DEPARTMENT OF THE ARMY TECHNICAL MANUAL

OPERATOR

ORGANIZATIONAL, DS, GS

AND DEPOT MAINTENANCE MANUAL

INCLUDING

REPAIR PARTS AND SPECIAL TOOL LISTS

FREQUENCY METERS

AN/USM-26 AND AN/USM-26A

This copy is a reprint which includes current pages from Changes 1.

HEADQUARTERS, DEPARTMENT OF THE ARMY

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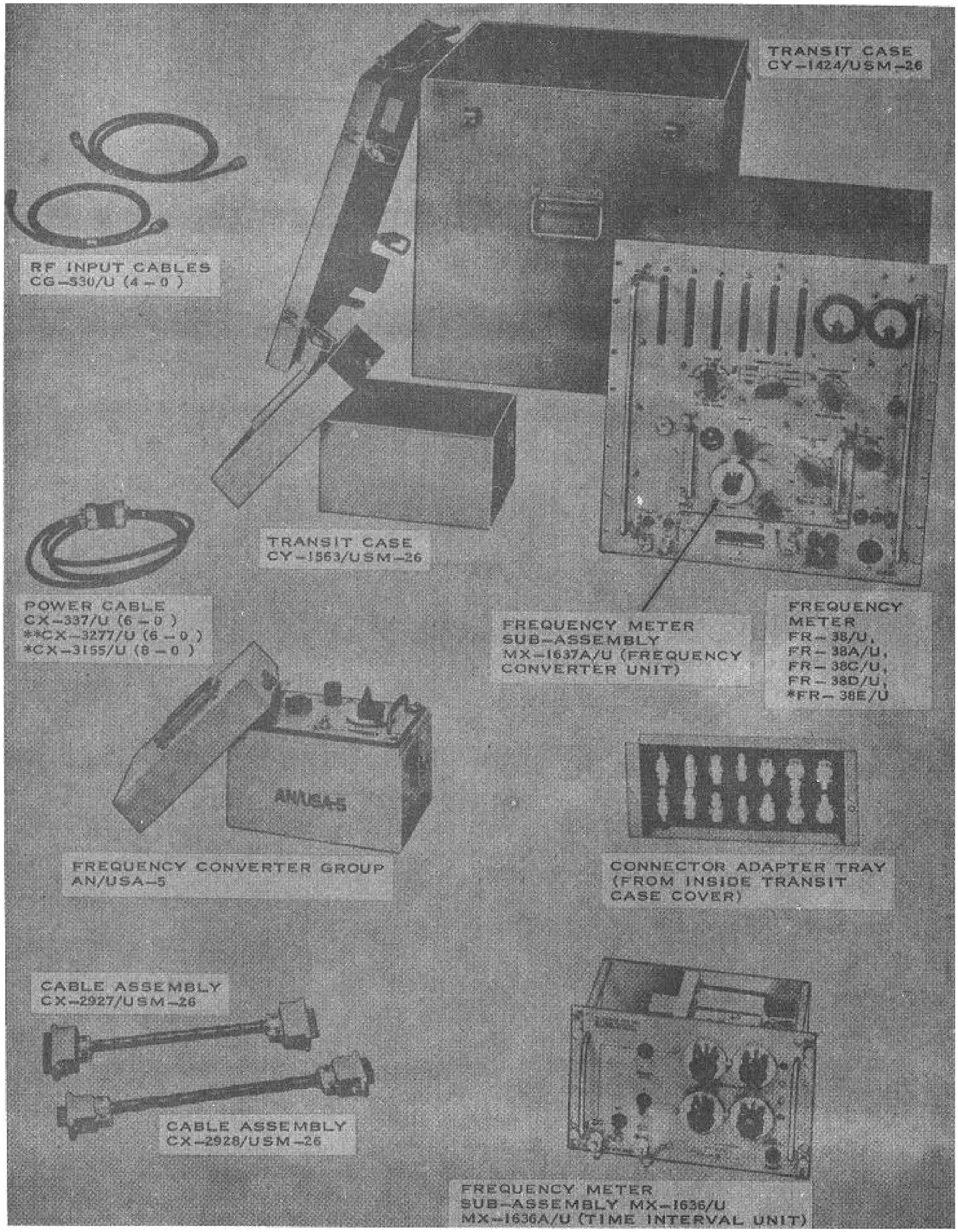
NOTE

This publication also covers Frequency Meter FR-38C/U and FR-38D/U as manufactured by Northeastern Engineering, Inc., Manchester, New Hampshire. All references to FR-38/U also apply to FR-38C/U and FR-38D/U except where differences are noted in the text.

Frequency Meter FR-38C/U and FR-38D/U may be used with a special frequency converter (not supplied) to extend the frequency range to 220 megacycles.

This publication also covers Frequency Meter AN/USM-26A and its main components; Frequency Meter FR-38E/U, Frequency Meter Subassembly MX-1636A/U and Frequency Meter Subassembly MX-1637A/U as manufactured by Crescent Communications Corp., New London, Connecticut. All references to FR-38/U, MX-1636/U and MX-1367/U apply to FR-38E/U, MX-1636A/U and MX-1637A/u except where differences are noted in the text.

Frequency Meter FR-38E/U may be used with a special frequency converter (not supplied) to extend the frequency range to 510 megacycles.



** Used in FR-38D/U

* Used in AN/USM-26A

Figure 1-1. Frequency Meter AN/Usm-26 and Frequency Converter Group AN/USA-5, Equipment Supplied.

SECTION I
INTRODUCTION

1-A.1. SCOPE.

a. This manual describes the general use and application, basic operating principles, installation, and detailed operating and repair procedures for Frequency Meters AN/USM-26 and AN/USM-26A and Frequency Converter Group AN/USA-5.

b. The basic issue items list appears in appendix B, the maintenance allocation chart appears in appendix C, and the repair parts and special tool lists appears in appendix D.

NOTE

Appendixes C, and D are current as of 31 March 1969. Appendixes B is current as of 11 June 1973.

1-1. INDEXES OF PUBLICATIONS.

a. DA Pam 310-4. Refer to the latest issue of DA Pam :3104 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

b. DA Pam 310-7. Refer to DA Pam 310-7 to determine whether there are modification work orders (MWO's) pertaining to the equipment.

1-2. FORMS AND RECORDS.

a. Reports of Maintenance and Unsatisfactory Equipment. Maintenance forms, records, and reports which are to be used by maintenance personnel at all maintenance levels are listed in and prescribed by TM 38-750.

b. Report of Packaging and Handling Deficiencies. Fill out and forward DD Form 6 (Report of Packaging and Handling Deficiencies) as prescribed in AR 700-58/NAVSUP PUB 378/AFR 71-4/MCO P4030.29, and DSAR 4145.8.

c. Discrepancy in Shipment report (DISREP) (SF .161). Fill out and forward Discrepancy in Shipment Report (DISREP)(SF:361) as prescribed in AR55-38/NAVSUPINST 4610.33/AFM 75-18/MCO P4610.19A and DSAR 4500.15.

1-2.1. REPORTING OF ERRORS.

The reporting of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 20,28 (Recommended Changes to Publications and Blank Forms) and forwarded direct to Commander, US Army Electronics Command, ATTN: AMSEL-MA-C, Fort Monmouth, NJ 0770:3.

1-3. PURPOSE OF EQUIPMENT.

1-4. Frequency Meter AN/USM-26 is a precision instrument that automatically measures frequencies to 100 megacycles and automatically displays its answers in digital form on an eight-place panel indicating system. Frequency Converter Group AN/USA-5 extends the frequency range to 220 megacycles. In addition to making direct measurements of frequency, Frequency Meter AN/USM-26 also measures period (time of one cycle of periodic wave), time intervals, frequency ratios and total events, and may be used to count random events such as those encountered in nuclear work. Table 1-1 summarizes the measurements that can be made with the equipment. The equipment further includes a self-check feature that enables the operator to verify the proper operation of the equipment for most types of measurements.

Table 1-1. Measurements Made by Frequency Meter AN/USM-26

1.	FREQUENCY	10 cps to 220 megacycles. The frequency can be regular, as with electrical frequencies, or random, as with nuclear particles, Maximum pulse resolution is 0.1 microsecond for double pulses, 0.2 microsecond for triple pulses.
2.	PERIOD	100 microseconds to 100 seconds (0.01 cps to 10 kc). A panel switch also permits measuring the average of 10 periods to obtain greater accuracy.
3.	TIME INTERVAL	1.0 microsecond to 10,000,000 seconds. An adjustable 'threshold" feature permits starting and stopping the measurement with signals of predetermined amplitude and polarity.
4.	TOTAL EVENTS	1 to 100,000,000 events. Maximum pulse resolution of 0.1 microsecond when the unit is used as a high speed scaler and totalizer.
5.	TIME OR FREQUENCY RATIOS	100,000,000: 1 maximum. The lower of the two frequencies can be as high as 10 kc; the higher can be as much as 10 mc.

1-5. Because of the accuracy with which it measures frequencies, the AN/USM-26 equipment can be considered to be a new type of secondary frequency standard that replaces more elaborate installations of conventional precision frequency-measuring equipment. For example, the meter has been found particularly useful for frequency measurements in quartz crystal grinding work as well as for general laboratory-quality frequency measurements. Other typical frequency-measurement applications for the equipment include calibration of transmitters, oscillators, signal generators, etc.

1-6. In combination with tachometer generators or other suitable transducers, the equipment can be used to make precision tachometry measurements. In tachometry work it is particularly useful for measuring high speed devices.

1-7. Time measurements that the equipment will make include pulse length, pulse interval, time delay, etc.

1-8. Since the indicating system in the equipment presents the measured frequency in up to 8 significant figures, the equipment is especially useful for measuring very small frequency changes, such as are encountered when making measurements for frequency stability of oscillators and similar frequency generators.

1-9. ITEMS COMPRISING AN OPERABLE EQUIPMENT.

1-10. THE ITEMS COMPOSING AN OPERABLE FREQUENCY METER.
AN/USM-26 is shown in Figure 1-1 and listed in Table 1-2. The main components of the Frequency Meter AN/USM-26 are shown in Figures 1-2, 1-3, and 14. Figure 1-2 shows the Frequency Meter FR-38/U, the actual frequency-measuring component Figures 1-3 and 14 show the plug-in units: Frequency Meter Subassembly MX-1637/U and Frequency Meter Subassembly MX-1636/U, respectively. These plug-in units are commonly referred to by names descriptive of the functions performed by each, i.e., Frequency Converter Unit (MX-1637/U) and Time Interval Unit (MX-1636/U) and these names will be used hereafter in this manual. A later model of the FR-38/U manufactured by the Hewlett-Packard Company is called the FR-38A/U. The operating instructions given for the FR-38/U in this manual also apply to the FR-38A/U Frequency Meter. The differences between the FR-38/U and the FR-38A/U are solely in the internal components and do not affect the operating instructions given in this manual. The AN/USA-5 is described in paragraph 1-46.

Table 1-2. Items Comprising an Operable Equipment

FSN	*Qty*	*Nomenclature*	*Usable on code*	*Overall Dimensions (in.)* Length	Width	Depth	*Weight (lbs)*
6625-543-1356		Frequency Meters AN/USM-26 and AN[USM-26A: consisting of: NOTE Number 1 in the usable on code column refers to items comprising an operable AN/USM-26; number 2 refers to items comprising an operable AN/USM-26A					
5935-201-300	2	Adapter, Connector, Electrical UG-201A/U:	1,2	15/16 5/32.1			
5935-149-3914	2	Adapter, Connector, Electrical UG-255/U:	1,2	1 11/32	5/8		0.1
5935-149-3534	2	Adapter, Connector, Electrical UG-273A/U:	1,2	15/16	23/32		0.1
5935-552-7112	2	Adapter, Connector, Electrical UG-282A/U:	1,	2 1/8	5/8		0.1
5935-201-3091	2	Adapter, Connector, Electrical UG-394A/U:	1,2	1 9/16	19/32		0.1
5935-280-1454	2	Adapter, Connector, Electrical UG-914/U:	1,2	1 9/32	7/16		0.03
5935-204-5098	2	Adapter, Connector, Electrical UG-1034A/U:	1,2	1 1/2	25/32		0.1
6625-557-8771	1	Cable Assembly, Power, Electrical CX-337/U (6 ft) p/o FR-38A, C/U:	1	72			0.6
6625-681-6497	1	Cable Assembly, Power, Electrical CX-3277/U (6 ft) p/o FR-38D/U:	1				0.2
5995-167-7473	1	Cable Assembly, Power, Electrical CX-3155/U (8 ft)	2				
5995-9268330	2	Cable Assembly, Radio Frequency CG-530D/U (4 ft 6 in.)	1,2	48			
6625-605-7191	1	Cable Assembly, Special Purpose, Electrical CX-2927/USM-26:	1,2	13 1/2			0.4
6625-605-7190	1	Cable Assembly, Special Purpose, Electrical CX-2928USM-2):	1,2	13 1/2			0.3
6625-605-7189	1	Frequency Meter FR-38A,C,D,E/U:	1,2	19 7/32	19	18 5/8	109
6625-964-7441	1	Frequency Meter Subassembly MX-1636A/U:	1,2	6 3/8	10	6 1/8	5
6625-553-4006	1	Frequency Meter Subassembly MX-1637A/U:	1,2	6 3/8	10	6 1/8	4

1-11. All components of this equipment except the Time Interval front panel plug-in unit are housed in the large transit case CY-1424/USM-26. The Time Interval front panel plug-in unit is housed in the smaller transit case CY-156/USM-26.

1-12. EQUIPMENT REQUIRED BUT NOT SUPPLIED.

1-13. No equipment is required which is not supplied.

1-14. GENERAL ELECTRICAL CHARACTERISTICS

1-15. The actual frequency-measuring component of the AN/USM-26 equipment is Frequency Meter FR-38/U. This instrument measures frequencies from 10 cycles to 10 megacycles per second as well as the period (1/f) of frequencies from 0.01 cps to 10 kilocycles per second. To extend the range of its measurements, however, the FR-38/U Frequency Meter is designed for use with either of two front panel plug-in units which are part of the equipment supplied.

1-16. The first plug-in unit, the Frequency Converter Unit shown in figure 13, extends the upper measurable frequency from 10 megacycles to 100 megacycles. The second plug-in unit, the Time Interval Unit, shown in figure 14, permits measurements of time intervals between two electrical events or between physical events that can be converted into electrical pulses. Time intervals as short as 1 microsecond or as long as 10,000,000 seconds can be measured.

1-17. The accuracy of the FR /U when measuring frequencies between 10 cycles and 10 megacycles is ±0.0002% ±0.1 cps for an input signal of 0.2 volt rms or more. When using the Frequency Converter plug-in unit, frequencies to 100 megacycles are measured with the same accuracy. The voltage sensitivity of the equipment in the 10 to 100 megacycle range is increased by the video amplifier of the Converter unit to 0.02-volt rms.

1-18. The accuracy of the FR 38/U when measuring the period of sine wave frequencies up to 10 kilocycles is ±0.03% for input signals of 1-volt rms. Greater accuracy can be achieved for period measurements when higher signal voltages are used.

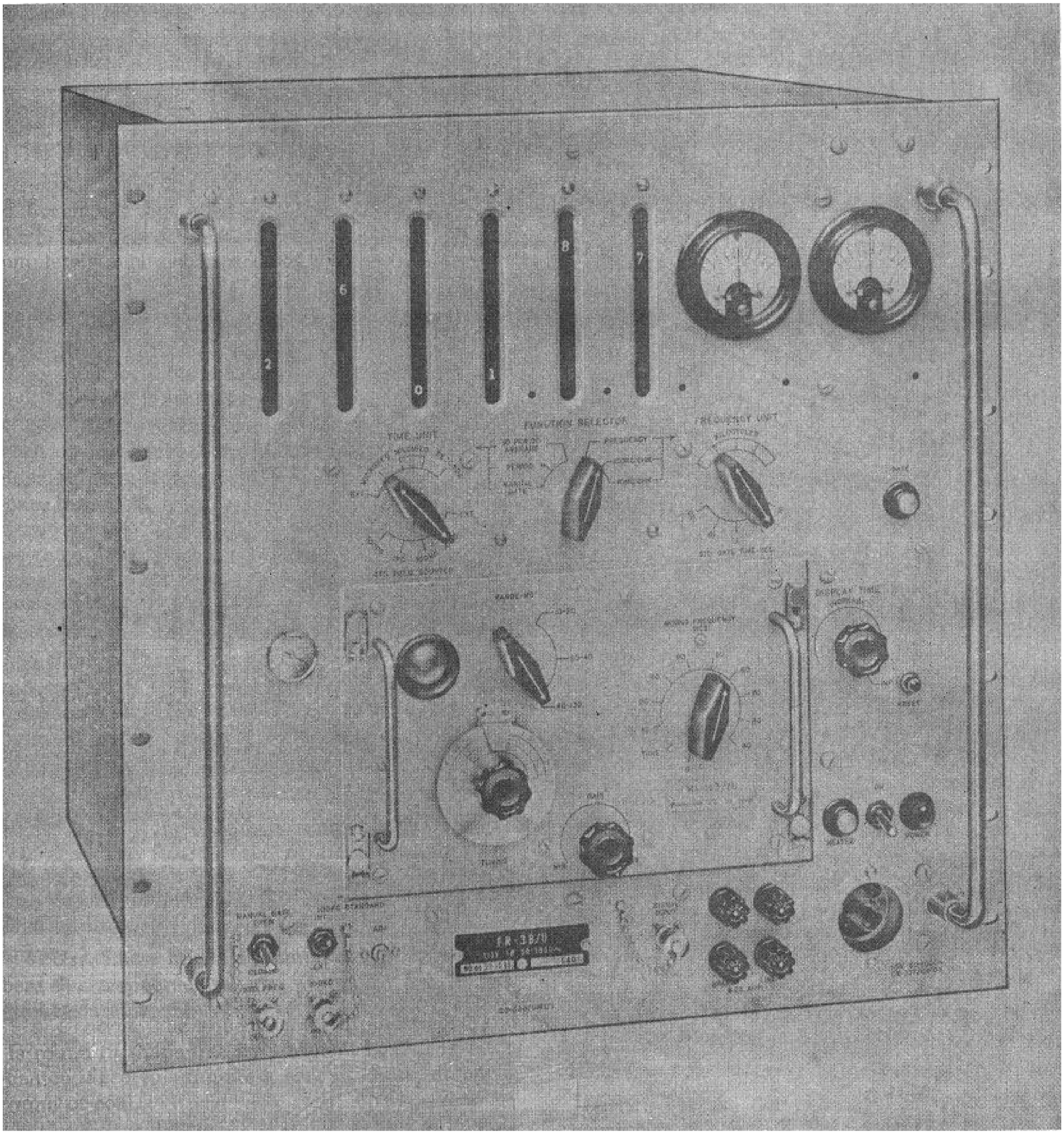


Figure 1-2. Frequency Meter FR-38/U

1-19. The Time Interval plug-in unit enables the instrument to measure time intervals from 1 microsecond to 10,000,000 seconds. These measurements are accurate within ±0.0002% ±0.1 microsecond, provided the rise times of the start and stop signals are negligible compared to the interval being measured.

1-20. A threshold feature is designed into the instrument to simplify measurements of time intervals. This feature permits measurements to be started and

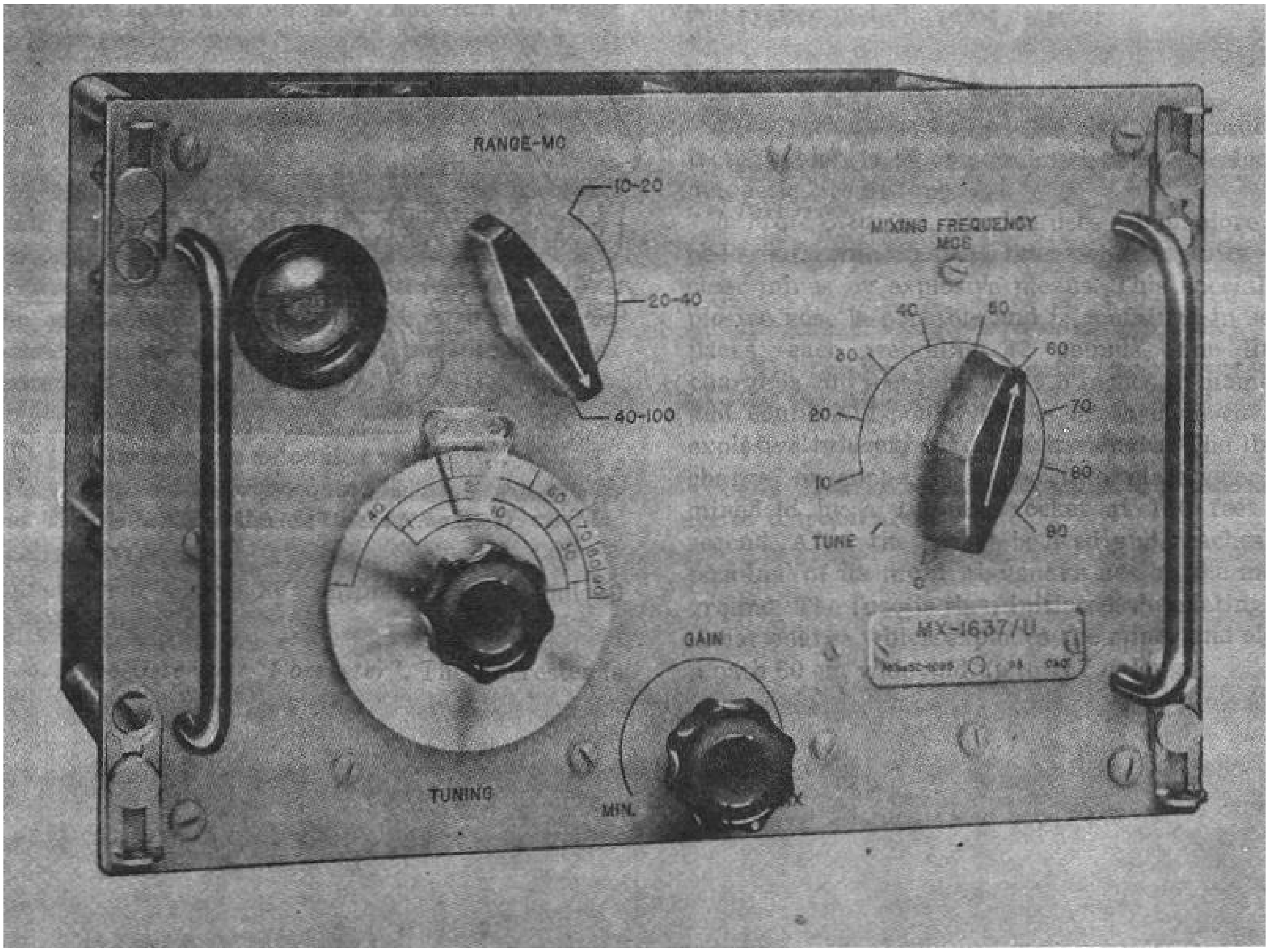


Figure 1-3. Frequency Meter Subassembly MX-1637/U (Frequency Converter Unit)

stopped, independently, from either positive-going or negative-going signals. In addition, the voltage levels at which the measurement is started and stopped are independently adjustable from -200 to +200 volts. This arrangement permits nearly any type of signal to be used for starting or stopping the measurements and also permits measurements to be made from one part of a waveform to another part of the same waveform.

1-21. The complete specifications for the equipment are set out in Table 1-3.

1-22. BASIC OPERATING PRINCIPLES.

1-23. Frequency Meter FR-38/U uses a new type of frequency-measuring circuit known as a frequency counter. Figure 1-5 shows the basic circuit arrangement. The frequency to be measured is passed from the input terminal to an electronic gate whose opening and closing is controlled by a precision time base generator. When the gate is open, the frequency to be measured is applied to a series of digital type counter circuits. When the gate is closed, the counters visually display the total number of cycles applied while the gate was open. Since the precision time base generator holds the gate open for an accurately-known interval of time, the displayed count has the dimension of frequency, i.e., total number of cycles divided by time. Although the displayed value could be given directly in cycles per second, the illuminated decimal point in the FR-38/U is arranged so that the display is directly in kilocycles.

1-24. To measure period and time intervals, the FR38/U uses a variation of the arrangement it uses for measuring frequency. Referring to the dashed lines in Figure 1-5, the frequency whose period is to be measured is used to open and close the gate, while one of the frequencies generated by the time base generator is applied to the gate input. The arrangement is such that the gate is opened by one cycle of the frequency to be measured and closed by the succeeding cycle. The counters thus indicate the number of cycles of the time base generator that occur during one period of the frequency to be measured. The frequencies obtained from the time base generator have been selected so that the measured periods will be displayed in direct-reading units of time, i.e., seconds, milliseconds, or microseconds.

1-25. Provision is also made in the circuit so that a measurement can be made of the average of 10 periods

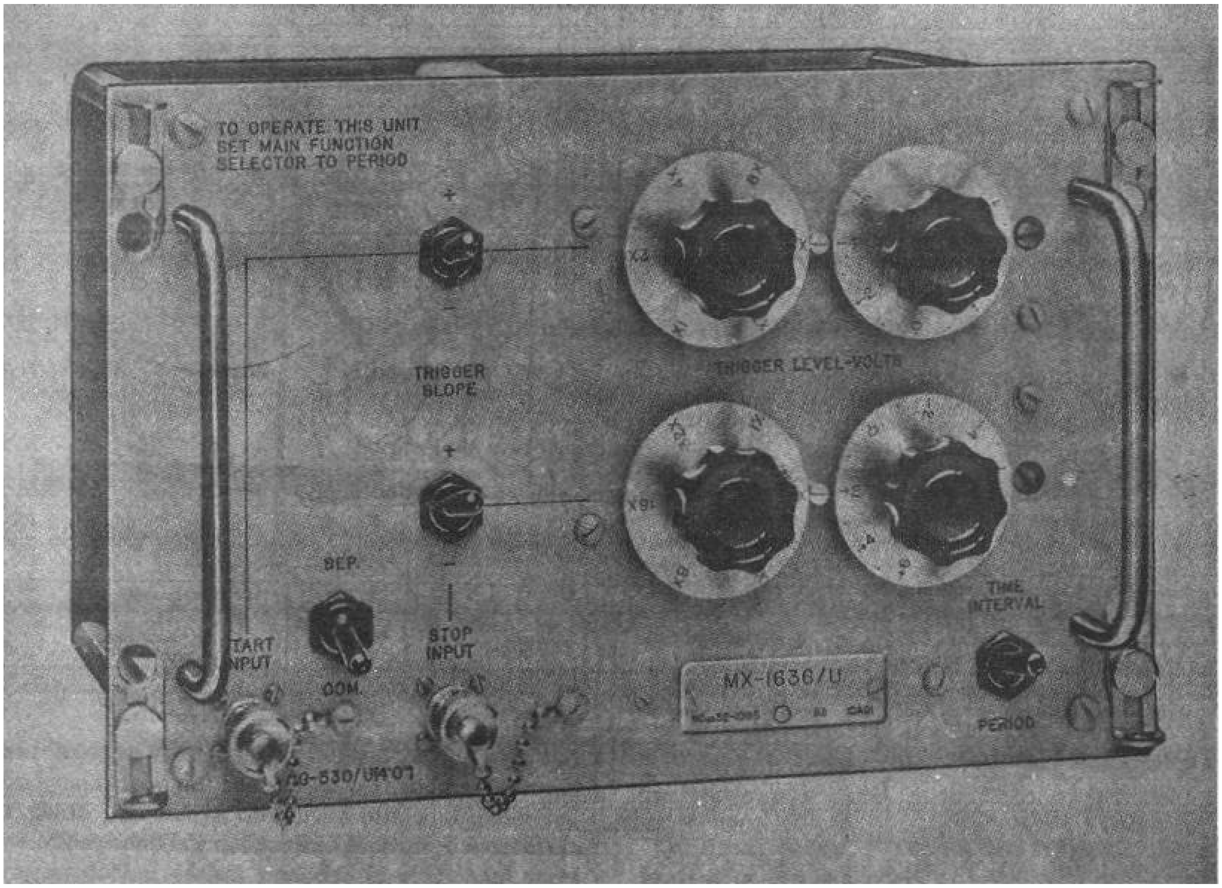


Figure 1-4. Frequency Meter Subassembly MX-1636/U (Time Interval Unit)

of the unknown frequency. This arrangement is useful when measuring shorter periods so that higher accuracy can be obtained in the measurement.

1-26. Time intervals are measured by an arrangement similar to period measurements, except that suitable circuitry is included in the instrument so that the voltage threshold and slope for the measurements can be selected.

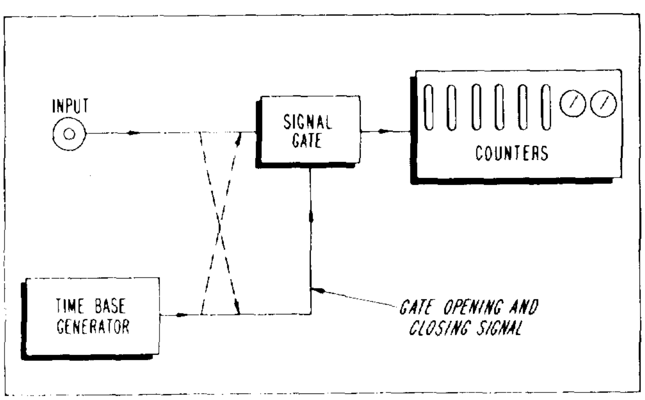


Figure 1-5. Basic Circuit Diagram, Frequency Meter FR-38/U

1-27. MEASUREMENT DISPLAY SYSTEM.

1-28. When a measurement has been made, the answer is automatically displayed in digital form across the front panel on the display system shown in Figure 1-6.
The "units" digit and the " tens" digit are indicated by two adjacent meters on the right-hand side of the panel; the remaining six places, 100 through 10,000,000 digits, are indicated by illuminated numerals in the six columns to the left of the meters. For example, for the reading shown in Figure 1-6, the measured value would be 9,257.437 kilocycles if frequency were being measured.

1-29. As a part of the display system, an illuminated decimal point is automatically located for each type of measurement, regardless of the gate time being used or standard frequency counted. This decimal point minimizes the possibility of an incorrect interpretation of the displayed value.

1-30. When a measurement has been made, the answer remains displayed for a time chosen by the operator. This display time may be adjusted from 0.3 seconds to 5 seconds or to continuous display (infinite time) by a display time control on the front panel.

Table 1-3. Specifications for FREQUENCY METER AN/USM-26

	FREQUENCY MEASUREMENT
Range:	10 cps to 100 Mc (direct reading).
Accuracy:	±1 count ±0.0002%* (±0.1 cps ±0.0002% on 10-second gate).
Input Requirements:	0.2 v rms to 10 Mc; 0.02 v rms 10 Mc to 100 Mc. 1 v rms using Time Interval Unit.
Input Impedance:	0-10 Mc: approx. 1 megohm shunted by 40 μμf; 10-100 Mc: approx. 50 ohms.
Gate Time:	.001, .01, 0.1, 1, or 10 sec.; selected by panel control.
Display Time:	Continuously variable from 0.3 to 5 seconds by a panel control. In manual operation, display continues until reset.
	PERIOD MEASUREMENT
Range:	0.01 cps to 10 kc (100 μsec).
Accuracy:	±0.03%
Input Requirements:	1 v rms, minimum; 200 v rms, maximum.
Input Impedance:	Approximately 1 megohm shunted by 40 μμf.
Gate Time:	Counts for 1 or 10 cycles of input signal as desired.
Units of Measurement:	0.1 μsec, 0.01 millisecond, 1 millisecond, or 0.1 second.
Display Time:	Same as for Frequency Measurement.
	TIME INTERVAL MEASUREMENT
Range:	1.0 microsecond to 10,000,000 seconds.
Accuracy:	±0.1 microsecond ±0.0002%,*.
Input Requirements:	2 v peak minimum; 200 v peak maximum.
Input Impedance:	Approx. 1 megohm shunted by 20 - 40 μμf (each channel).
Independent Start and Stop Channels:	Triggers from either positive-going or negative-going input voltages at levels from -200 to +200 volts. Separate or common direct-coupled inputs.
Display Time:	Same as for Frequency Measurement.

*Internal Standard
The accuracy figure of 0.0002% is due to the internal crystal oscillator, which has a long time stability of within two parts/million/week. Short time stability is within one part/million. A panel connector permits use of an external 100 kc primary standard signal to obtain higher accuracy.

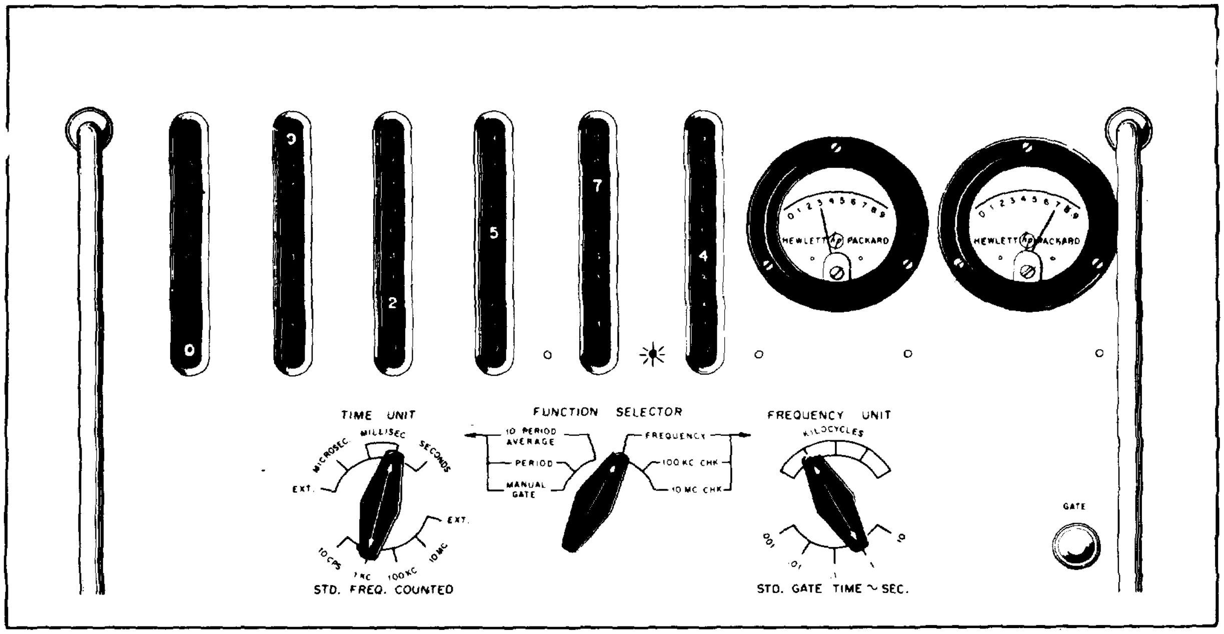


Figure 1-6. Measurement Display System

When repetitive measurements are made (the usual condition with frequency measurement), a new answer is automatically obtained and displayed when the selected display time of a previous answer is ended.

If a single measurement is made (a typical case in time interval measurement), the answer to the measurement can remain displayed indefinitely or until the next measurement is made.

1-31. GENERAL DESCRIPTION.

1-32. Physically, Frequency Meter FR-38/U with one plug-in unit weighs approximately 114 pounds and is constructed for mounting in a standard 19-inch wide relay rack. The instrument is enclosed in an aluminum cabinet. The physical dimensions and mounting information for the units are shown in Figure 1-7.

Both the cabinet and the front panel are finished in a light, non-reflecting gray paint. Guard-rail type handles are provided to assist in handling and to protect the front panel controls.

1-33. The time base generator in the equipment includes a crystal-controlled, 100-kc, precision oscillator whose crystal is housed in a thermostatically-controlled oven. The oven temperature is indicated by a dial-type thermometer which is visible at the front panel. As long as the equipment is connected to a power source, the crystal temperature is controlled regardless of whether the power switch on the panel Is turned on or off. When the power switch Is off and the instrument remains connected to a power source, a white pilot lamp on the panel indicates that power is applied to the instrument. In addition, when the white pilot lamp is on, space heaters within the cabinet are energized to maintain the internal cabinet temperature a few degrees above the ambient temperature in order to minimize moisture condensation within the cabinet. When the power switch is turned on and the measuring circuits are energized, a red pilot lamp on the panel lights and the white lamp is turned off.

1-34. Forced ventilation for the cabinet is provided by a blower at the rear of the cabinet. The air drawn into the cabinet is filtered by a renewable air cleaner.

1-35. To reduce leakage of high frequency signals generated within the frequency meter, a metal gasket is placed in a milled slot in the front panel around the opening which receives the front panel plug-in unit.

The frequency meter also contains electrical noise filters to prevent noise from being conducted out of the instrument through the power cord.

1-36. Bar type knobs are used on selector switches to enhance ease of operation.

1-37. Tube replacement in many cases is possible from the front panel without removing the instrument from the cabinet or rack in which it is mounted. Removal of the front panel plug-in unit gives access to all electron tubes within the instrument with the exception of those in the counting units behind the slots in the front panel.

1-38. All input jacks are of the BNC type with protective caps and are located on the front panel. All fuses for the equipment are replaceable from the front panel and spare fuses are contained in two spare fuseholders also located on the front panel. Ten spare crystal diodes are located inside the Frequency Meter chassis, mounted on a clip-in type mounting board.

1-39. TRANSIT CASES.

1-40. Transit Cases CY-1424/USM-26 and CY-1563/ USM-26 are provided with Frequency Meter FR-38/U and are shown in Figure 1-8. These cases are designed to be water-tight and contain space and mounting provisions for the accessories and manuals

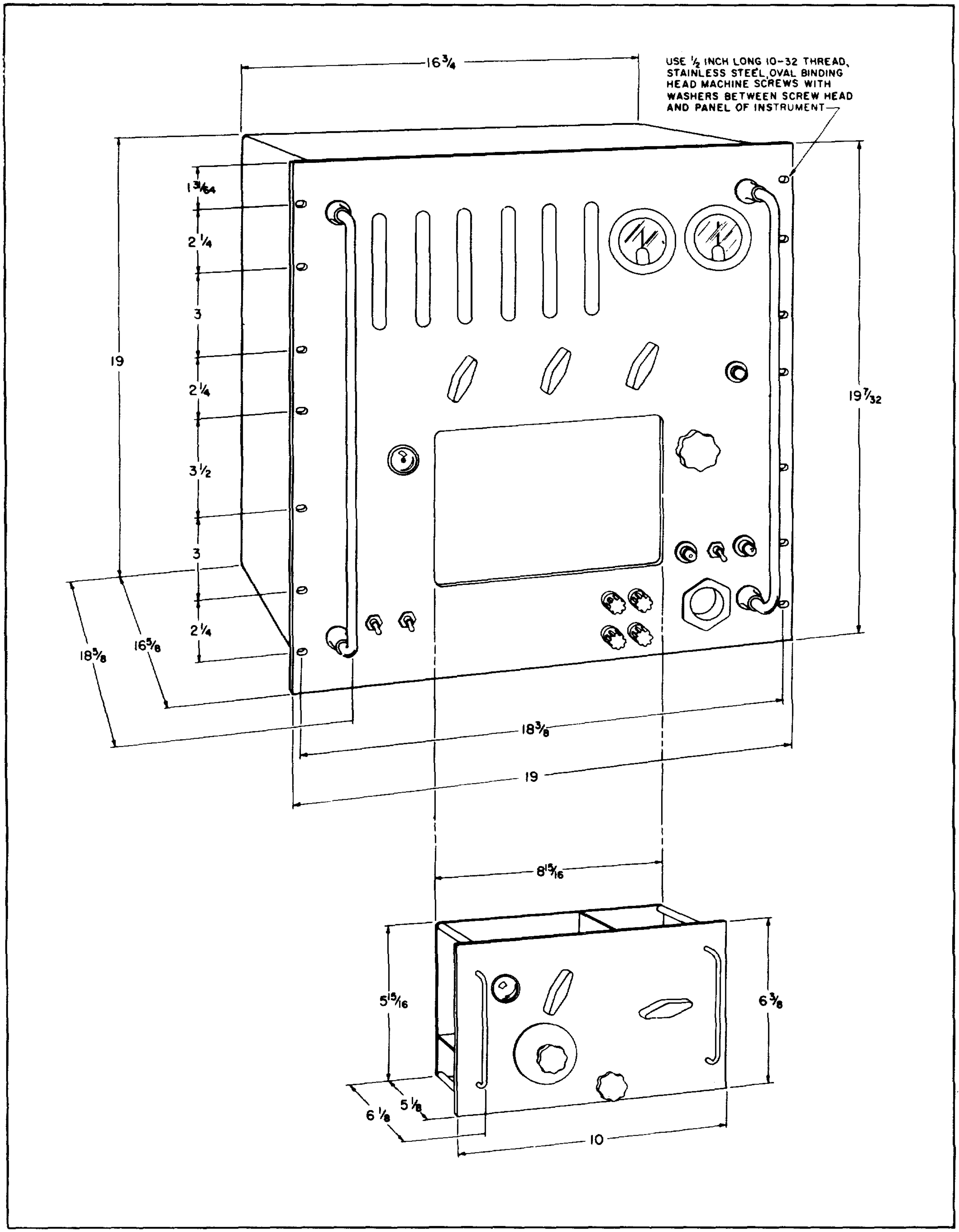


Figure 1-7. Dimensions of Frequency Meter FR-38/U and Plug-in Unit

which are supplied with the instrument (see Figure 1-9). Figure 1-10 shows the adapters as they are stowed in a tray in the main transit case.

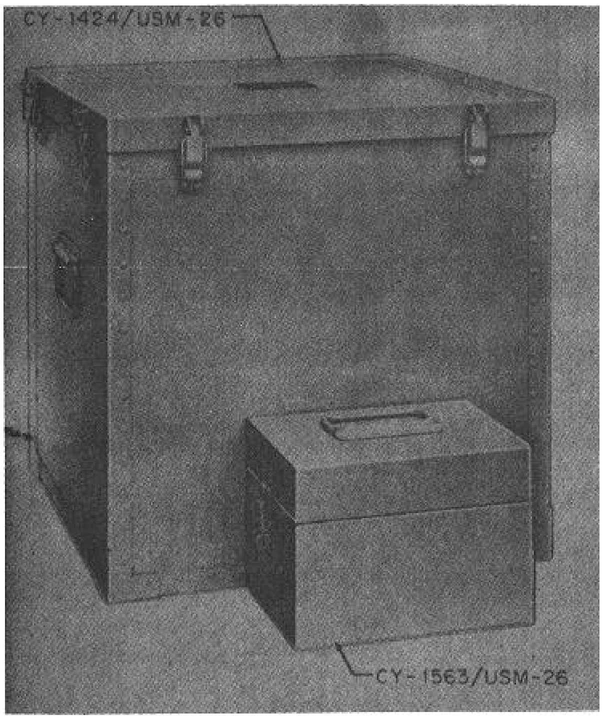


Figure 1-8. Transit Cases CY-1424/USM-26 and CY-1563/USM-26

1-41. The transit case is constructed of a special laminated material consisting of wood covered on each side with aluminum sheeting. The cover for the transit case is provided with a double lip which is filled with sponge rubber. The double lip effects a watertight seal when the cover for the case is closed. The cover is attached to the case by eight trunk-type latches.

1-42. ACCESSORIES.

1-43. The purpose of the various accessories provided with the equipment is described below.

a. Cord CG-530/U (4'0") is the signal input cable and consists of approximately four feet of RG-62/U cable with a UG-260/U plug on each end. Two such cords are supplied with the instrument.

b. Cord CX-337/U (6'0") is provided for connecting the power plug on the instrument to the a-c supply. The cord consists of approximately six feet of two conductor cable with a conventional power plug on one end and a motor body on the opposite end.

c. Cord CX-2927/USM-26 is a special purpose test cable, 13-1/2 inches long, with special 16-connector Amphenol type plugs on each end. The cable provides electrical connection for either plug-in unit when it is physically removed from the main instrument for test and adjustments.

d. Cord CX-2928/USM-26 is a special purpose test cable, 13-1/2 inches long, with special 8-connector Amphenol type plugs on each end. The cable provides electrical connection for either plug-in unit when it is physically removed from the main instrument for test and adjustments.

e. Adapter UG-201A/U is provided for adapting a type N male connector to a type BNC female connector. Two such adapters are provided with each instrument.

f. Adapter UG-255/U is provided for adapting a UHF female connector to a type BNC male connector. Two such adapters are provided with each instrument.

g. Adapter UG-273/U is provided for adapting a UHF male connector to a type BNC female connector. Two such adapters are provided with each instrument.

h. Adapter UG-282/U is provided for adapting the type BNC male connector to a common binding post. Two such adapters are provided with each instrument.

i. Adapter UG-349A/U is provided for adapting a type N female connector to a type BNC male connector. Two such adapters are provided with each instrument.

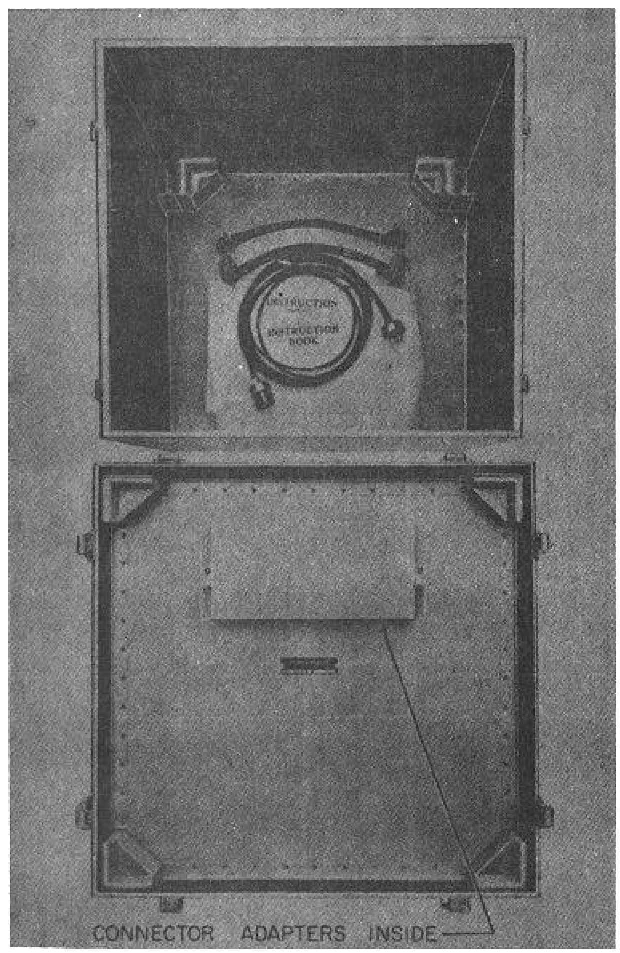


Figure 1-9. Cable and Accessory Storage in Transit Case CY-1424/USM-26

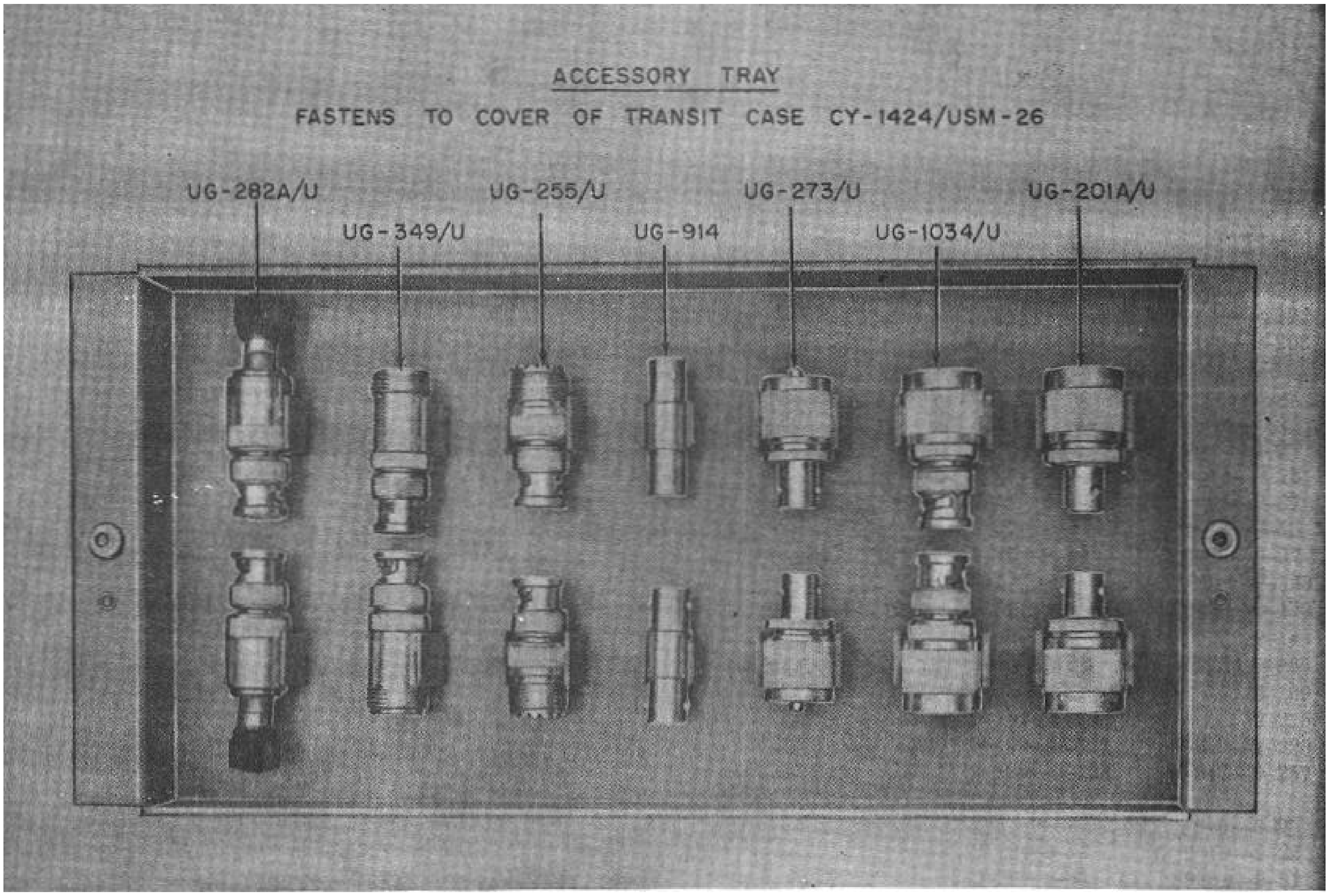


Figure 1-10. Accessory Tray Showing Connector Adapters

j. Adapter UG-914/U is a type BNC double female connectors together. Two such adapters are provided 6connector provided for connecting two BNC type male with each instrument.

Table 1-4. Tubes and Indicator Lamps

JAN or NAVY TYPE	QUANTITY	JAN or NAVY TYPE	QUANTITY
OB2WA	1	5725/6AS6W	9
5Y3WGTA	1	5727/2D21W	2
5R4WGA	3	5726/6AL5W	3
6AH6	11 (12*)	5844	1
6AU6WA	7 (5*)	5963	40
6CB6	5 (6*)	6005/6AQ5W	2
6E5	1	6080WA	2
12AT7WA	3	Mazda 47 (lamp)	8
5654/6AK5W	6	G-11A Crystal diodes	63
5687	1	Spare G-1 1A Crystal diodes	10
		Diodes rNI16, CK705, and 1910-0011 (used interchangeably)	66**

*For FR-38A/U, FR-38C/U, and FR-38D/U
**Used in place of G-11A diodes on FR-38A/U

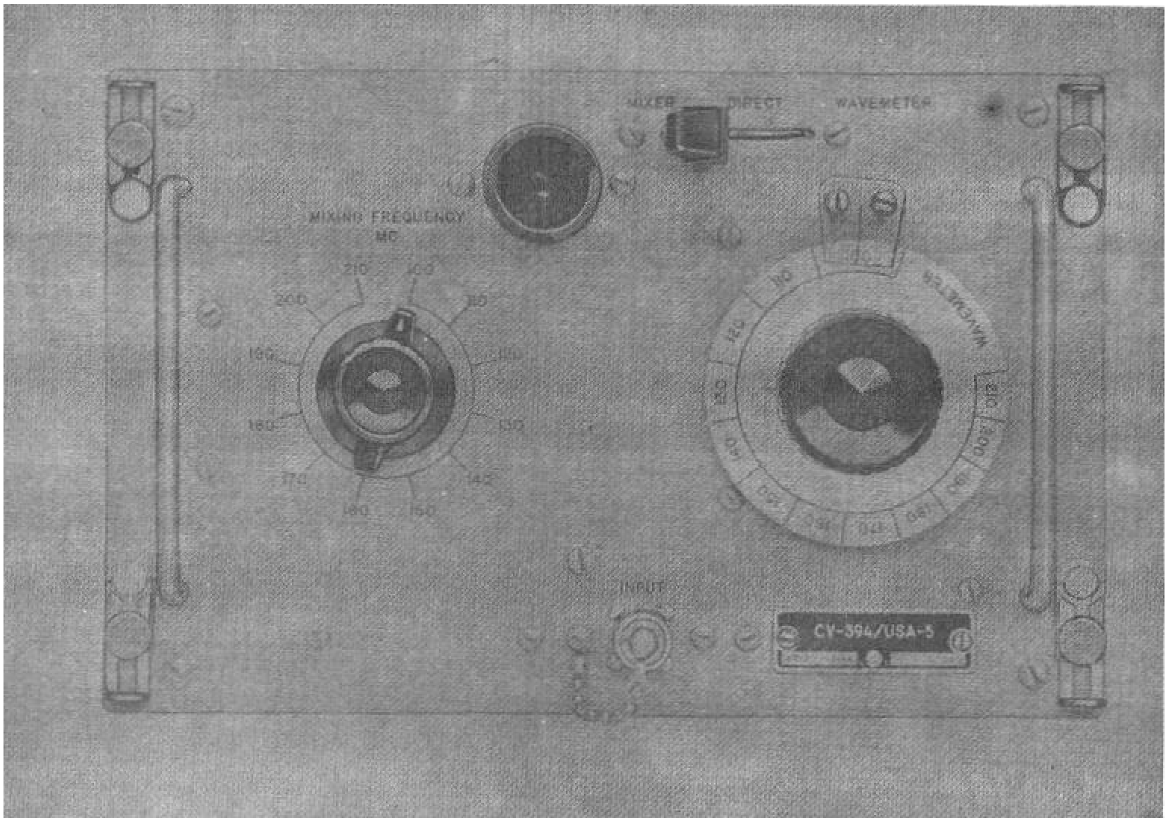


Figure 1-11. Frequency Converter CV-394/USA-5

k. Adapter CG-1034/U is provided for adapting a type N male connector to a type BNC male connector. Two such adapters are provided with each instrument.

1-44. QUANTITY AND TYPES OF TUBES AND LAMPS.

1-45. The vacuum tubes and lamps used in Frequency Meter FR-38/U are listed in Table 1-4 together with the quantities used of each.

1-46. GENERAL DESCRIPTION OF FREQUENCY CONVERTER GROUP AN, USA-5.

1-47. PURPOSE. Frequency Converter Group AN/USA-5 is designed to extend the counting range of the AN/USM-26 to include frequencies from 100 to220megacycles. The accuracy of measurement when the AN/USA-5 is used is the same as that of the AN/USM-26, because the AN/USA-5 derives its mixing frequencies from the 100-kc standard in the AN/USM-26.

1-48. EQUIPMENT SUPPLIED. Frequency Converter Group AN/USA-5 consists of a plug-in Electronic Frequency Converter CV-394/USA-5 and a Transit Case CY-1563/USM-26. The plug-in frequency converter is similar to the MX-1637/U and fits into the front of Frequency Meter FR-38/U. The two components of the AN/USA-5 are shown in Figure 1-1. Electronic Frequency Converter CV-394/USA-5 is shown in Figure 1-11, and the transit case is shown in Figure 1-8. For convenience and clarity, the frequency converter portion of the AN/USA-5 will hereafter be referred to as Frequency Converter CV-394/USA-5.

1-49. GENERAL ELECTRICAL CHARACTERISTICS. Electrical characteristics of Frequency Converter CV-394/USA-5 are given in Table 1-5.

1-50. BASIC OPERATING PRINCIPLES. Frequency Converter CV-394/USA-5 is provided with a wavemeter which, when tuned to the unknown frequency, indicates the correct mixing frequency to be used. This mixing frequency is a multiple of 10 megacycles, derived from the 100-kc standard in the FR-38/U. When the correct mixing frequency is mixed with the unknown frequency, the difference frequency is within the range of the FR-38/U and can be read directly. The unknown frequency is then the sum of the mixing frequency and the FR-38/U reading.

1-51. PHYSICAL DESCRIPTION. The AN/USA-5, including frequency converter and transit case, weighs approximately 11 pounds. The physical dimensions of the plug-in Frequency Converter CV-394/USA-5 are shown in Figure 1-7. Transit Case CY-1563/USM-26 is described in paragraph 1-39 and shown in Figure 1-8.

Table 1-5. Electrical Characteristics and Physical Specifications of Frequency Converter CV-394/USA-5

Range:	100 mc to 220 mc.
Accuracy:	Retains accuracy of Frequency Meter FR-38/U.
Display:	Nine-place indication; first two places indicated on converter MIXING FREQUENCY switch, next seven places indicated on FR-38/U digital display units and meters.
Input Voltage:	0.2-volt rms minimum.
Input Impedance:	Approximately 50 ohms.
INPUT Connector:	BNC type.

1-52. QUANTITY AND TYPES OF TUBES AND DIODES. The vacuum tubes and diodes, and the quantities of each, used in Frequency Converter CV-394/USA-5 are listed in Table 1-6.

Table 1-6. Tubes and Diodes in Frequency Converter CV-394/USA-5

JAN or NAVY TYPE	QUANTITY
5654	1
5725	1
6AH6	3
6E5	1
IN198 diodes	2

SECTION II

INSTALLATION AND OPERATION

2-1. FUNCTION OF EQUIPMENT.

2-2. Frequency Meter FR-38/U with its two panel plug-in units is a precision instrument that automatically measures frequencies up to 220 megacycles and presents the value of the measured frequency on a direct-reading digital indicating system. In addition to measuring frequency, the instrument also measures period (1/f), time intervals, frequency ratios, and the total number of electrical events that occur during the course of a measurement. The equipment will also "self-check" its own circuits for proper operation. The capabilities of the instrument in making these measurements are summarized in Table 1-3 of Section I.

2-3. INSTALLATION.

2-4. The FR-38/U equipment is designed primarily for mounting in a relay rack, although it may also be used on a test bench. The following information assumes, however, that the instrument will be rackmounted.

2-5. After unpacking the equipment, remove it from its transit cases. Install the main component in a relay rack, referring to Figure 1-7 for necessary mounting dimensions. Assuming that the rack is tapped for #10-24 machine screws, install the equipment using fourteen #10-24 by 1/2-inch screws. Oval head binder screws with large flat washers are recommended. The mounting arrangement should assure a free intake of air for the fan at the back of the cabinet as well as adequate circulation of air around the cabinet.

2-6. The FR-38/U has provisions whereby an external frequency standard can be used in place of the 100 kc internal precision crystal oscillator. Information pertaining to the use of the external frequency standard is found in paragraph 3-10.

2-7. A space convenient to the equipment for stowing one of the panel plug-in units is also desirable.

2-8. POWER CONNECTION. The equipment operates from a nominal 115-volt, 50-1000 cps single phase power source. The power connector is located on the front panel. A six-foot power cord is provided. It is highly desirable that the power source is not subject to interruption, since the equipment contains a quartz crystal in a temperature-regulated oven. The oven circuit is always energized as long as the equipment is connected to a power source.

2-9. Turn off POWER switch on equipment and install either of the plug-in units in the large opening in the panel.

CAUTION

The POWER switch on the instrument must be turned off (in "down" position) before installing or removing a front panel plug-in unit. Failure to do so may cause voltage arcing as the pins of the 8- and 16-contact plug-in connectors engage or disengage.

2-10. TURNING ON EQUIPMENT. After the equipment has been installed and connected to a power source, turn the POWER switch on and allow equipment to warm up for 15 minutes or longer.

CAUTION

During the first warm-up period, keep a close watch on the crystal oven thermometer on the front panel to be sure of proper operation. It will normally require about one-half hour for the oven to reach its operating temperature of 65° ±5°C (149° ±9°F) and about two hours for the crystal itself to be heated thoroughly. If thermometer overshoots its reading, DISCONNECT EQUIPMENT FROM POWER SOURCE and investigate source of trouble.

2-11. TURNING OFF EQUIPMENT. During periods when the equipment is not in use, it can be turned off by setting the POWER switch to the standby or down position. When the POWER switch is in the standby position, the crystal oven heater circuits are energized so that the crystal temperature is regulated. DO NOT disconnect the equipment from its power source.

2-12. OPERATING CONTROLS, DIALS, AND TERMINALS.

2-13. Table 2-1 summarizes the functions of each of the operating controls, dials, and terminals of the FR-38/U equipment. The numbers shown in the table correspond to the numbers assigned to the panel controls in Figure 2-1. The functions of each of the controls are further discussed in this section as part of the operating information.

2-14. SELF-CHECK FEATURE.

2-15. GENERAL. By means of the self-check feature, the operator can in one simple procedure check out for satisfactory operation those circuits that are used in the various measurement functions performed by the instrument. These circuits include those used when measuring frequencies below 10 megacycles, measuring period, totalizing, or measuring frequency

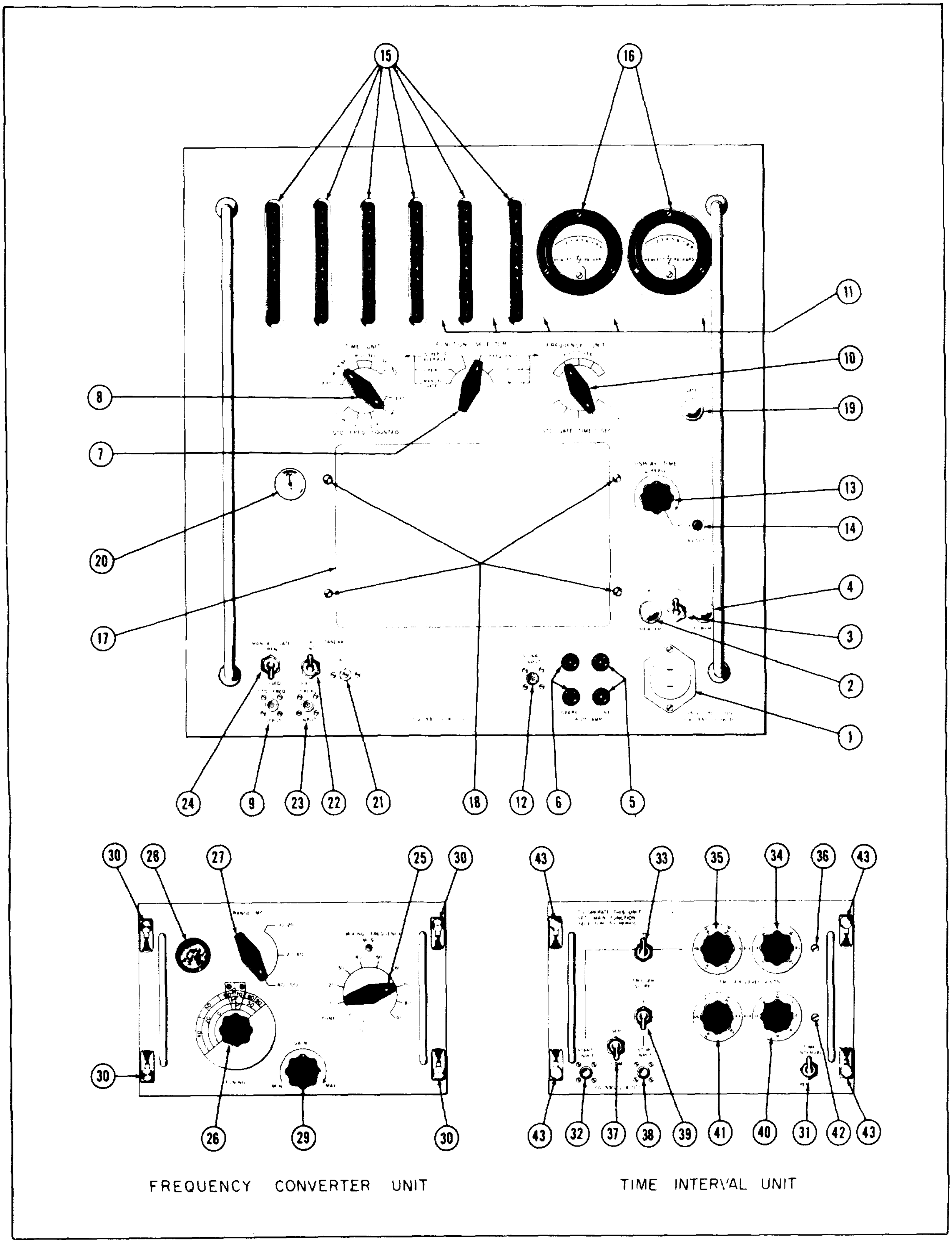


Figure 2-1. Frequency Meter FR-38/U and Plug-in Units, Controls Numbered

ratios and those circuits, excluding the Time Interval Unit, that are used for time interval measurement. This includes essentially all circuits in the main cabinet of the equipment. The self-check feature, however, does not check the operation of the panel plug-in units, nor does it give an indication of the accuracy of the internal 100 kc precision crystal oscillator. To check the operation of the plug-in units, it is necessary to make a frequency measurement and a time interval measurement as described in paragraphs 2-21 and 2-69. Adjusting the frequency of the 100 kc oscillator is described in paragraph 3-4.

Table 2-1. Panel Controls and Connectors

Ref. No. Fig. 2-1	Designation	Function
1	115v 50-1000 CX-337/U (6'0")	AC Power Input Connector.
2	HEATER	White pilot lamp that indicates when crystal heater and space heater are energized. Lighted at all times if power is supplied to (1), except when red pilot lamp (4) is lighted.
3	ON	Power switch. "ON": All circuits energized. Opposite position: Only crystal heater and space heater energized.
4	POWER	Red pilot light that indicates when all circuits are energized.
5	LINE	Fuse holders - one for each side of line.
6	SPARE	Holders for spare fuses.
7	FUNCTION SELECTOR	Master control that prepares instrument for type of measurement to be made.
8	TIME UNIT	Selects standard frequency to be counted for 10 Period Average, Period, Manual Gate, and Time Interval operation.
9	STD. FREQ. OUTPUT	Type BNC jack at which is available standard frequency pulse output as selected by "Time Unit" (8) switch. 1 volt peak is available into 1000 ohm load. When Time Unit (8) switch is in EXT position, external frequency to be counted should be connected to this terminal.
10	FREQUENCY UNIT	Selects standard gate time for all frequency measurements and self-check positions.
11	- - - -	Illuminated decimal points.
12	SIGNAL INPUT	Type BNC jack which receives signal frequency to be measured for all measurements except time interval and totalizing.
13	DISPLAY TIME	Control that regulates display time.
14	RESET	Manual reset for starting new count when Display Time (13) set to "INF" position. Returns counters to zero in "MANUAL GATE" operation
15	- - - -	Illuminated columns of numbers that indicate first six digits of display.
16	- - - -	Meters that indicate last two digits of display.
17	- - - -	Aperture for panel Plug-in Units.

Table 2-1. Panel Controls and Connectors (Cont.)

Ref. No. Fig. 2-1	Designation	Function
18	- - - -	Panel Plug-in Unit retaining studs.
19	GATE	Neon lamp that lights when gate is open (not used for operating purposes).
20	- - - -	Crystal oven temperature indicator. Correct oven temperature is 65° ±5°C (149° ±9°F).
21	ADJ	Screwdriver operated trimmer capacitor that adjusts internal 100 kc standard frequency. (Not an ordinary operating adjustment.)
22	100 KC STANDARD INT EXT	Switch that arranges instrument to operate using internal 100 kc standard oscillator or using external 100 kc standard frequency.
23	100 KC INPUT	Type BNC jack that receives external 100 kc standard frequency. 1 volt peak minimum into approx. 1 megohm is required.
24	MANUAL GATE OPEN	Switch that opens and closes gate when Function Selector (7) is set to "MANUAL GATE".
The following controls are located on the Time Interval Plug-in Unit.		
25	MIXING FREQUENCY MCS	Switch that selects mixing frequency.
26	TUNING	Tuning dial for preselector.
27	RANGE - MC	Range selector switch for TUNING dial (26).
28	- - - -	Preselector tuning indicator "eye" when MIXING FREQUENCY (25) switch is in TUNE position; indicates output level of Converter plug-in unit for all other positions of switch.
29	GAIN	Control that adjusts gain of amplifier in Converter unit so that proper output level is obtained.
	- - - -	Snap-slide fasteners for securing plug-in unit. Connects with retaining studs (18).
The following controls are located on the Time Interval Plug-in Unit.		
31	TIME INTERVAL PERIOD	Switch that permits time interval or period measurements to be made when T-I unit is plugged in and FUNCTION SELECTOR (7) is set to PERIOD.
32	START INPUT	Type BNC jack that accepts start signals of either polarity and up to 200 volts peak amplitude.
33	TRIGGER SLOPE	Switch that sets start channel to trigger on either positive- or negative-going signals.
34	TRIGGER LEVEL VOLTS	Control that adjusts start channel (in combination with control 35) to trigger at any point between -200 and +200 volts peak.
35	TRIGGER LEVEL VOLTS	Multiplier for-control (34).
36	- - - -	Screwdriver-operated calibration adjustment for start trigger level control (34). (Not an ordinary operating control.)

Table 2-1. Panel Controls and Connectors (Cont.)

Ref. No. Fig. 2-1	Designation	Function
37	SEP COM	Separates or connects start and stop input connectors (32 and 38).
38	STOP INPUT	Type BNC jack that accepts stop signals of either polarity and up to 200 volts peak amplitude.
39	TRIGGER SLOPE	Switch that sets stop channel to trigger on either positive- or negative-going signals.
40	TRIGGER LEVEL VOLTS	Control that adjusts stop channel (in combination with control 41) to trigger at any point between -200 and +200 volts peak.
41	TRIGGER LEVEL VOLTS	Multiplier for control (40).
42	- - - -	Screwdriver operated calibration adjustment for stop trigger level control (40). (Not an ordinary operating control.)
43	- - - -	Snap-slide fasteners for securing plug-in units. Connects with retaining studs (18).

2-16. It is necessary that one of the panel plug-in units be in place to self-check the instrument. However, none of the controls on the plug-in units are used. It is not necessary that any cables that connect the instrument to an external frequency source be disconnected.

2-17. WHAT SELF CHECK DOES. For the purpose of considering the self-check feature, the circuit of the FR-38/U can be represented by the simplified diagram shown in Figure 2-2. The time base generator supplies two frequencies, 100 kc and 10 mc, which are derived from the precision 100 kc oscillator. This oscillator is part of the time base generator. Either of these frequencies can be passed through the gate circuits to the counters. At the same time, any of the five gate times that the instrument provides can be used.

2-18. Since the values of the two self-check frequencies are known, the accuracy of the reading on the counters for any of the five gate times can be established. By noting the readings obtained when these frequencies are measured, it is possible to determine that the equipment is operating properly.

2-19. The self-check feature can also be used when a 100 kc frequency from an external standard is being used in place of the internal oscillator. In this case, the equipment will derive the two self-check frequencies from the external frequency.

2-20. STEP-BY-STEP PROCEDURE FOR SELFCHECKING FREQUENCY METER FR-38/U.

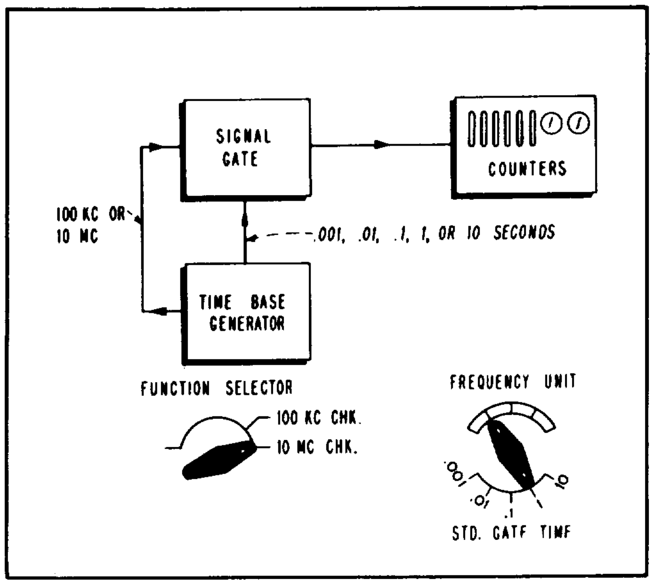


Figure 2-2. Self-Check, Circuit Block Diagram

a. If an external 100 kc frequency is being used in place of the 100 kc frequency generated by the internal precision oscillator as described in paragraph 3-10, the self-check feature will check out the equipment in terms of this external frequency. Therefore, the connection between the equipment and the external standard should be allowed to remain.

b. One of the two panel plug-in units must be in place. Turn power switch (3) off before removing or installing a panel plug-in unit.

c. Turn on power switch (3) and allow equipment to heat for at least 5 minutes. A longer warm-up should be allowed if ambient temperature is below normal room temperature.

d. Set MANUAL GATE (24) switch to closed position.

e. Set FUNCTION SELECTOR (7) to 100 KC CHECK position.

f. Adjust DISPLAY TIME (13) control for desired display. The extreme counterclockwise position is usually best. (Display time cannot be adjusted to be less than gate time.)

g. Note readings obtained on display system for each position of FREQUENCY UNIT (10) switch. These readings should agree with values in Table 2-2. If readings do not agree with the table after equipment has had an adequate warm-up period, the phantastron circuits should be checked.

h. Now set FUNCTION SELECTOR (7) to 10 MC CHECK position.

i. Repeat step g. However, when checking 10 mc, note that a discrepancy of ±1 count in the last digit is acceptable because of tolerances in the operation of the gate circuits.

j. If the correct readings are obtained, the equipment can be considered to be operating properly. If the readings are incorrect, the instrument should be referred to proper maintenance personnel for repair.

Table 2-2. Counter Readings for Self-Check Operations

GATE TIME	100 KC CHECK	10 MC CHECK
10 sec	0100.0000	0000.0000 ± .0001
1 sec	00100.000	10000.000 ± .001
0.1 sec	000100.00	010000.00 ± .01
0.01 sec	0000100.0	0010000.0 ± 1
0.001 sec	00000100.	00010000. ±1

2-21. FREQUENCY MEASUREMENT.

2-22. When the AN/USM-26 is being used to measure frequency, its circuit arrangement is as indicated by the block diagrams of Figures 2-3 and 2-4. If the frequency to be measured is known to be less than 10 megacycles, the Frequency Converter Unit does not necessarily need to be used, although it is necessary that one of the panel plug-in units be in place. Use of the Converter unit when measuring frequencies below 10 megacycles will, however, increase the sensitivity of the instrument from 1 volt rms to 0.2 volt rms.

2-23. Frequencies higher than 10 megacycles are applied to the Converter where their approximate frequency is measured by a preselector. The preselector,

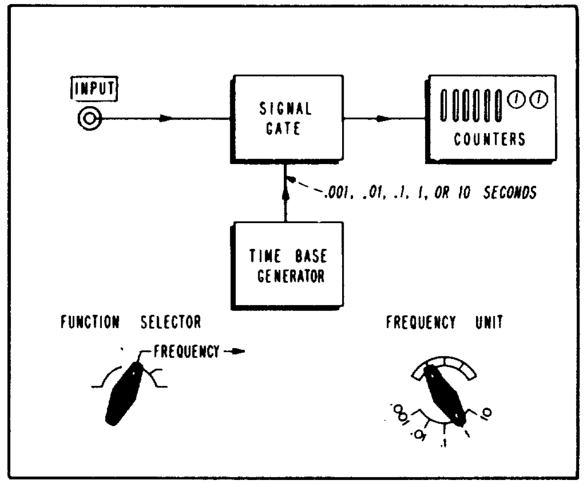


Figure 2-3. Frequency Measurement Below 10 Mc, Circuit Block Diagram

instead of being calibrated to indicate directly the frequency be measured, is calibrated to indicate the mixing frequency that should be selected for the frequency under measurement. When the proper mixing frequency has been selected, the output of the converter will be a frequency not higher than 10.1 megacycles. For example, if a frequency of 44 megacycles is to be measured, the preselector will indicate that a mixing frequency of 40 megacycles should be selected. When this mixing frequency is selected by the control on the Converter panel, the output from the Converter will be the difference frequency of 4 megacycles. This difference frequency will be applied to the signal gate and subsequently measured by the counter circuits.

2-24. To insure its proper use, the Converter unit has a "tuning eye" tube that indicates preselector tun

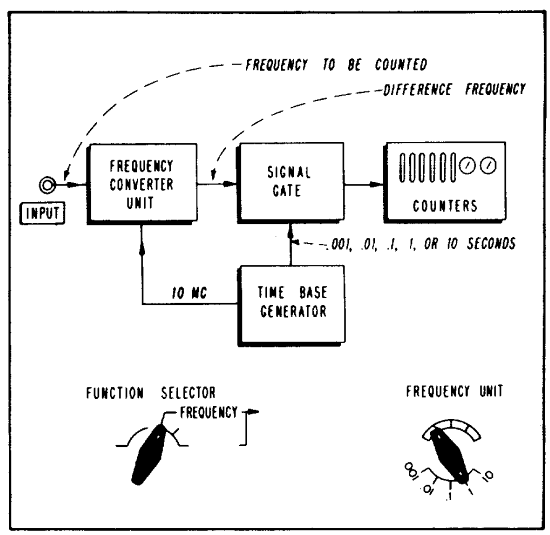


Figure 2-4. Frequency Measurement Above 10 Mc, Circuit Block Diagram

ing as well as the output level of the difference frequency produced by the Converter.

2-25. If the frequency to be measured is less than 10 megacycles, it is not converted. In such a case, it is amplified by the video amplifier in the Converter unit and applied to the signal gate and counters for direct measurement.

2-26. CONTROLS AND TERMINALS USED IN FREQUENCY MEASUREMENTS. (See Figure 2-1.)

2-27. The FUNCTION SELECTOR (7) is the master control and must be set to FREQUENCY for any frequency measurement.

2-28. The FREQUENCY UNIT (10) switch selects the length of time that the gate will be open and thus the length of time that the input frequency will be counted. Five of these standard gate times are available: 10 seconds, 1 second, 0.1 second, 0.01 second, and 0.001 second. Greatest accuracy is obtained using the 10second gate time. The shorter gate times offer a continuous display of the measured frequency when minimum display time is used. They are thus useful for making rough tuning adjustments on external equipment when measurement accuracy is secondary to the convenience of continuous display. The FREQUENCY UNIT switch also locates the illuminated decimal point.

2-29. The automatic display time is adjustable from at least 0.3 to 5 seconds (DISPLAY TIME 13) except that the display time cannot be adjusted to be less than the gate time used. A longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET button (14) is pressed. This resets the counter to zero and allows a new count to be started.

2-30. The SIGNAL INPUT connector (12) is provided to receive the frequency to be measured, both when the Frequency Converter Unit is used and when it is not used. In the range below 10 mc, the input impedance at this connector is approximately 1 megohm shunted by 40 µµf. In the range above 10 mc, the input impedance is approximately 50 ohms. Below 10 mc, a minimum input voltage of 0.2 volt rms is required if the Frequency Converter Unit is in place. If the Time Interval Unit is used when measuring frequencies below 10 mc, a minimum input voltage of 1 volt rms is required. Above 10 mc, where use of the Frequency Converter is required, a minimum input voltage of at least 0.02 volt rms is necessary. Maximum permissible noise in the input signal is 2 millivolts when the Converter is in place or 10 millivolts when the Time Interval Unit is in place. An unstable reading on the counters is an indication of excessive noise or insufficient signal.

2-31. The 100 KC INPUT connector (23) is provided to receive a standard frequency from an external frequency standard whose accuracy exceeds that of the internal standard. Details of this arrangement are described in paragraph 3-11.

2-32. The STD. FREQ. OUTPUT connector (9) provides any one of the four frequencies indicated by the TIME UNIT switch (8). Any one of these frequencies is available for external use when any type of frequency measurement is being made. The output waveform from the connector is a pulsed waveform except for a nominal sinusoidal waveform for the 10 mc frequency. At least 1 volt peak is available into a load impedance of 1000 ohms.

2-33. The Frequency Converter panel plug-in unit extends the frequency measurement range of the FR38/U from 10 to 100 megacycles. From an operating viewpoint, the Converter does two things. It indicates the approximate value of the frequency to be measured, and it converts this frequency to a difference frequency that is always below 10.1 megacycles and can thus be measured by the main part of the equipment.

2-34. When the MIXING FREQUENCY (25) switch is in the TUNE position, the plug-in unit is prepared to measure the approximate value of the unknown frequency. The TUNING dial (26) has three arcs of calibration which correspond to the three positions of the RANGE - MC switch (27). When the TUNING dial is tuned to the frequency of the unknown, the tuning eye (28) will close or partially close.

2-35. The TUNING dial (26) is not calibrated in terms of the frequency of the unknown; rather, it is calibrated in terms of the mixing frequency that should be used for the measurement. When an indication is obtained on the tuning eye, then the TUNING dial shows the frequency to which the MIXING FREQUENCY control (25) should be set. For example, if an unknown frequency of, say, 55 megacycles were being measured, an indication should be obtained on the tuning eye when the TUNING dial was approximately at the middle of its "50" region and the RANGE - MC switch in the 40 - 100 position. The reading of the TUNING dial thus indicates that the MIXING FREQUENCY control should be set to its "50" position for the measurement.

2-36. When the MIXING FREQUENCY control is set to any of its positions other than TUNE, the tuning eye changes from a tuning indicator to an indicator of the voltage level of the video output frequency of the Converter. To continue with the above example, then, when the MIXING FREQUENCY control was set to "50", the tuning eye would at least partially close. In order for the difference frequency to be at the proper level to be measured, the GAIN control (29) should be adjusted so that the tuning eye is approximately closed but does not overlap.

2-37. The reading obtained on the display system, combined with the setting of the MIXING FREQUENCY switch, indicates the value of the frequency being measured. In the above example, a reading of 5,000.000 kilocycles would have been obtained on the display system. Since the MIXING FREQUENCY switch was in the 50 megacycle position, the value of the frequency being measured is 55 megacycles.

2-38. FREQUENCY MEASUREMENT TECHNIQUE. In any heterodyne system in which the mixing frequency is close to the heterodyned frequency, there is possibility for ambiguity. Thus, when measuring a frequency of, say, 49.98 megacycles, the preselector will indicate that the frequency is approximately 50 megacycles; and a reading on the counter of 0.02 megacycles will be obtained. The question is whether this reading should be subtracted or added to the 50-megacycle mixing frequency.

2-39. This example demonstrates that it has been necessary to design the equipment so that the mixing frequency will not be worked close to the frequency being measured. For this reason, the preselector tuning control has been calibrated in such a way that the mixing frequency will not be selected to be within 100 kc of the unknown. Thus, the dividing points on the TUNING dial correspond to unknown frequencies of 10.1, 20.1, 30.1, etc., megacycles. As a result, the counter readings will always lie between 100 kc and 10.1 megacycles.

2-40. This arrangement calls for a special technique when measuring a frequency that lies on or very near the dividing lines on the TUNING dial. In such cases, the MIXING FREQUENCY switch should always be set first to the lower of the two possible mixing frequencies. If a frequency of 70.05 megacycles were to be measured, for example, the TUNING dial would point to the division mark between 60 and 70. In such a case the MIXING FREQUENCY switch should be set first to 60 megacycles so that a counter reading of 10.05 megacycles would be obtained. The measurement can then be double-checked by setting the MIXING FREQUENCY switch to 70 megacycles so that a counter reading of 0.05 megacycles will be obtained. In this particular example, a triple-check could be made by setting the MIXING FREQUENCY switch to 80 megacycles, in which case a reading of 9.95 megacycles would occur. Subtracted from 80 megacycles, this again gives the value of the unknown as 70.05 megacycles.

2-41. Since the counter circuits directly count frequencies as high as 10 megacycles, preselection and mixing are not necessary for frequencies below 10 megacycles. Frequencies in this range will be amplified if the Converter unit is in place and passed directly through the gate to the counters.

2-42. The GAIN control of the Frequency Converter Unit is effective when the MIXING FREQUENCY switch is in the 0 position (i.e., when measuring frequencies below 10.1 megacycles). This is often of value when measuring frequencies that have a low signal-to-noise ratio.

2-43. When measuring frequencies below 10.1 megacycles with the Frequency Converter in place, the GAIN control should be adjusted so that the tuning eye just closes. When this is done with a signal that has a poor signal-to-noise ratio, it may be found that the reading on the display system is erratic or erroneous, because some of the noise frequencies are being measured along with the desired signal. In such a case, the setting of the GAIN control can be reduced in slight steps until a stable, accurate reading is obtained. The final reading should be stable over a significant range of GAIN settings before the readings can be considered to be unaffected by noise. This procedure is usually useful with signal-to-noise ratios as low as 20 db.

2-44. ACCURACY OF FREQUENCY MEASUREMENT (USING FREQUENCY CONVERTER UNIT).

2-45. The accuracy of the Model FR-38/U is determined by an internal oscillator that is accurate within approximately 2 parts per million per week and by a possible error of ±1 count that is inherent in the gate and counter type of instrument. Accuracy at the higher frequencies is determined primarily by the oscillator, which is equal to a high-quality secondary frequency standard. At the lower frequencies, those below 10 kc, the percentage error due to the ±1 count increases rapidly. Below 316 cycles per second, greater accuracy is obtained by measuring the period of the wave that can be obtained by measuring the frequency directly. Techniques for measuring period are described later.

2-46. In counting terms, frequency measurements are accurate within 0.0002% ±0.1 cycle if the sampling time is 10 seconds (10-second .standard gate time) or 0.002% ±1 cycle if the sampling time is 1 second. For shorter sampling times the accuracy will be correspondingly less. A plot of the accuracy obtained for each of the standard gate times (for the entire frequency range) is shown in Figure 2-5.

2-47. Where there is at hand a 100 kc primary standard of better accuracy than that of the internal oscillator, the accuracy of the FR-38/U can be increased by substituting the laboratory standard for the internal oscillator. A panel connector and switch are provided for this purpose. When using an external standard, the maximum accuracy of the equipment becomes the accuracy of the external standard ±1 count (±0.1 cycle on 10 sec gate).

2-48. STEP-BY-STEP PROCEDURES FOR FREQUENCY MEASUREMENT.

2-49. A summary of specifications and step-by-step operating procedures for frequency measurement are given in paragraph 2-116.

2-50. PERIOD MEASUREMENT.

2-51. Besides being arranged to measure frequency directly, the FR-38/U is also arranged so that it can measure directly the period (1/frequency) of the frequency to be measured. Period measurements become valuable when measuring low frequencies, where on direct frequency measurements the available sampling times would permit only a few cycles of the unknown to be measured. The ability to make period measurements extends the measurement range of the instrument to frequencies as low as 0.01 cps.

2-52. When set for period measurements, the time base and the signal input circuits are interchanged from their frequency measurement positions, as indicated in Figure 2-6. When the circuits are so connected, the counters count the output of the time base for the period of the unknown input signal. Thus, the standard frequencies generated in the time base are used as units of time to measure the unknown period in terms of microseconds, milliseconds, or seconds. To improve further the accuracy of the measurement,

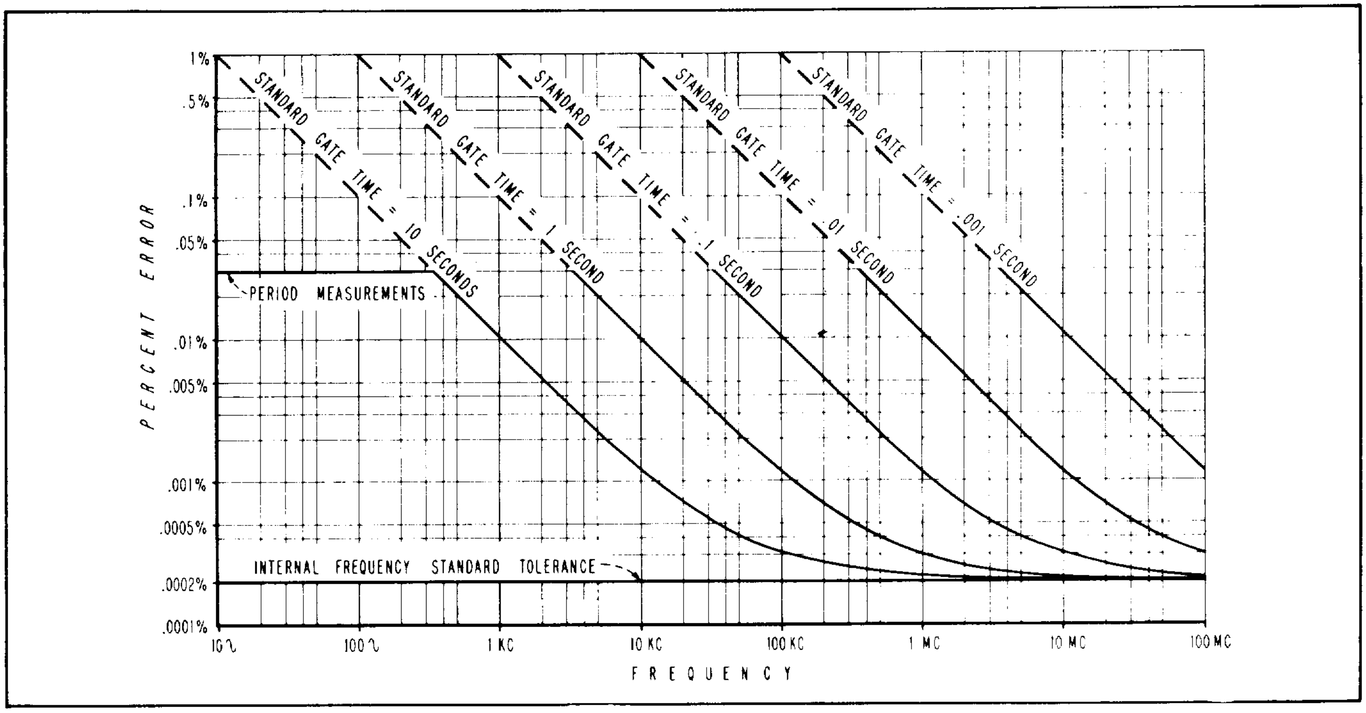


Figure 2-5. Frequency Measurement Accuracy curves

circuits are included that shape the incoming waves so that the gate opens and closes at the same point on the measured waveform.

2-53. The FR-38/U will measure either one period or the average of 10 periods of an unknown. Ten period average measurements are more accurate and are particularly recommended for measuring the shorter periods. Switching the FR-38/U to 10 period average connects the decade divider and automatically locates the illuminated decimal point one place to the left.

2-54. CONTROLS AND TERMINALS USED IN PERIOD MEASUREMENTS. (See Figure 2-1.)

2-55. The FUNCTION SELECTOR (7) is the master control and must be set to PERIOD for period measurement or to 10 PERIOD AVERAGE for 10 period average measurement. Ten period measurement is more accurate, while single period measurement is faster.

2-56. The TIME UNIT (8) switch selects the standard frequency that will be counted and indicates the units of time in which the answer will be presented. Four internal standard frequencies are available: 10 megacycles, 100 kc, 1 kc, and 10 cps. These frequencies correspond to time units of microseconds (in units of 0.1 microsecond), milliseconds (in units of 0.01 millisecond), milliseconds (in units of 1.0 millisecond), and seconds (in units of 0.1 second). The greatest accuracy of measurement will be obtained when using the internal frequency that gives the largest number of counts on the display system.

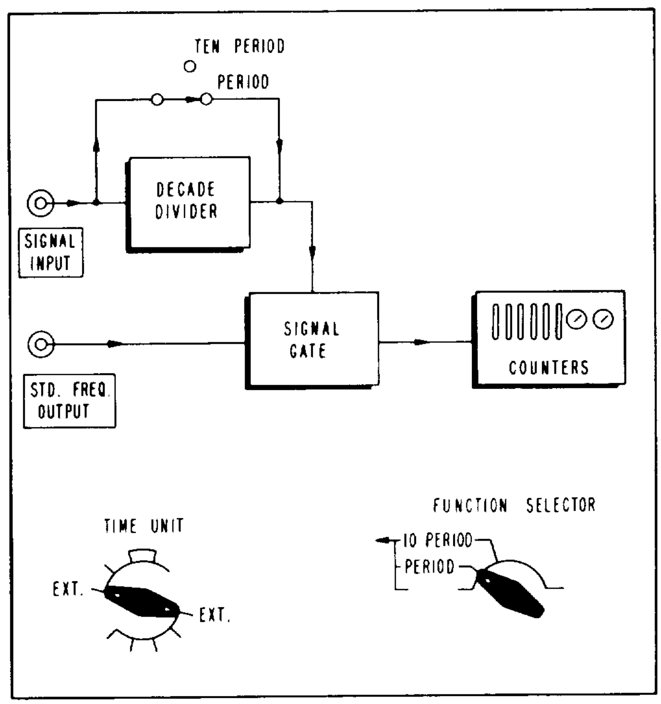


Figure 2-6. Period Measurement, Circuit Block Diagram

2-57. The EXT position of the TIME UNIT switch permits an external standard frequency to be applied to the STD. FREQ. OUTPUT connector (9) and to be counted in place of one of the internal standard frequencies.

The internal standard frequencies selected by the TIME UNIT switch are available for external use at the STD. FREQ. OUTPUT (9) connector. The voltages appearing at this connector have an amplitude of at least 1 volt peak into 1000 ohms.

CAUTION

The load impedance of STD. FREQ. OUTPUT connector J-205 is approximately 1000 ohms. Excessive loading resistively or capacitively (by long cable lengths) of J-205 must be avoided since it will also load the internal standard frequencies counted during Period, Time Interval, or Manual Gate operations and cause erratic count. During any operation where internal standard frequencies are counted, it may be necessary to remove cables from STD. FREQ. OUTPUT to obtain correct readings.

2-58. The automatic display time is adjustable from at least 0.3 to 5 seconds (DISPLAY TIME 13). A longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET (14) button is pressed, which resets the count to zero and allows a new count to start.

2-59. As the panel plug-in units take no active part in the period measuring functions of the FR-38/U, either unit may be used. One or the other of the plug-in units must be in place, however, ill order to complete the input circuit. With one exception, the controls of the panel plug-in units are not used. The one exception is that the TIME INTERVAL - PEIUOD switch (25) on the Time Interval Unit must be in the PEIIOD position.

2-60. The SIGNAL, INPUT (12) connector is provided to receive the signal whose period is to be measured. The input signal must not be less than 1 volt rms nor more than 200 volts rms. It may have any rise time, although maximum accuracy requires fast rise time. The input impedance is approximately one megohm shunted by 40 µµf.

2-61. PERIOD MEASUREMENT TECHINIQUE. As lower and lower frequencies are measured, the tolerance of ±1 count in gate operation becomes increasingly important on a percentage basis. Where a tolerance of one count in one hundred million is but 0.000001%, a tolerance of one count in one hundred thousand is 0.001%. Finally a point is reached where measurements can be made with greater accuracy by reversing the frequency measurement process; that is, by determining frequency through a measurement of its period. This transition for a one-volt input signal occurs at 316 cycles per second. Frequencies above 316 cycles are most accurately measured by direct frequency measurement while frequencies below 316 cps are most accurately measured by measuring their 10 period average.

2-62. Period measurements are fully automatic and little or no special operating technique is involved. The FR-38/U directly measures and directly displays the period of the unknown in the time units indicated by the setting of the TIME UNIT switch.

2-63. ACCURACY OF PERIOD MEASUREMENT. For frequencies below 316 cps, the accuracy of period measurement is largely determined by the accuracy with which triggering occurs at the same point on consecutive cycles of signal voltages having a slow rate of-rise. Errors caused by imperfect triggering will be proportional to the change in the triggering level and inversely proportional to the slope of the negative going input voltage (at the zero-volt level) in volts per-microsecond. Since the maximum slope of a sine wave is proportional to both the amplitude and frequency, the error in microseconds for a given fluctuation in the triggering level is inversely proportional to both amplitude and frequency. Thus, for a constant input amplitude, the percentage error due to a given fluctuation in the triggering level will be constant. In the FR-38/U this error has been held to ±0.3% for a one-volt rms sine wave input for single period measurement and to ±0.03% when the average of 10 periods is measured. For a 10-volt rms sine wave input, this error would become ±0.03% for a single period measurement and 0.003% for a 10-period average measurement. A complete presentation of the possible error is shown in Figure 2-7 where a graph plotting the error for both period and 10-period average measurement for a one-volt rms sine wave input is shown.

2-64. In order that the FR-38/U may follow the slowest changing waveforms, the period and 10-period average input circuits are direct-coupled and are designed to trigger at the zero-volt crossing of a negative-going voltage. Any d-c component in the input signal will shift the triggering level so that the maximum slope no longer occurs at the zero-volt level, resulting in a loss of accuracy.

2-65. The above figures are for a pure sine wave in the absence of noise. The additional error due to superimposed noise is given by:

$$\text{Maximum additional possible error} = \frac{23 \times \text{peak noise voltage}}{\text{No. of Periods} \times \text{RMS signal voltage}} \%$$

2-66. The accuracy of triggering is considerably improved where the waveforms being measured have a sharp rise-time of high slope as they pass through zero-volt level. For example, a significant reduction ill error can be obtained when square waves instead of sine waves are used as the input signal. Square waves or pulse repetition rates in excess of 316 pulses per second are more accurately determined by direct frequency measurement.

2-67. STEP-BY-STEP PROCEDURE FOR PERIOD MEASUREMENT.

2-68. A summary of specifications and a step-by-step operating procedure for period measurement is given in paragraph 2-116.

2-69. TIME INTERVAL MEASUREMENT.

2-70. Time interval measurements are similar to period measurements except that the point on the signal waveform or waveforms at which the measurement starts and stops is adjustable. This adjustable

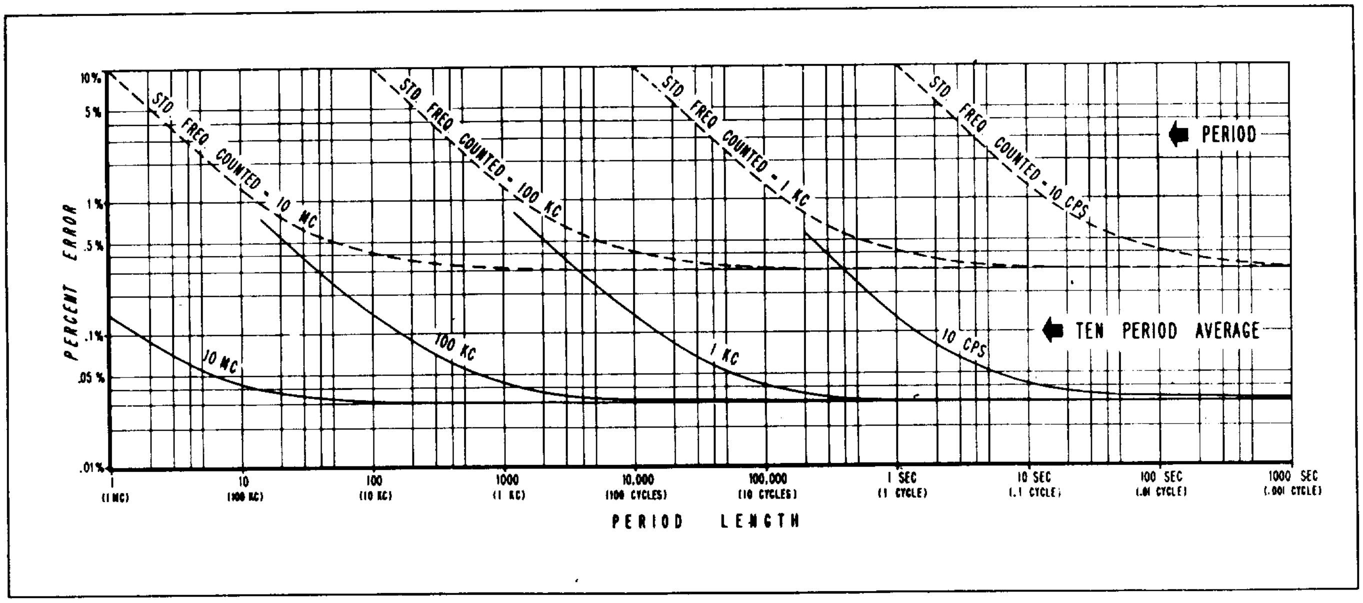


Figure 2-7. Period Measurement Accuracy Curves

threshold feature permits separate signals to be used as start and stop signals or permits measurements to be made from one part of a waveform to another part of the same waveform.

2-71. As in the case of period measurement, the input signals control the opening and closing of the gate while the standard frequencies are passed to the counters, as indicated in the block diagram of Figure 2-8. Thus, the accurate frequencies generated in the time base are used as units of time to measure the unknown

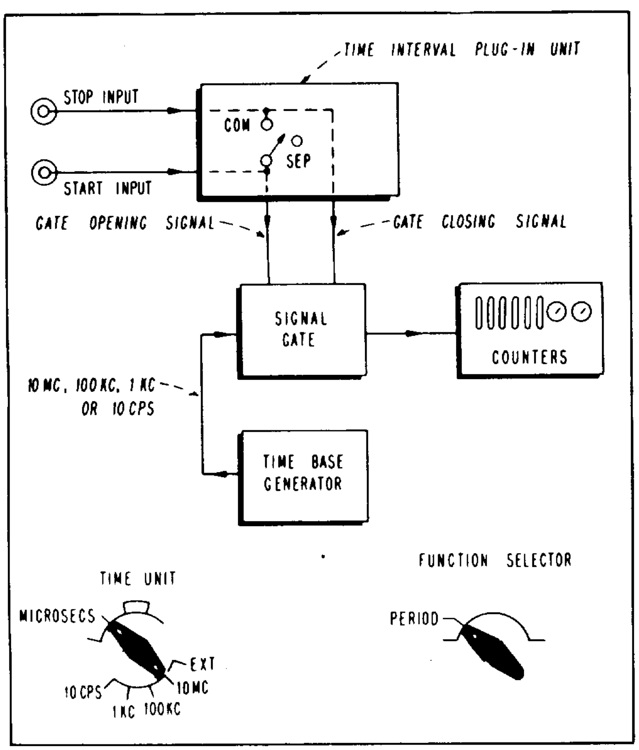


Figure 2-8. Time Interval Measurement, Circuit Block Diagram

interval in terms of microseconds, milliseconds, or seconds.

2-72. The special threshold-selecting controls adjust the start and stop channels so that they will be actuated only by signals of pre-determined polarity, amplitude, and slope. Two sets of controls are provided to permit each channel to be operated by separate waveforms. Each set consists of a trigger slope selector and a trigger level selector,.

2-73. The trigger slope switch prepares the channel to trigger only from the positive-going or only from the negative-going slopes of the signal waveform. The voltage at which the channel will trigger (anywhere from -200 to +200 volts peak) is selected by the trigger level controls. The two sets of controls thus permit each channel to be triggered from any one of four combinations of slope and polarity: Positive or negative slopes of positive voltages, or positive or negative slopes of negative voltages. For each of these combinations the voltage level at which triggering occurs is adjustable from -200 volts through 0 volts to +200 volts.

2-74. CONTROLS AND TERMINALS USED FOR TIME INTERVAL MEASUREMENTS. (See Figure 2-1.)

2-75. The FUNCTION SELECTOR (7) is the master control and must be set to PERIOD for time interval measurement.

2-76. The TIME UNIT (8) switch selects the standard frequency to be counted, indicates the unit of time in which the measurement is presented, and locates the illuminated decimal point. Four internal standard frequencies can be used: 10 megacycles, 100 kc, 1 kc, and 10 cps. These frequencies correspond to time units of microseconds (in units of 0.1 microsecond), milliseconds (in units of 0.01 milliseconds or 1.0 milliseconds), and seconds (in units of 0.1 second). The greatest accuracy of measurement is obtained when using the frequency that gives the highest number of counts on the display system.

2-77. The EXT position of the TIME UNIT switch permits an external frequency to be counted in place of the internal standard frequencies. This arrangement permits use of an external frequency that may have special relation to the interval being measured, i.e., the displayed reading will be in units of feet, yards, miles, etc. The standard frequencies selected by the Time Unit switch are available for external use at the STD. FREQ. OUTPUT (9) connector. This same connector serves as the input connector when the EXT position of the TIME UNIT switch is used. Details of voltages and impedance involved are described in paragraph 2-107. It should be noted that the STD. FREQ. OUTPUT connector is direct-coupled when it is used as an input connector; therefore, it is important that the input signal be free from d-c voltages. If necessary, a blocking capacitor should be connected in series with the connector externally to block any external dc. The amplitude of the signal voltage applied must lie between 1.5 and 10 volts peak.

CAUTION

The load impedance of STD. FREQ. OUTPUT connector J-205 is approximately 1000 ohms. Excessive loading resistively or capacitively (by long cable lengths) of J-205 must be avoided since it will also load the internal standard frequencies counted during Period, Time Interval, or Manual Gate operations and cause erratic count. During any operation where internal standard frequencies are counted, it may be necessary to remove cables from STD. FREQ. OUTPUT to obtain correct readings.

2-78. The automatic display time is adjustable from at least 0.3 to 5 seconds (DISPLAY TIME 13). A longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET (14) is pressed, which resets the counters to zero and allows a new count to start.

2-79. Separate "start" and "stop" input channels and their special threshold-selecting controls are contained in the TIME INTERVAL UNIT. The signal that is to start the measurement is connected to the START INPUT (32) connector. The input signal slope (positive going or negative-going), from which it is desired to start the measurement, is selected by the TRIGGER SLOPE (33) switch. The voltage level (anywhere between -200 and +200), at which the measurement is to begin, is selected by TRIGGER LEVEL (34 and 35) controls. The signal that is to stop the measurement is connected to STOP INPUT (38), and the "threshold" is selected in the same manner as it was for the start channel using the stop channel TRIGGER SLOPE (39) and TRIGGER LEVEL VOLTS controls (40 and4Al). If the input signals are taken from separate sources, the COM SEP (37) switch is placed in the SEP position. If both input signals originate from the same source, the COM SEP (37) switch is placed in the COM position and either the START INPUT or the STOP INPUT connector may be used. The COM SEP switch shorts the two input connectors together when in the COM position.

2-80. The TIME INTERVAL - PERIOD (31) switch, when in the TIME INTERVAL position, connects the adjustable threshold circuits to the gate control circuits and connects, when in the PERIOD position, the SIGNAL INPUT (12) to the gate control system. Time interval measurements can be made only when the TIME INTERVAL - PERIOD switch is in the TIME INTERVAL position.

2-81. The START INPUT and STOP INPUT connectors each have an input impedance of approximately 1 megohm shunted by 20-40 micromicrofarads. When the SEP - COM switch is in the COM position, these impedances are paralleled, giving an input impedance of approximately 0.5 megohm shunted by 40-80 micromicrofarads.

2-82. TIME INTERVAL MEASURING TECHNIQUES.

2-83. Time interval measurements begin when the start signal crosses the selected start threshold value in the selected direction and end when the stop signal crosses the selected stop threshold value in the selected direction. The threshold values are indicated by the calibration of the threshold controls. It should be noted, however, that the calibration of these controls is only approximate and that in some applications it will be necessary to take special precautions in order to obtain a measurement of the desired interval.

2-84. The input circuits in the Time Interval Unit are direct-coupled and will therefore pass d-c voltages as well as a-c voltages. When a pulse or other signal is superimposed on a d-c voltage, then it will be necessary to set the threshold controls accordingly (or to remove the d-c component with an external blocking capacitor).

2-85. If an uncomplicated waveform is being used as the start and/or stop signal, the threshold controls can usually be adjusted without special precautions. For example, if a sharp pulse like that shown in' Figure 2-9 is used, there will be little difference whether the measurement begins at point A or point B.

2-86. If a more complex waveform like that shown in Figure 2-10 is being used, however, greater care must

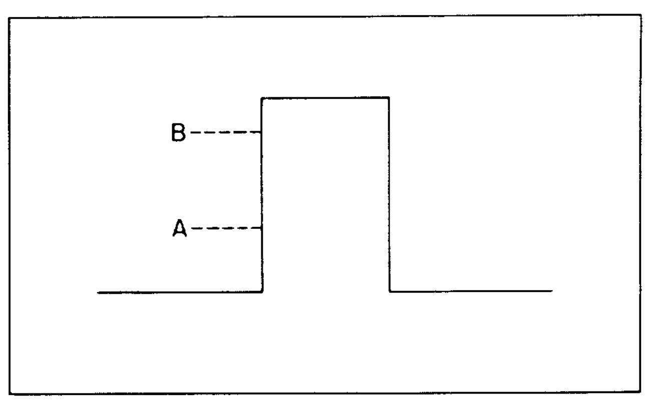


Figure 2-9. Time Interval Measurement of Uncomplicated Waveform

be taken to avoid measuring an undesired value. If it is desired to measure the interval "x", for example, an inadvertent measurement of "y" can easily be made. To avoid measuring an undesired interval in such a case, it is desirable to set the threshold controls near zero as a preliminary adjustment so that a measurement of "y" will be obtained. If the settings of the start threshold controls are then increased, a point will be observed where the start measurement suddenly changes from below the step in the waveform to the rise that is above the step. This change will be reflected in a change in the measured time interval. Similarly, the stop threshold controls can be increased until a discrete change occurs in the measured value.

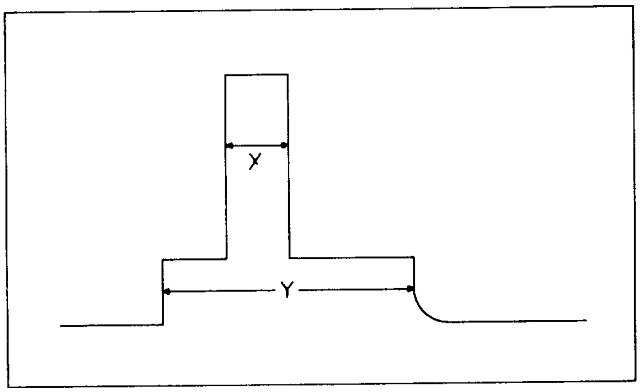


Figure 2-10. Time Interval Measurement of Complex Waveform

2-87. By exercising similar precautions with other complex waveforms, accurate measurements can usually be obtained without difficulty.

2-88. Occasionally, spurious signals will accompany start and stop signals. If these spurious signals have characteristics that appear to the start or stop channels as genuine start or stop signals, the measurement obtained will be an accurate measurement, but will not be a measurement of the desired interval. It is therefore highly desirable that the start and stop signals be carefully examined on an oscilloscope before attempting a measurement, both to determine that the signals are free from spurious signals and so that the waveform will be known accurately.

2-89. STEP-BY-STEP PROCEDURE FOR TIME INTERVAL MEASUREMENT.

2-90. A summary of specifications and a step-by-step operating procedure for time interval measurements are given in paragraph 2-116.

2-91. MEASURING TOTAL EVENTS.

2-92. The FR-38/U can be used as a high-speed totalizer capable of counting at a maximum rate of 10 million events per second. The maximum capacity of the display system is 99,999,999 counts, returning to 00,000,000 on the one hundred millionth count. The resolution time of the instrument is 0.1 microsecond for double pulses and 0.2 microsecond for triple pulses.

The waveform of the electrical events to be counted must have a rise time of not less than 1 millisecond and a minimum amplitude of 1.5 volts peak. Maximum allowable amplitude for this purpose is 10 volts peak.

2-93. Figure 2-11 shows the basic circuit arrangement of the equipment when used as a totalizer. The opening and closing of the signal gate is controlled manually, while the signal to be counted is connected through the STD. FREQ. OUTPUT connector (9)-. The TIME UNIT switch (8) must be in the EXT position.

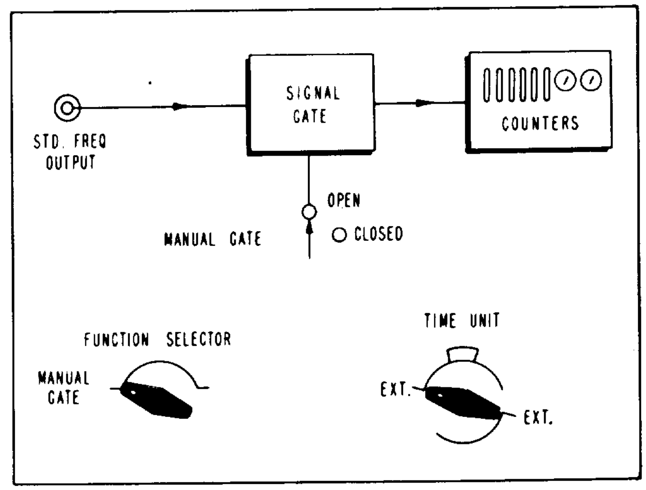


Figure 2-11. Totalizing Measurement, Circuit Block Diagram

2-94. CONTROLS AND TERMINALS USED FOR TOTALIZING. (See Figure 2-1.) 2-95. The FUNCTION SELECTOR (7) must be get to the MANUAL GATE position when totalizing. In this condition the signal gate can only be opened and closed by the MANUAL GATE switch.

2-96. The TIME UNIT switch (8) must be placed in the EXT position. This permits the signal to be counted to be introduced through the STD. FREQ. OUTPUT connector (9) which can be gated with the MANUAL GATE switch.

2-97. The MANUAL GATE switch (24) is effective only when the FUNCTION SELECTOR is in the MANUAL GATE position. The MANUAL GATE switch interrupts the circuit between the STD. FREQ. OUTPUT connector and the signal gate and thus begins and ends a totalizing measurement.

2-98. STEP-BY-STEP PROCEDURE FOR TOTALIZING MEASUREMENT.

2-99. A summary of specifications and a step-by-step operating procedure for totalizing measurement are given in paragraph 2-116.

2-100. TIME AND FREQUENCY RATIO MEASUREMENT.

2-101. Another valuable feature of the FR-38/U is its ability to measure the ratio of two frequencies. As illustrated in Figure 2-12, the higher of the two frequencies is connected to the EXT channel of the TIME UNIT switch and passed through the signal gate to the counters. This signal is counted for a period of time determined by either one period or ten periods of the lower frequency, which controls the opening and closing of the gate.

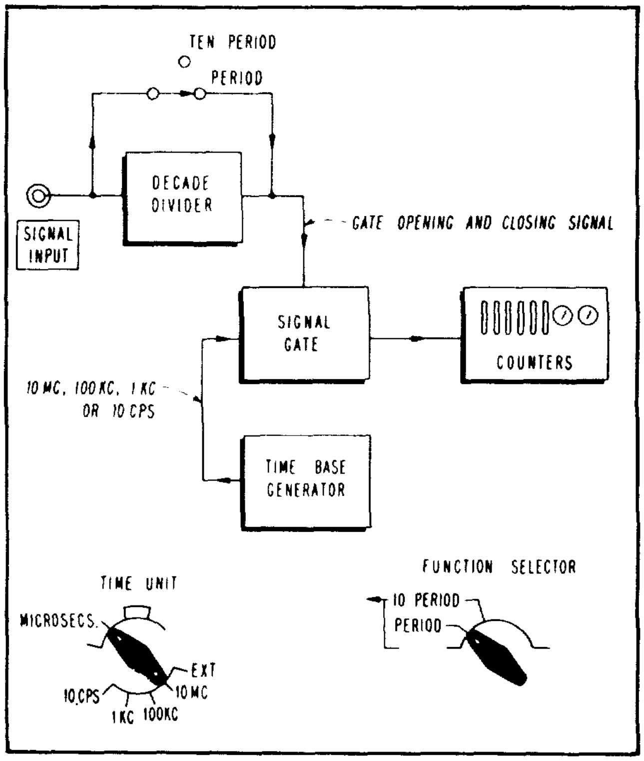


Figure 2-12. Ratio Measurement, Circuit Block Diagram

2-102. CONTROLS AND TERMINALS USED FOR RATIO MEASUREMENT. (See Figure 2-1.)

2-103. The FUNCTION SELECTOR (7) is the master control and must be set to either PERIOD or 10 PERIOD AVERAGE for ratio measurement. When the PERIOD position is used, the counters display the number of cycles of the higher frequency per cycle of the lower frequency. In the 10 PERIOD AVERAGE position the counters display the number of cycles of the higher frequency per 10 cycles of the lower.

2-104. When the instrument is used to measure ratios, the TIME UNIT (8) switch is placed in the EXT position and the higher of the two input frequencies is introduced through the STD. FREQ. OUTPUT (9) connector. The illuminated decimal point is disabled.

2-105. The automatic display time is adjustable from 0.3 to 5 seconds (DISPLAY TIME 13). Longer display time may be obtained by setting the display time control to INF. In this position a count will be displayed until the RESET (14) button is pressed, which resets the counters to zero. Use the INF position if the period of the lower input frequency exceeds approximately one second.

2-106. As the panel plug-in units take no active part in ratio measurement, either unit may be used. One or the other of the units must be in place, however. Turn the instrument off when changing plug-in units. With one exception, the controls of the panel plug-in units are not used. The one exception is that the TIME INTERVAL - PERIOD (31) switch on the Time Interval Unit must be in the PERIOD position.

2-107. The STD. FREQ. OUTPUT (9) connector is used as the input connector for the higher of the two input frequencies, which may be as high as 10 me or as low as 10 cps. The input signal must have a rise time of at least one millisecond, a minimum amplitude of 1.5 volts peak, and a maximum amplitude not in excess of 10 volts. The input impedance of the connector is 1 megohm shunted by 100 µµf. The circuits behind this connector are direct-coupled so that no d-c component should be present in the applied signal. If necessary, an external blocking capacitor should be used to block out a d c component.

2-108. The SIGNAL INPUT (12) connector is used as the input connector for the lower of the two input frequencies. The lower frequency may be as high as 10 kc or as low as 0.01 cps. It must not be less than 1.5 volts peak nor more than 280 volts peak. It may have any rise time, although maximum accuracy requires fast rise time. The input impedance is approximately 1 megohm shunted by 40 µµf.

2-109. The time base generator is not used when making ratio measurements. If an external 100 kc standard is connected to the instrument, however, there is no need to disconnect it.

2-110. RATIO MEASUREMENT ACCURACY.

2-111. Ratio measurement accuracy is determined by the same factors as period measurement accuracy: Consistency of triggering by the lower input frequency and the inherent error of ±1 count of the higher input frequency. The error due to inconsistency of triggering, as explained in paragraph 2-63, has been held to ±0.3% for a sine wave input of 1 volt rms for single period measurement, and to ±0.03% when 10 periods are measured.

2-112. As smaller and smaller ratios are measured, the tolerance of ±1 count becomes increasingly important on a percentage basis. Thus, when measuring the ratio of 100: 1 (e.g., 1000 cps to 10 cps), the i1 count tolerance would result in a possible error of 1% for single period or 0.1% for 10-period measurement.

2-113. Figure 2-13 shows the total error for ratio measurements for the range from 100,000,000 to 1 to 10 to 1 for a lower frequency input of 1 volt rms sine wave. Single period error is shown in dotted line while 10 period error is shown in solid line. The error can be significantly reduced by use of higher input voltages with fast rise times.

2-114. STEP-BY-STEP PROCEDURE FOR RATIO MEASUREMENT.

2-115. A summary of specifications and a step-by-step operating procedure are given in paragraph 2-116.

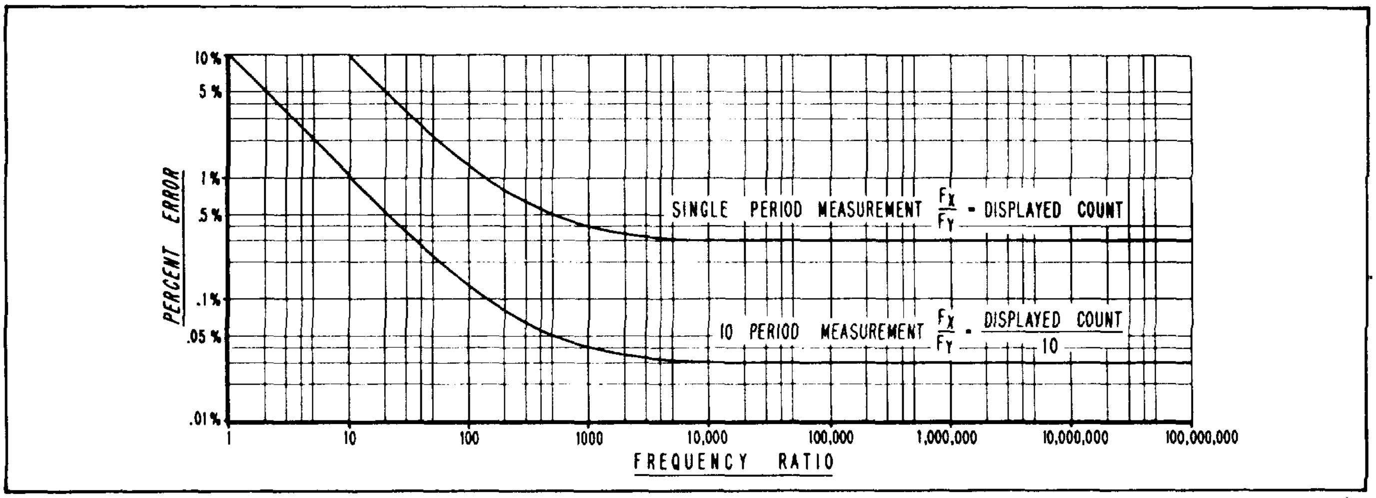


Figure 2-13. Ratio Measurement Accuracy Curves

2-116. SPECIFICATION SUMMARY.

2-117. A summary of specifications and step-by-step operating procedures for all of the measurement functions performed by the AN/USM-26 are given in pages 26-32 at the end of this section.

2-118. OPERATION INSTRUCTIONS FOR FREQUENCY CONVERTER GROUP AN/USA-5.

2-119. GENERAL. To permit measurement of frequencies between 100 and 220 megacycles on Frequency Meter FR-38/U, the Frequency Converter CV-394/USA-5 should be removed from its carrying case and used as directed in the following paragraphs.

2-120. DESCRIPTION OF CONTROLS. The operating controls of Frequency Converter CV-394/USA-5 are illustrated in Figure 2-14 and described in Table 2-3.

2-121. FREQUENCY MEASUREMENT OF SIGNALS BETWEEN 100 AND 220 MC. When Frequency Converter CV-394/USA-5 is used with the FR-38/U to measure frequency, the circuit arrangement is as indicated by the block diagram of Figure 2-4. Frequencies higher than 100 megacycles are applied to the Frequency Converter CV-394/USA-5, where their approximate frequency is measured by a wavemeter. The wavemeter, instead of being calibrated to indicate directly the frequency being measured, is calibrated to indicate the mixing frequency that should be used with the frequency under measurement. When the proper mixing frequency has been selected, the output of the converter will be a frequency not higher than 10.1 megacycles. For example, if a frequency of 114 megacycles is to be measured, the wavemeter will indicate that a mixing frequency of 110 megacycles should be selected. When this mixing frequency is selected on the converter, the converter output will be the difference frequency of four megacycles. This difference frequency will be applied to the signal gate of the FR-38/U and subsequently measured by the counter circuits.

2-122. To insure its proper use, Frequency Converter CV-394/USA-5 has a tuning eye tube that indicates wavemeter tuning as well as the output level of the difference frequency produced by the converter. If the frequency to be measured is less than 10 megacycles, it is not converted. Instead, it is passed directly to the FR-38/U for counting.

2-123. FREQUENCY MEASUREMENT TECHNIQUE WHEN UNKNOWN SIGNAL IS NEAR THE MIXING FREQUENCY. The frequency conversion method used is a heterodyne process, and when the mixing frequency is close to the unknown frequency there is a possibility for ambiguity in determining whether the difference frequency should be added to or subtracted from the mixing frequency in order to properly determine the unknown signal. Thus, when measuring a frequency of, say, 149.98 megacycles, the MIXING FREQUENCY MC switch may be set at 150; and a reading of 0.02 megacycles will be obtained on the FR-38/U. The question is whether this difference frequency reading should be added or subtracted from the 150-megacycle mixing frequency. To minimize this problem, the WAVEMETER dial of Frequency Converter CV-394/USA-5 has been calibrated so that the dividing points actually correspond to 100.1, 110.1, 120.1, etc., megacycles, even though they are calibrated as 100, 110, 120, etc. In this way, the MIXING FREQUENCY MC switch setting, determined by the WAVEMETER dial reading, will be from 0.1 to 10.1 megacycles below the unknown signal (except in the lowest range). Accordingly, the FR-38/U counter readings should always lie between 100 kilocycles and 10.1 megacycles, to be added to the mixing frequency.

2-124. This arrangement calls for a special technique when measuring a frequency that lies on or very near the dividing lines on the WAVEMETER dial. In such cases, the MIXING FREQUENCY MC switch should always be set first to the lower of the two possible mixing frequencies. If a frequency of 170.05 megacycles were to be measured, for example, the WAVEMETER dial would point approximately to the division mark between 160 and 170. In such a case, the MIXING FREQUENCY MC switch should be set first to 160 megacycles, so that a FR-38/'U counter indication of 10.05 megacycles would be obtained. The measurement can then be double-checked by setting the MIXING FREQUENCY MC switch to the 170-mc position, so that a counter reading of 0.05 megacycles would be obtained. In this particular example, a triple-check could be made by setting the MIXING FREQUENCY MC switch

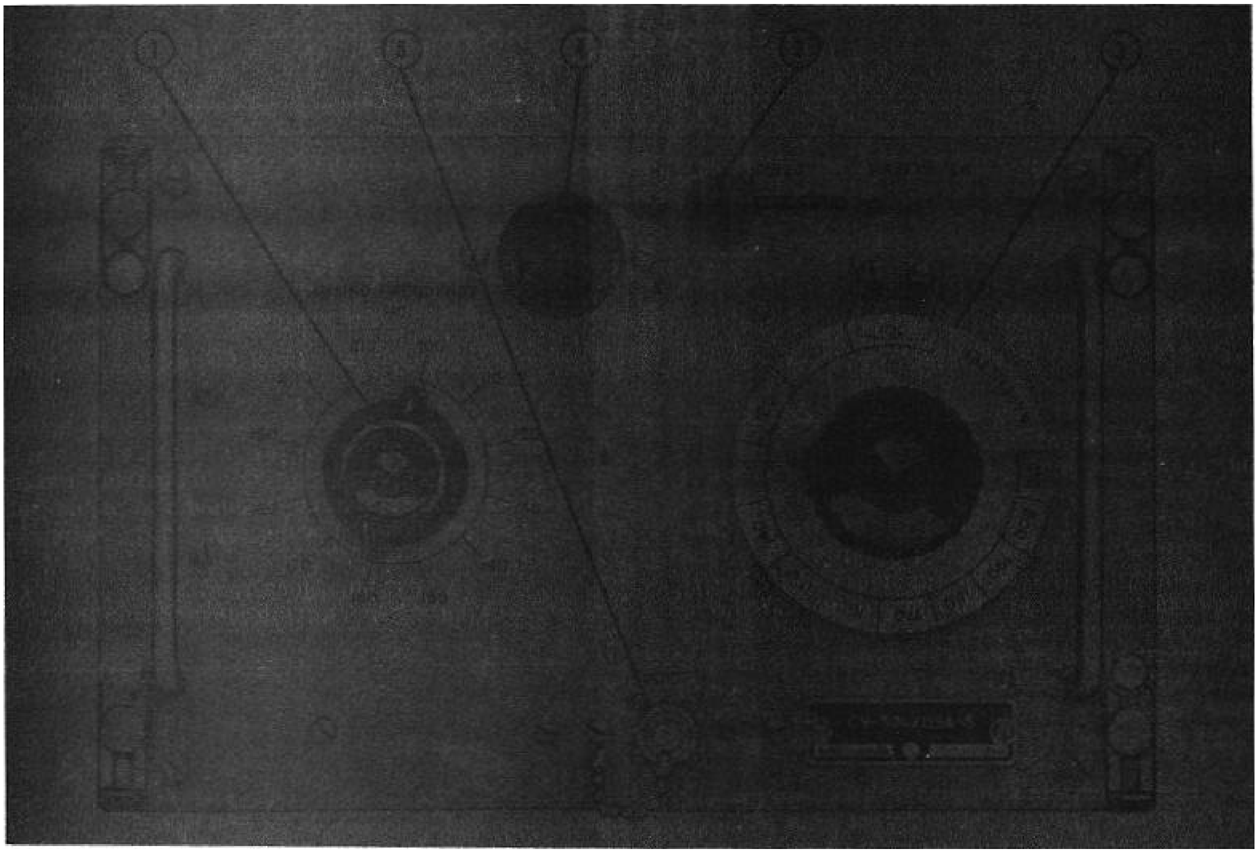


Figure 2-14. Frequency Converter CV-394/USA-5, Controls Numbered

Table 2-3. Operating Controls of Frequency Converter CV-394/USA-5

Ref. No. Fig. 2-14	Designation	Function
1	MIXING FRE-QUENCY MC	This 12-position rotary switch selects the mixing frequency by connecting into the harmonic generator the proper tuned circuit to obtain the desired frequency.
2	MIXER-DIRECT-WAVEMETER	This 3-position lever switch is the Function switch, providing the following functions: MIXER: Provides mixing of a selected frequency with the input signal, with the resultant output signal coupled to the FR-38/U. DIRECT: Allows direct transmission of an input signal to the FR-38/U without mixing. WAVEMETER: Sets up the converter to approximately measure the unknown frequency with the wavemeter circuit, to determine the proper mixing frequency.
3	WAVEMETER	This calibrated dial provides for tuning to the approximate frequency of the input dial signal when the Function switch is in the WAVEMETER position. The tuning eye indicates when the wavemeter is properly tuned, and the WAVEMETER dial indicates the proper mixing frequency.
4	Tuning eye	This electron ray indicator gives a pattern-narrowing visual indication when the WAVEMETER dial is properly tuned to the input signal when the Function switch is in the WAVEMETER position. When the Function switch is in the MIXER position, the tuning eye indicates when the signal amplitude supplied to the FR-38/U is sufficient to operate the counting circuits.
5	INPUT	This female-type BNC connector accepts the unknown input signal.

to the 180-mc position, in which case a reading of 9.95 megacycles would be obtained on the FR-38/U counter. Subtracting from 180 mc, because mixing frequency in this case is clearly higher than the unknown, this would again verify the value of the unknown as 170.05 megacycles.

2-125. STEP-BY-STEP PROCEDURE FOR FREQUENCY MEASUREMENT. Proceed as follows to make frequency measurements using Frequency Converter CV-394/USA-5:

a. Turn off the Power switch on the FR-38/U. Then install the plug-in Frequency Converter CV-394/USA-5 in the large opening in the front panel of the FR-38/U. Engage the snap-slide fasteners to hold the plug-in unit to the FR-38/U retaining studs.

CAUTION

The Power switch on the instrument must be turned off (in "down" position) before installing or removing a front panel plug-in unit. Failure to do so may cause voltage arcing as the pins of the 8- and 16-contact plug-in connectors engage or disengage.

b. Turn the Power switch or and allow the equipment to warm up for 15 minutes or longer.

c. Set the FR-38/U controls as follows:

FUNCTION SELECTOR	-FREQUENCY
FREQUENCY UNIT	-10 STD. GATE TIME - SEC. (or other desired setting)
DISPLAY TIME	-Fully CCW (or other desired setting)

d. Connect signal to INPUT connector of Frequency Converter CV-394/USA-5. This signal must have an amplitude of at least 0.2 volt rms.

e. To select the mixing frequency, make a wavemeter measurement. First turn the 100 KC STANDARD switch on the FR-38/U to the EXT. position. Turn the Function switch of Frequency Converter CV-394/USA-5 to the WAVEMETER position. Starting at the lowest position of the WAVEMETER dial on the frequency converter, slowly adjust this dial until the tuning eye indicates by narrowing its shadow. At the point of sharpest tuning, the eye angle shadow will be at its narrowest. The WAVEMETER dial should be adjusted for sharpest tuning. The WAVEMETER indication at this point indicates the mixing frequency to use in measuring the unknown signal.

NOTE

When adjusting the WAVEMETER dial, always start at the lowest frequency and proceed toward the highest. This procedure minimizes the possibility of tuning to a harmonic of the frequency to be measured.

f. If the WAVEMETER dial indication in step e above is within an arc on the dial designated with a specific frequency, set the MIXING FREQUENCY MC switch to the same frequency. If the WAVEMETER dial indication in step e above is on the line between two frequencies, set the MIXING FREQUENCY MC switch to the lower of those two frequencies. Then return the 100 KC STANDARD switch on the FR-38/U to the INT. position.

g. Turn the function switch of Frequency Converter CV-394/USA-5 to the MIXER position. With the MIXING FREQUENCY MC switch set as in step f above, the tuning eye shadow should be almost closed, indicating that the frequency converter output voltage is of sufficient amplitude to operate the FR-38/U. This indication should be obtained when the input signal level to the converter is 0.2 volt rms or above.

h. If the WAVEMETER dial indication in step e is on the line between two frequencies and the FR-38/U indication is unstable with the MIXING FREQUENCY MC switch set to the lower of those two frequencies, change the setting of the MIXING FREQUENCY MC switch to the higher of the two.

i. To obtain the frequency of the signal under measurement, add the setting of the MIXING FREQUENCY MC switch on the frequency converter to the frequency indication on the FR-38/U. Be sure to interpret the FR-38/U reading correctly in accordance with the decimal point lights and with the setting of the FREQUENCY UNIT control, as described in paragraph 2-26. For example, if the MIXING FREQUENCY MC switch is set at 160 (megacycles) and the FR-38/U counter display is 9243.3546 (kilocycles), the frequency of the unknown is 169,243.3546 kilocycles or 169.24533546 megacycles (stability $\pm 2x10^{-6}$). A further discussion of accuracy considerations and use of the ten-second and one-second gate times is given in paragraph 2-44.

j. To turn off the equipment, turn the FR-38/U Power switch to the off position. The plug-in Frequency Converter CV-394/USA-5 can be removed after the Power switch has been turned off.

CAUTION

To prevent arcing of connectors, do not unplug the frequency converter unless the Power switch is in the off position.

2-126. FREQUENCY MEASUREMENT OF SIGNALS UP TO 10.1 MC. To measure signals in this range when Frequency Converter CV-394/USA-5 is plugged into the FR-38/U, turn the converter Function switch to the DIRECT position. The unknown signal can then be connected to the INPUT connector of the converter, and it will be transferred directly to the FR-38/U without any frequency conversion taking place. To measure signals in the frequency range between 10.1 megacycles and 100 megacycles, the Frequency Converter Unit MX-1637/U must be used instead of the CV-394/USA-5.

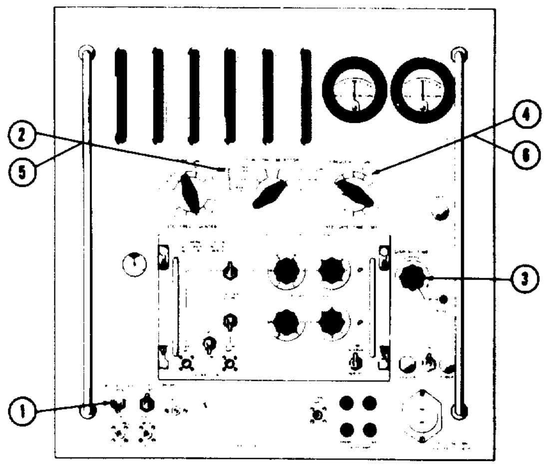
2-127. SUMMARY OF STEP-BY-STEP PROCEDURE. A summary of specifications and step-by-step operating procedures using Frequency Converter CV-394/USA-5 is given in the last two pages of this section.

PRELIMINARY SET-UP INSTRUCTIONS FOR ALL MEASUREMENTS

A. If internal 100 kc frequency standard is being used, make certain crystal oven thermometer reads 65° ±5°C (149° ±9°F). If external standard is used, make certain 100 KC STANDARD switch is in EXT position.

B. Turn off power switch and install proper panel plug-in unit. Then turn on power switch and allow a warm-up period until proper readings on 100 kc and 10 mc self-check are consistently obtained. Repeat self-check occasionally.

PROCEDURE FOR SELF-CHECK



1. Set MANUAL GATE switch to CLOSED.

2. Set FUNCTION SELECTOR switch to 100 KC CHK.

3. Adjust DISPLAY TIME control for desired display time (usually CCW).

4. Note reading on display system for each position of FREQUENCY UNIT switch. These readings should agree with the table below. Check phantastron circuit adjustments if readings do not agree with the table.

5. Now set FUNCTION SELECTOR switch to 10 MC CHK.

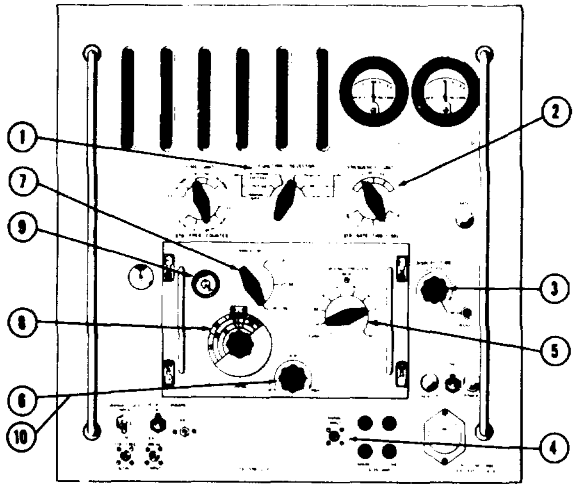
6. Repeat step 4. When checking 10 mc, note that a discrepancy of ±1 count in the last digit is acceptable because of inherent error due to the counting system.

7. If correct readings are obtained, the equipment can be considered to be operating properly. If readings are incorrect, the instrument should be turned over to servicing personnel.

------------------ Counter Readings for Self-Check Operations ----------------

GATE TIME	100 KC CHECK	10 MC CHECK
10 sec	0100.0000	0000.0000 ± .0001
1 sec	00100.000	10000.000 ± .001
0.1 sec	000100.00	010000.00 ± .01
0.01 sec	0000100.0	0010000.0 ± .1
0.001 sec	00000100.	00010000. ± 1

PROCEDURE FOR FREQUENCY MEASUREMENT



PROCEDURE 1. 10 CPS- 10.1 MC

Any plug-in unit may be used. Sensitivity with Time Interval unit is 1 volt rms. Frequency Converter Unit affords variable sensitivity down to 0.2 volts rms.

