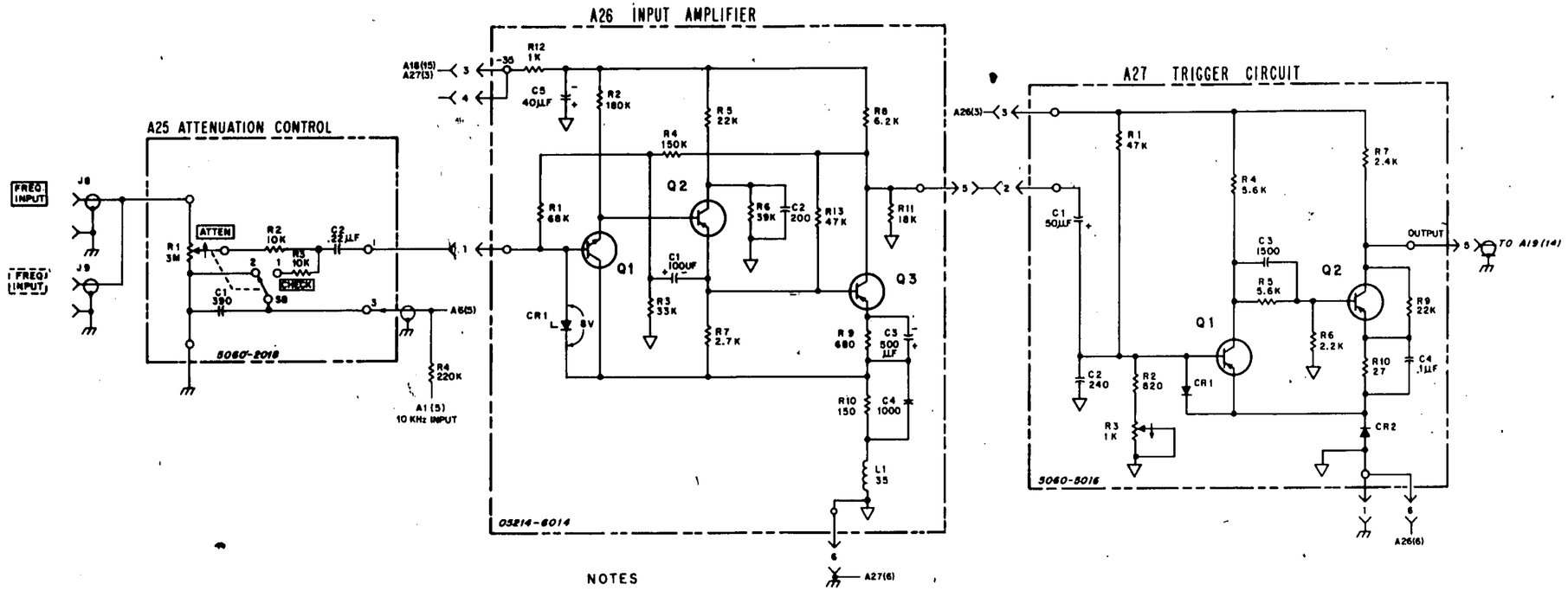
Stock No. 05214-6014 (Serial Prefix 501 thru 637)

(A26) Input Amplifier
(See parts list beginning on page 5-30.)



Stock No. 5060-5016 (Serial Prefix 501 thru 637)

(A27) Trigger
(See parts list beginning on page 5-31.)

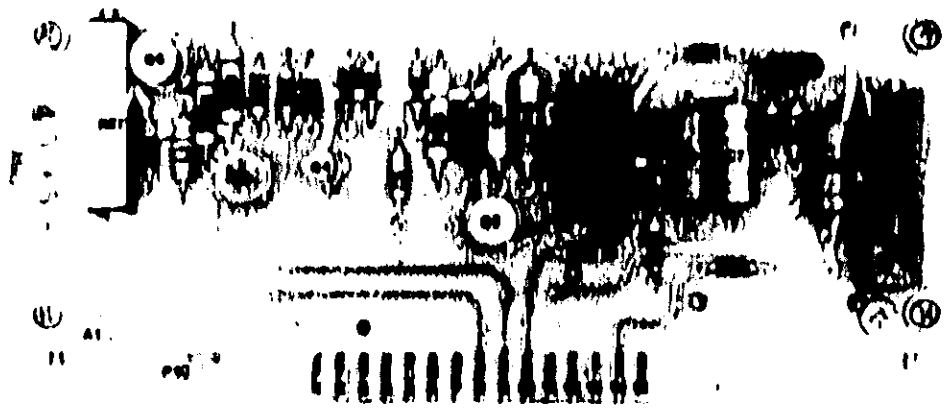


NOTES

1. UNLESS OTHERWISE INDICATED, RESISTANCE IN OHMS, CAPACITANCE IN PICOFARADS, AND INDUCTANCE IN MICROHENRIES.
2. ▽ CIRCUIT COMMON
3. ⏚ CHASSIS GROUND

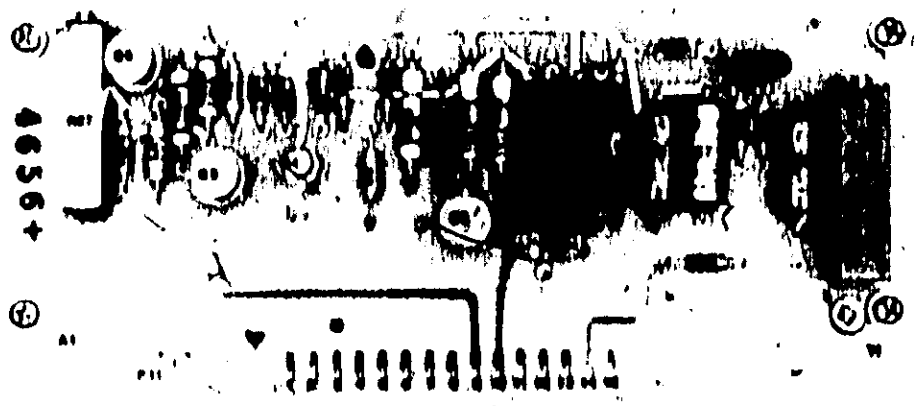
05950-1523

Figure 4-28. Attenuation Control (A25), Input Amplifier (A26), and Trigger (A27) For Serial Prefix 501 thru 637



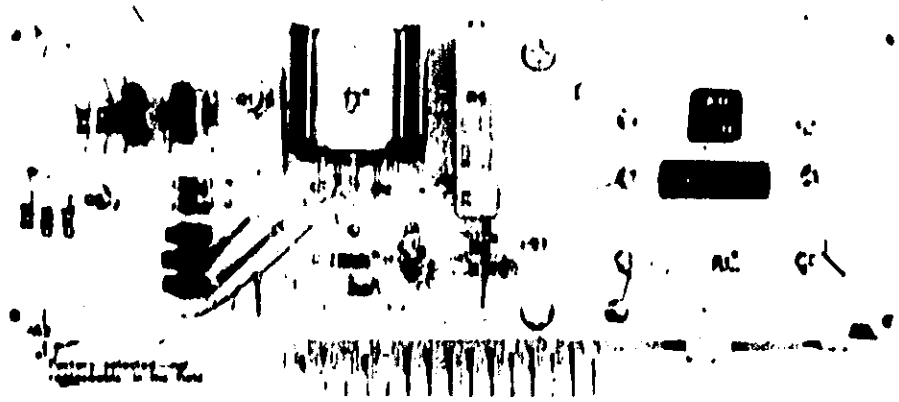
Stock No. 5060-6275

(A32A1) Amplifier Printed Circuit Subassembly
(See parts list beginning on page 5-37.)



Stock No. 5060-6274

(A33A1) Amplifier Printed Circuit Subassembly
(See parts list beginning on page 5-38.)



Stock No. 5060-3838

(A32A2 or A33A2) Binary Printed Circuit Subassembly
(See parts list beginning on page 5-38.)

(A28) DC Attenuator - See Figure 4-4
(A32) Negative Channel - Stock No. 5060-5001
(A33) Positive Channel - Stock No. 5060-3849

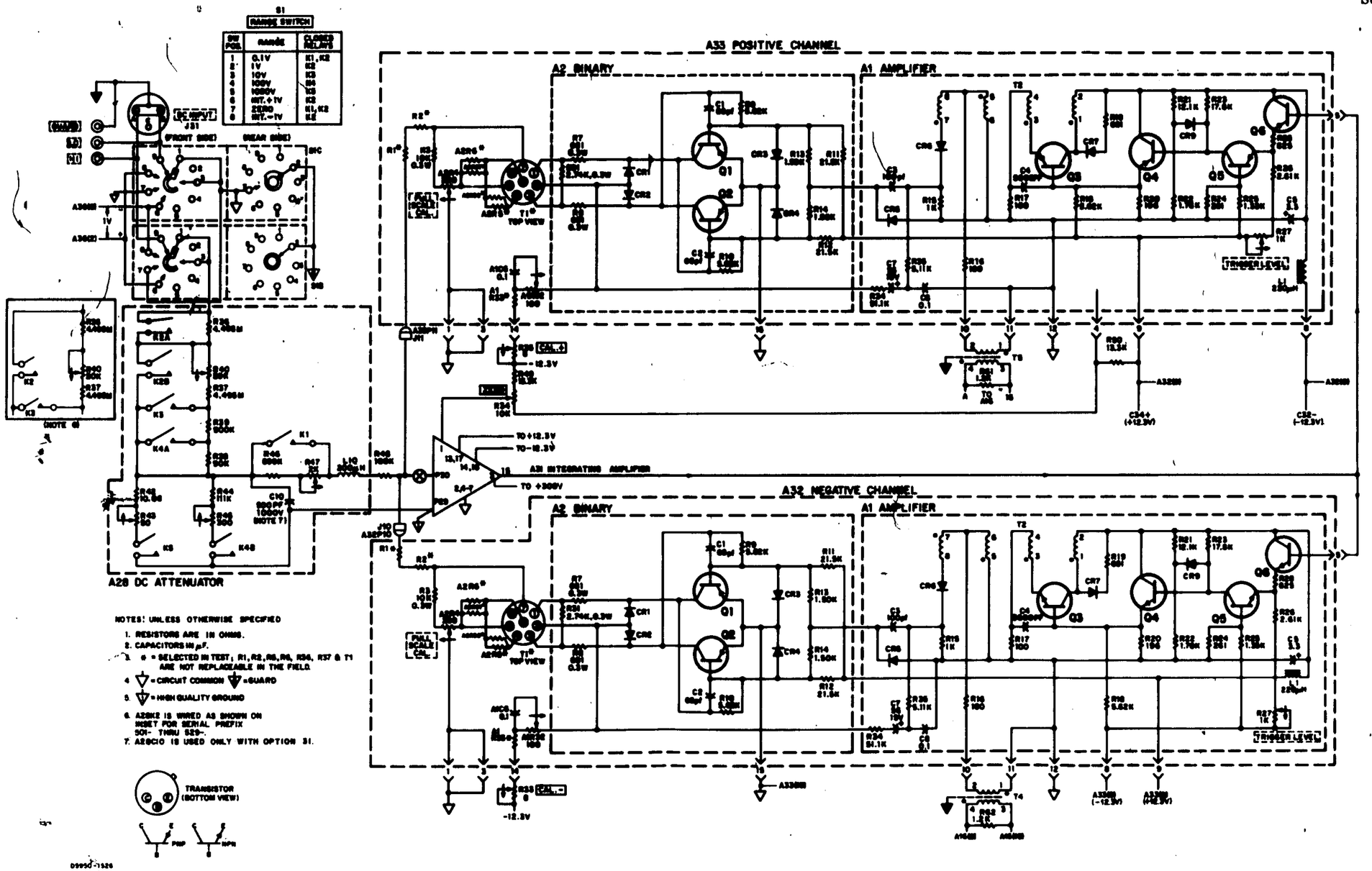
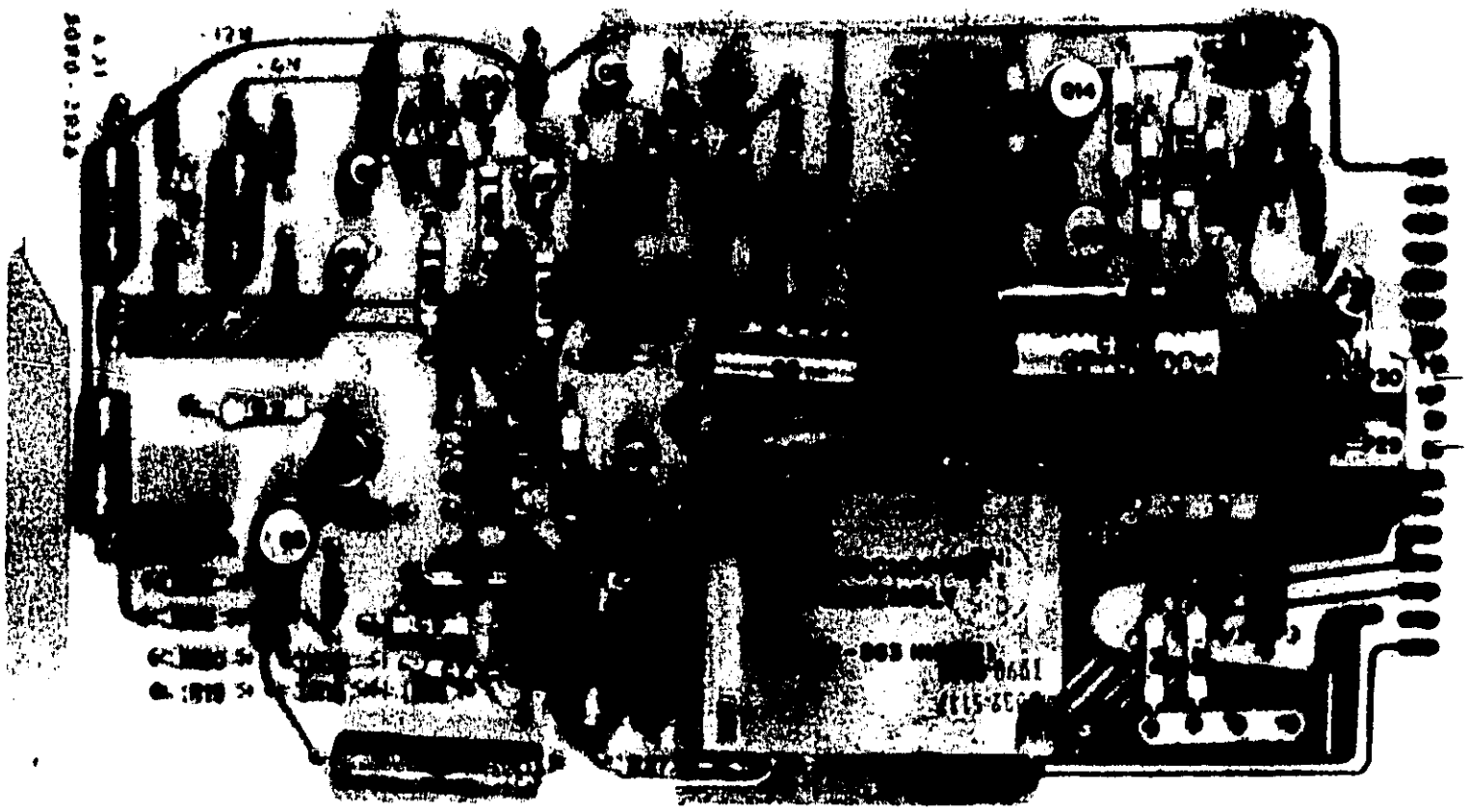
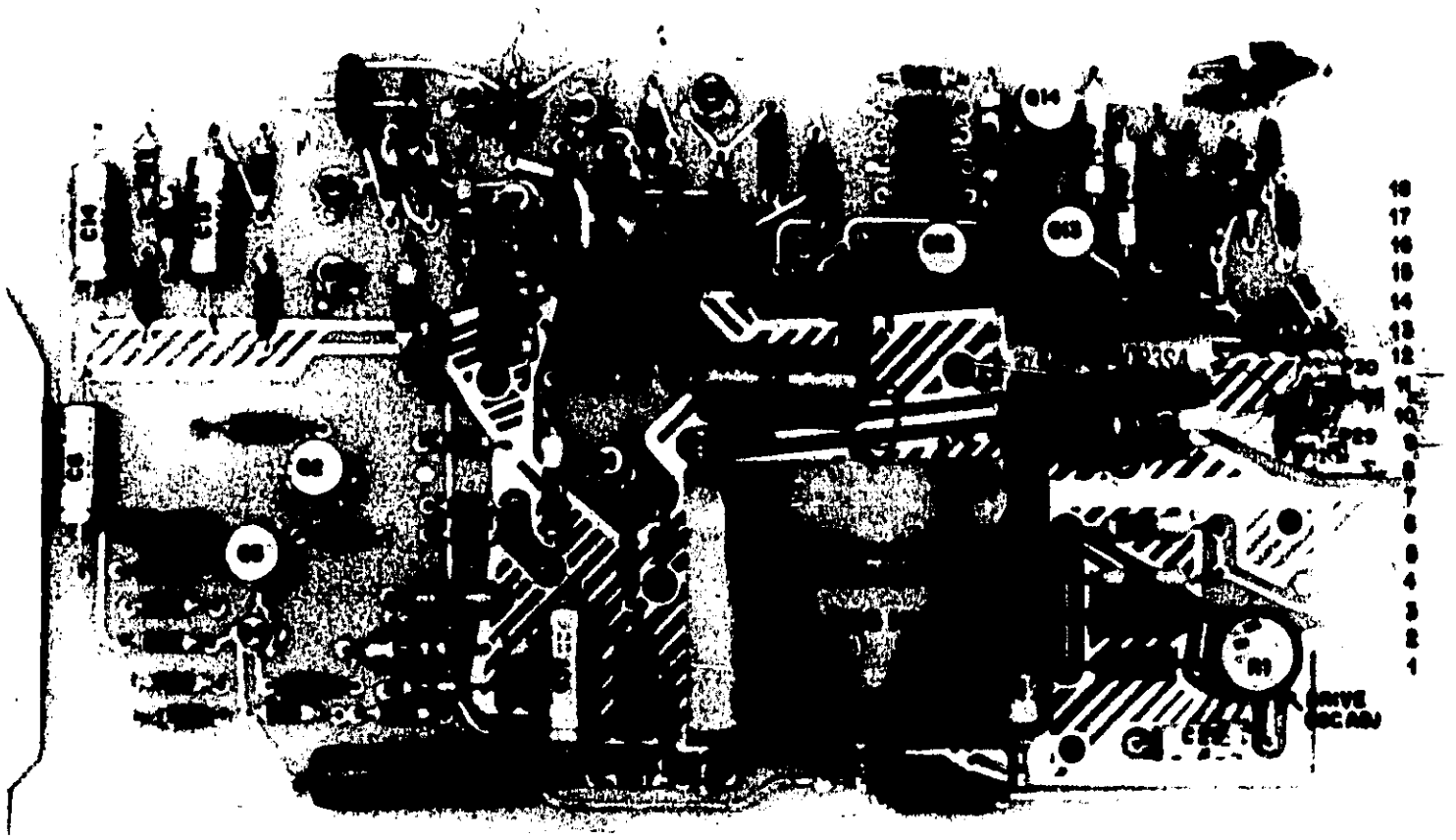


Figure 4-29. DC Attenuator (A28), Negative Channel (A32), and Positive Channel (A33)

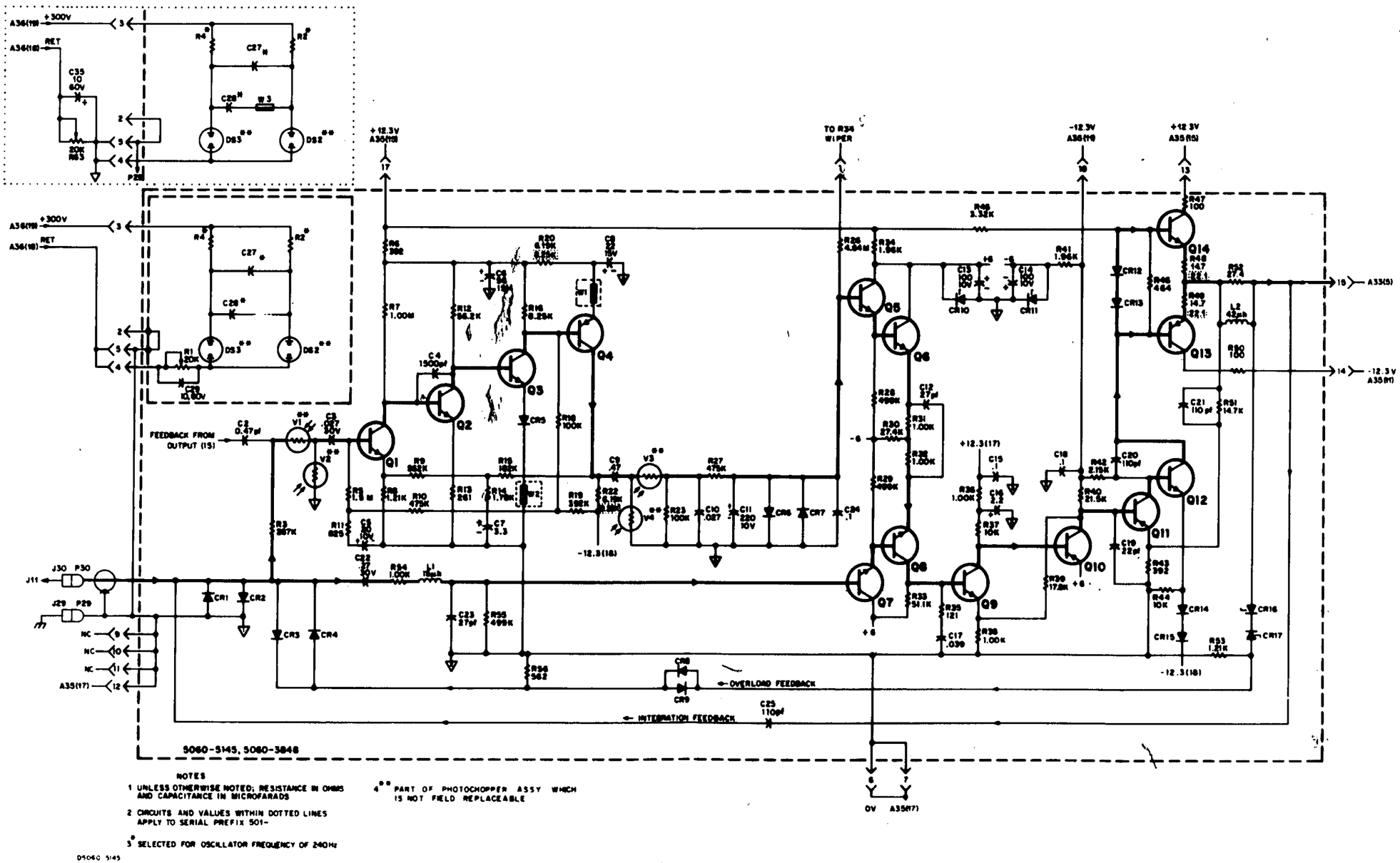


Stock No. 5060-3848 (Serial Prefix 501)



Stock No. 5060-5145 (Serial Prefix 521 and above)

(A31) Integrating Operational Amplifier
(See parts list beginning on page 5-34.)



NOTES

1 UNLESS OTHERWISE NOTED; RESISTANCE IN OHMS AND CAPACITANCE IN MICROFARADS

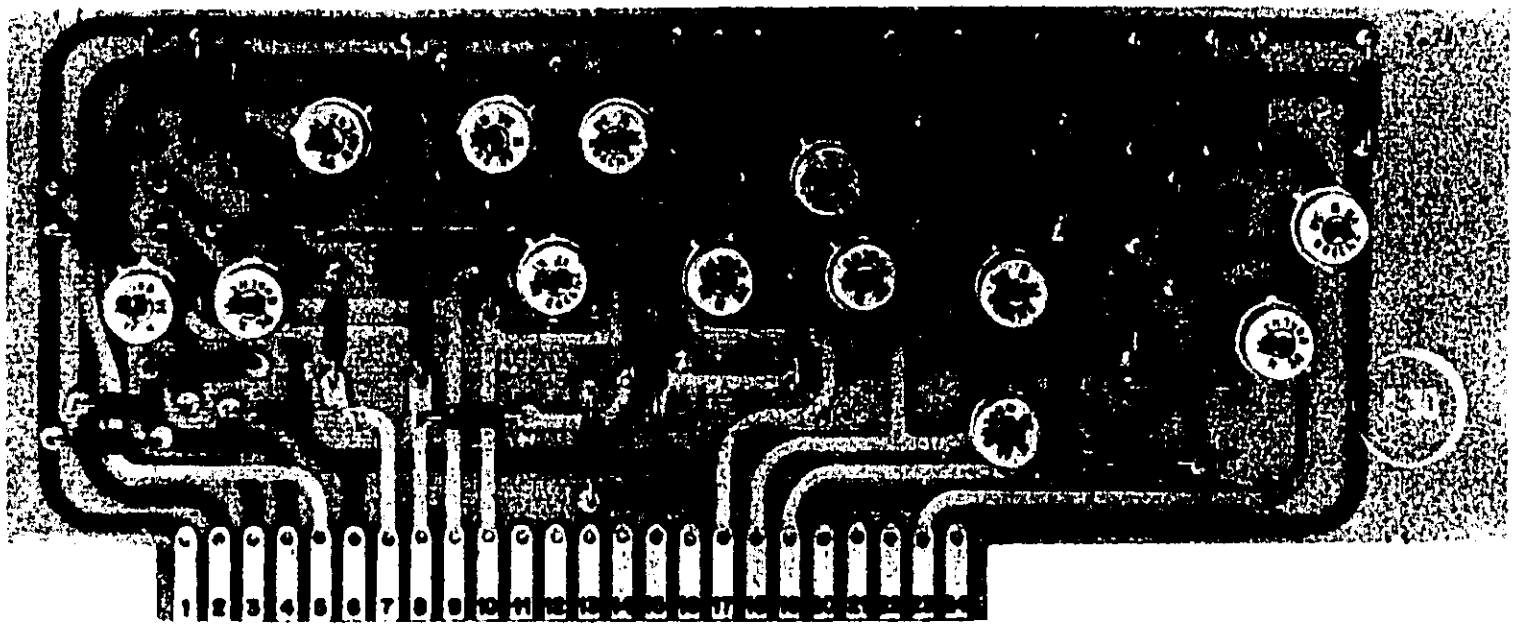
2 CIRCUITS AND VALUES WITHIN DOTTED LINES APPLY TO SERIAL PREFIX 501-

3 * SELECTED FOR OSCILLATOR FREQUENCY OF 240Hz

4 ** PART OF PHOTOCHOPPER ASSY WHICH IS NOT FIELD REPLACEABLE

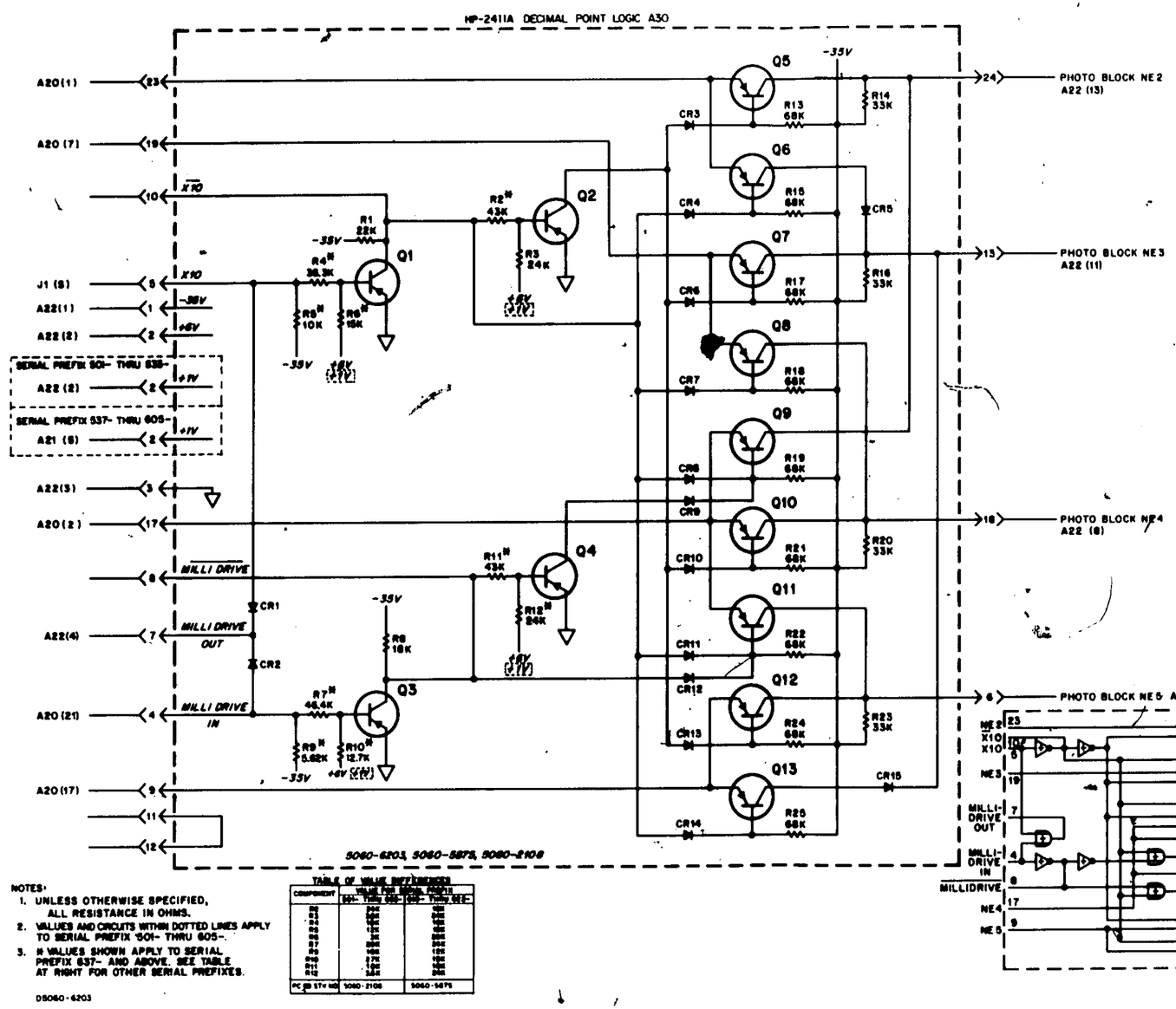
D5060 5145

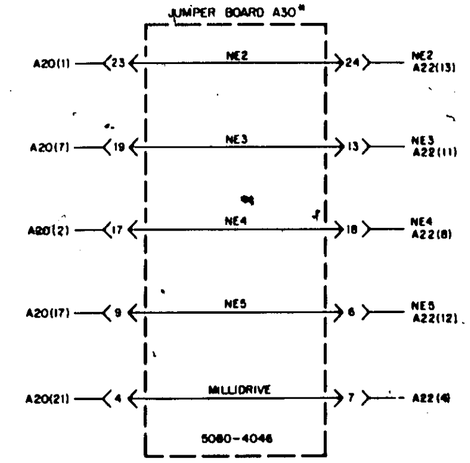
Figure 4-30. Integrating Operational Amplifier (A31)



Stock No. 5060-2108 (Serial Prefix 501 thru 605)
Stock No. 5060-5875 (Serial Prefix 610 thru 622)
Stock No. 5060-6203 (Serial Prefix 637 and above)

(A30) HP 2411A Decimal Point Logic
(See parts list beginning on page 5-32.)





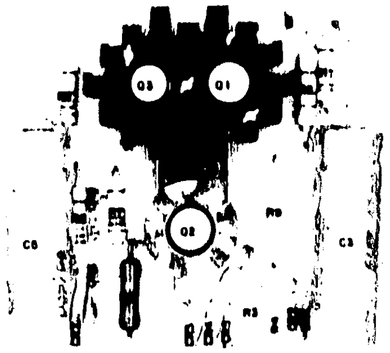
NOTES:
1. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCE IN OHMS.
2. VALUES AND CIRCUITS WITHIN DOTTED LINES APPLY TO SERIAL PREFIX 501- THRU 605-.
3. # VALUES SHOWN APPLY TO SERIAL PREFIX 637- AND ABOVE. SEE TABLE AT RIGHT FOR OTHER SERIAL PREFIXES.

05060-6203

TABLE OF VALUE DIFFERENCES

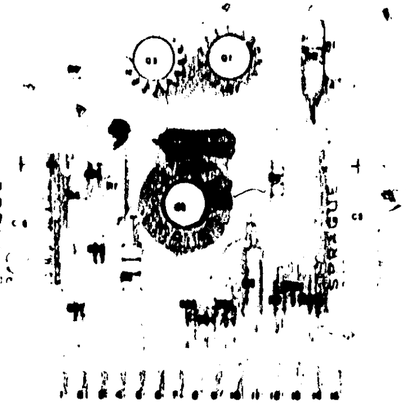
COMPONENT	VALUE FOR SERIAL PREFIX 501- THRU 605-	VALUE FOR SERIAL PREFIX 606- THRU 636-
R2	43K	43K
R4	36.3K	36.3K
R5	10K	10K
R6	15K	15K
R7	46.4K	46.4K
R9	5.62K	5.62K
R10	12.7K	12.7K
R11	43K	43K
R12	24K	24K
PC BD STK NO.	5060-2108	5060-5875

Figure 4-31. HP 2411A Decimal Point Logic (A30)

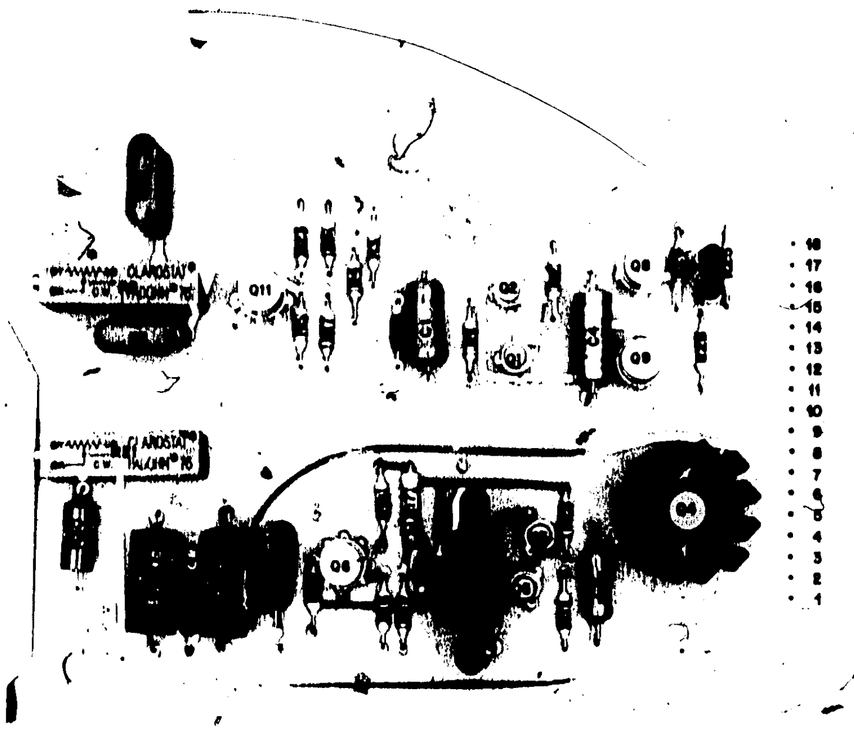


Stock No. 5060-3782
(For Serial Prefix 811 and above)

(A34) Series Regulator Assembly
(See parts list beginning on page 5-40.)



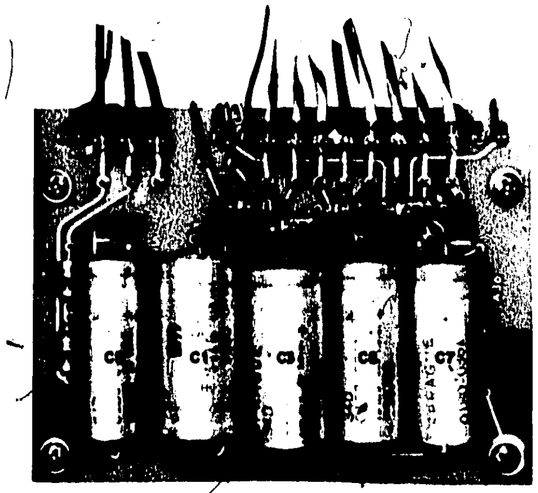
Stock No. 5060-3782
(For Serial Prefix 751 and below)



NOTE: Instruments with Serial No. 637-01388 thru 637-01687 had a leadwire connecting base of Q4 to Pin 5. A trace was added to the PC board beginning with Serial No. 637-01688.

Stock No. 5060-3783

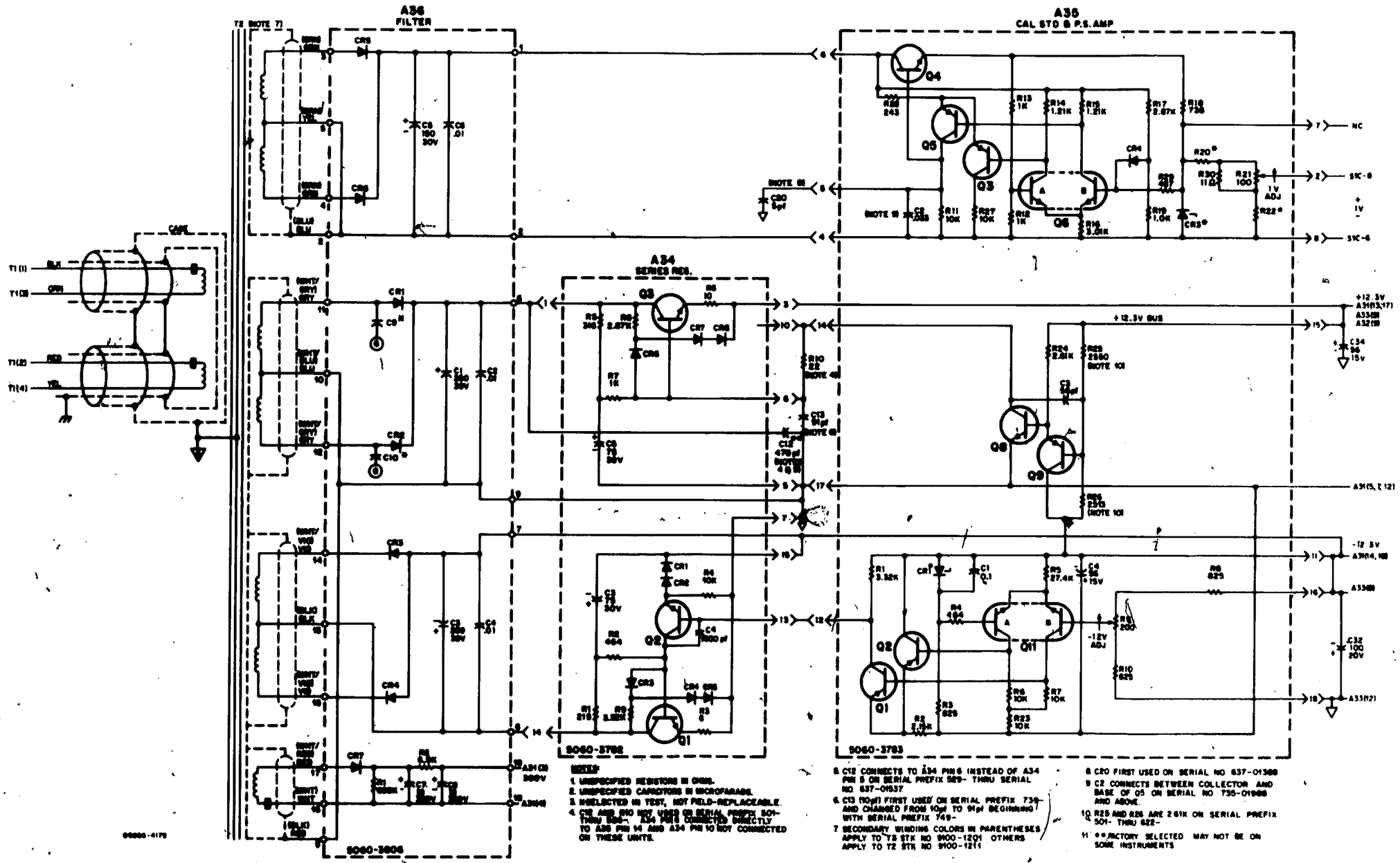
(A35) Calibration Standard and Power Supply Amplifier Assembly
(See parts list beginning on page 5-40.)



*May be installed after selection by test

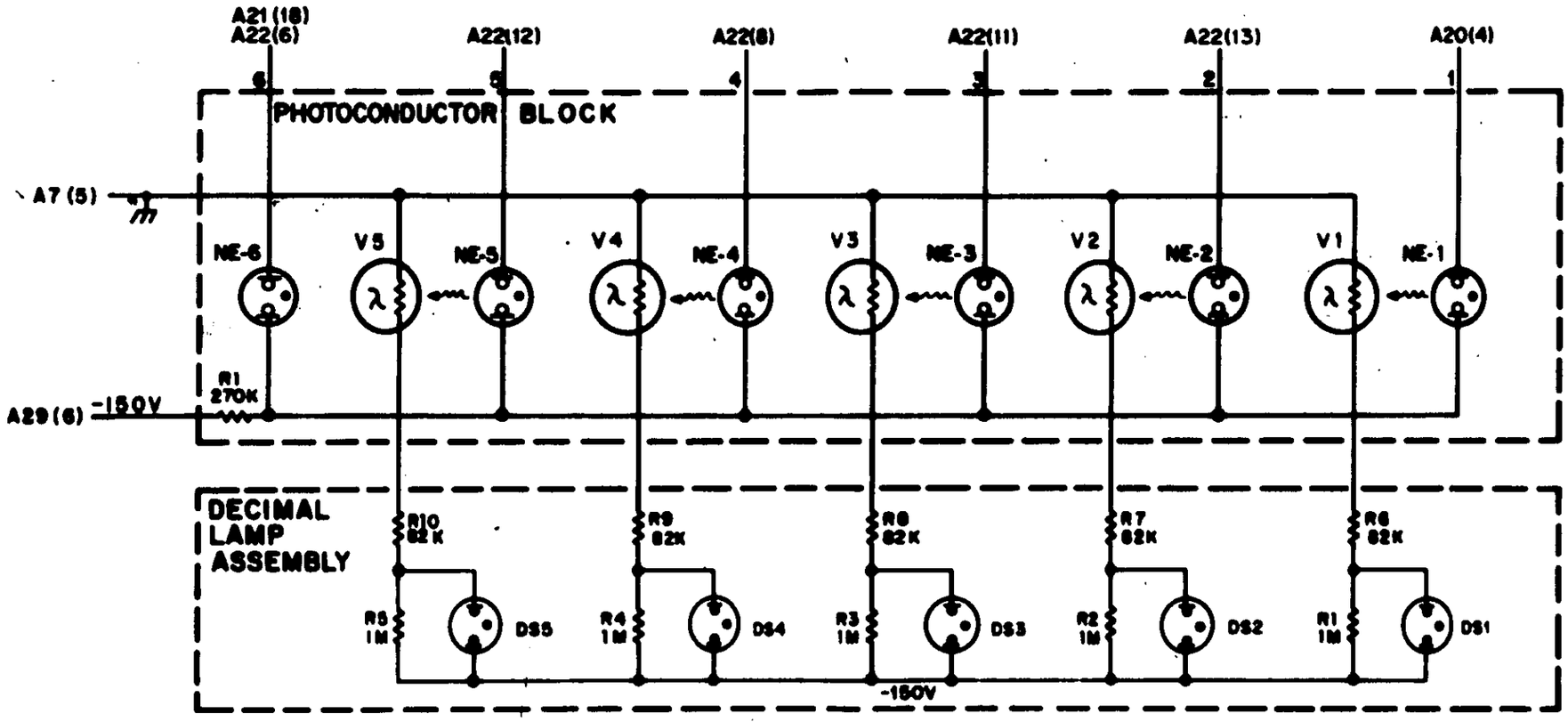
Stock No. 5060-3806

(A36) Filter Board
(See parts list beginning on page 5-42.)



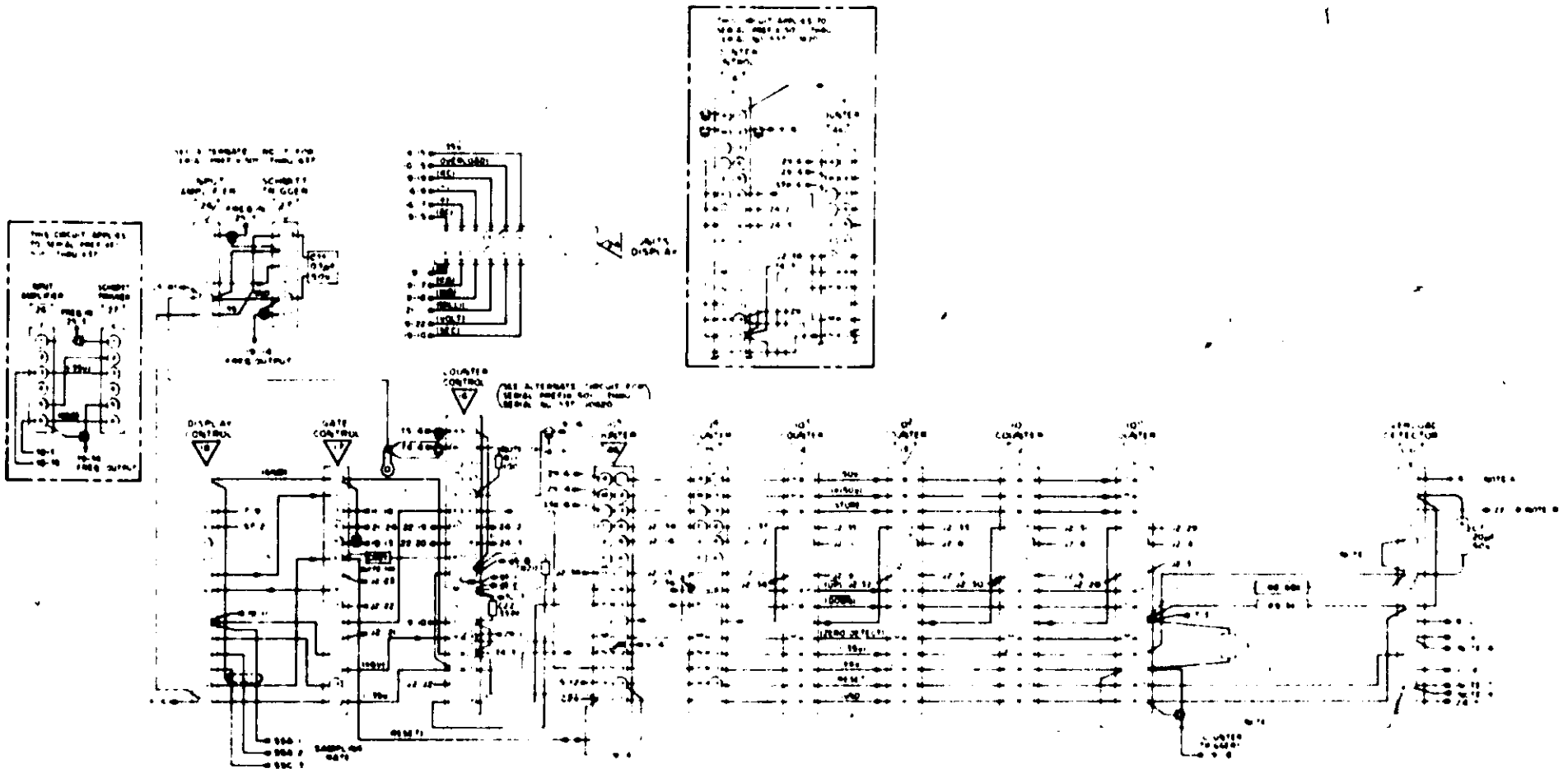
NOTES:
1. UNSPECIFIED RESISTORS IN OHMS.
2. UNSPECIFIED CAPACITORS IN MICROFARADS.
3. #SELECTED IN TEST, NOT FIELD-REPLACEABLE.
4. C32 AND R10 NOT USED ON SERIAL PREFIX 501- THRU 522-. A34 P14 IS CONNECTED DIRECTLY TO A36 P4 AND A34 P4 IS NOT CONNECTED ON THESE UNITS.
5. C12 CONNECTS TO A34 PIN 6 INSTEAD OF A34 PIN 5 ON SERIAL PREFIX 529- THRU SERIAL NO 637-01937.
6. C13 (10pf) FIRST USED ON SERIAL PREFIX 739- AND CHANGED FROM 10pf TO 91pf BEGINNING WITH SERIAL PREFIX 749-.
7. SECONDARY WINDING COLORS IN PARENTHESES APPLY TO T2 STK NO 9100-1201 OTHERS APPLY TO T2 STK NO 9100-1211.
8. CR0 FIRST USED ON SERIAL NO 637-01388
9. C2 CONNECTS BETWEEN COLLECTOR AND BASE OF Q5 ON SERIAL NO 735-01988 AND ABOVE.
10. R25 AND R26 ARE 2.61K ON SERIAL PREFIX 501- THRU 622-.
11. **FACTORY SELECTED MAY NOT BE ON SOME INSTRUMENTS

Figure 4-32. Power Supply Circuits (A34, A35, and A36)



C9990-1528

Figure 4-33. Photoconductor and Decimal Lamp



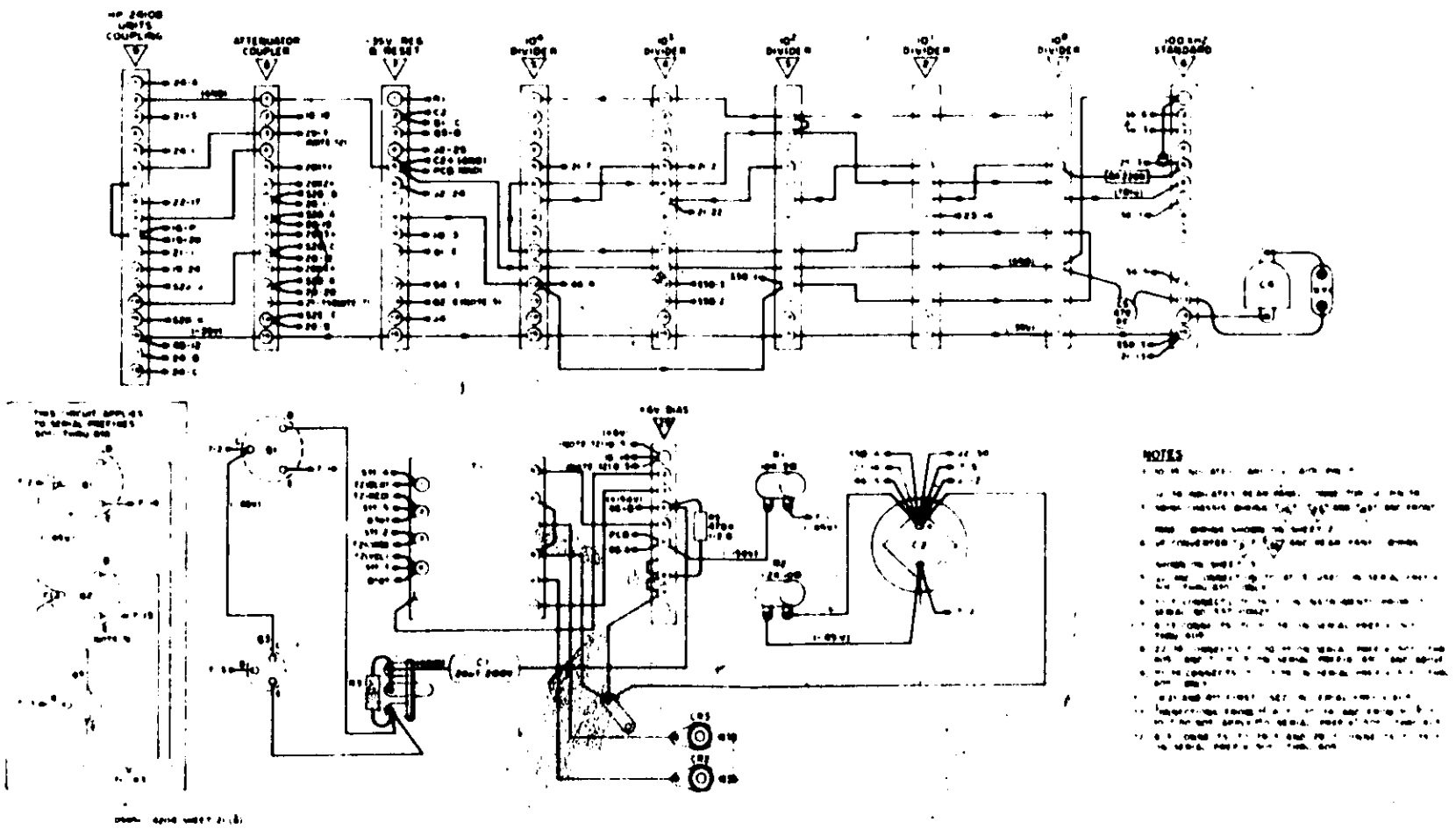
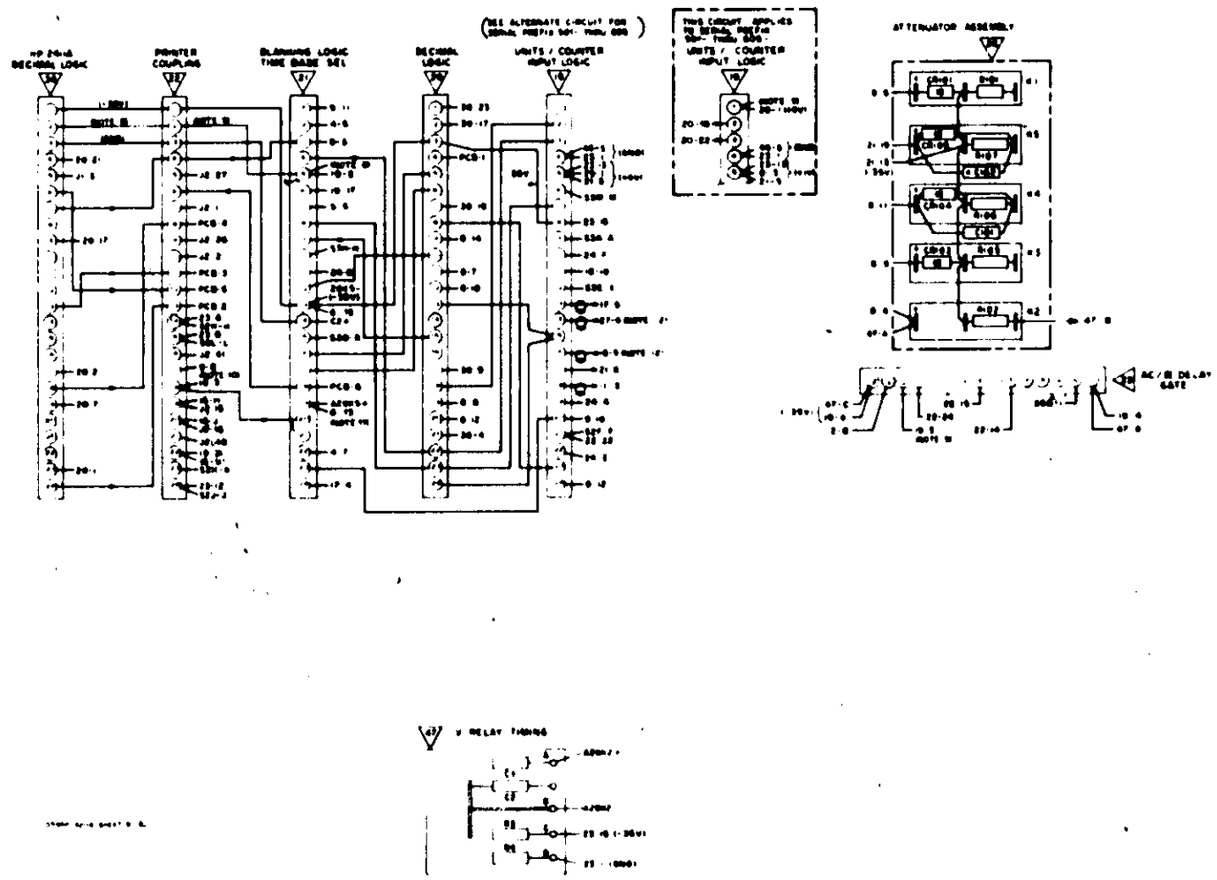


Figure 4-34. Interconnections (Sheet 1 of 3)



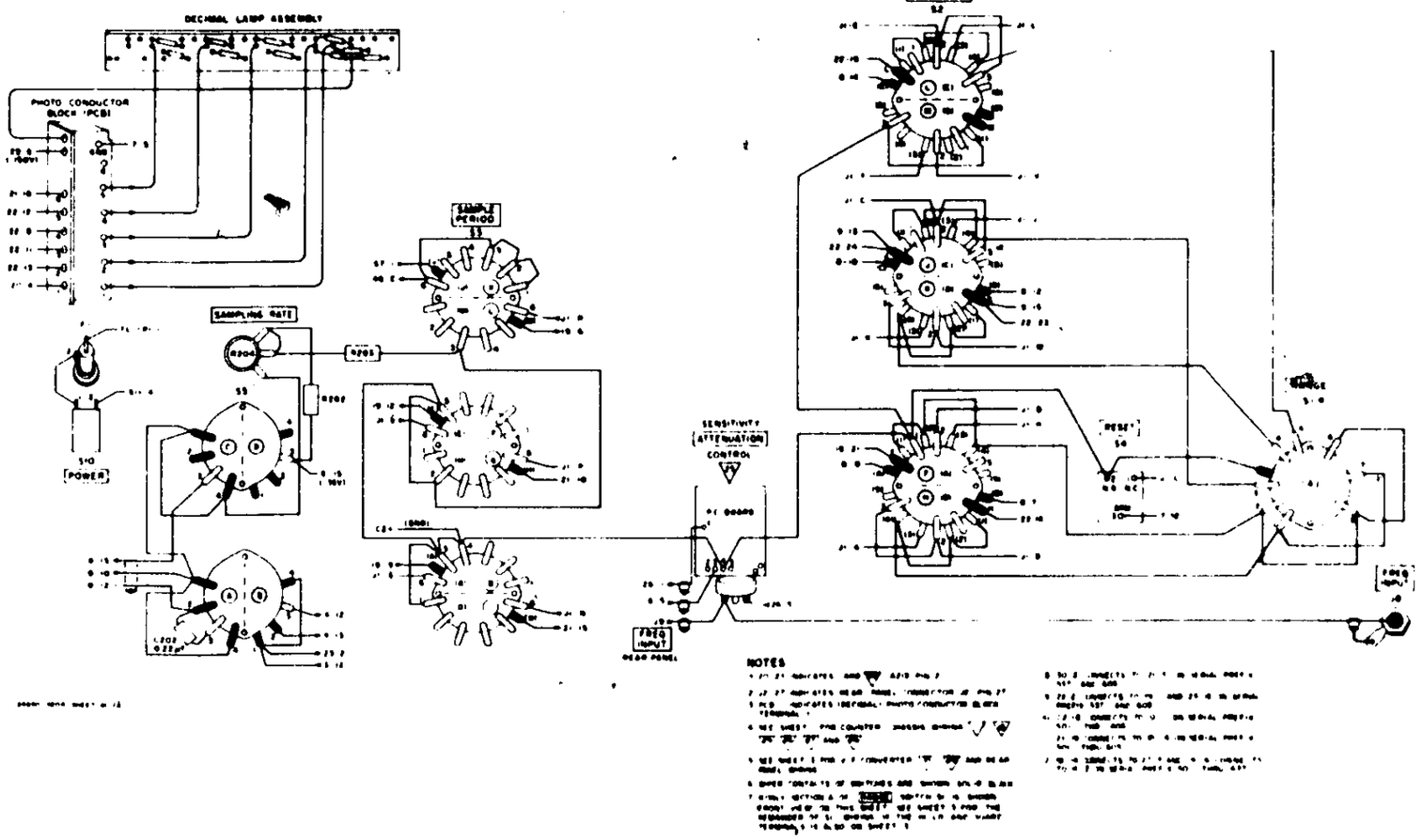


Figure 4-34. Interconnections (Sheet 2 of 3)

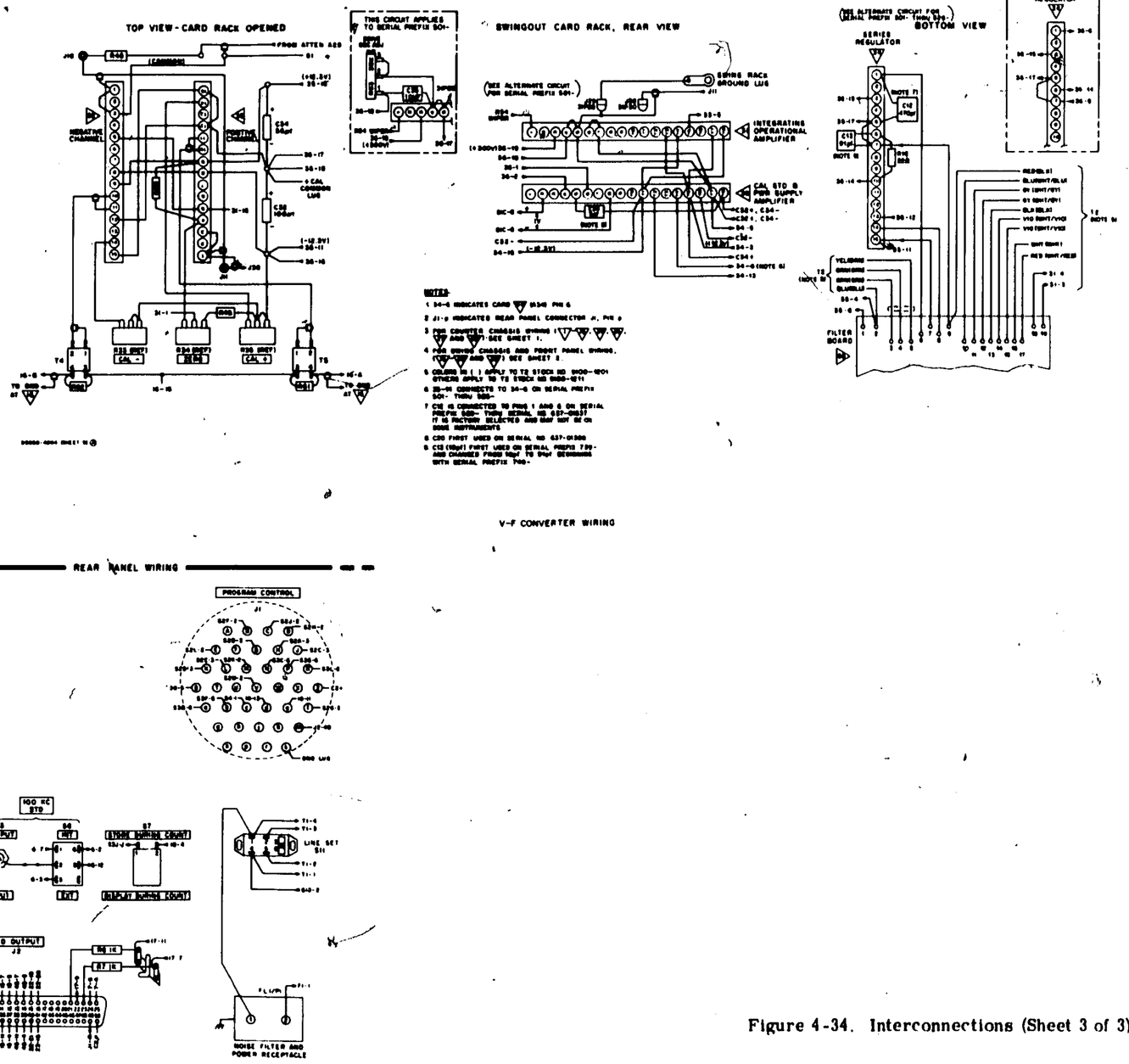


Figure 4-34. Interconnections (Sheet 3 of 3)

PARTS LIST

SECTION V
CONTENTS

LIST OF BOARD ASSEMBLIES

NOTE: Refer to introduction of this section for an explanation of letter codes in note column.

* 5060-6205 May Replace 5060-2015 or 5060-5871.

LIST OF BOARD ASSEMBLIES (Cont'd)

NOTE: Refer to introduction of this section for an explanation of letter codes in note column.

Reference Designation(s)	Description	Stock Number	Note	Page No.
A22	Logic Card	5060-2111	A-E	5-24
		5060-5610	F-X	5-26
A23	AC and Ohms Delay Gate	5060-3771	A-H†	5-28
		5060-5874	J-L†	5-28
		5060-6206	M-X	5-28
A24	Units Display	5060-3818		5-29
A25	Attenuator Control	5060-2018		5-29
A26	Input Amplifier	05212-6014	A-S	5-30
		05232-6007	T-X	5-30
A27	Schmitt Trigger	5060-5016	A-S	5-31
		05232-6006	T-X	5-31
A28	Programmable DC Attenuator	5060-5115		5-46
A29	+6V Bias Supply	5060-3805		5-32
A30	HP 2411A Decimal Point Logic	5060-2108	A-H**	5-32
		5060-5875	J-L**	5-32
		5060-6203	M-X	5-32
A31#	Operational Amplifier	5060-3848	A	5-34
		5060-5145	B-X	5-34
A32#	Negative Channel PC	5060-5001		5-37
A32A1	Amplifier PC	5060-6275		5-37
A32A2	Binary PC	5060-3838		5-38
A33#	Positive Channel PC	5060-3849		5-38
A33A1	Amplifier PC	5060-6274		5-38
A33A2	Binary PC	5060-3838		5-39
A34	Series Regulator	5060-3782		5-40
A35#	Power Supply Amplifier	5060-3783		5-40
A36	Rectifier Filter PC	5060-3806		5-42
A46	Reversible Decade Counter	5060-3781		5-42
A47	Relay Time Circuit	5060-3691		5-42

† 5060-6206 May Replace 5060-3771 or 5060-5874.
** 5060-6203 May Replace 5060-2108 or 5060-5875.
# Not Field-Repairable.

SECTION V
PARTS LIST

5.1 INTRODUCTION

This section contains two lists of information for ordering replacement parts. Table 5-1 lists parts alpha-numerically by reference designation. It provides HP part numbers, a general description of the parts and any applicable notes. The Note column also contains letter codes which identify parts variations between instruments having different serial prefix numbers. Where the Note column has been left blank, the parts apply to all instruments. Following are the codes for the instruments covered by this manual.

Code	Ser Prefix/Ser No.	Code	Ser Prefix/Ser No.
A	501-	M	637-01271
B	521-	N	637-01388
C	526-	P	637-01488
D	529-	Q	637-01588
E	533-	R	637-01738
F	537-00371	S	637-01938
G	537-00621	T	735-
H	605-	U	739-
J	610-	V	749-
K	614-	W	751-
L	622-	X	811-

Table 5-2 lists parts alpha-numerically by their HP part numbers and provides the following information on each part:

a. General description of the part.

b. Typical manufacturer of the part expressed as a five-digit code. (A list of manufacturers and their code numbers appear in Table 5-3.)

c. Manufacturer's part, stock, or drawing number.

d. Total quantities used.

5.2 ORDERING INFORMATION

To order a part from Hewlett-Packard Co., address your order or inquiry to your local Hewlett-Packard Sales and Service Office. See the listing at the rear of this manual.

Specify the following information on each part:

a. Model number and complete serial number of instrument.

b. Stock number.

c. Circuit reference designation.

d. Description.

To order a part not listed in Table 5-1, give complete description and include function and location of the part in the instrument and/or system.

5.3 ABBREVIATIONS USED

REFERENCE DESIGNATION

A	= assembly	F	= fuse	MK	= microphone	V	= vacuum tube, neon bulb, photocell, etc.
B	= motor	FL	= filter	P	= plug connector	VR	= voltage regulator
BT	= battery	IC	= integrated circuit	Q	= transistor	W	= cable, jumper
C	= capacitor	J	= receptacle connector	R	= resistor	X	= socket
CP	= coupler	K	= relay	RT	= thermistor	Y	= crystal
CR	= diode	L	= inductor	S	= switch	Z	= tuned cavity, network
DL	= delay line	LS	= loud speaker	T	= transformer		
DS	= device signaling (lamp)	M	= meter	TB	= terminal board		
E	= misc hardware	MC	= microcircuit	TP	= test point		

ABBREVIATIONS

A	= amperes	H	= henries	N O	= normally open	RMO	= rack mount only
AFC	= automatic frequency control	HDW	= hardware	NPO	= negative positive zero (zero temperature coefficient)	RMS	= root-mean square
AMPL	= amplifier	HEX	= hexagonal			RWV	= reverse working voltage
		HG	= mercury	NPN	= negative-positive-negative		
BFO	= beat frequency oscillator	HR	= hour(s)			S-B	= slow-blow
BE CU	= beryllium copper	HZ	= hertz	NRFR	= not recommended for field replacement	SCR	= screw
BH	= binder head					SE	= selenium
BP	= bandpass	IF	= intermediate freq	NSR	= not separately replaceable	SECT	= section(s)
BRS	= brass	IMPG	= impregnated			SEMICON	= semiconductor
BWO	= backward wave oscillator	INCD	= incandescent			SI	= silicon
		INCL	= include(s)	OBD	= order by description	SIL	= silver
CCW	= counter clockwise	INS	= insulation(ed)	OH	= oval head	SL	= slide
CER	= ceramic	INT	= internal	OX	= oxide	SPG	= spring
CMO	= cabinet mount only					SPL	= special
COEF	= coefficient	K	= kilo = 1000	P	= peak	SST	= stainless steel
COM	= common			PC	= printed circuit	SR	= split ring
COMP	= composition	LH	= left hand	PF	= picofarads = 10^{-12} farads	STL	= steel
COMPL	= complete	LIN	= linear taper			TA	= tantalum
CONN	= connector	LK WASH	= lock washer	PH BRZ	= phosphor bronze	TD	= time delay
CP	= cadmium plate	LOG	= logarithmic taper	PHL	= Phillips	TGL	= toggle
CRT	= cathode-ray tube	LPF	= low pass filter	PIV	= peak inverse voltage	THD	= thread
CW	= clockwise			PNP	= positive-negative-positive	TI	= titanium
		M	= milli = 10^{-3}			TOL	= tolerance
DEPC	= deposited carbon	MEG	= meg = 10^{6}	P O	= part of	TRIM	= trimmer
DR	= drive	MET FLM	= metal film	POLY	= polystyrene	TWT	= traveling wave tube
		MET OX	= metallic oxide	PORC	= porcelain		
ELECT	= electrolytic	MFR	= manufacturer	POS	= position(s)	U	= micro = 10^{-6}
ENCAP	= encapsulated	MHZ	= mega hertz	POT	= potentiometer	VAR	= variable
EXT	= external	MINAT	= miniature	PP	= peak-to-peak	VDCW	= dc working volts
		MOM	= momentary	PT	= point		
F	= farads	MTG	= mounting	PWV	= peak working voltage	W	= with
FH	= flat head	MY	= "mylar"			W	= watts
FIL H	= fillister head			RECT	= rectifier	WIV	= working inverse voltage
FXD	= fixed	N	= nano (10^{-9})	RF	= radio frequency		
		N C	= normally closed	RH	= round head or right hand	WW	= wirewound
G	= giga (10^{9})	NE	= neon			W O	= without
GE	= germanium	NI PL	= nickel plate				
GL	= glass						
GRD	= ground(ed)						

5.4 RECOMMENDED INDUSTRIAL SPARES

In situations where down-time of the equipment is of critical importance, it is recommended that one of each of the following plug-in etched circuit boards or assemblies be stocked. The instrument can then be kept in operation while the faulty board or assembly is being repaired. Where more than one stock number is listed, check the instrument serial number prefix and Paragraph 5.1 to determine the applicable stock number.

Circuit Reference	Description	HP Stock No.	Usable On Code
A1-A5	Decade Divider	5212A-65C	
A6	100kHz Oscillator	5212A-65F	
A7	-35V Regulator & Reset	5060-3830	A-J
		5060-2006	K-X
A10	Overload Detector	5060-2181	A-H
		5060-5655	J-X
A11-A15, A46	Reversible Decade	5060-3781	
A16	Reversible Counter Logic	5060-3809	
A17	Gate Control	5060-5002	A-L
		5060-6224	M-X
A18	Display Control	5060-2052	
A19	Control Logic A	5060-3829	A-H
		5060-5872	J-X
A26	Input Amplifier	5060-6014	A-S
		5060-6007	T-W
A27	Schmitt Trigger	5060-5016	A-S
		5060-6006	T-X
A31*	Operational Amplifier	5060-3848	A
		5060-5145	B-X
A32*	Negative Channel	5060-5001	
A33*	Positive Channel	5060-3849	
A34	Series Regulator	5060-3782	
A35*	Power Supply Amplifier	5060-3783	

*** NOTE: Not field-repairable.**

Table 5-1. Reference Designation Index

Reference Designation	Part No.	Description #	Note
		A1 5212A-65C	
A1	5212A-65C	DECADE DIVIDER	
A1C1	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A1C2	0140-0194	C:FXD MICA 110 PF 5%	
A1C3	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A1C4	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A1C5	0140-0196	C:FXD MICA 150 PF 5%	
A1C6	0140-0196	C:FXD MICA 150 PF 5%	
A1C7	0140-0196	C:FXD MICA 150 PF 5%	
A1C8	0140-0199	C:FXD MICA 240 PF 5%	
A1C9	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A1C10	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A1C11	0140-0194	C:FXD MICA 110 PF 5%	
A1C12	0140-0196	C:FXD MICA 200 PF 5%	
A1C13	0140-0198	C:FXD MICA 200 PF 5%	
A1C14	0140-0200	C:FXD MICA 390 PF 5%	
A1CR1	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A1CR2	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A1CR3	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A1CR4	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A1CR5	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A1Q1-A1Q8	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A1R1	0683-3915	R:FXD COMP 390 OHM 5% 1/4W	
A1R2	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R3	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R4	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R5	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A1R6	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R7	0683-2015	R:FXD COMP 200 OHM 5% 1/4W	
A1R8	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R9	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R10	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R11	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A1R12	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R13	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R14	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R15	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R16	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A1R17	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R18	0683-2015	R:FXD COMP 200 OHM 5% 1/4W	
A1R19	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R20	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R21	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A1 5212A-65C (CONT'D) A2-A5 5212A-65C A6 5212A-65F	
A1R22	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A1R23	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R24	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A1R25	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R26	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R27	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R28	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A1R29	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R30	0683-2015	R:FXD COMP 200 OHM 5% 1/4W	
A1R31	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R32	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R33	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R34	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A1R35	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R36	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R37	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R38	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R39	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A1R40	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R41	0683-2015	R:FXD COMP 200 OHM 5% 1/4W	
A1R42	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A1R43	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A1R44	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A1R45	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A1R46	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A2		SAME AS A1, USE PREFIX A2	
A3		SAME AS A1, USE PREFIX A3	
A4		SAME AS A1, USE PREFIX A4	
A5		SAME AS A1, USE PREFIX A5	
A6	5212A-65F	100KHZ OSCILLATOR	
A6C1	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A6C2	0170-0072	C:FXD MY 1 UF 10% 200VDCW	
A6C3	0140-0156	C:FXD MICA 1500 PF 2%	
A6CR1	1901-0016	DIODE:SILICON	
A6Q1	1851-0006	TRANSISTOR:GE NPN	A-K
	1854-0003	TRANSISTOR:NPN SILICON	L-X
A6Q2	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A6Q3	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A6R2	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A6R3	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A6R4	0686-2235	R:FXD COMP 22K OHM 5% 1/2W	A-K
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	L-X
A6R5	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A6 5212A-65F (CONT'D)	
		A7 5060-3830	A - J
		5060-2006	K - X
A6R6	0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	
A6R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A6R8	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	A-K
	0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	L-X
A6R9	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A6R10	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A6R11	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A6R12	0683-4705	R:FXD COMP 47 OHM 5% 1/4W	
A6R13	0686-3925	R:FXD COMP 3900 OHM 5% 1/2W	
A6R14	0686-2235	R:FXD COMP 22K OHM 5% 1/2W	A-K
	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	L-X
A6R15	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A6T1	5212A-9A	TRANSFORMER	
A7	5060-3830	-35V REGULATOR & RESET CIRCUIT	A - J
	5060-2006	-35V REGULATOR & RESET CIRCUIT	A - X
A7C1	0170-0024	C:FXD MY 0.022UF 20% 200VDCW	
A7C2	0180-0197	C:FXD ELECT 2.2 UF 10% 20VDCW	
A7C3	0150-0014	C:FXD CER 0.005 UF 500VDCW	A-P
	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	Q-X
A7C4	0150-0014	C:FXD CER 0.005 UF 500VDCW	A-P
	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	Q-X
A7C5	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A7CR1	1902-0033	DIODE:BREAKDOWN 6.2V	
A7CR2	1902-0025	DIODE:BREAKDOWN 10.0V 5% 400 MW	
A7CR3	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A7CR4	1901-0061	DIODE:SILICON	
A7CR5	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A7CR6	1902-0022	DIODE:BREAKDOWN 2.67V	
A7Q1	1850-0124	TRANSISTOR:GERMANIUM PNP	
A7Q2	1850-0032	TRANSISTOR:GERMANIUM PNP	A-J
A7Q3	1850-0032	TRANSISTOR:GERMANIUM PNP	
A7Q4	1850-0111	TRANSISTOR:GERMANIUM PNP	
A7Q5	1850-0111	TRANSISTOR:GERMANIUM PNP	
A7Q6	1850-0111	TRANSISTOR:GERMANIUM PNP	
A7Q7	1851-0024	TRANSISTOR:GERMANIUM NPN	
A7R1	0812-0045	R:FXD WW 0.15 OHM 5% 3W	A-J
A7R2	0812-0045	R:FXD WW 0.15 OHM 5% 3W	A-J
A7R4	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A7R5	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	
A7R6	0686-3625	R:FXD COMP 3600 OHM 5% 1/2W	
A7R7	0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A7 5060-3830 (CONT'D)	A-J
		5060-2006 (CONT'D)	K-X
		A8 5060-2014	A-H
		5060-5870	J-X
A7R8	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A7R9	0727-0739	R:FXD CARBON FLM 464 OHM 1% 1/2W	
A7R10	2100-0490	R:VAR WW 100 OHM 10% 1/2W	
A7R12	0727-0764	R:FXD CARBON FLM 2.37K OHM 1% 1/2W	
A7R13	0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	
A7R14	0686-2025	R:FXD COMP 2000 OHM 5% 1/2W	
A7R15	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	
A7R16	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A7R17	0683-4725	R:FXD COMP 4700 OHM 5% 1.4W	
A7R18	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A7R19	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A7R20	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A7R21	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A7R22	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A7R23	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A7R24	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	
A7R25	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A7R26	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A7R27	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A7R28	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A7R29	0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	
A7R30	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A7R31	0683-1015	R:FXD COMP 100 OHM 5% 1/4W	
A7W1	8159-0005	JUMPER WIRE	K-X
A8	5060-2014	ATTENUATOR COUPLING LOGIC	A-H
	5060-5870	ATTENUATOR COUPLING LOGIC	J-X
A8CR1	1901-0025	DIODE:SILICON 100WV 100MA	A-H
	1901-0434	DIODE:SILICON 100MA 50 WIV	J-W
A8CR2	1901-0025	DIODE:SILICON 100WV 100MA	
A8CR3	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A8CR4	1901-0025	DIODE:SILICON 100WV 100MA	
A8CR5	1901-0025	DIODE:SILICON 100WV 100MA	
A8CR6	1901-0025	DIODE:SILICON 100WV 100MA	
A8CR7-A8CR16	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A8CR17	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A8Q1	1850-0128	TRANSISTOR:PNP GERMANIUM	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-X
A8Q2	1850-0113	TRANSISTOR:GERMANIUM PNP	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-X
A8Q3	1850-0128	TRANSISTOR:PNP GERMANIUM	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-W
A8Q4	1850-0113	TRANSISTOR:GERMANIUM PNP	
A8Q5	1850-0092	TRANSISTOR:GERMANIUM	
A8Q6	1850-0128	TRANSISTOR:PNP GERMANIUM	
A8Q7	1850-0128	TRANSISTOR:PNP GERMANIUM	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A8 5060-2014 (CONT'D)	A-H
		5060-5870 (CONT'D)	J-X
		A9 5060-2015	A-H*
		5060-5871	J-L*
		5060-6205	M-X
A8Q8	185C-0128	TRANSISTOR:PNP GERMANIUM 2N398B	
A8Q9	1850-0128	TRANSISTOR:PNP GERMANIUM 2N398B	
A8R1	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	J-X
A8R2	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	A-H
	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	J-X
A8R3	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	A-H
	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	J-X
A8R4	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	J-X
	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	A-H
A8R5	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	J-X
A8R6	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	A-H
	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	J-X
A8R7	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A8R8	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	A-H
	0757-0968	R:FXD FLM 68K OHM 2% 1/8W	J-X
A8R9	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	A-H
	0757-0958	R:FXD FLM 27K OHM 2% 1/8W	J-X
A8R10	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	A-H
	0757-0946	R:FXD FLM 10K OHM 2% 1/8W	J-X
A8R11	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0757-0939	R:FXD FLM 4.3K OHM 2% 1/8W	J-X
A8R12	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	A-H
	0757-0953	R:FXD FLM 16K OHM 2% 1/8W	J-X
A8R13	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A8R14-A8R18	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A8R19	0686-4725	R:FXD COMP 4700 OHM 5% 1/2W	
A8R20	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A8R21	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A8R22	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A8R23	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A9	5060-2015	HP 2410B UNIT COUPLING LOGIC	A-H*
	5060-5871	HP 2410B UNIT COUPLING LOGIC	J-L*
	5060-6205	HP 2410B UNIT COUPLING LOGIC	M-X
A9CR1	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A9CR2	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A9CR3	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A9CR4	1901-0025	DIODE:SILICON 100WV 100MA	
A9CR5	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A9CR6	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A9CR7	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	

*5060-6205 MAY REPLACE 5060-2015 OR 5060-5871.

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A9 5060-2015 (CONT'D)	A-H*
		5060-5871 (CONT'D)	J-L*
		5060-6205 (CONT'D)	M-X
A9CR8	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	M-X
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-L
A9CR10	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0434	DIODE:SILICON 100MA 50 WIV	J-X
A9CR11	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0434	DIODE:SILICON 100MA 50 WIV	J-X
A9CR12	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A9CR13	1901-0025	DIODE:SILICON 100WV 100MA	
A9Q1	1850-0128	TRANSISTOR:PNP GERMANIUM 2N398B	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-L
	1853-0007	TRANSISTOR:SILICON PNP	M-X
A9Q2	1850-0128	TRANSISTOR:PNP GERMANIUM 2N398B	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-L
	1853-0008	TRANSISTOR:SILICON PNP	M-X
A9Q3	1850-0128	TRANSISTOR:PNP GERMANIUM 2N398B	
A9Q4	1850-0128	TRANSISTOR:PNP GERMANIUM 2N398B	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-L
	1853-0008	TRANSISTOR:SILICON PNP	M-X
A9Q5	1850-0128	TRANSISTOR:PNP GERMANIUM 2N398B	
A9R1	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A9R2	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
	0698-3449	R:FXD MET FLM 28.7K OHM 1% 1/8W	A-L
A9R3	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	M-X
	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	A-H
	0757-0439	R:FXD MET FLM 6.81K OHM 1% 1/8W	J-L
A9R4	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	M-X
	0683-3635	R:FXD COMP 36K OHM 5% 1/4W	A-H
	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	J-L
A9R5	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	M-X
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0683-4335	R:FXD COMP 43K OHM 5% 1/4W	J-L
A9R6	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	M-X
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	A-H
A9R7	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	J-X
A9R8	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A9R9	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A9R10	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A9R11	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A9R12	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-H
	0757-0444	R:FXD MET FLM 12.1K OHM 1% 1/8W	J-L
A9R13	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	M-X
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	A-H
	0698-3161	R:FXD MET FLM 38.3K OHM 1% 1/8W	J-L
A9R14	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	M-X
	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-H
	0757-0446	R:FXD MET FLM 15.0K OHM 1% 1/8W	J-L
A9R15	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	M-X
A9R16	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A9R17	0689-3315	R:FXD COMP 330 OHM 5% 1W	

See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A10 5080-2181	A-H
A10	5080-2181	OVERLOAD DETECTOR	A-H
A10C1	0160-0257	C:FXD MICA 50.6PF 5%	
A10C6	0160-0184	C:FXD MICA 220PF 5% 300VDCW	
A10C7	0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	
A10C8	0160-0163	C:FXD MY 0.033 UF 10% 200VDCW	
A10C9	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C10	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
	0160-0166	C:FXD MY .068 UF 10%	A-G H*
A10CR1	1901-0071	DIODE:SILICON 30WV	
A10CR2	1901-0071	DIODE:SILICON 30WV	
A10CR6	1903-0003	DIODE:SILICON 38V	
A10CR7	1901-0025	DIODE:SILICON 100WV 100MA	
A10CR8	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A10CR9	1902-0022	DIODE BREAKDOWN:2.67V	
A10Q2	1850-0040	TRANSISTOR:GERMANIUM PNP	
A10R1	0727-0751	R:FXD DEPC 1000 OHM 1% 1/2W	
	0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	A-F G-H
A10R2	2100-0369	R:VAR WW 200 OHM 10% LIN 1/4W	
A10R3	0727-0766	R:FXD CARBON FLM 2.87K OHM 1% 1/2W	
	0698-3101	R:FXD MET FLM 2.87K OHM 1% 1/2W	A-F G-H
A10R4	0727-0792	R:FXD CARBON FLM 31.6K OHM 1% 1/2W	
	0698-3419	R:FXD MET FLM 31.6K OHM 1% 1/2W	A-F G-H
A10R10	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R11	0758-0004	R:FXD MET OX 2700 OHM 5% 1/2W	
A10R12	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R13	0683-1005	R:FXD COMP 10 OHM 5% 1/4W	
A10R14	0689-1815	R:FXD COMP 180 OHM 5% 1W	
A10R15	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A10R16	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R18	0683-1015	R:FXD COMP 100 OHM 5% 1/4W	
A10R19	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A10A1	5060-2012	VOLTAGE COMPARATOR	
A10A1C2	0160-2940	C:FXD MICA 470 PF 5% 300VDCW	
A10A1C3	0160-0303	C:FXD MYLAR .15 UF 10% 200VDCW	
A10A1C4	0180-0050	C:FXD ELECT 40 UF +75-10% 50VDCW	
A10A1C5	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10A1CR3	1901-0058	DIODE:SILICON 150V	

* THE FOLLOWING SERIAL NUMBERS USE 0160-0161:605-00671, 00672, 00674, 00677, 00682, 00683, 00685, 00690, 00691, 00692, AND 00699.

See introduction to this section for ordering information

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A10 5080-2181 (CONT'D)	A-H
		5080-5655	J-X
A10A1CR4	1901-0058	DIODE:SILICON 150V	
A10A1CR5	1910-0023	DIODE:GERMANIUM 83 WIV	
A10A1L1	9140-0053	CHOKE/COIL:FXD 1 MH 10%	
A10A1Q1	1850-0048	TRANSISTOR:GERMANIUM 2N650 PNP	
A10A1R5	0727-0274	R:FXD DEPC 1 MEGOHM 1% 1/2W	
A10A1R6	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A10A1R7	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A10A1R9	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10A1T1	5080-1454	TRANSFORMER:PULSE	
A10	5080-5655	OVERLOAD DETECTOR	J-X
A10C1	0160-0257	C:FXD MICA 50.6PF 5%	
A10C2	0180-0049	C:FXD AL ELECT 20UF 50VDCW	
A10C3	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C4	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C5	0160-0166	C:FXD MY .068 UF 10%	
A10C6	0160-2940	C:FXD MICA 470 PF 5% 300VDCW	
A10C7	0160-0263	C:FXD CER 0.22 UF 20% 50VDCW	
A10C8	0180-0050	C:FXD ELECT 40 UF +75-10% 50VDCW	
A10C9	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C10	0140-0194	C:FXD MICA 110 PF 5%	
A10C11	0140-0191	C:FXD MICA 56 PF 5%	
A10C12	0140-0191	C:FXD MICA 56 PF 5%	
A10C13	0140-0194	C:FXD MICA 110 PF 5%	
A10CR1-A10CR5	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A10CR6	1902-0022	DIODE BREAKDOWN:2.67V	
A10CR7	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A10CR8	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A10L1	9140-0210	COIL:FXD RF 100 UH 5%	
A10L2	9140-0053	CHOKE/COIL:FXD 1 MH 10%	
A10Q1	1850-0040	TRANSISTOR:GERMANIUM PNP	
A10Q2	1850-0048	TRANSISTOR:GERMANIUM	J-P
	1850-0184	TRANSISTOR:GERMANIUM PNP	Q-X
A10Q3	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A10Q4	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A10Q5	1850-0183	TRANSISTOR:GERMANIUM PNP	
A10R1	0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A10 5060-5655 (CONT'D)	J-X
A10R2	0698-3419	R:FXD MET FLM 31.6K OHM 1% 1/2W	
A10R3	2100-0369	R:VAR WW 200 OHM 10% LIN 1/4W	
A10R4	0698-0024	R:FXD MET FLM 2.61K OHM 1% 1/2W	
A10R5	OBD	FACTORY SELECTED	
A10R6	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A10R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A10R8	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R9	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R10	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R11	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A10R12	0683-1015	R:FXD COMP 100 OHM 5% 1/4W	
A10R13	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A10R14	0689-2725	R:FXD COMP 2.7K OHM 5% 1W	
A10R15	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A10R16	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A10R17	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	
A10R18	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	
A10R19	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R20	0689-3925	R:FXD COMP 3.9K OHM 5% 1W	
A10R21	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A10R22	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A10R23	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A10R24	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A10R25	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A10R26	0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	
A10R27	0692-1815	R:FXD COMP 180 OHM 5% 2W	
A10T1	5060-2577	TRANSFORMER:PULSE	J-L
	9100-1221	TRANSFORMER:PULSE	M-W

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A11 5060-3781	
A11	5060-3781	REVERSIBLE DECADE COUNTER	
A11A1	NSR	READOUT BLOCK ASSY	
A11C1	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C2	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C3	0140-0219	C:FXD MICA 180 PF 2%	
A11C4	0140-0219	C:FXD MICA 180 PF 2%	
A11C5	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C6	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C7	0140-0219	C:FXD MICA 180 PF 2%	
A11C8	0140-0219	C:FXD MICA 180 PF 2%	
A11C9	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C10	0140-0219	C:FXD MICA 180 PF 2%	
A11C11	0140-0219	C:FXD MICA 180 PF 2%	
A11C12	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C13-A11C18	0140-0194	C:FXD MICA 110 PF 5%	
A11CR1-A11CR8	1901-0025	DIODE:SILICON 100WV 100MA	
A11CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR10	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR11	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR13-A11CR24	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR26-A11CR34	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11Q1-A11Q8	1850-0184	TRANSISTOR:GERMANIUM PNP	
A11R1	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R2	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R3	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R4	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R5	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R6	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R8	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R9	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R10	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R11	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R12	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R13	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R14	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R15	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A11 5080-3781 (CONT'D) A12-A15, A46 5080-3781	
A11R16	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R17-			
A11R26	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R27	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R28	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R29	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R30	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R31	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R32	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R33	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R34	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R35	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R36	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R37	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R38	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R39-			
A11R46	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A11R47	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R48	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R49	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R50	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R51	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R52	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R53	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R54	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R55	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R56	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R57	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R58	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R59	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R60	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R61	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R62	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R63	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R64	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R65	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R66	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R67	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R68	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R69	0686-4735	R:FXD COMP 47K OHM 5% 1/2W	
A11V1	1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	
A12		SAME AS A11, USE PREFIX A12	
A13		SAME AS A11, USE PREFIX A13	
A14		SAME AS A11, USE PREFIX A14	
A15		SAME AS A11, USE PREFIX A15	
A46		SAME AS A11, USE PREFIX A16	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A16 5080-3809	
A16	5080-3809	COUNTER CONTROL	
A16C2	0160-0134	C:FXD MICA 220PF 5% 300VDCW	A-F
	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	G-X
A16C4	0160-0134	C:FXD MICA 220PF 5% 300VDCW	A-F
	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	G-X
A16C5	0140-0194	C:FXD MICA 110 PF 5%	
A16C6	0140-0194	C:FXD MICA 110 PF 5%	
A16C7	0140-0194	C:FXD MICA 110 PF 5%	
A16C8	0140-0194	C:FXD MICA 110 PF 5%	
A16C9	0140-0194	C:FXD MICA 110 PF 5%	
A16C10	0160-0938	C:FXD MICA 1000PF 5%	
A16C11	0140-0194	C:FXD MICA 110 PF 5%	
A16C12	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A16C13	0160-2101	C:FXD MICA 27PF 2% 300VDCW	
A16C14	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A16C15	0140-0218	C:FXD MICA 160 PF 2%	
A16C16	0140-0218	C:FXD MICA 160 PF 2%	
A16C18	0140-0194	C:FXD MICA 110 PF 5%	
A16C19	0160-0938	C:FXD MICA 1000PF 5%	
A16CR1-			
A16CR37	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A16CR38	1901-0143	DIODE:SILICON	
A16CR39	1901-0143	DIODE:SILICON	
A16CR40	1901-0081	DIODE:SILICON 50 VOLTS WORKING	H-X
A16Q1	1853-0008	TRANSISTOR:SILICON PNP	
A16Q2	1853-0008	TRANSISTOR:SILICON PNP	
A16Q3	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q4	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q5	1850-0111	TRANSISTOR:GERMANIUM PNP	
	1853-0036	TRANSISTOR:SILICON PNP	A-S T-X
A16Q6	1850-0111	TRANSISTOR:GERMANIUM PNP	A-S
	1853-0036	TRANSISTOR:SILICON PNP	T-X
A16Q7	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q8	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q9	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q10	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q11-			
A16Q14	1854-0039	TRANSISTOR:SILICON	
A16Q15	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q16	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q17	1853-0008	TRANSISTOR:SILICON PNP	
A16Q18	1853-0008	TRANSISTOR:SILICON PNP	
A16Q19	1853-0008	TRANSISTOR:SILICON PNP	
A16Q20	1854-0039	TRANSISTOR:SILICON	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A16 5060-3809 (CONT'D)	
A16Q22	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q23	1850-0111	TRANSISTOR:GERMANIUM PNP	
A16Q24	1850-0111	TRANSISTOR:GERMANIUM PNP	A-S
	1853-0036	TRANSISTOR:SILICON PNP	T-X
A16Q25	1853-0008	TRANSISTOR:SILICON PNP	
A16R1	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R2	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A16R3	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A16R4	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A16R5	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A16R6	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A16R7	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A16R8	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A16R9	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A16R10	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R11	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R12	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R13	0683-1135	R:FXD COMP 11K OHM 5% 1/4W	
A16R14	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R15	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R16	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A16R17	0757-0943	R:FXD FLM 6.2K OHM 2% 1/8W	
A16R18	0757-0943	R:FXD FLM 6.2K OHM 2% 1/8W	
A16R19	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A16R20	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A16R21	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A16R22	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A16R23	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A16R24	0757-0943	R:FXD FLM 6.2K OHM 2% 1/8W	
A16R25	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A16R26	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R27	0686-3925	R:FXD COMP 3900 OHM 5% 1/2W	
A16R28	0686-3925	R:FXD COMP 3900 OHM 5% 1/2W	
A16R29	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A16R30	0683-1135	R:FXD COMP 11K OHM 5% 1/4W	
A16R31	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R32	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R33	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R34	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A16R35	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A16R36	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R37	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R38	0683-1135	R:FXD COMP 11K OHM 5% 1/4W	
A16R39	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A16R40	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R41	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A16R42	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A16R43	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A16R44	0683-3305	R:FXD COMP 33 OHM 5% 1/4W	
A16R45	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A16 5060-3809 (CONT'D)	
		A17 5060-5002	A-L
		5060-6224	M-X
A16R46	0683-3305	R:FXD COMP 33 OHM 5% 1/4W	
A16R47	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R48	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A16R49	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A16R50	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A16R51	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R52	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A16R53	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A16R54	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A16R55	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A16R56	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A16R57	0686-4725	R:FXD COMP 4700 OHM 5% 1/2W	
A16R58	0683-4335	R:FXD COMP 43K OHM 5% 1/4W	
A16R60	0686-3325	R:FXD COMP 3300 OHM 5% 1/2W	
A16R61	0683-4335	R:FXD COMP 43K OHM 5% 1/4W	
A16R63	0757-0954	R:FXD FLM 18K OHM 2% 1/8W	
A16R64	0757-0954	R:FXD FLM 18K OHM 2% 1/8W	
A16R65	0757-0931	R:FXD FLM 2.0K OHM 2% 1/8W	
A16R66	0757-0952	R:FXD FLM 15K OHM 2% 1/8W	
A16R67	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A16R68	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A16R69	0683-4725	R:FXD COMP 4.7K 5% 1/4W	A-F
	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	G-X
A16R70	0689-2225	R:FXD COMP 2200 OHM 5% 1W	
A16R71	0683-1015	R:FXD COMP 100 OHM 5% 1/4W	
A16R72	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	A-K
	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	L-X
A16R73	0683-4335	R:FXD COMP 43K OHM 5% 1/4W	
A16R74	0689-2725	R:FXD COMP 2.7K OHM 5% 1W	
A16R75	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A16R76	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	A-G
	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	H-X
A16R77	0757-0943	R:FXD FLM 6.2K OHM 2% 1/8W	
A16R78	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R79	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	
A16R80	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A16R81	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A16R82	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A16R83	0683-4325	R:FXD COMP 4300 OHM 5% 1/4W	
A16R84	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A16R85	0683-4725	R:FXD COMP 4.7K 5% 1/4W	A-F
	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	G-X
A16R86	2100-0369	R:VAR WW 200 OHM 10% LIN 1/4W	
A17	5060-5002	GATE CONTROL	A-L
	5060-6224	GATE CONTROL	M-X
A17C1	0140-0194	C:FXD MICA 110 PF 5%	
A17C2	0140-0194	C:FXD MICA 110 PF 5%	
A17C3	0140-0200	C:FXD MICA 390 PF 5%	
A17C4	0140-0200	C:FXD MICA 390 PF 5%	
A17C5	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A17 5080-5002 (CONT'D)	A-L
		5080-6224 (CONT'D)	M-X
A17C6	0140-0198	C:FXD MICA 200 PF 5%	
A17C7	0150-0093	C:FXD CER 0.01 UF +80-20% 100VDCW	
	0160-0938	C:FXD MICA 1000PF 5%	A-B C-X
A17CR1	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A17CR2	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A17CR3	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A17CR4	1901-0061	DIODE:SILICON	
A17CR5	1901-0061	DIODE:SILICON	
A17CR6	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A17CR7	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A17CR8	1902-0094	DIODE:BREAKDOWN 4.85V 250MW	
A17CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A17CR10	1901-0050	DIODE:SILICON 75V	M-X
A17Q1	1850-0111	TRANSISTOR:GERMANIUM PNP	
A17Q2	1850-0111	TRANSISTOR:GERMANIUM PNP	
A17Q3	1854-0003	TRANSISTOR:NPN SILICON	
A17Q4	1850-0111	TRANSISTOR:GERMANIUM PNP	
A17Q5	1851-0024	TRANSISTOR:GERMANIUM NPN	
A17Q6	1851-0024	TRANSISTOR:GERMANIUM NPN	
A17Q7	1854-0003	TRANSISTOR:NPN SILICON	
A17Q8	1854-0003	TRANSISTOR:NPN SILICON	
A17R1	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A17R2	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A17R3	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A17R4	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A17R5	0761-0027	R:FXD MET FLM 2.7K OHM 5% 1W	
A17R6	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A17R7	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A17R8	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	
A17R9	0683-2705	R:FXD COMP 27 OHM 5% 1/4W	
A17R10	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A17R11	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A17R12	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A17R13	0761-0027	R:FXD MET FLM 2.7K OHM 5% 1W	
A17R14	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A17R15	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A17R16	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A17R17	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A17R18	0686-3925	R:FXD COMP 3900 OHM 5% 1/2W	
A17R19	0683-4705	R:FXD COMP 47 OHM 5% 1/4W	
A17R20	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A17R21	0686-3925	R:FXD COMP 3900 OHM 5% 1/2W	
A17R22	0683-4705	R:FXD COMP 47 OHM 5% 1/4W	
A17R23	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A17R24	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A17R25	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A17 5080-5002 (CONT'D)	A-L
		5080-6224 (CONT'D)	M-X
		A18 5080-2052	
A17R26	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A17R27	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A17R28	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A17R29	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A17R30	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	M-X
A17W1	8159-0005	JUMPER WIRE	A-L
A18	5080-2052	DISPLAY CONTROL	
A18C1	0160-2940	C:FXD MICA 470 PF 5% 300VDCW	
A18C2	0160-0127	C:FXD CER 1.0 UF 20% 25VDCW	
A18C3	0180-0116	C:FXD ELECT 6.8 UF 10% 35VDCW	
A18C4	0140-0200	C:FXD MICA 390 PF 5%	
A18C5	0140-0200	C:FXD MICA 390 PF 5%	
A18C6	0150-0014	C:FXD CER 0.005 UF 500VDCW	
A18C7	0140-0152	C:FXD MICA 1000 PF 5% 300VDCW	
A18C8	0180-0058	C:FXD ELECT 50UF -10%+100% 25VDCW	
A18C9	0150-0014	C:FXD CER 0.005 UF 500VDCW	
A18C10	0180-0049	C:FXD AL ELECT 20UF 50VDCW	
A18C11	0160-0155	C:FXD MY 3300 PF 10%	
A18CR1	1901-0025	DIODE:SILICON 100WV 100MA	
A18CR2	1901-0025	DIODE:SILICON 100WV 100MA	
A18CR3	1910-0011	DIODE:GERMANIUM 5MA AT 1V	A-L
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	M-X
A18CR4	1910-0011	DIODE:GERMANIUM 5MA AT 1V	A-B
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	M-X
A18CR5	1910-0011	DIODE:GERMANIUM 5MA AT 1V	A-L
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	M-X
A18CR6	1910-0011	DIODE:GERMANIUM 5MA AT 1V	A-L
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	M-X
A18CR7	1902-0223	DIODE BREAKDOWN:SILICON 15.4V	A-Q
	1902-0675	DIODE:BREAKDOWN 5% 15.4V	R-X
A18CR8	1901-0025	DIODE:SILICON 100WV 100MA	
A18CR9	1901-0025	DIODE:SILICON 100WV 100MA	
A18Q1	1850-0040	TRANSISTOR:GERMANIUM PNP	
A18Q2	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A18Q3	1850-0040	TRANSISTOR:GERMANIUM PNP	
A18Q4	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A18Q5	1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	
A18Q6	1850-0040	TRANSISTOR:GERMANIUM PNP	
A18Q7	1851-0024	TRANSISTOR:GERMANIUM NPN	
A18R1	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A18R2	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	
A18R3	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	
A18R4	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	
A18R5	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A18 5060-2052 (CONT'D)	
		A19 5060-3829	A-H
		5060-5872	J-X
A18R6	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A18R7	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A18R8	0686-6825	R:FXD COMP 6800 OHMS 5% 1/2W	
A18R9	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A18R10	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A18R11	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A18R12	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	
A18R13	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A18R14	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	
A18R15	0683-3915	R:FXD COMP 390 OHM 5% 1/4W	
A18R16	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A18R17	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A18R18	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	
A18R19	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A18R20	0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	
A18R21	0686-1025	R:FXD COMP 1000 OHM 5% 1/2W	
A18R22	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A18R23	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A18R24	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A18R25	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	C-L
A19	5060-3829	CONTROL LOGIC A	A-H
	5060-5872	CONTROL LOGIC A	J-X
A19CR1	1901-0061	DIODE:SILICON	A-H
A19CR2	1901-0061	DIODE:SILICON	A-H
A19CR3	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR4	1910-0037	DIODE:GERMANIUM	
A19CR5	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A19CR6	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A19CR7	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A19CR8	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A19CR9	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A19CR10	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A19CR11	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR12	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A19CR13	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR14	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A19CR15	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR16	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR17	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR18	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR19	1901-0081	DIODE:SILICON 50 VOLTS WORKING	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A19 5060-3829 (CONT'D)	A-H
		5060-5872 (CONT'D)	J-X
A19CR20	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19CR21	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A19Q1-A19Q7	1850-0128	TRANSISTOR:PNP GERMANIUM 2N3988	A-H
		TRANSISTOR:GERMANIUM PNP	J-X
	1850-0111		
A19Q8	1850-0113	TRANSISTOR:GERMANIUM PNP	A-H
	1850-0145	TRANSISTOR:GERMANIUM PNP	J-X
A19Q9	1850-0128	TRANSISTOR:PNP GERMANIUM 2N3988	
A19Q10	1850-0113	TRANSISTOR:GERMANIUM PNP	
A19Q11	1850-0113	TRANSISTOR:GERMANIUM PNP	
A19Q12	1850-0113	TRANSISTOR:GERMANIUM PNP	
A19R1	0757-0336	R:FXD MET FLM 340 OHM 1% 1/4W	A-H
A19R2	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A19R3	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A19R4	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A19R5	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A19R6	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	A-H
	0683-3035	R:FXD COMP 30K OHM 5% 1/4W	J-X
A19R7	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	A-H
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-X
A19R8	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A19R9	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	A-H
	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	J-X
A19R10	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-H
	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	J-X
A19R11	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	J-X
A19R12	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	A-H
	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	J-X
A19R13	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-H
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	J-X
A19R14	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	J-X
A19R15	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A19R16	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	A-H
	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	J-X
A19R17	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-H
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	J-X
A19R18	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	J-X
A19R19	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	A-H
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-X
A19R20	0689-1035	R:FXD COMP 10K OHM 5% 1W	
A19R21	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A19R22	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	A-H
	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	J-X

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A19 5060-3829 (CONT'D)	A-H
		5060-5872 (CONT'D)	J-X
		A20 5060-2000	
A19R23	0683-1035	RESISTOR:FXD COMP 10K OHM 5% 1W	A-H
	0683-1635	RESISTOR:FXD COMP 16K OHM 5% 1/4W	J-X
A19R24	0683-3025	RESISTOR:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-1335	RESISTOR:FXD COMP 13K OHM 5% 1/4W	J-X
A19R25	0683-1835	RESISTOR:FXD COMP 18K OHM 5% 1/4W	
A19R26	0689-1035	RESISTOR:FXD COMP 10K OHM 5% 1W	A-H
	0757-0947	RESISTOR:FXD FLM 9.1K OHM 2% 1/8W	J-X
A19R27	0683-8225	RESISTOR:FXD COMP 8200 OHMS 5% 1/4W	A-H
	0757-0944	RESISTOR:FXD FLM 6.8K OHM 2% 1/8W	J-X
A19R28	0683-2735	RESISTOR:FXD COMP 27K OHM 5% 1/4W	A-H
	0757-0950	RESISTOR:FXD FLM 12K OHM 2% 1/8W	J-X
A19R29	0683-1835	RESISTOR:FXD COMP 18K OHM 5% 1/4W	
A19R30	0689-1035	RESISTOR:FXD COMP 10K OHM 5% 1W	A-H
	0757-0946	RESISTOR:FXD FLM 8.2K OHM 2% 1/8W	J-X*
A19R31	0683-1835	RESISTOR:FXD COMP 18K OHM 5% 1/4W	A-H
	0757-0940	RESISTOR:FXD FLM 4.7K OHM 2% 1/8W	J-X
A19R32	0683-2725	RESISTOR:FXD COMP 2700 OHM 5% 1/4W	A-H
	0757-0944	RESISTOR:FXD FLM 6.8K OHM 2% 1/8W	J-X
A19R33	0689-3315	RESISTOR:FXD COMP 330 OHM 5% 1W	
A19R34	0689-1035	RESISTOR:FXD COMP 10K OHM 5% 1W	
A19R35	0689-3315	RESISTOR:FXD COMP 330 OHM 5% 1W	
A19R36	0683-4735	RESISTOR:FXD COMP 47K OHM 5% 1/4W	
A19R37	0683-4735	RESISTOR:FXD COMP 47K OHM 5% 1/4W	
A19R38	0683-4715	RESISTOR:FXD COMP 470 OHM 5% 1/4W	
A19R39	0683-4735	RESISTOR:FXD COMP 47K OHM 5% 1/4W	
A19R40	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A19R41	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20	5060-2000	CONTROL LOGIC B	
A20CR1-A20CR5	1901-0025	DIODE:SILICON 100WV 100MA	
A20CR6-A20CR23	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A20CR24-A20CR28	1901-0025	DIODE:SILICON 100WV 100MA	
A20CR29-A20CR44	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A20Q1-A20Q14	1850-0128	TRANSISTOR:PNP GERMANIUM 2N3988	
A20R1-A20R5	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R6	0683-1035	RESISTOR:FXD COMP 10K OHM 5% 1/4W	
A20R8	0683-1035	RESISTOR:FXD COMP 10K OHM 5% 1/4W	
A20R9	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R10	0683-1045	RESISTOR:FXD COMP 100K OHMS 5% 1/4W	
A20R11	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A20 5060-2000 (CONT'D)	
		A21 5060-2010	A-H
		5060-5872	J-X
A20R12	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R13	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R14	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R15	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R16	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R17	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R18	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R19	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R20	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R21	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R22	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R23	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R24	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R25	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R26	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A20R27	0683-3335	RESISTOR:FXD COMP 33K OHM 5% 1/4W	
A20R28	0683-1835	RESISTOR:FXD COMP 18K OHM 5% 1/4W	
A20R29	0683-4335	RESISTOR:FXD COMP 43K OHM 5% 1/4W	
A21	5060-2010	CONTROL LOGIC C	A-H
	5060-5872	CONTROL LOGIC C	J-X
A21CR1-A21CR4	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-X
A21CR6	1901-0025	DIODE:SILICON 100WV 100MA	
A21CR7	1901-0025	DIODE:SILICON 100WV 100MA	
A21CR8	1901-0025	DIODE:SILICON 100WV 100MA	
A21CR10	1901-0025	DIODE:SILICON 100WV 100MA	
A21CR12	1901-0025	DIODE:SILICON 100WV 100MA	C-X
A21CR13	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A21CR14	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A21CR15	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A21CR16	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A21L1	9140-0107	COIL:FXD RF 27 MH 10%	
A21L2	9140-0107	COIL:FXD RF 27 MH 10%	
A21Q1	1850-0128	TRANSISTOR:PNP GERMANIUM 2N3988	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-X
A21Q2	1850-0128	TRANSISTOR:PNP GERMANIUM 2N3988	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-X
A21Q3	1850-0128	TRANSISTOR:PNP GERMANIUM 2N3988	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-X
A21Q4	1850-0128	TRANSISTOR:PNP GERMANIUM 2N3988	
A21Q5	1850-0113	TRANSISTOR:GERMANIUM PNP	A-H
	1850-0145	TRANSISTOR:GERMANIUM PNP	J-X
A21Q7	1850-0113	TRANSISTOR:GERMANIUM PNP	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A21 5080-2816 (CONT'D)	A-H
		5080-6573 (CONT'D)	J-X
		A22 5080-2111	A-E
A21Q8	1850-0113	TRANSISTOR:GERMANIUM PNP	
A21Q9	1850-0113	TRANSISTOR:GERMANIUM PNP	
A21R1	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	A-H
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	J-X
A21R2	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	A-H
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-X
A21R3	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	J-X
A21R4	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A21R5	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	A-H
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	J-X
A21R6	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	J-X
A21R7	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	A-H
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-X
A21R8	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A21R9	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-H
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-X
A21R10	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	A-H
	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	J-X
A21R11	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-X
A21R12	0686-3315	R:FXD COMP 330 OHM 5% 1W	
A21R13	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A21R14	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	A-H
	0757-0948	R:FXD FLM 10K OHM 2% 1/8W	J-X
A21R15	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0757-0950	R:FXD FLM 12K OHM 2% 1/8W	J-X
A21R16	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	A-H
	0757-0948	R:FXD FLM 10K OHM 2% 1/8W	J-X
A21R17	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A21R20	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A21R21	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A21R22	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A21R23	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A21R24	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A21R25	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22	5080-2111	LOGIC CARD	A-E
A22CR1	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR2	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR3-A22CR6	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR7	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR8-A22CR12	1901-0025	DIODE:SILICON 100WV 100MA	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A22 5080-2111 (CONT'D)	A-E
A22CR13	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR14	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR15	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR16	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR18	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR19	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR20	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR21-A22CR35	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR36	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR37	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR38	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR39	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR40	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR41	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR42	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR43	1901-0025	DIODE:SILICON 100WV 100MA	
A22CR44	1901-0025	DIODE:SILICON 100WV 100MA	
A22Q1-A22Q9	1850-0128	TRANSISTOR:PNP GERMANIUM	
A22R1	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R2	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22R3	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R4	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R5	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R6	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R7	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22R8	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R9	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R10	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22R11	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A22R12	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R13	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R14	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R15	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R16	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22R17	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A22R18	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R19	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R20	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R21	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22R22-A22R30	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R31	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22R32	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A22R39	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A22 5080-5610	F-X
A22	5080-5610	LOGIC CARD	F-X
A22CR1- A22CR6	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR10	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR12	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR13	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR15	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR16	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR17	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR18	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR23	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR25	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR27	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR28	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR35	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR36	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR37	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR38	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR39	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR40- A22CR47	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR50- A22CR54	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22Q1- A22Q14	1850-0111	TRANSISTOR:GERMANIUM PNP	
A22R1	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R2	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R3	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R4	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R5	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R6	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R7	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R8	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R9	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R10	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R11	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R12	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R13	0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	
A22R14	0757-0950	R:FXD FLM 12K OHM 2% 1/8W	
A22R15	0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	
A22R16	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R17	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R18	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R19	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R20	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A22 5080-5610 (CONT'D)	F-X
A22R21	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R22	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R23	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R24	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R25	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R26	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R27	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R28	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	
A22R29	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A22R30	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	
A22R31	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R32	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R33	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R34	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R35	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R36	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R37	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R38	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R39	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R40	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R41	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R42	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R43	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R44	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R45	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R46	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R47	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R48	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R49	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R50	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R51	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R52	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R53	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R54	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R55	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R56	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R57	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R58	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22W1- A22W4	8159-0005	JUMPER WIRE	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A23 5060-3771	A-H*
		5060-5874	J-L*
		5060-6206	M-X
A23	5060-3771	AC & OHMS DELAY GATE	A-H*
	5060-5874	AC & OHMS DELAY GATE	J-L*
	5060-6206	AC & OHMS DELAY GATE	M-X
A23C1	0180-0196	C:FXD ELECT 56 UF 15VDCW	
A23C2	0140-0194	C:FXD MICA 110 PF 5%	
A23C3	0140-0200	C:FXD MICA 390 PF 5%	
A23C4	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A23C5	0140-0200	C:FXD MICA 390 PF 5%	
A23C6	0140-0194	C:FXD MICA 110 PF 5%	
A23C7	0140-0194	C:FXD MICA 110 PF 5%	
A23C8	0180-0291	C:FXD ELECT 1UF 10% 35VDCW	
A23CR1-A23CR4	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A23CR5	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-L
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	M-X
A23CR6	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-L
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	M-X
A23CR7	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0081	DIODE:SILICON 50 VOLTS WORKING	J-L
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	M-X
A23CR8	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A23CR9	1901-0061	DIODE:SILICON	
A23CR10	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A23Q1	1851-0024	TRANSISTOR:GERMANIUM NPN	
A23Q2	1850-0111	TRANSISTOR:GERMANIUM PNP	A-L
	1853-0008	TRANSISTOR:SILICON PNP	M-X
A23Q3	1850-0111	TRANSISTOR:GERMANIUM PNP	
A23Q4	1850-0113	TRANSISTOR:GERMANIUM PNP	
A23Q5	1851-0006	TRANSISTOR:2N169A NPN	
A23Q6	1850-0111	TRANSISTOR:GERMANIUM PNP	
A23Q7	1850-0113	TRANSISTOR:GERMANIUM PNP	
A23R1	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	A-H
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	J-X
A23R2	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	A-H
	0683-4335	R:FXD COMP 43K OHM 5% 1/4W	J-X
A23R3	0686-5135	R:FXD COMP 51K OHM 5% 1/2W	

*5060-6206 MAY REPLACE 5060-3771 OR 5060-5874.

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A23 5060-3771 (CONT'D)	A-H*
		5060-5874 (CONT'D)	J-L*
		5060-6206 (CONT'D)	M-X
		A24 5060-3818	
		A25 5060-2018	
A23R4	0683-1005	R:FXD COMP 10 OHM 5% 1/4W	
A23R5	0683-1005	R:FXD COMP 10 OHM 5% 1/4W	
A23R6	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	A-H
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	J-L
	0698-3161	R:FXD MET FLM 38.3K OHM 1% 1/8W	M-X
A23R7	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	J-L
	0757-0444	R:FXD MET FLM 12.1K OHM 1% 1/8W	M-X
A23R8	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	A-H
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-L
	0757-0446	R:FXD MET FLM 15.0K OHM 1% 1/8W	M-X
A23R9	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A23R10	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A23R11	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A23R12	0761-0027	R:FXD MET FLM 2.7K OHM 5% 1W	
A23R13	NSN	FACTORY SELECTED PART	
A23R14	0683-2705	R:FXD COMP 27 OHM 5% 1/4W	
A23R15	0683-5625	R:FXD COMP 5.6K OHM 5% 1/4W	A-H
	0761-0027	R:FXD MET FLM 2.7K OHM 5% 1W	J-X
A23R16	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A23R17	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A23R18	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A23R19	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A23R20	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A23R21	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A23R22	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A23R23	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A23R24	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A23R25	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A23R26	0683-2705	R:FXD COMP 27 OHM 5% 1/4W	
A24	5060-3818	UNITS DISPLAY ASSY	
A24DS1-A24DS12	2140-0037	LAMP:INCANDESCENT 0.04A 28V	
A25	5060-2018	ATTENUATION CONTROL	
A25C1	0140-0200	C:FXD MICA 390 PF 5%	
A25C2	0170-0038	C:FXD MY 0.22 UF 10% 200VDCW	
A25R1	2100-0273	R:VAR COMP 3 MEGOHM 20% 5 CCWLOG 1/4W	
A25R2	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A25R3	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A25S8		SWITCH:DPST (PART OF R1)	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A26 05214-6014 05232-6007	A-S T-X
A26	05214-6014	INPUT AMPLIFIER	A-S
A26C1	0180-0039	C:FXD ELECT 100UF 12VDCW	
A26C2	0140-0198	C:FXD MICA 200 PF 5%	
A26C3	0180-0063	C:FXD ELECT 500UF -10%+100% 3VDCW	
A26C4	0140-0152	C:FXD MICA 1000 PF 5% 300VDCW	
A26C5	0180-0050	C:FXD ELECT 40 UF +75-10% 50VDCW	
A26CR1	1902-0199	DIODE:BREAKDOWN 8.8/10.8V 100MW	
A26L1	9140-0027	COIL:FXD RF 35 UH	
A26Q1	1854-0003	TRANSISTOR:NPN SILICON	
A26Q2	1850-0037	TRANSISTOR:GERMANIUM	
A26Q3	1850-0037	TRANSISTOR:GERMANIUM	
A26R1	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A26R2	0683-1845	R:FXD COMP 180K OHM 5% 1/4W	
A26R3	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A26R4	0683-1545	R:FXD COMP 150K OHM 5% 1/4W	
A26R5	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A26R6	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A26R7	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	
A26R8	0683-6225	R:FXD COMP 6200 OHM 5% 1/4W	
A26R9	0683-6815	R:FXD COMP 680 OHM 5% 1/4W	
A26R10	0683-1515	R:FXD COMP 150 OHM 5% 1/4W	
A26R11	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A26R12	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A26R13	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A26	05232-6007	INPUT AMPLIFIER	T-X
A26C1	0180-0039	C:FXD ELECT 100UF 12VDCW	
A26C2	0180-0124	C:FXD ELECT 200UF 6VDCW	
A26C3	0180-0104	C:FXD ELECT 200UF 15VDCW	
A26C4	0180-0050	C:FXD ELECT 40 UF +75-10% 50VDCW	
A26C5	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A26C6	0140-0177	C:FXD MICA 400 PF 1%	
A26CR1	1910-0011	DIODE:GERMANIUM 5MA AT 1V	
A26Q1	1854-0003	TRANSISTOR:NPN SILICON	
A26Q2	1853-0009	TRANSISTOR:SILICON PNP	
A26Q3	1853-0009	TRANSISTOR:SILICON PNP	
A26Q4	1853-0009	TRANSISTOR:SILICON PNP	
A26R1	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A26R2	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A26R3	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A26R4	0683-6225	R:FXD COMP 6200 OHM 5% 1/4W	
A26R5	0683-1815	R:FXD COMP 180 OHM 5% 1/4W	
A26R6	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A26 05232-6007 (CONT'D) A27 5080-5016 02532-6006	T-X A-S T-X
A26R7	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A26R8	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A26R9	0683-3315	R:FXD COMP 330 OHM 5% 1/4W	
A26R10	0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	
A26R11	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A26R12	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A26R13	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A27	5080-5016	SCHMITT TRIGGER	A-S
A27C1	0180-0058	C:FXD ELECT 50UF -10%+100% 25VDCW	
A27C2	0140-0199	C:FXD MICA 240 PF 5%	
A27C3	0140-0156	C:FXD MICA 1500 PF 2%	
A27C4	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A27CR1	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A27CR2	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A27Q1	1850-0111	TRANSISTOR:GERMANIUM PNP	
A27Q2	1850-0111	TRANSISTOR:GERMANIUM PNP	
A27R1	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A27R2	0683-8215	R:FXD COMP 820 OHM 5% 1/4W	
A27R3	2100-0154	R:VAR COMP 1K OHM 30% LIN 0.15W	
A27R4	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A27R5	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A27R6	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A27R7	0761-0024	R:FXD MET OX 2.4 OHM 5% 1W	
A27R9	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A27R10	0683-2705	R:FXD COMP 27 OHM 5% 1/4W	
A27	05232-6006	INPUT TRIGGER	T-X
A27C1	0180-0094	C:FXD ELECT 100UF 25VDCW	
A27C2	0140-0203	C:FXD MICA 30 PF 5%	
A27CR1	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A27CR3	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A27L1	9140-0112	COIL:FXD RF 4.7 UH	
A27Q1	1853-0009	TRANSISTOR:SILICON PNP	
A27Q2	1853-0009	TRANSISTOR:SILICON PNP	
A27Q3	1853-0009	TRANSISTOR:SILICON PNP	
A27R1	0683-3315	R:FXD COMP 330 OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A27 05232-6008 (CONT'D)	T-X
		A29 5080-3805	
		A30 5060-2108	A-H*
		5060-5875	J-L*
		5060-6203	M-X
A27R2	2100-0355	R:VAR COMP 2000 OHM 20% LIN 1/8W	
A27R3	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A27R4	0758-0042	R:FXD MET OX 1300 OHM 5% 1/2W	
A27R5	0683-9105	R:FXD COMP 91 OHM 5% 1/4W	
A27R6	0683-7525	R:FXD COMP 7500 OHM 5% 1/4W	
A27R7	0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	
A27R8	0758-0003	R:FXD MET OX 1000 OHM 5% 1/2W	
A27R9	0758-0042	R:FXD MET OX 1300 OHM 5% 1/2W	
A29	5080-3805	+6V BIAS SUPPLY	
A29C1	0180-0363	C:FXD ELECT 150UF -10+100% 30VDCW	
A29C2	0180-0137	C:FXD ELECT 100 UF 20% 10VDCW	
A29C3	0180-0367	C:FXD ELECT 20UF -10+75% 200VDCW	
A29CR1	1901-0026	DIODE:SILICON 0.75A 200 PIV	
A29CR2	1901-0026	DIODE:SILICON 0.75A 200 PIV	
A29CR3	1902-3117	DIODE:BREAKDOWN 2% 6.34V	A-R
	1902-3119	DIODE BREAKDOWN:6.49V 2%	S-X
A29CR4	1901-0029	DIODE:SILICON 600 PIV	
A29CR5	1901-0029	DIODE:SILICON 600 PIV	
A29Q1	1854-0039	TRANSISTOR:SILICON	
A29R1	0683-0565	R:FXD COMP 5.6 OHM 5% 1/4W	
A29R2	0757-1078	R:FXD MET FLM 1.47K OHM 1% 1/2W	
A29R3	0683-4745	R:FXD COMP 470K OHM 5% 1/4W	
A30	5080-2108	HP 2411A DECIMAL POINT LOGIC	A-H*
	5080-5875	HP 2411A DECIMAL POINT LOGIC	J-L*
	5080-6203	HP 2411A DECIMAL POINT LOGIC	M-X
A30CR1-A30CR15	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A30Q1	1850-0128	TRANSISTOR:PNP GERMANIUM	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-L
	1853-0008	TRANSISTOR:SILICON PNP	M-X
A30Q2	1850-0128	TRANSISTOR:PNP GERMANIUM	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-L
	1853-0008	TRANSISTOR:SILICON PNP	M-X
A30Q3	1850-0128	TRANSISTOR:PNP GERMANIUM	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-L
	1853-0007	TRANSISTOR:SILICON PNP	M-X
A30Q4	1850-0128	TRANSISTOR:PNP GERMANIUM	A-H
	1850-0111	TRANSISTOR:GERMANIUM PNP	J-L
	1853-0008	TRANSISTOR:SILICON PNP	M-X

*5060-6203 MAY REPLACE 5060-2108 OR 5060-5875.

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A30 5060-2108 (CONT'D)	A-H
		5060-5875 (CONT'D)	J-L
		5060-6203 (CONT'D)	M-X
A30C5-A30Q13	1850-0128	TRANSISTOR:PNP GERMANIUM	M-X
A30R1	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A30R2	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0683-4335	R:FXD COMP 43K OHM 5% 1/4W	J-L
A30R3	0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	M-X
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	A-H
			J-K
A30R4	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-L
	0698-3161	R:FXD MET FLM 38.3K OHM 1% 1/8W	M-X
A30R5	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-L
	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	M-X
A30R6	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	A-H
	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	J-L
	0757-0446	R:FXD MET FLM 15.0K OHM 1% 1/8W	M-X
A30R7	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	A-H
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	J-L
	0698-3162	R:FXD MET FLM 46.4K OHM 1% 1/8W	M-X
A30R8	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A30R9	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	A-H
	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	J-L
	0757-0748	R:FXD MET FLM 5.62K OHM 1% 1/4W	M-X
A30R10	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	A-H
	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	J-L
	0693-3359	R:FXD MET FLM 12.7K 1% 1/8W	M-X
A30R11	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	J-L
	0683-4335	R:FXD COMP 43K OHM 5% 1/4W	M-X
A30R12	0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	A-H
	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	J-X
A30R13	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R14	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A30R15	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R16	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A30R17	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R18	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R19	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R20	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A30R21	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R22	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R23	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A30R24	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A30R25	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A31 5080-3848 5080-6146	A B-X
A31	5080-3848	OPERATIONAL AMPLIFIER	A †
	5080-6146	OPERATIONAL AMPLIFIER	B-X †
A31C2	0150-0021	C:FXD TT DIOX 0.47PF 5% 500VDCW	
A31C3	0160-0961	C:FXD POLY 0.027UF 20% 30VDCW	
A31C4	0140-0156	C:FXD MICA 1500 PF 2%	
A31C5	0180-0193	C:FXD ELECT 20 UF 10VDCW	
A31C6	0180-0196	C:FXD ELECT 56 UF 15VDCW	
A31C7	0180-0210	C:FXD ELECT 3.3 UF 20% 15VDCW	
A31C8	0180-0365	C:FXD TA 22UF 10% 15VDCW	
A31C9	0160-0970	C:FXD MY 0.47UF 10% 60VDCW	
A31C10	0170-0066	C:FXD MY 0.027UF 10% 200VDCW	
A31C11	0180-0159	C:FXD ELECT 220 UF 10% 10VDCW	
A31C12	0160-0378	C:FXD MICA 27PF 5%	
A31C13	0180-0137	C:FXD ELECT 100 UF 20% 10VDCW	
A31C14	0180-0137	C:FXD ELECT 100 UF 20% 10VDCW	
A31C15	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A31C16	0180-0197	C:FXD ELECT 2.2 UF 10% 20VDCW	
A31C17	0160-0164	C:FXD MY 0.039 UF 10% 200VDCW	
A31C18	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A31C19	0140-0145	C:FXD MICA 22 PF 5%	
A31C20	0140-0194	C:FXD MICA 110 PF 5%	
A31C21	0140-0194	C:FXD MICA 110 PF 5%	
A31C22	0160-0960	C:FXD POLY 0.27 UF 20% 30VDCW	
A31C23	0160-0378	C:FXD MICA 27PF 5%	
A31C24	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	
A31C25	0160-0268	C:FXD PORC 110 PF 5% 500VDCW	
A31C27	080	FACTORY SELECTED PART	
A31C28	080	SELECTED IN CONJUNCTION WITH C27	
A31C29	0180-0079	C:FXD ELECT 10UF -15+20% 60VDCW	B-X
A31CR1- A31CR4	1901-0156	DIODE:SILICON	
A31CR5	1901-0025	DIODE:SILICON 100WV 100MA	
A31CR6	1901-0025	DIODE:SILICON 100WV 100MA	
A31CR7	1901-0025	DIODE:SILICON 100WV 100MA	
A31CR8	1901-0156	DIODE:SILICON	
A31CR9	1901-0156	DIODE:SILICON	
A31CR10	1902-0096	DIODE:AVALANCHE 6.2V	
A31CR11	1902-0096	DIODE:AVALANCHE 6.2V	
A31CR12	1901-0025	DIODE:SILICON 100WV 100MA	
A31CR13	1901-0025	DIODE:SILICON 100WV 100MA	
A31CR14	1901-0025	DIODE:SILICON 100WV 100MA	
A31CR15	1901-0025	DIODE:SILICON 100WV 100MA	
A31CR16	1902-0770	DIODE:BREAKDOWN SILICON	
A31CR17	1902-0770	DIODE:BREAKDOWN SILICON	
A31L1	9140-0082	COIL:FXD RF 15 UH	

† NOT FIELD REPAIRABLE

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A31 5080-3848 (CONT'D) 5080-6146 (CONT'D)	A B-X
A31L2	9140-0040	COIL:FXD RF 42UH	
A31P29	0360-0462	TERMINAL:PROBE	
A31P30	0360-0462	TERMINAL:PROBE	
A31Q1	5080-6621	TRANSISTOR:SILICON NPN	
A31Q2	1854-0003	TRANSISTOR:NPN SILICON	
A31Q3	1854-0003	TRANSISTOR:NPN SILICON	
A31Q4	1853-0008	TRANSISTOR:SILICON PNP	
A31Q5- A31Q9	5080-6620	TRANSISTOR:SILICON NPN	
A31Q10	1853-0008	TRANSISTOR:SILICON PNP	
A31Q11	1853-0008	TRANSISTOR:SILICON PNP	
A31Q12	1854-0003	TRANSISTOR:NPN SILICON	
A31Q13	1853-0001	TRANSISTOR:PNP SILICON 30V 900MW	
A31Q14	1854-0003	TRANSISTOR:NPN SILICON	
A31R1	2100-0364	R:VAR WW 20K OHM 5% LIN 1.0W	
A31R2	NRFR	FACTORY SELECTED	B-X
A31R3	0727-0819	R:FXD DEPC 287K OHM 1% 1/2W	
A31R4	080	FACTORY SELECTED	
A31R5	0757-0456	R:FXD MET FLM 1.5 MEGOHM 1% 1/2W	
A31R6	0757-0413	R:FXD MET FLM 392 OHM 1% 1/8W	
A31R7	0757-0344	R:FXD MET FLM 1.00 MEGOHM 1% 1/4W	
A31R8	0757-0274	R:FXD MET FLM 1.21K OHM 1% 1/8W	
A31R9	0757-0483	R:FXD MET FLM 562K OHM 1% 1/8W	
A31R10	0757-0481	R:FXD MET FLM 475K OHM 1% 1/8W	
A31R11	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A31R12	0757-0459	R:FXD MET FLM 56.2K OHM 1% 1/8W	
A31R13	0698-3132	R:FXD MET FLM 261 OHM 1% 1/8W	
A31R14	0757-0278	R:FXD MET FLM 1.78K OHM 1% 1/8W	
A31R15	0757-0471	R:FXD MET FLM 182K OHM 1% 1/8W	
A31R16	0757-0441	R:FXD MET FLM 8.25K OHM 1% 1/8W	
A31R18	0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	
A31R19	0757-0479	R:FXD MET FLM 392K OHM 1% 1/8W	
A31R20	0757-0441	R:FXD MET FLM 8.25K OHM 1% 1/8W	A
	0757-0290	R:FXD MET FLM 6.19K OHM 1% 1/8W	B-X
A31R22	0757-0441	R:FXD MET FLM 8.25K OHM 1% 1/8W	A
	0757-0290	R:FXD MET FLM 6.19K OHM 1% 1/8W	B-X
A31R23	0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	
A31R26	0727-0862	R:FXD CARBON FLM 4.64 MEGOHM 1% 1/2W	
A31R27	0757-0481	R:FXD MET FLM 475K OHM 1% 1/8W	
A31R28	0757-0327	R:FXD MET FLM 499K OHM 1% 1/4W	
A31R29	0757-0327	R:FXD MET FLM 499K OHM 1% 1/4W	
A31R30	0757-0452	R:FXD MET FLM 27.4K OHM 1% 1/8W	
A31R31	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A31R32	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A31R33	0757-0458	R:FXD MET FLM 51.1K OHM 1% 1/8W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A31 5080-3848 (CONT'D) 5080-6146 (CONT'D)	A B-X
A31R34	0698-0083	R:FXD MET FLM 1.96K OHM 1% 1/8W	
A31R35	0757-0403	R:FXD MET FLM 121 OHM 1% 1/8W	
A31R36	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A31R37	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A31R38	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A31R39	0698-3136	R:FXD MET FLM 17.8K OHM 1% 1/8W	
A31R40	0757-0199	R:FXD MET FLM 21.5K OHM 1% 1/8W	
A31R41	0698-0083	R:FXD MET FLM 1.96K OHM 1% 1/8W	
A31R42	0698-0084	R:FXD MET FLM 2.15K OHM 1% 1/8W	
A31R43	0757-0413	R:FXD MET FLM 392 OHM 1% 1/8W	
A31R44	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A31R45	0757-0743	R:FXD MET FLM 3.32K OHM 1% 1/4W	
A31R46	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A31R47	0757-0198	R:FXD MET FLM 100 OHM 1% 1/2W	
A31R48	0757-0992	R:FXD MET FLM 22.1 OHM 1% 1/2W	A
	0698-3388	R:FXD MET FLM 14.7 OHM 1% 1/2W	B-X
A31R49	0757-0992	R:FXD MET FLM 22.1 OHM 1% 1/2W	A
	0698-3388	R:FXD MET FLM 14.7 OHM 1% 1/2W	B-X
A31R50	0757-0198	R:FXD MET FLM 100 OHM 1% 1/2W	
A31R51	0698-3156	R:FXD MET FLM 14.7K OHM 1% 1/8W	
A31R52	0757-0387	R:FXD MET FLM 27.4 OHM 1% 1/8W	
A31R53	0757-0274	R:FXD MET FLM 1.21K OHM 1% 1/8W	
A31R54	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A31R55	0757-0327	R:FXD MET FLM 499K OHM 1% 1/4W	
A31R56	0757-0417	R:FXD MET FLM 562 OHM 1% 1/8W	
A31W1	8159-0005	JUMPER WIRE	
A31W2	8159-0005	JUMPER WIRE	
A31W3	8159-0005	JUMPER WIRE	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A32 5080-5001	
A32	5080-5001	NEGATIVE CHANNEL	†
A32P10	1251-0381	PLUG:TERMINAL FEEDTHRU TEFLON	
A32R1	NRFR	FACTORY SELECTED	
A32R2	NRFR	FACTORY SELECTED	
A32R3	0698-3171	R:FXD MET FLM 10K OHM 1% 0.3W	
A32T1	NRFR	TRANSFORMER:PULSE FACTORY SELECTED	
A32A1	5060-6275	AMPLIFIER PC	†
A32A1C3	0140-0176	C:FXD MICA 100 PF 2%	
A32A1C4	0160-0158	C:FXD MYLAR 5600PF 10%	
A32A1C5	0180-0210	C:FXD ELECT 3.3 UF 20% 15VDCW	
A32A1C6	0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	
A32A1C7	0180-0388	C:FXD ELECT 56 UF 10% 20VDCW	
A32A1C8	0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	
A32A1CR5	1910-0025	DIODE:GE 15WIV 6NS	
A32A1CR6	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A32A1CR7	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A32A1CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A32A1L1	9140-0174	COIL:FXD RF 220 MH 5%	
A32A1L2	9140-0075	COIL:FXD RF 270 UH	‡
A32A1Q3	1851-0034	TRANSISTOR:GERMANIUM NPN	
A32A1Q4	5080-6620	TRANSISTOR:SILICON NPN	
A32A1Q5	1851-0031	TRANSISTOR:GERMANIUM NPN	
A32A1Q6	1851-0034	TRANSISTOR:GERMANIUM NPN	
A32A1R15	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A32A1R16	0757-1102	R:FXD MET FLM 180 OHM 1% 1/8W	
A32A1R17	0757-0198	R:FXD MET FLM 100 OHM 1% 1/2W	
A32A1R18	0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	
A32A1R19	0757-0816	R:FXD MET FLM 681 OHM 1% 1/2W	
A32A1R20	0757-1060	R:FXD MET FLM 196 OHM 1% 1/2W	
A32A1R21	0757-0444	R:FXD MET FLM 12.1K OHM 1% 1/8W	
A32A1R22	0757-0278	R:FXD MET FLM 1.78K OHM 1% 1/8W	
A32A1R23	0698-3136	R:FXD MET FLM 17.8K OHM 1% 1/8W	
A32A1R24	0698-3132	R:FXD MET FLM 261 OHM 1% 1/8W	
A32A1R25	0698-3134	R:FXD MET FLM 1.33K OHM 1% 1/4W	
A32A1R26	0698-0085	R:FXD MET FLM 2.61K OHM 1% 1/8W	
A32A1R27	2100-0371	R:VAR WW 1K OHM 10% LIN 1/4W	
A32A1R28	0757-0731	R:FXD MET FLM 825 OHM 1% 1/4W	
A32A1R32	2100-1433	R:VAR WW 100 OHM 5% 3/4W	
A32A1R33	NRFR	R:FXD CARBON FLM 5-40 OHM SELECTED IN TEST.	‡‡

† NOT FIELD REPAIRABLE

‡ REPLACES C6 IN CERTAIN APPLICATIONS

‡‡ SUBSTITUTED FOR W1 WHEN L2 IS USED

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A32 5060-5001 (CONT'D) A33 5060-3840	
A32A1R34	0757-0458	R:FXD MET FLM 51.1K OHM 1% 1/8W	
A32A1R35	0757-0438	R:FXD MET FLM 5.11K OHM 1% 1/8W	
A32A1T2	9130-0028	TRANSFORMER	
A32A1W1	8159-0005	JUMPER WIRE	
A32A2	5060-3838	BINARY PC	
A32A2C1	0140-0192	C:FXD MICA 68 PF 5%	
A32A2C2	0140-0192	C:FXD MICA 68 PF 5%	
A32A2CR1	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A32A2CR2	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A32A2CR3	1910-0025	DIODE:GE 15WIV 6NS	
A32A2CR4	1910-0025	DIODE:GE 15WIV 6NS	
A32A2Q1	1850-0075	TRANSISTOR:GERMANIUM PNP	
A32A2Q2	1850-0075	TRANSISTOR:GERMANIUM PNP	
A32A2R4	2100-0738	R:VAR COMP 200 OHM 10% 1W	
A32A2R5	NRFR	FACTORY SELECTED	
A32A2R6	NRFR	FACTORY SELECTED	
A32A2R7	0698-3133	R:FXD MET FLM 681 OHM 1% 3/10W	
A32A2R8	0698-3133	R:FXD MET FLM 681 OHM 1% 3/10W	
A32A2R9	0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	
A32A2R10	0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	
A32A2R11	0757-0199	R:FXD MET FLM 21.5K OHM 1% 1/8W	
A32A2R12	0757-0199	R:FXD MET FLM 21.5K OHM 1% 1/8W	
A32A2R13	0757-0427	R:FXD MET FLM 1500 OHM 1% 1/8W	
A32A2R14	0757-0427	R:FXD MET FLM 1500 OHM 1% 1/8W	
A32A2R31	0698-3135	R:FXD MET FLM 2740 OHM 1% 3/10W	
A32A2R36	NRFR	FACTORY SELECTED	
A32A2R37	NRFR	FACTORY SELECTED	
A33	5060-3840	POSITIVE CHANNEL	†
A33P11	1251-0381	PLUG:TERMINAL FEEDTHRU TEFLON	
A33R1	NRFR	FACTORY SELECTED	
A33R2	NRFR	FACTORY SELECTED	
A33R3	0698-3171	R:FXD MET FLM 10K OHM 1% 0.3W	
A33T1	NRFR	TRANSFORMER:PULSE FACTORY SELECTED	
A33A1	5060-6274	AMPLIFIER PC	
A33A1C3	0140-0176	C:FXD MICA 100 PF 2%	
A33A1C4	0160-0158	C:FXD MYLAR 5600PF 10%	
A33A1C5	0180-0210	C:FXD ELECT 3.3 UF 20% 15VDCW	
A33A1C6	0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	
A33A1C7	0180-0388	C:FXD ELECT 56 UF 10% 20VDCW	