PROCEDURE 2. 10.1 MC - 100 MC

Frequency Converter plug-in unit must be used. Sensitivity 0.02 volt rms.

PROCEDURE 1.

1. Set FUNCTION SELECTOR switch to FREQUENCY.
2. Set FREQUENCY UNIT switch to desired gate time (usually 1 or 10 seconds).
3. Set DISPLAY TIME control to desired display time (usually CCW).
4. Connect signal to SIGNAL INPUT.

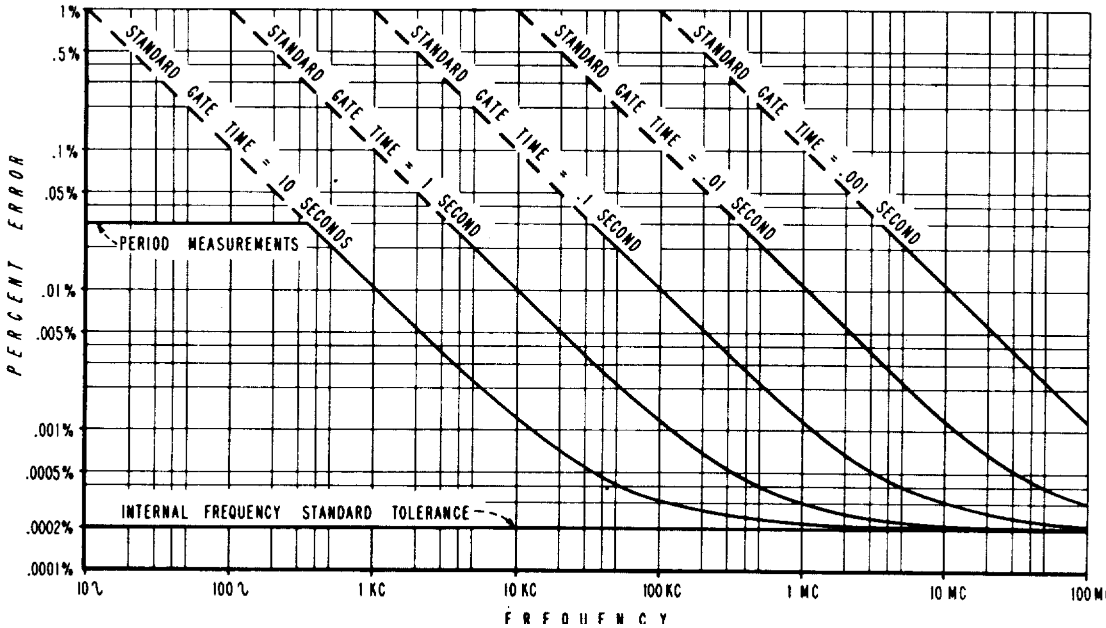
Note

If FREQUENCY CONVERTER unit is used, set MIXING FREQUENCY control to "O" and adjust GAIN control until tuning eye just closes.

PROCEDURE 2.

1. Set FUNCTION SELECTOR switch to FREQUENCY.
2. Set FREQUENCY UNIT switch to desired gate time (usually 1 or 10 seconds).
3. Set DISPLAY TIME control to desired display time (usually CCW).
4. Connect signal to SIGNAL INPUT.
5. Set MIXING FREQUENCY switch to TUNE.
6. Set GAIN control to maximum clockwise position.
7. Set RANGE - MC switch to 10-20 position.
8. Set TUNING control to left end of "10" region. Adjust control slowly until minimum shadow is obtained on tuning eye, changing RANGE - MC switch as necessary. If eye overlaps, reduce GAIN control setting and retune TUNING control.
9. When indication on eye is observed, set MIXING FREQUENCY control to position indicated by TUNING dial.
10. Adjust GAIN control until eye just closes, but does not overlap.
11. Unknown frequency is read by adding reading of MIXING FREQUENCY switch (frequency in megacycles) to reading on display system (frequency in kilocycles).

PROCEDURE FOR FREQUENCY MEASUREMENT (Continued)



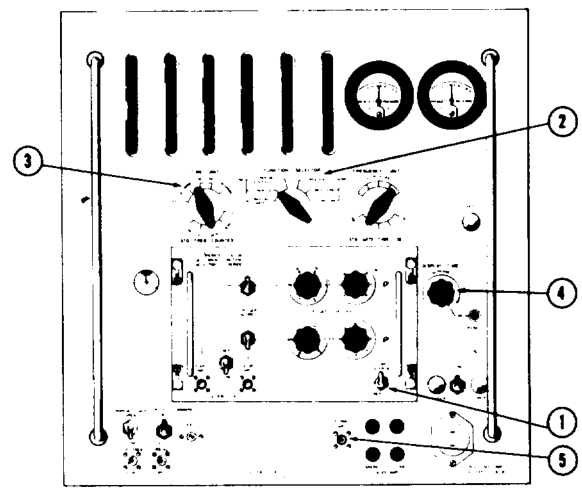
Frequency Measurement Accuracy Curves

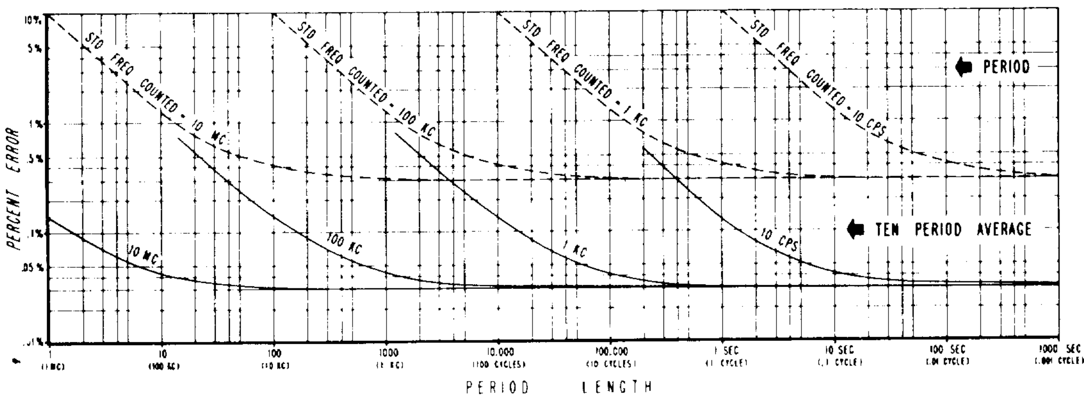
------- Reference Table for Measuring Frequency with Frequency Converter Unit -------

Required Input Signal:	Below 10 Mc: at least 0.2 volt rms. 10 Mc to 100 Mc: 0.02 volt rms. Maximum - 200 volts peak.
Input Impedance:	Below 10 Mc: approximately one megohm shunted by 40 mmf. 10 - 100 Mc: approximately 50 ohms.
Frequency Measurement Range:	10 cps to 100 megacycles.
Accuracy:	±0.0002% ±0.1 cps on 10-second gate.

PROCEDURE FOR PERIOD MEASUREMENT

1. Any plug-in unit may be used. If Time Interval unit is used, set TIME INTERVAL PERIOD switch to PERIOD.
2. Set FUNCTION SELECTOR switch to PERIOD or 10 PERIOD AVERAGE.
3. Set TIME UNIT switch to desired time units (usually largest number of count).
4. Set DISPLAY TIME control for desired display time (usually CCW).
5. Connect signal to SIGNAL INPUT.
6. Period of frequency being measured will now be indicated on display system in units selected by setting of TIME UNIT switch.





Period Measurement Accuracy Curves

----- Reference Table for Measuring Period ------

Required Input Signal:	Minimum: 1 volt rms Maximum: 200 volts rms
Input Impedance:	Approximately 1 megohm shunted by 40 mmf
Period Measurement Range:	100 microseconds to 100 seconds (0.01 cps - 10 kc)
Accuracy:	±0.03% ±0.1 microsecond

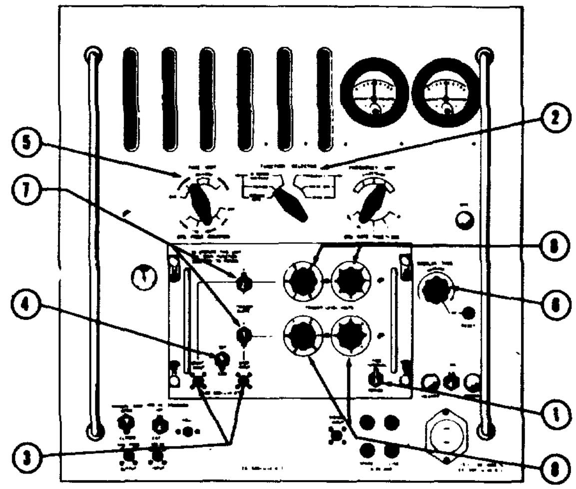
PROCEDURE FOR TIME INTERVAL MEASUREMENT

1. Time Interval plug-in unit must be used. TIME INTERVAL - PERIOD switch must be in TIME INTERVAL position.
2. Set FUNCTION SELECTOR switch to PERIOD.
3. Connect signals to START INPUT and STOP INPUT.
4. Set SEP-COM switch to SEP.

Note

If start and stop signals are from same source, either input connector can be used and SEP-COM switch set to COM.

5. Set TIME UNIT switch to desired time unit (usually for largest number of counts).
6. Set DISPLAY TIME control for desired display time (usually CCW).
7. Set start and stop channel TRIGGER SLOPE switches for measurement start point (positive going or negative-going slope).
8. Adjust TRIGGER LEVEL controls for measurement start point (voltage level -200 to +200 volts).



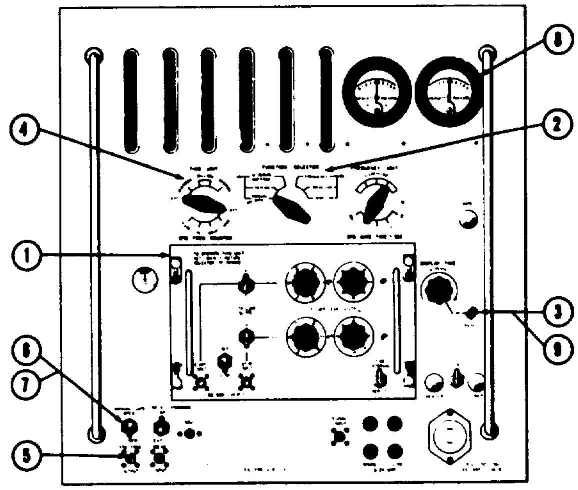
9. Measured time interval will now be displayed in time units selected by TIME UNIT switch.

------- Reference Table for Measuring Time Interval -------

Required Input Signal:	Minimum: 2 volts peak Maximum: ±200 volts peak
Input Impedance:	1 megohm shunted by 20 to 40 mmf approximately (each channel)
Time Interval Range:	1.0 microsecond to 10,000,000 seconds
Control Range for Independent Start and Stop Channels:	Trigger for either positive-going or negative-going input voltages at levels from -200 to +200 volts. Separate or common direct coupled inputs.
Accuracy:	0.1 microsecond ±0.0002% (when counting 10 mc fast rise time pulses). The trigger level controls are accurate to about 20% ±0.2 volts variation in the zero level.

PROCEDURE FOR TOTALIZING

1. Any plug-in unit may be used.
2. Set FUNCTION SELECTOR to MANUAL GATE.
3. Press RESET button to clear counter.
4. Set TIME UNIT switch to EXT.
5. Connect signal to be counted to STD. FREQ. OUTPUT.
6. To begin count, set MANUAL GATE switch to OPEN.
7. To end count, set MANUAL GATE switch to CLOSED.
8. The total number of pulses received during counting period will now appear on counter.
9. Clear counter by pressing RESET button.

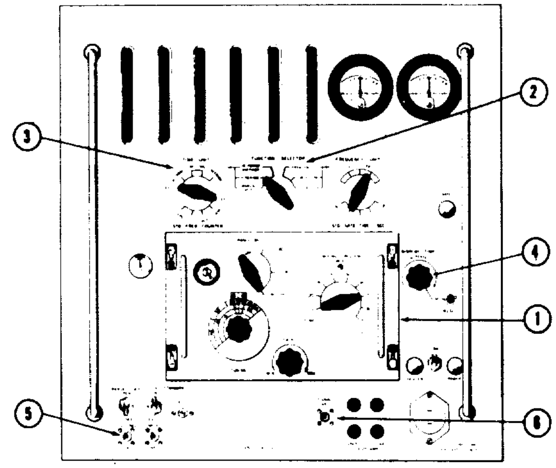


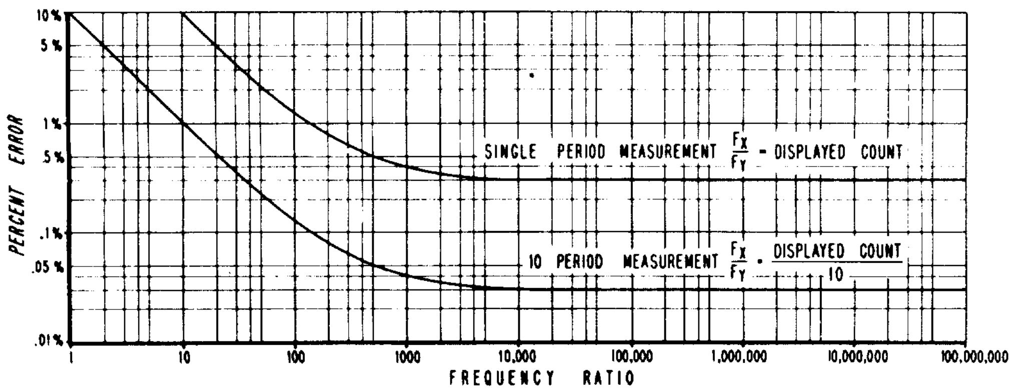
------- Reference Table for Totalizing -------

Input Signal:	Minimum:	1.5 volts peak
	Maximum:	10 volts peak
	Minimum Rise Time:	1 millisecond
Input Impedance:	1 megohm shunted by 100 micro-microfarads	
Counting Capacity:	100,000,000 after which it recycles	
Resolution:	Double pulse - 0.1 microsecond Triple pulse - 0.2 microsecond	

PROCEDURE FOR MEASURING RATIO

1. Any plug-in unit may be used.
2. Set FUNCTION SELECTOR switch to PERIOD or 10 PERIOD AVERAGE.
3. Set TIME UNIT switch to EXT.
4. Set DISPLAY TIME control for desired display time (usually CCW).
5. Connect higher of two input frequencies to STD. FREQ. OUTPUT.
6. Connect lower of two input frequencies to SIGNAL INPUT.
7. Number of cycles of the higher input frequency per cycle or per 10 cycles of the lower input frequency is automatically measured and answer displayed.



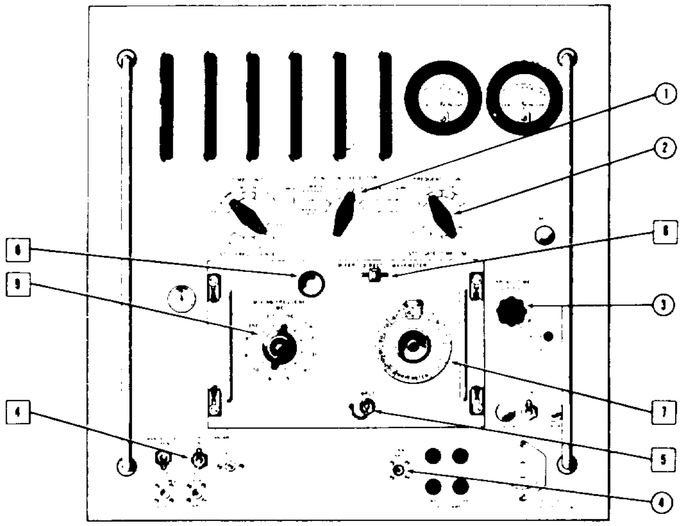


Ratio Measurement Accuracy Curves

------- Reference Table for Ratio Measurements -------

	Higher Frequency		Lower Frequency	
Required Input Signal:	Minimum: Maximum: Minimum rise time:	1.5 volts peak 10 volts peak 1 millisecond	Minimum: Maximum: Rise time:	1.5 volts peak 280 volts peak Any
Input Impedance:	1 megohm shunted by 100 mmf		1 megohm shunted by 40 mmf	
Ratio Measurement Range:	10 mc per second to 10 cps		10 kc to 0.01 cps	
Accuracy:		±0.03% of the total count ±1/total count, for 10 period measurement with one volt rms sine wave		

PROCEDURE FOR FREQUENCY MEASUREMENT USING FREQUENCY CONVERTER CV-394/USA-5



PROCEDURE 1. 10 CPS-10.1 MC

This plug-in unit may be used by turning the Function switch 6 to the DIRECT position. The Frequency Converter is inoperative in this function, and a minimum signal level of 0.2 volts is required.

PROCEDURE 2. 100 MC-220 MC

Frequency Converter plug-in unit must be used. Sensitivity 0.2 volt rms.

PROCEDURE 1.

(1) Set FUNCTION SELECTOR switch to FREQUENCY.

(2) Set FREQUENCY UNIT switch to desired gate time (usually 1 or 10 seconds).

(3) Set DISPLAY TIME control to desired display time (usually CCW).

(4) Connect signal to SIGNAL INPUT.

PROCEDURE 2.

(1) Set FR-38/U FUNCTION SELECTOR switch to FREQUENCY.

(2) Set FREQUENCY UNIT switch to desired gate time (usually 1 or 10 seconds).

(3) Set DISPLAY TIME control to desired display time (usually CCW).

(4) Turn 100 KC STANDARD switch to the EXT. position.

(5) Connect signal to Frequency Converter INPUT connector.

(6) Set Function switch to WAVEMETER position.

(7) Starting at low-frequency end of dial, tune WAVEMETER dial for narrowest indication on tuning eye.

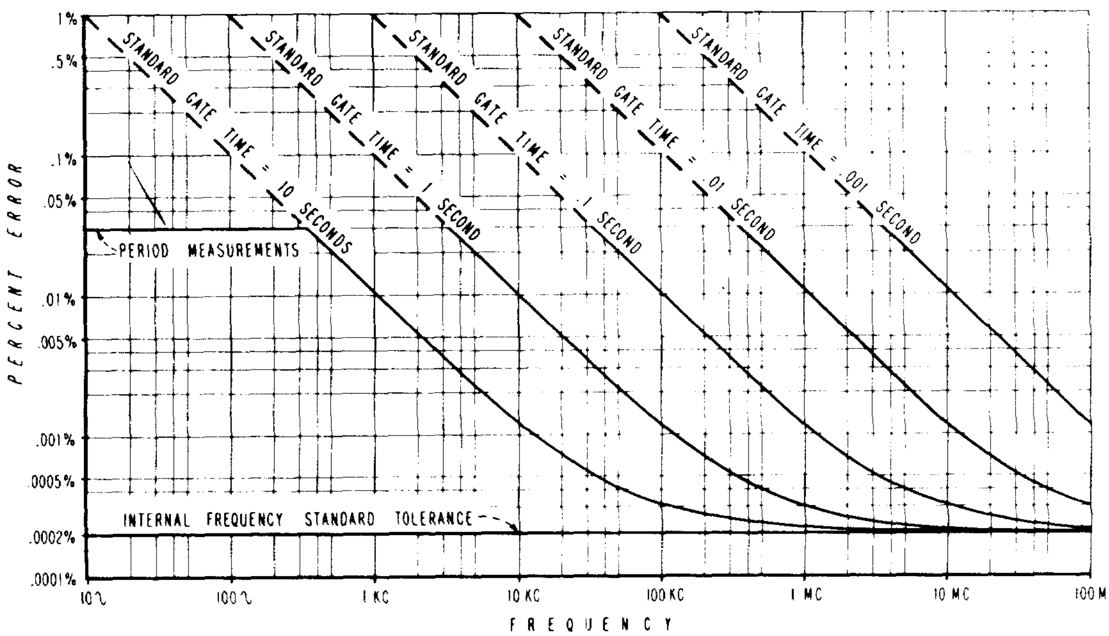
(8) When tuning eye shows narrowest indication, note reading of WAVEMETER dial. Then turn 100 KC STANDARD switch to INT. position.

(9) Turn MIXING FREQUENCY MC switch to the same frequency as the WAVEMETER dial indication. If the WAVEMETER dial position is on the line between two frequencies, set the MIXING FREQUENCY MC switch to the lower of those two frequencies.

10. Turn the Frequency Converter Function switch to the MIXER position. If signal level of input signal is adjustable, adjust it until tuning eye just closes.

11. Read unknown frequency by adding the reading of the MIXING FREQUENCY MC switch (frequency in megacycles) to the reading on the FR-38 U display system (frequency in kilocycles).

PROCEDURE FOR FREQUENCY MEASUREMENT USING FREQUENCY CONVERTER CV-394/USA-5 (Continued)



Frequency Measurement Accuracy Curves

------- Reference Table for Measuring Frequency with Frequency Converter Unit -------

Required Input Signal:	Below 10 Mc: at least 0.2 volt rms. 100 Mc to 220 Mc: at least 0.2 volt rms. Maximum - 200 volts peak.
Input Impedance:	Approximately one megohm shunted by 40 mmf.
Frequency Measurement Range:	10 cps to 10.1 Mc; 100 Mc to 220 Mc.
Accuracy:	±0.0002% ±0.1 cps on 10-second gate.

SECTION III

OPERATING CHECKS AND ADJUSTMENTS

3-1. GENERAL.

3-2. The following paragraphs describe operating checks that should be made prior to actual operation. These checks are required to maintain the accuracy of the instrument.

3-3. STABILIZING 100-KC CRYSTAL. After installing the equipment, it usually requires several days of operation for the crystal in the internal frequency standard to reach its specified stability of 2 parts per million per week.

3-4. STANDARDIZING 100-KC CRYSTAL OSCILLATOR. In order to maintain the accuracy of the FR-38/U, the internal 100 kc crystal-controlled oscillator should be standardized at regular intervals unless an external frequency standard is being used. The long-time drift of the oscillator is within ±2 parts per million per week. If maximum accuracy is to be maintained, therefore, the oscillator should be standardized approximately once a week. Because of the importance of maintaining the accuracy of the oscillator, the adjusting process has been made simple.

3-5. There are two methods for standardizing the oscillator. The first method consists of measuring an accurately-known standard frequency and adjusting the oscillator until the FR-38/U reads correctly. The other method uses a communication type radio receiver to beat a harmonic of 100 kc internal standard with National Bureau of Standards Station WWV.

CAUTION

The first method of standardizing the oscillator is only satisfactory as long as the external standard frequency used is known to be more accurate than the FR-38/U. The FR-38/U is a very accurate instrument, and one of the common causes of in operation occurs from attempting to standardize it against less accurate equipment. Since the FR-38/U is generally more accurate than any frequency standard available at most naval installations, the second method will usually have to be used.

3-6. METHOD I. The quicker of the two possible methods for standardizing the internal oscillator is to apply to the FR-38/U for counting, an external standard frequency of high accuracy. The internal oscillator can then be adjusted until the reading obtained on the counter is accurate. The external standard frequency to be used will usually be available only from an external frequency standard and should have the following characteristics:

a. It should be not less than 1 megacycle nor more than 10 megacycles. A frequency of 10 megacycles is ideal for standardizing.

b. It should be accurate within approximately 8 to 10 parts in 10^7. However, if the FR-38/U has not been standardized for an extended interval, such as three months, a standard frequency of less precision may be useful.

c. It must have an amplitude of at least 0.2 volt rms when applied to the SIGNAL INPUT terminal of the FR-38/U. At this connector the input impedance is 1 megohm shunted by approximately 40 µµf. This assumes that the Frequency Converter is in place.

d. It must have a signal/noise ratio of at least 40 db.

3-7. PROCEDURE FOR STANDARDIZING USING METHOD I.

a. The FR-38/U must be thoroughly heated. If it is being standardized for the first time, it should be allowed to operate continuously (POWER switch in standby or down position) for at least several days before the standardization can be considered complete.

b. Install the Frequency Converter plug-in unit. Turn off power switch before removing or installing.

c. Self-check the instrument as described in paragraph 2-14. If the self-check does not show the equipment to be operating properly, the trouble must be repaired before proceeding.

d. Apply the standard frequency to the SIGNAL INPUT terminal of the FR-38/U.

e. Set FUNCTION SELECTOR switch to FREQUENCY.

f. If a 10-megacycle standardizing frequency is being used, set FREQUENCY UNIT switch for a 1second gate time. If a 1-megacycle standardizing frequency is being used, set FREQUENCY UNIT switch for a 10-second gate time.

g. Set DISPLAY TIME control fully counterclockwise.

h. Using a screwdriver, turn ADI control at lower left of front panel until counter reading is accurate, paying particular attention to the accuracy of the two meter readings. The ADJ control is provided with a 5/16-inch locknut. However, this nut has been set at the factory so that it acts as a high-torque device and does not lock firmly. If the setting of the nut has been subsequently tightened, it must be loosened before making the adjustment.

i. The control should be adjusted so that the reading on the counters is 10,000,000 if a 1-megacycle or 10-megacycle standardizing frequency is being used. If other than these values are being used, the control should be adjusted until the counter reading accurately displays the frequency used.

j. If a 10-megacycle frequency is being used, the above procedure requires that the adjustment be made using a 1-second gate. After the adjustment has been made, the FUNCTION SELECTOR can be set for a 10-second gate and the reading on the counters noted. The reading should be within ±10 of 100,000,000. Ordinarily, the reading will be within ±1 part of 100,000,000.

3-8. METHOD II. The second method for standardizing the internal oscillator is to zero-beat the oscillator against Bureau of Standards Station WWV, using a communications receiver to detect the beat. The internally-generated 100 kc frequency is available at the STD. FREQ. OUTPUT connector on the front panel and has sufficient harmonic content so that a beat can be obtained at least as high as the 10-megacycle transmission from WWV. It should be noted that, although WWV is rated as accurate within 2 parts in 10^8, doppler effects in the transmission reduce this accuracy. As a result, the received frequency is usually accurate within a few parts in 10^8, although on occasion it may be worse.

3-9. PROCEDURE FOR STANDARDIZING USING METHOD II.

a. Follow steps a through c from paragraph 3-7 above.

b. Set TIME UNIT switch to 100 kc.

c. Set 100 KC STANDARD switch to INT position.

d. Couple the 100 kc signal from the STD. FREQ. OUTPUT connector to the antenna of a communications receiver. This coupling should be loose and can ordinarily be made by running a single wire from STD. FREQ. OUTPUT near the antenna lead-in. If additional coupling is required, the wire can be wrapped a few times loosely around the lead-in.

e. Adjust the receiver so that the beat can be heard.

f. Turn ADJ control at lower left of front panel with a screwdriver until zero beat is obtained. See note in paragraph 3-7h regarding locknut on ADJ control.

3-10. USING AN EXTERNAL 100 KC STANDARD. The FR-38/U is arranged so that it can use an external 100 kc standard frequency in place of the internally generated 100 kc frequency. This arrangement is provided for situations where there is available an external 100 kc primary frequency standard that has higher accuracy than the internal oscillator which is stable within 2 parts per million per week.

3-11. The external standard frequency should be connected to the 100 KC INPUT connector (23) and must have an amplitude between 1 volt and 10 volts rms at the 100 KC INPUT connector. The input impedance at this connector is 1 megohm shunted by 30 µµf. When using an external standard frequency, the 100 KC STANDARD switch must be in the EXT position.

SECTION IV

EMERGENCY OPERATION AND REPAIR

CAUTION

Frequency Meter AN/USM-26 is a precision measuring instrument equivalent to a high quality secondary frequency standard. It is strongly recommended that operating personnel do not attempt any maintenance or troubleshooting work on the equipment beyond the scope of information in this manual. Experience with this equipment has shown that haphazard replacement of tubes or other components will only obscure any trouble that may occur.

Any test prods used for measurement purposes should be carefully wrapped with electrical insulating tape so that only the extreme tip of the probe is exposed. Accidentally shorting certain circuits to ground or to another circuit, even momentarily, can burn out a large number of the crystal diodes used in the equipment.

4-1. EMERGENCY OPERATION.

4-2. In order to gain access to some of the adjustments described in the following paragraphs, it is necessary to unscrew the cabinet removal screws (shown in Figure 4-1) and slide off the cabinet.

4-3. ADJUSTING PHANTASTRONS. The standard gate times that are used for frequency measurements are derived from the internal 100 kc precision crystal oscillator in the FR-38/U. To obtain these gate times, a series of decade frequency dividers known as phantastrons are used. Occasionally, the circuit constants may change with time to the point where the phantastron may begin dividing by a factor of 9 or 11 instead of by 10. If this happens, a simple adjustment will restore the accuracy of the circuit.

4-4. When the dividing factor of a phantastron changes to 9 or 11, the readings obtained when self-checking the equipment will appear to have spurious 9's or 11's

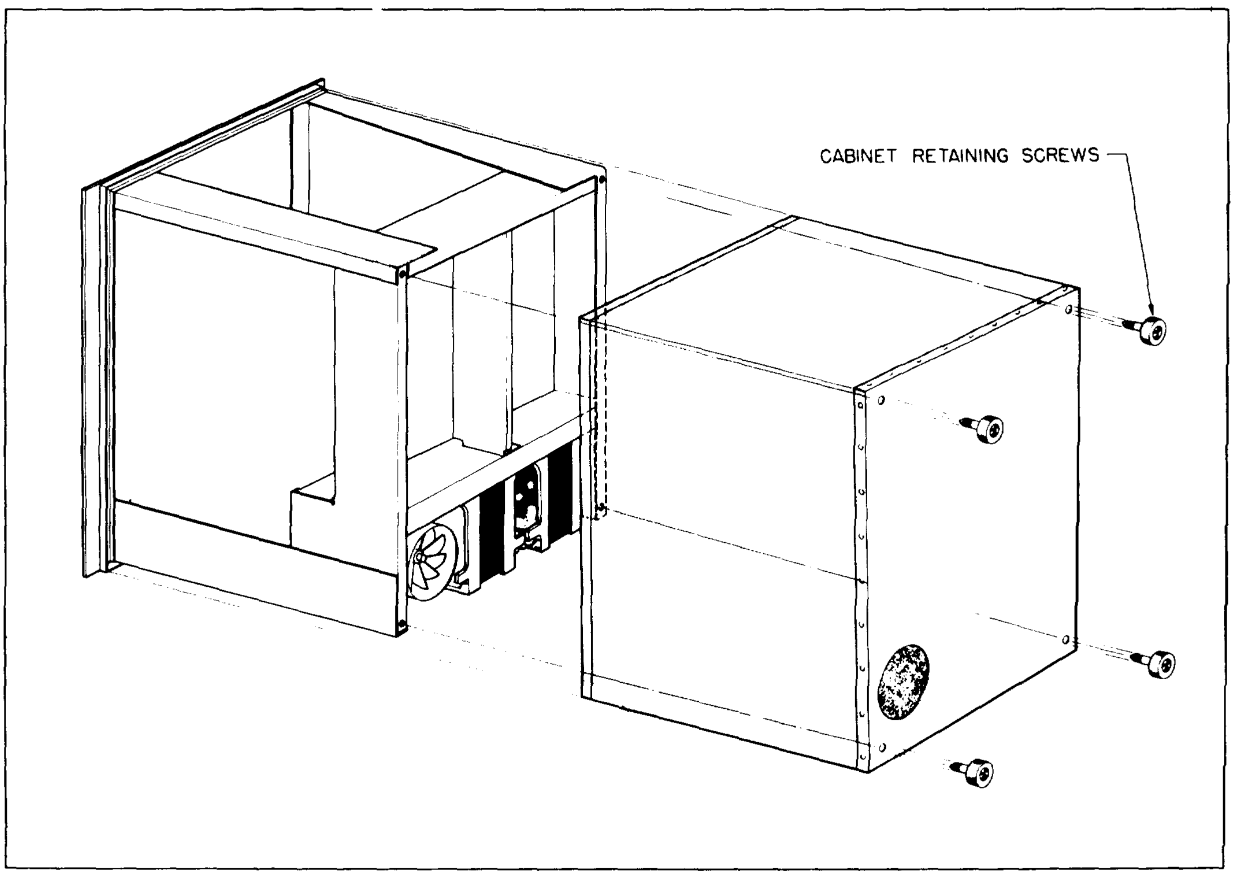
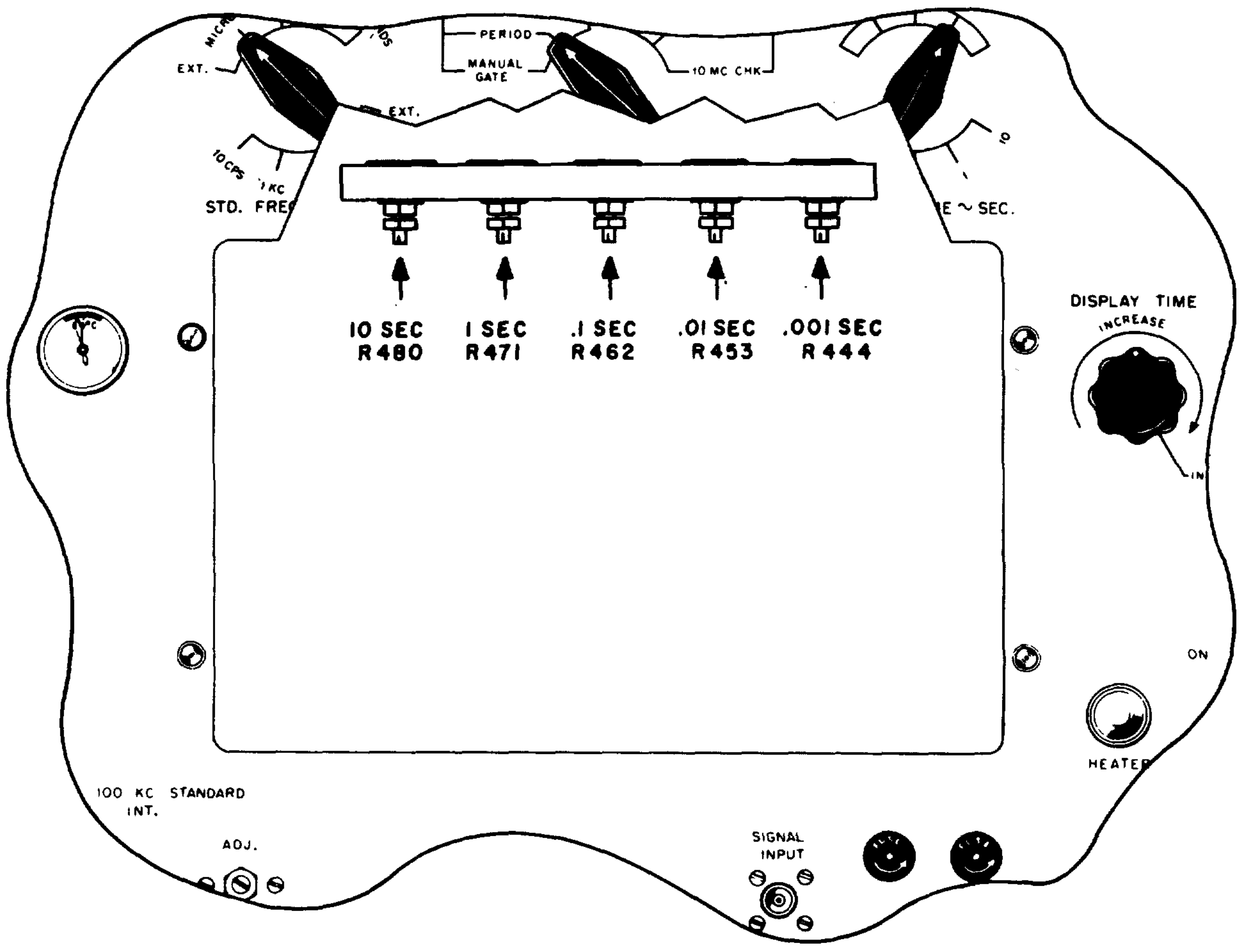


Figure 4-1. Frequency Meter FR-38/U Chassis and Cabinet, Showing Cabinet Removal Screws



PHANTASTRON ADJUSTMENTS

PART NO.	R444	R453	R462	R471	R480
PHAN.	1ST	2ND	3RD	4TH	5TH
GATE TIME	.001 SEC	.01 SEC	.1 SEC	1 SEC	10 SEC
FREQ.	10 KC	1 KC	100∿	10∿	1∿

Figure 4-2. Phantastron Adjustments, Location Diagram

instead of 10's in the displayed value. To correct this error, the following procedure should be used.

4-5. PROCEDURE FOR ADJSTING PHANTASTRONS.

a. Turn off POWER switch and remove panel plug-in unit. Turn on POWER switch and allow the instrument to warm up for at least 15 minutes.

b. Set FUNCTION SELECTOR to 100 KC CHECK.

c. Set FREQUENCY UNIT switch to 0.001 second gate time.

d. Set DISPLAY TIME control for minimum display time.

e. Reading on counter should now be 00000100. If a reading such as 00000090 or 00000110 (or even 00000080 or 00000120) is obtained, the first phantastron will require adjusting. A series of potentiometers are provided for adjusting the phantastrons and are located just inside the upper edge of the plug-in aperture in the front panel (Figure 4-2). R-444 should be adjusted until it is set in the center of the region where a stable reading of 00000100 is obtained. The adjusting potentiometers are provided with locknuts, but the locknuts have been set at the factory to have a high torque effect instead of a locking effect. Consequently, the potentiometers can be adjusted without disturbing the locknut.

f. Set FREQUENCY UNIT switch to 0.01 second gate time.

g. Reading on counter should now be 0000100.0. If the reading is "90.0" or "110.0" instead of "100.0", adjust R-453 (Figure 4-2) in a manner similar to the adjustment of R-444. However, R-453 should be set so that it is in the middle of its region that gives a correct reading on the counters.

h. Set FREQUENCY UNIT switch to 0.1 second gate time.

i. Reading on counter should now be 0000100.00. If reading is "90.00" or "110.00" instead of "100.00", adjust R-462. Set R-462 so that it is in the middle of the region that gives an accurate reading.

j. Proceed in a similar manner for the 1-second and 10-second gate times, setting R-471 and R-480, respectively. Set both potentiometers so that they are in the middle of the regions that give accurate counter readings.

4-6. ADJUSTING GATE LENGTH. R-224 is a screwdriver-operated potentiometer that adjusts the grid bias on the Gate Amplifier V-203. Since the bias on V-203 affects to a slight extent the length of the gate time, it is important that the bias be correct, although, in general, it will only be necessary to reset this bias when replacing V-203 or V-208. The procedure for adjusting the bias on V-203 is as follows:

a. Install one of the panel plug-in units, making certain that the POWER switch is off before the unit is installed.

b. Remove cabinet from FR-38/U. See Figure 4-1 for location of cabinet-securing screws.

c. Turn on the equipment and allow a five-minute warm-up.

d. Set FUNCTION SELECTOR switch to 10 MC CHECK position and set FREQUENCY UNIT switch to 1 second gate position.

e. Adjust GATE LENGTH control R-224 with a screwdriver until the counter reads 10,000.000 ±1. The location of R-224 is shown in Figure 4-3. Note that R-224 is a locking-type potentiometer. The locknut has been set at the factory so that it has high-torque action instead of a locking action. If this adjustment has not been disturbed, it will not be necessary to loosen the locknut.

f. Re-adjust R-224, using the above procedure after 24 hours of continuous operation.

4-7. ADJUSTING BIAS OF TRIGGER UNIT Z-201. The grid bias on V-601B in Trigger Unit Z-201 (signal channel trigger unit) is made adjustable so that the sensitivity of the trigger unit can be adjusted. If this sensitivity adjustment is incorrect, it can cause counting at half the proper rate and at twice the proper rate. Usually, the adjustment is required only when V-601, V-802, or V-603 in the trigger unit is replaced. The procedure is as follows:

a. Install one of the panel plug-in units, making certain that the POWER switch is off before the unit is installed.

b. Remove cabinet from the FR-38/U. See Figure 4-1 for location of cabinet securing screws.

c. Turn on POWER switch and allow equipment to warm up for five minutes.

d. Set FUNCTION SELECTOR to MANUAL GATE position.

e. Set TIME UNIT switch to 100 KC position.

f. Set MANUAL GATE switch to OPEN. A continuously-increasing reading should now be obtained on display system.

g. Adjust FREQ. SENS. potentiometer R-211 (shown in Figure 4-3) with a screwdriver until bias is correct. To do this, first turn R-211 fully counterclockwise and note reading being obtained on the counters. The counter is being supplied with a 100 kc frequency and its reading will increase by 100,000 counts each second. If this is happening, it indicates that circuit is operating satisfactorily except for incorrect bias. Turning R-211 fully clockwise will cause the count to stop. This indicates that range of bias is satisfactory since it has cut off the amplifier in the trigger unit. Next, turn R-211 slowly counterclockwise while watching the counters. At first, the counters will begin an erratic or slow count equal probably to 50 kc. Slowly continue the counterclockwise adjustment until counters operate at the correct rate (i.e., 100 kc each second). Note the two panel meter readings to see that these readings are stable and do not occasionally "jump". If they are slightly erratic, increase counterclockwise setting of R-211 very slightly.

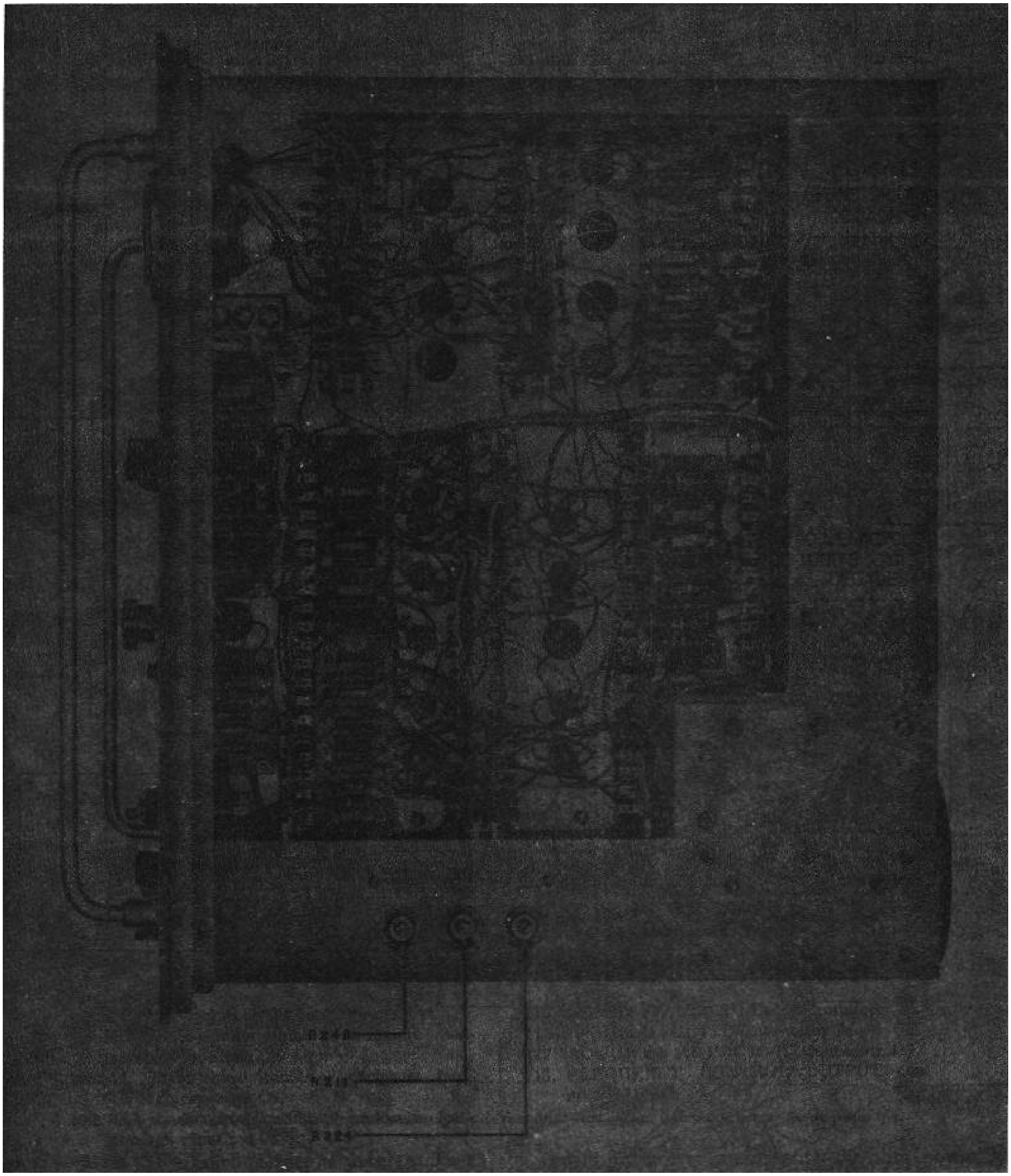


Figure 4-3. Frequency Meter FR-38/U, Right Side View

4-8. ADJUSTING BIAS ON TIME INTERVAL PLUG-IN UNIT. Two screwdriver-operated potentiometers are available at the front panel of the Time Interval plug-in unit. (See Figure 2-1, controls 36 and 42.) These potentiometers affect the accuracy of calibration of the Trigger Level controls on the front of the Time Interval Unit. Although the calibration of these controls is only approximate (within 20%), it is advisable to set the calibration when replacing V-601, V602, or V-603.

a. If Time Interval panel plug-in unit is not in place, turn off POWER switch and install that unit.

b. With POWER switch off, remove cabinet from the FR-38/U. See Figure 4-1.

c. Turn on POWER switch and allow equipment to warm up for approximately five minutes.

d. Set FUNCTION SELECTOR to PERIOD.

e. Set TIME UNIT switch to 10 MC.

f. Set TIME INTERVAL - PERIOD switch on Time Interval unit to TIME INTERVAL.

g. Set SEP-COM switch on Time Interval unit to COM.

h. Set both TRIGGER SLOPE switches on Time Interval unit so that they indicate same polarity (either + or -).

i. Set both TRIGGER LEVEL controls to 0.

j. Set both TRIGGER LEVEL multipliers to x1.

k. Connect a 1 kc sine wave voltage of approximately 1 volt rms amplitude to START INPUT or STOP INPUT terminal.

l. Now rotate start channel TRIGGER LEVEL control on positive side of zero and note reading of control at which the measurement ceases to recur. Repeat for the negative side of zero.

m. It the two points at which the measurement ceases are not symmetrically located around the zero calibration, adjust R-119 at the upper right of the Time Interval unit panel until this condition is achieved.

n. After the start channel calibration has been adjusted, the procedure can be repeated for the stop channel by adjusting R-107 at the lower right of the Time Interval unit panel until the calibration of the stop channel TRIGGER LEVEL control is symmetrical.

CAUTION

Test prods used with the FR-38/U should be taped with insulating tape so that only the extreme tip of the prod has exposed metal. Accidentally shorting the +70 or +90 volt buses to ground or to the +210 volt bus with a test prod can destroy most of the crystal diodes used in the equipment.

4-9. ADJUSTING POWER SUPPLY VOLTAGES. The power supply section of the FR-38/U provides four regulated d-c voltages: -195, +70, +90, and +210 volts. These voltages are interdependent so that when one voltage is adjusted for any reason, all four voltages should be checked. Usually, it will not be necessary to adjust the power supply voltages except when a tube or other component in the power supply section is replaced. All power supply adjustments are shown in Figure 4-4. The adjustment procedure is as follows:

a. One of the panel plug-in units must be in place.

b. With the POWER switch turned off, remove the cabinet from the FR-38/U. Figure 4-1 shows location of cabinet-securing screws.

c. Turn on the POWER switch and allow the equipment to warm up for five minutes. Turn the equipment so that the back of the power supply, deck is accessible.

d. It is advisable that the line voltage from which the FR-38/U is operating be 115 volts ±2%. In any case the line voltage should not be less than 105 volts nor more than 125 volts.

e. First adjust the -195 volt supply. To do this, set a high-resistance d-c voltmeter such as the AN/PSM-4 to measure -195 volts dc and connect between ground and the green wire end of R-523 or R-526 (see Figure 4-4). Adjust R-524 until voltmeter reads -195 volts..

f. Next, adjust the +210 volt supply. Set the voltmeter to read +210 volts. Connect voltmeter between ground and the red wire end of R-502 or R-505 (see Figure 4-4). Adjust R-501 until voltmeter reads +210 volts.

g. Next, adjust +90 volt supply. Set voltmeter to read +90 volts. Connect voltmeter between ground and purple wire end of R-510 or R-509. Adjust R-509 until voltmeter reads +90 volts.

h. Finally, adjust the +70 volt supply. Set voltmeter to read +70 volts. Connect voltmeter test leads between ground and orange wire end of R-517 or C-346. Adjust R-516 until voltmeter reads +70 volts.

i. Since the settings are interdependent, the adjustments should now be checked and repeated if necessary.

4-10. TROUBLE-SHOOTING DECIMAL COUNTING UNITS Z-204 to Z-209. When a Decimal Counting Unit (DCU) is suspected of counting incorrectly, it should be interchanged with another unit in the equipment or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully; the counting units are the indicating devices of the equipment, and faulty operation may be ascribed to them when the symptoms are actually the external indication of some other fault in the equipment.

4-11. Two methods are recommended for finding the trouble in a faulty counting unit. First, the lighting sequence can be observed while driving the equipment at a low repetition rate. Second, the waveform of each stage can be studied while

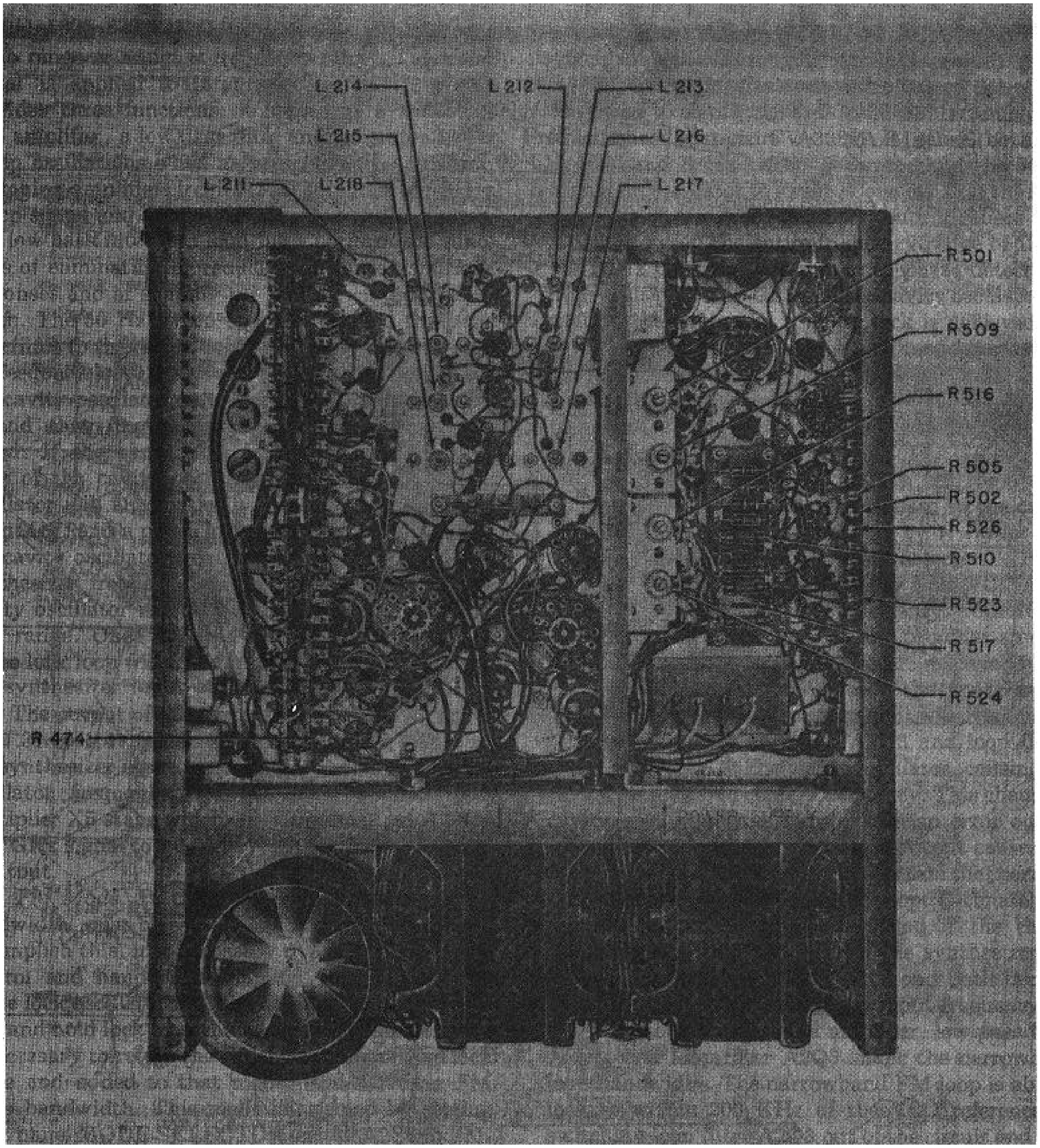


Figure 4-4. Frequency Meter FR-38/U, Rear View

driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. In difficult cases, both methods should be tried. Marginal failures may occur at high counting speeds and not at lower speeds, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

4-12. In general, try replacing tubes first when it has been determined that a DCU is defective. Then check the +300 vdc unregulated source.

4-13. CLEANING CONNECTOR CONTACTS. If the contacts on the 8- and 16-contact plug-in connectors (P1, P2, J201, J202, etc.) become dirty, erratic counting may occur when measuring low frequencies of approximately 10 kc and below. This effect is usually noticeable when using low signal levels of 0.2 volt or so while the Frequency Converter unit is in place. With the power switch off, the contacts can be cleaned approximately once a month with a soft, lint-free, dry cloth.

4-14. In persistent cases, the cloth may be dampened with cleaning solvent, taking suitable precautions against possible explosion or fire.

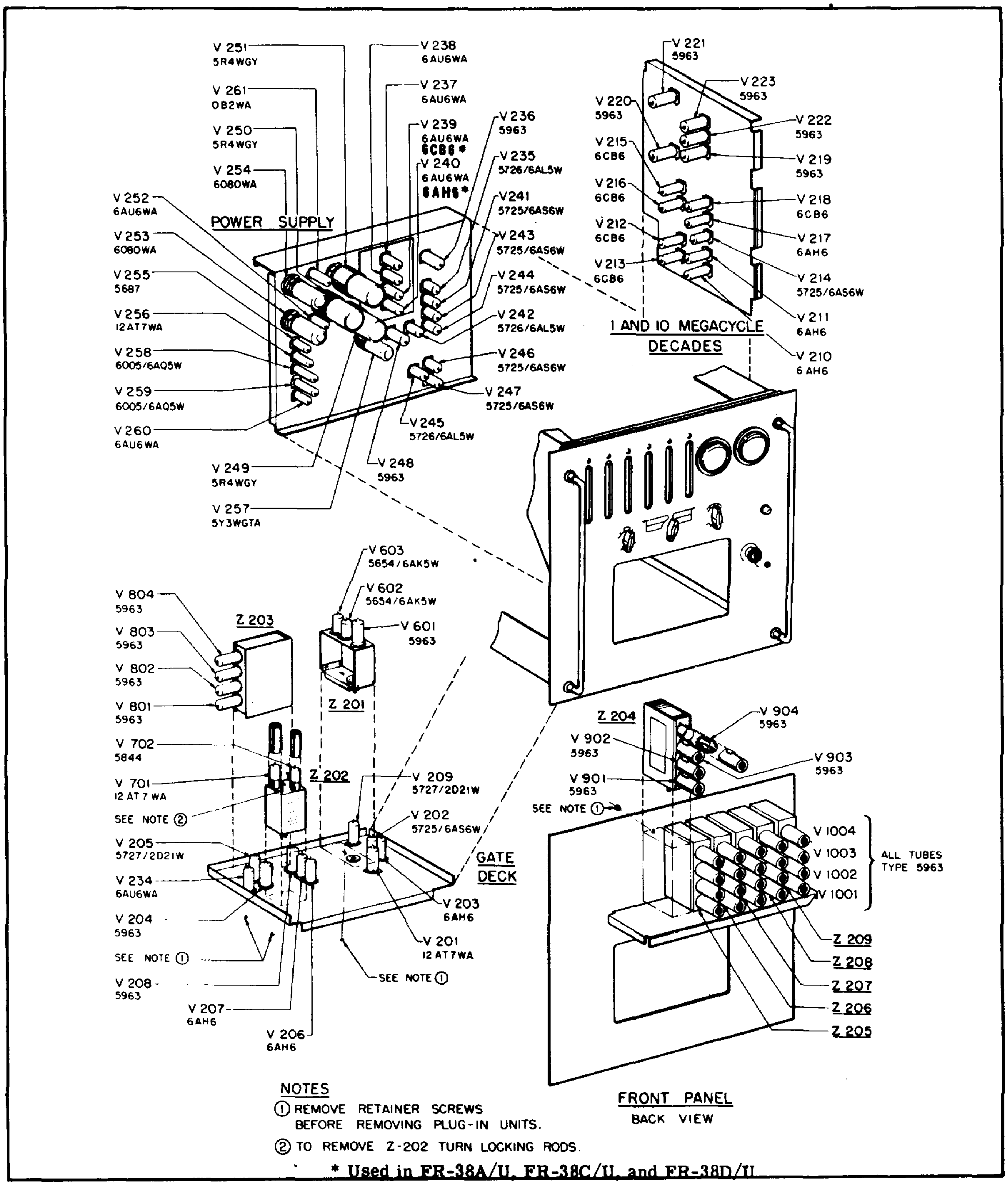


Figure 4-5. Frequency Meter FR-38/U, Tube Location Diagram

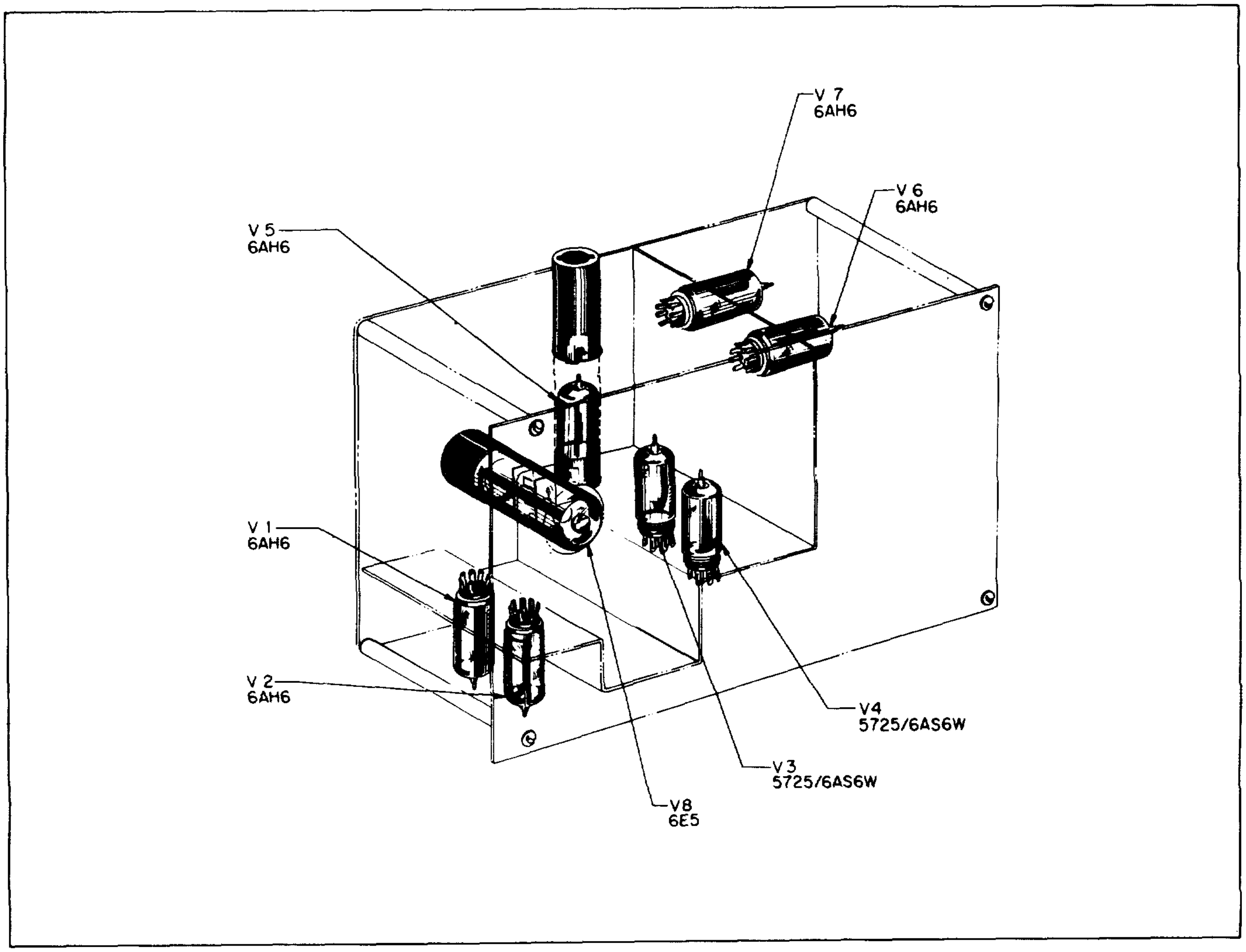


Figure 4-6. Frequency Converter Unit, Tube Location Diagram

4-15. ADDITIONAL ADJUSTMENTS.

4-16. If the adjustments described in preceding paragraphs do not restore satisfactory operation, other troubles are indicated. Major repair and troubleshooting requires careful servicing and should be referred to the proper maintenance personnel.

4-17. EMERGENCY REPAIR.

4-18. LOCATION OF TUBES, FUSES, AND LAMPS. The location of tubes is shown in Figures 4-5, 4-6, and 4-7. The location of fuses is shown in the front panel illustration, Figure 2-1. Spare fuses are located in fuseholders on the front panel so that the blown fuse may be replaced from a spare fuseholder adjacent to the blown fuse. The pilot lamps (Figure 2-1) are Mazda #47, rated at 6-8 volts at 0.15 ampere, and can be replaced by unscrewing the jewel from the lampholder.

4-19. TUBE REPLACEMENT. In the event of equipment malfunctioning or failure, the equipment can be examined for obvious tube failure, i.e., cold tubes (burned-out filament), and the tube or tubes replaced. Weak tubes may also cause improper operation. If power supply voltages are checked and found normal, weak tubes may be replaced in circuits such as the phantastrons or power supply and require only minor circuit adjustments to again obtain satisfactory operation. If the replacement tube does not correct the operation, the original tube should be replaced in the socket The procedures given in paragraphs 4-3 through 4-14 are, in general, those procedures that must be followed when replacing these tubes. Replacement of tubes in other circuits is not recommended unless the equipment can be given a complete servicing check.

4-20. AIR FILTER. The air filter element is a renewable type which can be cleaned by washing with a solution of ordinary household detergent and water. The filter should be inspected weekly and cleaned if the collected dirt is appreciable enough to hamper free air circulation.

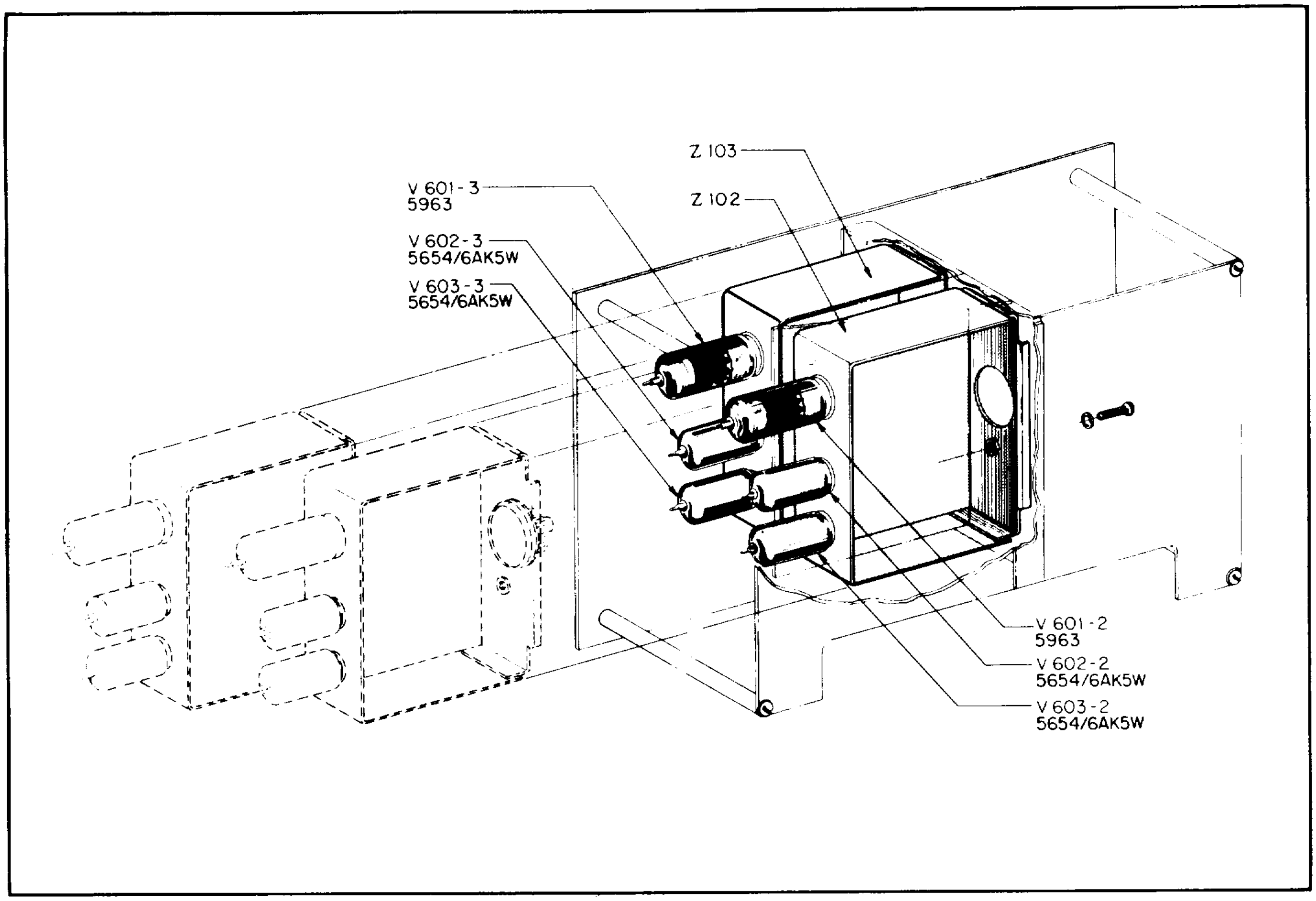


Figure 4-7. Time Interval Unit, Tube Location Diagram

4-21. EMERGENCY OPERATION AND REPAIR OF AN/USA-5. No emergency operation procedures are specified or authorized for the AN/USA-5. Emergency repair of this unit is limited to replacing certain tubes in Frequency Converter CV-394/USA-5. It is preferred that tube replacement, when necessary, be carried out by organizational maintenance personnel following instructions given in this manual When necessary, tubes V2 througnV6 may be checked by the substitution method and replaced if defective. If tubes V2, V3, or V6 are replaced, the unit should be checked and adjusted by organizational or squadron maintenance personnel as soon as possible after this emergency replacement. Tube V1 must be replaced only by organizational or squadron maintenance personnel, using the tube selection procedures given in this manual.

SECTION IV

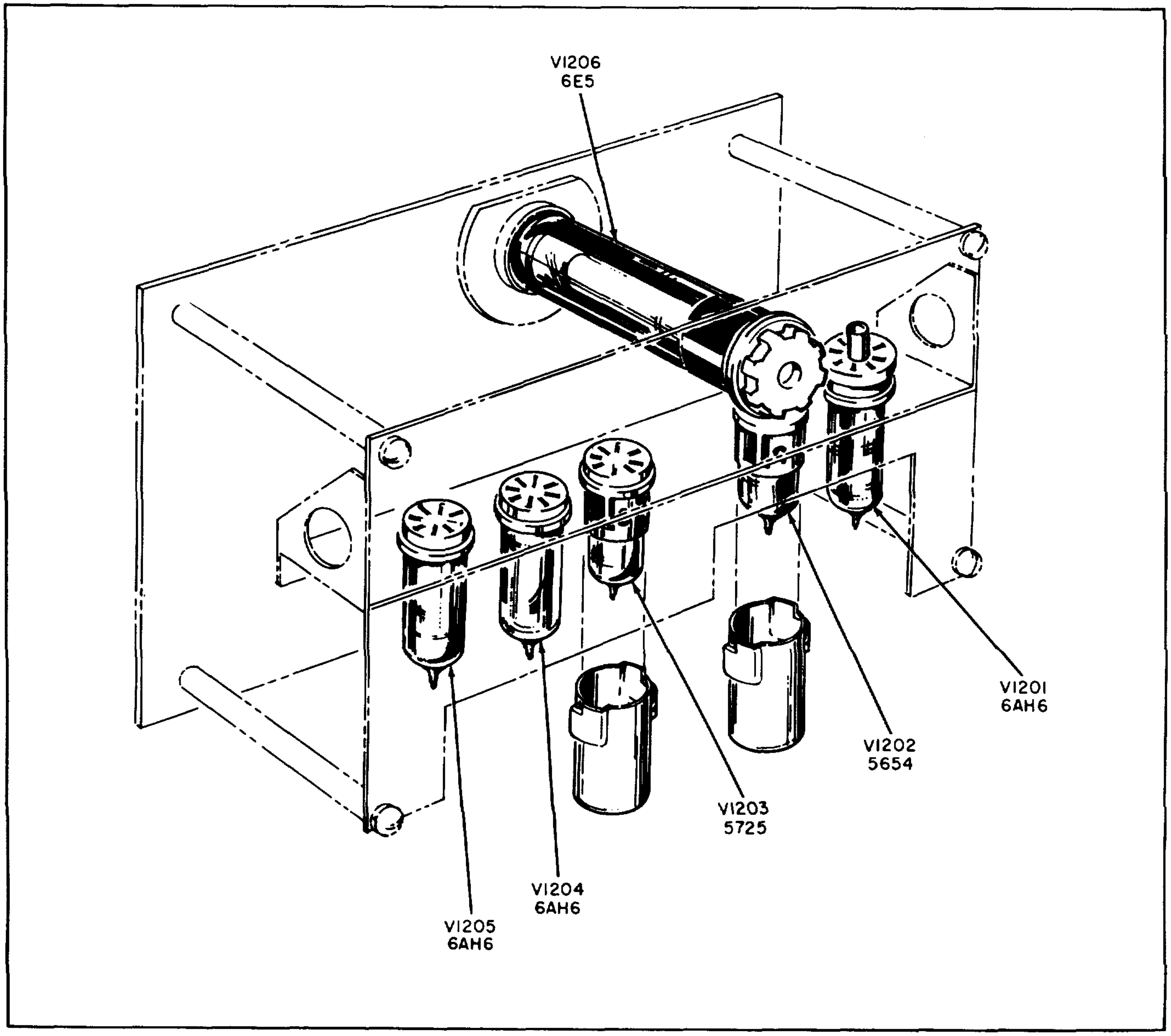


Figure 4-8. Frequency Converter CV-394/USA-5, Tube Location Diagram

SECTION V

OPERATOR DIFFERENCE DATA SHEETS

Operating instructions for the models included in this section are the same as the procedures for the AN/USM-26 Frequency Meter except for the specific differences noted by the applicable Difference Data Sheet. Sections I through IV contains complete operating instruction information for the AN/USM-26 Frequency Meter.

Index to Difference Data Sheets

Frequency Meter **Contract No. N383(MIS-11-383)78111** **Model AN/USM-26A**

The Instructions Contained in Preceding Sections of This Manual Apply Except for the Differences Given in This Data Sheet

GENERAL DESCRIPTION

PREPOSE OF EQUIPMENT
Refer to paragraph 1-3. Same as for the AN/USM-26 except in Table 1-1 the frequency range is from 10cps to 510 megacycles and the Period measurement range is from 10 microseconds to 100 seconds (.01cps to 100KC). In the time or frequency ratios measurement range the lower of the two frequencies can be as high as 100KCS.

EQUIPMENT SUPPLIED
Refer to paragraph 1-9. Same as for the AN/USM-26 except as follows:

a. The equipment supplied with the AN/USM-26A are listed in Table 5-1.

b. The main components of the Frequency Meter AN/USM-26A are shown in Figure 5-1, 1-3, and 1-4. Figure 5-1 shows the Frequency Meter FR-38E/U, the actual frequency-measuring component.

c. A later model of the FR-38/U, manufactured by Crescent Communications Corp. Is called the FR-38E/U.

d. The operating instructions given for the FR-38/U in this manual also apply to the FR-38E/U except where differences are detailed in the DIFFERENCE DATA SHEETS. The FR-38E/U differs from FR-38/U in physical appearance, location of certain operating controls, and in the electrical specifications. Extensive differences in component location and type are described in sections 7 through 14.

GENERAL ELECTRICAL CHARACTERISTICS
Refer to paragraph 1-14. Same as for the AN/USM-26 except as follows:

a. The PERIOD measurement range of the FR-38-E/U is from 0.01CPS to 100 KILOCYCLES per second.

b. The accuracy of the FR-38E/U when measuring frequencies between 10 cycles and 10 megacycles is ± 0.000005% ± 0.1 CPS for an input signal of 0.1 volt RMS or more. The voltage sensitivity of the equipment in the 10 to 100 megacycle range is increased by the video amplifier of the converter unit to 0.01 volt RMS.

c. The accuracy of the FR-38E/U when measuring the period of sine wave frequencies trip to 100 kilocycles is ±0.03% for input signals of 1 volt RMS.

d. The Time Interval Plug-in unit enables the instrument to measure time intervals from 1 micro-second to 10,000,000 seconds. These measurements are accurate within ± 0.000005% ± 0.1 microsecond, provided the rise times of the start and stop signals are negligible compared to the interval being measured.

e. The complete specifications for the equipment are set out in Table 5-2.

MEASUREMENT DISPLAY SYSTEM
Refer to Paragraph 1-27. Same as for the AN/USM-26 except as follows:

a. In the FR-38E/U all of the digits are indicated by illuminated numerals.

Table 5-1. Equipment Supplied with AN/USM-26A

Quan. Per Equip.	Item	AN Type Designation	Overall Dimensions (in.) Ht. or Length	Width	Depth	Wt. (lbs)
1	Frequency, Meter	FR-38E/U	19-7/32	19	18-5/8	109
1	Frequency Converter Unit	MX-1636A/U	6-3/8	10	6-1/8	5
1	Time Interval Unit	MX-1637A/U	6-3/8	10	6-1/8	4
1	Power Cable	CX-3155/U (8'0")	96			0.6
Rest same as for AN/USM-26 - Refer to Table 1-2						

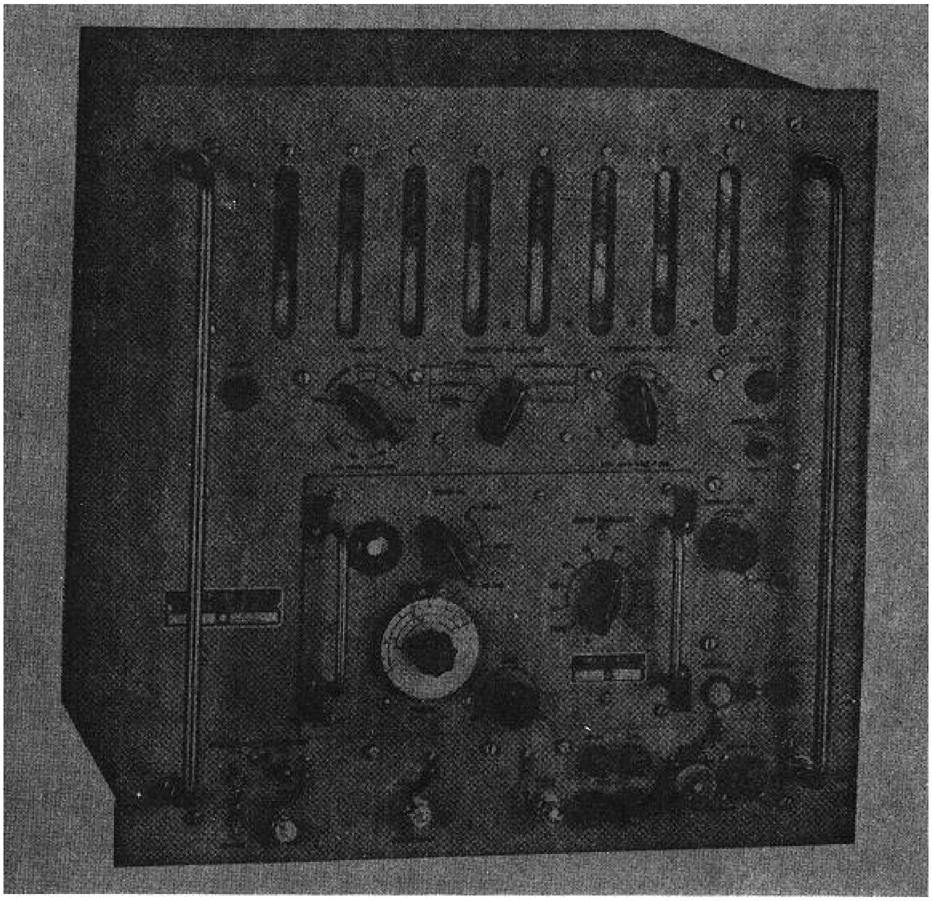


Figure 5-1. Frequency Meter FR-38E/U

GENERAL DESCRIPTION
Refer to paragraph 1-31. Same as for the AN/USM-26 except as follows:

a. The Time Base Generator in the FR-38E/U includes a crystal controlled 1MC precision oscillator whose crystal is housed in a thermostatically controlled oven. Proper operation of the oven is indicated by the ON-OFF cycling of an indicator lamp mounted on the front panel.

ACCESSORIES:
Refer to Paragraph 1-42. Same as for the AN/USM-26 except as follows:

a. Cord CX-3155/U (8'0") is provided for connecting the power plug on the instrument to the A-C supply. The cord consists of approximately eight feet of three conductor cable with a conventional power plug on one end and a receptacle on the opposite end.

QUANTITY AND TYPE OF TUBES AND LAMPS
Refer to Paragraph 1-44. The vacuum tubes and lamps used in the frequency meter FR-38E/U are listed in Table 5-3 together with the quantities used of each.

Table 5.2. Specifications for FREQUENCY METER AN /USM-26A

FREQUENCY MEASUREMENT

Range: 10 CPS to 100 Mc (direct reading).

Accuracy: ±1 count ±0.000005%*

(±0.1 CPS±0.000005% on 10 second gate).

Input Requirements: 0.1 v rms to 10 Mc; 0.01 v rms 10 Mc to 100 Mc.1 v rms using Time Interval Unit.

PERIOD MEASUREMENT

Range: 0.01 CPS to 100 kc (10,usec).

TIME INTERVAL MEASUREMENT

Accuracy: ±0.1 microsecond ±0.000005%*

**INTERNAL STANDARD*
The accuracy figure of ±0.00005% is due to the Internal Crystal Oscillator, which has a long time stability of within 5 parts 100 million/week. Short time stability is within 1 part 100 million/day. A panel connector permits use of an external 100 KC or 1MC primary standard signal to obtain higher accuracy.

Table 5-3. Tubes and Indicator Lamps for AN/USM-26A

JAN or NAVY TYPE	QUANTITY	JAN or NAVY TYPE	QUANTITY
OB2WA	1	5726/6AL5W	4
6AH6WA	12	5844	1
6AU6WA	6	5963	39
6CB6A	6	6005/6AQ5W	2
6E5	1	6080WA/6AS7GA	2
12AT7WA	3	6211	4
5654/6AK5W	6	Mazda 47 (lamp)	7
5687WA	1	Crystal Rectifier 1N198j	65
5725/6AS6W	10	Spare Crystal Rectifier 1N198j	10
5727/2D21W	2	Rectifier Diode 50M-S-379	8

INSTALLATION AND OPERATION

INSTALLATION. Refer to Paragraph 2-3. Same as for the FR-33/U except as follows:

a. The internal precision oscillator has a frequency of 1MC.

POWER CONNECTION. Refer to paragraph 2-8. Same as for the FR-38/U except as follows:

a. The Frequency Meter FR-38E/U operates from a nominal 115 Volt, 50 to 70 CPS or 115 Volt, 380 to 420 CPS single phase power source. Separate input connectors are provided on the front panel to cover the two ranges of power input frequency. An eight-foot power cord is provided.

CAUTION

Abnormal operation and possible failure of the blower motor will result if the power source is connected to the power input connector with the wrong power source frequency range.

TURNING ON THE EQUIPMENT. Refer to paragraph 2-10. Same as for the FR-38/U except as follows:

CAUTION

During the warm up period keep a close watch on the crystal oven indicator lamp on the front panel. The lamp will be on continuously for the first one-half hour and then commence cycling ON and OFF, as the correct operating temperature of the oven is approached. If the indicator lamp fails to cycle, DISCONNECT EQUIPMENT FROM POWER SOURCE and investigate source of trouble.

OPERATING CONTROLS, DIALS, AND TERMINALS. Refer to paragraph 2-12. Table 5-4 summarizes the functions of each of the operating controls, dials, and terminals of the FR-38/U equipment. The numbers shown in the table correspond to the numbers assigned to the panel controls in Figure 5-2.

TABLE 5-4. PANEL CONTROLS AND CONNECTORS FOR FR-38E/U

SAME AS FR-38/U. Table 2-1 except as noted. Refer to Figure 5-2 for all numbered locations.

Ref. No. Fig. 5-2	Designation	Function
1A	115V 50-70 cps	AC Power Input connector
1B	115V 380-420 cps	
	CX-3135/U (8'0")	
15	----	Illuminated columns of numbers that indicate eight digits of display.
16	----	Not Used.
20	----	Crystal Oven temperature operation indicating lamp.
21A	FREQUENCY STANDARD ADJ FINE COARSE	Screw driver operated trimmer capacitor that adjusts internal 1MC standard frequency. (Not an ordinary operating adjustment)
22	FREQUENCY STANDARD INT EXT	Switch that arranges instrument to operate using internal 1MC standard oscillator or using external 100 KC or 1MC standard frequency.
23 2	INPUT 100 KC/1MC	Type BNC Jack that receives external 100KC or 1MC standard frequency. volt RMS minimum into 57KOHMS shunted by 40pf.

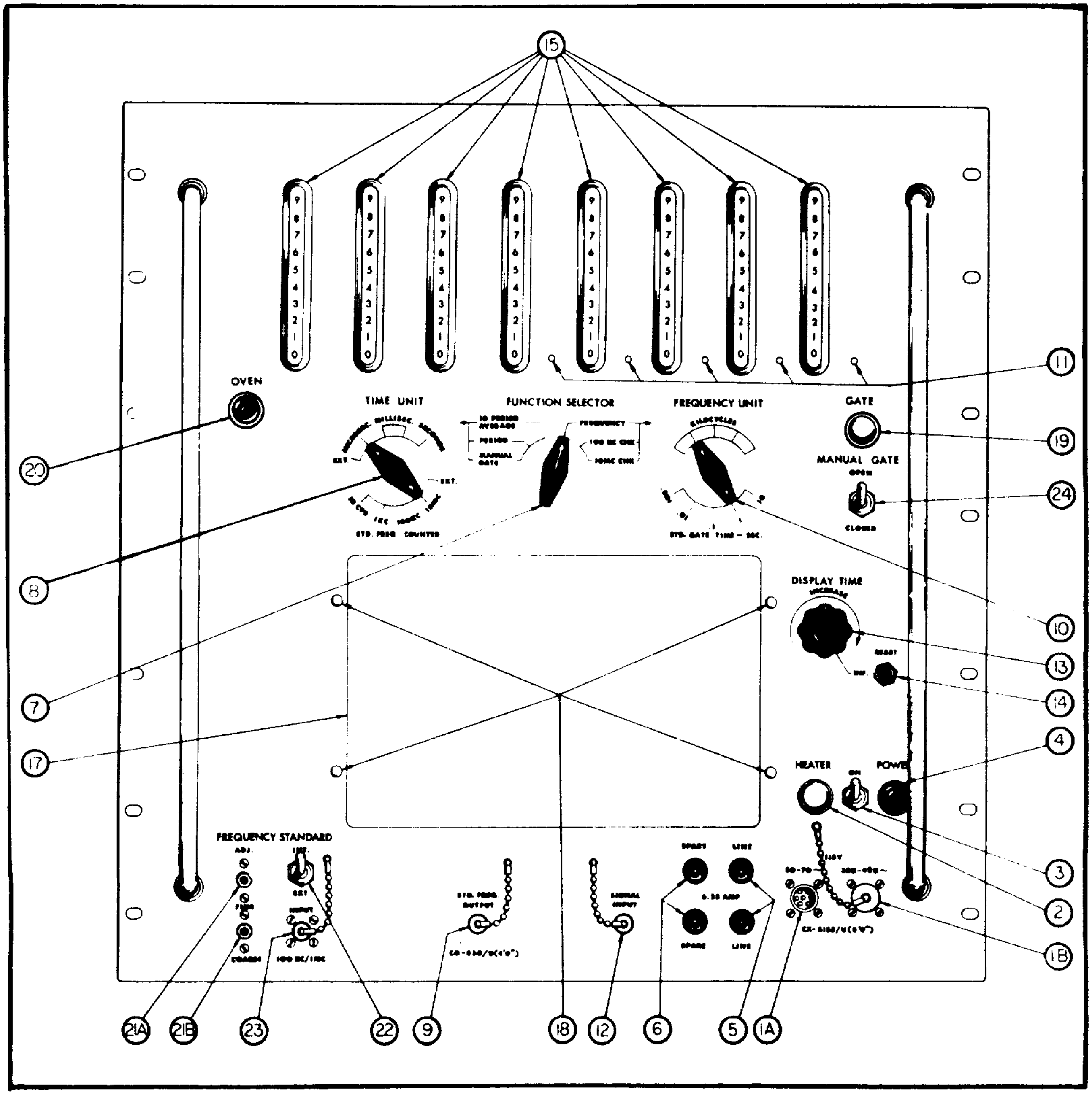


Figure 5-2. Frequency Meter FR-38E/U Controls Numbered

FREQUENCY MEASUREMENTS Refer to paragraph 2-21. Same as for FR-38/U except as follows:

a. Sensitivity of the FR-38E/U when using the Frequency Converter unit is 0.1 volts RMS for signals below 10MC and 0.01 volt RMS for signals from 10MC to 100MC.

ACCURACY OF FREQUENCY MEASUREMENT (USING THE FREQUENCY CONVERTER UNIT) Refer to paragraph 2-44 same as for the FR-38/U except as follows:

a. The accuracy of the FR-38E/U is determined by the internal oscillator that is accurate 5 parts/100 million per week and by a possible error of ± 1 count that is inherent in the gate and counter type of instrument.

Frequency measurements are therefore accurate within ± 0.000005% ±0.1 cycle if the sampling time is 10 seconds or ± 0.000005% ± 1 cycle if the sampling time is 1 second.

b. A plot of the accuracy obtained for each of the standard gate times (for the entire frequency range) is shown Figure 5-3.

c. The accuracy of the FR-38E/U can be increased by substituting for the internal oscillator a 100KC or 1MC primary standard of better accuracy.

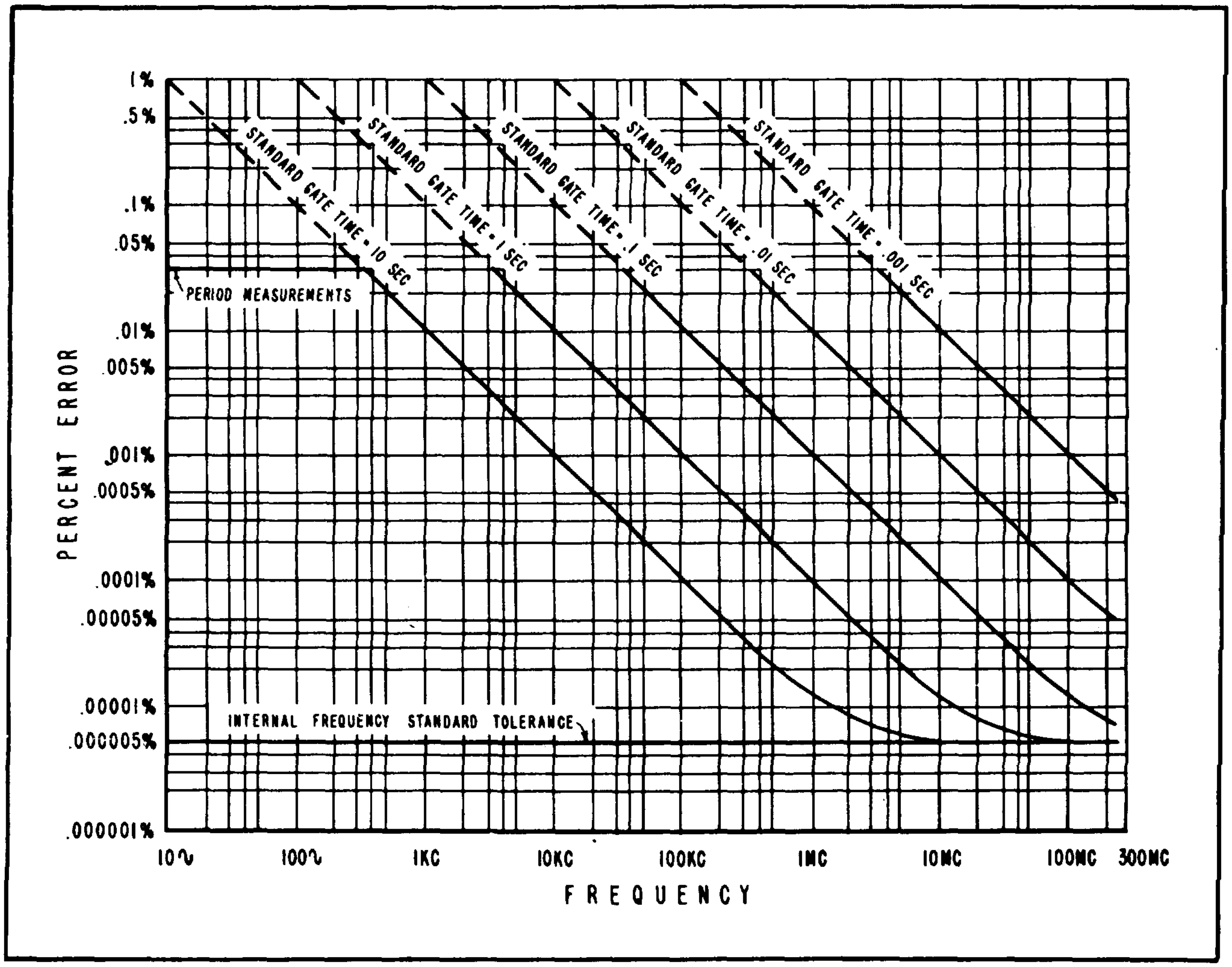


Figure 5-3. Frequency Measurement Accuracy Curves for the FR-38E/U

PRELIMINARY SET UP INSTRUCTIONS FOR ALL MEASUREMENTS

Refer to page 26. Same as for FR-38/U except as follows:
A. If internal 1MC frequency standard is used make certain crystal oven indicator lamp is cycling ON-OFF. If external standard is used, make certain frequency standard INT EXT switch is in EXT position.

PROCEDURE FOR SELF-CHECK

Refer to page 26. Same as for FR-38/U except refer to Figure 5-2 for location of MANUAL GATE switch referenced in step 1.

PROCEDURE FOR FREQUENCY MEASUREMENT

Refer to page 27 and 28. Same as for FR-38/U except:

a. In procedure 1 sensitivity is 0.1 volts RMS.
b. In Procedure 2 sensitivity is 0.01 volts RMS.
c. Refer to Figure 5-3 for Frequency Measurement accuracy curves for the FR-38E/U.
d. Accuracy of the FR-38E/U is ±0.000005% ±0.1CPS on the 10 second gate.

PROCEDURE FOR PERIOD MEASUREMENT

Refer to page 29. Same as for FR-38/U except Period Measurement Range is 10 Microseconds to 100 seconds (0.01CPS-100KC).

PROCEDURE FOR TIME INTERVAL MEASUREMENT

Refer to page 30. Same as for FR-38/U except accuracy is 0.1 microseconds ± 0.000005% when counting 10MC fast rise time pulses).

PROCEDURE FOR TOTALIZING

Refer to page 31. Same as for FR-38/U except refer to Figure 5-2 for location of STD. FREQ. OUTPUT in Step 5 and MANUAL GATE SWITCH in Step 6 and 7.

PROCEDURE FOR MEASURING RATIO

Refer to page 32. Same as for FR-38/U except refer to Figure 5-2 for location of STD, FREQ, OUTPUT in Step 5. LOWER FREQUENCY range of the FR-38E/U is from 100KC to 0.01 CPS.

PROCEDURE FOR FREQUENCY MEASUREMENT USING FREQUENCY CONVERTER CV-394/USA-5

Refer to page 32A and 32B. Same as for FR-38/U except refer to figure 5-3 for frequency measurement accuracy curves.

OPERATING CHECK AND ADJUSTMENT

STABILIZING THE 1MC CRYSTAL. Refer to paragraph 3-3. Same as for the FR-38/U except:

a. The frequency of the oscillator is 1 MC and its specified stability is 5 parts per 100 million per week.

CAUTION

To maintain oscillator stability keep the FR-38E/U connected to the Power Source at all times. With the instrument in stand-by (Power switch in the OFF position), the crystal oven remains in operation and keeps the crystal at its operation temperature.

STANDARDIZING THE 1MC CRYSTAL OSCILLATOR

Refer to Paragraph 3-4. Same as for the FR-38/U except that the frequency of the oscillator is 1 MC and its specified stability is 5 parts per 100 million per week.

METHOD I

Refer to paragraph 3-6. Same as for FR-38/U except

a. The external standard should have a frequency of approximately 10 megacycles and should be accurate within 1 part in 10^8. The external standard must have an amplitude of at least 0.1 Volt RMS when applied to the SIGNAL INPUT terminal of the FR-38E/U.

PROCEDURE FOR STANDARDIZING USING METHOD I

a. Refer to Paragraph 3-7. Same as for FR-38/U except that there are two adjustments for frequency at lower left of front panel, a COARSE adjustment and a FINE adjustment. The FINE adjustment should be turned first and the reading on the counter noted. If the FINE adjustment will not bring the oscillator on frequency the COARSE adjustment should then be used.

b. If a 10 megacycle frequency is being used, the reading should be within ± 1 part in 100,000,000 when the 10 second gate is used.

PROCEDURE FOR STANDARDIZING USING METHOD II

Refer to paragraph 3-9. Same as for FR-38/U except

a. Set FREQUENCY STANDARD switch to INT. Position.

b. Turn FINE ADJ located at the lower left of front panel with a screwdriver until zero beat is obtained. If a zero beat cannot be obtained using the FINE ADJ the COARSE ADJ should then be used.

USING AN EXTERNAL 100KC OR 1MC STANDARD

Refer to paragraph 3-10 and 3-11

a. The FR-38E/U is arranged so that it can use an external 100KC or 1MC standard Frequency in place of the internally generated 1MC frequency. This arrangement is provided for situations where there is available an external 100KC or 1MC primary frequency standard, which has higher accuracy than the internal oscillator which is stable within 5 parts per 100 million per week.

b. The external standard frequency should he connected to the 100KC/1MC connector (23) and must have an amplitude of at least 2 volts RMS. When using an external frequency, the FREQUENCY STANDARD switch must be in the EXT position.

EMERGENCY OPERATION AND REPAIR

ADJUSTING GATE LENGTH AND BIAS OF TRIGGER UNIT Z-201

Refer to paragraph 4-6 and 4-7. Same as for FR-38/U except access to GATE LENGTH potentiometer R-224 and FREQ. SENS. potentiometer R211 may be made by removing the respective button plugs in the cabinet. The potentiometers are in the same relative position as shown in Figure 4-3.

ADJUSTING POWER SUPPLY VOLTAGES

Refer to paragraph 4-9. Same as for FR-38/U except refer to Figure 5-4 for location of power supply adjustments and component locations.

TROUBLE SHOOTING THE DECIMAL COUNTING UNITS

Refer to paragraph 4-10. Same as for FR-38/U except that the FR-38E/U has two types of Plug-in decimal counting units: Z204 to Z209 the slow speed type and Z1200, the high speed type. Trouble-shooting techniques are similar for both types.

LOCATION OF TUBES FUSES AND LAMPS

Refer to paragraph 4-18. The location of tubes is shown in figures 5-5, 4-6 and 4-7. The location of fuses is shown in the front panel illustration, figure 5-2. Spare fuses are located in fuseholders on the front panel so that the blown fuse may be replaced from a spare fuseholder adjacent to the blown fuse, The pilot lamps (Figure 5-2) are MAZDA #47, rated 6-8 volts at 0.15 ampere and can be replaced by unscrewing the jewel from the lampholder.

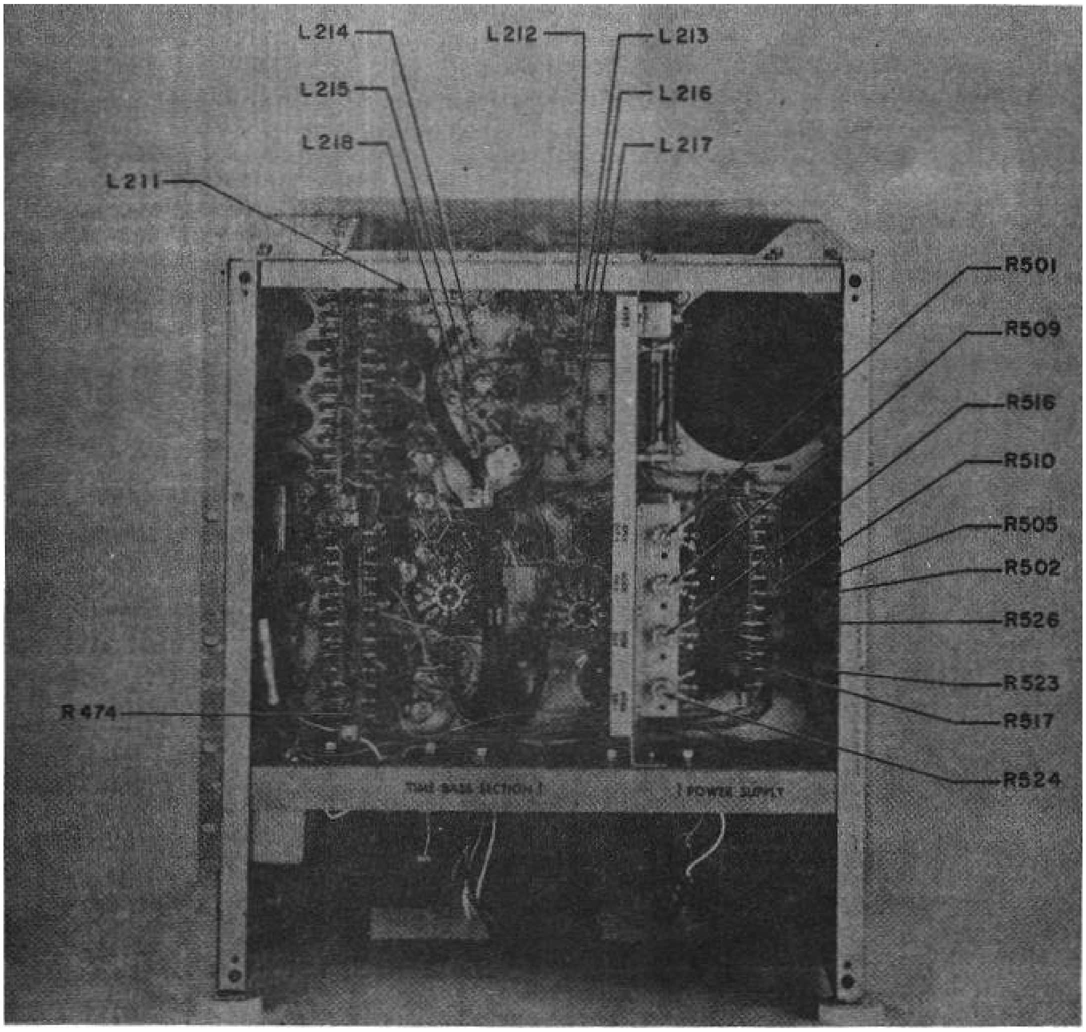


Figure 5-4. Frequency Meter FR-38E/U, Rear View

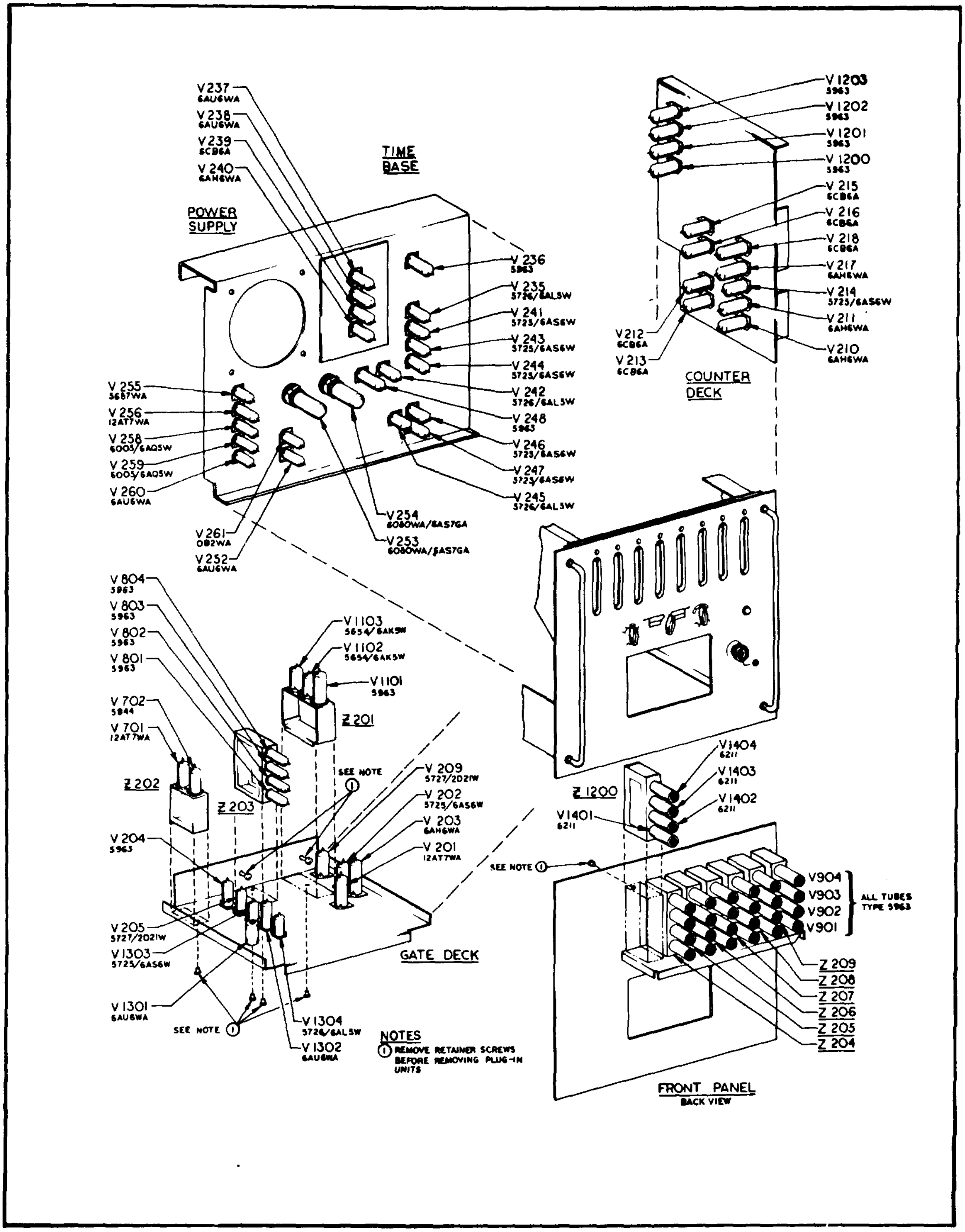


Figure 5-5. Frequency Meter FR-38E/U Tube Location Diagram

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SECTION VI

PREVENTIVE MAINTENANCE INSTRUCTIONS

6-1. Scope of Maintenance

The maintenance duties assigned to the operator of the equipment are as follows:

a. Daily preventive maintenance checks and services (para 6-4).

b. Cleaning (para 6-5).

6-2. Preventive Maintenance

Preventive maintenance is the systematic care, servicing, and inspection of equipment to prevent the occurrence of trouble, reduce downtime, and assure that the equipment is serviceable.

a. Systematic Care. The procedures given in paragraph 6-5 cover routine, systematic care and cleaning essential to the proper upkeep and operation of the AN/USM-26 and AN/USM-26A.

b. Preventive Maintenance Checks and Services The preventive maintenance checks and services chart (para 6-4) outlines functions to be performed daily. These checks and services are to maintain Army electronic equipment in a combat-serviceable condition; that is, in good general (physical) condition and in good operating condition. To assist operators in maintaining combat serviceability, the chart indicates what to check, how to check, and the normal conditions. If the defect cannot be remedied by performing the corrective action indicated, higher category maintenance or repair is required. Records and reports of these checks and services must be made in accordance with the requirements set forth in TM 38-750.

6-3. Operator's Preventive Maintenance Checks and Services Periods

Preventive maintenance checks and services of the equipment are required daily. Paragraph 6-4 specifies the checks and services that must be accomplished daily (or at least once each week if the equipment is maintained in standby condition).

6-4. Operator's Daily Preventive Maintenance Checks and Services Chart

Sequence No.	Item to be inspected	Procedure	References
1	Completeness..	Check to see that equipment is complete.	Appx B.
2	Exterior surface	Clean exterior surfaces, including panel. Check meter glasses for cracks.	Para 6-5
3	Connectors	Check tightness of all connectors.	None.
4	Controls and indicators.	While making the operating checks (item 5), observe that mechanical action of each switch and control is smooth and free of external or internal binding, and there is no excessive looseness.	None.
5	Operation	During operation, be alert for any unusual performance or condition.	None.

6-5. Cleaning

The exterior surfacs of the AN/USM-26 and AN/USM-26A must be free of dust, grease, and fungus.

a. Remove dust and loose dirt with a clean cloth.

Warning

Prolonged breathing of cleaning compound is dangerous; make sure adequate ventilation is provided. Cleaning compound is flammable, DO NOT use near a flame. Avoid contact with the skin; wash oft. any that spills on the hands.

b. Remove grease, fungus, and ground-in dirt from the case and cover of the test set. Use a cloth dampened (not wet) with Cleaning Compound (FSN 7930-395-9542).

c. Remove dust or dirt from plugs and jacks with a brush.

d. Clean the front panel and the control knobs with a soft, clean cloth. If dirt is difficult to remove, dampen the cloth with water; use mild soap if necessary.

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SECTION VII

SPECIAL TEST EQUIPMENT

7-1. TEST EQUIPMENT.

7-2. No special test equipment has been procured for maintenance. However, the test equipment listed in the following table is required to perform the various tests and adjustments indicated in Section X and Section XI.

7-3. SPECIAL TOOLS.

7-4. No special tools are required for servicing the AN/USM-26.

7-5. CABLE FABRICATION.

7-6. Figures 7-1, 7-2, 7-3, and 7-4 show the fabrication of test cables. The cables shown in Figures 7-1 and 7-2 are supplied with the instrument and the fabrication information is presented in the event a new or replacement cable is required. The cables shown in Figures 7-3 and 7-4 are special cables required for service and maintenance of the AN/USM-26. These cables are not supplied as part of the instrument.

7-7. SPECIAL TEST EQUIPMENT FOR AN/USA-5. No additional test equipment is required.

Table 7-1. Test Equipment Required for Maintenance

FIG. AND INDEX NO.	NAME	AN TYPE OR CHARACTERISTIC	ALTERNATE	APPLICATION
Throughout Section	Oscilloscope	AN/USM-140 or AN/USM-281	Tektronix Model 513-D, 514-D, or 524-D. Dumont Model 303A or 303AH. Browning Labs. Model L-23.	Waveform Observation.
	Variable Frequency Oscillator	AN/URM-25	Hewlett-Packard Model 650A.	Externally supplied Input Signal to drive FR-38/U.
	Variable Frequency Oscillator	AN/USM-44	Hewlett-Packard Model 608A, 608B, 608C, or 608D.	Externally supplied Input Signal to drive Frequency Conver-ter MX-1637/U.
	Pulse Generator	AN/PPM-1	Hewlett-Packard Model 212A.	Delay Line Testing.
	Multi meter	ME- 2aA/U	Hewlett-Packard Model 410A/B.	Voltage measure-ment.
	Continuously Variable Transformer	0-130v ac from 115v ac line con-tinuously variable (not steps). 5 amp maximum load.	Variac Powerstat.	Vary power input voltage.
	AC voltmeter	0-150v ac ±2% (iron vane type Meter).		Monitor variable transformer.

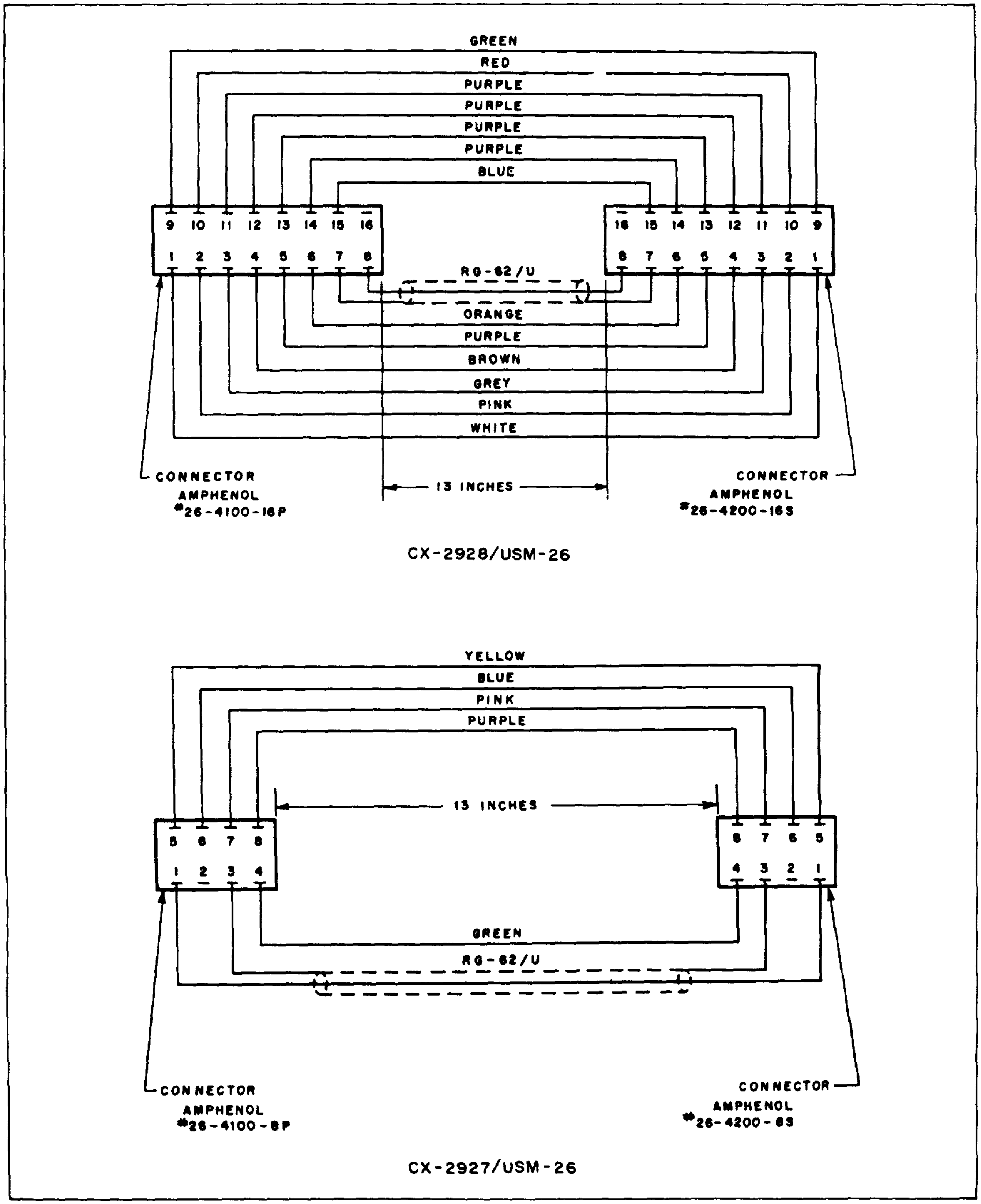


Figure 7-1. Fabrication of Cable Assemblies CX-2927/USM-26 and CX-2928/USM-26

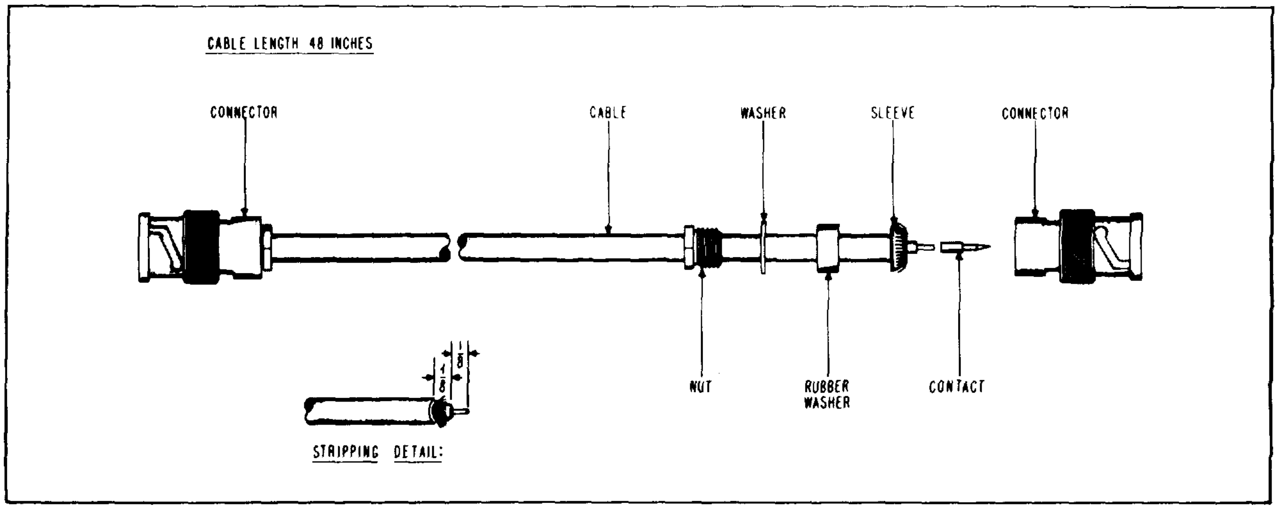


Figure 7-2. Fabrication of Video Cord CG-530/U

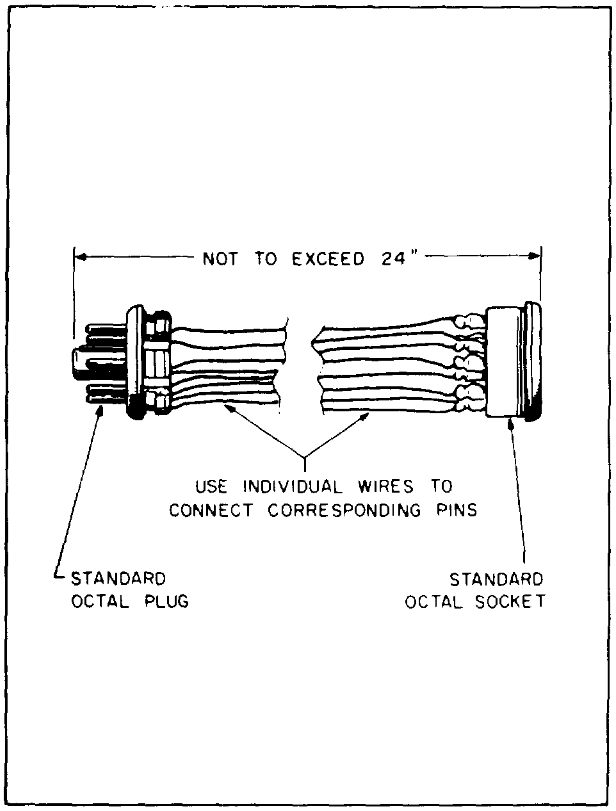


Figure 7-3. Test Cable for Internal Plug-In Units

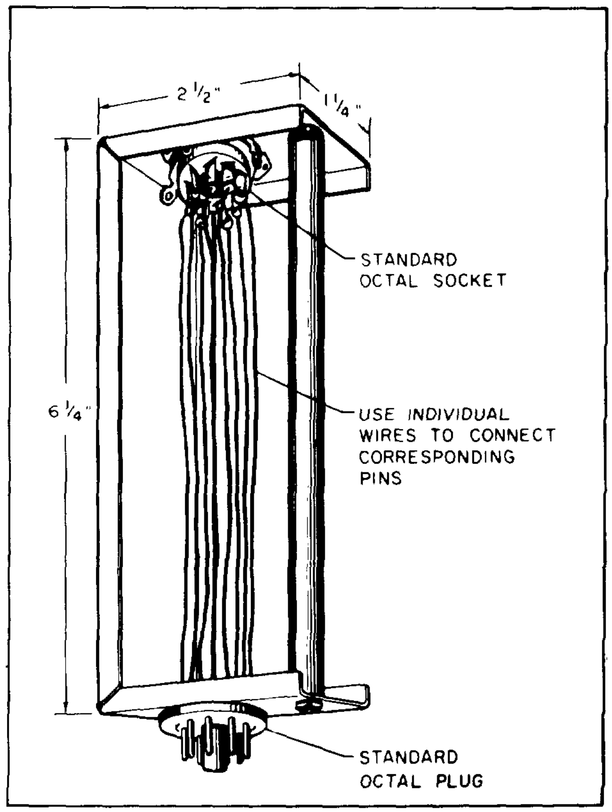


Figure 7-4. Test Cable for Decade Counters

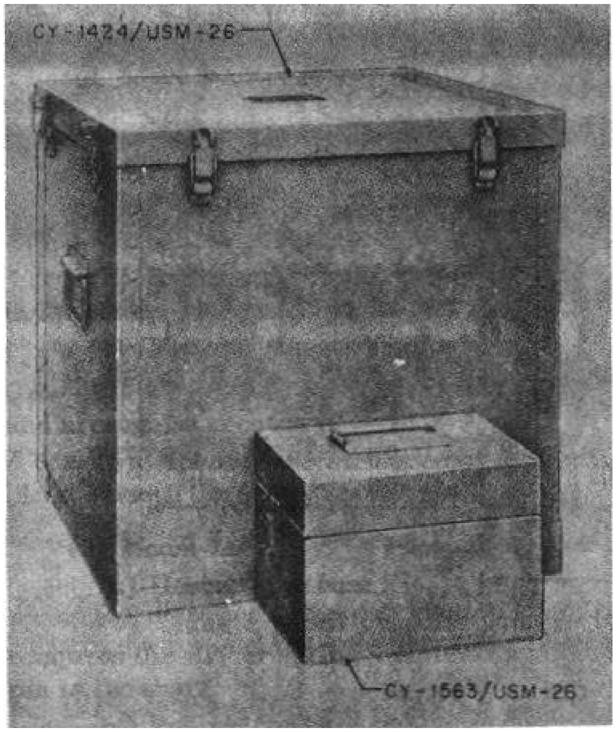


Figure 8-1. Transit Cases CY-1424/USM-26 and CY-1563/USM-26

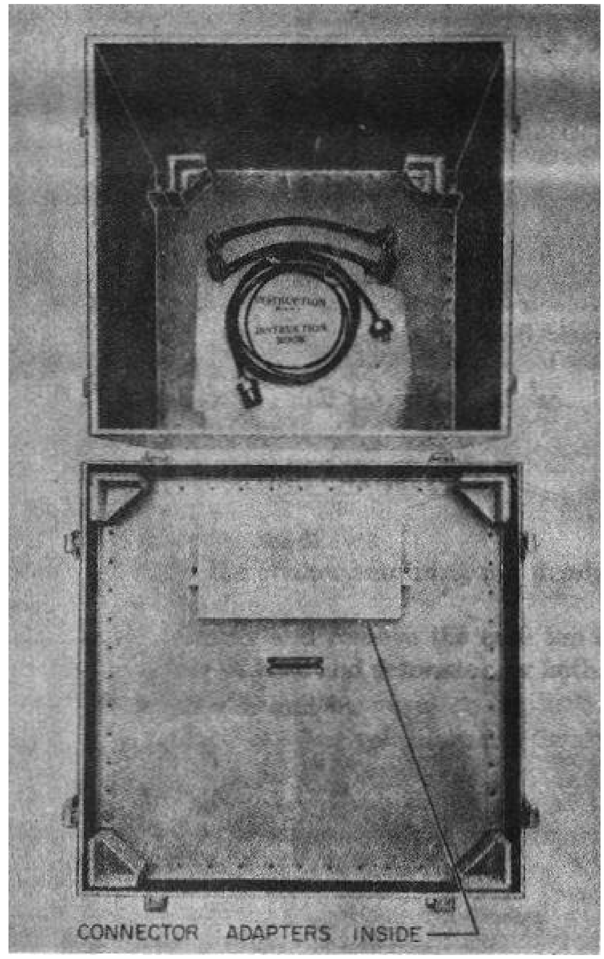


Figure 8-2. Cable and Accessory Storage in Transit Case CY-1424/USM-26

SECTION VIII

PREPARATION FOR USE AND RESHIPMENT

8-1. PREPARATION FOR USE.

8-2. The covers of the equipment's transit cases, CY-1424/USM-26 and CY-1563/USM-26, Figure 8-1, are secured by trunk type latches. Transit Case CY-1424/USM-26, housing the FR-38/U Frequency Meter, should be placed on the floor to facilitate removal of the equipment which rests freely on rubber shock mounts at the bottom of the case. The accessory cables and cords are stowed in the bottom of the transit case under the frequency meter. The connector adapters are located in a tray secured to the cover of Transit Case CY-1424/USM-26. Transit Case CY-1563/USM-26 houses the Frequency Meter Subassembly MX-1636/U. Check to see that all items shown in Figure 1-1 are present.

8-3. All controls and indicators referred to in the following steps are the same as those called out in Figure 2-1. Proceed as follows:

a. Locate the equipment so that the louvers on the cabinet are clear of obstructions and other equipment to insure free intake and exhaust of air by the equipment blower unit within the cabinet.

b. Remove the cables and cords from the transit case.

c. Place the power switch in down, or standby, position. This is the normal position of this switch when the equipment is not in use.

d. Connect Power Cable CX-337/U (6'0") between power input connector on front panel of Frequency Meter FR-38/U and source of power. The power source should be 115-volt, 50-1000 cycles per second, single phase alternating current.

e. When the connection from the instrument to the required power source has been completed, the HEATER indicator (white pilot lamp), located to the left of the power switch, will light, indicating power is being supplied to the instrument.

f. Connect one Video Cord CG-530/U (4'0") to SIGNAL INPUT.

8-4. EQUIPMENT WARM-UP.

8-5. With the electrical power source connected to the instrument (para 8-3d), the equipment should be allowed to warm up for at least 4 hours. This permits the crystal oven to stabilize at the required temperature of 65° $\pm$ 5 C° (149° $\pm$ 9° F) and energizes the space heaters to dry out any excessive moisture in the unit created by humidity that may short out electrical circuits.

a. After suitable warm-up, the POWER switch can be set to ON; the power indicator will light: a and the blower motor will start.

b. The Controls should now be set and the equipment self-checked as described in paragraph 4-22.

8-6. PREPARATION FOR RESHIPMENT.

8-7. The following procedure should be employed when preparing the equipment for reshipment:

a. Place the Transit Case CY-1424/USM-26 on the floor with the open end upward.

b. Disconnect all cables from the connectors on the instrument. Place these cables and accessory cables neatly coiled in the bottom of the transit case as shown in Figure 3-2.

c. Carefully slide the Frequency Meter FR-38/U into the transit case, making certain that the back of the frequency meter resets securely on the sponge rubber shock mounts.

d. Make certain all connector adapters are clipped in the accessory tray and fasten tray to cover of transit case.

e. Place cover of transit case in position and secure in place with the eight trunk latches provided.

f. Transit Case CY-1563/USM-26 can be placed on a bench with the open end upward.

g. Slide Frequency Meter Subassembly MX-1636/U (Time Interval Unit) into case so that it rests securely on the rubber shock mounts.

h. Place cover of transit case in position and secure in place with the two trunk latches provided.

8-8. FREQUENCY CONVERTER GROUP AN/USA-5. The AN/USA-5 includes a Transit Case CY-1563/USM-26, identical to that used for the MX-1636/U, as shown in Figure 8-1. The use of the transit case for Frequency Converter CV-394/USA-5 is identical to the procedure described above for the MX-1636/U.

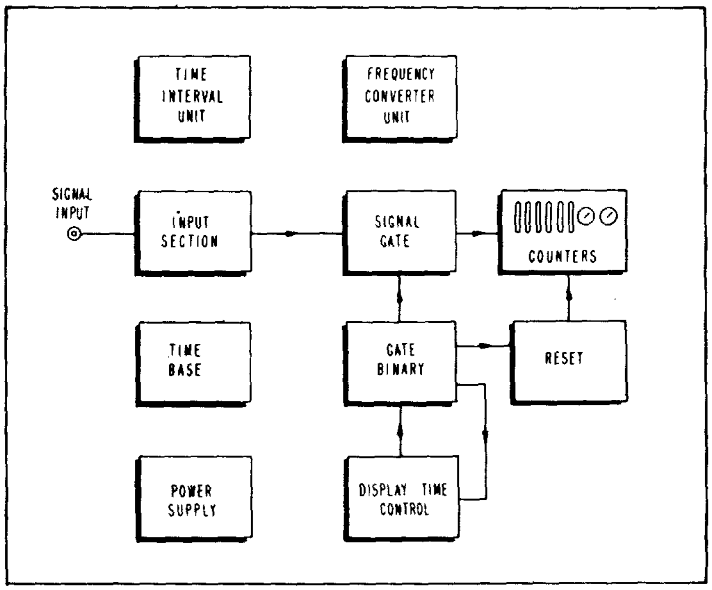


Figure 9-1. Simplified Block Diagram of Frequency Meter FR-38/U

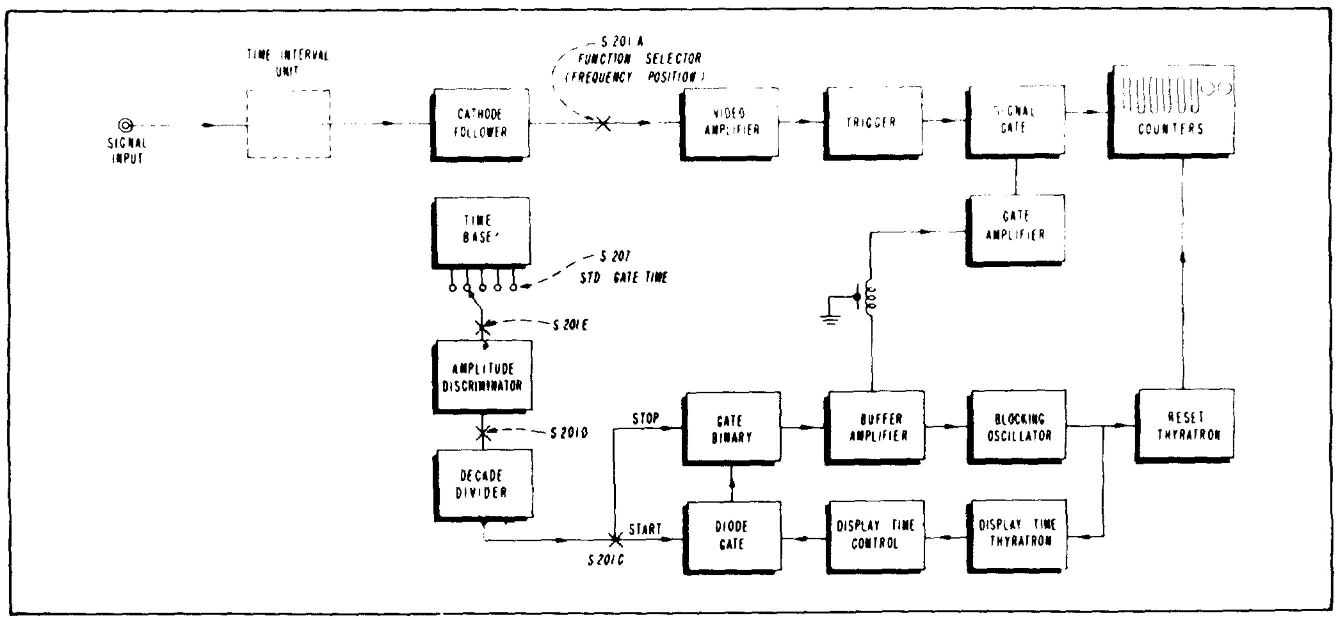


Figure 9-2. Block Diagram for Frequency Measurement (10 CPS to 10 MC)

SECTION IX

THEORY OF OPERATION

9-1. GENERAL SYSTEM OPERATION.

9-2. For purposes of description, the circuit of Frequency Meter FR-38/U can be considered to consist of the seven basic circuits shown in the simplified System Block Diagram, Figure 9-1. These are:

a. Input section where input signals are amplified and shaped before they are fed into the counters and the control circuits. Trigger circuits in this section assure that strong, sharp triggering pulses are always supplied to the high-speed circuits.

b. Time base section which supplies the internal standard frequencies for the FR-38/U. This unit consists of a 100 kc crystal oscillator and frequency multiplier and divider circuits.

c. Gate section which opens and closes the signal path to the counter. The circuit also controls the display time and resets the counters to zero.

d. Counter section which consists of eight cascaded decade scalers, each with an indicating system.

e. Frequency converter, a front panel plug-in unit which extends the basic frequency measurement range of the FR-38/U from 10 mc to 100 mc.

f. Time interval, also a front panel plug-in unit, which contains the adjustable threshold input channels (START INPUT and STOP INPUT) that are used for measuring the time between two electrical events.

g. Power supply which develops all of the necessary operating potentials for the FR-38/U circuits.

9-3. MEASUREMENT FUNCTIONS.

9-4. The circuits of the FR-38/U are designed to allow the instrument to perform a number of measurement functions. These functions are described below with block diagrams to show the various circuits that are operative during each function.

9-5. FREQUENCY MEASUREMENTS USING TIME INTERVAL UNIT.

9-6. Measurement of frequencies below 10 mc is performed by the basic circuits of the FR-38/U, with the time interval plug-in unit in place as shown in Figure 9-2. The time interval unit provides a direct connection (pins 2 and 5) from the SIGNAL INPUT connector J-203 to the counter circuits of the FR-38/U. It serves no other purpose in this measurement. With FUNCTION SELECTOR switch S-201A set at FREQUENCY, signals applied to the SIGNAL INPUT connector pass directly to input cathode follower V-201A and the counting circuits of the instrument. Any one of five internal standard frequencies derived by the TIME BASE (.001,.01,.1, 1 and 10 seconds) is selected by FREQUENCY UNIT - STD. GATE TIME - SEC switch S-207B and fed to the amplitude discriminator, where the incoming wave is shaped providing suitable trigger pulses for the control of the gating circuit. The input signal is counted and displayed. The illuminated decimal point is automatically located and the answer is read directly in kilocycles.

9-7. FREQUENCY MEASUREMENTS USING FREQUENCY CONVERTER UNIT.

9-8. The arrangement shown in Figure 9-3 may be used for measurement of frequencies from 10 cps to 100 mc. With the FUNCTION SELECTOR switch S-201A in FREQUENCY position. the opening and closing of the signal gate is controlled by one of the five internal standard frequencies selected by the FREQUENCY UNIT - STD. GATE TIME switch S-207B. The unknown frequency is applied to the SIGNAL INPUT connector.

9-9. The frequencies from 10 cps to 10 mc (0 position of the MIXING FREQUENCY control) bypass the tuning and mixing stages of the frequency converter and go directly through the video amplifiers V-6 and V-7 to the counting circuits. A 20 db increase in sensitivity is obtained in this measurement over the one previously described in paragraph 9-6 due to the gain of the video amplifier. The measurement is the same in all other respects.

9-10. Input signals above 10 mc pass through the tuned amplifiers to the mixer. By heterodyne action the input signal is mixed with a mixing frequency from the harmonic generator selected by MIXING FREQUENCY control S-1. The difference frequency, which must be between 0.1 and 10.1 mc, is then passed to the counters and is displayed as before. The total count is obtained by adding the MIXING FREQUENCY, which will always be megacycles, and the displayed count, which will always be kilocycles.

9-11. The tuning "eye" is used as indicator for frequencies above 10 mc (MIXING FREQUENCY control in TUNE position). After the mixing frequency has been selected (0 for frequencies below 10 mc), the "eye" serves as a signal level indicator. The GAIN control R-5 is manually adjusted until the "eye" just closes, indicating the input signal to the trigger circuit is at optimum level.

9-12. PERIOD MEASUREMENT.

9-13. For period (1/frequency) measurement standard frequencies are counted during the interval the signal gate is held open by the input signal. With the

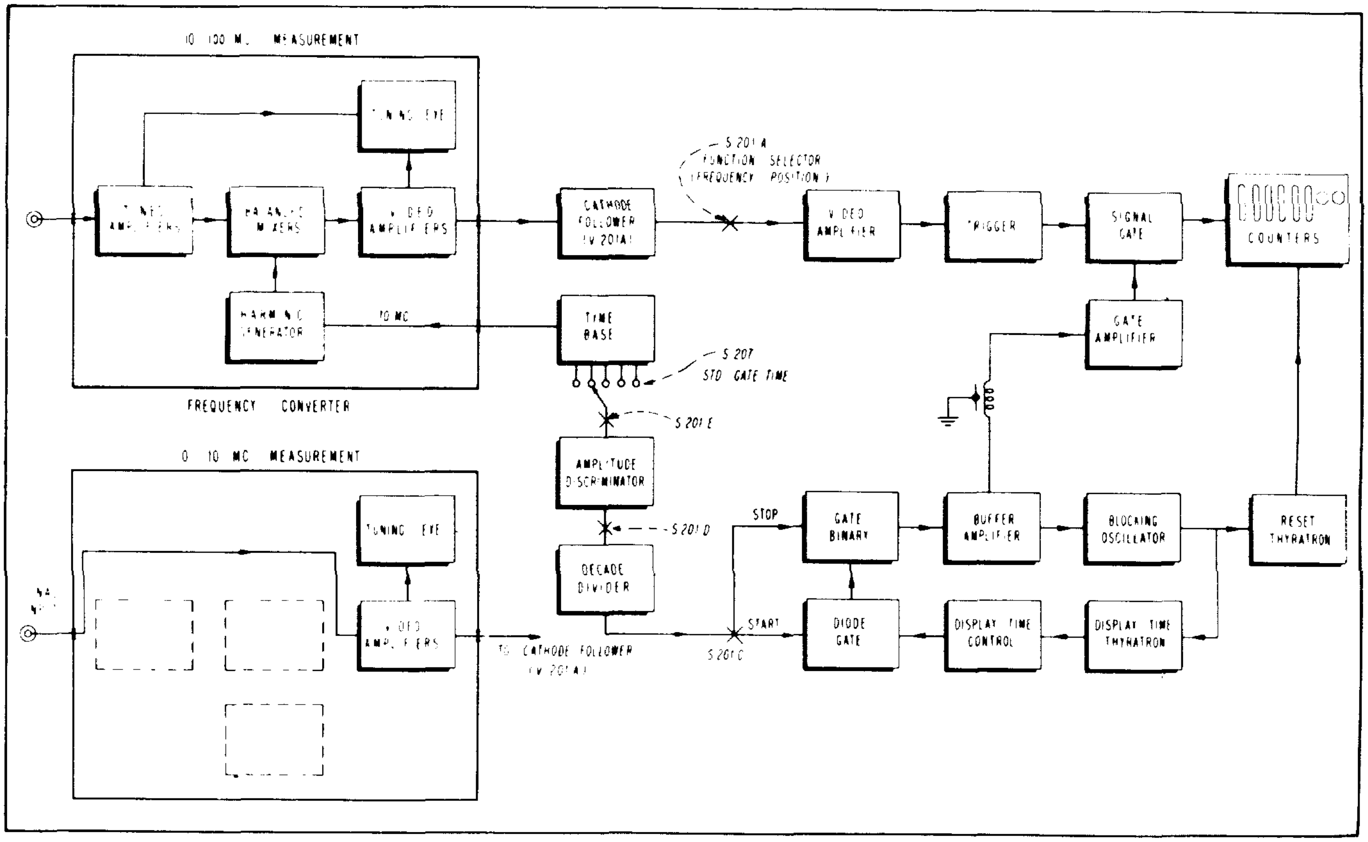


Figure 9-3. Block Diagram for Frequency Measurement (10 MC to 100 MC)

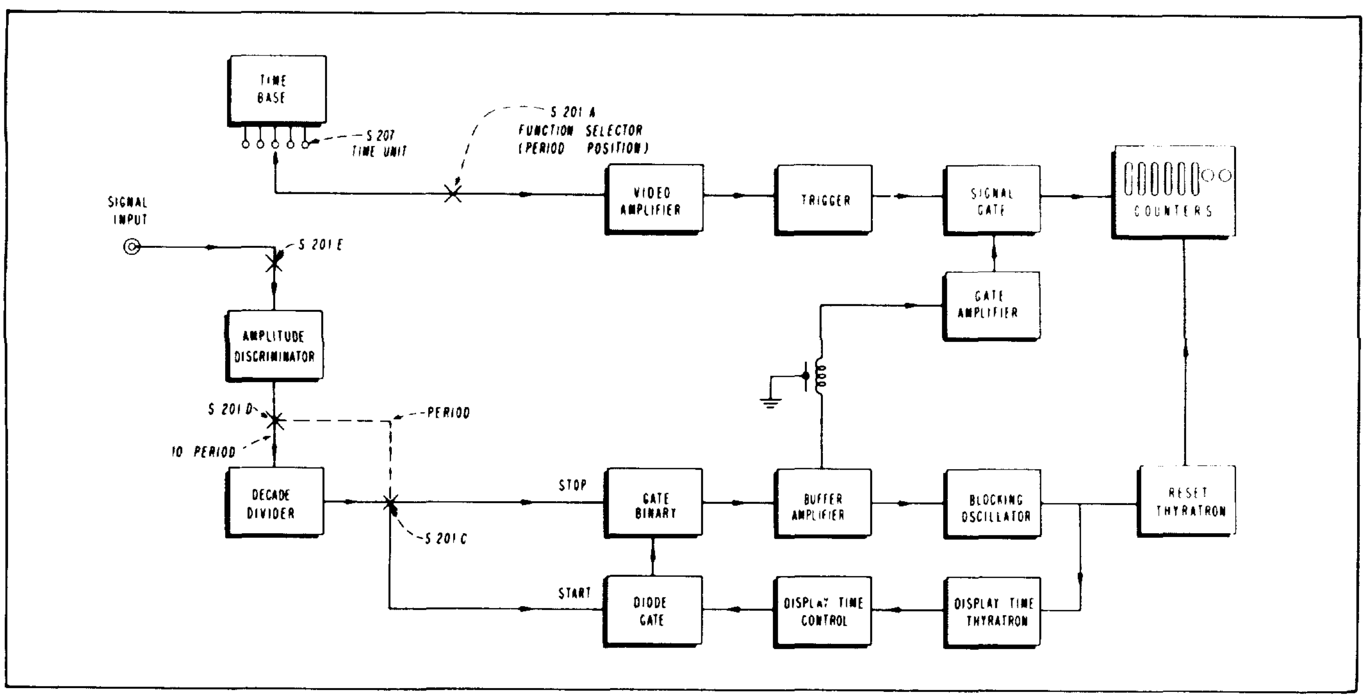


Figure 9-4. Block Diagram for Period Measurement

FUNCTION SELECTOR S-201A in PERIOD position, an external signal applied to SIGNAL INPUT passes through the amplitude discriminator to the gate control circuits as shown in Figure 9-4. The amplitude discriminator shapes the incoming wave so that the gate opens and closes at the same point on the cycle. 10 PERIOD measurements provide greater accuracy as the decade divider is switched into the circuit, which slows the gating time, since it delivers only one output pulse for every ten input pulses.