† NOT FIELD REPAIRABLE

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A33 5060-3840 (CONT'D)	
A33A1C8	0160-0166	C:FXD MY 0.1 UF 10% 200VDCW	
A33A1CR5	1910-0025	DIODE:GE 15WIV 6NS	
A33A1CR6	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A33A1CR7	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A33A1CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A33A1L1	9140-0174	COIL:FXD RF 220 MH 5%	
A33A1L2	9140-0075	COIL:FXD RF 270 UF	::
A33A1Q3	1850-0111	TRANSISTOR:GERMANIUM PNP	
A33A1Q4	1853-0008	TRANSISTOR:SILICON PNP	
A33A1Q5	1850-0032	TRANSISTOR:GERMANIUM PNP 2N404	
A33A1Q6	1850-0032	TRANSISTOR:GERMANIUM PNP 2N404	
A33A1R15	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A33A1R16	0757-1102	R:FXD MET FLM 180 OHM 1% 1/8W	
A33A1R17	0757-0198	R:FXD MET FLM 100 OHM 1% 1/2W	
A33A1R18	0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	
A33A1R19	0757-0816	R:FXD MET FLM 681 OHM 1% 1/2W	
A33A1R20	0757-1060	R:FXD MET FLM 196 OHM 1% 1/2W	
A33A1R21	0757-0444	R:FXD MET FLM 12.1K OHM 1% 1/8W	
A33A1R22	0757-0276	R:FXD MET FLM 1.78K OHM 1% 1/8W	
A33A1R23	0698-3136	R:FXD MET FLM 17.8K OHM 1% 1/8W	
A33A1R24	0698-3132	R:FXD MET FLM 261 OHM 1% 1/8W	
A33A1R25	0698-3134	R:FXD MET FLM 1.33K OHM 1% 1/4W	
A33A1R26	0698-0085	R:FXD MET FLM 2.61K OHM 1% 1/8W	
A33A1R27	2100-0371	R:VAR WW 1K OHM 10% LIN 1/4W	
A33A1R28	0757-0731	R:FXD MET FLM 825 OHM 1% 1/4W	
A33A1R32	2100-1433	R:VAR WW 100 OHM 5% 3/4W	
A33A1R33	NRFR	R:FXD CARBON FLM 5-40 OHM SELECTED IN TEST.	:::
A33A1R34	0757-0458	R:FXD MET FLM 51.1K OHM 1% 1/8W	
A33A1R35	0757-0438	R:FXD MET FLM 5.11K OHM 1% 1/8W	
A33A1T2	9130-0028	TRANSFORMER	
A33A1W1	5950-0001	JUMPER WIRE	
A33A2	5060-3838	BINARY PC	
A33A2C1	0140-0192	C:FXD MICA 68 PF 5%	
A33A2C2	0140-0192	C:FXD MICA 68 PF 5%	
A33A2CR1	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A33A2CR2	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A33A2CR3	1910-0025	DIODE:GE 15WIV 6NS	
A33A2CR4	1910-0025	DIODE:GE 15WIV 6NS	
A33A2Q1	1850-0075	TRANSISTOR:GERMANIUM PNP	

:: REPLACES C6 IN CERTAIN APPLICATIONS
::: SUBSTITUTED FOR W1 WHEN L2 IS USED

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No. #	Description #	Note
		A33 5080-3840 (CONT'D) A34 5080-3782 A35 5080-3783	
A33A2Q2	1850-0075	TRANSISTOR:GERMANIUM PNP	
A33A2R4	2100-0738	R:VAR COMP 200 OHM 10% 1W	
A33A2R5	NRFR	FACTORY SELECTED	
A33A2R6	NRFR	FACTORY SELECTED	
A33A2R7	0698-3133	R:FXD MET FLM 681 OHM 1% 3/10W	
A33A2R8	0698-3133	R:FXD MET FLM 681 OHM 1% 3/10W	
A33A2R9	0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	
A33A2R10	0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	
A33A2R11	0757-0199	R:FXD MET FLM 21.5K OHM 1% 1/8W	
A33A2R12	0757-0199	R:FXD MET FLM 21.5K OHM 1% 1/8W	
A33A2R13	0757-0427	R:FXD MET FLM 1500 OHM 1% 1/8W	
A33A2R14	0757-0427	R:FXD MET FLM 1500 OHM 1% 1/8W	
A33A2R31	0698-3135	R:FXD MET FLM 2740 OHM 1% 3/10W	
A33A2R36	NRFR	FACTORY SELECTED	
A33A2R37	NRFR	FACTORY SELECTED	
A34	5080-3782	SERIES REGULATOR	
A34C3	0180-1804	C:FXD ELECT 75 UF +75-10% 40VDCW	
A34C4	0140-0156	C:FXD MICA 1500 PF 2%	
A34C5	0180-1804	C:FXD ELECT 75 UF +75-10% 40VDCW	
A34CR1- A34CR8	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A34Q1	1854-0362	TRANSISTOR:SILICON	
A34Q2	1854-0003	TRANSISTOR:NPN SILICON	
A34Q3	1854-0362	TRANSISTOR:SILICON	
A34R1	0698-0088	R:FXD MET FLM 215 OHM 1% 1/4W	
A34R2	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A34R3	0727-0704	R:FXD DEPC 6 OHM 1% 1/2W	
A34R4	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A34R5	0698-0087	R:FXD MET FLM 316 OHM 1% 1/4W	
A34R6	0698-0093	R:FXD MET OX 10 OHM 5% 1W	
A34R7	0757-0338	R:FXD MET FLM 1.00K OHM 1% 1/4W	
A34R8	0698-0086	R:FXD MET FLM 2.87K OHM 1% 1/4W	
A34R9	0757-0743	R:FXD MET FLM 3.32K OHM 1% 1/4W	
A35	5080-3783	POWER SUPPLY AMPLIFIER	
A35C1	0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	
A35C2	0160-0163	C:FXD MY 0.033 UF 10% 200VDCW	
A35C3	0140-0191	C:FXD MICA 56 PF 5%	
A35C4	0180-0196	C:FXD ELECT 56 UF 15VDCW	
A35CR1	5080-1471	DIODE:BREAKDOWN 6.15-6.5V 400 MW	
A35CR3	NRFR	DIODE/RESISTOR SET	

†NOT FIELD REPAIRABLE

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No. #	Description #	Note
		A35 5080-3783 (CONT'D)	
A35CR4	1901-0156	DIODE:SILICON	
A35Q1	1853-0008	TRANSISTOR:SILICON PNP	
A35Q2	1853-0008	TRANSISTOR:SILICON PNP	
A35Q3	1853-0009	TRANSISTOR:SILICON PNP	
A35Q4	1854-0003	TRANSISTOR:NPN SILICON	
A35Q5	1853-0009	TRANSISTOR:SILICON PNP	
A35Q6	1854-0014	TRANSISTOR:DUAL NPN SILICON	
A35Q7	1854-0014	TRANSISTOR:DUAL NPN SILICON	
A35Q8	1854-0003	TRANSISTOR:NPN SILICON	
A35Q9	1853-0001	TRANSISTOR:PNP SILICON 30V 900MW	
A35Q10	1854-0014	TRANSISTOR:DUAL NPN SILICON	
A35Q11	1854-0014	TRANSISTOR:DUAL NPN SILICON	
A35R1	0757-0433	R:FXD MET FLM 3.32K OHM 1% 1/8W	
A35R2	0698-0084	R:FXD MET FLM 2.15K OHM 1% 1/8W	
A35R3	0698-0091	R:FXD MET FLM 825 OHM 1% 1/8W	A-J
	0811-0961	R:FXD WW 825 OHM 0.1% 1/4W	K-X
A35R4	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A35R5	0757-0456	R:FXD MET FLM 27.4K OHM 1% 1/8W	
A35R6	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A35R7	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A35R8	0811-0961	R:FXD WW 825 OHM 0.1% 1/4W	
A35R9	2100-1420	R:VAR WW 200 OHM 5% 3/4W	
A35R10	0811-0961	R:FXD WW 825 OHM 0.1% 1/4W	
A35R11	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A35R12	0811-0963	R:FXD WW 1K 0.25% 1/4W	
A35R13	0811-0963	R:FXD WW 1K 0.25% 1/4W	
A35R14	0757-0274	R:FXD MET FLM 1.21K OHM 1% 1/8W	
A35R15	0757-0274	R:FXD MET FLM 1.21K OHM 1% 1/8W	
A35R16	0757-0273	R:FXD MET FLM 3.01K OHM 1% 1/8W	
A35R17	0698-0086	R:FXD MET FLM 2.87K OHM 1% 1/4W	
A35R18	0811-0962	R:FXD WW 738 OHM 1% 1/2W	
A35R19	0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	
A35R20	NRFR	FACTORY SELECTED:PART OF CR3	
A35R21	2100-1433	R:VAR WW 100 OHM 5% 3/4W	
A35R22	NRFR	FACTORY SELECTED:PART OF CR5	
A35R23	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A35R24	0698-0085	R:FXD MET FLM 2.61K OHM 1% 1/8W	
A35R25	0698-0092	R:FXD MET FLM 2.61K OHM 1% 1/8W	A-L
	0811-1394	R:FXD WW 2550 OHM 0.1% 1/8W	M-X
A35R26	0698-0092	R:FXD MET FLM 2.61K OHM 1% 1/8W	A-L
	0811-2388	R:FXD WW 2513 OHM 0.1% 1/8W	M-X
A35R27	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
A35R28	0757-0408	R:FXD MET FLM 243 OHM 1% 1/8W	
A35R29	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A35R30	0811-0995	R:FXD WW 11 OHM 5% 3/16W	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A36 5080-3806 A46 5080-3781 A47 5080-3891 MAIN CHASSIS	
A36	5080-3806	RECTIFIER/FILTER	
A36C1	0180-0364	C:FXD ELECT 250UF -10+100% 30VDCW	
A36C2	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
A36C3	0180-0364	C:FXD ELECT 250UF -10+100% 30VDCW	
A36C4	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
A36C5	0180-0363	C:FXD ELECT 150UF -10+100% 30VDCW	
A36C6	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
A36C7	0180-0361	C:FXD ELECT 10 UF +50-10% 350VDCW	
A36C8	0180-0361	C:FXD ELECT 10 UF +50-10% 350VDCW	
A36C9	OBD	C:FXD, SELECTED IN TEST	
A36C10	OBD	C:FXD, SELECTED IN TEST	
A36CR1- A36CR6	1901-0026	DIODE:SILICON 0.75A 200 PIV	
A36CR7	1901-0036	DIODE:SILICON 1000 PIV	
A36R1	0686-6845	R:FXD COMP 680K OHM 5% 1/2W	
A36R2	0686-6825	R:FXD COMP 6800 OHMS 5% 1/2W	
A46		SAME AS A11, USE PREFIX A46	
A47	5080-3891	RELAY TIME CIRCUIT	
A47C1	0170-0040	C:FXD MY .047 UF 10% 200VDCW	
A47C2	0180-0010	C:FXD ELECT 8 UF -15+20% 30VDCW	
A47CR1	1901-0025	DIODE:SILICON 100WV 100MA	
A47Q1	1851-0024	TRANSISTOR:GERMANIUM NPN	
A47R1	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A47R2	0683-2715	R:FXD COMP 270 OHM 5% 1/4W	
A47R3	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A47R4	0686-8225	R:FXD COMP 8200 OHM 5% 1/2W	
		MAIN CHASSIS	
B101	3160-0026	FAN:TUBEAXIAL 50-60CPS	A-V
	3160-0097	FAN:TUBE AXIAL	W-X
C1	0180-0367	C:FXD ELECT 20UF -10+75% 200VDCW	
C2	0180-0047	C:FXD ELECT 500 UF 75VDCW	
C3	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
C4	0130-0001	C:VAR CER 7-45PF 500VDCW	
C5	0160-2940	C:FXD MICA 470 PF 5% 300VDCW	
C7	0180-0049	C:FXD AL ELECT 20UF 50VDCW	
C11	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	T-X
C22	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	G-X
C202	0170-0038	C:FXD MY 0.22 UF 10% 200VDCW	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		MAIN CHASSIS (CONT'D)	
CR2	1901-0060	DIODE:SILICON	
CR3	1901-0060	DIODE:SILICON	
CR20	1901-0081	DIODE:SILICON 50 VOLTS WORKING	G-X
CR21	1901-0081	DIODE:SILICON 50 VOLTS WORKING	H-X
F1	2110-0006	FUSE:CARTRIDGE 2AMP 125V SLOW BLOW	
F2	2110-0007	FUSE:CARTRIDGE 1 AMP 250V SLOW BLOW REPLACES F1 FOR 230V OPERATION.	
FL1	9110-0103	FILTER:LINE 3 WIRE 1.5A	A-T
	9100-2477	FILTER:LINE 3 WIRE 1.5A	U-X
J1	1251-0119	CONN:FEMALE 37 CONTACTS	
J2	1251-0087	CONNECTOR:FEMALE 50-PIN MINAT	
J3	1250-0118	CONNECTOR:BNC	
J4	1250-0118	CONNECTOR:BNC	
J8	1250-0118	CONNECTOR:BNC	
J9	1250-0118	CONNECTOR:BNC	
J31	1251-0349	CONN:GUARDED CHASSIS 3 PIN MALE	
L1	9110-0067	CHOKE:35 MH 1.5A	
Q1	1850-0132	TRANSISTOR:GERMANIUM PNP	A-J
	1853-0031	TRANSISTOR:SILICON PNP	K-X
Q2	1850-0132	TRANSISTOR:GERMANIUM PNP	A-J
Q3	1850-0064	TRANSISTOR:GERMANIUM PNP 2N1183	G-X
Q5	1853-0008	TRANSISTOR:SILICON PNP	
R1	0813-0007	R:FXD WW 10K OHM 10% 5W	
R2	0816-0014	R:FXD WW 1250 OHM 10% 10W	
R3	0692-1025	R:FXD COMP 1K OHM 5% 2W	A-J
	0686-6825	R:FXD COMP 6800 OHMS 5% 1/2W	K-X
R4	0683-2245	R:FXD COMP 220K OHM 5% 1/4W	
R5	0686-4745	R:FXD COMP 470K OHM 5% 1/2W	
R6	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
R7	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
R8	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
R9	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
R11	0683-1015	R:FXD COMP 100 OHM 5% 1/4W	H-X
R12	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	H-X
R202	0686-1135	R:FXD COMP 11K OHM 5% 1/2W	
R203	0686-4335	R:FXD COMP 43K OHM 5% 1/2W	
R204	NSR	(PART OF S5)	
S1	3100-1402	SWITCH:ROTARY 8 POS 3 SECT	
S2	3100-0711	SWITCH:ROTARY 12 POLE 3 OR 4 POS	
S3	3100-0464	SWITCH:ROTARY 6 POLE 6 POS	
S4	3101-0004	SWITCH:PUSHBUTTON SPDT	
S5	3100-0466	SWITCH:ROTARY W/250K OHM RESISTOR	
S6	3101-0005	SWITCH:TOG DPDT JAN #ST22N	
S7	3101-0001	SWITCH:TOGGLE SPST	
S10	3101-0001	SWITCH:TOGGLE SPST	
S11	3101-0033	SWITCH:SLIDE DPDT	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		MAIN CHASSIS (CONT'D)	
T1	9100-0211	TRANSFORMER:POWER	
XA1-XA8	1251-0135	CONNECTOR:BODY 15 PIN	
XA9	1251-0141	CONN:PC 18 CONTACTS	
XA10	1251-0135	CONNECTOR:BODY 15 PIN	
XA11	1251-1024	CONN:PC 30(2X15) CONTACTS	
XA12	1251-1024	CONN:PC 30(2X15) CONTACTS	
XA13	1251-1024	CONN:PC 30(2X15)CONTACTS	
XA14	1251-1024	CONN:PC 30(2X15)CONTACTS	
XA15	1251-1024	CONN:PC 30(2X15)CONTACTS	
XA16	1251-1035	CONN:PC 36(2X18) CONTACTS	
XA17	1251-0135	CONNECTOR:BODY 15 PIN	
XA18	1251-0135	CONNECTOR:BODY 15 PIN	
XA19	1251-0332	CONN:PC 24 CONTACTS	
XA20	1251-0332	CONN:PC 24 CONTACTS	
XA21	1251-0332	CONN:PC 24 CONTACTS	
XA22	1251-0332	CONN:PC 24 CONTACTS	
XA24	1251-1034	CONN:PC 20(2X10) CONTACTS	
XA26	1251-0475	CONNECTOR:PC 6 CONTACT	
XA27	1251-0475	CONNECTOR:PC 6 CONTACT	
XA29	1251-0166	CONN:PC 10 CONTACTS	
XA31	1251-0141	CONN:PC 18 CONTACTS	
XA32	1251-0135	CONNECTOR:BODY 15 PIN	
XA33	1251-0135	CONNECTOR:BODY 15 PIN	
XA34	1251-0135	CONNECTOR:BODY 15 PIN	
XA35	1251-0141	CONN:PC 18 CONTACTS	
XA46	1251-1024	CONN:PC 30(2X15)CONTACTS	
XF1	1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	
Y1	0410-0021	CRYSTAL:QUARTZ 100 KHZ	
	5060-3639	DECIMAL LAMP ASSY	
	5060-5019	NEON PHOTOCONDUCTOR BLOCK ASSY	

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		V/F CONVERTER	
		VOLTAGE TO FREQUENCY CONVERTER CHASSIS	
C12	0160-2940	C:FXD MICA 470 PF 5% 300VDCW	D-X
C13	0160-2197	C:FXD MICA 10 PF 5%	U
	0160-2203	C:FXD MICA 91 PF 5%	V-X
C20	0150-0008	C:FXD CER 5 PF 500VDCW	N-X
C32	0180-0098	C:FXD ELECT 100 UF 20% 20VDCW	
C34	0180-0196	C:FXD ELECT 56 UF 15VDCW	
C35	0180-0079	C:FXD ELECT 10UF -15+20% 60VDCW	A
J10	1251-0373	CONN:TEFLON WHITE FEMALE	
J11	1251-0373	CONN:TEFLON WHITE FEMALE	
J29	1251-0373	CONN:TEFLON WHITE FEMALE	
J30	1251-0373	CONN:TEFLON WHITE FEMALE	
R10	0683-2205	R:FXD COMP 22 OHM 5% 1/4W	D-X
R33	2100-0963	R:VAR WW 8 OHM 10% 2W	
R34	2100-0704	R:VAR WW 10K OHM 10% 2W	
R35	2100-0963	R:VAR WW 8 OHM 10% 2W	
R48	0811-0354	R:FXD WW 100K OHM 1/100% 1W	
R49	0757-0289	R:FXD MET FLM 13.3K OHM 1% 1/8W	
R50	0757-0289	R:FXD MET FLM 13.3K OHM 1% 1/8W	
R61	0757-0926	R:FXD FLM 1.2K OHM 2% 1/8W	
R62	0757-0926	R:FXD FLM 1.2K OHM 2% 1/8W	
R63	2100-0364	R:VAR WW 20K OHM 5% LIN 1.0W	A
T2	9100-1201	TRANSFORMER:POWER	*
	9100-1211	TRANSFORMER:POWER	D-X
T4	5080-1439	TRANSFORMER:PULSE (SHIELDED)	
T5	5080-1439	TRANSFORMER:PULSE (SHIELDED)	
XA23	1251-0135	CONNECTOR:BODY 15 PIN	

*USABLE ON CODE A THRU C EXCEPT STOCK NUMBER 9100-1211 USED ON SOME INSTRUMENTS. CHECK STOCK NUMBER ON TRANSFORMER CASE BEFORE ORDERING.

See introduction to this section for ordering information

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		A28 5060-6118	
A28	5060-6118	PROGRAMMABLE DC ATTENUATOR ASSEMBLY	
A28C101	0180-0349	C:FXD TANT ELECT 0.68 UF 10% 35VDCW	A-W
	OBD	FACTORY SELECTED PART	X
A28C102	0180-0347	C:FXD TANT ELECT 1.5 UF 10% 35VDCW	A-W
	OBD	FACTORY SELECTED PART	X
A28CR101	1901-0028	DIODE:SILICON 100WV 100MA	
A28CR103	1901-0025	DIODE:SILICON 100WV 100MA	
A28CR104	1901-0025	DIODE:SILICON 100WV 100MA	
A28CR105	1901-0025	DIODE:SILICON 100WV 100MA	
A28K1-A28K5	0490-0099	RELAY:COIL	
	0490-0137	SWITCH:MAGNETIC REED	A-E
		CONTACTS FOR K1,K2,K4B,AND K5.	
	0490-0137	SWITCH:MAGNETIC REED	F-X
		CONTACTS FOR K1,K2A,K2B,K4B,AND K5.	
	0490-0094	SWITCH:MAGNETIC REED	
		CONTACTS FOR K3 AND K4A.	
A28L10	9140-0237	COIL:FXD 200 UH 5%	
A28R36	0811-1516	R:FXD WW 4.495 MEGOHM .05% 2 PPM DEG C	
A28R37	0811-1516	R:FXD WW 4.495 MEGOHM .05% 2 PPM DEG C	
A28R38	0811-0152	R:FXD WW 90K OHM 0.01% 1/8W	
A28R39	0811-0201	R:FXD WW 900K OHM 0.01% 1/4W	
A28R40	2100-0708	R:VAR WW 20K OHM 10% 2W	
A28R42	0811-0154	R:FXD WW 10.080K OHM 0.1% 3/8W	
A28R43	2100-1454	R:VAR WW 50 OHM 5% 3/4W	
A28R44	0811-0150	R:FXD WW 111K OHM 0.05% 1/8W	
A28R45	2100-1455	R:VAR WW 300 OHM 5% 3/4W	
A28R46	0811-0355	R:FXD WW 899K OHM 0.05% 1/4W	
A28R47	2100-1456	R:VAR WW 2K OHM 5% 3/4W	
A28R101	0689-3915	R:FXD COMP 390 OHM 5% 1W	
A28R102	0689-4715	R:FXD COMP 470 OHM 5% 1W	
A28R105	0689-3915	R:FXD COMP 390 OHM 5% 1W	
A28R106	0689-3915	R:FXD COMP 390 OHM 5% 1W	
A28R107	0689-3915	R:FXD COMP 390 OHM 5% 1W	

See introduction to this section for ordering information

Table 5-2. Replaceable Parts

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
0130-0001	C:VAR CER 7-45PF 500VDCW	28480	0130-0001	1
0140-0145	C:FXD MICA 22 PF 5%	28480	0140-0145	1
0140-0152	C:FXD MICA 1000 PF 5% 300VDCW	04062	DM16F102J	2
0140-0156	C:FXD MICA 1900 PF 2%	28480	0140-0156	4
0140-0176	C:FXD MICA 100 PF 2%	28480	0140-0176	2
0140-0177	C:FXD MICA 400 PF 1%	28480	0140-0177	1
0140-0191	C:FXD MICA 56 PF 5%	28480	0140-0191	3
0140-0192	C:FXD MICA 68 PF 5%	28480	0140-0192	4
0140-0194	C:FXD MICA 110 PF 5%	28480	0140-0194	62
0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	04062	DM15F131J 300V	61
0140-0196	C:FXD MICA 150 PF 5%	28480	0140-0196	35
0140-0198	C:FXD MICA 200 PF 5%	28480	0140-0198	12
0140-0199	C:FXD MICA 240 PF 5%	28480	0140-0199	6
0140-0200	C:FXD MICA 390 PF 5%	28480	0140-0200	12
0140-0203	C:FXD MICA 30 PF 5%	28480	0140-0203	1
0140-0218	C:FXD MICA 160 PF 2%	28480	0140-0218	2
0140-0219	C:FXD MICA 180 PF 2%	28480	0140-0219	36
0150-0008	C:FXD CER 5 PF 500VDCW	28480	0150-0008	1
0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	56289	29C214A3	5
0150-0014	C:FXD CER 0.005 UF 500VDCW	9600	D1-4	4
0150-0021	C:FXD TI DIOX 0.47PF 5% 500VDCW	7840	TYPE GA	1
0150-0093	C:FXD CER 0.01 UF +80-20% 100VDCW	91418	TA	1
0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	56289	5C50B1S-CML	15
0160-0127	C:FXD CER 1.0 UF 20% 25VDCW	56289	5C13C5-CML	1
0160-0134	C:FXD MICA 220PF 5% 300VDCW	14655	RDM15F221J3C	3
0160-0155	C:FXD MY 3300 PF 10%	28480	0160-0155	1
0160-0158	C:FXD MYLAR 5600PF 10%	28480	0160-0158	2
0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	28480	0160-0161	6
0160-0163	C:FXD MY 0.033 UF 10% 200VDCW	28480	0160-0163	2
0160-0164	C:FXD MY 0.039 UF 10% 200VDCW	28480	0160-0164	1
0160-0166	C:FXD MY .068 UF 10%	28480	0160-0166	2
0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	28480	0160-0168	6
0160-0257	C:FXD MICA 50.6PF 1%	72136	RCM15E150.6J1	2
0160-0263	C:FXD CER 0.22 UF 20% 50VDCW	56289	5C5285-CML	1
0160-0268	C:FXD PURC 110 PF 5% 500VDCW	95275	VY13C111J	1
0160-0303	C:FXD MYLAR .15 UF 10% 200VDCW	28480	0160-0303	1
0160-0378	C:FXD MICA 27PF 5%	72136	RDM15E270J5S	2
0160-0938	C:FXD MICA 1000PF 5%	28480	0160-0938	3
0160-0960	C:FXD POLY 0.27 UF 20% 30VDCW	56289	114P2740R354	1
0160-0961	C:FXD POLY 0.027UF 20% 30VDCW	56289	114P2730R354	1
0160-0970	C:FXD MY 0.47UF 10% 80VDCW	56289	192P4749R0-P15	1
0160-2101	C:FXD MICA 27PF 2% 300VDCW	72136	RDM19E270G3C	1
0160-2197	C:FXD MICA 10 PF 5%	28480	0160-2197	1
0160-2203	C:FXD MICA 91 PF 5%	28480	0160-2203	1
0160-2232	C:FXD MICA 33 PF 2% 300VDCW	72136	RDM15E330G3C	1
0160-2940	C:FXD MICA 470 PF 5% 300VDCW	72136	RDM15E471J3C	5
0170-0024	C:FXD MY 0.022UF 20% 200VDCW	56289	192P22302	1
0170-0038	C:FXD MY 0.22 UF 10% 200VDCW	56289	148P22492 PUM	2
0170-0040	C:FXD MY .047 UF 10% 200VDCW	28480	0170-0040	1
0170-0066	C:FXD MY 0.027UF 10% 200VDCW	28480	0170-0066	1
0170-0072	C:FXD MY 1 UF 10% 200VDCW	84411	HFM 54	1
0180-0010	C:FXD ELECT 8 UF -15+20% 30VDCW	56289	1370805C203000 DYM	1
0180-0039	C:FXD ELECT 100UF 12VDCW	56289	30D107G012DC4M1	2

See introduction to this section for ordering information

Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
0180-0047	C:FXD ELECT 500 UF 75VDCW	56289	D32443 UFP	1
0180-0049	C:FXD AL ELECT 20UF 50VDCW	56289	30D206G050DCoM1	3
0180-0050	C:FXD ELECT 40 UF +75-10% 50VDCW	28480	0180-0050	4
0180-0058	C:FXD ELECT 50UF -10%+100% 25VDCW	56289	30D506G025DD4M1	2
0180-0063	C:FXD ELECT 500UF -10%+100% 3VDCW	56289	30D507G003DH6M1	1
0180-0079	C:FXD ELECT 10UF -15+20% 60VDCW	10411	MTA10-60	2
0180-0094	C:FXD ELECT 100UF 25VDCW	56289	30D107G025DH4	1
0180-0098	C:FXD ELECT 100 UF 20% 20VDCW	28480	0180-0098	1
0180-0104	C:FXD ELECT 200UF 15VDCW	56289	30D207G015DH4	1
0180-0116	C:FXD ELECT 6.8 UF 10% 35VDCW	56289	150D685X9035B2	1
0180-0124	C:FXD ELECT 200UF 6VDCW	56289	30D207G006DF4	1
0180-0137	C:FXD ELECT 100 UF 20% 10VDCW	28480	0180-0137	3
0180-0159	C:FXD ELECT 220 UF 10% 10VDCW	28480	0180-0159	1
0180-0193	C:FXD ELECT 20 UF 10VDCW	56289	109D206G2010C2	1
0180-0196	C:FXD ELECT 56 UF 15VDCW	82647	SCM566GP015D2	4
0180-0197	C:FXD ELECT 2.2 UF 10% 20VDCW	56289	150D225X9020A2	2
0180-0210	C:FXD ELECT 3.3 UF 20% 15VDCW	82376	TES 3.3M-15	3
0180-0291	C:FXD ELECT 1UF 10% 35VDCW	56289	150D105X9035A2	1
0180-0361	C:FXD ELECT 10 UF +50-10% 350VDCW	28480	0180-0361	2
0180-0363	C:FXD ELECT 150UF -10+100% 30VDCW	56289	D39794-D85	2
0180-0364	C:FXD ELECT 250UF -10+100% 30VDCW	56289	34D257G030GJ4-D58	2
0180-0365	C:FXD TA 22UF 10% 15VDCW	56289	150D226X9015B2	1
0180-0367	C:FXD ELECT 200UF -10+75% 200VDCW	56289	34D206F200FJ4-D58	2
0180-0388	C:FXD ELECT 56 UF 10% 20VDCW	56289	130D275	2
0180-1804	C:FXD ELECT 75 UF +75-10% 40VDCW	56289	34D756G040EJ2-D58	2
0360-0462	TERMINAL:PROBE	28480	0360-0462	2
0410-0021	CRYSTAL:QUARTZ 100 KHZ	28480	0410-0021	1
0490-0094	SWITCH:SPST 250V 1A 15W	95348	MR-600-1	2
0490-0099	RELAY:COIL	04404	0490-0099	5
0490-0137	SWITCH:MAGNETIC REED	28480	0490-0137	9
0683-0565	R:FXD COMP 5.6 OHM 5% 1/4W	01121	CB 0565	1
0683-1005	R:FXD COMP 10 OHM 5% 1/4W	01121	CB 1005	3
0683-1015	R:FXD COMP 100 OHM 5% 1/4W	01121	CB 1015	5
0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	01121	CB 1025	14
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	76
0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	01121	CB 1045	38
0683-1135	R:FXD COMP 11K OHM 5% 1/4W	01121	CB 1135	3
0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	01121	CB 1225	5
0683-1235	R:FXD COMP 12K OHM 5% 1/4W	01121	CB 1235	18
0683-1335	R:FXD COMP 13K OHM 5% 1/4W	01121	CB 1335	3
0683-1515	R:FXD COMP 150 OHM 5% 1/4W	01121	CB 1515	1
0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	01121	CB 1525	2
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	24
0683-1545	R:FXD COMP 150K OHM 5% 1/4W	01121	CB 1545	1
0683-1635	R:FXD COMP 16K OHM 5% 1/4W	01121	CB 1635	20
0683-1815	R:FXD COMP 180 OHM 5% 1/4W	01121	CB 1815	1
0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	01121	CB 1825	2
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	51
0683-1845	R:FXD COMP 180K OHM 5% 1/4W	01121	CB 1845	1
0683-2015	R:FXD COMP 200 OHM 5% 1/4W	01121	CB 2015	20
0683-2035	R:FXD COMP 20K OHM 5% 1/4W	01121	CB 2035	7
0683-2045	R:FXD COMP 200K OHM 5% 1/4W	01121	CB 2045	4
0683-2205	R:FXD COMP 22 OHM 5% 1/4W	01121	CB 2205	1

See introduction to this section for ordering information

Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	01121	CB 2225	4
0683-2235	R:FXD COMP 22K OHM 5% 1/4W	01121	CB 2235	124
0683-2245	R:FXD COMP 220K OHM 5% 1/4W	01121	CB 2245	1
0683-2435	R:FXD COMP 24K OHM 5% 1/4W	01121	CB 2435	15
0683-2705	R:FXD COMP 27 OHM 5% 1/4W	01121	CB 2705	4
0683-2715	R:FXD COMP 270 OHM 5% 1/4W	01121	CB 2715	1
0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	01121	CB 2725	11
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	57
0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	01121	CB 3025	39
0683-3035	R:FXD COMP 30K OHM 5% 1/4W	01121	CB 3035	1
0683-3305	R:FXD COMP 33 OHM 5% 1/4W	01121	CB 3305	2
0683-3315	R:FXD COMP 330 OHM 5% 1/4W	01121	CB 3315	2
0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	01121	CB 3325	6
0683-3335	R:FXD COMP 33K OHM 5% 1/4W	01121	CB 3335	179
0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	01121	CB 3625	3
0683-3635	R:FXD COMP 36K OHM 5% 1/4W	01121	CB 3635	1
0683-3915	R:FXD COMP 390 OHM 5% 1/4W	01121	CB 3915	6
0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	01121	CB 3925	40
0683-3935	R:FXD COMP 39K OHM 5% 1/4W	01121	CB 3935	1
0683-3945	R:FXD COMP 390K OHM 5% 1/4W	01121	CB 3945	4
0683-4725	R:FXD COMP 4.7K OHM 5% 1/4W	01121	CB 4725	2
0683-4325	R:FXD COMP 4300 OHM 5% 1/4W	01121	CB 4325	1
0683-4335	R:FXD COMP 43K OHM 5% 1/4W	01121	CB 4335	18
0683-4705	R:FXD COMP 47 OHM 5% 1/4W	01121	CB 4705	1
0683-4715	R:FXD COMP 470 OHM 5% 1/4W	01121	CB 4715	4
0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	01121	CB 4725	19
0683-4735	R:FXD COMP 47K OHM 5% 1/4W	01121	CB 4735	105
0683-4745	R:FXD COMP 470K OHM 5% 1/4W	01121	CB 4745	1
0683-5125	R:FXD COMP 5100 OHM 5% 1/4W	01121	CB 5125	1
0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	01121	CB 5625	12
0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	01121	CB 5635	51
0683-6225	R:FXD COMP 6200 OHM 5% 1/4W	01121	CB 6225	2
0683-6815	R:FXD COMP 680 OHM 5% 1/4W	01121	CB 6815	1
0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	01121	CB 6825	44
0683-6835	R:FXD COMP 68K OHM 5% 1/4W	01121	CB 6835	51
0683-7525	R:FXD COMP 7500 OHM 5% 1/4W	01121	CB 7525	1
0683-8215	R:FXD COMP 820 OHM 5% 1/4W	01121	CB 8215	1
0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	01121	CB 8225	1
0683-9105	R:FXD COMP 91 OHM 5% 1/4W	01121	CB 9105	1
0683-9135	R:FXD COMP 91K OHM 5% 1/4W	01121	CB 9135	7
0686-1025	R:FXD COMP 1000 OHM 5% 1/2W	01121	EB 1025	1
0686-1135	R:FXD COMP 11K OHM 5% 1/2W	01121	EB 1135	1
0686-2025	R:FXD COMP 2000 OHM 5% 1/2W	01121	EB 2025	1
0686-2235	R:FXD COMP 22K OHM 5% 1/2W	01121	EB 2235	2
0686-3325	R:FXD COMP 3300 OHM 5% 1/2W	01121	EB 3325	1
0686-3625	R:FXD COMP 3600 OHM 5% 1/2W	01121	EB 3625	1
0686-3925	R:FXD COMP 3900 OHM 5% 1/2W	01121	EB 3925	5
0686-4335	R:FXD COMP 43K OHM 5% 1/2W	01121	EB 4335	1
0686-4725	R:FXD COMP 4700 OHM 5% 1/2W	01121	EB 4725	2
0686-4735	R:FXD COMP 47K OHM 5% 1/2W	01121	EB 4735	6
0686-4745	R:FXD COMP 470K OHM 5% 1/2W	01121	EB 4745	1
0686-5135	R:FXD COMP 51K OHM 5% 1/2W	01121	EB 5135	1
0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	01121	EB 5625	56
0686-6825	R:FXD-COMP 6800 OHMS 5% 1/2W	01121	EB 6825	3
0686-6845	R:FXD COMP 680K OHM 5% 1/2W	01121	EB 6845	1

See introduction to this section for ordering information

Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	01121	EB 7525	2
0686-8225	R:FXD COMP 8200 OHM 5% 1/2W	01121	EB 8225	1
0689-1035	R:FXD COMP 10K OHM 5% 1W	01121	GB 1035	5
0689-1815	R:FXD COMP 180 OHM 5% 1W	01121	GB 1815	1
0689-2225	R:FXD COMP 2200 OHM 5% 1W	01121	GB 2225	1
0689-2725	R:FXD COMP 2.7K OHM 5% 1W	01121	GB 2725	2
0689-3315	R:FXD COMP 330 OHM 5% 1W	01121	GB 3315	10
0689-3915	R:FXD COMP 390 OHM 5% 1W	01121	GB 3915	4
0689-3925	R:FXD COMP 3.9K OHM 5% 1W	01121	GB 3925	1
0689-4715	R:FXD COMP 470 OHM 5% 1W	01121	GB 4715	1
0692-1025	R:FXD COMP 1K OHM 5% 2W	01121	HB 1025	1
0692-1815	R:FXD COMP 180 OHM 5% 2W	01121	HB 1815	1
0693-3359	R:FXD MET FLM 12.7K 1% 1/8W	28480	0693-3359	1
0698-0024	R:FXD MET FLM 2.61K OHM 1% 1/2W	28480	0698-0024	1
0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	28480	0698-0082	2
0698-0083	R:FXD MET FLM 1.96K OHM 1% 1/8W	28480	0698-0083	2
0698-0084	R:FXD MET FLM 2.15K OHM 1% 1/8W	28480	0698-0084	2
0698-0085	R:FXD MET FLM 2.61K OHM 1% 1/8W	28480	0698-0085	3
0698-0086	R:FXD MET FLM 2.87K OHM 1% 1/4W	28480	0698-0086	2
0698-0087	R:FXD MET FLM 316 OHM 1% 1/4W	28480	0698-0087	1
0698-0088	R:FXD MET FLM 215 OHM 1% 1/4W	28480	0698-0088	1
0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	28480	0698-0090	1
0698-0091	R:FXD MET FLM 825 OHM 1% 1/8W	28480	0698-0091	1
0698-0092	R:FXD MET FLM 2.61K OHM 1% 1/8W	28480	0698-0092	2
0698-0093	R:FXD MET OX 10 OHM 5% 1W	28480	0698-0093	1
0698-3101	R:FXD MET FLM 2.87K OHM 1% 1/2W	28480	0698-3101	1
0698-3132	R:FXD MET FLM 261 OHM 1% 1/8W	28480	0698-3132	3
0698-3133	R:FXD MET FLM 681 OHM 1% 3/10W	28480	0698-3133	4
0698-3134	R:FXD MET FLM 1.33K OHM 1% 1/4W	28480	0698-3134	2
0698-3135	R:FXD MET FLM 2740 OHM 1% 3/10W	28480	0698-3135	2
0698-3136	R:FXD MET FLM 17.8K OHM 1% 1/8W	28480	0698-3136	3
0698-3156	R:FXD MET FLM 14.7K OHM 1% 1/8W	28480	0698-3156	1
0698-3161	R:FXD MET FLM 38.3K OHM 1% 1/8W	28480	0698-3161	3
0698-3162	R:FXD MET FLM 46.4K OHM 1% 1/8W	28480	0698-3162	1
0698-3171	R:FXD MET FLM 10K OHM 1% 0.3W	18612	C302	2
0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	28480	0698-3178	1
0698-3388	R:FXD MET FLM 14.7 OHM 1% 1/2W	28480	0698-3388	2
0698-3419	R:FXD MET FLM 31.6K OHM 1% 1/2W	28480	0698-3419	2
0698-3449	R:FXD MET FLM 28.7K OHM 1% 1/8W	28480	0698-3449	1
0727-0274	R:FXD DEPC 1 MEGOHM 1% 1/2W	28480	0727-0274	10
0727-0704	R:FXD DEPC 6 OHM 1% 1/2W	28480	0727-0704	1
0727-0739	R:FXD CARBON FLM 464 OHM 1% 1/2W	28480	0727-0739	1
0727-0751	R:FXD DEPC 1000 OHM 1% 1/2W	28480	0727-0751	1
0727-0764	R:FXD CARBON FLM 2.37K OHM 1% 1/2W	28480	0727-0764	1
0727-0766	R:FXD CARBON FLM 2.87K OHM 1% 1/2W	19701	MF7C	1
0727-0792	R:FXD CARBON FLM 31.6K OHM 1% 1/2W	28480	0727-0792	1
0727-0819	R:FXD DEPC 287K OHM 1% 1/2W	28480	0727-0819	1
0727-0862	R:FXD CARBON FLM 4.64 MEGOHM 1% 1/2W	28480	0727-0862	1
0757-0156	R:FXD MET FLM 1.5 MEGOHM 1% 1/2W	28480	0757-0156	1
0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	28480	0757-0159	2
0757-0198	R:FXD MET FLM 100 OHM 1% 1/2W	28480	0757-0198	4
0757-0199	R:FXD MET FLM 21.5K OHM 1% 1/8W	28480	0757-0199	5
0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	28480	0757-0200	6
0757-0273	R:FXD MET FLM 3.01K OHM 1% 1/8W	28480	0757-0273	1

See introduction to this section for ordering information

Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
0757-0274	R:FXD MET FLM 1.21K OHM 1% 1/8W	28480	0757-0274	4
0757-0278	R:FXD MET FLM 1.78K OHM 1% 1/8W	28480	0757-0278	3
0757-0280	R:FXD MET FLM 1K OHM 1% 1/8W	28480	0757-0280	8
0757-0289	R:FXD MET FLM 13.3K OHM 1% 1/8W	28480	0757-0289	2
0757-0290	R:FXD MET FLM 6.19K OHM 1% 1/8W	28480	0757-0290	2
0757-0327	R:FXD MET FLM 499K OHM 1% 1/4W	28480	0757-0327	3
0757-0336	R:FXD MET FLM 340 OHM 1% 1/4W	28480	0757-0336	1
0757-0338	R:FXD MET FLM 1.00K OHM 1% 1/4W	28480	0757-0338	1
0757-0344	R:FXD MET FLM 1.00 MEGOHM 1% 1/4W	28480	0757-0344	1
0757-0387	R:FXD MET FLM 27.4 OHM 1% 1/8W	19701	MF5C 1-0	1
0757-0403	R:FXD MET FLM 121 OHM 1% 1/8W	28480	0757-0403	1
0757-0408	R:FXD MET FLM 243 OHM 1% 1/8W	28480	0757-0408	1
0757-0413	R:FXD MET FLM 392 OHM 1% 1/8W	28480	0757-0413	2
0757-0417	R:FXD MET FLM 562 OHM 1% 1/8W	28480	0757-0417	1
0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	28480	0757-0421	1
0757-0427	R:FXD MET FLM 1500 OHM 1% 1/8W	28480	0757-0427	4
0757-0433	R:FXD MET FLM 3.32K OHM 1% 1/8W	28480	0757-0433	1
0757-0438	R:FXD MET FLM 5.11K OHM 1% 1/8W	28480	0757-0438	2
0757-0439	R:FXD MET FLM 6.81K OHM 1% 1/8W	28480	0757-0439	1
0757-0441	R:FXD MET FLM 8.25K OHM 1% 1/8W	28480	0757-0441	3
0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	28480	0757-0442	9
0757-0444	R:FXD MET FLM 12.1K OHM 1% 1/8W	28480	0757-0444	2
0757-0446	R:FXD MET FLM 15.0K OHM 1% 1/8W	28480	0757-0446	3
0757-0452	R:FXD MET FLM 27.4K OHM 1% 1/8W	28480	0757-0452	2
0757-0458	R:FXD MET FLM 51.1K OHM 1% 1/8W	28480	0757-0458	3
0757-0459	R:FXD MET FLM 56.2K OHM 1% 1/8W	28480	0757-0459	1
0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	28480	0757-0465	2
0757-0471	R:FXD MET FLM 182K OHM 1% 1/8W	28480	0757-0471	1
0757-0479	R:FXD MET FLM 392K OHM 1% 1/8W	28480	0757-0479	1
0757-0481	R:FXD MET FLM 475K OHM 1% 1/8W	28480	0757-0481	2
0757-0483	R:FXD MET FLM 562K OHM 1% 1/8W	28480	0757-0483	1
0757-0731	R:FXD MET FLM 825 OHM 1% 1/4W	28480	0757-0731	2
0757-0743	R:FXD MET FLM 3.32K OHM 1% 1/4W	28480	0757-0743	2
0757-0748	R:FXD MET FLM 5.62K OHM 1% 1/4W	28480	0757-0748	1
0757-0816	R:FXD MET FLM 681 OHM 1% 1/2W	28480	0757-0816	2
0757-0926	R:FXD FLM 1.2K OHM 2% 1/8W	28480	0757-0926	2
0757-0931	R:FXD FLM 2.0K OHM 2% 1/8W	28480	0757-0931	1
0757-0939	R:FXD FLM 4.3K OHM 2% 1/8W	28480	0757-0939	1
0757-0940	R:FXD FLM 4.7K OHM 2% 1/8W	28480	0757-0940	1
0757-0943	R:FXD FLM 6.2K OHM 2% 1/8W	28480	0757-0943	4
0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	28480	0757-0944	3
0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	28480	0757-0946	2
0757-0947	R:FXD FLM 9.1K OHM 2% 1/8W	28480	0757-0947	1
0757-0948	R:FXD FLM 10K OHM 2% 1/8W	28480	0757-0948	3
0757-0950	R:FXD FLM 12K OHM 2% 1/8W	28480	0757-0950	3
0757-0952	R:FXD FLM 15K OHM 2% 1/8W	28480	0757-0952	1
0757-0953	R:FXD FLM 16K OHM 2% 1/8W	28480	0757-0953	1
0757-0954	R:FXD FLM 18K OHM 2% 1/8W	28480	0757-0954	2
0757-0958	R:FXD FLM 27K OHM 2% 1/8W	28480	0757-0958	1
0757-0968	R:FXD FLM 68K OHM 2% 1/8W	28480	0757-0868	1
0757-0992	R:FXD MET FLM 22.1 OHM 1% 1/2W	28480	0757-0992	2
0757-1060	R:FXD MET FLM 196 OHM 1% 1/2W	28480	0757-1060	2
0757-1078	R:FXD MET FLM 1.47K OHM 1% 1/2W	28480	0757-1078	1
0757-1102	R:FXD MET FLM 180 OHM 1% 1/8W	28480	0757-1102	2

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Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
0758-0003	R:FXD MET OX 1000 OHM 5% 1/2W	28480	0758-0003	1
0758-0004	R:FXD MET OX 2700 OHM 5% 1/2W	28480	0758-0004	1
0758-0042	R:FXD MET OX 1300 OHM 5% 1/2W	28480	0758-0042	2
0761-0024	R:FXD MET OX 2.4 OHM 5% 1W	28480	0761-0024	1
0761-0027	R:FXD MET FLM 2.7K OHM 5% 1W	28480	0761-0027	4
0811-0150	R:FXD WW 111K OHM 0.05% 1/8W	28480	0811-0150	1
0811-0152	R:FXD WW 90K OHM 0.01% 1/8W	28480	0811-0152	1
0811-0154	R:FXD WW 10.040K OHM 0.1% 3/8W	28480	0811-0154	1
0811-0201	R:FXD WW 900K OHM 0.01% 1/4W	28480	0811-0201	1
0811-0354	R:FXD WW 100K OHM 1/100% 1W	28480	0811-0354	1
0811-0355	R:FXD WW 899K OHM 0.05% 1/4W	28480	0811-0355	1
0811-0961	R:FXD WW 825 OHM 0.1% 1/4W	28480	0811-0961	3
0811-0962	R:FXD WW 738 OHM 1% 1/2W	28480	0811-0962	1
0811-0963	R:FXD WW 1K 0.25% 1/4W	28480	0811-0963	2
0811-0995	R:FXD WW 11 OHM 5% 3/16W	28480	0811-0995	1
0811-1394	R:FXD WW 2550 OHM 0.1% 1/8W	28480	0811-1394	1
0811-1516	R:FXD WW 4.495 MEGOHM .05% 2 PPM DEG C	04404	0811-1516	2
0811-2388	R:FXD WW 2513 OHM 0.1% 1/8W	28480	0811-2388	1
0812-0045	R:FXD WW 0.15 OHM 5% 3W	28480	0812-0045	2
0813-0007	R:FXD WW 10K OHM 10% 5W	28480	0813-0007	1
0816-0014	R:FXD WW 1250 OHM 10% 10W	28480	0816-0014	1
1250-0118	CONNECTOR:BNC	28480	1250-0118	4
1251-0087	CONNECTOR:FEMALE 50-PIN MINAT	28480	1251-0087	1
1251-0119	CONN:FEMALE 37 CONTACTS	71468	MS3102A28-21S	1
1251-0135	CONNECTOR:BODY 15 PIN	28480	1251-0135	15
1251-0141	CONN:PC 18 CONTACTS	13511	143-018[illegible]	3
1251-0166	CONN:PC 10 CONTACTS	13511	143-010-08	1
1251-0332	CONN:PC 24 CONTACTS	28480	1251-0332	5
1251-0349	CONN:GUARDED CHASSIS 3 PIN MALE	28480	1251-0349	1
1251-0373	CONN:TEFLON WHITE FEMALE	98291	SKT-23	4
1251-0381	PLUG:TERMINAL FEEDTHRU TEFLON	98291	FTM14	2
1251-0475	CONNECTOR:PC 6 CONTACT	28480	1251-0475	2
1251-1024	CONN:PC 30(2X15)CONTACTS	28480	1251-1024	6
1251-1034	CONN:PC 20(2X10) CONTACTS	28480	1251-1034	1
1251-1035	CONN:PC 36(2X18) CONTACTS	95238	600-111-18X	1
1400-0084	FUSEHOLDER:EXTRACTOR POST TYPE	79515	342014	1
1850-0032	TRANSISTOR:GERMANIUM PNP	02735	2N404	4
1850-0037	TRANSISTOR:GERMANIUM 2N274 PNP	86684	2N274	2
1850-0040	TRANSISTOR:GERMANIUM PNP	28480	1850-0040	5
1850-0048	TRANSISTOR:GERMANIUM PNP	04713	2N650	2
1850-0062	TRANSISTOR:GERMANIUM ALLOY JUNCTION	28480	1850-0062	47
1850-0064	TRANSISTOR:GERMANIUM PNP	86684	2N1183	1
1850-0075	TRANSISTOR:GERMANIUM PNP	87216	2N779A	4
1850-0111	TRANSISTOR:GERMANIUM PNP	01295	2N404A	68
1850-0113	TRANSISTOR:GERMANIUM PNP	01295	2N1997	12
1850-0124	TRANSISTOR:GERMANIUM PNP	04713	2N466	1
1850-0128	TRANSISTOR:PNP GERMANIUM	01295	2N3988	59
1850-0132	TRANSISTOR:GERMANIUM PNP	04713	2N1540	2
1850-0145	TRANSISTOR:GERMANIUM PNP	03508	2N1926	2
1850-0097	TRANSISTOR:GERMANIUM	28480	1850-0147	1
1850-0183	TRANSISTOR:GERMANIUM PNP	28480	1850-0183	1
1850-0184	TRANSISTOR:GERMANIUM PNP	02735	38339	49
1851-0006	TRANSISTOR:GERMANIUM NPN	03508	2N169A	2
1851-0024	TRANSISTOR:GERMANIUM NPN	01295	2N388A	6

See introduction to this section for ordering information

Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
1851-0031	TRANSISTOR:GERMANIUM NPN	01295	2N1605	2
1851-0034	TRANSISTOR:GERMANIUM NPN	01295	2N1605A	1
1853-0001	TRANSISTOR:PNP SILICON 30V 900MW	28480	1853-0001	2
1853-0007	TRANSISTOR:SILICON PNP	07263	2N3251	2
1853-0008	TRANSISTOR:SILICON PNP	01295	2N3250	19
1853-0009	TRANSISTOR:SILICON PNP	28480	1853-0009	8
1853-0031	TRANSISTOR:SILICON PNP	04713	2N3789	1
1853-0036	TRANSISTOR:SILICON PNP	28480	1853-0036	3
1854-0003	TRANSISTOR:NPN SILICON	28480	1854-0003	13
1854-0014	TRANSISTOR:DUAL NPN SILICON	28480	1854-0014	4
1854-0039	TRANSISTOR:SILICON	02735	2N3053	6
1854-0362	TRANSISTOR:SILICON NPN	04713	MM3006	2
1901-0016	DIODE:SILICON	04713	1N1566	1
1901-0025	DIODE:SILICON 100WV 100MA	28480	1901-0025	122
1901-0026	DIODE:SILICON 0.75A 200 PIV	28480	1901-0026	8
1901-0029	DIODE:SILICON 600 PIV	28480	1901-0029	2
1901-0036	DIODE:SILICON 1000 PIV	28480	1901-0036	1
1901-0050	DIODE:SILICON 75V	28480	1901-0050	1
1901-0058	DIODE:SILICON 150V	03877	1N628	2
1901-0060	DIODE:SILICON	28480	1901-0060	2
1901-0061	DIODE:SILICON	03877	1N816	6
1901-0071	DIODE:SILICON 30WV	28480	1901-0071	2
1901-0081	DIODE:SILICON 50 VOLTS WORKING	28480	1901-0081	272
1901-0143	DIODE:SILICON	28480	1901-0143	2
1901-0156	DIODE:SILICON	28480	1901-0156	7
1901-0434	DIODE:SILICON 100MA 50 WIV	28480	1901-0434	3
1902-0022	DIODE:BREAKDOWN 2.67V	28480	1902-0022	3
1902-0025	DIODE:BREAKDOWN 10.0V 5% 400 MW	28480	1902-0025	1
1902-0033	DIODE:BREAKDOWN 6.2V	04713	1N823	1
1902-0094	DIODE:BREAKDOWN 4.85V 250MW	28480	1902-0094	1
1902-0096	DIODE:AVALANCHE 6.2V	28480	1902-0096	2
1902-0199	DIODE:BREAKDOWN 8.8/10.8V 100MW	28480	1902-0199	1
1902-0223	DIODE:BREAKDOWN SILICON 15.4V	28480	1902-0223	1
1902-0675	DIODE:BREAKDOWN 5% 15.4V	28480	1902-0675	1
1902-0770	DIODE:BREAKDOWN SILICON	28480	1902-0770	2
1902-3117	DIODE:BREAKDOWN 2% 6.34V	28480	1902-3117	1
1902-3119	DIODE:BREAKDOWN:6.49V 2%	28480	1902-3119	1
1903-0003	DIODE:SILICON 30V	28480	1903-0003	1
1910-0011	DIODE:GERMANIUM 5MA AT 1V	28480	1910-0011	5
1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	28480	1910-0016	145
1910-0023	DIODE:GERMANIUM 83 WIV	28480	1910-0023	1
1910-0025	DIODE:GE 15WIV 6NS	03877	1N995/5555G	6
1910-0037	DIODE:GERMANIUM	28480	1910-0037	1
1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	83594	85991	6
2100-0154	R:VAR COMP 1K OHM 30% LIN 0.15W	28480	2100-0154	1
2100-0273	R:VAR COMP 3 MEGOHM 20% 5 CCWLOG 1/4W	28480	2100-0273	1
2100-0355	R:VAR COMP 2000 OHM 20% LIN 1/8W	28480	2100-0355	1
2100-0364	R:VAR WW 20K OHM 5% LIN 1.0W	28480	2100-0364	2
2100-0369	R:VAR WW 200 OHM 10% LIN 1/4W	28480	2100-0369	3
2100-0371	R:VAR WW 1K OHM 10% LIN 1/4W	28480	2100-0371	2
2100-0490	R:VAR WW 100 OHM 10% 1/2W	28480	2100-0490	1
2100-0704	R:VAR WW 10K OHM 10% 2W	28480	2100-0704	1
2100-0708	R:VAR WW 20K OHM 10% 2W	28480	2100-0708	1
2100-0738	R:VAR COMP 200 OHM 10% 1W	28480	2100-0738	2
2100-0963	R:VAR WW 8 OHM 10% 2W	28480	2100-0963	2

See introduction to this section for ordering information

Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
2100-1420	R:VAR WW 200 OHM 5% 3/4W	28480	2100-1420	1
2100-1433	R:VAR WW 100 OHM 5% 3/4W	28480	2100-1433	3
2100-1454	R:VAR WW 50 OHM 5% 3/4W	28480	2100-1454	1
2100-1455	R:VAR WW 300 OHM 5% 3/4W	28480	2100-1455	1
2100-1456	R:VAR WW 2K OHM 5% 3/4W	28480	2100-1456	1
2110-0006	FUSE:CARTRIDGE 2AMP 125V SLOW BLOW	71400	MDL2	1
2110-0007	FUSE:CARTRIDGE 1 AMP 250V SLOW BLOW	75915	313001	1
2140-0037	LAMP:INCANDESCENT 0.04A 28V	24455	2187D	12
3100-0464	SWITCH:ROTARY 6 POLE 6 POS	28480	3100-0464	1
3100-0466	SWITCH:ROTARY W/250K OHM RESISTOR	28480	3100-0466	1
3100-0711	SWITCH:ROTARY 12 POLE 3 OR 4 POS	28480	3100-0711	1
3100-1402	SWITCH:ROTARY 8 POS 3 SECT	04404	3100-1402	1
3101-0001	SWITCH:TOGGLE SPST	04009	80994-H8	2
3101-0004	SWITCH:PUSHBUTTON SPDT	28480	3101-0004	1
3101-0005	SWITCH:TUG DPDT JAN #ST22N	04009	95691	1
3101-0033	SWITCH:SLIDE DPDT	79727	6510 C	1
3160-0026	FAN:TUBEAXIAL 50-60CPS	28480	3160-0026	1
3160-0097	FAN:TUBE AXIAL	28480	3160-0097	1
5060-2006	-35V REGULATOR & RESET CIRCUIT	04404	5060-2006	1
5060-2009	CONTROL LOGIC B	04404	5060-2009	1
5060-2010	CONTROL LOGIC C	04404	5060-2010	1
5060-2012	VOLTAGE COMPARATOR	04404	5060-2012	1
5060-2014	ATTENUATOR COUPLING LOGIC	04404	5060-2014	1
5060-2015	HP 2410B UNIT COUPLING LOGIC	04404	5060-2015	1
5060-2018	ATTENUATION CONTROL	04404	5060-2018	1
5060-2052	DISPLAY CONTROL	04404	5060-2052	1
5060-2108	HP 2411A DECIMAL POINT LOGIC	04404	5060-2108	1
5060-2111	LOGIC CARD	04404	5060-2111	1
5060-2181	OVERLOAD DETECTOR	04404	5060-2181	1
5060-2577	TRANSFORMER:PULSE	28480	5060-2577	1
5060-3639	DECIMAL LAMP ASSY	04404	5060-3639	1
5060-3691	RELAY TIME CIRCUIT	04404	5060-3691	1
5060-3771	AC & OHMS DELAY GATE	04404	5060-3771	1
5060-3781	REVERSIBLE DECADE COUNTER	04404	5060-3781	6
5060-3782	SERIES REGULATOR	04404	5060-3782	1
5060-3783	POWER SUPPLY AMPLIFIER	04404	5060-3783	1
5060-3805	+6V BIAS SUPPLY	04404	5060-3805	1
5060-3806	RECTIFIER/FILTER	04404	5060-3806	1
5060-3809	COUNTER CONTROL	04404	5060-3809	1
5060-3818	UNITS DISPLAY ASSY	04404	5060-3818	1
5060-3829	CONTROL LOGIC A	04404	5060-3829	1
5060-3830	-35V REGULATOR & RESET CIRCUIT	04404	5060-3830	1
5060-3838	BINARY PC	04404	5060-3830	2
5060-3848	OPERATIONAL AMPLIFIER	5060-	3848	1
5060-3849	POSITIVE CHANNEL	04404	5060-3849	1
5060-5001	NEGATIVE CHANNEL	04404	5060-5001	1
5060-5002	GATE CONTROL	04404	5060-5002	1
5060-5016	SCHMITT TRIGGER	04404	5060-5016	1
5060-5019	NEON PHOTOCONDUCTOR BLOCK ASSY	04404	5060-5019	1
5060-5115	ATTENUATOR ASSY	04404	5060-5115	1
5060-5145	OPERATIONAL AMPLIFIER	04404	5060-5145	1
5060-5610	LOGIC CARD	04404	5060-5610	1
5060-5655	OVERLOAD DETECTOR	04404	5060-5655	1
5060-5870	ATTENUATOR COUPLING LOGIC	04404	5060-5870	1

See introduction to this section for ordering information

Table 5-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
5060-5871	HP 2410B UNIT COUPLING LOGIC	04404	5060-5871	1
5060-5872	CONTROL LOGIC A	04404	5060-5872	1
5060-5873	CONTROL LOGIC C	04404	5060-5873	1
5060-5874	AC & OHMS DELAY GATE	04404	5060-5874	1
5060-5875	HP 2411A DECIMAL POINT LOGIC	04404	5060-5875	1
5060-6203	HP 2411A DECIMAL POINT LOGIC	04404	5060-6203	1
5060-6205	HP 2410B UNIT COUPLING LOGIC	04404	5060-6205	1
5060-6206	AC & OHMS DELAY GATE	04404	5060-6206	1
5060-6224	GATE CONTROL	04404	5060-6224	1
5060-6274	AMPLIFIER PC	04404	5060-6274	1
5060-6275	AMPLIFIER PC	04404	5060-6275	1
5080-1439	TRANSFORMER:PULSE (SHIELDED)	04404	5080-1439	2
5080-1454	TRANSFORMER:PULSE	28480	5080-1454	1
5080-1471	DIODE:BREAKDOWN 6.15-6.5V 400 MW	03877	SV9417	1
5080-6620	TRANSISTOR:SILICON NPN	28480	5080-6620	6
5080-6621	TRANSISTOR:SILICON NPN	28480	5080-6621	1
8159-0005	JUMPER WIRE	28480	8159-0005	9
9100-0211	TRANSFORMER:POWER	28480	9100-0211	1
9100-1201	TRANSFORMER:POWER	28480	9100-1201	1
9100-1211	TRANSFORMER:POWER	28480	9100-1211	1
9100-1221	TRANSFORMER:PULSE	28480	9100-1221	10
9100-2477	FILTER:LINE 115-0-115V 1.5A	28480	9100-2477	1
9110-0067	CHOKE:35 MH 1.5A	28480	9110-0067	1
9110-0103	FILTER:LINE 3 WIRE 1.5A	56289	JN10-11528	1
9130-0028	TRANSFORMER	56289	662808	2
9140-0027	COIL:FXD RF 35 UH	28480	9140-0027	1
9140-0040	COIL:FXD RF 42UH	99848	1042-15-420	1
9140-0053	CHOKE/COIL:FXD 1 MH 10%	99848	31000-15-102	1
9149-0075	COIL:FXD RF 270 UF	28480	9140-0075	1
9140-0082	COIL:FXD RF 15 UH	28480	9140-0082	1
9140-0107	COIL:FXD RF 27 MH 10%	99800	1840-38	2
9140-0112	COIL:FXD RF 4.7 UH	28480	9140-0112	1
9140-0174	COIL:FXD RF 220 MH 5%	76493	9210-92	2
9140-0210	COIL:FXD RF 100 UH 5%	28480	9140-0210	1
9140-0237	COIL:FXD 200 UH 5%	28480	9140-0237	1
05214-6014	INPUT AMPLIFIER	04404	05214-6014	1
05232-6006	INPUT TRIGGER	04404	05232-6006	1
05232-6007	INPUT AMPLIFIER	04404	05232-6007	1
5212A-65C	DECADE DIVIDER	28480	05212A-65C	5
5212A-65F	100KHZ OSCILLATOR	04404	5212A-65F	1
5212A-9A	TRANSFORMER	28480	5212A-9A	1

See introduction to this section for ordering information

2401C Section V

TABLE 5-3. 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.