9-14. TIME INTERVAL.

9-15. The block diagram in Figure 9-5 shows the circuit arrangement for time interval measurements. The FUNCTION SELECTOR switch S-201A is set in PERIOD position. The time interval plug-in unit is provided with two connectors, START INPUT and STOP INPUT, to accept separate gate control signals. The trigger units shape the input wave and are adjustable so that they trigger at a predetermined level at either positive or negative polarity. Trigger slope controls at the output of the discriminator prepare the channels to trigger from either the positive or negative slope of the waveform. A switch, COM - SEP S-102, is also available to permit the use of a common signal for start and stop control of gating circuit. During the open condition of the signal gate, standard frequencies derived from the time base are counted and displayed. When measuring time, answers are given in microseconds, milliseconds and seconds. The illuminated decimal point is automatically located.

9-16. HIGH SPEED TOTALIZER.

9-17. The FR-38/U serves as a high-speed scaler and totalizer when the FUNCTION SELECTOR is set to MANUAL GATE and the TIME UNIT switch is set to EXT, see Figure 9-6. Used this way, the unit is capable of totaling pulses arriving at rates up to 10 million per second. It has a double-pulse resolving time of 0.1 microsecond, and a triple-pulse resolving time of 0.2 microsecond. There is no lower limit of pulse rate. The input signals are connected to the STD. FREQ. OUTPUT connector. The MANUAL GATE toggle switch S-202 should be in OPEN position. shifting the grid voltage of the gate control amplifier from positive to negative and holding the signal gate in "open" position. Pressing the reset button returns the counters to zero. One of the plug-in units must be in place for this measurement.

9-18. The unit can also be used as a highly accurate clock by counting the standard frequencies from the time base. The TIME UNIT switch selects the unit of measure and locates the decimal point.

9-19. TIME AND FREQUENCY RATIOS.

9-20. Ratios are measured with the unit set up for period measurement, except that the TIME UNIT switch is set to EXT. The higher frequency of the ratio is applied to the STD. FREQ. OUTPUT connector, and the lower frequency is applied to the SIGNAL INPUT connector. Either plug-in unit may be used as de scribed earlier for period measurements.

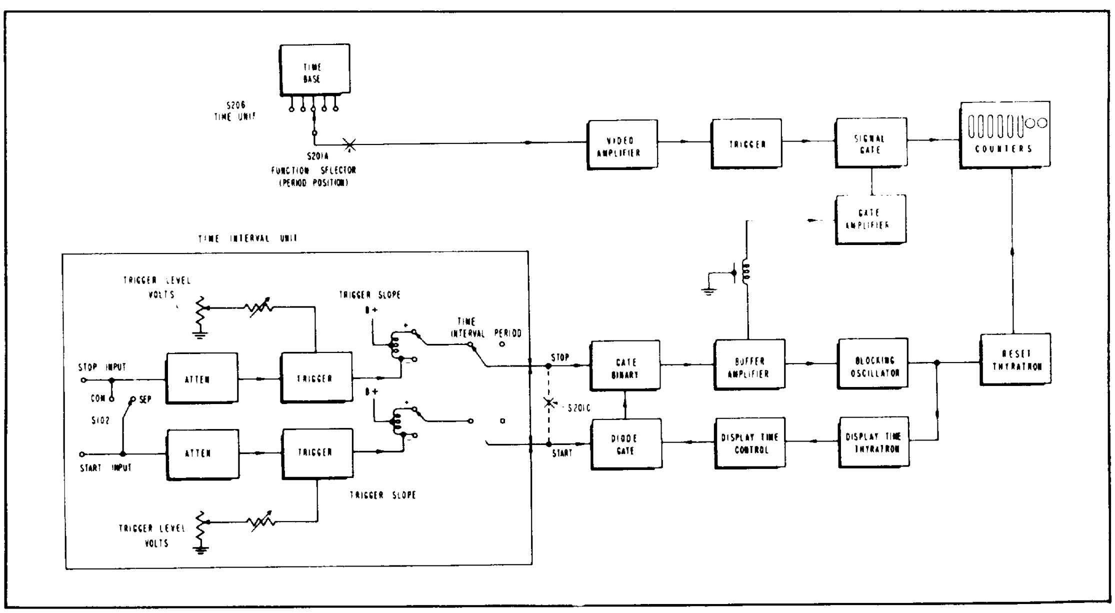


Figure 9-5. Block Diagram for Time Interval Measurement

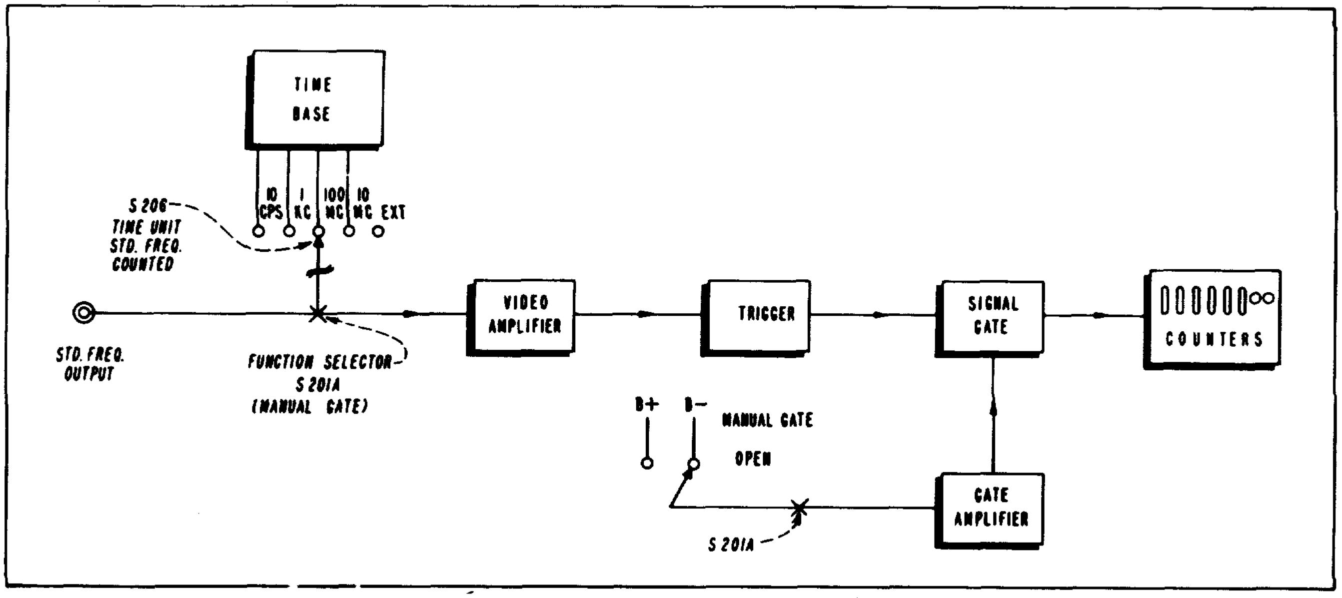


Figure 9-6. Block Diagram of High Speed Totalizer

9-21. The range for ratio measurements is from 1:1 to 10,000,000:1. The higher frequency may be as high as 10 megacycles; the lower frequency may be as high as 10 kc. There is no lower limit for either frequency.

9-22. THE SELF-CHECK FEATURE.

9-23. The FR-38/U is designed so that it can partially check its own circuits by counting its internal standard frequencies for standard gate times. The circuit arrangement is shown in Figure 9-7. This check function insures that the counters are operating properly and that the standard frequencies have the proper ratios, but does not insure that the 100 kc Standard Oscillator is accurately adjusted. This adjustment is described in paragraph 10-36.

9-24. 100 KC CHECK. To check the unit, place the FUNCTION SELECTOR in the 100 KC CHK position and adjust the DISPLAY TIME for minimum time. Set the 100 KC STD. INT - EXT switch to INT and the MANUAL GATE to closed position. The remaining controls may be in any position. Test each standard gate time by switching to each position of the FREQUENCY UNIT switch. The correct

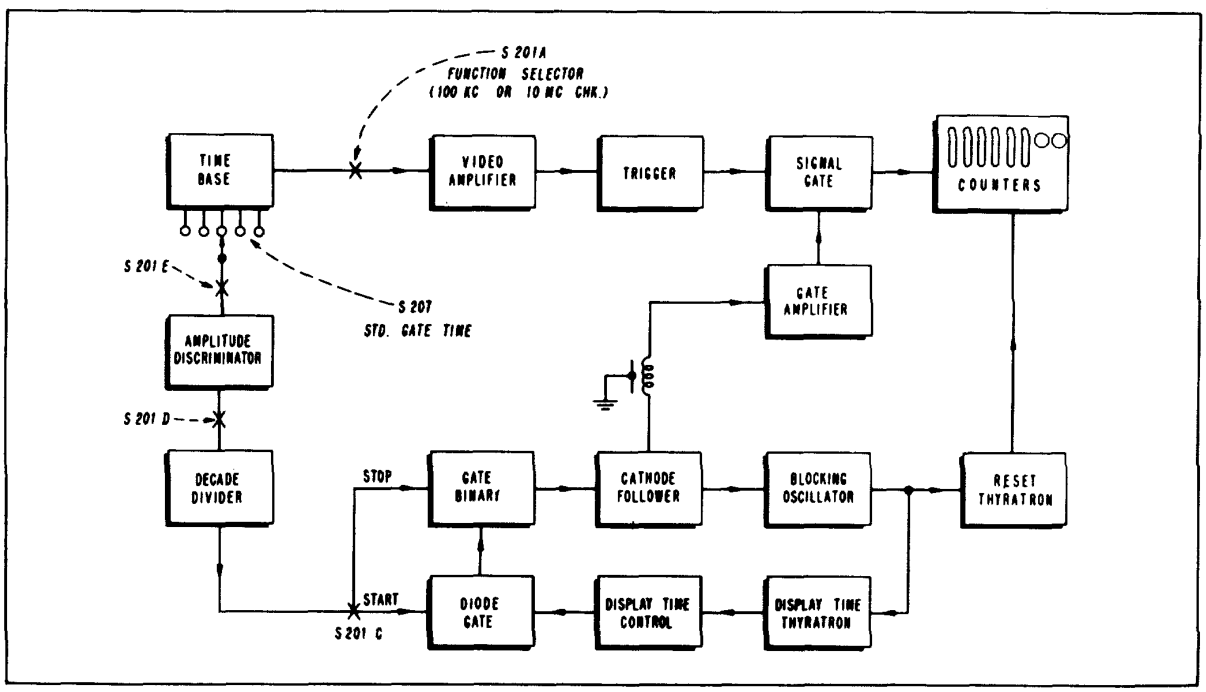


Figure 9-7. Block Diagram of Self-Check

display for each standard gate time is shown in Table 9-1.

9-25. 10 MC CHECK. Now switch the FUNCTION SELECTOR to the 10 MC CHK position and test each position of the FREQUENCY UNIT switch. The correct display for each standard gate time is shown in Table 9-1.

Table 9-1. Counter Readings for Self-Check Operations

GATE TIME	100 KC CHECK	10 MC CHECK
10 sec	0100.0000	0000.0000 ± .0001
1 sec	00100.000	10000.000 ± .001
0.1 sec	000100.00	010000.00 ± .01
0.01 sec	0000100.0	0010000.0 ± .1
0.001 sec	00000100.	00010000. ± 1

9-26. CIRCUIT SWITCHING. The switching of circuits in the FR-38/U for the various measurements previously described is accomplished by multiple-contact wafer switches. The switching diagrams for the instrument appear in Section XII.

9-27. TIME BASE SECTION.

9-28. 100 KC CRYSTAL. The 100 kc internal standard frequency, is controlled by a low temperature coefficient crystal, Y-201. Frequency accuracy of 2 parts per million per week or better is obtained by maintaining the 100 kc crystal at a uniform temperature in a heater oven. The crystal oven, Z-235, is wired into the primary power circuit and is "on" as long as the instrument is connected to the power source. A panel-mounted thermometer provides a continuous indication of crystal temperature which is nominally 65°C. Oven heater circuits are shown in the Power Supply Schematic. Figure 9-8 shows a block diagram of the complete time base.

9-29. CRYSTAL OSCILLATOR. The 100 kc crystal oscillator V-234 in Figure 9-9 is a modified Pierce circuit. Frequency can be changed ±2 cps by adjusting the capacity across the crystal. This change is made by screwdriver adjustment of capacitor C-294, located at the lower left corner on the front panel of the instrument. Larger changes can be made by adjusting capacitors C-295 and C-296 located on the deck behind the crystal oven. The output from the crystal oscillator drives blocking oscillator V-236A. The output voltage is also fed to FUNCTION SELECTOR switch S-201A for self-check operation, as described in paragraph 9-22.

9-30. EXTERNAL STANDARD FREQUENCY. Where a primary frequency standard is available, an external 100 kc standard frequency may be connected to 100 KC INPUT, connector J-204, on the front panel. With switch S-205 in EXT position, V-234 is converted to amplifier operation as shown in Figure 9-9.

9-31. BLOCKING OSCILLATOR. To reduce the loading and provide isolation from the remaining circuits, blocking oscillator V-236A follows the crystal oscillator. This oscillator drives itself beyond cut-off within one cycle of operation.

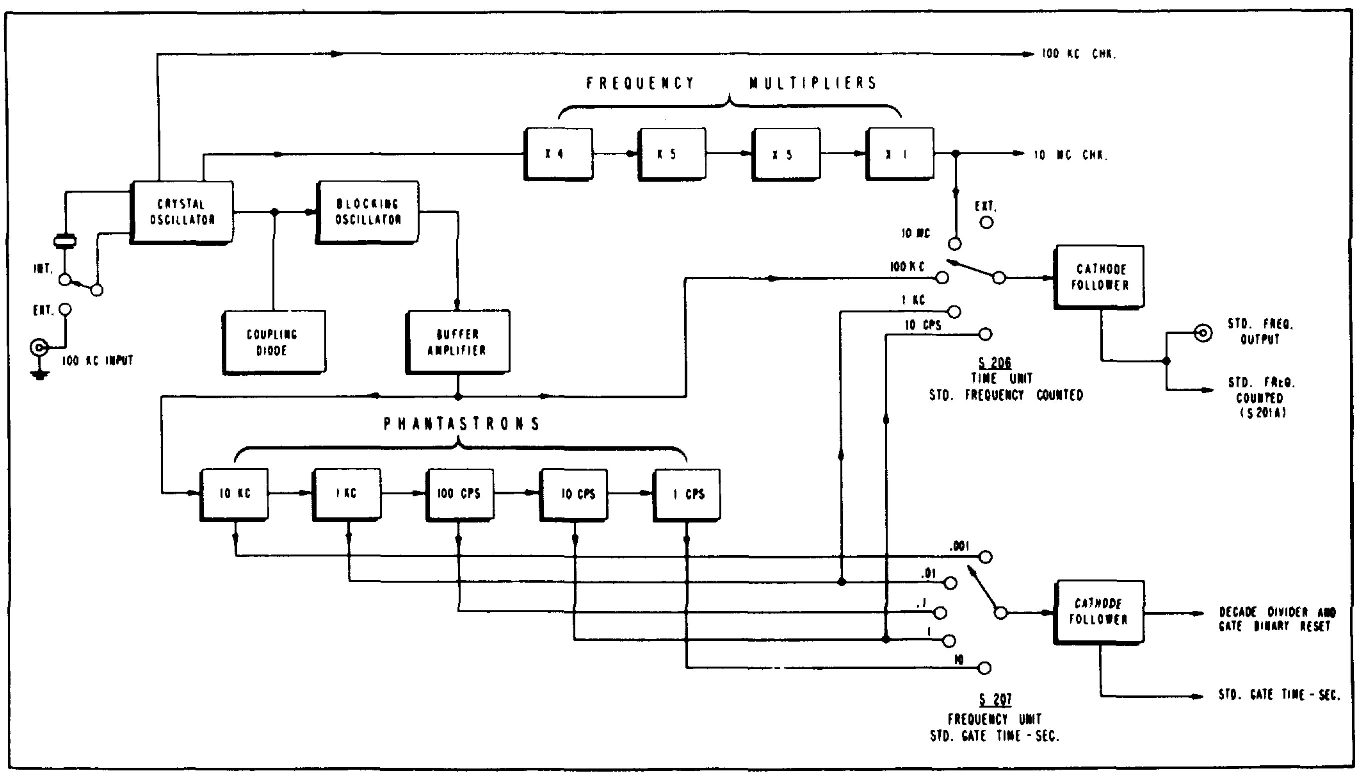


Figure 9-8. Block Diagram of the Time Base

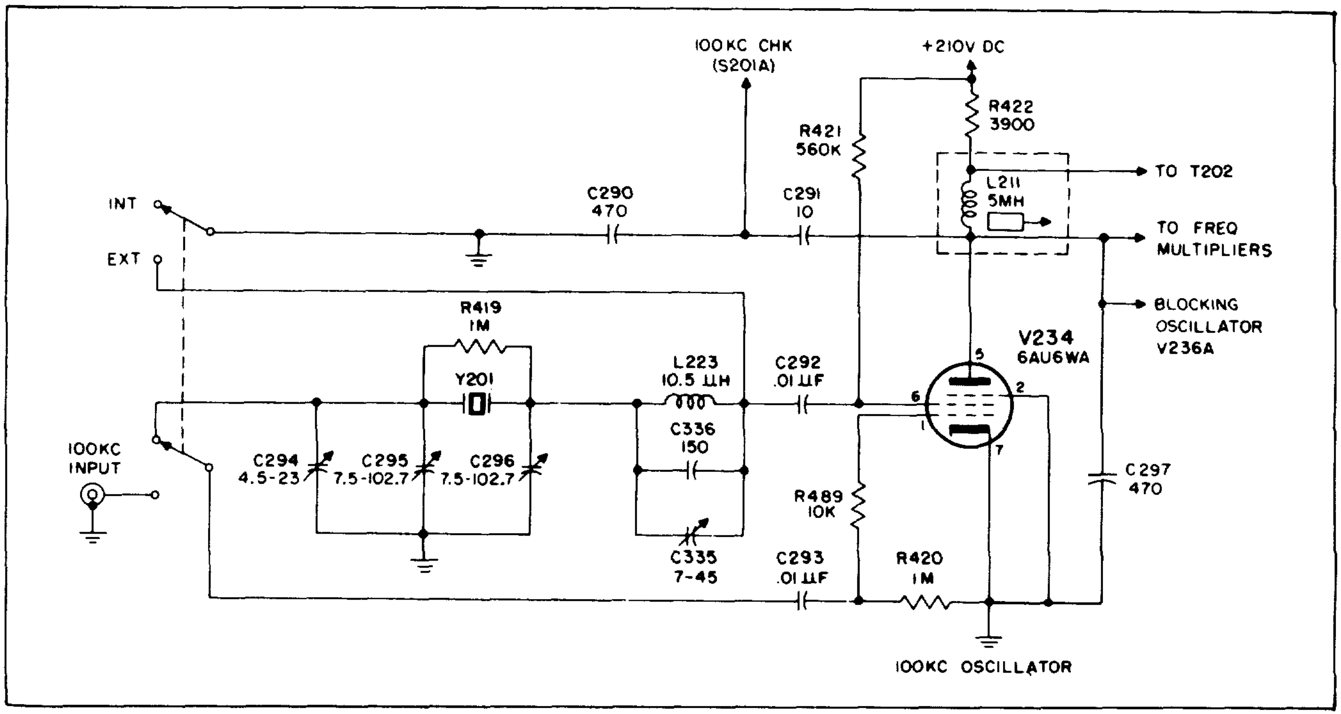


Figure 9-9. Schematic of Crystal Oscillator

The action is initiated by the 100 KC crystal oscillator V-234 and results in a sharp output pulse accurately repeated at a repetition rate of 100 kc per second. A simplified schematic of the blocking oscillator circuit appears in Figure 9-10. It consists of V-236A, a special iron core transformer T-202, and associated components.

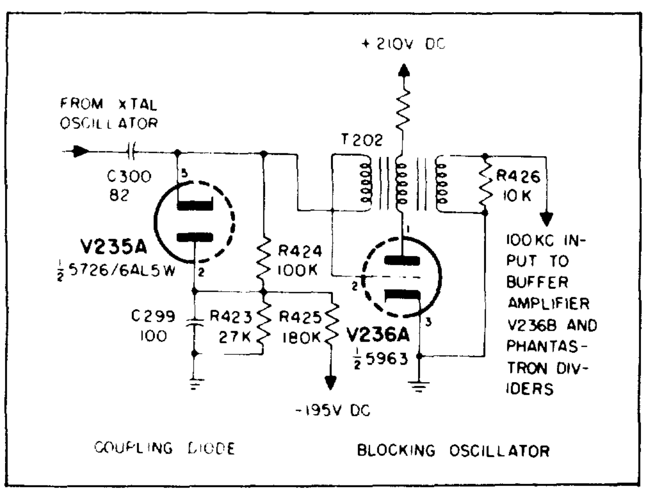


Figure 9-10. Schematic of Blocking Oscillator

9-32. OPERATION OF BLOCKING OSCILLATOR. The positive-going portion of the signal from the 100 kc crystal oscillator is applied to the grid of V-236A causing an increase in plate current. This causes a build-up of the magnetic field in transformer T-202. The transformer is connected so that a voltage is induced which serves to drive the grid more positive, further increasing the plate current. When the grid is driven to a point where it is positive with respect to cathode, it draws current and electrons accumulate in capacitor C-299. Electrons accumulate faster than they can escape via resistor R-423 because of its large value. This process continues until the plate current reaches saturation and the magnetic field of transformer T-202 ceases to increase. For an instant, no voltage is induced in the grid winding, no charging current is applied, and C-299 begins to discharge. This starts the grid on its negative excursion, reducing the plate current and collapsing the transformer field. The collapsing field now induces a negative voltage on the grid. The process is cumulative until the grid is driven beyond cut-off. Further oscillation is prevented by the charge of C-299. The rate that the charge leaks off through R-423 is calculated to hold the grid beyond cut-off until the next triggering pulse is received.

9-33. CUT-OFF BIAS. The circuit of the blocking oscillator has been modified to provide more rapid rise time by applying cut-off bias on the grid of V-236A. The cut-off bias is provided by R-423, R-424 and R-425. C-299 and R-423 operate as previously described.

9-34. COUPLING DIODE. Coupling diode V-235A by-passes all negative-going pulses to C-299, while positive-going pulses are applied to the grid of blocking oscillator V-236A.

9-35. OUTPUT OF BLOCKING OSCILLATOR. The output pulses from V-236A have sharp leading edges capable of more accurately triggering the succeeding phantastron divider stages than the relatively sloping waveform of the 100 kc crystal oscillator. Output voltage is taken from the third winding of transformer T-202 and fed to the frequency divider chain.

9-36. FREQUENCY MULTIPLIER CHAIN. The 100 kc signal from the crystal oscillator is fed through coupling capacitor C-301 to the grid of V-237, the first stage in the frequency multiplier chain. This section comprises four amplifier stages which multiply the 100 kc, delivering a standard frequency output of 10 mc. The stages function identically except for the multiplication factor. Figure 9-11 is a simplified schematic diagram of a typical multiplier stage. The chain multiplies by factors of 4-5-5-1, the last stage serving primarily as an isolating amplifier. The complete circuit diagram is shown in the time base section schematic.

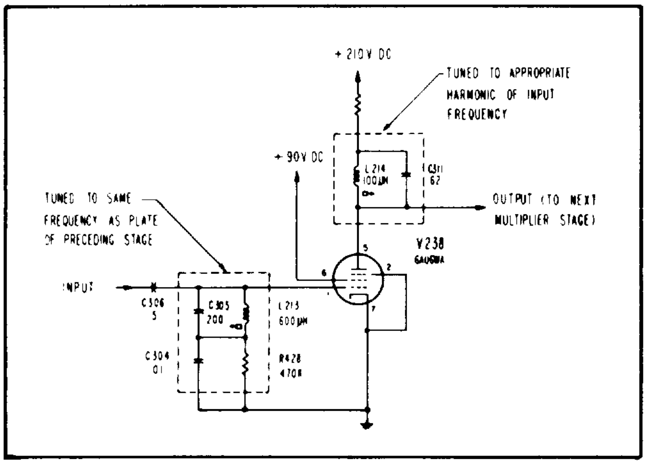


Figure 9-11. Schematic of Typical Frequency Multiplier

9-37. FREQUENCY MULTIPLIER OPERATION. The circuit shown in Figure 9-11 is an overdriven class C amplifier having a nearly square current waveform, rich in harmonics. The first multiplier stage V-237 is driven by the 100 kc signal from the crystal oscillator. The plate of V-237 is a tuned circuit L-212 and C-307 which is tuned to the fourth harmonic (400 kc) of the input signal. The output signal of V-237 drives the tuned circuit (400 kc) in the grid of the following stage, V-238. Frequencies of the tuned circuits for all multiplier stages appear in the time base schematic in Section VII. The output of the fourth stage V-240, the 10 mc amplifier, goes to FUNCTION SELECTOR switch S-201A for self-check operation, as described in paragraph 4-22 and the TIME UNIT - STD. FREQUENCY COUNTED switch S-206A.

9-38. BUFFER AMPLIFIER. The 100 kc output pulse from the blocking oscillator is applied to the grid of buffer amplifier V-236B. The plate voltage of V-236B is a negative pulse used to drive the diode in the first divider stage. A voltage taken across R-434 in the cathode circuit of V-236B is connected to selector switch S-206A TIME UNIT - STD. FREQUENCY COUNTED for use in the counting circuit.

9-39. FREQUENCY DIVIDERS. The frequency divider chain is made up of five 10:1 phantastron dividers as shown in the schematic diagram of the time base section. A typical phantastron circuit and theoretical waveforms appear in Figures 9-12 and 9-13, respectively. As shown in Figure 9-12, the phantastron circuit consists of V-242A and V-243 and the associated components. Tube V-243 is the actual frequency divider, operating as a controlled one-shot multivibrator. The time constants of the circuit are adjusted so that the circuit is retriggered by every tenth input pulse.

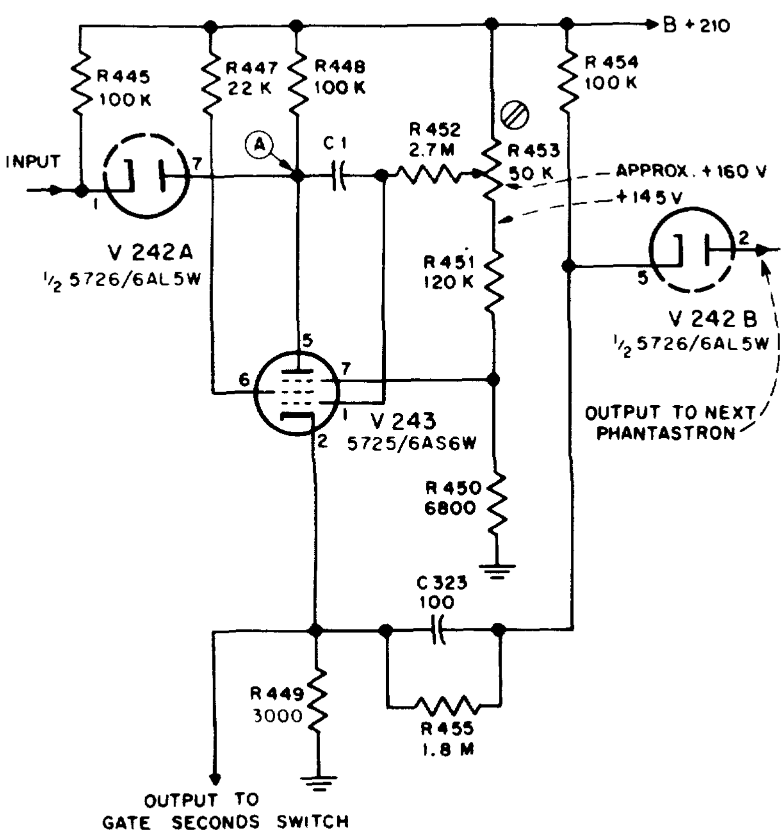
9-40. PHANTASTRON OPERATION. A negative pulse is required to drive the phantastron circuit. Initially, the diode V-242A has the same potential on the plate and cathode (+205V dc). If a positive pulse is applied to the cathode from the preceding stage, the cathode becomes more positive than the plate and the tube appears as an open circuit. A negative pulse makes the cathode less positive with respect to the plate, the diode conducts and a pulse appears at point (A) in Figure 9-12.

9-41. The type 6AS6 tube used as the phantastron divider has two separate grids affecting the same electron stream. Operation of the circuit depends upon the fact that grid 1 (pin 1) controls total space current while grid 3 (pin 7) controls the division of the space current between the plate and the screen. In the stable or quiescent state, the dc voltages are as shown at point 1 in Figure 9-13. Plate voltage is +205V as plate current is cut off (by bias on grid 3, pin 7). Screen voltage is low because total space current is high (zero bias on grid 1) and the screen is now functioning as the plate of the tube. Grid 1, pin 1, is at zero bias because C-322 is fully charged and grid 1 is returned to a high potential by R-452. Grid 3 is at cut-off bias because the heavy space current (to the screen grid acting as a plate) develops +25V at the cathode across R-449 while grid 3 is maintained at +15V by the voltage divider consisting of R-453, R-451 and R-450. The effective bias on grid 3 is - 10V.

9-42. When the negative trigger pulse reaches the plate of V-243, plate voltage drops from +205 to +170 volts. The charge on C-322 cannot change instantaneously so the bias on grid 1 is (+170V) + (-180V) = -10V. The -10V on grid 1 begins the phantastron cycle. See voltages at point 2 of Figure 9-13. Grid 1 bias is now low (-10V) but not low enough to cut the tube off. Grid 3 has a positive bias as the cathode voltage is now +5V and grid 3 is still connected to +15V. Plate voltage drops as most of the space current now goes to the plate (instead of the screen) and plate current increases. The screen voltages increase rapidly when the space current goes to the plate instead of the screen grid.

9-43. Capacitor C-322 begins to discharge through R-452. Grid 1 is no longer drawing current so that its impedance is high. The charge leaking off C-322 changes the voltage across C-322 faster than the voltage at the plate of V-243 is falling, resulting in a gradual decrease in plate voltage and a rise (decrease in bias) of the voltage at grid 1. Total space current is increasing which means that grid 2 is again approaching cut-off so that the screen grid receives more of the total space current.

9-44. Grid 1 reaches a voltage near zero bias and begins the second part of the phantastron (cycle at a time corresponding

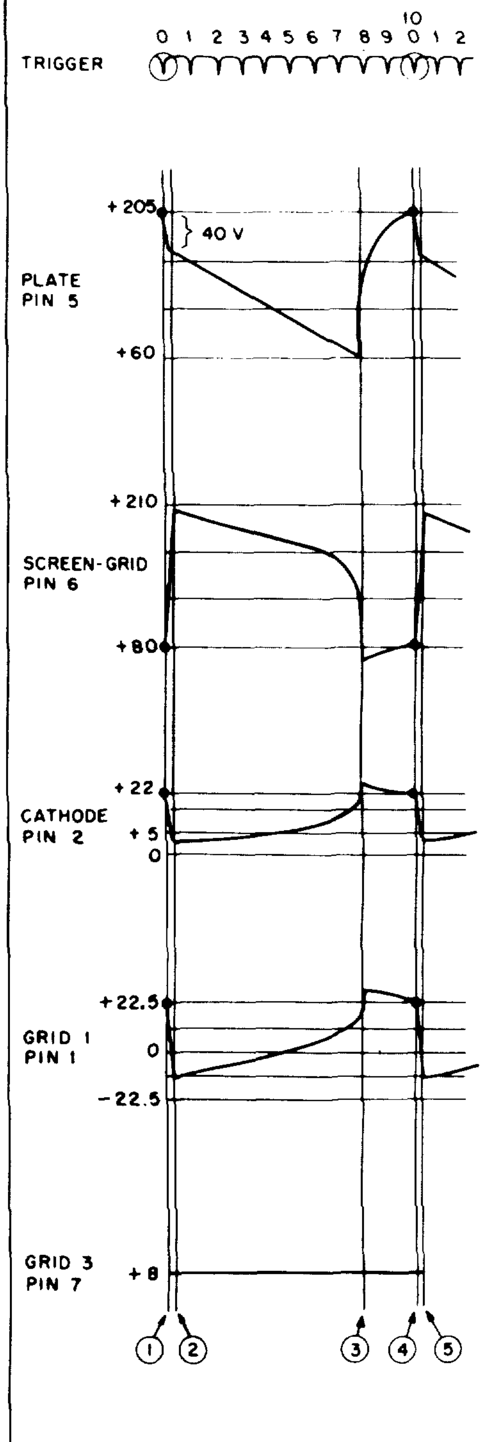


PHANTASTRON	FREQUENCY	C 1
1st	10 KC	47 µµF C 320
2nd	1 KC	470 µµF C 322
3rd	100 ∿	4700 µµF C 324
4th	10 ∿	.05 µF C 326
5th	1 ∿	.5 µF C 328

ALL VOLTAGES MEASURED WITH A DC VOLTMETER. SNAP 100KC STD. SWITCH TO EXT. TO TURN THE TIME BASE OFF.

V 503 PIN NO.	TUBE ELEMENT	TIME BASE	
		OFF	OPERATING
5	PLATE	+ 205	+ 130
6	SCREEN	+ 80	+ 180
2	CATHODE	+ 22	+ 10
1	CONTROL GRID 1	+ 22.5	+ 3.5
7	CONTROL GRID 2	+ 8.8	+ 8.4

TYPICAL PHANTASTRON DIVIDER



THEORETICAL WAVEFORMS IN PHANTASTRON DIVIDER

Figure 9-12. Schematic of Typical Phantastron Divider

Figure 9-13. Theoretical Waveforms in Phantastron Divider

to the 7th and 8th input pulse (determined by the size of C-322, R-452 and circuit voltage). See voltages at point 3 in Figure 9-13. Cathode voltage increases rapidly because grid 1 is zero biased. Grid 3 remains at a fixed potential as this increase in cathode voltage tends to bias it toward cut-off. Plate voltage rises (space current is switched over to the screen grid when grid 3 is cut off). Grid 1 tries to go more positive when the plate voltage rises (positive feedback) so a rapid switching takes place.

9-45. Plate voltage does not rise instantaneously when plate current is cut off as C-322 must charge through R-448. The diode V-242A has +200V on the cathode, pin 1, and some less positive voltage (starting from +60V on its plate, pin 7). Therefore, V-242A cannot conduct unless negative pulses at B have a high amplitude. As C-322 charges, plate voltage rises until, as at point 4 in figure 9-13, C-322 has become fully charged and the phantastron is again in its stable state (since the plate of V-243 is now at +205V) and the diode no longer has any bias on it. The next negative trigger pulse 10 passes through the diode and triggers another cycle of operation.

9-46. This divider circuit is highly stable and will operate for long periods of time without correction. The remaining divider circuits are connected in cascade and are driven from the cathode circuit of V-241. A rectangular wave is present at the cathode and this wave, after differentiation, triggers the following divider. The remaining divider circuits operate in a similar manner, the difference being that the timing capacitor (C-322 in Figure 9-12) is selected to accommodate the lower repetition rates involved.

9-47. The repetition rates of the various dividers are 10 kc, 1 kc, 100 cps, 10 cps and 1 cps. Output voltages are taken from the cathodes of the phantastrons and selected by S-207B, FREQUENCY UNIT STD. GATE TIME SEC, to be fed to the gating circuits.

9-48- STD. FREQ. OUTPUT CATHODE FOLLOWER. V-248B is a conventional cathode follower. It receives frequencies selected by TIME UNIT - STD. FREQ. COUNTED switch S-206 and delivers them at a relatively low impedance from the cathode to connector J-205 STD. FREQ. OUTPUT on the front panel. The same signal from the cathode of V-248B is connected internally to FUNCTION SELECTOR switch S-201A for time interval and period measurements.

9-49. The load impedance of STD. FREQ. OUTPUT connector J-205 is approximately 1,000 ohms. Excessive loading resistively or capacitively (by long cable lengths) of J-205 must be avoided since it will also load the internal standard frequencies counted during Period, Time Interval or Manual Gate operations and cause erratic count. During any operation where internal standard frequencies are counted, it may be necessary to remove cables from STD. FREQ. OUTPUT to obtain correct readings.

9-50. STD GATE TIME CATHODE FOLLOWER. Frequencies from FREQUENCY UNIT - STD. GATE TIME SEC. switch S-207 are applied to the grid of cathode follower V-248A. The output voltage taken across resistor R-485 is directly coupled through S-201E, part of the FUNCTION SELECTOR switch, to the amplitude discriminator Z-202.

9-51. STANDARDIZATION OF CRYSTAL FREQUENCY. The frequency stability of the crystal oscillator in the FR-38/U is approximately 2 parts per million per week. The short time stability of the oscillator is approximately 1 part per million. To achieve this short-time accuracy, however, the internal oscillator must be freshly standardized against a more accurate external frequency standard. The internal oscillator can be standardized by applying the external frequency to the SIGNAL INPUT connector J-203 and adjusting the ADJ trimmer C-294 at the front panel until an accurate reading is obtained on the counters. The external frequency must be 10 megacycles for this adjustment to be made with the highest degree of precision. The standardizing procedure is described fully in Section X of this manual.

9-52. AMPLITUDE DISCRIMINATOR. The amplitude discriminator Z-202 consists of a direct-coupled amplifier and a Schmitt Trigger circuit. When triggered by the incoming signal, the discriminator supplies fast rise time pulses to drive the decade divider and the gating circuits. The amplitude discriminator receives its input signal from the time base unit during frequency measurements and self-check operations and from the signal applied to SIGNAL INPUT connector J-203 during period measurements.

9-53. DC AMPLIFIER. The dc amplifier consists of two stages, as shown in A, figure 9-14. Due to the voltage divider, consisting of R-702 and R-704,across the plate of the first stage V-701A, the total gain of this stage is unity. The second stage, V-701B, is a linear amplifier and represents the total gain of the dc amplifier. The output voltage is directly coupled to the grid pin 5 of V-702, the Schmitt Trigger.

9-54. AMPLIFIER STABILIZATION. Stabilization for any change in trigger level is required for maximum discriminating sensitivity. The zero signal output voltage level (plate voltage) is designed to be in the-middle of the hysteresis range of the trigger circuit. When this is done, the amplitude discriminator operates on the zero voltage crossing at the input to V-701A. As a result, any change of 1 volt or more in the input level causes the output voltage of the amplifier to cross the triggering level of the triggering circuit.

9-55. The circuit of the amplifier provides stabilization of the dc plate voltage of V-701B by minimizing changes in tube characteristics caused by line voltage variations. This can be seen by assuming a decrease in line voltage. The transconductance of V-701B will become lower and its plate voltage will rise. However, the plate voltage of V-701A will also have a rise which, when applied to the grid of V-701B, will compensate for the change. Further stabilization is achieved by the connection of R-705 to B- instead of ground. The reason for this is that any changes in voltage are divided over a larger range, and as a result, cause a smaller percentage change in circuit voltages. A twin triode was selected for the circuit because the cathode characteristics of a pair of tubes in the envelope, made at the same time by one manufacturer, and operated in the same manner are likely to remain more alike than the characteristics of a pair of random tubes.

9-56. SCHMITT TRIGGER. The second portion of the amplitude discriminator is a Schmitt Trigger circuit. This circuit is a cathode-coupled bistable multivibrator, being stable in either of two states. The transition between two stable states is dependent upon the instantaneous dc value of the control voltage (input from dc amplifier). Therefore, the circuit will remain in one stable state for any input signal above the triggering potential, and remain in the other state for input signals below the triggering potential. The operation of the circuit may be described by referring to B, Figure 9-14.

9-57. Assume a dc input signal that may be varied at will is applied to the grid of V-1. As the applied voltage is increased, nothing will happen until the trigger potential "e_1" is reached. At this point, the plate voltage of V-1 drops, driving the grid of V-2 negative. The cathode voltage also drops, reinforcing the positive rise of V-1 grid. Thus, regeneration occurs, causing a change in state and an output rise at the plate of V-2. Any further increase in the applied voltage produces no change.

9-58. As the input voltage is now lowered, the circuit will not return to its original state until the input signal falls to the value "e_2". This difference in trigger point of rising and falling voltages (e_1 - e_2) is known as the circuit hysteresis. The circuit constants have been adjusted so that the hysteresis is about 1 volt. The circuit hysteresis is of importance, since it is the factor that limits the sensitivity of the input discriminators. To produce an output signal, the input signal must swing through both hysteresis limits.

9-59. DECADE DIVIDER. The output of the amplitude discriminator Z-202 is fed through switch S-201D, part of the FUNCTION SELECTOR switch, directly to the gate flip-flop, or to the decade divider Z-203. The decade divider delivers one output pulse for every ten input pulses, regardless of frequency. It is a plug-in unit and is similar to the decade counters, except that no indicating lamps are required. The output of the decade divider is differentiated and applied to diode gate CR-205. A detailed discussion of decade counter theory of operation is presented in paragraph 9-110.

9-60. GATING SECTION.

9-61. GENERAL. The function of the gating section is to open and close the signal path from the input amplifiers and triggering circuits to the counters by means of an electronic "gate". This section also controls the display time and supplies the reset pulse to clear the previous count from the counters before the gate opens. A block diagram of the gating section is shown in Figure 9-15.

9-62. GATE BINARY AND DIODE GATE. The gate binary (V-206 and V-207) is a modified Eccles-Jordan flip-flop circuit, which has the function of furnishing the signal gate with the proper voltage to hold it open for a time interval between the two negative input pulses (start and stop) to the binary. The

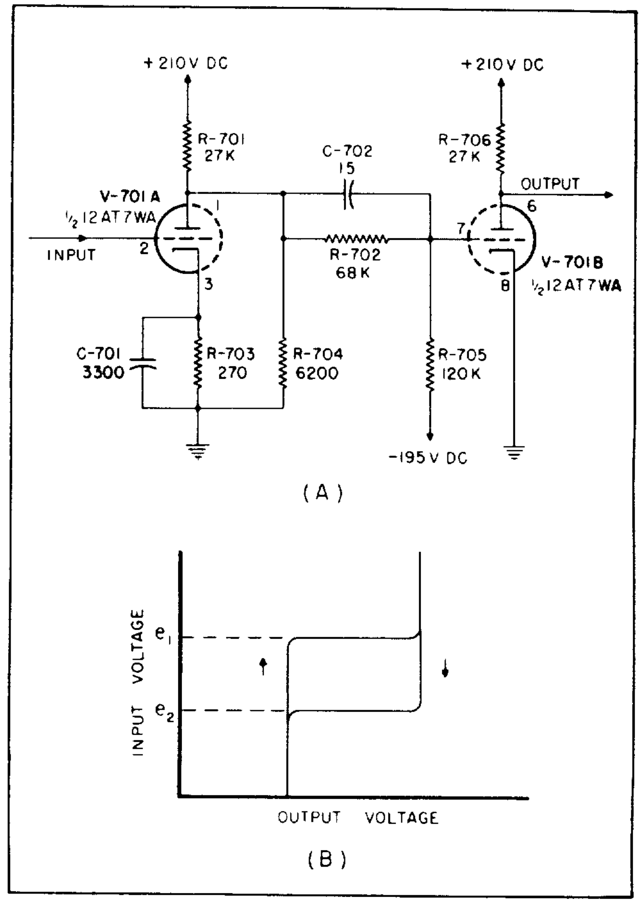


Figure 9-14. Schematic of DC Amplifier and Hysteresis Voltage Curve

diode gate (CR-205), which is controlled by the display time circuits, prevents the gate binary from being retriggered during the display time. This isolation of the gate binary is accomplished by blanketing any negative triggering pulses with a high back bias placed on the diode gate (CR-205) by the display time control tube V-204. The bias is removed at the end of the display time and the system is ready to start the new count. A simplified schematic of the binary and diode gate is shown in Figure 9-16. The basic binary is discussed in detail in paragraph 9-95.

9-63. To insure positive operation of the gate binary by any one of the several types of driving pulses, the basic binary circuit is modified by use of R-251, R252, R-267 and R-268. These resistors form two voltage dividing networks that apply back bias to the grid crystal (CR-205 or CR-210) of whichever tube is cut-off and zero bias to the grid crystal of the conducting tube. Due to this bias, triggering pulses reach only the grid of the conducting tube, the back bias absorbing those that would be applied to the grid of the cut-off tube. Each triggering of the binary shifts the bias so that the back bias always shields the cut-off half of the binary from any triggering pulse. The shift (due to stray capacity) takes approximately 0.7 microseconds, or somewhat longer than the 0.1 microsecond shift time of the binary. This delay

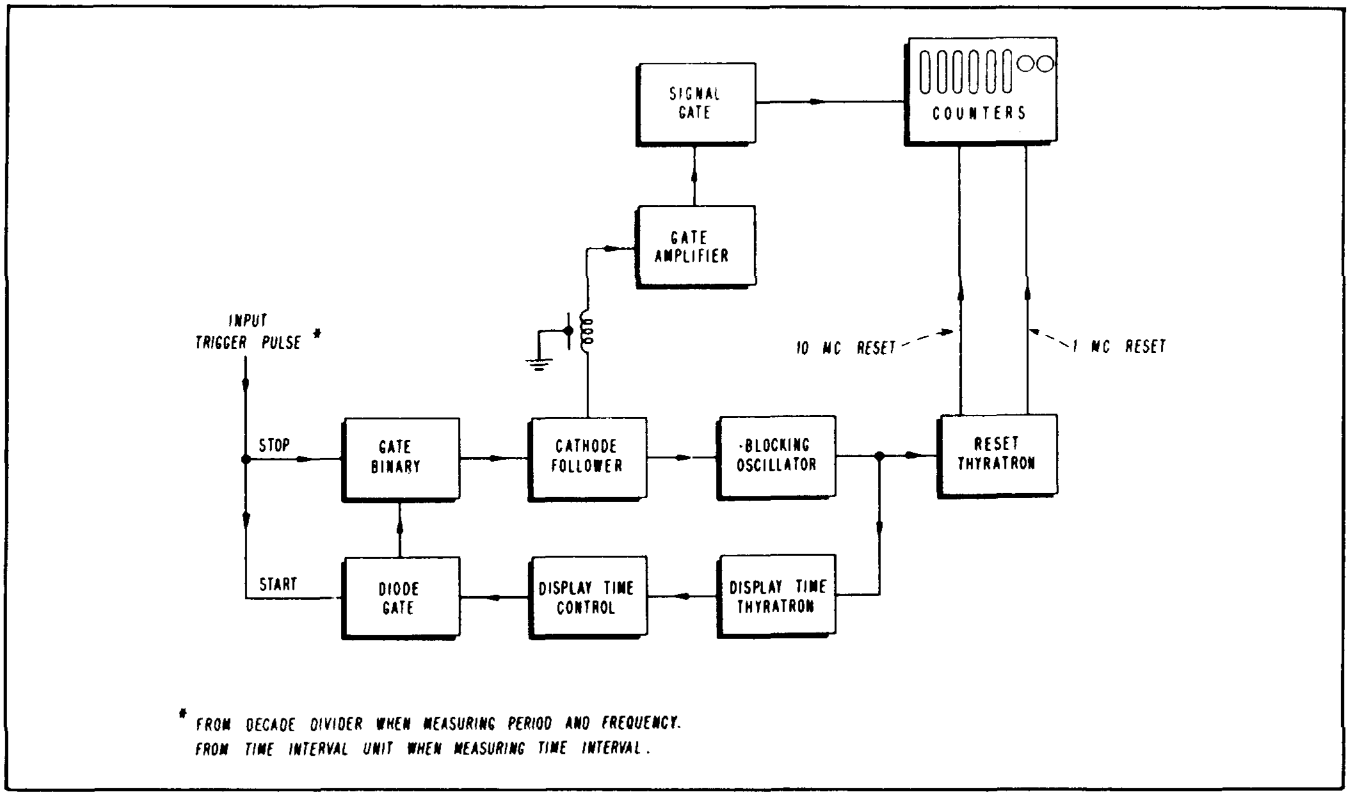


Figure 9-15. Block Diagram of Gate Section

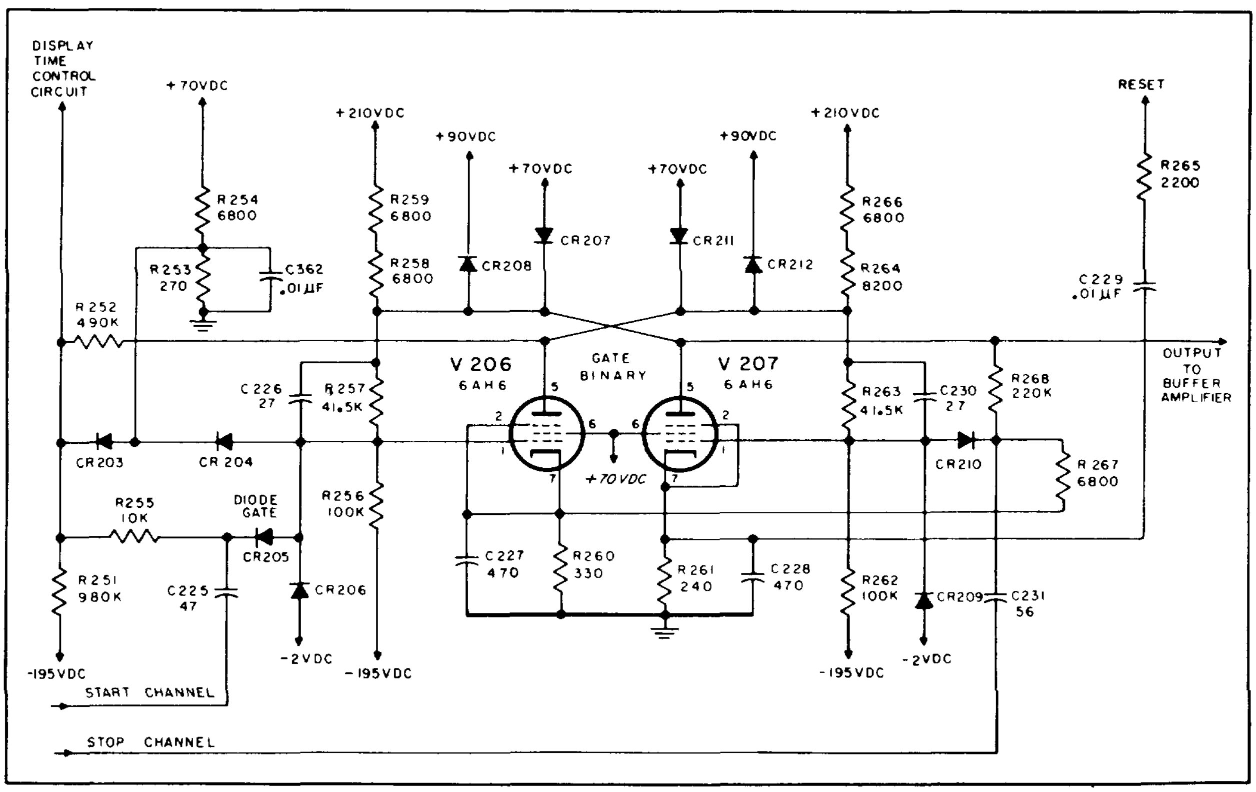


Figure 9-16. Simplified Schematic of Gate Binary and Diode Gate

allows lengthy triggering pulses to die down and eliminates possible erratic triggering of the gate binary.

9-64. The source of the negative input pulse to the gate binary depends on the measurement function performed by the instrument. For "period" measurements, the input trigger pulse is obtained from an external signal applied to SIGNAL INPUT and goes through the amplitude discriminator Z-202 directly to the diode gate CR-205. In "10 period" measurements, the external signal passes through the amplitude discriminator Z-202 and the decade divider. The output pulse from the decade divider is differentiated and passes through the open diode gate CR-205 to trigger the gate binary. For "time interval" measurements, external signals fed into the input connectors of the time interval plug in unit pass through the wave shaping circuits and are applied directly to the diode gate and gate binary.

9-65. During "frequency" measurements, the internal standard frequencies derived from the time base are fed to the amplitude discriminator and decade divider to provide start and stop signals for the gate binary.

9-66. Since the accuracy of the gate period depends upon the speed with which this circuit flips from one state to the other, a flip-flop circuit similar to that found in the 10 mc high-speed decade is used. As the circuit is triggered from one state to the other, the plate voltage of V-206 is switched from +70 to +90 volts, with the plate of V-207 always in the opposite state. The gate is open when the plate of V-207 is at +70 volts and closed when the plate is at +90 volts. Output is taken from the plate of V-207 and fed to the buffer amplifier V-208A.

9-67. BUFFER AMPLIFIER. The output pulse of the gate binary is applied to the grid of buffer amplifier V-208A. Two signals are taken from this tube, one from the cathode circuit and one from the plate circuit as shown in Figure 4-17. The circuit is used to prevent excessive loading of the flip-flop and to present a lower impedance to the delay line.

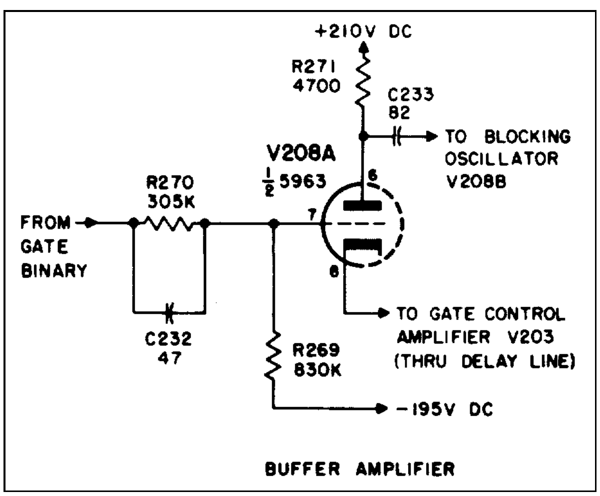


Figure 9-17. Schematic of Buffer Amplifier

9-68. The positive pulse from the plate fires the reset and display time thyratrons, V-209 and V-205, respectively, by means of blocking oscillator V-208B.

9-69. A negative pulse from the cathode of buffer amplifier V-208A passes through delay line DL-201 to the gate control amplifier V-203 to open the signal gate V-202. The opening of the signal gate begins the count by passing the signal from the trigger unit to the counter. The delay introduced by delay line DL-201 allows time for the transients, due to resetting the counters, to die down before opening the gate.

9-70. DELAY LINE. Delay line DL-201 is a distributed constant type made by winding fine wire on a silver-coated paper form. The line is folded and encapsulated in plastic sealing compound. The line delay is approximately 5 microseconds, sufficient time for reset circuit transients to die down.

9-71. GATE CONTROL AMPLIFIER. Figure 9-18 is a simplified schematic of the gate control amplifier and signal gate circuits. The negative-going pulse applied to the grid of gate control amplifier V-203 reduces its plate current and allows the plate voltage to rise to the +90 volt clamp. This potential, applied directly to the suppressor grid of the signal gate V-202, opens the gate. The positive-going pulse reduces the plate voltage of the gate control amplifier to the +70 volt level, cutting off V-202 and closing the gate.

9-72. SIGNAL GATE. The signal gate V-202 is a 6AS6 which is specially designed and constructed for gating purposes. The suppressor grid is rather closely wound and is used as a second control grid. By lowering the suppressor grid voltage, plate current is cut off. When this grid is driven beyond "cut-off" (+70V), any signal impressed on the main control grid (pin 1) does not appear in the plate circuit and the gate is considered closed. When the voltage on the suppressor grid is positive (+90V) with respect to its cathode, the tube functions as an ordinary amplifier, the control grid signal appears in the plate circuit, and the gate is considered open.

9-73. Neon lamp I-201 is used as a visual indicator of the gate condition, i.e.. open or closed. I-201 is a gas-filled diode with the cathode connected to voltage divider R-222 and R-221 between +210V dc and the suppresser grid of V-202, the signal gate. When the potential on the suppresser grid reaches +90 volts to open the signal gate (depending on the drive from gate control amplifier V-203), the cathode of I-201 reaches the ionization potential or firing point and the lamp glows. When the grid potential drops to +70 volts, closed gate condition, the cathode voltage of I-201 falls below the minimum voltage required for conduction and the lamp deionizes.

9-74. MANUAL GATE OPERATION. When MANUAL GATE switch S-202 is in the OPEN position, this manually shifts the grid voltage of the gate control amplifier V-203 from positive to negative. Beyond this, the signal gate and gate amplifier operate as described in paragraphs 9-71 and 9-72.

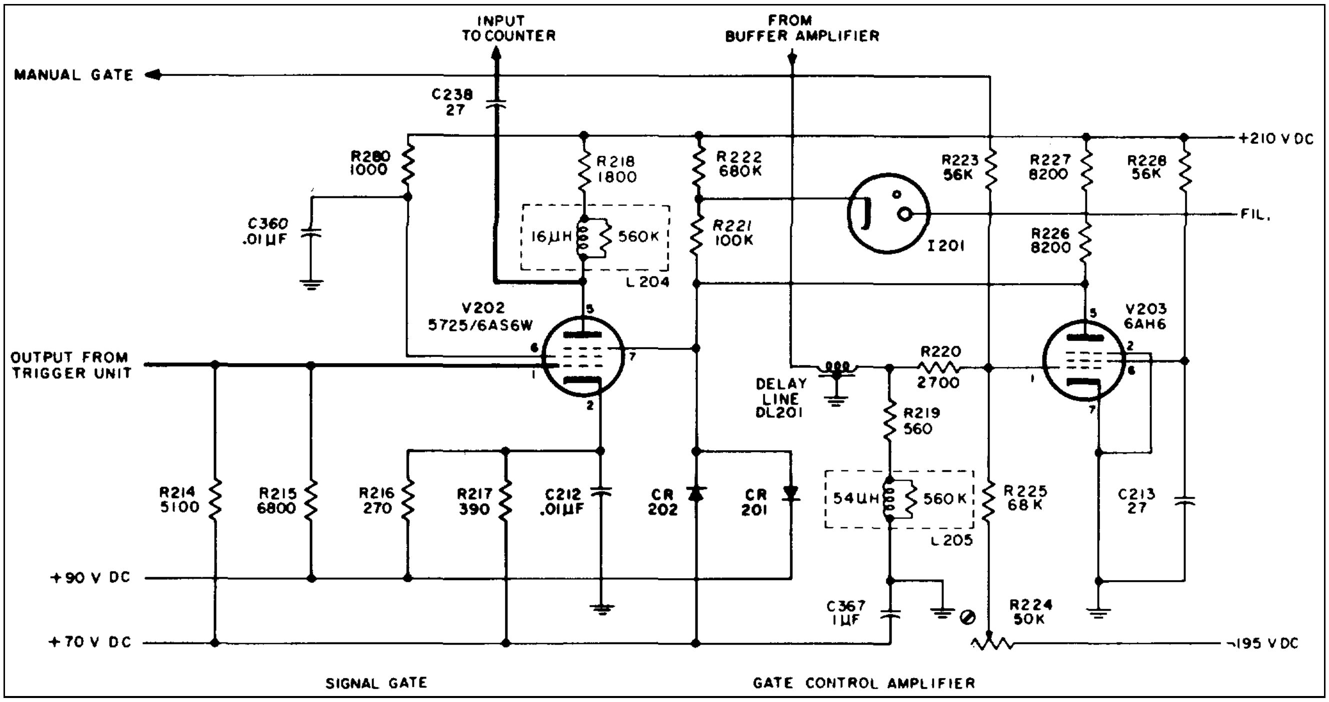


Figure 9-18. Schematic of Gate Control Amplifier and Gate Tube

9-75. RESET CIRCUITS. The grid circuits of both reset and display time thyratrons V-209 and V-205 are connected together and are fired simultaneously. The reset of the counter system is accomplished by the negative pulse from the plate and the positive pulse from the cathode of reset thyratron V-209 (see Figure 9-19). The 10 mc decade is reset through the -2 volt bus grid clamp by the positive pulse from the cathode of V-209. The 1 mc decade is reset by the negative pulse through its plate circuit. The decimal counting units are reset through their grid circuits. These reset circuits are shown on the schematic of the counter section.

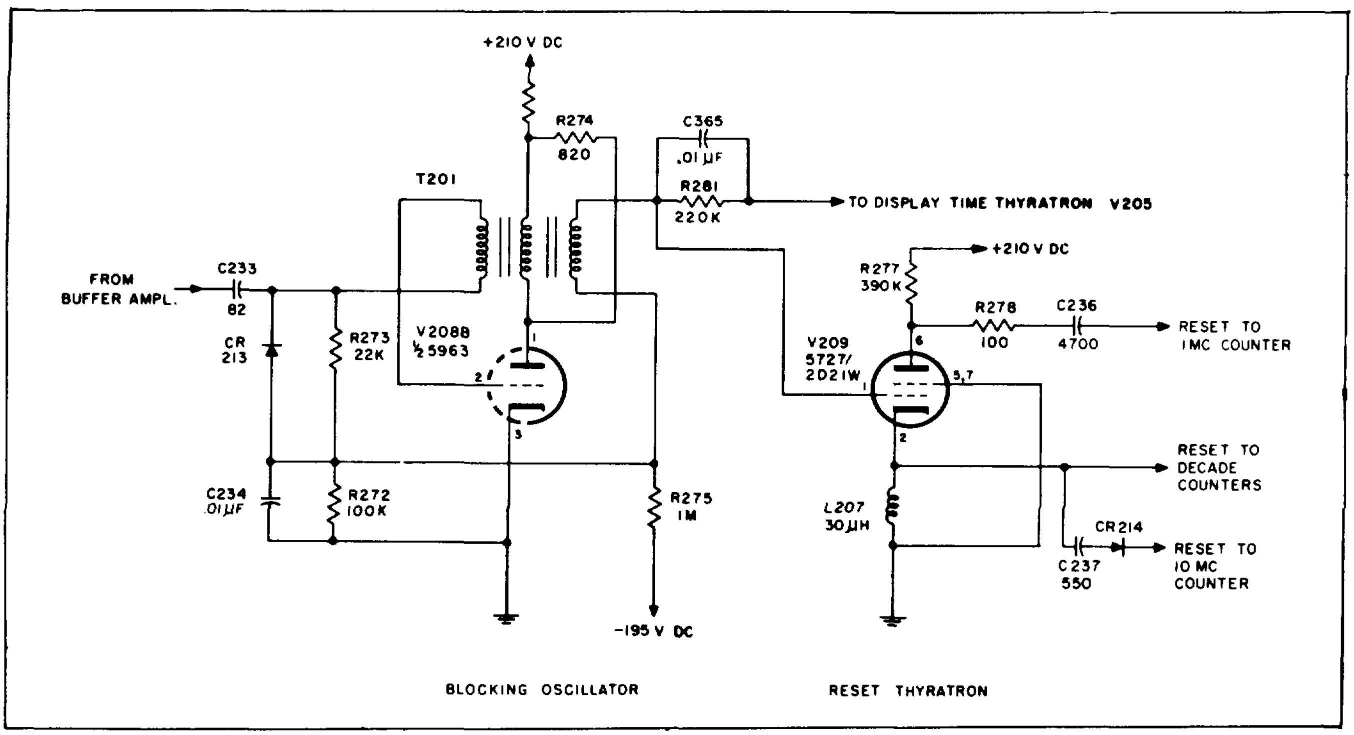


Figure 9-19. Schematic of Reset Thyratron

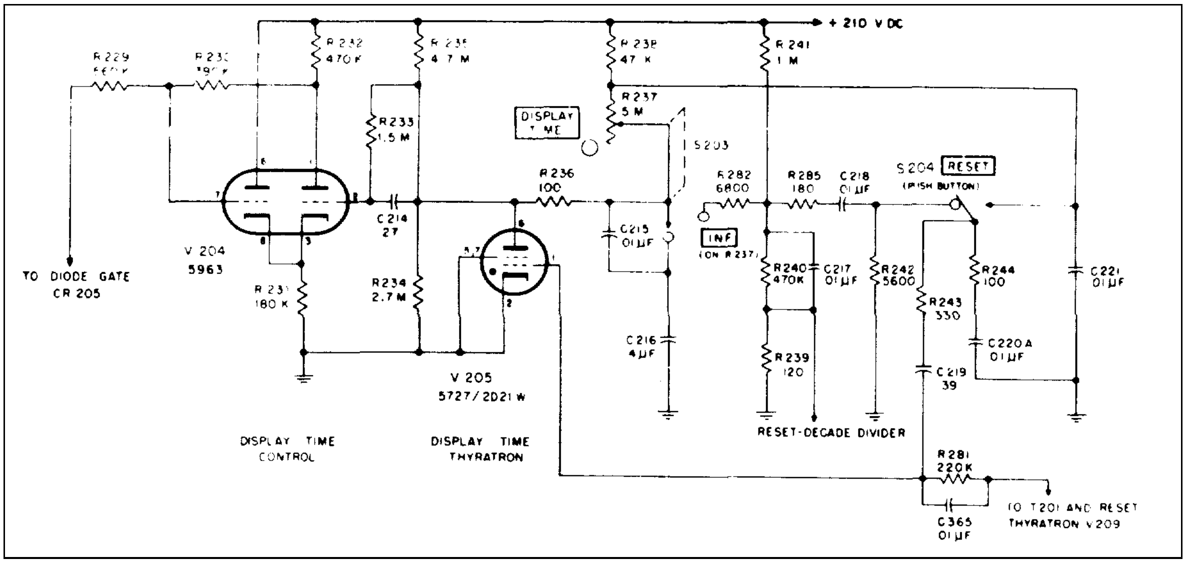


Figure 9-20. Schematic of Display Time Control Circuits

9-76. DISPLAY TIME CIRCUITS. The display time of the count in the FR-38/U is controlled by the display time thyratron V-205, the display time control tube, V-204 and associated components as shown in Figure 9-20. Display time may be controlled automatically beginning with the start pulse and ending with the stop pulse, or controlled manually permitting observation of the count for any selected period.

9-77. DISPLAY TIME THYRATRON. When the positive pulse from V-208B reaches the grid, the gas in the display time thyratron V-205 ionizes and capacitor C-216 discharges. When C-216 is nearly discharged and the plate voltage of V-205 is very low, the gas in the tube deionizes and the tube returns to a resting state. The grid is biased and returns to this condition as the pulse on the grid decays. The operation of V-205 is described in paragraph 9-76.

9-78. DISPLAY TIME CONTROL TUBE. The display time control tube V-204 is a medium mu twin triode. The two sections of the tube comprise a Schmitt Trigger circuit, designed with a wide hysteresis limit. This hysteresis limit is employed during manual display time, discussed in paragraph 9-80. The function of V-204 is to produce an output voltage that is used to bias the diode gate to a closed condition. The trigger circuit operates during either automatic or manual display time and is described in paragraphs 9-79 and 9-80.

9-79. AUTOMATIC DISPLAY TIME. The positive going output pulse of blocking oscillator V-208B is applied to the grid of display time thyratron V-205. When V-205 is triggered, capacitor C-216 is discharged causing a reduction in grid potential (pin 2) of the display time control tube V-204. The two sections of V-204 comprise a Schmitt Trigger circuit. When the triggering cuts off one-half of the tube, the other half conducts. C-216 slowly recharges through R-237, the voltage (on the grid (pin 2) recrosses the triggering level and both sections of V-204 revert to their original condition, removing the closing bias from the diode gate CR-205. The display time cycle is now complete and the diode gate is open and able to pass the next start pulse. R-237, the display time control, is continuously adjustable to provide a display period from 0.1 second to approximately 5 seconds.

9-80. MANUAL DISPLAY TIME. In manual display operation, the count is displayed until the RESET button is pushed, resetting the counters. The circuit is operated by turning the DISPLAY TIME control R-237 to the INF position S-203. This places a bias voltage on the grid (pin 2) of the display time control tube V-204 that is approximately halfway between the triggering levels of the tube. When the RESET button is pushed, capacitor C-220A is charged by B+ voltage through R-238 and R-244. When the RESET button is released, C-220A discharges through R-242 and R-244. The resulting positive pulse on R-242 is large enough to reset the gate binary and decade divider and trigger V-204 which opens the diode gate to pass the next start pulse. The positive pulse from the gate binary fires the display time thyratron V-205 which triggers V-204 to again close the diode gate. The hysteresis range of V-204 is wide enough so that neither pulse crosses both trigger levels.

9-81. TIME GATE CHANGE RESET. A reset system also operates when the gate time is changed iii the middle of a counting period, i.e., whenever the FREQUENCY UNIT-STD. GATE TIME switch S-207A is changed from one position to another during count. The reset line is momentarily opened as the switch S-207A is rotated, allowing C-332 to charge through R-486. As the switch makes contact at the next position. the capacitor discharge is applied to the line that resets the decade divider and gate binary. The gate binary is reset to the proper position to start a new count. The decade divider is reset to a count of 6 so that it will not be necessary to wait for the unit to completely re cycle. The display time is not reset and will run its set time unless the RESET button is depressed. The circuit is shown in Figure 9-21.

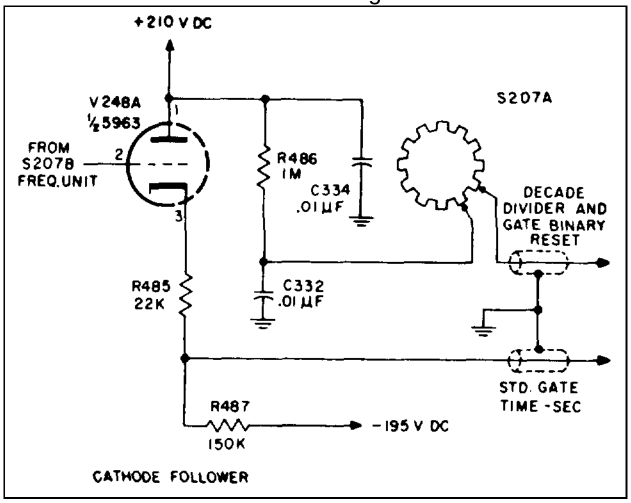


Figure 9-21. Schematic of Time Gate Reset

9-82. GATE SYSTEM ERROR. There are several small error possibilities that should be considered in connection with measurement accuracy. They are discussed in the following paragraphs.

9-83. PLUS OR MINUS ONE COUNT. There is always the possibility that the gate will open or close at the exact instant that a pulse would be entering the counter. In this case, an infinitely small increase or decrease in the input frequencies would determine whether or Dot that pulse would be counted. There is always a possible ±1 ambiguity in the last digit due to this. This type of inaccuracy is inherent in this method of measuring frequencies.

9-84. GATE "JITTER". The second possibility of error arises from the fact that the gate takes a finite time to open or close, and the exact time of opening or closing may "jitter" with respect to the time base signal. The total error in the time interval due to this effect is held to less than 1/10 microsecond in the FR-38/U. This is equivalent to an additional 1 count tolerance at 10 megacycles, ±1/2 count at 5 megacycles, etc., on the one second gate.

9-85. ANTI-SLEEPING SICKNESS TUBES. A problem of concern in electronic computers and similar devices employing "on-off" control applications has been the loss of emission from vacuum tubes after long periods of operation under cut-off conditions. Tube types are available which are specially designed for such service exhibiting stable cut-off characteristics and emission capabilities. Two tubes of this type, the 5963 and 5844, are employed in FR-38/U circuits.

9-86. Sleeping sickness may be described as a decay characteristic of the cathode in vacuum tubes. Experiments indicated that this characteristic is exhibited only fly tubes operated under long periods of quiescent conditions, i.e., biased beyond cut-off so that no emission current flowed. The decay has been interpreted in terms of the resistance and capacitance of the interface layer which lies between the base metal and the cathode coating. The interface compound is formed in a solid state reaction between the oxide coating and the base metal. Since the electrons emitted from the vacuum surface must traverse both the coating and interface, the electronic properties of both influence the operating characteristic of the cathode. A gradual decay in electron emission has been traced to increased resistively of the interface layer which occurs in vacuum tubes operated during long periods of cut-off conditions. The resistive effect of the interface layer may cause a relatively large voltage drop when current is drawn from the cathode, and may, under conditions of higher emission current, actually limit the maximum available current. This decay is responsible for many tube failures in electronic computer applications.

9-87. FAST TRIGGER.

9-88. DC AMPLIFIER. The fast trigger circuit comprises a frequency-compensated dc amplifier and a Schmitt Trigger. The fast trigger is similar in operation to the amplitude discriminator discussed in paragraph 9-52. However, the circuit design has been changed to accommodate the faster (one-tenth microsecond) pulse. The two-stage amplifier V-601A and V-601B, a medium-mu twin triode, is designed with a very wide pass band. The circuit has unity gain from the grid of V-601A to the grid of V-601B by means of the voltage divider R-603 and R-605. There are two signal paths from the plate of V-601A. The low frequency path is through R-603, R-606 and R-607 to the grid of V-601A. At high frequencies the signal path is through C-601, the network of R-607, R-606 and C-602 appearing as a low impedance to the grid of V601A. The cathode of the two stages are tied together and returned to -195V through R-609 and R-608. The large resistance stabilizes the cathode current. The cathode returned to -195V instead of ground is for convenience to maintain propel operating voltages for the tubes. The gain of V-601B represents the gain of the entire amplifier. V-601A is used for stabilization of the circuit only. A twin triode was selected because the characteristics of the pair are likely to remain more alike than the characteristics of a pair of random tubes.

9-89. SCHMITT TRIGGER. The second portion of the amplitude discriminator is a Schmitt Trigger circuit. This circuit is a cathode -could bistable multivibrator which is stable in either of two states. This circuit operates in a manner similar to that described in paragraph 9-56, except that load impedances have been chosen for more rapid switching.

9-90. INPUT CATHODE FOLLOWER. V-201A is a conventional cathode follower. External signals connected to SIGNAL INPUT J-203 are applied to grid of V-201A. The output voltage is taken from the cathode across R-204 and passes to the video amplifier V-201B via FUNCTION SELECTOR switch S-201A (FREQUENCY position).

9-91. INPUT VIDEO AMPLIFIER. V-201B operates as a linear amplifier. The signal applied to the grid is selected by FUNCTION SELECTOR switch S-201A. With switch S-201A in FREQUENCY position, the output voltage from the input cathode follower is applied to the grid of V-201B. In PERIOD, 10 PERIOD, 100 KC CHK, or 10 MC CHK position, internal standard frequencies from the time base section are fed to V-201B. For the MANUAL GATE position, the grid of V-201B is driven by signals applied to STD. FREQUENCY OUTPUT (totalizing measurement). The output voltage from the plate of V-201B drives the trigger unit Z-201.

9-92. COUNTER SECTION.

9-93. GENERAL. The pulse counting circuit consists of decade counters, such as those used in digital computers and nuclear instruments. Each counter performs two functions: First, it divides the frequency of the incoming pulses by ten and presents the lower frequency at its output. Secondly, it remembers indefinitely the number of input pulses received since it delivered the last output pulse and displays this number by some means. Thus, when a number of counters are connected in cascade, each dividing by ten and indicating the remainder, each digit in the total number of pulses received will be displayed.

9-94. COUNTING CIRCUITS. The counter section of the FR-38/U employs eight decade counters. Two of the decades, the 1 mc decade and the 10 mc decade, display the residual counts on meters. The six remaining decade counters are plug-in units. Five of these, Z-205 through Z-209, are decade counters with a maximum counting rate of 30 kc. One, Z-204, has a top frequency of 100 kc. The residual counts of these decades are displayed by means of neon lamps.

9-95. BASIC BINARY SCALER. Since counters must be usable over wide frequency ranges, counting circuits must be a periodic. This requirement has led to the use of Eccles-Jordan trigger circuits or flip-flops and a binary system for counting purposes. A basic flip-flop circuit is shown in Figure 9-22.

9-96. If crystal diodes CR-1 and CR-2 and resistors R-3 and R-4 were removed, this would be a conventional free-running multivibrator circuit which would operate at a frequency determined by C-1, R-5, C-2, R-6 and circuit voltages. If R-1 = R-2, C-1 = C-2 and R-5 = R-6, the circuit is electrically symmetrical so the output would be a square wave, with time required for each half being equal.

9-97. The addition of R-3 and R-4 provides a dc coupling in addition to the ac coupling provided by C-1 and C-2 from the plate of one tube to the grid of the other. The circuit will no longer free-run as the voltage drop across R-3 or R-4 will maintain the voltages on C-1 or C-2 indefinitely.

9-98. Such a circuit has two stable states; either one or the other of the two tubes conducts at any one time while the remaining tube is cut off by high grid bias. When triggered by

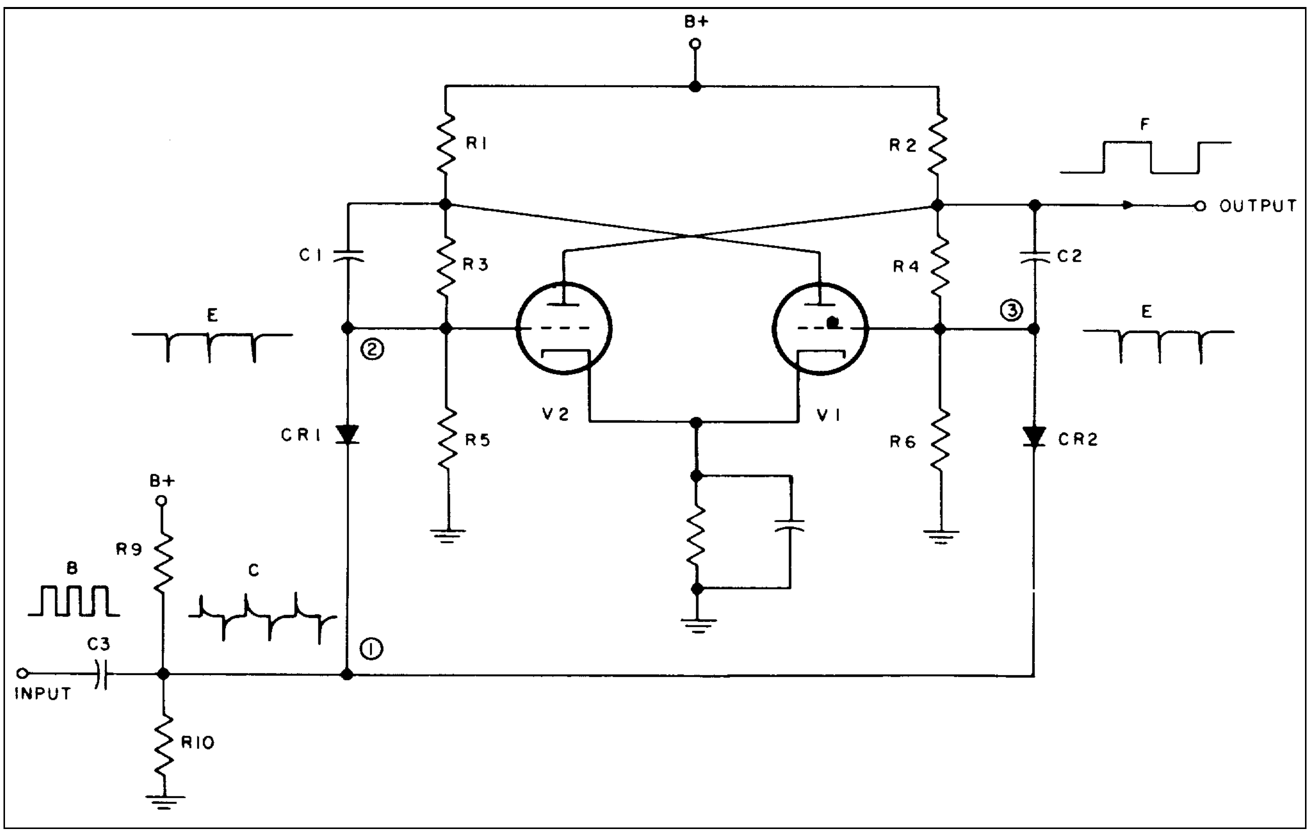


Figure 9-22. Basic Binary Circuit

a suitable incoming pulse, the conducting tube is cut off and the other tube conducts. The flip-flop remains in this condition until a second trigger causes the circuit to revert to its initial state, producing a pulse of given polarity at the output of V-2. This is in contrast to the free-running multivibrator which switches by itself when a capacitor (C-2 if tube V-1 is cut off) charges through R-6 and a return circuit including the power supply and plate load resistor of V-1. This type of circuit can be arranged to trigger from, say, only negative pulses and to produce a negative pulse at the output of V-2 for every second trigger pulse applied. An arrangement such as this, then, divides the triggering pulses by factor of two and is the fundamental principle used in most scalers.

9-99. In a typical circuit, the input is differentiated by the values of C-3 and R-10 giving the waveform at C in Figure 9-23. Notice in the differentiated waveform, C, a positive pulse when the square wave goes from a low to a high potential and a negative pulse when the square wave goes from a high to low potential. It is possible to sketch the differentiated (trigger) waveform at the binary if the square wave driving it is known by following the simple procedure above. This will be helpful when examining the operation of the counter circuits later. The output of a flip-flop is a square wave so it can be differentiated without further amplification to get the trigger pulses for the flip-flop following it.

9-100. A flip-flop can be triggered by both positive and negative pulses if the amplitude is sufficient. If resistors were used in place of crystal diodes CR-1 and CR-2, a positive trigger pulse could drive the grid of the cut-off tube.

9-101. Assume for the moment that V-1 is conducting and V-2 is cut off. If resistors were used in place of CR-1 and CR-2 a positive trigger at (1) would appear at both grids (2) and (3). V-1 is already conducting, which means its grid (3) is already positive, consequently, no change would take place. V-2 is cut off, however, so if the positive pulse at its grid (2) is of sufficient amplitude, it will begin the switching (multivibrator) action which will now make V-2 the conducting tube and V-1 cut-off. This is just the opposite of the original state.

9-102. The next trigger pulse at (1) is negative. Since V-1 is now cut off and V-2 is conducting, a negative pulse at the grid (3) of V-1 would have no effect as the grid is already biased to cut-off. V-2, however, is conducting so if the negative pulse at its grid (2) is of sufficient amplitude, a switching action begins when this grid (2) is driven toward cut-off.

9-103. Notice now what has taken place in the two steps above. A positive pulse initiated switching by pulling the cut-off grid up into conduction. A negative pulse initiated switching by driving the conducting grid toward cut-off. When this happens, the output wave shape and repetition rate are the same as the input and the flip-flop has accomplished nothing. See B, C, and D of Figure 9-23.

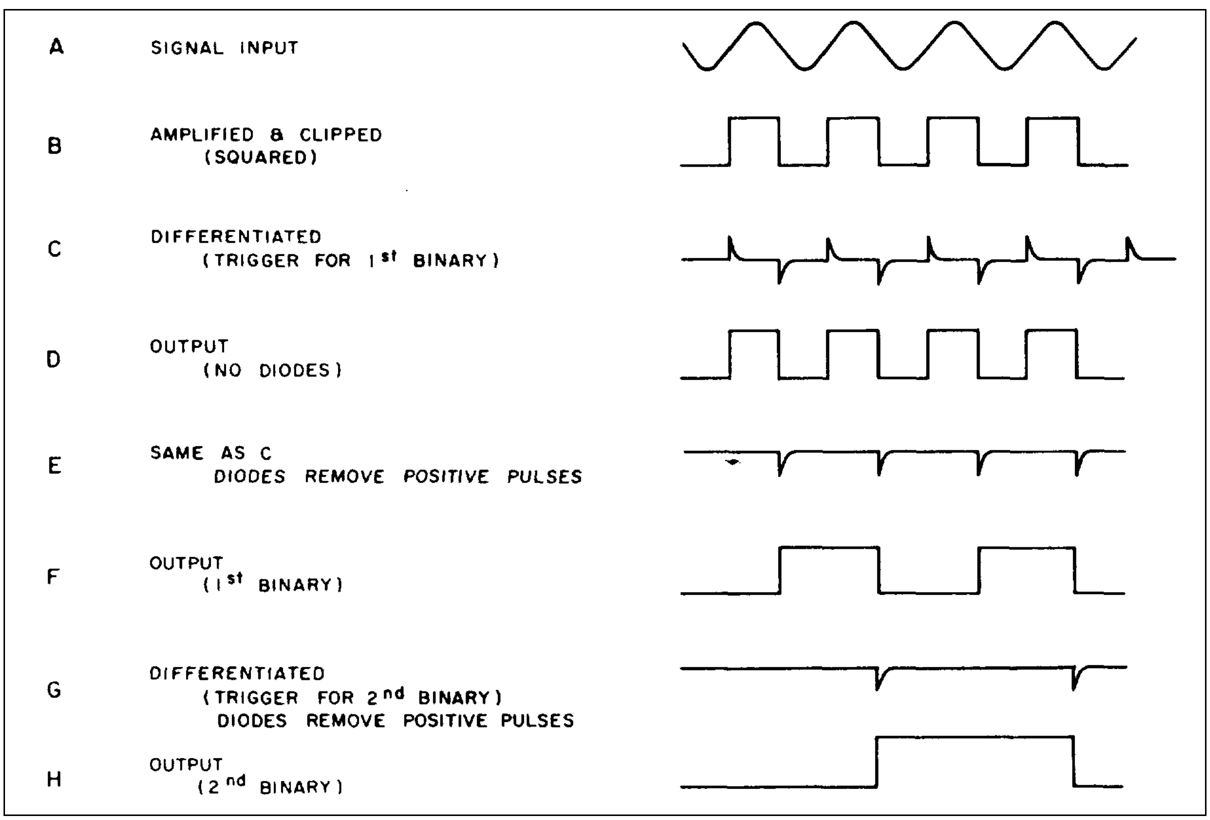


Figure 9-23. Waveforms of Typical Binary Scaler

9-104. If now, unilateral elements of some sort are installed for CR-1 and CR-2 (germanium crystal diodes in this case), the situation is different. Positive and negative trigger pulse (differentiated square waves) are still present at 1. The diodes look like open circuits to voltage of one polarity as in Figure 9-24, case (A), and short circuits (or low resistance elements) to voltage of the other polarity, case (B). Because of this, grids see only one polarity of pulse, depending on the direction in which the diode is installed. In the FR-38/U, all grid input diodes are installed so that only the negative pulses appear at the grids 2, 3, even though the trigger signal 1 contains both positive and negative pulses.

9-105. Assume again that V-1 is conducting and V-2 is cut off. A positive trigger pulse at 1 is effectively "erased", as far as the grids of the flip-flop are concerned, because the diodes CR-1 and CR-2 look like open circuits, consequently the state of the flip-flop does not change. The next trigger pulse at 1 is negative. Both diodes, CR-1 and CR-2, look like short circuits to the negative pulse, so it appears at both grids 2 and 3. V-2 is already cut off, so a negative pulse at its grid has no effect. V-1 is conducting, however, so a negative pulse on its grid will begin the switching action. The new stable state will be with V-1 cut-off and V-2 conducting. As before, the grids 2 , 3 will not see the positive pulse because the crystal diodes look like open circuits. The next negative pulse will trigger the flip-flop back to its original state. See Figure 4-23 B, C, E, F, G, H. Thus, it is the diodes in the grid circuit which make this flip-flop into a binary (capable of dividing by 2) circuit.

9-106. The negative pulse acting on the grid that is conducting always initiates the switching (multivibrator) action in all flip-flop circuits in the FR-38/U counter section.

9-107. From the above description, it becomes apparent why germanium diodes with high back resistance are important in the FR- 38/U counter, particularly as grid coupling diodes. A diode with low back resistance looks electrically like a perfect diode (∞ back resistance) shunted by a resistor of some value. If this resistance gets too low, a flip-flop may trigger on positive pulses part of the time and thus give erratic counts. In extreme cases, if all positive pulses also trigger a flip-flop, the count will be twice what it should be.

9-108. In a final analysis of a binary count, what is wanted is basically a circuit that will put out one pulse for each two pulses in, regardless of repetition rate and equality of spacing.

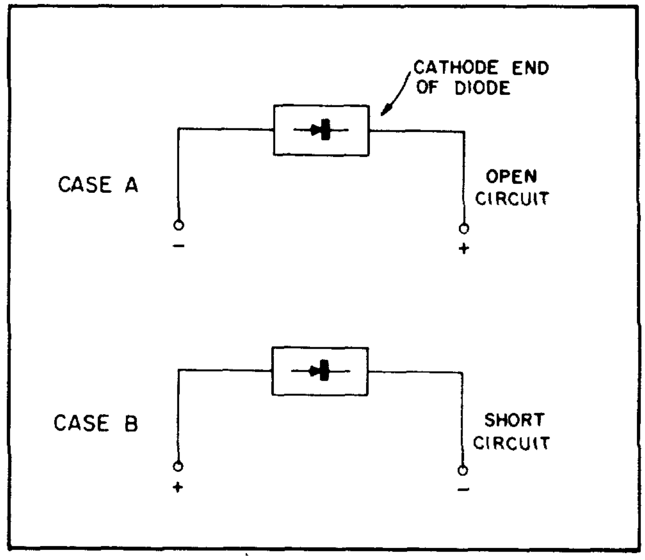


Figure 9-24. Crystal Diode Polarity

9-109. For convenience of use, it is desirable that a counting device divide by a factor much larger than two. Therefore, several flip-flops are usually connected in cascade in a circuit such as that of Figure 9-25 where four stages divide in a binary manner by a factor of 16. That is, every sixteenth pulse applied to the input flip-flop results in a single output pulse from the output flip-flop, as illustrated diagrammatically in Figure 9-26.

9-110. DECADE COUNTERS.

9-111. Because of the wide preference for decimal rather than binary dividing ratios, compounded binary systems such as that in Figure 9-25 are often modified by means of a feedback circuit so as to recycle after the tenth applied triggering pulse. This operation is best described by reference to Figure 9-27.

9-112. Starting with the plate (pin 6) of each of the binaries down (conducting), the plates would be as shown at 1 in Figure 9-27. If it were now possible to cut off plate current in tubes B and C, their plates would go to the up position (+200 volts). This change to +200 volts would correspond to skipping from a place just after the 8th input pulse 1 over to a place just following the 14th input pulse 2 in the straight binary system (see trigger pulses opposite 4 in Figure 9-27. The six plate voltage states corresponding to input pulses 8,

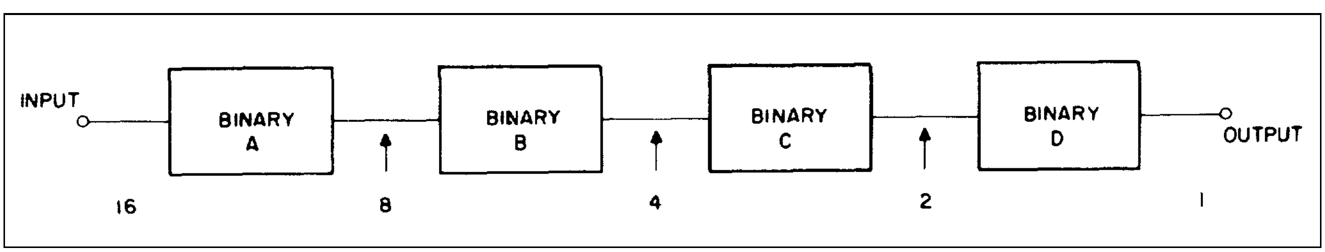


Figure 9-25. Flip-Flop Chain Used in Scale-of-16 Circuit

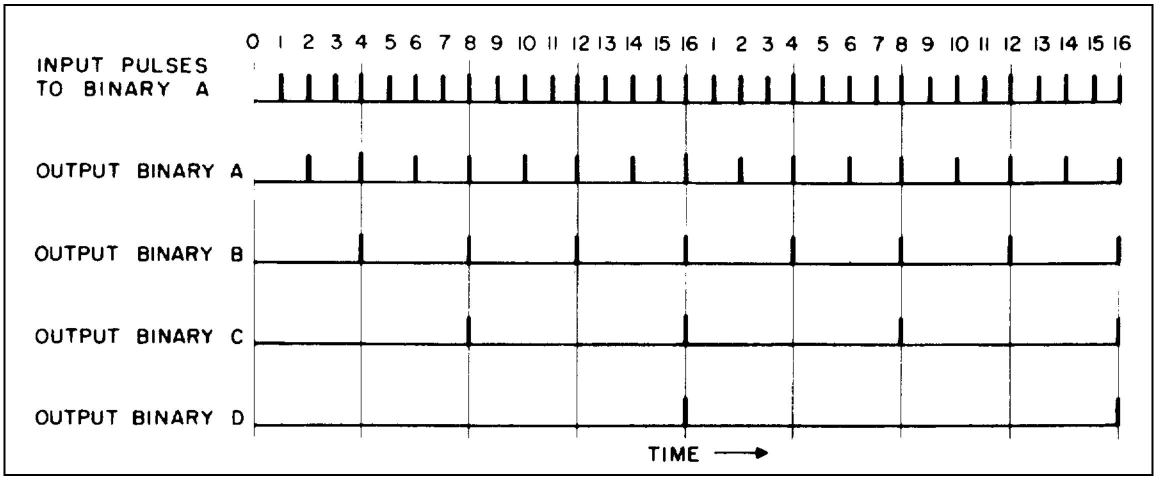


Figure 9-26. Schematic Representation of Operation of Scale-of-16 Circuit

9, 10, 11, 12, and 13 in the binary system 4 would thus be skipped. From this point, two more input pulses, 9 and 10, (see Trigger Pulses opposite 5) would return all four plates to the down (conducting) state from which they started. The four stages have now cycled in 10 counts instead of 16. A block diagram of such a feedback circuit is shown for the 1 mc decade in Figure 9-28.

9-113. A limitation of such a feedback circuit at high speeds arises from the fact that the switching action in a flip-flop is not instantaneous. Rather, a short interval of time is required for the switching action to occur, resulting in a short delay before the next flip-flop in the chain can be triggered. At high pulse rates, these delays are such that the switching time becomes an appreciable fraction of the flip-flop half-cycle. As a result, the time interval required after the eighth applied pulse for the 2nd binary to be reset is the sum of the delays in each binary as the trigger is passed through the chain and back to the 2nd binary (Figure 9-29), five separate delays. Instead of being retriggered immediately, flip-flop "B" will not be retriggered at the time of the last (tenth) pulse of the cycle. In a straight binary system, the delay between the 1st and 4th binary is relatively unimportant. In a decade counter, however, this delay has been a limiting factor.

9-114. 10 MC DECADE - FAST COUNTER. To develop a scaler capable of operating at a 10 mc rate, it is apparent from the above that two important points must be accomplished. First, the flip-flops themselves must be designed to switch as rapidly as possible; second, the cumulative delay in the retriggering circuit must be reduced substantially.

9-115. Figure 9-30 shows the basic high-speed flip-flop used in the 10 mc decade of the FR-38/U. Three important steps have been taken to increase the basic speed of this circuit over the fundamental circuit of Figure 9-22. First, the rise-time of each stage has been made short through the use of high G_m pentodes and by minimizing stray capacities.

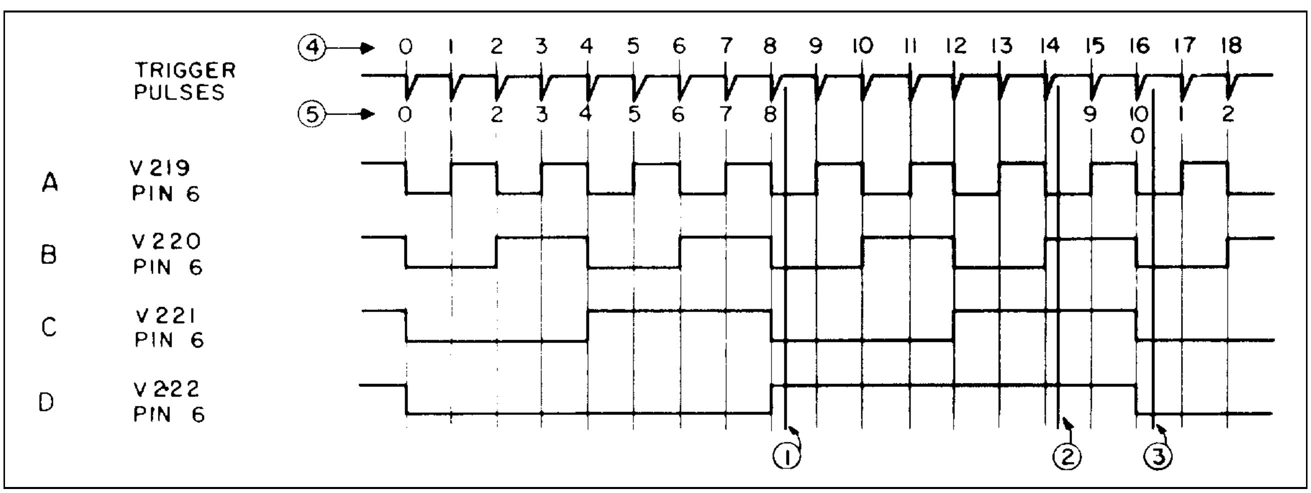


Figure 9-27. Waveforms of a 4-Stage Binary Counter

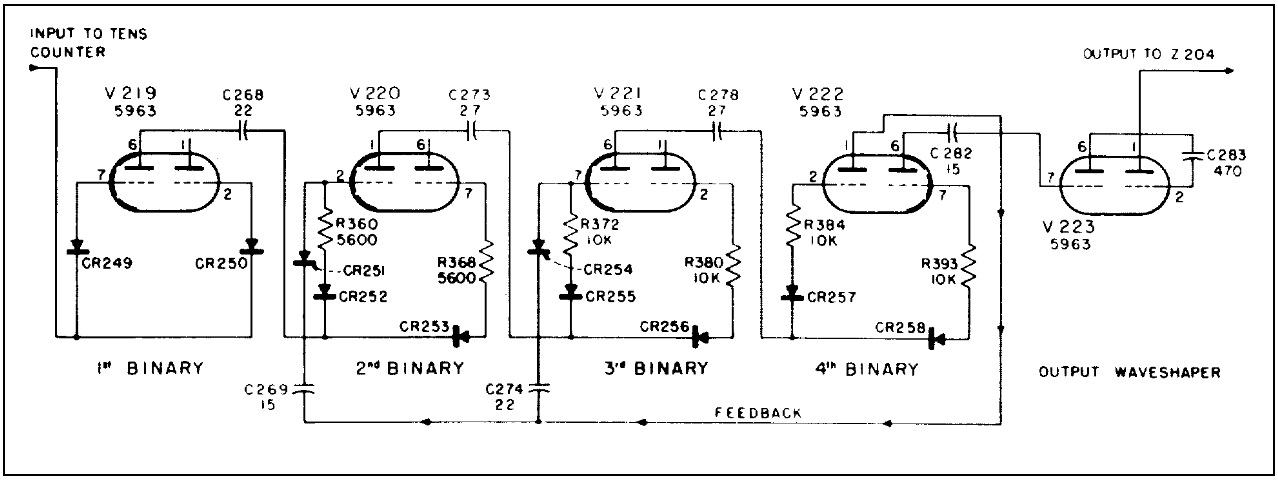


Figure 9-28. Simplified Schematic of 1 MC Decade Showing Feedback

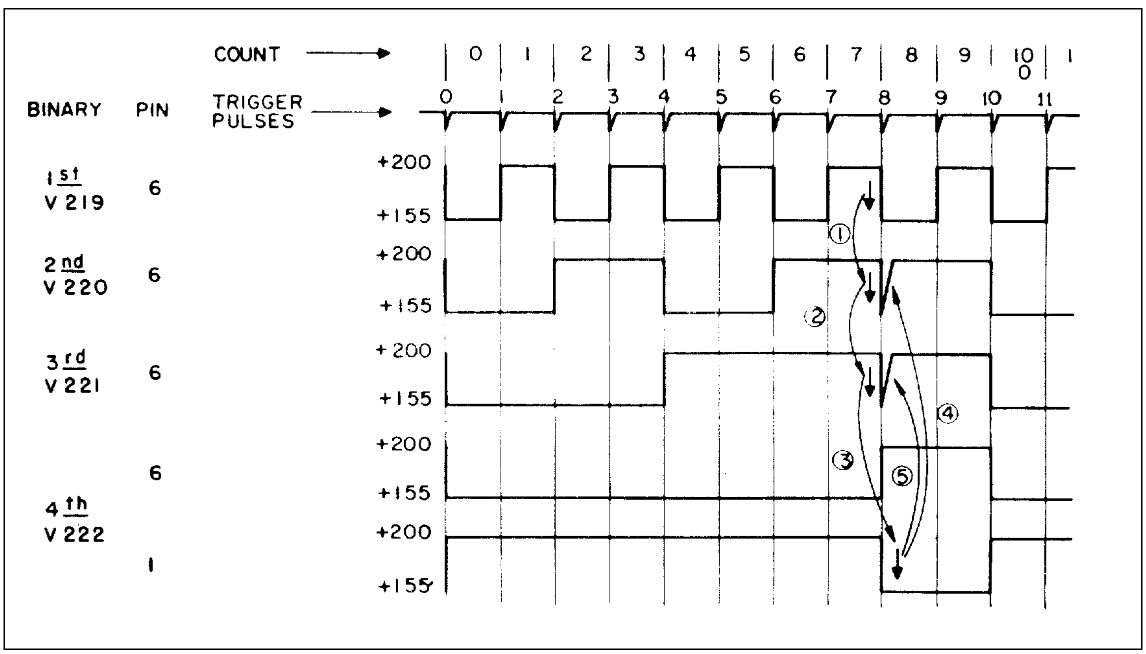


Figure 9-29. Plate Waveforms of 1 MC Section Showing Operation of Feedback

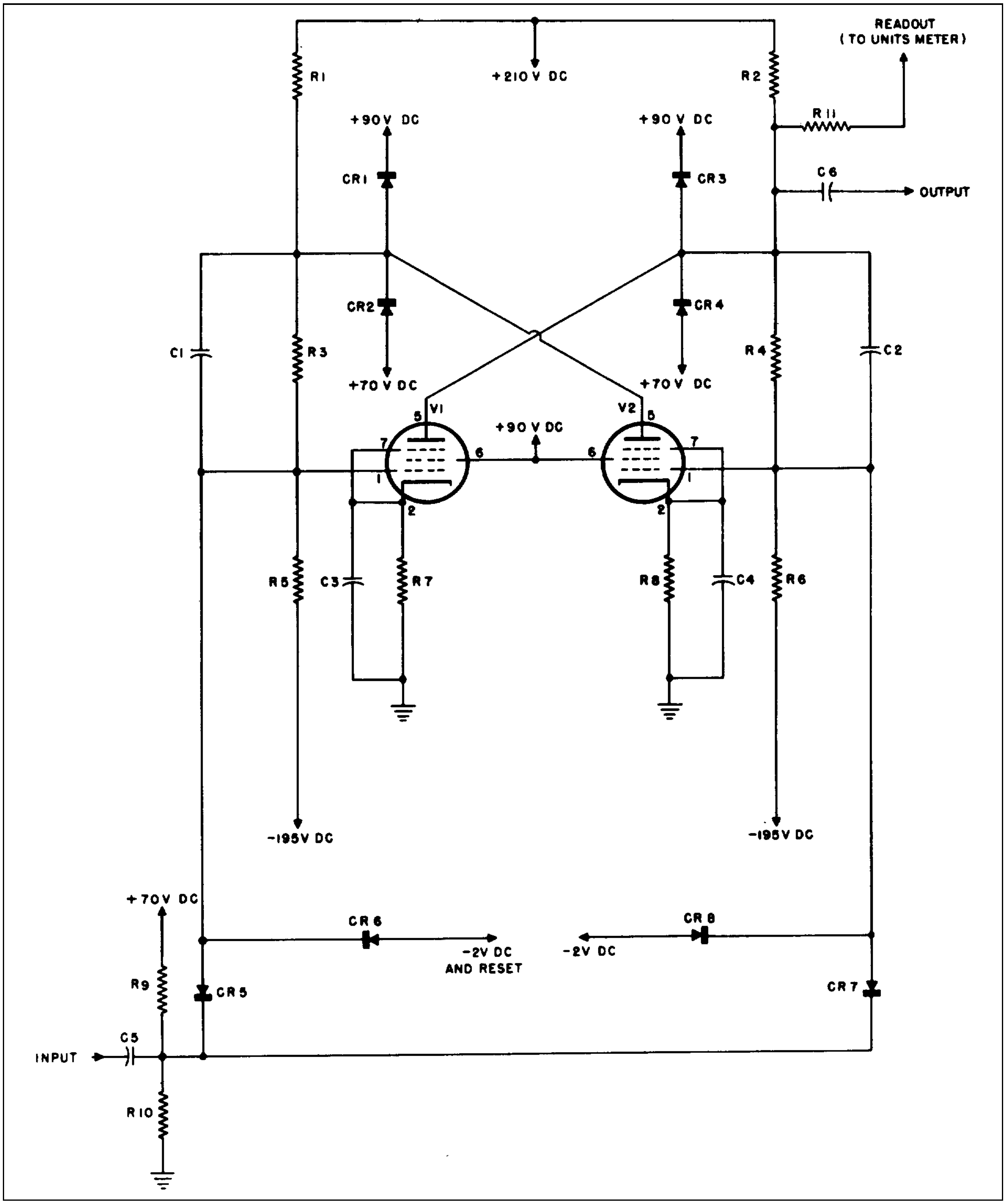


Figure 9-30. Basic High-Speed Binary Circuit

Second, the grid is clamped by diodes CR-3 and CR-4 so that it cannot be driven below 2 volts. Instead of the need of the grid circuits recovering from a value far below cutoff during the switching, the grid is required to change only about 2 volts.

9-116. In high speed circuits, it is customary to use small plate resistors in order to minimize rise and decay times. However, this scheme also reduces the available output voltage. Other factors being fixed, the minimum usable plate resistor is thus limited by the voltage necessary to drive the following grid. In flip-flop applications, the use of a small load resistor tends to introduce unreliability, as a tube whose G_m becomes low may not give the required amplitude of plate swing. This condition is illustrated in Figure 9-31.

9-117. In the 10 mc decade, a plate clamping arrangement is used to overcome the disadvantages of the use of small plate resistors. The plates of the tubes are clamped by diodes such as CR-1 and CR-2 in Figure 4-30, so that only a 20-volt plate swing is obtained between the conducting and non-conducting conditions. This arrangement offers a two-fold advantage. By clamping the plates, the operation of the flip-flops is made substantially independent of normal variation in tube characteristics, even at high pulse rates. In addition, plate clamping gives a more desirable rise and decay characteristic and allows a favorable portion of this characteristic to be used.

9-118. When the plate circuit is clamped, the situation is as illustrated in Figure 9-31. A relatively high value of B+ and a large plate resistor are used, giving a rise time characteristic that is much longer than with a small plate resistor but having the same initial slope. The plate clamps limit the operation to only a portion of the characteristic as shown. The rise-time of this portion can be shown to be somewhat faster than the total rise-time of a circuit that used a small plate resistor.

9-119. The reliability of the clamped plate circuit is much better than in the case of the small plate resistor. This is illustrated by the dashed line in Figure 9-31. If a tube having low Gm is used, only a slight decrease in rise time is obtained. In addition, the required amplitude of plate swing will almost always be obtained.

9-120. It should be noted that for optimum resolving time, the rise and decay times should' be equal. Since the decay characteristic is the inverse of the rise characteristic shown in Figure 9-31, the clamped region must be placed approximately midway between the limits of the unclamped plate excursions to give the necessary symmetry to the operation of the circuit.

9-121. HIGH SPEED FEEDBACK GATE. A final factor in speeding up the counter is the use of a highspeed feedback circuit that avoids the delays described before. The circuit used can be described by referring to Figure 9-32 and Figure 9-33. In Figure 9-32 it is shown that in the interval between the seventh and eighth applied pulses, the 1st, 2nd and 3rd binaries are all in the same sense. This interval is the only time that the first three binaries are aligned and thus would be susceptible to a feedback pulse. To accomplish this, the binaries are coupled through a coincidence network (Figure 9-33) which can only be opened when the 2nd and 3rd binaries are "up". The output of the gating tube V-214 is coupled to the 4th binary. On the eighth applied pulse, the sharp negative pulse from the 1st binary triggers the 4th binary before the gate, controlled by the 2nd and 3rd binaries, closes. A second feedback network allows the sharp rise in the 4th binary to retrigger the 2nd and 3rd binaries as indicated in Figure 9-32. After being retriggered by the ninth and tenth applied pulses, all binaries revert to the same sense as after the tenth pulse of the previous group, thereby completing a cycle. This circuit removes the major delays from former types of feedback circuits.

9-122. FEEDBACK GATE. The feedback circuit, used to speed up the counter, is shown in Figure 9-33. V211 in the first binary is connected directly to the input of V-217 in the fourth binary through V-214, the feedback gate. If a "gate" were not in the circuit, a negative driving pulse would be delivered to the fourth binary each time V-210 in the first binary went from +90 to +70 volts. The output of V-211 drives the feedback gate V-214 as its plate goes from +70 to +90 volts, delivering a positive pulse to the grid of V-214. The negative pulse from the plate of V-214 is then applied to the grids of V-217 and V-218 in the fourth binary.

9-123. COINCIDENCE NETWORK. The gate V-214 is opened and closed by the coincidence network shown in Figure 4-34. This network consists of crystal diodes CR-231 and CR-233 connected between the plates of V-212 and V-216 in the second and third binary. The diodes are considered open or short circuits, depending upon the voltages across them established by the plate voltage state of V-212 and V-216. The various conditions shown below can exist. The feedback gate V-214 is open only when the output of the coincidence network is +90 volts.

9-124. The table below shows that the gate is closed for the counts 0 through 5. The 6th input pulse operates V-212 to the up position which opens the feedback gate V-214. The 6th input pulse does not trigger the 4th binary because the gate did not open until after the 1st binary had changed its state to drive the 2nd binary. The 7th input pulse does not trigger the 4th binary

COUNT	V-212 (2nd Binary)	V-216 (3rd Binary)	OUTPUT OF COINCIDENCE NETWORK	V-214 FEEDBACK GATE
0 and 1	+70V	+70V	+70V)	
2 and 3	+90V	+70V	+70V)	Closed
4 and 5	+70V	+90V	+70V)	
6 thru 9	+90V	+90V	+90V	Open

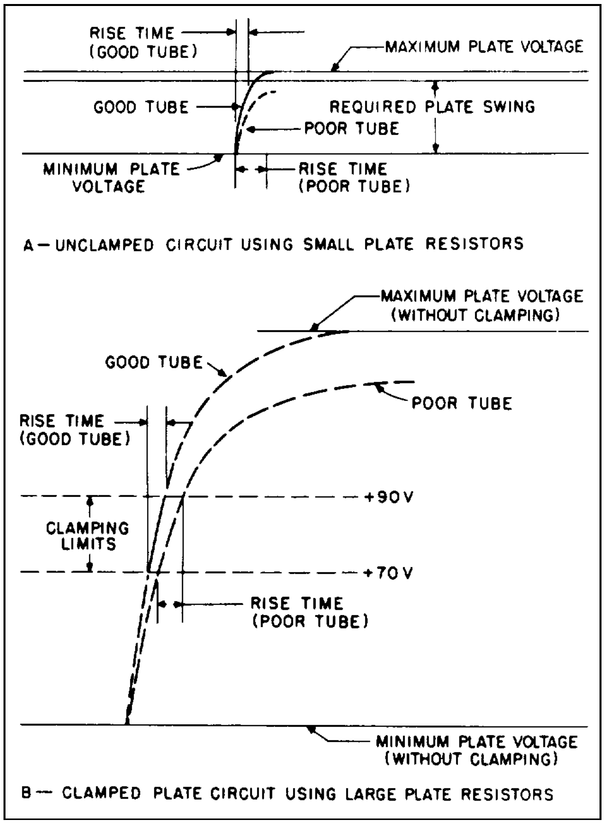


Figure 9-31. Comparison of Rise and Decay Characteristics of Unclamped and Clamped Plate Circuits

as the plate voltage of 1st binary is in the wrong direction (only a downward swing of the plate voltage of V-210 will set up a trigger for the 4th binary). The eighth pulse is the first one to trigger the 1st binary in the proper direction (V-210 from +90 to +70 volts) to the trigger of the 4th binary. The 9th input pulse triggers V-210 from +70 to +90V, which is the wrong direction to trigger the 4th binary. The 10th pulse triggers V-210 in the correct direction to also trigger the 4th binary. At the same time, the 1st binary triggers the 2nd and feedback gate is again closed as the 2nd binary operates.

9-125. It is apparent that the feedback gate V-214 can be started by the 6th pulse, even though it is not needed until the 8th. When the 8th pulse enters the 1st binary, the gate V-214 is already open and looks like a direct connection from the 1st to the 4th binary, which cuts down any circuit delay.

9-126. 1 MC DECADE. The output of the 10 mc decade feeds into the 1 mc decade. The 1 mc counter is less elaborate than the high-speed circuit, since the significant time intervals are ten times as long. The flip-flops and feedback circuit for this decade are essentially as described in paragraphs on basic counter circuits.

9-127. METERING OR READOUT CIRCUITS. The number of input pulses since the last output pulse is indicated on meters in the 10 MC SECTION and 1 MC SECTION and on banks of neon lights for all other counters. The 1 mc decade readout is described below.

9-128. The indicating circuit for the 1 mc decade consists of a meter whose deflection is proportional to the residual count in the decade. The meter reads the sum of four currents, one from each binary pair. The magnitude of the current from a particular pair indicates the relative position of that pair in the decade, while the sign of the current indicates which tube in the pair is conducting. During the counting period, the pointers on both front panel meters will lie at center scale between 4 and 5. At the end of the counting period, they will fall to the proper digit and remain there for a time approximately equal to the counting period.

9-129. The readout circuit consists basically of a resistor network and a meter that totals the current supplied by one plate in each of the four binaries. Referring to Figure 9-35, notice that the count of zero corresponds to plate pin 6 of each tube at +155V. Each input pulse applied thereafter will set up a new pattern of plate voltage for the four stages. The pattern does not repeat until the 10th input pulse, at which time all plate voltages are again +155V.

9-130. Suppose that if plate (pin 6) of a binary is at +155V, it contributes zero units of count, but if it is at +200V, it contributes the number of units of count shown in Table 9-2.

Table 9-2. Number of Units Count Per Binary

1st Binary	1	Unit
2nd Binary	2	Units
3rd Binary	4	Units
4th Binary	2	Units

9-131. In the basic metering unit, Figure 4-35, the plate (pin 6) of each tube shown may be at either +155 V or at +200V. Assume for a moment that all plates are at +155V. A meter connected from "A" (the metering bus) to a +155V point on a voltage divider will remain on zero because it has the same potential on either side.

9-132. Suppose now the plate of the 2nd binary goes to +200V, the other three remaining at +155V. It should be possible to choose a value of R2 such that two units of current (milliamps, for instance) will flow through the meter and cause it to read 2 on a scale marked off 0 to 9 (Figure 9-35). Assume 200K was necessary to get 2 milliamps of current. (Think of this as a count of 2.) Looking back at Table 9-3, the 1st binary is to contribute 1 milliamp whenever its plate (pin 6) is at +200V. This condition can be met by making R1 = 390K. (Resistor is twice as large as R2, so only half as much current will flow through the meter.) Likewise for the 3rd binary, 4 ma of current are wanted when its plate (pin 6) is +200V. This

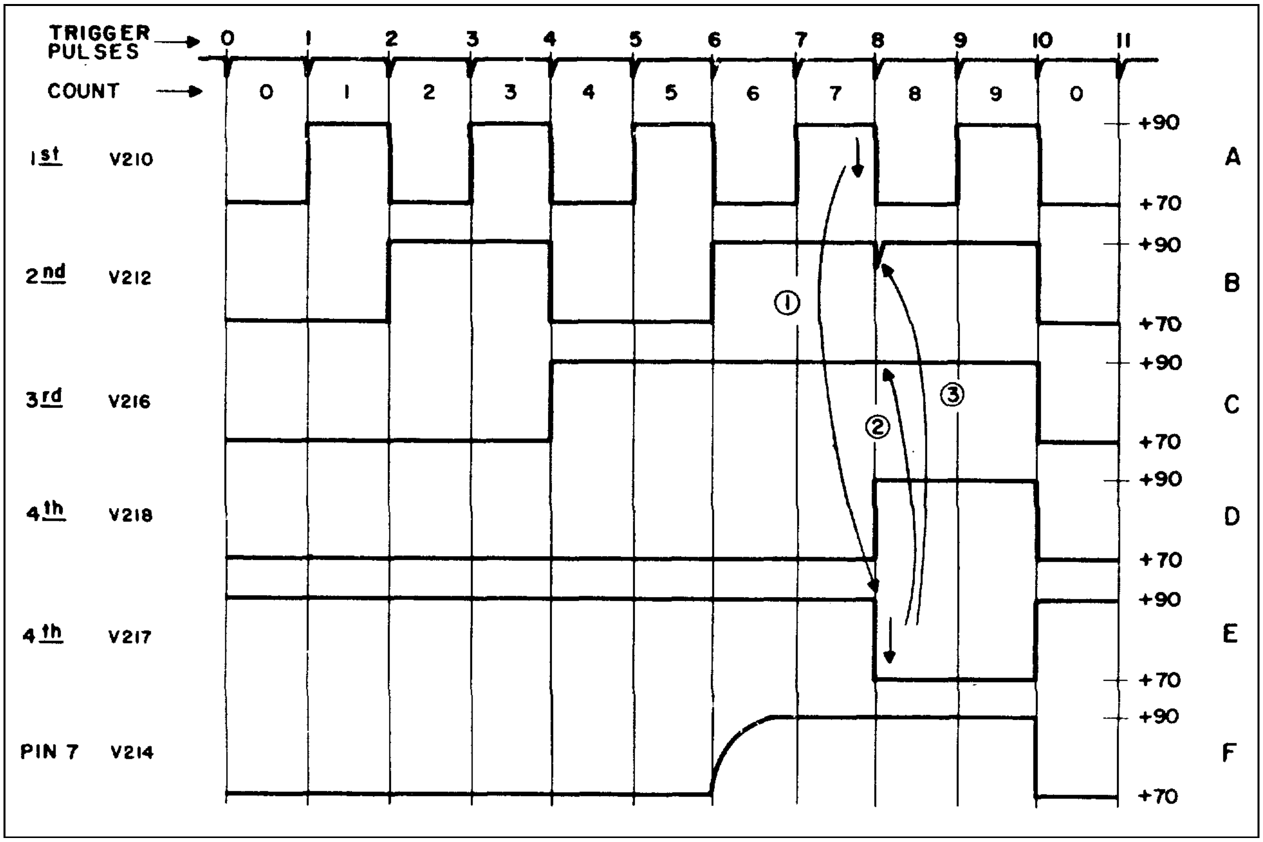


Figure 9-32. Plate Waveforms of 10 MC Section Showing Operation of Feedback Network

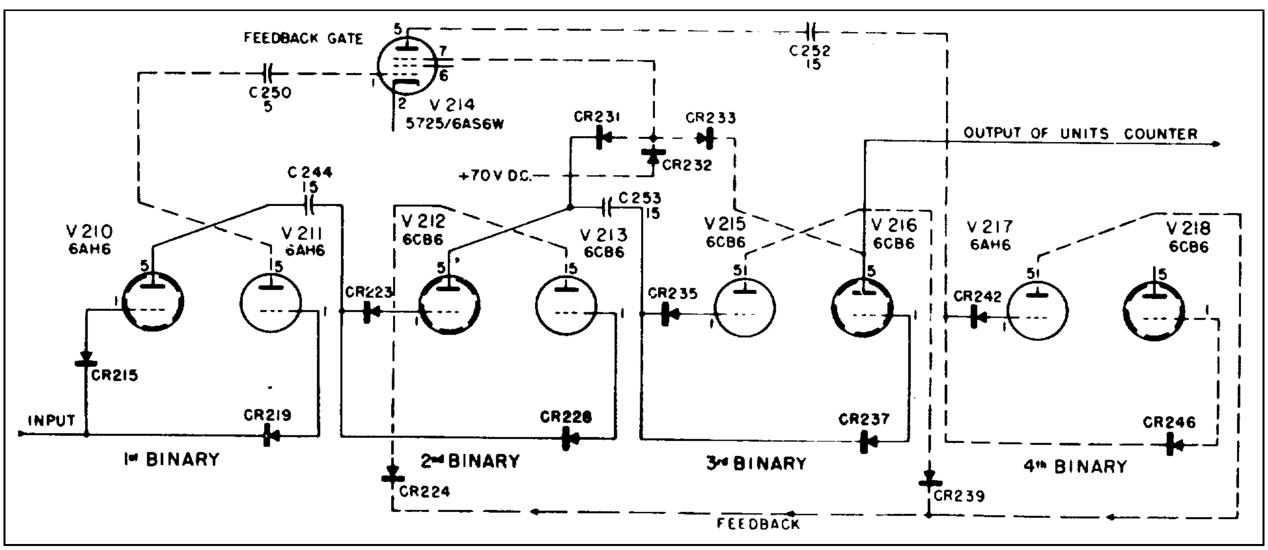


Figure 9-33. Simplified Schematic of 10 MC Decade Showing Feedback

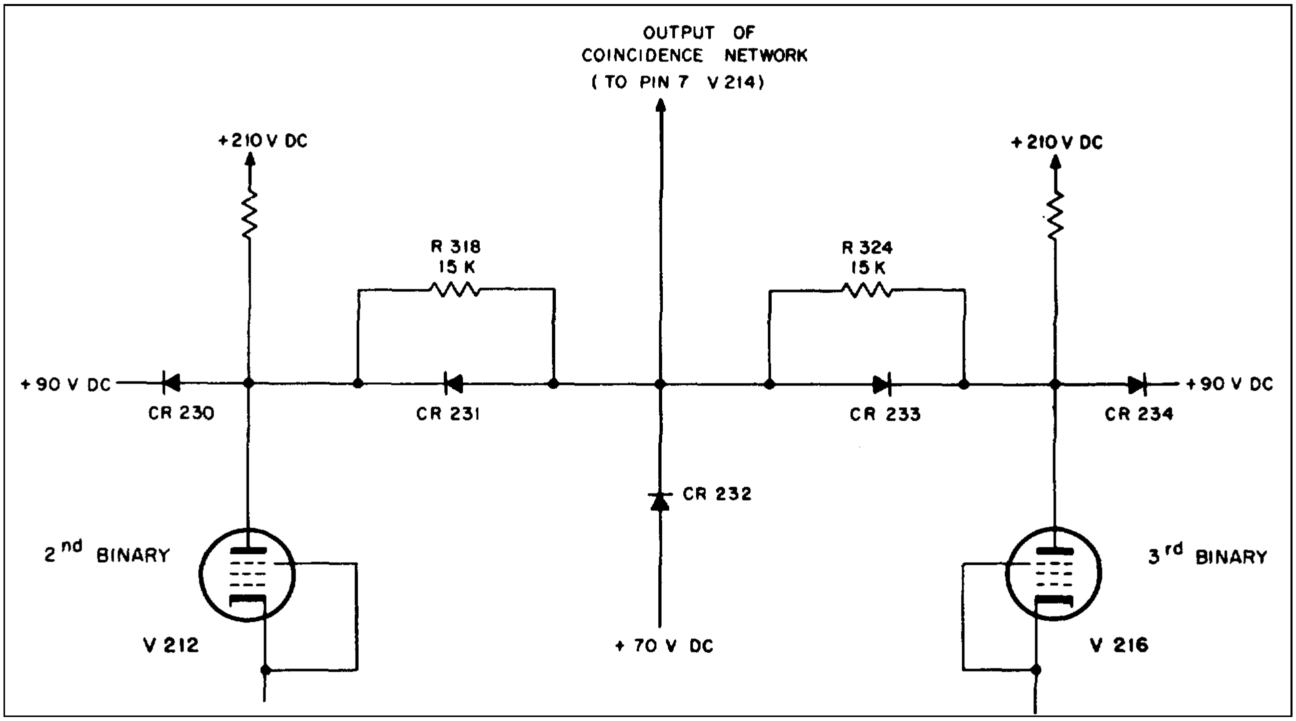


Figure 9-34. Schematic of Coincidence Network

Table 9-3. Cumulative Count of Binaries

		1st		2nd		3rd		4th		
	Start*									
		0	+	0	+	0	+	0	=	0
After the	1st input pulse	1	+	0	+	0	+	0	=	1
	2nd input pulse	0	+	2	+	0	+	0	=	2
	3rd input pulse	1	+	2	+	0	+	0	=	3
	4th input pulse	0	+	0	+	4	+	0	=	4
	5th input pulse	1	+	0	+	4	+	0	=	5
	6th input pulse	0	+	2	+	4	+	0	=	6
	7th input pulse	1	+	2	+	4	+	0	=	7
	8th input pulse	0	+	2	+	4	+	2	=	8
	9th input pulse	1	+	2	+	4	+	2	=	9
	10th input pulse	0	+	0	+	0	+	0	=	0
	11th input pulse	1	+	0	+	0	+	0	=	1
	etc.									

*All four binaries (plate pin 6) at +155V.

condition can be met by making R3 = 100K. (Resistor half as large as R2, so twice as much current flows.) The 4th binary is to contribute the same amount of current as the 2nd, so a single 200K resistor is used for R4.

9-133. if more than one plate is at +200V at one time, the currents from each will add in a manner shown in Table 4-3 to give total currents of 0, 1, 2, 3, 4, etc. milliamps. R5 can be used as an electrical "zero adjust" on the meter to set it to a zero indicator when all plates are at +155V. R6 is a shunt to control the sensitivity of the meter and is set so the meter reads nine (1 + 2 + 4 + 2 = 9) when all four plates are at +200V.

9-134. In the actual readout circuit zero center meters are used instead of a meter with a zero at the left of the scale. The operation is essentially the same but tracking (the ability of the meter to stop exactly on a number) is better. The meter is now returned to a voltage midway between +155V and +200V (+177.5V).

9-135. When all plates are at +155V, the voltage across the meter (zero center meter) is in such a direction to pull it down to the left end of the scale (marked 0) (see Figure 9-36). When all plates are at +200V, the voltage across the meter is of the magnitude but the opposite polarity, so the meter moves to the right end of its scale (marked 9) as in Figure 9-36. The 1st binary then contributes -1/2 unit of current when its plate is at +155V, and +1/2 unit of current when its plate is at +200V. All others do likewise.

	Plate Voltage	Unit of Current
1st	+200	+1/2
	+155	-1/2
2nd	+200	+1
	-155	-1
3rd	+200	+2
	-155	-2
4th	+200	+1
	-155	-1

9-136. Starting with the dot between 4 and 5 on the meter representing zero current, + 1/2 unit of current (plate pin 6 V-219 at +200V) will cause it to indicate 5, etc. Although the milliamps were used in the example, the meters are actually 100 - 0 - 100 microamp movements. This minimizes the unbalancing effect of the meter on the binaries.

9-137. The waveform at meter terminal is a staircase. See Figure 9-37. This waveform can be observed with a dc voltmeter if the SIGNAL INPUT frequency is low (1 cps) or can be observed on an oscilloscope when the counting rate is high. The UNITS and TENS meters will step along one number at a time if the SIGNAL INPUT frequency is low. At high frequencies, the meters can no longer follow each individual count but should remain on the dot between 4 and 5 on the meter scale while a count is in progress. This is

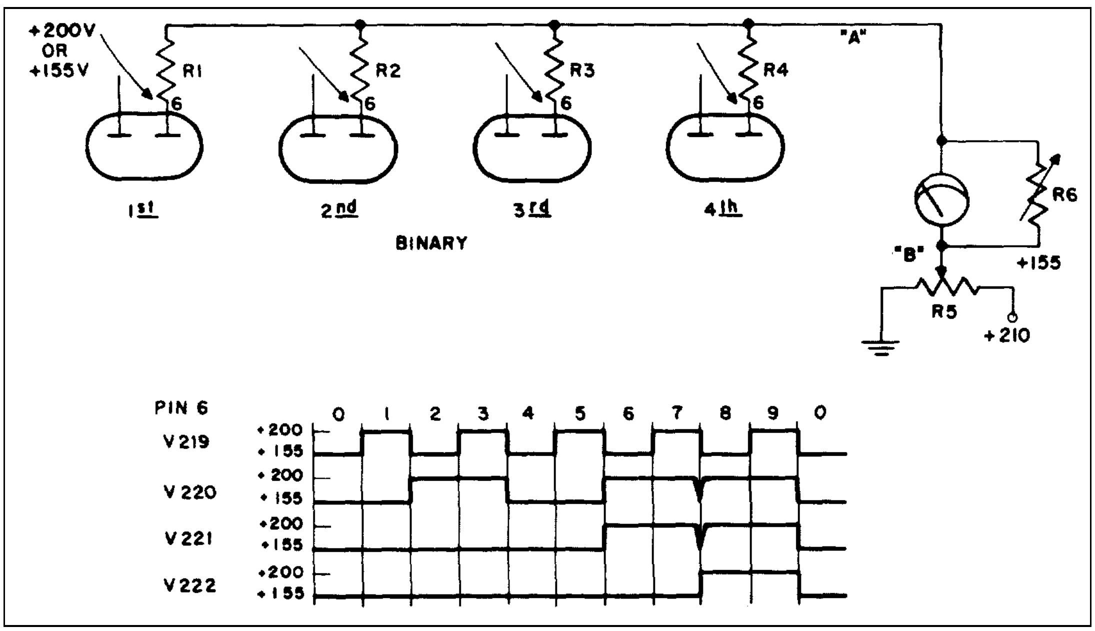


Figure 9-35. Basic Metering Circuit

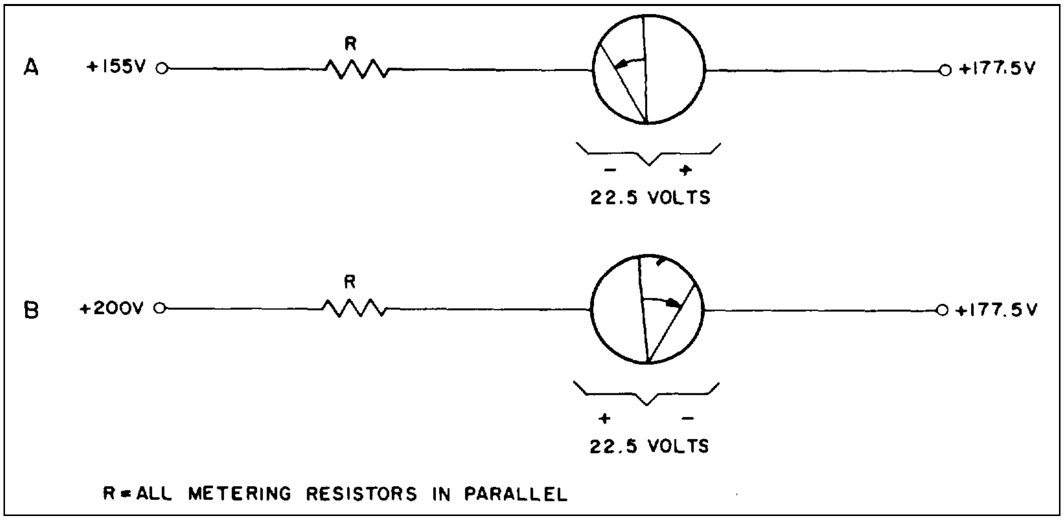


Figure 9-36. Basic Metering Circuit Using Zero Center Meters

because the staircase, Figure 9-37, averages to 177.5 volts, so there is no net voltage on the meter. At input frequencies toward 10 megacycles, the meters may tend to indicate to the right of the dot. This is because the staircase voltage is no longer systematical (plate voltage wave shapes are not as square as at lower frequencies) so the average voltage is no longer +177.5 for the 1 MC SECTION. This is normal.

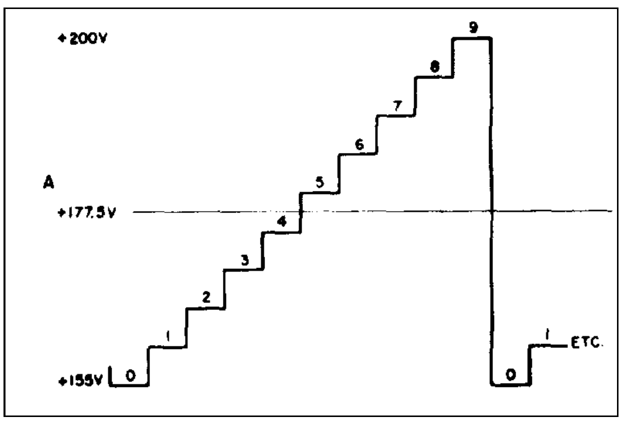


Figure 9-37. "Stairstep" Waveform at Meter Terminal

9-138. METER ADJUSTMENTS.

9-139. R-398 is the electrical centering control and is used to adjust the voltage at the right side of the meter to the average value of the staircase voltage while a count is in progress on 100 KC "CHECK". When this adjustment is correctly made, the meter points to the dot between 4 and 5 while a count is in progress. R-396 is a meter sensitivity control (shunt) used to adjust the meter sensitivity so the pointer points to 0 at completion of the count on 100 KC "CHECK".

9-140. TIME INTERVAL UNIT. A block diagram of the time interval unit is shown in Figure 9-38. This unit provides circuits that enable the FR-38/U to measure time intervals from a minimum of one microsecond up to 10,000,000 seconds with a high degree of accuracy. The time is displayed on the counters and may be read directly in seconds, milliseconds, or microseconds, as indicated in the TIME UNIT control.

9-141. CIRCUIT DESCRIPTION. Two separate input channels are provided. One accepts a start signal and the other accepts a stop signal which opens and closes the electronic gate in the FR-38/U. Special threshold selecting controls are provided for the trigger circuits in both the start and stop channels so that they will be actuated only by signals of pre-determined amplitude, slope and polarity. The trigger circuits Z-102 and Z-103 shape the input waveforms into suitable start and stop trigger pulses for the gate binary. See Figure 9-38. TRIGGER LEVEL VOLTS switches S-101 and S-103 select the voltage at which the channel will trigger. These controls are calibrated from +192 to -192 volts. TRIGGER SLOPE SWITCHES S-105 and S-106 prepare the channels to trigger only from the positive or only from the negative slope of the waveform. The two controls permit each channel to be triggered by any one of four combinations of slope and polarity: Positive or negative slopes of positive voltages, and positive or negative slopes of negative voltages. For each of these combinations, the voltages at which triggering occurs is adjustable from approximately 1 to 192 volts. Switch S-102 COM SEP is provided so that the start and stop channels can be operated from the same input (COM position), if desired. The slope and level controls for each channel remain operative, permitting measurements to be started and stopped from different portions of the signal. The trigger units Z-102 and Z-103 are identical in design and operation to trigger unit Z-201 described in paragraph 9-87.

9-142. FREQUENCY CONVERTER. The frequency converter plug-in unit extends the frequency measurement range of the FR-38/U from 10 mc up to 100 mc. A block diagram of the unit appears in Figure 4-39.

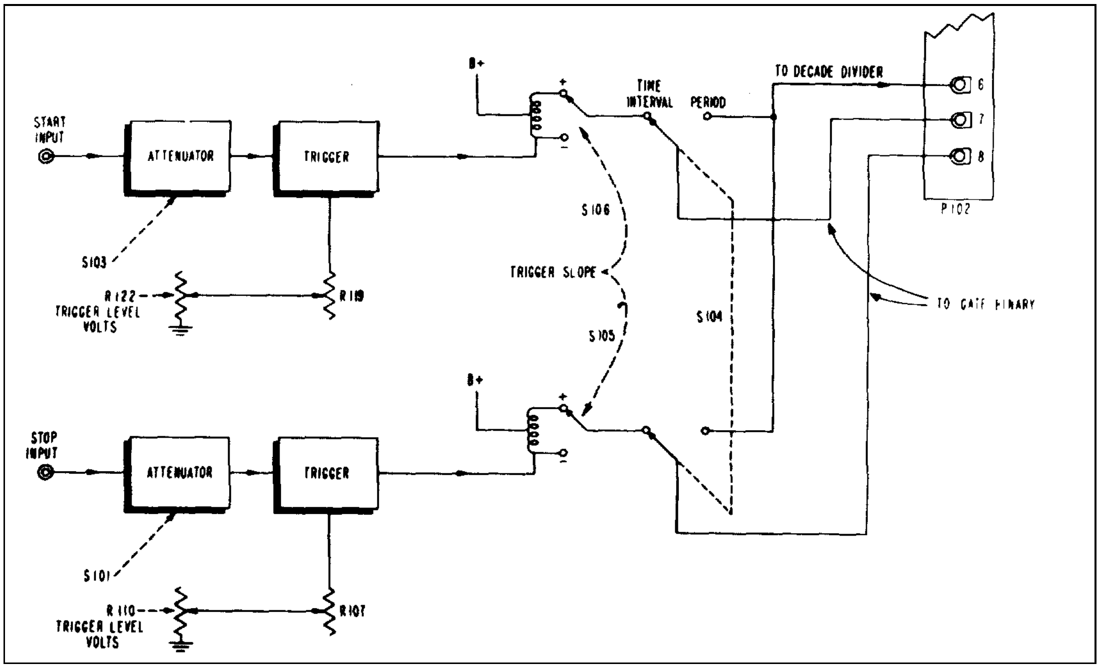


Figure 9-38. Block Diagram of Time Interval Unit

9-143. Although the basic purpose of the frequency converter is to extend the frequency measurement range, measurement of lower frequencies can still be made. The MIXING FREQUENCY control S-1 is placed in 0 position for measurement of frequencies below 10 mc. Input signals bypass the tuned amplifier and mixer stages and are applied directly to video amplifiers V-6 and V-7. Because of the additional gain (due to V-6 and V-7), the frequency measurement sensitivity of the FR-38/U up to 10 mc is increased about 20 db when the frequency converter unit is in place.

9-144. For measurement of frequencies from 10 to 100 mc input, signals are fed into the tuned amplifiers V-1 and V-2. These amplifiers operate in push-pull, with a tuned plate circuit consisting of C- 12 and C-14 (TUNING) and L-3, L-4, L-5, L-6 (TUNING RANGE MC). The plate circuit of V-1 and V-2 is tuned by setting TUNING RANGE - MC and TUNING controls for maximum deflection of the tuning eye indicator. Adjustment of the TUNING control also adjusts C-64, the 10 mc trap in the output of the frequency converter.

9-145. With the MIXING FREQUENCY control set to TUNE, the tuning eye indicator will close as the unknown frequency is located. If the "eye" overlaps in closing, the input signal should be reduced with GAIN control R-5, the grid bias resistor, to protect against overloading the tuned amplifiers. If the "eye" does not close with maximum GAIN, the amplitude of the input signal is too small for accurate counting. The output voltages from the plates of V-1 and V-2 are applied to the grids of V-3 and V-4, the balanced mixer.

9-146. The mixers V-3 and V-4 are dual-control r-f pentodes. The input signal is applied to control grid 1 (pin 1) while the mixing signal is applied to the second control grid (pin 7). Capacitor C-17 (BALANCE ADJ) balances the drive from the tuned amplifiers to the balanced mixers V-3 and V-4. C-17 should be set to minimize the 10 mc carrier frequency at the output of the video amplifiers in the unit. (See tune-up procedure for Frequency Converter Unit in Maintenance Section of this manual.)

9-147. Variable resistor R-15 is the cathode resistor for V-3 and V-4 and balances the transconductance of the mixer tubes. Capacitors C-18 and C-21 neutralize. the inputs to the balanced mixers.

9-148. The MIXING FREQUENCY control S-1 is now set to the frequency indicated by the dial of the TUNING control. The control S-1 selects the proper frequency from the

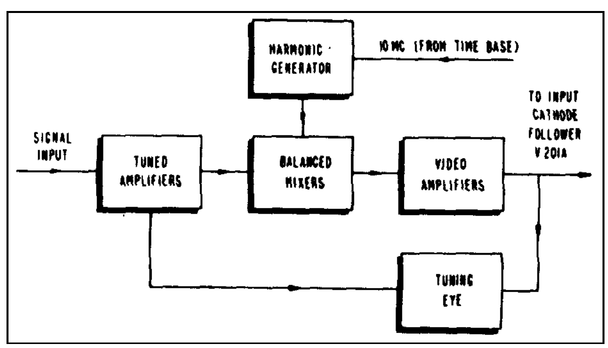


Figure 9-39. Block Diagram of Frequency Converter Unit

harmonic generator by switching in appropriate tuned circuits. The harmonic frequency is applied to the suppressor grid of V-3 and V-4 where the signal is mixed with the input frequency applied to the control grids. The difference frequency, obtained at the parallel plates of V-3 and V-4, is fed through the video amplifiers V-6 and V-7 to the counting circuits.

9-149. The total count is obtained by adding the MIXING FREQUENCY figure and the displayed count. The MIXING FREQUENCY figure will always be megacycles and the displayed count will be kilocycles.

9-150. The harmonic frequency generator V-5 is a sharp cut-off r-f pentode. The control grid is driven by a 10 mc signal from the time base. Operating as a class C amplifier, the plate current of V-5 has a high harmonic content (harmonics of the exciting voltage applied to the control grid).

9-151. POWER SUPPLY. The power supply is designed to supply all of the operating potentials required for the FR-38/U Frequency Meter. The unit provides +210V dc, +90V dc, +70V dc and -195V dc regulated voltage and an unregulated voltage of +300V dc. Full wave rectifier circuits are employed with electronic regulation. The power supply also provides all of the filament power required by the vacuum tubes in the instrument.

9-152. Two separate full wave rectifier circuits are used; one supplies the positive voltages, and the other supplies -195V dc. Electronic regulation makes the output voltage substantially independent of the load impedance. Screwdriver adjustments are provided to set all regulated voltages.

9-153. The -195 volts is supplied by V-257 and regulated by V-258 and V-259. V-261 is used as a reference voltage for the -195V supply. V-260 controls -195 voltage with respect to ground. The control tube V-252 acts to hold a constant ratio between the +210 and -195 voltages. V-256, control tube for +90 volts and +70 volts, takes reference voltages from the resistor "stick" connected between +210 and -195 volts; therefore, it tends to hold +70 and +90 at a constant ratio with that of the -195 and +210 volt supplies. This ratio control between +210 and -195 volt supplies is more important for proper biasing of the fast flip-flops than absolute control of voltage levels.

9-154. THEORY OF OPERATION OF AN/USA-5.

9-155. GENERAL. Frequency Converter CV-394/USA-5 is the operating plug-in unit of the AN/USA-5. When plugged into the FR-38/U Frequency Meter of the AN/USM-26, this converter may be arranged, by means of a Function switch, to perform any of the following three functions:

a. Measure the approximate frequency of an input signal through operation as a wavemeter.

b. Convert a signal in the 100-mc to 220-mc range to a frequency within the 100-kc to 10.1-mc range suitable for the

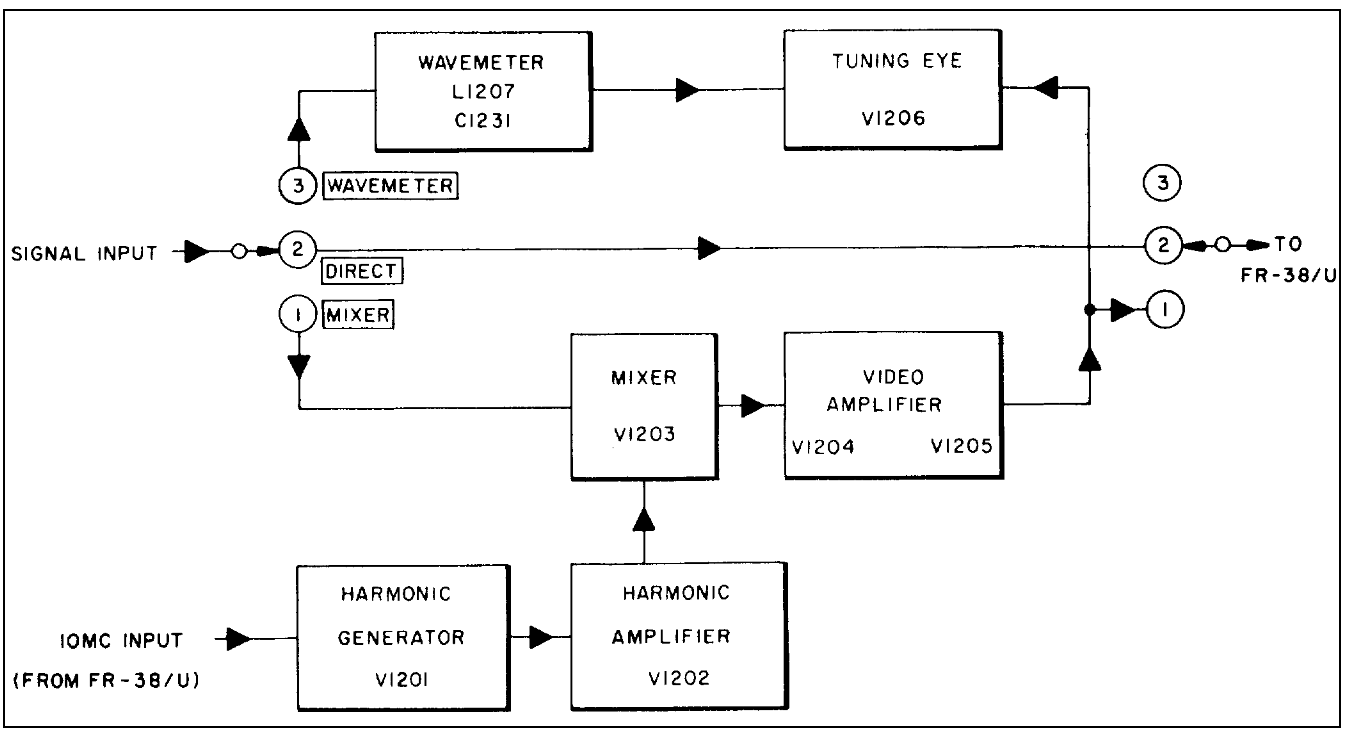


Figure 9-40. Block Diagram of Frequency Converter CV-394/USA-5

FR-38/U; check that the voltage level of the signal is high enough to operate the FR-38/U, and connect the signal to the FR-38/U.

c. Pass a signal directly to the FR-38/U (when the signal is within the 100-kc to 10.1-mc range).

9-156. BLOCK DIAGRAM. The circuits of Frequency Converter CV-394/USA-5 are shown in block diagram form in Figure 4-40. The circuits consist of a Function switch (MIXER-DIRECT-WAVEMETER), a wavemeter circuit, a tuning eye circuit, a harmonic generator and amplifier and associated 12-position tuning switch (MIXING FREQUENCY MC), a mixer, and a two-stage video amplifier. The circuit details are shown in the complete schematic diagram in Figure 7-54. Circuit operation in each of the three modes is described in the following paragraphs.

9-157. APPROXIMATE MEASUREMENT OF FREQUENCY.

9-158. When the Function switch is in the WAVEMETER position, the CV-394/USA-5 functions as a wavemeter to make approximate measurement of an unknown frequency signal in the range 100 mc to 220 mc. In this operation, the CV-394/USA-5 is plugged into the FR-38/U, but performs the wavemeter measurement independently, utilizing the FR-38/U only for power. Indication of tuning is given by the narrowing of the tuning eye beam, and tuning adjustment is made by use of the WAVEMETER dial.

9-159. Refer to the complete schematic diagram, Figure 7-54. When the Function switch is in the WAVEMETER position, the input signal is connected directly to a wavemeter circuit consisting of coil L1207 and variable capacitor C1231. Capacitor C1231 is tuned by means of the WAVEMETER dial, which is calibrated to read directly in frequency. Electron ray tube V1206 gives the tuning indication. This tube is a high-vacuum type designed to indicate visually the effect of change in controlling voltage. The shaded pattern displayed by the tube on its fluorescent target varies through an angle from 90° to approximately 0°, as the voltage on its control electrode is increased. The input circuit to the control electrode is set up so that the peak voltage corresponding to the tuned condition of the parallel-resonant wavemeter circuit produces a narrow shaded pattern approaching 0.

9-160. The ray control electrode of tube V1206 is an extension of the triode plate and is located between the cathode and target. The voltage on the ray control electrode is determined by the voltage applied to the grid of the triode, connected as a d-c amplifier. When the V1206 grid bias is increased in the negative direction, the voltage on the ray control electrode is changed in a positive direction, and the angle of the shaded area narrows. Conversely, an increase of the grid bias in the positive direction produces a decrease in the ray control electrode voltage, and the angle of the shaded area widens. Diode CR1201 is connected in such a way that only negative-going portions of waveforms reaching the junction of CR1201 and CR1202 are applied to the grid of V1206.

9-161. When L1207 and C1231 are resonated with an input frequency and the input voltage level is at least 0.2 volts rms, the resonant action of the wavemeter circuit is such that capacitor C1230 couples approximately four times the input voltage to the junction of CR1201 and CR1202. This will provide an increased negative-going grid bias to the grid of V1206. Diodes CR1201 and CR1202 are connected to form a voltage doubling circuit with C1233 so that the actual signal applied to the grid of V1206 is further multiplied approximately 2.5 times. C1233, R1222, and C1234 constitute a low-pass filter so that V1206 responds only to the d-c component of the applied signal. When the wavemeter is operated, L1208 and C1232 serve to isolate the junction of CR1201, CR1202, and C1230 from the output transformer T1201. Variable resistor R1223 in the cathode circuit of V1206 is provided for adjustment of the sensitivity of the tuning eye.

9-162. FREQUENCY CONVERSION.

9-163. When the Function switch is in the MIXER position, the CV-394/USA-5 functions as a frequency converter to convert the input signal to a frequency within the range of the FR-38/U. For this function, the CV-394/USA-5 is plugged into the FR-38/U, where it draws power and also connects the reduced-frequency signal through the mating plug-in connectors. The mixing frequency is furnished by the harmonic generator circuit, and any one of 12 frequencies may be used, corresponding to the panel markings of the MIXING FREQUENCY MC switch.

9-164. Refer to the complete schematic diagram, Figure 7-54. The MIXING FREQUENCY MC switch S1201 includes three similar sections (A, B, C) assembled on a common shaft. Each of these sections is an assembly of capacitors of various values, each section including the same range of capacitance values, so that when S1201 is in any one of the 12 positions, like values of capacitance are connected into each of three circuits. The three circuits served by S1201 are: a tuned circuit in the output of the harmonic generator, a tuned circuit it the output of the harmonic amplifier, and a tuned circuit connected to the suppresser grid of the mixer.

9-165. The primary 10-megacycle frequency for the harmonic generator is supplied from the FR-38/U frequency multiplier (via pin 8 of connector P1201) and is coupled to the grid of harmonic generator V1201 by capacitor C1209. At 10 megacycles, variable capacitor C1210 in the input circuit resonates with coil L224 in the Gate Section of the FR-38/U. Harmonic generator V1201 is a sharp cutoff r-f pentode arranged as a class C amplifier. Its output, rich in 10-megacycle harmonics, is coupled by capacitor C1211 to an LC circuit tuned to the frequency designated by the setting of the MIXING FREQUENCY MC switch. Voltage from this tuned inter stage circuit (coil L1201 and the capacitance introduced by Section A of switch S1201) is applied directly to the grid of harmonic amplifier V1202. The amplified signal is coupled by capacitor C1219 to another LC circuit (coil L2 and capacitance introduced by the B section of switch S1201) which is tuned to the same frequency as the tuned circuit in the output of the harmonic generator. Capacitor C1216 and variable coil L1204 connected across the output of the amplifier suppress an undesired mode of amplification in V2.

9-166. The harmonic amplifier output is coupled inductively to the suppressor grid circuit of mixer V1203 through coils L1202 and L1203. The LC circuit at the mixer input (coil L1203 and the capacitance introduced by the C section of S1201) is also tuned to the desired mixing frequency. With the unknown input signal applied to the grid of V1203 and a mixing frequency of approximately the same value in megacycles applied to the suppressor grid, the mixer output will include a difference frequency within the range of the FR-38/U. A series peaking interstage network (C1221 and L1205), designed to pass frequencies from 0.1 to 10.1 megacycles, accepts only the desired difference frequency from the mixer and applies it to the grid of pentode V1204 in the first stage of the video amplifier. The output of V1204 is passed through another series peaking interstage network, which also accepts frequencies only within the range 0.1 to 10.1 megacycles, to the grid of pentode V1205 in the second stage of the amplifier.

9-167. Transformer T1201 in the plate circuit of V1205 couples the amplified voltage through contacts on the Function switch to: (1) the FR-38/U, through pin 4 on connector P1202 (2) to the tuning eye V1206 for a measurement of the voltage level. The coupling to the circuit of V1206 is through C1232 and L1208. When the output from the AN/USA-5 has a level of one volt or above, the angle of the tuning eye shaded area will just barely close. If the level of the output voltage drops below approximately one volt, the angle of the shaded area will widen.

9-168. DIRECT TRANSMISSION PATH.

9-169. When the input signal is in the range below 10 megacycles, the Function switch is set at DIRECT. In this position of S1202, the input signal is transmitted directly through to the FR-38/U, through pin 4 of connector P1202, and the grid of mixer tube V1203 is grounded to prevent generation of spurious signals.

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SECTION X

ORGANIZATIONAL MAINTENANCE

CAUTION

Frequency Meter AN/USM-26 is a precision measuring instrument equivalent to a high quality secondary frequency standard. It is strongly recommended that unqualified personnel do not attempt any maintenance or trouble-shooting work on the equipment beyond the scope of information in this section. Experience with this equipment has shown that haphazard replacement of tubes or other components will only obscure any trouble that may occur. Any test prods used for measurement purposes should be carefully wrapped with electrical insulating tape so that only the extreme tip of the probe is exposed. Accidentally shorting certain circuits to ground or to another circuit, even momentarily, can burn out a large number of the crystal diodes used in the equipment.

10-1. MINIMUM PERFORMANCE STANDARDS.

10-2. This section contains the description of tests necessary to determine whether circuits in the AN/USM-26 meet minimum standards of performance, as well as possible causes of malfunction or failure in these circuits. The maintenance discussion is restricted to those malfunctions which can be detected by panel indications and voltage measurements and which can be corrected by circuit adjustment and tube or crystal diode replacement.

10-3. NECESSARY TEST EQUIPMENT. Of the equipment listed in Section VIII the two voltmeters, the variable transformer and the signal generators (AN/URM25 and AN/USM-44), are required. Be sure that the test probes used with the voltmeter are carefully wrapped with electrical insulation so that only the extreme tip of the probe is exposed. Accidental shorting, even momentarily, of certain circuits to ground or to another circuit can damage the crystal diodes used in the equipment.

10-4. The variable transformer is used to vary the line voltage between 103.5 volts ac and 126.5 volts ac. The ac voltmeter is used to monitor this line voltage. Each step of the following step-by-step procedure is completed at 115 volts ac line and is then repeated once at high-line voltage (126.5 volts) and once at lowline voltage (103.5 volts). The tests at line voltage extremes, help to accentuate circuit failures or weak components and thus make them easier to locate.

10-5. Equipment for testing crystal diodes is discussed in paragraph 11-43, Section XI of this manual. Crystal diodes found defective may be replaced with the spare units mounted on the FR-38/U chassis: see Figure 11-1. If additional crystal diodes are required, they must be selected as described in paragraph 11-43.

10-6. SYSTEM ANALYSIS. Following is a step-by step trouble-shooting procedure (Table 10-1). Take the steps in order because each step is intended to check a specific circuit. Skipping steps may leave important circuits untested. The steps (1 through 15) in the Check Chart form the main test procedure. If correct indications are received for each of these steps, the instrument is operating properly, and meets minimum standards of performance. If incorrect indications are received, correct them before proceeding. Wherever incorrect indications involve large circuit groups, trouble-shooting is broken down on tables 10-2 through 10-10 which are used in the same manner as the main group, but to cover small portions *of* the instrument in greater detail.

10-7. In servicing the AN/USM-26, it must be remembered that random replacement of tubes and crystal diodes or random altering or circuit adjustments may serve only to obscure otherwise easily located troubles. If tube replacement does not restore normal operation, replace the original tube. If an adjustment does not restore normal operation, return the adjustment to the original setting.

10-8. To begin servicing, remove the case of the instrument as described in paragraph 10-11. Check the fuses and power cord. Connect the instrument to the variable transformer and set the line voltage to 115V ac. The white pilot light should light when the instrument is plugged in. If not, check the power input circuit and the space heater circuit.

10-9. Let the instrument remain in this standby condition until the crystal oven comes up to temperature, about 1/2 hour from a cold start. If the oven does not appear to operate, check as outlined in Section VI of this manual. When the oven is at the correct temperature, proceed with step 1 of Table 10-1.

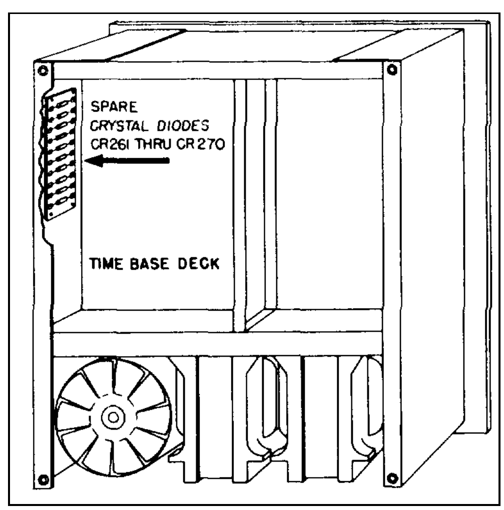

Figure 10-1. Location of Spare Crystal Diodes

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Table 10-1. Step-By-Step System Analysis

CONTROL SETTING		PLUG-IN UNIT CONTROL SETTINGS	
Power switch	off	COM SEP	COM
FUNCTION SELECTOR	100 KC CHK	TRIGGER SLOPE	Start + Stop -
FREQUENCY UNIT	10 SEC.	TRIGGER LEVEL	Both 0 x 1
TIME UNIT	100 KC	TIME INTERVAL PERIOD	PERIOD
DISPLAY TIME	Minimum		
100 KC STANDARD	INT		
MANUAL GATE	CLOSED		
Plug-in unit	TIME INTERVAL		
Line volts	115V ac		

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step 1a Turn power switch to ON.	Red pilot marked POWER lights.	If crystal oven and standby heater circuits are operated correctly as described in Paragraph 10-8 and 10-9, failure of red pilot to light indicates failure in either the lamp circuit or in T-205.
	Blower operation can be heard.	If blower does not operate, check blower and its rectifier (CR-260).
	At least one number on each decimal counter lights.	If some, but not all, decimal counters light, replace the tubes or the units which do not light. If none of the decimal counters light, see Table 10-2.
	Tube filaments light except V-261.	Replace tubes in which the filaments do not light. Check Table 10-2 for necessary circuit adjustments. If all, or large groups, of tubes do not light, check T-205.
Step 1b Check regulated voltages	Test Point ★1 -195V dc Test Point ★2 +210V dc Test Point ★3 +90V dc Test Point ★4 +70V dc	Adjust as described in Paragraph 10-17. If adjustment cannot restore correct voltages, see Table 10-2. **CAUTION** **If +210V dc bus remains above +240V dc or the +70V dc and +90V dc busses are more than 50V apart, turn instrument off at once to protect crystal diodes throughout the circuit.**

Table 10-1. Step-By-Step System Analysis (Contd.)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step 1c Observe the count. Use a watch to time the 10 second count and display intervals.	After a few moments warm-up, the instrument will count for 10 seconds and for 10 seconds will display the number 0100.0000. Neon gate lamp on during counting and off during display.	If the instrument counts correctly but neon gate lamp does not indicate correctly, check I-201 and its circuit. If the instrument consistently counts and displays the wrong answer, see Table 10-3 . If the instrument counts and displays but adds each new count to the preceding count (does not reset to zero), replace V-208 or V-209. If V-208 is replaced, adjust GATE LENGTH, Paragraph 10-23.If tube replacement does not restore normal operation, see Steps C11 and C12 of Table 10-4. If neon gate lamp remains on and counters run continuously but attempt to reset every 20 seconds, adjust GATE LENGTH, Paragraph 10-23.If adjustment does not restore normal operation, see Steps C10 and Steps C13 and C14 in Table 10-4. If neon gate lamp remains on, remains off, or operates erratically, disregard the counter display and see Table 10-4. If the neon gate lamp operates correctly but the counters do not indicate correctly, adjust FREQ. SENS., Paragraph 10-22. If adjustment does not restore normal operation, see Table-. If the units meter consistently counts and indicates "0", the trouble may lie in the input circuits (Table 10-5) but. probably lies in the counter circuits (Table 10-8) .
Step 2. Set FUNCTION SELECTOR to 10 MC CHK.	Correct count is 0000.0000±1.	If count is consistently one or two counts in error, adjust GATE LENGTH, Paragraph 10-23 If adjustment does not restore normal operation, see Table 10-6.
Step 3. Set FREQUENCY UNIT to .01 SEC. Set FUNCTION SELECTOR to FREQUENCY and connect a one volt rms signal of approximately 1 mc to SIGNAL INPUT. Slowly increase frequency until counter indication begins to decrease, stops, or becomes erratic.	Consistent readings should be possible at least as high as 10.6 mc.	If the instrument will not consistently count all frequencies up to 10.6 megacycles, or higher, increase input signal to 2 volts. If increasing input signal voltage restores normal operation, see Table 10-5. If increasing the input voltage does not restore normal operation, see Table 10-8. If no indication or an erratic indication is obtained at all frequencies, check the circuit of V-201A.

Table 10-1. Step-By-Step System Analysis (Contd.)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step 4. For the frequencies listed measure the minimum input voltage that will consistently yield the correct indication. Set FREQUENCY UNIT to 1 SEC.	10 mc - 0.7V rms 3 mc - 0.6V rms 1 mc - 0.55V rms 100 kc - 0.5V rms 10 kc - 0.55V rms 1 kc - 0.55V rms 100 cps - 0.55V rms 10 cps - 0.54V rms	If instrument is not sufficiently sensitive, adjust FREQ. SENS., Paragraph 10-22. If adjustment does not restore normal operation, check tubes in the input circuits (V-201, V-202,*V-601,*V-602 and *V-603). *V-1101 V-1102, V-1103 in FR-38C/U and FR-38D/U
Step 5. Set FUNCTION SELECTOR to 10 MC CHK. Raise the front of the instrument about one inch above the bench and allow it to drop to the bench.	Instrument should display 10000.000.	Any other count indicates microphonic components. Check by tapping until faulty element is isolated.
Step 6. Increase automatic display time to maximum.	Display time will be approximately 5 seconds and counting time will be exactly one second.	If display time equals counting time, replace V-205. If the display time is erratic, check circuit of V-204. Replace tube if necessary.
Step 7. Set DISPLAY TIME to INF position.	Instrument counts for 1 second and displays until RESET is pressed.	Any other indication, check circuits of S-203 and S-204. Failure to reset properly may indicate a poor V-208 or V-209.
Step 8. Set FUNCTION SELECTOR to MANUAL GATE. MANUAL GATE switch to OPEN. Test each position of TIME UNIT switch.	Neon gate lamp lights when MANUAL GATE switch is set to OPEN. Counters count signal for each position of TIME UNIT except EXT position.	If neon gate lamp does not light, check MANUAL GATE switch and its circuit. If neon gate lamp lights and no count is obtained, check circuits of V-248 and S-206.
Step 9. Set FUNCTION SELECTOR to PERIOD, TIME UNIT to 10 MC, MANUAL GATE to CLOSED. Connect a 0.26 volt rms signal at 10 kc to SIGNAL INPUT.	0000100.0 microsecond, the period of the 1 kc signal, depending on the accuracy of the signal generator.	Any other count indicates the need of adjusting Z-202 (PERIOD SENS.), Paragraph 10-21. If adjustment does not restore normal operation, check tubes of Z-202.
Step 10. Set FUNCTION SELECTOR to 10 PERIOD AVERAGE.	000100.00 microsecond, the average of 10 periods of the 1 kc input signal.	Any other count indicates improper operation of Z-203. Check the tubes, replace the unit if tube replacement does not restore normal operation.

Table 10-1. Step-By Step System Analysis (Contd.)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step 11. Set FUNCTION SELECTOR to PERIOD, PERIOD-TIME INTERVAL switch to TIME INTERVAL, disconnect 10 kc signal from SIGNAL INPUT, and connect to START INPUT on plug-in unit. Increase signal level to 2 volts rms.	0000050.0 microsecond, (approximately) the 1/2 period of the 1 kc signal allowing for variation due to tolerance of trigger level controls.	If count begins, but does not end correctly, check Z-102 by exchanging it with Z-201 while self-checking the instrument. Replace tubes or unit, whichever is necessary. If count does not begin, check Z-103 by exchanging it with Z-201 while self-checking the instrument. Replace tubes or unit, whichever is necessary. If either tubes or units are replaced, center the trigger level adjustments as described in Paragraph 10-24.
Step 12. Turn the instrument off, remove the TIME INTERVAL UNIT, and plug-in the FREQUENCY CONVERTER. Turn instrument on. Set FUNCTION SELECTOR to FREQUENCY.	Field of "eye" lights in bright green.	Failure to light indicates failure of circuit of V8 or of V8 itself.
Step 13. Set MIXING FREQUENCY to 0. Connect a 10 mc signal of 0.3 volts rms to SIGNAL INPUT, GAIN to MIN. 10 MC std. frequency from STD. FREQ. OUTPUT may be used.	10000.000	Any other count is wrong. Check V6 and V7, replace if necessary. If replacement does not restore normal operation, return original tubes.
Step 14. Measure, as described in the Operating Handbook AN 16-30USM26-1, the following known input frequencies using the Specified Mixing Frequencies. Known Input Frequency / Specified Mixing Frequency 15 mc / 10 mc 20.1 mc / 10 mc 20.1 mc / 20 mc 35 mc / 30 mc 45 mc / 40 mc 50.1 mc / 40 mc 50.1 mc / 50 mc 65 mc / 60 mc 70.1 mc / 60 mc 70.1 mc / 70 mc 85 mc / 80 mc 90.1 mc / 80 mc 90.1 mc / 90 mc	 05000.000 10100.000 * 00100.000 05000.000 05000.000 10100.000 * 00100.000 05000.000 10100.000 * 00100.000 05000.000 10100.000 * 00100.000	Discrepancies indicate weak tubes or improper adjustment. Check and, if necessary, replace V1, V2, V3, V4 and V5. Adjust circuit as described in Paragraphs 10-25 through 10-29 if discrepancies occur only with difference fre-quencies near 10100.000 (*), replace V6 and V7. If tube replacement does not restore normal operation, return original tubes. Due to push-pull and balanced circuits in this unit, tube failure or weakness is difficult to isolate. General symptoms are loss of sensitivity, erratic counting, and non-operation, in whole or in part.

Table 10-1. Step-By-Step System Analysis (Contd.)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step 15. Repeat Steps 1 through 13 once at a line voltage of 103.5V ac and once at 126.5V ac.	Indications in each step should be the same.	Low line voltage operation tends to reveal weak tubes while high line voltage reveals partial shorts and leakages.

Table 10-2. Step-By-Step System Analysis of the Power Supply

If in Step 1a (Table 10-1)the decade counters do not light, or in Step 1b (Table 10-1),the regulated voltages cannot be properly adjusted, set the controls as indicated below and proceed with the following steps.

CONTROL SETTING		PLUG-IN UNIT CONTROL SETTINGS	
Power switch	off	COM SEP	COM
FUNCTION SELECTOR	100 KC CHK	TRIGGER SLOPE	Both +
FREQUENCY UNIT	10 SEC.	TRIGGER LEVEL.	Both 0 x 1
TIME UNIT	10 KC	TIME INTERVAL PERIOD	PERIOD
DISPLAY TIME	Minimum		
100 KC STANDARD	INT		
MANUAL GATE	CLOSED		
Plug-in unit	TIME INTERVAL		
Line volts	115V ac		

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step A1 Using a tube checker. check all the tubes in the power supply section (V-249 through V-261) for emission and for internal short.			Replace all tubes that are weak or otherwise defective. Test all tubes for shorts and microphonics by tapping the tube envelope in perpendicular directions.
Step A2 Turn the instrument on and measure the voltage at pin 2 of V-253.	(A)	+325V dc	If no voltage is present, check the circuit of V-249, V-250 and V-251. If the voltage is significantly low, a partial short may exist in the instrument circuit. Voltages above +325 indicate improper operation of the regulator circuit which will be checked in the following steps.

Table 10-2. Step-By-Step System Analysis of the Power Supply (Contd)

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step A3 Measure the voltage at pin 5 of V-258.	(B)	+135V dc	If no voltage is present, or if the voltage is low, check the circuit of V-257 and V-260. If the voltage measured is high, check V-258 and V-259. Also check the -195V dc circuits for partial short.
Step A4 Measure the voltage at pin 7 of V-261.	★1 (C)	-195V dc	If adjustment as described in Paragraph 10-17 is not possible, check the circuits of V-258, V-259, V-260 and V-261. This circuit must operate correctly before the remainder of the power supply will regulate.
Step A5 Measure the voltage at pin 1 of	★2 (D)	+210V dc	If adjustment as described in Paragraph 10-17 is not possible, check the circuits of V-252, V-253and V-255 V-254. This circuit must operate properly before the 70V dc or the 90V dc circuits will regulate.
Step A6 Measure the voltage at pin 6 of V-255	★3 (E)	+90V dc	If adjustment as described in Paragraph 10-17 is not possible, check the circuits of V-255 and V-256.
Step A7 Measure the voltage at pin 3 of V-255	★4 (F)	+70V dc	If adjustment as described in Paragraph 10-17 is not possible, check the circuits of V-255 and V-256. The +210V dc, +90V dc and +70V dc circuits are interrelated and alteration of one will affect the other two.
Step A8 Repeat Steps A1 through A7 at 103.5 volts ac line and at 126.5 volts ac line.		Regulated voltages should remain within 1% of the correct values.	

Table 10-3. Step-By-Step System Analysis of Adjustments

If in Step 1c (Table -10-1), the instrument consistently counts and displays the wrong answer, set the controls as indicated below and proceed with the following steps.

CONTROL SETTINGS

Power switch	ON
FUNCTION SELECTOR	100 KC CI1K
FREQUENCY UNIT	.001 SEC.
TIME UNIT	100 KC
DISPLAY TIME	Minimum
100 KC STD.	INT
MANUAL GATE	CLOSED
Plug-in unit	TIME INTERVAL
Line volts	115V ac

PLUG-IN UNIT CONTROL SETTINGS

COM SEP	COM
TRIGGER SLOPE	Both +
TRIGGER LEVEL	Both 0 x 1
TIME INTERVAL PERIOD	PERIOD

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step B1 The instrument is now set for 100 KC CHK, using the .001 second standard gate time.	00000100.	A count of 0000008., 00000090., 00000110., 00000120., or 00000130. indicates failure of the first phantastron. Adjust as described in Paragraph 10-18. Replace V-235 or V-241, if necessary. Return original tubes if replacement does not restore normal operation. Any other count may indicate need of adjustment of PERIOD SENS., Paragraph 10-21. If circuit adjustment restores normal operation, proceed with Step B3; if normal operation is not restored, proceed with Step B2.
Step B2a Set FUNCTION SELECTOR to PERIOD and connect a 2 volt rms signal of 100 cps to SIGNAL INPUT.	000010.00 for PERIOD measure.	The answer received in Step B2a and B2b should agree as indicated. If they do not agree, replace the tubes in Z-203 (V-801. V-802, V-803 and V-804). Return original tubes if replacement does not restore normal operation. If necessary, replace Z-203.
Step B2b Set FUNCTION SELECTOR to 10 PERIOD AVERAGE.	00010.000 for 10 PERIOD AVERAGE measure.	If the two answers agree, but are wrong, see Table 10-5 before proceeding with Step B3.
Step B3 Set the controls as described for Step B1, except set FREQUENCY UNIT to .01 SEC.	0000100.0	Any other count indicates needed adjustment of the second phantastron circuit. Adjust as described in Paragraph 10-18. If necessary, replace V-242 or V-243. Return original tubes if replacement does not restore normal operation.
Step B4 Set FREQUENCY UNIT to .1 SEC.	000100.00	Any other count indicates needed adjustment of the third phantastron circuit. Adjust as described in Paragraph 10-18. If necessary, replace V-242 or V-244. If replacement does not restore normal operation, return original tubes.

Table 10-3. Step-By-Step System Analysis of Adjustments (Contd.)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step B5 Set FREQUENCY UNIT to 1 SEC.	00100.000	Any other count indicates needed adjustment of the fourth phantastron circuit. Adjust as described in Paragraph 10-18.If necessary, replace V-245 or V-246. Return original tubes if replacement does not restore normal operation.
Step B6 Set FREQUENCY UNIT to 10 SEC.	0100.0000	Any other count indicates needed adjustment of the fifth phantastron circuit. Adjust as described in Paragraph 10-18. If necessary, replace V-245 or V-247. Return if replacement does not restore normal operation.
Step B7 Repeat Steps B1 through B6 at 103.5 volts ac line and at 126.5 volts ac line.	Indications for each step should be the same as those obtained at 115 line volts.	Low line voltage operation tends to reveal weak tubes, while high line voltage reveals partial shorts and leakage.

Table 10-4. Step-By-Step System Analysis of the Gate Section

If in Step 1c (Table 10-1) the neon gate lamp remains on, remains off, or operates erratically, disregard the counter display, set the controls as indicated below, and proceed with the following steps.

CONTROL SETTINGS

Power switch	ON
FUNCTION SELECTOR	100
FUNCTION SELECTOR	100 KC CHK
FREQUENCY UNIT	.001 SEC.
TIME UNIT	100 KC
DISPLAY TIME	mid-range (white dot up)
100 KC STANDARD	INT
MANUAL GATE	CLOSED
Plug-in unit	TIME INTERVAL UNIT
Line volts	115V ac

PLUG-IN UNIT CONTROL SETTINGS

COM SEP	COM
TRIGGER SLOPE	Both +
TRIGGER LEVEL	Both 0 x 1
TIME INTERVAL PERIOD	PERIOD

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step C1 Observe counter indication and neon gate lamp.		Counter indication should be 00000100. Neon gate lamp on during counting, off during display.	If operation is normal, or if indicated count is consistent but wrong, see Table 10-3.If neon gate lamp remains on, remains off, or operates erratically, adjust PERIOD SENS., Paragraph 10-21. If adjustment does not restore normal operation, proceed with Step C2.

Table 10-4. Step-By-Step System Analysis of the Gate Section (Contd.)

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step C2 Set FREQUENCY UNIT to 10 SEC. Use a VTVM to measure the voltage at pin 5 of Z-202. Use a watch to check the number of cps.	11	Meter swings at one cycle per second rate between approximately 1V and 0V.	Failure to swing as described indicates malfunction of the Time Base. See Table 10-7.
Step C3 Check voltage and swing rate at pin 3 of Z-202.	12	Meter needle swings at one cycle per second rate between +170 and +205.	If meter fails to swing at proper rate, replace V-701 and V-702. Return original tubes if replacement does not restore normal operation. Replace Z-202, if necessary. If unit or tubes are replaced, adjust PERIOD SENS., as described in Paragraph 10-21
Step C4 Set FREQUENCY UNIT to 1 SEC. and measure volts at pin 2 of Z-203.	13	Meter swings between +40 and +100V dc at one cycle per second rate.	Replace V-801. V-802, V-803, or V-804 as necessary, to restore operation. If operation is not restored, return original tubes. Replace Z-203, if necessary.
Step C5 Measure the voltage at the junction of CR-205 and R-255.	K	+3V dc at end of display period, increasing to +18 volts at start of count, dropping to +3V dc by end of display period. May hesitate near +7V dc during drop. Voltage returns to +3V dc when RESET is pressed.	If voltage remains at or is less than +3V dc, check CR-203. If voltage remains between +7 and +15V dc, replace V-204. Check also CR-205. If voltage rises only to about +10 volts and does not hesitate at +7V dc, check circuits of V-205. If V-205 is out, display time control has no effect and display time will always equal gate time.
Step C6 Measure voltage at pin 1 of V-206	M	+3V dc during display, -2V dc during counting. Returns to +3 when reset is pressed.	Operation at double the correct 2 cps rate indicates that CR-205 or CR-210 is shorted. If voltage is higher than 3V dc, check CR-204. If voltage remains at either level continuously, binary is not operating. Replace both V-206 and V-207. If voltage falls below -2, check CR-206.
Step C7 Measure voltage at pin 5 of V-206.	N	+70V dc during display, +90V dc during count. Resets to +70V dc.	Voltages below +70, check CR-211; voltages above +90, check CR-212; voltages slightly above +70 during display, check V-206. If defective. replace both V-206 and V-207.
Step C8 Measure voltage at pin 5 of V-207.	14	+70V dc during count, +90V dc during display. Resets to +90V dc.	Voltages above +90, check CR-208; voltages below +70, check CR-207; voltages slightly above +70 during count, check V-207. If defective, replace both V-206 and V-207.

Table 10-4. Step-By-Step System Analysis of the Gate Section (Contd.)

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step C9 Measure voltage at pin 1 of V-207.	O	+3V dc during count, -2V dc during display. Resets to -2V dc.	Voltages below -2, check CR-209; voltages above +3, check CR-210.
Step C10 Measure voltage at pin 8 of V-208.	15	+6V dc during count, +12V dc during display. Returns to +6V dc when RESET is pressed.	Failure to obtain these nominal values. Replace V-208. Check delay line DL-201 for open. Adjust GATE LENGTH as described in Paragraph 10-23 if tube is replaced.
Step C11 Measure voltage at pin 2 of V-208.	E_2	- 18V dc with slight waver when pin 6 of V-208 goes positive or reset is pressed.	Check and replace V-208. Failure causes counters not to reset to zero. Pulses present in this circuit are too fast for meter to follow.
Step C12 Measure voltage at pin 1 of V-209.	T	- 15V dc with slight waver corresponding to waver at pin 2 of V-208 or pressing of reset button.	Failure of counters to reset to zero indicates failure of V-209. Check and replace if necessary. If 10 mc decade only fails to reset, check CR-214.
Step C13 Measure voltage at pin 1 of V-203	16	-3.5V dc during count, +0.3V dc during display. Returns to +0.3 when reset button is pressed.	Voltages significantly above or below these, check GATE LENGTH adjustment which is described in Paragraph 10-23.
Step C14 Measure voltage at pin 5 of V-203.	17	+90V dc during count (neon gate lamp on), +70V dc during display (neon gate lamp off). Returns to +70V dc when reset button is pressed.	Voltage remains at 90, replace V-203; voltage rises above 90, check CR-202. Voltage falls below 70, check CR-201. Voltage remains at 70, check Steps C9 and C12. If neon gate lamp does not operate correctly, check lamp and its circuits.
Step C15 Measure voltage at pin 5 of V-202.	18	+210V dc during display, +209V dc during count.	Failure of voltage to fluctuate indicates weak V-202.
Step C16 Repeat Steps C1 through C15 at both 103.5V ac line and 126.5V ac line.		Indication for each step should be the same. Voltages within 2%.	Testing at high and low line helps isolate marginal components.

Table 10-5. Step-By-Step System Analysis of the Input Circuits

If in Step 1c (Table 10-1), the neon gate lamp operates correctly, but the counters do not count correctly, set the controls as described below and proceed with Steps DI through D5.

CONTROL SETTINGS

Power	ON
FUNCTION SELECTOR	MANUAL GATE
FREQUENCY UNIT	.001 SEC.
TIME UNIT	100 KC
DISPLAY TIME	Minimum
100 KC STANDARD	INT
MANUAL GATE	CLOSED
Plug-in unit	TIME INTERVAL UNIT
Line volts	115V ac

PLUG-IN UNIT CONTROL SETTINGS

COM SEP	COM
TRIGGER SLOPE	Both +
TRIGGER LEVEL	Both 0 x 1
TIME INTERVAL PERIOD	PERIOD

Connect STD. FREQ. OUTPUT to pin 1 of V-202 (Test Point S) with a single (not shielded) wire and a 100 mmf capacitor.

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step D1 Set MANUAL GATE to OPEN position.	(S)	Counter counts at 100 kc rate.	If counter operation is not restored, replace V-202. If replacement of V-202 restores normal operation, proceed to Step D2. If replacement does not restore normal operation, return original tube and proceed to Table 10-8 .
Step D2 Remove the patch connection from pin 1 of V-202 and connect it to pin 6 of V-201.	★ 19	Counter counts at 100 kc rate.	If counter operation is not restored, replace the trigger unit tubes (V-601, V-602 and V-603) and adjust as described in Paragraph 10-22. If tube replacement does not restore operation, return original tubes and replace Z-201 by exchanging it with either Z-102 or Z-103 from the TIME INTERVAL plug-in unit.
Step D3 Remove patch connection to SIGNAL INPUT,		Counter counts at 100 kc rate.	If normal operation is not restored, replace V-201 and V-248. Return original tubes if replacement does not restore normal operation.
Step D4 Set FUNCTION SELECTOR to frequency.		00000100.	Improper operation indicates failure of the A section of V-201. Replace V-201.
Step D5 Repeat Steps D1 through D4 at both 103.5V ac line and 130V ac line.		Indication for each step should be the same. Voltages should be within 2%.	

Table 10-6. Step-By-Step System Analysis of the 10 Megacycle Multiplier

If in Step 3 (Table 10-1), the 10 MC CHK function cannot be correctly adjusted, set the controls as indicated below and proceed with the following steps.

CONTROL SETTINGS

Power switch	ON
FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	1 SEC.
TIME UNIT	100 KC
DISPLAY TIME	Minimum
100 KC STD.	INT
MANUAL GATE	CLOSED
Plug-in unit	FREQUENCY CONVERTER
Line volts	115V ac

PLUG-IN UNIT CONTROL SETTINGS

GAIN	MAX
MIXING FREQUENCY	"0"
TUNING AND RANGE	ANY POSITION

If the 0-10 mc channel of the converter is not operating properly, use the Time, Interval Unit. In Steps E2 and E3, when using the Time Interval Unit, couple the plates of V-237 and V-238 directly to SIGNAL INPUT, using a 10 mmf coupling capacitor. Loose coupling may not yield consistent results.

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step E1 Connect a 1 volt rms signal at 10 mc to SIGNAL INPUT.		10000.000 ±1 stability of signal generator.	If correct operation is obtained, proceed with Step E2 below. If correct operation is not obtained, check circuit of V-201A. If tube replacement does not restore normal operation, see Table 10-8.
Step E2 Disconnect input signal. Using a single wire with an alligator type clip, loose couple plate lead (blue wire) of V-237 to SIGNAL INPUT.		00400.000	Any other display indicates failure of the circuit of V-237. Adjust as described in paragraph 10-20 Replace tube and adjust if necessary.
Step E3 Move the loose coupling from plate of V-237 to the plate lead (blue wire) of V-238.		02000.000	Any other display indicates failure of the circuit of V-238. Adjust as described in Paragraph 10-20. Replace tube and adjust if necessary.
Step E4 Disconnect the loose coupling entirely and set FUNCTION SELECTOR to 10 MC CHK.		10000.000	Any other count indicates failure in the circuit of V-239 or V-240. Adjust as described in Paragraph 10-20 Replace tubes one at a time and adjust if necessary.

Table 10-6. Step-By-Step System Analysis of the 10 Megacycle Multiplier (Contd.)

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step E5 Repeat Steps E1 through E4 once at a line voltage of 103.5V ac and once at 126.5V ac.		Indications in each step should be the same.	Low line voltage operation tends to reveal weak tubes while high line voltages reveal partial shorts and leakages.

Table 10-7. Step-By-Step System Analysis of the Time Base

If in Step C1 (Table 10-4),the voltage measured at pin 5 of Z-202 does not swing between +1 volt and 0 volts at a one-cycle per second rate, set the controls as indicated below and proceed with the following steps.

CONTROL SETTINGS

Power switch	ON
FUNCTION SELECTOR	100 KC CHK
FREQUENCY UNIT	10 SEC.
TIME UNIT	10 cps
DISPLAY TIME	Minimum
100 KC STANDARD	INT
MANUAL GATE	CLOSED
Plug-in unit	TIME INTERVAL UNIT
Line volts	115V ac

PLUG-IN UNIT CONTROL SETTINGS

COM SEP	COM
TRIGGER SLOPE	Both +
TRIGGER LEVEL	Both 0 x 1
TIME INTERVAL PERIOD	PERIOD

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step F1 Using the VTVM, measure the voltage at pin 5 of V-234.		+190V dc	If the voltage is +210, the circuits of either V-234 or Y-201 (the 100 kc quartz crystal) are not operating. Replace the tube. If replacement restores normal operation, adjust the circuit as described in Paragraph 10-19 and proceed with Step F3. If replacement does not restore normal operation, return the original tube and proceed to Step F2.
Step F2 Set 100 KC STANDARD to EXT, connect a 1-volt rms 100 KC signal to 100 KC INPUT, and measure the voltage at pin 5 of V-234.		+190V dc	If the voltage remains near +210, the circuits associated with V-234 are faulty. If the voltage is correct for Step F2 but remains near +210 in Step F1, the 100 KC quartz crystal (Y-201) is probably not functioning. Replace as described in Section XI.

Table 10-7. Step-By-Step System Analysis of the Time Base (Contd.)

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step F3 Measure the voltage at pin 1 of V-236.	A3	+185V dc	If the voltage remains near +210, replace V-235A or V-236A one at a time. Return the original tubes if normal operation is not restored. If V-235 is replaced, adjust phantastrons as described in Paragraph 10-16.
Step F4 Measure the voltage at pin 5 of V-241.	A5	+135V dc	If the voltage is +210, replace V-236B, V-235B, or V-241 one at a time. Return the original tubes if replacement does not restore normal operation. If V-235 or V-241 are replaced, adjust phantastrons as described in Paragraph 10-16.
Step F5 Measure the voltage at pin 5 of V-243.	B2	+135V dc	If the voltage is +210, replace V-242 or V-243 one at a time. Return the original tubes to their places if replacement does not restore normal operation. If either tube is replaced, adjust the phantastrons as described in Paragraph 10-16.
Step F6 Measure the voltage at pin 5 of V-244.	B5	+135V dc	If the voltage is +210, replace V-242 or V-243 one at a time. Return the original tubes if replacement does not restore normal operation. If tubes are replaced, adjust phantastrons as described in Paragraph 10-16.
Step F7 Measure the voltage at pin 5 of V-246.	B6	+ 135V dc	If the voltage is +210V dc, replace V-245A and V-246 one at a time. Return the original tubes if replacement does not restore normal operation. If either tube is replaced, adjust phantastrons as described in Paragraph 10-16.
Step F8 Measure the voltage at pin 5 of V-247.	B7	Fluctuates between +60V dc and +200V dc at a one-cycle per second rate.	If the voltage does not fluctuate between the correct voltage limits, replace V-245B and V-247 one at a time. Return the original tubes if replacement does not restore normal operation. If either tube is replaced, adjust phantastrons as described in Paragraph 10-16.
Step F9 Measure the voltage at pin 3 of V-248.	B8	Fluctuates between +30V dc and +13V dc at a one-cycle per second rate.	If the voltage does not fluctuate as described, (check V-248. If the voltage remains at +30V dc, check V-248 and its circuit as well as the circuits of S-207.
Step F10 Measure the voltage at pin 7 of V-248.	B9	+0.6V dc. The meter indicator wavers at a 10 cps rate.	If the voltage remains near +1.7V dc. check V-248 and the circuits of S-206.
Step F11 Repeat Steps F1 through F10 at 103.5 volts line, and at 126.5 volts ac line.		Indications should be nearly the same and voltages should be within 2%.	

Table 10-8. Step-By-Step System Analysis of the Counters

CONTROL SETTINGS

Power switch	ON
FUNCTION SELECTOR	100 KC CHK
FREQUENCY UNIT	1 SEC.
TIME UNIT	100 KC
DISPLAY TIME	Minimum
100 KC STANDARD	INT
MANUAL GATE	CLOSED
Plug-in unit	TIME INTERVAL UNIT
Line volts	115V ac

PLUG-IN UNIT CONTROL SETTINGS

COM SEP	COM
TRIGGER SLOPE	Both +
TRIGGER LEVEL	Both 0 x 1
TIME INTERVAL PERIOD	PERIOD

Connect pin 2 of V-247 to the STD. FREQ. OUTPUT connector, using a single open-wire clip lead. This connection supplies a 1 cps signal to the counters.

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step G1 Observe the displayed count.		00100.000. Meters point between 4 and 5 during counting and to 0 during display.	If no count is obtained, check V-210 and V-211 and associated crystal diodes. Return original parts if replacement does not restore normal operation.
			If the count is erratic or otherwise wrong in each decade, proceed with Step G2.
			If the units meter (right hand) operates normally and all other decades are wrong, proceed with Step G5.
			If both meters operate correctly, but all decade counter units do not, first check V-223, then -check V-901, V-902, V-903 and V-904 in Z-204. If tube replacement does not restore normal operation, service Z-204 as described in Paragraph 11-170.
			If both meters and the right-hand decade counter unit operate correctly but all or some of the remaining decade counters do not, interchange the units until the defective counter is isolated. Replace tubes in the defective unit. If tube replacement does not restore operation, service as described in Paragraph 11-170.
Step G2 Disconnect the outer ends of CR-215, CR-219 and R-290 (on Z-215) and remove V-216. Use an open clip lead to connect the holder of R-290 (R-290 removed) to the outer side of C-264 (on Z-216). This connection bypasses the units counter. Observe the displayed count.	23 28	01000.00x. X may be any number.	If the correct indication is obtained, the units decade is not operating properly. Proceed with Step G3. If the indication is wrong or erratic, the trouble probably lies in the input circuits. See Table 10-5. In either case, restore original circuit -v before proceeding,

Table 10-8. Step-By-Step System Analysis of the Counters (Contd.)

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step G3 Set FUNCTION SELECTOR to MANUAL GATE, MANUAL GATE to OPEN, and replace V-216. Using a vacuum tube voltmeter, measure the dc voltage at pin 5 of each tube in the decade (V-210, through V-218).	24 W 25 Y DD AA 26 CC 27	V-210, 80V dc V-211, 80V dc V-212, 82V dc V-213, 78V dc V-214, (use pin 7), 78V dc V-215, 78V dc V-216, 82V dc V-217, 86V dc V-218, 74V dc	Check and replace tubes and associated crystal diodes wherever measured voltages are not correct. Service decade as described in Paragraph 11-152.
Step G4 Set TIME UNIT to EXT. Check the counting sequence of the units meter		Meter should count 0123456789-012345, etc.	Any other order of count is wrong. Table 10-9 lists most of the common improper counting sequences and their probable causes of malfunction.
Step G5 Set FUNCTION SELECTOR to MANUAL GATE, MANUAL GATE to OPEN, and TIME UNIT to 100 KC. Using a vacuum tube voltmeter, measure the dc voltage at pin 1 and at pin 6 of each tube in the decade (V-219 through V-223).	29 FF 30 HH 31 JJ LL 32 33	V-219 pin 6, 180V dc pin 1, 180V dc V-220 pin 1, 185V dc pin 6, 175V dc V-221 pin 6, 185V dc pin 1, 175V dc V-222 pin 1, 190V dc pin 6, 165V dc V-223 pin 6, 32V dc pin 1, 230V dc	Check and replace tubes and associated crystal diodes wherever measured voltages are not correct. Service decade as described in Paragraph 11-161.

Table 10-8. Step-By-Step System Analysis of the Counters (Contd.)

PROCEDURE	TEST POINT	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step G6 Set TIME UNIT to 10 CPS. Check the counting sequence of the tens meter.		Meter should count 012345678901234, etc.	Any other order of count is wrong. Table 10-10 lists most of the common improper counting sequences and their probable causes of malfunction.
Step G7 Set FUNCTION SELECTOR to FREQUENCY, FREQUENCY UNIT to .01 SEC., and MANUAL GATE to CLOSED. Connect a two volt rms signal of approximately 1 mc. Slowly increase frequency until counter indication begins to decrease, stops, or becomes erratic.		Consistent readings should be possible at least as high as 10.6 mc.	If. considering the stability of the signal generator, the units meter is operating erratically, replace the tubes in the units decade (V-210 through V-218). Replace V-210 and V-211 first. In each case, try several tubes. If the units meter appears stable, replace tubes in first decade that is operating incorrectly. In each case, try several tubes.
Step G8 Repeat Steps G1 through G7, once at a line voltage of 103V ac and once at 126.5V ac.		Indications in each step should be the same.	

10-10. SPECIAL PRECAUTIONS CONCERNING REMOVAL AND REPLACEMENT OF CABINET, INTERNAL PLUG-IN UNITS, TUBES AND CRYSTAL DIODES.

10-11. PROCEDURE FOR REMOVAL OF CABINET. The cabinet retaining screws are shown in figure 10-2. Once these screws are loose, the cabinet may easily be pulled free of the chassis.

10-12. SPECIAL PRECAUTIONS CONCERNING REMOVAL OF INTERNAL PLUG-IN UNITS. The internal plug in units, i.e., those internal subassemblies that are constructed on tube bases, are secured either by a screw or a latch. The following tabulation indicates which type of securing is used for each of the internal plug in units. The location of the retaining screws are shown in Figures 10-4 and 10-5. Make certain that the screws are removed or the latches loosened before attempting to remove any of the internal units.

Z-102 Stop Trigger Z-103 Start Trigger Z-201 Trigger Unit	Before removing the unit, release the captive screw from under the chassis. See Figures 10-4 and 10-5.
Z-202 Amplitude Discriminator	Before removing the unit, release the two latches in the upper corners of the discriminator, See Figure 10-5.
Z-203 Decade Divider	Before removing the unit, release the two captive screws from under the chassis. See Figure 10-5.
Z-204 Z-205 Z-206 Decade Z-207 Counter Z-208 Units Z-209	Before removing the unit. Release the retaining screw on the front panel at the top of the number column. See Figure 10-5.

10-13. SPECIAL PRECAUTIONS WHEN REPLACING TUBES. The tubes in the AN/USM-26 equipment can, in general, be replaced without special selection, although some cases, a special adjustment of the circuit should be made after the replacement tube has been installed. Table 10-11 indicates the procedures necessary for replacing any given tube. The information also includes hints that will simplify the physical replacement of some of the tubes. The location of the tubes is shown in Figures 10-3, 10-4, and 10-5.

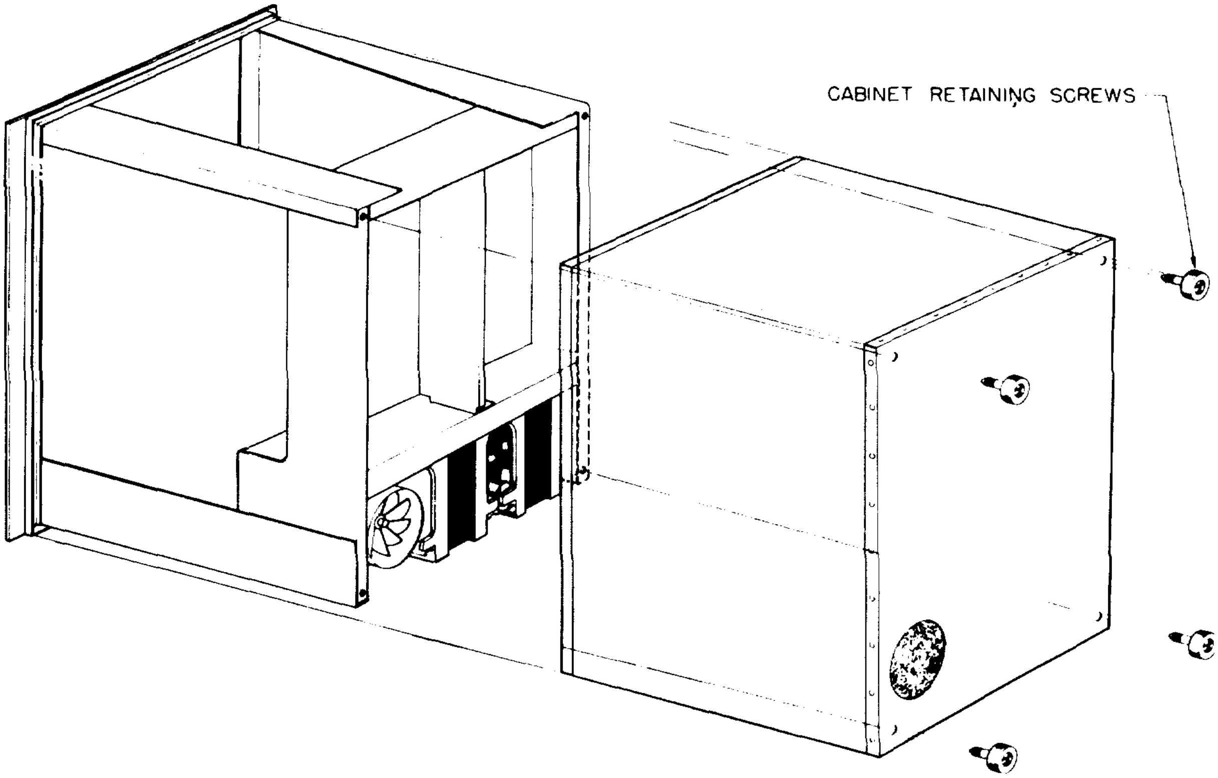


Figure 10-2. Frequency Meter FR-38/U Showing Cabinet Retaining Screws

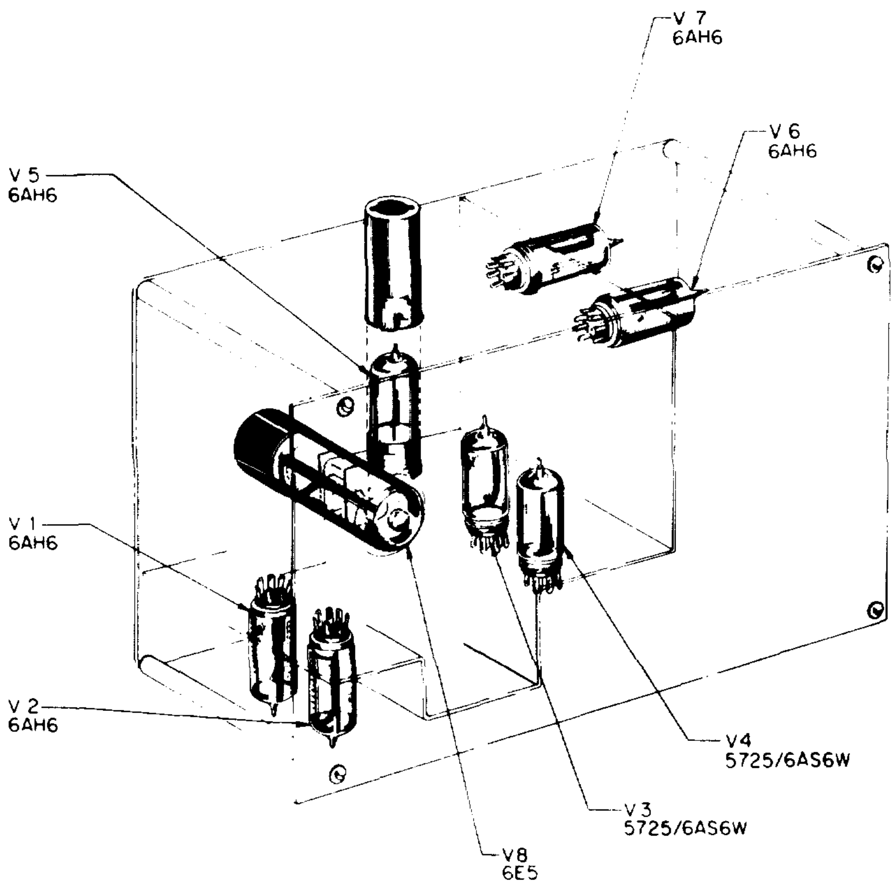


Figure 10-3. Tube Location Diagram, Frequency Meter Subassembly Unit MX-1637/U

Table 10-9. Improper Counting Sequences - Ten Megacycle Counter (Units Meter)

The SEQUENCE column refers to the counting sequence of the right-hand (UNITS) meter. The correct sequence is: 012345678901234567890, etc. Any other counting sequence is wrong. The TUBE NO. (V) column and the CRYSTAL DIODE NO. (CR) column indicate which tubes or crystal diodes normally cause the improper counting sequence listed to the first column.

SEQUENCE	TUBE NO. (V)	CRYSTAL DIODE NO. (CR)
Odd numbers only	210, 211	216, 218, 221
Even numbers only	210, 211	220,222
01	210	223, 228
23	212, 213	225, 229, 230
67	217, 218	243, 245, 246
89	214, 217, 218	232, 242, 244, 247
0123	215, 216	233, 236, 237, 240
0129		224
0145	212, 213	223, 226, 227
0189		224
0246	210, 211	215, 217, 220, 222
1256		223
1456		223
2334		237
2345	215, 216	237, 241
6789	210, 211, 212	225, 229, 230
02468	210, 211	215, 220, 222
13579	210, 211	218, 219, 221
012389	218	239, 242
014589		238
016789	215, 216	235, 238
034789		228
123489		234
124589		234
126789		238
136789		230
236789	212, 213	225, 228, 229, 230, 234
456789	215, 216	234, 235, 238, 241
01234567	214, 217, 218	232, 243, 245, 248
01234589	212, 213, 214	224, 229, 230, 239, 242
01235689	212, 213	229, 230
01236789		229
01256789		223
01456789		226, 231
12235689	218	230
12235789		230
12236789		229
0123346789	215, 216	233
0134456789	218	234, 238
1234567889		244

10-14. When replacing any tube, self-check the instrument (100 KC CHECK and 10 MC CHECK) as described in Section II to assure proper operation. If normal operation is not restored after trying several replacement tubes, return the original tube to its position and continue testing.

WARNING

Be sure that the instrument is turned off when changing tubes in the power supply section. Do not turn the instrument on if any tubes are removed from the power supply.

Table 10-10. Improper Counting Sequences - One Megacycle Counter (Tens Meter)

The SEQUENCE column refers to the counting sequence of the left-hand (TENS) meter. The correct sequence is: 012345678901234567890, etc. Any other sequence is wrong. The TUBE NO. (V) column and the CRYSTAL DIODE NO. (CR) column indicate which tubes or crystal diodes normally cause the improper sequence listed to the left.

SEQUENCE	TUBE NO. (V)	CRYSTAL DIODE NO. (CR)
Failure to operate	215, 219	
Even numbers only	219	249
Odd numbers only	219	250
23	219	250, 254, 255
67	220	250, 254, 258
89	222	250, 254, 257
0123	221	255
0145	220	252
2345	221	25-
4567	221, 222	253, 258
6789	221	253
02468	219	249
13579	219	250
014567	220	252
056789	221	253
236789	220	254
456789	221	253
01234567	222	258
0123456723456789		252, 255
012345674567890		252
0123456767890		255

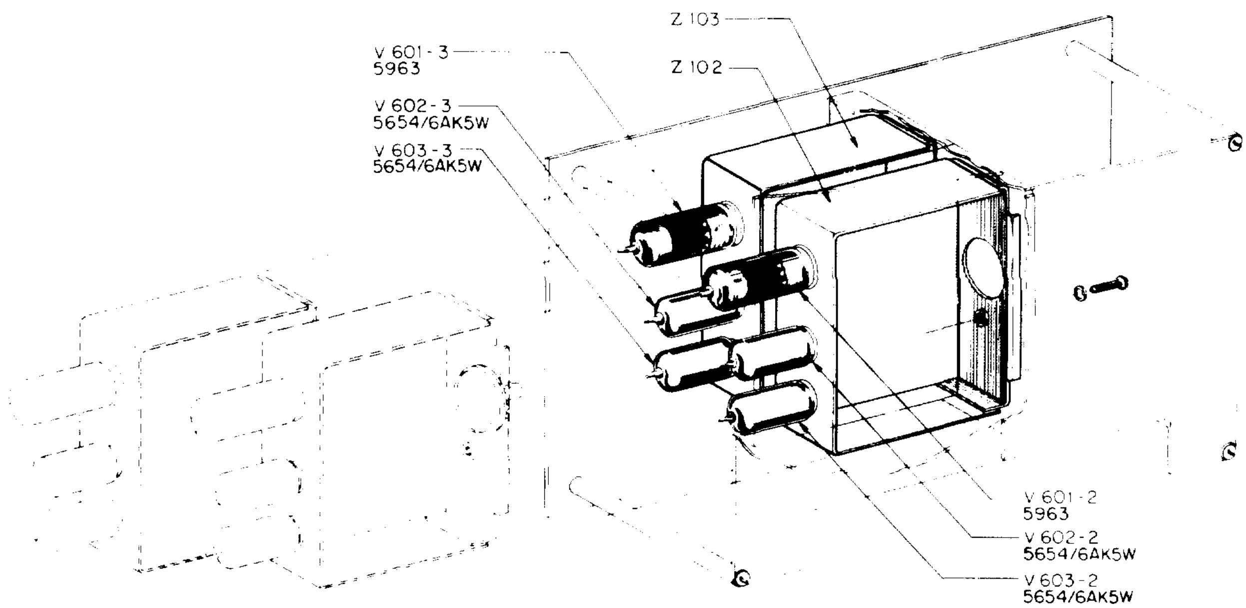
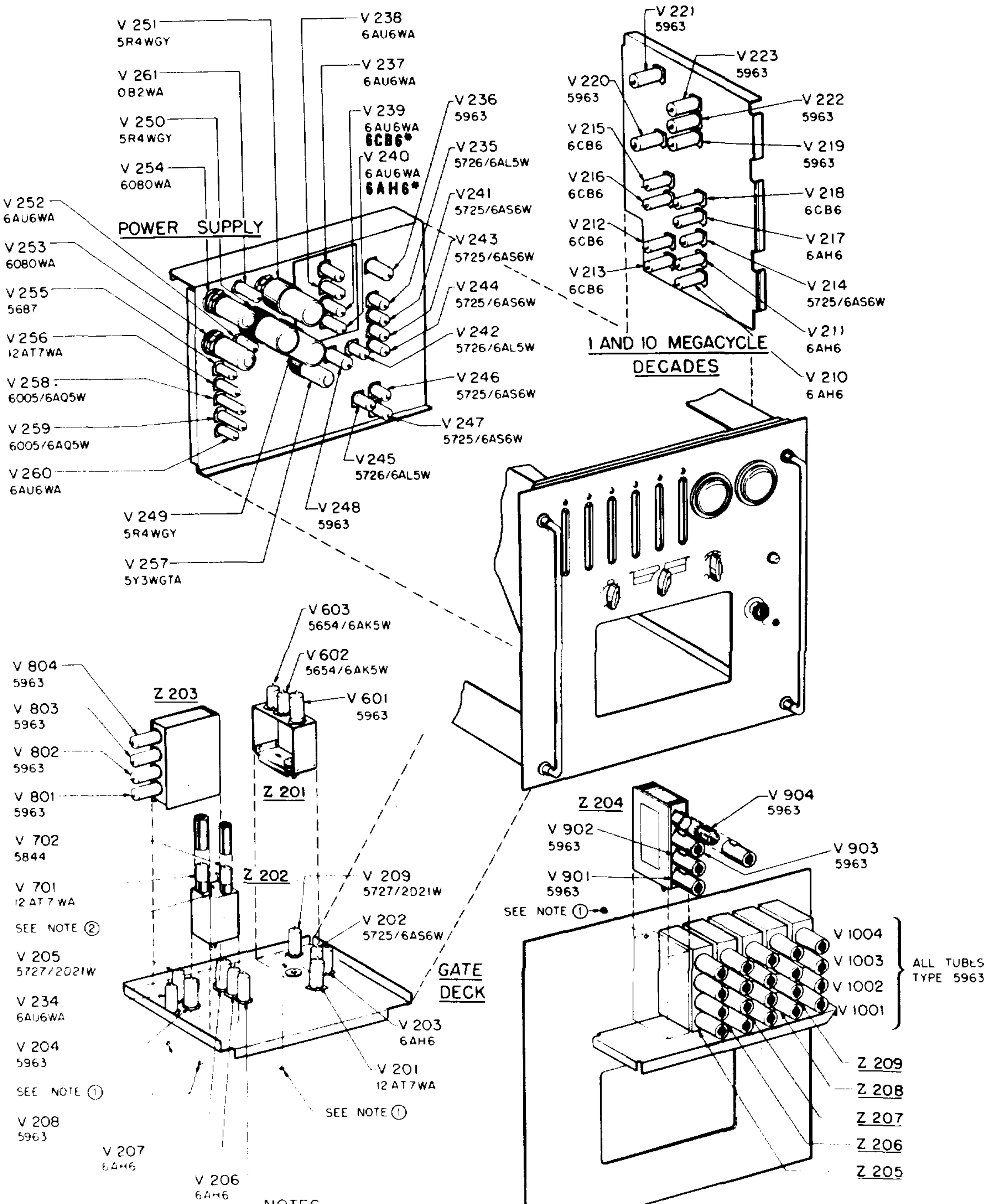


Figure 10-4. Tube Location Diagram, Frequency Meter Subassembly Unit MX-1636/U



NOTES
① REMOVE RETAINER SCREWS BEFORE REMOVING PLUG-IN UNITS.
② TO REMOVE Z-202 TURN LOCKING RODS.

* Used in **FR-38C/U** and **FR-38 D/U**

Figure 10-5. Tube Location Diagram, Frequency Meter FR-38/U

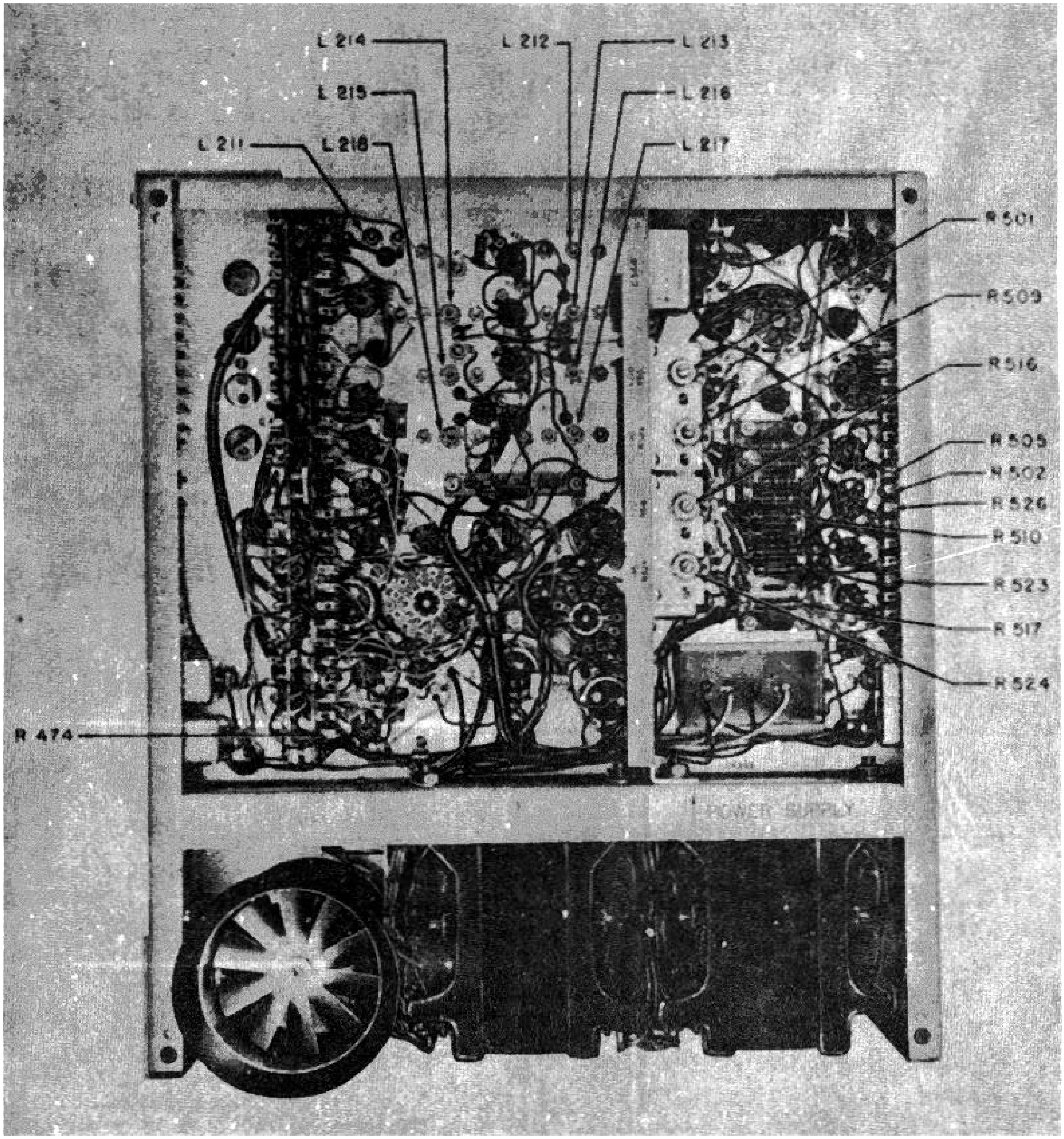


Figure 10-6. Frequency Meter FR-38/U, Rear View

10-15. CRYSTAL DIODE REPLACEMENT. The crystal diodes in the FR-38/U are especially selected for high back resistance at high temperatures. Ten of these crystals are included as spares and are mounted on a clip board inside the chassis in the Time Base Section (Figure 10-1). If it is necessary to select additional diodes for the instrument, the procedure outlined in Section XI of this manual must be used.

CAUTION

Observe correct polarity when replacing crystal diodes. Polarity is marked on each resistor board where a crystal is mounted. Polarity for crystal diodes is shown in Figure 9-24.

Table 10-11. Table of Adjustments to be Made When Replacing Tubes (Contd.)
GATE SECTION (Contd.)

CIRCUIT REFERENCE AND TUBE TYPE		TUBE USE	NECESSARY ADJUSTMENTS
V- 204:	5963	display time control	-----
V-205:	5725/2D21W	display time thyratron	-----
V-206:	6AH6	gate binary	Adjust GATE LENGTH. See para 10-23.
V-207:	6AH6	gate binary	Same as V-206.
V- 208:	5963	amplifier and blocking oscillator	Same as V-206.
# V-209:	5725/2D21W	reset thyratron	-----
Z-201 (trigger unit)			
V-601: *V-1101	5963	amplifier	Adjust FREQ. SENS. See para 10-22.
V-602: *V1102	5654/6AK5W	trigger	Same as V-601.
V-603: *V-1103	5654/6AK5W	trigger	Same as V-601.
Z-202 (amplitude discriminator)			
V-701:	12AT7	amplifier	Adjust PERIOD SENS. See para 10-21.
V-702:	5844	trigger	Same as V-701.
Z-203 (decade divider)			
V-801:	5963	1st binary	-----
V-802:	5963	2nd binary	-----
V-803:	5963	3rd binary	-----
V-804:	5963	4th binary	-----

To remove V-202, V-203 or V-209, first remove V-210 to V-218. Remove and replace tubes through the front panel opening (#17) .

* Used in FR-38C/U and FR-38D/U

COUNTER SECTION

CIRCUIT REFERENCE AND TUBE TYPE		TUBE USE	NECESSARY ADJUSTMENTS
(10 mc decade)			
V-210:	6AH6	1st binary	-----
V-211:	6AH6	1st binary	-----
V-212:	6CB6	2nd binary	-----
V-213:	6CB6	2nd binary	-----
V-214:	5725/6AS6W	gate	-----

Table 10-11. Table of Adjustments to be Made When Replacing Tubes (Contd.)
COUNTER SECTION (Contd.)

CIRCUIT REFERENCE AND TUBE TYPE		TUBE USE	NECESSARY ADJUSTMENTS
V-215:	6CB6	3rd binary	-----
V-216:	6CB6	3rd binary	-----
V-217:	6AH6	4th binary	-----
V-218:	6CB6	4th binary	-----
(1 mc decade)			
V-219:	5963	1st binary	-----
V-220:	5963	2nd binary	-----
V-221:	5963	3rd binary	-----
V-222:	5963	4th binary	-----
V-223:	5963	wave shaper	-----
DECADE COUNTER UNITS			
Z-204			
V-1001:	5963	1st binary	-----
V-1002:	5963	2nd binary	-----
V-1003:	5963	3rd binary	-----
V-1004:	5963	4th binary	-----
Z-205			
V-901:	5963	1st binary	-----
V-902:	5963	2nd binary	-----
V-903:	5963	3rd binary	-----
V-904:	5963	4th binary	-----
Z-206			
V-901:	5963	1st binary	-----
V-902:	5963	2nd binary	-----
V-903:	5963	3rd binary	-----
V-904:	5963	4th binary	-----

Defective crystal diodes are isolated, using the technique described in paragraph 11-43 of Section XI of this manual. When doing maintenance work on an FR38/U which has been in use for 2000 hours or more, it is good practice to check all crystal diodes first.

10-16. ALIGNING R-38/U. The following paragraphs give the complete procedure for aligning the FR-38/U. The power supply voltages should be checked and adjusted before making any adjustments. Table 10-11 lists the adjustments required when replacing any one tube in the unit; complete alignment of the instrument is not necessary.

10-17. ADJUSTING POWER SUPPLY VOLTAGES. When tubes are replaced in the power supply and before other circuit adjustments are made, the regulated supply voltages (-195, +70, +90 and +210) should be set. These voltages are interdependent so that when one voltage is adjusted for any reason, all four voltages should be checked. These adjustments should be made with a supply line voltage of 115 volts ac (adjust with Variac). In any case, the line voltage should not be less than 103.5 volts nor more than 126.5 volts.

CAUTION

Test prods should be wrapped with insulating tape so that only the extreme tip of the prod has exposed metal. Accidentally shorting the +70 or +90 volt busses to ground, or to the +210 volt bus with a test prod can destroy most of the crystal diodes used in the equipment.

The adjustment procedure is as follows:

a. With either plug-in unit in place, turn the power on and allow the unit to warm up for at least five minutes.

b. Set the variable transformer for 115 volts ac line.

c. Connect a high-resistance dc voltmeter (AN/URM25 or equal) to pin 7 of V-261. The voltage present should be -195V dc.

d. Adjust R-524 (Figure 10-6) until the voltmeter reads -195 volts.

e. Connect the voltmeter to pin 1 of V-255. The voltage present should be +210 volts.

f. Adjust R-501 (Figure 10-6) until the voltmeter reads +210 volts.

g. Connect the voltmeter to pin 6 of V-255. The voltage should be +90 volts.

h. Adjust R-509 (Figure 10-6) until the voltmeter reads +90 volts.

i. Connect the voltmeter to pin 3 of V-255. The voltage present should be +70 volts.

j. Adjust R-516 (Figure 10-6) until the voltmeter reads +70 volts.

k. Since the settings are interdependent, the adjustments should now be checked and repeated if necessary.

l. Readjust all four regulated power supply voltages after 24 hours of continuous operation.

m. If necessary, reset the high-torque action of the adjustment lock nuts.

10-18. PHANTASTRON ADJUSTMENT. With the power off, remove the panel plug-in unit. Turn the power on and allow the FR-38/U to warm up thoroughly (approximately 15 minutes). The adjustments for the phantastron circuits are located just inside the upper edge of the plug-in aperture in the front panel (Figure 10-7).The adjusting potentiometers are provided with lock nuts, which have been set at the factory to have a high-torque effect instead of locking action. Consequently, the potentiometers can be adjusted without disturbing the lock nut.

CONTROL SETTINGS

FUNCTION SELECTOR	100 KC CHK.
FREQUENCY UNIT	.001 SEC.
DISPLAY TIME	Minimum (ccw)
100 KC STANDARD	INT

a. Adjust R-444 (Figure 10-7) to the center of the range where a stable counter reading of 00000100. is obtained.

b. Set FREQUENCY UNIT to .01 SEC. Adjust R-453 (Figure 10-7) to the center of the range where a stable counter reading of 0000100.0 is obtained.

c. Set FREQUENCY UNIT to .1 SEC. Adjust R-462 (Figure 10-7) to the center of the range where a stable counter reading of 000100.00 is obtained.

d. Set FREQUENCY UNIT to 1 SEC. Adjust R-471 (Figure 10-7) to the center of the range where a stable counter reading of 00100.000 is obtained.

e. Set FREQUENCY UNIT to 10 SEC. Adjust R-(Figure 10-7) to the center of the range where a stable counter reading of 0100.0000 is obtained.

f. If tubes have been replaced before adjustment, readjust after allowing the FR-38/U to operate continuously for 24 hours.

10-19. 100 KC OSCILLATOR ADJUSTMENT. With neither plug-in unit in place, turn the FR-38/U on and allow it to warm up thoroughly (approximately 15 minutes). After setting the panel controls as indicated below, proceed with steps 'a' through "e".

CONTROL SETTINGS

FUNCTION SELECTOR	100 KC CHK
FREQUENCY UNIT	.1 SEC.
TIME UNIT	100 KC
DISPLAY TIME	Minimum (ccw)
100 KC STANDARD	INT

Table 10-11. Table of Adjustments to be Made When Replacing Tubes

CIRCUIT REFERENCE AND TUBE TYPE		TUBE USE	NECESSARY ADJUSTMENTS
FREQUENCY CONVERTER UNIT			
V-1:	6AH6	tuned amplifier	Adjust balanced mixer drive. See para 10-27.
V-2:	6AH6	tuned amplifier	Same as V-1.
V-3:	5725/6AS6W	mixer	Adjust balanced mixer drive, mixer balance, and harmonic generator output. See para 10-25, 10-26, 10-27, and 10-28.
V-4:	5725/6AS6W	mixer	Same as V-3
V-5:	6AH6	harmonic generator	Adjust 10 mc input, See para 10-29.
V-6:	6AH6	video amplifier	
V-7:	6AH6	video amplifier	
* V-8:	6E5	indicator	
* Remove tube socket mounting bracket to replace tube.			
TIME INTERVAL UNIT			
Z- 102 (stop trigger unit)			
V-601: 5963		amplifier	Calibrate stop trigger level control. See para 10-24.
V- 602:	5654/6AK5W	trigger	Same as V-601.
V-603:	5654/6AK5W	trigger	Same as V-601
Z-103 (start trigger unit)			
V-601: 5963		amplifier	Calibrate start trigger level control. See para 10-24.
V-602:	5654/6AK5W	trigger	Same as V-601.
V-603:	5654/6AK5W	trigger	Same as V-601.
GATE SECTION			
V-201:	12AT7	input amplifier	-----
# V-202:	5725/6AS6W	signal gate	-----
# V-203:	6AH6	gate amplifier	Adjust GATE LENGTH. See par2 10-23.
# To remove V-202, V-203 or V-209, first remove V-210 to V-218. Remove and replace tubes through the front panel opening (#17)10-4.			

Table 10-11 Table of Adjustments to be Made When Replacing Tubes (Contd.)

DECADE COUNTER UNITS (Contd.)

CIRCUIT REFERENCE AND TUBE TYPE			TUBE USE	NECESSARY ADJUSTMENTS
Z-207				
V-901:	5963		1st binary	-----
V-902:	5963		2nd binary	-----
V-903:	5963		3rd binary	-----
V-904:	5963		4th binary	-----
Z-208				
V-901:	5963		1st binary	-----
V-902:	5963		2nd binary	-----
V-903:	5963		3rd binary	-----
V-904:	5963		4th binary	-----
Z-209				
V-901:	5963		1st binary	-----
V-902:	5963		2nd binary	-----
V-903:	5963		3rd binary	-----
V-904:	5963		4th binary	-----
TIME BASE SECTION				
V-234: 6AU6			100 kc oscillator	Peak and standardize oscillator. See para 10-19.
V-235:	5726/6AL5W		coupling diode	Adjust phantastrons. See para 10-18.
V-236:	5963		blocking oscillator and amplifier	
V-237:	6AU6		multiplier	Align multiplier. See para 10-20.
V-238:	6AU6/6AU6WA		multiplier	Same as V-237.
V-239:	6AU6	*(6CB6)	multiplier	Same as V-237.
V-240:	6AU6	*(6AH6)	multiplier output amplifier	Same as V-237.
V-241:	5725/6AS6W		1st phantastron	Adjust phantastrons. See para 10-18,
V-242:	5726/6AL5W		coupling diode	Same as V-241.
V-243:	5725/6AS6W		2nd phantastron	Same as V-241.
V-244:	5725/6AS6W		3rd phantastron	Same as V-241.
V-245:	5726/6AL5W		coupling diode	Same as V-241.

*Used in FR 38C/U and FR 38D/U

Table 10-11. Table of Adjustments to be Made When Replacing Tubes (Contd.)

TIME BASE SECTION (Contd.)

CIRCUIT REFERENCE AND TUBE TYPE		TUBE USE	NECESSARY ADJUSTMENTS
V-246:	5725/6AS6W	4th phantastron	Same as V-241
V-247:	5725/6AS6W	5th phantastron	Same as V-241
V-248:	5963	output cathode follower	-----
POWER SUPPLY			
WARNING Turn instrument off before removing tubes from power supply. Do not turn on unless all power supply tubes are in place.			
** V-249:	5R4WGY	rectifier	-----
** V-250:	5R4WGY	rectifier	-----
V-251:	5R4WGY	rectifier	-----
V-252:	6AU6	+210V dc control tube	Adjust power supply. See para 10-17.
V-253:	6080	regulator +210V dc	-----
V-254:	6080	regulator +210V dc	-----
V-255:	5687	+90 and +70V dc regulator	Same as V-252.
V-256:	12AT7	+90 and +70V dc control tube	Same as V-252.
V-257:	5Y3WGTA	rectifier	-----
V-258:	6005/6AQ5W	-195V dc regulator	-----
V-259:	6005/6AQ5W	-195V dc regulator	-----
V-260:	6AU6	-195V dc control tube	Same as V-252.
V-261:	OB2	voltage reference	Same as V-252.

** To remove V-249 or V-250, first remove V-251. Loosen the clamp around the tube base before removing.

a. Set ADJ on the front panel so that the screwdriver slot is in the vertical position.

b. Using C-295 and C-296 (Figure 10-8) instead o ADJ, standardize the 100 kc oscillator by either method described in paragraph 5-36. Adjust C-295 and C-296 for approximately equal capacitance. When correctly set, retighten the lock nuts.

c. Now, connect the ac probe of a vacuum tube voltmeter (type AN/URM-25 or equal) to the junction of C-290 and C-291 (Figurel0-8).The voltage present should be approximately 1 volt rms at 100 kc.

d. Tune L-211 (Figure 10-6) or a maximum voltage indication on the voltmeter.

e. Allow the FR-38/U to operate continuously for 24 hours and then standardize the 100 kc oscillator as described in paragraph10-36.

10-20. TUNING 10 MC MULTIPLIER. With the power off, install the Frequency Converter. Turn the power on and allow the equipment to warm up for 15 minutes or more.

CONTROL SETTINGS

FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.1 SEC.
TIME UNIT	10 MC
DISPLAY TIME	Minimum (ccw)
100 KC STANDARD	INT
MIXING FREQUENCY	0

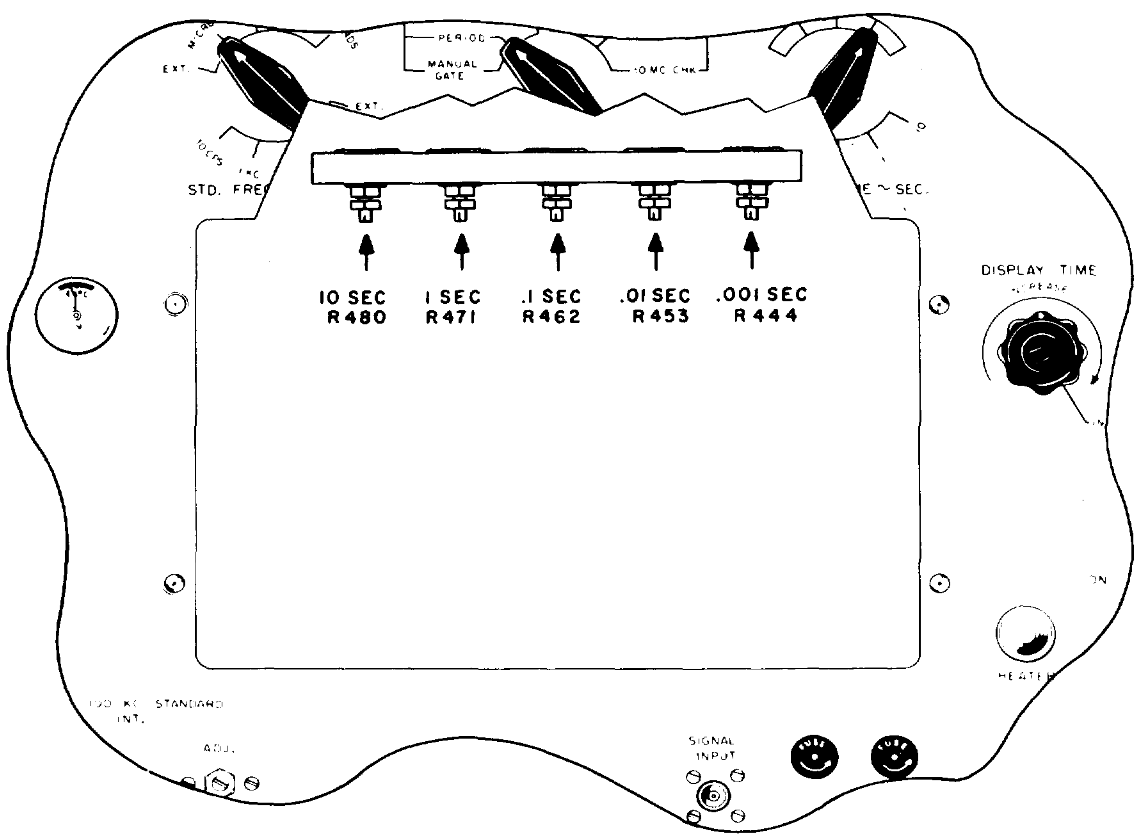
a. Using a single open-wire lead, loose couple the plate of V-237 (blue lead to pin 5) to SIGNAL INPUT. An alligator type clip clamped over the insulation of the blue plate lead is sufficient. Connect also the ac probe of a vacuum tube voltmeter (AN /URM-25 or equal) to SIGNAL INPUT.

NOTE

If the Frequency Converter Unit is working properly, the tuning eye can be used in place of the vacuum tube voltmeter. Adjust GAIN until the eye is just short of closing. Circuits adjustments described below are tuned for maximum closure of the eye.

b. Carefully adjust L-212 (Figure 10-6) for a maximum indication on the meter or maximum closure o) the eye in the range through which the counter consistently reads 000400.00.

c. Move the loose coupling from the plate lead of Figure 10-7. Location of Phantastron Adjustments V-237 to the plate lead (blue wire at pin 5) of V-238. The counter should now count 002000.00.



PHANTASTRON ADJUSTMENTS

PART NO.	R444	R453	R462	R471	R480
PHAN.	1ST	2ND	3RD	4TH	5TH
GATE TIME	.001 SEC	.01 SEC	.1 SEC	1 SEC	10 SEC
FREQ.	10KC	1KC	100∿	10∿	1∿

Figure 10-7. Location of Phantastron Adjustments

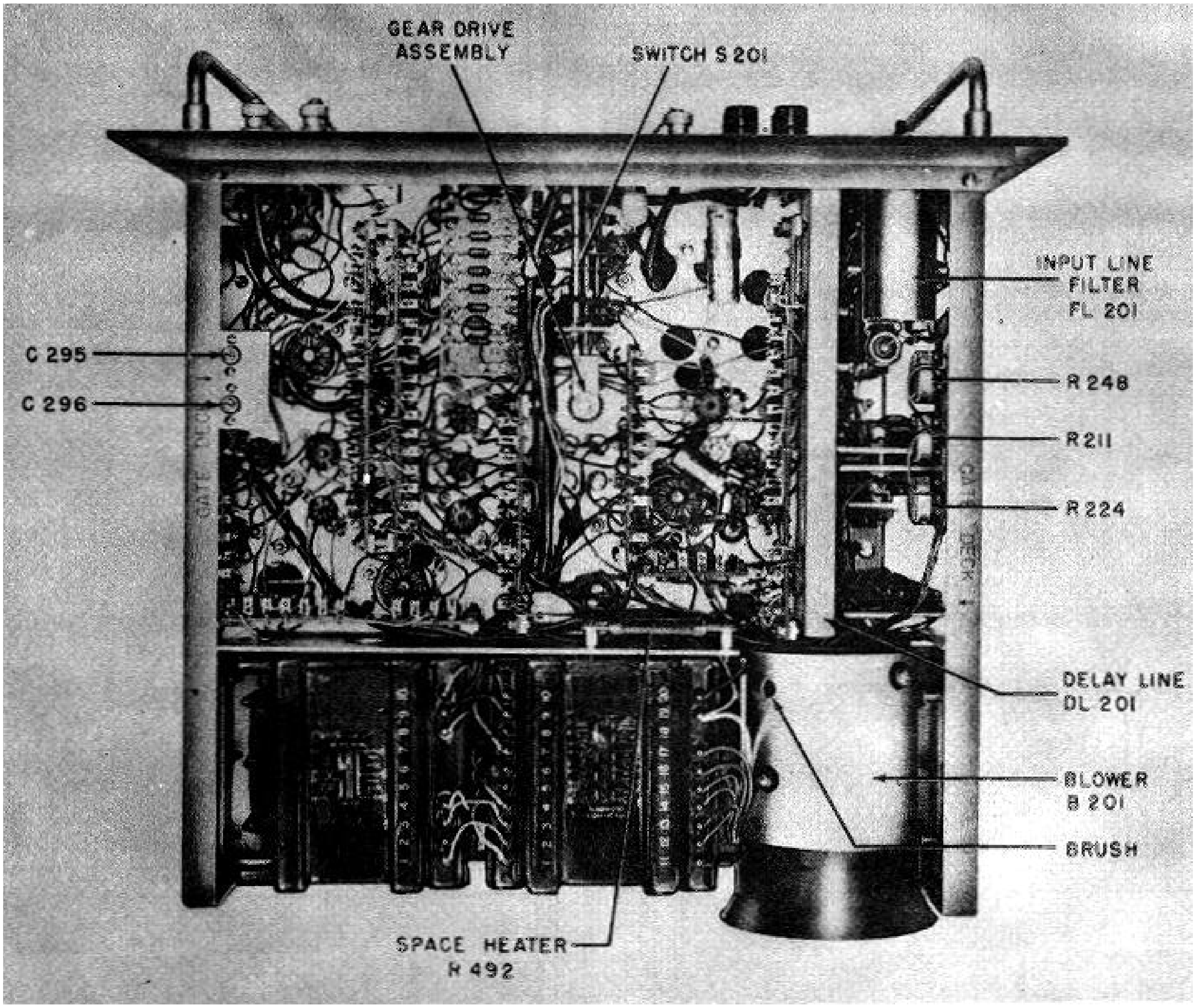


Figure 10-0- Frequency Meter FR-38/U, bottom view

d. Carefully adjust L-213 and L-214 (Figure 10-6) for a maximum indication of the meter or maximum closure of the eye in the range through which the counter counts 002000.00.

e. Remove the loose coupling from the plate lead of V-238 and, using the same single wire, couple STD. FREQ. OUTPUT directly to SIGNAL INPUT. Retain the meter connection to SIGNAL INPUT. The counter should now count 010000.00.

f. Carefully adjust L-215, L-216, L-217 and L-218 (Figure 10-6) for a maximum indication on the meter or maximum closure of the eye in the range through which the counter consistently reads 010000.00.

5-21. ADJUSTING PERIOD SENS. With the power switch off, install either of the plug-in units. Turn the power on and allow the equipment to warm up for five minutes. The adjustment procedure is as follows:

CONTROL SETTINGS

FUNCTION SELECTOR	PERIOD
TIME UNIT	10 MC
DISPLAY TIME	Minimum
100 KC STANDARD	INT

a. Connect a 1 kc input signal of 2 volts rms amplitude to SIGNAL INPUT.

b. If necessary, adjust R-248 PERIOD SENS. (Figure 10-9) until consistent operation of 'he counter is obtained.

c. Now reduce output voltage from audio oscillator in small steps, readjusting R-248 after each step so that consistent operation is obtained.

d. The adjustment should be capable of being continued until output of oscillator is approximately 0.3 volts rms.

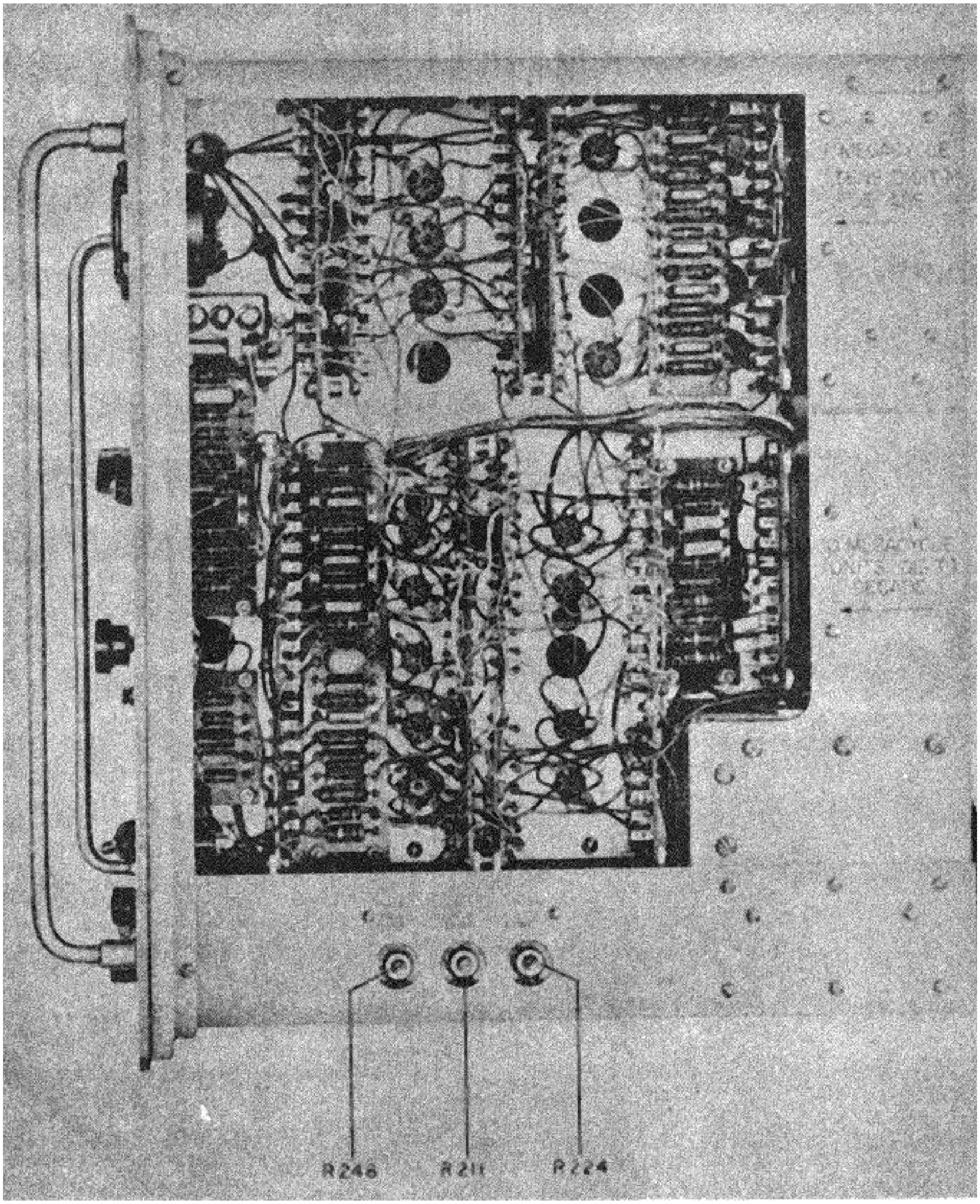


Figure 10-9. Frequency Meter FR-38/U, Right Side View

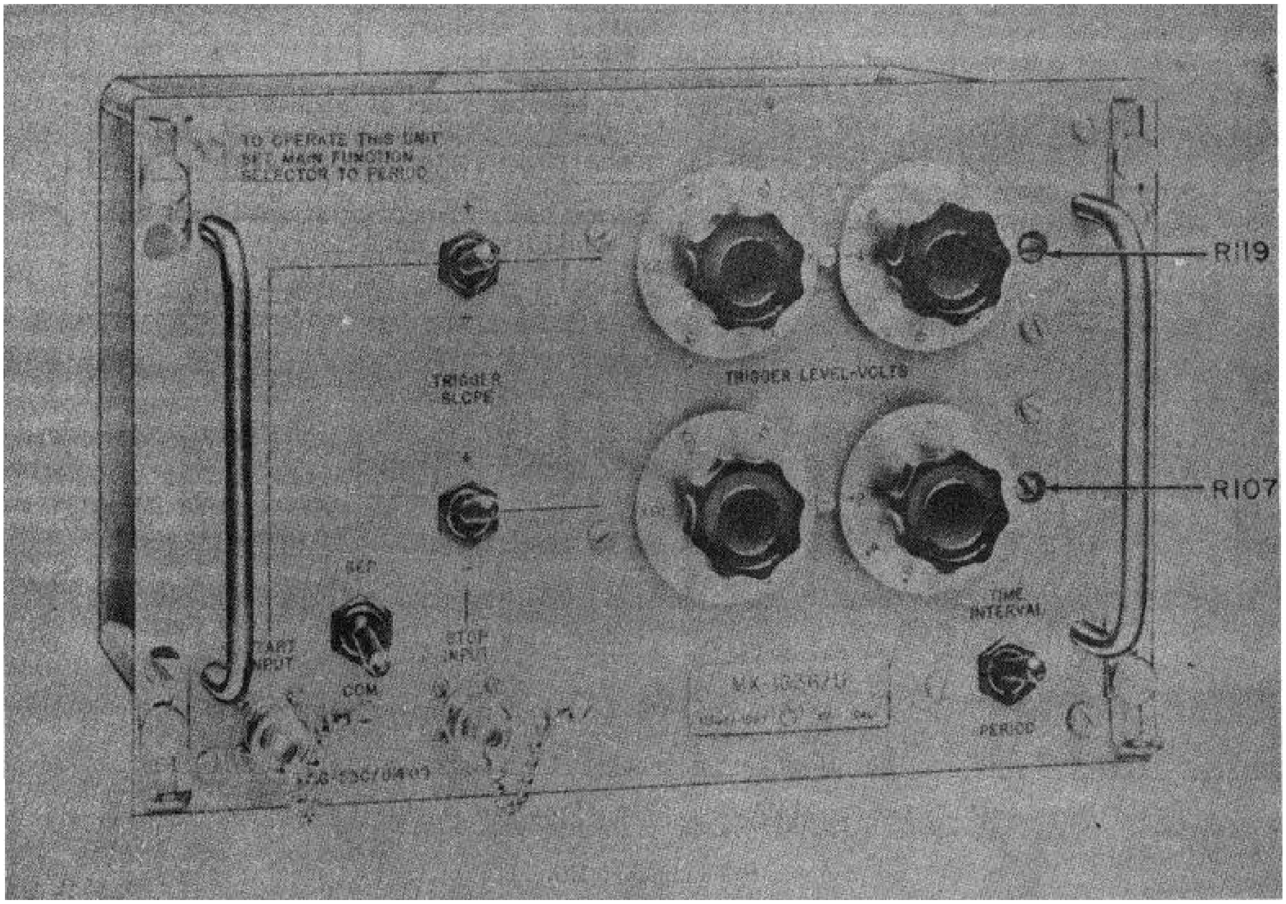


Figure 10-10. Time Interval Unit MX- 1636,,'U, Front View

e. Readjust R-248 after 24 hours of continuous operation.

f. If necessary, reset the high-torque action of the adjustment lock nut.

10-22. ADJUSTING FREQ. SENS. Install one of the plug-in units, making certain that the p6wer is off before the unit is installed. Turn the power on and allow the equipment to warm up for five minutes. Set the controls as listed below and proceed with the following steps:

CONTROL SETTINGS

FUNCTION SELECTOR	MANUAL GATE
TIME UNIT	100 KC
100 KC STANDARD	INT
MANUAL GATE	OPEN

a. Set R-211 (FREQ. SENS., Figure 10-9 to the full clockwise position. If necessary, loosen the shaft lock nut, b. Turn R-211 (FREQ. SENS) slowly counterclockwise while watching the counters. At first, the counters will begin an erratic or slow count equal probably to 50 kc. Slowly continue the counterclockwise adjustment until counters operate at the correct rate (i.e., counter reading increases by 100,000 counts each second).

c. Note the two panel meter readings to see that these readings are stable and do not occasionally "jump". If they are slightly erratic, increase counterclockwise setting of R-211 very slightly.

d. Readjust R-211 after 24 hours of continuous operation.

e. Retighten the lock nut of R-211 if necessary.

10-23-ADJUSTING GATE LENGTH. With the power off, install either of the two panel plug-in units. Turn the power on and allow the equipment to warm up for five minutes. Set the controls as indicated and proceed with the following steps:

CONTROL SETTINGS

FUNCTION SELECTOR	10 MC CHK
FREQUENCY UNIT	1 SEC.
DISPLAY TIME	Minimum ((-cw)
100 KC STANDARD	INT

a. Adjust R-224 (GATE LENGTH, Figure 10-9 until the counter reads 10000.000 ±1.

b. Readjust R-244 as in step "a" after 24 hours of continuous operation.

c. If necessary, reset the high-torque action of the adjustment lock nut.

10-24. ADJUSTING TIME INTERVAL PLUG-IN UNIT. The calibration of the trigger level controls must be set whenever V-601, V-602 or V-603 in either Z-102 or Z-103 is replaced. Adjustment is by means of R-119 and R- 107 (screwdriver operated) which are available at the front panel of the Time Interval Unit. Turn the power off and insert the Time Interval Unit (do not use the special test cables). Turn the power on and allow the equipment to thoroughly warm up.

CONTROL SETTINGS

FUNCTION SELECTOR	PERIOD
TIME UNIT	10 MC
DISPLAY TIME	Minimum (ccw)
TIME INTERVAL-PERIOD	TIME INTERVAL
SEP-COM	COM
TRIGGER SLOPE	Both +
TRIGGER LEVEL	Both 0 x 1

a. Connect a 1 kc sine wave voltage of approximately 1 volt rms amplitude to either START INPUT or STOP INPUT connector.

b. Rotate start channel TRIGGER LEVEL on positive side of zero and note reading of control at which the measurement ceases to recur. Repeat for the negative side of zero.

c. If the two points at which the measurement ceases are not symmetrically located on either side of the zero calibration, adjust R119 (Figure 10-10) at the upper right of the Time Interval Unit panel until this condition is achieved.

d. After the start channel calibration has been adjusted, the procedure can be repeated for the stop channel by adjusting R107 (Figure 10-10) at the right of the panel until the calibration of the stop channel TRIGGER LEVEL control is symmetrical.

10-25. ALIGNING FREQUENCY CONVERTER UNIT. The following paragraphs give the complete procedure (in the recommended order) for aligning the entire Frequency Converter Unit. Although recommended, complete alignment need not be made when replacing any one tube in the unit. The following tabulation states the alignment necessary after replacing a given tube in the converter.

Tube Replaced	Adjustment Required
V1, V2	Adjust balanced mixer drive.
V3, V4	Adjust balanced mixer drive, mixer balance, and Harmonic Generator Output.
V5	Adjust 10 mc Std. Frequency Input.
V6, V7	No adjustment required.
V8	No adjustment required.

CAUTION

Do not move the wires within the converter unit as slight displacement can result in sufficient change of stray capacities to seriously alter circuit balance and adjustment.

10-26. ADJUSTING HARMONIC GENERATOR OUTPUT. With the power switch off, connect the converter to the FR-38,'U, using the two special test cables (CX-2927 USM-26 and CX-2928,'USM-26) provided with the equipment. After connecting, turn the power on and allow the equipment to warm up thoroughly (at least 15 minutes). It is important that the ambient temperature of the instrument be equal to normal room temperature when any of the following alignment is done.

CONTROL SETTINGS

FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.01 SEC.
DISPLAY TIME	Minimum (ccw)
100 KC STANDARD	INT
TUNING RANGE MC.	10-20
MIXING FREQUENCY	TUNE
GAIN	MAX

a. Connect signal generator AN,/USM-44, or equal, to SIGNAL INPUT on the FR-38/U. Adjust signal generator for a cw output frequency of 15 megacycles and an output voltage of 20 millivolts (the input impedance of the FR-38/U at this frequency is approximately 50 ohms).

b. Adjust TUNING dial on converter for maximum deflection of the converter tuning eye.

c. Set MIXING FREQUENCY switch to 10 (megacycle) position.

d. Now adjust C-32 (Figure 10-12)and then C-49 (Figure 10-12)with a low capacity aligning tool for maximum deflection of the tuning eye. If the tuning eye closes completely, reduce the output voltage from the signal generator so that a clear indication is obtained on the eye.

e. Since the settings of C-32 and C-49 are interdependent, the adjusting procedure (step "d") should be repeated several times.

f. Repeat the adjustment procedure (steps "a" through "e"), using the following signal generator frequencies and converter unit control settings.

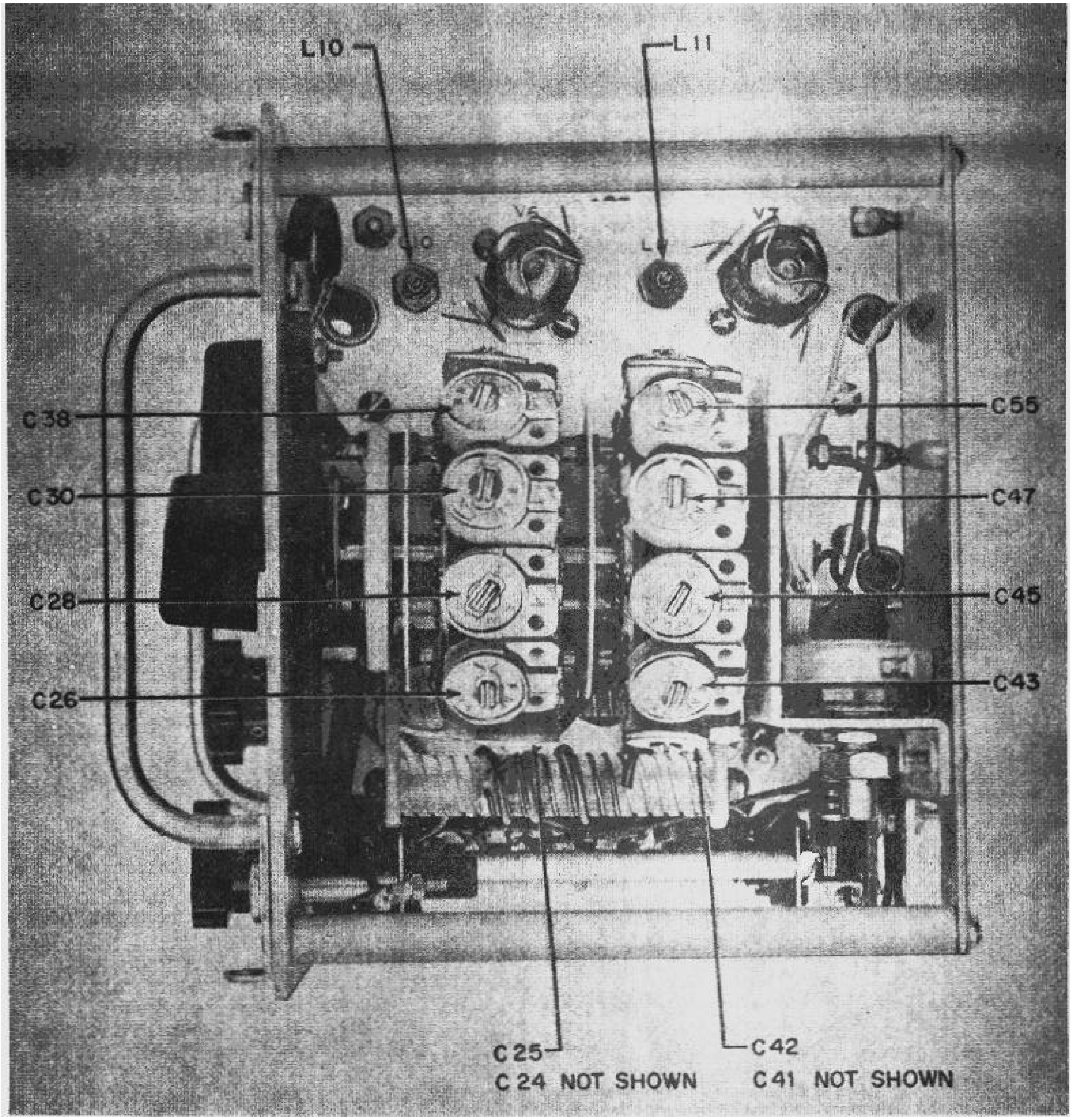


Figure 10-11. Frequency Converter MX-1637 'U, Right Side View

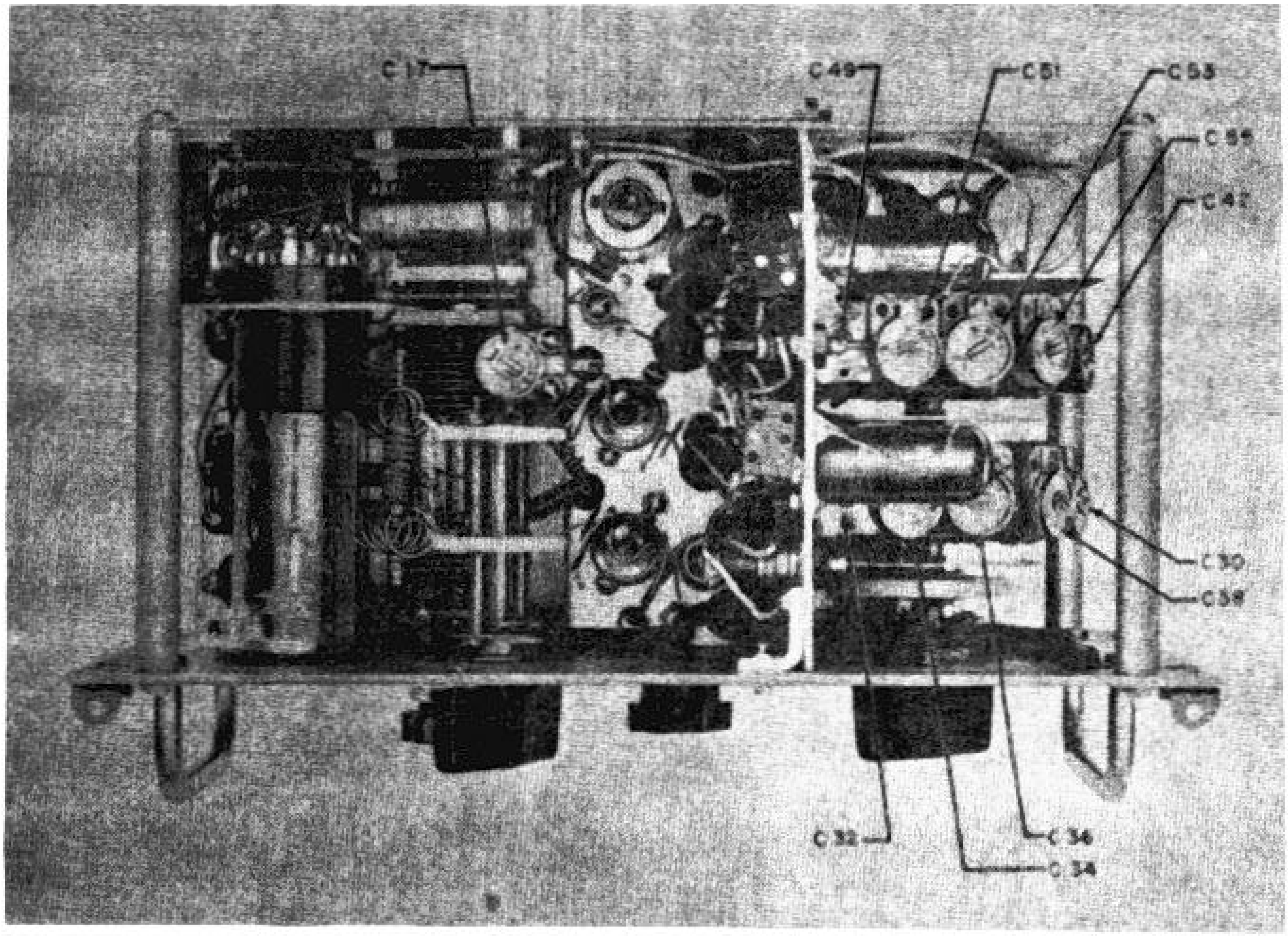


Figure 10-12. Frequency Converter MX-1637/U, Top View

Sig. Gen. Freq. (Mc)	Tuning Range Mc	MIXING FREQUENCY Position	Adjust (See Fig. 5-11 and 5-12)
25	20-40	20	C-34, C-51
35	20-40	30	C-36, C-53
45	40-100	40	C-38, C-55
55	40-100	50	C-30, C-47
65	40-100	60	C-28, C-45
75	40-100	70	C-26, C-43
85	40-100	80	C-25, C-42
95	40-100	90	C-24, C-41

The indicated reading on the counters in each case should be approximately 0005000.0 (depending on the calibration accuracy of the signal generator). If the signal generator frequency is increased slightly, the counter reading should increase accordingly.

10-27. ADJUSTING BALANCED MIXER DRIVE. With the power switch off, connect the converter to the FR-38/U, using the two special test cables (CX-2927/ USM-26 and CX-2928/USM-26) provided with the equipment.. After connecting, turn the power on and allow the equipment to warm up thoroughly (at least 15 minutes).

CONTROL SETTINGS

FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.01 SEC.
DISPLAY TIME	Minimum (ccw)
100 KC STANDARD	EXT (no connection to 100 KC INPUT)
TUNING RANGE MC.	10-20
MIXING FREQUENCY	TUNE

a. Adjust signal generator for an output frequency of 10.1 megacycles and an output voltage of 20 milli volts. Adjust TUNING for maximum deflection of the tuning eye.

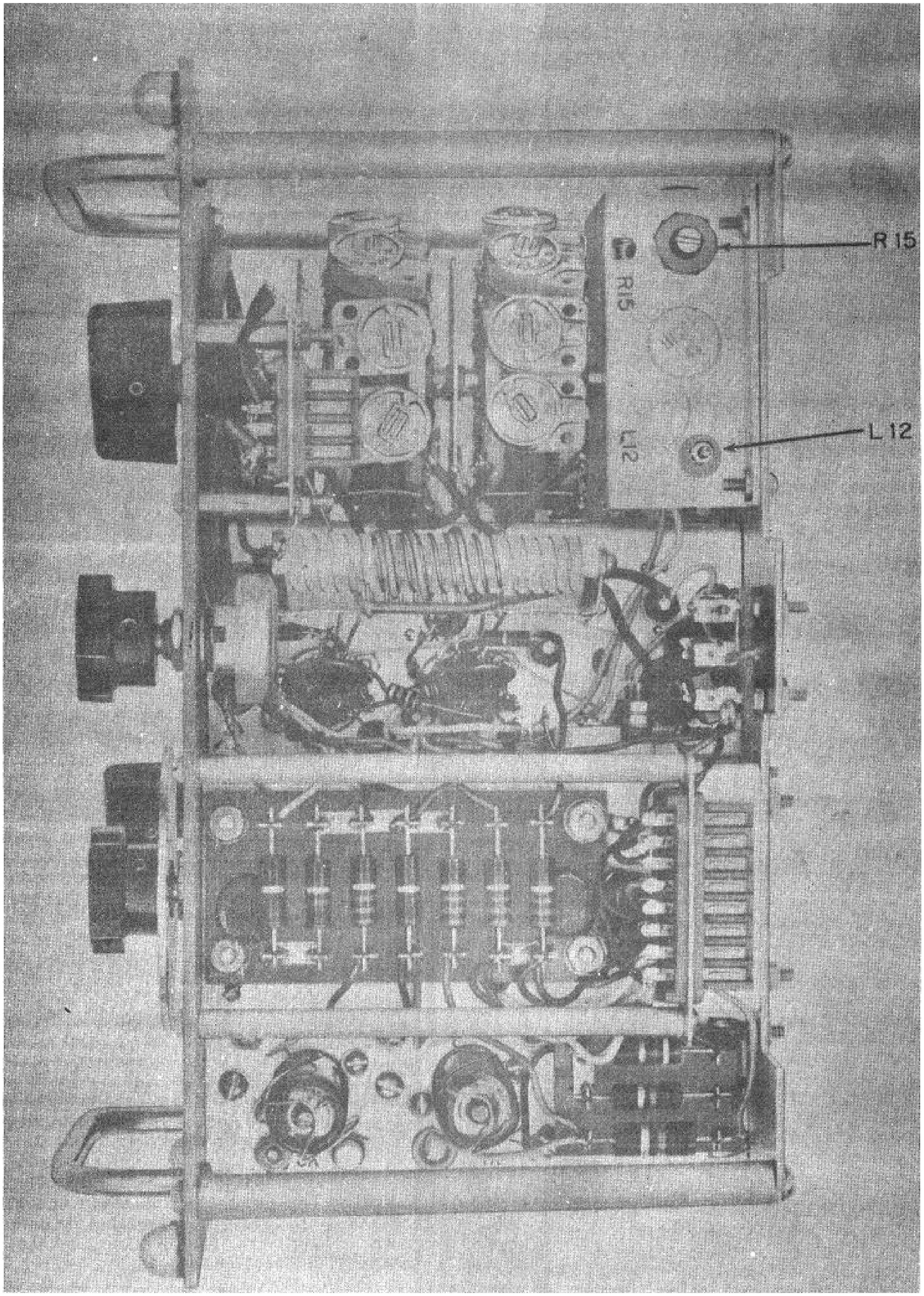


Figure 10-13. Frequency Converter MX- 1637/U, Bottom View

b. Connect the ac probe of a vacuum tube voltmeter (AN/URM-25 or equal) to pin 7 of Z-201.

c. Set MIXING FREQUENCY to 20.

d. Adjust C-17 (Figure 10-12) for minimum voltage. The voltage should be adjusted to be considerably less than 0.1 volt. If this is not possible, check also the balance of the balanced mixer (paragraph 10-28).

10-28. ADJUSTING BALANCE OF BALANCED MIXER. Conditions for adjusting the balance of the mixer are the same as those for adjusting the drive to the mixer (paragraph 10-27) . Whenever the balance is adjusted, the drive must also be adjusted.

CONTROL SETTINGS

FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.01 SEC.
DISPLAY TIME	Minimum (ccw)
100 KC STANDARD	INT
TUNING	90 (megacycles)
MIXING FREQUENCY	10 (megacycles)

a. Disconnect signal generator from SIGNAL INPUT connector.

b. Connect the ac probe of a vacuum tube voltmeter (AN URM-25 or equal) to pin 7 of Z-201 on the FR-38/U.

c. Adjust R-15 (Figure 10-13) for minimum voltage. The voltage should be adjusted to be considerably less than 0.1 volt.

d. Adjustment of the balance and drive to the balanced mixer are interdependent. Therefore, steps "d" of paragraph 10-27 and steps "a", "b", and "c" of paragraph10-28 should be repeated several times.

10-29. ADJUSTING 10 MC. STD. FREQUENCY INPUT. With the power switch off, insert the converter into the FR-38/U in the regular manner (do not use the special test cables). Turn the power on and allow the equipment to warm up thoroughly.

CONTROL SETTINGS

FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.01 SEC.
DISPLAY TIME	Minimum (ccw)
100 KC STANDARD	INT
TUNING RANGE MC	10-20
MIXING FREQUENCY	TUNE
GAIN	MAX

a. Connect Signal Generator (AN /URM-44 or equal), to SIGNAL INPUT on the FR-386/U. Adjust signal generator for a cw output of 15 megacycles and an output voltage of 20 millivolts (the input impedance of the FR-38'/U at this frequency is approximately 50 ohms).

b. Adjust TUNING dial on converter for maximum deflection of the converter tuning eye.

c. Set MIXING FREQUENCY switch to 10 (megacycles) position.

d. Now adjust L-218 (Figure 10-6) FR-38/U Time Base Multiplier Section) for maximum deflection on the tuning eye. If the tuning eye closes completely, reduce the output voltage from the signal generator so that a clear indication is obtained on the eye.

10-30. PERIODIC CHECKS. Because the self-check feature enables the operator to determine that most of the circuits in the equipment are operating satisfactorily, only a few periodic maintenance checks are required. These checks are as follows:

Periodic Check	Recommended Time
Standardize internal 100 kc oscillator.	Weekly
Clean air filter element.	Monthly
Clean plug-in unit connectors.	Monthly
Inspect motor brushes in blower.	Yearly

10-31. Standardizing the internal 100 kc oscillator against an external frequency standard or against Bureau of Standards station WWV at weekly intervals maintains the accuracy of the FR-38 'U within its original specifications. If equipment is not available for standardizing, however, the FR-38/U can still be used, although its accuracy may be reduced at the rate of 2 parts per million per week. The procedure for standardizing is given in paragraph 10-36.

10-32. The air filter element is a renewable type which can be cleaned by washing with a solution of ordinary household detergent and water. After washing the element, it is desirable that it be sprayed with a mist of light machine oil to increase its dirt-holding ability. The element is removed from the inside of the cabinet. Cabinet removal is demonstrated in Figure 10-2.

10-33. The motor in the air blower is a permanent-magnet dc motor. It is expected that the motor brushes will operate satisfactorily for several years of normal operation. However, the brushes should be inspected yearly and replaced if necessary.

10-34. The contacts on the 8- and 16-contact plug-in connectors (P1, P2, J-201, etc.) should be cleaned approximately once a month with a soft, lint-free, dry cloth. If the contacts become dirty, erratic counting may occur when measuring low frequencies of approximately 10 kc and below. This effect is usually first noticeable when using low signal levels of 0.2 volt or so while the frequency converter unit is in place. In persistent cases, the cloth may be dampened with cleaning solvent, taking suitable precautions against possible explosion or fire.

10-35.STABILIZING 100 KC CRYSTAL. After installing the equipment, it usually requires several days of operation for the crystal in the internal frequency standard to reach its specified stability of 2 parts per million per week.

10-36. STANDARDIZING 100 KC CRYSTAL OSCILLATOR. In order to maintain the accuracy of tie FR-38/U, the internal 100 kc crystal-controlled oscillator should be standardized at regular intervals unless an external frequency standard is being used. The long-time drift of the oscillator is within ±2 parts per million per week. If maximum accuracy is to be maintained, therefore, the oscillator should be standardized approximately once a week. Because of the importance of maintaining the accuracy of the oscillator, the adjusting process has been made simple.

10-37. There are several methods for standardizing the oscillator. The first method consists of measuring an accurately-known standard frequency and adjusting the oscillator until the FR-38/U reads correctly. Another method uses a communication type radio receiver to beat a harmonic of 100 kc internal standard with National Bureau of Standards station WWV. A third method uses the eye of the frequency converter to zero-beat the internal 10 mc standard frequency with an external 10 mc standard frequency.

CAUTION

The first and third methods of standardizing the oscillator are only satisfactory as long as the external standard frequency used is known to be more accurate than the FR-38/U. The FR-38/U is a very accurate instrument, and one of the common causes of inoperation occurs from attempting to standardize it against less accurate equipment. Since the FR-38/U is generally more accurate than any frequency standard available at most installations, the second method will usually have to be used.

10-38. **METHOD 1**. The first of the several possible methods for standardizing the internal oscillator is to apply to the FR-38/U for counting an external standard frequency of high accuracy. The internal oscillator can then be adjusted until the reading obtained on the counter is accurate. The external standard frequency to be used will usually be available only from an external frequency standard and should have the following characteristics:

a. It should be not less than 1 megacycle nor more than 10 megacycles. A frequency of 10 megacycles is ideal for standardizing.

b. It should be accurate within approximately 8 to 10 parts in 107. However, if the FR-38/U has not been standardized for an extended interval, such as three months, a standard frequency of less precision may be useful.

c. It must have an amplitude of at least 0.2 volt rms when applied to the SIGNAL INPUT terminal of the FR-38/U. At this connector, the input impedance is 1 megohm shunted by approximately 40 mmf. This assumes that the Frequency Converter is in place.

d. It must have a signal/noise ratio of at least 40 db.

10-39. PROCEDURE FOR STANDARDIZING USING METHOD I.

a. The FR-38/U must be thoroughly heated. If it is being standardized for the first time, it should be allowed to operate continuously (POWER switch in standby or down position) for at least several days before the standardization can be considered complete.

b. Install the Frequency Converter plug-in unit. Turn off power switch before moving or installing.

c. Self-check the instrument as described in paragraph 2-20. If the self-check does not show the equipment to be operating properly, the trouble must be repaired before proceeding.

d. Apply the standard frequency to the SIGNAL INPUT terminal of the FR-38/U.

e. Set FUNCTION SELECTOR switch to FREQUENCY.

f. If a 10-megacycle standardizing frequency is being used, set FREQUENCY UNIT switch for a I-second gate time. If a 1-megacycle standardizing frequency is being used, set FREQUENCY UNIT switch for a 10second gate time.

g. Set DISPLAY TIME control fully counterclockwise.

h. Using a screwdriver, turn ADJ control at lower left of front panel until counter reading is accurate, paying particular attention to the accuracy of the two meter readings. The ADJ control is provided with a 5/16-inch lock nut. However, this nut has been set at the factory so that it acts as a high-torque device and does not lock firmly. If the setting of the nut has been subsequently tightened, it must be loosened before making the adjustment.

i. The ADJ control should be adjusted so that the reading on the counters is 1000.0000 if a 1-megacycle, or 10000.000 if a 10-megacycle standardizing frequency is being used. If other than these values are being used, the control should be adjusted until the counter reading accurately displays the frequency used.

j. If a 10-megacycle frequency is being used, the above procedure requires that the adjustment be made using a 1-second gate. After the adjustment has been made, the FUNCTION SELECTOR can be set for a 10second gate and the reading on the counters noted. The reading should be within ±10 of l0000.0000(displayed as 00000.000 on the 8-place counter). Ordinarily, the reading will be within ±1 part of 10000.0000.

10-40. METHOD II. The second method for standardizing the internal oscillator is to zero-beat the oscillator against Bureau of Standards station WWV, using a communications receiver to detect the beat. The internally-generated 100 kc frequency is available at the STD. FREQ. OUTPUT connector on the front panel and has sufficient harmonic content so that a beat can be obtained at least as high as the 10-megacycle transmission from WWV. It should be noted that although WWV is rated as accurate within 2 parts in 108 doppler effects in the transmission reduce this accuracy. As a result, the received frequency is usually accurate within a few parts in 108, although on occasion it may be worse.

10-41. PROCEDURE FOR STANDARDIZING USING METHOD II.

a. Follow steps "a" through "c" from paragraph 10-39.

b. Set TIME UNIT switch to 100 kc.

c. Set 100 KC STANDARD switch to INT position.

d. Couple the 100 kc signal from the STD. FREQ. OUTPUT connector to the antenna of a communications receiver. This coupling should be loose and can ordinarily be made by running a single wire from STD. FREQ. OUTPUT near the antenna lead-in. If additional coupling is required, the wire can be wrapped a few times loosely around the lead-in.

e. Adjust the receiver so that the beat can be heard.

f. Turn ADJ control at lower left of front panel with screwdriver until zero-beat is obtained. See note in paragraph 10-39h, regarding lock nut on ADJ control.

10-42. METHOD III. The quickest method for standardizing the internal oscillator is to zero-beat the internal 10-megacycle standard frequency against an external 10-megacycle signal, using the "eye" of the frequency converter to detect the beat. The external 10-megacycle signal to be used should have the following characteristics:

a. It should be accurate within approximately 8 to 10 parts in 107.

b. It must have an amplitude of at least 0.2 volt rms when applied to the SIGNAL INPUT terminal of the FP-38/U. At this connector, the input impedance is 1 megohm shunted by approximately 40 mmf

c. It must have a signal noise,: ratio of at least 40 db).

10-43. PROCEDURE FOR STANDARDIZING USING METHOD III.

a. Follow steps "a" through "d" from paragraph 10-39.

b. Set MIXING FREQUENCY to TUNE and adjust TUNING for maximum deflection of indicator eye.

c. Set MIXING FREQUENCY to 10 me position.

d. Adjust ADN until a stationary pattern on the indicator eye of the frequency converter indicates zero-beat.

e. Set MIXING FREQUENCY to 20 mc position.

f. Continue adjusting ADJ as described in step "d" above.

10-44. ORGANIZATIONAL MAINTENANCE OF AN/USA-5.

10-45. GENERAL. Refer to the caution notice at the front I of this section. The paragraphs which follow describe tests necessary to determine whether circuits in Frequency Converter CV-394/USA-5 (the operating portion of the AN/USA-5) meet minimum standards of performance. Causes of probable malfunctions or failures are also given. The maintenance discussion is restricted to those malfunctions which can be corrected by circuit adjustment and tube or semiconductor diode replacement. Of the test equipment listed in Section VII the two volt meters and the AN USM-44 Signal Generator are required for testing of the CV-394/USA-5.

10-46. MINIMUM PERFORMANCE STANDARDS AND TROUBLE SHOOTING. Table 10-12 is a combined minimum performance standards test and troubleshooting chart. A step-by-step procedure is given, with the correct indication listed and with possible causes of improper indications or malfunctions shown in a separate column, with reference to the text paragraph that describes the remedy. If the correct indication, as listed in Table 10-12, is produced for each step of the check, Frequency Converter CV-394, USA-5 is operating in accordance with its minimum performance standards. To use Table 10-12 as a trouble shooting chart, either refer to the step which seems to cover the abnormal operation which was observed, or follow through the procedure systematically, step-by-step, until the trouble is located.

10-47. TUBE REPLACEMENT. Except for tube V1201, any tube in the CV-394f USA-5 may be replaced with a tube having standard characteristics for that military tube type. Tube V1201 is critical, and replacement of this tube requires careful selection. A replacement for this tube must be tentatively installed and then tested for proper output of harmonic frequencies within all bands, following the procedure given in paragraph 10-49. Several tubes may have to be tested before a satisfactory one is found. Whenever a tube is replaced, refer to Table 10-13 to determine which circuit adjustments, if any, are required.

10-48. REMOVAL OF TUBES. To remove any of the tubes, the CV-394/USA-5 must be removed from its mounting within the FR-38/U. Tubes V1201 through V1205 are mounted on a shelf at the bottom of the chassis(Figure 10-14) and removal of these tubes is standard, The electron ray tuning eye tube V1206 is accessible from the top of the unit (Figure 10-16). To remove tube V126, proceed as follows:

a. Loosen the screw which attaches the tube clamp to its standoff mounting.

b. Release the tube clamp.

c. Carefully rotate the tube and socket toward the outside of the chassis, leading with the socket end. The front (eye) end of the tube will remain snugly against the front panel bezel grommet until the socket end of the tube is rotated clear of the rear of the chassis, at which time the tube and socket can be moved far enough away from the front panel that the tube will clear the bezel.

d. Disconnect the old tube from the socket and install the new tube in its place.