Code No	Manufacturer	Address
00000	U S A Common	Any supplier of U S.
00136	McCoy Electronics	Mount Holly Springs, Pa
00213	Sage Electronics Corp	Rochester N Y
00287	Cemco Inc	Danielson Conn
00334	Humidial	Colton, Calif
00348	Microtron Co , Inc	Valley Stream N Y.
00373	Garlock Inc	Cherry Hill N J
00656	Aerovox Corp	New Bedford Mass
00779	Amp Inc	Harrisburg Pa
00781	Aircraft Radio Corp	Boonton N J
00815	Northern Engineering Laboratories Inc	
		Burlington Wis
00853	Sangamo Electric Co Pickens Div	
		Pickens S C
00866	Goe Engineering Co	City of Industry Cal
00891	Carl E Holmes Corp	Los Angeles Calif
00929	Microlab Inc	Livingston N J
01002	General Electric Co Capacitor Dept	
		Hudson Falls, N Y
01009	Alden Products Co	Brockton Mass
01121	Allen Bradley Co	Milwaukee Wis
01255	Litton Industries Inc	Beverly Hills, Calif
01281	TRW Semiconductors Inc	Lawndale Calif
01295	Texas Instruments Inc	
	Transistor Products Div	Dallas Texas
01349	The Alliance Mfg Co	Alliance Ohio
01589	Pacific Relays Inc	Van Nuys Calif
01670	Gudebrod Bros Silk Co	New York N Y
01930	Amerock Corp	Rockford Ill
01961	Pulse Engineering Co	Santa Clara Calif
02114	Ferroxcube Corp of America	Saugerties N Y.
02116	Wheelock Signals Inc	Long Branch, N J
02280	Cole Rubber and Plastics Inc	Sunnyvale Calif
02660	Amphenol Borg Electronics Corp	Broadview, Ill
02735	Radio Corp of America Semiconductor	
	and Materials Div	Somerville N J
02771	Vocaline Co of America Inc	
		Old Saybrook Conn
02777	Hopkins Engineering Co	San Fernando Calif
[illegible]	Hudson Tool & Die Co	Newark N J
03508	G E Semiconductor Prod Dept	Syracuse N Y
03705	Apex Machine & Tool Co	Dayton Ohio
03797	Eldema Corp	Compton Calif
03818	Parker Seal Co	Los Angeles Calif
03877	Transitron Electric Corp	Wakefield Mass
03888	Pyrofilm Resistor Co Inc	Cedar Knolls N J
03954	Singer Co Diehl Div	
	Finderne Plant	Somerville N J
04009	Arrow Hart and Hegeman Elect Co	
		Hartford Conn
04013	Taurus Corp	Lambertville N J
04062	Arco Electronics Inc	Great Neck N Y
04222	Hi Q Division of Aerovox	Myrtle Beach S C
04354	Precision Paper Tube Co	Wheeling Ill
04404	Dymec Division of Hewlett Packard Co	
		Palo Alto Calif
04651	Sylvania Electric Products Microwave	
	Device Div	Mountain View Calif
04673	Dakota Engr Inc	Culver City Calif
04713	Motorola Inc Semiconductor Prod Div	
		Phoenix Arizona
04732	Filtron Co Inc Western Div	
		Culver City Calif
04773	Automatic Electric Co	Northlake Ill
04796	Sequoia Wire Co	Redwood City Calif
04811	Precision Coil Spring Co	El Monte Calif
04870	P M Motor Company	Westchester Ill
04919	Component Mfg Service Co	
		W Bridgewater Mass
05006	Twentieth Century Plastics Inc	
		Los Angeles Calif
05245	Components Corp	Chicago Ill
05277	Westinghouse Electric Corp	
	Semi Conductor Dept	Youngwood Pa
05347	Ultronix Inc	San Mateo Calif
05397	Union Carbide Corp Elect Div	
		New York N Y
05574	Viking Ind Inc	Canoga Park Calif
05593	Icore Electro Plastics Inc	Sunnyvale Calif
05616	Cosmo Plastic	
	(c o Electrical Spec Co)	Cleveland Ohio
05624	Barber Colman Co	Rockford Ill
05728	Tiffen Optical Co	
		Roslyn Heights Long Island N Y
05729	Metro Tel Corp	Westbury, N Y
05783	Stewart Engineering Co	Santa Cruz Calif
05820	Wakefield Engineering Inc	Wakefield Mass
06004	Bassick Co Div of Stewart Warner Corp	
		Bridgeport Conn
06090	Raychem Corp	Redwood City, Calif
06175	Bausch and Lomb Optical Co	Rochester N Y
06402	E T A Products Co of America	Chicago Ill
06540	Amatom Electronic Hardware Co Inc	
		New Rochelle N Y
06555	Beede Electrical Instrument Co Inc	
		Penacook N H
06666	General Devices Co Inc	Indianapolis Ind
06751	Components Inc Ariz Div	Phoenix Ariz
06812	Torrington Mfg Co West Div	
		Van Nuys Calif
06980	Varian Assoc Eimac Div	San Carlos Calif
07088	Kelvin Electric Co	Van Nuys Calif
07126	Digitran Co	Pasadena Calif
07137	Transistor Electronics Corp	Minneapolis Minn
07138	Westinghouse Electric Corp	
	Electronic Tube Div	Elmira N Y
07149	Filmohm Corp	New York N Y
07233	Cinch Graphik Co	City of Industry Calif
07256	Silicon Transistor Corp	Carle Place N Y
07261	Avnet Corp	Culver City Calif
0726?	Fairchild Camera & Inst Corp	
	Semiconductor Div	Mountain View Calif
07322	Minnesota Rubber Co	Minneapolis Minn
0736?	Birtcher Corp The	Monterey Park Calif
07397	Sylvania Elect Prod Inc	Mt View Operations
		Mountain View Calif
07700	Technical Wire Products Inc	Cranford N J
07829	Bodine Elect Co	Chicago Ill
07910	Continental Device Corp	Hawthorne Calif
07933	Raytheon Mfg Co	
	Semiconductor Div	Mountain View Calif
07980	Hewlett Packard Co Boonton Radio Div	
		Rockaway N J
08145	U S Engineering Co	Los Angeles Calif
08289	Blinn Delbert Co	Pomona Calif
08358	Burgess Battery Co	
		Niagara Falls Ontario Canada
08524	Deutsch Fastener Corp	Los Angeles Calif
08664	Bristol Co The	Waterbury Conn
08717	Sloan Company	Sun Valley Calif
08718	ITT Cannon Electric Inc Phoenix Div	
		Phoenix Arizona
08727	National Radio Lab Inc	Paramus N J
08792	CBS Electronics Semiconductor	
	Operations Div of C B S Inc	
		Lowell Mass
08806	General Electric Co Miniature Lamp Dept	
		Cleveland Ohio
08984	Mel Rain	Indianapolis Ind
09026	Babcock Relays Div	Costa Mesa Calif
09134	Texas Capacitor Co	Houston Texas
09145	Tech Ind Inc Atohm Elect	Burbank Calif
09250	Electro Assemblies Inc	Chicago, Ill
09353	C & K Components Inc	Newton Mass
09569	Mallory Battery Co of	
	Canada Ltd	Toronto Ontario, Canada
09922	Burndy Corp	Norwalk, Conn
10214	General Transistor Western Corp	
		Los Angeles, Calif
10411	Ti Tal Inc	Berkeley, Calif
10646	Carborundum Co	Niagara Falls N Y
11236	CTS of Berne Inc	Berne, Ind
11237	Chicago Telephone of California, Inc	
		So Pasadena, Calif
11242	Bay State Electronics Corp	Waltham, Mass
11312	Teledyne Inc Microwave Div	Palo Alto Calif
11314	National Seal	Downey Calif
11453	Precision Connector Corp	Jamaica, N.Y.
11534	Duncan Electronics Inc	Costa Mesa, Calif
11711	General Instrument Corp Semiconductor	
	Div / Products Group	Newark N J
11717	Imperial Electronic Inc	Buena Park Calif
11870	Melabs, Inc	Palo Alto Calif
12040	National Semiconductor	Danbury Conn
12136	Philadelphia Handle Co	Camden, N J
12361	Grove Mfg Co Inc	Shady Grove Pa
12574	Gulton Ind Inc D[illegible] Div	
		Albuquerque N M
12697	Clarostat Mfg Co	Dover N H
12728	Elmar Filter Corp	W Haven, Conn
12859	Nippon Electric Co Ltd	Tokyo Japan
12881	Metex Electronics Corp	Clark N J
12930	Delta Semiconductor Inc	Newport Beach Calif
12954	Dickson Electronics Corp	Scottsdale Arizona
13103	Thermolloy	Dallas Texas
13396	Telefunken (GmbH)	Hanover Germany
13835	Midland Wright Div of Pacific Industries Inc	
		Kansas City Kansas
14099	Sem Tech	Newbury Park Calif
14193	Calif Resistor Corp	Santa Monica Calif
14298	American Components Inc	Conshohocken Pa
14433	ITT Semiconductor A Div of Int Telephone	
	& Telegraph Corp	West Palm Beach Fla
14493	Hewlett Packard Company	Loveland Colo
14655	Cornell Dubilier Electric Corp	Newark N J
14674	Corning Glass Works	Corning N Y
14752	Electro Cube Inc	San Gabriel Calif
14960	Williams Mfg Co	San Jose Calif
15203	Webster Electronics Co	New York N Y
15287	Scionics Corp	Northridge Calif
15291	Adjustable Bushing Co	N Hollywood Calif
15558	Micron Electronics	
		Garden City Long Island N Y
15566	Amprobe Inst Corp	Lynbrook N Y
15631	Cabletronics	Costa Mesa Calif
15772	Twentieth Century Coil Spring Co	
		Santa Clara Calif
15801	Fenwal Elect Inc	Framingham Mass
15818	Amelco Inc	Mt View Calif
16037	Spruce Pine Mica Co	Spruce Pine N C
16179	Omni Spectra Inc	Farmington Mich
16352	Computer Diode Corp	Lodi N J
16585	Boots Aircraft Nut Corp	Pasadena Calif
16688	Ideal Prec Meter Co Inc	
	De Jur Meter Div	Brooklyn N Y
16758	Delco Radio Div of G M Corp	Kokomo Ind
17109	Thermonetics Inc	Canoga Park Calif
17474	Tranex Company	Mountain View Calif
17554	Components Inc	Biddeford Me
17675	Hamlin Metal Products Corp	Akron Ohio
17745	Angstrohm Prec Inc	No Hollywood Calif

TABLE 5-3. CODE LIST OF MANUFACTURERS (Continued)

Code No	Manufacturer	Address
17870	McGraw Edison Co	Manchester N H
18042	Power Design Pacific Inc	Palo Alto Calif
18083	Clevite Corp Semiconductor Div	
		Palo Alto Calif
18324	Signetics Corp	Sunnyvale Calif
18476	Ty Car Mfg Co Inc	Holliston Mass
18486	TRW Elect Comp Div	Des Plaines Ill
18583	Curtis Instrument Inc	Mt Kisco N Y
18612	Vishay Instruments Inc	Malvern Pa
18873	E I DuPont and Co Inc	Wilmington Del
18911	Durant Mfg Co	Milwaukee Wis
19315	The Bendix Corp Navigation & Control Div	
		Teterboro N J
19500	Thomas A Edison Industries Div of	
	McGraw Edison Co	West Orange N J
19589	Concoa	Baldwin Park Calif
19644	LRC Electronics	Horseheads N Y
19701	Electra Mfg Co	Independence Kansas
20183	General Atronics Corp	Philadelphia Pa
21226	Executone Inc	Long Island City, N Y
21335	Fafnir Bearing Co The	New Britain Conn
21520	Fansteel Metallurgical Corp	N Chicago Ill
23042	Texscan Corp	Indianapolis Ind
23783	British Radio Electronics Ltd	Washington D C
24455	G E Lamp Division	
		Nela Park Cleveland Ohio
24655	General Radio Co	West Concord Mass
24681	Memcor Inc Comp Div	Huntington Ind
24796	Parelco Inc	San Juan Capistrano Calif
26365	Gries Reproducer Corp	New Rochelle N Y
26462	Grobet File Co of America Inc	
		Carlstadt N J
26851	Compac Hollister Co	Hollister Calif
26992	Hamilton Watch Co	Lancaster Pa
27251	Specialties Mfg Co Inc	Stratford Conn
28480	Hewlett Packard Co	Palo Alto Calif
28520	Heyman Mfg Co	Kenilworth N J
30817	Instrument Specialties Co Inc	
		Little Falls N J
33173	G E Receiving Tube Dept	Owensboro Ky
35434	Lectrohm Inc	Chicago Ill
36196	Stanwyck Coil Products Ltd	
		Hawkesbury Ontario Canada
36287	Cunningham W H & Hill Ltd	
		Toronto Ontario Canada
37942	P R Mallory & Co Inc	Indianapolis Ind
39543	Mechanical Industries Prod Co	Akron Ohio
40920	Miniature Precision Bearings Inc	Keene N H
42190	Muter Co	Chicago Ill
43990	C A Norgren Co	Englewood Colo
44655	Ohmite Mfg Co	Skokie Ill
46384	Penn Eng & Mfg Corp	Doylestown Pa
47904	Polaroid Corp	Cambridge Mass
48620	Precision Thermometer & Inst Co	
		Southampton Pa
49956	Microwave & Power Tube Div	Waltham Mass
52090	Rowan Controller Co	Westminster Md
52983	Sanborn Company	Waltham Mass
54294	Shallcross Mfg Co	Selma N C
55026	Simpson Electric Co	Chicago Ill
55933	Sonotone Corp	Elmsford N Y
55938	Raytheon Co Commercial Apparatus &	
	Systems Div	So Norwalk Conn
56137	Spaulding Fibre Co Inc	Tonawanda N Y
56289	Sprague Electric Co	North Adams Mass
59446	Telex Corp	Tulsa Okla
59730	Thomas & Betts Co	Elizabeth N J
60741	Triplett Electrical Inst Co	Bluffton Ohio
61775	Union Switch and Signal Div of	
	Westinghouse Air Brake Co	Pittsburgh Pa
62119	Universal Electric Co	Owosso Mich
63743	Ward Leonard Electric Co	Mt Vernon N Y
64959	Western Electric Co Inc	New York N Y
65092	Weston Inst Inc Weston Newark	Newark N J
66295	Wittek Mfg Co	Chicago Ill
66346	Minnesota Mining & Mfg Co Revere Mincom Div	
		St Paul Minn
70276	Allen Mfg Co	Hartford Conn
70309	Allied Control	New York N Y
70318	Allmetal Screw Product Co Inc	
		Garden City N Y
70417	Amperex Div of Chrysler Corp	Detroit Mich
70485	Atlantic India Rubber Works Inc	Chicago Ill
70563	Amperite Co Inc	Union City N J
70674	ADC Products Inc	Minneapolis Minn
70903	Belden Mfg Co	Chicago Ill
70998	Bird Electronic Corp	Cleveland Ohio
71002	Birnbach Radio Co	New York N Y
71034	Bliley Electric Co Inc	Erie Pa
71041	Boston Gear Works Div of Murray Co	
	of Texas	Quincy Mass
71218	Bud Radio Inc	Willoughby Ohio
71279	Cambridge Thermionic Corp	Cambridge Mass
71286	Camloc Fastener Corp	Paramus N J
71313	Cardwell Condenser Corp	
		Lindenhurst L I N Y
71400	Bussmann Mfg Div of McGraw Edison Co	
		St Louis Mo
71436	Chicago Condenser Corp	Chicago Ill
71447	Calif Spring Co Inc	Pico Rivera Calif
71450	CTS Corp	Elkhart Ind
71468	ITT Cannon Electric Inc	Los Angeles Calif
71471	Cinema Div Aerovox Corp	Burbank Calif
71482	C P Clare & Co	Chicago Ill
71590	Centralab Div of Globe Union Inc	
		Milwaukee Wis
716??	[illegible]	Chicago Ill
71700	[illegible] The	New York N Y
717??	[illegible] Inc	Providence R I
71744	Chicago Miniature Lamp Works	Chicago Ill
71785	Cinch Mfg Co Howard B Jones Div	
		Chicago Ill
71984	Dow Corning Corp	Midland Mich
72136	Electro Motive Mfg Co Inc	Willimantic Conn
72619	[illegible]	[illegible] N Y
72656	Indiana General Corp Electronics Div	
		Keasbey N J
72699	[illegible]	[illegible] Newark, N J
72765	Drake Mfg Co	[illegible]
72825	Hugh H Eby Inc	Philadelphia Pa
72928	[illegible]	Chicago Ill
72962	[illegible]	[illegible] N J
72964	[illegible]	Los Angeles Calif
72982	[illegible]	Erie Pa
73061	[illegible] Mfg Co	[illegible]
73076	[illegible]	Chicago Ill
73138	[illegible]	
		[illegible] Calif
73293	Hughes [illegible]	[illegible]
	[illegible]	[illegible] Calif
73445	Amperex Electronic [illegible]	[illegible] N Y
73506	[illegible]	New Haven Conn
73559	Carling Electric [illegible]	Hartford Conn
73586	[illegible] Mfg Co	[illegible]
7368?	[illegible]	
	[illegible]	Philadelphia Pa
73734	[illegible]	Chicago Ill
737??	[illegible] Mfg Co	Cincinnati Ohio
73793	[illegible] The	[illegible] Ohio
7384?	[illegible]	[illegible] Ind
[illegible]	[illegible]	[illegible]

TABLE 5-3.

CODE LIST OF MANUFACTURERS (Continued)

Code No	Manufacturer	Address
80486	All State Ceramics Inc	Defiance Ohio
80509	Avery Label Co	Monrovia Calif
80583	Hollingsead Co Inc	Mars Hill, N C
80640	Stevens-Arnold Co Inc	Boston Mass
80811	Ohmite Mfg Co	Skokie, Ill
81010	International Instruments Inc	Orange Conn
81073	Graphtol Co	LaGrange Ill.
81095	Triad Transformer Corp	Venice Calif
81312	Winchester Elec Div of Litton Ind Inc	Oakville Conn
81349	Military Specification	
81483	International Rectifier Corp	El Segundo Calif
81541	Airpax Electronics Inc	Cambridge Maryland
81610	Barry Controls Div Barry Wright Corp	Watertown Mass
81947	Carter Precision Electric Co	Skokie, Ill
82087	Speer Faraday Inc Copper Hewitt Electric Div	Hoboken, N J
82116	Electric Regulator Corp	Norwalk Conn
82142	Jeffers Electronics Division of Speer Carbon Co	Du Bois, Pa
82170	Fairchild Camera & Instr Corp Space & Defense System Div.	Paramus, N J
82209	Maguire Industries Inc	Greenwich Conn
82219	Sylvania Electric Prod Inc Electronic Tube Division	Emporium, Pa
82376	Ashton Corp	East Newark Harrison N J
82389	Switchcraft Inc	Chicago Ill
82647	Metals & Controls Inc Spencer Products	Attleboro Mass
82866	Phillips Advance Control Co	Joliet, Ill
82964	Research Products Corp	Madison, Wis
83017	Hutton Mfg Co Inc	Woodstock N Y
83093	Vector Electronics Co	Glendale Calif
83014	Hartwell Corp	Los Angeles Calif
83058	Carl Eastener Co	Cambridge, Mass
83061	New Hampshire Ball Bearing Inc	Peterborough, N H
83179	General Instrument Corp Capacitor Div	Darlington S C
83180	ITT Wire and Cable Div	Los Angeles, Calif
83181	Victory Eng Corp	Springfield, N J
83298	Hamlin Corp Red Bank Div	Red Bank, N J
83315	Rubbell Corp	Mundelein Ill
83324	Rosan Inc	Newport Beach, Calif
83330	Smith Herman H Inc	Brooklyn N Y
83332	Tech Labs	Palisades Park N J
83388	Central Screw Co	Chicago, Ill
83501	Gavitt Wire and Cable Co Div of Amerace Corp	Brookfield, Mass
83594	Burroughs Corp Electronic Tube Div	Plainfield, N J
83740	Union Carbide Corp Consumer Prod Div	New York, N Y
83777	Model Eng and Mfg Inc	Huntington Ind
83821	Lloyd Scruggs Co	Festus Mo
83942	Aeronautical Instr & Radio Co	Lodi N J
84171	Arco Electronics Inc	Great Neck, N Y
84196	A J Glesener Co Inc	San Francisco, Calif
84411	TRW Capacitor Div	Ogallala, Neb
84970	Sarkes Tarzian Inc	Bloomington, Ind
85454	Bonnica Molding Company	Boonton, N J
85471	A D Lloyd Co	San Francisco, Calif
85474	R M Bozzamonte & Co	San Francisco Calif
85660	Rolled Rods Inc	Hamden, Conn
85911	Seamless Rubber Co	Chicago, Ill
86176	Fafnir Bearing Co	Los Angeles Calif
86197	Clifton Precision Products Co Inc	Clifton Heights Pa
86579	Precision Rubber Products Corp	Dayton, Ohio
86684	Radio Corp Of America Electronic Comp & Devices Div	Harrison, N J
86928	Spectrum Mfg Co	Glendale, Calif.
87034	Norris Industries	Anaheim, Calif.
87216	Philco Corporation (Lansdale Division)	Lansdale Pa
87473	Western Filtrons Glass Products Co	San Francisco, Calif
87664	Van Waters & Rogers Inc	San Francisco, Calif.
87930	Tower Mfg Corp	Providence, R I
88140	Cutler Hammer Inc	Lincoln, Ill.
88220	Gould National Batteries Inc	St. Paul, Minn
88698	General Mills Inc	Buffalo, N Y
89731	Graybar Electric Co	Oakland, Calif
89873	D I Distributing Corp	Schenectady, N Y
89963	United Transformer Co	Chicago, Ill
90013	United Shoe Machinery Corp	Beverly, Mass
90179	U S Rubber Co Consumer Ind & Plastics Prod Div	Passaic, N J
90970	Bearing Engineering Co	San Francisco, Calif
91146	ITT Cannon Elect. Inc Salem Div	Salem, Mass
91260	Conrad Spring Mfg Co	San Francisco, Calif
91338	Metals Heat & Appropriate Co	El Monte, Calif
91418	Radio Materials Co	Chicago, Ill
91506	Augat Inc	Attleboro Mass
91637	Dale Electronics, Inc	Columbus, Nebr
91662	Elco Corp	Willow Grove, Pa
91737	Glenair Mfg Co Inc	Wakefield, Mass
91827	K F Development Co	Redwood City, Calif
91836	Malco Mfg Co Inc	Chicago, Ill
91929	Honeywell Inc Micro Switch Div	Freeport, Ill
91961	Hahn Brass Spring Co	Oakland, Calif
92160	The Capacitor Corp	Peabody, Mass
92367	Elgeet Optical Co Inc	Rochester, N Y
92607	Tensolite Insulated Wire Co Inc	Tarrytown, N Y
92702	IMC Magnetics Corp	Westbury Long Island, N Y
92916	Hudson Lamp Co	Kearney, N J
93332	Sylvania Electric Prod Inc Semiconductor Div	Woburn, Mass
93369	Robbins & Myers Inc	Palisades Park N J
93410	Stevens Controls Div of Essex Wire Corp	Mansfield, Ohio
93632	Waters Mfg Co	Culver City, Calif
93829	G V Controls	Livingston, N J
94137	General Cable Corp	Bayonne N J
94142	Phelps Dodge	Yonkers N Y
94144	Raytheon Co Comp Div Ind Comp Operations	Quincy, Mass
94148	Sterling Electronics Products, Inc	Loveland, Colo
94154	Wagner Elect Corp Tung Sol Div	Newark N J
94197	Curtiss Wright Corp Electronics Div	East Paterson, N J
94222	South Chester Corp	Chester, Pa
94360	Wire Cloth Products, Inc	Bellwood, Ill
94375	Automatic Metal Products Co	Brooklyn, N Y
94582	Worcester Pressed Aluminum Corp	Worcester, Mass
94696	Magnecraft Electric Co	Chicago, Ill
95071	George A Philbrick Researchers Inc	Boston, Mass
95236	Allies Products Corp	Davis, Fla
95238	Continental Connector Corp	Woodside, N Y
95243	Leecraft Mfg Co Inc	Long Island, N Y
95265	National Coil Co	Sheridan Wyo
95275	Vitramon, Inc	Bridgeport, Conn
95348	Gordos Corp	Bloomfield, N J
95354	Methode Mfg Co	Rolling Meadows, Ill
95566	Arnold Engineering Co	Marengo, Ill.
95742	Dage Electric Co Inc	Franklin, Ind
95984	Simpson Mfg Co	Wayne, Ill
95987	Weckesser Co	Chicago, Ill.
96067	Microwave Assoc., West Inc	Sunnyvale, Calif.
96095	Fil Q Div of Aerovox Corp	Olean, N Y
96256	Thordarson-Meissner Inc	Mt Carmel, Ill
96296	Solar Manufacturing Co	Los Angeles, Calif
96306	Microswitch, Div. of Minn. Honeywell	Freeport, Ill.
96330	Chelton Screw Co	Chicago, Ill.
96341	Microwave Associates, Inc	Burlington, Mass
96501	Excel Transformer Co	Oakland, Calif.
96733	San Fernando Elect. Mfg. Co.	San Fernando, Calif.
96881	Thomson Ind Inc.	Long Is., N Y.
97464	Industrial Retaining Ring Co	Irvington, N J
97539	Automatic & Precision Mfg	Englewood, N J.
97979	Reon Resistor Corp	Yonkers, N Y.
97983	Litton System Inc Adler-Westrex Commun Div	New Rochelle, N Y
98141	R-Tronics, Inc	Jamaica, N Y
98159	Rubber Teck, Inc.	Gardena, Calif
98220	Hewlett-Packard Co Moseley Div	Pasadena, Calif.
98278	Microdot, Inc	So Pasadena, Calif
98291	Seatectro Corp	Mamaroneck, N Y
98376	Zero-Mfg Co	Burbank, Calif
98410	J F D Inc	Cleveland, Ohio
98731	General Mills Inc Electronics Div	Minneapolis, Minn
98734	Poeco Div. of Hewlett Packard Co	Palo Alto, Calif.
98821	North Hills Electronics, Inc	Glen Cove, N Y
98978	International Electronic Research Corp	Burbank, Calif
99109	Columbia Technical Corp	New York, N Y.
99313	Varian Associates	Palo Alto, Calif.
99378	Ajlep Corp	Winchester, Mass.
99515	Marshall Ind Capacitor Div	Monrovia, Calif
99707	Control Switch Division, Controls Co of America	El Segundo, Calif.
99800	Delevan Electronics Corp	East Aurora, N Y
99848	Wilco Corporation	Indianapolis, Ind
99928	Bramson Corp	Whippany, N J.
99934	Renbrandt, Inc	Boston, Mass
99942	Hoffman Electronics Corp Semiconductor Div	El Monte, Calif.
99957	Technology Instrument Corp of Calif	Newbury Park, Calif

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK

00001	Malco Tool and Die	Los Angeles, Calif
00002	Willow Leather Products Corp	Newark, N J
00AAB	LTA	England
00BBB	Precision Instrument Components Co	Van Nuys, Calif
00CCS	Hewlett-Packard Co., Colorado Springs	Colorado Springs, Colorado
00MM	Rubber Eng & Development	Hayward, Calif
00NN	A N D Mfg Co	San Jose, Calif
00QQ	Coelition	Oakland, Calif
00WW	Californeia Eastern Lab	Burlington, Calif
00YY	S K Smith Co	Los Angeles, Calif

MANUAL SUPPLEMENT

Model HP-2401C
Integrating Digital Voltmeter
Option 21

21.1 GENERAL DESCRIPTION

The HP-2401C-21 Integrating Digital Voltmeter provides positive true recorder outputs in 8-4-2-1 binary code instead of the 4-2'-2-1 code provided by the standard HP-2401C recorder outputs. (See Tables 2-4 and 21-1.) Except for this difference in coding, the specifications in Section 1.7 apply without change to the HP-2401C-21.

21.2 INSTALLATION AND OPERATION

Install, operate, and program the HP-2401C-21 as specified in Section II of this manual.

21.3 THEORY OF OPERATION

The theory of operation of the HP-2401C-21 is the same as that of the standard HP-2401C except as noted in the following paragraphs.

21.3.1 Printer Coupling Logic A22 (Figure 21-1)

The logic and circuitry shown in Figure 21-1 converts decimal and function inputs to 8-4-2-1 BCD outputs for recording. The decimal 10^{-n} and function numbers from this assembly are identical to those from a standard printer coupling logic assembly, but they are in 8-4-2-1 code instead of 4-2'-2-1 code.

21.3.2 Reversible Decade Counters A11-A15 and A46 (Figure 21-2)

The decade counter shown in Figure 21-2 differs from that shown in Figure 4-17 only in the arrangement of feedback. The waveforms associated with forward and backward counting of HP-2401C-21 decades are shown in the circuit diagram, Figure 21-2.

The decades always count up during frequency measurements and during the first phase of voltage measurements. Up counting is enabled when the count $\overline{\text{down}}$ line is clamped to ground (positive true) and the count $\overline{\text{up}}$ line is near -35v. Both of these signals are provided by Counter Control Logic on A16. These states close the down count AND gates and open the up count AND gates. Positive triggers are coupled from the collectors of odd-numbered transistors (Q1, Q3, Q5, Q7) to succeeding stages. Each trigger advances the count by one. When the count is advanced from nine to zero, the turn on of Q7 generates a trigger that increases by one the count in the

next decade, and so on through all six counting units. The up count progression is as follows:

Up Count	Even-Numbered Transistors On	BCD Output Table
0	None	0
1	Q2	1
2	Q4	2
3	Q2, Q4	1 + 2
4	Q6	4
5	Q2, Q6	1 + 4
6	Q4, Q6	2 + 4
7	Q2, Q4, Q6	1 + 2 + 4
8	Q8	8
9	Q2, Q8	1 + 8
10	None	0 + Trigger to Next Decade

At the forward count of eight, conduction through Q8 and CR20 inhibits triggering of Q3-Q4 by Q1, assuring that Q3-Q4 and Q5-Q6 remain in zero state (Q3 and Q5 on), when the count of ten resets Q1-Q2 to zero state. The resetting of Q1-Q2 to zero state also resets Q7-Q8 to zero state through forward count AND diode CR13 and OR diode CR21.

Down counting is commanded by the Counter Control Logic on A16 when the polarity of the input voltage reverses. This is enabled by the positive-true state of the count $\overline{\text{up}}$ line, which closes the up count AND gates, and the negative-true state (near -35v) of the count $\overline{\text{down}}$ line, which opens the $\overline{\text{down}}$ count AND gates. Positive triggers are then coupled from the collectors of even-numbered transistors to succeeding stages. The count progression is exactly the reverse of the up count progression, which is summarized above.

Starting from the zero state:

a. The first reverse count trigger sets binary Q1-Q2, triggering binaries Q3-Q4, Q5-Q6, and Q7-Q8 to set state through reverse count AND diodes CR14, CR16, and CR18. Turn-on of Q8 triggers binaries Q3-Q4 and Q5-Q6 back to zero state, leaving Q2 and Q8 on, representing a nine count.

b. The next trigger sets Q1-Q2 to zero state, reducing the count to eight.

c. The third trigger sets Q2, Q4, and Q6 on, which resets Q7-Q8 to zero state, establishing the count of seven.

The remaining triggers continue subtraction as indicated so long as the reverse count is enabled. Each time a trigger sets the decade from zero to nine during reverse counting, the turn on of Q8 triggers the next decade through reverse count AND diode CR22, reducing the count of the next decade by one.

21.4 MAINTENANCE

Figures 4-17, 4-23, and 4-24 are superseded by Figures 21-1 and 21-2 in this section; performance checks 15 and 16 of Table 4-3 are replaced by checks 21.1 and 21.2 in Table 21-2. Otherwise, the maintenance instructions in Section IV of this manual are directly applicable without change to the HP-2401C-21.

Table 21-1 Function Coding

Data	Function	Logic	8	4	2	1
0	Period (W/30)		0	0	0	0
1	+VDC		0	0	0	1
2	-VDC		0	0	1	0
3	KC		0	0	1	1
4	KΩ (W/HP-2410B)		0	1	0	0
5	MΩ (W/HP-2410B)		0	1	0	1
6	Spare		0	1	1	0
7	Spare		0	1	1	1
8	Time		1	0	0	0
9	Overload		1	0	0	1
	VAC (W/HP-2410B)		1	0	1	1

21.5 PARTS LIST

The Parts List in Section V of this manual applies to the HP 2401C-21 except as indicated in Tables 21-3 and 21-4.

Table 21-2. In-Cabinet Performance Checks
Perform checks 1 through 14 and 17 through 24 as specified in Table 4-3 and Section 4.2.

21.1 RECORDING OUTPUTS - BCD FUNCTION

1 digit.
4-line 8-4-2-1 code.
"0" state level, -35 to -24.5V; "1" state level, -2.5 to 0V.
Source impedance, 33K.

a. Determine and record dc function levels at the following pins of J2:

Function	Control Settings	J2 Pin:	41	40	16	15
		Code:	8	4	2	1
+VDC	VOLTS, INT+1V		0	0	0	1
-VDC	VOLTS, INT-1V		0	0	1	0
KC	FREQ		0	0	1	1
KΩ (W/DY-2410B)	EXT SEL, 1V		0	1	0	0
MΩ (W/DY-2410B)	EXT SEL, 1V		0	1	0	1
OVERLOAD	VOLTS, 1V*		1	0	0	1
VAC (W/DY-2410B)	EXT SEL, 1V		1	0	1	1

*W/dc input sufficient to produce OVERLOAD indication.

b. The source impedance is determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram in Figure 21-1.

21.2 RECORDING OUTPUTS - BCD DECIMAL POINT

Specifications same as for 21-1.

a. Set HP-2401C FUNCTION switch to VOLT, other controls as specified below; determine and record dc decimal levels at the following pins of J2; short-circuit HI, LO, and GUARD terminals to assure all zeros reading.

Range	Sample Period	Decimal Position	J2 Pin:	27	26	2	1	
			Code:	8	4	2	1	
1000V	.01 Sec	000000. V		0	0	0	0	(10^{-0})
1000V	0.1 Sec	00000.0 V		0	0	0	1	(10^{-1})
100 V	0.1 Sec	0000.00 V		0	0	1	0	(10^{-2})
10 V	0.1 Sec	000.000 V		0	0	1	1	(10^{-3})
1 V	0.1 Sec	00.0000 V		0	1	0	0	(10^{-4})
0.1 V	0.1 Sec	0000.00 MV		0	1	0	1	(10^{-5})
0.1 V	1.0 Sec	000.000 MV		0	1	1	0	(10^{-6})
0.1 V	1.0 Sec	00.0000 MV		0	1	1	1**	(10^{-7})

**W/HP-2411A at +10 gain (10 MV full scale), FUNCTION at EXT SEL, Card A30 installed.

b. Disconnect short from HI, LO, and GUARD terminals. Set HP-2401C FUNCTION switch to FREQ, ATTENUATION control just clockwise from switched CHECK position, other controls as specified below. Use DC Null Voltmeter to check decimal levels at the following pins of J2.

Sample Period	Decimal Position	J2 Pin:	27	26	2	1	
		Code:	8	4	2	1	
.01 Sec	00000.0 KC		0	0	0	1	(10^{-1})
0.1 Sec	0000.00 KC		0	0	1	0	(10^{-2})
1.0 Sec	000.000 KC		0	0	1	1	(10^{-3})
STOP	000000		1	0	1	1	(10^{-0})

c. The source impedances are determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram in Figure 21-1.

HP-2401C PERFORMANCE CHECK TEST CARD

SER ____ - ____ DATE ____

DESCRIPTION	CHECK RESULTS

21.1 RECORDING OUTPUTS - BCD FUNCTION

Function:	Outputs Correct at J2 Pins 41	40	16	15	
+VDC	0	0	0	1	?
-VDC	0	0	1	0	?
KC	0	0	1	1	?
KΩ	0	1	0	0	?
MΩ	0	1	0	1	?
OVERLOAD	1	0	0	1	?
VAC	1	0	1	1	?

(yes)

21.2 RECORDING OUTPUTS - BCD DECIMAL POINT

Display:	Outputs Correct at J2 Pins 27	26	2	1	
000000. V	0	0	0	0	?
00000.0 V	0	0	0	1	?
0000.00 V	0	0	1	0	?
000.000 V	0	0	1	1	?
00.0000 V	0	1	0	0	?
0000.00 MV	0	1	0	1	?
000.000 MV	0	1	1	0	?
00.0000 MV	0	1	1	1	?
00000.0 KC	0	0	0	1	?
0000.00 KC	0	0	1	0	?
000.000 KC	0	0	1	1	?
000000	1	0	1	1	?

(yes)

"1" = -2.5 to 0V DC.

"0" = -35. to -24.5V DC.

Table 21-3. Reference Designation Index

Reference Designation	Part No.	Description #	Note
		OPTION 21 **A11 5060-5066**	
		MAKE THE FOLLOWING CHANGES TO TABLE 5-1 TO MAKE THE TABLE APPLICABLE TO THE HP2401C-21:	
		DELETE THE FOLLOWING:	
A11- A15	5060-3781	REVERSIBLE DECADE COUNTER	
A22	5060-2111	LOGIC CARD	A-E
	5060-5610	LOGIC CARD	F-X
A46	5060-5066	REVERSIBLE DECADE COUNTER	
		ADD THE FOLLOWING:	
A11- A15	5060-5066	REVERSIBLE DECADE COUNTER	
A22	5060-5611	PRINTER COUPLING LOGIC	
A46	5060-5066	REVERSIBLE DECADE COUNTER	
A11	**5060-5066**	**REVERSIBLE DECADE COUNTER**	
A11A1	NSR	READOUT BLOCK ASSY	
A11C1- A11C6	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C7	0140-0219	C:FXD MICA 180 PF 5%	
A11C8	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C9	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C10	0140-0194	C:FXD MICA 110 PF 5%	
A11C11	0140-0194	C:FXD MICA 110 PF 5%	
A11C12	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C13- A11C18	0140-0194	C:FXD MICA 110 PF 5%	
A11CR1- A11CR8	1901-0025	DIODE:SILICON 100WV 100MA	
A11CR9- A11CR24	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR26- A11CR34	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11Q1- A11Q8	1850-0184	TRANSISTOR:GERMANIUM PNP	
A11R1	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R2	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R3	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R4	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R5	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R6	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R8	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R9	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R10	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	

Table 21-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 21 A11 5060-5066 (CONT'D)	
A11R11	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R12	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R13	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R14	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R15	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R16	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R17- A11R23	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R24	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R25	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R26	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A11R27	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R28	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R29	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R30	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R31	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R32	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R33	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R34	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R35	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R36	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R37	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R38	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R39- A11R46	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A11R47	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R48	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R49	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R50	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R51	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R52	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R53	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R54	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R55	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R56	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R57	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R58	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R59	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R60	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R61	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R62	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R63	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R64	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R65	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R66	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A11R67	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R68	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R69	0686-4735	R:FXD COMP 47K OHM 5% 1/2W	
A11R70	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11V1	1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	

2401C

Table 21-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 21 A12-A15 5060-5066 A22 5060-5611	
A12		SAME AS A11, USE PREFIX A12	
A13		SAME AS A11, USE PREFIX A13	
A14		SAME AS A11, USE PREFIX A14	
A15		SAME AS A11, USE PREFIX A15	
A22	5060-5611	PRINTER COUPLING LOGIC	
A22CR1- A22CR6	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR10	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR12	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR13	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR16	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR18	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR19	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR20	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR21	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR23	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR25	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR27	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR28	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR37	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR38	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR39	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A22CR40- A22CR45	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR48	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR49	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR50	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR52	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR53	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR54	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22Q1- A22Q16	1850-0111	TRANSISTOR:GERMANIUM PNP	
A22R1	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R2	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R3	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R4	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R5	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R6	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R7	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R8	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R9	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R10	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	

Table 21-3. Reference Designation Index (Cont'd)

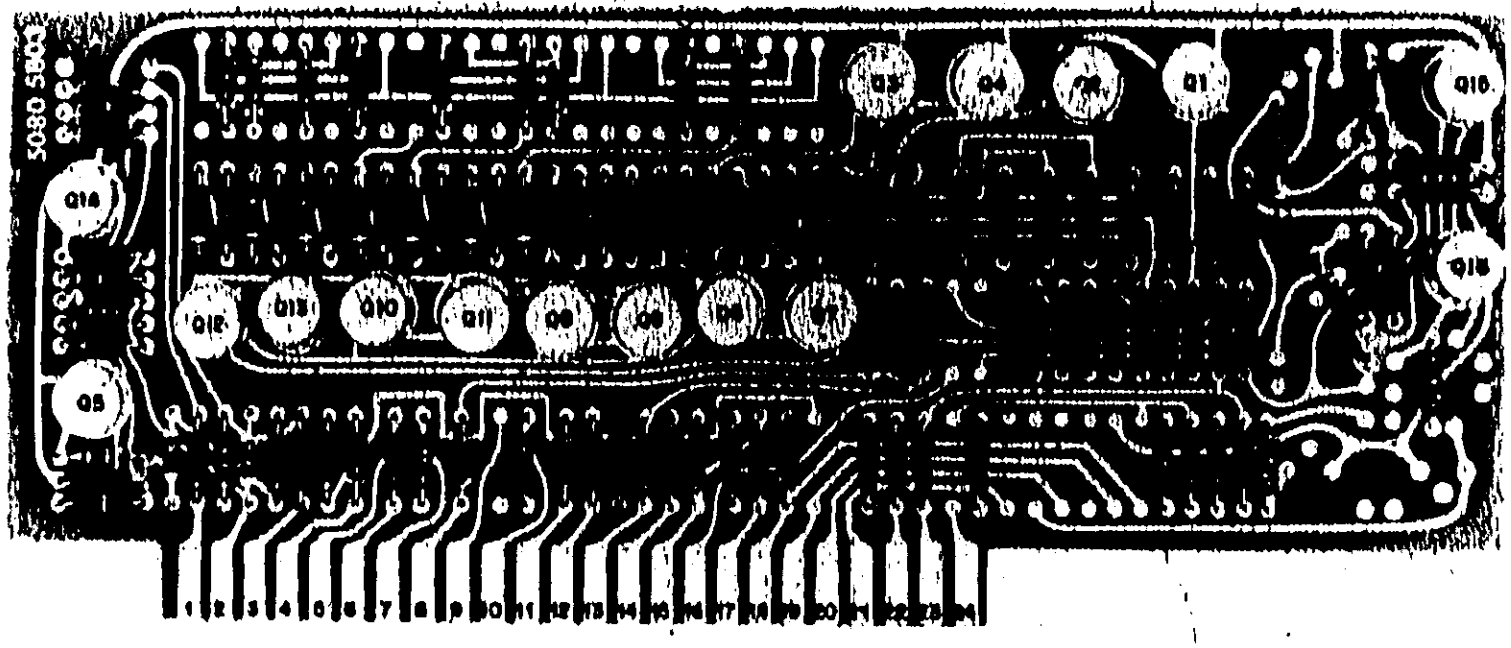
Reference Designation	Part No.	Description #	Note
		OPTION 21 A22 5060-5611 (CONT'D)	
A22R11	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R12	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R13	0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	
A22R14	0757-0950	R:FXD FLM 12K OHM 2% 1/8W	
A22R15	0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	
A22R16	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R17	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R18	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R19	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R20	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R21	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R22	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R23	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R24	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R25	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R26	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R27	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R28	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	
A22R29	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A22R30	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	
A22R31	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R32	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R33	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R34	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R35	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R36	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R37	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R38	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R39	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R40	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R41	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R42	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R43	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R44	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R45	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R46	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R47	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R48	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R49	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R50	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R51	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R52	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R53	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R54	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R55	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R56	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R57	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R58	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R59	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	

Table 21-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 21 A22 5060-5611 (CONT'D) A46 5060-5066	
A22R60	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R61	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R62	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	
A22R63	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R64	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A22R65	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A22R66	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R67	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R68	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	
A46		SAME AS A11, USE PREFIX A46	

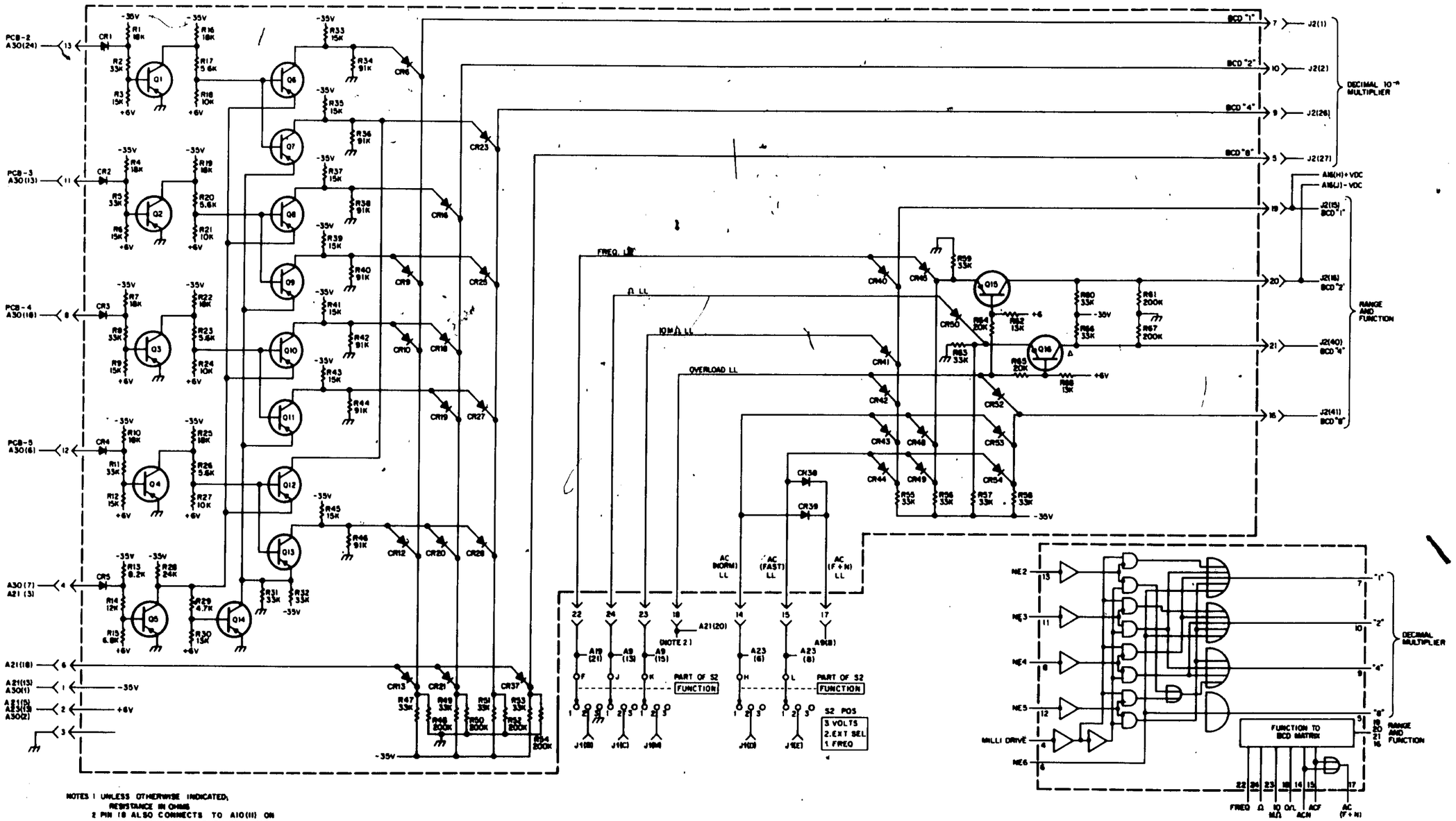
Table 21-4. Replaceable Parts

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 21			
0140-0194	C:FXD MICA 110 PF 5%	28480	0140-0194	18
0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	04062	DM15F131J 300V	54
0140-0219	C:FXD MICA 180 PF 2%	28480	0140-0219	6
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	4
0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	01121	CB 1045	24
0683-1335	R:FXD COMP 13K OHM 5% 1/4W	01121	CB 1335	3
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	17
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	8
0683-2035	R:FXD COMP 20K OHM 5% 1/4W	01121	CB 2035	2
0683-2045	R:FXD COMP 200K OHM 5% 1/4W	01121	CB 2045	6
0683-2235	R:FXD COMP 22K OHM 5% 1/4W	01121	CB 2235	96
0683-2435	R:FXD COMP 24K OHM 5% 1/4W	01121	CB 2435	1
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	48
0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	01121	CB 3025	36
0683-3335	R:FXD COMP 33K OHM 5% 1/4W	01121	CB 3335	1
0683-3945	R:FXD COMP 390K OHM 5% 1/4W	01121	CB 3945	66
0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	01121	CB 4725	24
0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	01121	CB 5625	1
0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	01121	CB 5635	4
0683-6835	R:FXD COMP 68K OHM 5% 1/4W	01121	CB 6835	48
0683-9135	R:FXD COMP 91K OHM 5% 1/4W	01121	CB 9135	36
0686-4735	R:FXD COMP 47K OHM 5% 1/2W	01121	EB 4735	7
0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	01121	EB 5625	6
0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	28480	0757-0944	48
0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	28480	0757-0946	1
0757-0950	R:FXD FLM 12K OHM 2% 1/8W	28480	0757-0950	1
1850-0111	TRANSISTOR:GERMANIUM PNP	01295	2N404A	1
1850-0184	TRANSISTOR:GERMANIUM PNP	02735	38339	16
1901-0025	DIODE:SILICON 100WV 100MA	28480	1901-0025	46
1901-0081	DIODE:SILICON 50 VOLTS WORKING	28480	1901-0081	48
1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	28480	1910-0016	183
1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	83594	B5991	2
5060-5066	REVERSIBLE DECADE COUNTER	04404	5060-5066	6
5060-5611	PRINTER COUPLING LOGIC	04404	5060-5611	6



Stock No. 5060-5611 (For Serial Prefix 537 and above)

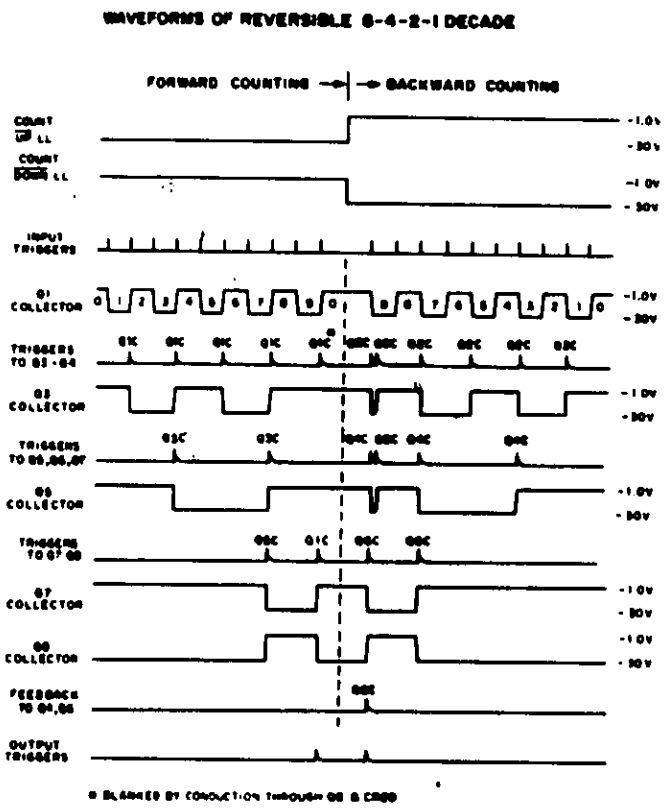
A22 Printer Coupling

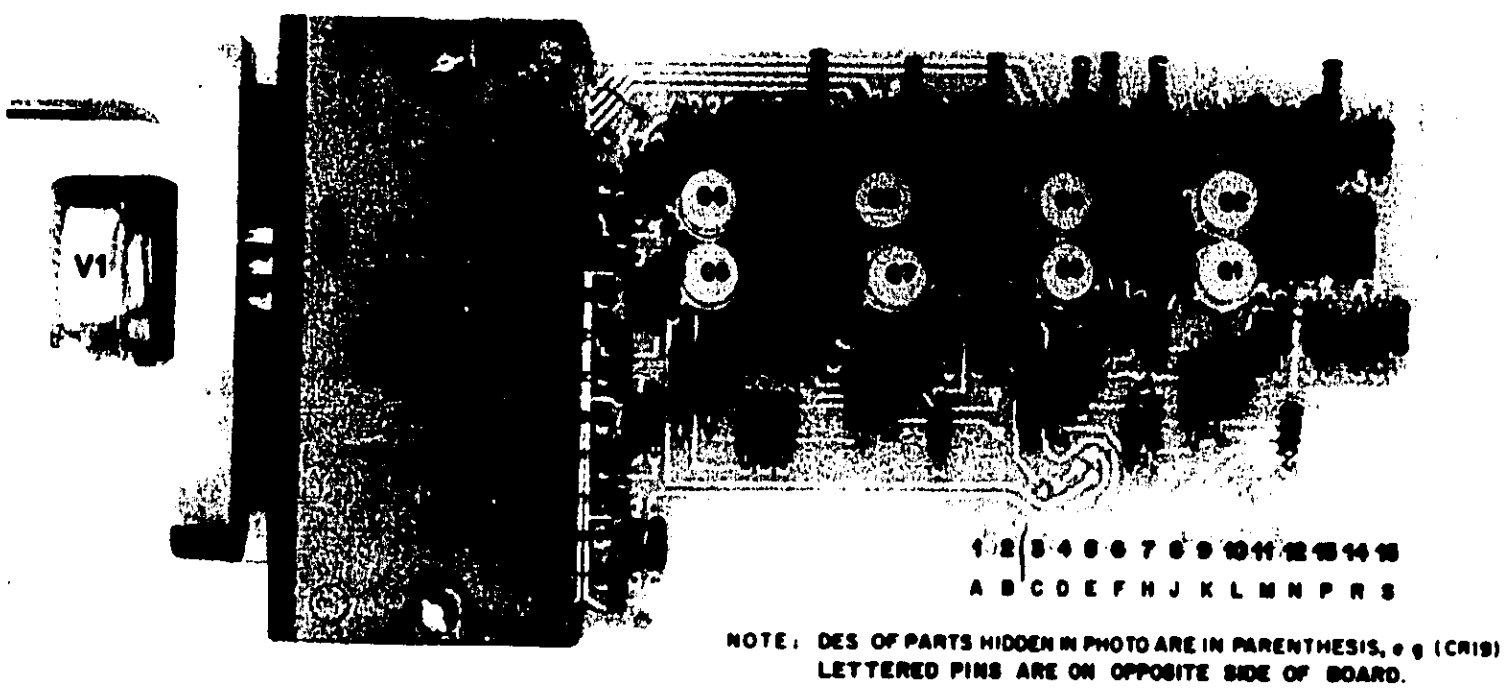


NOTES 1 UNLESS OTHERWISE INDICATED, RESISTANCE IN OHMS.
2 PIN 18 ALSO CONNECTS TO A10(11) ON SERIAL PREFIX 537- THRU 605- AND TO A10(3) ON SERIAL PREFIX 610- AND ABOVE

05060-9611

Figure 21-1. Printer Coupling (A22) for Option 21





NOTE: DES OF PARTS HIDDEN IN PHOTO ARE IN PARENTHESIS, e g (CR19)
LETTERED PINS ARE ON OPPOSITE SIDE OF BOARD.

Stock No. 5060-5066

(A11-A15, A46) Reversible +8-4-2-1 Decade Counter for Option 21

DIGIT	4 LINE CODE (0= −, 1= +) D	C	B	A	V1	RELEVANT STAGES BINARY D	C	B	A
0	0	0	0	0	KPRT				
1	0	0	0	1	FMOT				
2	0	0	1	0	HNRT				
3	0	0	1	1	EMOT				
4	0	1	0	0	JPRT				
5	0	1	0	1	DLOT				
6	0	1	1	0	GNRT				
7	0	1	1	1	CLOT				
8	1	0	0	0	BS				
9	1	0	0	1	AS				

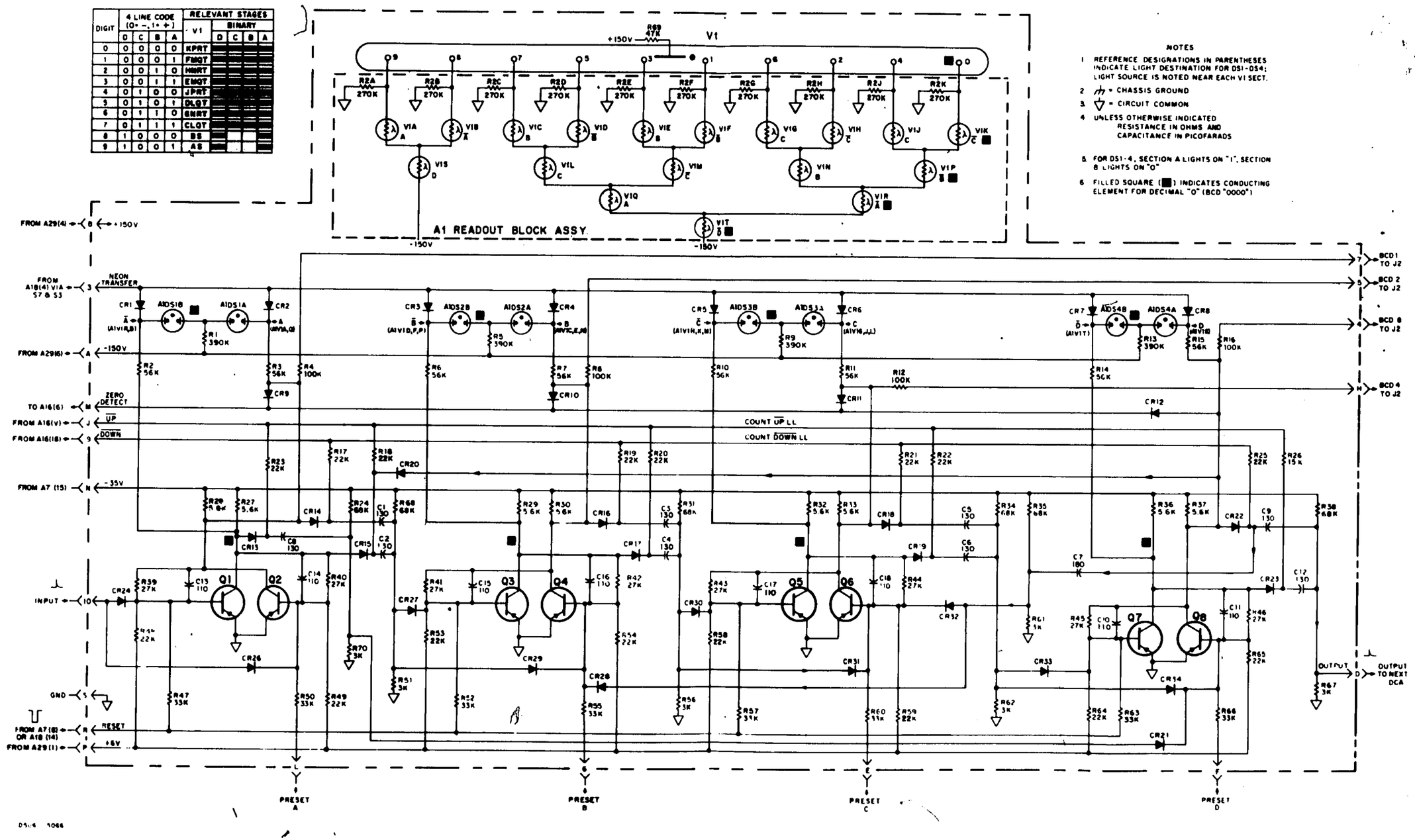


Figure 21-2. Reversible +8-4-2-1 Decade Counter (A11-A15, A46) for Option 21

MANUAL SUPPLEMENT
MODEL HP-2401C
Integrating Digital Voltmeter
Option 29

29.1 GENERAL DESCRIPTION

The HP-2401C-29 Integrating Digital Voltmeter is capable of frequency measurement to 1.2 megahertz. This option is available with 8-4-2-1 positive-true or negative-true BCD output. The specifications in Section 1.7 of this manual apply without change to the HP-2401C-29.

29.2 INSTALLATION AND OPERATION

Install, operate, and program the HP-2401C-29 as specified in Section II of this manual.

29.3 THEORY OF OPERATION

The theory of operation of the HP-2401C-29 is the same as that of the standard HP-2401C, except as noted in the following paragraphs.

29.3.1 1 MHz Input Amplifier and Trigger Assemblies A26 and A27 (Figure 29-1, Standard on Serial Prefix 735 and Above)

The Input Amplifier (A26) and Schmitt Trigger (A27) assemblies used in the HP-2401C-29 incorporate circuit constants and transistors which are selected to achieve amplification and switching of signals with frequencies up to 1.2 megahertz. Otherwise these circuits, shown in Figure 29-1, are identical to those used in the standard HP-2401C.

29.3.2 1 Megahertz Gate Assembly A38 (Figure 29-2)

In the HP-2401C-29, a special 1 megahertz gate assembly, A38 performs the counter input gating functions which are performed by circuitry on A19 in the standard instrument. To minimize degradation of the input signal and reduce noise susceptibility of the instrument, the gate assembly is located close to the 1 megahertz counting/display decade, A11.

As indicated in Figure 29-2, frequency pulses are received from Schmitt Trigger A27(6). Whenever the FREQ function is selected, the negative-true state (near -35v) of the $\overline{\text{freq}}$ line opens AND gate CR1-CR2 to the frequency input pulses. At the same time, the positive-true state (near ground) of the $\overline{\text{volt}}$ line closes AND gate CR4-CR5 to volt pulses which are received from Counter Control Assembly A16.

Selection of the VOLT function reverses the states that are applied to A38. The negative-true state of the $\overline{\text{volt}}$ line opens AND gate CR4-CR5 and the positive-true state of the $\overline{\text{freq}}$ line closes AND gate CR1-CR2.

Inverted frequency pulses from Q1 or volt pulses from Q2 are coupled through counter driver Q3 to counter decade A11. The output from Q3 is differentiated

by C4-R11-R12 to produce the positive spike that is required for triggering the counting decade.

29.3.3 Reversible 1 MHz +4-2'-2-1 Decade Counter A11 (Figure 29-3)

The transistors and circuit constants of decade counter A11 are selected to achieve the fast switching that is required for counting signal frequencies to 1.2 megahertz. The base-emitter junctions of the transistors are protected from reverse bias punch-through by diodes CR25 and CR35-CR41. Otherwise decade A11 is identical to decades A12-A15 and A46.

29.3.4 Reversible 8-4-2-1 Decade Counter (Figure 29-4)

Except for the circuit constants and transistors (which are selected for fast switching) and diodes CR25 and CR35-CR41 (which protect the transistors from reverse bias punch-through), the decade counter A11 used in HP-2401C-29/21 and 29/35 instruments is the same as the decade counter described in Sections 21 and 35 of this manual.

The BCD output logic (negative-true or positive-true) supplied from the basic 8-4-2-1 decade is determined by the connection of shorting links. The circuit in Figure 29-4 shows the connections used for negative-true BCD output, wherein the "1" state is near -35v and the "0" state is near ground. As shown, the shorting links are connected between -1, -2, -4, and -8 terminals and the BCD outputs of the decade. Positive-true BCD output is provided from this basic decade by connecting the shorting links from the +1, +2, +4, and +8 terminals to the BCD outputs. Positive-true output reverses the states previously mentioned: "1" state is near ground and "0" state is near -35v.

29.4 MAINTENANCE

Figures 29-1 through 29-4 show parts placement and circuit configurations of A11, A26, A27, and A38 for HP-2401C-29, 29/21, and 29/35 instruments. See Figure 29-5 for location of A38, R12, and R13 added for Option 29. Figure 29-6 shows interconnections of the HP-2401C-29 where they differ from those of the standard HP-2401C. Except for the foregoing, the maintenance information in Section IV (and Section 21 or 35 if applicable) of this manual applies without change to all versions of the HP-2401C-29. Assemblies A26 and A27 described in this section are standard on instruments with serial prefix 735 and above.

29.5 PARTS LIST

The Parts List in Section V of this manual applies to the various versions of the HP 2401C-29 except as indicated in Tables 29-1 and 29-2.

Table 29-1. Reference Designation Index

Reference Designation	Part No.	Description #	Note
		OPTION 29 A11 5060-5647	
		MAKE THE FOLLOWING CHANGES TO TABLE 5-1 TO PROVIDE A REPLACEABLE PARTS LIST FOR THE HP2401C-29.	
		DELETE THE FOLLOWING FROM TABLE 5-1:	
A11	5060-3781	REVERSIBLE DECADE COUNTER	A-S
A26	05214-6014	INPUT AMPLIFIER	A-S
A27	5060-5016	SCHMITT TRIGGER	
C3	0140-0195	C:FXD MICA 130 PF 5% 300VDCW	
R8	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
R9	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
		ADD THE FOLLOWING TO TABLE 5-1:	
A11	5060-5647	1 MHZ REVERSIBLE DECADE COUNTER	
A26	05232-6007	1 MHZ INPUT AMPLIFIER	A-S
A27	05232-6006	1 MHZ INPUT TRIGGER	A-S
A38	5060-5700	1 MHZ GATE ASSEMBLY	
C11	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	A-S
R12	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	M-X
R13	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	
XA38	1251-0135	CONNECTOR:BODY 15 PIN	
A11	5060-5647	1 MHZ REVERSIBLE DECADE COUNTER	
A11A1	NSR	READOUT BLOCK ASSY	
A11C1	0160-2101	C:FXD MICA 27PF 2% 300VDCW	
A11C2	0160-2101	C:FXD MICA 27PF 2% 300VDCW	
A11C3	0140-0191	C:FXD MICA 56 PF 5%	
A11C4	0140-0191	C:FXD MICA 56 PF 5%	
A11C5	0160-2101	C:FXD MICA 27PF 2% 300VDCW	
A11C6	0160-2101	C:FXD MICA 27PF 2% 300VDCW	
A11C7	0140-0191	C:FXD MICA 56 PF 5%	
A11C8	0140-0191	C:FXD MICA 56 PF 5%	
A11C9	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C10	0140-0191	C:FXD MICA 56 PF 5%	
A11C11	0140-0191	C:FXD MICA 56 PF 5%	
A11C12	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C13-A11C18	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11CR1-A11CR8	1901-0025	DIODE:SILICON 100WV 100MA	
A11CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR10	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR11	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR13-A11CR24	1901-0081	DIODE:SILICON 50 VOLTS WORKING	

See introduction to this section for ordering information

Table 29-1. Reference Designation Index (Cont'd)

Reference Designation	HP Part No.	Description #	Note
		OPTION 29 A11 5060-5647 (CONT'D)	
A11CR25	1901-0143	DIODE:SILICON	
A11CR26-			
A11CR34	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR35	1901-0143	DIODE:SILICON	
A11CR36	1901-0143	DIODE:SILICON	
A11CR37	1901-0143	DIODE:SILICON	
A11CR38	1901-0143	DIODE:SILICON	
A11CR39	1901-0143	DIODE:SILICON	
A11CR40	1901-0143	DIODE:SILICON	
A11CR41	1901-0143	DIODE:SILICON	
A11Q1-			
A11Q8	5080-0615	TRANSISTOR:MATCHED PAIR	
A11R1	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R2	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R3	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R4	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R5	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R6	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R8	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R9	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R10	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R11	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R12	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R13	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R14	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R15	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R16	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R17	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	A-G
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	H-X
A11R18	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	A-G
	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	H-X
A11R19	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	A-G
	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	H-X
A11R20	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R21	0683-3035	R:FXD COMP 30K OHM 5% 1/4W	
A11R22	0683-3035	R:FXD COMP 30K OHM 5% 1/4W	
A11R23	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A11R24	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A11R25	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-G
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	H-X
A11R26	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	A-G
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	H-X
A11R27	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R28	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R29	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R30	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R31	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	H-X

Table 29-1. Reference Designation Index (Cont'd)

Reference Designation	HP Part No.	Description #	Note
		OPTION 29 A11 5060-5647 (CONT'D) A26 05232-6007 A27 05232-6006	 A-S A-S
A11R32	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R33	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R34	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	H-X
A11R35	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	H-X
A11R36	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R37	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R38	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	H-X
A11R39-			
A11R50	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R51	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R52	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R53	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R54	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R55	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R56	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R57	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R58	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R59	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R60	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R61	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R62	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R63	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R64	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R65	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R66	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R67	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R68	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	H-X
A11R69	0686-4735	R:FXD COMP 47K OHM 5% 1/2W	
A11V1	1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	
A26	05232-6007	INPUT AMPLIFIER	A-S*
A27	05232-6006	INPUT TRIGGER	A-S**

* SEE PAGE NO. 5-30
** SEE PAGE NO. 5-31

Table 29-1. Reference Designation Index (Cont'd)

Reference Designation	HP Part No.	Description #	Note
		OPTION 29 A38 5060-5700	
A38C1	0160-0356	C:FXD MICA 18 PF 5%	
A38C2	0140-0201	C:FXD MICA 12 PF 5%	
A38C3	0160-0356	C:FXD MICA 18 PF 5%	
A38C4	0140-0014	C:FXD MICA 56 PF 10%	
A38CR1- A38CR8	1901-0061	DIODE:SILICON 50 VOLTS WORKING	
A38Q1	1853-0008	TRANSISTOR:SILICON PNP	
A38Q2	1853-0008	TRANSISTOR:SILICON PNP	
A38Q3	1853-0008	TRANSISTOR:SILICON PNP	
A38R1	0757-0947	R:FXD FLM 9.1K OHM 2% 1/8W	
A38R2	0757-0956	R:FXD FLM 27K OHM 2% 1/8W	
A38R3	0757-0949	R:FXD FLM 11K OHM 2% 1/8W	
A38R4	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A38R5	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A38R6	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A38R7	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A38R8	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A38R9	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A38R10	0689-2725	R:FXD COMP 2.7K OHM 5% 1W	
A38R11	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A38R12	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	

Table 29-1. Reference Designation Index (Cont'd)

Reference Designation	HP Part No.	Description #	Note
		OPTION 29/21, 29/35	
		MAKE THE FOLLOWING CHANGES TO TABLE 5-1 TO PROVIDE A REPLACEABLE PARTS LIST FOR THE HP2401C-29/21.	
		DELETE THE FOLLOWING:	
A11- A15	5060-3781	REVERSIBLE DECADE COUNTER	
A22	5060-2111	PRINTER LOGIC	
	5060-5610	PRINTER LOGIC	A-E
A26	05214-6014	INPUT AMPLIFIER	F-X
A27	5060-5016	SCHMITT TRIGGER	A-S
A46	5060-3781	REVERSIBLE DECADE COUNTER	A-S
C3	0140-0195	C:FXD MICA 130 PF 5% 300VDCW	
R8	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
R9	0683-3025	R:FXD COMP 3K OHM 5% 1/4W	
		ADD THE FOLLOWING TO TABLE 5-1 FOR THE HP2401C-29/21:	
A11	5060-6545	1MHz REVERSIBLE DECADF COUNTER	
A12- A15	5060-5066	REVERSIBLE DECADE COUNTER	
A22	5060-5611	PRINTER LOGIC	
A26	05232-6007	INPUT AMPLIFIER	A-S
A27	05232-6006	SCHMITT TRIGGER	A-S
A38	5060-5700	1MHz GATE ASSEMBLY	
A46	5060-5066	REVERSIBLE DECADE COUNTER	
C11	0150-0121	C:FXD CER 0.1 UF +80-20% 50 VDCW	
R12	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	A-S
R13	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	M-X
XA38	1251-0135	CONNECTOR:BODY 15 PIN	
		MAKE THE FOLLOWING CHANGES TO TABLE 5-1 TO PROVIDE A REPLACEABLE PARTS LIST FOR THE HP2401C-29/35.	
		DELETE THE FOLLOWING:	
A11- A15	5060-3781	REVERSIBLE DECADE COUNTER	
A22	5060-2111	PRINTER LOGIC	
	5060-5610	PRINTER LOGIC	A-E
A26	05214-6014	INPUT AMPLIFIER	F-X
A27	5060-5016	SCHMITT TRIGGER	A-S
A46	5060-3781	REVERSIBLE DECADE COUNTER	A-S
C3	0140-0195	C:FXD MICA 130 PF 5% 300VDCW	
R8	0683-6835	R:COMP 68K OHM 5% 1/4W	
R9	0683-3025	R:FXD 3K OHM 5% 1/4W	
		ADD THE FOLLOWING TO TABLE 5-1 FOR THE HP2401C-29/35:	
A11	5060-5646	1MZ REVERSIBLE DECADE COUNTER	
A12- A15	5060-5644	REVERSIBLE DECADE COUNTER	
A22	5060-5612	PRINTER COUPLING LOGIC	

Table 29-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 28/21, 28/35 A11 5080-5645 5080-5646	
A26	05232-6007	INPUT AMPLIFIER	A-S
A27	05232-6006	SCHMITT TRIGGER	A-S
A38	5060-5700	1MHz GATE ASSEMBLY	
A46	5060-5644	1MHz REVERSIBLE DECADE COUNTER	
C11	0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	A-S
CR1	1901-0025	DIODE:SILICON 100MV 100MA	
CR4- CR11	1901-0025	DIODE:SILICON 100MV 100MA	
R12	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	M-X
R13	0683-4715	R:FXD COMP 470 OHM 5% 1/4W	
XA38	1251-0135	CONNECTOR:BODY 15 PIN	
A11	5080-5645	1 MHZ REVERSIBLE DECADE COUNTER	
	5080-5646	1 MHZ REVERSIBLE DECADE COUNTER	
A11A1	NSR	READOUT BLOCK ASSY	
A11C1- A11C6	0160-2101	C:FXD MICA 27PF 2% 300VDCW	
A11C7	0140-0191	C:FXD MICA 56 PF 5%	
A11C8	0160-2101	C:FXD MICA 27PF 2% 300VDCW	
A11C9	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C10	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11C11	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11C12	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C13	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11C14	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11C15	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11C16	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11C17	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11C18	0160-2232	C:FXD MICA 33 PF 2% 300VDCW	
A11CR1- A11CR8	1901-0025	DIODE:SILICON 100WV 100MA	
A11CR9- A11CR24	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR25	1901-0143	DIODE:SILICON	
A11CR26- A11CR34	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR35- A11CR41	1901-0143	DIODE:SILICON	
A11Q1- A11Q8	1853-0008	TRANSISTOR:SILICON PNP	
A11R1	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R2	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R3	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R4	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R5	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R6	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	

Table 29-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 28/21, 28/35 A11 5080-5645 (CONT'D) 5080-5646 (CONT'D)	
A11R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R8	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R9	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R10	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R11	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R12	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A11R13	0683-3945	R:FXD COMP 390K OHM 5% 1/4W	
A11R14	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R15	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R16	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	A-G
A11R17	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-G
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	H-X
A11R18	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A11R19	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R20	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R21	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R22	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A11R23	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A11R24	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	H-X
A11R25	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-G
	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	H-X
A11R26	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	A-G
A11R27	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R28	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R29	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R30	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R31	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	H-X
A11R32	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R33	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R34	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	H-X
A11R35	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
A11R36	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R37	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A11R38	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	H-X
A11R39- A11R50	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R51	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R52	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R53	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R54	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R55	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R56	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R57	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R58	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R59	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R60	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	

Table 29-1. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 28/21, 28/35	
		A11 [illegible] (CONT'D)	
		[illegible] (CONT'D)	
		A12-	
		A13 [illegible]	
		[illegible]	
		A22 [illegible]	
		[illegible]	
		A26 [illegible]	
		A27 [illegible]	
		A28 [illegible]	
		A46 [illegible]	
		[illegible]	
A11R61	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R62	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R63	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R64	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R65	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R66	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A11R67	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11R68	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	A-G
	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	H-X
A11R69	0686-4735	R:FXD COMP 47K OHM 5% 1/2W	
A11R70	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
A11V1	1970-0009	TUBE:ELECTRON NIXIE 0-9	
A11Z1	5080-6555	NETWORK:DIODE/RESISTOR	H-X
A12	[illegible]	REVERSIBLE DECADE COUNTER	**
	[illegible]	REVERSIBLE DECADE COUNTER	***
A13	[illegible]	SAME AS A12 USE PREFIX A13	**
	[illegible]	SAME AS A12 USE PREFIX A13	***
A14	[illegible]	SAME AS A12 USE PREFIX A14	**
	[illegible]	SAME AS A12 USE PREFIX A14	***
A15	[illegible]	SAME AS A12 USE PREFIX A15	**
	[illegible]	SAME AS A12 USE PREFIX A15	***
A22	[illegible]	PRINTER LOGIC	**
	[illegible]	PRINTER LOGIC	***
A26	05232-6007	INPUT AMPLIFIER	A-S*
A27	05232-6006	SCHMITT TRIGGER	A-S*
A28	[illegible]	1 MHZ GATE ASSEMBLY	****
A46	[illegible]	SAME AS A12, USE PREFIX A46	**
	[illegible]	SAME AS A12, USE PREFIX A46	***

* SEE TABLE 5-1
** SEE PARTS LIST IN SECTION 21.
*** SEE PARTS LIST IN SECTION 35.
**** SEE PARTS LIST ON PAGE 29-6.