Table 10-12. Step-by-Step Analysis of Frequency Converter CV-394/USA-5

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step 1a Plug the CV-394/USA-5 into position in FR-38/U.	-----	-----
Step 1b Connect power to FR-38/U and turn its Power switch ON.	Tuning eye (tube V1206) in CV-3941USA-5 should glow.	If the tuning eye does not glow, replace it with a tube known to be good (paragraph 10-47),If the replacement tube glows, the old tube was defective. If the replacement tube does not glow, check for the following: A. Trouble in tuning eye circuit - see paragraph 11-194. B. FR-38/U power supply defective - check for trouble in FR-38/U, as directed in previous paragraphs. C. Short in power supply input circuit through P1201 - check for short in FR-38,/U and in CV-394,,'USA-5.
Step 2a Turn CV-394/USA-5 Function switch to the MIXER position.	Random counting indications should appear on digital display indicators of FR-38/U. (If this correct indication is observed, skip to Step 3.)	If there is no indication on the counter, localize the trouble by turning the Function switch to DIRECT and connecting 10-mc signal from the AN/USM-44 Signal Generator to the INPUT connector of the CV-394/USA-5, and by observing the FR-38/U. If there is still no indication on the FR-38/U, the trouble is in the FR-38/U and should be localized as directed in preceding paragraphs; then resume this test procedure starting with step 3. If there is a proper indication of 10 mc on the FR-38/U, the trouble is in the CV-394/USA-5 and should be localized as described in step 2b.
Step 2b Proceed as follows: Use test cables (fig. 7-1) to connect between P1201 and P1202 and their respective mating receptacles in the chassis of the FR-38/,U, to permit remote operation of the CV-394/USA-5 for access to test points within the chassis. Connect the CV-394/USA-5 to the test cables, apply power to the FR-38/U, and set the Function switch at MIXER. Connect a 10-mc test signal from the AN/USM-44 to the INPUT jack of the CV-394, USA-5. Adjust the test signal to a level of about 40 millivolts. Connect a high-impedance voltmeter (ME-25A/U) across R1221, with the ground lead to test point 00 and the probe to test point NN. (See Figures 10-14, 10-18, and 12-54 for location of test points.)	VTVM should indicate a signal level of one volt, indicating that the mixer-video amplifier section is functioning properly. or	If VTVM does indicate one volt but tuning eye still does not glow, check the circuit of V1206, as directed in paragraph 11-154. If VTVM does not indicate one volt, check for trouble in the mixer- video amplifier section the harmonic generator - harmonic ampli - fier section. Proceed as follows: A. Check tubes V1203, V1204, and V1205 paragraph 10-47) and replace any that are defective. B. Check d-c voltages at test points Fl, F2, F3, F4, F5, and F6, with ground lead to test point B, using voltmeter ME-25A/U. The voltages measured should be within ±5%o of the following values: F1 + 110V F3 + 140V F4 + 1.7V F5 + 1.8V F6 + 1.6V

Table 10-12. Step-by-Step Analysis of Frequency Converter CV-394/USA-5 (Contd.)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
		If the voltages measured are incorrect and no tubes are defective, check circuit components in the mixer-video amplifier circuits, as directed in Section XI, and replace and that are defective. C. Measure the voltage level of the rectified 10-mc signal at the grid of tube V1201, test point PP. Using the voltmeter ME-25A/U, connecting the ground lead to test point OO or other suitable ground, and the probe to test point BB. If the voltmeter indicates -65V dc ±10%, check tubes V1201 and V1202 and replace if defective (paragraph 10-47). If tube replacement does not solve the difficulty, check circuit components in the harmonic generator and harmonic amplifier circuits as directed in Section VII. If the voltmeter does not indicate -65V dc ±10%, perform the 10-mc self-check on the FR-38/U to determine whether there is a fault in that unit. If the FR-38/U is operating properly, try replacing V1201. If the trouble remains, check circuit components in the harmonic generator circuit as directed in Section VII.
Step 3 Retain the test connections used in step 2b. Adjust the AN/USM-44 to provide a 120-mc test signal. Turn CV-394/USA-5 Function switch to WAVEMETER position. Turn the 100 KC STANDARD switch on the FR-38/U to EXT. Attempt to tune the AN/USA-5 wavemeter to the same frequency by adjusting the WAVE-	Tuning eye should give sharp indication when WAVEMETER dial is set at 120. graph 11-198.	If tuning eye glows but does not give a sharp indication, check tube V1206 and replace if defective. Check diodes CR1201 and CR1202 and replace if defective. If the trouble remains, check circuit components in the tuning eye circuit as directed in Section VII. If tuning eye gives a sharp indication at the wrong frequency, and the AN/USM-44 is known to be properly calibrated, check the calibration of the WAVEMETER dial as directed in para-
Step 4a Retain the test connections used in step-3. Leave the AN/USM-44 set to provide a 120-mc test signal. Turn the AN/USA-5 Function switch to the MIXER position and leave the MIXING FREQUENCY MC switch in the 120 position. See that the 100 KC STANDARD switch on the FR-38/U is in the INT. position, and that the STD. GATE TIME-SEC. switch is in the 10 position.	The indication on the FR-38/U should be 0000.0000 ±1 count ± the accuracy of the signal generator.	If the indication has greater error, check the alignment and adjustment of the CV-394/USA-5 as directed in paragraph 10-50.

Table 10-12. Step-by-Step Analysis of Frequency Converter CV-394/USA-5 (Contd.)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step 4b After making a measurement with the MIXING FREQUENCY MC switch in the 120 position, repeat the measurement with that switch in the 110 and 130 position.	The indication should be 0000.0000 ±101 counts ± the accuracy of the signal generator.	If the indication has greater error, check the alignment and adjustment of the CV-394/USA-5 as directed in paragraph 10-50.
Step 5 Perform a test similar to that of step 4, measuring arty test signal frequency within the range of the CV-394/USA-5, using the next lower frequency setting of the MIXING FREQUENCY MC switch. Example: with 205-mc input signal, use 200 setting on the MIXING FREQUENCY MC switch.	In each case, with the STD. GATE TIME-SEC. switch in the 10 position, the count indication on the FR-38/U should be within 0.0002% of the correct difference frequency ±1 count ± the accuracy of the signal generator.	If the indication has greater error, check the alignment and adjustment of the CV-394/USA-5 as directed in paragraph 10-50.

Table 10-13. Table of Adjustments to be Made When Replacing Tubes in Frequency

CIRCUIT REFERENCE AND TUBE TYPE	TUBE USE	NECESSARY ADJUSTMENTS
V1201: 6AH6	Harmonic Generator	Adjust capacitors in section A of switch S1201 (paragraph 10-51).
V1202: 5654	Harmonic Amplifier	Adjust capacitors in sections A and B of S1201 (paragraph 10-51).
V1203: 5725	Mixer	Adjust capacitors in section C of S1201 (paragraph 10- 51).
V1204: 6AH6	First Stage Video Amplifier	No adjustment required.
V1205: 6AH6	Second Stage Video Amplifier	No adjustment required.
V1206: 6E5	Tuning Eye	Calibrate tuning eye (paragraph 10-53).

NOTE: Adjustment of capacitors in sections A, B, and C of S1201 is interdependent, as stated in paragraph 10-51. When replacing V1203, the adjustment procedure for each set of three capacitors should start with the capacitor in section C. Then the corresponding capacitor in sections A and B can be adjusted slightly to improve the- over-all alignment. When replacing V1201 or V1202, start the adjustment procedure with the capacitor in section A as directed in paragraph 5-51.

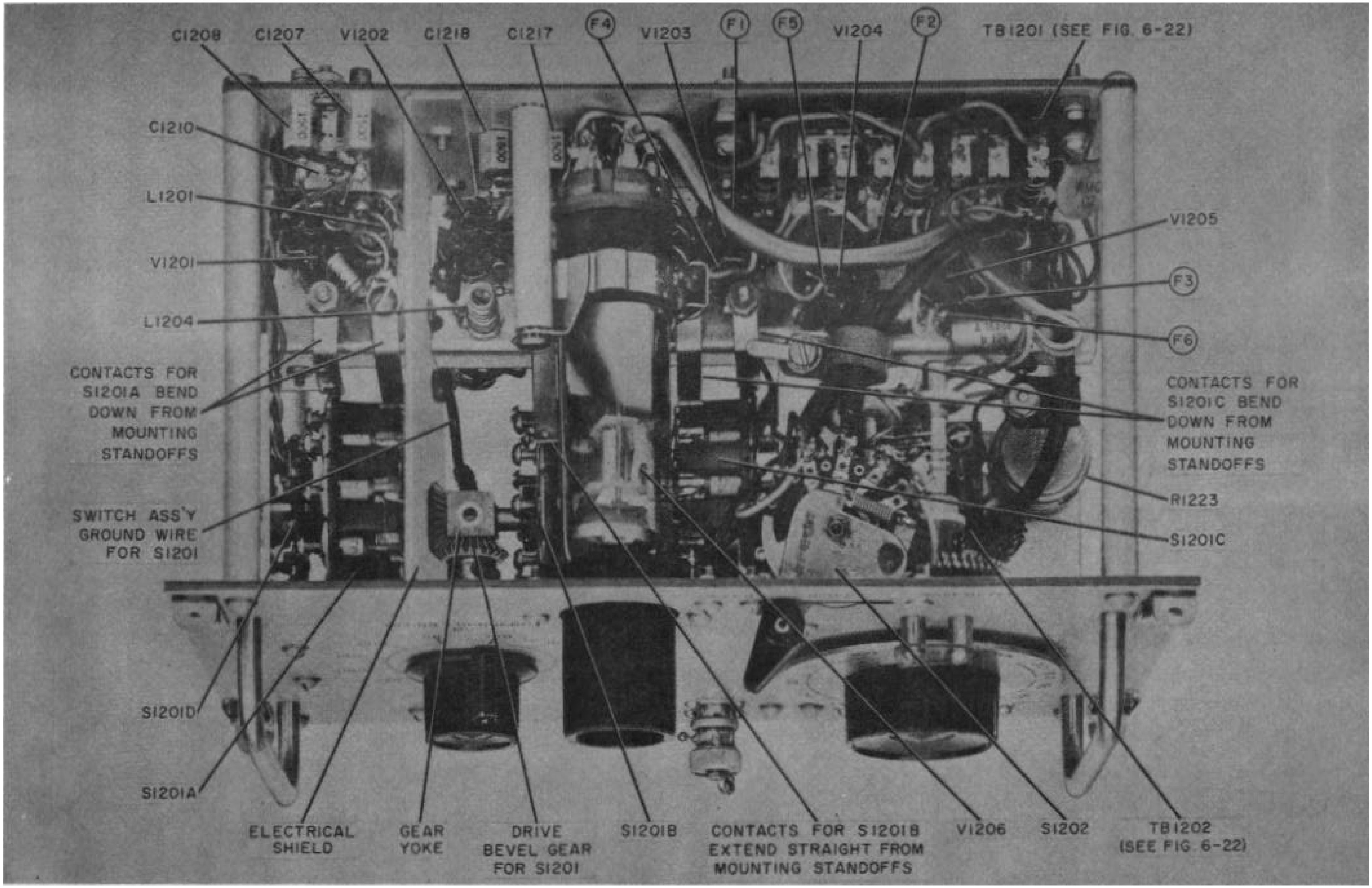


Figure 10-14. Frequency Converter CV-394/USA-5, Top View

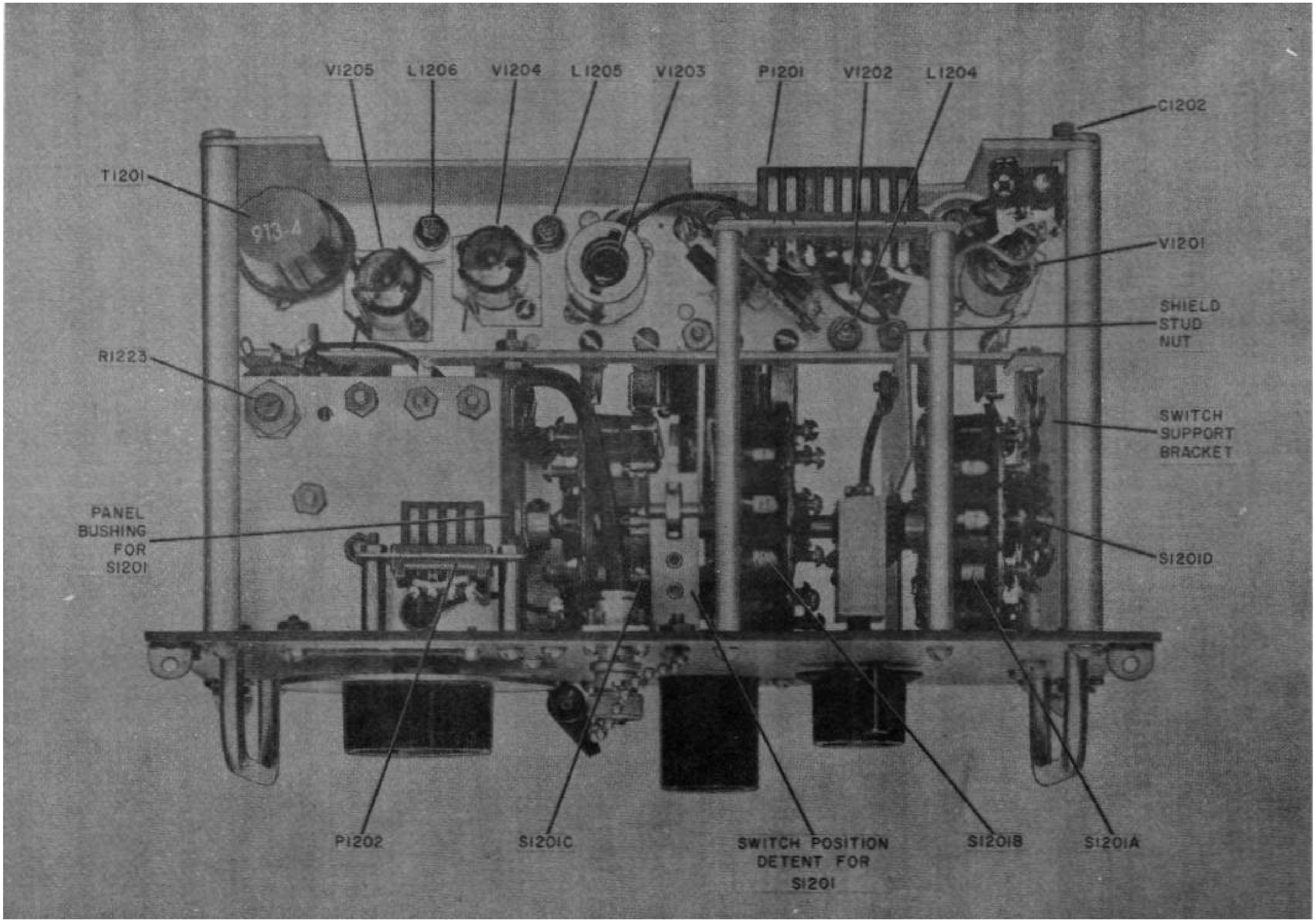


Figure 10-15. Frequency Converter CV-394/USA-5, Bottom View

e. Replace the tube in position by performing steps a through c in reverse, placing the eye end of the tube through the clamp and resting it in the bezel grommet while the socket end is moved into position against the rear of the chassis.

10-49. REPLACEMENT OF HARMONIC GENERATOR TUBE V1201. If this tube becomes defective, the replacement tube must be selected with care to ensure that the full range of harmonics will be generated. In general, if the replacement tube is found to generate the mid-band frequencies (140 to 170 megacycles) in a satisfactory manner, the tube will usually have satisfactory generating characteristics over the entire band. Therefore, a tube being considered as a replacement should be tested first at 140, 150, 160, and 170 megacycles, using the same test procedure given in paragraph 10-51 for harmonic generator adjustment. If the prospective replacement tube generates the mid-band frequencies properly, it should then be tested over the entire frequency range, using the same test procedure. It may be necessary to test a number of 6AH6 tubes before a replacement is found which has the harmonic-generating properties necessary for performing the function of V1201.

10-50. ALIGNMENT OF FREQUENCY CONVERTER CV-394/'USA-5. The following paragraphs give the complete procedure for aligning the CV-394/USA-5. When complete alignment is performed, it should be done in the order of the following paragraphs. Complete alignment should be performed annually and at other times when several tubes are replaced. When a single tube is replaced, it is necessary only to perform the adjustments called for in Table 10-13.

10-51. ADJUSTMENT OF HARMONIC GENERATOR AND HARMONIC AMPLIFIER. Proceed as follows:

a. With the Power switch of the FR-38/U turned off, remove the CV-394/USA-5 from the FR-38/U and set the CV-394/USA-5 on the bench in front of the FR-38/U. Use test cables CX-2927/USM-26 and CX-2928/USM-26 as shown in figure 1-1 and 2-1 to connect the two connectors at the back of the CV-394/USA-5 to the mating connectors in the FR-38/U to permit remote operation.

b. Turn the FR-38/U Power switch to ON and allow the equipment to warm up thoroughly (at least 15 minutes). During the adjustment procedure, it is desirable to have the ambient temperature be the normal room temperature in which the equipment operates.

c. Set the controls on the two equipments as follows:

FR-38/U CONTROLS	SETTING
FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	01 STD. GATE TIME-SEC.
100 KC STANDARD	INT.
DISPLAY TIME	Completely counter-clockwise

CV-394/USA-5 CONTROLS	SETTING
MIXING FREQUENCY MC	100
Function switch	MIXER

d. At the INPUT connector of the CV-394/USA-5, connect a signal generator capable of generating frequencies in the 100-megacycle to 220-megacycle range, such as the AN/USM-44. Adjust the signal generator for a CW output of 105 megacycles and an output voltage of approximately 500 millivolts.

e. With a low-capacity aligning tool, adjust C1264 on sections A, B, and C of S1201 for a maximum closing of the tuning eye. If the tuning eye closes completely, reduce the output voltage of the signal generator so that less than total deflection occurs, enabling a clear indication to be obtained on the eye. Disregard any erratic indications on the FR-38/U, as these may be due to the attenuation introduced by the test cables. Capacitor C1264 in each section is the one capacitor which has the adjusting screw exposed through the adjusting access hole for that section when the MIXING FREQUENCY MC switch is in the 100 position. The adjusting access holes are shown in Figures 10-16 and 10-17.

NOTE

For each position of the MIXING FREQUENCY MC switch, the capacitor in each section which can be adjusted to calibrate that position is exposed at the adjusting access hole for that section. These same capacitors are, when in that position, connected into their respective circuits by the contacts mounted to the chassis on standoffs. The proper adjusting access hole for each section is evident from Figures 10-16 and 10-17 but any question as to the correct capacitor for each position of the MIXING FREQUENCY MC switch can be clarified by observing which capacitor is contacted by the standoff-mounted switch contacts when the switch is in the position being considered.

f. Since the settings of C1264 in sections A, B, and C of S1201 are interdependent, the adjusting procedure should be repeated several times to obtain the best overall adjustment.

g. The indicated reading on the FR-38/U should be approximately 5000 kc (depending on the calibration accuracy of the signal generator). If the signal generator frequency is increased slightly, the FR-38l/U indication should increase accordingly . If the indication on the FR-38/U is erratic, this condition may be caused by the test cables being used for remote operation, in which case it is necessary to disconnect the test cables and plug the CV-394/USA-5 into the FR-38/U for a check of frequency indication.

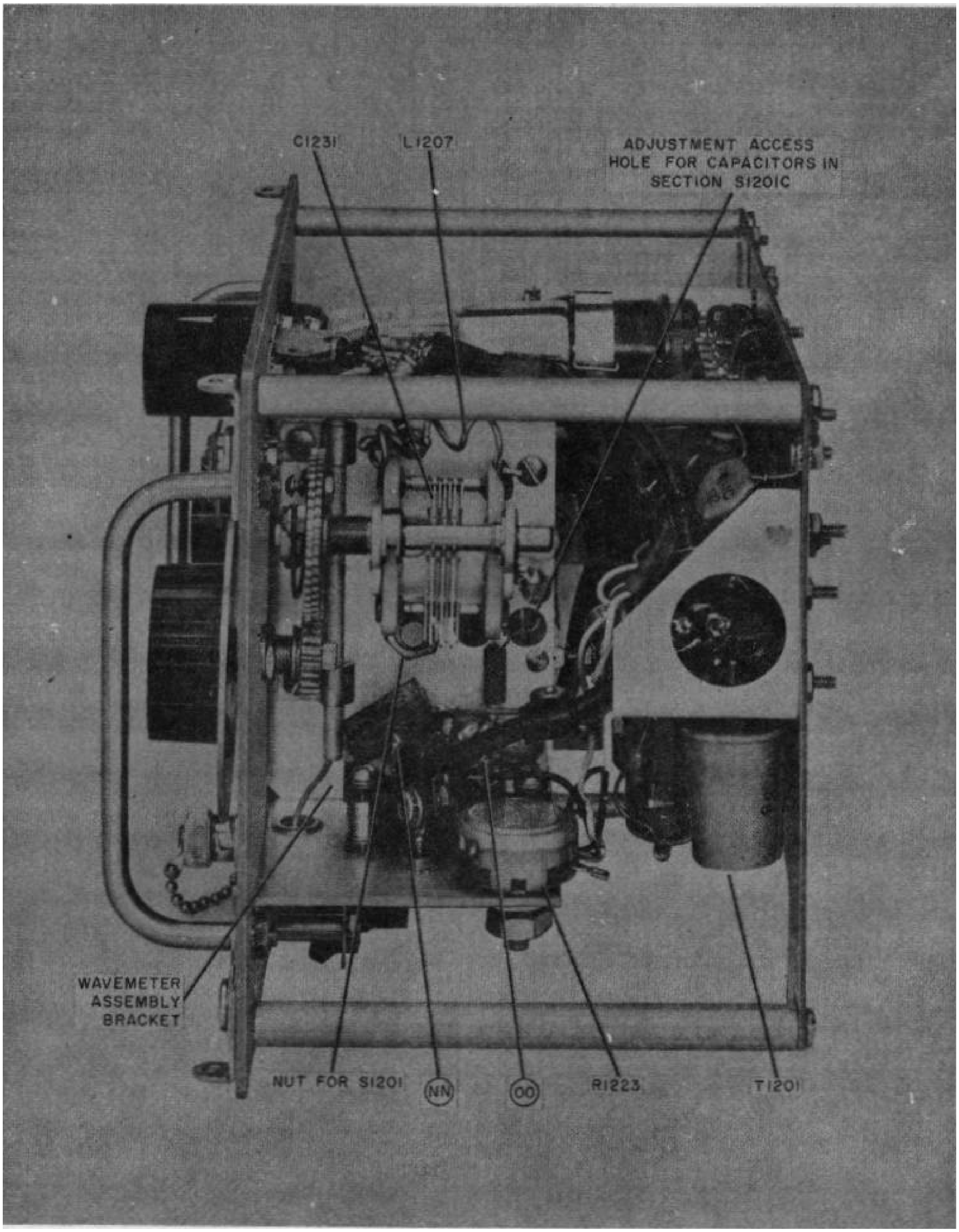


Figure 10-16. Frequency Converter CV-394/USA-5, Right Side View

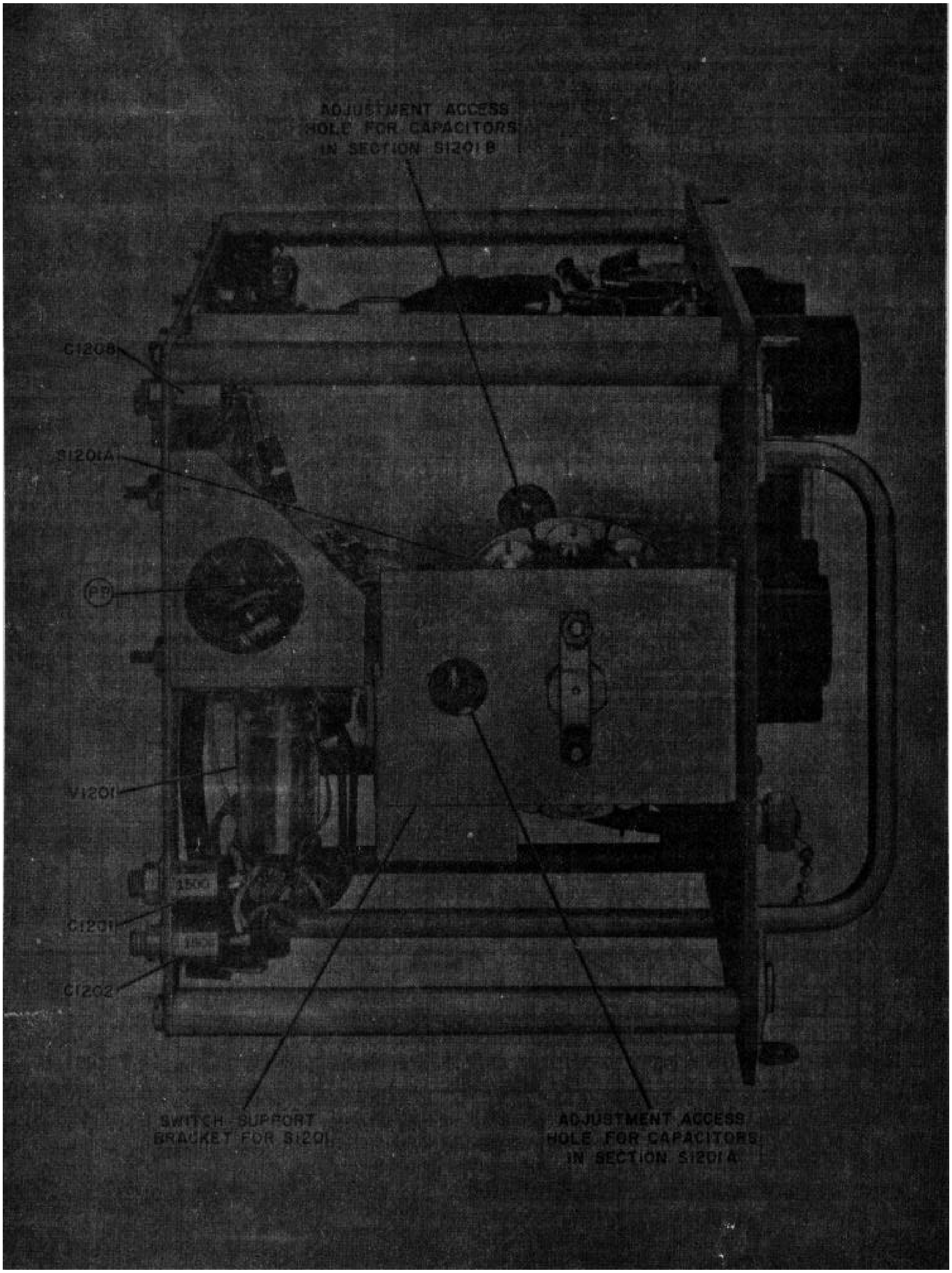


Figure 10-17. Frequency Converter CV-394/USA-5, Left Side View

CAUTION

Always turn the FR-38/U Power switch off before connecting or disconnecting the CV-394/USA-5, either through the remote cables o01 by direct plug-in. This is necessary because arcing may occur, damaging the connectors. Return the Power switch to the ON position after connections are firmly made.

NOTE

Because the CV-394/USA-5 harmonic generator derives its mixing frequencies from the master oscillator signal in the FR-38/U, and because these harmonics can be only whole-digit multiples of the 10-megacycle master oscillator signal, there is only one harmonic frequency produced at each setting if the MIXING FREQUENCY MC switch which will produce a mixed output signal within the range of the FR-38/U. Hence, the procedure described in this paragraph, which adjusts the tuned circuits in the harmonic generator and mixer so that the mixing frequency applied to the mixer is of maximum amplitude, is the only alignment necessary. The nonambiguity of each harmonic frequency guarantees that the frequency adjusted for maximum amplitude at each switch setting is the right frequency. For this reason, the actual indication of the FR-38/U after the capacitor adjustment of each section is not crucial. It should be approximately 5000 kc to indicate that the expected harmonic is being used; if a considerably different frequency is produced, check for component failure as directed in Section XI.

h. Repeat the adjustment procedure of steps a through g for the other capacitors of all three sections, using the following signal generator frequencies and MIXING FREQUENCY MC switch settings.

Signal Generator Input Frequency (MC)	MIXING FREQUENCY MC Switch Position	Capacitor To Be Adjusted
115	110	C1262
125	120	C1259
135	130	C1257
145	140	C1254
155	150	C1252
165	160	C1249
175	170	C1247
185	180	C1245
195	190	C1243
205	200	C1241
215	210	C1240

10-52. ADJUSTMENT OF VIDEO AMPLIFIER RESPONSE. This portion of the alignment of the CV-394/USA-5 serves to maximize the high-frequency response of the video amplifier. Use the same equipment, setup, and switch settings as specified in steps a through c of paragraph 10-51 above. Then proceed as follows:

a. With the CV-394/USA-5 Function switch set at MIXER and the MIXING FREQUENCY MC switch set at 100, adjust the signal generator to provide a test signal of 110.1 megacycles and adjust the signal generator output voltage to produce approximately half deflection on the tuning eye.

b. Adjust L5 and L6 (shown in Figure 10-15) with an insulated tuning tool to secure maximum narrowing of the tuning eye pattern.

10-53. CALIBRATION OF TUNING EYE TUBE CIRCUIT. Proceed as follows:

a. Adjust the controls of the CV-394/USA-5 and of the FR-38/U as directed in step c of paragraph 10-51.

b. At the INPUT connector of the CV-394/USA-5, connect a signal generator capable of generating frequencies in the 100-mc to 220-mc range, such as the AN/USM-44. Adjust the signal generator for a CW output of 102 megacycles.

c. Measure the output level of the resultant 2-mc output signal of the AN/USM-44, across resistor R1221, between test points NN and OO (Figure 10-16). Make the measurement with a high impedance vacuum tube voltmeter, such as the ME-25A/U.

d. Adjust the output of the AN USM-44 signal generator until a one-volt reading is obtained on the ME-25A/U connected across R1221.

e. Adjust resistor R23 (Figure 10-15) so that the tuning eye just barely closes.

10-54. ADJUSTMENT OF 10 MC VOLTAGE INPUT TO HARMONIC GENERATOR. To adjust the level of the 10-megacycle input signal from the master oscillator of the FR-38 U to the harmonic generator circuit of the AN USA-5, proceed as follows:

a. Turn the Power switch of the FR-38/U to the off position.

b. Remove the cabinet from the FR-38/U.

c. Make the adjustment of L218 within the FR-38/U while driving the Frequency Converter Unit MX-1637/U, as described in paragraph 5-29.

d. Turn the Power switch of the FR-38/U to the off position, remove the MX-1637/U, and plug in the CV-394/USA-5.

e. Turn the FR-38/U Power switch to the ON position and allow the equipment to warm up thoroughly (at least 15 minutes).

f. Set the controls on the two equipments as follows:

FR-38/U CONTROLS	SETTING
FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.01 STD. GATE TIME- SEC.
100 KC STANDARD	INT.
DISPLAY TIME	Completely counter-clockwise

CV-394/USA-5 CONTROLS	SETTING
MIXING FREQUENCY MC	210
Function switch	MIXER

g. At the INPUT connector to the CV-394/USA-5, connect a signal generator capable of generating a 220-megacycle signal, such as the AN/USM-44. Adjust this signal generator for a CW output of 220 megacycles, with signal amplitude sufficient to provide approximately half-deflection of the tuning eye.

h. Adjust capacitor C1210 (Figure 10-14) for maximum narrowing of the tuning eye pattern.

10-55. ADJUSTMENT OF 360-MC MODE SUPPRESSOR. This adjustment is set at the factory in such a way that the original setting should be good for the life of the equipment. It is improbable that readjustment will be required in the field. If necessary, however, the mode suppressor can be adjusted as follows:

a. Adjust the controls of the CV-394/USA-5 and of the FR-38/U as directed in step c of paragraph 10-51.

b. Switch the 100 KC STANDARD switch on the FR-38/U to the EXT. position, and disconnect any external signal from the 100 KC INPUT connector.

c. At the INPUT connector of the CV-394/USA-5, connect a signal generator capable of generating a signal in the 350 mc to 400 mc region, such as the AN/USM-44.

d. Adjust the signal generator output to its maximum level and vary the frequency slowly from 350 mc to 400 mc while watching the tuning eye. If the tuning eye registers the presence of a voltage, adjust L1204 (Figure 10-15) for zero output, so that there is no indication on the tuning eye.

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SECTION XI

GENERAL SUPPORT AND DEPOT MAINTENANCE

11-1 .MINIMUM PERFORMANCE STANDARDS.
11-2. GENERAL. The indications, readings, and tests described in this section serve as minimum standards of performance for the Frequency Meter AN/USM-26.

11-3. TEST EQUIPMENT REQUIRED. In addition to the test equipment used in Section V (see paragraph 5-3), an oscilloscope, a pulse generator, and a 20,000 ohms per volt multimeter are required to complete the tests described in this section. A complete list of test equipment required is found in Section VII.

11-4. OSCILLOSCOPE REQUIREMENTS. A good oscilloscope is the one most important piece of test equipment for correct and rapid maintenance of this counter.
Operation of the counter is based on the application of pulse techniques. An input signal is squared, then differentiated to get a pulse which the decade counters can handle. Pulse techniques are also used in the timing and gating circuits to achieve the one second and other gates with a jitter of less than the 1/10 microsecond necessary to meet the overall accuracy specification of the FR-38/U Frequency Meter. These pulses have a rise time of considerably less than 1/10 microsecond in many of the circuits.

11-5. Diagnosis and correction of malfunction of the FR-38/U are most easily accomplished in a minimum of time if the pulses at various places in the circuit can be displayed on the screen of a cathode ray tube.
Comparison can then be made with photographs of correct pulses obtained in an FR-38/U that is functioning properly under similar operating conditions. The effect of changing components can also be observed in terms of changes in pulse shapes. To be able to show these changes, an oscilloscope must have the following characteristics:

a. A wide band vertical amplifier that will not ring on pulses of fast rise.

b. Good vertical sensitivity; pulses of two or three volts amplitude must give a deflection of a couple of centimeters when applied to the VERTICAL INPUT through a 10 to 1 voltage divider probe. (This 10: 1 divider probe is necessary to keep the load impedance on the circuit under observation greater than 5 megohms and 15 mmf.).

c. A maximum sweep rate in the order of 0.1 microsecond per centimeter (to observe ten input pulses and their relationship to the output pulse in the high speed scaler when the FR-38/U is operating at its maximum input rate of 10 megacycles).

d. A stable sweep which will synchronize either with the vertical input internally or with an external synchronizing signal fed in through a front panel connection.

e. Accelerating potentials high enough to give a sharp, bright trace without requiring a hood or darkened room.

f. Internal voltage and time calibrations are convenient, as they speed up maintenance work. A 0.25 microsecond delay in the vertical amplifier is desirable but not necessary.

11-6. The response of the vertical amplifier should be checked on sine wave input to about 15 megacycles to see that there are no peaks or, better yet. the output of a pulser with good rise time (0.02 microseconds or faster) should be observed. This check should be made at the input of the 10: 1 voltage divider probe.

11-7. When checking an oscilloscope with a pulser, be sure that the pulser is terminated by the correct load impedance and that the ground lead at the end of the oscilloscope probe is connected directly to the pulser ground. A pulser such as the Hewlett-Packard 212A, or equivalent, can be used for this check.

11-8. The oscilloscope pattern on a 0.1 to 1.0 microsecond pulse should have a smooth rise of about 0.04 microseconds and a smooth decay of the same time.
Watch particularly for "ringing", as this will mask the portion of FR-38/U waveforms in which you are most interested. This "ringing" effect is illustrated in Figure 11-1.

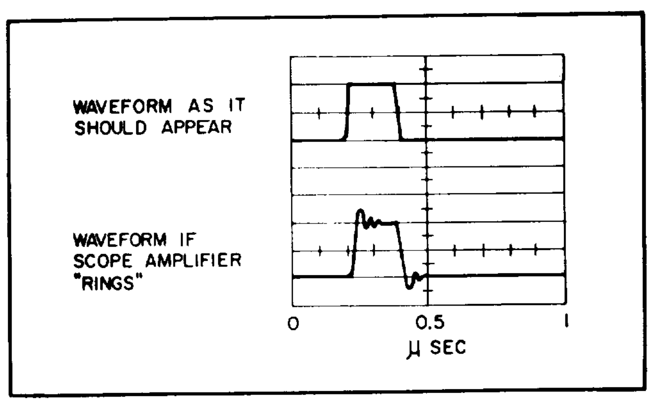


Figure 11-1. Typical Waveforms When Checking Oscilloscope Amplifier for "Ringing"

11-9. INPUT PROBE. An input probe is necessary when observing waveforms in an FR-38/U Frequency Meter with an oscilloscope to prevent the loading of the oscilloscope from altering waveforms or, in some cases, from stopping the operation of a stage completely. Before using an oscilloscope, check the adjustment of the input probe. Follow the oscilloscope manufacturer's instructions for adjusting the probe.

11-10. Figure 11-2 shows the correct adjustment of a probe as well as the effect of incorrect adjustment on waveforms. Check also the pulse response of the oscilloscope after adjusting the probe.

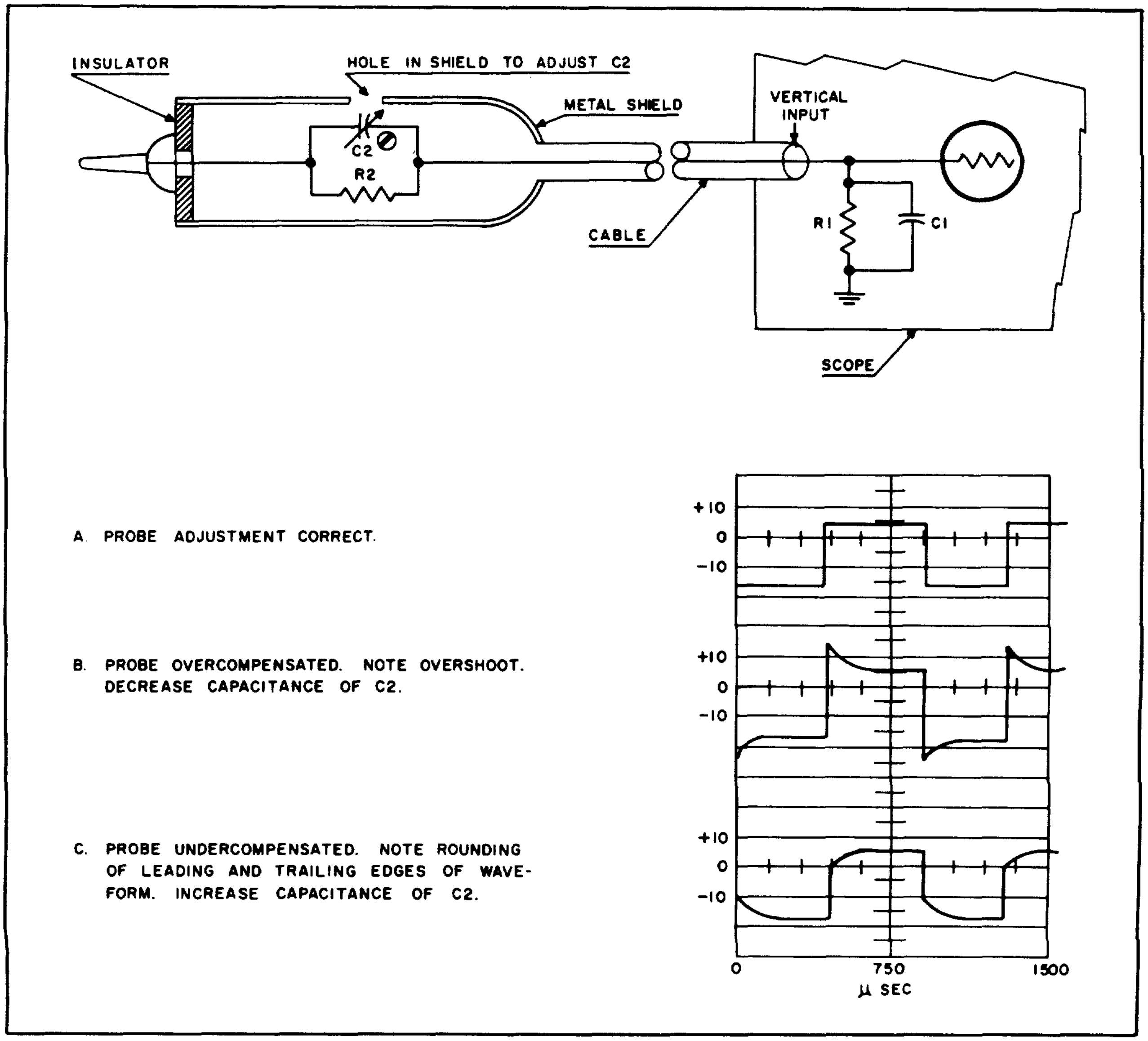


Figure 11-2. Oscilloscope Probe Adjustment

11-11. The waveforms in this section are reproductions of photographs of those in an FR-38/U Frequency Meter. The oscilloscope used to obtain these waveforms was a Tektronix Model 524D. An input probe with a voltage division ratio of 10: 1 and an impedance of 10 megohms shunted by 14 mmf was used.

11-12. OSCILLOSCOPE GRATICULE. A graticule that has 10 horizontal divisions is a convenient one to use.
Thus, if one complete cycle of a decade counter stage is set so that it begins and ends at the two edges of the graticule, then all transitions or changes of state will occur at marked points on the oscilloscope screen.
If the oscilloscope has some other type of graticule, a new one can be made from 1/8-inch clear plastic.

11-13. GENERAL WAVEFORM INFORMATION. Panel control settings of the FR-38/U are indicated for each group of waveforms shown in the System Analysis Chart. Controls not mentioned do not affect the particular group of waveforms. Information on the oscilloscope SWEEP SPEED and on the place from which to obtain synchronizing voltage for the oscilloscope when set for EXT SYNC is also shown in case it is desired to reproduce the waveforms exactly as shown.

11-14. All voltage amplitudes on waveforms are peak-to-peak voltages at the input to the probe. Do not neglect the 10: 1 voltage division ratio of the probe when using the built-in VOLTAGE CALIBRATOR of the oscilloscope. All voltages are shown plus and minus with respect to zero, as the oscilloscope was set for ac input when observing these waveforms. To determine an instantaneous dc level, use the instantaneous voltages shown in conjunction with static dc voltages listed in the voltage tables of Section VII. It is important to choose a static voltage obtained when a stage is in a non-operating condition to avoid the possibility of getting a dc voltage that is the average of some varying voltage rather than that obtained when the stage is in a stable state. This non-operating condition is obtained with the time base off (i.e., 100 KC STANDARD switch to EXT position with no connection to 100 KC INPUT) and no connection to SIGNAL INPUT.

11-15. Waveforms in the System Analysis Chart were obtained with the oscilloscope sweep synchronized from an external source in order to maintain correct time relationships of a particular group. Synchronizing voltage is usually taken from the output of a section to position waveforms with respect to time as shown. However, for most servicing and maintenance work the actual waveform is usually more important than the time relationship to other waveforms and internal synchronization is usually more convenient to use.

11-16. CHECK CHART. The following check chart shows which factors are to be checked to determine whether or not the Frequency Meter AN USM-26 meets minimum performance standards. The check chart steps should be followed in the order given when it is necessary to check out an instrument. Trouble-shooting information presented in Table 10-1 is useful in isolating troubles to particular circuits and components.

MINIMUM PERFORMANCE STANDARDS CHECK CHART

To Check	Refer To Paragraph
Visual Inspection	11-33
Power Supply	11-68
100 KC Crystal Oscillator	11-78
Phantastrons	11-83
Multipliers	11-98
Amplitude Discriminator (Period Sensitivity)	11-100
Decade Divider	11-102
Gate Section (Gate Length)	11-107 - 11-164
Display Time Operation	11-119
Trigger Unit (Frequency Sensitivity)	11-126
10 MC Deck	11-152
1 MC Deck	11-161
Gate Accuracy	11-130
1-10 MC Check	11-61
Trigger Unit (Frequency Sen-sitivity)	11-126

11-17. GENERAL TESTING INFORMATION.

11-18. The following sections present procedures for completely testing the AN,/USM-26 Frequency Meter. Typical sources of troubles are mentioned along with information as to their external indications (display on meters and plug-in counters) and methods of correcting them. In many cases, a trouble can be located by determining first just how a stage should be functioning. With this information, variations in waveforms and voltages in circuits provide some indication as to the source of trouble.

11-19. LINE VOLTAGE. Checks made at the line voltage extremes (103.5 volts and 126.5 volts), as well as the normal 115 volts line, are especially valuable for preventive maintenance checks to detect marginal operation in FR-38/U circuits and components (especially tubes) before actual failure occurs. Line voltage can be varied by means of an adjustable Variac transformer (5 amps or more).

11-20. 1 to 10 MC CHECK. The 1 to 10 mc check described in paragraph 6-61 is an excellent over-all check on the FR-38/U. This check is also good for periodic preventive maintenance checks; any FR-38/U that works satisfactorily when checked by this method is probably in good electrical condition.

11-21. TUBES. Tubes are not a critical component in most of the FR-38/U circuits. but the use of a correct type is important. The tubes used in the instrument are, in some cases, especially designed for counter type service. Do not substitute other tube types, except as recommended in the maintenance of modernization sections of this manual. Do not switch tubes indiscriminately.

Replace the original tubes if the replacement tube does not correct the trouble.

11-22. CHECKING FR-38/U AFTER LONG PERIODS OF USE. When repairing or servicing FR-38/U instruments that have been in use for long periods, check all crystal diodes first. Replace poor ones and proceed with the regular test procedure.

11-23. Check resistances from all regulated voltage busses to ground in power supply. If resistances are not correct, check the power supply separately on a resistance load. (See paragraph 11-73) Check settings of regulated voltages.

11-24. If the instrument exhibits signs of intermittent operation, try localized tapping of vacuum tubes and flexing of components, connections and wiring with a fibre stick.

11-25. The microphonics check (Table 10-1, step 5) should be made while the counter is Operating with 10 mc self-check.

11-26. LOOSE COUPLING When loose coupling is specified in the test procedure, i.e., coupling through I to 2 micromicrofarads, it can be obtained by clipping a Mueller type 60 alligator clip on a test lead or oscilloscope probe over the insulation on a wire. Be certain that the clip teeth do not bite through the wire insulation.

11-27. SOLDERING. Soldering on vertically mounted resistor boards should be done (carefully to avoid burning wires or damaging adjacent components. An electric soldering gun or a soldering iron with a chisel point, the last 1/2-inch of the tip bent at a 45-degree angle, is recommended. This arrangement allows the bottom connection on resistor boards to be reached without burning wiring on an adjacent board.

11-28. SYSTEM ANALYSIS.

11-29. GENERAL. This section contains servicing data in the form of waveform analysis and a symptomatic trouble-shooting chart, and step-by-step procedures to determine and correct specific circuit failures. Refer to Section V for information on tube replacement.

11-30. Check the operation of the power supply prior to system analysis or trouble-shooting. Many troubles in FR-38/U circuits are directly traceable to malfunction in the power supply. If the regulated voltages are low or if the power supply is not regulating, many circuits will operate poorly or erratically. This is especially true in binary circuits.

11-31. First check the resistances from the regulated voltage busses to ground, as described in paragraph 11-72.U the resistances check out satisfactorily, turn on the power and check the setting of all regulated voltages. The procedure for adjustment of voltages is given in paragraph 10-17.

11-32. If the resistances do not check out properly, check for defective components in the appropriate circuit before proceeding.

11-33. MECHANICAL AND VISUAL INSPECTION.

11-34. All mechanical parts and assemblies of the instrument should be visually inspected. Check the operation of all controls to make sure the controls operate smoothly and mechanical stops are properly set. Check all set screws. Inspect solder connections individually to make sure that there is no evidence of cold soldering and make sure that flux has been carefully cleaned from joints. Remove loose particles or chips of solder.

Table 11-1. Power Supply Trouble Shooting Chart

SYMPTOM	POSSIBLE CAUSE	REMEDY
+210 voltage lower than normal.	Defective series regulator V-253 or V-254. (Limited regulation if only one-half tube out.)	Replace V-253 or V-254.
+90 voltage bus low or zero.	Defective +90 volt regulator V-255A.	Replace V-255.(See para 10-17 for adjustments required.) Readjust after 24 hours continuous operation.
+70 volt bus low or zero.	Defective +70 volt regulator V-255B.	Replace V-255 (See para 10-17 for adjustments required.)
+90 volt bus higher than normal and without regulation. +210 and +70 volt bus less affected.	Defective +90 volt control tube V-256A.	Replace V-256. (See para 10-17 for adjustments required.)
+70 volt bus higher than normal and without regulation. +210	Defective +70 volt control tube V-256B.	Replace V-256. (See para 10-17 for adjustments required.)
and +90 volt bus less. -195 volt absent. Other regu-lated voltages low.	Defective rectifier V-257.	Replace V-257. (See para 10-17 for adjustments required.)
-195 volt low (closer to zero with no or limited regulation.	Defective regulators V-258 or V-259.	Replace V-258 or V-259. (See para 10-17 for adjustments required)
All regulated voltages higher than normal. - 195 volts more negative and without regulation.	Defective -195 volt control tube V-260.	Replace V-260. (See para 10-17 for adjustments required.)
	Defective voltage reference tube V-261.	Replace V-261. (See para 10-17 for adjustments required.
Power supply regulation poor at low line voltages.	Defective reference tube V-261.	Replace V-261.
+300 volt supply low.	Defective resistors in voltage networks.	Check and replace R-525 and R-523, R-502 and R-526, R-510 and R-527, R-517 and R-528
	Open resistors R-503, R-506, R-511 and R-513.	Replace defective resistors R-503, R-506, R-511 or R-513.
+210, +90 and +70 voltages higher than normal. No regulation.	Defective +210 volts control tube V-252.	Replace V-252. (See para 10-17 for adjustments required.) Readjust after 24 hours continuous operation.

11-35. WARM-UP. The equipment should be warmed up (POWER ON) at least 15 minutes prior to testing at 115 volts at room temperature. The instrument is presumed to have been on STANDBY (POWER OFF) for at least 4 hours to allow the crystal oven of the internal standard to reach a stabilized, controlled temperature.

11-36. SPACE HEATERS. Space heaters R-490, R-491 and R-492 are fixed, wirewound resistors and are located in the main instrument to maintain the internal temperature approximately 6°C (42°F) above ambient while the equipment is in standby condition.

11-37. These resistors should not normally cause any trouble. However, if excessive moisture is evident on chassis components. the heater resistors should be checked. If the equipment is to be operated where condensation is apt to be present (such as moving the equipment from a cool storage room to a warm test location for use), make certain the equipment is allowed to operate on standby for at least 4 hours prior to use.

11-38. AIR FILTER. The air filter located in the back of the cabinet for the FR-38/U is a permanent type and should not require replacement. It should, however, be cleaned at least twice a month to insure maximum air intake into the equipment. When the filter becomes dirty, clean as follows:

a. Unloosen cabinet retaining screws (Figure 5-2) and slide cabinet from chassis.

b. Remove the filter by unscrewing the four screws on the rear of the cabinet that secure the filter bracket.

Remove surface dirt from the filter by vacuuming it or gently tapping it with the surface down.

c. Direct a stream of hot water at the intake side of the filter to flush out dirt. A detergent or soap may be used if the equipment is used under abnormally dusty conditions.

d. Shake out excess water and allow the filter to dry.

e. Slip filter back into the filter bracket and tighten the four bracket mounting screws.

11-39. WAVEFORM ANALYSIS. The following charts are designed to aid in isolating a malfunction in the different sections of the instrument, such as Time Base, Gate, Counters, etc., of the FR-38/U and the two accessory plug-in units. It is assumed here that it has been determined that the source of malfunction is in a particular section as determined by procedures outlined in Section V. In general, the trouble-shooting is carried out by observing the waveforms on an oscilloscope connected successively to various points in the frequency meter and plug-in units. When a malfunction is observed, further investigation is carried out with a voltmeter and an ohmmeter. Refer to voltage and resistance diagrams Figure 12-24 through 12-30.

11-40. REMOVAL AND REPLACEMENT OF INDIVIDUAL PARTS AND SUBASSEMBLIES.

11-41. SPECIAL PRECAUTIONS. All internal plug-in units and subassemblies in the AN/USM-26 are securely fastened by captive screws or retaining latches. Care should be exercised in removing such units to avoid irreparable damage to the part.

11-42. Detailed instructions on removal of plug-in units and tubes are given in paragraph 10-12 and should De consulted before proceeding.

11-43. CRYSTAL DIODES. The Hewlett-Packard Stock No. 212-G11A crystal diodes used in the FR-38/U are germanium diodes (50 milliamps forward current, 50 volts back voltage) that have been selected for a back resistance of at least 75,000 ohms at 65'C (149'F).

11-44. Ten crystals are included as spares and are mounted on a clip board inside the chassis in the Time Base Section (as shown in Figure 10-1). If it is necessary to select additional crystals for the instruments the following procedures given in paragraphs 11-45 and 11-47 should be used.

Table 11-2. System Analysis Chart

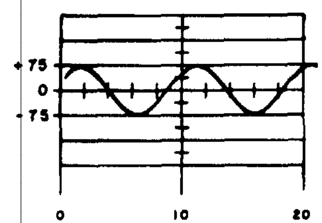
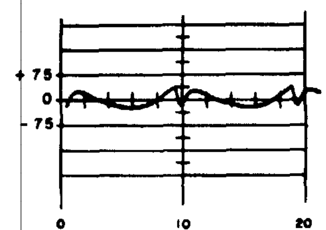
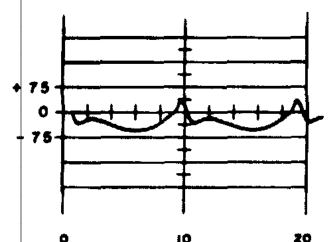
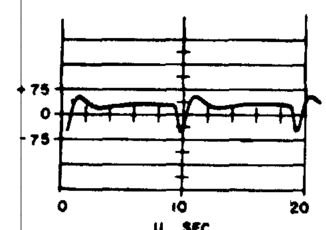
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
1	Connect oscillo-scope to pin 5 of V-234 	100 kc standard INT Line voltage 115	Sync: +EXT from pin 5 of V-234 through 2 uuf. Sweep: 2 µsec/cm		Check V-234. If operation normal with external standard, check 100 kc crystal Y-201. If waveform shows spurious signal, adjust C-335.
2	Connect oscillo-scope to pin 5 of V-235 				Check V-235.
3	Connect oscillo-scope to pin 2 of V-236 				Check V-236, V-235 and associ-ated circuit elements.
4	Connect oscillo-scope to pin 1 of V-236 				Check V-236, C-299, R-423, R-424, R-425.

Table 11-2. System Analysis Chart (Contd.)

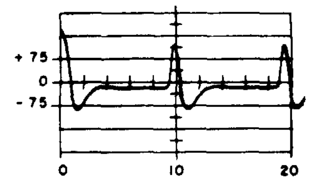
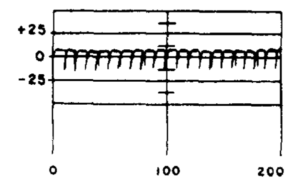
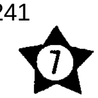
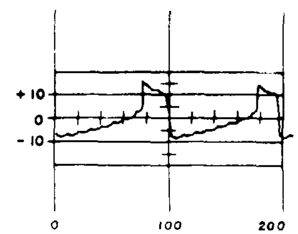
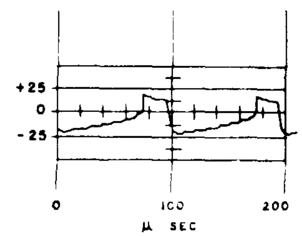
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
5	Connect oscillo-scope to junction of R-426 and C-318 				Check V-236 and associated cir-cuit elements.
6	Connect oscillo-scope to pin 1 of V-235 		Sync: -EXT from pin 2 of V-243 Sweep: 20 µsec/cm		Check V-236 and associated cir-cuit elements.
7	Connect oscillo-scope to pin 2 of V-241 				Check V-235, C-320, R-443, R-444 and R-442.
8	Connect oscillo-scope to pin 1 of V-241 				Same as step 7.

Table 11-2. System Analysis Chart (Contd.)

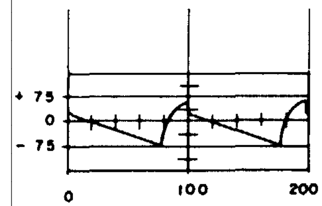
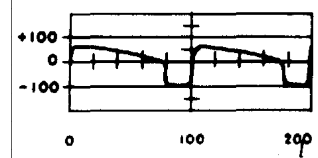
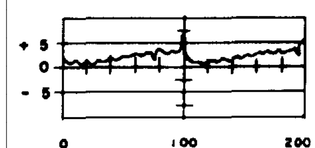
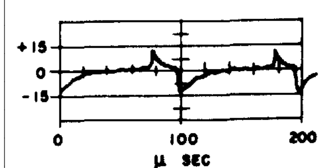
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
9	Connect oscillo-scope to pin 5 of V-241 (A5)				Same as step 7. Note: Phantastron may divide by 11 when scope is coupled to plate.
10	Connect oscillo-scope to pin 6 of V-241 (A6)				Same as step 7.
11	Connect oscillo-scope to pin 7 of V-241 (A7)				Same as step 7.
12	Connect oscillo-scope to pin I of V-242 (H)				Check V-242 or V-241 and assoc-iated circuit elements.

Table 11-2. System Analysis Chart (Contd.)

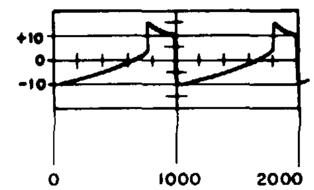
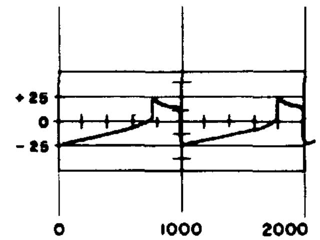
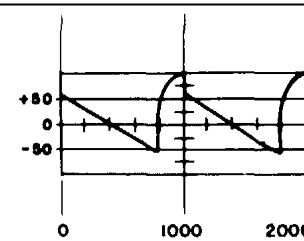
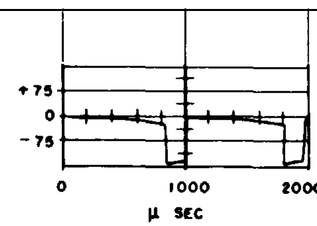
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
13	Connect oscillo-scope to pin 2 of V-243 		Sync: -EXT from pin 2 of V-244. Sweep: 200 µsec/cm		Check V-242, V-243, C-322, R-452, R-453, and R-451.
14	Connect oscillo-scope to pin 1 of V-243 				Same as step 13.
15	Connect oscillo-scope to pin 5 of V-243. 				Same as step 13. Note: Phantastron may divide by 11 when oscilloscope is con-nected to the plate.
16	Connect oscillo-scope to pin 6 of V-243 				Same as step 13.

Table 11-2. System Analysis Chart (Contd.)

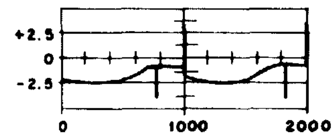
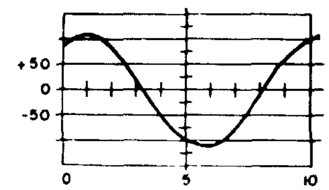
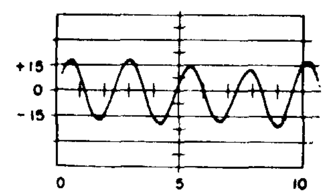
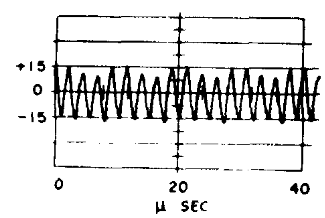
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
17	Connect oscillo-scope to pin 7 of V-243 B4				Same as step 13.
18	Connect oscillo-scope to pin 5 of V-234 5	Freq. Converter in place	Sync: -EXT from output of 100 kc blocking oscil-lator V-236 through 2 µµf. Sweep: 1 µsec/cm		Check V-234 and associated cir-cuit elements. See step 1
19	Connect oscillo-scope to pin 5 of V-237 C1				Check V-237 and associated cir-cuit elements. Check C-301.
20	Connect oscillo-scope to pin 5 of V-237 C1		Sweep: 4 µsec,/cm		Same as step 19. Waveform shows multiplication factor of stage (four times).

Table 11-2. System Analysis Chart (Contd.)

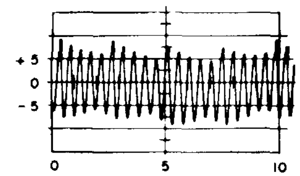
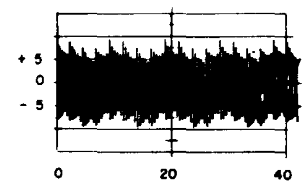
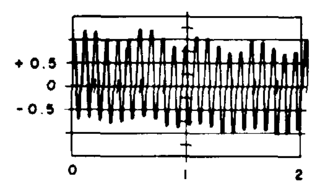
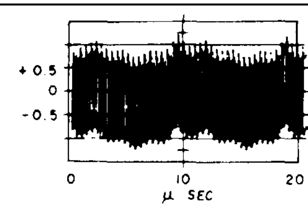
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
21	Connect oscillo-scope to pin 5 of V-238 C2		Sweep: 1 µsec/cm		Check V-238 and tuned input circuit to grid pin 1. Stage multiplies by 5.
22	Connect oscillo-scope to pin 5 of V-238 C2		Sweep: 4 µsec/cm		Same as step 21.
23	Connect oscillo-scope to pin 5 of V-239 C3		Sweep: 0.2 µsec/cm		Check V-239. Check tuned input circuit to grid pin 1. Stage multiplies by 5.
24	Connect oscillo-scope to pin 5 of V-239 C3		Sweep: 2 µsec/cm		Same as step 23.

Table 11-2. System Analysis Chart (Contd.)

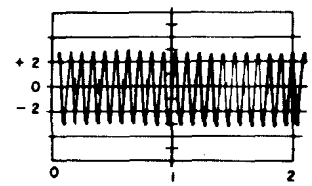
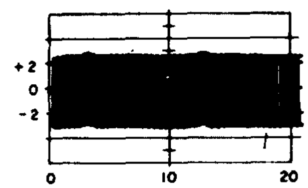
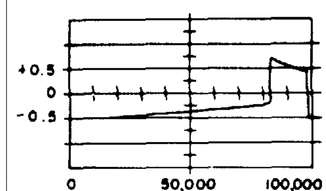
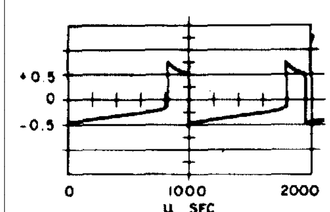
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
25	Connect oscillo-scope to pin 5 of V-240 		Sweep: 0.2 µsec/cm		Check V-240. Check tuned input circuit to grid pin 1. 10 mc amp-lifier.
26	Connect oscillo-scope to pin 5 of V-240 		Sweep: 2 µsec/cm		Same as step 25.
27	Connect oscillo-scope to STD. FREQ. OUTPUT (#9) connector 	Std. Frequency Counted - 10 cps	Sweep: 10,000 µsec/cm Sync: Signal		Check pin 2 of V-246. The wave-form should be similar to that shown here. If proper waveform is obtained, check pin 7 of V-248. If proper signal is obtained, check V-248. If no signal is ob-tained, check switch S-206A.
28	Connect oscillo-scope to STD. FREQ. OUTPUT (#9) connector 	Std. Frequency Counted - 1 kc	STD. FREQ. COUNTED 1 kc Sweep: 200 µsec/cm Sync: Signal		Check pin 2 of V-243. The wave-form should be similar to that shown here. If proper waveform is obtained, check pin 7 of V-248. If proper signal is obtained, check V-248. If no signal is ob-tained, check switch S-206A.

Table 11-2. System Analysis Chart (Contd.)

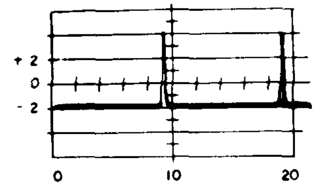
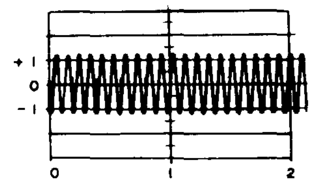
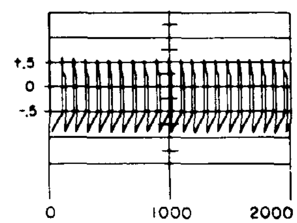
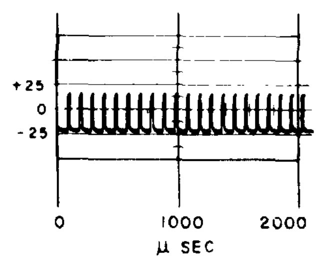
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
29	Connect oscilloscope to STD. FREQ. OUTPUT (#9) connector 	Std. Freq. Counted - 100 kc	Sweep: 2 µsec/cm Sync: Signal		Check pin 8 of V-236. The waveform should be similar to that shown here. If proper waveform is obtained, check pin 7 of V-248. If signal is obtained, check V-248. If no signal is obtained, check switch S-206A.
30	Connect oscilloscope to STD. FREQ. OUTPUT (#9) connector 	Std. Freq. Counted - 10 mc	Sweep: 0,2 µsec/cm Sync: Signal		Check V-240, V-248 and switch S-206A. Check also C-329 and R-481.
31	Connect oscilloscope to pin 5 of Z-202 	Remove V-205 Func. Sel. - Freq. Unit - .001. Display Time - min. 100 kc Std. - INT Time Unit - 100 kc. Manual Gate - Closed. Sig. Input - Std. Freq. Output Mixing Freq. - 0. Power - ON	Sync: -EXT from pin 1 of V-209 and S-201E.		Check V-248 and associated circuit elements. Check also R-286
32	Connect oscilloscope to pin 3 of Z-202 	.			Check V-701 and V-702 and associated circuit elements in Z-202

Table 11-2. System Analysis Chart (Contd.)

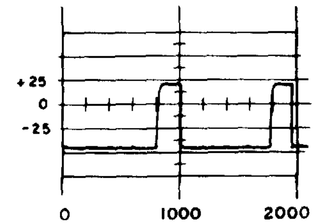
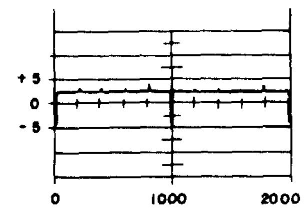
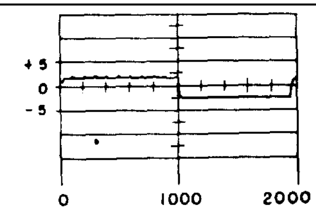
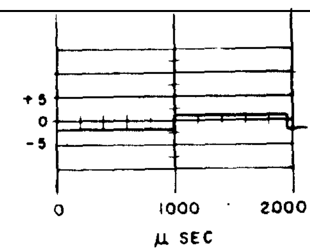
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
33	Connect oscilloscope to pin 2 of Z-203 (13)				Check V-801, V-802, and V-803 and V-804, and associated circuit elements of Decade Divider Z-203. Check also S-201D.
34	Connect oscilloscope to junction of C-225 and S-201C, C-231 and S-201C (I) (J)				Check C-223, R-250, and L-206.
35	Connect oscilloscope to junction of C-225, R-255 (K)				Check C-225, R-255. Check V-204 and associated circuit elements.
36	Connect oscilloscope to junction of C-231, R-267, R-268 (L)				Check C-231, R-267, R-268.

Table 11-2. System Analysis Chart (Contd.)

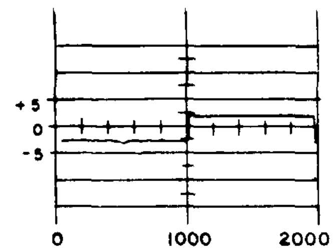
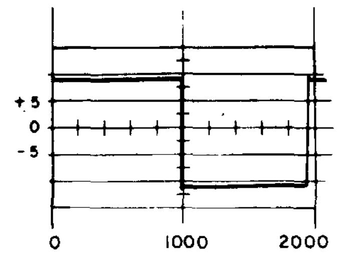
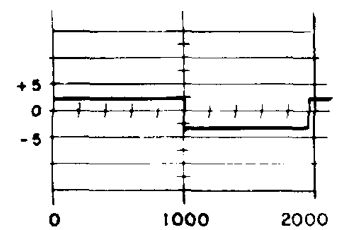
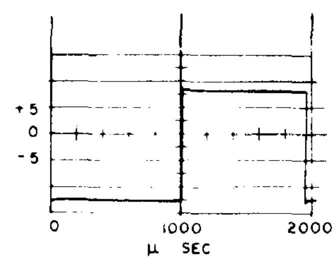
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
37	Connect oscilloscope to pin 1 of V-206 (M)				Check CR-205.
38	Connect oscilloscope to pin 5 of V-206 (N)				Check V-206 and V-207 and associated circuit elements. Check also V-204.
39	Connect oscilloscope to pin 1 of V-207 (O)				Check V-206 and V-207 and associated circuit elements. Check also V-204.
40	Connect oscilloscope to pin 5 of V-207 (14)				Check V-207, CR-207, and CR-208.

Table 11-2. System Analysis Chart (Contd.)

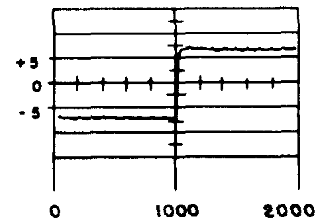
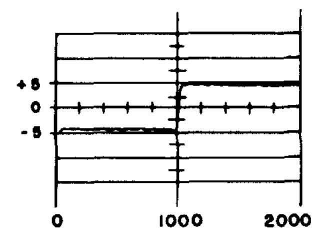
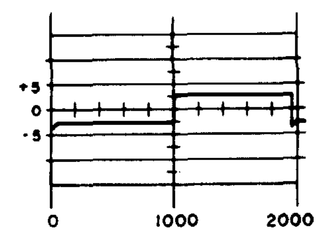
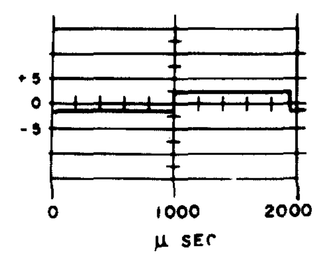
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
41	Connect oscilloscope to pin 7 of V-208 (P)				Check V-206 and V-207. Also check R-270 and C-232.
42	Connect oscilloscope to pin 8 of V-208 ★ 15				Check V-208.
43	Connect oscilloscope to junction of R-219 and R-220. (Q)				Check DL- 201, R-219 and and L-205.
44	Connect oscilloscope to pin 1 of V-203 ★ 16				Check R-220, R-225, and GATE LENGTH ADJ., R-224.

Table 11-2. System Analysis Chart (Contd.)

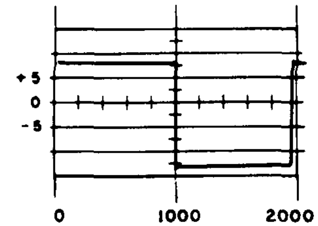
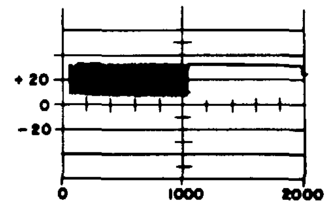
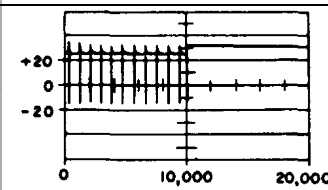
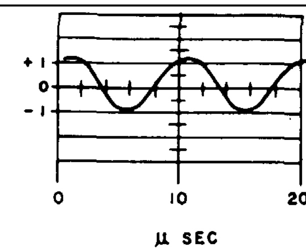
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
45	Connect oscilloscope to pin 5 of V-203 and pin 7 of V-202 				Check V-203, CR-201, and CR-202, and associated circuit elements.
46	Connect oscilloscope to pin 5 of V-202 				Check V-202 and associated circuit elements. Check also V-203 and output of Z-201, pin 1.
47	Connect oscilloscope to pin 5 of V-202 				
48	Connect oscilloscope to pin 2 of V-201 	Freq. Converter in place. GAIN - max. Signal input - .01v rms, 100 kc	Sync: +EXT from 100 kc signal input. Sweep: 2 µsec/cm		Check C-201, R-201, and contacts on J-202. Check also for broken lead from J-203.

Table 11-2. System Analysis Chart (Contd.)

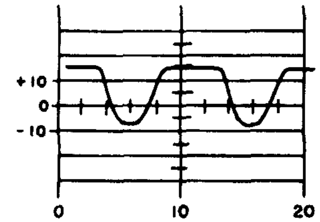
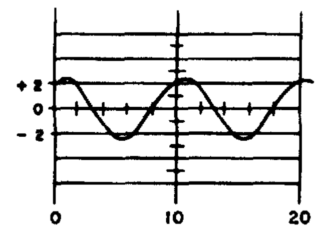
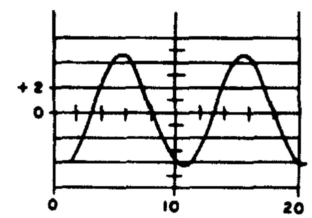
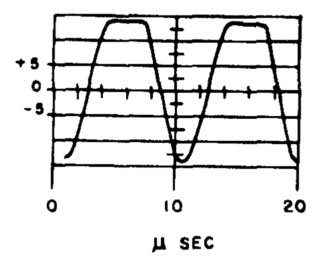
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
49	Connect oscilloscope to pin 2 of V-201 	Signal input - 2v rms			
50	Connect oscilloscope to pin 3 and pin 7 of V-201  	Time Interval Unit in place. Signal input - 2v rms			Check V-201 and associated circuit elements. Check also S-201A.
51	Connect oscilloscope to pin 6 of V-201 				Check V-201 and associated circuit elements.
52	Connect oscilloscope to pin 6 of V-201 	Signal input - 10v rms			

Table 11-2. System Analysis Chart (Contd.)

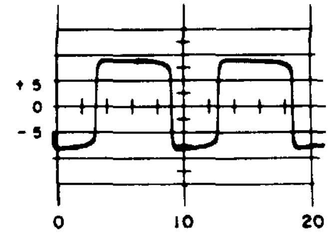
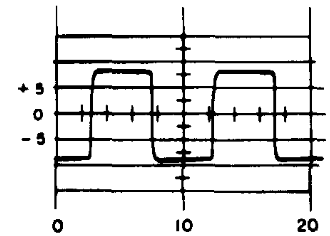
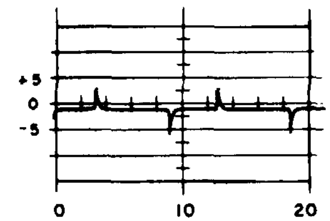
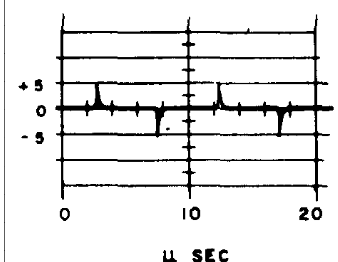
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
53	Connect oscilloscope to pin 1 of Z-201 	Signal input - 0.5v rms			Check V-601*, V-602*, and V-603*. Check also FREQ. SENS. ADJ. R-211. *V1101, V1102, V1103 used in FR-38C/U and FR-38D/U
54	Connect oscilloscope to pin 1 of Z-201 	Signal input - 2v rms			
55	Connect oscilloscope to pin 1 of V-202 				Check Z-201, R-213, L-203, and C-211.
56	Connect oscilloscope to pin 1 of V-202 	Signal input - 2v rms			

Table 11-2. System Analysis Chart (Contd.)

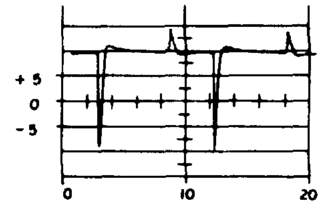
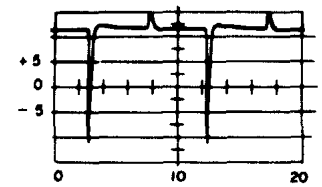
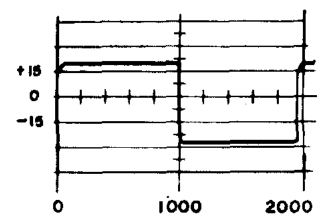
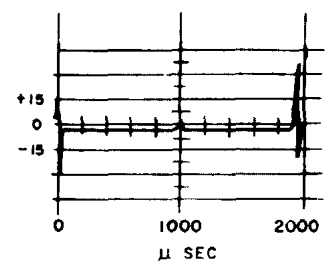
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
57	Connect oscilloscope to pin 5 of V-202 				Signal Gate output when open. Remove V-206 to open gate. See step 46.
58	Connect oscilloscope to pin 5 of V-202 				See step 46.
59	Connect oscilloscope to pin 6 of V-208 	Freq. Converter in place. Remove V-205. See control settings in step 31	Sync: -EXT pin 1 of V-209 Sweep: 200 µsec/cm		Check V-208 and associated circuit elements.
60	Connect oscilloscope to pin 2 of V-208 				Check T-201, C-233.

Table 11-2. System Analysis Chart (Contd.)

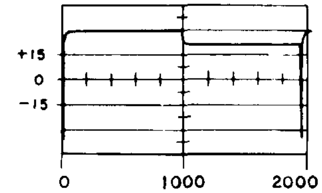
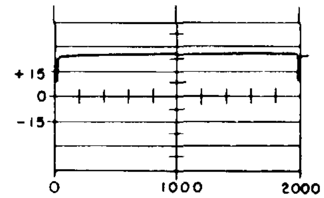
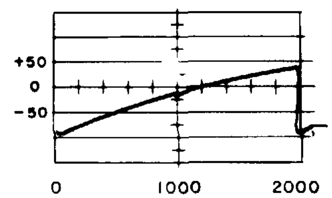
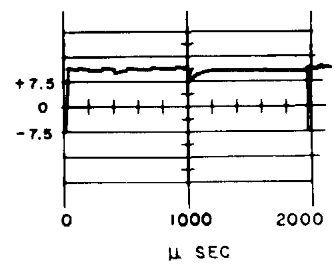
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
61	Connect oscilloscope to pin 1 of V-208 				Check V-208.
62	Connect oscilloscope to pin 1 of V-209 				Check V-208, T-201.
63	Connect oscilloscope to pin 6 of V-209 				Check V-209 and associated circuit elements.
64	Connect oscilloscope to junction of C-236, R-358 				Check R-278 and C-236. Reset to 1 Mc Decade V-219 through V-222.

Table 11-2. System Analysis Chart (Contd.)

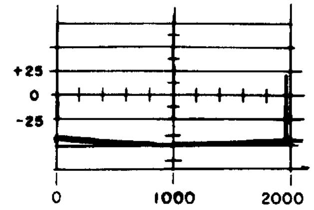
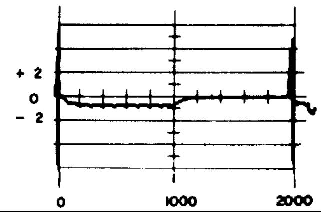
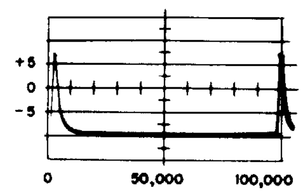
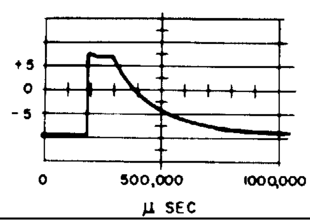
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
65	Connect oscilloscope to pin 2 of V-209 Z-209. (E5)				Check V-209, L-207. Reset to Decade Counters Z-204 through
66	Connect oscilloscope to junction of CR-214 (white wire) (E6)				Check CR-214, C-237. Reset to 10 MC Decade V-210 through V-218.
67	Connect oscilloscope to pin 1 of V-205 (U)	Install V-205. See control settings in step 31.	Sync: -EXT from pin 1 V- 208 Sweep: 10,000 µsec/cm		Check T-201, R-281, and C-365.
68	Connect oscilloscope to pin 1 of V-205 (U)				

Table 11-2. System Analysis Chart (Contd.)

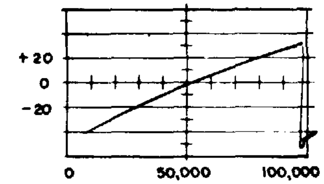
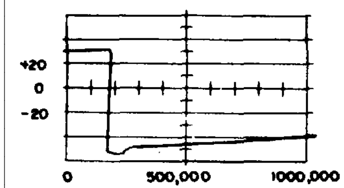
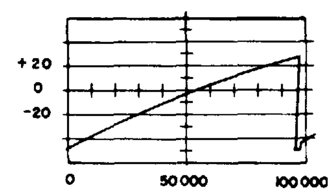
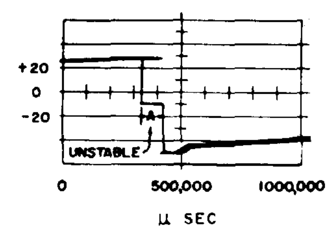
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
69	Connect oscilloscope to pin 6 of V-205 (V)				Check V-205 and associated circuit elements. Check also V-209.
70	Connect oscilloscope to pin 6 of V-205 (V)				Check V-205.
71	Connect oscilloscope to pin 2 of V-204 (E7)				Check C-214, V-205 and associated circuit elements.
72	Connect oscilloscope to pin 2 of V-204. (E7)				

Table 11-2. System Analysis Chart (Contd.)

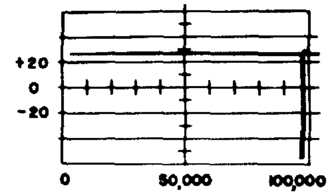
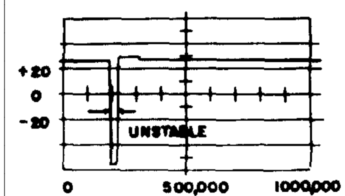
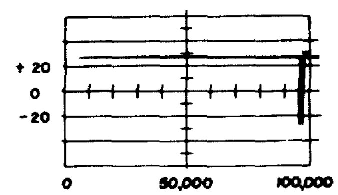
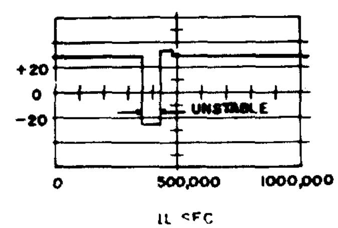
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
73	Connect oscilloscope to pin 1 of V-204 				Check V-204 and associated circuit elements.
74	Connect oscilloscope to pin 1 of V-204 				
75	Connect oscilloscope to pin 7 of V-204 				Check R-230.
76	Connect oscilloscope pin 7 of V-204 				

Table 11-2. System Analysis Chart (Contd.)

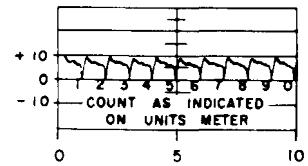
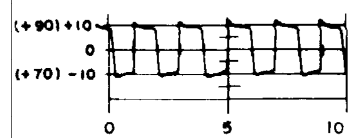
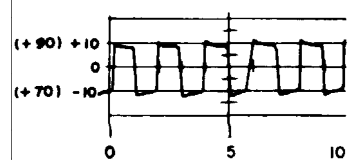
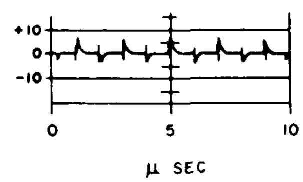
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
77	Connect oscilloscope to junction of CR-215 and CR-219  	Time Interval unit in place. FUNC. SEL. - MAN. GATE TIME UNIT - EXT. STD. FREQ. COUNTED MAN. GATE - OPEN STD. FREQ. OUTPUT - signal source to 1 mc, 2v rms min. POWER - ON Line volts - 115	Sync: -EXT from junction of R-340 and R-341 (plate lead of V-218) Sweep: 1 μsec/cm	 	Check V-202, pin 5.
78	Connect oscilloscope to pin 5 of V-210  			 	Check V-210 and V-211 and associated circuit elements. Also check CR-221, CR-222.
79	Connect oscilloscope to pin 5 of V-211  			 	Check V-210 and V-211 and associated circuit elements. Also check CR-216 and CR-217.
80	Connect oscilloscope to junction of C-244 and CR-223  			 	Check V-210 and V-211, C-244

Table 11-2. System Analysis Chart (Contd.)

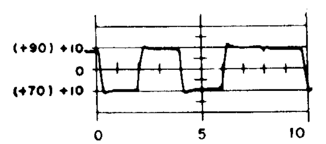
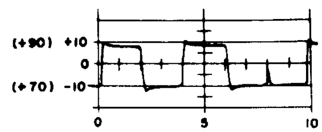
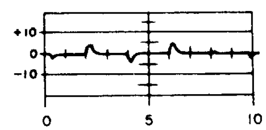
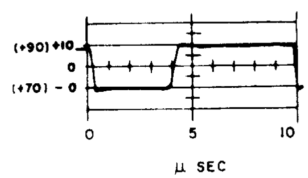
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
81	Connect oscilloscope to pin 5 of V-212 (25)				Check V-212 and V-213 and associated circuit elements, and CR-230, CR-232.
82	Connect oscilloscope to pin 5 of V-213 (Y)				Check V-212 and V-213 and associated circuit elements, and CR-225, CR-226.
83	Connect oscilloscope to junction of C-253 and CR-235 (Z)				Check- V-212 and V-213, C-253.
84	Connect oscilloscope to pin 5 of V-216 (26)				Check V-215 and V-216 and associated circuit elements. CR-234 and CR-232.

Table 11-2. System Analysis Chart (Contd.)

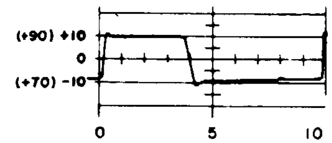
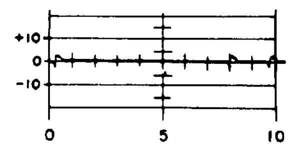
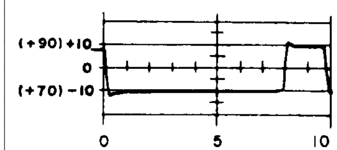
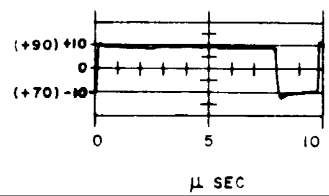
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
85	Connect oscilloscope to pin 5 of V-215 (AA)				Check V-215 and V-216 and associated circuit elements, and CR-240, CR-241.
86	Connect oscilloscope to junction of CR-242 and CR-246 (BB)				Check V-214 and associated circuit elements. Check also V-210 and V-211.
87	Connect oscilloscope to pin 5 of V-218 (27)				Check V-217 and V-218 and associated circuit elements, CR-243, CR-244.
88	Connect oscilloscope to pin 5 of V-217 (CC)				Check V-217 and V-218 and associated circuit elements.

Table 11-2. System Analysis Chart (Contd.)

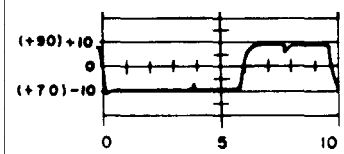
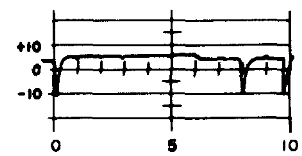
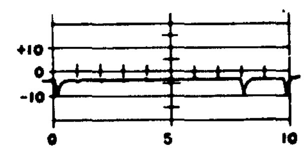
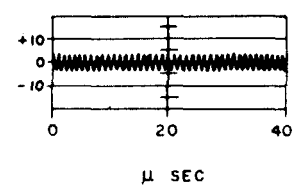
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
89	Connect oscilloscope to junction of CR-231, CR-232 and CR-233 (DD)				Check CR-231, CR-232 and CR-233, R-318, and R-324, V-212 and V-216.
90	Connect oscilloscope to pin 5 of V-214 (EE)				Check V-214 and associated circuit elements. Check also V-211.
91	Connect oscilloscope to pin 5 of V-214 (EE)				
92	Connect oscilloscope to junction of CR-215 and CR-219 (23)	FUNC. SEL - MAN. GATE TIME UNIT - 10 MC STD. FREQ. COUNTED 100 KC STD. - INT. MAN. GATE - OPEN Line volts - 115	Sync: - EXT from junction of R-340 and R-341 (plate load of V-218) Sweep: .4 µsec/cm		See step 77.

Table 11-2. System Analysis Chart (Contd.)

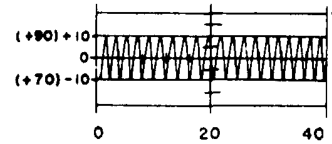
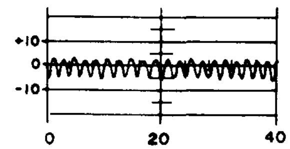
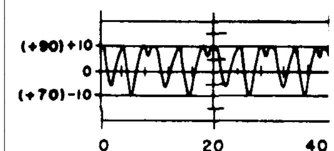
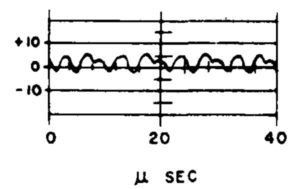
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
93	Connect oscilloscope to pin 5 of V-210 (24)				See step 78.
94	Connect oscilloscope to junction of C-244 and CR-223 (X)				See step 80.
95	Connect oscilloscope to pin 5 of V-212 (25)				See step 81.
96	Connect oscilloscope to junction of C-253 and CR-235 (Z)				See step 83.

Table 11-2. System Analysis Chart (Contd.)

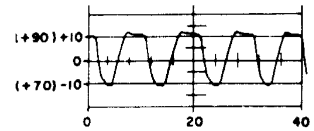
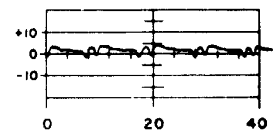
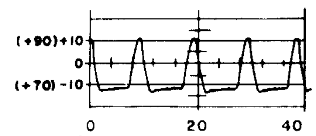
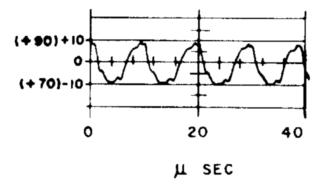
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
97	Connect oscilloscope to pin 5 of V-216 26				See step 84.
98	Connect oscilloscope to junction of CR-242 and CR-246 BB				See step 86.
99	Connect oscilloscope to pin 5 of V-218 27				See step 87.
100	Connect. oscilloscope to junction of CR-231, CR-232. and CR-233 DD				See step 89.

Table 11-2. System Analysis Chart (Contd.)

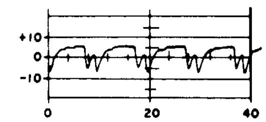
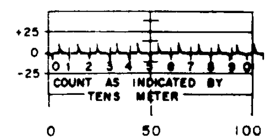
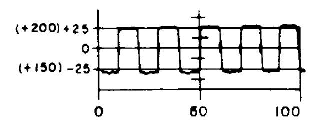
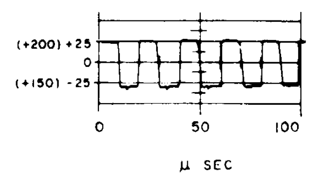
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
101	Connect oscilloscope to pin 5 of V-214 (EE)				See step 90.
102	Connect oscilloscope to junction of C-264, CR-249, and CR-250 (28) .	FUNC. SEL. - MAN. GATE TIME UNIT - EXT STD. FREQ. COUNTED 100 KC STD - INT. MAN. GATE - OPEN Signal input - 1 mc 2v rms min.	Sync: -EXT from pin 6 of V-222 Sweep: 10 µsec/cm		Check V-215, V-216, and C-264.
103	Connect oscilloscope to pin 6 of V-219 (29)	Line volts - 115			Check V-219 and associated circuit elements.
104	Connect oscilloscope to pin 1 of V-219 (FF)				Check V-219 and associated circuit elements.

Table 11-2. System Analysis Chart (Contd.)

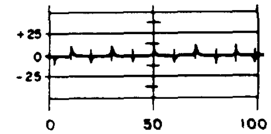
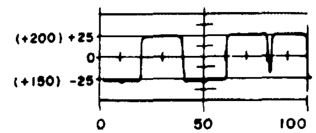
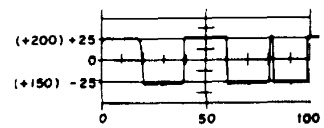
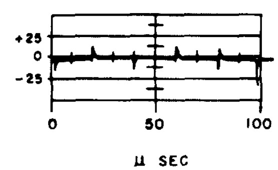
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
105	Connect oscilloscope to junction of C-268, CR-252, and CR-253 (GG)				Check V-219, C-268.
106	Connect oscilloscope to pin 1 of V-220 (30)				Check V-220 and associated circuit elements
107	Connect oscilloscope to pin 6 of V-220 (HH)				Check V-220 and associated circuit elements.
108	Connect oscilloscope to junction of C-273, CR-255, and CR-256 (II)				Check V-220, C-273.

Table 11-2. System Analysis Chart (Contd.)

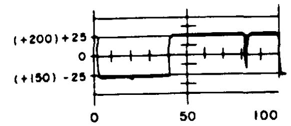
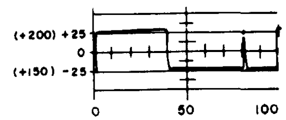
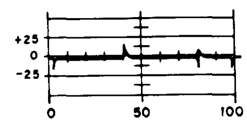
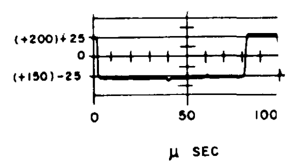
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
109	Connect oscilloscope to pin 6 of V-221 31				Check V-221 and associated circuit elements.
110	Connect oscilloscope to pin 1 of V-221 JJ				Check V-221 and associated circuit elements.
111	Connect oscilloscope to junction of C-278, CR-257 and CR-258 KK				Check V-221, C-278.
112	Connect oscilloscope to pin 6 of V-222 32				Check V-222 and associated circuit elements.

Table 11-2. System Analysis Chart (Contd.)

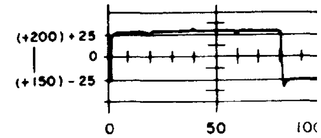
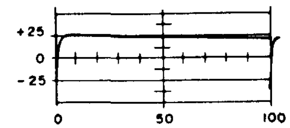
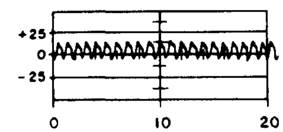
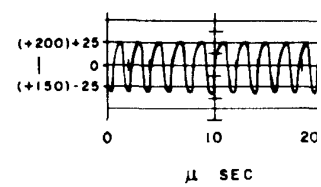
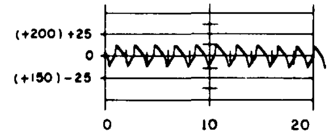
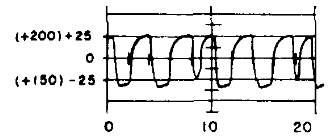
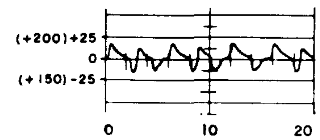
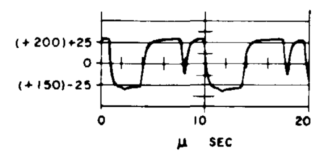
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
113	Connect oscilloscope to pin 1 of V-222 (LL)				Check V-222 and associated circuit elements.
114	Connect oscilloscope to pin 1 of V-223 33				Check V-223 and associated circuit elements. Check also V-222, C-282.
115	Connect oscilloscope to junction of C-264, CR-249, and CR-250 28	FUNC. SEL. - MAN. GATE TIME UNIT - 10 MC STD. FREQ. COUNTED 100 KC STD - INT. MAN. GATE - OPEN Line volts - 115	Sync: -EXT from pin 6 of V-222 Sweep: 2 µsec/cm		See step 102.
116	Connect oscilloscope to pin 6 of V-219 29				See step 103.

Table 11-2. System Analysis Chart (Contd.)

STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
117	Connect oscilloscope to junction of C-268, CR-252, and CR-253 (GG)				See step 105.
118	Connect oscilloscope to pin 1 of V-220 (30)				See step 106
119	Connect oscilloscope to junction of C-273, CR-255, and CR-256 (II)				See step 108.
120	Connect oscilloscope to pin 6 of V-221 (31)				See step 109.

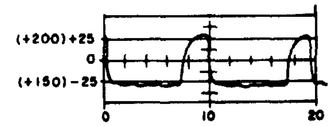
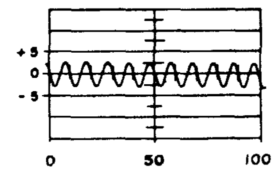
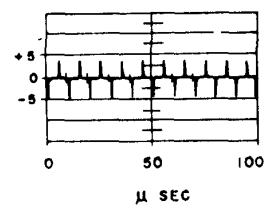
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
121	Connect oscilloscope to junction of C-278, CR-257, and CR-258 KK				See step 111.
122	Connect oscilloscope to pin 6 of V-222 32				See step 112.
123	J-102 and/or J-101, Time Interval Unit MM	FUNC. SEL. - PERIOD DISPLAY TIME - MIN. Time Interval unit in place COM-SEP - COM. TRIGGER SLOPE - Both minus. TRIGGER LEVEL - Both 1x0 TIME INT - PER: T.I. START INPUT: 100 kc, 2v rms	Sync: -EXT from 100 kc input Sweep: 10 µsec/ cm		
124	Connect oscilloscope to junction of C-225, S-201C (gray wire) I				See step 34.

Table 11-2. System Analysis Chart (Contd.)

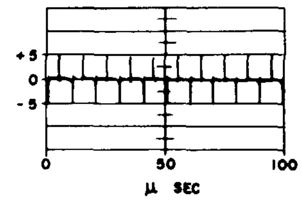
STEP	TEST POINT	CONTROL POSITION	TEST CONTROL POSITION	EQUIPMENT NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
125	Connect oscilloscope to junction of C-231, S-201C (green wire) 				See step 34.

Table 11-3. Trouble Shooting by Front Panel Indications
100 KC SELF-CHECK

SYMPTOM	POSSIBLE CAUSE	REMEDY
Counter readings on different gate periods do not agree. (This shows up as a count of 90, 990, 9900, etc., (for 100 KC self-check) if the 1st Phantastron only is dividing by 9; a count of 100, 900, 9900, etc., if the 2nd Phantastron only is dividing by 9; a count of 100, 1100, 9900, etc., if the 2nd Phantastron only is dividing by 11; and numbers such as 1000 if one is dividing by 9 and one by 12.)	Phantastron dividers out of adjustment.	Adjust R-480, R-471, R-462, R-453 and R-444 in order until correct readings are obtained. (See para 10-18.)
No standard frequencies at STD. FREQ. OUTPUT. No 100 KC or 10 MC. CHK or standard gate times.	Defective or incorrectly adjusted 100 KC Oscillator V-234.	Replace V-234 if defective.
	Shorted or dirty capacitor plates C-294, C-295 and C-296.	Readjust C-294, C-295 and C-296. (See para 12-79.)
	Failure of crystal Y-201 indicated if operation normal with external standard.	Clean plates of capacitors.
		Replace Y-201. Check also crystal oven assembly Z-235A. Oven temperature should be 65°C (149°F).
	Defective Std. Freq. Counted Cathode Follower V-248B.	Replace V-248.
No gating. 10 MC at STD. FREQ. OUTPUT but no lower frequency. OK on Period.	Defective Blocking Diode V-235A. (Also 1st Phantastron Coupling Diode V-235B.)	Replace V-235.
	Defective Blocking Oscillator V-236A.	Replace V-236.
10 MC and 100 KC at STD. FREQ. OUTPUT but no lower frequency. Period measurement normal only in 10 MC and 100 KC position on TIME UNIT switch.	Defective 1st Phantastron Coupling Diode V-235B.	Replace V-235. Adjust phantastrons. (See para 10-18.)
	Defective 1st Phantastron V-241.	Replace V-241. Adjust phantastrons. (See para 12-83.) Inability to adjust may indicate weak tube.
Neon indicator and display time normal on 0.001 second standard gate for self-check Other gate times inoperative.	Defective 2nd Phantastron Coupling Diode V-242A.	Replace V-242. Adjust phantastrons. (See .10-18.)
	Defective 2nd Phantastron V-243.	Replace V-243. Adjust phantastrons. (See para 11-83.)
Neon gate indicator and display time normal for 0.001 and 0.01 second standard gate time for self-check. Other gate times inoperative.	Defective 3rd Phantastron Coupling Diode V-242B.	Replace V-242. Adjust phantastrons. (See para 10-18.)
	Defective 3rd Phantastron V-244.	Replace V-244. Adjust phantastrons. (See para 11-83.)
Neon gate indicator and display time normal for 0.001, 0.01 and 0.1 second standard gate time for self-check. Other gate times inoperative.	Defective 4th Phantastron Coupling Diode V-245A.	Replace V-245. Adjust phantastrons. (See para 10-18.)
	Defective 4th Phantastron V-246.	Replace V-246. Adjust phantastrons. (See para 11-83.)

Table 11-3. Trouble Shooting by Front Panel Indications (Contd.)

SYMPTOM	POSSIBLE CAUSE	REMEDY
Self-check inoperative for 10-second standard gate time. All other gate times satisfactory.	Defective 5th Phantastron Coupling Diode V-245B.	Replace V-245. Adjust phantastrons. (See para 10-18.)
	Defective 5th Phantastron V-247.	Replace V-247. Adjust phantastrons. (See para. 11-83)
No gate time on self-check operation. STD. FREQ. OUTPUT OK Period and 10-Period measurements normal.	Defective Std. Gate Time Cathode Follower V-248A.	Replace V-248.
No standard gate time. Period measurement inoperative. Time Interval measurement normal.	Defective Amplitude Discriminator Z-202.	Check and replace V-701 and V-702. Adjust PER. SENS. (See para 10-21.)
No standard gate time. 10-Period measurement inoperative or erratic, but time interval measurement normal.	Defective Decade Divider Z-203.	Check and replace V-801, V-802, V-803 or V-804.
Counters free-run. Neon gate indicator remains on.	Defective Gate Control Tube V-203. (Weak tube may operate for totalizing measurement. See MANUAL GATE.)	Replace V-203. Adjust GATE LENGTH.(See para 10-23.)
	Defective diode clamps.	Replace CR-201 and CR-202.
	Defective Gate Binary V-206 and V-207.	Replace both V-206 and V-207. Check also all crystal diodes in Gate Binary circuit.
	Defective Buffer Amplifier or Blocking Oscillator V-208A or B.	Replace V-208. Adjust GATE LENGTH. (See para 10-23.)
	Defective Reset Thyratron V-209 (pressing RESET will not return counters to zero).	Replace V-209.
Neon gate indicator remains off. Display time including INF position erratic, or will not gate.	Defective Display Time Control V-204.	Replace V-204.
	Defective neon gate indicator I-201.	Replace I-201. Check also filament voltage on I-201.
Display Time always equals gate time regardless of Display Time Control setting.	Defective Display Time Thyratron V-205.	Replace V-205.
No count	Defective 1st Binary in 10 MC Counters.	Check all binaries.
	Incorrect adjustment of bias on Trigger Unit Z-201.	Adjust FREQ. SENS. potentiometer R-211. (See para 10-22.)
	Defective Trigger Unit Z-201.	*Check and replace V-601, V-602 and V-603, Adjust FREQ SENS. potentiometer R-211. (See para 10-22.)

* V-1101, V-1102 and V-1103 in FR-38C/U and FR-38D/U

Table 11-3. Trouble Shooting by Front Panel Indications (Contd.)

SYMPTOM	POSSIBLE CAUSE	REMEDY
	Defective Input Amplifier V-201B.	Replace V-201.
	Defective Signal Gate V-202.	Check and replace V-202. Check also V-203, and CR-201 and CR-202.
Readings add from one gate period to the next.	Failure of reset circuit.	Replace V-208 or V-209.
Counters counting at one-half or twice normal rate.	Grid bias on Fast Trigger set incorrectly.	Adjust FREQ. SENS. potentiometer R-211. (See para 10-22.)
	Defective Gate Binary V-206 and V-207.	Replace V-206 and V-207. Check associated circuit components.
	Defective 1 and 10 MC Counter.	Check all binaries in 1 and 10 MC Counter section.
	9 count trigger spike of phantastron triggering Z-202.	Check phantastron operation. Adjust as described in para. 10-18.
Units meter stops at "1".	Defective 1st Binary V-210 or V-211.	Replace V-210 and V-211.
	Defective crystal diodes in 1st Binary.	Check and replace all diodes in 1st Binary. (See para 11-43.)
Units meter stops at "2".	Defective 2nd or 4th Binaries V-212, V-213, V-217 or V-218.	Replace V-212 and V-213 or V-217 and V-218.
	Defective crystal diodes in 2nd or 4th Binaries.	Check and replace all diodes in 2nd or 4th Binaries. (See para 11-43.)
Units meter stops at "4".	Defective 3rd Binary V-215 or V-216.	Replace V-215 and V-216.
Units meter indicates "3, 5, 6, 7, 8 or 9".	Combination of defective binaries.	Check tubes V-210 through V-218. See Table 10-9. Improper counting sequence.
Tens Meter. Same symptoms as Units Meter.	Same as above.	Replace V-219, V-220, V-221, V-222 or V-223 as necessary.
Meter reading lies between 2 digits.	Improper power supply voltages.	Check regulated voltages and adjust as required. (See para 10-17.)
	Improper operation of 10 MC and 1 MC counters.	Check all binaries in 10 and 1 MC counters. Check also metering busses
	Meter tracking incorrect.	Adjust meter tracking. (See para. 11-148.) This adjustment should not be made until all other possible causes are checked.
Decade counters do not indicate properly. Meters OK.	Defective Decade Counter if count appears in first one or more circuits but not in others.	Check first defective unit. Check also output drive from last operating unit.
	Defective Output Waveshaper V-223.	Replace V-223.
Decade Counter oscillates or "runs wild".	Poor tube.	Check and replace tubes in defective unit.

Table 11-3. Trouble Shooting by Front Panel Indications

SYMPTOM	POSSIBLE CAUSE	REMEDY
Count stuck at one number.	Defective binaries as in 1 and 10 MC Counter.	Replace V-901, V-902, V-903 or V-904 in Z-204. Replace V-1001, V-1002, V-1003 or V-1004 in Z-205 through Z-209. See Table 10-8.
Displayed reading is K times proper reading, where K is ratio such as 10/16, 10/14, 10/12, 10/8, 10/5, etc.	Faulty Counters.	Check feedback circuits and tubes.
Erratic counting.	Poor rise time in Delay Line DL-201.	Replace DL-201.
	Poor Signal Gate V-202.	Replace V-202.
	Defective Output Waveshaper V-223.	Replace V-223.
	Defective Buffer Amplifier V-208A.	Replace V-208. Adjust GATE LENGTH Potentiometer R-224. (See para. 10-23)
	Defective Display Time Circuits.	Check and replace V-204, V-205 and V-209.
	Periodic malfunction of Time Base Circuit, especially 100 KC Oscillator V-234.	Check and replace V-234. Check also for intermittent crystal Y-201.
	Weak Rectifiers V-249, V-250 and V-251.	Replace V-249 V-250 or V-251. (See para 10-17 for adjustments
	Defective Reference Tube V-261.	Replace V-261.
	Defective resistors in voltage divider networks.	Check and replace R-525, and R-523, R-502 and R-526, R-510 and R-527, R-517 and R-528.
	Open resistors R-503, R-506, R-511 and R-513.	Replace defective resistors R-503, R-506, R-511 or R-513. If R-503, R-506, R-511 or R-513 is open, locate and remove short on +70, +90 or +210 volt bus.
	Defective Input Amplifier V-201B.	Replace V-201.
	Defective Trigger Unit Z-201 or bias incorrectly adjusted.	Check and replace V-601, V-602 or V- 603. Adjust FREQ. SENS. potentiometer R-211. (See para 10-22).
	Defective Gate Control tube V-203.	Replace V-203. Adjust GATE LENGTH potentiometer R-224. (See para 10-23).
-	Defective binary in 10 MC or 1 MC Counter.	Check and replace defective tubes. Check also crystal diodes in binary circuits.
	Defective Decade Counter.	Replace tubes in defective counters. (See para 11-179).

Table 11-3. Trouble Shooting by Front Panel Indications (Contd.)

SYMPTOM	POSSIBLE CAUSE	REMEDY
	Defective Gate Binary V-206 and V-207.	Replace V-206 and V-207. Check also crystal diodes in Gate Binary circuit.
	Defective Reset Thyratron V-209.	Replace V-209.
	10 MC SELF-CHECK	
No count. (See partial count to 4-5 MC, "Frequency" chart.)	Defective Trigger Unit Z-201.	Check and replace components of Z-201. Adjust FREQ. SENS. (See para 10-22.)
	Defective Signal Gate V-202.	Check and replace V-202. If V-202 satisfactory, check V-203.
	Defective 1st Binary in 10 MC Counter.	Check binary circuits in 1 and 10 MC sections of counter.
No 10 MC at STD FREQ. OUTPUT or self-check. Period measurements inoperative in 10 MC position of TIME UNIT switch. Frequency measurement to 10 MC OK.	Defective Frequency Multipliers V-237, V-238, V-239 and V-240.	Check and replace V-237, V-238, V-239 and V-240 if necessary. Align 10 MC Multipliers. (See para. 11-98.)
	Defective peaking coil L-212, L-214 or L-216.	Check and replace defective coil L-212, L-214 or L 216. Retune multipliers. (See para 11-98.)
	Trigger Unit Z-201 sensitivity incorrect.	Adjust FREQ. SENS. potentiometer R-211. (See para 10-22)
	Input capacity of load incorrect with Frequency Converter plug-in unit.	Defective Harmonic Generator V-5. Check for grid-to-cathode short. Replace V-5.
10 MC STD. FREQ. OUTPUT frequency low.	Peaking coil L-222 open (resistance core).	Replace L-222.
	Peaking coils in 10 MC multiplier defective.	Check for open coil L-212, L-214 and L-216- Retune multipliers. (See para 11-98.)
Counts end in 9 or 1 on all gates.	Grid bias on V-203 set incorrectly.	Adjust GATE LENGTH potentiometer R-224. (See para 10-23.)
	Phantastron jitter.	Check phantastron operation. Check and replace V-241, V-243, V-244, V-246 or V-247.
	Incorrect adjustment of bias on Amplitude Discriminator Z-202.	Adjust PERIOD SENS. potentiometer R-248. (See para 10-21)
±1 to 3 counts for 10 MC CHK.	Defective Gate Binary tubes V-206 and V-207.	Replace V-206 and V-207.
	Defective crystal diodes in Gate Binary.	Check and replace all crystal diodes Gate Binary. (See para 11-43.)
Erratic count on 10 MC self-check.	Defective Signal Gate V-202.	Replace V-202.
	Defective Gate Amplifier V-203.	Replace V-203. Adjust GATE LENGTH potentiometer R-224. (See para 10-23)
	Defective diode clamps.	Replace CR-201 and CR-202.

Table 11-3. Trouble Shooting by Front Panel Indications (Contd.)

SYMPTOM	POSSIBLE CAUSE	REMEDY
	Weak tubes V-206 and V-207 Gate Binary.	Replace both V-206 and V-207.
	Defective Tubes in Trigger Unit Z-201.	Replace tubes. Adjust FREQ. SENS. potentiometer R-211. (See a 10-22.)
	Bias of Trigger Unit Z-201 set incorrectly.	Adjust FREQ. SENS. potentiometer R-211. (See para 10-22.)
	Insufficient output from 100 KC Oscillator V-234.	Replace V-234. Check also for dirty capacitor plates C-294, C-295 and C-296.
	Insufficient output from 10 MC multiplier chain.	Check for weak or defective V-237, V-238, V-239 or V-240. Replace defective tubes and realign multipliers. (See para 11-98.)
	Poor tubes in 10 MC or 1 MC Counters.	Check and replace defective tubes.
	Defective diodes in 10 MC Counter.	Check and replace diodes. (See para. 11-43.)
	FREQUENCY	
Will self-check but will not measure frequency.	Defective Input Cathode Follower V-201A.	Replace V-201.
	Broken leads or connectors in input circuit.	Check lead to C-201. Check also plug-in connectors P-102 and J-102. Be sure plug-in unit is in place.
Frequency count OK to 4-5 MC; erratic higher frequencies.	Defective Signal Gate V-202.	Replace V-202.
		Check crystal diodes CR-201 and CR-202.
	Defective Trigger Unit Z-201 or bias incorrectly adjusted.	Check and replace V-1101. V-1102 and V-1103. Adjust FREQ. SENS. potentiometer R-211. (See para 10-22.)
	Defective binary in 10 MC or 1 MC Counters.	Check and replace defective tubes. Check also crystal diodes in all binary circuits.
	Defective Decade Counters.	Replace tubes in defective counter. (See para. 11-179.)
	Defective Output Waveshaper V-223.	Replace V-223.

Table 11-3. Trouble Shooting by Front Panel Indications (Contd.)

PERIOD AND 10 PERIOD

SYMPTOM	POSSIBLE CAUSE	REMEDY
Period and 10-Period measurements normal. No gate time on frequency or self-check operation. STD. FREQ. OUTPUT OK.	Defective Std. Gate Time Cathode Follower V-248A.	Replace V-248.
Period measurement inoperative. Time Interval measurement normal. No standard gate time on Frequency measurement.	Defective Amplitude Discriminator Z-202.	Check and replace V-701 and V-702. Adjust PER. SENS, (See para 10-21.)
10-Period measurement inoperative or erratic, but Period measurement normal. No standard gate time.	Defective Decade Divider Z-203.	Check and replace V-801, V-802, V-803 or V-804.
	MANUAL GATE	
No count of external signal when S-202 is in OPEN position.	Defective switch S-202.	Replace S-202.
	Defective Gate Control V-203.	Replace V-203. Adjust GATE LENGTH. (See para. 10-23.)
	Defective Signal Gate V-202.	Replace V-202.
	Defective diode clamps.	Replace CR-201 and CR-202.

Table 11-4. FR-38/U Checklist for Locating Trouble

Trouble in the FR-38/U can be checked by following the checklist below. All the information called for on this checklist can be obtained by using only a signal source, a DC voltmeter of 20,000 ohms per volt, or higher, or a vacuum tube voltmeter (VTVM). If this sheet is filled out, it is easier to locate and determine the source of trouble. Make ALL measurements in the order listed. The instrument should be modernized in accordance with paragraph 9-191.

GENERAL

Counter Serial No. ________.
Crystal oven temp. ________°C. Should be 65 ± 2°C.
Has instrument been modernized? (See paragraph 6-191.)
Date of modernization ________.

OPERATIONAL (With plug-in unit in place.)

Does it 100 KC CHK? ________. On all gates? ________.
10 MC CHK? ________.
Are 100 KC STD. and DISPLAY TIME switches set correctly? ________.
Are phantastrons set correctly? ________.
Does GATE light go on and off once a second when DISPLAY TIME is set MAX CCW and STD.
GATE TIME-SEC 1? ________.
Does it count correctly? ________. At all frequencies? ________.
Is indicated count incorrect by a definite ratio?
What is this ratio? ________:1
Does one particular decade seem defective? ________.
Which one? ________.
Does PERIOD measurement operate properly? ________.
Does 10 PERIOD AVERAGE operate properly? ________.
Set FUNCTION SELECTOR to MANUAL GATE. Do meters and counter units operate without jitter when gate is OPEN, stop when gate is CLOSED for conditions listed below?

	MANUAL GATE OPEN		MANUAL GATE CLOSED (Down)	
Neon Lamp	________	ON	________	OFF
10 cps)	________	TENSMETER	1 count/sec ________	DISPLAY
1 KC) STD.	________	2nd DECADE COUNTER	1 count/sec ________	DISPLAY
100 KC) FREQ.	________	4th DECADE COUNTER	1 count/sec ________	DISPLAY
10 MC) COUNTED	________	6th DECADE COUNTER	1 count/sec ________	DISPLAY
EXT)	________	NO COUNT	________	DISPLAY

Is counting sequence correct on all indicators?

________ UNITS METER
________ TENS METER
________ 1st DECADE COUNTER
________ 2nd DECADE COUNTER
________ 3rd DECADE COUNTER
________ 4th DECADE COUNTER
________ 5th DECADE COUNTER
________ 6th DECADE COUNTER

FUNCTIONAL

Set FR-38/U panel controls as follows:

FUNCTION SELECTOR	100 KC CHK
TIME UNIT	100 KC STD. FREQ. COUNTED
FREQUENCY UNIT	1 SEC. STD. GATE TIME
DISPLAY TIME	MAX CCW
100 KC STD.	INT

DC VOLTMETER

Make________
Model________
Ohms
Volt ________

Table 11-4. FR-38/U Checklist for Locating Trouble (Contd.)

A. Measure and record DC power supply voltages.

Line________ Vac.
+300 (pink) ________ +210 (red) ________ +90 (purple) ________
+70 (orange) ________ -195 (green) ________
Does +210 regulate for 103.5V ________ to 126.5V ________ line?

B. Measure voltage at pin 1 of V-234. Should be approximately -12V.

C. Check pin 2 of V-246. Should "kick" once every 1/10 second. Check pin 2 of V-247. Should "kick" once every second.

D. FREQUENCY UNIT to STD. GATE TIME-SEC. 10. Check pin 5 of Amplitude Discriminator socket, Z-202. Should "kick" once every second. ________
Check pin 3 of Z-202. Should "kick" once each second. ________ (Negative pulse)
Check pin 1 of Decade Divider, socket Z-203. Should "kick" once each second. ________ (Positive pulse)
FREQUENCY UNIT to STD. GATE TIME-SEC 1. Check pin 2 of Z-203. Should "kick" once per second. ________(VTVM only)

E. Measure and record voltage at following places:

	COUNT		DISPLAY
Plate Pin 5 V-207	________ +70	to	________ +90
Grid Pin 7 V-208	________ -1.5	to	________+15 VTVM only
Cathode Pin 8 V-208	________ +5	to	________ +14
Delay Line Pin 2 (output)	________ +1.5	to	________ +6
Grid Pin 1 V-203	________ -3.5	to	________ +0.5
Suppressor Pin 7 V-202	________ +91	to	________ +70

Accurately count the number of voltage swings from 70 to +91 at the suppressor of V-202 for two minutes. Should be 60 times. ________ times.

Set DISPLAY TIME control with dot straight up. Measure voltages of V-204 with VTVM.

Pin 1	________ +150	drops momentarily to ________ +60
Pin 7	________ +100	drops momentarily to ________ +40

F. Measure voltage at the plate pins of tubes in the 10 mc section. Voltage swings from the voltage listed under count to the voltage listed under display.

	COUNT	DISPLAY		COUNT	DISPLAY
V-210	________ 80	to ________ 70	V-215	________ 78	to ________ 90
V-211	________ 80	to ________ 90	V-216	________ 82	to ________ 70
V-212	________ 82	to ________ 70	V-217	________ 86	to ________ 90
V-213	________ 78	to ________ 90	V-218	________ 74	to ________ 70
			V-214 Pin 7	________ 78	to ________ 70

G. Measure voltage at Pins 1 and 6 of tubes in the 1 mc section. Should swing from the voltage listed under count to the voltage listed under display. (Approximate voltage.)

	Pin 1		Pin 6	
	COUNT	DISPLAY	COUNT	DISPLAY
V-219	________ 180	to ________ 200	from ________ 180	to ________ 155
V-220	________ 185	to ________ 155	from ________ 175	to ________ 200
V-221	________ 175	to ________ 200	from ________ 185	to ________ 155
V-222	________ 190	to ________ 200	from ________ 165	to ________ 155

11-45. BACK RESISTANCE CHECK. The back resistance of crystal diodes should be measured first at 65°C (149°F), using the test circuit shown in Figure 6-3. Short the diode clips (red and black) and adjust R1 for a reading of 30 microamps on meter M1. The diode is then inserted and the meter reading observed. Table 11-5 shows the diode resistance for various meter readings.

Table 11-5. Meter Calibration for Back Resistance Check

METER microamps	DIODE ohms
20	50K
17	75K
15	100K
12	150K
10	200K
7.5	300K
5.1	500K
2.7	1 MEG
1.4	2 MEG
1	3 MEG

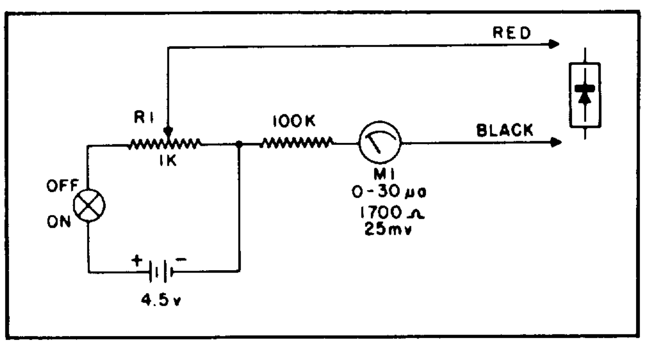


Figure 11-3. Circuit for Testing Back Resistance of Crystal Diodes

11-46. The back resistance checked at room temperatures (27°C (80°F)) should be 500,000 ohms or more when measured with a 20,000-ohm per volt multimeter such as the AN/PSM-4. This back resistance check at room temperature is the method used to locate defective diodes when servicing an FR-38/U. When making resistance checks, watch particularly for diodes that "creep", i.e., the back resistance decreases (back current increases) after the measuring circuit is connected. Diodes in which the resistance "creeps" more than 5% in a minute are not satisfactory, as their operation is likely to be unpredictable if installed.

11-47. FORWARD CURRENT CHECK. High forward current is not as important as high back resistance in this application of crystal diodes. A forward current I 5 milliamps or more at a voltage drop E = 1 volt is satisfactory (200 ohms approximately) at room temperature. A test circuit used in checking forward current is shown in Figure 6-4. Prior to making the check adjust R2 for a 1-volt reading on meter M3.

NOTE

When selecting <u>new</u> diodes for use in the FR-38/U, the room temperature check alone is not adequate. Measure at 65°C (145°F) first checking back of each diode. Forward resistance can be checked at room temperature.

11-48. In the FR-38/U circuits, crystal diodes are operated well within the manufacturer's ratings, but with use their back resistance drops, particularly if a dirty air filter or other trouble causes excessive temperatures inside the instrument. Crystal diode failure is usually due to back resistance dropping below the acceptable limit and shows up as erratic counter operation. Forward characteristics of the diode give little trouble, unless some other component fails.

11-49. DIODE TESTING AND REPLACEMENT. Diodes with small wire leads (Hughes HD Z116. etc.) are mounted in clips and do not require soldering to install or remove. When doing maintenance work on an FR-38/U counter which has been in operation foe 2000 hours or more, it is a good practice to check all crystal diodes first, using either the standard test Circuit or an ohmmeter. See paragraph 11-143 A battery operated ohmmeter is convenient to use, but resistance readings of the diodes will vary some, depending on the ohmmeter used. Each ohmmeter checks the diodes at a different forward voltage. All diodes can be unclipped at the end away from the deck to measure back resistance.

11-50. If an ac-operated ohmmeter circuit is used to check diode characteristics, lift out of the mounting clip the end of the diode that allows back resistance to be measured with the ungrounded lead of the ohmmeter circuit. Defective diodes can be bent back so that they can be readily identified and replaced later.

NOTE

OBSERVE CORRECT POLARITY when replacing diodes. Selected crystal diodes can be ordered from the Hewlett-Packard Company (Stock No. 212-G11A).

11-51. TEMPERATURE-CONTROLLED BOX FOR SELECTING DIODES. A temperature-controlled box for

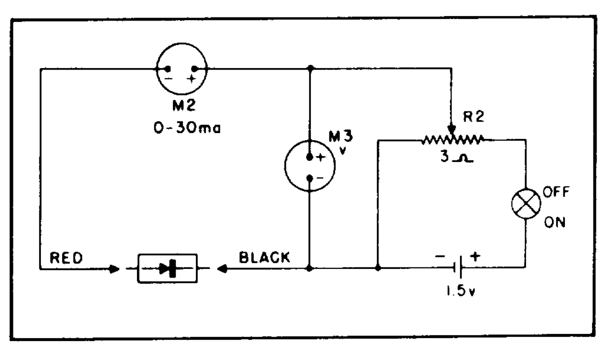


Figure 11-4. Circuit for Testing Forward Current of Crystal Diodes

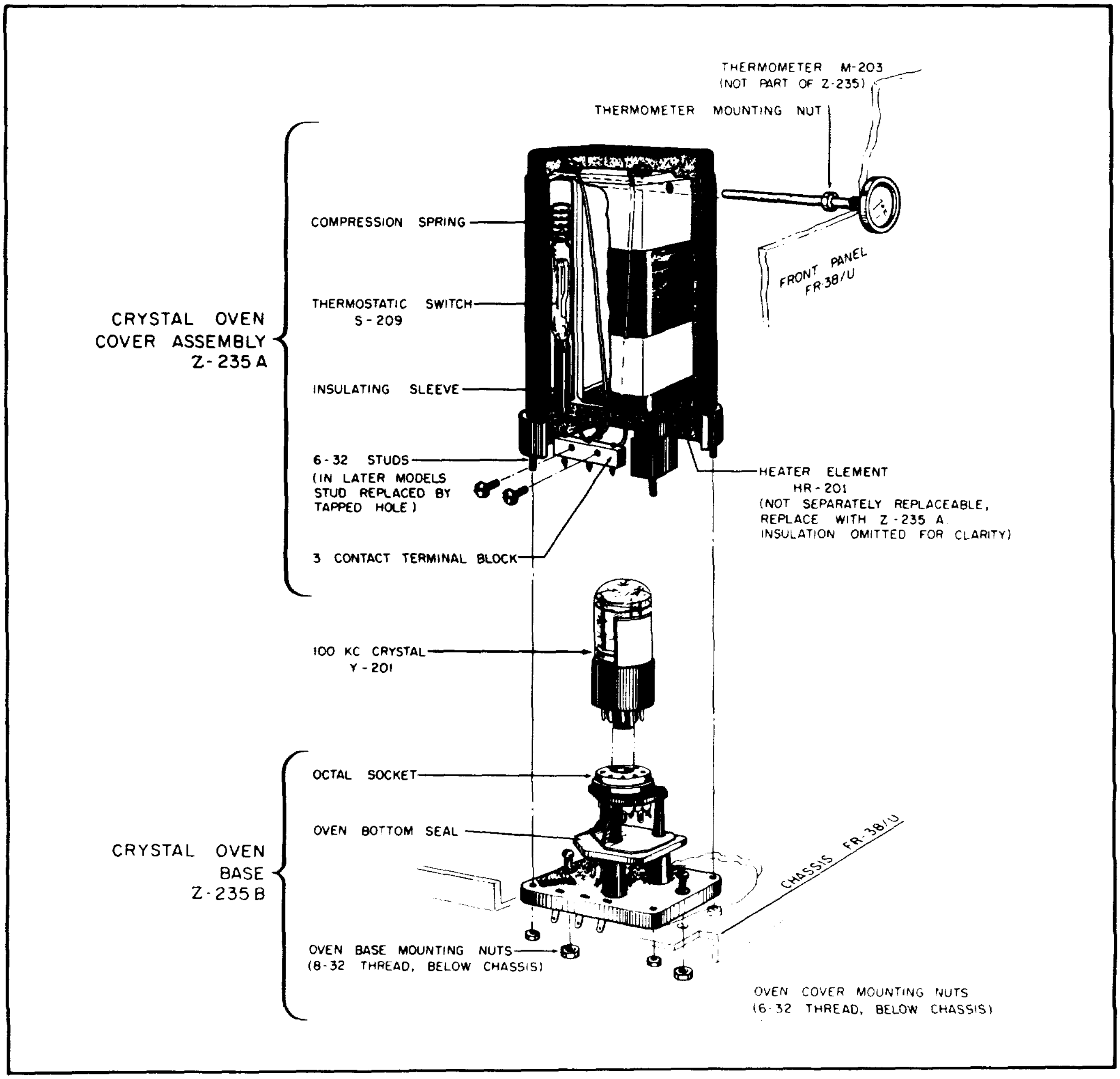


Figure 11-5. Exploded View of Crystal Oven, FR-38/U only.

selecting diodes can be built quite easily. Construct a box 14 in. long by 10 in. wide by 9 in. deep of 1/2 or 3/4-inch plywood and line the inside of the box with 1/2-inch Celotex. Make a flat cover and line the inside. Mount a 100-watt bulb inside to serve as a heater and control this with a thermostat that can be set to 65°C (149°F). A small motor with a 3- or 4-inch fan blade should be mounted inside the box. This is important in maintaining even temperatures. Ten pairs of spring clips of a type that will hold the diodes should be mounted on a 1-3/4 in. by 10 in. fibre board. Mounting brackets should be made to hold this whole assembly in the center of the temperature-controlled box. Leads from the clips are connected to a 10-point rotary switch outside the box. A dial thermometer is installed so that its stem is in close proximity with the diodes. To use the box, proceed with the following steps:

a. The heater should be turned on and the box allowed to come up to temperature of 65°C (149°F).

b. Put the board holding the diodes in place, allowing five minutes or more as necessary for the diodes to come up to temperature.

c. Measure the back current, using the circuit shown in Figure 11-3. The current should be 17 microamps or less for a good diode. Creep (resistance change) of more than 5 percent in a minute is unsatisfactory.

d. Use rotary switch to check each diode.

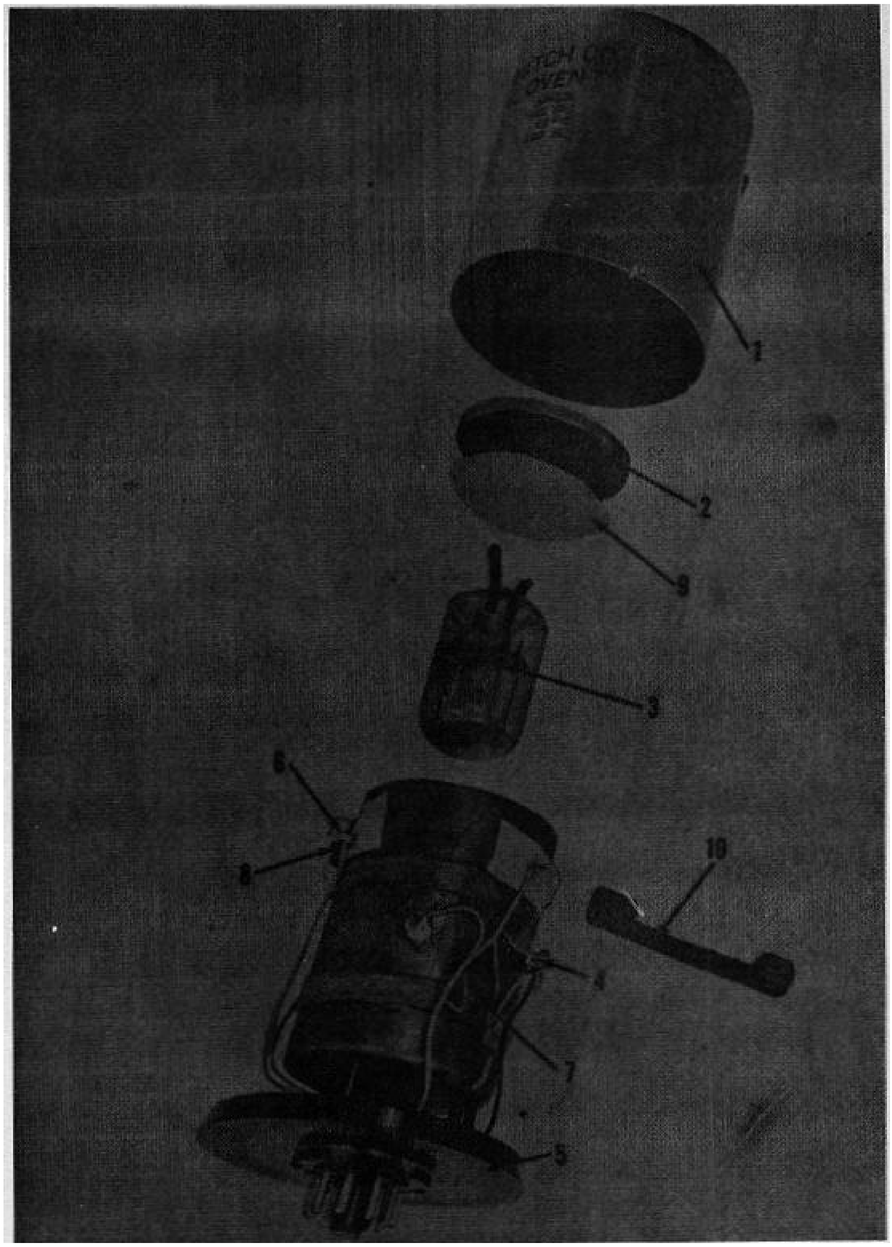


Figure 11-5A Exploded View of Crystal Oven, FR-38C/U and FR-38D/U

11-51A. REMOVAL OF CRYSTAL OVEN ASSEMBLY, CRYSTAL AND THERMOSTATIC SWITCH IN FR-38C/U AND FR-38D/U (see figure 11-5A).

WARNING

Disconnect input power cord from power source to remove power from crystal oven assembly before removing it from chassis

a. Remove thermostat M-203 by removing its mounting nut behind front panel and drawing thermometer out through front panel.

b. Pull crystal oven assembly from its socket.

c. Remove the four screws around the base of crystal oven assembly and remove cover.

d. Carefully remove all insulating material and retain for replacing.

e. Remove screws in top cap and lift off cap. This allows access to crystal Y-101.

f. Unsolder the two leads to crystal and withdraw it from its insulation packing.

g. Thermostatic switch S-209 is soldered to side of inner oven assembly. Unsolder leads to switch and the switch to replace.

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11-52. THERMOMETER, 100 KC CRYSTAL, AND THERMOSTATIC SWITCH FROM CRYSTAL OVEN ASSEMBLY.

WARNING

The input power cord must be disconnected from the instrument before attempting removal of the crystal oven parts or assembly. The oven is connected to the input power line continuously as long as input power is supplied to the instrument.

a. Remove thermometer M-203 by loosening the thermometer mounting nut behind the front panel. Draw the thermometer out through the front panel.

b. Crystal oven cover assembly Z-235A is removed by unscrewing the four mounting screws below the chassis. See Figure 6-5. The oven cover is now loosened and can be pulled straight up. The space above the oven is limited by the decade counter deck plate so that the cover does not completely clear the 100 kc crystal and base assembly Z-235B. Removal can be accomplished by raising the cover as far as it will go and loosening the 100 kc crystal Y-101 in its octal socket so that it is tipped slightly to one side. Then tip oven cover in the same manner for (complete removal. Be careful that the loosened crystal does not drop out as the cover is pulled away from the chassis.

NOTE

In earlier models (Serial Nos. 1 to 26) of the FR-38/U equipment, the crystal oven cover assembly was provided with four 6-32 mounting studs and is removed by removing the four mounting nuts below the chassis. Otherwise, the instructions for removal apply as stated.

c. The 100 kc crystal Y-101 is fitted with an octal tube base and is removed by pulling it straight out of the octal socket.

d. To remove the thermostatic switch S-209 from the oven assembly, first remove the two mounting screws securing the terminal block and draw the block out of the way. The switch is drawn out of the hole in the heater casting by pulling on the wire leads. If the switch resists pulling, insert a small screwdriver through the insulating sleeve and press lightly on the bottom of the switch while pulling gently on the wire leads of the switch. This is done until the switch frees itself and can be drawn from the casting.

11-53. REMOVAL OF CRYSTAL OVEN ASSEMBLY.

a. Proceed with steps 11-52a and b.

b. Wires connected to terminal lugs on the crystal oven base should be unsoldered. Note color coding and wire connections so that the repaired or replacement unit can be reconnected properly.

c. Remove the two 8-32 nuts below the chassis that secure the crystal oven base assembly Z-235B as shown in Figure 11-5.

d. The replacement unit is installed by tightening the two 8-32 mounting nuts that secure the base assembly. All wires should be reconnected to the proper terminals and soldered. After making certain that the crystal is firmly seated in its octal base, the oven cover assembly is then fastened in place by tightening the four 11-32 mounting screws. The thermometer M-203 is inserted through the front panel and locked in place by tightening the thermometer mounting nut on the washer behind the front panel.

11-54. MULTIPLIER ASSEMBLY. The multiplier assembly is mounted to the time base deck by eight mounting nuts pictured in Figure 11-6.

11-55. Each screw projecting through the deck plate is actually one of the mounting screws of the shield cans used in the multiplier.

a. Disconnect all wires from the multiplier circuit in the terminal strip and other connections, as shown in Figure 11-6.

b. Loosen and remove the eight mounting nuts securing the multiplier assembly to the time base deck plate. The assembly is now free and can be removed by lifting straight out.

c. The multiplier assembly is installed by positioning the unit so the outside mounting screw of the shield cans projects through the deck plate. The mounting nuts are then replaced and tightened.

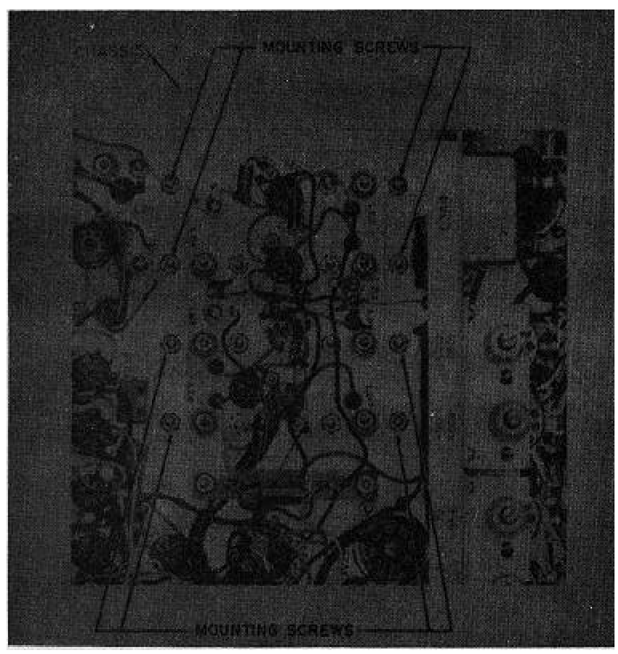


Figure 11-6. Multiplier Assembly Mountings

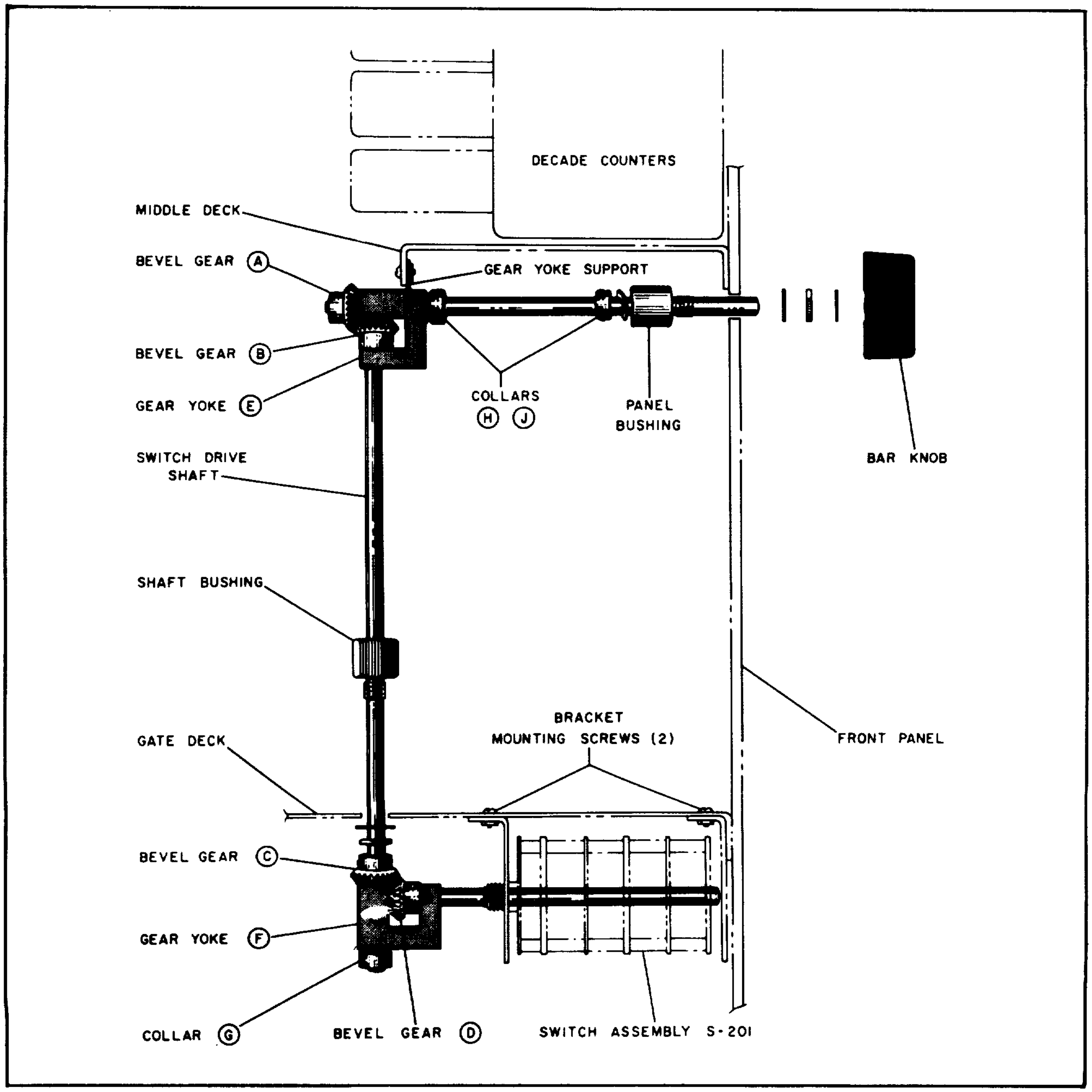


Figure 11-7. Switch Drive Assembly

d. All electrical wires should be reconnected and soldered.

NOTE

If the multiplier assembly is repaired or replaced, the unit should be realigned due to possible circuit changes in capacitance caused by wire connections to other parts of the instrument.

11-56. LINE FILTER. The power plug line filter assembly FL-201 shown in Figure 10-8 is removed by unscrewing the two screws securing the input power socket to the front panel. Electrical wires connected to the end of the filter should be unsoldered, and capacitor C-352 should be lifted from the clip mounting so that the filter assembly can be drawn forward from the front panel. The replacement filter is inserted into the panel opening and secured in place by the two mounting screws. The electrical leads should be reconnected and soldered. Capacitor C-352 must be secured in the clip mount.

11-57. BLOWER ASSEMBLY. The blower B-201 is secured to the chassis of the instrument by four screws. Two 8-32 screws are located on the lower right side of the chassis as shown in Figure 10-8 The other two screws, supporting the blower mounting bracket, are found on the deck plate immediately above the blower, one screw located on each side of the time base deck plate. The capacitor, C-350 and C-351, across the blower motor is fastened directly to the mounting bracket. The electrical power leads from the blower motor to the bridge rectifier CR-260 must be disconnected before the blower assembly can be removed or replaced.

11-58. SWITCH DRIVE ASSEMBLIES. The drive assemblies on the three front panel controls (TIME UNIT, FUNCTION SELECTOR, FREQUENCY UNIT) are relatively simple mechanically and should not normally present any maintenance problem. The drive mechanism of the FUNCTION SELECTOR is the most complicated of the three assemblies, since it involves bevel gears to link the main switch to the wafer switch mounted in the front center position under the gate deck. The gear drive mechanism and the wafer switch S-201 is shown in Figure 11-7 In the event maintenance or repair of switch S-201 is necessary, the following procedure should be followed.

a. Release the two set screws in the shaft collar (G) with an Allen wrench.

b. Next. loosen the two allen-head set screws in bevel gears (B) and (C) in Figure 11-7) to release the switch drive shaft.

c. The switch drive shaft can now be drawn out from the gear assembly by gripping the exposed shaft end with pliers and pulling straight out. In some cases, burrs caused by set screws imbedding in the shaft will make it difficult to draw the shaft out. This can be overcome by working the shaft back and forth gently until the burred portions on both shaft ends are exposed. The surface of the shaft then can be cleaned by sanding with fine grade emery cloth. Do not try to draw the shaft through the shaft bushing on the gate deck until it is completely free of burrs.

d. The gear yoke (F) can be removed by unscrewing the two allen-head set screws in bevel gear (D) and pulling the yoke off the switch shaft.

e. The switch assembly S-201 is then removed by unscrewing the four 6-32 screws which secure the switch mounting brackets.

11-59. REMOVAL OF INDICATOR METERS.

11-60. Either indicator meter (M-201 or M-202) can be removed for repair or replacement by the following method.

a. Disconnect wires on the two terminals on the rear of the meter. (See Figure 11-8)

b. Remove meter from panel by unscrewing the three mounting screws. The screws thread into tapped holes in the front panel.

c. Meters are replaced by tightening the three mounting screws to secure the meter and replacing the wires to the proper terminal on the rear of the meter.

11-61. 1 TO 10 MC CHECK.

11-62. This 1 to 10 megacycle check is the one check that will determine better than any other if the counter circuits, gating circuits, and power supply are functioning as they should. As such, it is an invaluable check for detecting marginal functioning of components before actual counter failure takes place. To make this check, set the FR-38/U panel controls as follows:

CONTROL SETTINGS

FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.01 SEC.
TIME UNIT	100 KC
DISPLAY TIME	Minimum
100 KC STANDARD	INT

11-63. Connect a variable frequency oscillator that covers the range of 1 to 10 megacycles to SIGNAL INPUT of the FR-38/U. With 115 volts line to the counter, start with 1 mc and slowly increase the input frequency. (An external vernier on the tuning drive of the oscillator may be necessary so that the frequency can be increased slowly and evenly.

a. The UNITS meter (M201) should increase one number at a time. Any tendency to hesitate on a number or to skip numbers is an indication of trouble in the 10 MC SECTION.

b. The TENS meter (M202) should increase 1 count each time the UNITS meter goes from 9 to 0.

c. Decade counter Z-204 should increase one count each time the TENS meter goes from 9 to 0, and so on, down the line of plug-in decade counters.

d. The TENS meter should drop from 9 to 0, not 9 to 6 to 0. If this meter goes from 9 to 6 to 0, check the capacitance of C-244 (15 mmf ±10%). Too large a capacitor here may be the cause of the trouble. This same trouble will also show up as an indication 10 to 20 counts short with a 10 MC SIGNAL INPUT and a 1-second gate.

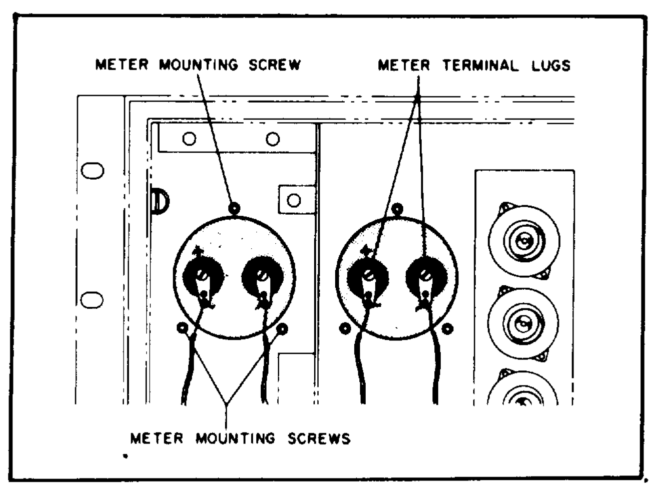


Figure 11-8. Meter Mounting

e. As the frequency of the test oscillators is slowly increased from 1 to 10 megacycles, the indicated reading on the FR-38/U should increase smoothly without instability or hiatus.

11-64. At SIGNAL INPUT frequencies near 10 megacycles, it is not feasible to stop the meters on each count. Trouble is easily detected even at these frequencies, however, because each meter should swing back and forth at an even rate if the FR-38/U is working properly.

NOTE

IMPORTANT! Repeat the check as outlined above at 103.5 volts line and at 126.5 volts line.

11-65. ISOLATING CAUSES OF INSTABILITY. If instability is noticed at any frequency, careful study of the meters can give an indication of the section in which the trouble originates.

a. If the UNITS meter swings smoothly as frequency is increased, but the reading on the TENS meter and on all following plug-in decimal counters becomes unstable at some frequency, the 10 MC SECTION is probably functioning correctly and the trouble is in the 1 MC SECTION.

b. If the UNITS and TENS meters both operate smoothly, but the count jitters on the decade counter Z-204 and all following decade counter units, the trouble is probably in Z-204 or V-223.

NOTE

At any particular frequency, decrease the SIGNAL INPUT voltage to the FR-38/U to see how this instability manifests itself in the meter indications and on the plug-in decade counters. If in doubt about an indicated count, turn DISPLAY TIME control to INF and depress RESET push button several times to take readings.

11-66. CORRECTION OF INSTABILITY. If meter instability has developed, check waveforms in the counter (see paragraph 6-39) with an oscilloscope, maintaining the same INPUT SIGNAL frequency and line voltage that caused the trouble to show up.

11-67. If the UNITS meter jitters, the trouble may be in tie GATE SECTION, TIME BASE. or POWER SUPPLY. Check delay line DL-201 for poor output waveform, a condition which might cause retriggering of V-203. Extra counts can come through even when the gate is supposed to be closed, resulting in a count that is always larger than it should be. If the trouble is not immediately evident, use an oscilloscope and check the circuit waveforms. See System Analysis, paragraph 11-28.

11-68. POWER SUPPLY.

11-69. Correct operation of the power supply is vital proper operation of the FR-38/U. Hum, noise or other variations on the regulated voltage lines (particularly +210 regulated (red) and -195 (green)) can cause the gate circuits, the phantastron dividers, the binaries in the counter section and other circuits to operate in a random and erratic manner. It is advisable to make a resistance and voltage check on the power supply prior to any maintenance work. This will eliminate such factors as low voltages or poor regulation as causes of improper operation.

11-70. VOLTAGE ADJUSTMENT. Five separate dc voltages are present in the power supply; four of these (-195, +210, +90, +70) are interdependent. The unregulated 300 volts supplied by V-249, V-250 and V-251 are independent. The regulated power supply voltages are adjusted by potentiometer controls R-524 (-195 volts), R-501 (+210 volts), R-509 (+90 volts) and R-516 (+70 volts). The location of these controls is shown in Figure 5-6 and the adjustment procedure is given in paragraph 5-17.

11-71. Abnormally high voltages on the +210 regulated bus or deviation of the +90 or +70 terminal far from the correct values can cause damage to the plate clamp crystal diodes. A spread of more than 50 volts between the +70 and the +90 volt terminals can cause serious damage to the crystal diodes. If such a spread is noted and cannot be corrected by proper adjustment, turn the unit off immediately and locate the fault by measuring resistance to ground of all regulated voltage busses.

CAUTION

Tape up all but the very tips of voltmeter test prods and oscilloscope probe. A single slip of a test lead which shorts +90 or +70 to +210 or to ground can cause irreparable damage to many of the crystal diodes in the FR-38/U.

11-72. RESISTANCE CHECK. Resistance checks will quickly indicate the presence of defective components. The resistance measured from the regulated voltage busses to chassis ground with a 20,000 ohm per volt ohmmeter (or multimeter) should read:

- 195 volt bus	5000 ohms to chassis
+210 volt bus	1400 ohms to chassis
+ 90 volt bus	1000 ohms to chassis
+ 70 volt bus	725 ohms to chassis

These values, ±10%, should be obtained. If other readings are found, check the particular circuit for defective components.

11-73. EXTERNAL RESISTANCE LOAD. The operation of the power supply can be checked with an external resistance load connected in place of the counters. This precautionary measure will prevent damage to the crystal diodes that might otherwise result from faulty power supply operation.

Table 11-6. Equivalent Resistance Load for Power Supply

Nominal Supply Voltage	Average Load Current	Equivalent Resistive Load for Power Supply Test	
Volts	Ma		
+210	355	600	75W
+ 90	21	4K	2W
70	39	1.8K	5W
-195	7	28K	2W

CAUTION

Do not turn power supply on with either +210, +90 or +70 volt busses disconnected. If one bus is removed, disconnect all three. Turn power switch to standby (down position) before replacing any tubes in the power supply.

11-74. VOLTAGE REGULATION. The power supply regulation can be checked by connecting a dc voltmeter to the +210 (red) bus and observing the operation of the regulator for line voltages from 103.5 to 126.5 volts ac. Waveforms showing normal and abnormal regulation of power supply voltages are shown in Table 10-7. The regulator will function over this range if there is no trouble in the power supply circuits. Failure to regulate, particularly near the minimum voltage limit of 103.5 volts, will probably manifest itself as erratic counter operation later on.

11-75. A convenient way to determine when the regulator takes over is to drop the input line voltage to about 90 volts (low enough so that the regulator definitely drops out of operation) and then gradually increase the line voltage with a Variac transformer. Connect a dc voltmeter to the +210 volt (red) bus. The +210 volt bus should increase with line voltage until the regulator takes over. Between the limits of 103.5 and 126.5 volts the +210 bus should not increase more than 3 volts. If the regulator is not operating properly, a 10% increase in line voltage should increase the +210 volt bus by 10%.

11-76. An oscilloscope can also be used to check the operation of the regulator. The waveforms shown in Table 11-7 should be observed.

11-77. TIME BASE SECTION.

11-78. PEAKING OSCILLATOR. When the internal 100 kc oscillator tube V-234 is replaced, two adjustments should be made. First, the voltage generated by the oscillator should be maximized, and second, the oscillator should be standardized in accordance with paragraph 1-79. The procedure for peaking the oscillator voltage output is as follows:

a. Turn off POWER switch and remove cabinet from equipment.

b. Turn on power. Set 100 KC STANDARD switch to INT. The settings of the other controls do not matter and neither of the plug-in units need be in place.

c. Connect the high impedance probe of an oscilloscope such as the OS-4(XN-1)/AP to the junction of C-290 and C-291. Adjust the oscilloscope until the 100 kc voltage at this junction is conveniently displayed. "S" type operation for the oscilloscope is desirable.

d. Now tune L-211 (see Figure 10-6) until the 100 kc voltage is at maximum.

e. After peaking the oscillator in the above manner, standardize the oscillator as described in paragraph 11-79. It is desirable to allow the replacement tube to operate for 24 hours or so before standardizing. If the ADJ control on the front panel will not change the oscillator frequency an amount sufficient for standardizing, see paragraph 10-19.

11-79. SETTING FREQUENCY OF 100 KC CRYSTAL OSCILLATOR.

11-80. The frequency of the 100 kc crystal oscillator may be standardized by several methods, as described in paragraph 10-36. If comparison with WWV is not convenient (Method II, paragraph 10-40) it is also possible to use a primary frequency standard, an oscilloscope, and the following procedure.

a. Using a primary frequency standard (two parts per million or better), connect a clip lead from 100 KC STD. FREQ. OUTPUT to the VERTICAL input of the oscilloscope.

b. Connect a ground wire between the oscilloscope GROUND and the FR-38/U chassis.

c. Connect the 100 kc primary frequency standard to the HORIZONTAL input of the oscilloscope. A 1:1 Lissajous pattern as shown in Figure 11-9) should result if the crystal oscillator is on frequency. The crystal oscillator and the 100 kc standard are operating at exactly the same frequency if the pattern remains stationary. If the pattern moves one way or the other, adjust C-294 (ADJ) on the front panel of the FR-38/U. If this adjustment will not make the pattern stationary, adjust C-295 and C-296 (see paragraph 10-19 and Figure 10-8.)

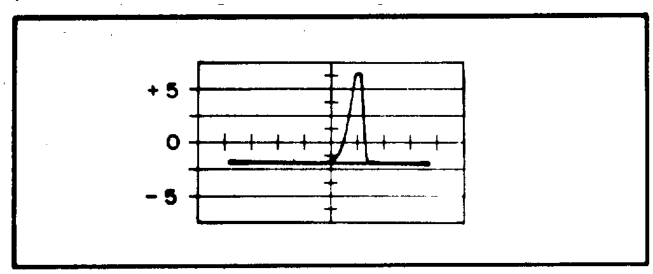


Figure 11-9. 100 KC Oscillator Lissajous Pattern

11-81. ADJUSTMENT OF 160 KC TRAP. The 160 kc trap (C-335, C-336 and C-223) in the grid circuit of Crystal Oscillator V-234 is used to damp a secondary mode of the 100 kc crystal Y-201. The spurious signal is at approximately 160 kc and can be observed by loosely coupling an oscilloscope to the plate or screen lead of V-234. The presence of the 160 kc signal is observed as a broadening or thickening of the output waveform of V-234. Note that the spurious signal can be most easily observed by coupling to the screen grid (pin 6) of V-234. It is more difficult to observe on the plate lead (pin 5) because of the 100 kc tuned circuit. The spurious mode is sometimes difficult to detect because it may appear as an intermittent or random condition, depending on factors such as crystal heating or power supply voltages.

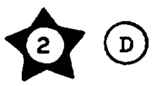
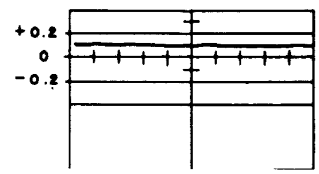
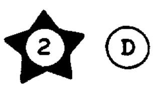
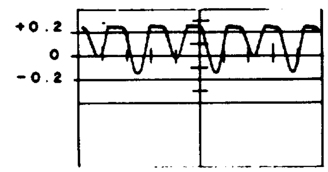
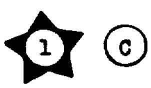
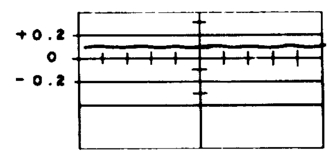
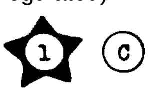
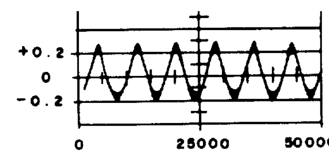
11-82. The trap may be tuned to eliminate the 160 kc by the following method:

Table 11-7. Power Supply Waveforms

Conditions of Observation:
Model FR-38/U

Oscilloscope
SWEEP: 5000 microsec/cm

100 KC STANDARD: EXT (no connection to 100 KC INPUT)
Line 85 to 130 volts as indicated
No INPUT to the instrument

TEST POINT AND LOCATION	TO CHECK	
+210V (regulated) 	Correct operation of the +210 regulator. (Line voltage, 115 volts)	
+210V (regulated) 	Just below correct operation of +210 regulator. (Line voltage, 95 volts)	
-195V (regulated) 	Correct operation of -195V regulator. (Line voltage, 115 volts)	
-195V (regulated) 	Just below correct operation of - 195V regulator. (Line voltage, less than 85 volts)	

a. With the Crystal Oscillator V-234 operating, an oscilloscope should be coupled loosely (through approximately 2 mmf) to the screen lead (pin 6 of V-234).

b. C-335 located on the left side of chassis, as shown in Figure 6-10, should be adjusted until a clean 100 kc waveform is obtained.

11-83. PHANTASTRONS.

11-84. The circuitry of all five phantastrons is identical except for the value of the timing capacitors which increase in decade steps as listed in Table 11-8.

Table 11-8. Values of Timing Capacitance in Phantastrons

Phantastron	Part	mmf	Freq.	Gate Sec.
1st	C320	47	10 kc	.001
2nd	C322	470	1 kc	.01
3rd	C324	4700	100 cps	.1
4th	C326	50,000	10 cps	1.
5th	C328	500,000 (.5 mfd)	1 cps	10.

11-85. The operation of the phantastrons can be checked by two methods: Self-check and external check.

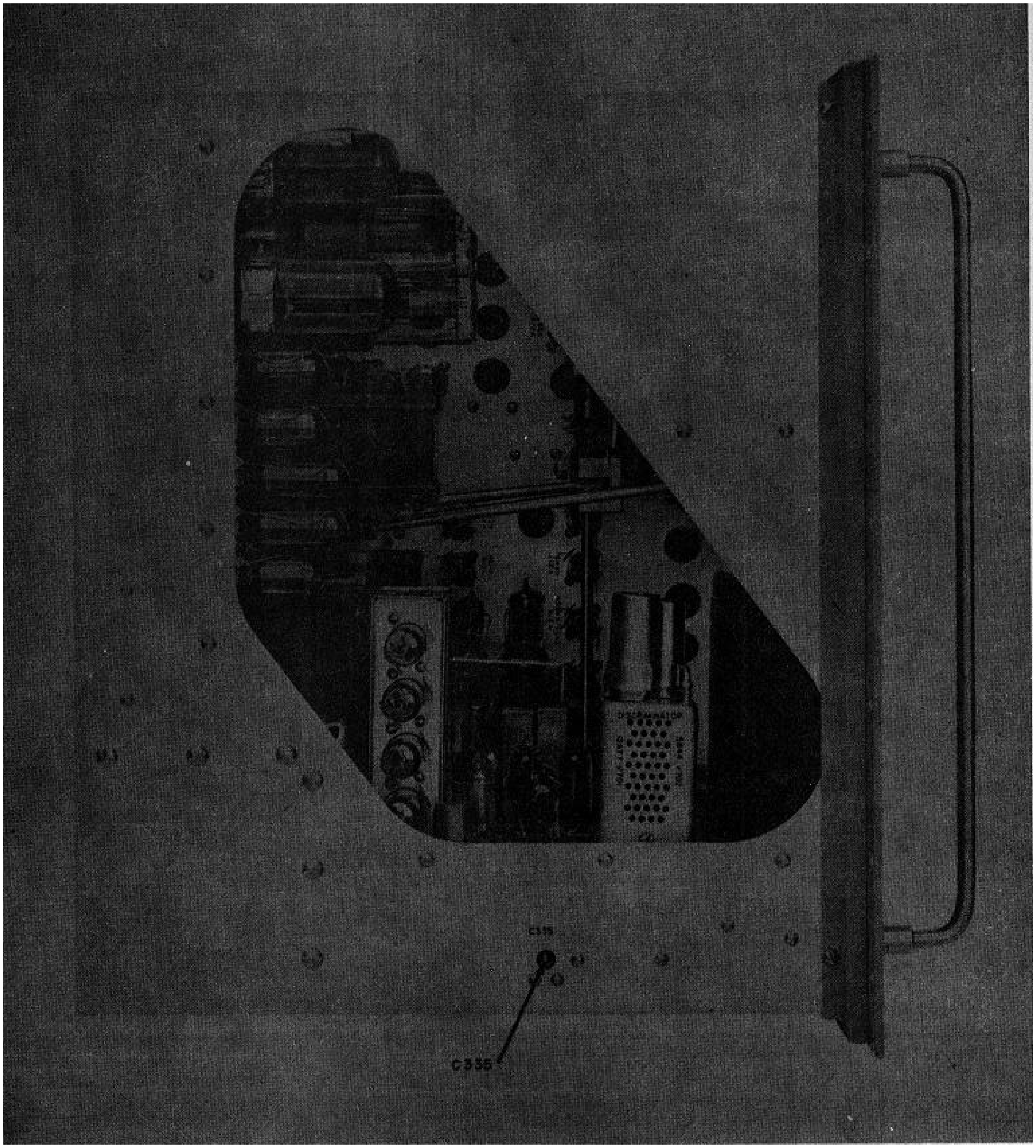


Figure 11-10. Frequency Meter FR-38/U, Left Side View

The self-check method can be employed when the FR-38/U will count its own internal standard; no external equipment is required. The external check method, used Then the instrument will not count its own internal standard correctly, requires an external frequency standard and an oscilloscope.

11-86. METHODS OF CHECKING PHANTASTRON OPERATION: I. SELF-CHECK.

11-87. If the FR-38/U will count its crystal standard with the FUNCTION SELECTOR switch S-201 in 100 KC CHK position, follow the procedure outlined under "Phantastron Adjustment" in paragraph 10-18.

11-88. In the Block Diagram of the Time Base Section of the FR-38/U (Figure 9-43, notice that for the 0.001 GATE SECONDS only the first (10 kc) phantastron is used; the others need not be operating, or they may be set to divide by 9, 10, 11, 12 or 13 without affecting the first. Similarly, for the 0.01 GATE SECONDS the first and second phantastrons only are used, etc.

11-89. EXTERNAL CHECK OF PHANTASTRON OPERATION.

11-90. In some cases, maintenance work on other circuits, particularly the GATE SECTION, can be carried out more easily if it is known that the phantastron dividers are functioning correctly. Only the power sup ply and crystal oscillator need be working to completely test and adjust the TIME BASE SECTION, using the procedure outlined below.

11-91. Set the FR-38/U panel controls as follows:

a. Connect the output of an accurate frequency standard (sine wave outputs of 100 kc, 10 kc, 1 kc, 100~/ sec and 10~/sec) to the HORIZONTAL input of an oscilloscope. (If a frequency standard is not available, a wide-band test oscillator can be used to make these checks. Connect the output of the oscillator to the HORIZONTAL input of the oscilloscope and set the dial for the desired frequency. When the VERTICAL input of the oscilloscope is connected to the phantastron, adjust the frequency of the oscillator slightly if necessary to stop the movement of the pattern.)

b. Set frequency standard to 10 kc output.

c. Connect the VERTICAL input of the oscilloscope (probe) to the cathode pin 2 of V-241. A 1:1-pattern results if the first (10 kc) phantastron is dividing by 10 as shown in Figure 11-11 while a rather complicated pattern of lines if the counter is dividing by a number other than 10 (i.e., 8, 9, 11, 12). A straight horizontal line will be seen if the phantastron is not functioning at all.

d. The 1:1 pattern will rotate slowly if the 100 kc crystal in the FR-38/U and the one in the frequency standard are not both tuned to exactly the same frequency. The pattern can be stopped by adjusting either crystal oscillator or by connecting the 100 kc output of the frequency standard (1 volt or more rms) to the 100 KC STD. INPUT and throwing the switch to EXT.

e. Turn R-444 completely counterclockwise, then back clockwise until the pattern just changes from one similar to the 1.2:1 ratio shown in Figure 6-11 to the 1:1 ratio. R-444 should be set in the middle of the region where a division by 10 is obtained.

f. Follow steps "a" through "f" for the 2nd, 3rd and 4th phantastrons, adjusting R-453, R-462 and R-471 for the respective stages to obtain the correct division ratio.

11-92. The 5th phantastron (1 cps) cannot be checked by this method unless a 1 cps standard and low-frequency oscilloscope with a long-persistence screen are available. If the first four phantastrons are operating properly, all other counter adjustments can be made, at which time the 5th phantastron can be adjusted by following regular procedure in Section V.

11-93. CHECKING PHANTASTRONS WITH AN OSCILLOSCOPE.

11-94. The calibrated sweep on the oscilloscope can be used to check the operation of the phantastron if a frequency standard is not available. Sweep accuracy of the oscilloscope is easily checked by observing the FR-38/U's 100 kc crystal oscillator and counting the number of cycles across the screen. The complete procedure is as follows:

a. Connect the oscilloscope probe to cathode pin 2 of V-241.

b. Calibrate the oscilloscope sweep at 200 micro-seconds full scale.

c. The period P (Figure 11-12) should be 100 microseconds for the first phantastron. P is an indication of the number by which the 1st phantastron is dividing; 80, 90, 100, 110, 120, 130 or 140 microseconds indicate division by 8, 9, 10, 11, 12, 13 or 14.

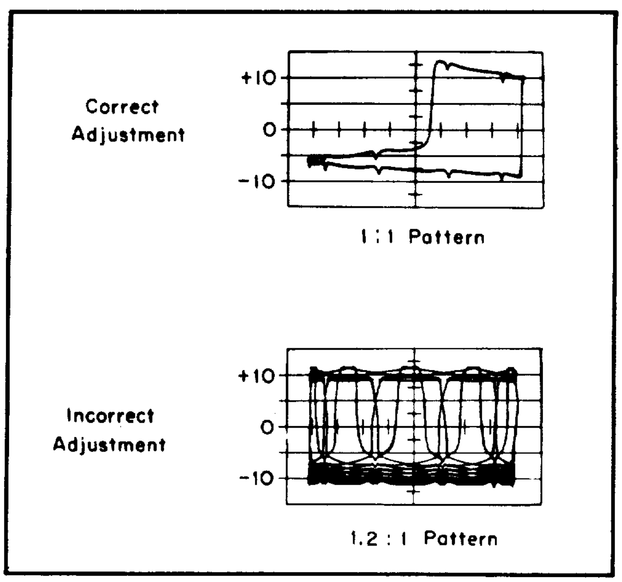


Figure 11-11. Phantastron Lissajous Patterns

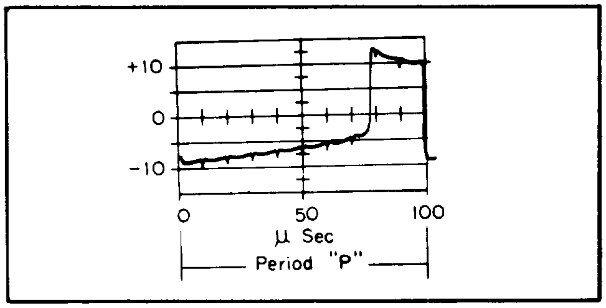


Figure 11-12. Phantastron Waveform Showing "Period"

d. Turn R-444 completely counterclockwise, then back clockwise until the period P just changes from 110 microseconds to 100 microseconds:

e. Follow steps "a" through "d" for the other phantastron stages, adjusting R-453, R-462 and R-471 respectively.

Table 11-9. Oscilloscope Sweep Settings Used When Checking Phantastrons

Phantastron	Period (P)	Scope Sweep
2nd	1000 microsec.	2000 microsec.
3rd	10,000 microsec.	20,000 microsec.
4th	100,000 microsec.	200,000 microsec.

NOTE

A simple TIME BASE CHECK on the phantastrons can be made with a vacuum tube voltmeter. Connect the VTVM to pin 5 of V-247. It should "kick" once a second if all five phantastrons are functioning properly. Count the number of "kicks" in a minute or two. Any great error in operation of the time base will be quite apparent.

11-95. In cases of erratic operation. recheck operation of the +210 regulator in the power supply, particularly if operation is erratic at low line voltages.

11-96. CHECKING PHANTASTRON DIVIDERS FOR "FREE RUN".

11-97. After the phantastrons have been set up for correct division, make a final check to see if any one of them will "free run" with the 100 kc drive removed. Set the FR-38/U panel controls as follows:

CONTROL SETTINGS

FUNCTION SELECTOR	100 KC CHK
FREQUENCY UNIT	10 SEC.
TIME UNIT	100 KC
DISPLAY TIME	Minimum
100 KC STANDARD	INT

a. Drop line voltage to 103.5 volts rms with a Variac.

b. When count begins, snap 100 KC STANDARD INT-EXT switch to EXT. This stops the crystal oscillator, thus removing the drive from the phantastrons with the gate in the open position. The counters should run indefinitely, as the gate should stay open. If the counters stop, it is an indication that one or more of the phantastrons has operated as a free-running multivibrator and has closed the gate. Connect the oscilloscope to the cathode, pin 2 of V-241 of the first phantastron and watch for signs of operation. Repeat this on all others in turn. It is important to begin the check on the first phantastron and work toward the fifth, because any phantastron that free-runs sends a driving pulse to all others down the line.

c. When the free-running phantastron is located, try a new 5725/6AS6W. If all phantastrons free-run, check regulation of -210 volt power supply with an oscilloscope.

11-98. FREQUENCY MULTIPLIERS.

11-99. The multiplier section (V-237 through V-240) is straightforward and trouble-shooting is not difficult. If the multipliers are suspected of malfunction, check and replace tubes as necessary. The multiplication factor of each stage can be checked by methods described in Table 10-6 or can be checked by observation of the waveform (see Table 11-2 Steps 18 through 26). The tuned circuits on grids and plates can be peaked during either procedure referred to above for multiplication check.

11-100. AMPLITUDE DISCRIMINATOR.

11-101. The Amplitude Discriminator Z-202 supplies fast rise time pulses to drive the decade divider Z203 and the gating circuits. Potentiometer control R-248 (PERIOD SENS) adjusts the bias on V-701B and should be adjusted whenever any tubes in Z-202 are replaced. The procedure for adjustment of R-248 is given in paragraph 10-21. If Z-202 is suspected of malfunction. check the input and output waveforms (Steps 31 and 32 in Table 11-2). Lack of output signal may be due to non-operation of the unit. However, check to be certain that Z-202 is receiving a triggering signal voltage from the time base or from SIGNAL INPUT, depending on whether the instrument is set for frequency or period measurement. Check and replace weak tubes and adjust PERIOD SENS. potentiometer R-248. If replacement tubes do not correct operation, return original tubes to their sockets and check resistance and voltages from the tube sockets to locate defective components.

11-102. SERVICING DECADE DIVIDER.

11-103. The decade divider Z-203 is a basic four-stage (scale-of-16) binary with two feedback loops to convert to a scale-of-ten. Waveforms for the four stages will be similar to those for the 1 MC SECTION of the counters. The input signal to the decade divider comes from the time base section via switch S-201E and amplitude discriminator Z-202 for frequency measurement. The input signal comes from SIGNAL INPUT via amplitude discriminator Z-202 for 10-period measurement. Z-203 is by-passed in period measurement by switch S-201D. The same general principles apply in servicing the decade divider as apply to other binaries. Good balance should be maintained in the plate-to-grid resistors and capacitors and in the grid-to-ground resistors. The unit utilizes the "etched circuit" technique and faulty or defective components can be easily replaced. To remove components, pry them away from the board while applying heat to the solder. To avoid damaging the etched circuit, apply only enough heat to release the component.

11-104. If the decade divider is suspected of malfunctioning, it can be connected to the FR-38/U by an extension cord to facilitate service work. This cord should not be over 24 inches long and input and output (pins 1 and 2) must be run as single wires without shielding. They cannot be bound into a cable with other leads, as stray coupling will give misleading results. (See Figure 7-3.)

11-105. Set the FR-38/U panel controls as follows and proceed with the test procedure given below:

CONTROL SETTINGS

FUNCTION SELECTOR	100 KC SELF-CHECK
FREQUENCY UNIT	.01 SEC.
100 KC STANDARD	INT

a. Connect an oscilloscope to decade divider socket pin 2 to observe output, pin 1 to observe input. See steps 32 and 33, Table 11-2. The decade divider should deliver 1 output pulse for every 10 input pulses.

b. If the decade divider is suspected of faulty operation, a simple check can be made by removing it and connecting pin 1 to pin 2 in the decade divider socket as shown in Figure 21-13, The FR-38/U should operate normally in all respects, except that the counts in frequency and 10-period measurements will be smaller by a factor of 10 than they would be with the decade divider in place.

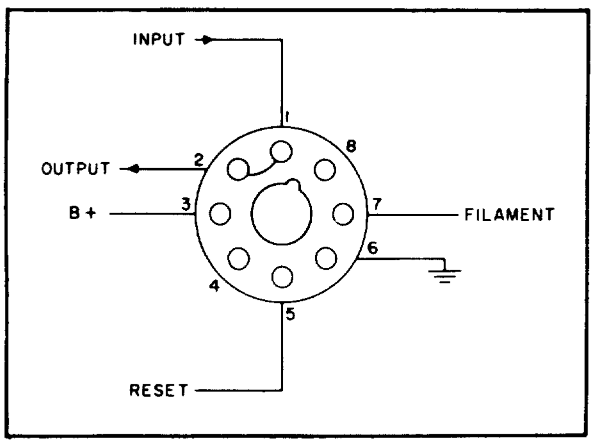


Figure 11-13. Decade Divider Socket Test Connection

11-106. Lack of input signal to the decade divider might be caused by malfunctioning of amplitude discriminator Z-202, failure of phantastron stages in time base, or switch S-201D and E.

11-107. GATE SECTION.

11-108. The operation of the gate section can be check- ed best by observation of the waveforms of each individual stage. It incorrect waveforms are observed, check and replace weak tubes. If circuit operation is still not correct, check voltage and resistances in the circuit for defective components. Gate section waveforms are shown in steps 34 through 47, Table 11-2.

11-109. GATE BINARY. The gate binary V-206 and V-207 is triggered by negative start pulse and stop pulse signals from decade divider Z-203. Connect an oscilloscope to the plate of the binary (pin 5, V-206 and V-207). The waveforms observed should be square waves occurring at one-half the frequency of the decade divider. See Steps 34 through 40 of Table 11-2 for correct binary waveforms.

11-110. If the waveforms of the binary are incorrect, determine first if the binary is functioning improperly because of a defect within the binary, because of improper drive to the binary, because of trouble in associated circuits, or because of undue loading or coupling caused by measuring instruments used.

11-111. Check both tubes in the binary for weak tubes and replace if necessary. Weak tubes may cause erratic operation in the binary, especially if line voltage is low. If the new tubes do not restore correct operation, replace original tubes and check dc voltages.

11-112. A dc voltage check can be made by removing the tubes from the binary and disconnecting the crystal diode clamps on the plates and grids (CR-207, CR-208, CR-210, CR-211, CR-206 and CR-209). Voltage measured at the plate and grid pins on the sockets should agree within 1 volt and the cathode voltage should be zero. This check will reveal large defects in components in the B+-to-plate, plate-to-grid, and grid-to-bias networks in the binary circuit. If the voltages do not agree, check resistances in the circuit to locate defective components. See voltage and resistance diagrams in Section XII. General troubleshooting information on binaries begins with paragraph 11-163 and should be consulted before proceeding.

11-113. CATHODE FOLLOWER. The cathode follower V-208A is driven by the output signal from the Gate Binary. The waveform observed at the cathode of V-208A (pin 8) should be the same as that present on the grid (pin 7) but down in amplitude. If the waveform is incorrect, check and replace tube.

11-114. DELAY LINE. The delay line DL-201 is driven directly by cathode follower V-208A. The output waveform of the delay line should be the same as the cathode waveform of V-208A. The output should normally be about one-half the amplitude of the input waveform. If the delay line is partially shorted, there will be a marked decrease in amplitude. Note also the shape of output waveform. The waveform must exhibit a clean, square waveform. If the waveform shows rounded edges indicating poor rise and decay times or "overshoot" indicating ringing, inaccurate triggering of the signal gate and erroneous counting may result. See separate discussion on delay line trouble-shooting in paragraph 11-135.

11-115. GATE CONTROL AMPLIFIER. The plate waveform of gate control amplifier V-203 (pin 5) should be a square wave with a 20 volt swing (clamped by CR-201 and CR-202). The grid waveform (pin 1) is the same as the delay line output.

11-116. Adjustment of GATE LENGTH potentiometer R-224, shown in Figure 10-9 sets the bias voltage on the grid of V-203, and thus determines the place on the delay line output where the gate opens or closes. The setting of R-224 may have to be adjusted slightly if the counter reads consistently plus 1 or minus 1 count. See Gate Accuracy, paragraph 6-130.

11-117. SIGNAL GATE. The operation of the signal gate V-202 is controlled by the voltage applied to the suppressor grid (pin 7). When the suppressor voltage is lowered to +70 volts, the plate current of V-202 is cut off (the closed gate condition). When the suppressor voltage is raised to +90 volts, plate current flows, the counted signal on the grid appears in the plate circuit and passes to the counter section.

11-118. If the stage seems to operate incorrectly, check first the clamping diodes CR-201 and CR-202 on the plate of V-203 (also suppressor clamps for V202). Check V-202 and replace if necessary.

11-119. DISPLAY TIME OPERATION.

11-120. AUTOMATIC. The automatic operation of the display time circuits (V-204 and V-205) can be checked in the following manner:

a. Set display time control to minimum (ccw).

b. Set function selector switch to 100 KC CHK.

c. Set frequency unit switch to 0.01 gate time.

d. Observe count indication on panel. Counters should alternate between count and display period. Now, as display time control is turned slowly in a clockwise direction, the display time of the count should gradually increase to approximately 5 seconds.

e. Now set display time control to INF position. Count should now count continuously until the RESET button is depressed. This resets the counter and the count should begin again.

11-121. MANUAL GATE. The manual gate operation can be checked as follows:

a. Set panel controls to:

FUNCTION SELECTOR	MANUAL GATE
TIME UNIT	1 KC
MANUAL GATE Switch	CLOSED (down)

b. Set the MANUAL GATE switch to OPEN (up) position. The counters should now indicate a progressive count.

c. Set the MANUAL GATE switch again to CLOSED (down) position. The count should stop.

d. Press the RESET button to clear the counter to zero.

e. Repeat steps "b" through "d" several times.

11-122. DISPLAY TIME THYRATRON. If the display time operation is correct, check the input and output waveforms of display time thyratron V-205 and reset thyratron V-209. The grids of both thyratrons are driven by the output of the blocking oscillator V-208B. The grids of V-205 and V-209 are decoupled by R-281 and C-365 to eliminate interaction by the longer discharge time constant of V-205. Malfunction of the reset thyratron may affect the operation of the display time thyratron. Replace one or both tubes as necessary.

11-123. DISPLAY TIME CONTROL TUBE. The display time control tube V-204 supplied the bias voltage that closes the diode gate CR-205. Failure of the tube to trigger properly may not apply closing bias to CR-205 and, as a result, the gate binary will be retriggered by the next negative pulse appearing from the decade divider.

11-124. Reference to paragraph 9-76 for theory of operation of display time circuits will aid in trouble- shooting. Check and replace weak tubes. Check also voltage and resistances to locate defective components.

11-125. RESET THYRATRON. Reset thyratron V-209 supplies the reset voltage for 1 and 10 mc counters and decade counters Z-204 through Z-209. If the counter circuit fails to reset properly, check V-209. Check also blocking oscillator V-208B and transformer T-201 if V-209 is not receiving the proper drive signal. If tube replacement fails to correct operation, check dc voltages and resistance to locate faulty components.

11-126. FAST TRIGGER.

11-127. The sensitivity of the fast trigger Z-201 is controlled by adjusting FREQ. SENS. potentiometer R-211. If R-211 (grid bias on V-601B) is set incorrectly, It can cause counting at half the proper rate or twice the proper rate. Adjustment is usually required whenever any of the tubes, V-601, V-602 or V-603 are replaced in the trigger unit. The procedure for this adjustment is described in paragraph 10-22. In FR-38C/U and FR-38D/U, tubes would be V-1101, V-1102 and V1103.

11-128. Input and output waveforms for the fast trigger unit are shown in steps 51 through 54, Table 11-2. Check and replace weak tubes. If tube replacements do not correct operation, replace original tubes and check voltage and resistances at the socket pins as shown in Figure 12.30.

11-129. The fast trigger Z-201 in FR-38/U only is identical to trigger units Z-102 and Z-103 in the Time Interval Plug-In Unit MX-1636/U. If the unit is suspected of malfunction, it can be exchanged with either Z-102 or Z-103 to test operation. Readjust R-211 if trigger unit Z-201 is changed.

11-130. GATE ACCURACY.

11-131. The gate accuracy of the FR-38/U should be 1/10-microsecond or better and it can be checked by the following procedure:

a. Set the FUNCTION SELECTOR switch for 10 mc self-check (10 MC CHK).
b. Observe indicated count for all gate time settings of FREQ. UNIT-STD. GATE TIME switch.
c. The indicated count should be as shown in Table 11-7 if the gate accuracy is 1/10-microsecond or better.
d. Repeat step "b" at 103.5 and 126.5 volts line voltage. The count should not change.

11-132. If the counts end in zero for most gates, the gate section is functioning properly. If the counts end in 9 or 1 on all gates, adjust GATE LENGTH potentiometer R-224 (see Figured and paragraph 10-23) until the count reads correctly.

11-133. If the count is correct for several gate times, for example, 0.001 and 0.01 seconds, but incorrect on all others, check phantastron adjustments on the 3rd, 4th and 5th phantastrons (see Figure 10-7 and paragraph 10-18. Always check the phantastron adjustments in order, the highest frequency phantastron or shortest gate time first. If this stage is dividing improperly, it will send incorrect driving pulses to the stages specified in Table 11-10.

Table 11-10. Correct Counts for Gate Accuracy Check

Gate Seconds		Count	
0.001	9 999	10 000	10 001
0.01	99 999	100 000	100 001
0.1	999 999	1 000 000	1 000 001
1.0	9 999 999	10 000 000	10 000 001
10.0	99 999 999	00 000 000	00 000 001

11-134. It may be possible to observe correct counts most of the time, but a random count shows gate error (more than ± 1 count). This may be caused by marginal operation of the triggering circuits Z-201 or Z-202. See Description of FREQ SENS and PERIOD SENS. adjustments, paragraphs 10-21 and 10-22.

11-135. DELAY LINE CHECK.

11-136. The delay line DL-201 is a distributed constant type made by winding fine wire on a silver-coated paper form. The line is folded and encapsulated in plastic sealing compound and normally requires no servicing. The line provides a delay of approximately 5 microseconds, sufficient time for reset circuit transients to die down.

11-137. A poor delay line that produces pulse shapes with poor rise time or excessive ringing can affect operation of the signal gate. If the ringing or noise is of sufficient amplitude, it may retrigger the gate, causing extra counts. The ringing following the pulse should not exceed 5% of the pulse amplitude. If a delay line is suspected of malfunction, check first its internal resistance with an ohmmeter. The resistance between pin 1 and pin 2 should be between 500 and 700 ohms. The resistance between pin 1 or pin 2 and pin G should be infinite. Replace a delay line that is open, shorted, or partially shorted. If resistance is normal, check delay line as described below.

11-138. The output impedance of the pulse generator should be properly matched to obtain a clean pulse (good rise and decay time characteristics) and avoid multiple reflections back to the generator. The Hewlett Packard Model 212A requires a 56-ohm resistor connected between the center conductor and the shield (ground) with a 560-ohm resistor in series with the center conductor to match the load resistance of the delay line.

11-139. Figure 11-14 shows the test setup for testing an external delay line removed from the instrument.
In this case, a separate 560-ohm resistor must be connected between pin 2 and pin G (ground) to properly terminate the delay line.

11-140. Typical test waveforms are shown in Figure 11-15. The control settings of the pulse generator and oscilloscope are indicated below.

11-141. Figure 11-15 "A" shows the input waveform from the pulse generator to pin 1 of the delay line. Figure 11-15 "B" shows the output waveform of the delay line, showing the delay. Figure 11-15 "C" is the same as Figure 11-15 "B" except a 50 mmf capacitor is" connected between pins 1 and 2 of DL-201. The capacitor causes the positive pip near the left edge which marks the start of the delay. Figure 11-15 "D" is the same as Figure 11-15 "B" except that the oscilloscope sweep time has been increased in order to show the complete pulse. Figure 11-15 "E" shows a poor delay line waveform. A defective delay line would produce the rounded corners, the irregular slope "A", the slow rise and decay time, and the variations in amplitude on top

PULSE GENERATOR		**OSCILLOSCOPE**:	
Pulse length	5 microseconds		
Pulse rate	5000 pps	Sensitivity	2V/cm
Attenuator	10 db	Sweep	1 microsecond/cm
Amplitude	50	Sync	-EXT, from pulse generator
Polarity	+		
Sync out	-		
Output	15V peak-to-peak across 56-ohm resistor		

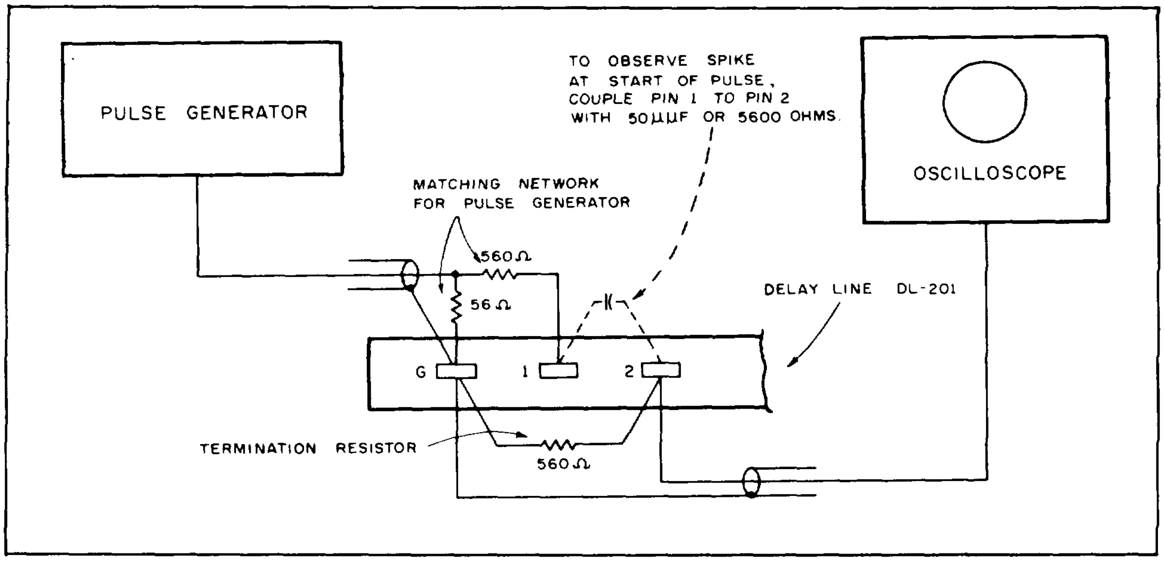


Figure 11-14. Delay Line Test Set-Up

of the pulse and following the pulse. These amplitude variations are caused by discontinuities in the line and in the termination.

11-142. The delay line DL-201 can be checked without removal from the instrument. Test equipment required consists of a pulse generator, such as the Hewlett-Packard Model 212A, and an oscilloscope, The input and output pins of the delay line are not readily accessible because of the mounting position in the instrument. The check can be accomplished by connecting the test instruments to related circuit points. Remove V-208 from socket. Terminate the pulse generator with its correct load resistor and connect to pin 8 of V-208 through a 560-ohm resistor (Figure 11-14). Ground the cable shield. The oscilloscope is connected to the junction of R-219 and R-220, (see Figure 7-13). Ground the cable shield to the pulser ground. R-219 serves as the termination resistor across the delay line.

11-143. The delay of the line can be measured by shorting pins 1 and 2 on the delay line with a 50 mmf capacitor (Figure 11-14). This couples sufficient signal to the oscilloscope to show the start of the pulse, as shown in Figure 11-15 "C". If the oscilloscope face is calibrated, or if the oscilloscope is provided with intensity markers, the delay can be measured easily. In Figures 6-15 "B" and "C". intensity markers (1 microsecond/cm sweep) show that the delay is approximately 5 microseconds.

11-144. PROCEDURE FOR SETTING THE METERS. The indicator meters M-201 and M-202 should not normally cause any trouble. If the meters read improperly or show other signs of malfunction, troubleshooting tests should be conducted very carefully, Since the meters are indicating devices of the instrument, faulty operation may be ascribed to them when the symptoms are actually the external indications of troubles elsewhere in the equipment. Electrical troubles, such as poor tracking or improper zeroing and centering, can be checked out with the procedures described below. If the pointer should stick, or if there is difficulty traceable to the meter movement, it is advisable to change the meter. See paragraph 11-59 for instructions on removal of meters.

11-145. The panel controls of the FR-38/U should be set as follows:

FUNCTION SELECTOR	FREQUENCY or 100 KC CHECK (as noted below)
FREQUENCY UNIT-STD. GATE TIME-SEC.	1 or 10
MANUAL GATE	(Closed or down position)
100 KC STD.	INT
SIGNAL INPUT	No connection
Line Voltage	115 volts

11-146. With the POWER switch in "down" position (HEATER on). the pointer of each meter should be centered on the dot between 4 and 5 on the meter scale. The pointer is centered by the mechanical zero adjustment screw on the face of the meter. The POWER switch is then snapped to ON and the instrument allowed to warm up for two or three minutes.

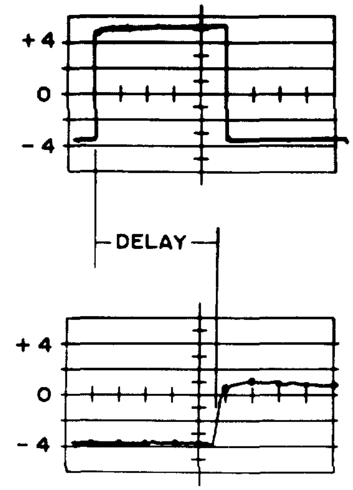
11-147. SETTING THE METERS. Set the FUNCTION SELECTOR to 100 KC CHK and STD. GATE TIME-SEC. to 10. When the count begins, adjust CENTER potentiometers located at top of chassis behind meters (R-349 for units meter and R-398 for tens meter), as shown in Figure 11-16 until the pointer is centered on the dot. This adjusts the meters electrically to the center of the plate voltage swing of the binaries. The ZERO controls (R-350 for the units meter and R-396

(A)

Pulse generator to Delay Line DL-201 between pin G and pin 1.

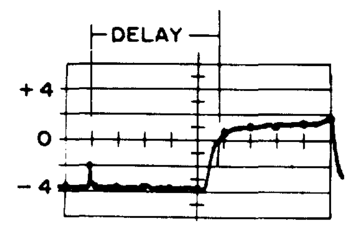
(B)

Output of Delay Line. Note delay of approximately 5 microsecond.



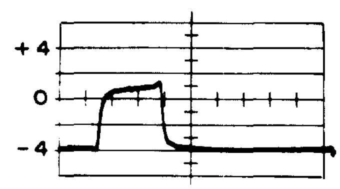
(C)

Same as "B" except pin 1 is coupled to pin 2 with .50 micromicrofarad capacitor, as in Figure 6-14, to show beginning of input pulse.



(D)

Same as "B" except oscilloscope sweep rate is increased to show complete pulse.



(E)

Poor delay line waveform. Change in slope at "A", variation in amplitude caused by reflections, rounder corners and poor risetime on waveform: these are indicative of a poor delay line.

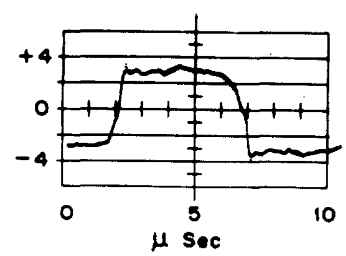


Figure 11-15. Typical Delay line Waveforms

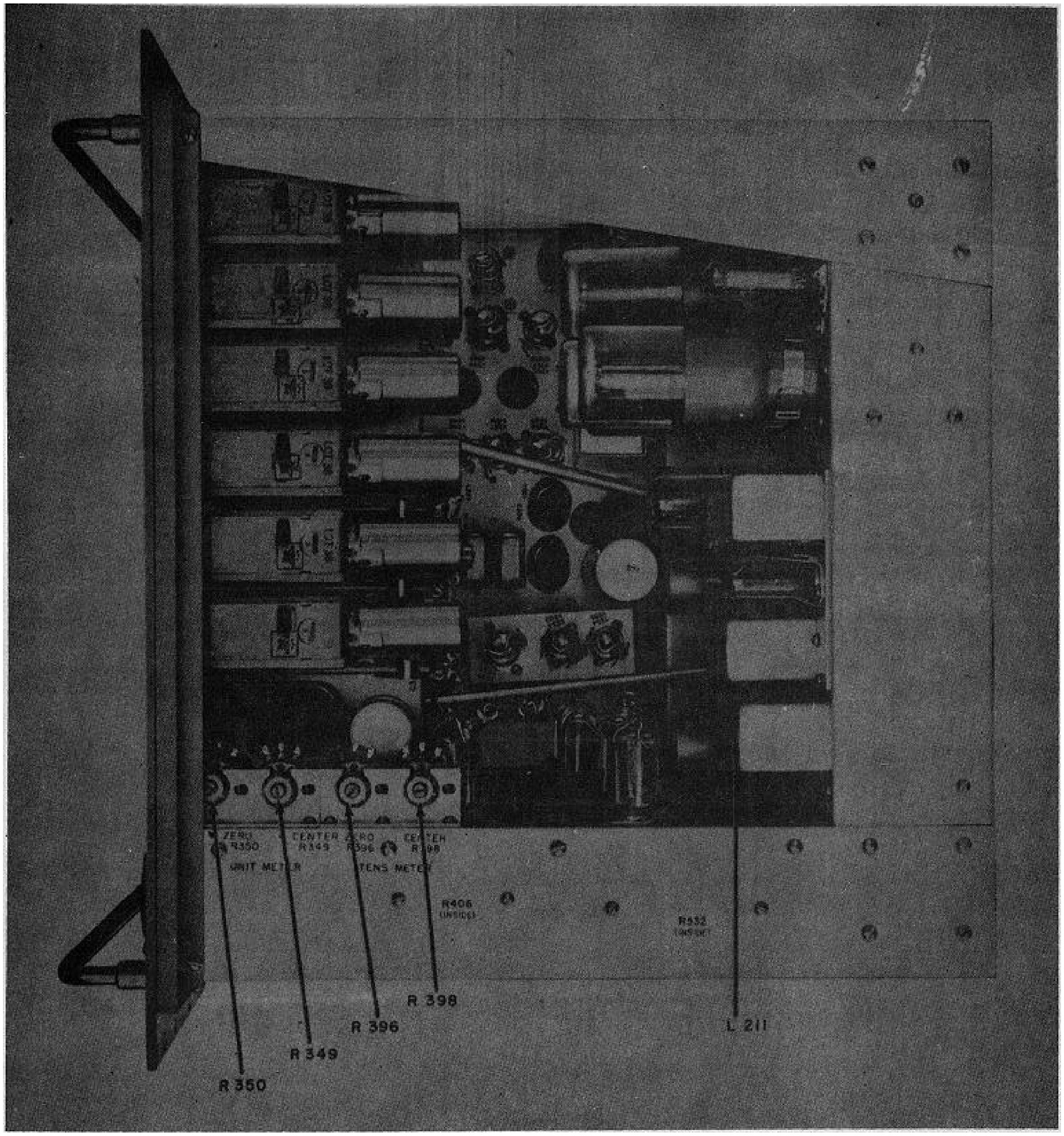


Figure 11-16. Frequency Meter FR-38 U, Top View

for the tens meter) are then adjusted for respective meters until the pointer stops at zero at the end of each swing.

11-148. METER TRACKING. After the meters have been set up by the above procedure, tracking can be checked on each number.

11-149. TRACKING UNITS METER. The panel controls should be set with FUNCTION SELECTOR in MANUAL GATE position, MANUAL GATE to OPEN, TIME UNIT - STD. FREQUENCY COUNTED to EXT. and 100 KC STD. to INT. A 1 cps signal should be connected to the STD. FREQ. OUTPUT connector, A 1 cps signal can be obtained by connecting a clip lead from the cathode of phantastron V-247 (resistor to R-474, bottom resistor on resistor board, Figure 10-6) to the STD. FREQ. OUTPUT connector on the front panel. As the (count begins. the units meter should move forward on(digit per second. The pointer should come close enough to each number so there is no doubt as to the indicated count. R-350 and R-349 (ZERO and CENTER controls) can be changed slightly if desired to improve over-all meter tracking.

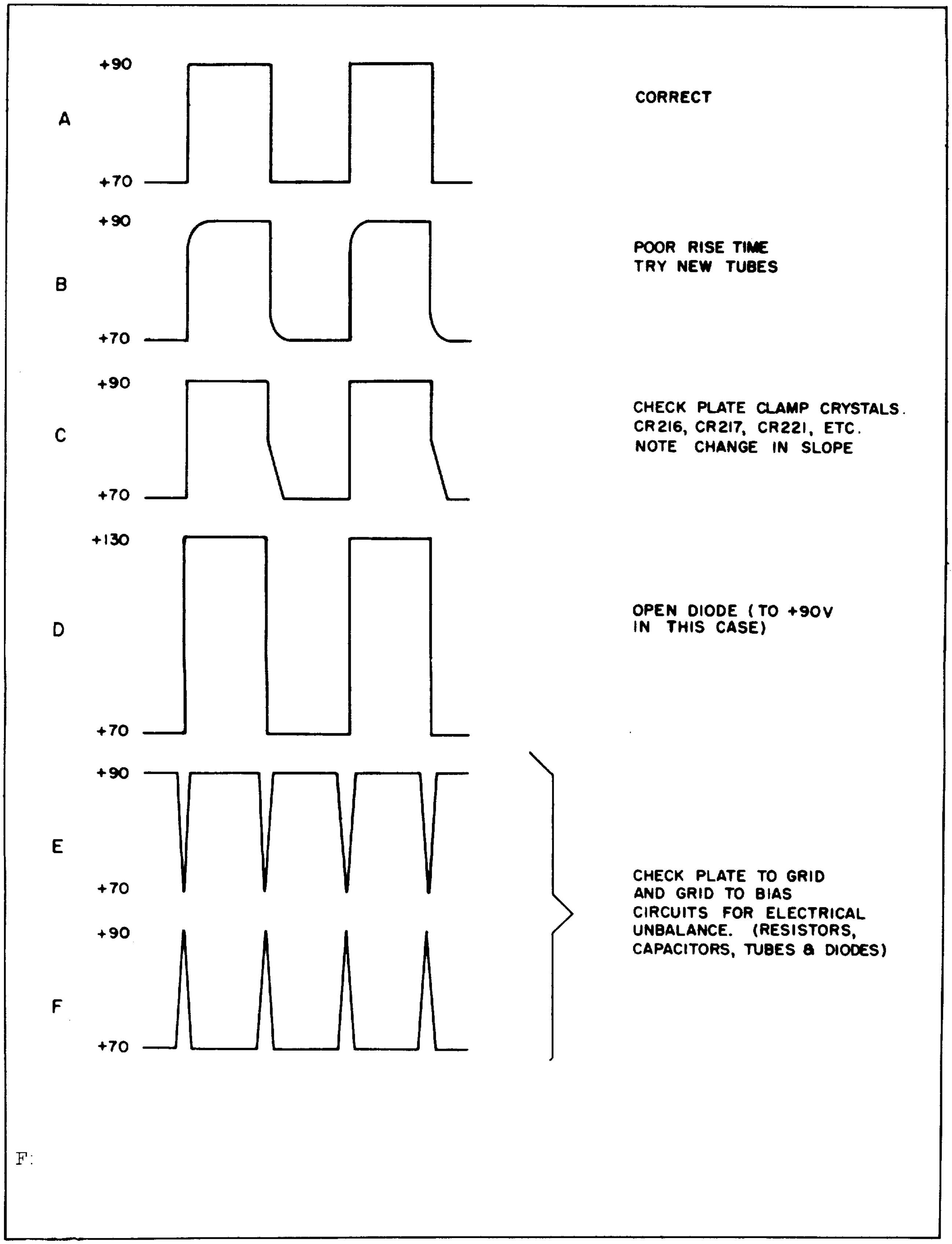


Figure 11-17. Some Incorrect Plate Waveforms for First Binary in 10 MC section (V-210 and V-211)

11-150. If the meter tracking is poor, +70 and +90 may be incorrectly set cr the tubes driving the metering circuit may not have the correct plate voltage swing. Check for poor tubes, defective plate clamp diodes, etc. In extreme cases, the metering resistors may be off value and resistances should be checked.

11-151. TRACKING TENS METER. The panel controls are set with FUNCTION SELECTOR to MANUAL GATE and FREQUENCY UNIT-STD GATE TIME-SEC to 1. MANUAL GATE is in OPEN position and 100 KC STD. to INT. The tens meter should advance one count each time the units meter goes from 9 to 0. ZERO and CENTER controls, R-396 and R-398, respectively, can be readjusted slightly, if necessary, to obtain better over-all meter tracking. Poor tracking of the tens meter is usually due to unbalance in the binaries of the 1-megacycle section. Check tubes and plate resistors, R-353, R-358, R,370, R-374, R-382, R-386 and R-395. All resistors are 5600 ohms 2 watt ± 5%.

11-152. TROUBLE-SHOOTING 10 MC COUNTER SECTION (V-210 TO V-218).

11-153. Typical waveforms throughout the counter section of the FR-38/U are shown in Table 11-2. The waveforms for the 10-megacycle counter section were made while a 1-megacycle external sine-wave frequency was applied to the FR-38/U for counting.

11-154. If trouble occurs in the equipment and seems to have its origin in the 10-megacycle counter section, the waveforms in the counter should be examined carefully, using an external 1-megacycle frequency and an oscilloscope, such as the OS-4(XN-1)/AP oscilloscope with its high-impedance (low-C) probe.

11-155. It is important that both V-210 and V-211, the "first binary", have good waveforms. Check the plate waveforms particularly for rounded leading edges, which indicate poor rise time for the stage. Figure 11-17 shows possible sources of trouble that can be observed at the first binary.

11-156. If troubles are difficult to locate or correct, observe each waveform with the line voltage at 103.5 and 126.5 volts. High or low line voltage often aggravates a trouble and makes it easier to locate. Low line voltages tend to reveal tubes that have low cathode emission, while high line voltages reveal shorts and leakage.

11-157. Using oscilloscope OS-4(XN-1)/AP, it is usually not possible to observe the waveforms at counting frequencies above about 1 megacycle because of the sync characteristics of the oscilloscope. Above 1 megacycle the waveforms deteriorate from those shown; however, it is important that the waveforms be free from spurious troughs. The rise and decay times of the plate voltages in the binaries is about the same at all input frequencies. Above 1 megacycle, the waves tend to appear triangular in shape because the rise and fall times become a significant proportion of the on or off time of the binary.

11-158. TOLERANCE OF BINARY PARTS IN 10 MC COUNTER. It should be noted that some of the resistors in the 10-megacycle section are precision parts. If these parts change value after a period of time, it will, in general, lead to erratic counting or failure of one of the binaries to operate. The following tabulation shows the tolerance of special parts in the 10-megacycle counter section.

a. Plate resistors (such as R-295, R-296, R-303, etc.) should be within 10% of specified value.
b. Plate-to-grid resistors (such as R-293, R-301, etc.) should be within 1% of specified value.
c. Grid-to-bias supply resistors (such as R-291, R-292, R-299, R-300, etc.) should be within 1% of specified value.
d. Other parts in the 10-megacycle section should be within 10% of specified value.

11-159. COINCIDENCE NETWORK. In the 10-megacycle counter section, the coincidence network, shown in Figure A, is important in the operation of the feedback network. If plate waveshapes are satisfactory, but if the output of the coincidence network is not as shown, check all five diodes in the network. Poor crystal diodes in the network will provide a low resistance path between the plates of V-212 and V-216. A weak tube in either of these locations may be "pulled" by the opposite tube through the path provided by R-318 and R-324. This can occur when one plate should be at +70 volts and the other plate at +90 volts. The result will be erratic counting. Check tubes and diodes.

11-160. Waveform 3 of Figure 11-19 is an example of an improper waveform at the plate of V-216. The plate of V-216 normally goes to +90 volts when the plate of V-212 goes to +70 volts on the count of 4. Low back resistance diodes at CR-231 and CR-233 will act to connect the two plates together through a low impedance so that the plate of V-216 can only go part way to +90 volts until the count of 6. At the count of 6, the plate of V-216 goes to +90 volts. This causes a "step" in the waveform. This step can also be caused by a poor tube at V-216. The "pull" effect between the second and third binaries of the 10-megacycle counter is most likely to occur at 103.5 volts line.

11-161. TROUBLE-SHOOTING 1 MC COUNTER SECTION (V-219 to V-223). If trouble occurs and seems to arise in the 1 megacycle counter section, the plate waveforms throughout the section should be carefully observed and compared with those shown in Table 11-2, Waveform Analysis. Comparing waveforms is one of the best attacks in trouble-shooting both the 10 megacycle and 1-megacycle sections. If the trouble seems to be caused by a particular binary, the dc voltages for that binary can be measured.

11-162. TOLERANCE OF BINARY PARTS IN 1 MC SECTION. In the 1-megacycle counter section, the values of the components should be accurate within the tolerances shown below. Components whose values are outside this tolerance can cause erratic counting at input frequencies of several megacycles and higher or failure of a binary to operate.

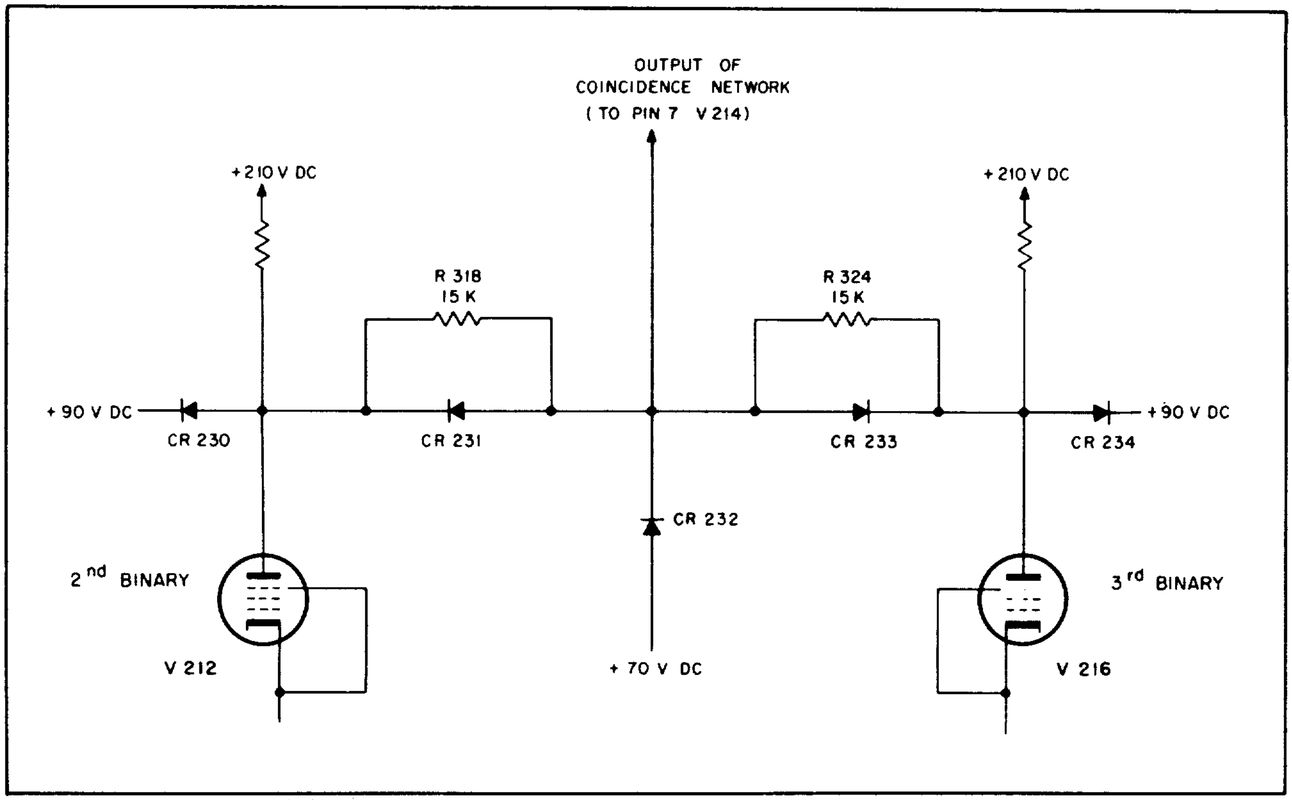


Figure 11-18. Coincidence Network, 10 MC Section

a. Plate resistors (such as R-363, R-368, etc.) should be within 5% of specified value of 5600 ohms.

b. Plate-to-grid resistors (such as R-352, R-357, etc.) should be within 1% of specified value of 62,000 ohms.

c. Grid-to-ground resistors (such as R-351, R-356, etc.) should be within 1% of specified value of 62,000 ohms.

d. Cathode resistors (such as R-355, etc.) should be within 5% of specified value of 11,000 ohms.

e. Other parts in the 1-megacycle section should be within 10% of specified value.

11-163. ISOLATING TROUBLES IN BINARIES.

11-164. The same general checks outlined in Table 11-7 apply to all binaries when it comes to locating trouble, as well as general comments on waveforms in Figure 11-17.

11-165. Determine first if the binary under observation is functioning improperly because of a defect within the binary, because of improper drive to the binary, because of trouble in associated circuits, or because of undue loading or coupling caused by the measuring instruments used.

11-166. DC VOLTAGES IN BINARIES. Once the trouble is traced to a particular stage, check dc voltages to see that they agree with those listed (see voltage and resistance diagrams in Section XII). Most of the tube pins have two voltages listed: One corresponds to the tube conducting, the other to the tube cutoff. When making measurements with a VTVM, connecting the voltmeter probe may cause the stage to operate in its other stable state, in which case the reading would be opposite the one that is expected. A convenient way to make these measurements is with 1~sec signal connected to the SIGNAL INPUT of the FR-38/U. The meter reading should alternate from one value to the other once a second.

11-167. A shorted 6AH6 (V-210 or V-211) can overload the cathode resistors R-297 or R-298, causing one of them to drop to about 60 ohms. This condition causes a DC unbalance which makes the binary easier to drive one way than the other. In some cases, a stage will not stay in one or the other of the two stable states if one of these resistors is too far off value.

11-168. If the cathode resistors are correct (± 10%), go on to check:

R1 - R2......................±10% tolerance satisfactory
R3 - R4......................±1% tolerance important;
R5 - R6...................... measure with a Wheatstone Bridge
C1 - C2......................±10% tolerance satisfactory
CR1 thru CR8............ See paragraph "Crystal Diodes"

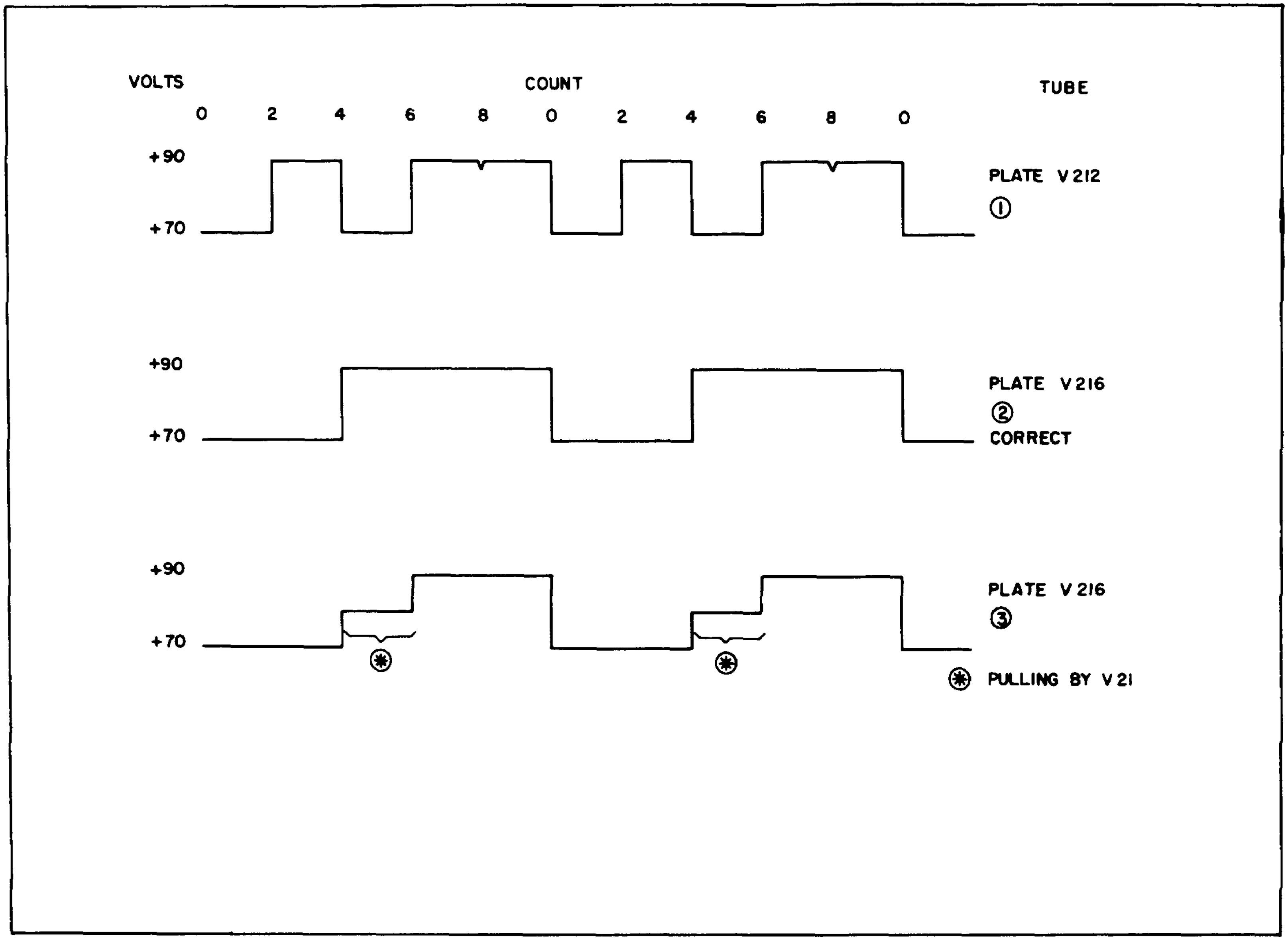


Figure 11-19. Waveforms in Coincidence Network

11-169. A dc voltage check can also be made by removing the tubes from the binary and disconnecting the plate and grid crystals associated with it. Voltages measured at plate and grid pins of the socket should now be equal for corresponding pins on each socket, and cathode voltages should be zero. This check will reveal large defects in components in the B+-to-plate, plate-to-grid, grid-to-bias resistor networks, R1, R3, R5 and R2, R4, R6 of Figure 9-30.

11-170. The same general methods discussed here for the 1st binary also apply to locating trouble in the 2nd and 3rd binaries. One difference exists, however; the plate of V-212 in the 2nd binary is connected directly to the plate of V-216 in the 3rd binary through CR-231, CR-233 and R-318, R-324. The crystal diodes are connected "back to back", so that with good diodes, one always looks like a high resistance unless both plates go to +90 volts. See Figure 11-19.

11-171. SCALE-OF-16 CHECK. Some troubles are more easily located if the 10 MC SECTION is operated as a straight binary. This section can be converted to binary operation by disconnecting one end of CR-224 and one end of CR-239 (these are the feedback diodes).

All plate waveforms should now be square waves; each of half the frequency of that in the previous stage.

11-172. The plate swing of V-217 is abnormally high with the feedback diodes removed because CR-224 and CR-239 are also the +70V clamp for V-217. Connecting the anode end of either of these two crystals to +70V with a jumper will restore the clamp and limit the plate swing of V-217 to 20 volts.

11-173. The count displayed by the FR-38/U will be large by a factor of 1.25: 1 because the 1 MC SECTION now gets a driving pulse from the 3rd binary in the 10 mc deck each time the plate of V-216 goes from +90V to +70V. This happens once every 8 counts when the feedback loop is open instead of once every 10 counts when the feedback circuit is operating. (Output is taken from the 3rd binary in 10 MC SECTION.)

11-174. MAINTENANCE OF DECADE COUNTERS Z-204 THROUGH Z-209.

11-175. The plug-in decade counters Z-204 through Z-209 are direct-reading electronic counters. Each unit counts from zero to nine, the tenth input signal returning the counter to zero and simultaneously generating an output signal. The number of counts received is indicated by the illumination of one of ten neon lamps placed behind a transparent numbered panel. Any number of these decade counters can be connected in cascade (the output of one unit driving the next) to form a counter whose total count capacity depends only on the number of decade counters. Thus, six units will count to 999,999 and reset to 000,000 on the 1,000,000th pulse.

11-176. POWER REQUIREMENTS. The plate power requirements are 250 to 350 volts (nominal 300 volts at 15 ma); filaments are 6.3 volts at 1.2 amperes.

11-177. INPUT REQUIREMENTS - WAVEFORMS AND AMPLITUDES. If the unit is powered by an unregulated supply, the drive amplitude should vary with the supply voltage. A negative transient (either a square

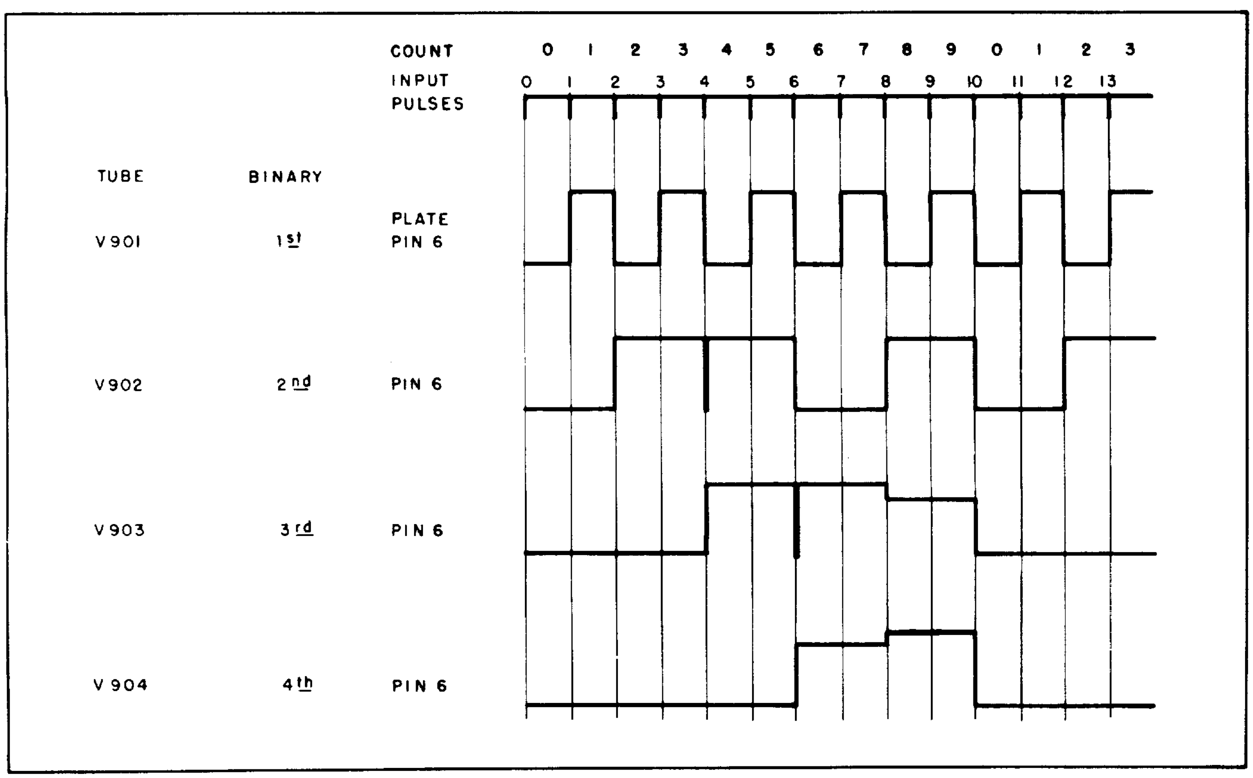


Figure 11-20. Idealized Waveforms for Decade Counters

wave or a rectangular pulse that is at least 2 microseconds wide) is required to drive the unit. The pulse amplitude in either case depends on the rise time as measured between the 10 percent and 90 percent value. The input load presented during triggering is equivalent to 100 mmf in series with 15,000 ohms. Input pulse requirements are summarized in Table 11-11.

11-178. OUTPUT. The load must not be more than 300k to ground or 100 mmf in series with 6000 ohms.

11-179. DECADE COUNTER Z-204. The output should be a rectangular waveform presented at the output terminal as a change in dc voltage (4th binary, Figure 6-20). On the counts from "0" through "5", its value is +55V. For the counts "16" and "7", the output is +125V, and for "8"' and "9", it is +135V.

11-180. DECADE COUNTERS Z-205 THROUGH Z-209. The output should be a rectangular waveform presented at the output terminal as a change in dc voltage (4th binary, Figure 11-20.) On the counts from "0" through "5", its value is +60V. For the counts "6" and "7", the output is +135V, and for "8" and "9", it is +145V.

11-181. RESET. Regardless of the number of units, all can be set back to zero by momentarily opening the ground connection to a common line connected to pin 2 of the octal socket. Care must be taken to avoid coupling voltage surges into the input or power supply circuits. otherwise, they may not remain at zero upon reconnecting to ground. All units can be reset to nine by coupling a 200-volt negative pulse of fast rise and slow decay to a low impedance connected between pin 2 of the octal base plug and ground.

11-182. READOUT. Plate voltage states of the four binaries are used to light one of ten neon lamps, numbered 0 through 9, by means of a resistor matrix. Each neon lamp is connected with one terminal to one of the plates of the 1st binary. The other terminal is connected to an adjacent lamp and to one plate each of two other binaries (2nd and 3rd, 3rd and 4th, or 2nd and 4th).

11-183. A neon lamp should light only if one terminal is connected to the plate of the section of the 1st binary at plate current cut-off (UP or high dc voltage at plate) and the two binaries connected to the common bus between pairs of lamps are both conducting (DOWN or low dc voltage at plate). For example, 1 will light only when plate (pin 6) of the 1st binary is UP and plates (pin 6) of both the 2nd and 4th binaries are DOWN. Similar voltage conditions are necessary to light any of the remaining nine lamps.

11-184. TROUBLE -SHOOTING. When a decade counter is suspected of counting incorrectly, it should be interchanged with another unit in the instrument, or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counter units are the indicating devices, faulty operation may be ascribed to them when the symptoms are actually the external indication of some other fault in the FR-38/U.

11-185. Two methods are recommended for finding the trouble in a faulty decade counter: First, by observing the lighting sequence while driving the unit at a slow repetition rate; second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be viewed conveniently on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a lamp failure can be located and can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. Check also the unregulated +300 volt source (pink wire). Table 11-12 lists common troubles in decade counters.

11-186. In general, try new tubes first when it has been determined that a plug-in decade counter is defective. Only computer type tubes such as the 5963 should be used for replacement purposes. Other twin triode types or premium type tubes are not necessarily designed for computer application and may produce unsatisfactory results due to gradual loss of emission under pulse operating conditions. See paragraph 4-85, Sleeping Sickness.

11-187. Balance between the following pairs of components is important to proper operation of these counter units. Refer to Figure 11-21 for parts notations.

R2 =R3	R6 =R7
R4= R5	C2 C3

Table 11-11. Input Pulse Requirements for Decade Counters

DECADE COUNTERS	INPUT PULSE	
	Width	Amplitude
<u>Z-204</u>		
Recommended values are I microsecond or less rise time and 100 volts amplitude for +300V plate supply	0.5 microsecond 2 microsecond	75 to 135V 120 to 165V
<u>Z-205 through Z-209</u>		
Recommended values are 1 microsecond time and 90 volts amplitude for a 300V plate supply.	0.5 microsecond 2 microsecond	60 to 150V 80 to 175V

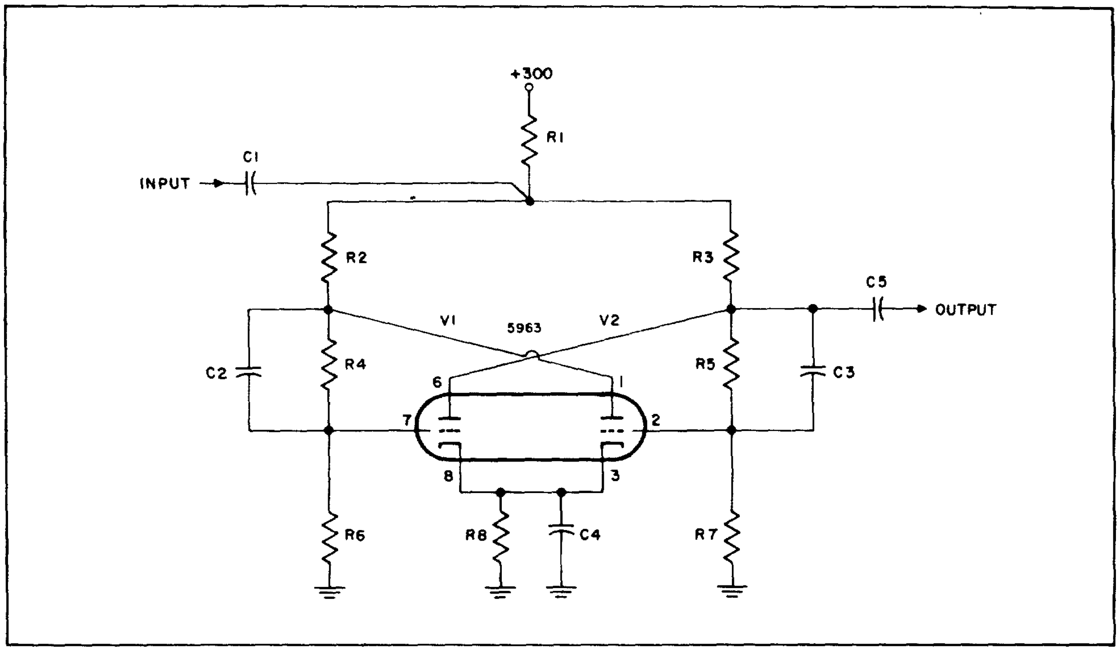


Figure 11-21. Basic Binary Circuit for Decade Counter Unit

Tolerance should be ±5% or better for these components. Check the values of components in the feedback circuit if a unit is not working correctly. If the failure is not found by the first method, the second should be used.

11-188. Figure 11-20 shows the idealized waveforms of each stage when the decade counter is working properly. A study of these and the corresponding ones on a faulty unit will help in finding component and tube failures. The spikes at the count of 4 on the second stage and on 6 on the third stage are caused by the first and second feedbacks, respectively.

11-189. Defective parts may be located by point-to-point resistance measurements or by voltage measurements. Only high impedance vacuum tube voltmeters and oscilloscopes can be used without disturbing the balanced circuits.

11-190. Voltages under nominal supply voltage conditions, measured between ground and the point indicated with a vacuum tube voltmeter, are shown on the schematic diagram. The unit must be set to zero to obtain the values shown, otherwise the voltage readings of pins 1 and 6 may be interchanged, and similarly pins 2 and 7.

11-191. EQUIPMENT MODERNIZATION. The electrical schematics of the AN/USM-26 presented in this section reflect all of the design changes as of the publication date of this handbook. Table 11-14 describes major design changes and serial numbers of equipment in which the changes became effective. Equipments with serial numbers below those listed should be modernized by incorporating the appropriate design changes.

11-192. GENERAL SUPPORT AND EPOT MAINTENANCE OF AN/USA-5.

11-193. MINIMUM PERFORMANCE STANDARDS. Minimum performance standards are given in conjunction with the test procedure of paragraph 10-46.

11-194. TROUBLE ANALYSIS. Step-by-step trouble analysis using procedures within the capabilities of organizational maintenance is covered in paragraph 10-46. Where difficulties cannot be remedied by tube replacement or simple adjustments, as directed in paragraph 10-46, use the following trouble-shooting chart, Table 11-15 for Frequency Converter CV-394/USA-5.

11-195. REPLACEMENT OF VARIABLE RESISTOR, COILS, AND CAPACITORS. Connections to most of the variable components are shown in Figure 11-22 for ease of reference. The capacitors of the three sections of MIXING FREQUENCY MC switch S1201 (capacitors C1240 through C1264) must be replaced as an assembly, following the instructions given in paragraph 11-196.

CAUTION

When replacing components, observe the dress of the wire leads to the old component before it is removed. Then dress the leads to the new component in the same way.

11-196. REPLACEMENTOF CAPACITORS ON MIXING FREQUENCY MC SWITCH. These capacitors must not

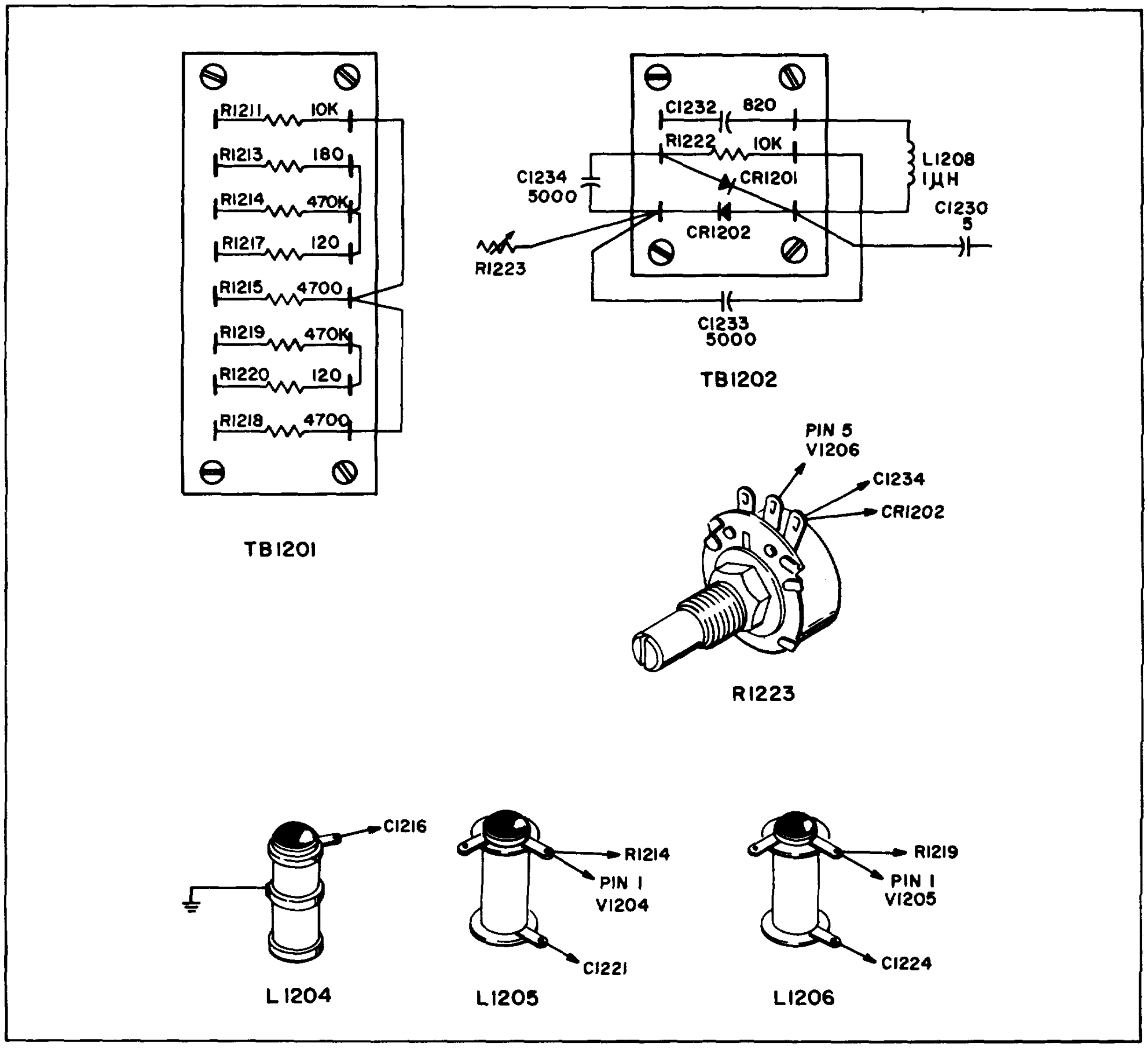


Figure 11-22. Details of Terminal Board and Variable Components, CV-394/USA-5

be replaced individually. When one or more capacitors C1240 through C1264 on any of the three sections of S1201 needs replacement, replace the switch as an assembly. These capacitors are ruggedly built, and before replacement is made, thorough checks should be carried out to assure that the trouble is not in some other component or in the spring-like electrical contacts which complete the circuit to one or more of the switch sections. If the contact mounting nuts are not securely tightened, the contacts may slip out of position when the rotating capacitor sections move. When necessary, replace the MIXING FREQUENCY MC switch assembly as follows:

a. Remove the nut (Figure 10-16) from the panel bushing (Figure 10-15) at the end of the switch shaft near the wavemeter capacitor C1231. Unscrew the bushing from the nut, using an open end wrench on the bushing from the bottom side and a long nose pliers or suitable open end wrench on the nut.

CAUTION

Be careful not to damage the variable wavemeter capacitor C1231 through accidental slippage of tools. Carry out this operation with extreme care.

b. Remove the two setscrews which attach the drive bevel gear (Figure 10-14) to the shaft operated by the MIXING FREQUENCY MC switch knob. Pull the shaft and knob out by pulling on the knob. This will release the drive bevel gear. Remove and save this gear.

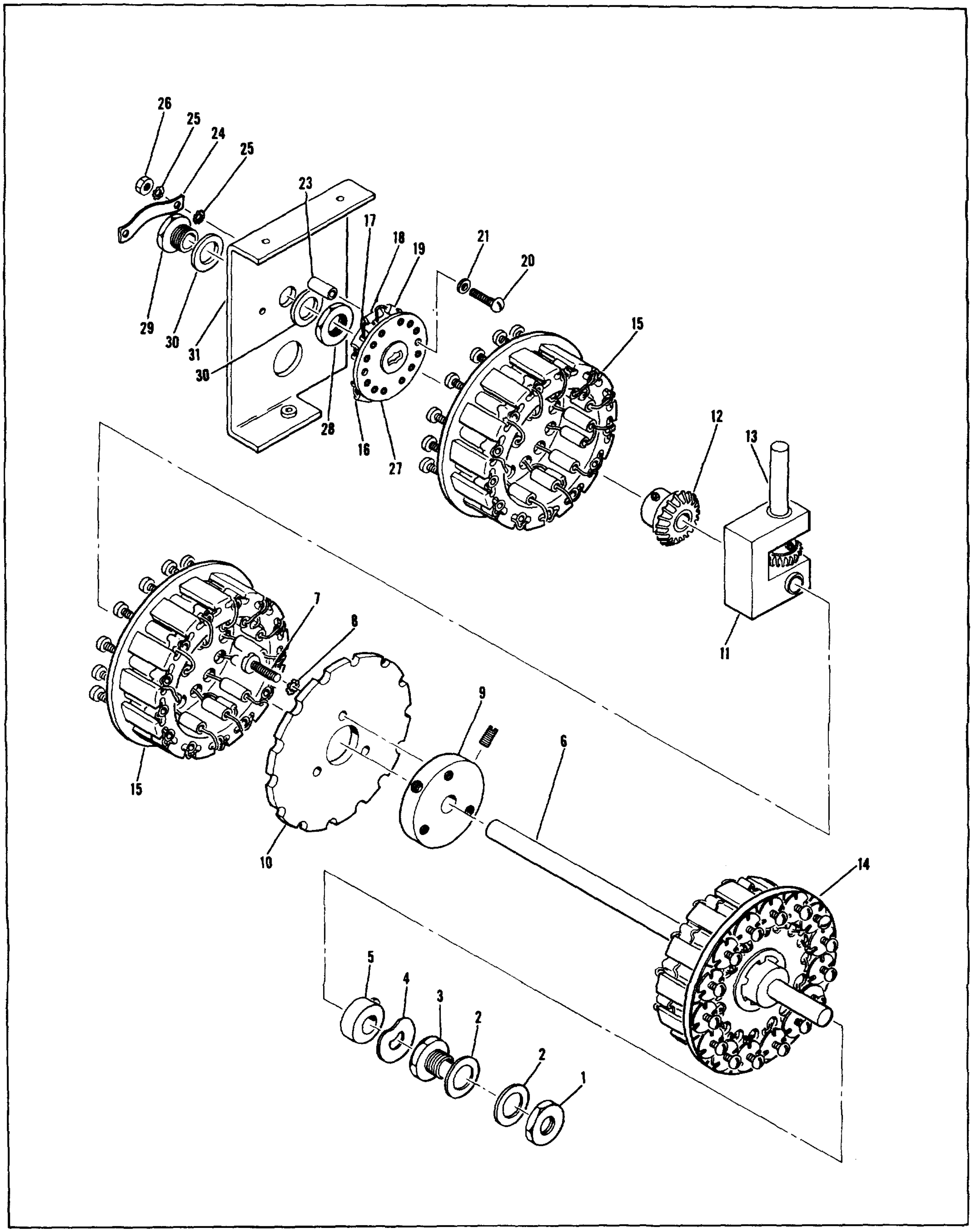


Figure 11-23. Exploded View of MIXING FREQUENCY MC Switch Showing Replacement of Sections Containing Capacitors, CV-394/USA-5

Legend for Figure 11-23

Index No. Fig. 6-23	Description	Quantity
-1	NUT, PLAIN, HEXAGON	1
-2	WASHER, FLAT	2
-3	BUSHING, PANEL	1
-4	WASHER, SPRING TENSION	1
-5	COLLAR,SHAFT	1
-6	SHAFT, SHOULDERED	1
-7	SCREW, MACHINE	3
-8	WASHER, LOCK	3
-9	COLLAR, SHAFT	1
-10	PLATE, Detent	1
-11	YOKE, Gear	1
-12	GEAR,BEVEL	2
-13	SHAFT, STRAIGHT	1
-14	TURRET ASSY "A"	1
-15	TURRET ASSY "B"	2
-16	RESISTOR, FIXED, COMPOSITION, 18K	1
-17	RESISTOR, FIXED, COMPOSITION, 330 ohms	1
-18	RESISTOR, FIXED, COMPOSITION, 82K	1
-19	RESISTOR, FIXED, COMPOSITION, 100K	1
-20	SCREW, MACHINE	2
-21	WASHER, LOCK	2
-22	WASHER, NONMETALLIC	2
-23	SPACER, SLEEVE	2
-24	STRAP, SHAFT GROUNDING	1
-25	WASHER, LOCK	4
-26	NUT, PLAIN, HEXAGON	2
-27	SWITCH, ROTARY	1
-28	NUT, PLAIN, HEXAGON	1
-29	BUSHING, PANEL	1
-30	WASHER, LOCK, phosphor bronze, 3/8 id by 1/2 in. od	2
-31	BRACKET, DOUBLE ANGLE	1

c. Remove the switch position detent (Figure 10-15) by removing the screw, washers, and nut which retain it to the front panel.

d. Remove the two attaching screws and lockwasher which attach the switch-supporting bracket (Figure 10-17) to the front panel. Also remove the one attaching screw' and lockwasher which attach this bracket to the backplate assembly.

e. Remove the screw and two lockwashers which attach the switch assembly ground wire (Figure 10-14) to the gear yoke (Figure 10-14) .

f. Remove the two screws and lockwashers which attach the electrical shield (Figure 10-14) to the backplate. Remove the nut and lockwasher (Figure 10-15) which attach the mounting stud of the same shield to the shelf plate. Remove the shield, with attached ground wire, from the top of the CV-394/USA-5.

g. Remove the two screws and flat washers which attach the standoffs for P1201 (Figure 10-15) to the front panel. Take cure not to strain the wiring to P1201 while the connector is not supported. Tilt the standoffs away from the front panel to make room for the switch assembly to pass upward.

h. Unsolder at standoff capacitors C1207 and C1208 the two wire leads from the switch wafer section, S1201D (Figure 10-14), after first tagging each lead with the reference designator of the capacitor to which it connects, to permit easy reconnection. In most units the leads are orange and red, and the orange lead attaches to the outermost capacitor, C1208.

i. Disengage the switch shaft end from the wavemeter assembly bracket (Figure 10-11) by pulling sideways slightly. Then lift the switch assembly - consisting of the three capacitor sections, S1201A, S1201B, S1201C, the switch wafer section, S1201D, the switch support bracket, and the associated shafts (Figure 10-15) upward and out of the CV-394/USA-5.

j. Replace the capacitor section(s) as required, or if necessary, obtain a complete replacement switch assembly consisting of the parts removed in step h above. Replace capacitor sections by removing the appropriate switch section(s) from the shaft in accordance with the exploded view given in Figure 11-23 and by installing the replacement sections.

k. Reinstall the repaired switch assembly following the reverse of steps a through i above, except do not yet install the switch position detent which was removed in step c above. The positioning of the three capacitor sections and the wafer section with respect to the switch knob position must now be checked and adjusted as directed in the remaining steps of this procedure.

l. Attach a continuity tester (the ohmmeter function of the ME-25A/U is suitable) between the leads from the switch wafer section which have been reconnected to C1207 and C1208. Observe the reading while the MIXING FREQUENCY MC switch is rotated through all its positions. There should be zero resistance in all but four adjacent positions. Adjust the switch knob on its shaft so that the four positions not showing zero resistance are positions 130, 140, 150, and 160, and so that the jump between zero resistance and non-zero resistance is symmetrically located between the 120 and 130 positions and between the 160 and 170 positions. Check that the setscrews holding the knob shaft to the shaft drive bevel gear (Figure 10-14) are tight.

m. Turn the MIXING FREQUENCY MC switch knob to the 100 position. Loosen the setscrews in the shaft collar (9 of Figure 11-23)which attaches the detent plate to the shaft. Install the switch position detent removed in step c above. Then, with the switch held exactly in the 100 position, tighten the detent plate shaft collar setscrews so that the detent action holds the switch in the exact position. Slip the detent plate shaft collar as necessary to achieve proper adjustment, but do not slip the switch knob on its shaft. Tighten the shaft collar setscrews securely when the adjustment is completed.

n. Note that the electrical contacts for the center capacitor section of the switch extend outward almost straight from their mounting standoffs, while the contacts for the two outer capacitor sections bend downward from their mounting standoffs. The sections must be adjusted so that the proper capacitor in each is contacted by these electrical contacts for each position of the switch. When the MIXING FREQUENCY MC switch knob is in the 100 position, the one capacitor in each section which has two pigtail leads on the side opposite the screw, extending to the padder capacitors underneath, should be in contact with the electrical contacts for that section. Loosen the two setscrews for each section, rotate the section so that the proper capacitor is centered on the contacts, then tighten the setscrews securely. Double-check that the proper capacitor (two pigtail leads) is in the contact position in each section when the switch is in the 100 position.

o. Adjust the capacitors as directed in paragraph 6-197.

11-197. ADJUSTMENT OF CAPACITORS ON MIXING FREQUENCY MC SWITCH. The adjustment of these capacitors constitutes the adjustment of the harmonic generator and the harmonic amplifier and is described in paragraph 10-51.

11-198. ADJUSTMENT OF WAVEMETER DIAL. The WAVEMETER dial is set at the factory and should require adjustment only if one of the components in the wavemeter circuit is replaced, or if the dial or drive gear should become loose allowing the adjustment to slip. When necessary, adjust the WAVEMETER dial as follows:

a. With the CV-394/USA-5 plugged into the FR-38/U, make control settings on both equipments as follows:

FR-38/U CONTROLS	SETTING
FUNCTION SELECTOR	FREQUENCY
FREQUENCY UNIT	.01 STD. GATE TIME-SEC.
100 KC STANDARD	EXT.
DISPLAY TIME	Completely counter-clockwise

CV-394/USA-5 CONTROLS	SETTING
Function switch	WAVEMETER
MIXING FREQUENCY MC	110

b. At the INPUT connector of the CV-394/USA-5, connect a signal generator capable of generating signals in the 100 to 220-megacycle range, such as the AN/USM-44. Adjust this signal generator to provide an output frequency of exactly 110.1 megacycles and an amplitude of 0.3 volts.

c. Turn the WAVEMETER dial to the division line between 100 and 110 megacycles. Observe the tuning eye indication when the WAVEMETER dial is moved to that division line.

d. If the most narrow point of the tuning eye indication does not coincide with the WAVEMETER indication at the division line between 100 and 110 megacycles, adjust the WAVEMETER dial on its shaft by loosening and then retightening the two attaching setscrews.

e. Adjust the signal generator output frequency to 200.1 megacycles, with output amplitude of 0.3 volts.

f. Turn the WAVEMETER dial to the division line between 190 and 200 megacycles. Observe the tuning eye indication when the WAVEMETER dial is moved to that division line..

g. If the most narrow point of the tuning eye indication does not coincide with the WAVEMETER indication on the division line between 190 and 200 megacycles, adjust the WAVEMETER dial on its shaft for the best compromise between accurate indications at each end of the dial, repeating the check of steps b through f above.

Table 11-12. Trouble - Shooting Chart for Decade Counters

NOTE: Reset Unit to 0 before trouble-shooting,

SYMPTOM	CAUSE
1. Unit fails to count	a. Insufficient supply voltage.
	b. Input signal of: (1) Insufficient amplitude. (2) Wrong polarity.
	c. First binary inoperative.
2. Unit counts spuriously	a. Stray input signal.
	b. Pulses received through power supply.
	c. External voltages picked up by output lead.
3. Unit counts erratically	a. Input signal too large or small, incorrect rise time.
	b. Supply voltage fluctuating too much.
4. Unit fails to reset	a. Stray pulses from reset line or associated circuitry.
	b. Defective component.
5. Unit skips every other number	a. First stage defective
	b. Input circuit supplies double pulses.
NOTE: In the following troubles, the pattern of lighting is repeated periodically, every six input pulses, only stipulation is that there be six distinct states per cycle.	
6. Two stable states per cycle	a. Second stage defective (count can be 01 or 45).
	b. Loss of drive to second stage (01).
7. Four stable states per cycle	a. Third stage defective (count can be 0123 or 6789).
	b. Loss of drive to third stage (0123).
8. Six stable states per cycle	a. Output excessively loaded (count can be 012345-012345).
	b. Last stage inoperative (count can be 01234501. etc., or $67^{89}_{23}89$. The count 8_2 indicates both "8" and "2" lamps are on.
	c. Loss of drive to fourth stage (count can be 012345).
9. Eight stable states per cycle or any failure where two successive numbers are skipped, such as 2 and 3, 4 and 5, or 6 and 7	a. Second or third stage failure.
10. Ten stable states per cycle, but the lighting sequence is incorrect.	a. Where the "0" neon lamp lights instead of the "4", the trouble is with either the "0", or "4" lamp, and in the majority of cases, it is "4"'. This can happen on any count; zero and four were used as examples. It is also possible that more than one lamp may light in place of, or with, the one that fails.

Table 11-12. Trouble-Shooting Chart for Decade Counters (Contd.)

SYMPTOM	CAUSE
11. Twelve stable states per cycle	a. When lighting sequence is $0123^{01}_{45}456789$-0, etc. (The count $\genfrac{}{}{0pt}{}{0}{4}$ indicates both "0" and "4" lamps are on.) First feedback failure . Second or third stage losing emission. b. When the lighting sequence is $01234567^{23}_{89}89$-0, etc. Second feedback failure. Third or fourth stage losing emission.

Table 11-13. Voltages and Resistances in Decade Counters

TUBE Z-204	TUBE Z-205-9	PIN NO.	DC TO GND Z-204	DC TO GND Z-205-9	RESISTANCE TO GND. Z-204	RESISTANCE TO GND. Z-205-9
V901	V1001	1	170	180	105K	130K
		2	17	15	85K	87K
		3,8	37	35	12K	15K
		4,5,9	Fil	Fil.		
		6	60	50	105K	130K
		7	30	35	85K	87K
V902	V1002	1	135	145	93K	110K
		2	15	20	83K	120K
		3,8	30	40	12K	15K
		4,5,9	Fil.	Fil.		
		6	55	60	93K	110K
		7	30	40	83K	120K
V903	V1003	1	135	145	100K	115K
		2	15	20	83K	120K
		3,8	30	40	12K	15K
		4,5,9	Fil.	Fil.		
		6	55	60	100K	115K
		7	30	40	83K	120K
V904	V1004	1	135	145	93K	110K
		2	15	20	83K	120K
		3,8	30	40	12K	15K
		4,5,9	Fil.	Fil.		
		6	55	60	93K	110K
		7	30	40	83K	120K

NOTE: All voltages in Table 11-13 were measured with a VTVM with the units indicating "0". All resistances were measure with the unit out of the socket and Pins 3 and 8 of the 8-pin plug shorted together.

All components have a tolerance of ±5%, except cathode resistors and condensers which are ±10%.

Table 11-13A. Typical Voltages and Resistances in Decade Counters; FR-38C/U and FR-38D/U

TUBE			DC TO GND		RESISTANCE TO GND.	
Z-204	Z-205-9	PIN NO.	Z-204	Z-205-9	Z-204	Z-205-9
V1301	V1201	1	72	62	140K	185K
		2	41	42	240K	310K
		3,8	41	42	10K	18K
		4, 5, 9	Fil.	Fil.	Fil.	Fil.
		6	210	205	160K	210K
		7	18	14	82K	125K
V1302	V1202	1	66	61	132K	185K
		2	38	40	245K	310K
		3, 8	36	40	10K	18K
		4, 5, 9	Fil.	Fil.	Fil.	Fil.
		6	170	155	150K	210K
		7	18	19	85K	125K
V1303	V1203	1	61	60	132K	185K
		2	33	39	245K	310K
		3, 8	33	40	10K	18K
		4, 5, 9	Fil.	Fil.	Fil.	Fil.
		6	160	140	150K	210K
		7	16	19	85K	125K
V1304	V1204	1	68	58	145K	185K
		2	43	39	250K	310K
		3,8	43	39	15K	18K
		4, 5, 9	Fil.	Fil.	Fil.	Fil.
		6	190	165	170K	210K
		7	18	18	88K	125K

NOTE: All voltages were measured with a VTVM with the units indicating "0".

All resistances were measured with the unit out of socket.

All components have a tolerance of ±5% except cathode resistors and capacitors which are±10%.

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Table 11-14A. Equipment Modernization

EQUIPMENT SERIALS	CHANGE	ADJUSTMENT REQUIRED
1 15 2 16 3 17 6 18 7 19 9 20 10 21 11 22 12 23 13 24 14 26	R-610 was 180K, change to 200K. R-246 was 1000, change to 1500 ohms. R-449 was 3300, change to 3000 ohms. R-467 was 3300, change to 3000 ohms.	Adj. FREQ. SENS. Adj. FREQ. SENS. Adj. 3rd Phan. Adj. 5th Phan.
2 20 3 21 4 22 6 23 7 24 8 26 9 27 10 28 11 31 12 33 13 37 14 42 15 43 16 44 17 46 18 48 19	R-488 was 15 megohms, change to 1M and connect to ground instead of to +210V dc.	No adjustment required.
1 to 100 (inclusive)	R-251 was 1M, change to 980K, 1% tolerance. R-252 was 470K, change to 490K, 1% tolerance. R-258 was 10%, change to 5% tolerance. R-259 was 10%, change to 5% tolerance. R-264 was 10%, change to 5%.tolerance. R-266 was 10%, change to 5% tolerance. R-261 was 220 or 200, change to 240 ohms, 5% tolerance. C-231 was 47, change to 56 ohms.	Adj. GATE LENGTH Adj. GATE LENGTH Adj. GATE LENGTH Adj. GATE LENGTH Adj. GATE LENGTH Adj. GATE LENGTH Adj. GATE LENGTH Adj. GATE LENGTH
1 to 101, inclusive, and 103 to 113, inclusive, and 115 to 128, inclusive, and 133 to 136, inclusive, and 144 153 145 160 147 164 148 165 150	Connect Pin 1 of V-209 to opposite end of R-281 and C-365 (directly to blocking oscillator transformer).	No adjustments required.
1 to 170, excepting some serials between 150 and 175.	R-288 was omitted.	Do not modify.

Table 11-14A. Equipment Modernization; FR-38D/U

EQUIPMENT SERIALS	CHANGE	ADJUSTMENT REQUIRED
All Models FR-38D/U Frequency Converter.	L 224 added at factory in output circuit to the	1. Plug in Converter MX-1637/U in position in FR-38D/U. Do not use special test cables. 2. Turn power ON. Allow unit to warm up thoroughly. 3. Set controls as follows: FR-38D/U FUNCTION SELECTOR - FREQUENCY FREQUENCY UNIT- .01 sec. TIME UNIT- 10 MC DISPLAY TIME- minimum (extreme CCW) 100 KC STANDARD- INT MX-1637/U MIXING FREQUENCY - 0 GAIN- MAX 4. Connect STD. FREQ OUTPUT connector to SIGNAL INPUT connector using single open wire. 5. Adjust L224 for minimum deflection (max opening) of the tuning eye. If tuning eye is completely closed reduce GAIN so that a clear indication is obtained on the eye.

Table 11-15. Trouble Shooting the CV-394/USA-5

SYMPTOM	PROBABLE CAUSE	REMEDY
Tuning eye does not glow when Power is ON.	Defective tube V1206.	Replace V1206.
	Defective component in circuit of V1206.	Measure circuit voltages using ME-25A/U and compare with values given In the schematic diagram, Figure 12-54. Check circuit components which may be defective, in accordance with voltage measurements, and replace any defective components.
Tuning eye glows properly, but no signal is counted by the FR-38/U.	Defective component in circuits of V1203, V1204, or V1205.	Measure circuit voltages using ME-25A/U and compare with values given in the schematic diagram, Figure 12-54. Check circuit components which may be defective, in accordance with voltage measurements, and replace any defective components.
	Defective component in circuits of V1201 and V1202.	Measure circuit voltages using ME-25A/U and compare with values given in the schematic diagram, Figure 12-54. Check circuit components which may be defective, in accordance with, voltage measurements, and replace any defective components. Check rectified 10-mc voltage at pin 1 of V1 (test point PP), which should be -65V dc ±10%. If voltage is incorrect, check C1209, C1210, and R1201.

SECTION XII

DIAGRAMS

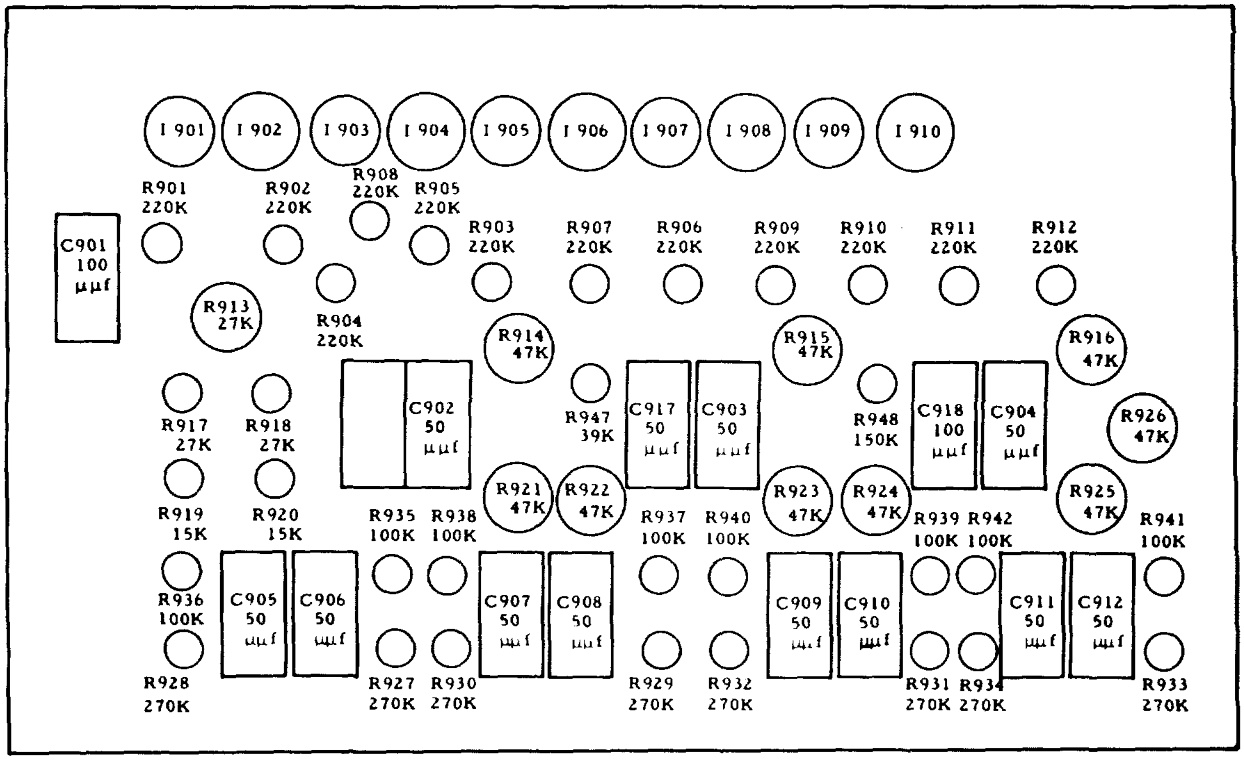

Figure 12-1. Parts Layout of Decade Counter Z-204

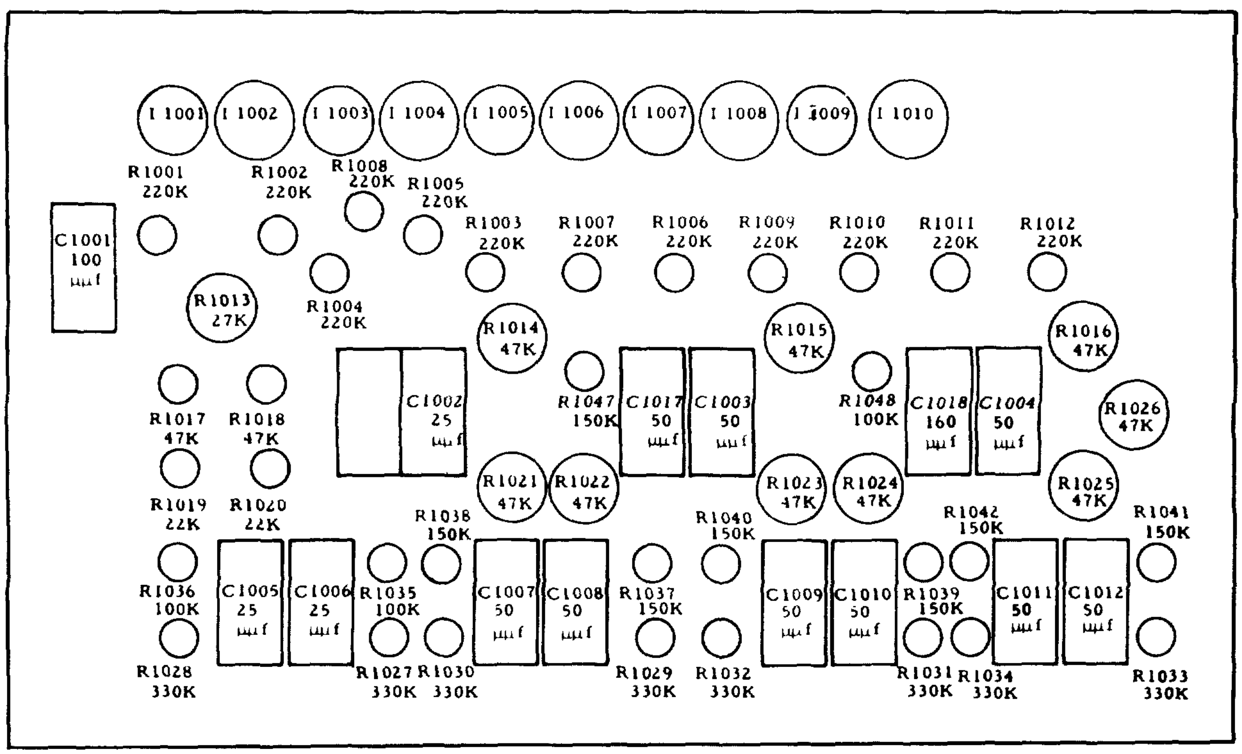

Figure 12-2. Parts Layout of Decade Counters Z-205 through Z-209

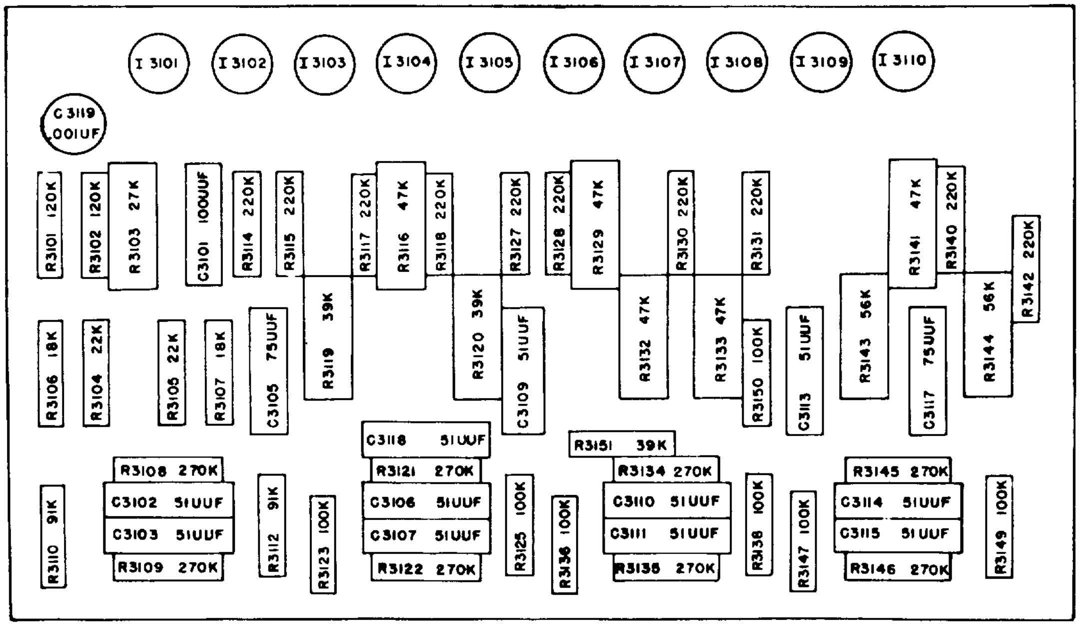

Figure 12-1.1. Parts Layout of Decade Counter Z-204, FR-38C/U and FR-38D/U

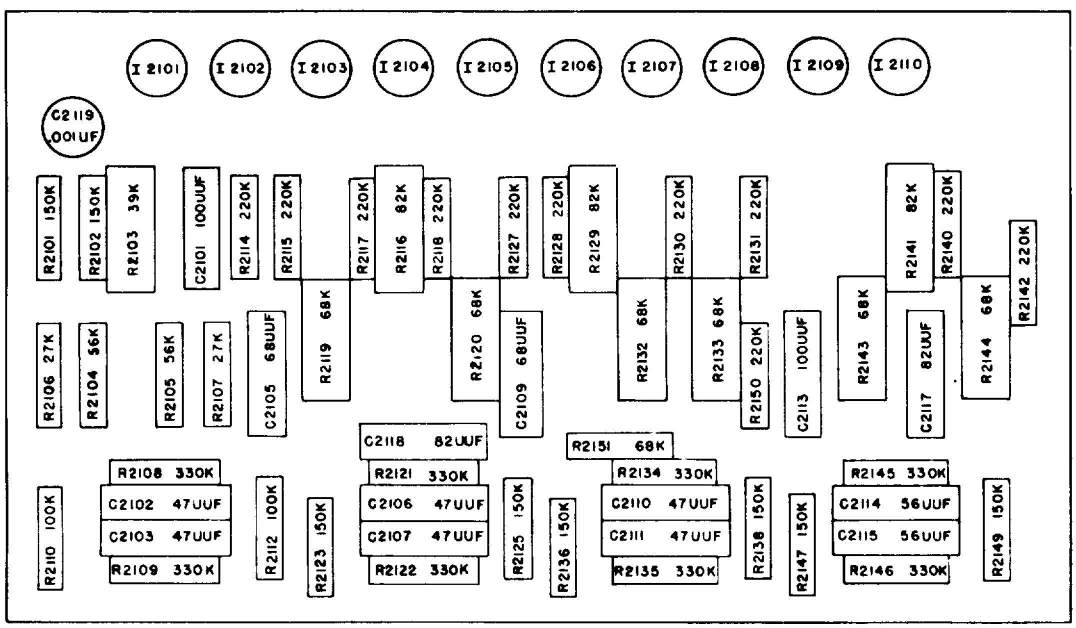

Figure 12-2.1. Parts Layout of Decade Counters Z-205 through Z-209, FR-38C/U and FR-38D/U

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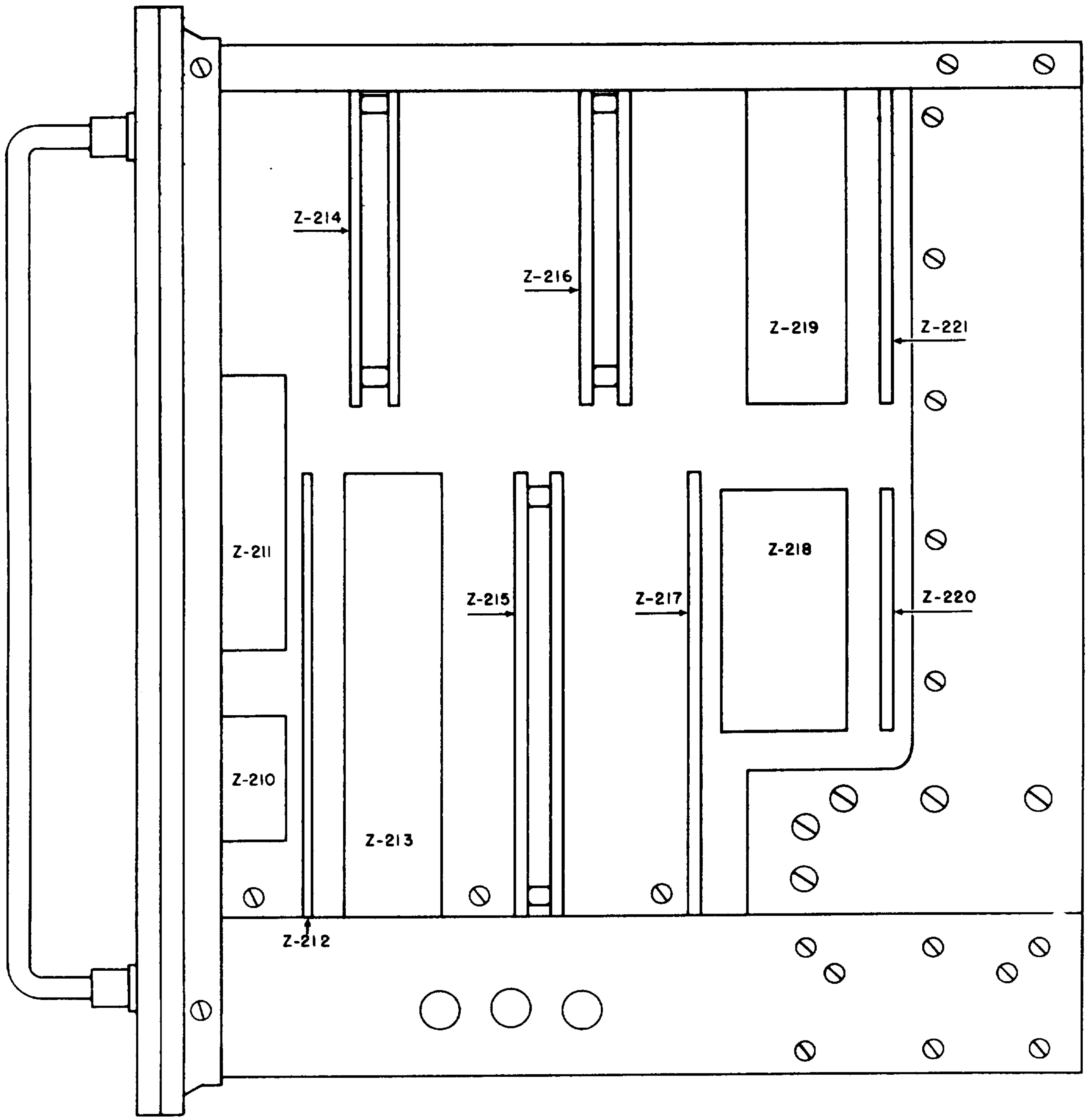


Figure 12-3. Counter Deck, Locating Resistor Boards Z-210 through Z-221

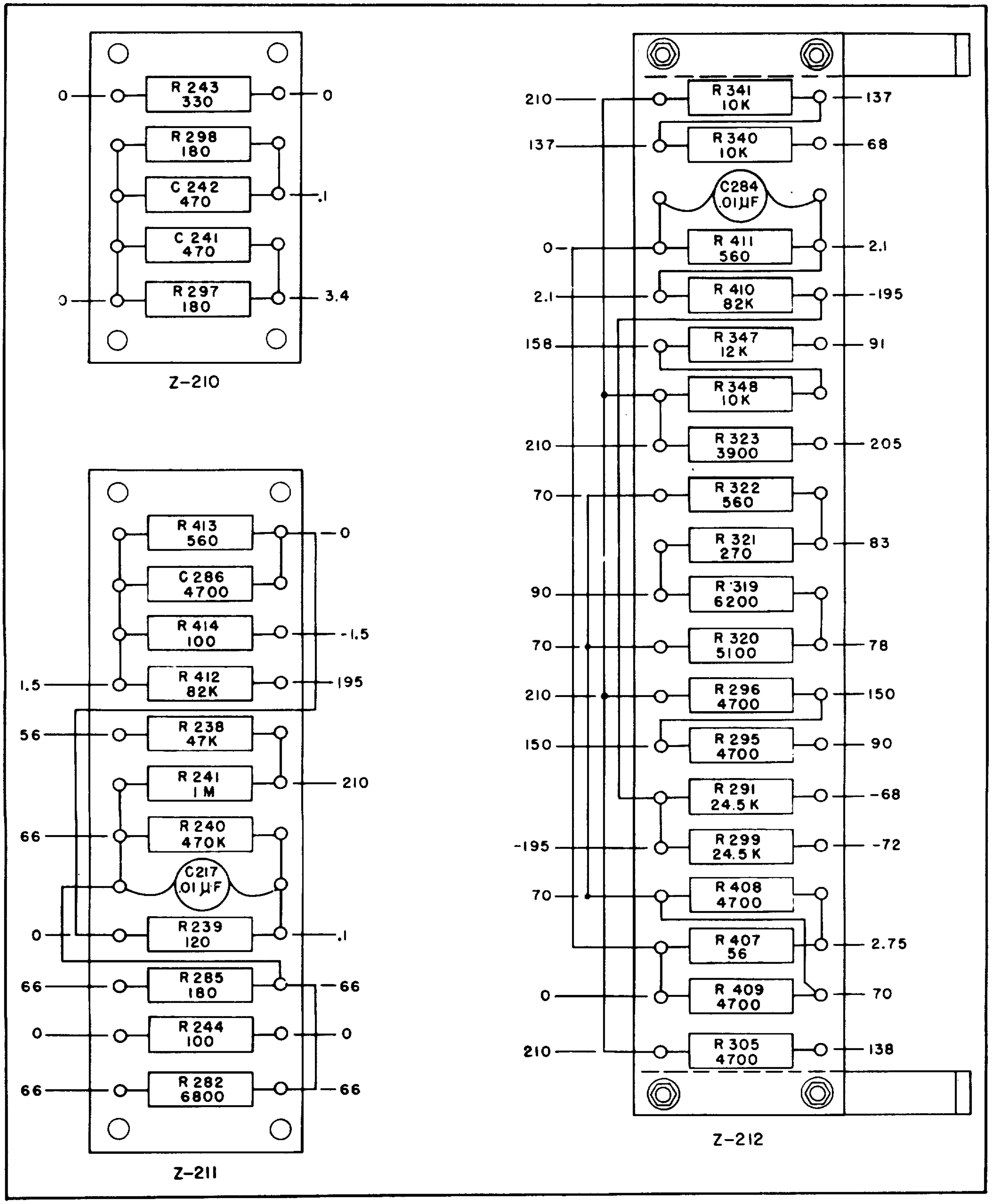


Figure 7-4. Resistor Board Diagram Z-210 through Z-212

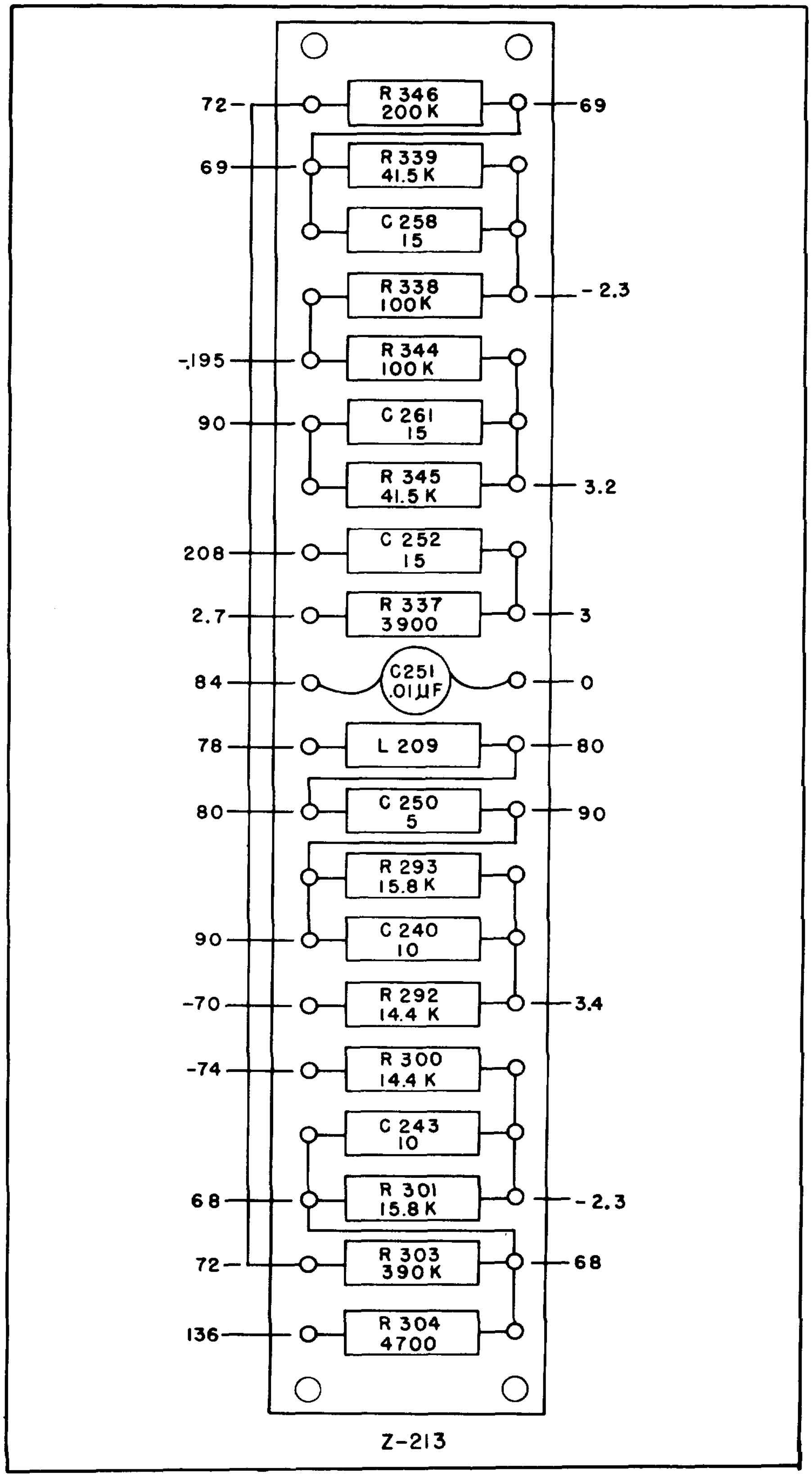


Figure 12-5. Resistor Board Diagram Z-213.