Table 29-2. Replaceable Parts

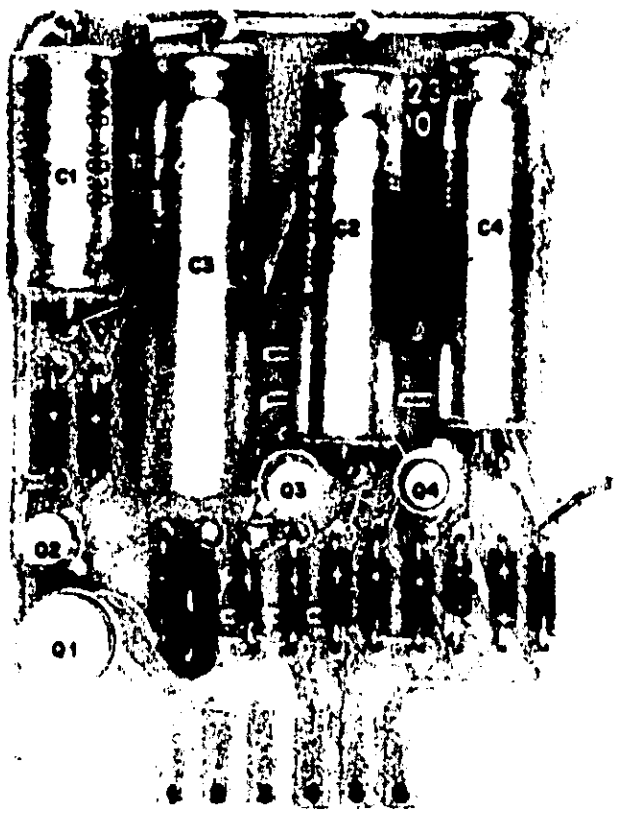
Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 28			
0140-0014	C:FXD MICA 56 PF 10%	00853	RCM15E560K	1
0140-0191	C:FXD MICA 56 PF 5%	28480	0140-0191	6
0140-0195	C:FXD MICA 130 PF 5% 300VDCW	04062	DM15F131J 300V	3
0140-0201	C:FXD MICA 12 PF 5%	28380	0140-0195	1
0160-0356	C:FXD MICA 18 PF 5%	28480	0160-0356	2
0160-2101	C:FXD MICA 27 PF 2% 300VDCW	72136	RDM15E270G3C	4
0160-2232	C:FXD MICA 33 PF 2% 300VDCW	72136	RDM15E330G3C	6
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	2
0683-1045	R:FXD COMP 100K OHM 5% 1/4W	01121	CB 1045	4
0683-1235		01121	CB 1235	2
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	3
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	3
0683-2235	R:FXD COMP 22K OHM 5% 1/4W	01121	CB 2235	5
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	3
0683-3025	R:FXD COMP 3K OHM 5% 1/4W	01121	CB 3025	7
0683-3035	R:FXD COMP 30K OHM 5% 1/4W	01121	CB 3035	2
0683-3935	R:FXD COMP 39K OHM 5% 1/4W	01121	CB 3935	3
0683-3945	R:FXD COMP 390K OHM 5% 1/4W	01121	CB 3945	4
0683-4735	R:FXD COMP 47K OHM 5% 1/4W	01121	CB 4735	1
0683-5635	R:FXD COMP 56K OHM 5% 1/4W	01121	CB 5635	33
0683-6825	R:FXD COMP 6.8K OHM 5% 1/4W	01121	CB 6825	1
0683-6835	R:FXD COMP 68K OHM 5% 1/4W	01121	CB 6835	7
0686-4735	R:FXD COMP 47K OHM 5% 1/2W	01121	EB 4735	1
0686-5625	R:FXD COMP 5.6K OHM 5% 1/2W	01121	EB 5625	9
0689-2725	R:FXD COMP 2.7K OHM 5% 1W	01121	GB 2725	1
0757-0947	R:FXD FLM 9.1K OHM 2% 1/8W	28480	0757-0947	1
0757-0949	R:FXD FLM 11K OHM 2% 1/8W	28480	0757-0949	1
0757-0958	R:FXD FLM 27K OHM 2% 1/8W	28480	0757-0947	1
1853-0008	TRANSISTOR:SILICON PNP	01295	2N3250	3
1901-0025	DIODE:SILICON 100MA 100V	284801	1901-0025	8
1901-0081	DIODE:SILICON 50VDCW	28480	1901-0081	13
1901-0143	DIODE:SILICON	28480	1901-0143	8
1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	83594	B5991	1
5060-5647	1MHz REVERSIBLE DECADE COUNTER	04404	5060-5647	1
5060-5700	1MHz GATE ASSEMBLY	04404	5060-5700	1
5080-0615	TRANSISTOR:MATCHED PAIR	04404	5080-0615	8
	OPTION 28/21			
0140-0014	C:FXD MICA 56 PF 10%	00853	RCM15E560K	4
0140-0191	C:FXD MICA 56 PF 5%	28480	0140-0191	1
0140-0194	C:FXD MICA 110 PF 5%	28480	0140-0194	40
0140-0195	C:FXD MICA 130 PF 5% 300VDCW	04062	DM15F131J 300V	47
0140-0201	C:FXD MICA 12 PF 5%	28480	0140-0195	1
0140-0219	C:FXD MICA 180 PF 2%	28480	0140-0219	5
0150-0121	C:FXD CER 0.1 UF +80-20% 50VDCW	56289	5C50B15-CML	1
0160-0356	C:FXD MICA 18 PF 5%	28480	0160-0356	2
0160-2101	C:FXD MICA 27 PF 2% 300VDCW	72136	RDM15E270G3C	7
0160-2232	C:FXD MICA 33 PF 2% 300VDCW	72136	RDM15E330G3C	8
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	1
0683-1045	R:FXD COMP 100K OHM 5% 1/4W	01121	CB 1045	24
0683-1335	R:FXD COMP 13K OHM 5% 1/4W	01121	CB 1335	1
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	17
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	1

Table 29-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 29/21 (CONT'D)			
0683-2035	R:FXD COMP 20K OHM 5% 1/4W	01121	CB 2035	2
0683-2045	R:FXD COMP 200K OHM 5% 1/4W	01121	CB 2045	6
0683-2235	R:FXD COMP 22K OHM 5% 1/4W	01121	CB 2235	79
0683-2435	R:FXD COMP 24K OHM 5% 1/4W	01121	CB 2435	1
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	40
0683-3025	R:FXD COMP 3K OHM 5% 1/4W	01121	CB 3025	37
0683-3335	R:FXD COMP 33K OHM 5% 1/4W	01121	CB 3335	58
0683-3935	R:FXD COMP 39K OHM 5% 1/4W	01121	CB 3935	2
0683-3945	R:FXD COMP 390K OHM 5% 1/4W	01121	CB 3945	24
0683-4715	R:FXD COMP 470 OHM 5% 1/4W	01121	CB 4715	2
0683-4725	R:FXD COMP 4.7K OHM 5% 1/4W	01121	CB 4725	1
0683-4735	R:FXD COMP 47K OHM 5% 1/4W	01121	CB 4735	2
0683-5625	R:FXD COMP 5.6K OHM 5% 1/4W	01121	CB 5625	44
0683-5635	R:FXD COMP 56K OHM 5% 1/4W	01121	CB 5635	73
0683-6825	R:FXD COMP 6.8K OHM 5% 1/4W	01121	CB 6825	1
0683-6835	R:FXD COMP 68K OHM 5% 1/4W	01121	CB 6835	37
0683-8225	R:FXD COMP 8.2K OHM 5% 1/4W	01121	CB 8225	1
0683-9135	R:FXD COMP 91K OHM 5% 1/4W	01121	CB 9135	7
0686-4735	R:FXD COMP 47K OHM 5% 1/2W	01121	EB 4735	6
0686-5625	R:FXD COMP 5.6K OHM 5% 1/2W	01121	EB 5625	9
0689-2725	R:FXD COMP 2.7K OHM 5% 1W	01121	GB 2725	1
0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	28480	0757-0944	1
0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	28480	0757-0946	1
0757-0947	R:FXD FLM 9.1K OHM 2% 1/8W	28480	0757-9747	1
0757-0949	R:FXD FLM 11K OHM 2% 1/8W	28480	0757-0949	1
0757-0950	R:FXD FLM 8.2K OHM 2% 1/8W	28480	0757-0950	1
0757-0958	R:FXD FLM 27K OHM 2% 1/8W	28480	0757-0958	1
1251-0135	CONNECTOR:BODY 15 PIN	28480	1251-0135	1
1850-0111	TRANSISTOR:GERMANIUM PNP	01295	2N404A	16
1850-0184	TRANSISTOR:GERMANIUM PNP	02735	38339	40
1853-0008	TRANSISTOR:SILICON PNP	01295	2N3250	11
1901-0025	DIODE:SILICON 100MA 100V	28480	1901-0025	48
1901-0081	DIODE:SILICON 50VDCW	28480	1901-0081	179
1901-0143	DIODE:SILICON	28480	1901-0143	8
1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	28480	1910-0016	2
1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	83594	B5991	6
5060-5066	REVERSIBLE DECADE COUNTER	04404	5060-5066	5
5060-5611	PRINTER LOGIC	04404	5060-5611	1
5060-5645	1MHz REVERSIBLE DECADE COUNTER	04404	5060-5645	1
5060-5700	1MHz GATE ASSEMBLY	04404	5060-5700	1
5080-6555	NETWORK:DIODE RESISTOR	04404	5080-6555	1
	OPTION 29/35			
0140-0014	C:FXD MICA 56PF 10%	00853	RCM15E560K	1
0140-0191	C:FXD MICA 56PF 5%	28480	0140-0191	1
0140-0194	C:FXD MICA 110PF 5%	28480	0140-0194	40
0140-0195	C:FXD MICA 130PF 5% 300VDCW	04062	DM15F131J	46
0140-0219	C:FXD MICA 180PF 2%	28480	0140-0219	5

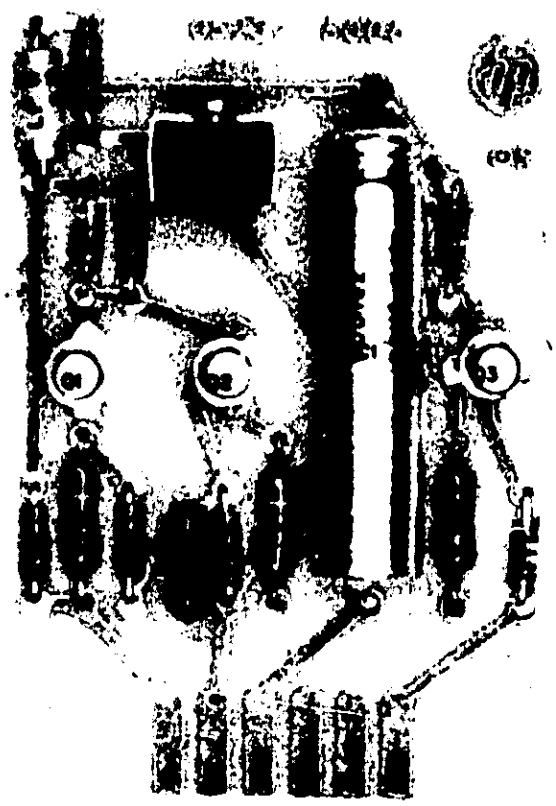
Table 29-2. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 29/35 (CONT'D)			
0150-0121	C:FXD CER 0.1UF +80-20% 50VDCW	56289	5C50B15-CML	1
0160-0356	C:FXD MICA 18PF 5%	28480	0160-0356	2
0160-2101	C:FXD MICA 27PF 2% 300VDCW	72136	RDM15E270G3C	7
0160-2232	C:FXD MICA 33PF 2% 300VDCW	72136	RDM15E330G3C	8
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	6
0683-1045	R:FXD COMP 100K OHM 5% 1/4W	01121	CB 1045	24
0683-1335	R:FXD COMP 13K OHM 5% 1/4W	01121	CB 1335	3
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	17
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	13
0683-2035	R:FXD COMP 20K OHM 5% 1/4W	01121	CB 2035	2
0683-2045	R:FXD COMP 200K OHM 5% 1/4W	01121	CB 2045	8
0683-2235	R:FXD COMP 22K OHM 5% 1/4W	01121	CB 2235	86
0683-2435	R:FXD COMP 24K OHM 5% 1/4W	01121	CB 2435	1
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	47
0683-3025	R:FXD COMP 3K OHM 5% 1/4W	01121	CB 3025	37
0683-3335	R:FXD COMP 33K OHM 5% 1/4W	01121	CB 3335	62
0683-3935	R:FXD COMP 39K OHM 5% 1/4W	01121	CB 3935	2
0683-3945	R:FXD COMP 390K OHM 5% 1/4W	01121	CB 3945	24
0683-4725	R:FXD COMP 4.7K OHM 5% 1/4W	01121	CB 4725	1
0683-4735	R:FXD COMP 47K OHM 5% 1/4W	01121	CB 4735	1
0683-5625	R:FXD COMP 5.6K OHM 5% 1/4W	01121	CB 5625	4
0683-5635	R:FXD COMP 56K OHM 5% 1/4W	01121	CB 5635	73
0683-6825	R:FXD COMP 6.8K OHM 5% 1/4W	01121	CB 6825	1
0683-6835	R:FXD COMP 68K OHM 5% 1/4W	01121	CB 6835	7
0683-8225	R:FXD COMP 8.2K OHM 5% 1/4W	01121	CB 8225	1
0683-9135	R:FXD COMP 91K OHM 5% 1/4W	01121	CB 9135	7
0686-4735	R:FXD COMP 47K OHM 5% 1/2W	01121	EB 4735	7
0686-5625	R:FXD COMP 5.6K OHM 5% 1/2W	01121	EB 5625	49
0689-2715	R:FXD COMP 270 OHM 5% 1W	01121	GB 2715	1
0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	28480	0757-0944	1
0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	28480	0757-0946	1
0757-0947	R:FXD FLM 9.1K OHM 2% 1/8W	28480	0757-0947	1
0757-0949	R:FXD FLM 11K OHM 2% 1/8W	28480	0757-0949	1
0757-0950	R:FXD FLM 12K OHM 2% 1/8W	28480	0757-0950	1
0757-0955	R:FXD FLM 20K OHM 2% 1/8W	28480	0757-0955	4
0757-0957	R:FXD FLM 24K OHM 2% 1/8W	28480	0757-0957	4
0757-0958	R:FXD FLM 27K OHM 2% 1/8W	28480	0757-0958	1
1251-0135	CONNECTOR:BOCY 15 PIN	28480	1251-0135	1
1850-0111	TRANSISTOR:GERMANIUM PNP	01295	2N404A	20
1850-0184	TRANSISTOR:GERMANIUM PNP	02735	38339	40
1853-0008	TRANSISTOR:SILICON PNP	01295	2N3250	11
1901-0025	DIODE:SILICON 100MA 100V	28480	1901-0025	57
1901-0051	DIODE:SILICON 1.5A 400V	28480	1901-0025	2
1901-0081	DIODE:SILICON 50V	28480	1901-0051	193
1901-0143	DIODE:SILICON	28480	1901-0143	8
1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	83594	B5991	6
5060-5612	PRINTER COUPLING LOGIC	04404	5060-5612	1
5060-5644	REVERSIBLE DECADE COUNTER	04404	5060-5644	6
5060-5646	1MHz REVERSIBLE DECADE COUNTER	04404	5060-5646	1
5060-5700	1MHz GATE ASSEMBLY	04404	5060-5700	1
5080-6555	NETWORK:DIODE/RESISTOR	04404	5080-6555	1



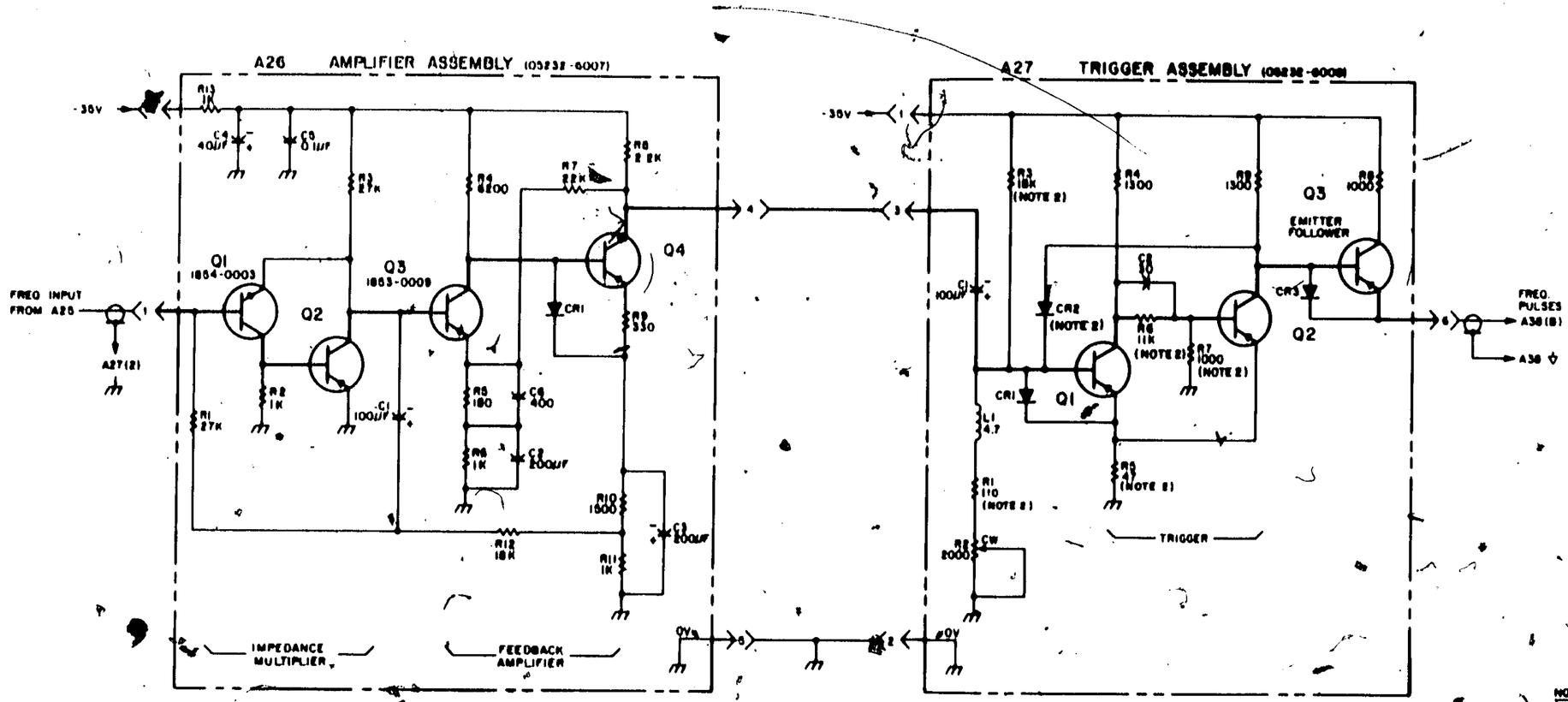
Stock No. 05232-6007 (Serif Prefix 637 and below)

(A26) Input Amplifier for Option 29



Stock No. 05232-6006 (Serial Prefix 637 and below)

(A27) Trigger for Option 29

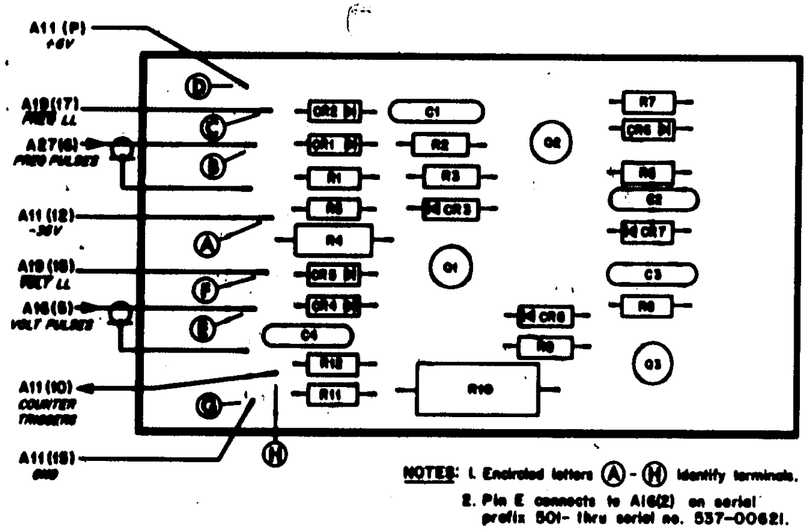


05980 4224

NOTES

1. UNLESS OTHERWISE INDICATED RESISTANCE IN OHMS, CAPACITANCE IN PICOFARADS AND INDUCTANCE IN MICROHENRIES
2. R1 IS 330, R3 IS 16K, R5 IS 91, R6 IS 7.5K, R7 IS 12K, AND CR2 IS NOT USED ON SERIAL NO 637-01406 THRU 637-01987

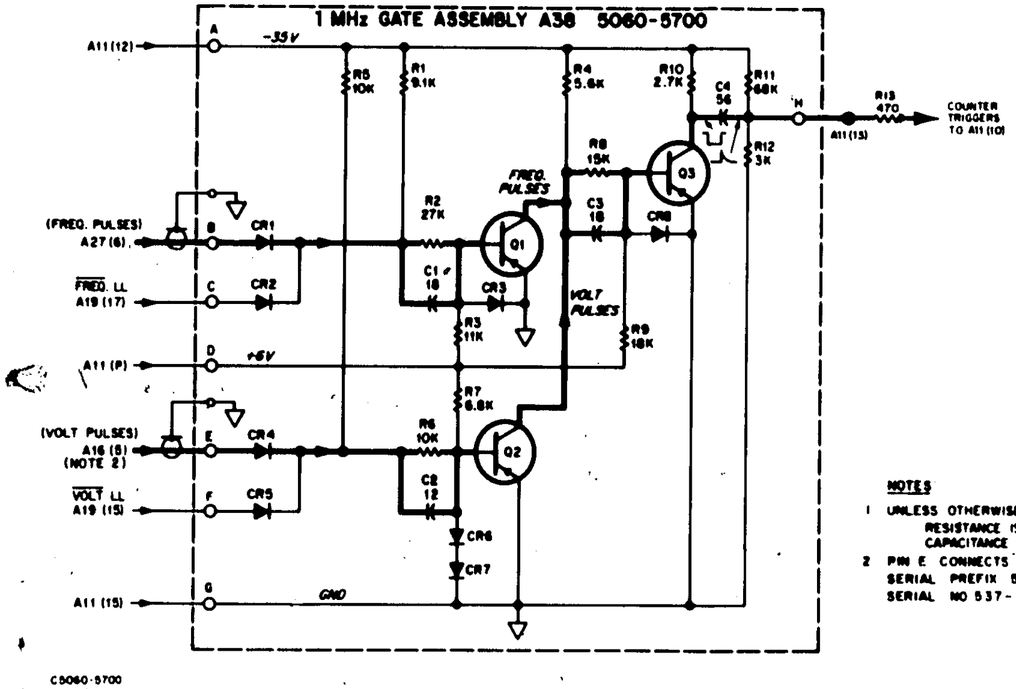
Figure 29-1. Input Amplifier (A26) and Trigger (A27) for Option 29 and Serial Prefix 637 and below



NOTES: 1. Encircled letters Ⓐ - Ⓗ identify terminals.
2. Pin E connects to A16(2) on serial prefix 501- thru serial no. 537-00621.

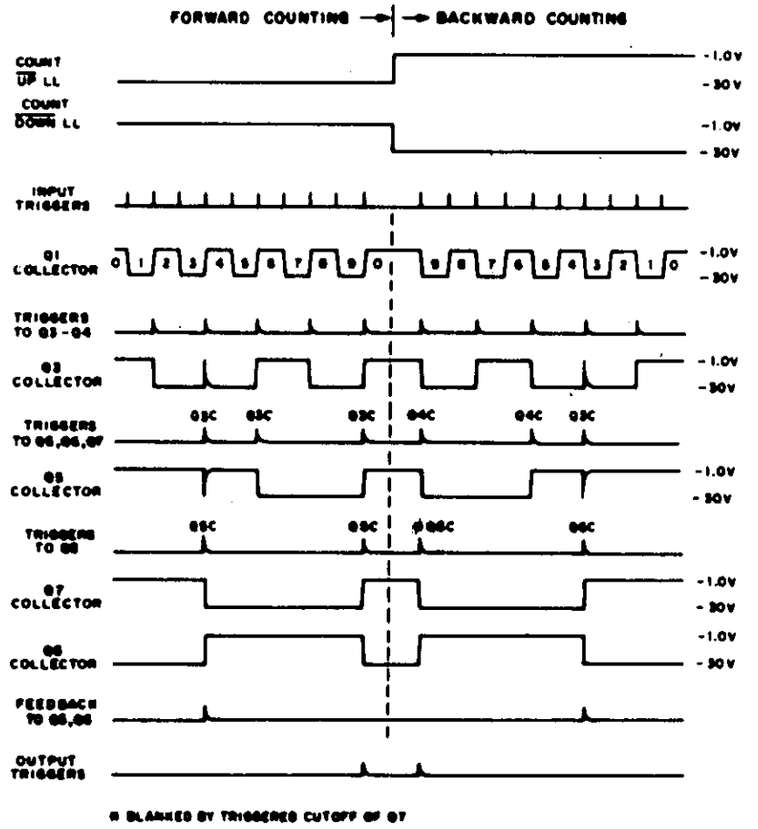
Stock No. 5060-5700

(A38) 1 Megahertz Gate for Option 29

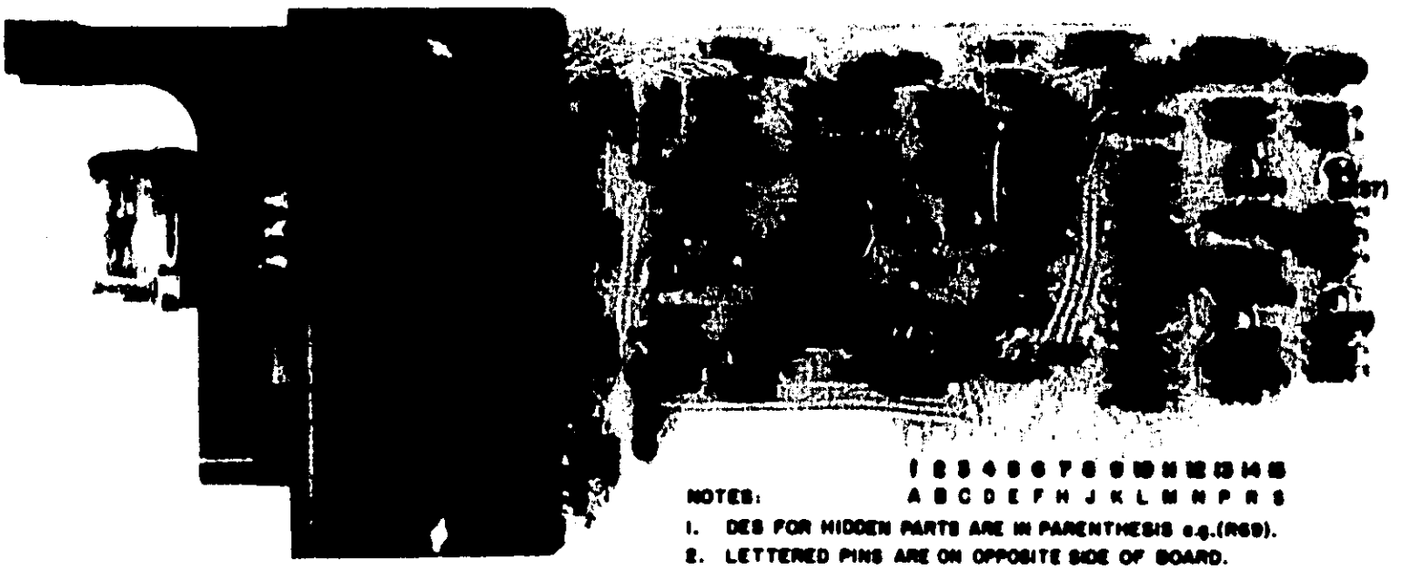


NOTES
1 UNLESS OTHERWISE INDICATED, RESISTANCE IS IN OHMS, AND CAPACITANCE IS IN PICOFARADS
2 PIN E CONNECTS TO A16(2) ON SERIAL PREFIX 501- THRU SERIAL NO 537-00621

Figure 29-2. 1 Megahertz Gate (A38) for Option 29



REVERSIBLE DECADE WAVEFORMS



Stock No. 5060-5647

(A11) Reversible 1 MHz +4-2'-2-1 Decade Counter for Option 29

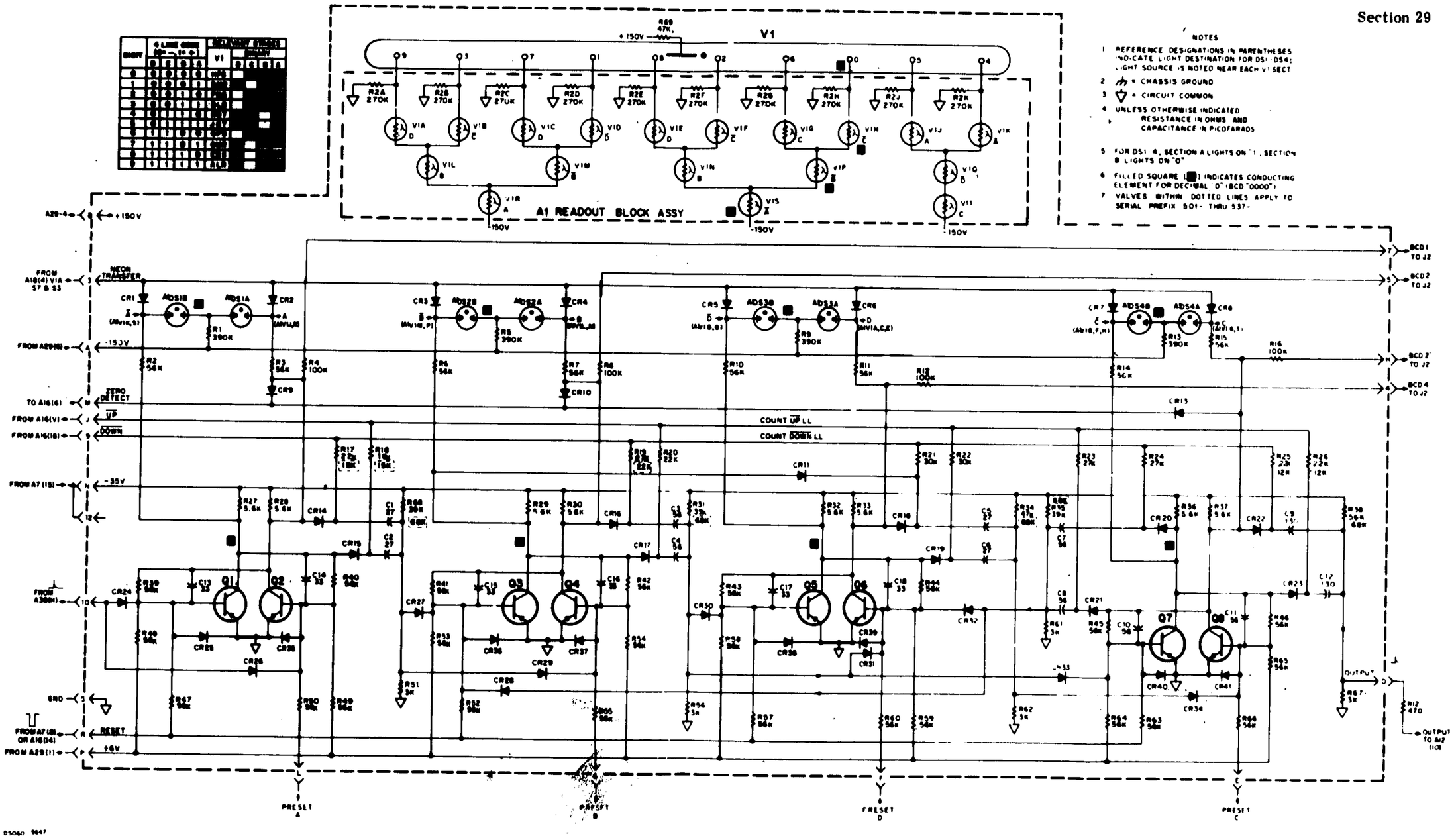
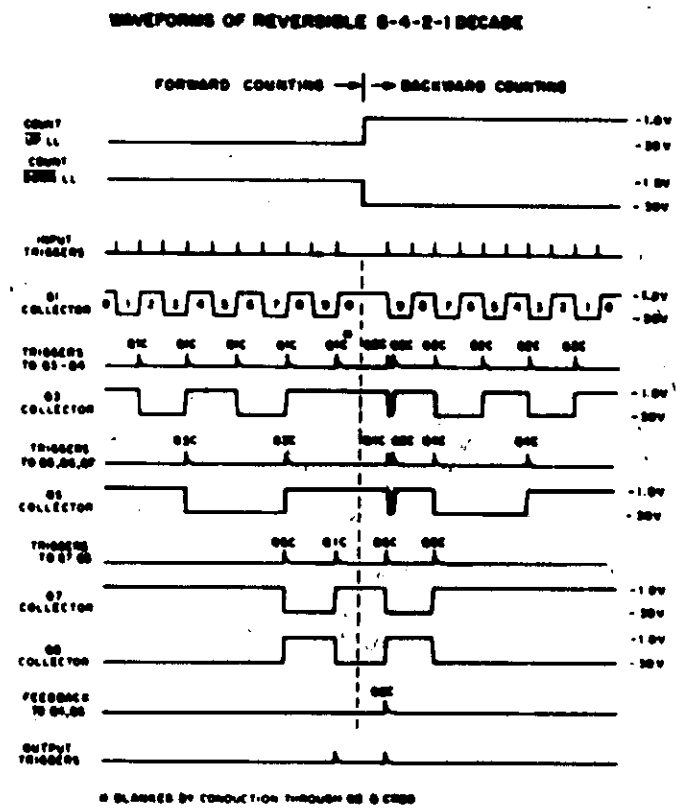
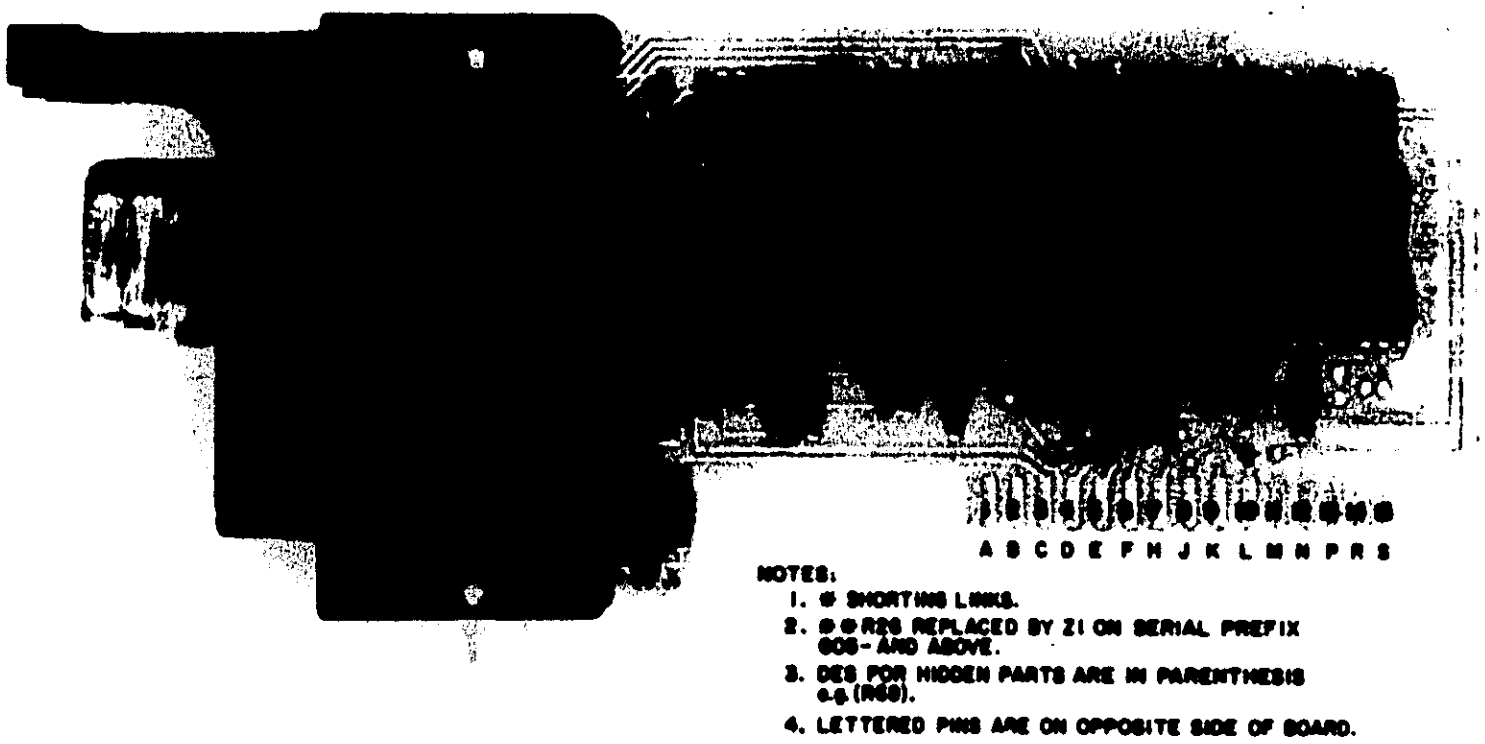


Figure 29-3. Reversible 1MHz +4-2'-2-1 Decade Counter (A11) for Option 29





NOTES:
1. # SHORTING LINKS.
2. # # R26 REPLACED BY Z1 ON SERIAL PREFIX 608- AND ABOVE.
3. DES FOR HIDDEN PARTS ARE IN PARENTHESIS e.g. (R69).
4. LETTERED PINS ARE ON OPPOSITE SIDE OF BOARD.

Stock No. 5060-5646

(A11) Reversible 1MHz 8-4-2-1 Decade Counter for Option 29/21 or 29/35

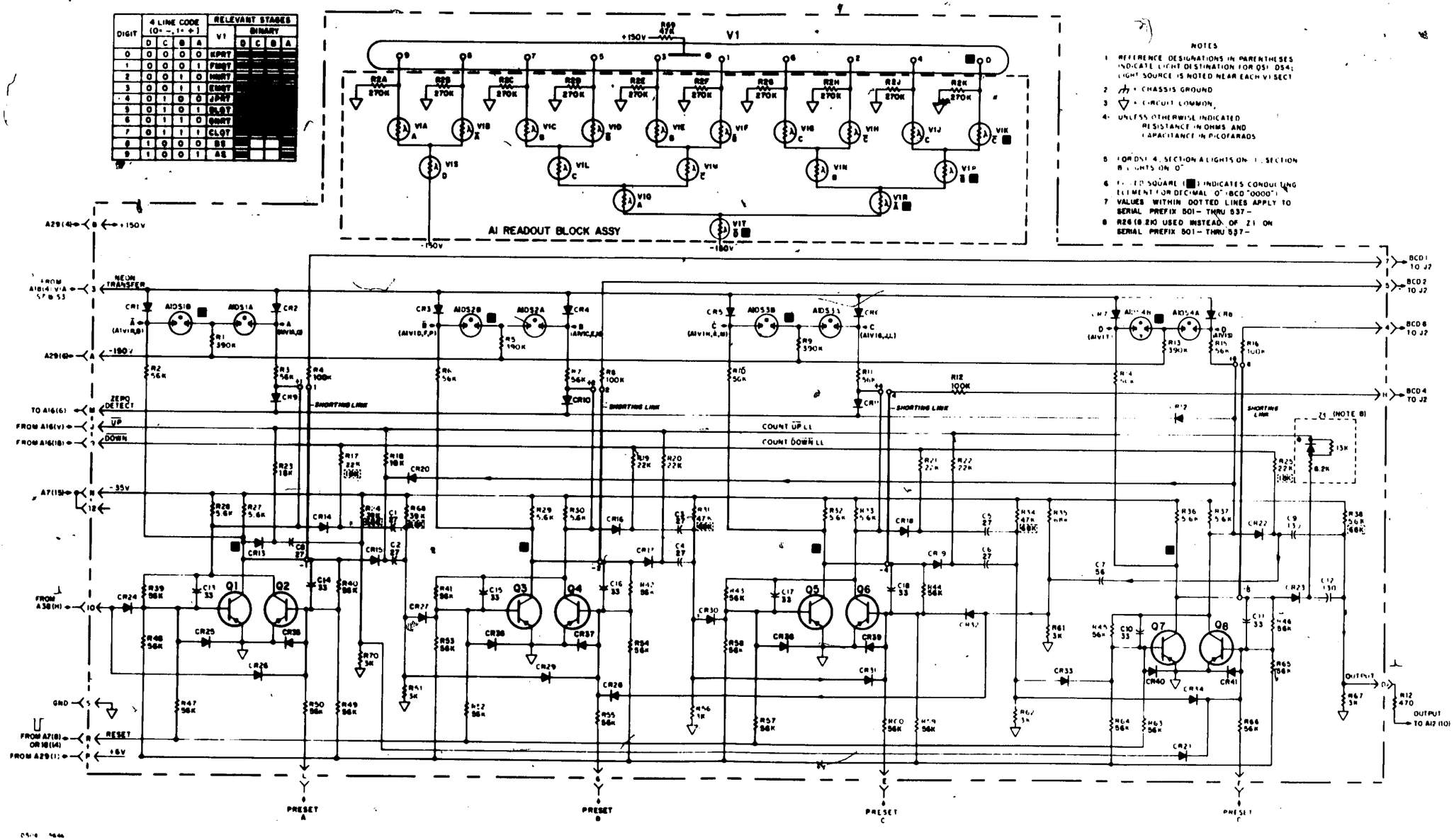


Figure 29-4. Reversible 1MHz 8-4-2-1 Decade Counter (A11) for Options 29/21 or 29/35

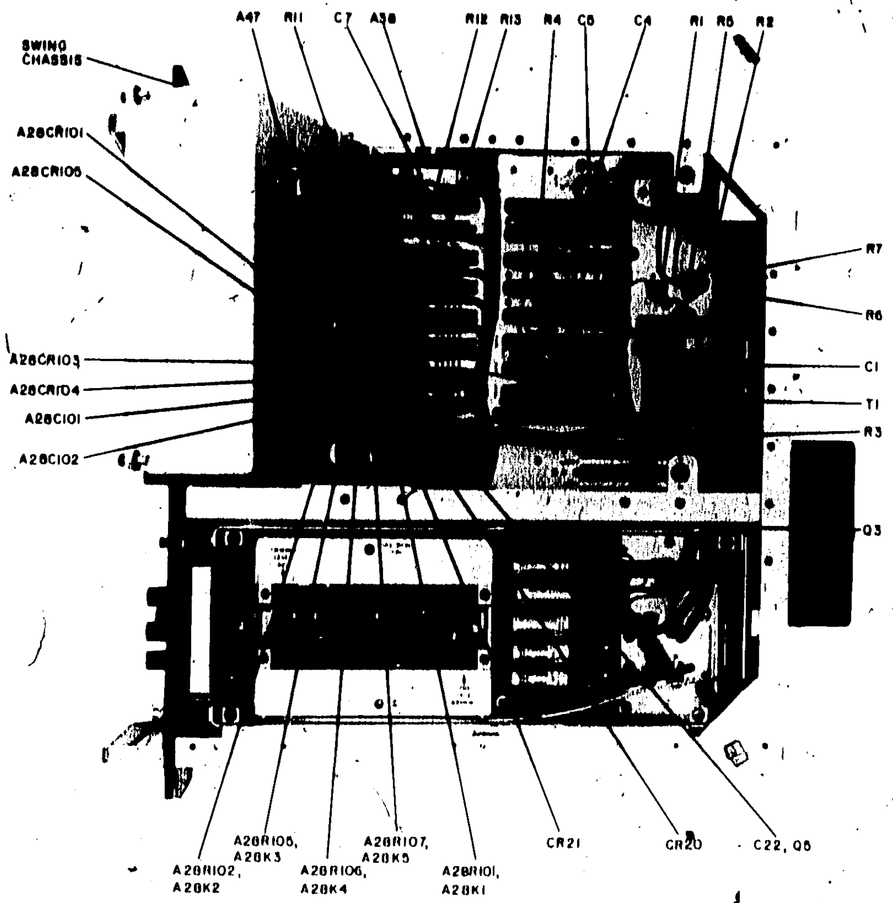


Figure 29-5. Bottom Internal View of HP 2401C-20

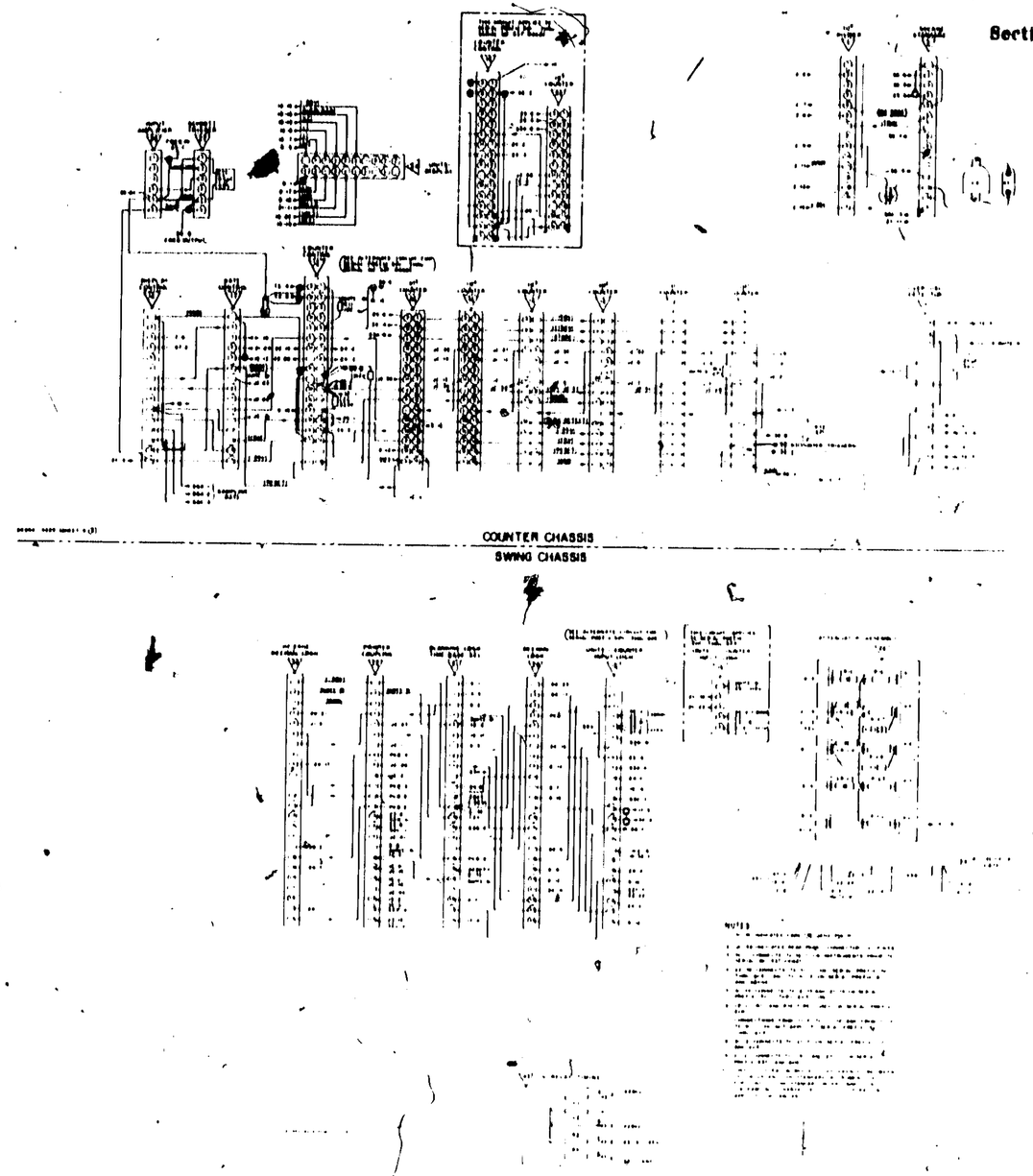


Figure 29-6. Interconnection Changes for Option 29

MANUAL SUPPLEMENT

MODEL HP-2401C
Integrating Digital Voltmeter
Option 30

30.1 GENERAL DESCRIPTION

The HP-2401C-30 Integrating Digital Voltmeter incorporates logic for period measurement in addition to all capabilities of the standard instrument. The six-digit display of the HP-2401C-30 provides direct readout of period, in milliseconds, with the decimal point properly placed. Period measurement specifications of Option 30 are presented in Section 1.7 of this manual.

30.2 INSTALLATION AND OPERATION

Install, operate, and program the HP-2401C-30 as specified in Section II of this manual.

30.3 THEORY OF OPERATION

Period is measured by reversing the signal routing used when measuring frequency. In the HP-2401C-30 this reversal is accomplished by period logic assembly A40 when the FUNCTION switch, S2, is set to PERIOD position, or when period measurement is programmed with the FUNCTION switch set to EXT SEL position. (See Figures 30-1 and 30-2.)

30.3.1 Frequency Measurement

When the FUNCTION switch is set to FREQ position, the false state (near -15 volts) of the period input logic line to pin 5 of A40 enables AND transistors Q5 and Q8. Through logic amplifiers Q1 and Q2 this establishes the frequency measurement connections whereby cycles of an unknown signal are counted by decade counters A11-A15 and A46 for a known sample period, which is derived by decade dividers A1-A5 from the 100 kHz time base output of A6.

30.3.2 Period Measurement

When the FUNCTION switch is set to PERIOD position, the true state (near ground) of the period input logic line enables A40 AND transistors Q6 and Q7 through logic amplifier Q1. This switches the known 10 kHz output from decade divider A1 to the decade counters and switches the unknown signal to the circuits that start and stop the gate period. The number of 100 kHz pulses (100 microsecond intervals) counted during the gate period yields a measurement of the period's duration. The decimal point is placed so that the measurement is direct reading in milliseconds.

The selection of SAMPLE PERIOD determines whether the unknown signal is divided by 1, 10, or 100. Division of the unknown signal improves the resolution of measurement because the number of counts of the known signal is multiplied by 10 or 100. The averaging of 10 periods in this manner yields 10 microsecond resolution. Averaging of 100 periods gives 1 microsecond resolution.

30.3.3 Other Functions

The remainder of the period logic on A40 controls display lamps of units indicator assembly A24 and the frequency logic line input to printer coupling logic assembly A22. The selection of either PERIOD or FREQ measurement FUNCTION applies a true state to the FREQ logic lines, assuring that frequency count AND transistor A19Q11 of counter input logic assembly A19 is opened.

30.3.4 Volt Measurement

Selection of VOLT measurement FUNCTION has the same effect upon the A40 circuits as the selection of FREQ except that the FREQ logic line is left false. The time base is derived for voltage measurements, but frequency count AND transistor A19Q11 is inhibited and voltage count AND transistor A19Q10 is enabled.

30.4 MAINTENANCE

Except as specified in the following paragraphs, service the HP-2401C-30 per the instructions in Section IV of this manual.

30.4.1 In-Cabinet Performance Checks

The In-Cabinet Performance Checks for the HP-2401C-30 are specified in Table 30-1. Any notations to check 30.1, etc. refer to that table only.

30.4.2 Location of A40 and Components

Figure 30-2 shows the parts location on A40 and Figure 30-3 shows the location of A40 in the HP-2401C-30.

30.4.3 Troubleshooting

Trouble in period logic assembly A40 can prevent counting by the decades when any FUNCTION is selected. (See Figures 30-1 and 30-2.) Figure 30-4 shows connections of the HP-2401C-30 where these differ from those of the standard HP-2401C. The other components involved in period measurement are checked adequately by following the troubleshooting instructions in Section 4.4 of this manual.

Table 30-1. In-Cabinet Performance Checks (Sheet 1 of 2)
Perform checks 1 through 24 as specified in Table 4-3 of this manual per instructions in Section 4.2.

30.1 PERIOD MEASUREMENT RANGES

1, 10, and 100 periods, 5 Hz (200 ms) to 10kHz (1 ms) - sine wave input*.

a. Set HP-2401C-30 Power switch to ON, other controls as follows:

FUNCTION:	PERIOD.
SAMPLE PERIOD:	.01 SEC.
SAMPLING RATE:	Fully clockwise.
ATTENUATION:	Fully clockwise.
100 KC STD (rear panel):	INT.

b. Connect output of portable oscillator to HP-2401C-30 FREQ INPUT and to input of oscilloscope with a BNC "T" connector. Set oscillator to provide 5 Hz 0.28v p-p output.

c. Check and record reading on the HP-2401C-30, which should be approximately 200.0 MILLISEC.

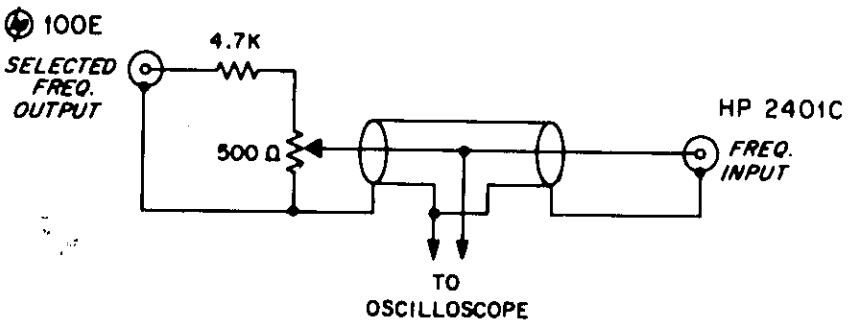
d. Set oscillator for reading of exactly 200.0 MILLISEC on the HP-2401C-30. Set SAMPLE PERIOD switch to .1 SEC position and check and record reading, which should be 200.00 ±the setting error in the last (10 μs) digit.

e. Set oscillator for reading of exactly 200.00 MILLISEC on the HP-2401C. Set SAMPLING PERIOD switch to 1 SEC position and check and record reading, which should be 200.000 MILLISEC ±the setting error in the last (1 μs) digit.

30.2 PERIOD MEASUREMENT ACCURACY

$$\frac{\pm 1 \text{ count} \pm \text{time base accuracy} \pm \text{trigger error}}{\text{number of periods averaged}}$$

a. Turn on frequency standard and connect its SELECTED FREQ OUTPUT to the HP-2401C-30 FREQ INPUT and oscilloscope as indicated below. Select 10 Hz output.



b. Set HP-2401C-30 Power switch to ON, other controls as follows:

FUNCTION:	PERIOD.
SAMPLE PERIOD:	.01 SEC.
SAMPLING RATE:	Fully clockwise.
ATTENUATION:	Fully clockwise.
100 KC STD (rear panel):	INT.

c. After required warmup of frequency standard, set 500Ω potentiometer for maximum p-p amplitude of signal to HP-2401C-30 FREQ INPUT. Then record period measurement displayed. This should be within the range of 100 ±0.1 MILLISEC.

*Measurement of period up to 99999.9 MILLISEC is possible with pulse input specified for frequency measurement.

Table 30-1. In-Cabinet Performance Check (Sheet 2 of 2)

30.2	d.	Slowly reduce signal amplitude tapped from the 500Ω potentiometer to the point where individual period measurement readouts on the HP-2401C-30 are as low as 00099.6 or as high as 00100.4 MILLISEC. Determine and record p-p amplitude of signal to FREQ INPUT of the HP-2401C-30. Amplitude should be no greater than 0.28v p-p (0.1v rms).
	e.	Set SAMPLE PERIOD switch to .1 SEC and record the most erroneous period measurement of the next ten. No readout should be lower than 0099.96 MILLISEC or higher than 0100.04 MILLISEC.
	f.	Repeat step e, above, at 1 SEC SAMPLE PERIOD. No readout should be lower than 099.996 MILLISEC or higher than 100.004 MILLISEC.
30.3	EXTERNAL PROGRAMMING - PERIOD FUNCTION	
		Period measurement is a programmable function of the HP-2401C-30; the requirements of check 20, Table 4-3, apply.
	a.	Prepare for period measurement as specified in check 30.1, except set the FUNCTION switch to EXT SEL.
	b.	Record lighted HP-2401C-30 units display, which should be VOLTS.
	c.	Connect a jumper between pins Z and f of J1 and record lighted HP-2401C-30 units display, which should be MILLISEC.

30.5 PARTS LIST

The Parts List in Section V of this manual applies to the HP 2401C-30 except as indicated in Tables 30-2 and 30-3.

HP-2401C **PERFORMANCE CHECK TEST CARD**

SER ____ - ____ DATE ____

DESCRIPTION	CHECK RESULTS
30.1 PERIOD MEASUREMENT RANGES	
Period	
1	____ ms
	(Approx. 200.0 ms)
10	____ ms
	(200.0? ms)
100	____ ms
	(200.00? ms)
30.2 PERIOD MEASUREMENT ACCURACY	
1 period reading, maximum amplitude input	____ ms
	(100.0 ±0.1 ms)
Input voltage producing specified trigger error	____ v p-p
	(0.28v p-p, max.)
10 period reading with specified trigger error	____ ms
	(100.00 ±0.04 ms)
100 period reading with specified trigger error	____ ms
	(100.000 ±0.004 ms)
30.3 EXTERNAL PROGRAMMING - PERIOD FUNCTION	
Program Connections / Function	
J1-Z to none / Volts	____
	(VOLTS)
J1-Z to f / Period	____
	(MILLISEC)

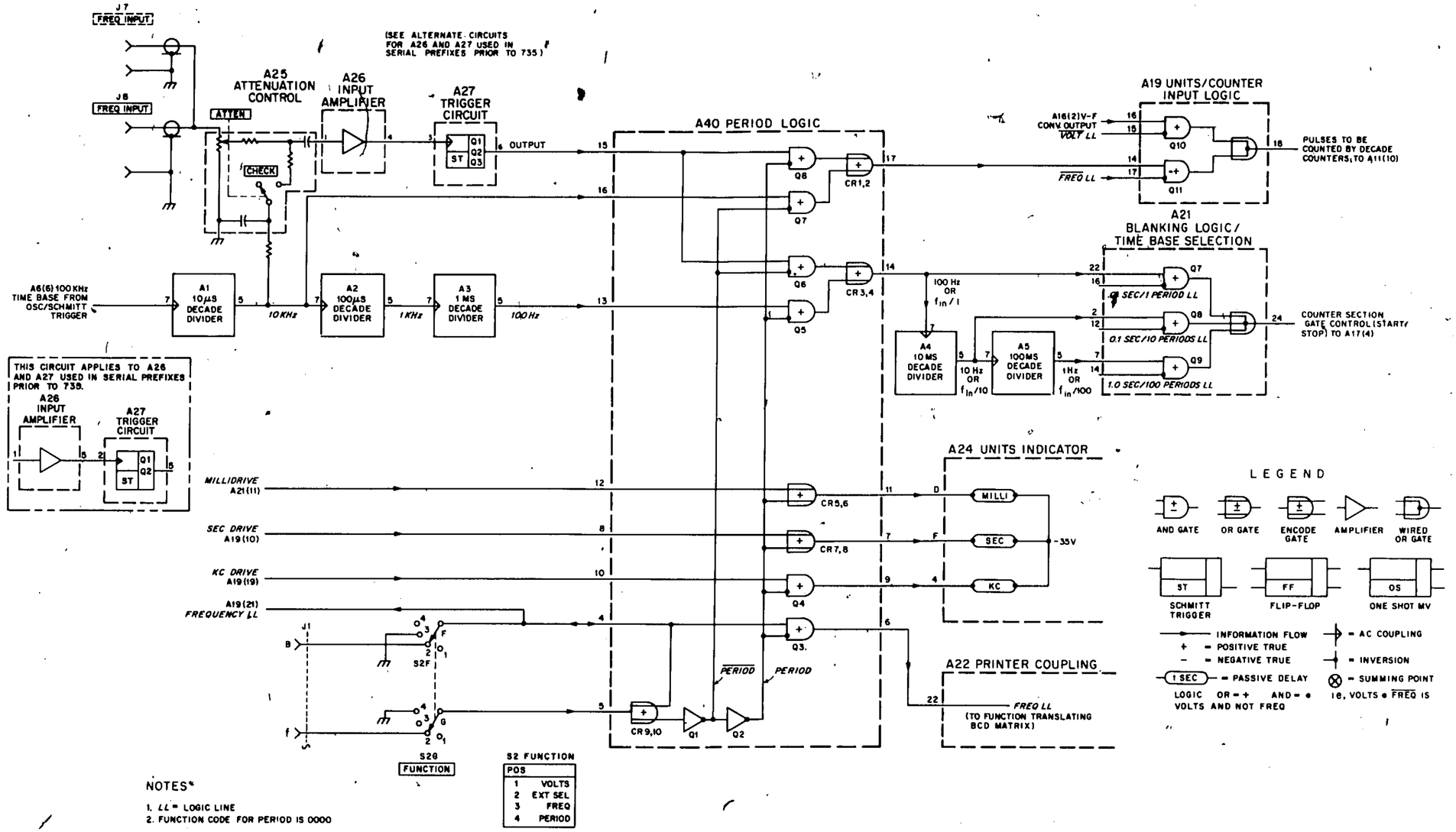
Table 30-2. Reference Designation Index

Reference Designation	Part No.	Description #	Note
		OPTION 30	
		A40 5060-2506	A-H
		5060-5876	J-X
		ADD THE FOLLOWING TO TABLE 5-1 TO MAKE THE TABLE APPLICABLE TO THE HP2401C-30.	
A40	5060-2506	PERIOD MEASUREMENT LOGIC	A-H
A40	5060-5876	PERIOD MEASUREMENT LOGIC	J-X
XA40	1251-0332	CONN:PC 24 CONTACTS	
A40	5060-2506	PERIOD MEASUREMENT LOGIC	A-H
	5060-5876	PERIOD MEASUREMENT LOGIC	J-X
A40CR1	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR2	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR3	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR4	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR5	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR6	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	A-H
	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR7	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR8	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR9	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR10	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR11	1901-0025	DIODE:SILICON 100WV 100MA	J-X
A40CR12	1901-0025	DIODE:SILICON 100WV 100MA	A-H
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	J-X
A40CR13	1901-0025	DIODE:SILICON 100WV 100MA	A-H
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	J-X
A40CR14	1901-0025	DIODE:SILICON 100WV 100MA	A-H
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	J-X
A40CR15	1901-0025	DIODE:SILICON 100WV 100MA	A-H
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	J-X
A40CR16	1901-0025	DIODE:SILICON 100WV 100MA	A-H
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	J-X
A40CR17	1901-0025	DIODE:SILICON 100WV 100MA	A-H
	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	J-X
A40Q1	1850-0113	TRANSISTOR:GERMANIUM PNP	
A40Q2	1850-0113	TRANSISTOR:GERMANIUM PNP	A-H
	1850-0145	TRANSISTOR:GERMANIUM PNP	J-X
A40Q3	1850-0128	TRANSISTOR:PNP GERMANIUM	
A40Q4	1850-0128	TRANSISTOR:PNP GERMANIUM	
A40Q5	1850-0113	TRANSISTOR:GERMANIUM PNP	
A40Q6	1850-0113	TRANSISTOR:GERMANIUM PNP	
A40Q7	1850-0113	TRANSISTOR:GERMANIUM PNP	
A40Q8	1850-0113	TRANSISTOR:GERMANIUM PNP	
A40Q9	1851-0034	TRANSISTOR:GERMANIUM NPN	J-X

Table 30-2. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 30 A40 5060-2506 (CONT'D) 5060-5876 (CONT'D)	A-H J-X
A40R1	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A40R2	OBD	R:FXD COMP 22-47K 5% 1/4W SELECTED	
A40R3	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A40R4	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A40R5	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A40R6	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A40R7	OBD	R:FXD COMP 47-100K 5% 1/4W SELECTED	
A40R8	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A40R9	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A40R10	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A40R11	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A40R12	0689-3315	R:FXD COMP 330 OHM 5% 1W	
A40R13	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A40R14	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A40R15	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A40R16	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	A-H
	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	J-X
A40R17	0758-0004	R:FXD MET OX 2700 OHM 5% 1/2W	
A40R18	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	A-H
A40R19	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	A-H
	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	J-X
A40R20	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	A-H
	0683-1635	R:FXD COMP 16K OHM 5% 1/4W	J-X
A40R21	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A40R22	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A40R23	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A40R24	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	J-X

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 30			
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	1
0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	01121	CB 1045	3
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	3
0683-1635	R:FXD COMP 16K OHM 5% 1/4W	01121	CB 1635	1
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	1
0683-3335	R:FXD COMP 33K OHM 5% 1/4W	01121	CB 3335	3
0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	01121	CB 4725	2
0683-4735	R:FXD COMP 47K OHM 5% 1/4W	01121	CB 4735	7
0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	01121	CB 8225	1
0689-3315	R:FXD COMP 330 OHM 5% 1W	01121	GB 3315	2
0758-0004	R:FXD MET OX 2700 OHM 5% 1/2W	28480	0758-0004	1
1251-0332	CONN:PC 24 CONTACTS	28480	1251-0332	1
1850-0113	TRANSISTOR:GERMANIUM PNP	01295	2N1997	6
1850-0128	TRANSISTOR:PNP GERMANIUM	01295	2N3988	2
1850-0145	TRANSISTOR:GERMANIUM PNP	03508	2N1926	1
1851-0034	TRANSISTOR:GERMANIUM NPN	01295	2N1605A	1
1901-0025	DIODE:SILICON 100WV 100MA	28480	1901-0025	6
1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	28480	1910-0016	6
5060-2506	PERIOD MEASUREMENT LOGIC	04404	5060-2506	1
5060-5876	PERIOD MEASUREMENT LOGIC	04404	5060-5876	1

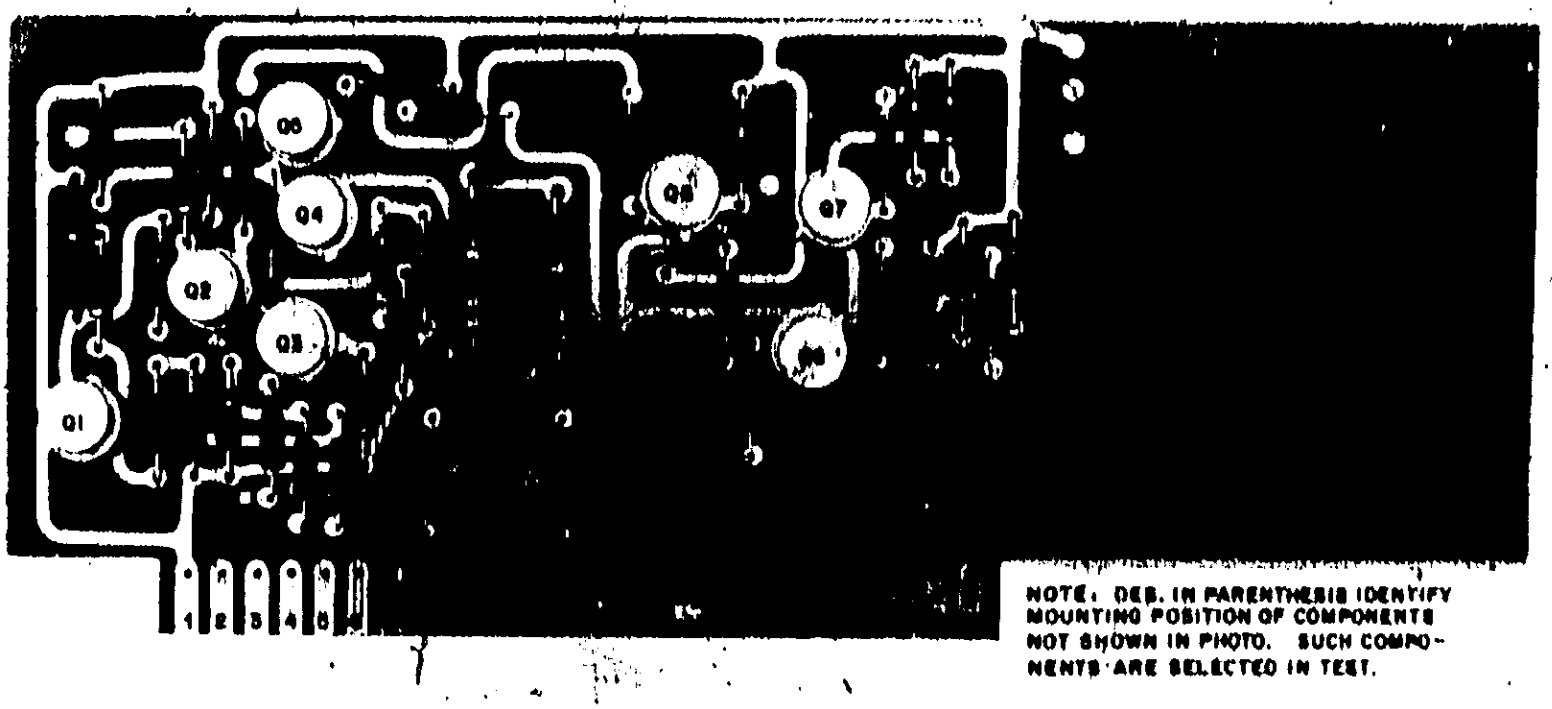


NOTES:

1. LL = LOGIC LINE
2. FUNCTION CODE FOR PERIOD IS 0000

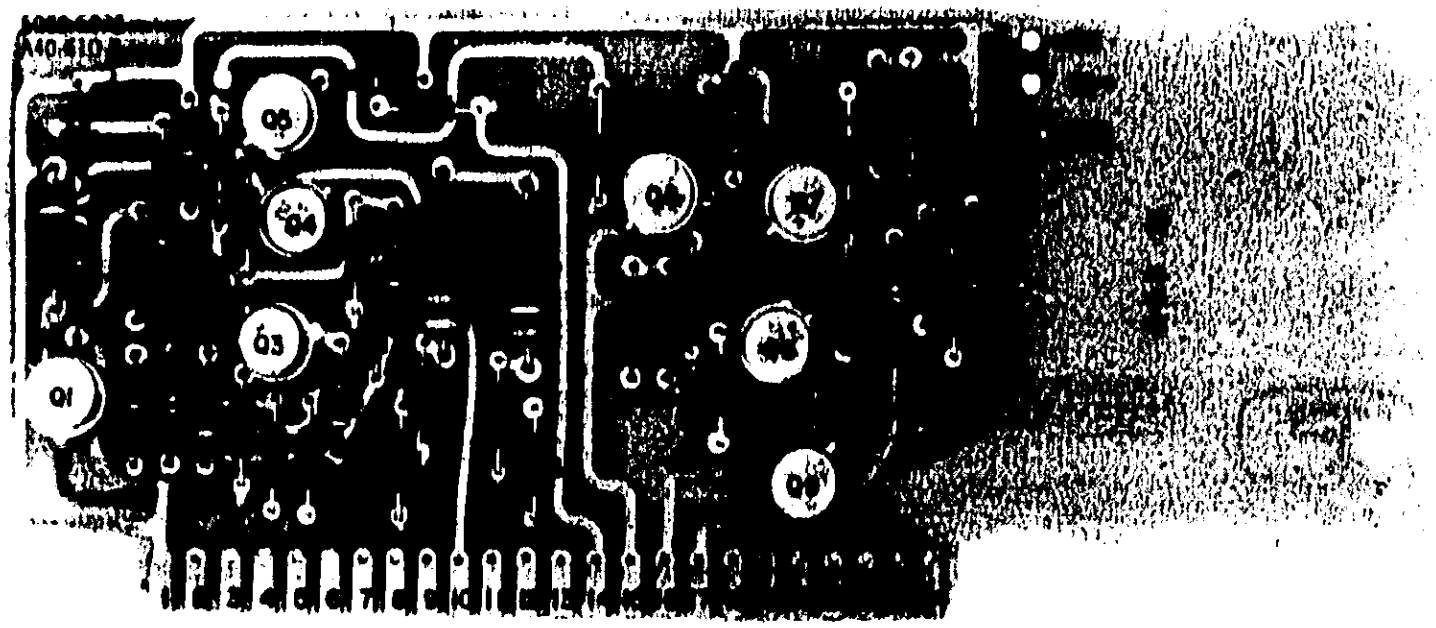
D5950-1529

Figure 30-1. Period Measurement Logic for Option 30



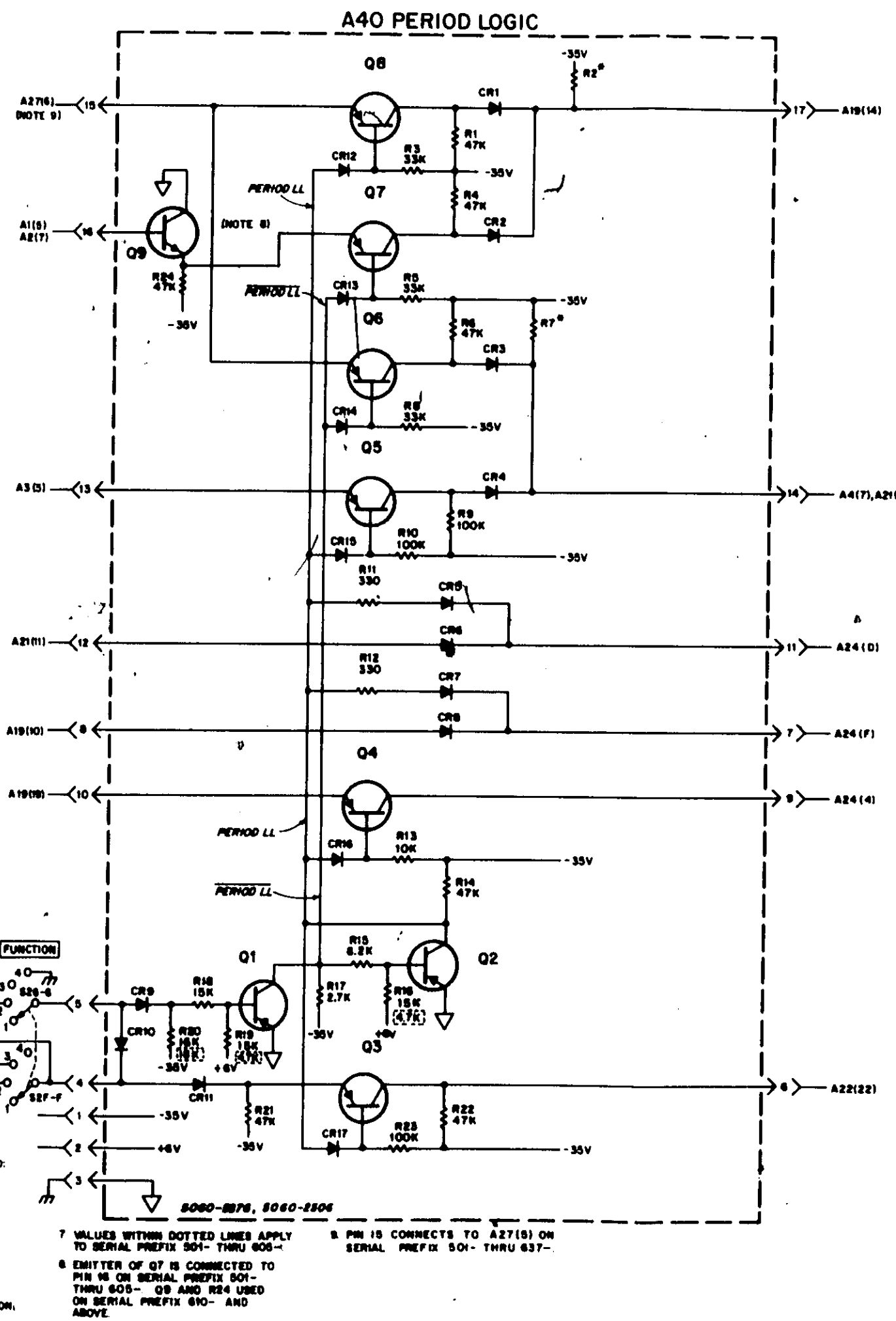
NOTE: DES. IN PARENTHESIS IDENTIFY MOUNTING POSITION OF COMPONENTS NOT SHOWN IN PHOTO. SUCH COMPONENTS ARE SELECTED IN TEST.

Stock No. 5060-2506 (Serial Prefix 501 thru 605)



Stock No. 5060-5876 (Serial Prefix 610 and above)

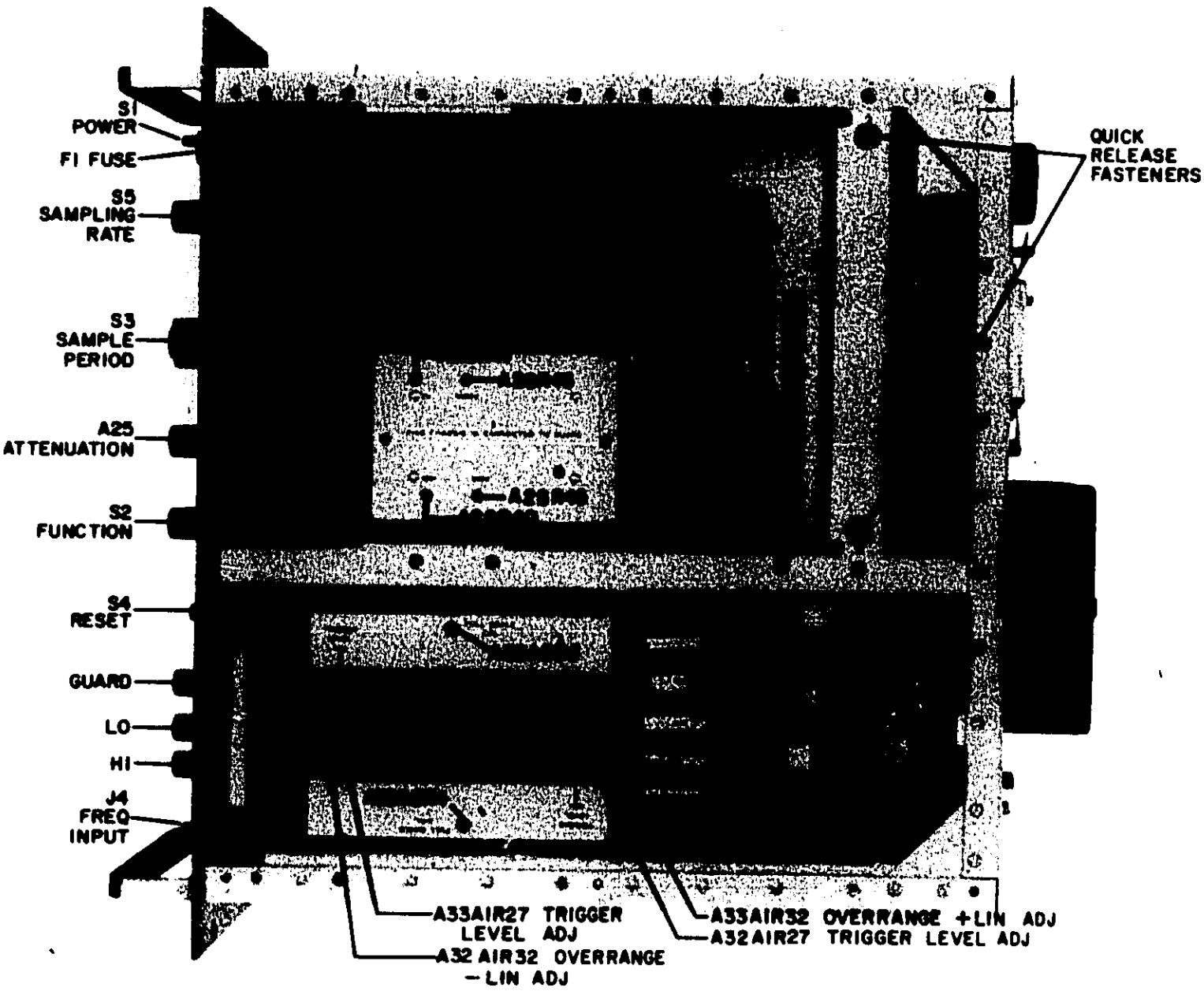
(A40) Period Logic for Option 30



NOTES

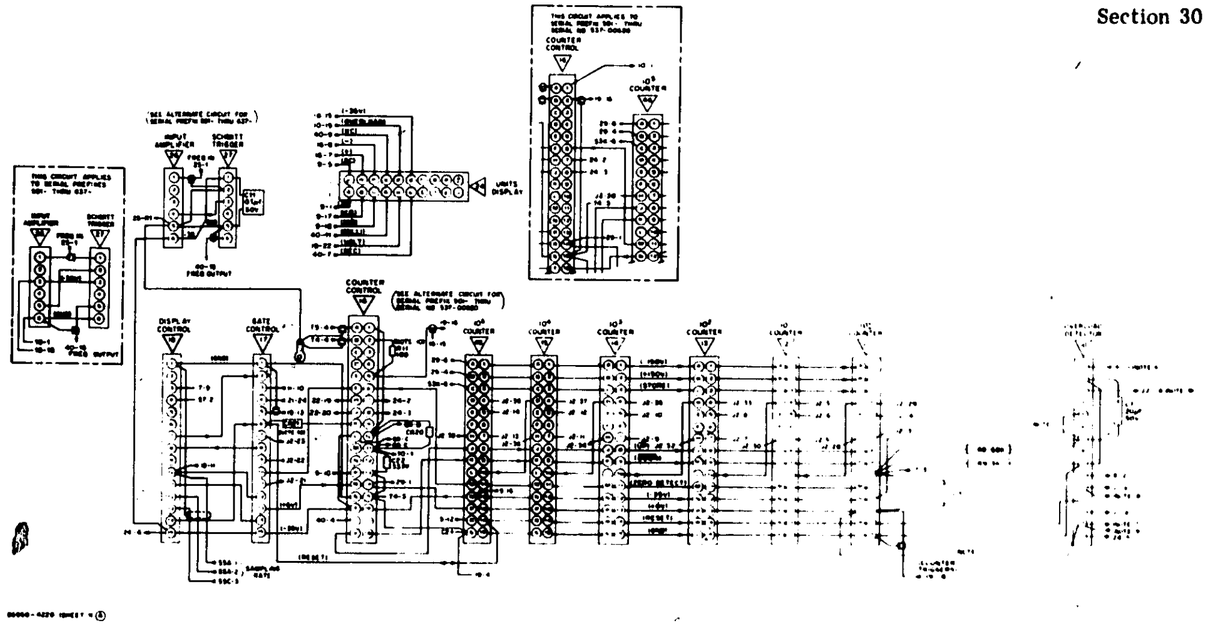
1. LL = LOGIC LINE
2. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS
3. ▽ = CIRCUIT COMMON
4. ⏚ = CHASSIS GROUND
5. S2 POSITIONS
   1. VOLTS 3. FREQUENCY
   2. EXT. SEL. 4. PERIOD
6. * SELECTED IN TEST, ORDER REPLACEMENT BY DESCRIPTION.
7. VALUES WITHIN DOTTED LINES APPLY TO SERIAL PREFIX 501- THRU 605-
8. EMITTER OF Q7 IS CONNECTED TO PIN 16 ON SERIAL PREFIX 501- THRU 605- Q9 AND R24 USED ON SERIAL PREFIX 610- AND ABOVE
9. PIN 15 CONNECTS TO A27(5) ON SERIAL PREFIX 501- THRU 637-

Figure 30-2. Period Logic (A40) for Option 30



* SUPPLIED WITH HP 2411A GUARDED DATA AMPLIFIER. JUMPER BOARD INSTALLED HERE IF HP 2401C IS ORDERED BY ITSELF.
** SUPPLIED WITH HP 2410B AC/OHMS CONVERTER.

Figure 30-3. Bottom Internal View of HP 2401C-30



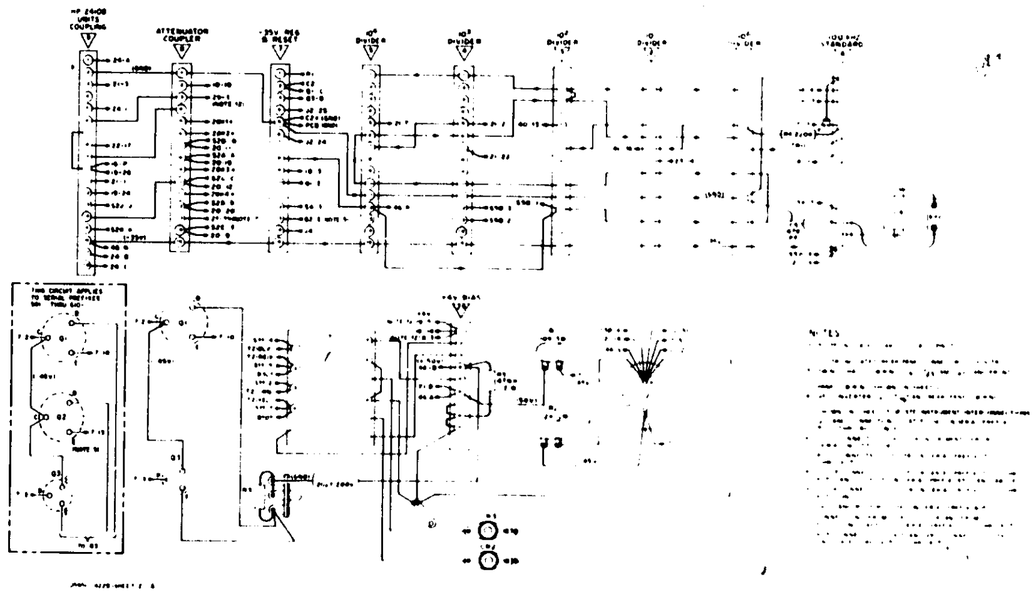
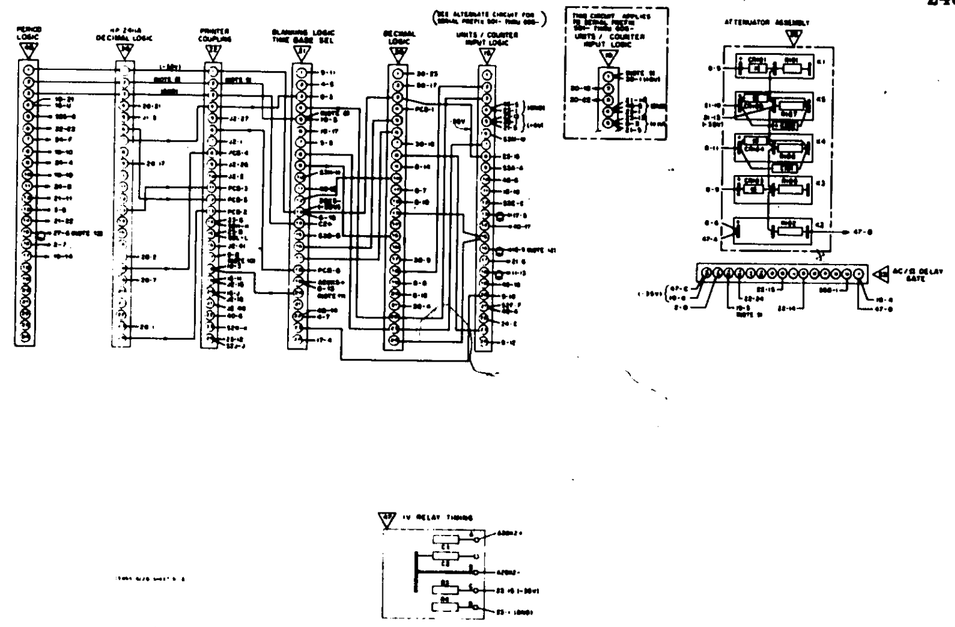


Figure 30-4. Interconnections for Option 30 (Sheet 1 of 2)



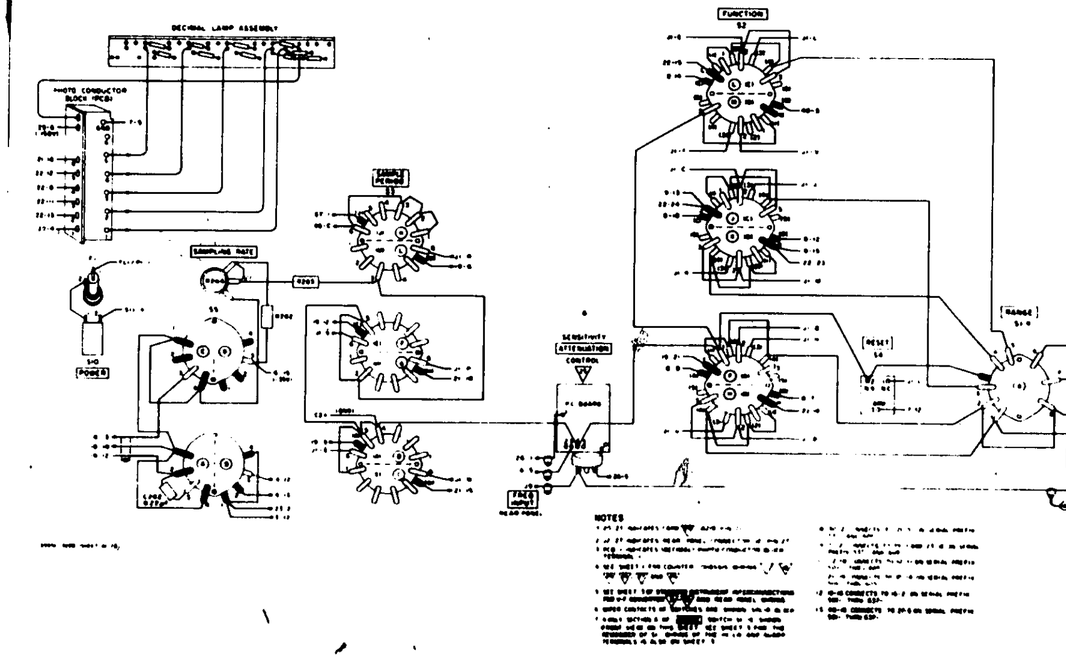


Figure 30-4. Interconnections for Option 30 (Sheet 2 of 2)

MANUAL SUPPLEMENT

MODEL HP-2401C
Integrating Digital Voltmeter
Option 31

31.1 GENERAL DESCRIPTION

The HP-2401C-31 Integrating Digital Voltmeter incorporates automatic selection of the appropriate input voltage range in addition to all capabilities of the standard instrument. The autoranging circuitry utilizes the full overrange capability of the standard HP-2401C, upranging at 310% of full scale. It downranges at 30% of full scale.

Operation of the autoranger is rapid - only 6 ms per range change. The autoranger proceeds automatically in the correct direction. Thus even if the appropriate range for a new input signal is at the opposite extreme from that required for the previous reading, the measurement usually commences in 34 ms. (This includes the normal encode delay of 9.7 ms when the correct range is reached.) However, if the autoranger has downranged from 1000V to .1V range, noise may force one or two uprangings, resulting in as much as 50 ms delay before the sample period begins. The HP-2401C-31 can therefore be used at high sampling rates with varying input signals, and permits rapid scanning rates when employed in multi-channel systems with widely varying signal levels. However, the maximum sampling rate is limited by the sample period and the time required to reach the correct range.

When used with a HP-2411A Guarded Data Amplifier, the HP-2401C-31 automatically selects the appropriate amplifier gain. It thereby provides six automatically selected ranges from 10 mV to 1000v full scale.

The HP-2401C-31 also provides range selection commands for a HP-2410B AC/Ohms Converter. (HP-2410B-17 for AC/Ohms Converters with serial prefixes earlier than 514-.) However, autoranging ac voltage measurement extends only to the 1v range; ac voltage measurements on the 0.1v range must be selected manually or by specific programming. The autorange logic is such that the record command outputs from the instrument are not necessarily identical to the counter gate time.

31.2 INSTALLATION AND OPERATION

For dc voltage measurement, install, operate, and program the HP-2401C-31 as specified in Section II of this manual. The following paragraphs briefly describe how to set controls for autoraning ac and resistance measurements using the HP-2410B AC/Ohms Converter and measurements down to 10 millivolts full scale using the HP-2411A Guarded Data Amplifier. Also briefly discussed is the autoranger's response to various situations during the operating cycle of the HP-2401C-31.

31.2.1 Autoranging with HP-2410B

For autoranging resistance or ac voltage measurements using a HP-2410B AC/Ohms Converter with a HP-2401C-31, set controls exactly as specified in Section 2.5.3, except for the HP-2410B RANGE switch. Instead of setting the HP-2410B RANGE switch to a specific range, set it to AUTO position. This programs autoranging operation of the HP-2401C-31 regardless of the HP-2410B FUNCTION selected and autoranging resistance or voltage measurements will be automatically completed on the range that yields the best resolution and accuracy.

NOTE

The logic in the HP-2401C-31 cannot select the 0.1v ac measurement range of the HP-2410B. Ac voltage measurements on the 0.1v ac range must be selected manually by means of the HP-2410B RANGE switch or by specific programming.

31.2.2 Autoranging with HP-2411A

For autoranging dc voltage measurement down to 10 millivolts (0.01v) full scale (30 millivolts overrange), using the HP-2411A Guarded Data Amplifier with the HP-2401C-31, set controls exactly as specified in Section 2.5.4 except for the HP-2401C-31 FUNCTION switch and the HP-2411A MODE selector. Instead of setting the HP-2401C-31 FUNCTION switch to EXT SEL, set it to AUTO RANGE position; use EXT SEL position only if autoranging measurements with the HP-2411A are to be programmed externally. Instead of setting the HP-2411A MODE selector to the desired mode, set it to EXT SEL.

31.2.3 Response Characteristics of the HP-2401C-31

Upranging

The HP-2401C-31 always responds to an input that exceeds 310% of full scale by upranging. During the display period, the autoranger switches directly to 1000V range; this is essentially the same as the response of the standard HP-2401C to an overload input, but the OVERLOAD indicator does not light when AUTO RANGE function is selected. Following the encode command, the HP-2401C-31 upranges one range at a time instead of skipping to the 1000v range.

Downranging

The HP-2401C-31 responds to an input that is less than 30% of full scale only during the encode delay interval that follows the encode pulse and precedes the sample period.

Design Objectives

These response characteristics are designed to achieve the following:

a. Maximum protection of the instrument from overloading.
b. Minimum delay between the encode command and the start of a valid measurement.

31.3 THEORY OF OPERATION

31.3.1 General

During autorange operation of the HP-2401C-31 the autorange logic selects the appropriate voltage range in response to over and under range input signals from Auto Range Rate Detector A10. The selection of range and

+1 or +10 gain are routed through PROGRAM CONTROL receptacle J1 to the HP-2410B or the HP-2411A, controlling their operation as well when either is used with the HP-2401C-31.

As shown in Figure 31-5, Auto Range Rate Detector A10 consists of two frequency-to-voltage converters (fvc's) and high and low rate level detectors. The high and low rate outputs from A10 are applied to the Range Gates on Assembly A44, as indicated in Figure 31-6. During the encode delay period, low or high rate pulses are passed to the count one-shot on Range Control Assembly A45. This one-shot produces a delayed trigger for the Range Counter on Assembly A43. The range counter counts up or down, depending upon the logic line input that it receives from the up/down flip-flop on A45. The range counters count down in response to low rate pulses because the down state of the up/down flip-flop is not changed. High rate pulses trigger the up/down flip-flop to up state, so that the range counters count up in response to high rate pulses. The states of the range counter binaries are decoded and amplified to program range selection. Down counts program progressively lower ranges and up counts program progressively higher ranges. The details of the autorange logic are discussed in the descriptions that start with Section 31.3.3.

31.3.2 Autorange Rate Detector A10 (Figure 31-7)

NOTE

Unless otherwise stated, incomplete designations (C7, A1, T1, CR4, etc.) which appear in the following discussions (Sections 31.3.2 through 31.3.5) identify components of the circuit assembly (A10, A43, A44, or A45) being described.

The auto range rate detector examines the combined channel pulse train output of the voltmeter vfc to determine if the pulse rate (input voltage) is low or high. If the vfc output is less than 30 kHz (i.e., the input signal is less than 30% of full scale), the low rate detector produces an output. When the vfc output is 310 kHz or greater (i.e., the input signal is at least 310% of full scale), the high rate detector produces an output. Between these extremes, no output is produced by either detector.

The output from either detector is essentially the same, a train of positive-going 2 μs pulses at 5.5 ms intervals. (The quoted duration and spacing are approximate.) The auto range rate detector also provides an overload reset pulse for the HP-2411A Guarded Data Amplifier.

High Rate Detector

As shown in Figure 31-7, the vfc pulses are received at pin 1 of A10 and coupled to the high rate detector via C7. The high rate detector output from the collector of Q1 is produced only when current can flow through the number 2 winding of T1. The switching of current flow between the number 1 and 2 windings of T1 is determined by the voltage levels at the cathodes of CR3 and CR4.

The voltage at the cathode of CR4, set by potentiometer R3, determines the high rate detector switchover point. The voltage at the cathode of CR3 is

determined by the frequency of the pulse input to pin 1 and the forward voltage drop across CR18. The pulses that are coupled through C7 and CR2 charge C2 positively. Between pulses C2 charges negatively. The average negative voltage across C2 increases for low input frequencies and decreases for high input frequencies.

With input pulse frequencies below 310 kHz, the voltage across C2 is such that the cathode of CR3 is slightly more negative than the cathode of CR4. (Under these conditions the voltage difference is essentially determined by a forward drop across CR18.) CR4 is cut off, closing the path for regenerative feedback between collector and base of Q1, which is a blocking oscillator.

When the input pulse frequency reaches 310 kHz, the voltage across C2 reaches a level where the cathode of CR3 becomes more positive than the cathode of CR4. This cuts off CR3 and enables conduction through CR4, opening the regenerative path required for cycling of blocking oscillator Q1-T1.

At this point, when current is switched from T1 winding no. 1 to no. 2, thermal noise voltage developed across R5 is amplified and inverted by Q1 and coupled back to winding no. 2. The feedback, now in phase, quickly saturates the blocking oscillator, generating a positive-going pulse at the collector of Q1. Current through Q1 increases to the point where the transformer core saturates and no longer provides the coupling action, disconnecting the regenerative path. Conduction through Q1 then decreases, returning to the unsaturated condition in approximately 2 μs. After a time delay that is essentially determined by the time constant of R5 and C3, the comparison circuit is ready to cycle again. This action continues as long as the overload remains, producing a train of positive-going pulses from the collector of Q1.

Low Rate Detector

The operation of the low rate detector is similar to that of the high rate detector, except that the action is reversed. At input pulse frequencies above 30 kHz the voltage developed across CR19 keeps the CR10 cathode more positive than the CR9 cathode. Below 30 kHz the C10 voltage falls to the point at which the CR10 cathode is more negative than the CR9 cathode, connecting regeneration that drives Q2 to saturation. The interval between positive pulses from the low rate output is determined by the time constant of R13 and C11.

Delay Between Rate Detector Pulses

R5 and R13 are factory selected to provide approximately 5.5 ms between rate detector output pulses. This delay allows time for a range change before the next high/low rate detector output pulse is generated. However, this does not delay the first high or low rate pulse, which is generated within a few hundred microseconds after the input frequency reaches 310 or 30 Khz. This is possible because C2 and C10 are partially charged by CR18 and CR19.

HP-2411A Reset Output

The reset pulse for the HP-2411A is generated by inverting amplifier Q3, which amplifies the internal reset pulse from the reset bus.

31.3.3 Range Gate A44 (Figures 31-6 and 31-9)

The logic on Range Gate Assembly A44 determines the response of the autoranger to pulses from A10. The low and high rate range gates are AND transistors Q1 and Q2. These gates are inhibited by any of several positive true inputs that may be applied through OR gates CR3-CR8 and CR9-CR12.

Display Period Logic

During the display period, Q1 and Q2 are inhibited (cut off) by the positive true state of the display holdoff signal from A18. This same state opens overload AND gate C5-R13 through logic amplifier Q3 and OR diode CR15. High rate pulses from A10 can then trigger flip-flop A45Q9-Q10 to overload state through overload OR diode A43CR45. This action, the only autoranger response permitted by the range gates during the display period, switches the attenuator directly to 1000v range, protecting the instrument from overload. Lighting of the OVERLOAD indicator is inhibited through OR diode A10CR16 by the positive true state of the autorange logic line when AUTO RANGE FUNCTION is selected.

Logic When AUTO RANGE Is Not Selected

The non-selection of AUTO RANGE function has the same effect upon operation of the range gates as the true state of the holdoff input from A18. In this instance, however, the positive true inhibit is derived by logic inverter A43-Q7 from the false state of the autorange logic line. Also, if the FUNCTION switch is not set to AUTO RANGE position, the OVERLOAD indicator is lighted by the overload state of flip-flop A45Q9-Q10. The overload state of A45Q9-Q10 cuts off A10Q4 through OR diode A10CR15 so that the OVERLOAD indicator is not lighted when there is no overload.

Encode Delay Period Logic

After the reset (encode) pulse, AND transistors Q1 and Q2 are no longer inhibited by the holdoff input from A18, which is false. But Q1 and Q2 are inhibited through logic inverter A45Q12 by the ac/ohms delay gate from A23 during resistance or ac voltage measurements with the HP-2410B.

The encode delay starts at the end of the ac/ohms delay gate, or immediately if resistance or ac voltage measurements are not being made. During this period, low rate pulses from A10 are gated through AND transistor Q1 while count flip-flop A45Q13-Q14 is in count down state. This continues until a high rate pulse is generated, the correct range is reached, or the next sample period starts.

A45Q13-Q14 is initially set to count down state by the reset pulse that starts the encode delay period. Any high rate pulse from AND transistor Q2 triggers A45Q13-Q14 to count up state, which inhibits low rate pulses from AND transistor Q1. This prevents upranging in response to low rate pulses. Thereafter, high rate pulses from A10 are gated through Q2 until the correct range is reached.

Low or high rate pulses are coupled to count one-shot A45Q5-Q7 through OR gate CR1-CR2. The remaining logic on assembly A44 derives the lowest and highest range signals that inhibit AND transistor Q1 or Q2 when the autoranger is at either end of its response range.

Sample Period Logic

During the sample period, the positive-true state of the record command line from A17 inhibits low rate AND transistor Q1 through OR diode CR4. This logic arrangement allows only upranging during the sample period.

31.3.4 Range Control A45 (Figures 31-6 and 31-10)

The logic on Range Control Assembly A45 stores the control states of the autoranging system, except for the range control states. The principal control memories are up/down flip-flop Q13-Q14 and overload flip-flop Q9-Q10. Also on this board are the count one-shot and the record flip-flop.

Up/Down Control Flip-Flop

Flip-flop Q13-Q14 is preset to count down state by each encode pulse from A7 or A18. This state places the count down and count up lines near ground and negative 35v, respectively. Thereafter, a high rate pulse from A44Q2 may trigger Q13-Q14 to count up state, reversing the potentials on the count down and count up lines. The control states from this flip-flop determine whether the autoranger switches to lower or higher ranges in response to the pulses that are passed by the range gates on A44.

Overload Flip-Flop

Flip-flop Q9-Q10 is preset to $\overline{\text{overload}}$ state by each encode pulse. It remains in this state (Q9 on, Q10 cut off) until a high rate pulse from AND gate A44C5-R13 triggers it to overload state. This can occur only during the display interval or when the FUNCTION switch is not set to AUTO RANGE position. Cutoff of Q9 during overload state turns on logic inverter Q11, switching the input attenuator to 1000v range. When the autorange logic line is false, the false state from Q9 also lights the OVERLOAD indicator on A24, through logic inverter A10Q4. If Q9-Q10 is in overload state, the encode pulse is gated through AND transistor Q15 to the range counters, setting them to the states that keep the attenuator switched to 1000v range. Thereafter the autoranger is switched to lower ranges if the 1000v range is too high.

Count One-Shot

Count one-shot Q5-Q7 delays range triggers that are applied to the range counter. Each range pulse from A44 triggers the one-shot to its unstable state. The positive-going trailing edge of the one-shot output from the Q7 collector triggers the range counter as the one-shot returns to its stable state. The delay allows time for a reversal of up/down logic state to settle before the range counter is triggered. Each positive pulse from the collector of Q5 is applied to the reset buss through inverter Q8.

Record Flip-Flop

Record flip-flop Q3-Q4 provides + and -record commands that signal an external recorder or data processing device that data is ready to be recorded or used. This flip-flop is triggered to record state (Q3 cut off and Q4 on) at the end of the sample period by the positive-going trailing edge of the +record command signal from A17. Each count pulse from

the count one-shot triggers the flip-flop to $\overline{\text{record}}$ state. This logic prevents issuance of a record command when a sample period is not completed because of upranging. A record command is issued only if the resetting of A17Q1-Q2 is not blanked by a negative pulse from Q7 of the count one-shot. The outputs from the record flip-flop are coupled to the record command outputs via emitter followers Q1 and Q4.

31.3.5 Range Counter A43 (Figures 31-6 and 31-8)

Flip-flops 1 through 3 and related diode AND gates make up a three-stage reversible counter with a digital range from 0 through 7, of which only 0 through 6 is used. Flip-flops 1 through 3 are identified A, B, and C in Figure 31-8. In the negative true matrix logic used to decode the flip-flop outputs, conduction through an even-numbered transistor (Q2, Q4, Q6) represents 0. Through an odd-numbered transistor (Q1, Q3, Q5) conduction represents a count value (A = 1, B = 2, C = 4). The operation of the counter is summarized in Table 31-1.

Table 31-1. Range Counter A43 Summary

Count	Off Transistors	C + B + A	AND Gate(s) and Logic Inverter(s)		Selected Range
0	Q2, Q4, Q6	0 0 0	CR2-5 CR6-8	Q8 Q9	+10 Gain* & .1V
1	Q2, Q4, Q5	0 0 1	CR6-8	Q9	.1V & +10 Gain
2	Q2, Q3, Q6	0 2 0	CR9-12	Q10	1V
3	Q2, Q3, Q5	0 2 1	CR13-16	Q11	10V
4	Q1, Q4, Q6	4 0 0	CR17-20	Q12	100V
5	Q1, Q4, Q5	4 0 1	CR21-24	Q13	1000V
6	Q1, Q3	4 2	CR25-27	Q14	10M**

* To HP-2411A Guarded Data Amplifier.
** To HP-2410B AC/Ohms Converter.

Up/Down Counting

During up counting, triggers are coupled from the collectors of odd-numbered transistors to succeeding stages. Down counting is inhibited by the positive true state of the count up line, which is applied to the cathodes of AND diodes CR29 and CR33 through R29 and R36. Down counting occurs when up counting is inhibited by the positive true state of the count down line from A45.

Coupling of Counter Outputs

Coupling of the range selected by the range counter to external circuits is enabled by the true state of the autorange logic line through logic inverter Q7. The inverted output from this line also serves as one of the inputs to HP-2410B control AND transistor Q15.

Control of the HP-2410B

AND transistor Q15 is enabled if:

a. The SAMPLING RATE control is in STOP position (used when the HP-2401C-31 is operated as part of a data acquisition system).

b. Autorange is programmed.

c. ACF or ACN is programmed.

d. A sample period is not in progress.

When each sample period ends, Q15 is enabled and the overload flip-flop is set via OR gate CR44-CR45. The HP-2401C-31 is switched to the 1000v range, and the HP-2410B is set to the 1000v range via J1, pin e, the overload signal output.

The encode pulse for the next measurement sets the Range Counter Assembly, A43, to 1000v and resets the overload flip-flop via A45CR11. This allows the HP-2401C-31 to switch to the 1v range (ac is programmed), and because the range counter is at 1000v, the HP-2410B remains on the 1000v range. If this is not the proper range, downranging occurs as described previously.

If the HP-2401C-31 is operated in the automatic re-cycle mode (SAMPLING RATE control not at the STOP position) or when ohms function is programmed, Q15 is inhibited and operation is the same as for dc voltages.

31.4 MAINTENANCE

Except as specified in the following paragraphs, service the HP-2401C-31 per the instructions in Section IV of this manual.

31.4.1 In-Cabinet Performance Checks

The in-cabinet performance checks for the HP-2401C-31 are specified in Table 31.2. The test setup is shown in Figure 31-1. Except where otherwise specified, any notations to check 31.1, etc., refer to that table only.

31.4.2 Troubleshooting

Trouble in A10, A43, A44, or A45 can prevent autoranging. Trouble in A10, A44, or A45 can prevent normal overload protection of the HP-2401C-31. (See Figures 31-4 through 31-6.) The other components involved in the operation of the HP-2401C-31 are checked adequately by following the troubleshooting instructions in Section 4.4 of this manual.

The locations of assemblies A10 and A43 through A45 are indicated in Figures 31-2 and 31-3. Figure 31-3 also shows the approximate locations of CR201 through CR205. Figures 31-7 through 31-10 show the location of components on these assemblies and the assembly circuits. Figure 31-11 shows connections to A17 and A18 for HP-2401C-31. Figure 31-12 shows interconnections of the HP-2401C-31.

31.4.3 Calibration of Rate Detection

Calibrate rate detection whenever the HP-2401C-31 uprange or downrange change point is incorrect. (See performance check 31.1, Table 31-2.) proceed as follows:

a. With FUNCTION switch set to VOLT, perform steps 1 through 5 of Section 4.7.3, but adjust A10R3 where adjustment of A10R2 is specified. (See Figure 31-2 for location of rate detection adjustments.)

b. Set HP-2401C-31 controls as follows:

FUNCTION:	AUTORANGE.
SAMPLING RATE:	FULLY CLOCKWISE.
SAMPLE PERIOD:	.01 SEC.

c. Set input voltage to 28.5% of any full scale range but the 0.1V range. For example, set input voltage to 28.5V, which is 28.5% of the 100V range.

d. Adjust A10R11 clockwise until the decimal jumps one place to the right on the digital display of the HP-2401C-31.

e. Verify correct calibration per performance check 31.1, Table 31-2.

31.5 PARTS LIST

The Parts List in Section V of this manual applies to the HP 2401C-31 except as indicated in Tables 31-3 and 31-4.

Table 31-2. In-Cabinet Performance Checks (Sheet 1 of 2)

Perform checks 1 through 24 as specified in Table 4-3 of this manual per instructions in Section 4.2.

31.1 AUTORANGING - RANGE CHANGE POINTS

Upranges at 310% of full scale. Downranges at 30% of full scale.

a. Set HP-2401C-31 Power switch to ON, other controls as follows:

FUNCTION:	AUTORANGE.
RANGE:	1V.
SAMPLE PERIOD:	1 SEC.
SAMPLE RATE:	Fully clockwise.
100 KC STD (Rear Panel):	INT.
STORE/DISPLAY (Rear Panel):	DISPLAY.

b. Connect the - and +OUTPUT terminals of the dc standard to the HI and LO terminals of the 31. Jumper the GUARD terminal to the LO terminal.

c. Turn on the dc standard and set it for 0.3V output. The HP-2401C-31 display readout should approximate -300.000 MILLIVOLTS.

d. During measurement, while counting is visible, slowly increase output from the dc standard until the decimal point on the 31 jumps one position to the right. Record the next measurement, which should be -312.5 ± 7.50 MILLIVOLTS.

e. Slowly decrease output from the dc standard until the decimal point on the 31 jumps one position to the left. Record the next measurement, which should be -285 ± 10.00 MILLIVOLTS.

31.2 EXTERNAL PROGRAMMING - AUTORANGE FUNCTION

Autoranging is a programmable function of the HP2401C-31; the requirements of check 20, Table 4-3 apply.

a. Repeat check 31.1, but with FUNCTION set to EXT SEL and pins Z and V of PROGRAM CONTROL receptacle J1 connected. The results of this check should be identical to those of 31.1. Record a yes on the test card if results are the same.

31.3 AUTORANGING - RANGE SELECT TIME

6 milliseconds, maximum, for each range change;
34 milliseconds, maximum, from encode command to start of measurement.

a. Make connections illustrated in Figure 31-1; set DC Standard for 800 output.

b. With the HP-2401C-31 on and operating, set controls as follows:

FUNCTION:	AUTORANGE.
RANGE:	1000V.
SAMPLE PERIOD:	.1 SEC.
SAMPLING RATE:	STOP.
100 KC STD (rear panel):	INT.
STORE/DISPLAY (rear panel):	STORE.

c. Set Oscilloscope as follows:

Trigger Level:	greater than 0
Trigger Slope:	greater than 0
Vertical Sensitivity:	2V/cm (use probe 10X)
Sweep Time:	1ms/cm

Table 31-2. In-Cabinet Performance Checks (Sheet 2 of 2)

d. Set switch S1 at 0V position, making sure S2 is open. Press RESET pushbutton on HP-2401C-31 front panel. The oscilloscope should display the following waveform:

e. Set switch S1 at .4V position. Set oscilloscope sweep time at 5 ms/cm.

f. Close switch S2. Record the time interval displayed on the oscilloscope (see above waveform). This time interval (upranging time) shall be no greater than 10 ms.

g. Open switch S2 and press the front panel RESET pushbutton. Record the time interval displayed on the oscilloscope. This time interval (downranging time) shall be no greater than 15 ms.

h. Repeat steps f and g for each of the other positions of switch S1. Record the upranging and downranging times for each position. These times shall be as follows:

Switch S1 Setting	Upranging Time (Max.)	Downranging Time (Max.)
0V	10 ms	10 ms
.4V	10 ms	15 ms
4V	16 ms	21 ms
40V	22 ms	27 ms
400V	27 ms	33 ms

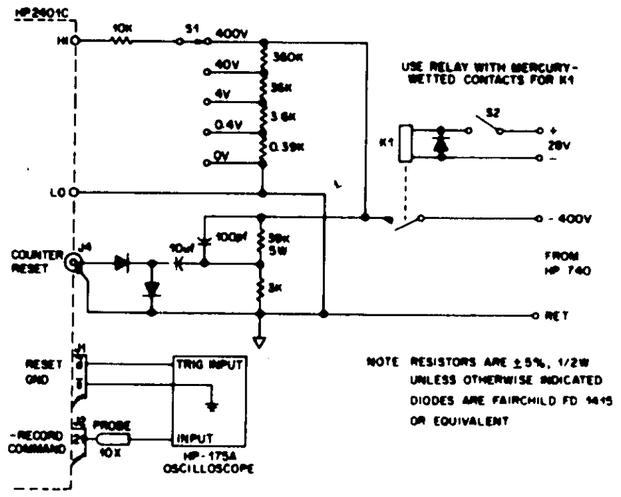


Figure 31-1. Setup for Check of Range Select Time

HP-2401C **PERFORMANCE CHECK TEST CARD**

SER ____ - ____ DATE ____

DESCRIPTION	CHECK RESULTS
31.1 AUTORANGING - RANGE CHANGE POINTS	
Upranges at	[ ] MV (312.5 ± 7.5)
Downranges at	[ ] MV (285 ± 10)
31.2 EXTERNAL PROGRAMMING - AUTORANGE	
Autorange programmed by connecting pin Z of J1 to pin V produces same results when check 31.1 is repeated?	[ ] (yes)
31.3 AUTORANGING - RANGE SELECT TIME	

Step	Test Switch S1 Position	Range Changes:	
d	0V	None	[ ] MS (10 ms. maximum)
f	.4V	.1V to 1V up-ranging	[ ] MS (10 ms. maximum)
g	.4V	1V to .1V down-ranging	[ ] MS (15 ms. maximum)

DESCRIPTION			CHECK RESULTS
31.3 (Cont'd)			
Step	Test Switch S1 Position	Range Changes:	
f	4V	.1V to 10V upranging	[ ] MS (16 ms, maximum)
g	4V	10V to .1V downranging	[ ] MS (21 ms, maximum)
f	40V	.1V to 100V upranging	[ ] MS (22 ms, maximum)
g	40V	100V to .1V downranging	[ ] MS (27 ms, maximum)
f	400V	.1V to 1000V upranging	[ ] MS (27 ms, maximum)
g	400V	1000V to .1V downranging	[ ] MS (33 ms, maximum)

Table 31-3. Reference Designation Index

Reference Designation	HP Part No.	Description #	Note
		OPTION 31 A10 5060-5021 5060-5878	A-H J-X
		MAKE THE FOLLOWING CHANGES TO TABLE 5-1 TO MAKE THE TABLE APPLICABLE TO THE HP2401C-31.	
		DELETE THE FOLLOWING:	
A10	5060-2181 5060-5655	OVERLOAD DETECTOR OVERLOAD DETECTOR	A-H J-X
		ADD THE FOLLOWING:	
A10 A43 A44 A45	5060-5021 5060-5878 5060-3785 5060-3684 5060-3851	AUTORANGE RATE DETECTOR AUTORANGE RATE DETECTOR RANGE COUNTER RANGE GATES RANGE CONTROL	A-H J-X
C10	0160-0806	C:FXD POLY 500 PF 10% 1000VDCW	
CR201- CR205	1901-0025	DIODE:SILICON 100WV 100MA	
XA43	1251-0332	CONN:PC 24 CONTACTS	
XA44 XA45	1251-0332 1251-0332	CONN:PC 24 CONTACTS CONN:PC 24 CONTACTS	
A10	5060-5021	AUTORANGE RATE DETECTOR	A-H
	5060-5878	AUTORANGE RATE DETECTOR	J-X
A10C1	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C2	0160-0161 0160-0166	C:FXD MY 0.01 UF 10% 200VDCW C:FXD MY .068 UF 10%	A-G H-X *
A10C3	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C4	0160-0263	C:FXD CER 0.22 UF 20% 50VDCW	
A10C5	0180-0050	C:FXD ELECT 40 UF +75-10% 50VDCW	
A10C6	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C7	0160-0257	C:FXD MICA 50.6PF 5%	
A10C8	0160-0252	C:FXD MICA 257.5 PF 0.5% 500VDCW	
A10C9	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C10	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C11	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C12	0160-0263	C:FXD CER 0.22 UF 20% 50VDCW	
A10C13	0180-0049	C:FXD AL ELECT 20UF 50VDCW	
A10C14	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A10C15	0160-2940	C:FXD MICA 470 PF 5% 300VDCW	C-X
A10CR1- A10CR12	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
		* THE FOLLOWING SERIAL NUMBERS USE 0160-0161: 605-00671,-00672,-00674, 00677,-00682,-00683,-00685,-00690, -00691,-00692, AND -00699.	

Table 31-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 31	
		A10 5080-5021 (CONT'D)	A-H
		5080-5878 (CONT'D)	J-X
A10CR13	1901-0081	DIODE:SILICON 50 VOLTS WORKING	A-H
A10CR14	1902-0022	DIODE BREAKDOWN:2.67V	
A10CR15	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A10CR16	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A10CR17	1901-0061	DIODE:SILICON	
A10CR18	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A10CR19	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A10CR20	1901-0061	DIODE:SILICON	
A10CR21	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	C-X
A10L1	9140-0053	CHOKE/COIL:FXD 1 MH 10%	
A10L2	9140-0210	COIL:FXD RF 100 UH 5%	
A10Q1	1850-0184	TRANSISTOR:GERMANIUM PNP	
A10Q2	1850-0184	TRANSISTOR:GERMANIUM PNP	
A10Q3	1850-0040	TRANSISTOR:GERMANIUM PNP	
A10Q4	1850-0145	TRANSISTOR:GERMANIUM PNP	
A10R1	0727-0751	R:FXD DEPC 1000 OHM 1% 1/2W	A-F
	0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	G-X
A10R2	0727-0792	R:FXD CARBON FLM 31.6K OHM 1% 1/2W	A-F
	0698-3419	R:FXD MET FLM 31.6K OHM 1% 1/2W	G-X
A10R3	2100-0369	R:VAR WW 200 OHM 10% LIN 1/4W	
A10R4	0727-0765	R:FXD CARBON FLM 2.61K 1% 1/2W	A-F
	0698-0024	R:FXD MET FLM 2.61K OHM 1% 1/2W	G-X
A10R5	0727-0838	R:FXD CARBON FLM 1.1 MEGOHM 1% 1/2W	A-T
	NSN	FACTORY SELECTED	U-X
A10R6	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A10R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A10R8	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R9	0727-0751	R:FXD DEPC 1000 OHM 1% 1/2W	A-F
	0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	G-X
A10R10	0698-3278	R:FXD MET FLM 66K OHM 1% 1/2W	
A10R11	2100-0369	R:VAR WW 200 OHM 10% LIN 1/4W	
A10R12	0727-0765	R:FXD CARBON FLM 2.61K 1% 1/2W	A-F
	0698-0024	R:FXD MET FLM 2.61K OHM 1% 1/2W	G-X
A10R13	0727-0840	R:FXD CARBON FLM 1.21 MEGOHM 1% 1/2W	
	NSN	FACTORY SELECTED	
A10R14	0683-4735	R:FXD COMP 47K OHM 5% 1/4W	
A10R15	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	
A10R16	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R17	0689-1815	R:FXD COMP 180 OHM 5% 1W	
A10R18	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R19	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R20	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A10R21	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A10R22	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A10R23	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	

Table 31-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 31	
		A10 5080-5021 (CONT'D)	A-H
		5080-5878 (CONT'D)	J-X
		A43 5080-3785	
A10R24	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A10R25	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A10R26	0686-4325	R:FXD COMP 4300 OHM 5% 1/2W	
A10T1	5060-2577	TRANSFORMER:PULSE	A-L
	9100-1221	TRANSFORMER:PULSE	M-X
A10T2	5060-2577	TRANSFORMER:PULSE	A-L
	9100-1221	TRANSFORMER:PULSE	M-X
A43	5080-3785	RANGE COUNTER	
A43C1	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A43C2	0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	
A43C3	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A43C4	0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	
A43C5	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A43C6	0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	
A43C7	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A43C8	0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	
A43C9	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A43C10	0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	
A43C11	0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	
A43C12	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A43CR1-A43CR45	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A43Q1-A43Q6	1850-0032	TRANSISTOR:GERMANIUM PNP	
A43Q7	1850-0111	TRANSISTOR:GERMANIUM PNP	
A43Q8	1850-0111	TRANSISTOR:GERMANIUM PNP	
A43Q9-A43Q14	1850-0145	TRANSISTOR:GERMANIUM PNP	
A43Q15	1850-0032	TRANSISTOR:GERMANIUM PNP	
A43R1	0683-3635	R:FXD COMP 36K OHM 5% 1/4W	
A43R2	0686-1035	R:FXD COMP 10K OHM 5% 1/2W	
A43R3	0683-4325	R:FXD COMP 4300 OHM 5% 1/4W	
A43R4	0683-7525	R:FXD COMP 7500 OHM 5% 1/4W	
A43R5	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R6	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R7	0686-1235	R:FXD COMP 12K OHM 5% 1/2W	
A43R8	0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	
A43R9	0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	
A43R10	0758-0004	R:FXD MET OX 2700 OHM 5% 1/2W	

Table 31-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 31 A43 5080-3786 (CONT'D)	
A43R11	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A43R12	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A43R13	0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	
A43R14	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A43R15	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A43R16	0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	
A43R17	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A43R18	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A43R19	0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	
A43R20	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A43R21	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A43R22	0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	
A43R23	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A43R24	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A43R25	0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	
A43R26	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A43R27	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R28	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A43R29	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A43R30	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A43R31	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R32	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A43R33	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A43R34	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A43R35	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A43R36	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A43R37	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A43R38	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R39	0683-20359	R:FXD COMP 20K OHM 5% 1/4W	
A43R40	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A43R41	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A43R42	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A43R43	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R44	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A43R45	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A43R46	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A43R47	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R48	0683-20359	R:FXD COMP 20K OHM 5% 1/4W	
A43R49	0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	
A43R50	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A43R51	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A43R52	0686-1045	R:FXD COMP 100K OHM 5% 1/2W	
A43R53	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A43R54	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A43R55	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A43R56	0683-8235	R:FXD COMP 82K OHM 5% 1/4W	
A43R57	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A43R58	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A43R59	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A43R60	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	

Table 31-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 31 A44 5080-3884	
A44	5080-3884	RANGE GATE	
A44C1	0160-0165	C:FXD MY 5600 PF 10%	
A44C2	0140-0037	C:FXD MICA 390 PF 5%	
A44C4	0140-0037	C:FXD MICA 390 PF 5%	
A44C5	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A44C6	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A44C7	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A44CR1	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A44CR2	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A44CR3-			
A44CR12	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR13	1901-0061	DIODE:SILICON	
A44CR14	1901-0061	DIODE:SILICON	
A44CR15-			
A44CR19	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR20	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A44CR21	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A44CR22	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR23	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR24	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A44CR25	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A44CR26	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR27	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR28	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
A44CR29	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR30	1901-0025	DIODE:SILICON 100WV 100MA	
A44CR31	1901-0025	DIODE:SILICON 100WV 100MA	
A44Q1	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44Q2	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44Q3	1850-0111	TRANSISTOR:GERMANIUM PNP	
A44Q4	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44Q5	1851-0054	TRANSISTOR:GERMANIUM NPN	
A44Q6	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44Q7	1850-0111	TRANSISTOR:GERMANIUM PNP	
A44Q8	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44Q9	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44Q10	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44Q11	1850-0128	TRANSISTOR:PNP GERMANIUM	
A44R1	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A44R2	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A44R3	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A44R4	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A44R5	0683-2245	R:FXD COMP 220K OHM 5% 1/4W	

Table 31-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 31 A44 5080-3884 (CONT'D) A45 5080-3831	
A44R7	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A44R8	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A44R9	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A44R10	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A44R11	0683-2245	R:FXD COMP 220K OHM 5% 1/4W	
A44R12	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A44R13	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A44R14	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A44R15	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R16	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R17	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A44R18	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A44R19	0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	
A44R20	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A44R21	0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	
A44R22	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A44R23	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A44R24	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R25	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R26	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R27	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A44R28	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	
A44R29	0686-1035	R:FXD COMP 10K OHM 5% 1/2W	
A44R30	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R31	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R32	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A44R33	0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	
A44R34	0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	
A44R35	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R36	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A44R37	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A44R38	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A44R39	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A45	5080-3831	RANGE CONTROL	
A45C1	0140-0200	C:FXD MICA 390 PF 5%	
A45C2	0140-0200	C:FXD MICA 390 PF 5%	
A45C3	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A45C4	0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	
A45C5	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A45C6	0170-0040	C:FXD MY .047 UF 10% 200VDCW	
A45C7	0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	
A45C8	0160-0156	C:FXD MY 0.0039 UF 10% 200VDCW	
A45C9	0140-0200	C:FXD MICA 390 PF 5%	
A45C10	0140-0200	C:FXD MICA 390 PF 5%	
A45C11	0160-0153	C:FXD MY 1000 PF 10% 200VDCW	
A45C12	0170-0040	C:FXD MY .047 UF 10% 200VDCW	
A45C13	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A45C14	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
A45C15	0160-0162	C:FXD MY 0.022 UF 10% 200VDCW	

Table 31-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 31 A45 5080-3831 (CONT'D)	
A45CR1	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A45CR2	1901-0061	DIODE:SILICON	
A45CR3	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A45CR4	1902-0022	DIODE BREAKDOWN:2.67V	
A45CR5	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A45CR6	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A45CR7	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A45CR9	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A45CR11	1901-0025	DIODE:SILICON 100WV 100MA	
A45CR12	1901-0025	DIODE:SILICON 100WV 100MA	
A45Q1	1851-0034	TRANSISTOR:GERMANIUM NPN	
A45Q2	1850-0184	TRANSISTOR:GERMANIUM PNP	
A45Q3	1850-0184	TRANSISTOR:GERMANIUM PNP	
A45Q4	1851-0034	TRANSISTOR:GERMANIUM NPN	
A45Q5	1850-0111	TRANSISTOR:GERMANIUM PNP	
A45Q6	1851-0031	TRANSISTOR:GERMANIUM NPN	
A45Q7	1850-0032	TRANSISTOR:GERMANIUM PNP	
A45Q8	1851-0024	TRANSISTOR:GERMANIUM NPN	
A45Q9	1850-0032	TRANSISTOR:GERMANIUM PNP	
A45Q10	1850-0032	TRANSISTOR:GERMANIUM PNP	
A45Q11	1850-0145	TRANSISTOR:GERMANIUM PNP	
A45Q12	1850-0111	TRANSISTOR:GERMANIUM PNP	
A45Q13	1850-0032	TRANSISTOR:GERMANIUM PNP	
A45Q14	1850-0032	TRANSISTOR:GERMANIUM PNP	
A45Q15	1850-0128	TRANSISTOR:PNP GERMANIUM	
A45R1	0683-4705	R:FXD COMP 47 OHM 5% 1/4W	
A45R2	0689-3925	R:FXD COMP 3.9K OHM 5% 1W	
A45R3	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A45R4	0689-3925	R:FXD COMP 3.9K OHM 5% 1W	
A45R5	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A45R6	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A45R7	0689-3925	R:FXD COMP 3.9K OHM 5% 1W	
A45R8	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A45R9	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
A45R10	0689-3925	R:FXD COMP 3.9K OHM 5% 1W	
A45R11	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A45R12	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A45R13	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A45R14	0683-4705	R:FXD COMP 47 OHM 5% 1/4W	
A45R15	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A45R16	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A45R17	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A45R18	0683-1135	R:FXD COMP 11K OHM 5% 1/4W	
A45R19	0683-1135	R:FXD COMP 11K OHM 5% 1/4W	
A45R20	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	

Table 31-3. Reference Designation Index (Cont'd)

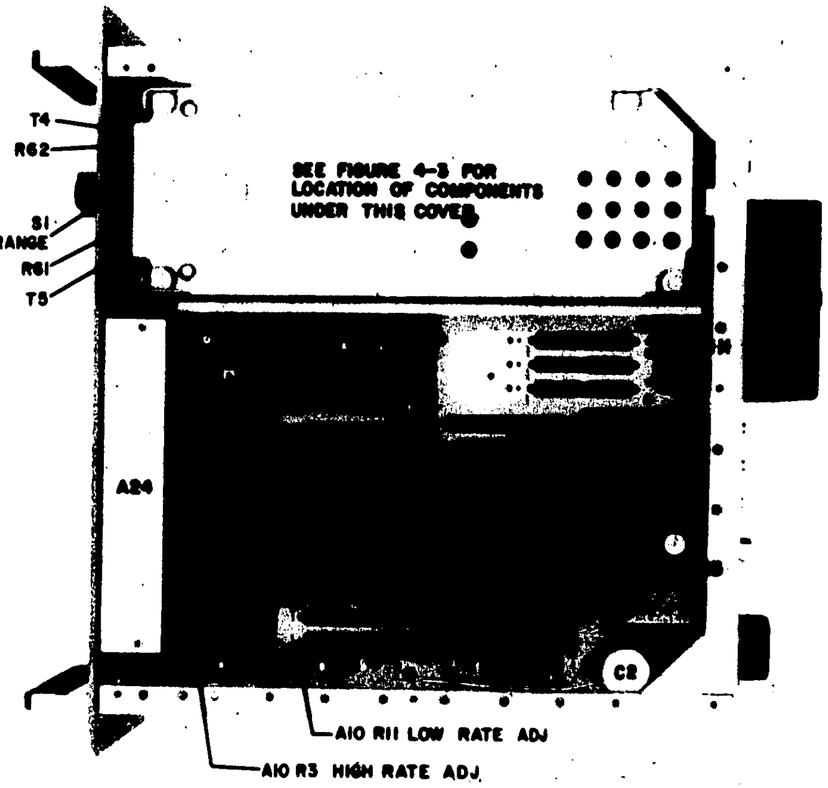
Reference Designation	Part No.	Description #	Note
		OPTION 31 A45 5080-3831 (CONT'D)	
A45R21	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A45R22	0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	
A45R23	0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	
A45R24	0683-2735	R:FXD COMP 27K OHM 5% 1/4W	
A45R25	0683-3935	R:FXD COMP 39K OHM 5% 1/4W	
A45R26	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	
A45R27	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A45R28	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A45R29	0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	
A45R30	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A45R31	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A45R32	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A45R33	0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	
A45R34	0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	
A45R35	0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	
A45R36	0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	
A45R37	0683-1055	R:FXD COMP 1 MEGOHM 5% 1/4W	
A45R38	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	
A45R39	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A45R40	0683-1235	R:FXD COMP 12K OHM 5% 1/4W	
A45R41	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A45R42	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A45R43	0683-9125	R:FXD COMP 9100 OHM 5% 1/4W	
A45R44	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	
A45R45	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A45R46	0683-9125	R:FXD COMP 9100 OHM 5% 1/4W	
A45R47	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A45R48	0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	
A45R49	0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	
A45R50	0683-9125	R:FXD COMP 9100 OHM 5% 1/4W	
A45R51	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A45R52	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	
A45R53	0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	
A45R54	0683-1015	R:FXD COMP 100 OHM 5% 1/4W	

Table 31-4. Replaceable Parts

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 31			
0140-0037	C:FXD MICA 390 PF 5%	72136	RCM15E391J	2
0140-0200	C:FXD MICA 390 PF 5%	28480	0140-0200	4
0160-0153	C:FXD MY 1000 PF 10% 200VDCW	28480	0160-0153	11
0160-0156	C:FXD MY 0.0039 UF 10% 200VDCW	28480	0160-0156	1
0160-0157	C:FXD MY 0.0047 UF 10% 200VDCW	28480	0160-0157	7
0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	28480	0160-0161	11
0160-0162	C:FXD MY 0.022 UF 10% 200VDCW	28480	0160-0162	1
0160-0165	C:FXD MY 5600 PF 10%	28480	0160-0165	1
0160-0166	C:FXD MY .068 UF 10%	28480	0160-0166	1
0160-0168	C:FXD MY 0.1 UF 10% 200VDCW	28480	0160-0168	1
0160-0252	C:FXD MICA 257.5 PF 0.5% 500VDCW	72136	RCM15E[275.5]E	1
0160-0257	C:FXD MICA 50.6PF 5%	72136	RCM15E[50.6]E	1
0160-0263	C:FXD CER 0.22 UF 20% 50VDCW	56289	5C5285-CML	2
0160-0806	C:FXD POLY 500 PF 10% 1000VDCW	56289	114P50191054	1
0160-2940	C:FXD MICA 470 PF 5% 300VDCW	72136	RDM15F471J3C	1
0170-0040	C:FXD MY .047 UF 10% 200VDCW	28480	0170-0040	2
0180-0049	C:FXD AL ELECT 20UF 50VDCW	56289	30D206G050DC6M1	1
0180-0050	C:FXD ELECT 40 UF +75-10% 50VDCW	28480	0180-0050	1
0683-1015	R:FXD COMP 100 OHM 5% 1/4W	01121	CB 1015	1
0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	01121	CB 1025	5
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	13
0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	01121	CB 1045	4
0683-1055	R:FXD COMP 1 MEGOHM 5% 1/4W	01121	CB 1055	1
0683-1135	R:FXD COMP 11K OHM 5% 1/4W	01121	CB 1135	2
0683-1225	R:FXD COMP 1200 OHM 5% 1/4W	01121	CB 1225	2
0683-1235	R:FXD COMP 12K OHM 5% 1/4W	01121	CB 1235	7
0683-1335	R:FXD COMP 13K OHM 5% 1/4W	01121	CB 1335	1
0683-1525	R:FXD COMP 1500 OHM 5% 1/4W	01121	CB 1525	2
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	4
0683-1825	R:FXD COMP 1800 OHM 5% 1/4W	01121	CB 1825	7
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	1
0683-2035	R:FXD COMP 20K OHM 5% 1/4W	01121	CB 2035	14
0683-2225	R:FXD COMP 2.2K OHM 5% 1/4W	01121	GB 2225	4
0683-2235	R:FXD COMP 22K OHM 5% 1/4W	01121	CB 2235	3
0683-2245	R:FXD COMP 220K OHM 5% 1/4W	01121	CB 2245	2
0683-2725	R:FXD COMP 2700 OHM 5% 1/4W	01121	CB 2725	1
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	1
0683-3325	R:FXD COMP 3300 OHM 5% 1/4W	01121	CB 3325	2
0683-3335	R:FXD COMP 33K OHM 5% 1/4W	01121	CB 3335	16
0683-3625	R:FXD COMP 3600 OHM 5% 1/4W	01121	CB 3625	3
0683-3635	R:FXD COMP 36K OHM 5% 1/4W	01121	CB 3635	1
0683-3925	R:FXD COMP 3900 OHM 5% 1/4W	01121	CB 3925	6
0683-3935	R:FXD COMP 39K OHM 5% 1/4W	01121	CB 3935	8
0683-4325	R:FXD COMP 4300 OHM 5% 1/4W	01121	CB 4325	1
0683-4705	R:FXD COMP 47 OHM 5% 1/4W	01121	CB 4705	2
0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	01121	CB 4725	4
0683-4735	R:FXD COMP 47K OHM 5% 1/4W	01121	CB 4735	2
0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	01121	CB 5625	2
0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	01121	CB 5635	2
0683-6825	R:FXD COMP 6800 OHM 5% 1/4W	01121	CB 6825	3
0683-7525	R:FXD COMP 7500 OHM 5% 1/4W	01121	CB 7525	1
0683-8225	R:FXD COMP 8200 OHMS 5% 1/4W	01121	CB 8225	10
0683-8235	R:FXD COMP 82K OHM 5% 1/4W	01121	CB 8235	1