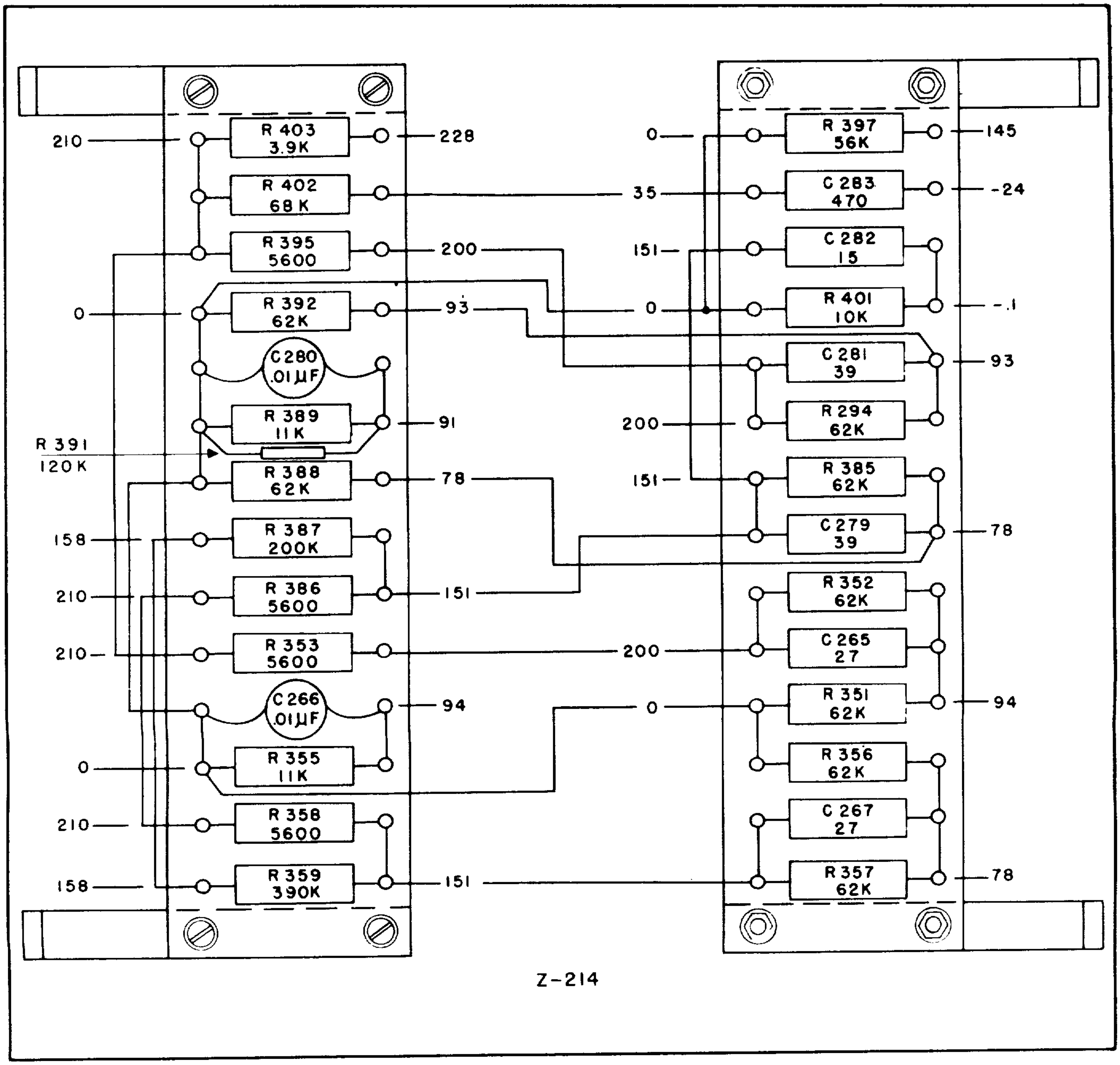
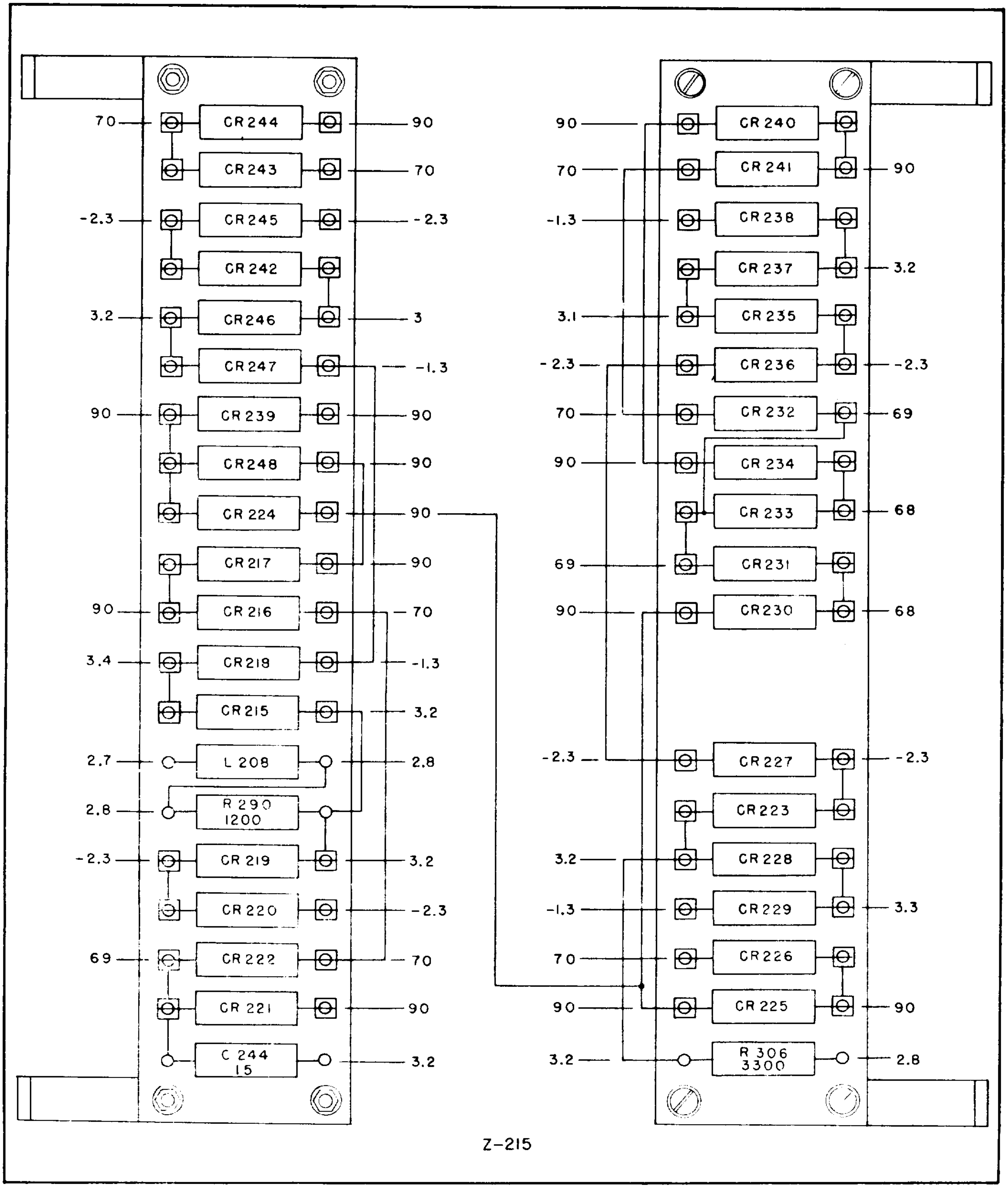


Figure 12-6. Resistor Board Diagram Z-214



Fl lure 12-7. Resistor Board Diagram Z-215

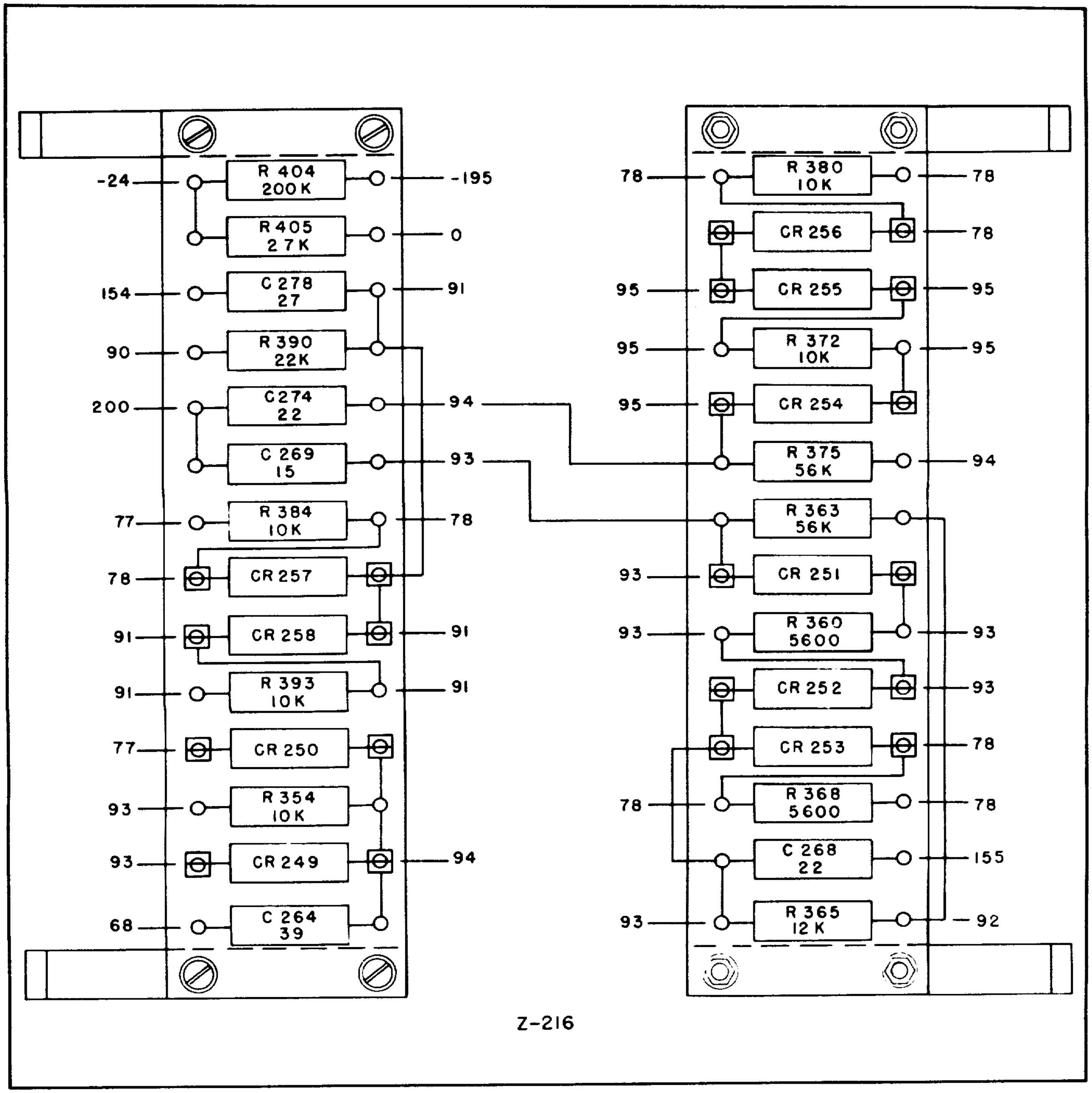


Figure 12-8. Resistor Board Diagram Z-216

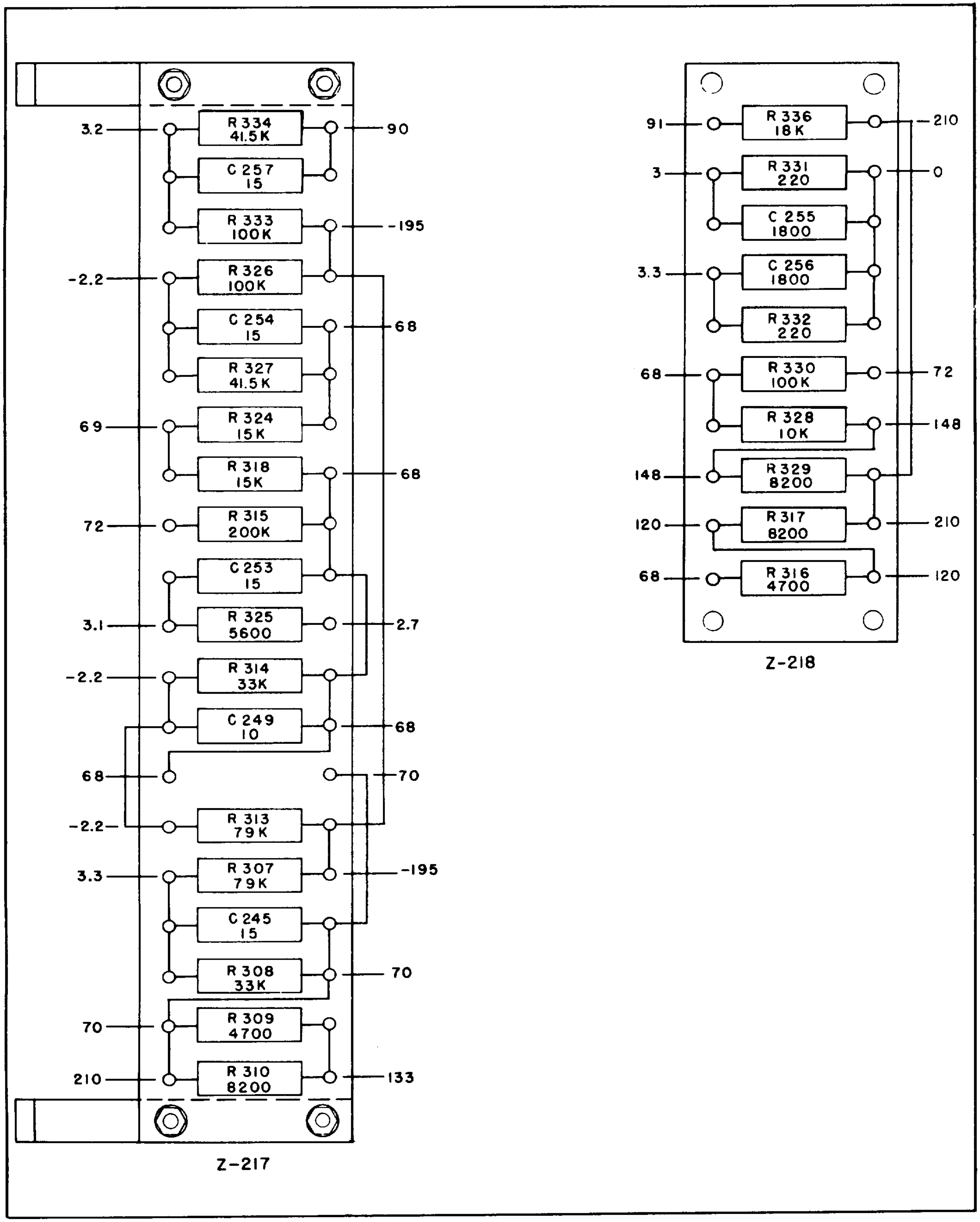


Figure 12-9. Resistor Board Diagrams Z-217 and Z-218

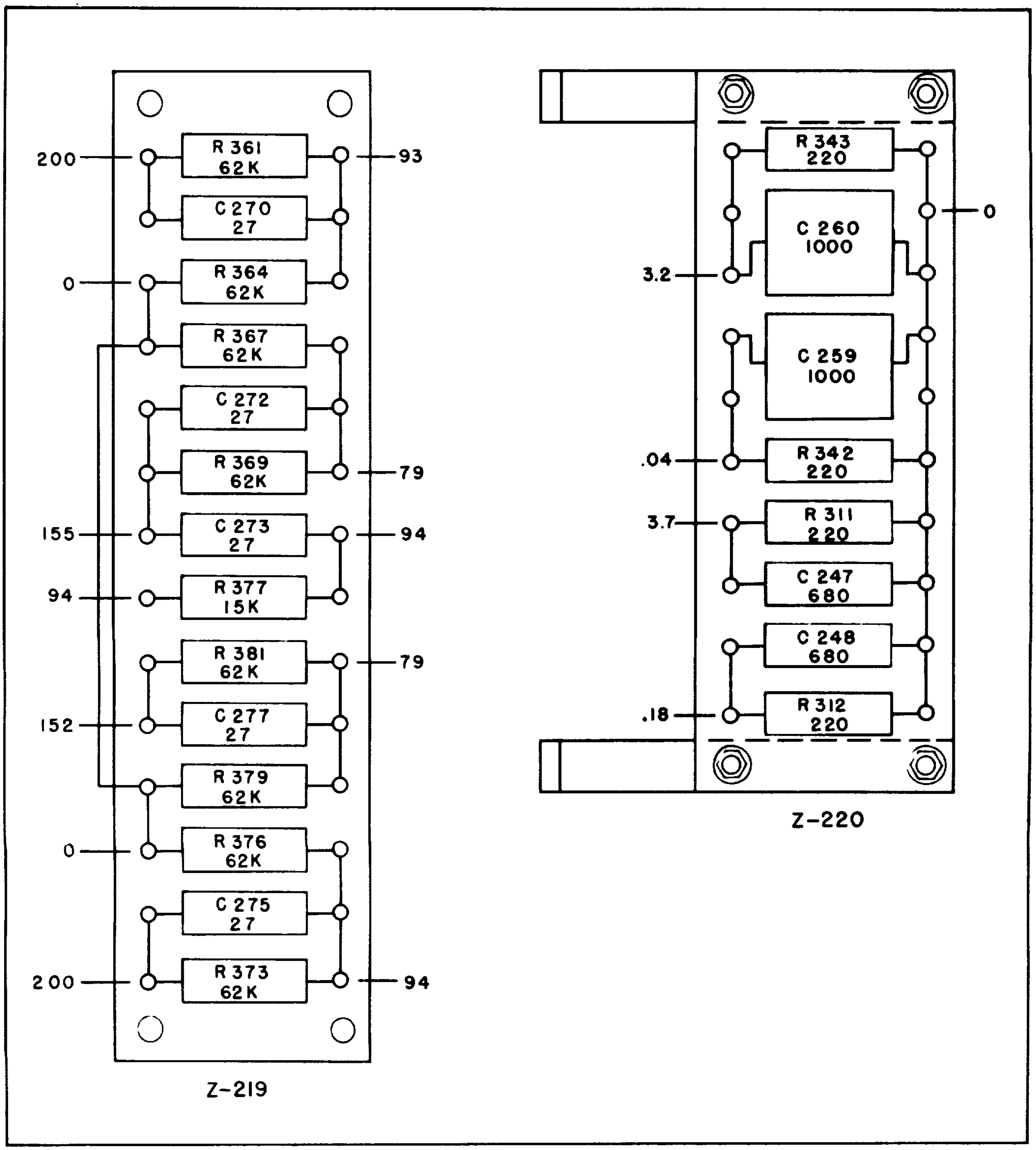


Figure 12-10. Resistor Board Diagrams Z-219 and Z-220

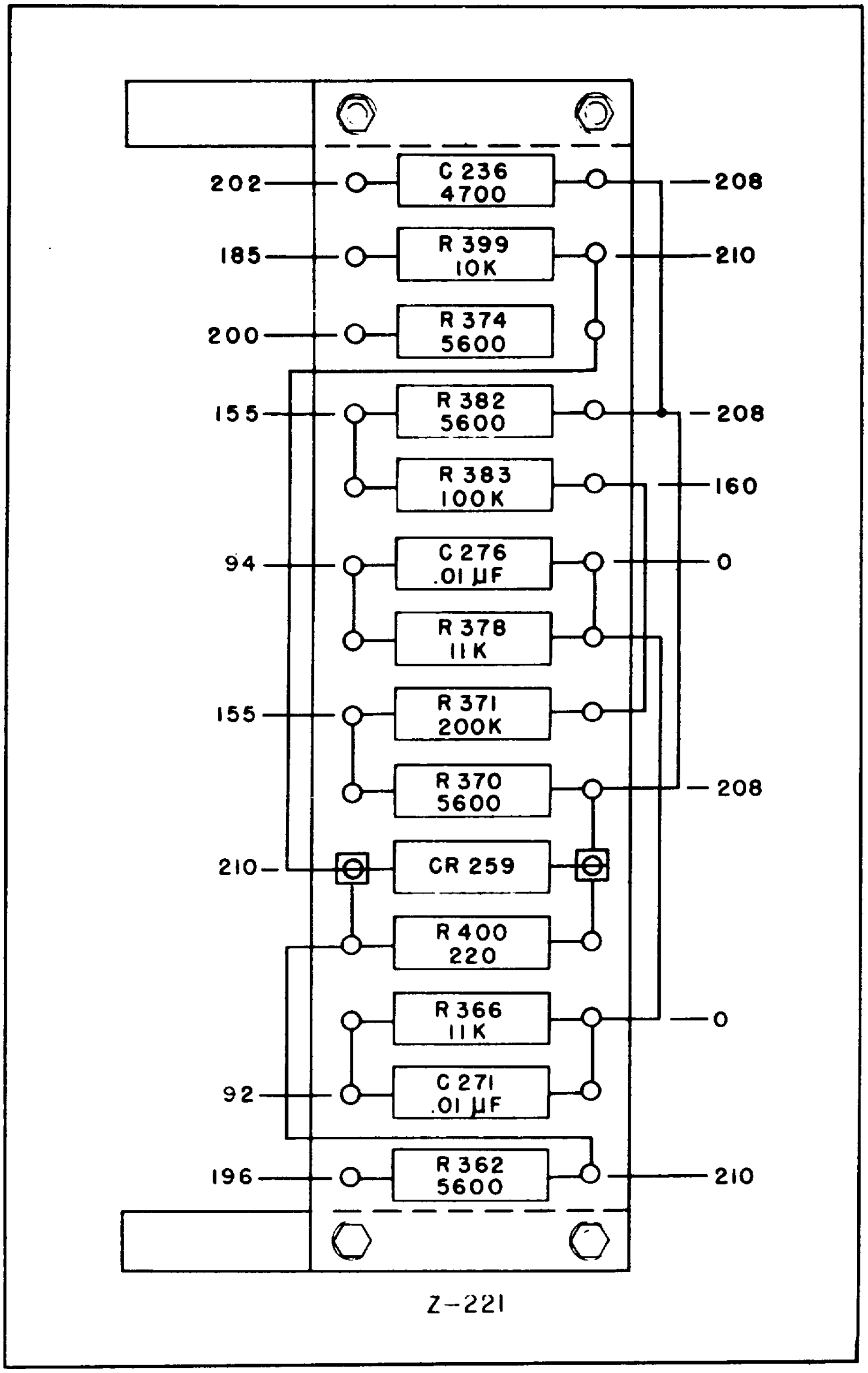


Figure 12-11. Resistor Board Diagram Z-221

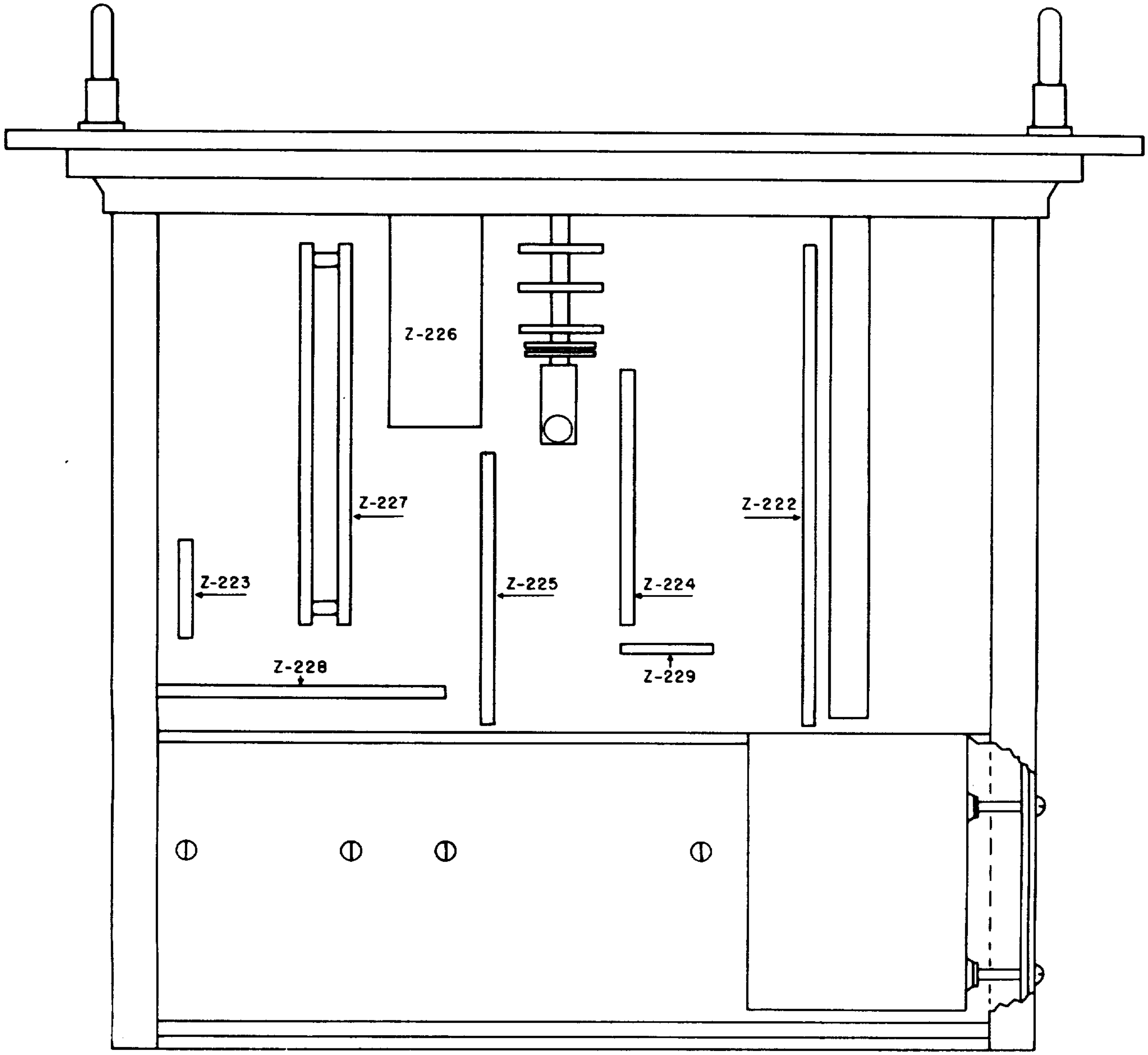
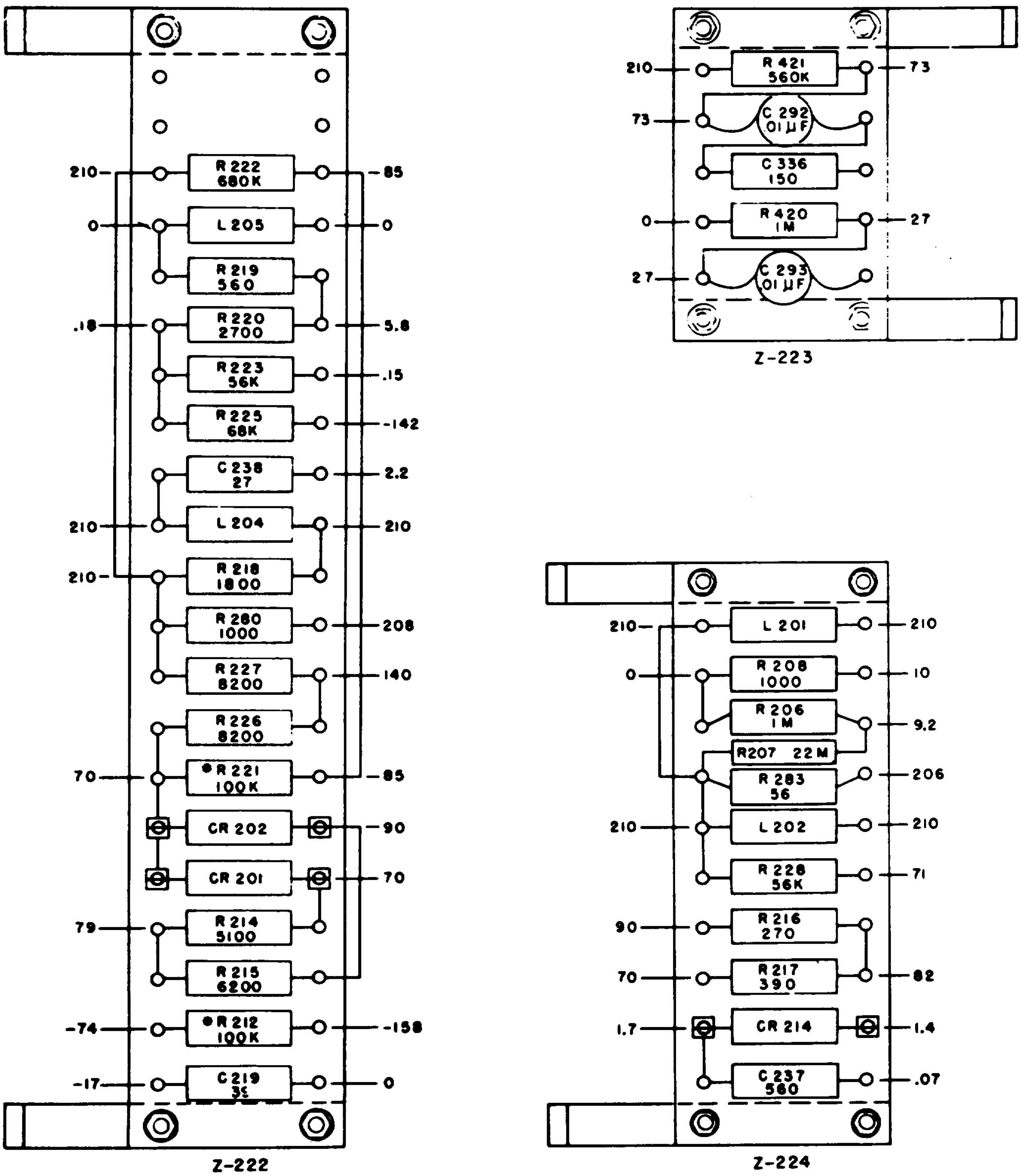


Figure 12-12. Gate Deck, Locating Resistor Boards Z-222 through Z-229



*R212 and R221 are 82K ohms in FR-38D/U

Figure 12-13. Resistor Board Drawings Z-222 through Z-224

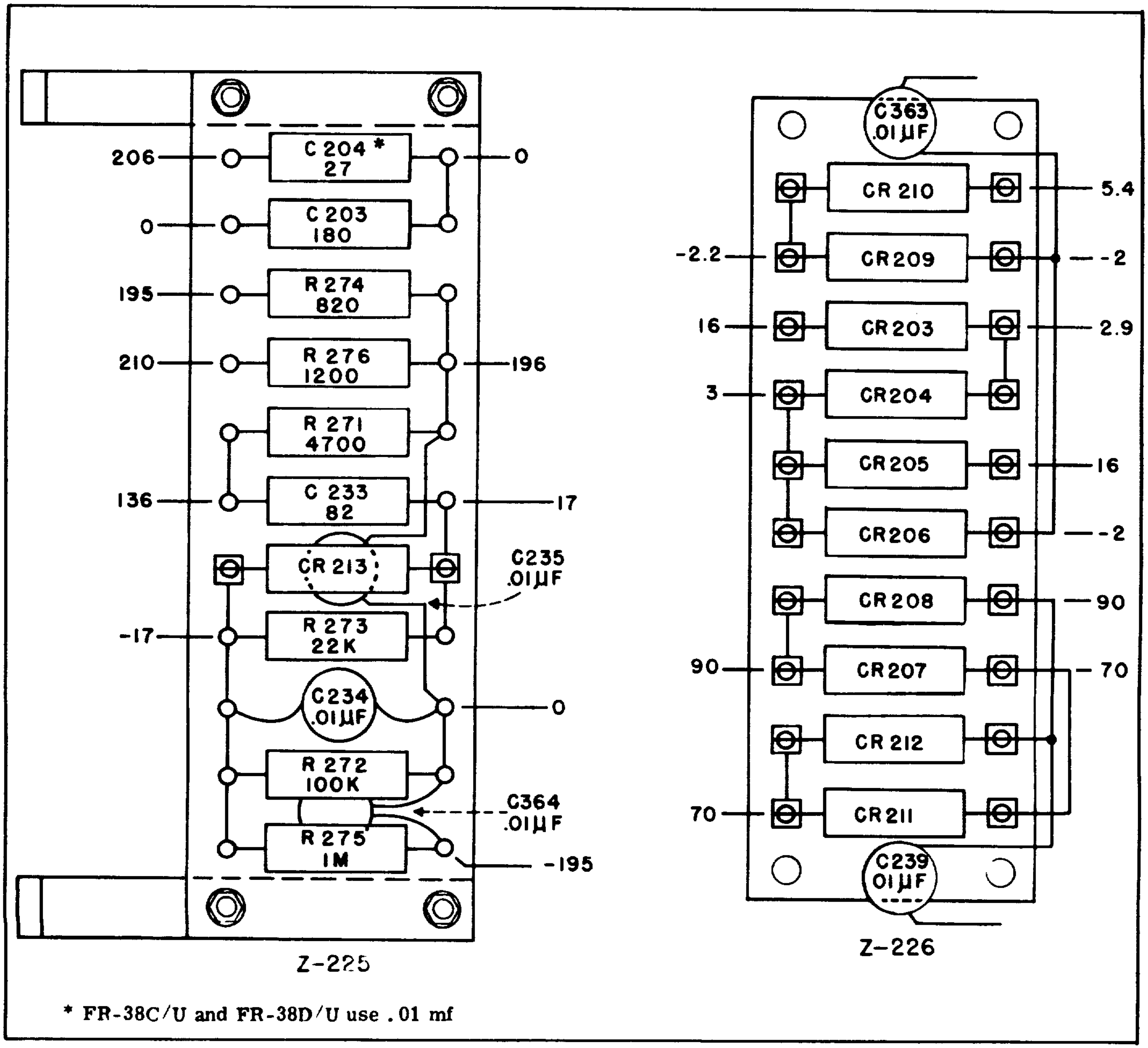
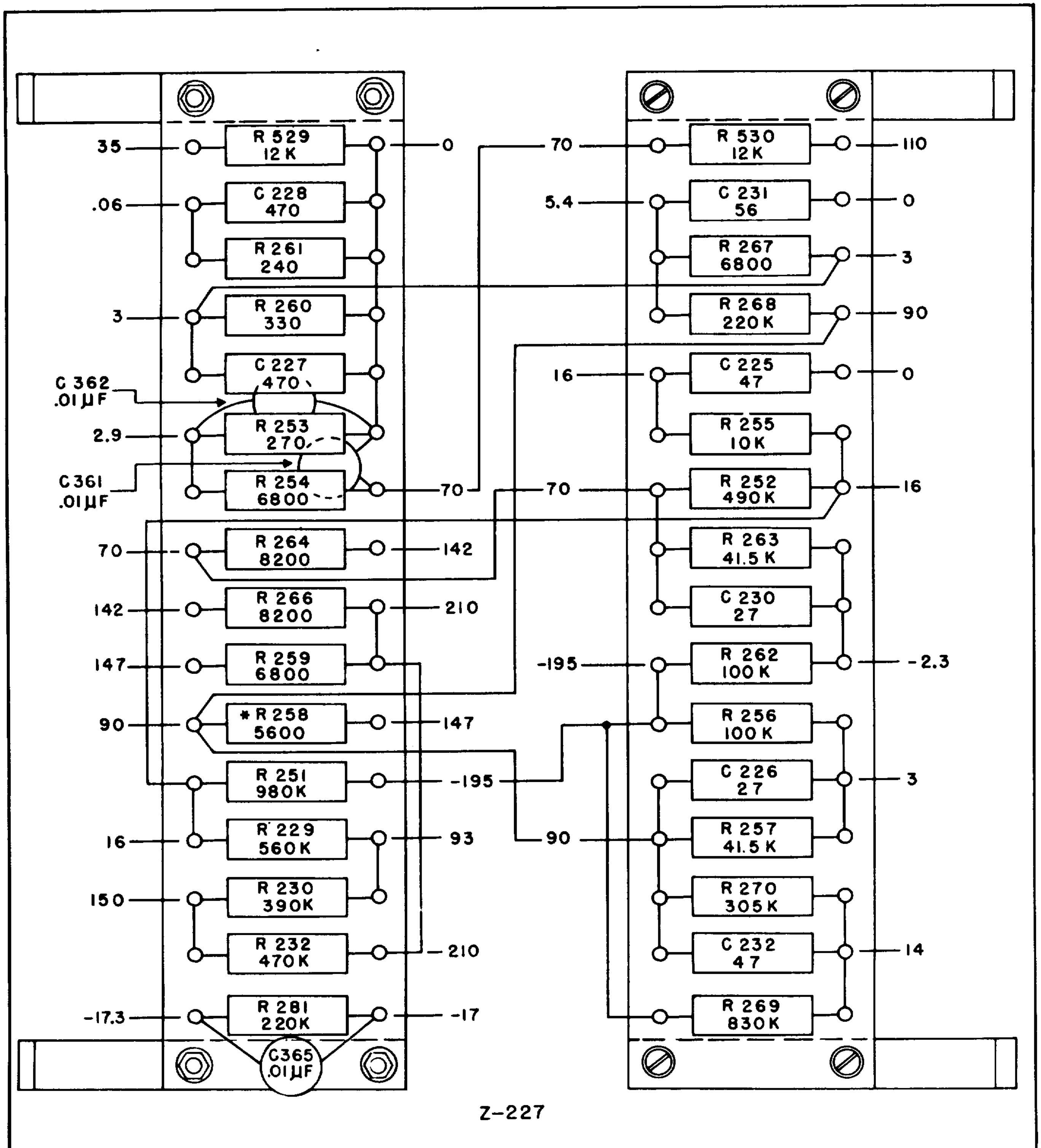


Figure 12-14. Resistor Board Drawings Z-225 and Z-226



*R258 is 6800 ohms in FR-38C/U and FR-38D/U.

Figure 12-15. Resistor Board Diagram Z-227

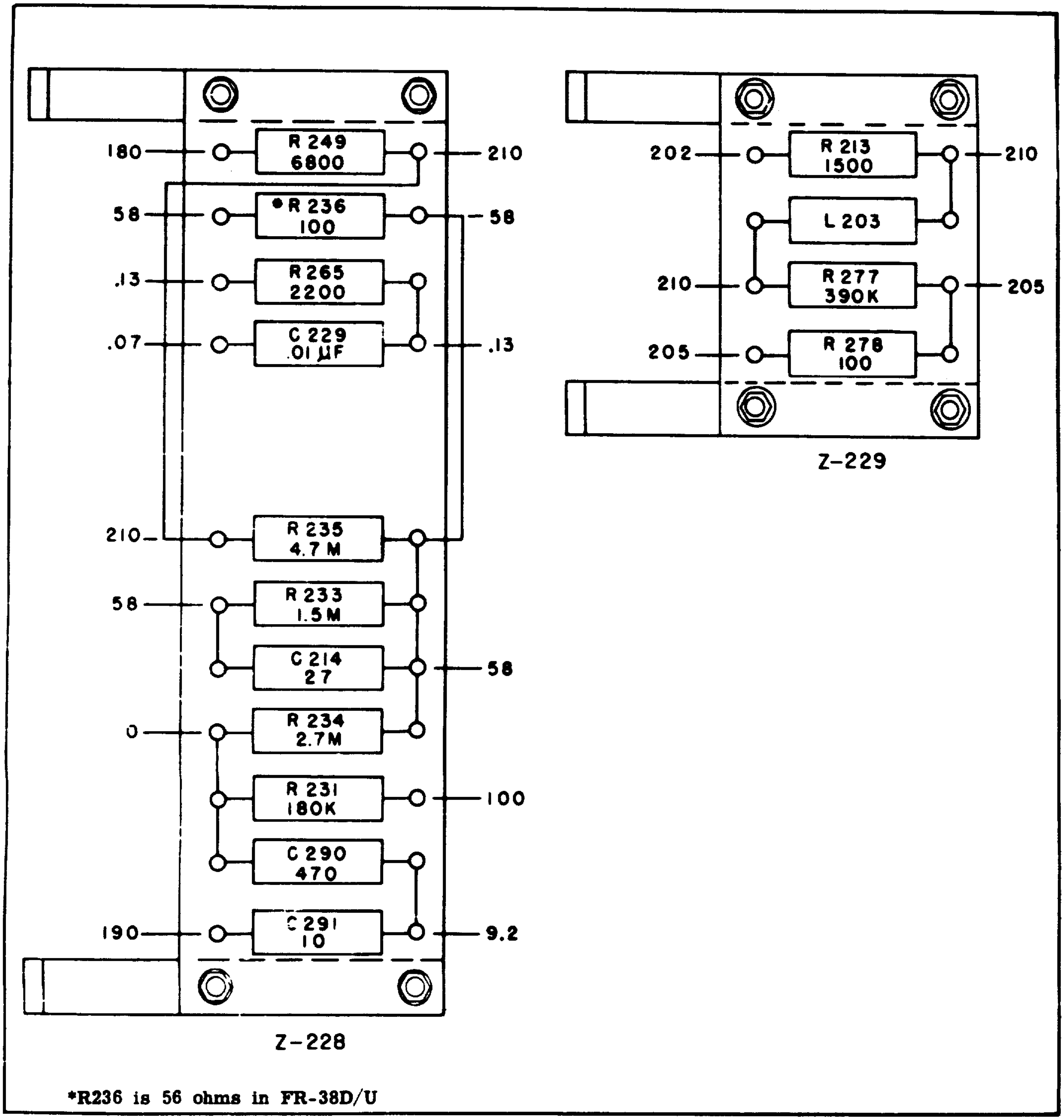


Figure 12-16. Resistor Board Diagrams Z-228 and Z-229

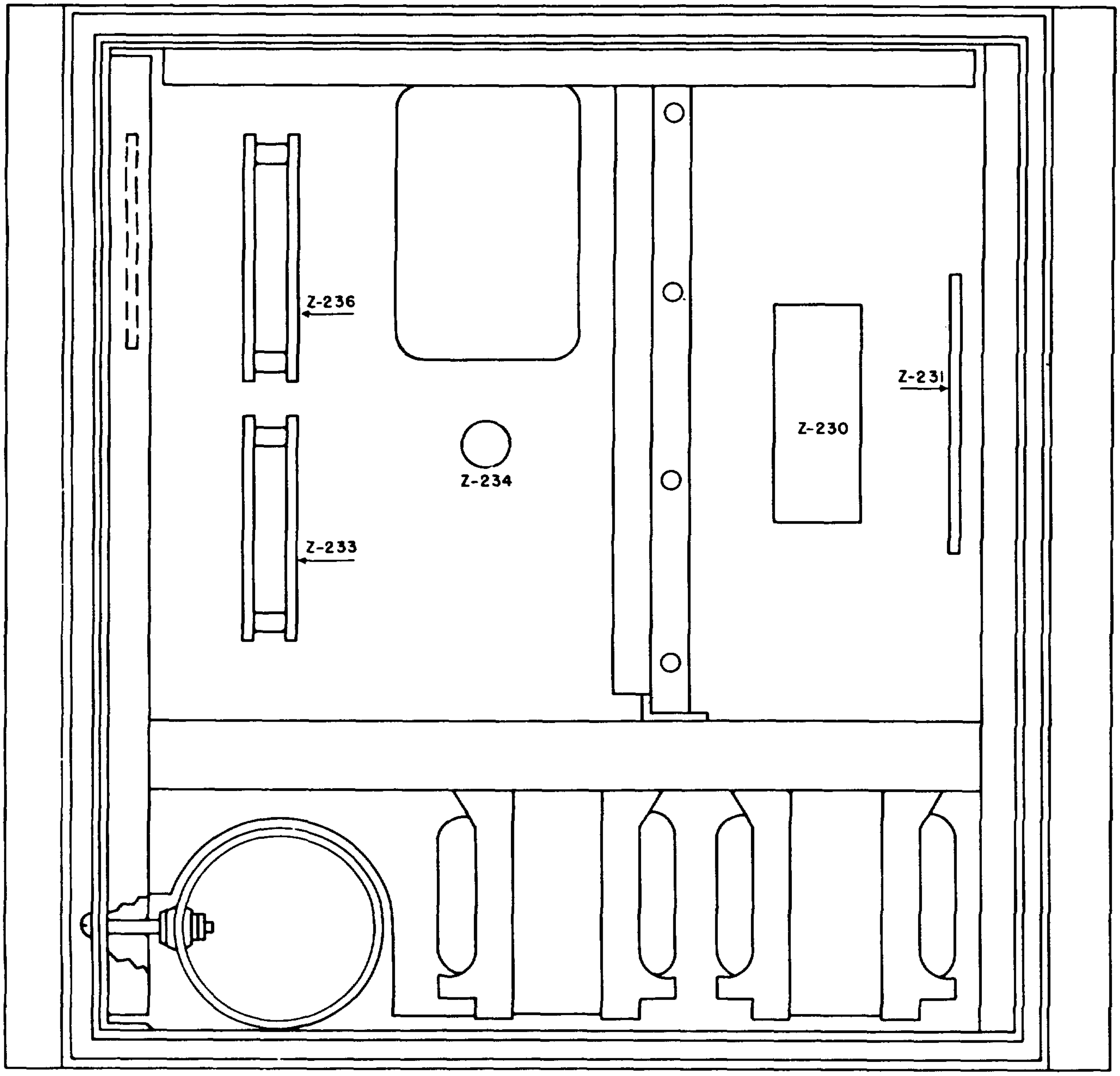


Figure 12-17. Time Base and Power Supply Deck, Locating Resistor Boards Z-230 through Z-236

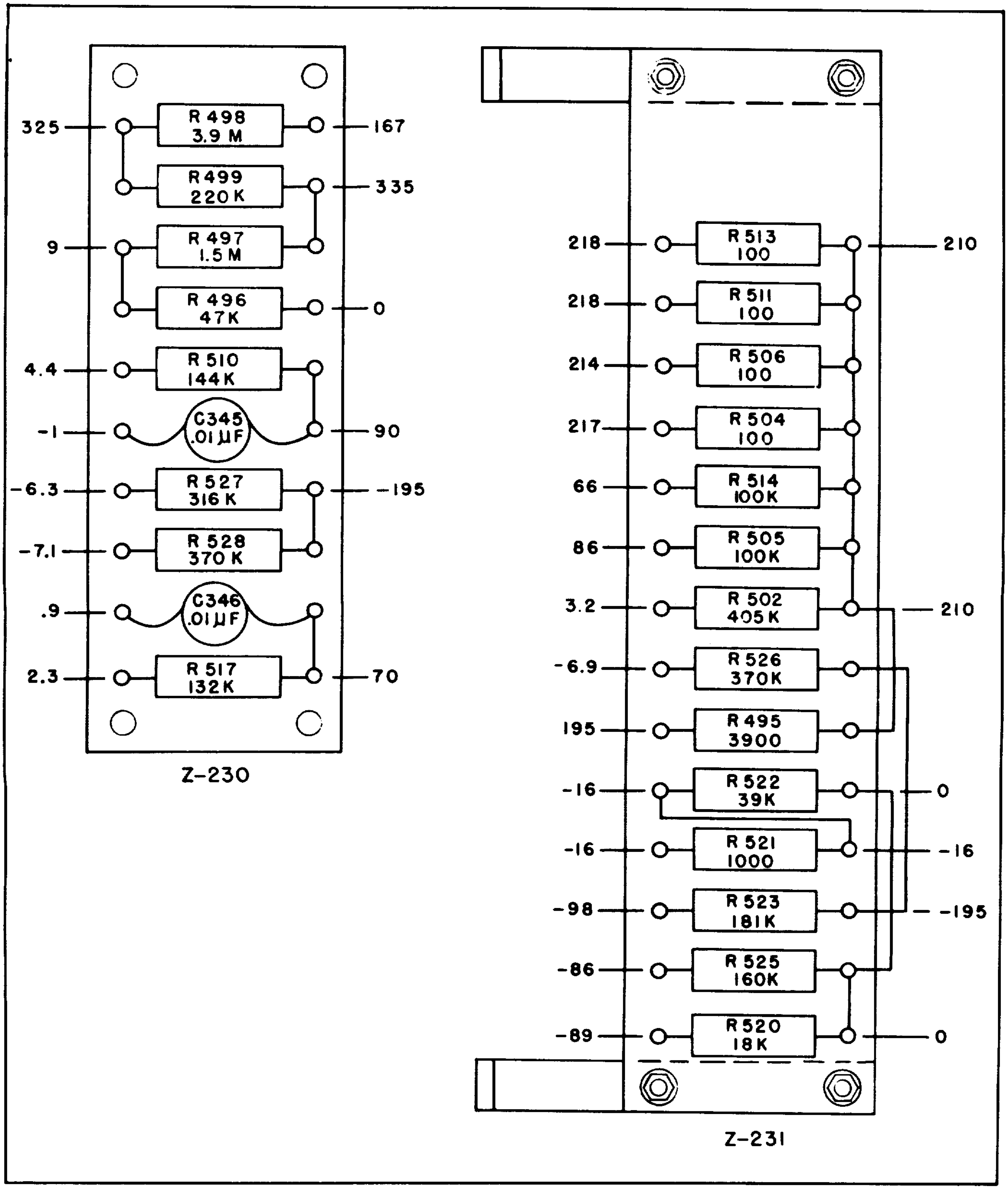


Figure 12-18. Resistor Board Diagrams Z-230 and Z-231

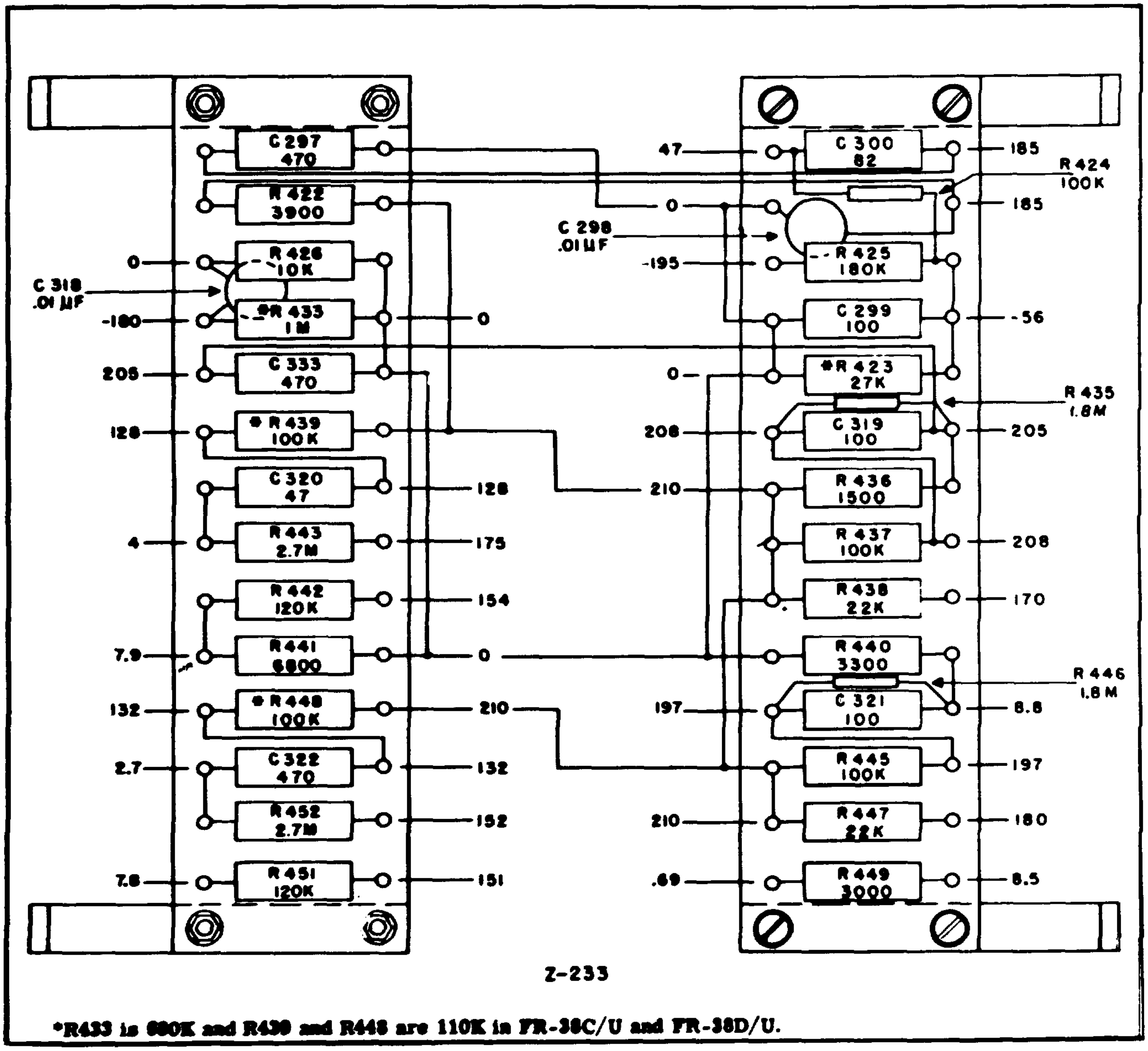


Figure 12-19. Resistor Board Diagram Z-233

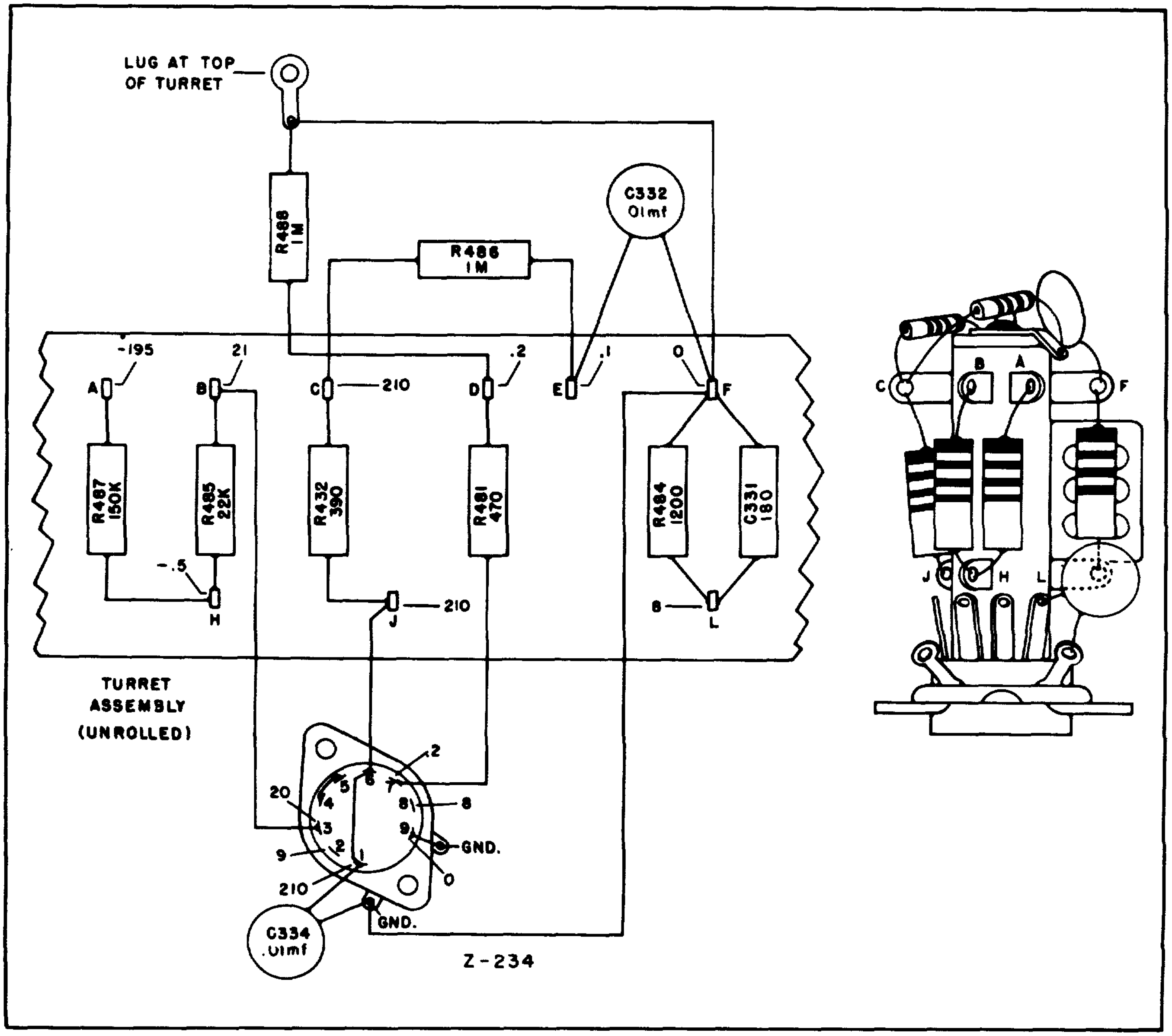


Figure 12-20. Resistor Board Drawing Z-234

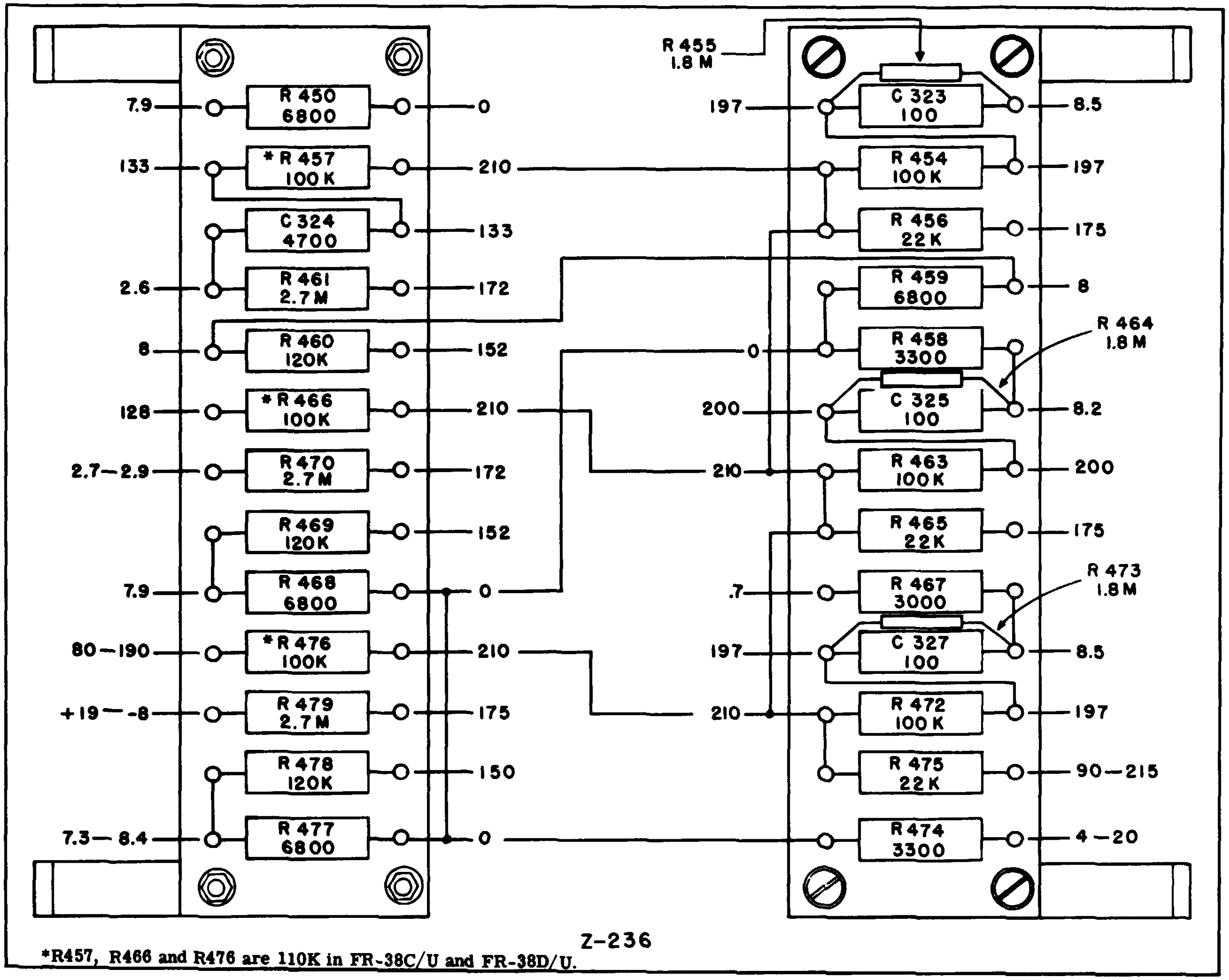


Figure 12-21. Frequency Resistor Board Diagram Z-236

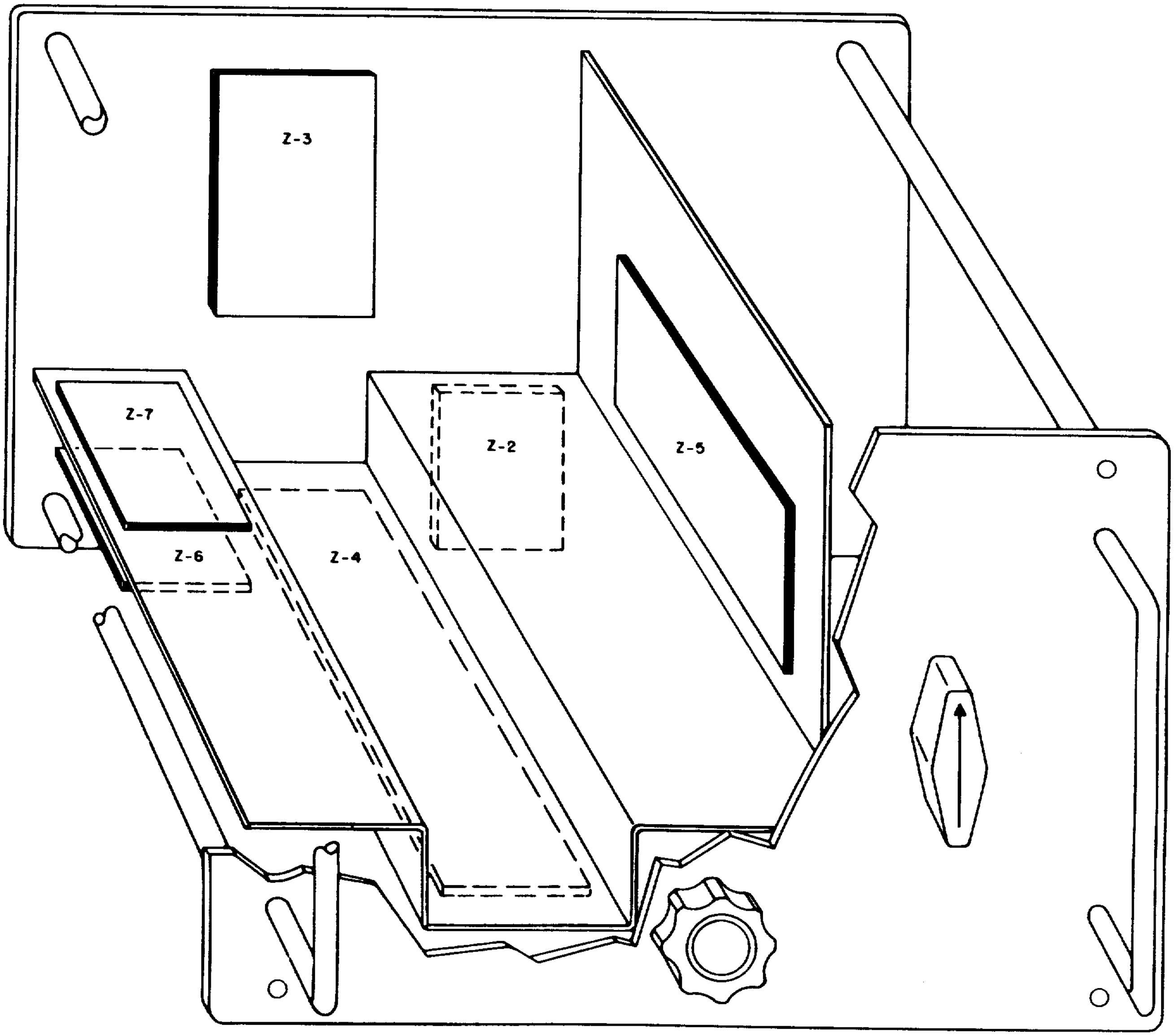


Figure 12-22. Frequency Converter Unit, Locating Resistor Boards Z-2 through Z-7

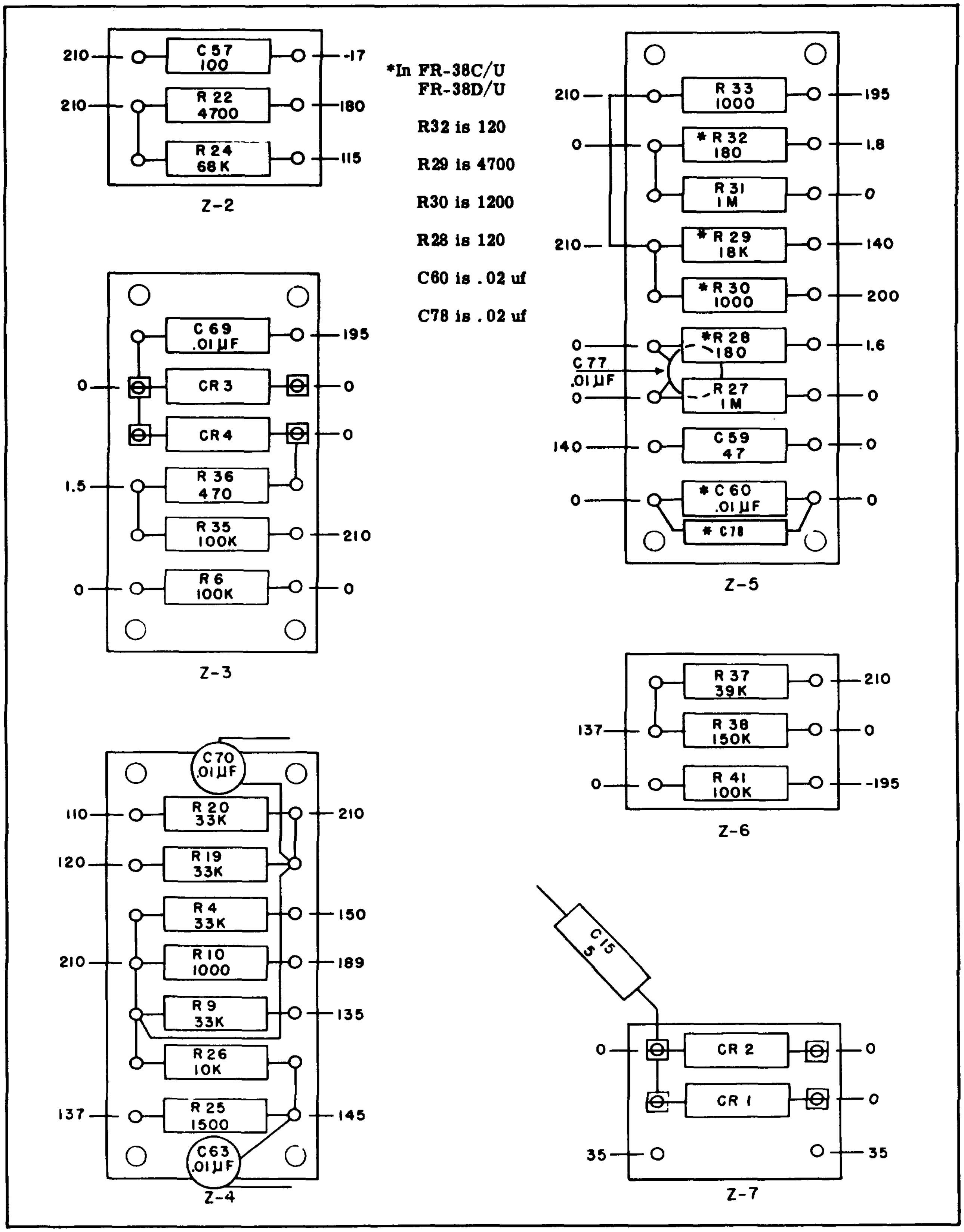
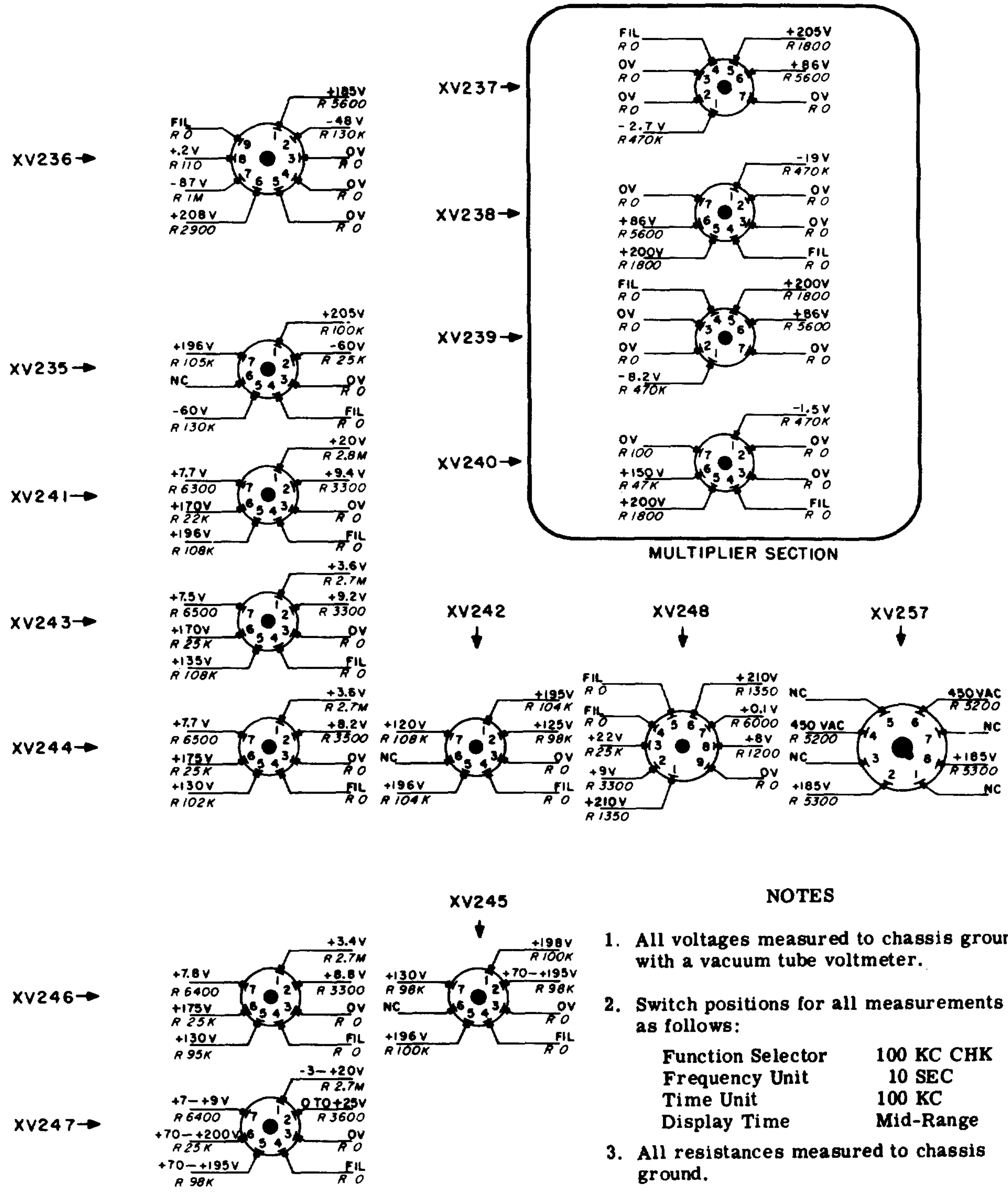


Figure 12-23. Resistor Board Diagrams Z-2 through Z-7



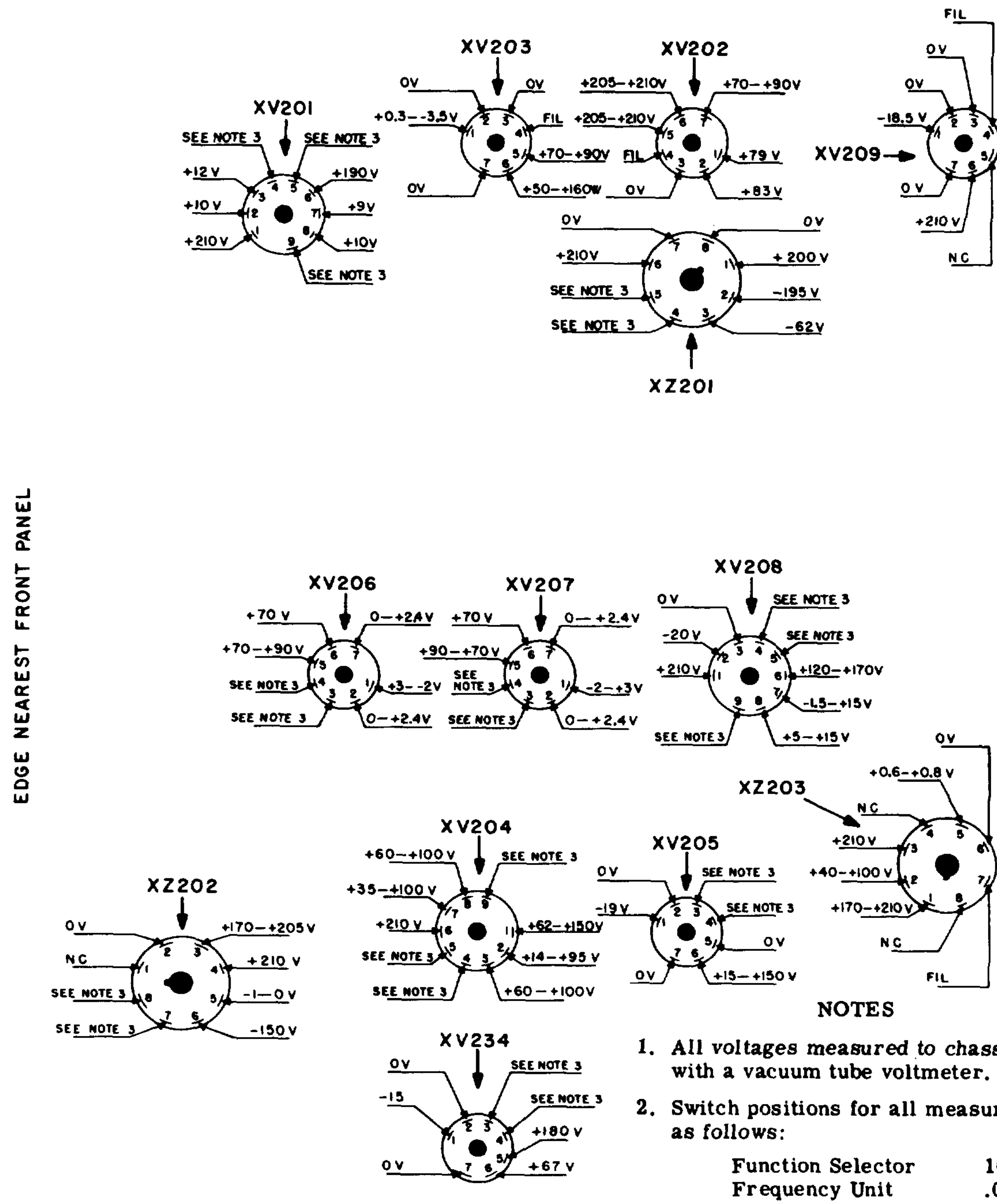
NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.
2. Switch positions for all measurements are as follows:

Function Selector	100 KC CHK
Frequency Unit	10 SEC
Time Unit	100 KC
Display Time	Mid-Range

3. All resistances measured to chassis ground.

Figure 12-24. Voltage and Resistance Diagrams for Time Base Section



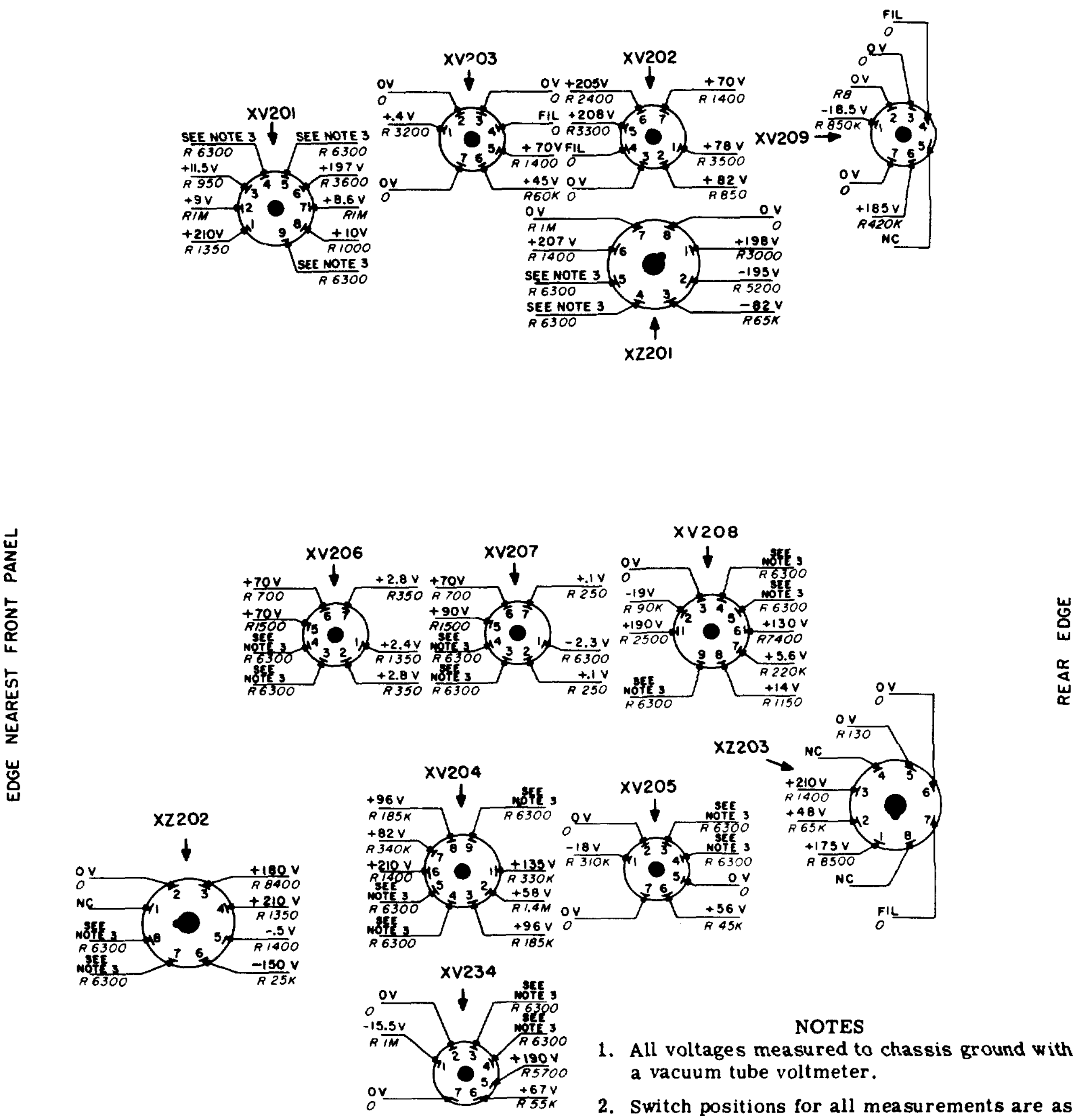
NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.
2. Switch positions for all measurements are as follows:

Function Selector	100 KC CHK
Frequency Unit	.001
Time Unit	100 KC
Display Time	Min.

3. 6.3 volt ac for heater biased 35 volts dc positive from ground.
4. All resistances measured to chassis ground.

Figure 12-25. Voltage and Resistance Diagrams for Gate Section (.001 Second Gate)



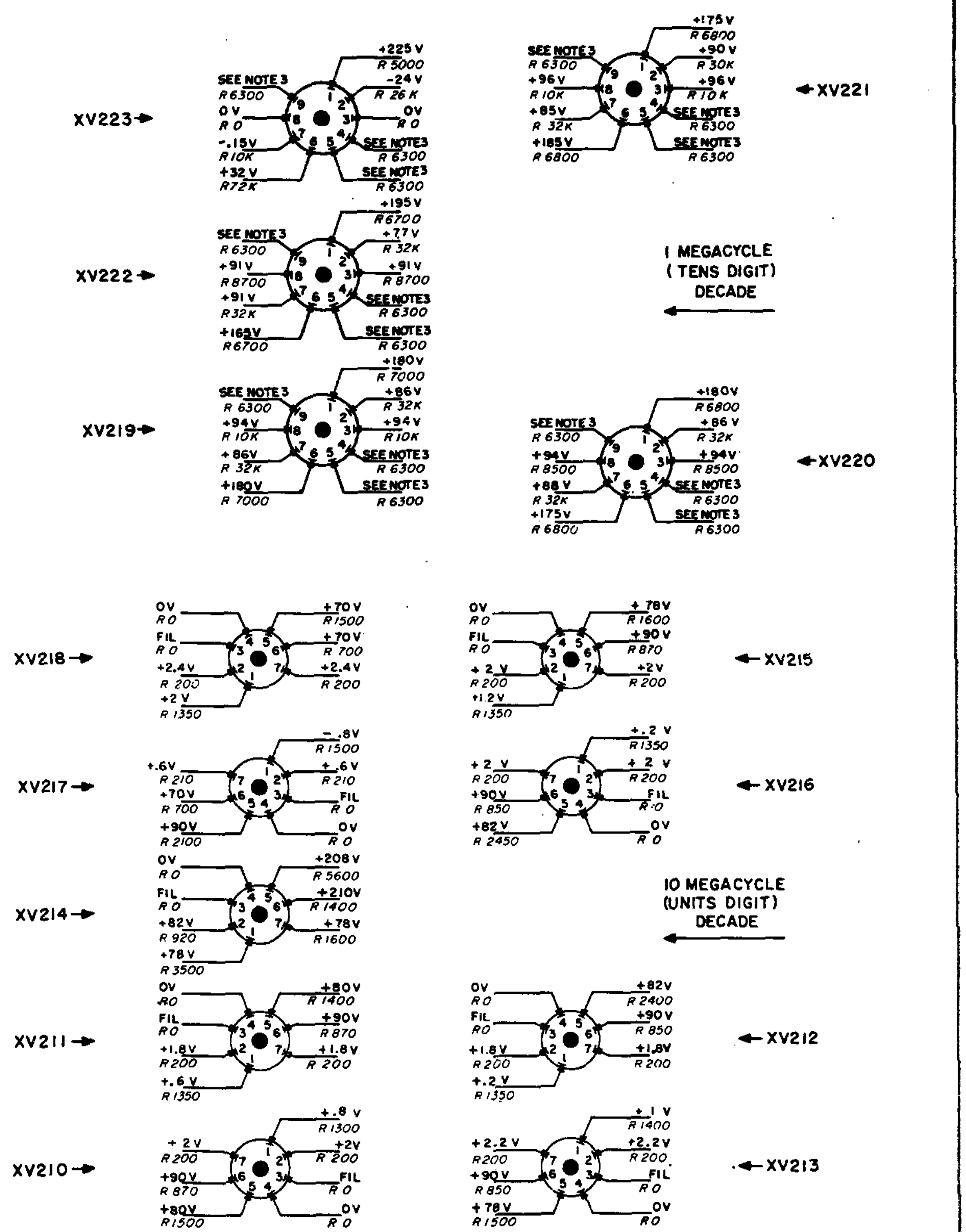
NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.
2. Switch positions for all measurements are as follows:

Function Selector	100 KC CHK
Frequency Unit	10 SEC
Time Unit	100 KC
Display Time	Mid-Range

3. 6.3 volt ac for heater biased 35 volts dc positive from ground.
4. All resistances measured to chassis ground.

Figure 12-26. Voltage and Resistance Diagram for Gate Section (10 Second Gate)



NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.

2. Switch positions for voltage measurements are as follows:

Function Selector	Manual Gate
Time Unit	100 KC
Manual Gate	OPEN

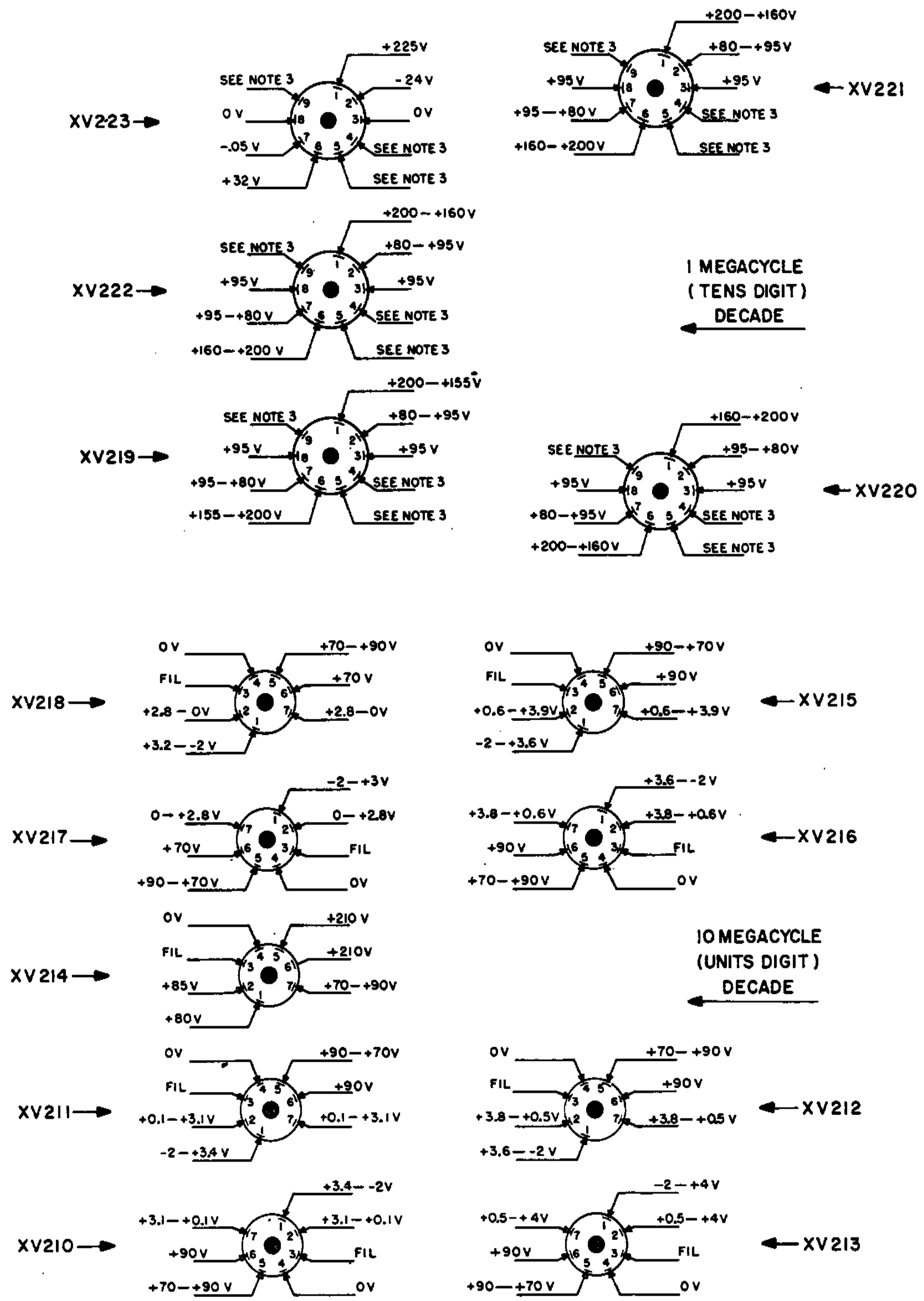
3. 6.3 volt ac for heater of 1 Megacycle Decade biased 35 volts dc positive from ground.

4. All resistances measured to chassis ground.

5. Switch positions for resistance measurements are as follows:

Function Selector	100 KC CHK
Frequency Unit	.001
Time Unit	100 KC
Display Time	Min.

Figure 12-27. Voltage and Resistance Diagrams for Counter Section (100 KC Signal Input)



NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.

2. Control settings.

   Voltage measurements for 10 Megacycle Decade:

Function Selector	Manual Gate
Time Unit	EXT
Manual Gate	OPEN

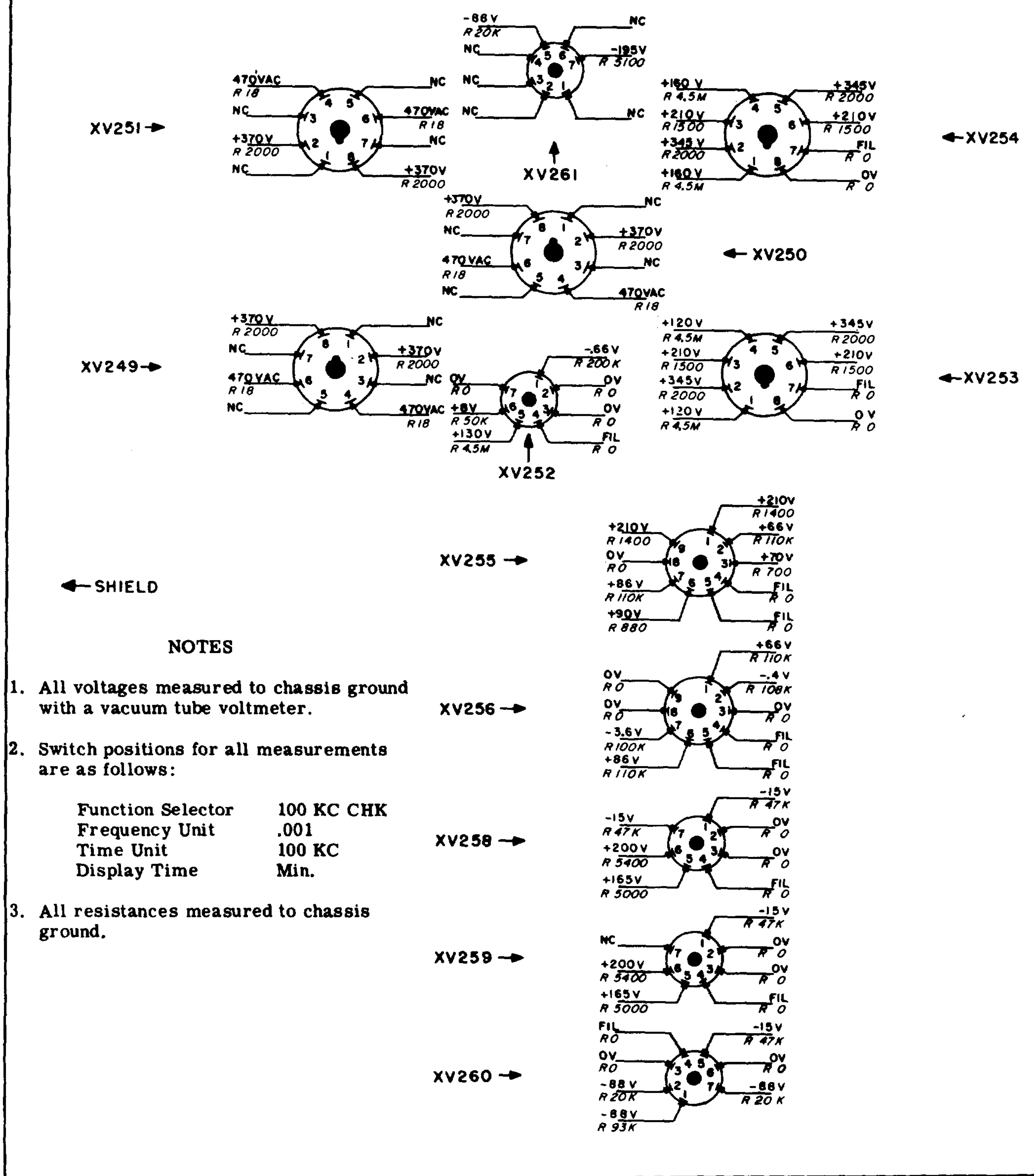
   Connect a clip lead from Pin 2 of V-247 (R-474, Figure 2-15) to the STD. FREQ. OUTPUT connector. Any other 1 cps signal source of 2 to 10 volts rms will serve equally well.

   Voltage measurements for 1 Megacycle Decade:

Function Selector	Manual Gate
Time Unit	10 cps
Manual Gate	OPEN

3. 6.3 volt ac for heater biased 35 volts dc positive from ground.

Figure 12-28. Voltage and Resistance Diagrams for Counter Section (1 cps Signal Input)



NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.

2. Switch positions for all measurements are as follows:

Function Selector	100 KC CHK
Frequency Unit	.001
Time Unit	100 KC
Display Time	Min.

3. All resistances measured to chassis ground.

Figure 12-29. Voltage and Resistance Diagrams for Power Supply

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NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.
2. Switch positions for all voltage measurements of Z-201 Z-202, Z-203 are as follows:

Function Selector	100 KC CHK
Frequency Unit	.001
Time Unit	100 KC
Display Time	Min.
Period-Time Interval	Period
Slope	Both -
Trigger Level	Both 0
Com Sep	Com

3. Switch positions for all voltage measurements of Frequency Converter Unit Z1 are as follows:

Function Selector	Frequency
Frequency Unit	.001
Time Unit	100 KC
Display Time	Min.
Gain	Max.
Mixing Frequency	0

4. 6.3 volt ac for heater biased 35 volts dc positive from ground.
5. All resistances measured to chassis ground.
6. Resistances of all plug-in units taken to chassis of unit while removed from instrument.

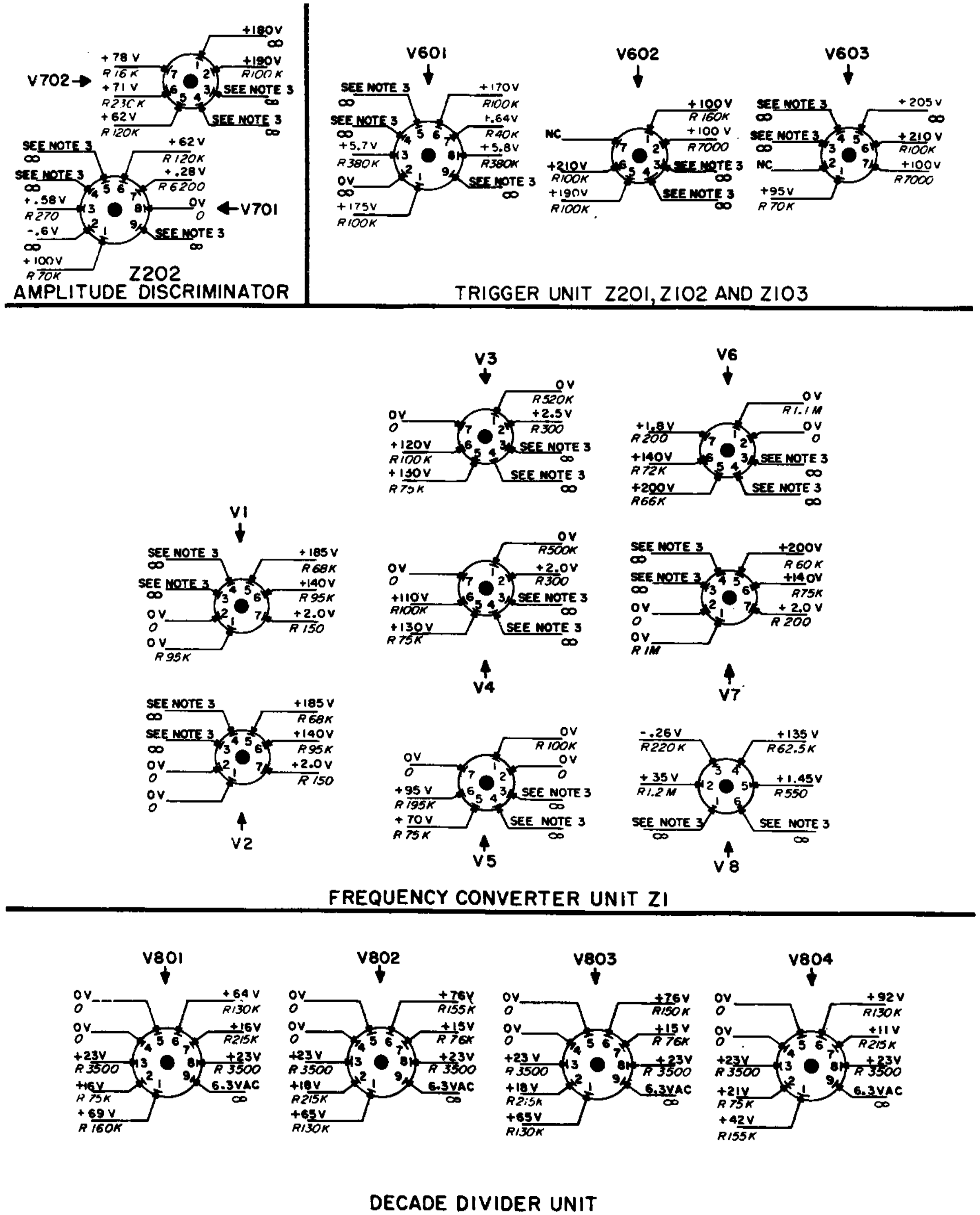


Figure 12-30. Voltage and Resistance Diagrams for Plug-In Units, Trigger Units Z-201, Z-102 and Z103, Amplitude Discriminator Z-202, and Decade Divider Z-203

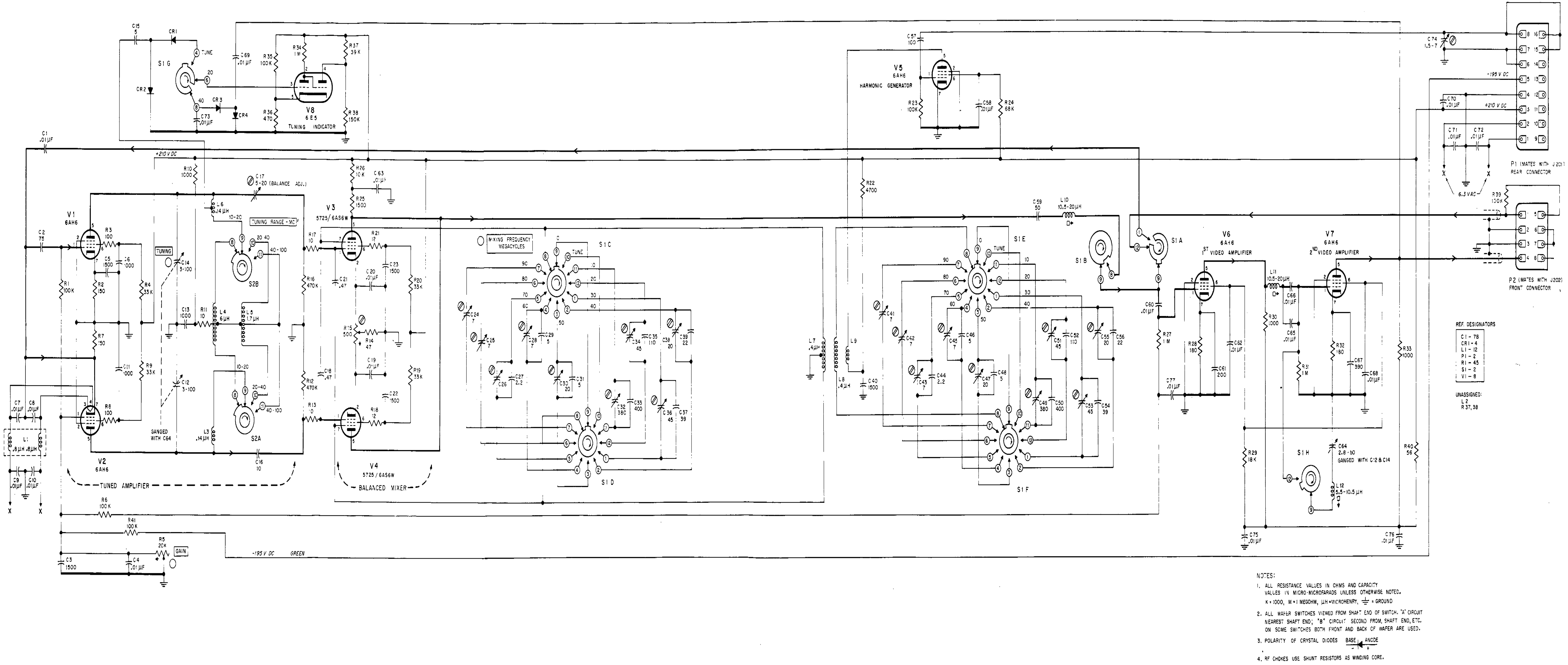


Figure 12-31. Schematic Diagram of Frequency Converter Panel Plug-In Unit MX-1637/U

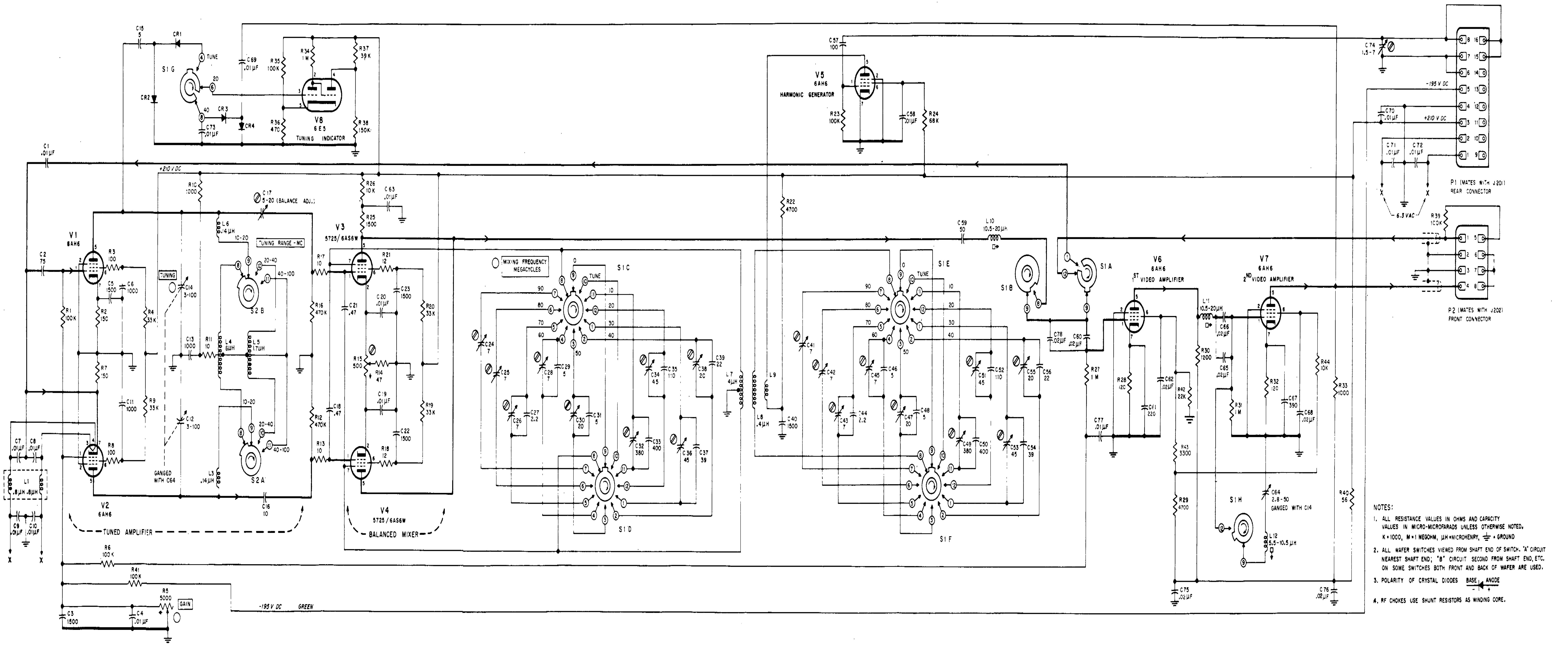


Figure 12-31A. Schematic Diagram of Frequency Converter Panel Plug-In Unit MX-1637/U Used in FR-38C/U and FR-38 D/U

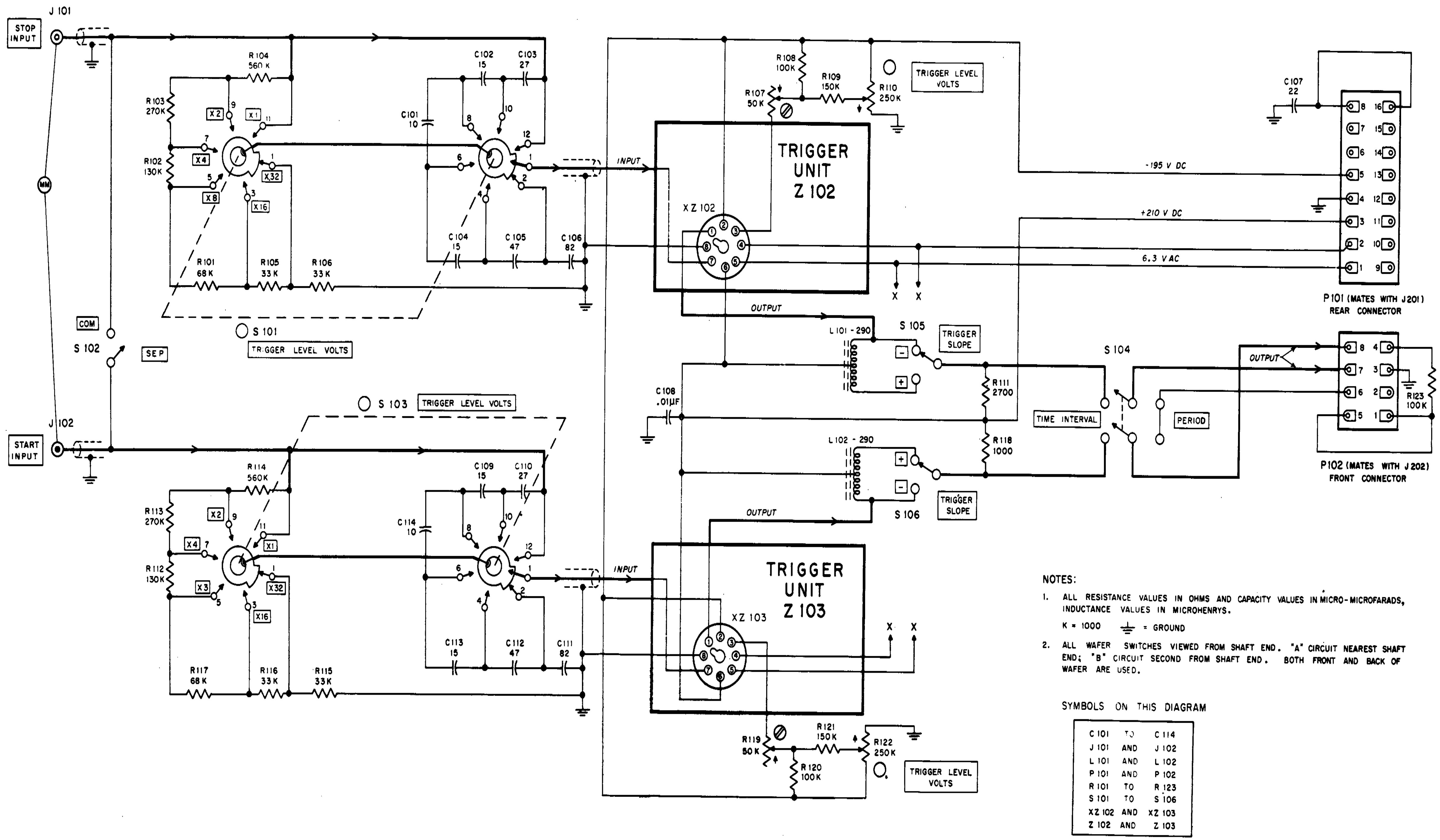


Figure 12-32. Schematic Diagram of Time Interval Panel Plug-In Unit MX-1636/U

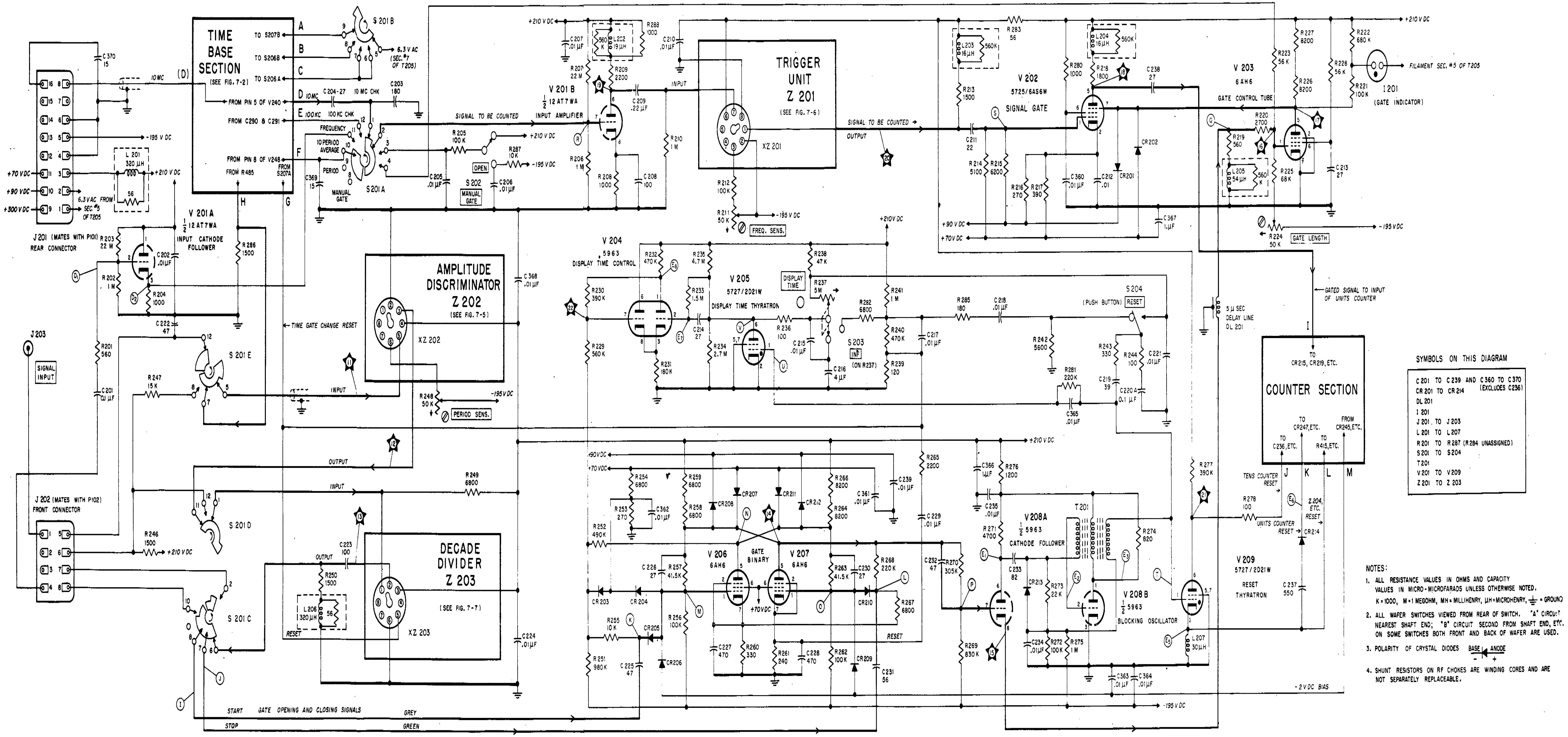


Figure 12-23. Schematic Diagram of Gate Section of Frequency meter FR-38/U

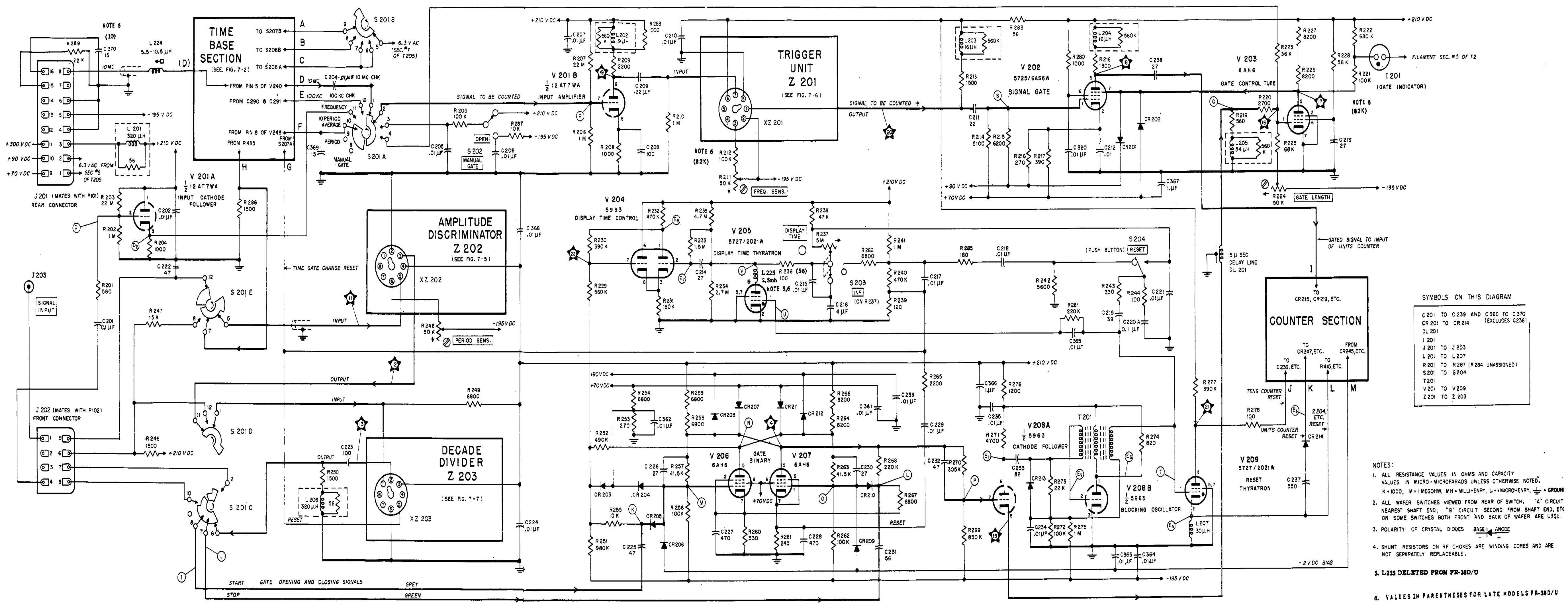


Figure 12-33.1. Schematic Diagram of Gate Section of Frequency Meter FR-38C/U and FR-38D/U

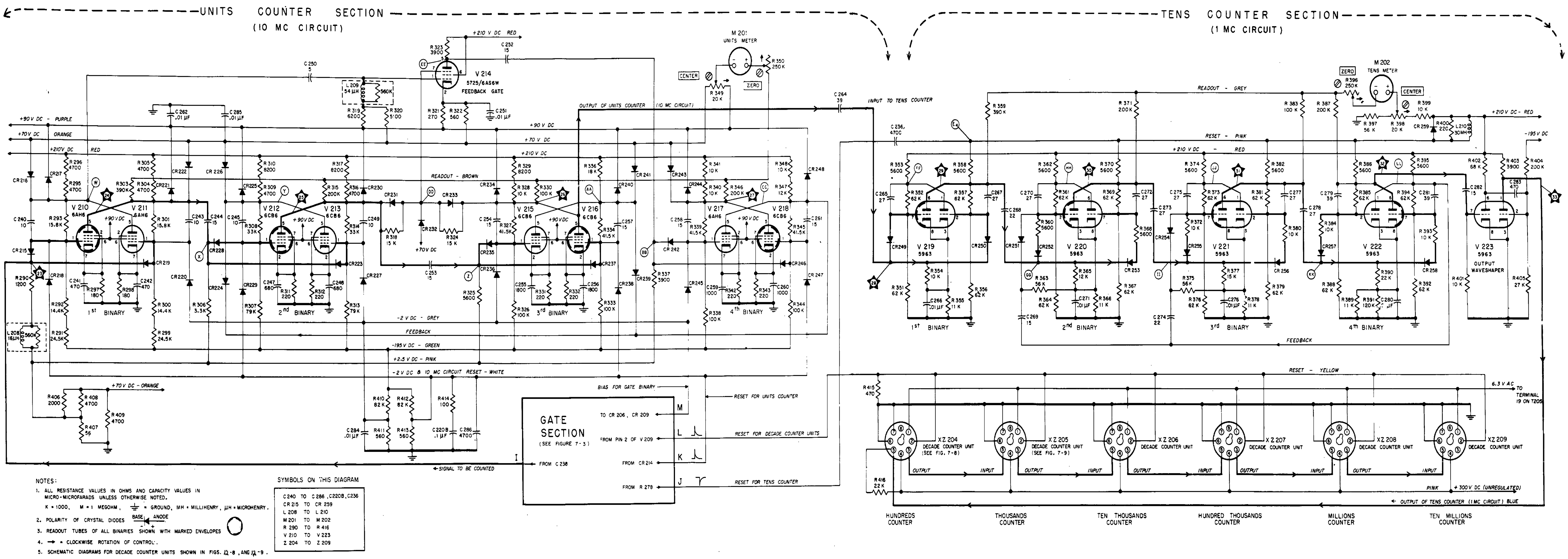


Figure 12-34. Schematic Diagram of Counter Section of Frequency Meter FR-38/U

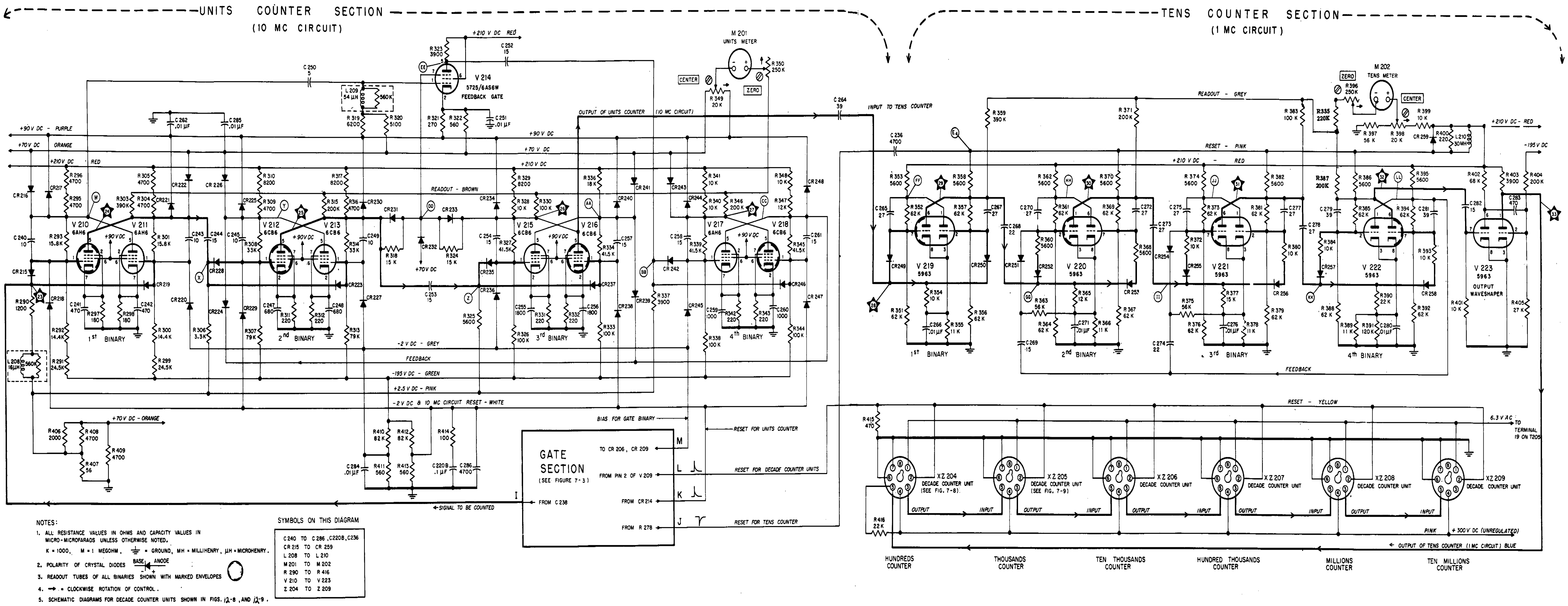


Figure 12-34.1. Schematic Diagram of Counter Section of Frequency Meter FR-38C/U and FR-38D/U

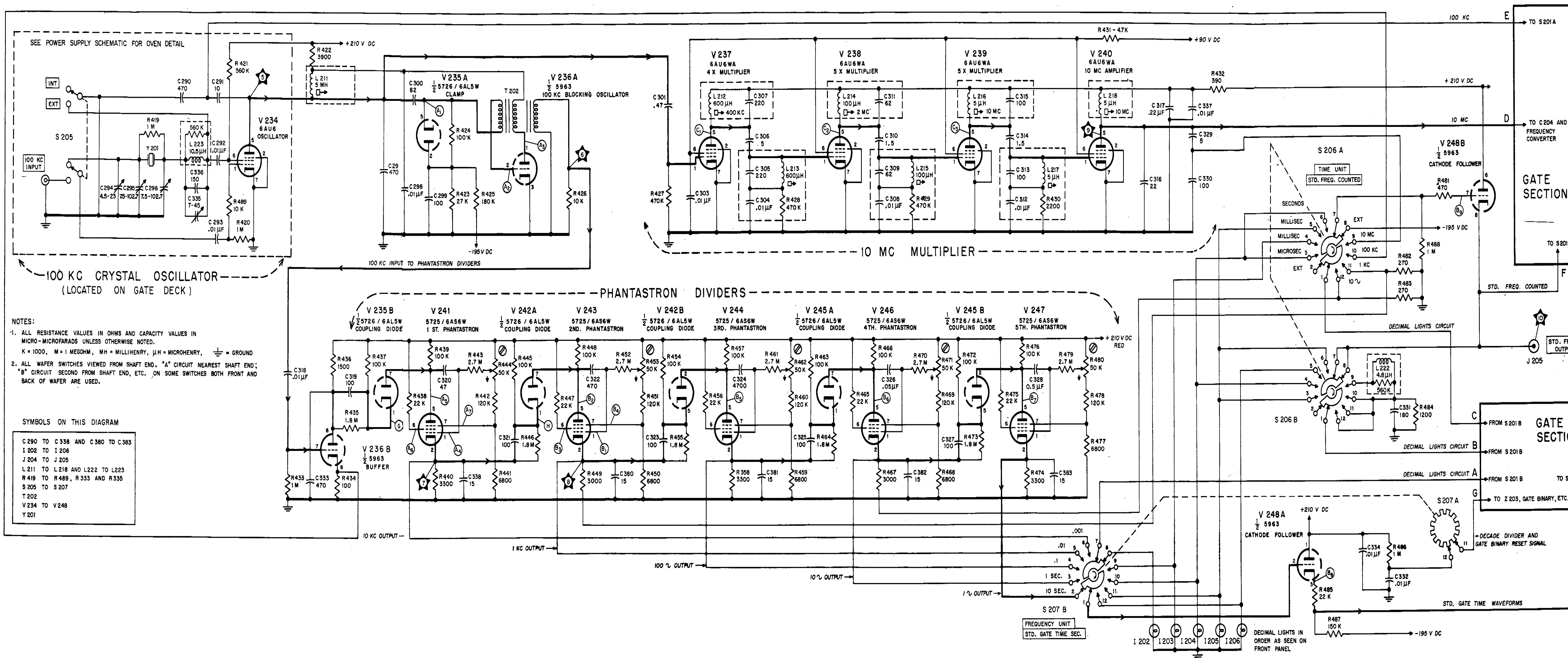


Figure 12-35. Schematic Diagram of Time Base Section of Frequency Meter FR-38/U

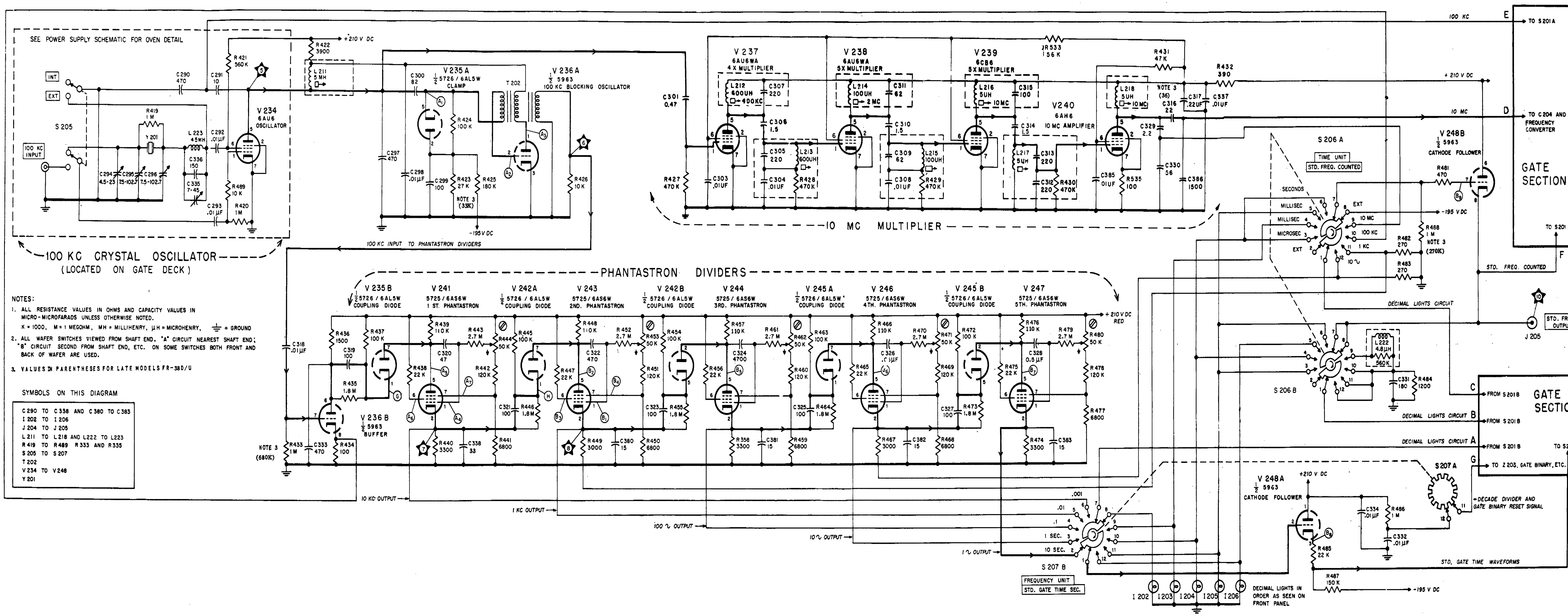


Figure 12-35A. Schematic Diagram of Time Base Section of Frequency Meter FR-38C/U and FR-38D/U

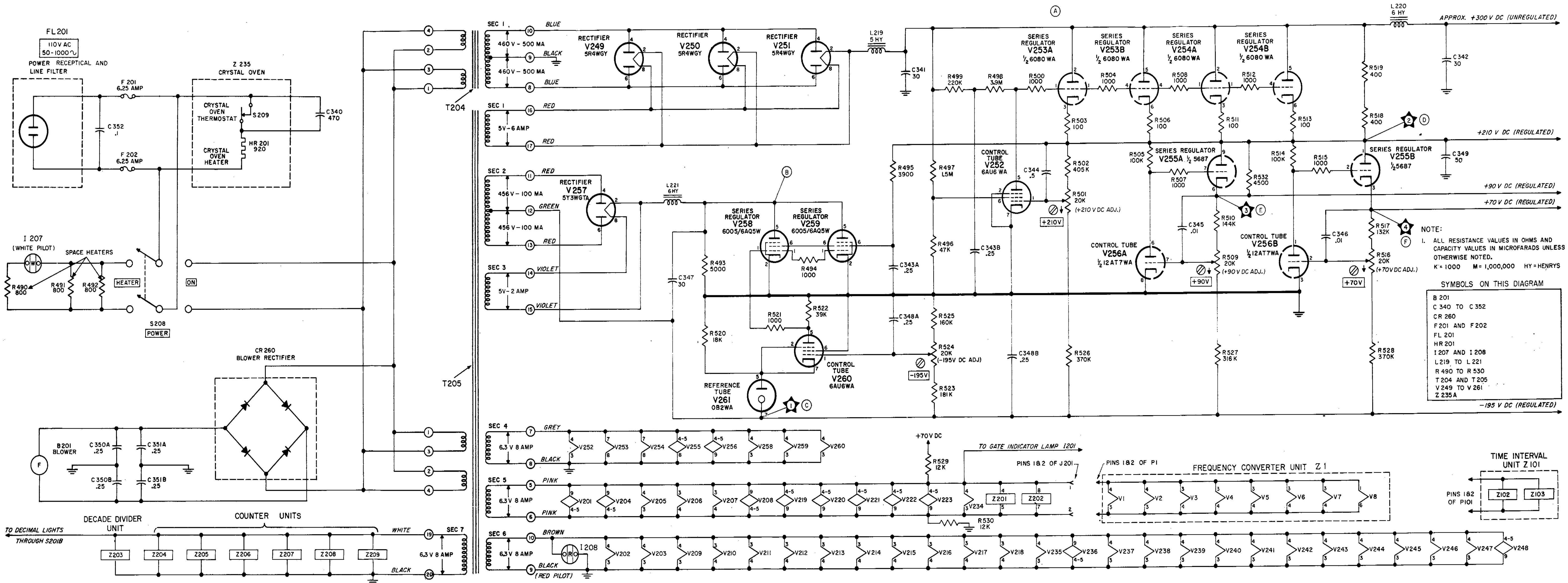


Figure 12-36. Schematic Diagram of Power Supply for Frequency Meter FR-38/U

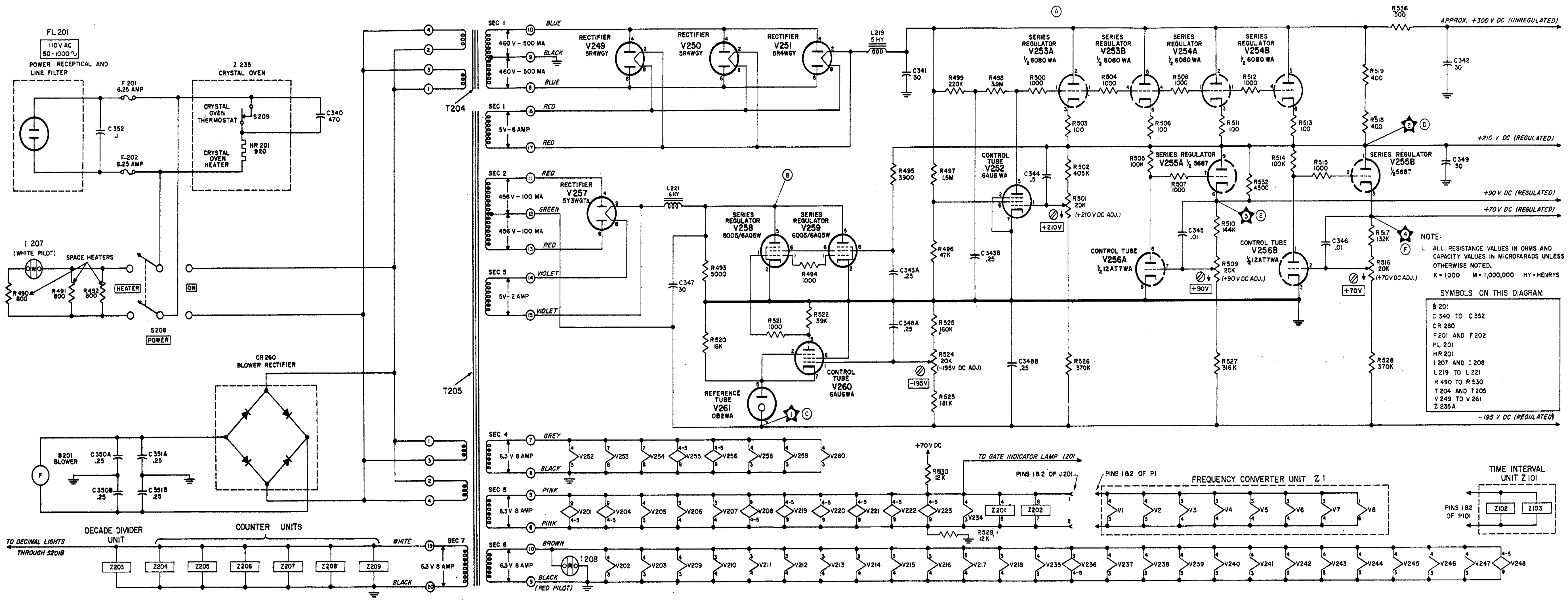


Figure 12-36A. Schematic Diagram Power Supply for Frequency Meter FR-38C/U and FR-38D/U

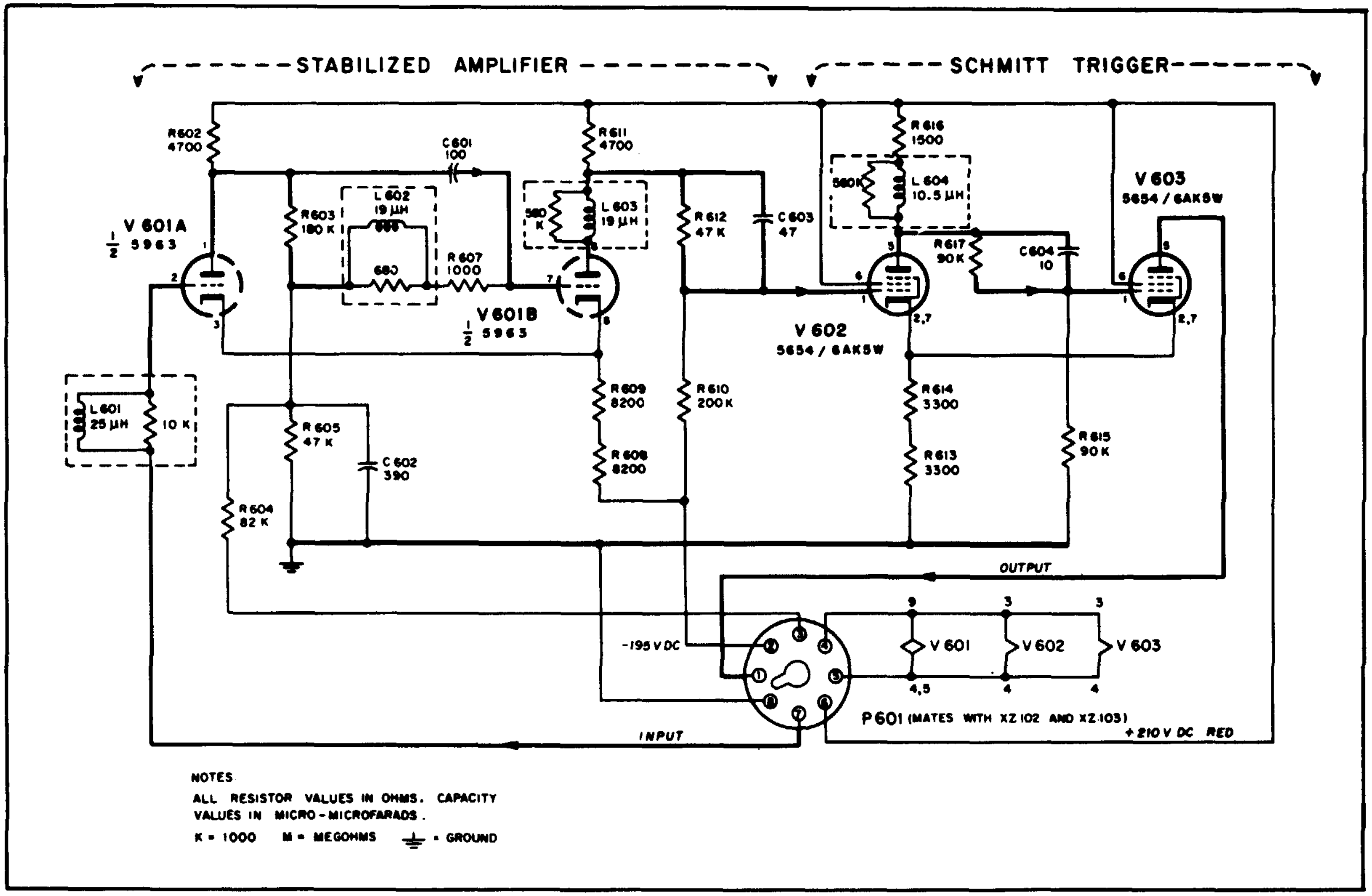


Figure 12-37. Schematic Diagram of Trigger Plug-In Unit for Frequency Meter FR-38/U

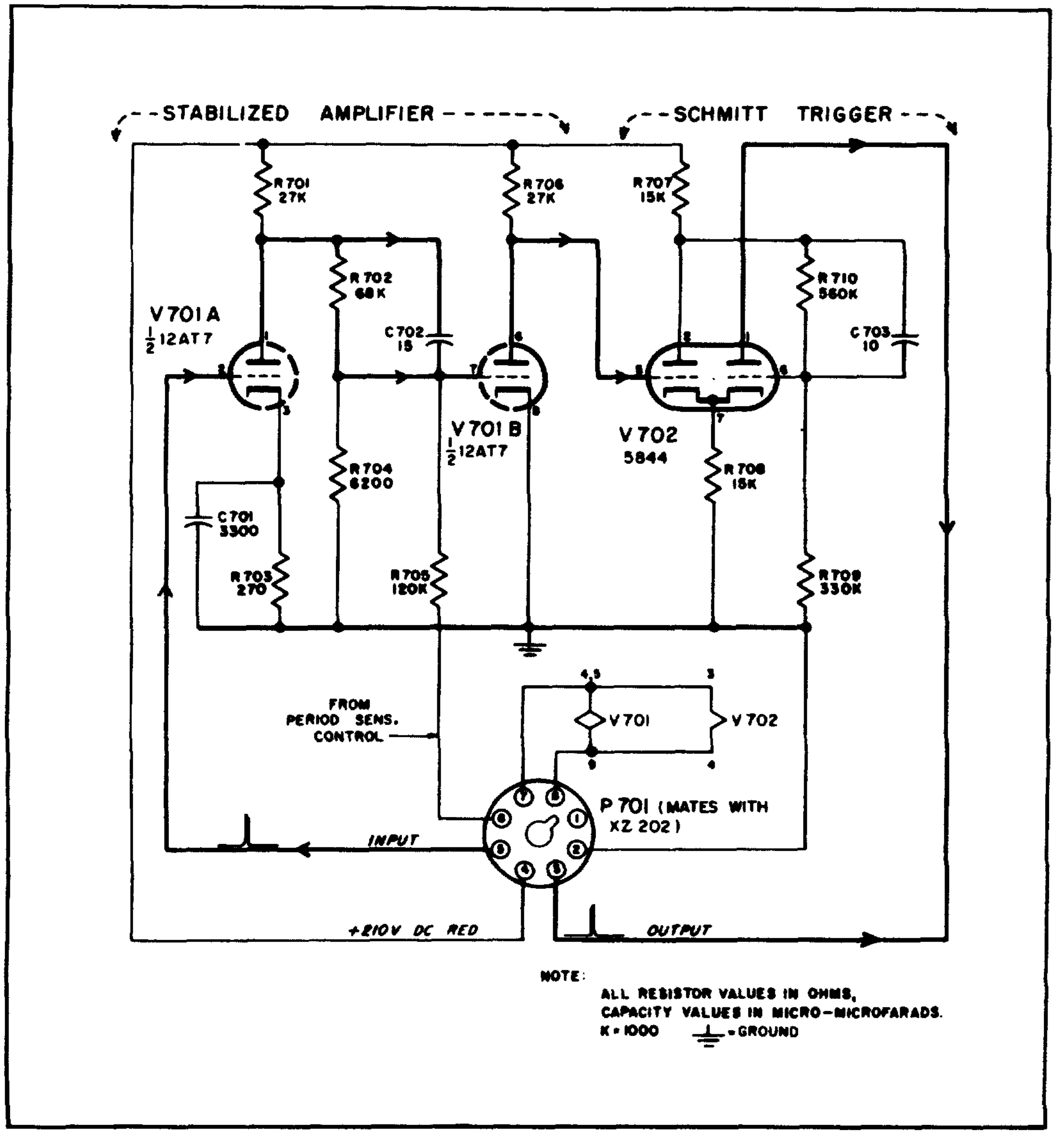
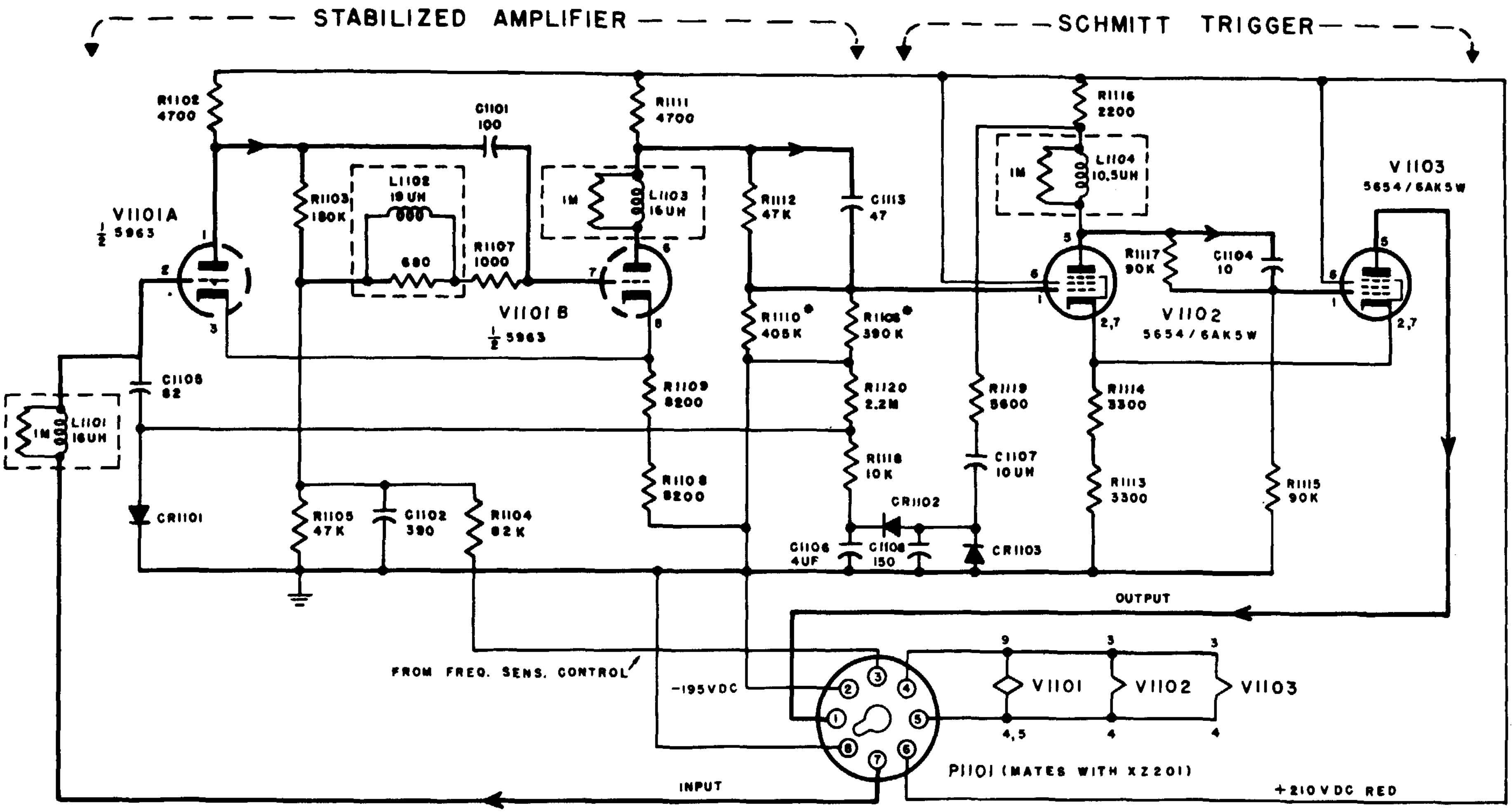


Figure 12-38. Schematic Diagram of Amplitude Discriminator Plug-In Unit for Frequency Meter FR-38/U



NOTES

ALL RESISTOR VALUES IN OHMS,
CAPACITY VALUES IN MICRO-MICROFARADS UNLESS OTHERWISE SPECIFIED

K = 1000, M = MEGOHMS ⏚ = GROUND

● REPLACED IN FR-38D/U BY R1110 180K

Figure 12-37A. Schematic Diagram of Trigger Plug-In Unit Z-201 for Frequency Meter FR-38C/U and FR-38D/U

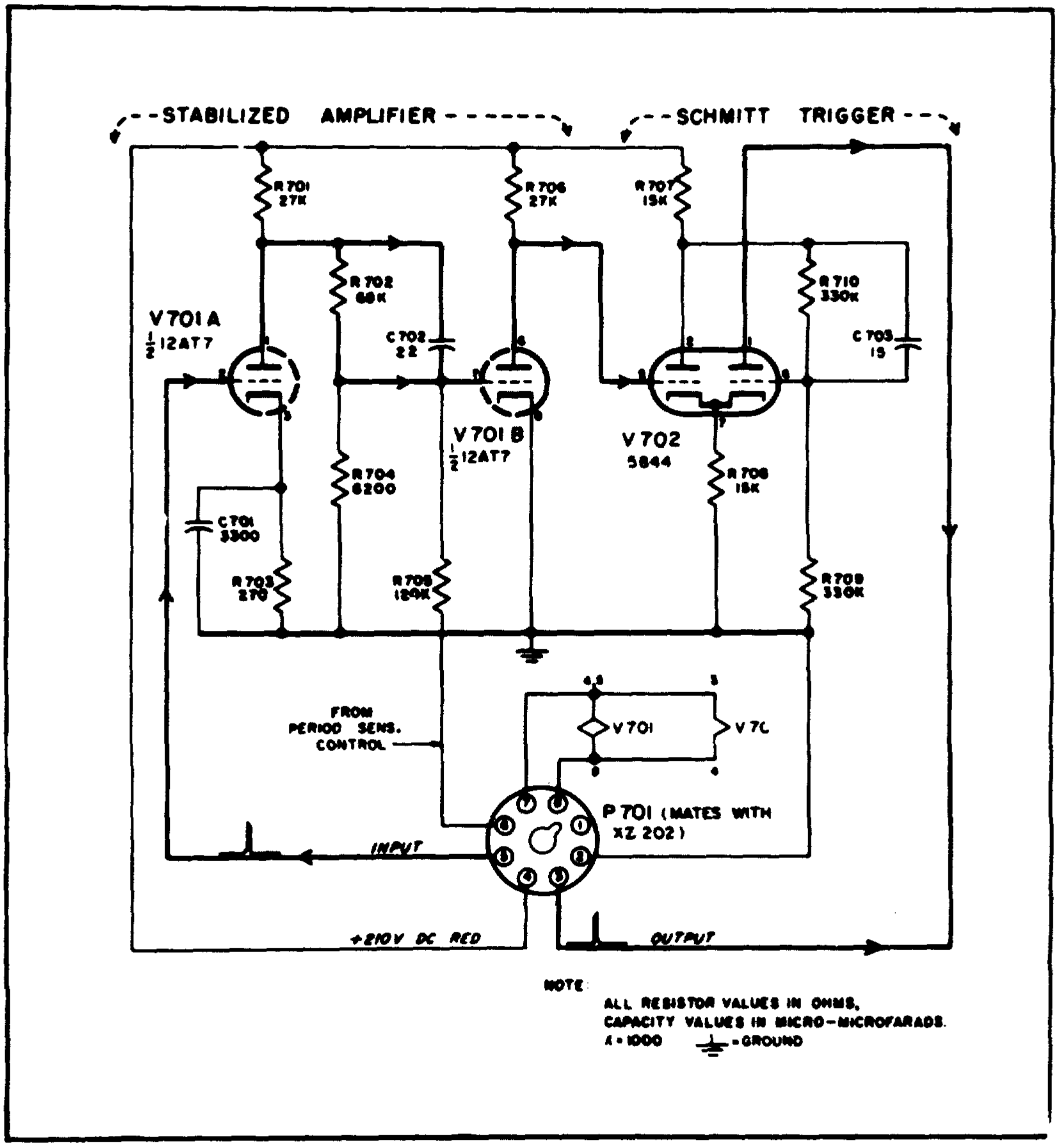


Figure 12-38A. Schematic Diagram of Amplitude Discriminator Plug-In Unit for Frequency Meter FR-38/U

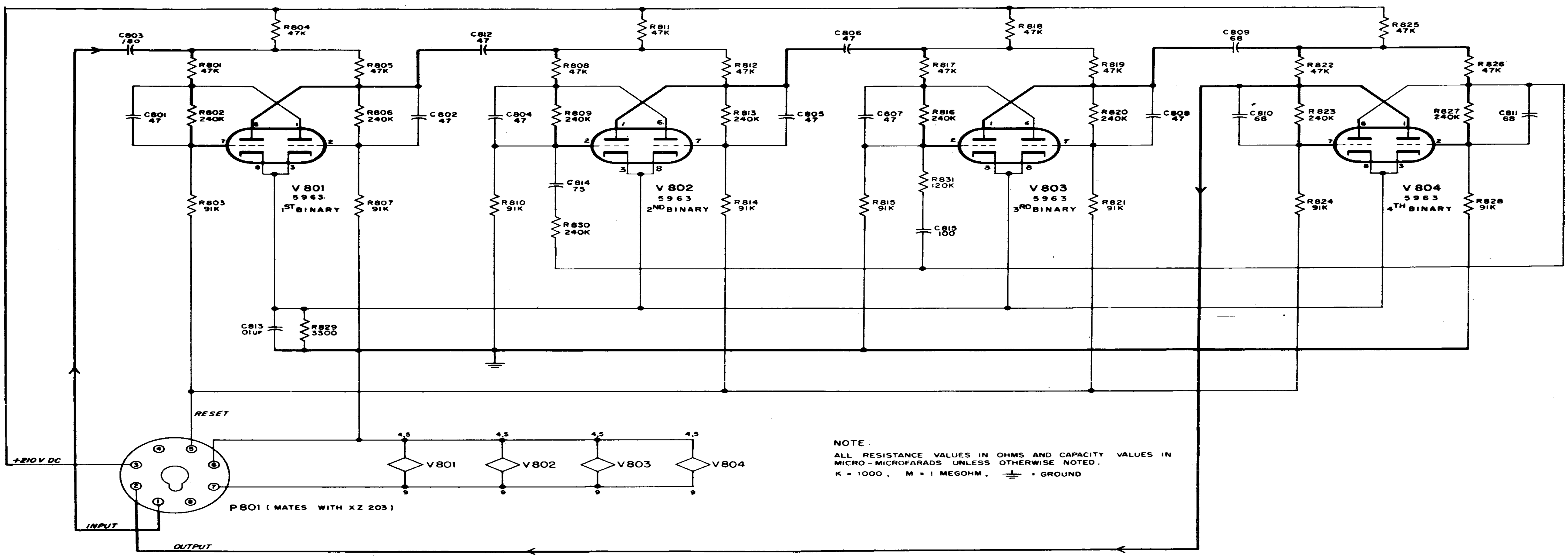


Figure 12-39. Schematic Diagram of Decade Divider Plug-In unit for Frequency Meter FR-38/U.