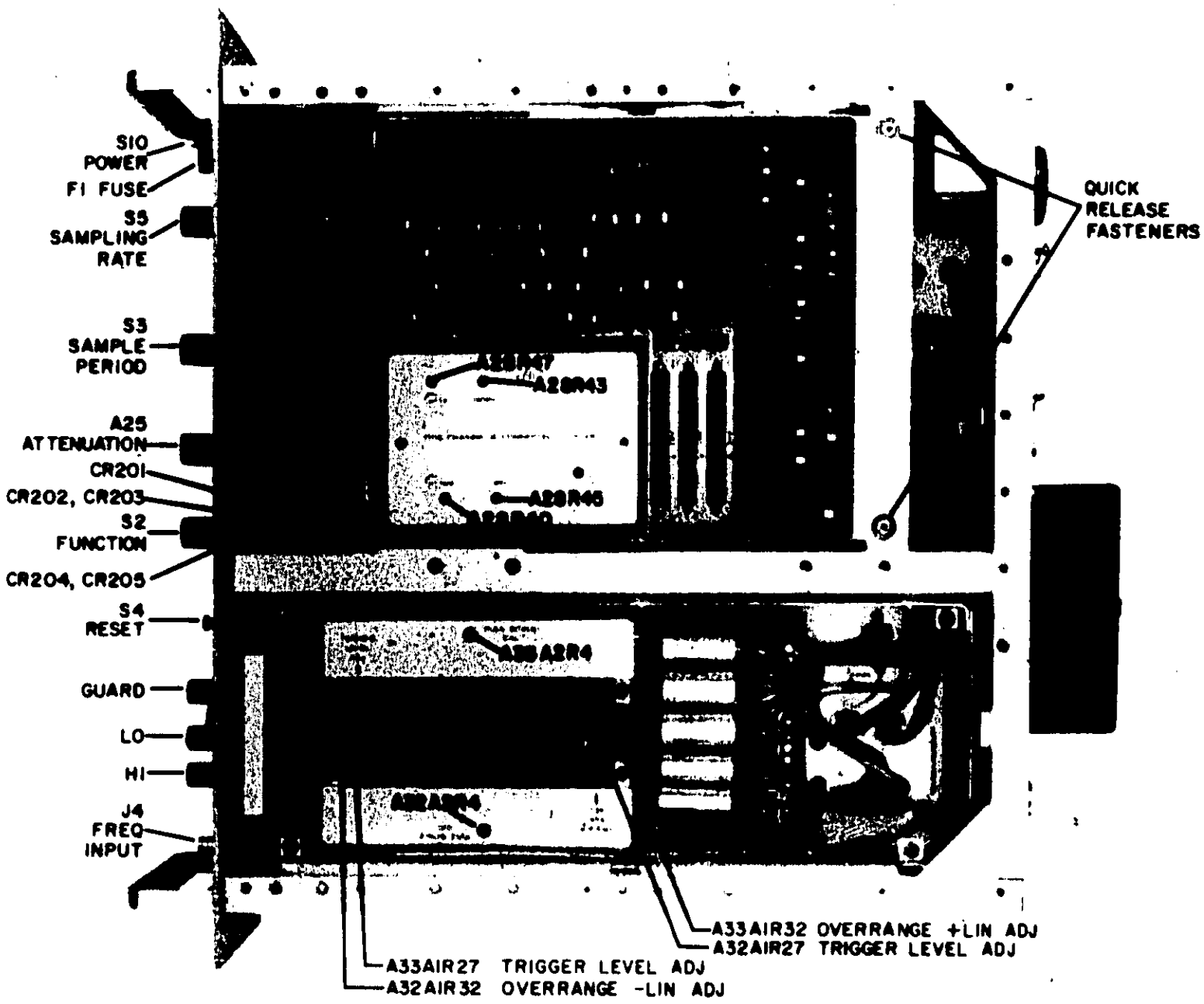
Table 31-4. Replaceable Parts (Cont'd)

Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 31			
0683-9125	R:FXD COMP 9100 OHM 5% 1/4W	01121	CB 9125	3
0686-1035	R:FXD COMP 10K OHM 5% 1/2W	01121	EB 1035	2
0686-1045	R:FXD COMP 100K OHM 5% 1/2W	01121	EB 1045	1
0686-1235	R:FXD COMP 12K OHM 5% 1/2W	01121	EB 1235	1
0686-4325	R:FXD COMP 4300 OHM 5% 1/2W	01121	EB 4325	1
0686-5125	C:FXD COMP 5.1K OHM 5% 1/2W	01121	EB 5125	7
0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	01121	EB 5625	2
0686-7525	R:FXD COMP 7500 OHM 5% 1/2W	01121	EB 7525	6
0689-1815	R:FXD COMP 180 OHM 5% 1W	01121	GB 1815	1
0689-3925	R:FXD COMP 3.9K OHM 5% 1W	01121	GB 3925	4
0698-0024	R:FXD MET FLM 2.61K OHM 1% 1/2W	28480	0698-0024	2
0698-3278	R:FXD MET FLM 64K OHM 1% 1/2W	19701	MF7C T-0	1
0698-3419	R:FXD MET FLM 31.6K OHM 1% 1/2W	28480	0698-3419	1
0727-0751	R:FXD DEPC 1000 OHM 1% 1/2W	28480	0727-0751	2
0727-0765	R:FXD CARBON FLM 2.6K OHM 1% 1/2W	28480	0727-0765	2
0727-0792	R:FXD CARBON FLM 31.6K OHM 1% 1/2W	28480	0727-0792	1
0727-0838	R:FXD CARBON FLM 1.1 MEGOHM 1% 1/2W	19701	MF7C	1
0727-0840	R:FXD CARBON FLM 1.21 MEGOHM 1% 1/2W	19701	MF7C	1
0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	28480	0757-0159	2
0758-0004	R:FXD MET OX 2700 OHM 5% 1/2W	28480	0758-0004	1
1251-0332	CONN:PC 24 CONTACTS	28480	1251-0332	3
1850-0032	TRANSISTOR:GERMANIUM PNP	02735	2N404	12
1850-0040	TRANSISTOR:GERMANIUM PNP	28480	1850-0040	1
1850-0111	TRANSISTOR:GERMANIUM PNP	01295	2N404A	6
1850-0128	TRANSISTOR:PNP GERMANIUM	01295	2N3988	9
1850-0145	TRANSISTOR:GERMANIUM PNP	03508	2N1926	8
1850-0184	TRANSISTOR:GERMANIUM PNP	02735	38339	4
1851-0024	TRANSISTOR:GERMANIUM NPN	01295	2N388A	1
1851-0031	TRANSISTOR:GERMANIUM NPN	01295	2N1605	1
1851-0034	TRANSISTOR:GERMANIUM NPN	01295	2N1605A	3
1901-0025	DIODE:SILICON 100MV 100MA	28480	1901-0025	29
1901-0061	DIODE:SILICON	03877	1N816	5
1901-0081	DIODE:SILICON 50 VOLTS WORKING	28480	1901-0081	69
1902-0022	DIODE BREAKDOWN:2.67V	28480	1902-0022	2
1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	28480	1910-0016	7
2100-0369	R:VAR WW 200 OHM 10% LIN 1/4W	28480	2100-0369	2
5060-2577	TRANSFORMER:PULSE	28480	5060-2577	2
5060-3684	RANGE GATE	04404	5060-3684	1
5060-3785	RANGE COUNTER	04404	5060-3785	1
5060-3831	RANGE CONTROL	04404	5060-3831	1
5060-5021	AUTORANGE RATE DETECTOR	04404	5060-5021	1
5060-5878	AUTORANGE RATE DETECTOR	04404	5060-5878	1
9100-1221	TRANSFORMER:PULSE	28480	9100-1221	2
9140-0053	CHOKE/COIL:FXD 1 MH 10%	99848	31000-15-102	1
9140-0210	COIL:FXD RF 100 UH 5%	28480	9140-0210	1



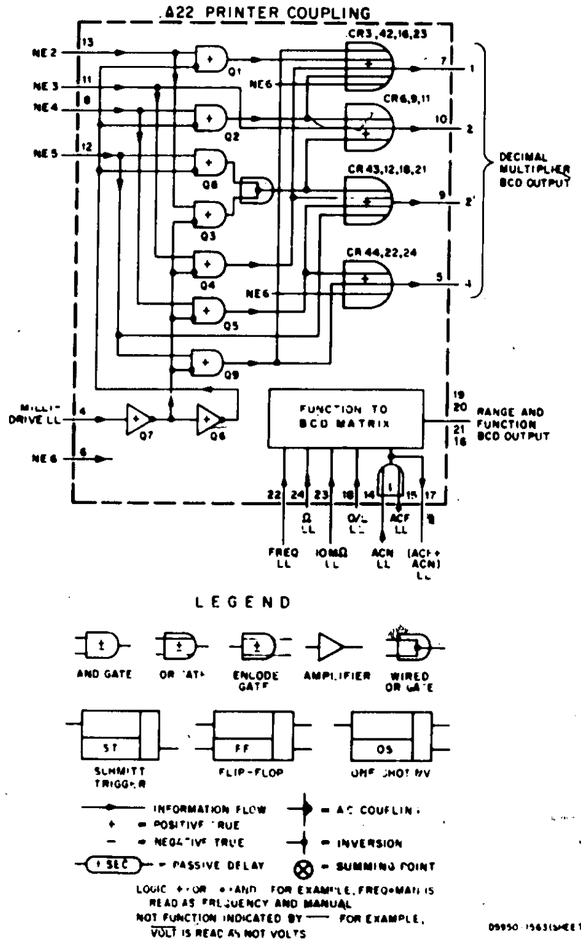
* SUPPLIED WITH HP 2410B AC/OHMS CONVERTER.
** SEE INSET ON FIGURE 4-3 FOR LOCATION OF Q1 ON SERIAL PREFIX 610- AND EARLIER

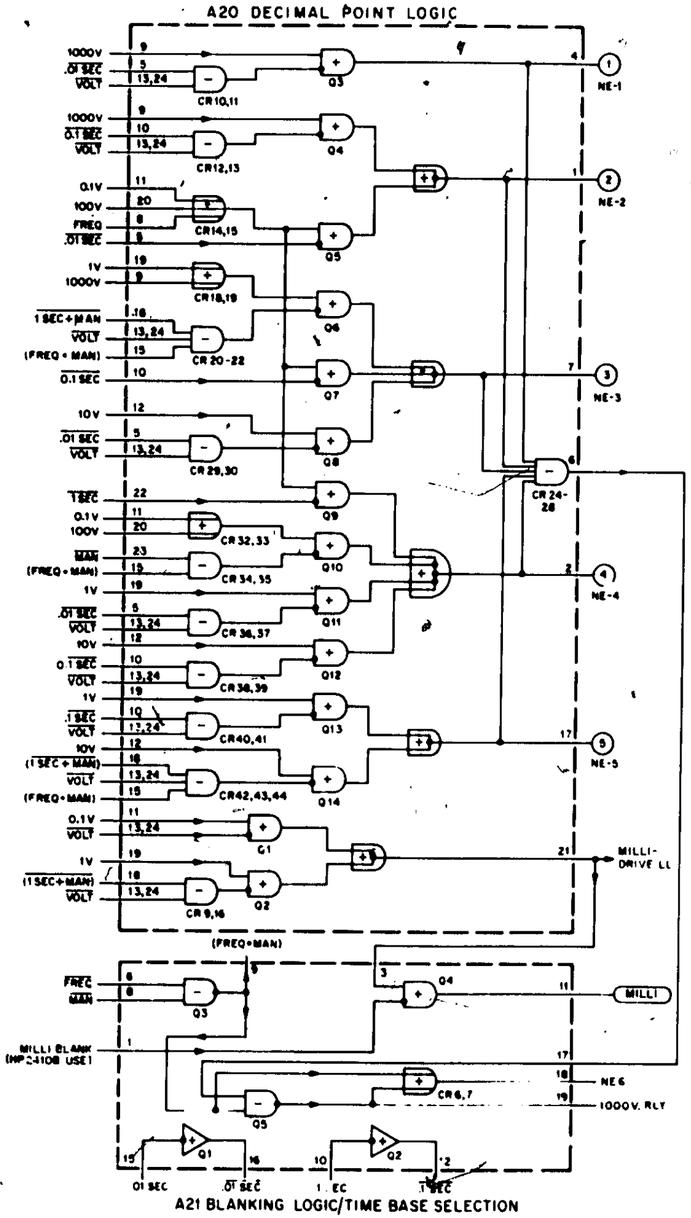
Figure 31-2. Top Internal View of HP 2401C-31

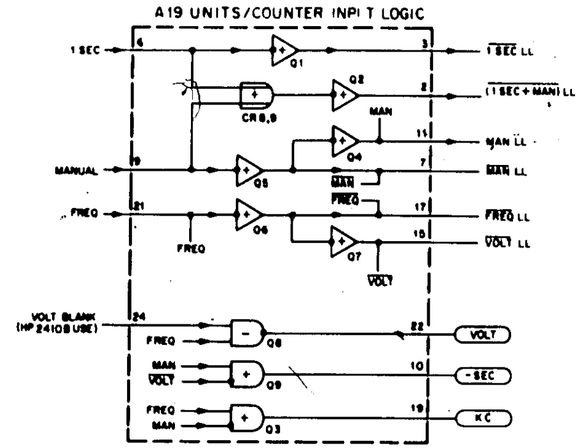


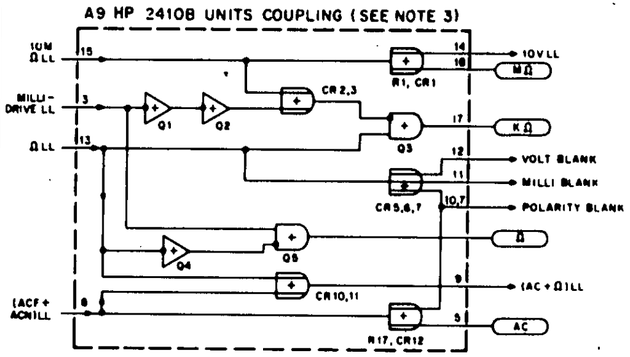
* SEE FIGURE 4-4 FOR A23 AND A30 USAGE.

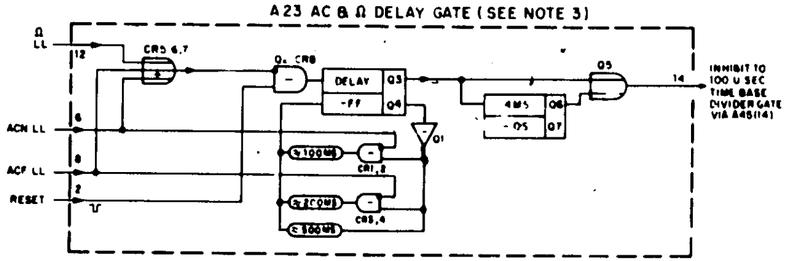
Figure 31-3. Bottom Internal View of HP 2401C-31











NOTES 1 LL = LOGIC LINES
2 ACF = AC FAST, ACN = AC NORMAL, O/L = OVERLOAD
3 USED ONLY WHEN 2401 IS USED WITH 2110R AC/OHMS CONVERTER

Figure 31-4. Decimal Point and Control Logic for Option 31

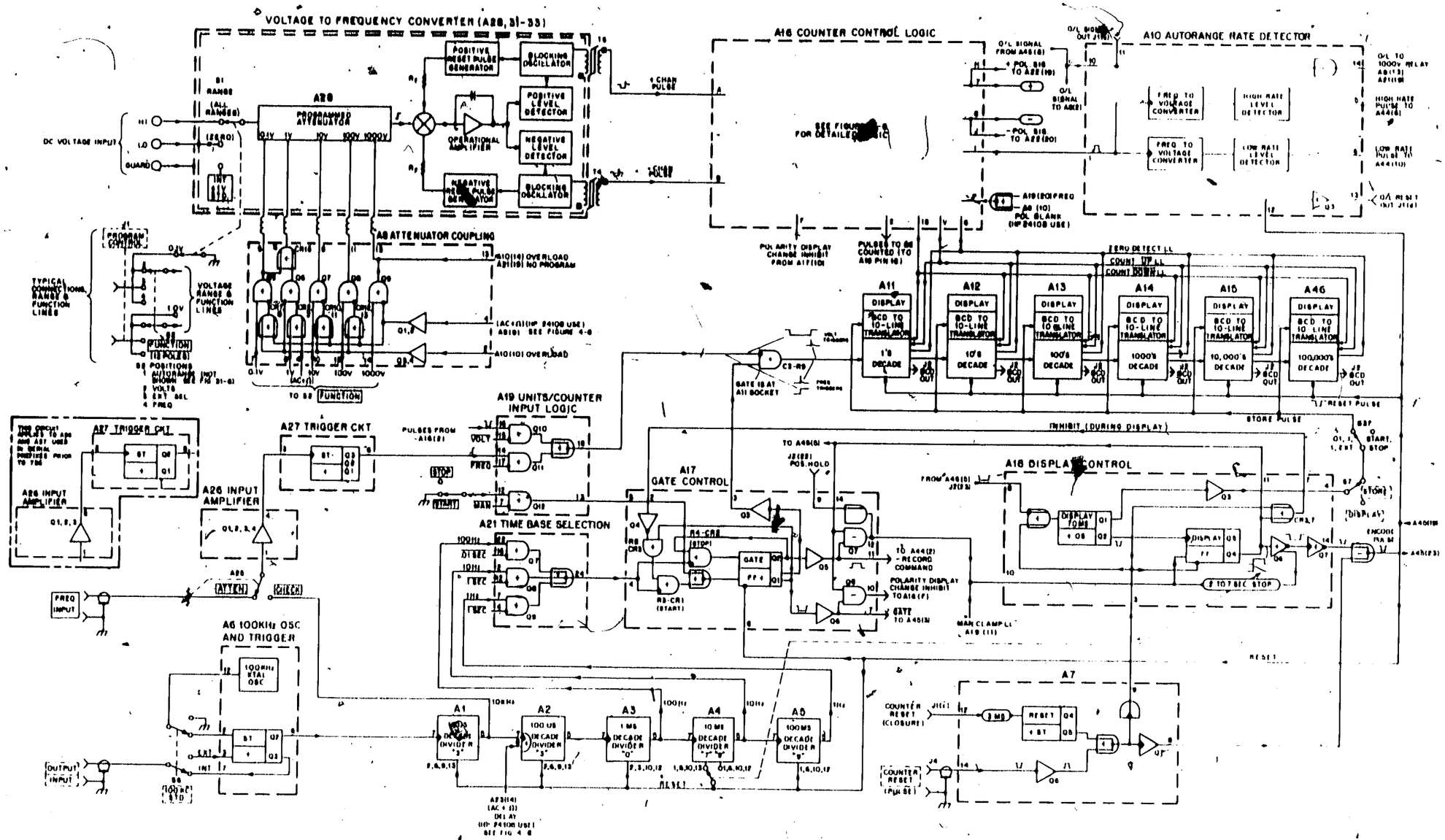


Figure 31-5. V-F Converter and Counter Logic for Option 31

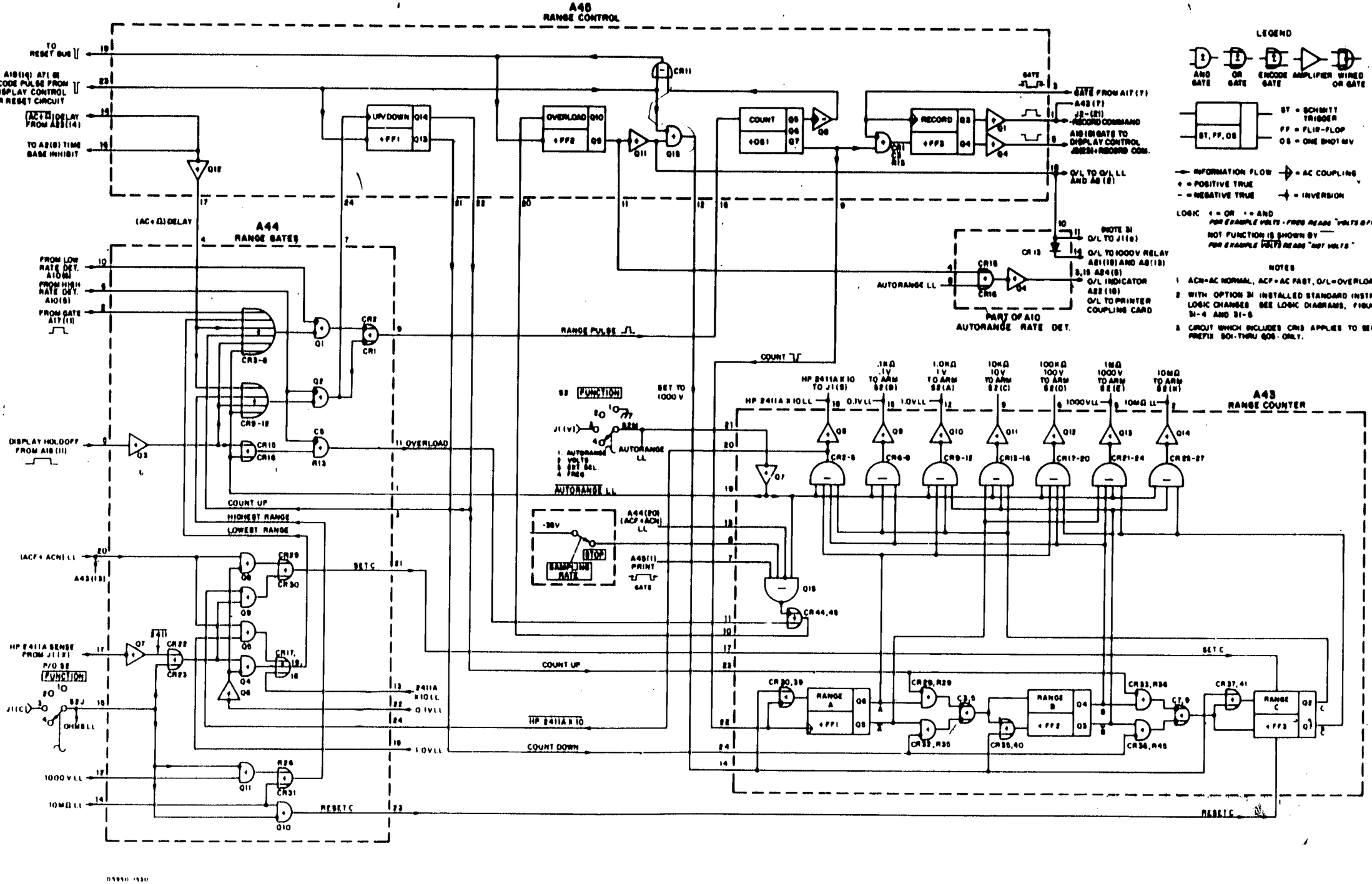
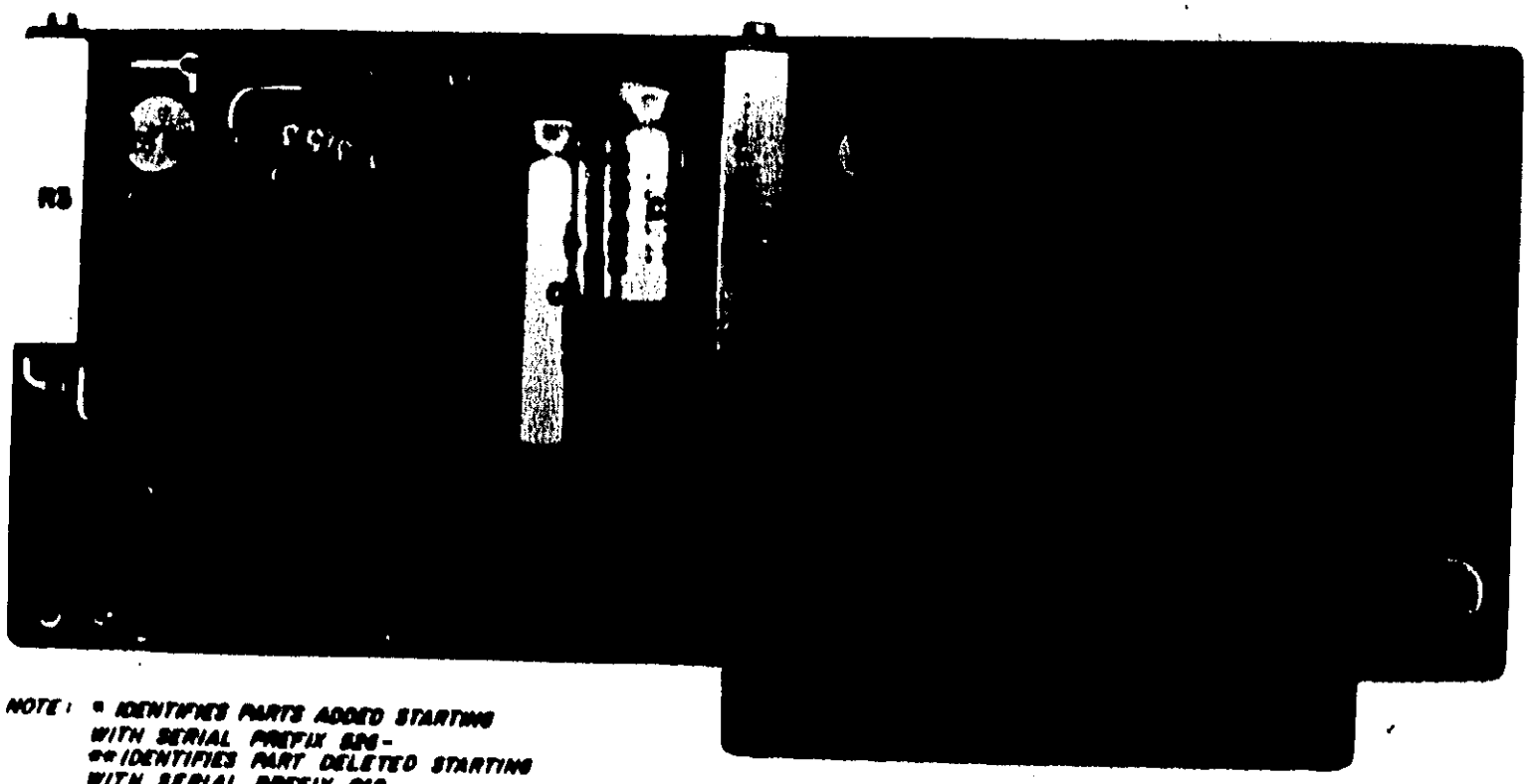
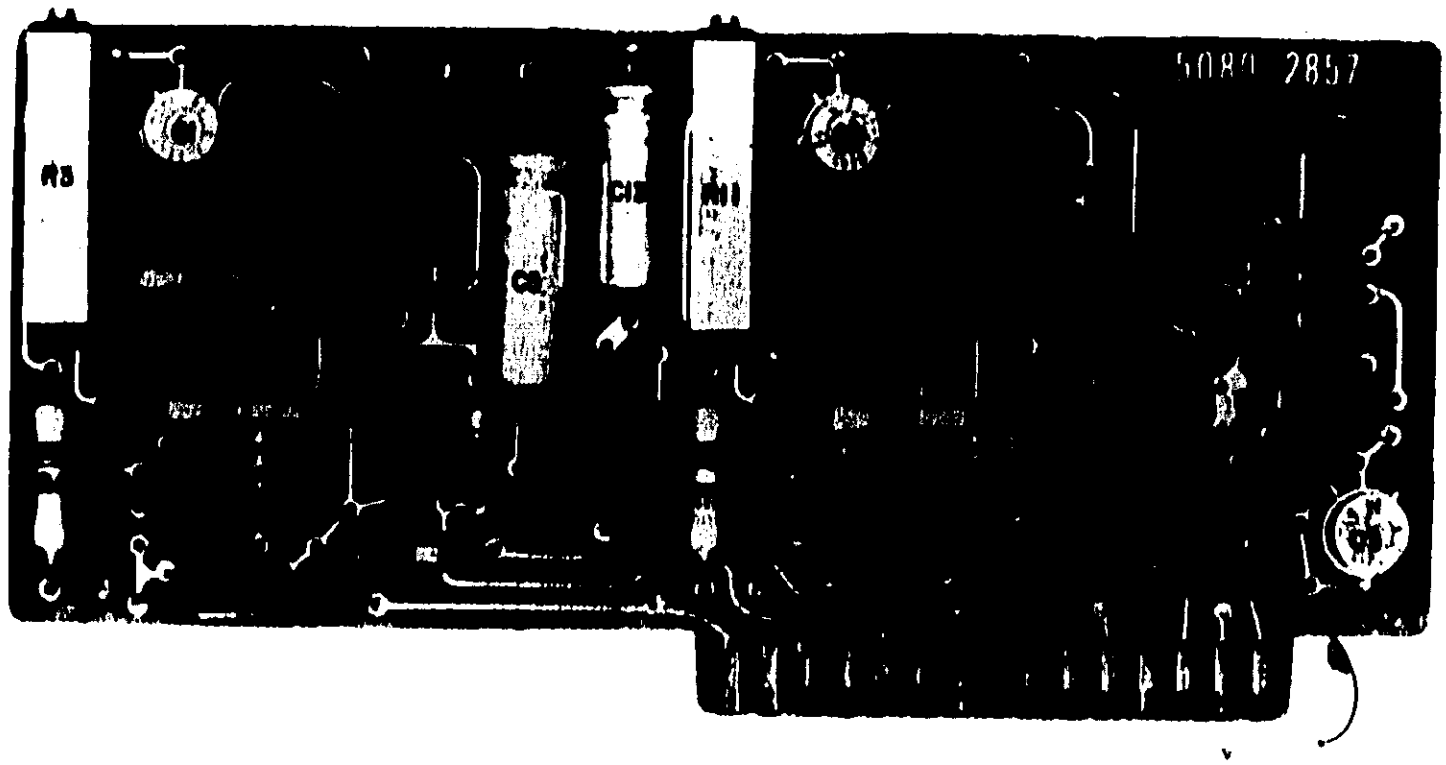


Figure 31-6. Autorange Logic for Option 31



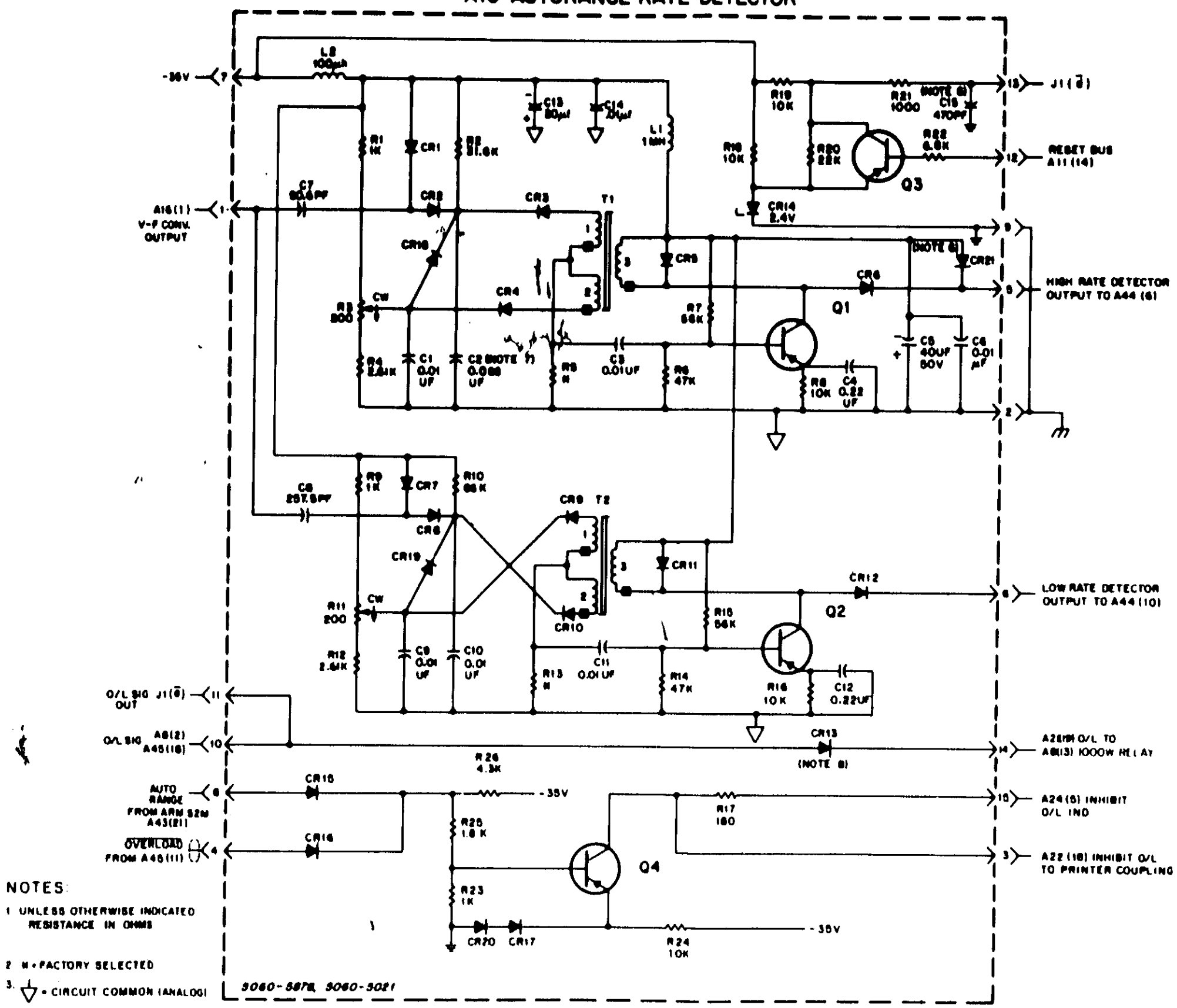
NOTE: * IDENTIFIES PARTS ADDED STARTING WITH SERIAL PREFIX 626-
** IDENTIFIES PART DELETED STARTING WITH SERIAL PREFIX 610-.

Stock No. 5060-5021 (Serial Prefix 501 thru 605)



Stock No. 5060-5878 (Serial Prefix 610 and above)

(A10) Autorange Rate Detector for Option 31



NOTES:

1 UNLESS OTHERWISE INDICATED RESISTANCE IN OHMS

2 M = FACTORY SELECTED

3. ▽ = CIRCUIT COMMON (ANALOG)

4 ⏚ = CHASSIS GROUND

5 ⏚ = CIRCUIT COMMON (DIGITAL)

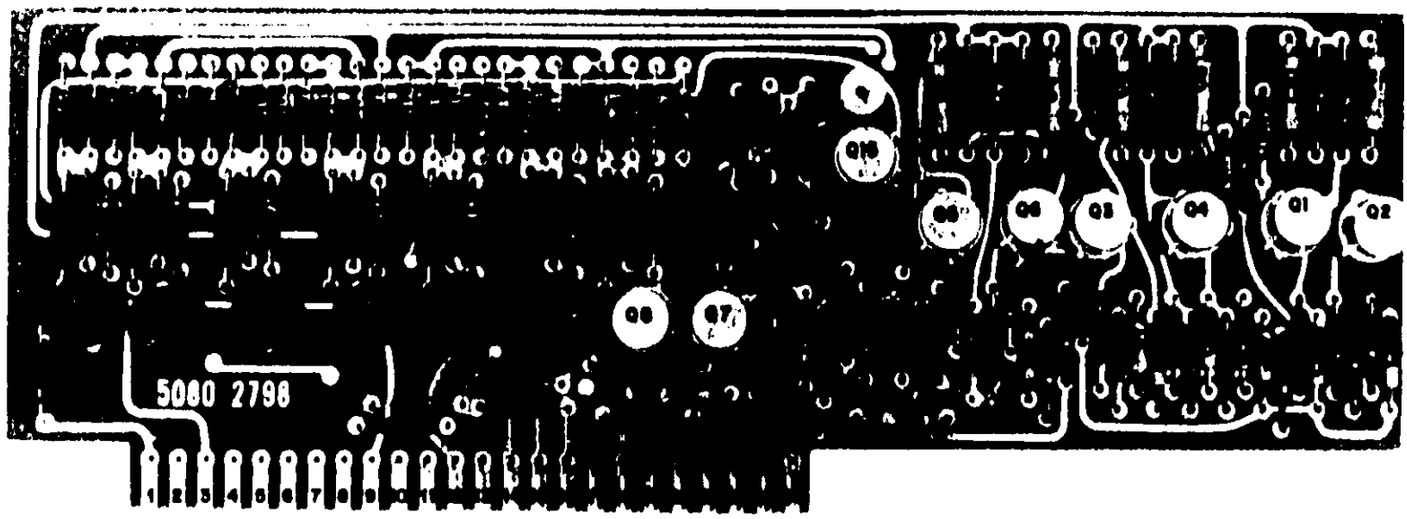
6 C15 AND CR21 NOT USED ON SERIAL PREFIX 501- AND 521-

7 C2 IS 0.01 μF ON SERIAL PREFIX 501- THRU 537- AND SOME 605-

8 CR13 AND CONNECTION TO PIN 14 APPLIES TO SERIAL PREFIX 501- THRU 605- ONLY

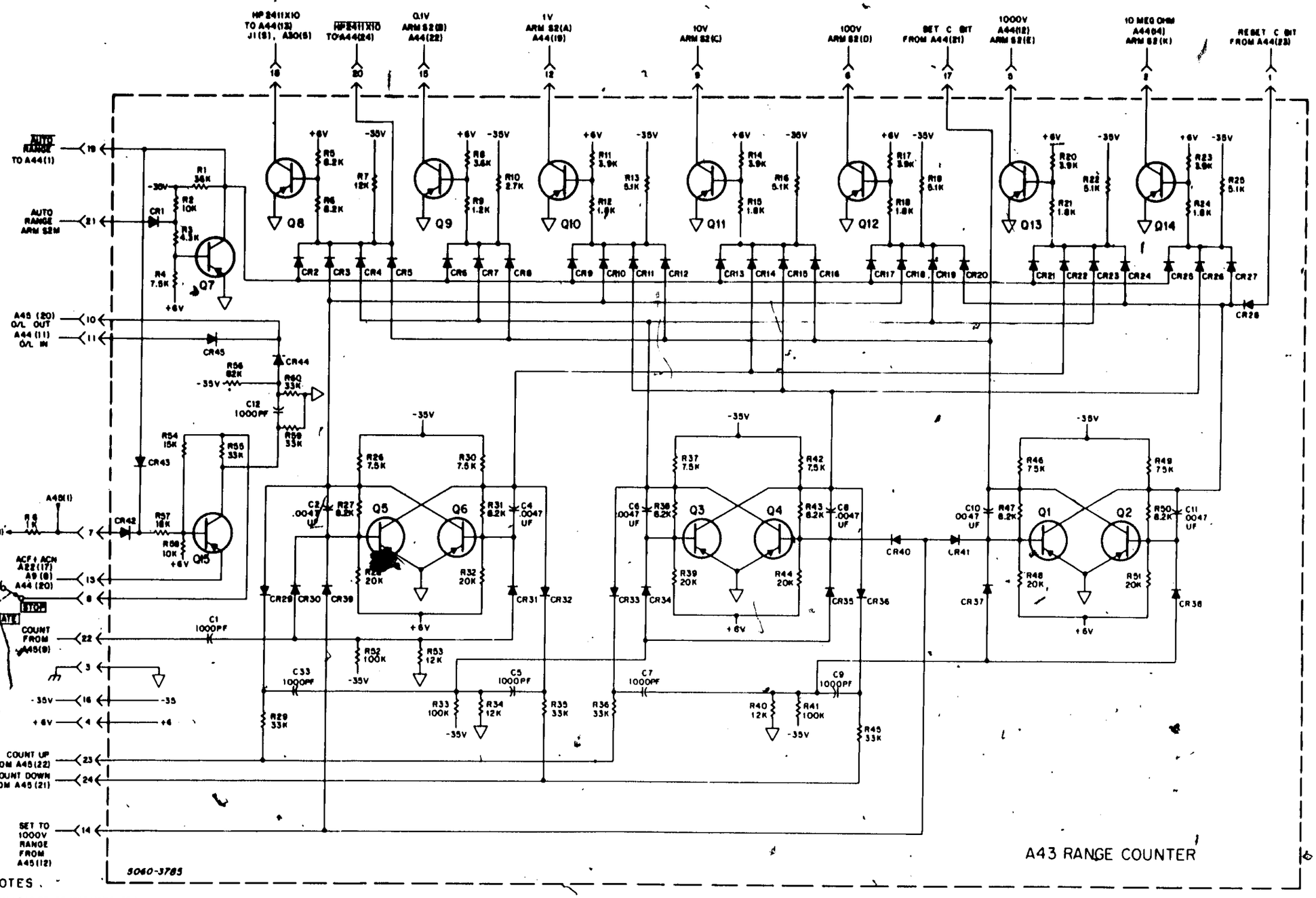
05060-5678

Figure 31-7. Autorange Rate Detector (A10) for Option 31



Stock No. 5060-3785

(A43) Range Counter for Option 31

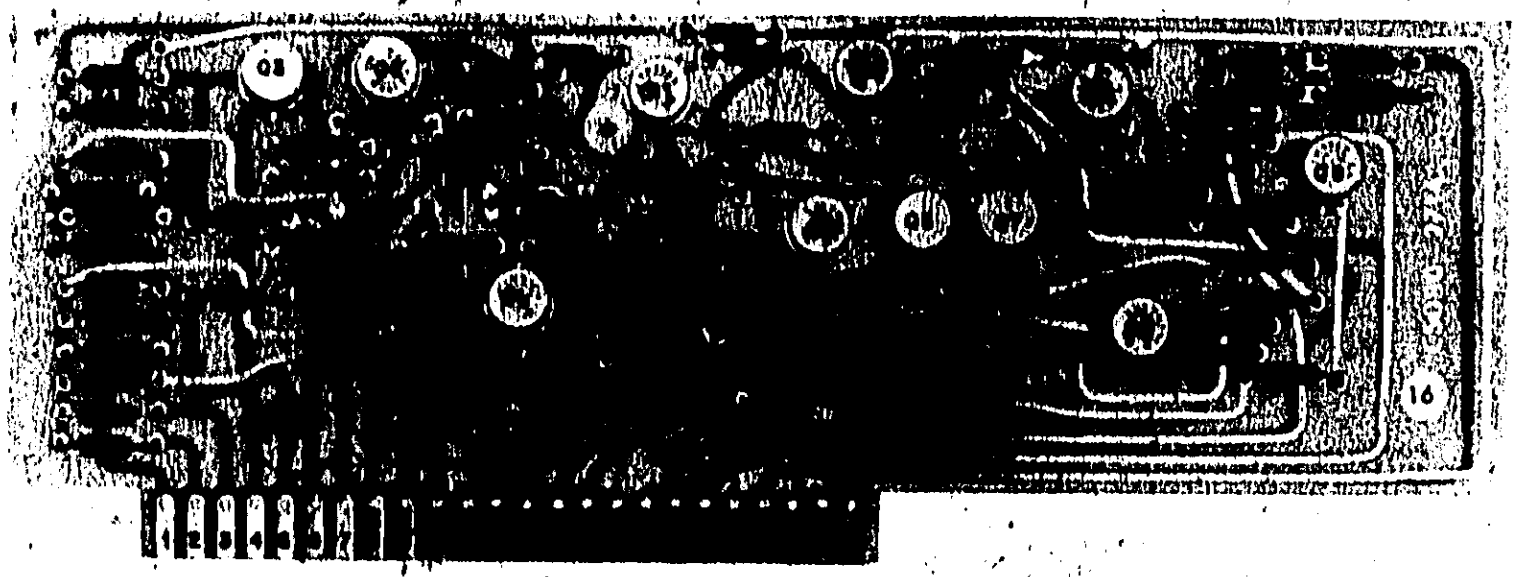


NOTES:

1. UNLESS OTHERWISE INDICATED, RESISTORS IN OHMS AND CAPACITANCE IN MICROFARADS
2. ▽ = CIRCUIT COMMON
3. ⏚ = CHASSIS GROUND

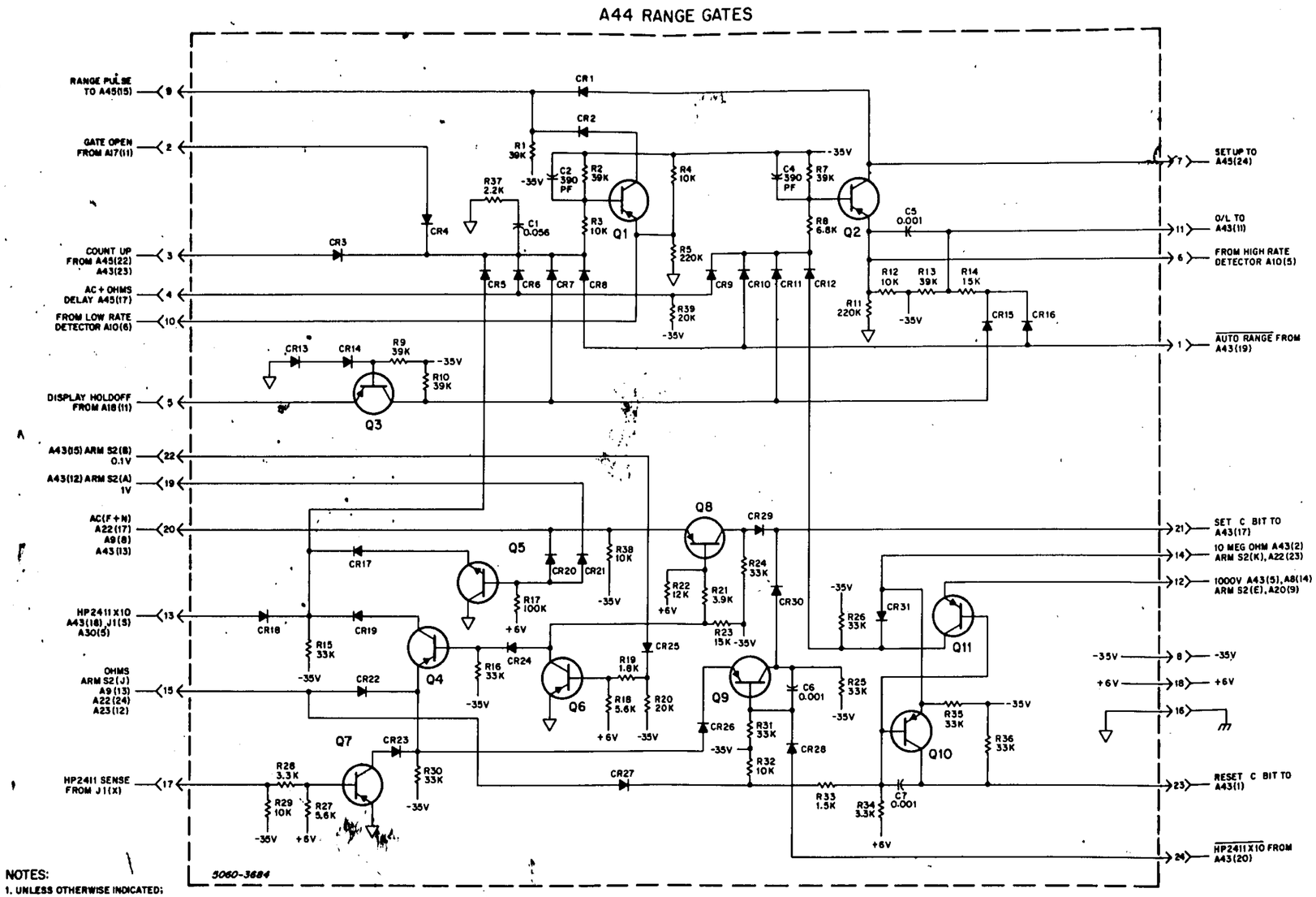
05060-3785-1

Figure 31-8. Range Counter (A43) for Option 31



Stock No. 5060-3684

(A44) Range Gates for Option 31

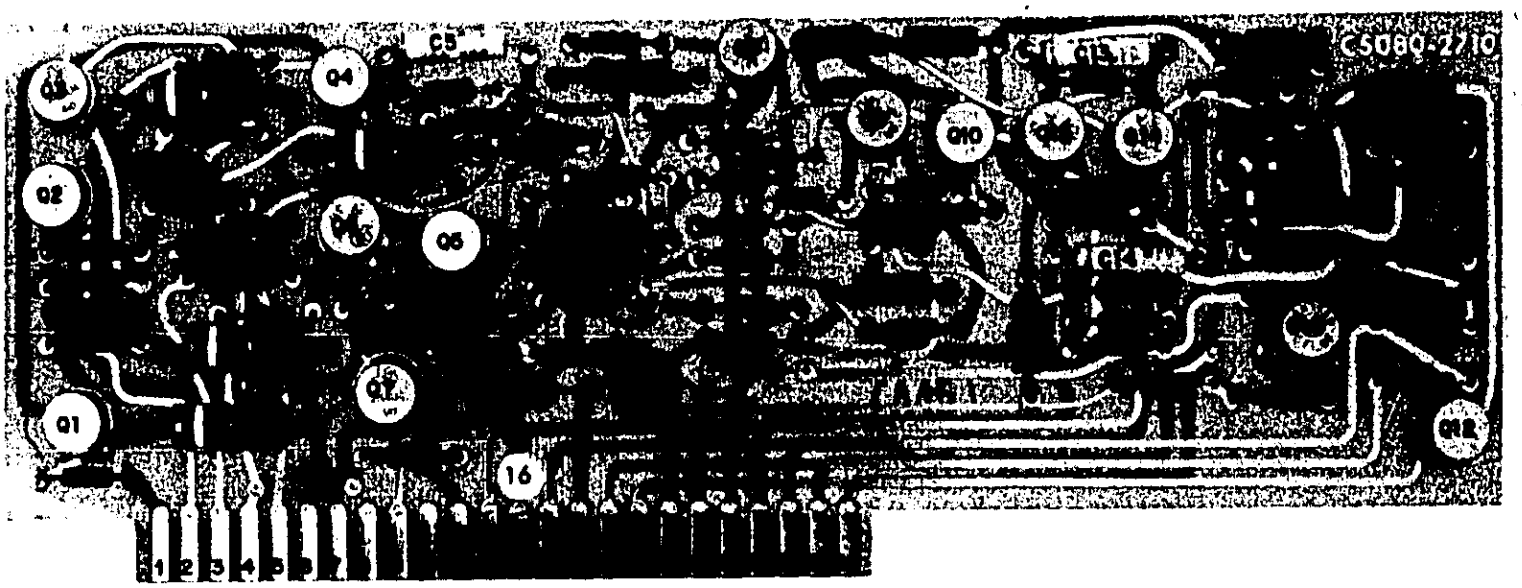


NOTES:

1. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS AND CAPACITANCE IN MICROFARADS
2. ▽ = CIRCUIT COMMON.
3. ⏚ = CHASSIS GROUND.

05060-3684

Figure 31-9. Range Gates (A44) for Option 31



Stock No. 5060-3831

(A45) Range Control for Option 31

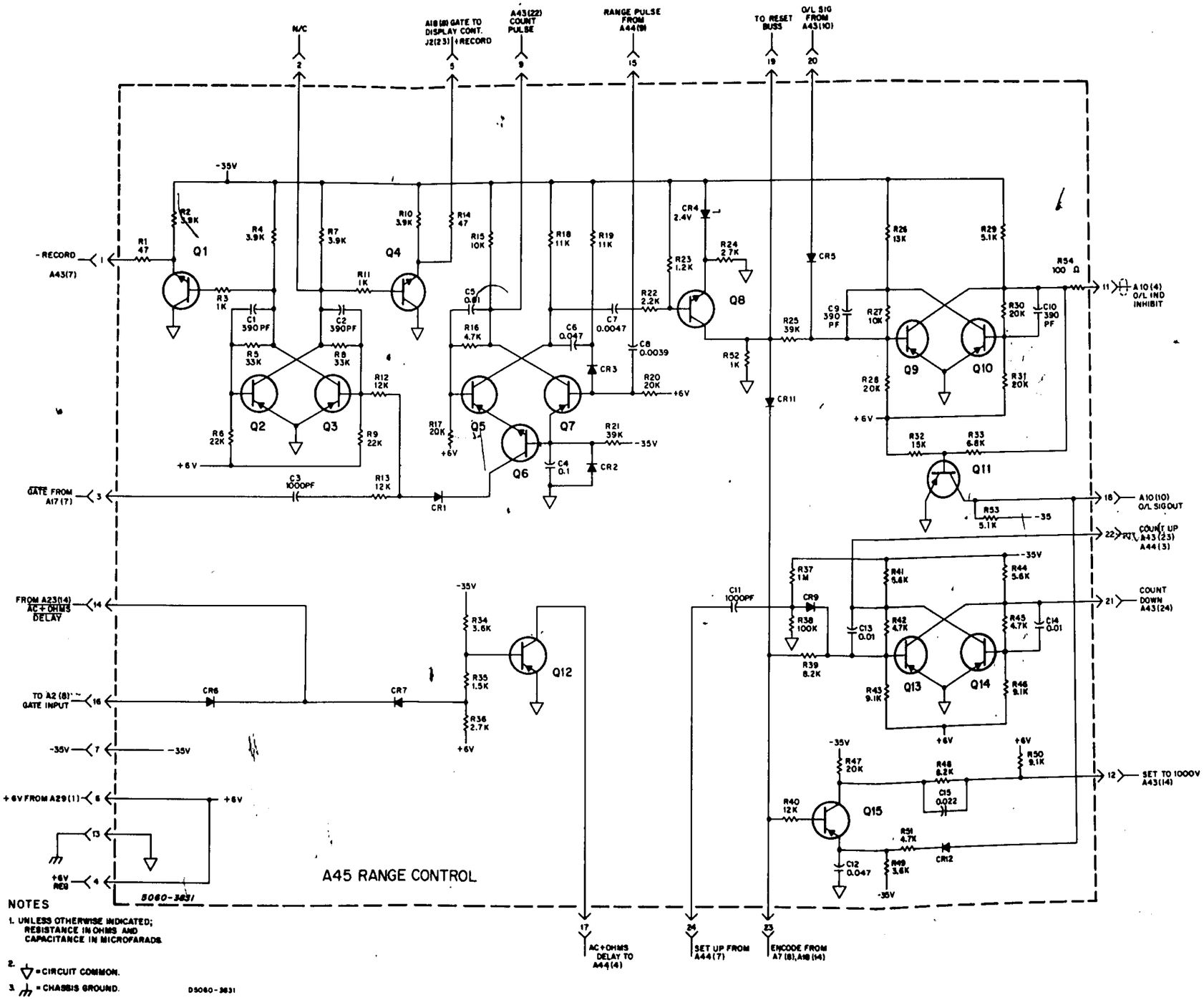
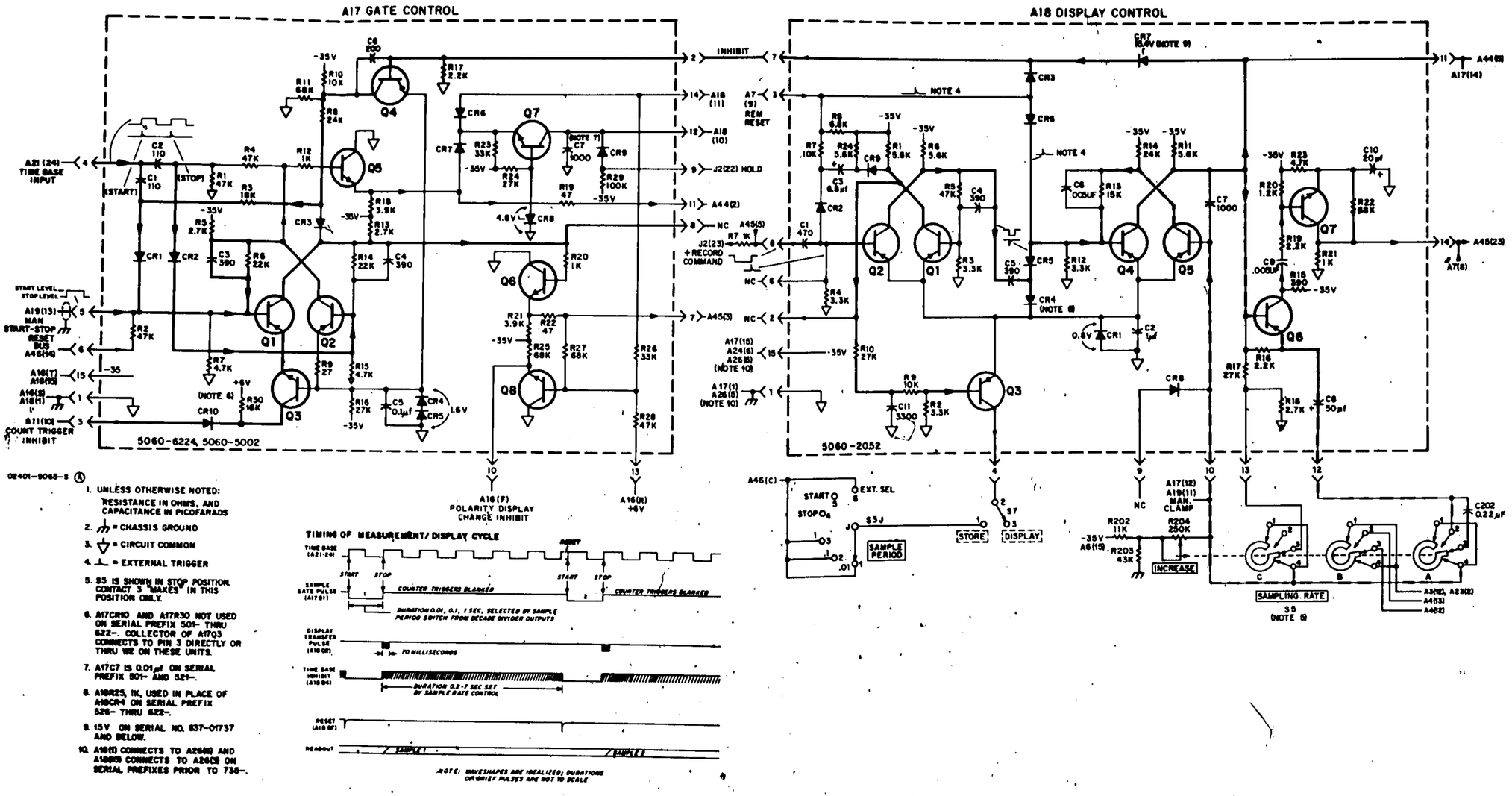


Figure 31-10. Range Control (A45) for Option 31



02401-9066-S (A)

1. UNLESS OTHERWISE NOTED: RESISTANCE IN OHMS, AND CAPACITANCE IN PICOFARADS
2. = CHASSIS GROUND
3. = CIRCUIT COMMON
4. = EXTERNAL TRIGGER
5. S5 IS SHOWN IN STOP POSITION. CONTACT 3 MAKES IN THIS POSITION ONLY.
6. A17CR10 AND A17R30 NOT USED ON SERIAL PREFIX 501- THRU 622-. COLLECTOR OF A17Q3 CONNECTS TO PIN 3 DIRECTLY OR THRU W2 ON THESE UNITS.
7. A17C7 IS 0.01 µf ON SERIAL PREFIX 501- AND 521-.
8. A18R25, 1K, USED IN PLACE OF A18CR4 ON SERIAL PREFIX 526- THRU 622-.
9. 15V ON SERIAL NO. 637-01737 AND BELOW.
10. A19(1) CONNECTS TO A24(6) AND A18(5) CONNECTS TO A26(5) ON SERIAL PREFIXES PRIOR TO 736-.

Figure 31-11. A17 and A18 Connections for Option 31

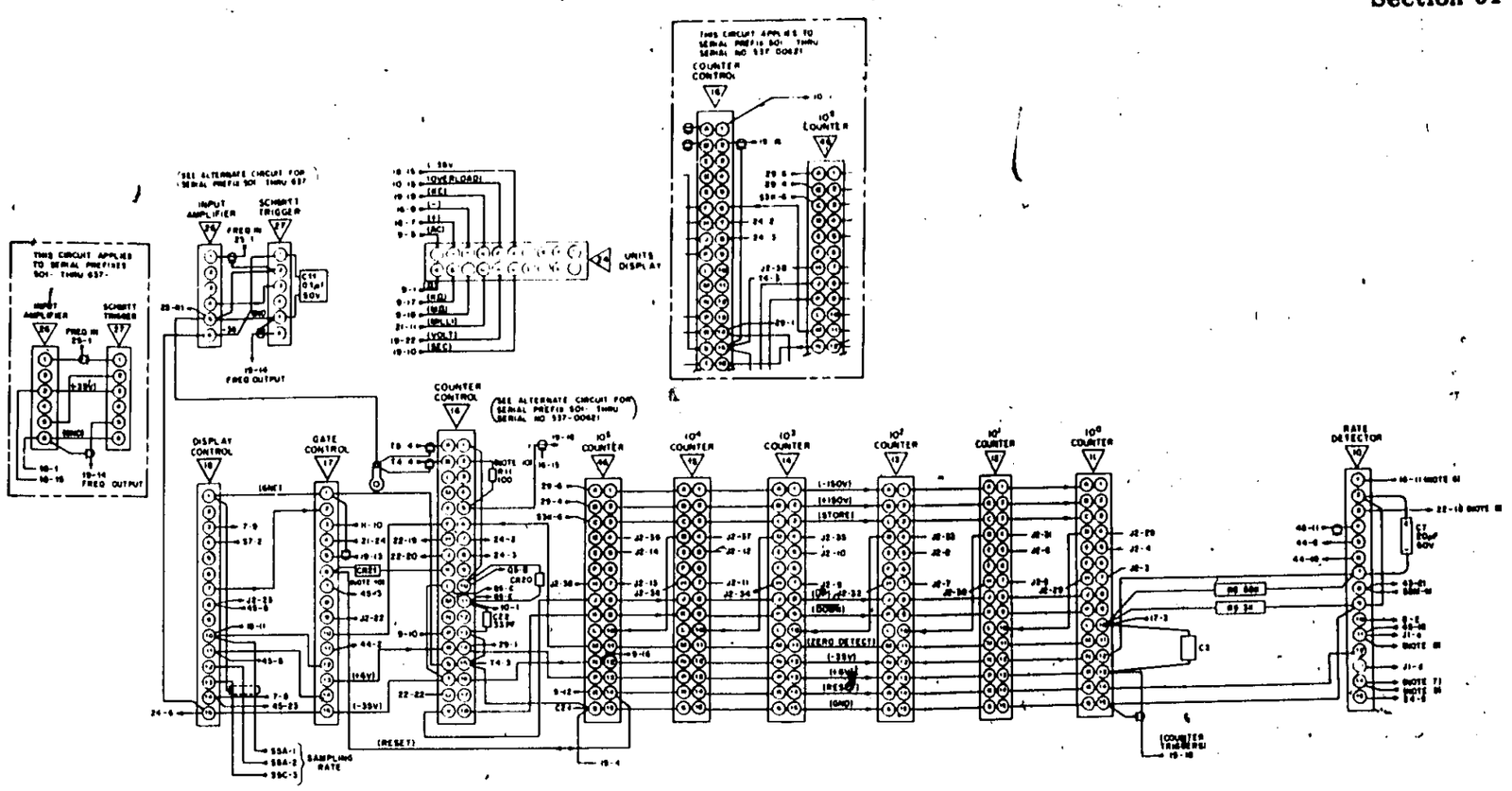
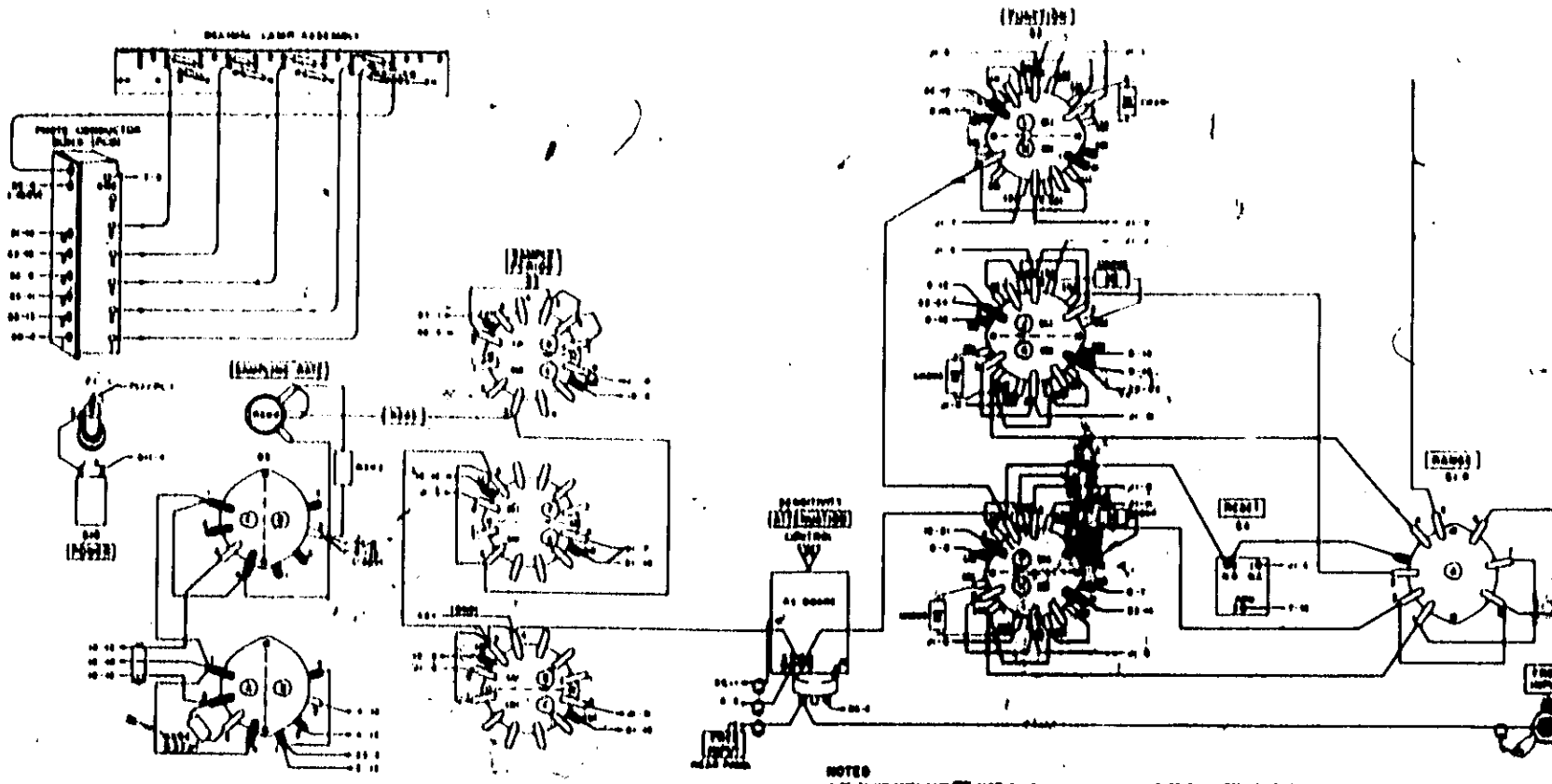


Figure 31-12. Interconnections for Option 31 (Sheet 1 of 3).



NOTES

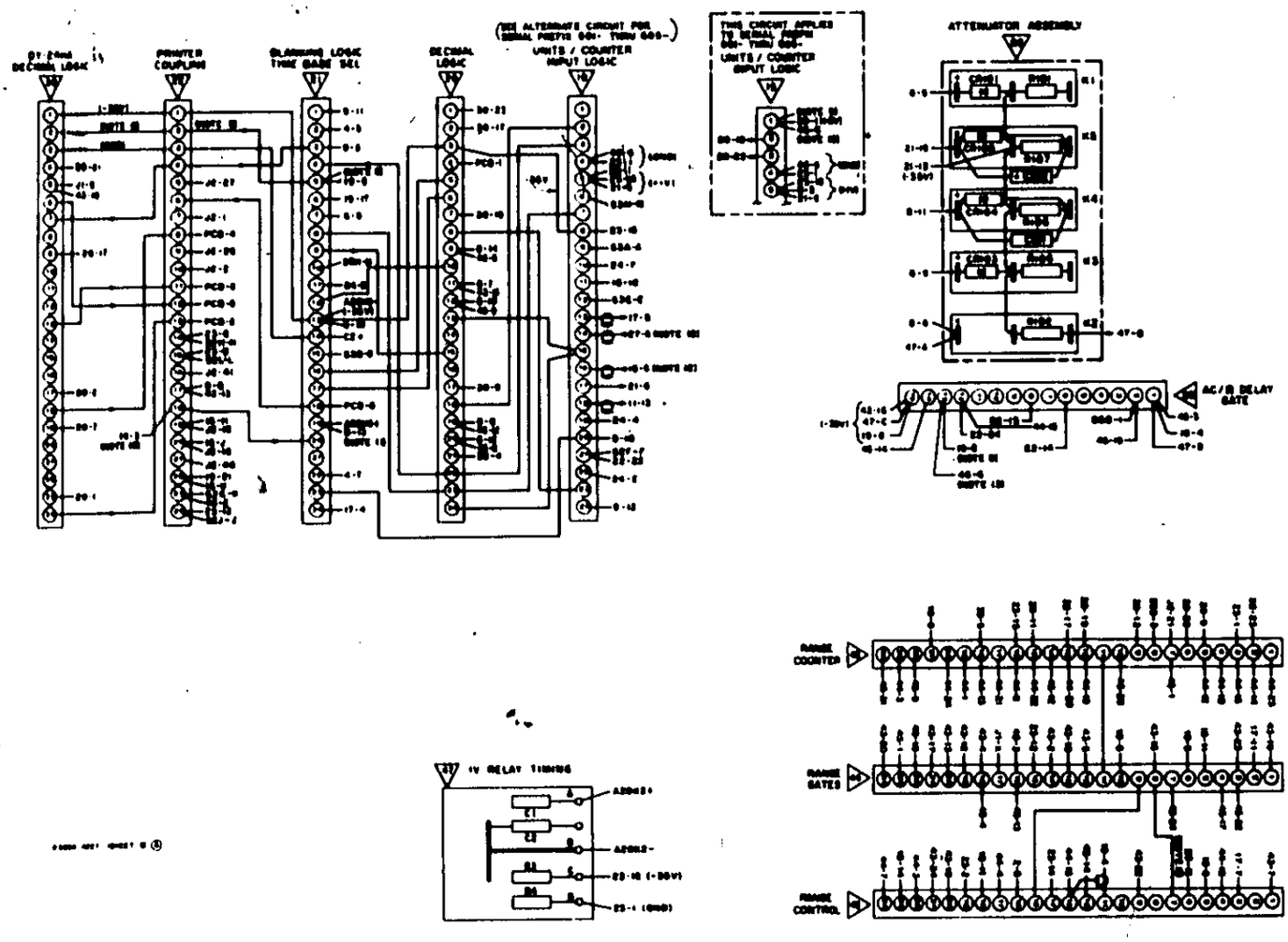


Figure 31-12. Interconnections for Option 31 (Sheet 2 of 3)

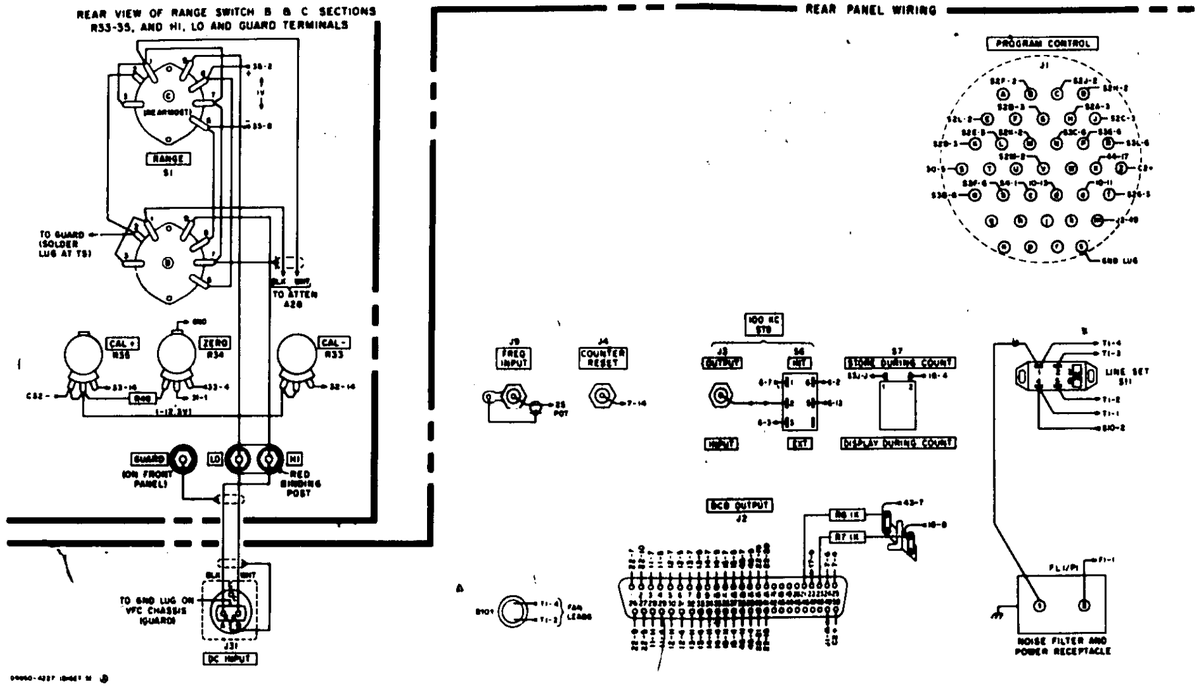


Figure 31-12. Interconnections for Option 31
(Sheet 3 of 3)

MANUAL SUPPLEMENT

MODEL HP-2401C
Integrating Digital Voltmeter
Option 35

35.1 GENERAL DESCRIPTION

The HP-2401C-35 Integrating Digital Voltmeter provides negative true recorder outputs in 8-4-2-1 binary code instead of the positive true 4-2'-2-1 code provided by the standard HP-2401C recorder outputs. (See Tables 2-4 and 35-1.) Except for this difference in coding, the Specifications in Section 1.7 of this manual apply without change to the HP-2401C-35.

35.2 INSTALLATION AND OPERATION

Install, operate, and program the HP-2401C-35 as specified in Section II of this manual.

35.2 THEORY OF OPERATION

The theory of operation of the HP-2401C-35 is the same as that of the standard HP-2401C except as noted in the following paragraphs:

35.3.1 Printer Coupling Logic A22 (Figure 35-1)

The logic and circuitry shown in Figure 35-1 converts decimal and function inputs to negative true 8-4-2-1 BCD outputs for recording. The decimal 10^{-n} and function numbers from this assembly are identical to those from a standard printer coupling logic assembly, but they are in -8-4-2-1 code instead of 4-2'-2-1 code. Logic inverters Q17 through Q20 produce the negative true function outputs in response to positive true inputs from the function-to-BCD matrix.

35.3.2 Change to Counter Control A16 (Figures 4-18 and 35-1)

Diodes CR8 and CR9, which connect A16 (H) and (J) to J2 (15) and (16), replace diodes A16CR6 and A16CR5. A16CR5 and A16CR6 are replaced by A16W1 and A16W2 as shown on Figure 35-1.

35.3.3 Reversible Decade Counters A11-A15 and A46 (Figure 35-2)

The decade counter shown in Figure 35-2 differs from that shown in Figure 4-17 only in the arrangement of feedback and the transistors from which the BCD outputs are taken. The negative true outputs are taken from the collectors of the odd numbered transistors (Q1, Q3, Q5, Q7). The waveforms associated with forward and backward counting of the HP-2401C-35 decades are shown in the circuit diagram, Figure 35-2.

The decades always count up during frequency measurements and during the first phase of voltage measurements. Up counting is enabled when the count down line is clamped to ground (positive true) and the count $\overline{up}$ line is near -35v. Both of these signals are provided by Counter Control Logic on A16.

These states close the down count AND gates and open the up count AND gates. Positive triggers are coupled from the collectors of odd-numbered transistors (Q1, 3, 5, 7) to succeeding stages. Each trigger advances the count by one. When the count is advanced from nine to zero, the turn-on of Q7 generates a trigger that increases by one the count in the next decade, and so on through all six counting units. The up count progression is:

Up Count	Odd-Numbered Transistors Off	BCD Output Table
0	None	0
1	Q1	1
2	Q3	2
3	Q1, Q3	1 + 2
4	Q5	4
5	Q1, Q5	1 + 4
6	Q3, Q5	2 + 4
7	Q1, Q3, Q5	1 + 2 + 4
8	Q7	8
9	Q1, Q7	1 + 8
10	None	0 + Trigger to Next Decade

At the forward count of 8, conduction through Q8 and CR20 inhibits triggering of Q3-Q4 by Q1, assuring that Q3-Q4 and Q5-Q6 remain in zero state (Q3 and Q5 on) when the count of 10 resets Q1-Q2 to zero state. The resetting of Q1-Q2 to zero state also resets Q7-Q8 to zero state through forward count AND diode CR13 and OR diode CR21.

Down counting is commanded by the Counter Control Logic on A16 when the polarity of the input voltage reverses. This is enabled by the positive-true state of the count $\overline{\text{up}}$ line, which closes the $\overline{\text{up}}$ count AND gates and the negative-true state (near -35v) of the count down line, which opens the down count AND gates. Positive triggers are then coupled from the collectors of even-numbered transistors to succeeding stages. The count progression is exactly the reverse of the up count progression, which is summarized above. Starting from the zero state, the first reverse count trigger sets binary Q1-Q2, triggering binaries Q3-Q4, Q5-Q6, and Q7-Q8 to set state through reverse count AND diodes, CR14, CR16, CR18. Turn on of Q6 triggers binaries Q3-Q4 and Q5-Q6 back to zero state, leaving Q1 and Q7 off, representing a 9 count. The next trigger sets Q1-Q2 to zero state, reducing the count to 8. The third trigger sets Q1, Q3, and Q5 off, which resets Q7-Q8 to zero state, establishing the count of 7. The remaining triggers continue subtraction as indicated so long as the reverse count is enabled. Each time a trigger sets the decade from 0 to 9 during reverse counting, the turn on of Q8 triggers the next decade through reverse count AND diode CR22, reducing the count of the next decade by 1.

35.4 MAINTENANCE

Figures 4-17, 4-23, 4-24 and 4-34, sheet 2, are replaced by Figures 35-1 through 35-3. Performance checks 35.1 and 35.2 in Table 35-2 replace checks 15 and 16 in Table 4-3. Shorting links W1 and W2 replace CR5 and CR6 on Counter Control assembly A16. Otherwise, Section IV instructions of this manual apply without change to the HP-2401C-35.

Table 35-1. Function Codes

Data	Function	Logic 8	4	2	1
0	Period (W/30)	0	0	0	0
1	+VDC	0	0	0	1
2	-VDC	0	0	1	0
3	KC	0	0	1	1
4	KΩ (W/HP-2410B)	0	1	0	0
5	MΩ (W/HP-2410B)	0	1	0	1
6	Spare	0	1	1	0
7	Spare	0	1	1	1
8	Time	1	0	0	0
9	OVERLOAD	1	0	0	1
	VAC (W/HP-2410B)	1	0	1	1

BCD Output Levels:

"1" State -35 to -24V: Data Function Decimal Point

"0" State -5 to -1V: Data Function Decimal Point

35.5 PARTS LIST

The Parts List in Section V of this manual applies to the HP 2401C-35 except as indicated in Tables 35-3 and 35-4.

Table 35-2. In-Cabinet Performance Checks

Perform checks 1 through 14 and 17 through 24 as specified in Table 4-3 and Section 4.2.

35.1 RECORDING OUTPUTS - BCD FUNCTION

1 digit.
4-line 8-4-2-1 code.
"1" state level, -35 to -24.5V; "0" state level, -2.5 to 0V.
Source impedance, 33K.

a. Determine and record dc function levels at the following pins of J2:

Control Settings	Function	J2 Pin Code	41 8	40 4	16 2	15 1
VOLTS, INT+1V	+VDC		0	0	0	1
VOLTS, INT-1V	-VDC		0	0	1	0
FREQ	KC		0	0	1	1
EXT SEL, 1V	KΩ (W/HP-2410B)		0	1	0	0
EXT SEL, 1V	MΩ (W/HP-2410B)		0	1	0	1
VOLTS, 1V*	OVERLOAD		1	0	0	1
EXT SEL, 1V	VAC (W/HP-2410B)		1	0	1	1

*W/dc input sufficient to produce OVERLOAD indication.

b. The source impedance is determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram, Figure 35-1.

35.2 RECORDING OUTPUTS - BCD DECIMAL POINT

Specifications same as for 35.1.

a. Set HP-2401C FUNCTION switch to VOLT, other controls as specified below; determine and record dc decimal levels at the following pins of J2; short-circuit HI, LO, and GUARD terminals to assure all zeros reading.

Range	Sample Period	Decimal Position	J2 Pin Code	27 8	26 4	2 2	1 1	
1000V	.01 Sec	000000. V		0	0	0	0	(10^{-0})
1000V	0.1 Sec	00000.0V		0	0	0	1	(10^{-1})
100V	0.1 Sec	0000.00V		0	0	1	0	(10^{-2})
10V	0.1 Sec	000.000V		0	0	1	1	(10^{-3})
1V	0.1 Sec	00.0000V		0	1	0	0	(10^{-4})
.1V	0.1 Sec	0000.00MV		0	1	0	1	(10^{-5})
.1V	1.0 Sec	000.000MV		0	1	1	0	(10^{-6})
.1V	1.0 Sec	00.0000MV**		0	1	1	1	(10^{-7})

**W/HP-2411A at +10 gain (10 MV full scale), FUNCTION at EXT SEL, Card A30 installed.

b. Disconnect short from HI, LO, and GUARD terminals. Set HP-2401C FUNCTION switch to FREQ, ATTENUATION control just clockwise from switched CHECK position, other controls as specified below. Use DC Null Voltmeter to check decimal levels at the following pins of J2:

Sample Period	Decimal Position	J2 Pin Code	27 8	26 4	2 2	1 1	
.01 Sec	00000.0KC		0	0	0	1	(10^{-1})
0.1 Sec	0000.00KC		0	0	1	0	(10^{-2})
1.0 Sec	000.000KC		0	0	1	1	(10^{-3})
STOP	000000		1	0	1	1	

c. The source impedance is determined by fixed value 33K resistors, which can be seen in the assembly A22 circuit diagram, Figure 35-1.

HP-2401C PERFORMANCE CHECK TEST CARD

SER ____ - ____ DATE _____

DESCRIPTION						CHECK RESULTS
35.1 RECORDING OUTPUTS - BCD FUNCTION						
	Outputs Correct At J2 Pins					
Function:	41	40	16	15		
+VDC	0	0	0	1	?	
-VDC	0	0	1	0	?	
KC	0	0	1	1	?	
KΩ	0	1	0	0	?	
MΩ	0	1	0	1	?	
OVERLOAD	1	0	0	1	?	
VAC	1	0	1	1	?	
						(yes)
35.2 RECORDING OUTPUTS - BCD DECIMAL POINT						
	Outputs Correct At J2 Pins					
Display:	27	26	2	1		
000000.V	0	0	0	0	?	
00000.0V	0	0	0	1	?	
0000.00V	0	0	1	0	?	
000.000V	0	0	1	1	?	
00.0000V	0	1	0	0	?	
0000.00MV	0	1	0	1	?	
000.000MV	0	1	1	0	?	
00.0000MV	0	1	1	1	?	
00000.0KC	0	0	0	1	?[1]	
0000.00KC	0	0	1	0	?	
000.000KC	0	0	1	1	?	
000000	1	0	1	1	?	
						(yes)

"0" = -2.5 to 0V DC.
"1" = -35 to -24.5V DC.

Table 35-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 35 A11 5060-5644	
		MAKE THE FOLLOWING CHANGES TO TABLE 5-1 TO MAKE THE TABLE APPLICABLE TO THE HP2401C-35.	
		DELETE THE FOLLOWING:	
A11- A15	5060-3781	REVERSIBLE DECADE COUNTER	
A22	5060-2111	LOGIC CARD	A-E
	5060-5610	LOGIC CARD	F-X
A46	5060-3781	REVERSIBLE DECADE COUNTER	
		ADD THE FOLLOWING:	
A11- A15	5060-5644	REVERSIBLE DECADE COUNTER	
A22	5060-5612	PRINTER COUPLING LOGIC	
A46	5060-5644	REVERSIBLE DECADE COUNTER	
CR1	1901-0025	DIODE:SILICON 100WV 100MA	
CR4- CR11	1901-0025	DIODE:SILICON 100WV 100MA	
		CR5 IS NOT USED FOR HP2401C-30/35.	
A11	5060-5644	REVERSIBLE DECADE DIVIDER	
A11A1	NSR	READOUT BLOCK ASSY	
A11C1- A11C6	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C7	0140-0219	C:FXD MICA 180 PF 2%	
A11C8	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C9	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C10	0140-0194	C:FXD MICA 110 PF 5%	
A11C11	0140-0194	C:FXD MICA 110 PF 5%	
A11C12	0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	
A11C13	0140-0194	C:FXD MICA 110 PF 5%	
A11C14	0140-0194	C:FXD MICA 110 PF 5%	
A11C15	0140-0194	C:FXD MICA 110 PF 5%	
A11C16	0140-0194	C:FXD MICA 110 PF 5%	
A11C17	0140-0194	C:FXD MICA 110 PF 5%	
A11C18	0140-0194	C:FXD MICA 110 PF 5%	
A11CR1- A11CR8	1901-0025	DIODE:SILICON 100WV 100MA	
A11CR9- A11CR24	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11CR26- A11CR34	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A11Q1- A11Q8	1850-0184	TRANSISTOR:GERMANIUM PNP	

Table 36-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #
		OPTION 36
		A11 6000-6044 (CONT'D)
A11R1	0683-3945	R:FXD COMP 390K OHM 5% 1/4W
A11R2	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R3	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R4	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W
A11R5	0683-3945	R:FXD COMP 390K OHM 5% 1/4W
A11R6	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R7	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R8	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W
A11R9	0683-3945	R:FXD COMP 390K OHM 5% 1/4W
A11R10	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R11	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R12	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W
A11R13	0683-3945	R:FXD COMP 390K OHM 5% 1/4W
A11R14	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R15	0683-5635	R:FXD COMP 56K OHMS 5% 1/4W
A11R16	0683-1045	R:FXD COMP 100K OHMS 5% 1/4W
A11R17	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R18	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R19	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R20	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R21	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R22	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R23	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R24	0683-6835	R:FXD COMP 68K OHM 5% 1/4W
A11R25	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R26	0683-1535	R:FXD COMP 15K OHM 5% 1/4W
A11R27	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R28	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R29	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R30	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R31	0683-6835	R:FXD COMP 68K OHM 5% 1/4W
A11R32	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R33	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R34	0683-6835	R:FXD COMP 68K OHM 5% 1/4W
A11R35	0683-6835	R:FXD COMP 68K OHM 5% 1/4W
A11R36	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R37	0686-5625	R:FXD COMP 5600 OHM 5% 1/2W
A11R38	0683-6835	R:FXD COMP 68K OHM 5% 1/4W
A11R39-		
A11R46	0683-2735	R:FXD COMP 27K OHM 5% 1/4W
A11R47	0683-3335	R:FXD COMP 33K OHM 5% 1/4W
A11R48	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R49	0683-2235	R:FXD COMP 22K OHM 5% 1/4W
A11R50	0683-3335	R:FXD COMP 33K OHM 5% 1/4W
A11R51	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W
A11R52	0683-3335	R:FXD COMP 33K OHM 5% 1/4W

Table 35-3. Reference Designation Index (Cont'd)

Note	Reference Designation	Part No.	Description #	Net
			OPTION 35	
			A11 5060-8844 (CONT'D)	
			A12-	
			A15 5060-8844	
			A22 5060-8812	
	A11R53	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
	A11R54	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
	A11R55	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
	A11R56	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
	A11R57	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
	A11R58	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
	A11R59	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
	A11R60	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
	A11R61	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
	A11R62	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
	A11R63	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
	A11R64	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
	A11R65	0683-2235	R:FXD COMP 22K OHM 5% 1/4W	
	A11R66	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
	A11R67	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
	A11R68	0683-6835	R:FXD COMP 68K OHM 5% 1/4W	
	A11R69	0686-4735	R:FXD COMP 47K OHM 5% 1/2W	
	A11R70	0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	
	A11V1	1970-0009	ELECTRON TUBE:INDICATOR 10 DIGIT	
	A12		SAME AS A11, USE PREFIX A12	
	A13		SAME AS A11, USE PREFIX A13	
	A14		SAME AS A11, USE PREFIX A14	
	A15		SAME AS A11, USE PREFIX A15	
	A22	5060-8812	PRINTER COUPLING LOGIC	
	A22CR1	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR2	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR3	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR4	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR5	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR7	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR8	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR11	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR14	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR15	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR17	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR22	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR24	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR26	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
		1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR29	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR30	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR31	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR32	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
	A22CR33	1901-0081	DIODE:SILICON 50 VOLTS WORKING	

Table 35-3. Reference Designation Index (Cont'd)

Reference Designation	Part No.	Description #	Note
		OPTION 35 A22 0000-0012 (CONT'D)	
A22CR34	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR35	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR36	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR38	1901-0051	DIODE:SILICON 1.5A 400NV	
A22CR39	1901-0051	DIODE:SILICON 1.5A 400NV	
A22CR40	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR41	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR42	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR43	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR44	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR45	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR48	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR49	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR50	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR52	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR53	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22CR54	1901-0081	DIODE:SILICON 50 VOLTS WORKING	
A22Q1- A22Q20	1850-0111	TRANSISTOR:GERMANIUM PNP	
A22R1	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R2	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R3	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R4	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R5	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R6	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R7	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R8	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R9	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R10	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R11	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R12	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R13	0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	
A22R14	0757-0950	R:FXD FLM 12K OHM 2% 1/8W	
A22R15	0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	
A22R16	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R17	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R18	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R19	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R20	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R21	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R22	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R23	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R24	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R25	0683-1835	R:FXD COMP 18K OHM 5% 1/4W	
A22R26	0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	
A22R27	0683-1035	R:FXD COMP 10K OHM 5% 1/4W	
A22R28	0683-2435	R:FXD COMP 24K OHM 5% 1/4W	
A22R29	0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	
A22R30	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	

Table 35-3. Reference Designation Index (Cont'd)

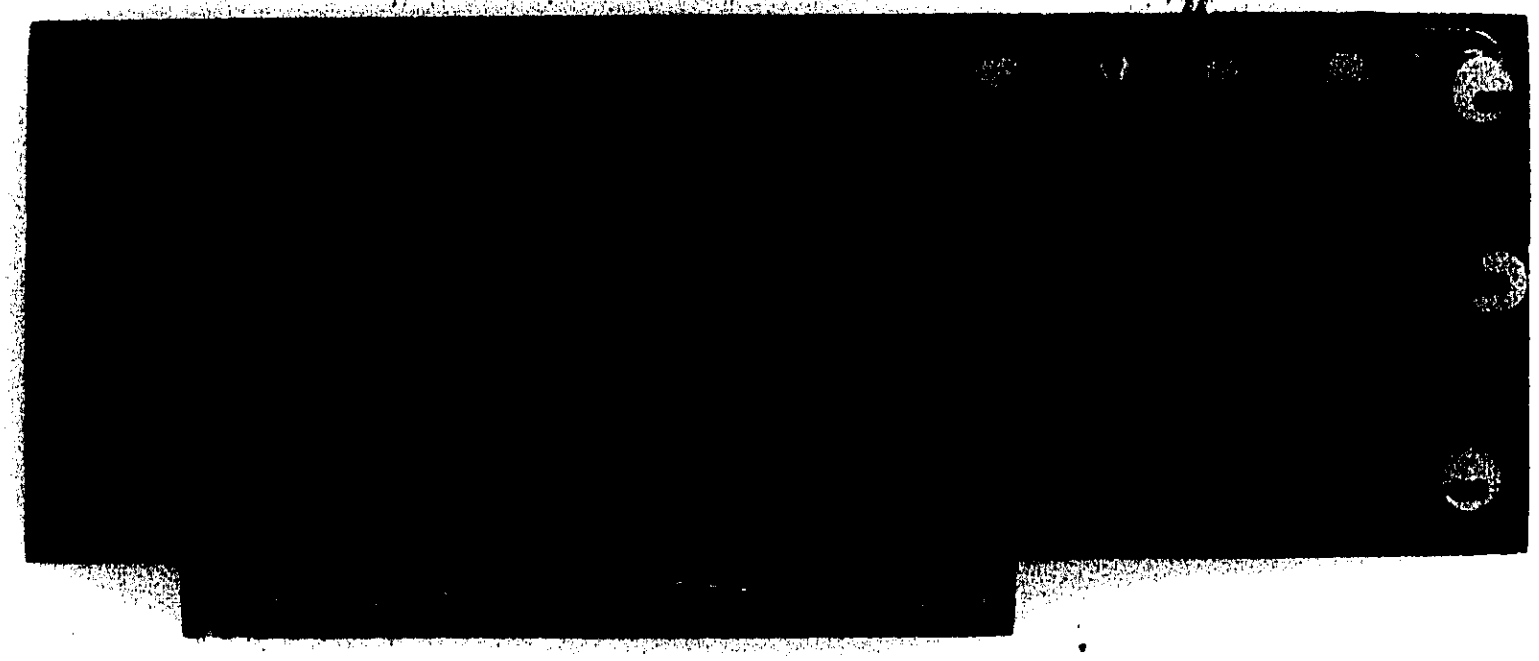
Reference Designation	Part No.	Description #	Note
		OPTION 25	
		A22 0683-6512 (CONT'D)	
A22R31	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R32	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R33	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R34	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R35	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R36	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R37	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R38	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R39	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R40	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R41	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R42	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R43	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R44	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R45	0683-1535	R:FXD COMP 15K OHM 5% 1/4W	
A22R46	0683-9135	R:FXD COMP 91K OHM 5% 1/4W	
A22R47	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R48	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R49	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R50	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R51	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R52	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R53	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R54	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R55	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R56	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R57	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R58	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R59	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R60	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R62	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	
A22R63	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R64	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A22R65	0683-2035	R:FXD COMP 20K OHM 5% 1/4W	
A22R66	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R68	0683-1335	R:FXD COMP 13K OHM 5% 1/4W	
A22R69	0757-0957	R:FXD FLM 24K OHM 2% 1/8W	
A22R70	0757-0955	R:FXD FLM 20K OHM 2% 1/8W	
A22R71	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R72	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R73	0757-0957	R:FXD FLM 24K OHM 2% 1/8W	
A22R74	0757-0955	R:FXD FLM 20K OHM 2% 1/8W	
A22R75	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R76	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R77	0757-0957	R:FXD FLM 24K OHM 2% 1/8W	
A22R78	0757-0955	R:FXD FLM 20K OHM 2% 1/8W	
A22R79	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R80	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A22R81	0757-0957	R:FXD FLM 24K OHM 2% 1/8W	

Table 35-3. Reference Designation Index (Cont'd)

Reference Designation	● Part No.	Description #	Note
		OPTION 28 A22 0688-0812 (CONT'D)	
A22R82	0757-0955	R:FXD FLM 20K OHM 2% 1/8W	
A22R83	0683-3335	R:FXD COMP 33K OHM 5% 1/4W	
A22R84	0683-2045	R:FXD COMP 200K OHM 5% 1/4W	
A48		SAME AS A11, USE PREFIX A48	

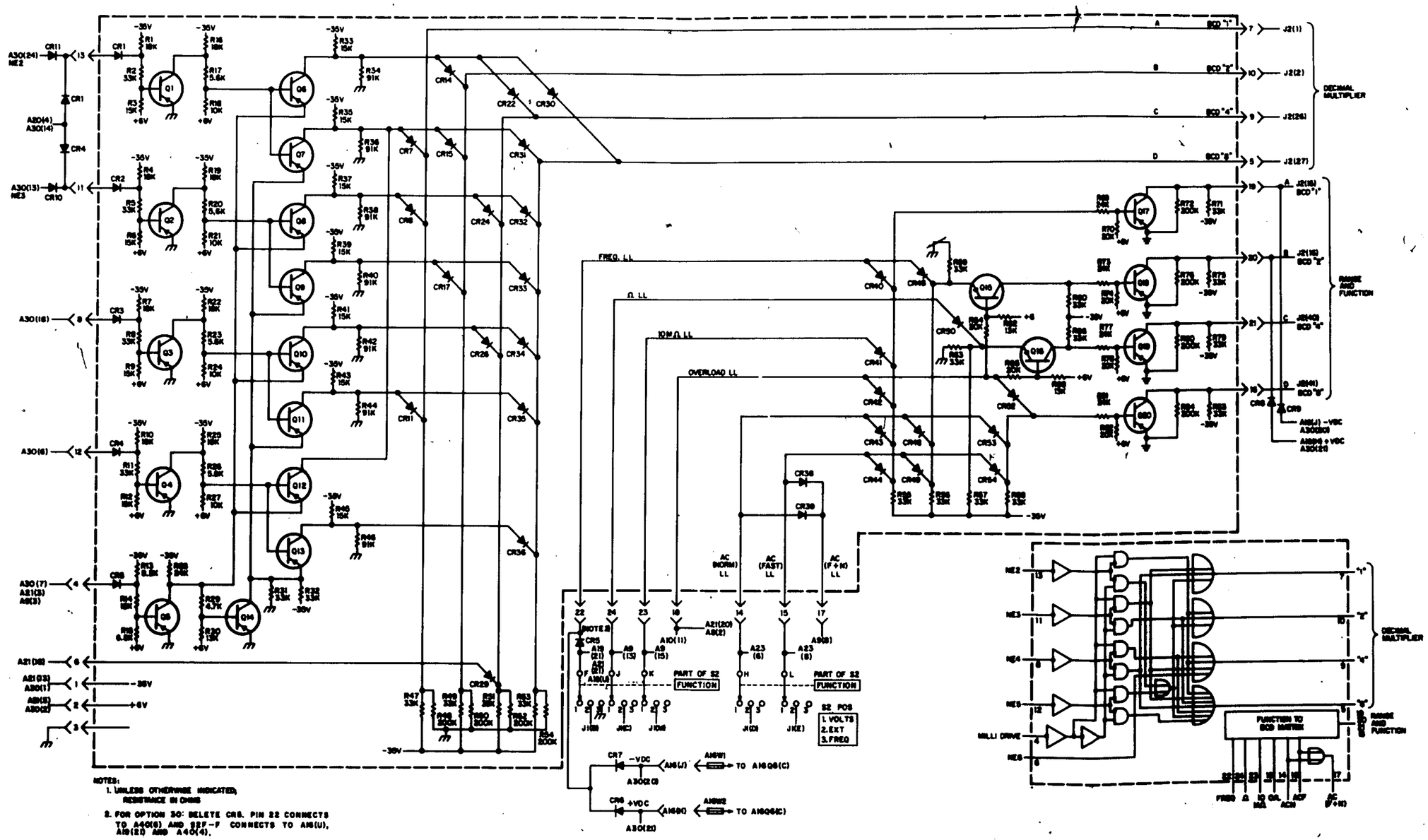
Table 35-4. Replaceable Parts

● Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 28			
0140-0194	C:FXD MICA 110 PF 5%	28480	0140-0194	48
0140-0195	C:FXD MICA 130 PF 5% 300 VDCW	04062	DM15F131J 300V	54
0140-0219	C:FXD MICA 180 PF 2%	28480	0140-0219	6
0683-1035	R:FXD COMP 10K OHM 5% 1/4W	01121	CB 1035	4
0683-1045	R:FXD COMP 100K OHMS 5% 1/4W	01121	CB 1045	24
0683-1335	R:FXD COMP 13K OHM 5% 1/4W	01121	CB 1335	3
0683-1535	R:FXD COMP 15K OHM 5% 1/4W	01121	CB 1535	17
0683-1835	R:FXD COMP 18K OHM 5% 1/4W	01121	CB 1835	8
0683-2035	R:FXD COMP 20K OHM 5% 1/4W	01121	CB 2035	2
0683-2045 U	R:FXD COMP 200K OHM 5% 1/4W	01121	CB 2045	8
0683-2235	R:FXD COMP 22K OHM 5% 1/4W	01121	CB 2235	96
0683-2435	R:FXD COMP 24K OHM 5% 1/4W	01121	CB 2435	1
0683-2735	R:FXD COMP 27K OHM 5% 1/4W	01121	CB 2735	48
0683-3025	R:FXD COMP 3000 OHM 5% 1/4W	01121	CB 3025	36
0683-3335	R:FXD COMP 33K OHM 5% 1/4W	01121	CB 3335	70
0683-3945	R:FXD COMP 390K OHM 5% 1/4W	01121	CB 3945	24
0683-4725	R:FXD COMP 4700 OHM 5% 1/4W	01121	CB 4725	1
0683-5625	R:FXD COMP 5600 OHM 5% 1/4W	01121	CB 5625	4
0683-5635	R:FXD COMP 56K OHMS 5% 1/4W	01121	CB 5635	48
0683-6835	R:FXD COMP 68K OHM 5% 1/4W	01121	CB 6835	6
0683-9135	R:FXD COMP 91K OHM 5% 1/4W	01121	CB 9135	7
0686-4735	R:FXD COMP 47K OHM 5% 1/2W	01121	EB 4735	6
0686-5625	R:FXD COMP 5600 OHM 5% 1/2W	01121	EB 5625	48
0757-0944	R:FXD FLM 6.8K OHM 2% 1/8W	28480	0757-0944	1
0757-0946	R:FXD FLM 8.2K OHM 2% 1/8W	28480	0757-0946	1
0757-0950	R:FXD FLM 12K OHM 2% 1/8W	28480	0757-0950	1
0757-0955	R:FXD FLM 20K OHM 2% 1/8W	28480	0757-0955	4
0757-0957	R:FXD FLM 24K OHM 2% 1/8W	28480	0757-0957	4
1850-0111	TRANSISTOR:GERMANIUM PNP	01295	2N404A	20
1850-0184	TRANSISTOR:GERMANIUM PNP	02735	38339	48
1901-0025	DIODE:SILICON 100PV 100MA	28480	1901-0025	48
1901-0051	DIODE:SILICON 1.5A 400MV	28480	1901-0051	2
1901-0081	DIODE:SILICON 50 VOLTS WORKING	28480	1901-0081	185
1970-0059	ELECTRON TUBE:INDICATOR 10 DIGIT	83594	85991	6
5060-5612	PRINTER COUPLING LOGIC	04404	5060-5612	1
5060-5644	REVERSIBLE DECADE DIVIDER	04404	5060-5644	6



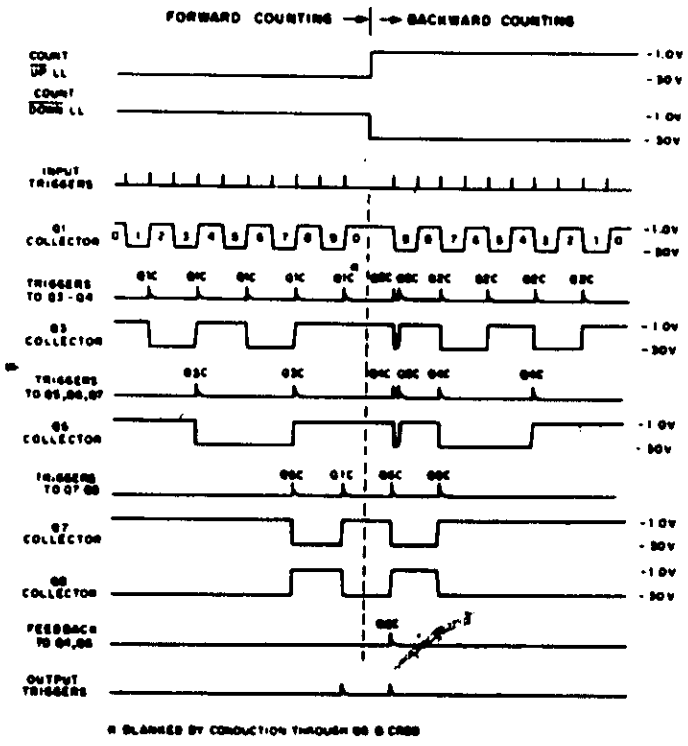
Stock No. 5060-5612

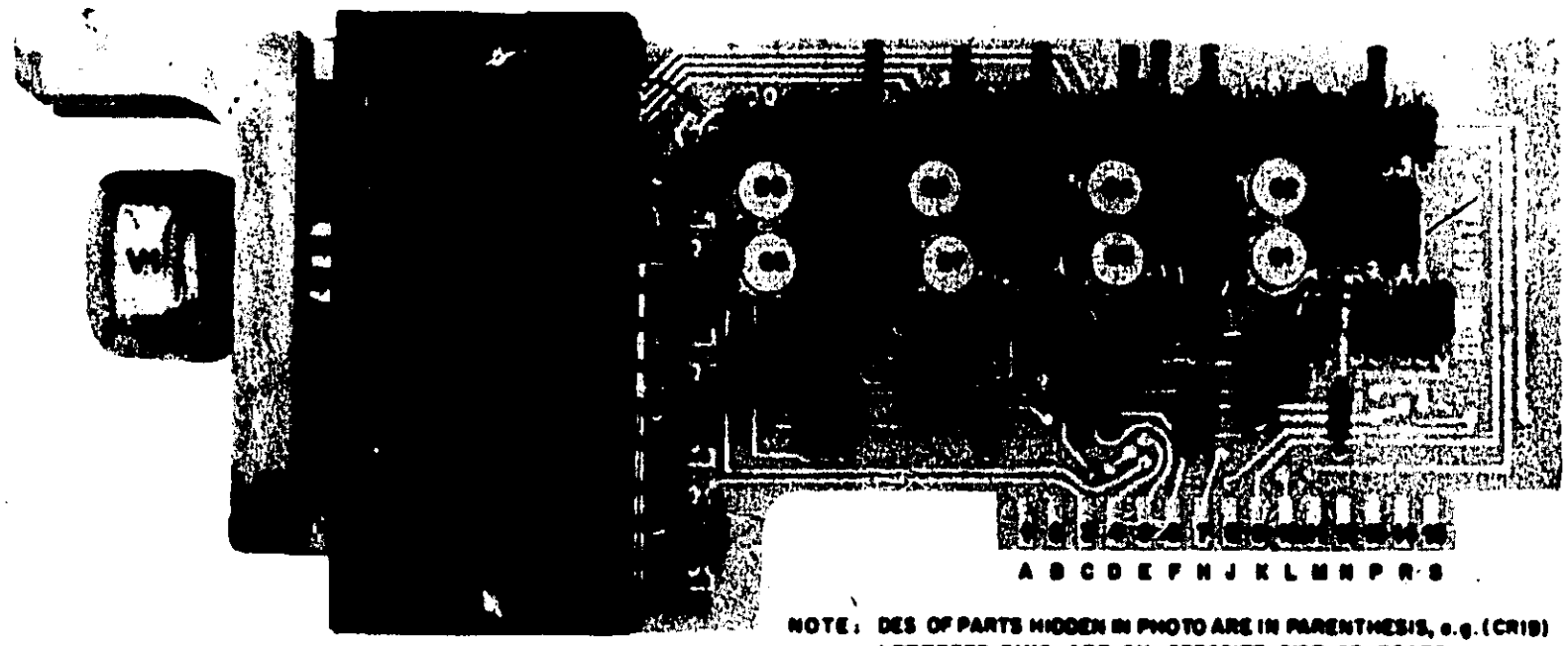
(A22) Printer Coupling for Option 35



NOTES:
1. UNLESS OTHERWISE INDICATED, RESISTANCE IN OHMS
2. FOR OPTION 30: DELETE CR8. PIN 22 CONNECTS TO A4Q6(S) AND 22F-F CONNECTS TO A16(U), A16(22) AND A4Q4(4).

Figure 35-1. Printer Coupling (A22) for Option 35





NOTE: DES OF PARTS HIDDEN IN PHOTO ARE IN PARENTHESIS, e.g. (CR19)
LETTERED PINS ARE ON OPPOSITE SIDE OF BOARD.

Stock No. 5060-5644

(A11-A15) Reversible -8-4-2-1 Decade Counter for Option 35

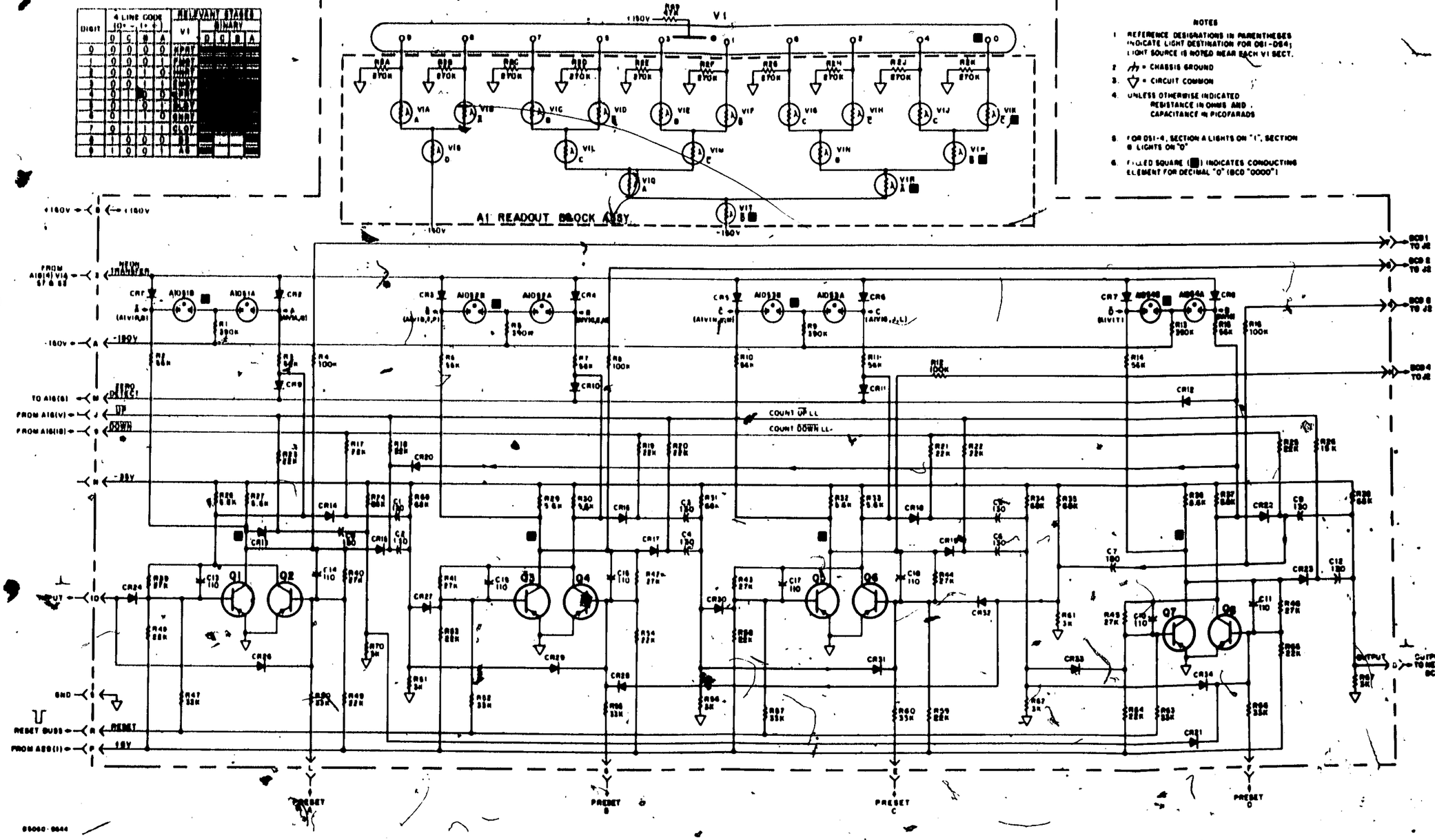


Figure 35-2. Reversible -8-4-2-1 Decade Counter (A11-A15, A46) for Option 35

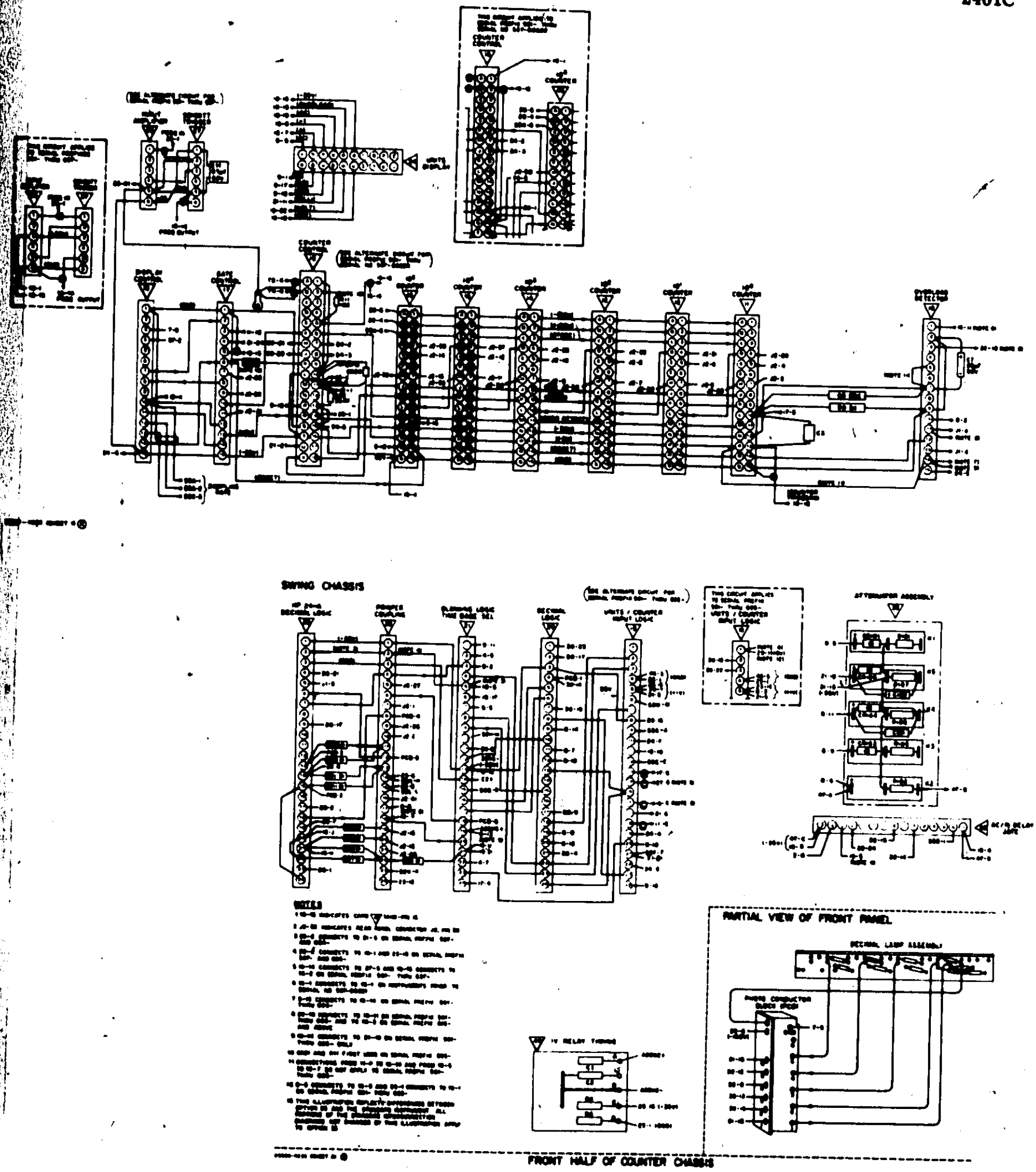


Figure 35-3. Interconnection Changes for Option 35

MANUAL SUPPLEMENT

MODEL HP-2401C

Integrating Digital Voltmeter

Option 146

146.1 GENERAL DESCRIPTION

The HP-2401C-146 Integrating Digital Voltmeter permits connecting command signals to a computer (such as the HP Model 2116 Computer) by a single connector. This is accomplished by internal wiring changes.

146.2 INSTALLATION AND OPERATION

Installation and operation of the HP-2401C-146 is the same as for the standard HP-2401C except a signal at COUNTER RESET connector J4 on the rear panel will be routed to the computer via pin n of PROGRAM CONTROL connector J1. The computer in turn will control counter reset via J1(c). Also, the +Record Command is routed to the Computer via J(r) as well as to pin 23 of BCD OUTPUT connector J2.

146.3 THEORY OF OPERATION

Theory of operation of the HP-2401C-146 is the same as for the standard HP-2401C except external programming signals are routed as explained in Section 146.2.

146.4 MAINTENANCE

Figure 146-1 shows the connections to A17, which differ from the standard HP-2401C. Figure 146-2 shows changes in interconnections for the HP-2401C-146. Otherwise, the maintenance instructions in Section IV of this manual are directly applicable without change to the HP-2401C-146.

146.5 PARTS LIST

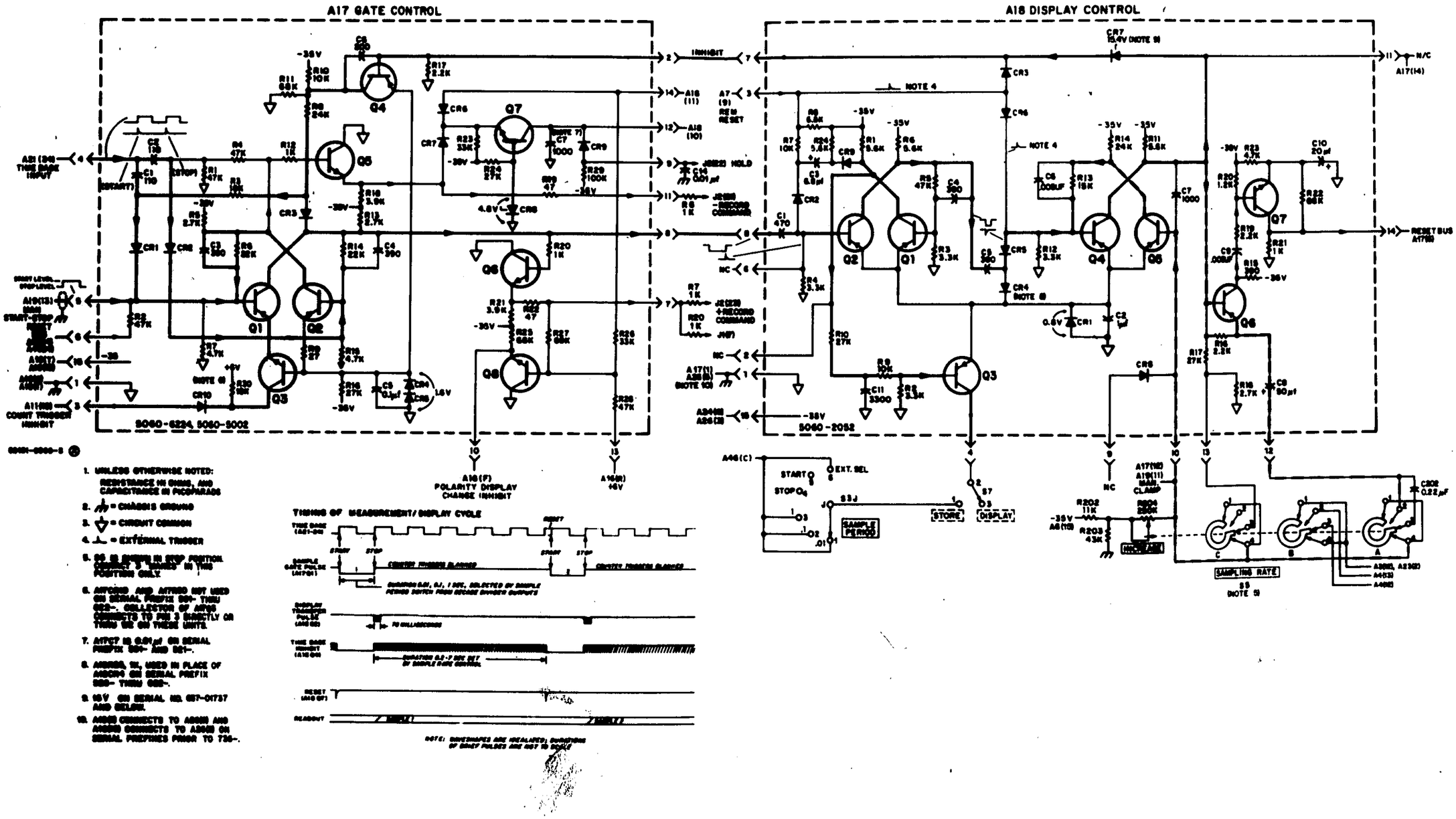
The Parts List in Section V of this manual applies to the HP-2401C-146 except as indicated in Tables 146-1 and 146-2.

Table 146-1. Reference Designation Index

Reference Designation	◆ Part No.	Description #	Note
		OPTION 146	
		ADD THE FOLLOWING TO TABLE 5-1 TO MAKE THE TABLE APPLICABLE TO THE HP2401C-146	
C14	0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	
R20	0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	

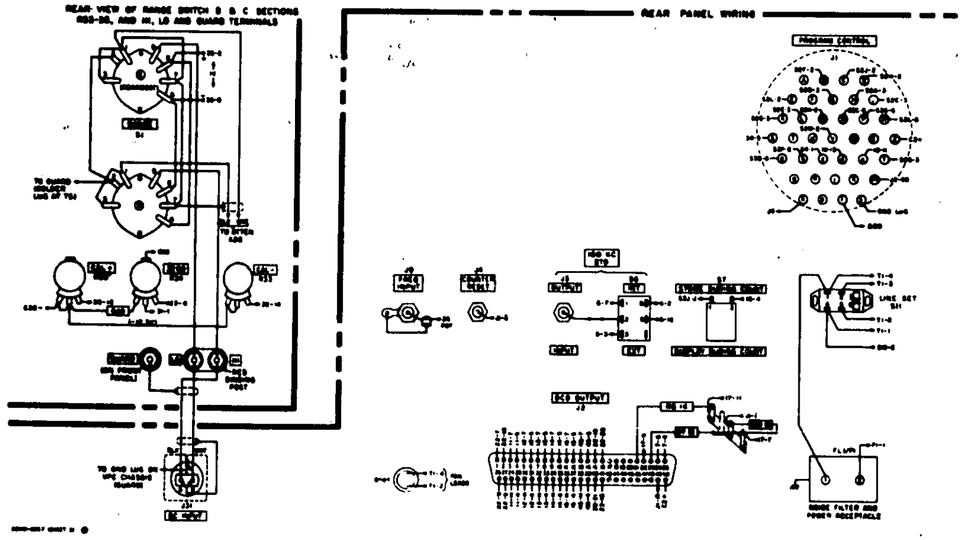
Table 146-2. Replaceable Parts

◆ Part No.	Description #	Mfr.	Mfr. Part No.	TQ
	OPTION 146			
0160-0161	C:FXD MY 0.01 UF 10% 200VDCW	28480	0160-0161	
0683-1025	R:FXD COMP 1000 OHM 5% 1/4W	01121	CB 1025	1



1. UNLESS OTHERWISE NOTED:
   RESISTANCE IN OHMS, AND CAPACITANCE IN MICROFARADS
2. = CHASSIS GROUND
3. = CIRCUIT COMMON
4. = EXTERNAL TRIGGER
5. S3 IS SHOWN IN STOP POSITION. CONTACTS 1, 2 CLOSED IN THIS POSITION ONLY.
6. A17CR10 AND A17R20 NOT USED ON SERIAL PREFIX 5001- THRU 5025-. COLLECTOR OF A17Q3 CONNECTS TO PIN 3 DIRECTLY OR THRU 5K ON THESE UNITS.
7. A17C7 IS 0.01 µF ON SERIAL PREFIX 5001- AND 5011-.
8. A18CR3, 4, USED IN PLACE OF A18CR4 ON SERIAL PREFIX 5005- THRU 5025-.
9. 15V ON SERIAL NO. 5011-01737 AND BELOW.
10. A18J2 CONNECTS TO A18J3 AND A18J3 CONNECTS TO A18J2 ON SERIAL PREFIXES PRIOR TO 7304-.

Figure 146-1. A17 and A18 Connections for Option 146



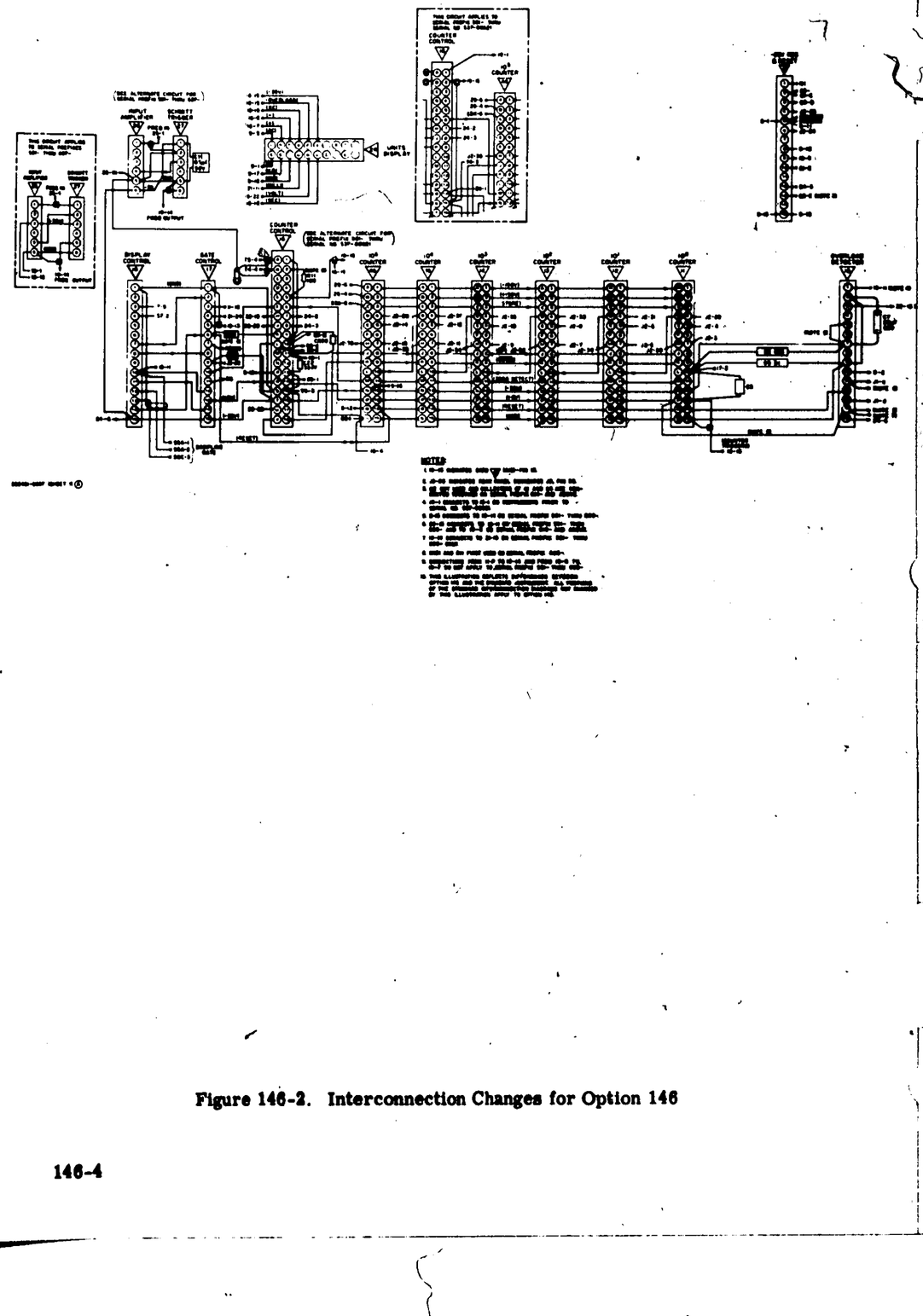


Figure 146-2. Interconnection Changes for Option 146

SERVICE NOTES

SERVICE NOTE

SUPERSEDES:

MODEL HP-2401B/C INTEGRATING DIGITAL VOLTMETERS

HP-2401B Serial Number Above 444-01536
HP-2401C Serial Number Below 526-00221

Some 2401B Voltmeters above serial number 444-01536 and 2401C Voltmeters below serial number 526-00221, have caused 2010 Systems to hang up, particularly when operated on .01 second gate with an -hp-562 Digital Recorder.

If voltmeter readings are initiated by "External Reset" pulses at certain repetition rates, transistor Q4 on Display Control Board A18 (Disply Flip-Flop) may not be turned off if the Display One-Shot (Q1,Q2) is triggered simultaneously. This is due to the reset pulse being excessively loaded by diode CR4.

The remedy is to replace CR4 with a 1KΩ, 0.25 watt, Allen - Bradley resistor, stock number 0683-1025. This change will be made on all 2401C Voltmeters, serial number 526-00221, and above.

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MODEL 2401C INTEGRATING DIGITAL VOLTMETER

Display Decades showing counts during Reset
Serials Prefixed Below 605

Some DY-2401C Voltmeters will show erratic counts during reset.

While re-setting the display decades, a binary, which is reset to its Zero state, will occasionally pass a pulse to the following binary. The following binaries will accept this pulse as a counter pulse at the time the reset pulse is removed.

The result is an occasional count appearing when the display decades should be reset to Zero.

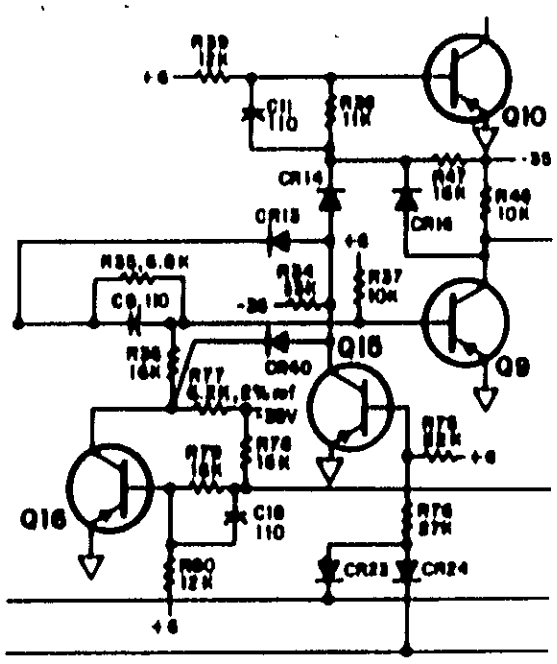
A simple cure for this is to gate off the up/down gates so that no pulse can be transferred during the reset period.

Please note that the following modification is broken down into 3 sections. Sections 1 and 2 should be done with all 2401C's except M70 or combinations with the M70. Sections 1 and 3 should be done with 2401C's having the M70.

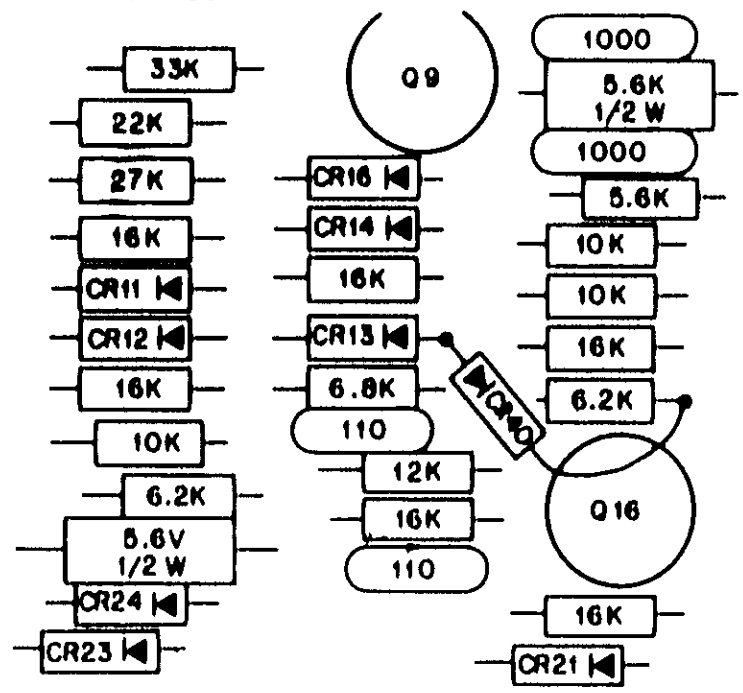
1. A 16 5060-3809

Add CR40	Diode	-hp- stock number	1901-0081
Del R76	Resistor 33K	-hp- stock number	0683-3335
Add R76	Resistor 27K	-hp- stock number	0683-2735

SCHEMATIC
D5060-3809



BOARD LAYOUT
C5100-1569



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HP-2401C M146 INTERGRATING DIGITAL VOLTMETER

FAILURE TO GIVE THE HP-2116A COMPUTER THE PROPER PRINT COMMAND

Serial Prefixes Below 739-

When using the 2401C M146 with the HP-2116A Computer, the voltmeter may not issue a print command to the DSI card in the computer. When this problem occurs, the 2116A Computer will appear to be at fault. The true source of the problem has been traced to the 2401C M146 Voltmeter.

The print command from the standard 2401C is normally 25 volts, however, when M146 is installed, a parallel print command is taken out on J1 pin $\bar{r}$. The print command on J1 $\bar{r}$ is an input to the DVM program board in the 2116A. The DVM board has an 8 volt Zener Diode in series with the print command which clamps the print command at a maximum of 8 volts. The parallel print command on J2 pin 23 is not large enough to trigger the DSI board in the 2116A Computer.

All 2401C M146 Voltmeters in the field should have the following modification installed:

Add: R20 Resistor, fixed, 1000 ohms HP stock number 0683-1025

Add: Terminal, stand off HP stock number 0360-0018

LV/lc/WA

9/67-6

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HP-2401C INTEGRATING DIGITAL VOLTMETER

REPLACEMENT OF THE AC LINE FILTER

Serial Prefixes 735 and Below

A new AC line filter has been developed for use in the HP-2401C. The new line filter will withstand a higher voltage in the line to ground insulation test.

The HP stock number for the preferred line filter is:

9100-2477

Be sure to update the Table of Replaceable Parts Section in your Operating and Service Manual.

LV/tj/wo

11/67-6

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HP-2401C INTEGRATING DIGITAL VOLTMETER

OSCILLATION OF THE +12 VOLT POWER SUPPLY

Serial Prefixes 739 and Below

Some 2401C voltmeters have shown noise counts in excess of the specifications (± 2 counts). This noise is caused by oscillation of the +12 volt power supply.

To correct this problem make the following modification:

1. Delete C13 10pf, hp stock number 0160-2197
   NOTE: On units below serial number 735-02037, C13 does not exist.
2. Add C13 91pf, hp stock number 0160-2203.
   The capacitor should be installed on connector XA34, pins 5 and 6.

In addition to the above change, if a field replacement of A34, A35, or A36 is made it may be necessary to make the following change:

1. Add or remove C12, hp stock number 0140-0149 on connector XA34, pins 1 and 5.
   NOTE: On units having the Paco power transformer, the capacitor C12 will be on connector XA34 pins 1 and 6.

This change is necessary because C12 is selected in production test to compensate for parameter changes due to lead lengths and dressing of the cable harness.

Be sure and update the Table of Replaceable parts in the Operating and Service Manual.

LV/tj/wo 1/68-6

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SERVICE NOTE

SUPERSEDES:

HP MODEL 2401C-M31

LOCK-UP ON ONE RANGE

Serial Number 751-02187 and below

When operated at ambient temperatures above 50°C, the HP 2401C-M31 autorange circuit tends to lock-up on one range. This problem has been traced to transistors A10Q1 and A10Q2 on the Auto-range Rate Detector Assembly A10 (HP Stk. No. 5060-5878). Typically, these transistors have a lower beta and frequency response than this circuit requires.

To correct this problem, make the following changes on A10: remove Q1 and Q2 (HP Stock No. 1850-0048) and replace them with two HP Stk. No. 1850-0184 transistors. Change the Table of Replaceable Parts to reflect this modification.

Calibration of the Auto-range Rate Detector circuit is required after this change. To calibrate this circuit, use the procedures given in the HP2401C Operating and Service Manual (page M31-10, table 31.2, performance check M31.1).

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FW/ep/wa

10/68-6

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SERVICE NOTE

SUPERSEDES:

HP 2401C
INTEGRATING DIGITAL VOLTMETER

NEGATIVE CHANNEL BOARD FAILURE
Serial Number 811-2568 and below

PROBLEM DESCRIPTION

When operating the 2401C IDVM in a data acquisition system with a scanner such as the 2901A Input Scanner or 2911 Crossbar Switch, switching transients may destroy transistor Q6 on the Negative Channel Board (A32). This problem has occurred when switching +750V through the scanner to the voltmeter.

PROBLEM SOLUTION

Replace transistor Q6 with a direct replacement having a higher breakdown voltage.

PROCEDURE

1. Remove A32 Negative Channel Board (Stock No. 5060-5001).
2. Remove transistor Q6 from Channel Board (Stock No. 1851-0031).
3. Install transistor Q6 (Stock No. 1851-0034).
4. Install A32 in 2401C IDVM.
5. Correct the Table of Replaceable Parts to reflect this change.
6. No adjustment or calibration of the instrument is necessary.

This change is incorporated in voltmeters with serial numbers 811-2569 and above.

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6/69-6

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SERVICE NOTE

SUPERSEDES:

HP 2401C
INTEGRATING DIGITAL VOLTMETER

NEGATIVE CHANNEL BOARD FAILURE
Serial Number 811-2568 and below

PROBLEM DESCRIPTION

When operating the 2401C IDVM in a data acquisition system with a scanner such as the 2901A Input Scanner or 2911 Crossbar Switch, switching transients may destroy transistor Q6 on the Negative Channel Board (A32). This problem has occurred when switching +750V through the scanner to the voltmeter.

PROBLEM SOLUTION

Replace transistor Q6 with a direct replacement having a higher breakdown voltage.

PROCEDURE

1. Remove A32 Negative Channel Board (Stock No. 5060-5001).
2. Remove transistor Q6 from Channel Board (Stock No. 1851-0031).
3. Install transistor Q6 (Stock No. 1851-0034).
4. Install A32 in 2401C IDVM.
5. Correct the Table of Replaceable Parts to reflect this change.
6. No adjustment or calibration of the instrument is necessary.

This change is incorporated in voltmeters with serial numbers 811-2569 and above.

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6/69-6

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S E R V I C E N O T E

SUPERSEDES:

None

HP MODEL 2401C-M31 DIGITAL VOLTMETER
Serial Numbers 1020A-02897 and Below

RECOMMENDED TRANSISTOR REPLACEMENT
A44Q5

Hewlett-Packard Part Number 1854-0071 is the recommended replacement for transistor A44Q5 (HP Part Number 1851-0034). The new transistor has greater reliability but is recommended for replacement only if failure occurs.

Instruments with serial numbers 1020A-02898 and above, have the 1854-0071 installed during manufacture.

Correct the Replaceable Parts List in your Operating and Service Manual.

DH/ep/WO

10/70-6

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MANUAL

CHANGES

HEWLETT hp PACKARD

INTEGRATING DIGITAL VOLTMETER

model 2401C

MANUAL UPDATING SUPPLEMENT 24 MARCH 1971

MANUAL PRINTED: June 1969

MANUAL PART NUMBER: 02401-9028

SERIAL NUMBERS COVERED: Serial numbers prefixed 501- through 811-

SUPPLEMENT DESCRIPTION: The purpose of this supplement is to correct manual errors, to describe differences between the instrument described in the manual and the instrument furnished, and to provide additional operating and service information, as required.

ITEM

DESCRIPTION

1 Serial numbers prefixed 1020A (Product Safety Improvements).

Starting with instruments having serial numbers prefixed 1020A, electrical parts changes were made to ac power input circuits as follows:

Page 1-8, ACCESSORIES FURNISHED, item 1. Change to read:

"1. Power Cord, Length 7-1/2 feet, plugs into rear connector. Stock No. 8120-1348."

Page 2-1, Paragraph 2.1.1. The line set switch now bears the nomenclature SELECTOR switch.

Page 2-4, Paragraph 2.4.1, last item. Change to read:

"POWER switch and ~ LINE (ac line) fuse: Controls ac power to the voltmeter. Legend 115V 2 AT prescribes 2-ampere fuse with normal time lag (slow-blow) for 115-volt operation and legend 230V 1 AT prescribes 1-ampere fuse with normal time lag for 230-volt operation."

Page 2-5, Paragraph 2.4.2, last item. Change to read:

"SELECTOR switch and ~ LINE receptacle. Switch sets the instrument for operation from 115 or 230 line voltage. Legend for ~ LINE receptacle includes operating line voltage and tolerance (115/230V ± 10%), line frequency range (48-66 ~), and maximum power consumption (150 VA MAX.)."

Page 4-87, Figure 4-34, sheet 3 of 3. In lower center of figure change LINE SET S11 switch to SELECTOR S11 switch.

Page 5-43, Table 5-1. Change part numbers and descriptions as follows:

Ref. Des.	Part No.	Description
F1	2110-0303	Fuse: Cartridge 2A, 250V, Slow-Blow
F2	2110-0312	Fuse: Cartridge 1A, 250V, Slow-Blow
FL1	9100-3115	Filter, Line, 6A
S7	3101-0030	Switch: Toggle SPST, 15A, 125VAC
S10	3101-0030	Switch: Toggle, SPST, 15A, 125VAC
S11	3101-1234	Switch: Slide, DPDT

Pages 5-54 and 5-55. Delete entire listing for 2110-0006, 2110-0007, 3101-0001, 3101-0033, and 9100-2477. Add new listings as follows:

Part No.	Description	Mfr	Mfr Part
2110-0303	Fuse: Cartridge 2A	71400	MDX-2A
2110-0312	Fuse: Cartridge 1A	71400	MDL-1A
3101-0030	Switch: Toggle, SPST	88140	8906K368
3101-1234	Switch: Slide, DPDT	82389	11A-1242
9100-3115	Filter: Line		

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