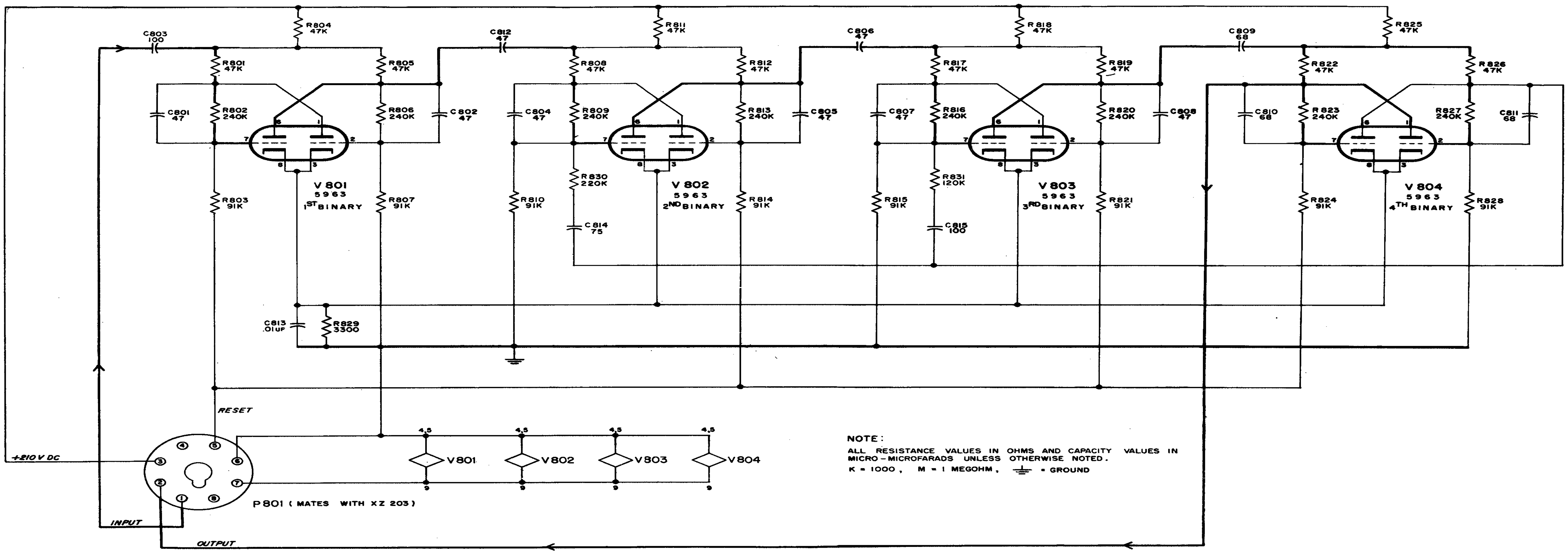


Figure 12-39A. Schematic Diagram of Decade Divider Plug-In for Frequency Meter FR-38C/U and FR-38D/U.

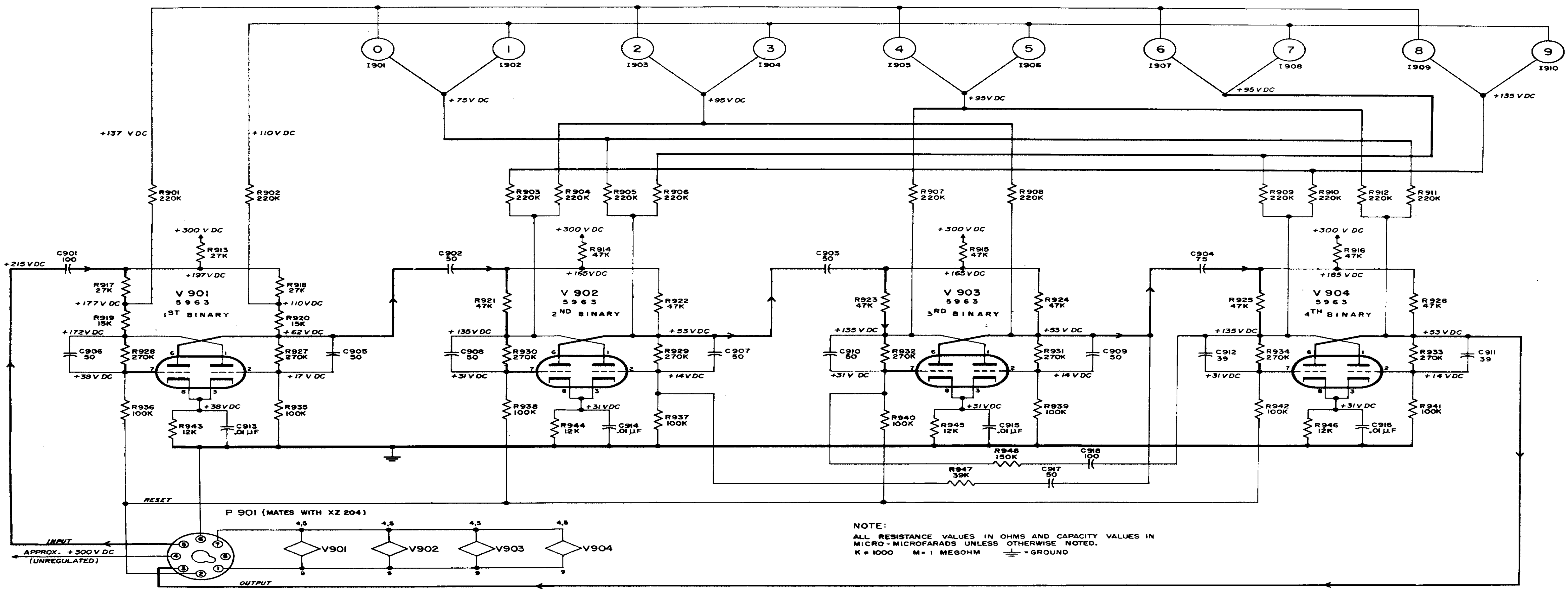


Figure 12-40. Schematic Diagram of Decade Counter Unit Subassembly Z-204.

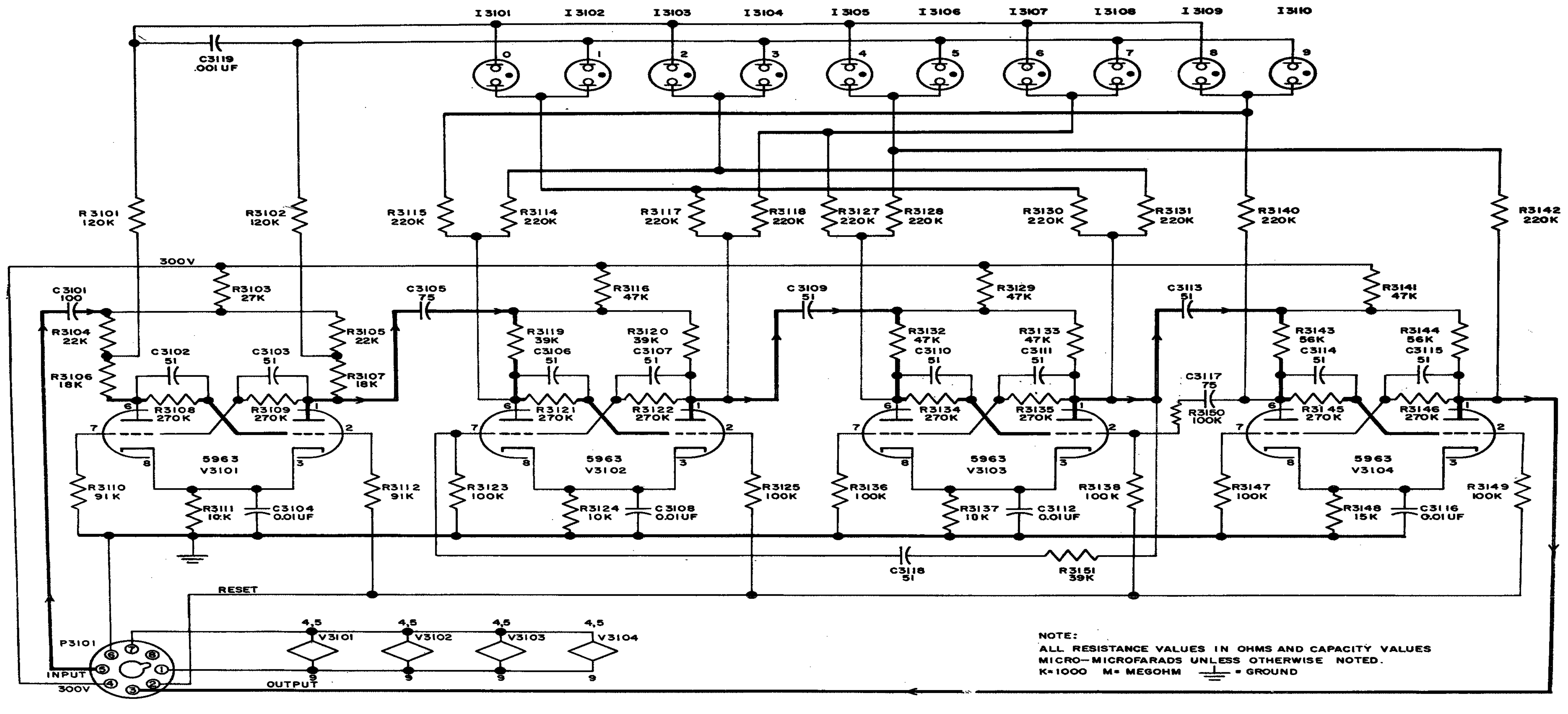


Figure 12-40 A. Schematic Diagram of Decade Counter Unit Z-204 for Frequency Meter FR-38C/U and Z-204 through Z-209 in FR-38D/U.

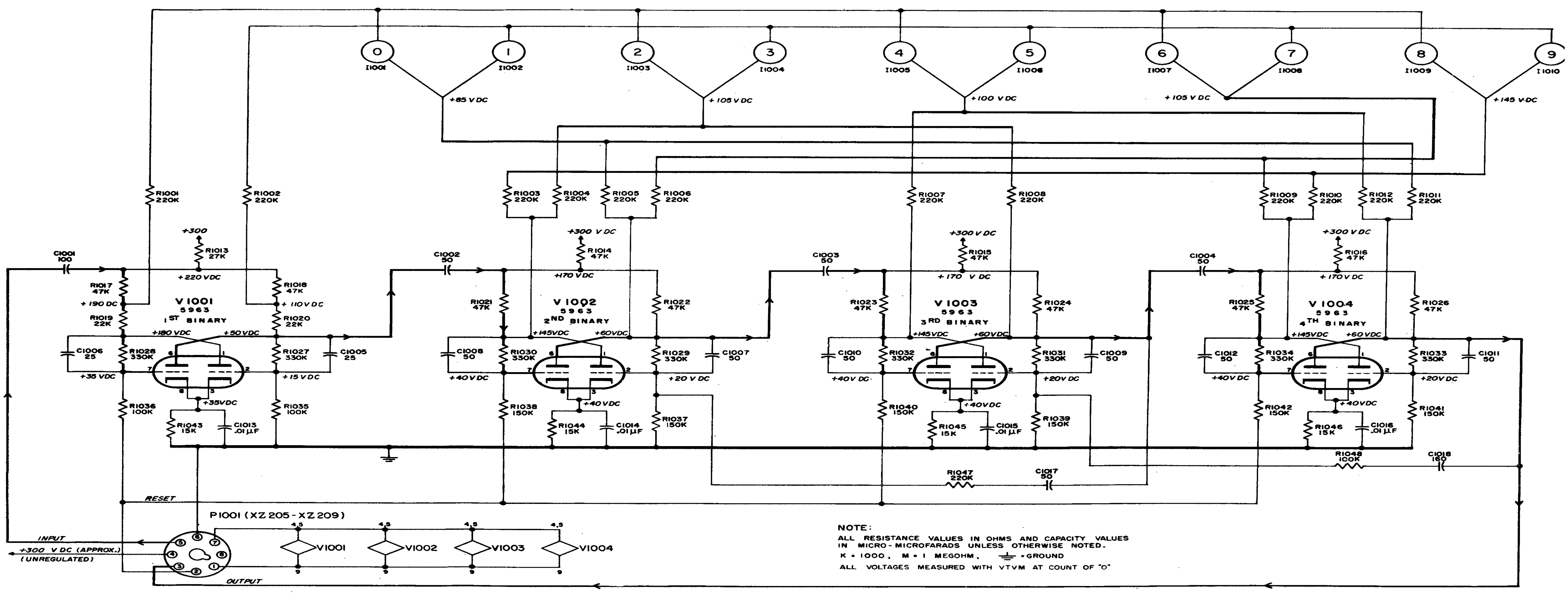


Figure 12-41. Schematic Diagram of Decade Counter Unit Subassemblies Z-205, Z-206, Z-207, Z-208, and Z-209.

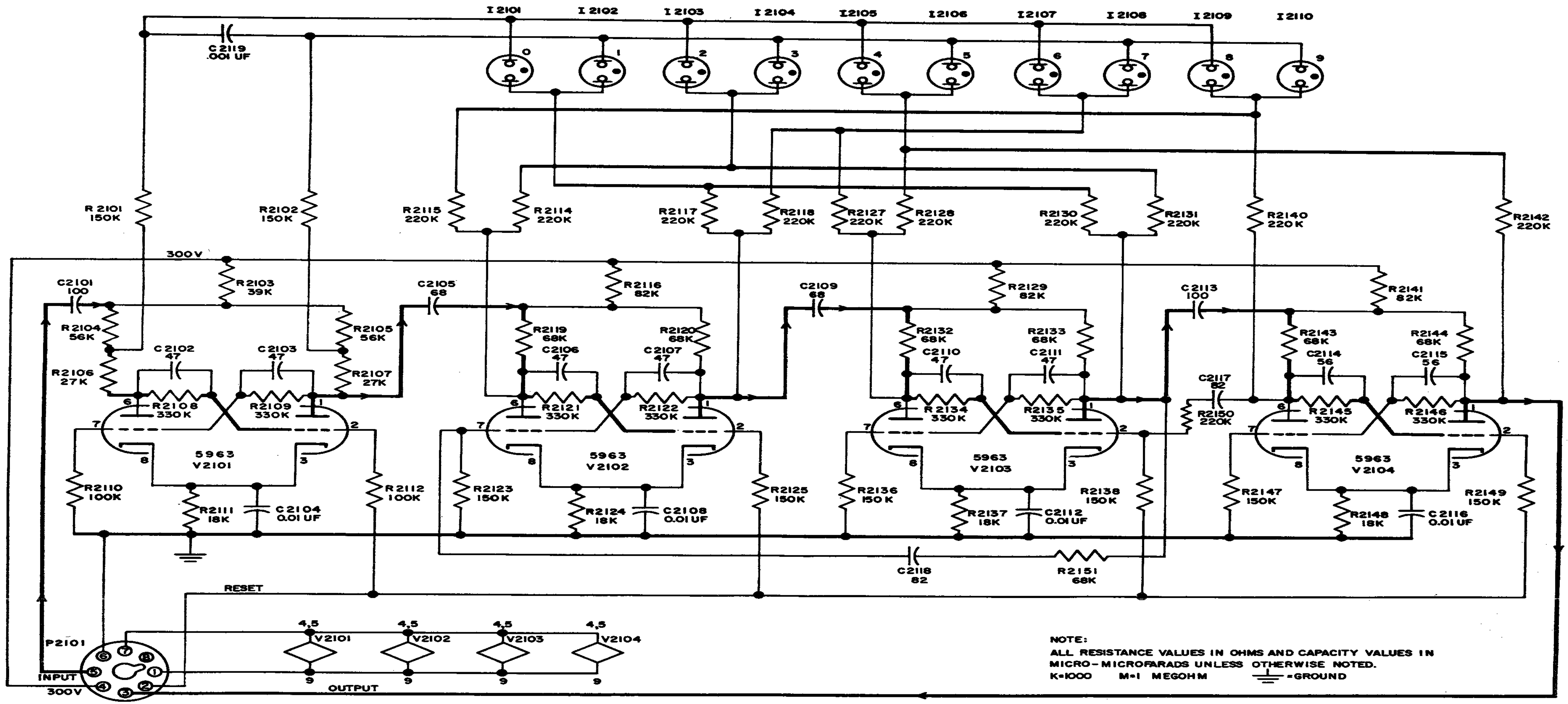


Figure 12-41A. Schematic Diagram of Decade Counter Unit Z-205 through Z-209 in Frequency Meter FR-38C/U.

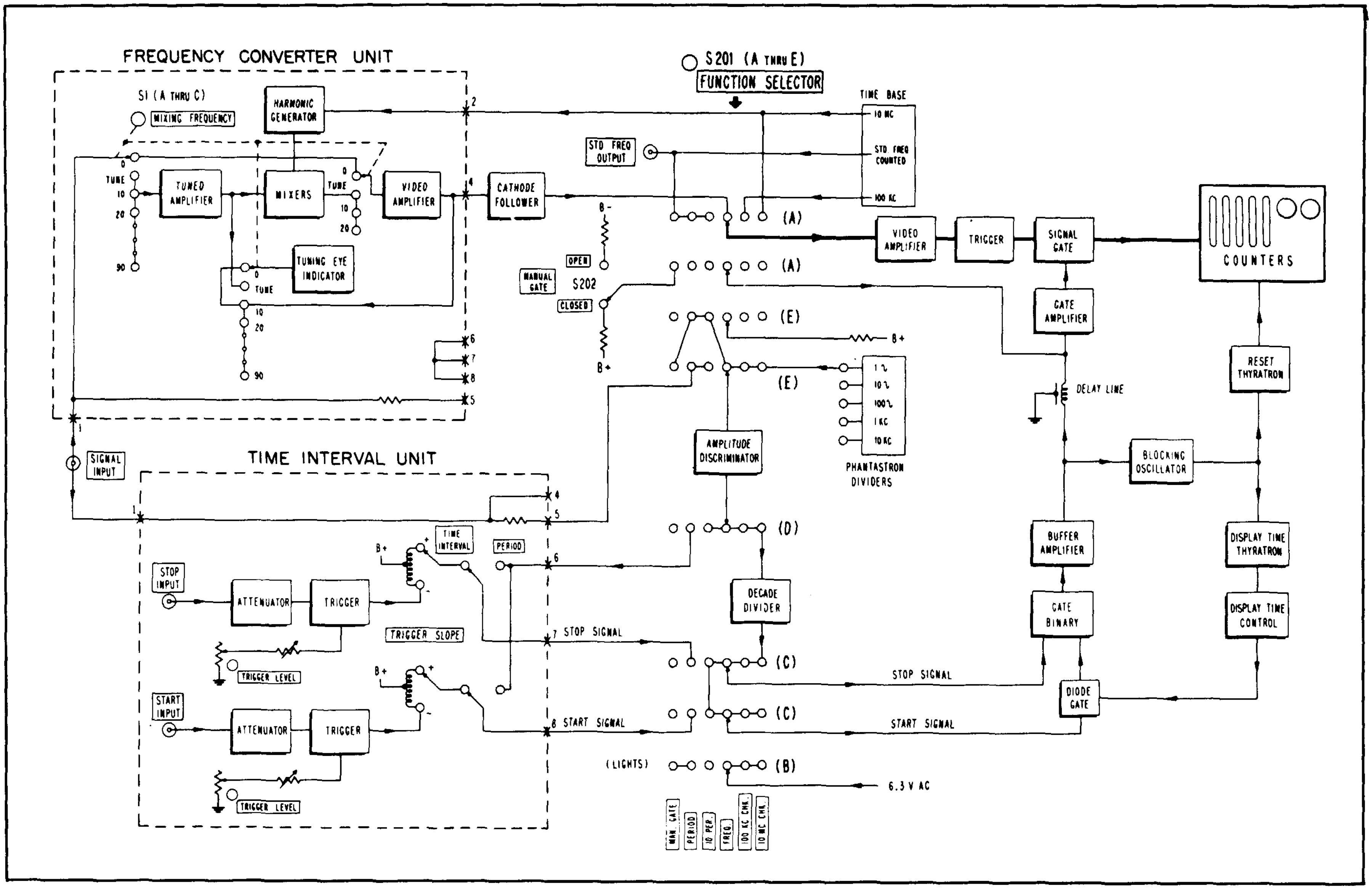


Figure 12-42. Voltage and Resistance Diagrams for Time Base Section.

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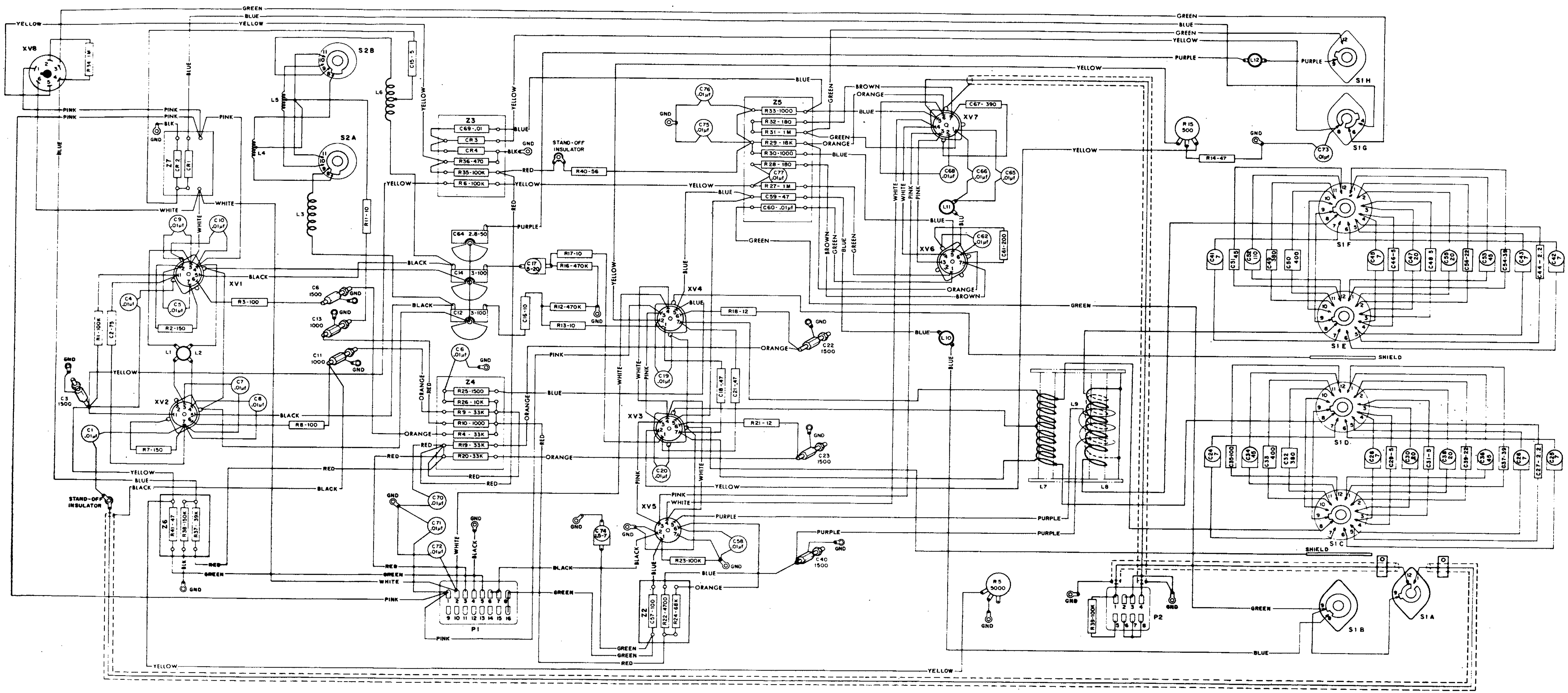

Figure 12-43. Practical Wiring Diagram of Converter Unit MX-1637/U.

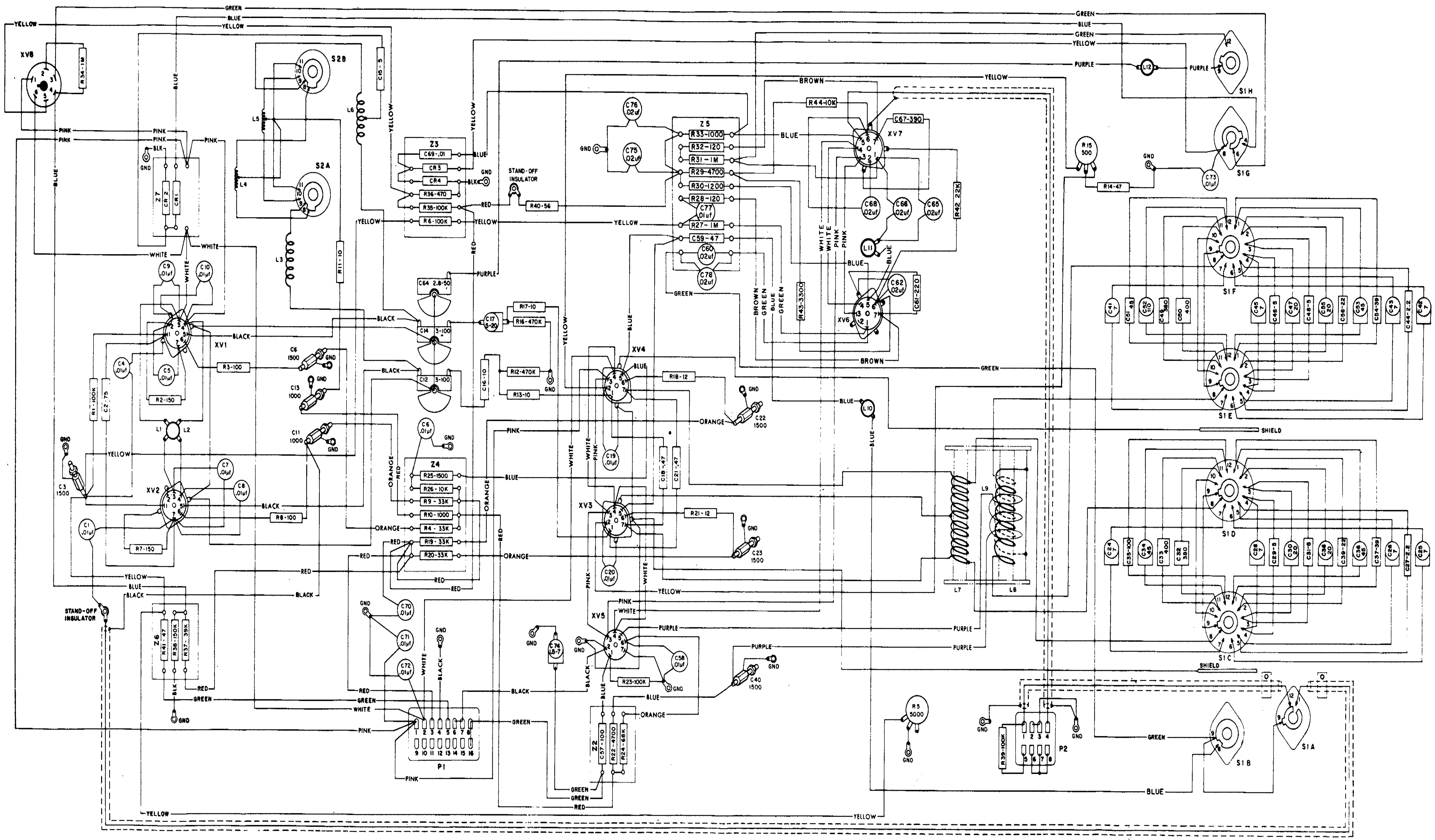

Figure 12-34A. Practical Wiring Diagram of Converter Unit MX-1637/U for FR-38 C/U and FR-38D/U

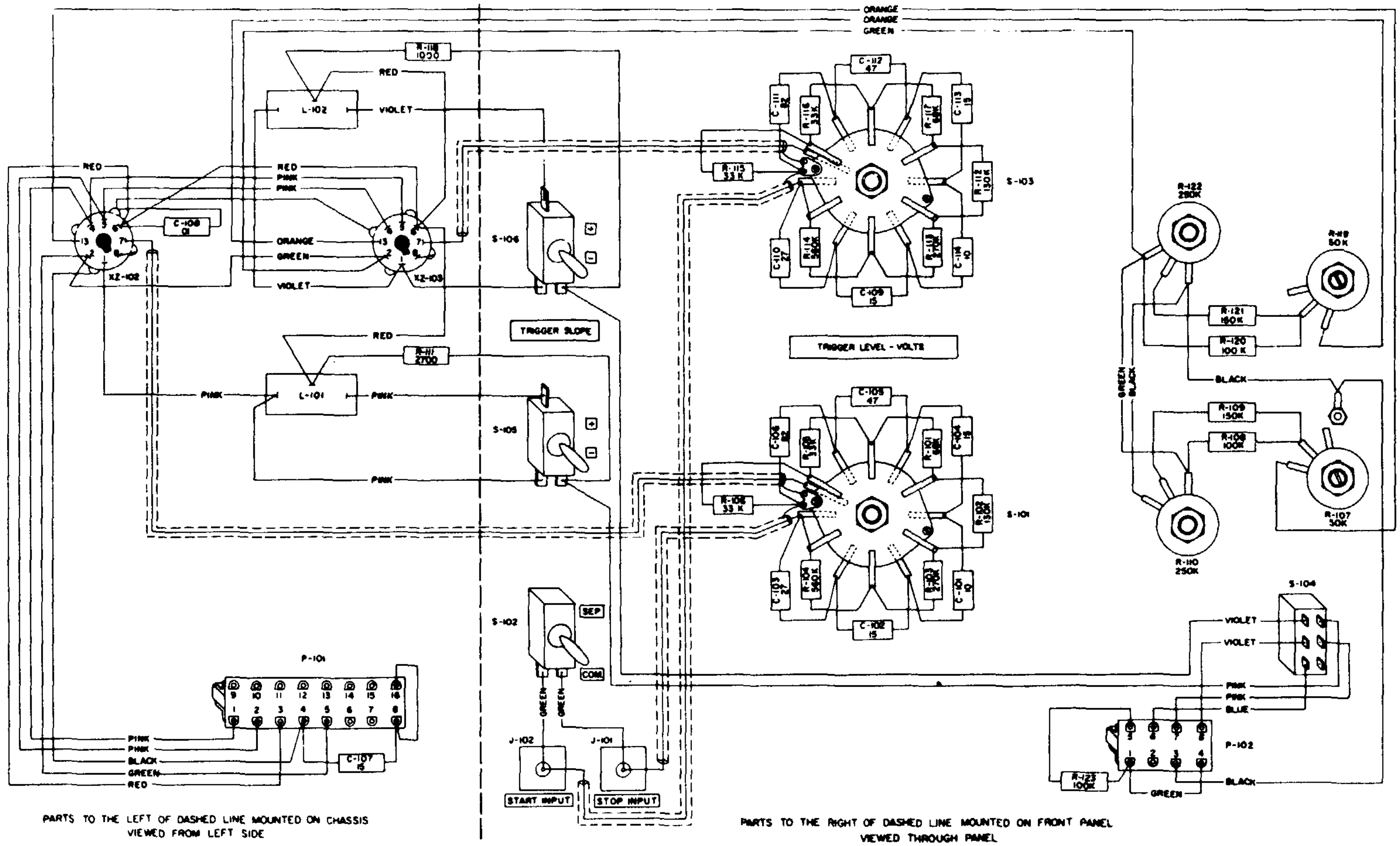

Figure 12-44A. Practical Wiring Diagram of Time Interval Unit MX-1636/U

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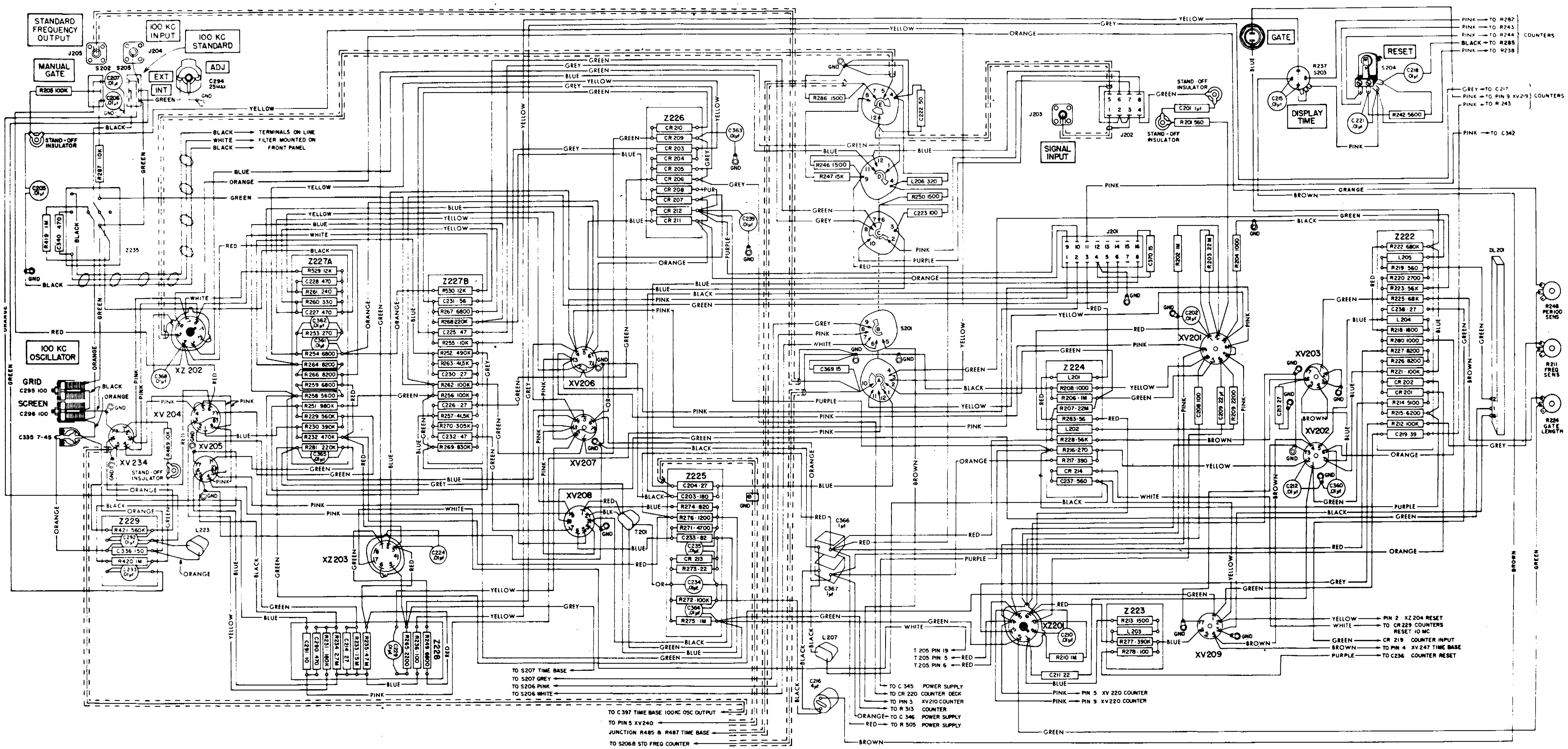


Figure 12-45. Practical Wiring Diagram of FR-38/U Gate Deck

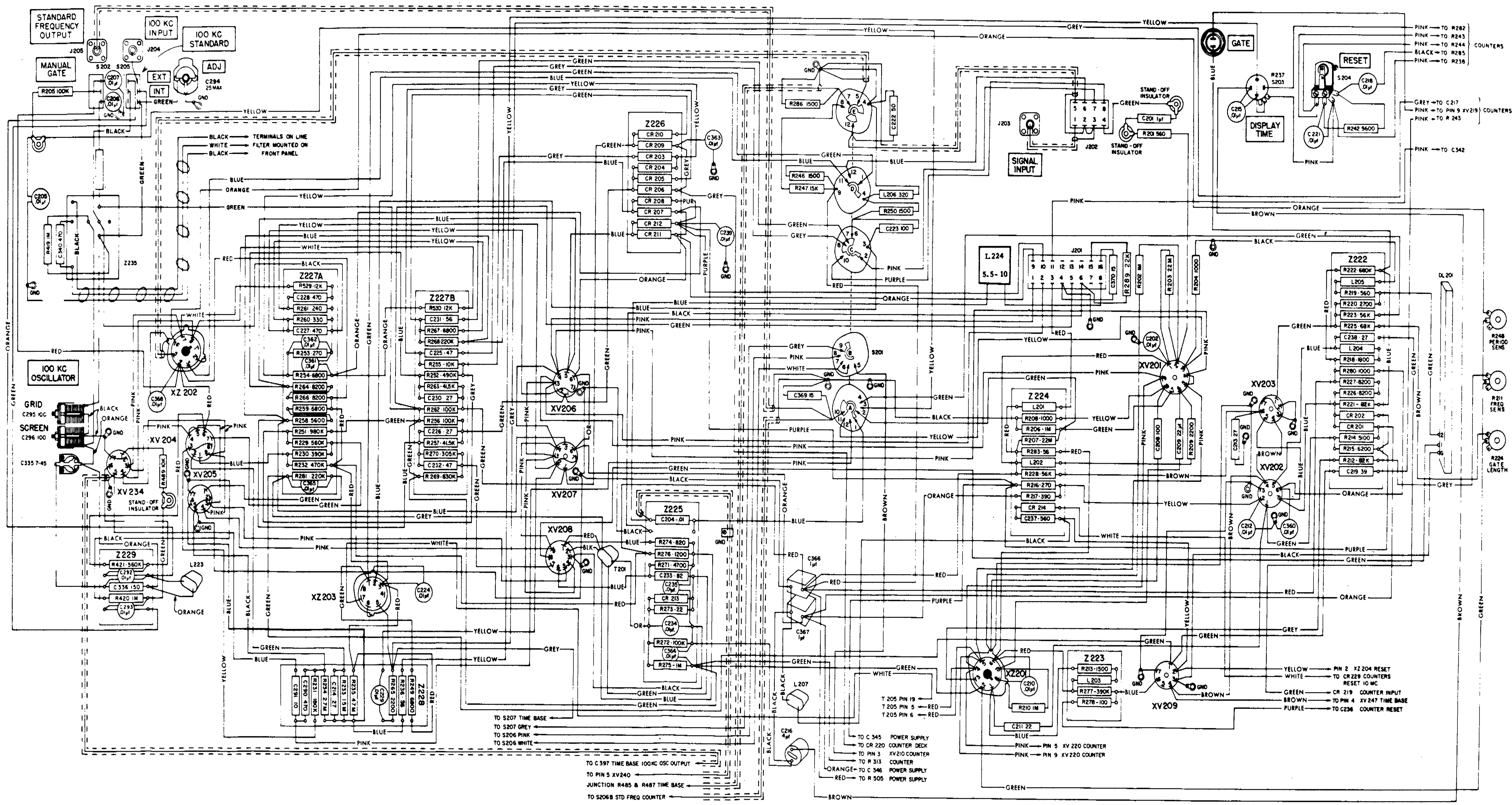


Figure 12-45A. Practical Wiring Diagram of FR-38C/U and FR-38D/U Gate Deck

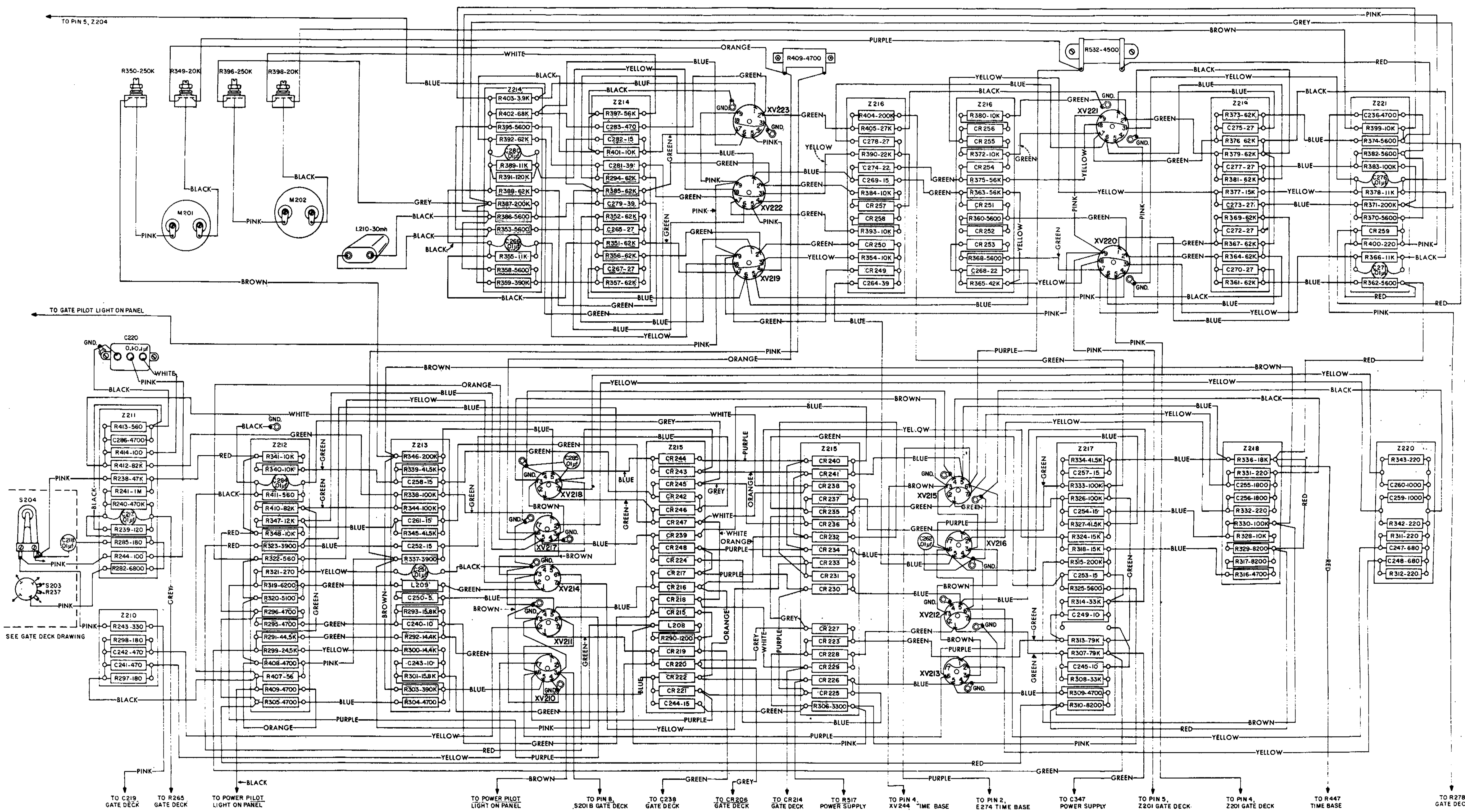


Figure 12-46. Practical Wiring Diagram of FR-38/U Counter Deck

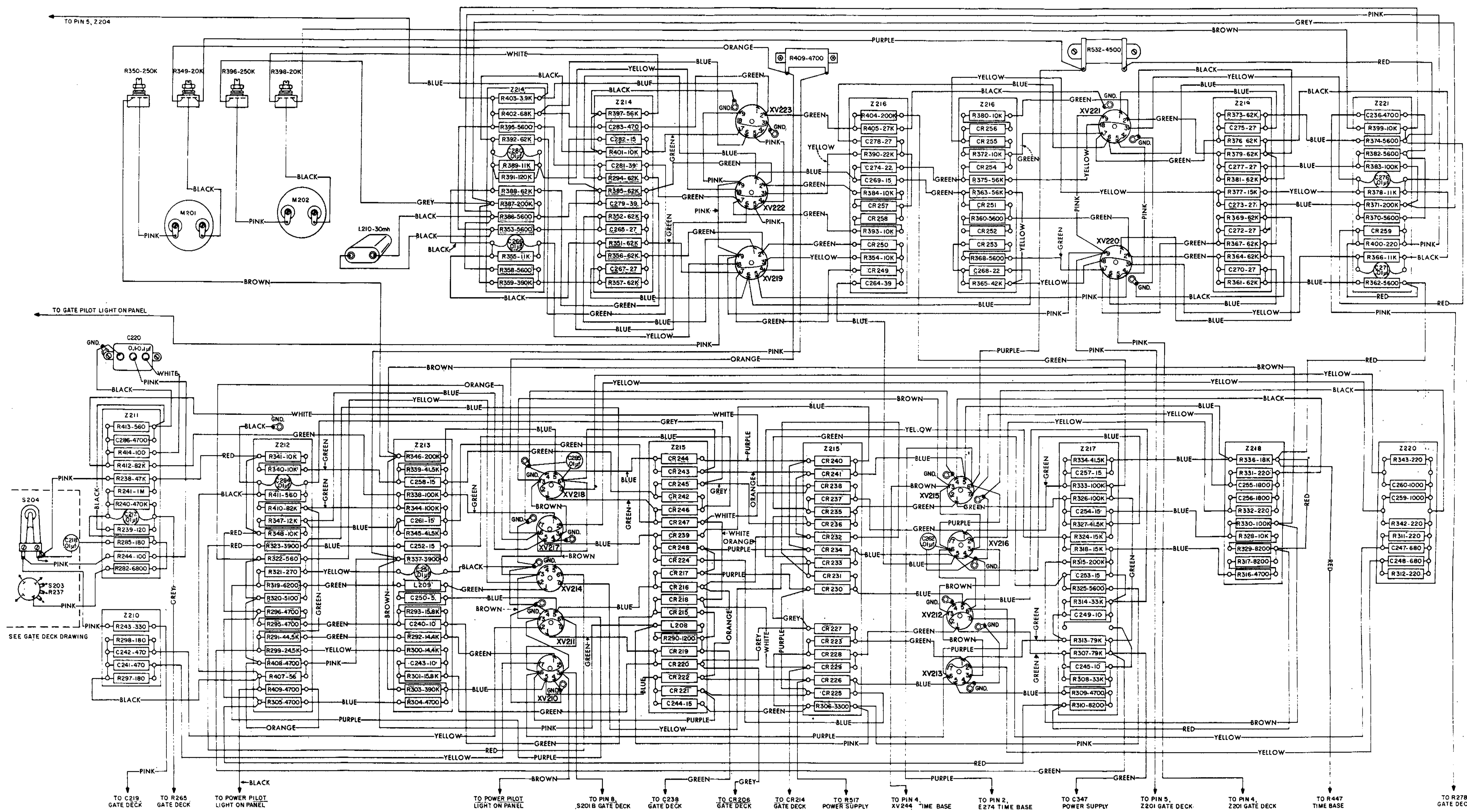
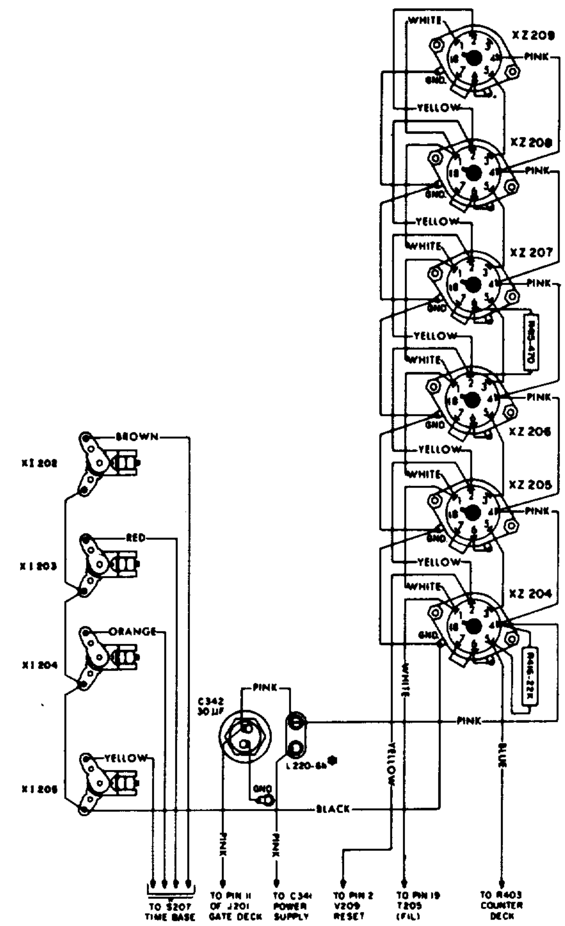


Figure 12-46A. Practical Wiring Diagram of FR-38/U Counter Deck



* FR-38C/U and FR-38D/U use R536 (500 ohms) in place of L220

Figure 12-47. Practical Wiring Diagram of FR-38/U Middle Deck

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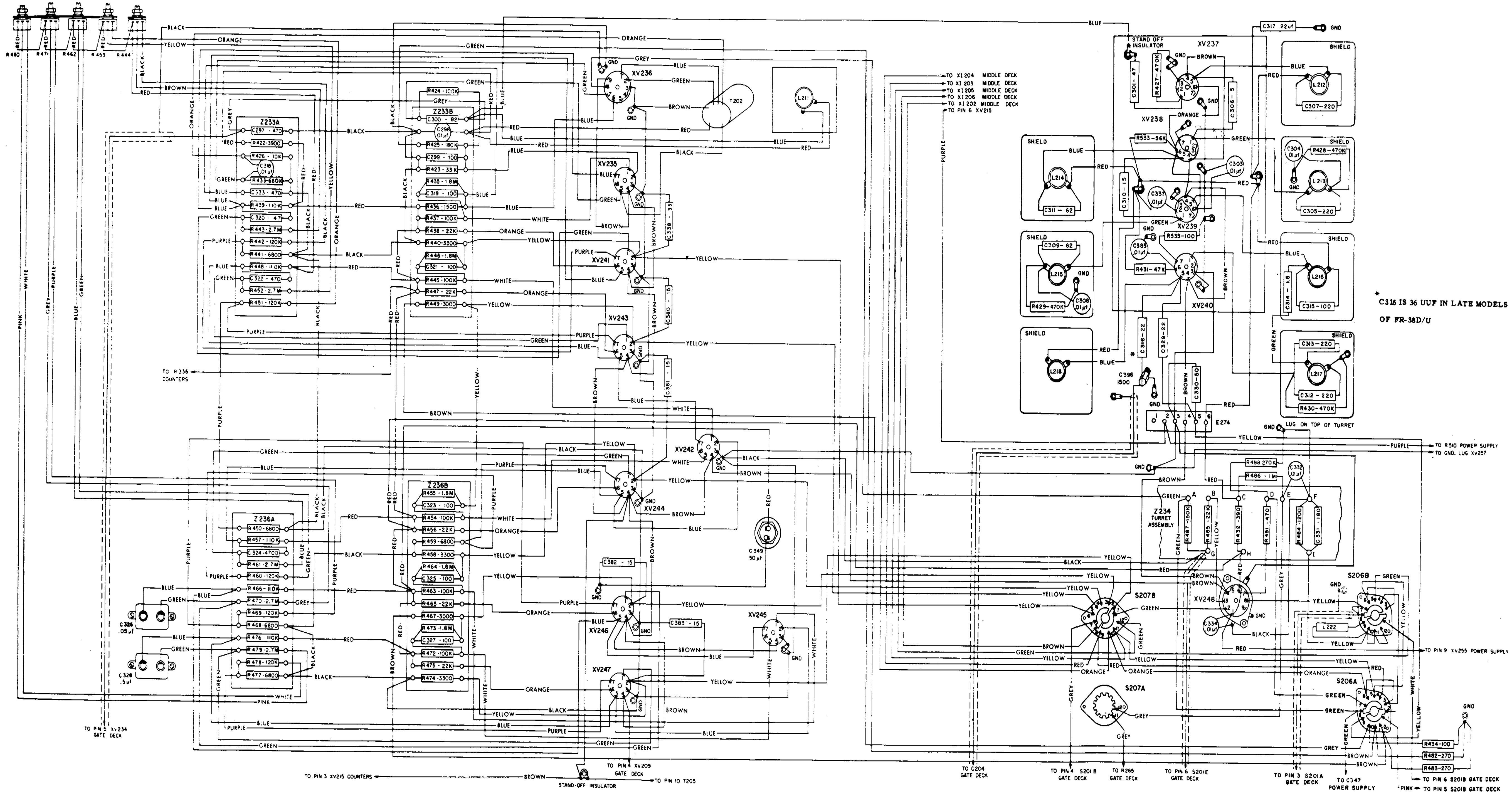

Figure 12-48. Practical Wiring Diagram of FR-38/U Time Base Deck

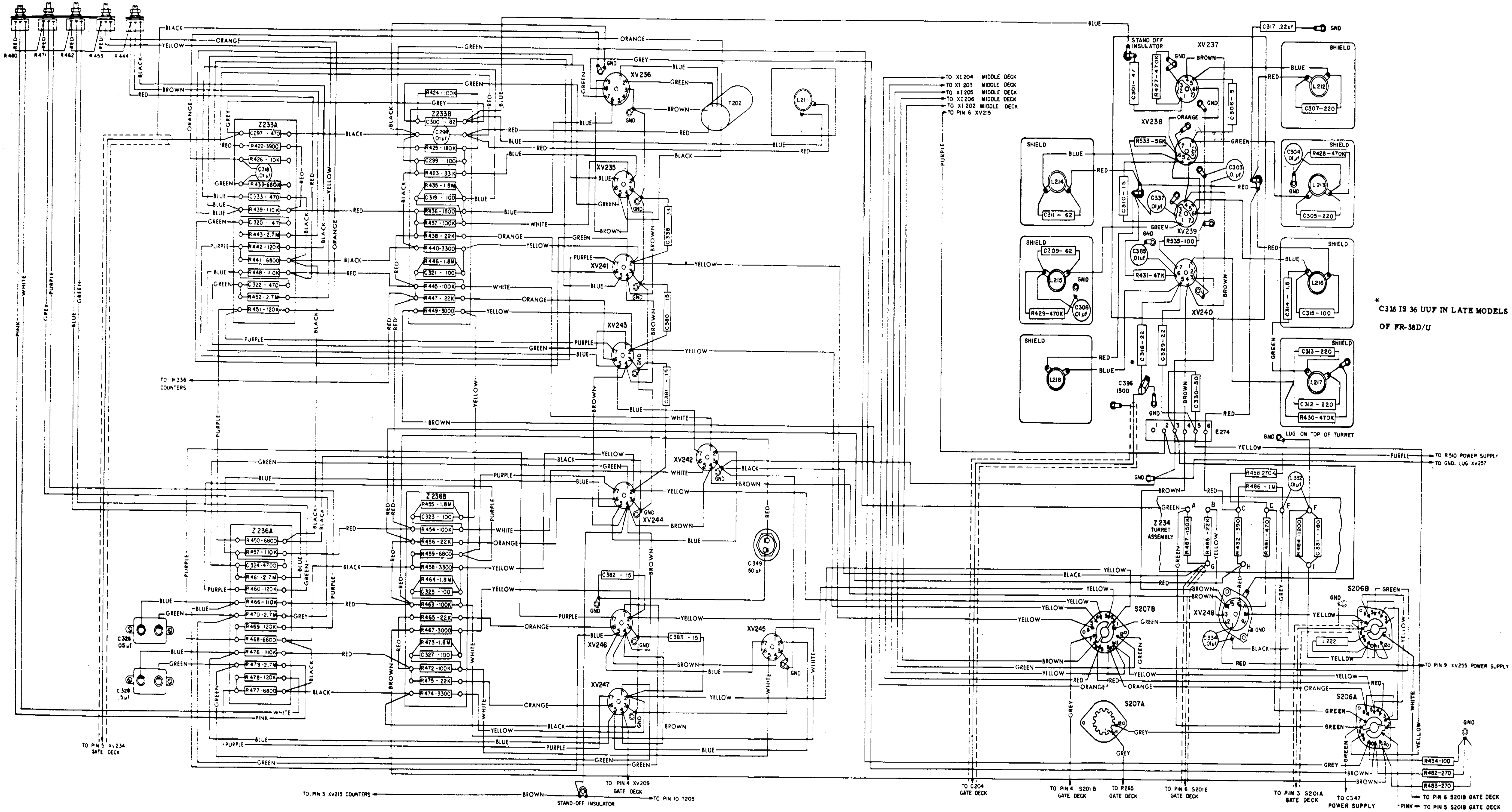

Figure 12-48A. Practical Wiring Diagram of FR-38C/U and FR-38D/U Time Base Deck

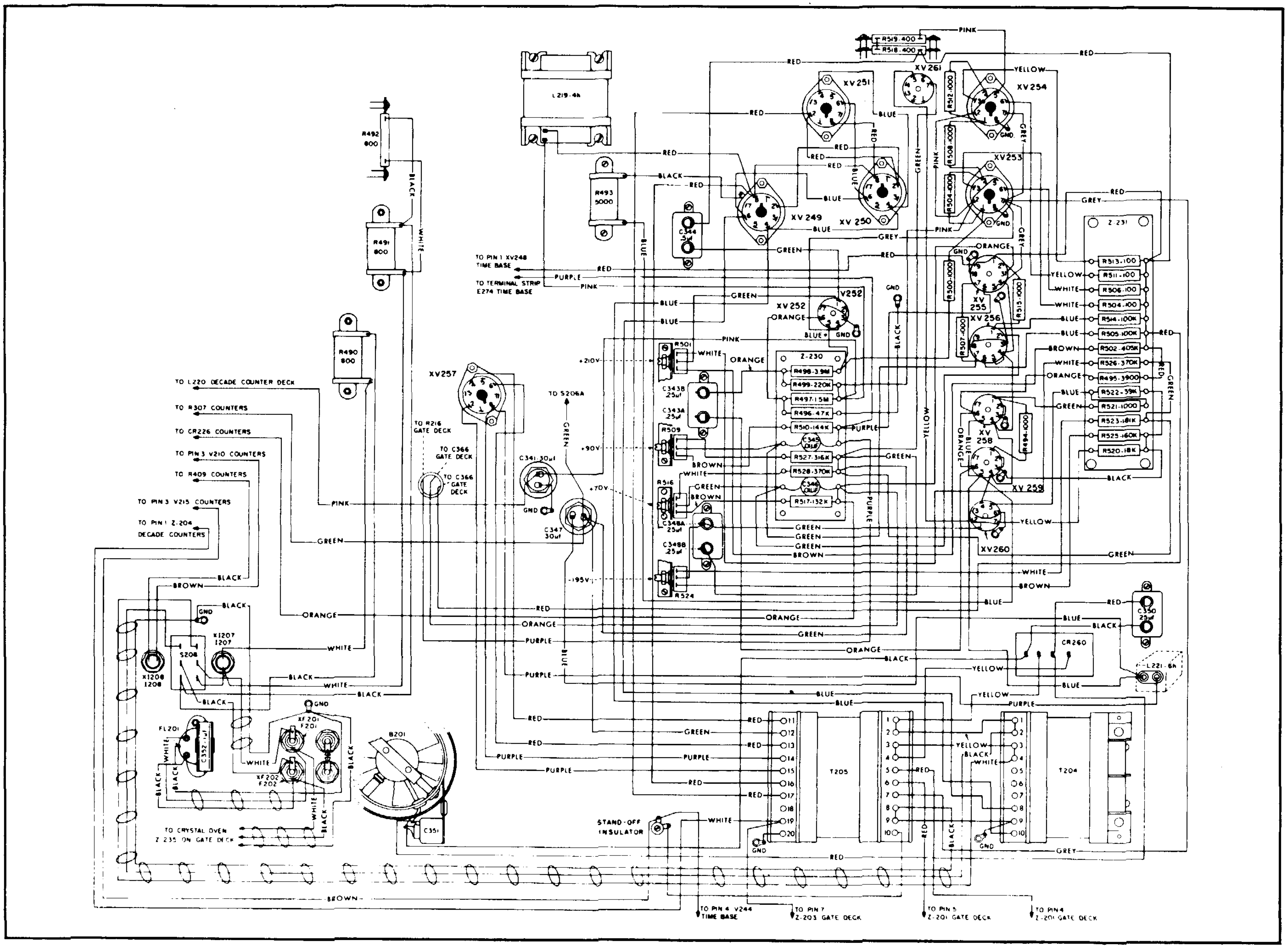

Figure 12-49. Practical Wiring Diagram of FR-38/U Power Supply

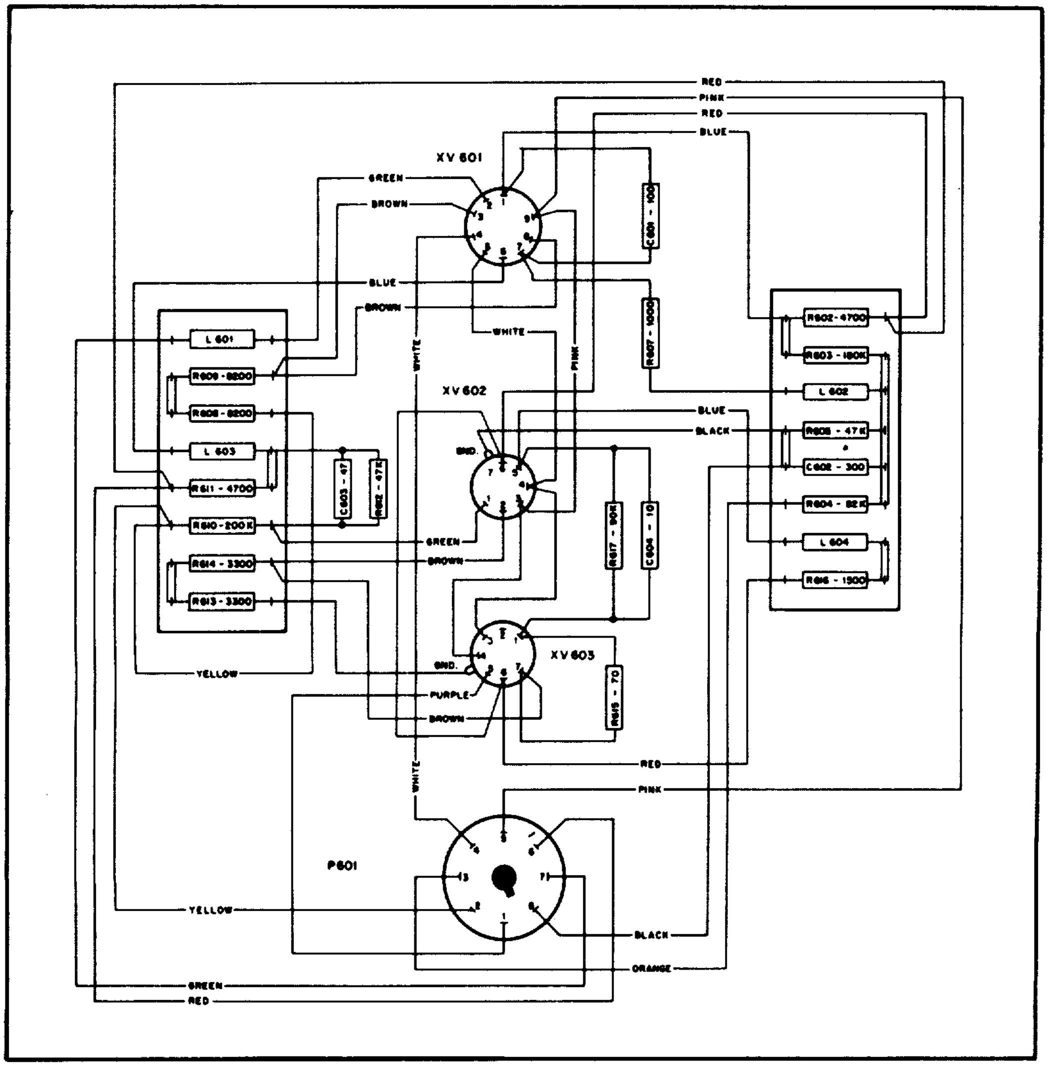

Figure 12-50A. Practical Wiring Diagram of FR-38/U Trigger Unit

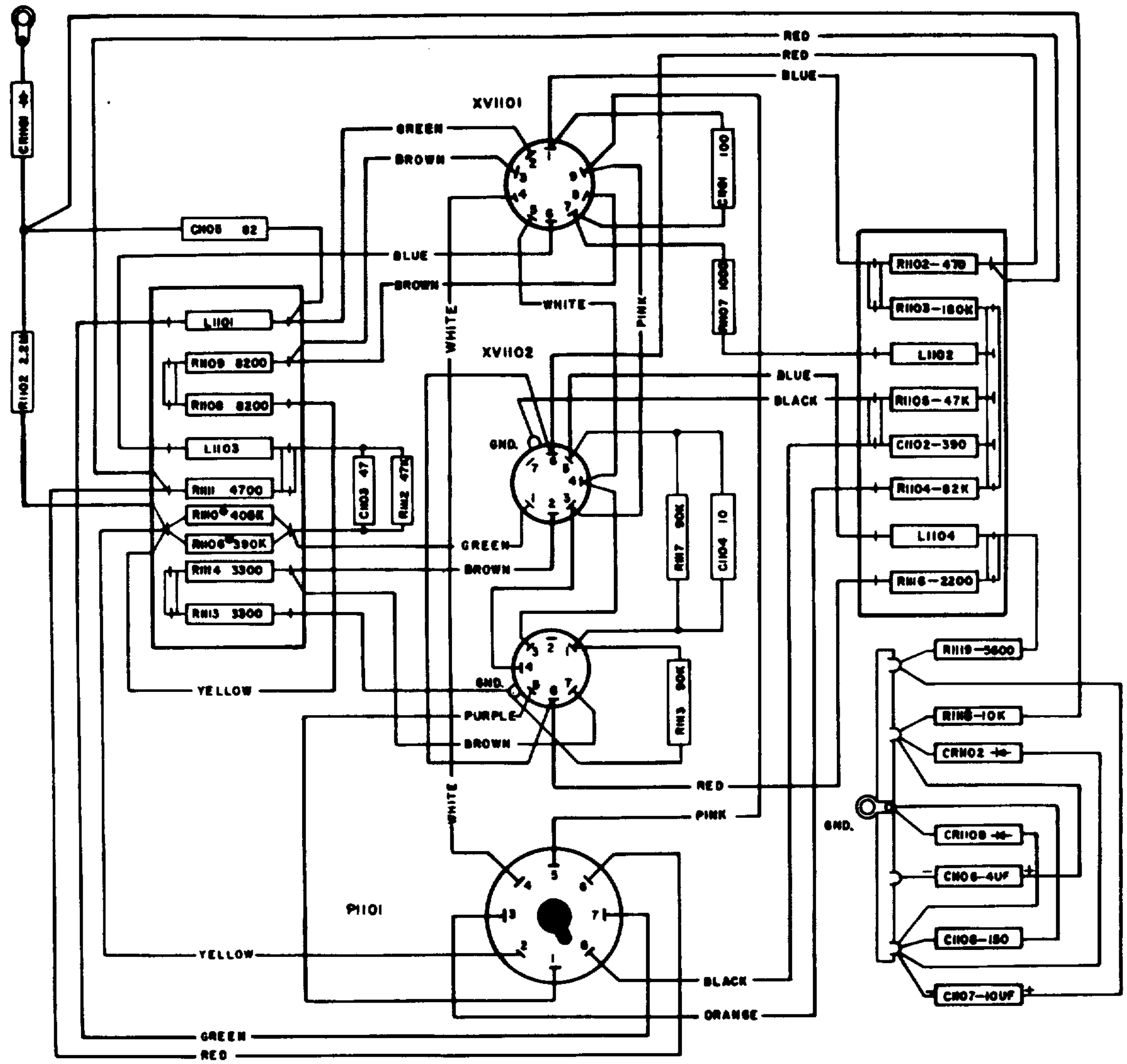

Figure 12-50A. Practical Wiring Diagram of FR-38C/U and FR-38D/U Trigger Unit, Z201

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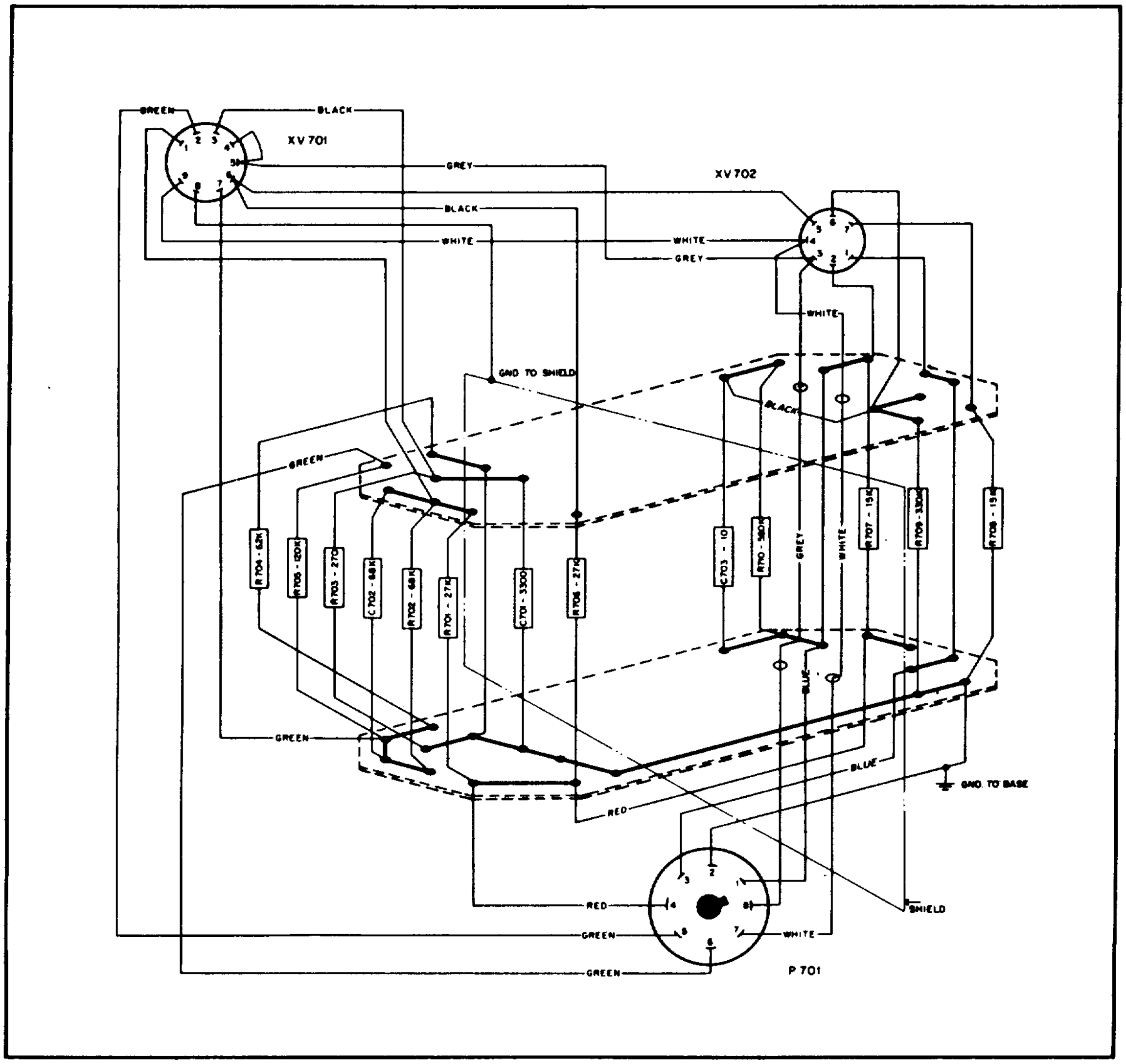


Figure 12-51. Practical Wiring Diagram of FR-38/U Amplitude Discriminator

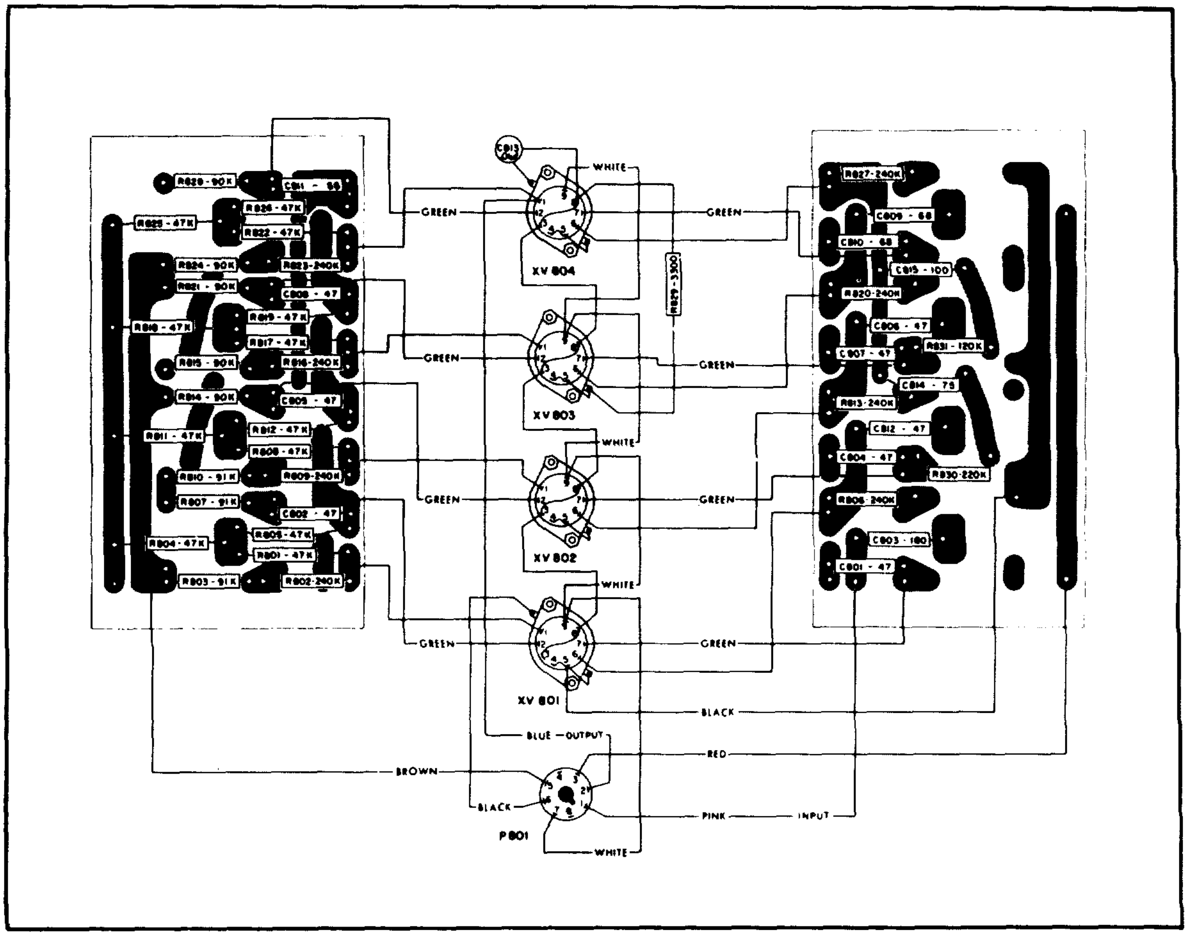


Figure 12-52. Practical Wiring Diagram of FR-38/U Decade Divider

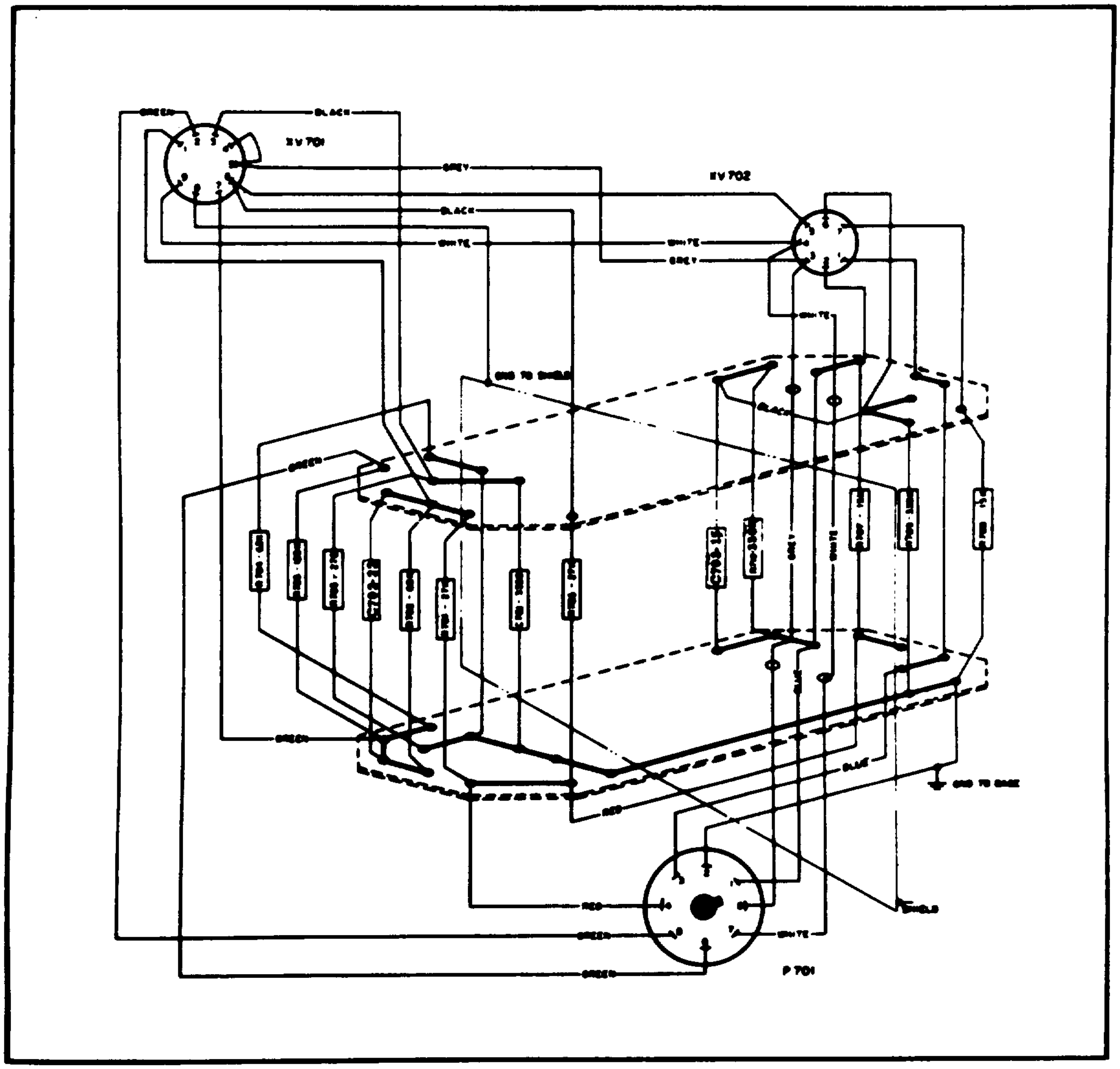


Figure 12-51A. Practical Wiring Diagram of FR-38D/U Amplitude Discriminator

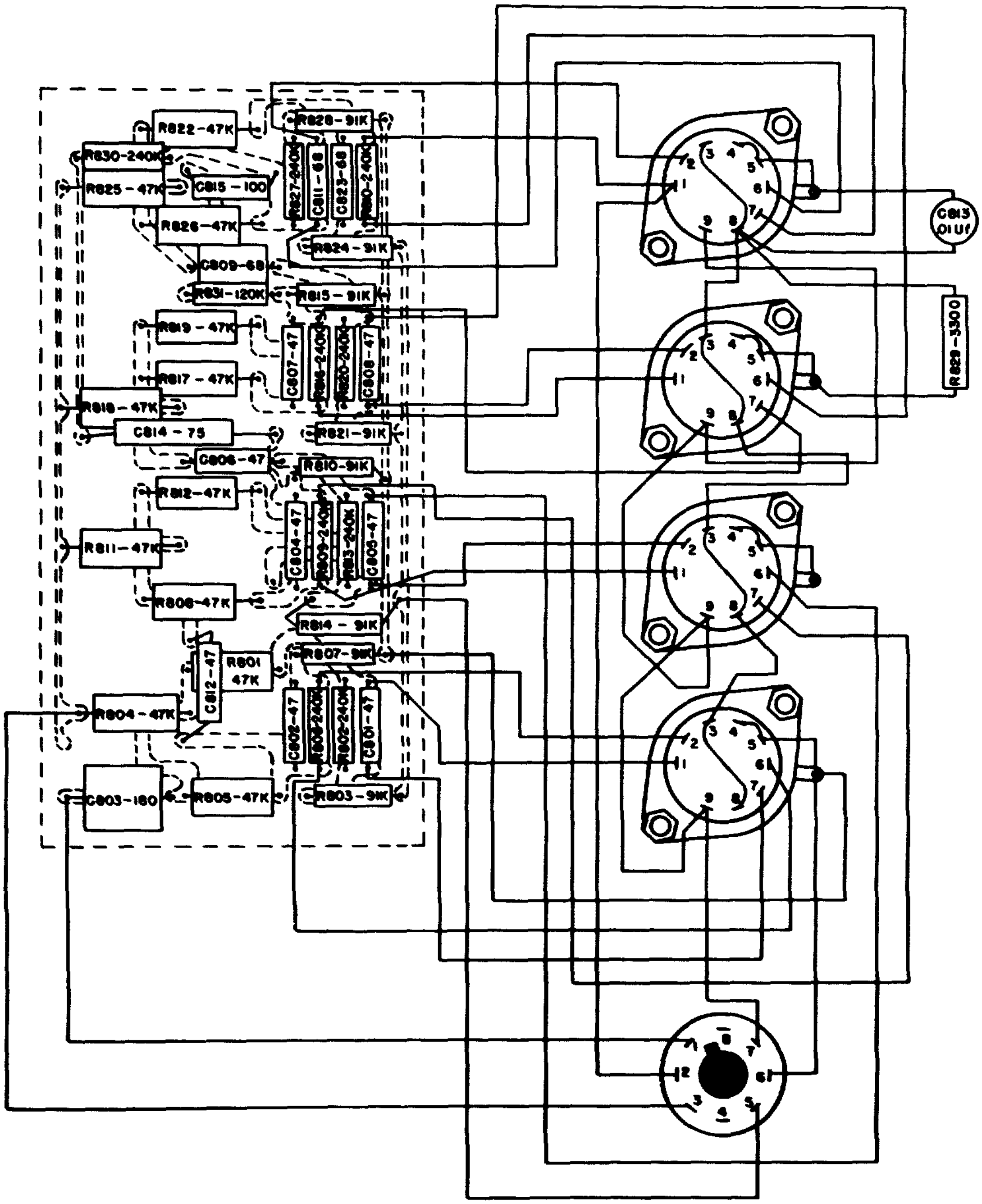
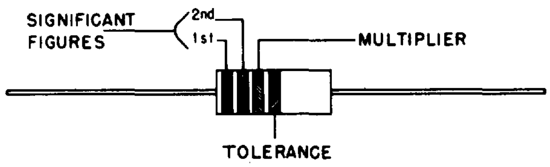


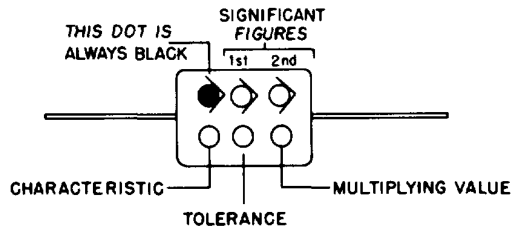
Figure 12-52A. Practical Wiring Diagram of Decade Divider, FR-38C/U and FR-38D/U

JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS



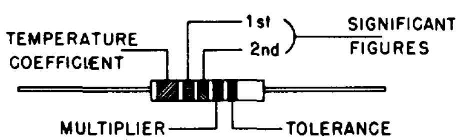
Color	Sig. Fig.	Multiplier	Tolerance
Black	0	1	-
Brown	1	10	±1%
Red	2	100	±2%
Orange	3	1000	±3%
Yellow	4	10000	±4%
Green	5	100000	±5%
Blue	6	1000000	±6%
Violet	7	10000000	±7%
Gray	8	100000000	±8%
White	9	1000000000	±9%
Gold			±5%
Silver			±10%
No color			±20%

JAN 6-DOT COLOR CODE FOR MICA-DIELECTRIC CAPACITORS



Color	CAPACITANCE Sig. Fig.	Multiplier	Tolerance	Char. Desig.
Black	0	1	±20%	A
Brown	1	10		B
Red	2	100	±2%	C
Orange	3	1000		D
Yellow	4	10000		E
Green	5			F
Blue	6			G
Violet	7			
Gray	8			
White	9			
Gold			±5%	
Silver			±10%	
No color				

JAN COLOR CODE FOR CERAMIC DIELECTRIC CAPACITORS (TEMPERATURE COMPENSATING)



Color	CAPACITANCE Sig. Fig.	Multi-plier	TOLERANCE In %. (Cap. More than 10 µµf)	In µµf. (Cap. Less than 10 µµf)	Char. Desig.
Black	0	1	±20	±2	C
Brown	1	10	±1		H
Red	2	100	±2		L
Orange	3	1000			P
Yellow	4				R
Green	5		±5	±0.5	S
Blue	6				T
Violet	7				U
Gray	8			±0.25	B
White	9		±10	±1	SL
Gold					A

COLOR CODE FOR MINIATURE CAPACITORS

Color Code	Value
Green and White	0.5 µµf
Violet and White	0.68 µµf
Brown (one band only)	1.0 µµf
Brown and Green	1.5 µµf
Red (one band only)	2.2 µµf
Orange (one band only)	3.3 µµf
Green (one band only)	4.7 µµf

COLOR CODE FOR WIRING OF AN/USM-26		
Pink	Unregulated	+300
Red	Regulated	+210
Purple	Regulated	+ 90
Orange	Regulated	+ 70
Green		-195
Gray		- 2

Figure 12-53. Resistor and Capacitor Color Code

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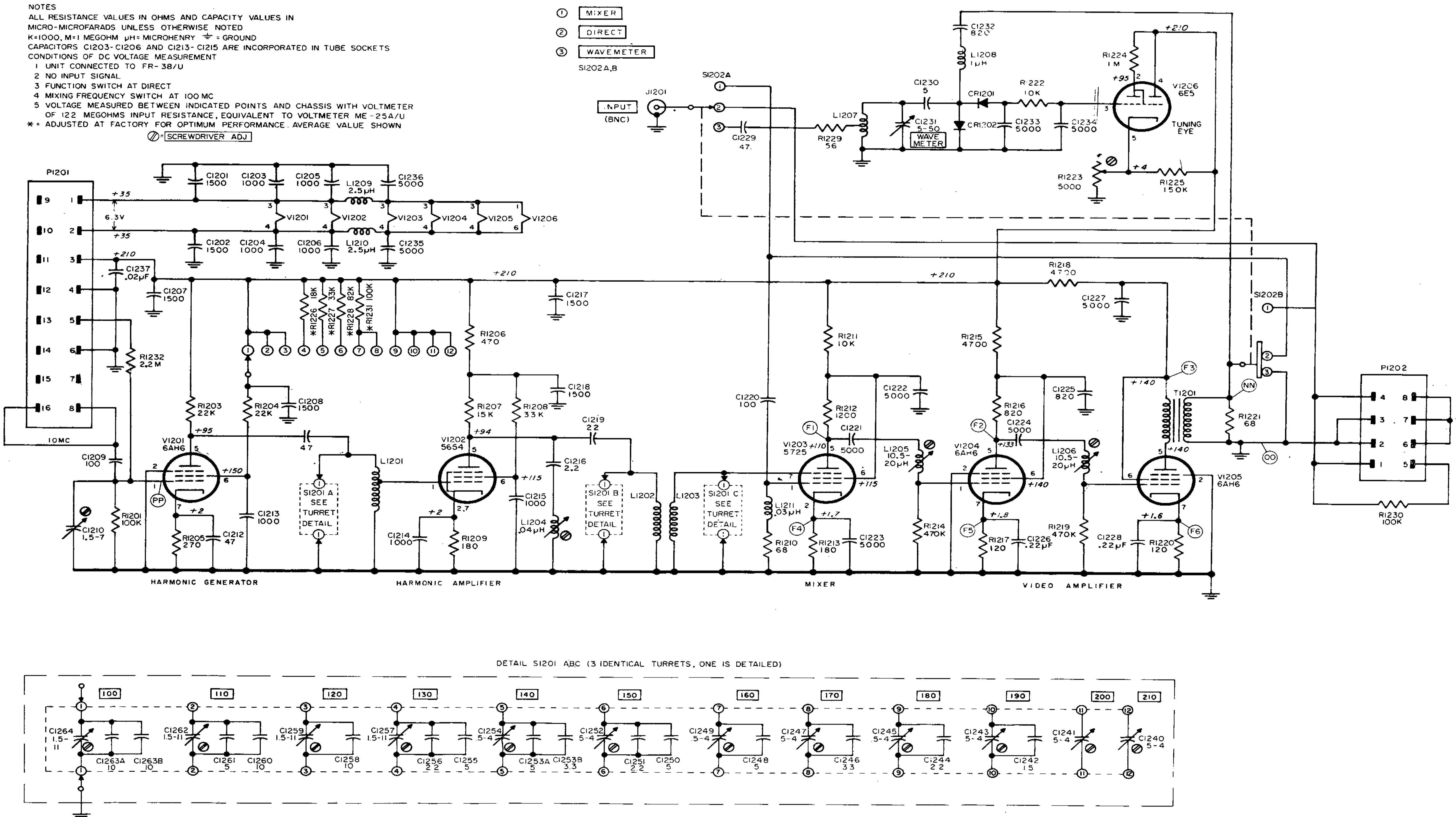
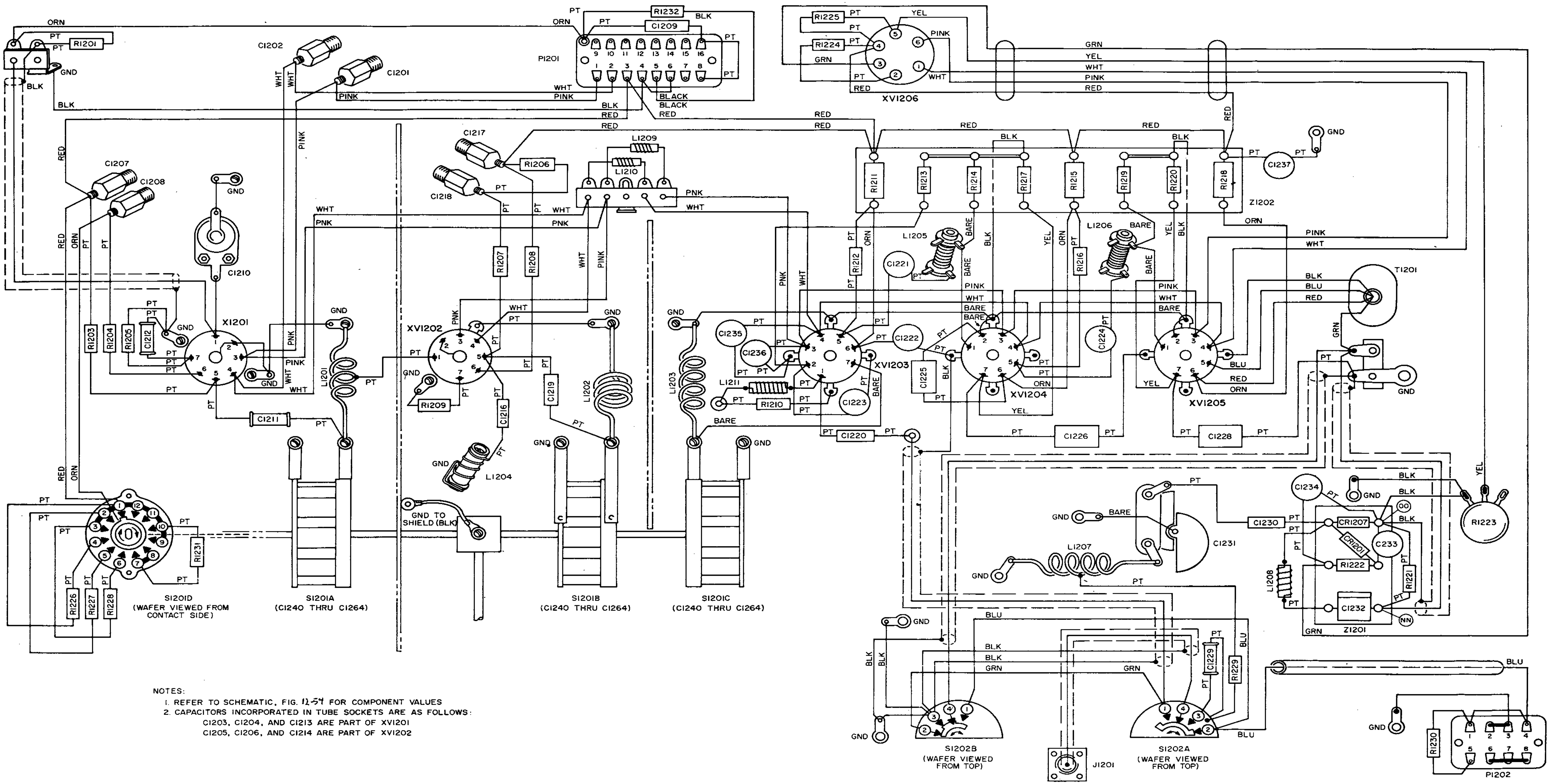


Figure 12-54. Schematic Diagram of Frequency Converter CV-394/USA-5



NOTES:

1. REFER TO SCHEMATIC, FIG. 12-54 FOR COMPONENT VALUES
2. CAPACITORS INCORPORATED IN TUBE SOCKETS ARE AS FOLLOWS:
   C1203, C1204, AND C1213 ARE PART OF XV1201
   C1205, C1206, AND C1214 ARE PART OF XV1202

Figure 12-55. Practical Wiring Diagram of Frequency Converter CV-394/USA-5

SECTION XIII

DIFFERENCE DATA SHEETS FOR FR-38D/U

Service instructions for the models included in this section are the same as the procedures for the FR-38/U Frequency Meter except for the specific differences noted by the applicable Difference Data Sheet.

Index to Difference Data Sheets

THE INSTRUCTIONS CONTAINED IN PRECEDING SECTONS OF THIS MANUAL APPLY EXCEPT FOR THE DIFFERENCES GIVEN IN THIS DATA SHEET.

DESCRIPTION AND LEADING PARTICULARS. Same as for FR-38/U, except that in Table 1-2, tubes V239 and V240 are same as for FR-38C/U, and diodes 1N116, CK705, and 1910-0011 are used in place of diodes 2l2-G11A. There are a total of 66 diodes-1N116 (Hughes), CK705 (Raytheon), and 1910-0011 (Hewlett-Packard)'

SPECIAL TEST EQUIPMENT. Same as for FR-38/U.

PREPARATION FOR USE AND RESHIPMENT. Same as for FR-38/U.

THEORY OF OPERATION. Same as for FR-38/U except that capacitor C306, in Figure 9-11 has a value of 1.5 µµf, and the digital display indicators (decade counters) Z204 through Z209, referred to in paragraph 9XA have a maximum counting rate of 120 kc.

ORGANIZATIONAL AND SQUADRON MAINTENANCE. Same as for FR-38/U, except as follows:

a. In step 4 of Table 10-1 the tubes to be checked should include V1101, V1102, and V1103, as annotated for the FR-38C/U.

b. Tubes V239 and V240, shown in Figure 10-5 are the same as annotated for the FR-38C/U.

c. The tube reference designators in digital display indicators Z204 through Z209, shown in Figure 10-5, are V901 through V904 in each of these six identical units. Tube type remains 5963.

d. The tube reference designators in plug-in trigger unit Z201, shown in Figure 10-5 are V1101, V1102, and V1103. Tube types are the same as those shown.

e. In Table 10-11, page 69, the tube reference designators in plug-in trigger unit Z201 should be V1101, V1102, and V1103, as annotated for the FR-38C/U.

f. In Table 10-11, page 71, the tube types for V239 and V240 should be as annotated for the FR-38C/U.

FIELD AND FASRON MAINTENANCE. Same as for FR-38/U,except as follows:

a. The tube reference designators in plug-in trigger unit Z201 are V1101, V1102, and V1103, instead of V601, V602, and V603. Text references to these tubes should be treated as annotated for the FR-38C/U on pages 103, 123, and 143.

b. Three types of semiconductor diodes are used in the FR-38A/U in place of the Hewlett-Packard 212-G11A used in the FR-38/U. The three types used are lN116 (Hughes), CK705 (Raytheon), and 1910-0011 (Hewlett Packard). Replacement diodes used should be of the same tees and should be selected as directed in paragraphs 11-43 through 11-51.The same forward current and back resistance specifications listed in those paragraphs apply to the three diode types used in the FR-38A/U. These three diode types can be used interchangeably for replacement purposes when necessary.

c. The AC-4A digital display indicators (decade counters) Z204 through Z209 used in the FR-38A/U differ from the digital display indicators used in the FR-38/U. The general maintenance instructions of paragraphs 6-174 to 6-190 still apply, except that voltages measured in these units should be checked against the values shown in the schematic diagram, Figure 13-2 a supplementary trouble-shooting table relating incorrect indications to faulty circuits is given as Table 13-1 and an illustration of actual waveforms obtained at the tube sockets, with the digital display indicator connected for remote operation, is given in Figure 13-1.

Table 13-1. Trouble Shooting the Digital Display Indicators of FR-38A/U

SYMPTOM		CAUSE
Resets to	Counting (cycle	Faulty tube or circuit as listed below)
0	0, 1, 8, 9, then repeats 6,7,8,9	V3
0	0, 2, 4, 6, 8	V1
0	0, 1, 2, 3, 4, 5	V4 or output circuit grounded.
0	0, 1, 2, 3, 6, 7, 8 & 2, 9 &3	V3
0	0, 1, 2, 3, 4, 5, 4 5, 6, 7, 8, 9	Feedback between V2 and V3.
0	0, 1, 2, 3, 4, 5, 6, 7, 8, & 2, 9 & 3, 8, 9	Feedback between V2 and V3.
0	0, 1, 2, 3, 4, 5, 4, 5, 6, 7, 8 & 2, 9 & 3, 6, 7, 8, 9	Both feedback loops.
1	Will not count	V1
2	2, 3	V4 or V2
4	4, 5	V2 or V3
6	6, 7, 8 & 2, 9 & 3, 8, 9	V4

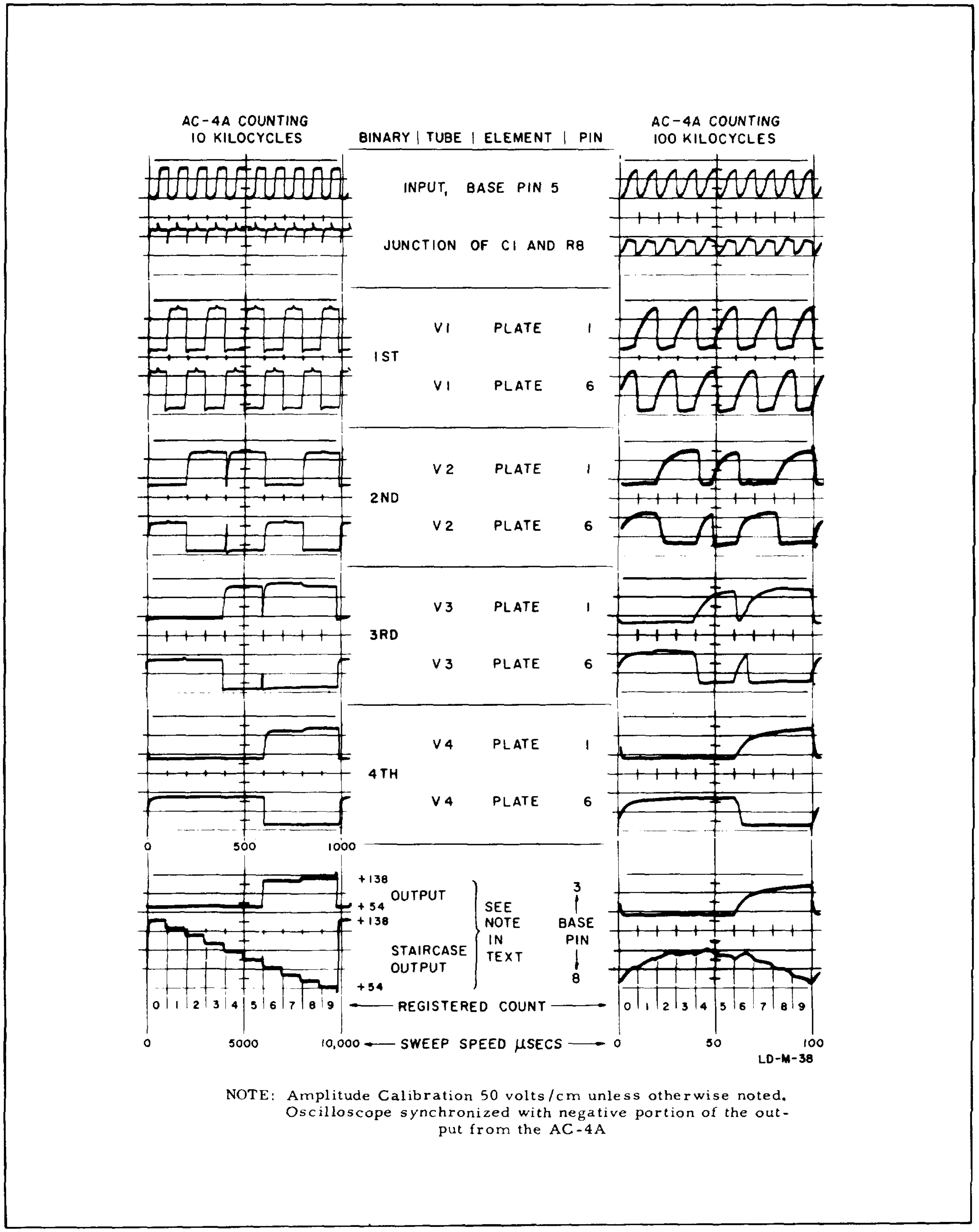


Figure 13-1. Oscillograms Obtained from an AC-4A Digital Display Indicator Used in FR-38A/U

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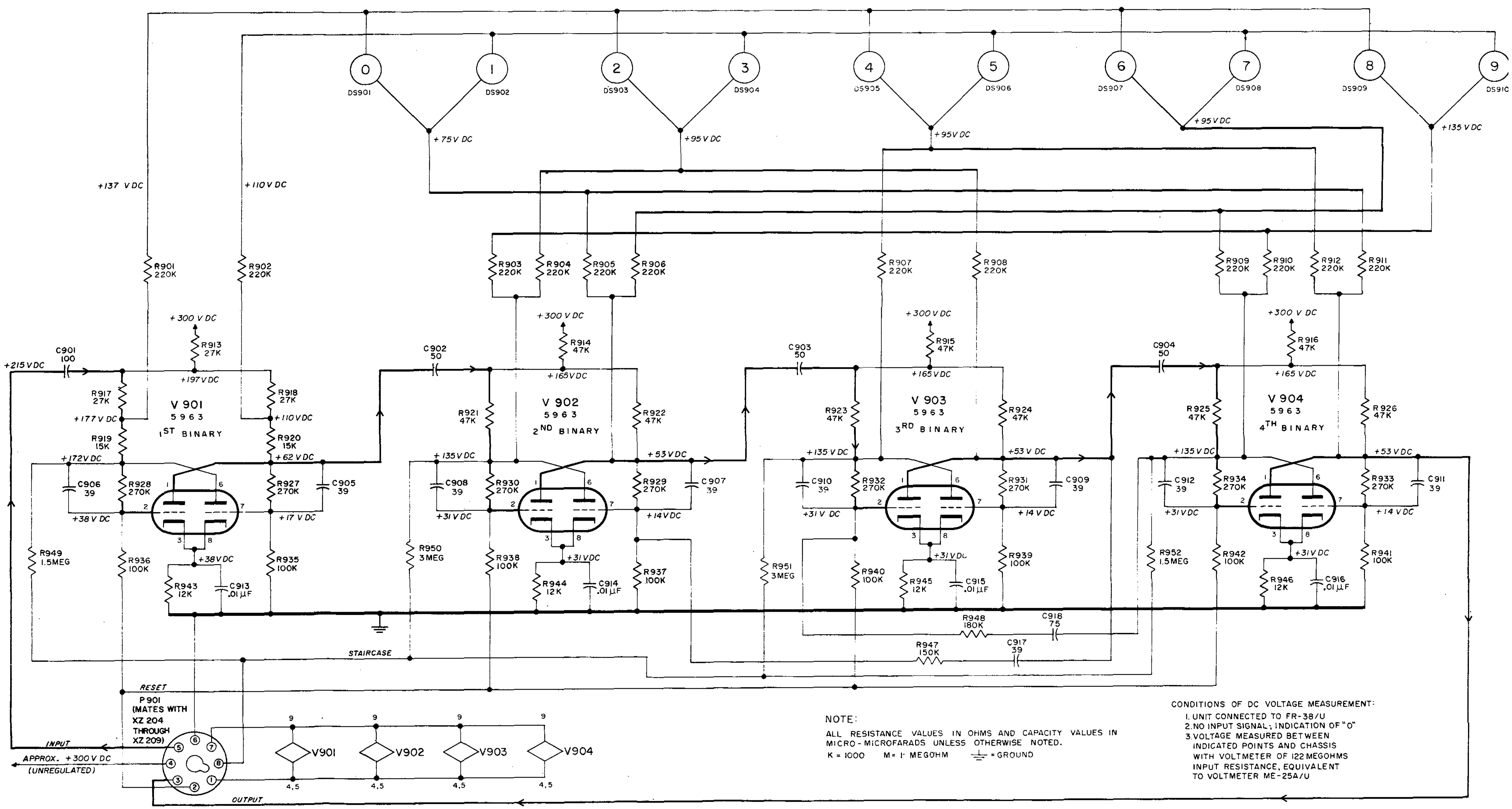

Figure 13-2. Schematic Diagram Display Indicators Z204 through Z209 in Frequency Meter FR-38A/U

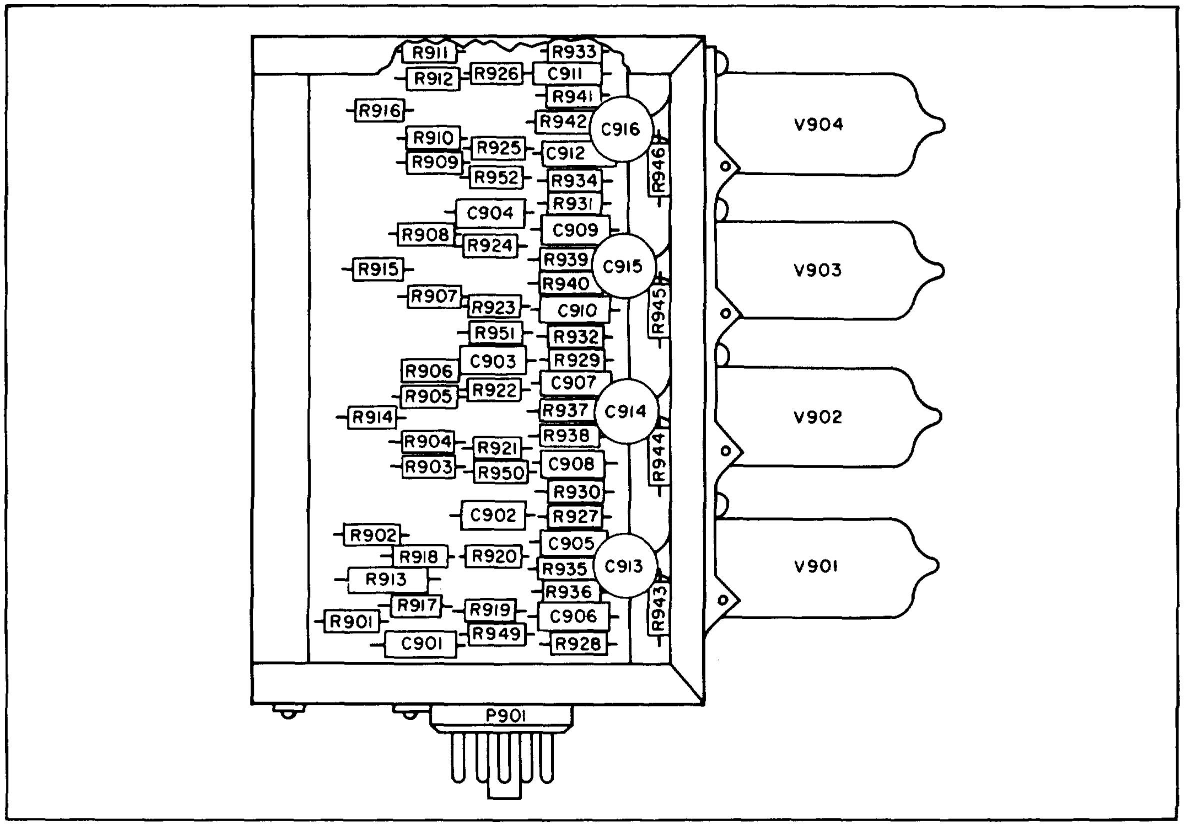

Figure 13.3 Right Side View of AC-4A Digital Display Indicator Showing Component Layout on Printed Circuit Board

DIAGRAMS. The diagrams given in Section XII fall into two categories: some are applicable to all models of the FR-38/U and others have been separated by figure number and title into paired diagrams, of which one is applicable to the FR-38/U and one to the FR-38C/U and FR-38D/U (with annotation where necessary on those diagrams to distinguish between the latter two instruments). The diagrams which apply to all models of the FR-38/U and the other diagrams arranged by title, figure number, and annotation to apply to the FR-38C/U, also apply to the FR-38A/U, except as follows:

a. For parts layout of digital display indicators (decade counters) Z204 through Z209, refer to Figures 13-3 and 13-4.

b. In Figure 12-14 C204 should have a value of 0.005 µf.

c. In Figure 12-19 R423, R433, R439, and R448 are correct as shown for the FR-38/U.

d. In Figure 12-21 R457, R466, and R476 are correct as shown for the FR-38/U.

e. In Figure 12-33A C204 should have a value of 0.005 µf.

f. In Figure 12-34.1 R335 is not present in the FR-38A/U; R402 should be 56K; and the schematic diagram reference for Z204 through Z209 should be Figure 13-2.

g. In Figure 12-35 C338 should be 15 µµf; L218 should be 5.5 to 10.5 µh (variable); L223 should be 10.5. µh: R439, R448, R457, R466, and R476 should be 100; and R461 should be 3.3 megohms.

h. Figure 13-2 is the correct schematic diagram for the six identical digital display indicators (decade counters) used in the FR-38A/U: Figures 12-40 and 12-41 do not apply.

i. Printed circuit wiring of digital display indicators (decade counters) Z204 through Z209 Is shown in Figures 13-3 and 13-4.

j. In Figure 12-45A C204 should have a value of 0.005 µf,

k. In Figure 12-46A R335 is not present in the FR-38A/ U; R402 should be 56K.

l. In Figure 12-48A *C338* should be 15 µµf; *R423* should be 27K; R433, R439, R448, R457, R466, and R476 should be 100K; and R461 should be 3.3 megohms.

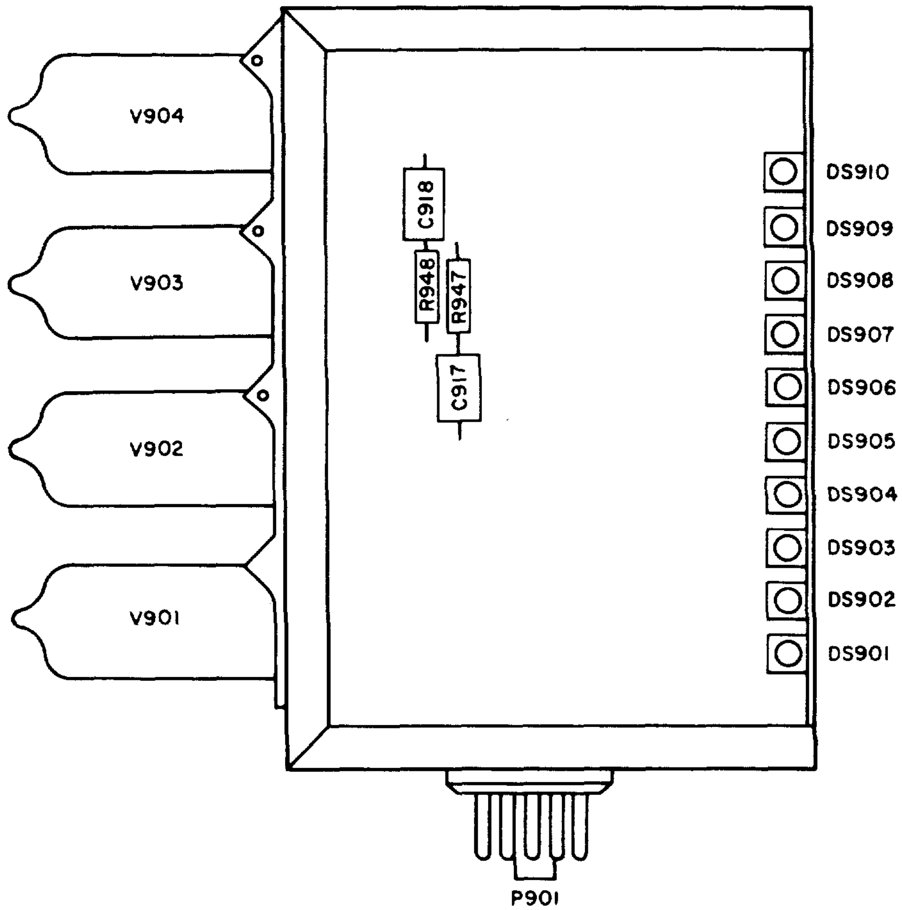

Figure 13.4 Left Side View of AC-4A Digital Display Indicator Showing Component Layout on Printed Circuit Board

SECTION XIV

DIFFERENCE DATA SHEETS FOR FR-38E/U

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Table 14-1. Tube Complement List of FR-38 E/U

Quan.	Type	Tube and Function	
1*	OB2WA		
12*	6AH6WA		
6	6AU6WA	V-237	Multiplier (4X)
		V-238	Multiplier (5X)
		V-252	Control
		V-260	Control
		V-1301	Oscillator
		V-1302	Amplifier
6*	6CB6A		
1*	6E5		
3*	12AT7WA		
6	5654/ 6AK5W	V-602	Schmitt Trigger
		V-603	Schmitt Trigger
		V-1102	Schmitt Trigger
		V-1103	Schmitt Trigger
1*	5687		
10	5725/6AS6W	V-1303 Mixer Rest Same as Table 1 -4	
2*	5727/2D21W		
4	5726/6AL 5w	V1304 Rest Same as Table 1-4	AGC Rectifier
1*	5844		
39	5963	V-204	Display Time Control
		V-208	Cathode Follower Blocking-Oscillator
		V-236	100 KC /blocking Oscillator - Buffer
		V-248	Cathode Follower
		V-601	Stabilized Amplifier
		V-801	First Binary (Decade Divider Plug-In Unit)
		V-802	Second Binary (Decade Divider Plug-In Unit)
		V-803	Third Binary (Decade Divider Plug-In Unit)
		V-804	Fourth Binary (Decade Divider Plug-In Unit)

Quan.	Type	Tube and Function	
		V-901	First Binary (Decimal Counting Unit Z-204 through Z-209)
		V-902	Second Binary (Decimal Counting Unit Z-204 through Z-209)
		V-903	Third Binary (Decimal Counting Unit Z-204 through Z-209)
		V-904	Fourth Binary (Decimal Counting Unit Z-204 through Z-209)
		V-1101	Amplifier (Stabilized)
		V-1200	First Readout Amplifier
		V-1201	Second Readout Amplifier
		V-1202	Third Readout Amplifier
		V-1203	Fourth Readout Amplifier
2*	6005/ 6AQ5W		
2*	6080WA/ 6AS7GA		
4	6211	V-1401	First Binary Decimal Counting Unit Z-1200)
		V-1402	Second Binary Decimal Counting Unit Z-1200)
		V-1403	Third Binary Decimal Counting Unit Z-1200)
		V-1404	Fourth Binary Decimal Counting Unit Z-1200)
65	1N198J		Plate Clamps Grid Clamps Coupling Diodes Detectors
8	50M-S-379		Rectifiers

*Same as in Table 1-4 for FR-38C/U

Table 14-2. Specifications for FREQUENCY METER AN/USM-26A

Same as FR-38/U, Table 1-3 except as noted.

FREQUENCY MEASUREMENT	
Range:	10 CPS to 100 Mc (direct reading).
Accuracy:	±1 count ±0.000005%* (±0.1 CPS ±0.000005 % on 10 second gate).
Input Requirements	0.1 v rms to 10 Mc; 0.01 v rms 10 Mc to 100 Mc.1 v rms using Time Interval Unit.
PERIOD MEASUREMENT	
	0.01 CPS to 100 kc (10jusec).
TIME INTERVAL MEASUREMENT	
Accuracy:	±0.1 microsecond ±0.000005%*

**INTERNAL STANDARD*

The accuracy figure of ±0.00005% is due to the Internal Crystal Oscillator, which has a long time stability of within 5 parts 100 million week. Short time stability is within 1 part/100 million/day. A panel connector permits use of an external 100 KC or 1MC primary standard signal to obtain higher accuracy.

c. 1 MC - 100 (KC DIVIDER. With switch S1301 in INT position the 1 mc signal is fed into the grid of V-903 which operates as a mixer. The plate circuit of V-90(3 is tuned by L-211 and C-1005 to 100 kc. This 100 kc signal drives blocking oscillator V-236A. The 100 kc pulse from blocking oscillator V-236/A resonates T-901 at a 900 kc rate. This 900 kc signal mixes with the 1 mc input at V-903 to produce the 100 kc output. The regenerative divider is not self starting. To start it relaxation oscillator, VR-1001 and VR-1002, periodically trigger the blocking oscillator, which pulses T-901. After the regenerative divider starts, rectifier V-235A cuts off the relaxation oscillator. Rectifier V-235A also controls the voltage applied to a hold-off circuit VR201 and VR-202 in the gate section. The 100 kc output from mixer V-903, drives the 10 mc multiplier section through capacitor C-.301. The 100 kc signal is also fed to FUNCTION SELECTOR switch S-201A for self check operation.

d. BLOCKING OSCILLATOR. The blocking oscillator V-236A, used as part of the 1 mc-100 KC divider, reduces the loading and provides isolation from the remainder of the circuit. It also acts as a harmonic generator for the 900 kc mixing frequency for V-1303. This oscillator drives itself beyond cutoff within one cycle of operation. The action is initiated by the 100 kc output from mixer V-1303 and results in a sharp output pulse accurately repeated at a repetition rate of 100 kc per second.

e. OPERATION OF BLOCKING OSCILLATOR. The positive-going portion of the 100 kc signal from mixer. V-1303 is injected through capacitor C-1004 into the grid of V-236A causing an increase in plate current. This causes a build up of the magnetic field in transformer T-202. The transformer is connected so that a voltage is induced which serves to drive the grid more positive, further increasing the plate current. This action continues until the plate current reaches saturation and the magnetic field of transformer T-202 ceases to increase. At this point as no more positive voltage is induced in the grid circuit the grid starts to go negative. This reduces the plate current and introduces a negative voltage on the grid. This process is cumulative until the grid is driven beyond cut-off. The circuit of the blocking oscillator has been modified to provide more rapid rise time by applying cutoff bias on the grid of V-236A. The cut-off bias is supplied through R-1003, R-1002 and R-1001.

Table 14-3. PANEL CONTROLS AND CONNECTORS FOR FR-38E/U

Same as FR-38/U, Table 6-6xcept as noted. Refer to Figurel4-1 for all numbered locations.

Ref. No. Fig. 14-1	DESIGNATION	FUNCTION
1A	115V 50-70 cps	AC Power Input connector
1B	15V 380-420 cps	
	CX-3135/U (8'0")	
15		Illuminated columns of numbers that indicate eight digits of display.
16		Not Used.
20		Crystal Oven temperature operation indicating lamp.
21A	FREQUENCY STANDARD ADJ FINE	Screw driver operated trimmer capacitor that adjusts internal 1MC standard frequency.
21B	COARSE	(Not an ordinary operating adjustment)
22	FREQUENCY STANDARD INT EX'I'	Switch that arranges instrument to operate using internal 1MC standard oscillator or using external 100 KC or 1MC standard frequency.
23	INPUT 100 KC /IMC	Type BNC Jack that receives external 100KC or 1MC standard frequency. 2 volt RMS minimum into 57KOHMS shunted by 40pf.

f. RECTIFIER. Rectifier, V-235A, is used to provide the proper bias voltage to both control the hold of circuit VR-201 and VR-202 in the gate circuit and to control the action of the relaxation oscillator VR-1001 and VR-1002.

g. OUTPUT OF BLOCKING OSCILLATOR. The output pulses from V-236A have sharp leading edges capable of more accurately triggering the succeeding phantastron diver stages than the relatively sloping wave form of the 100 kc mixer. Output voltage is taken from the third winding of transformer T-202 and fed to the frequency divider chain.

h. EXTERNAL STANDARD FREQUENCY. Where a primary frequency standard is available, an external 100 kc or 1 mc standard frequency may be connected to 100KC 1MC connector J-901 on the front panel. With switch S-1301 in EXT, the signal is fed directly to mixer V-903. The 1 mc oscillator is disabled by applying a negative voltage to the a.g.c. bias. When the external signal is 100 kc the mixer is operated as an amplifier.

i. STANDARDIZATION OF CRYSTAL FREQUENCY. Refer to paragraph9-51.Same as for the FR-38/U, except as follows: The frequency stability of the crystal oscillator in the FR-38/U is approximately 5 parts per 100 million per week. The short time stability of the oscillator is approximately 1 part per 100 million per day. To achieve this short time stability, however, the internal oscillator must be freshly standardized against a more accurate external frequency standard. The internal oscillator can be standardized by applying the external frequency to the SIGNAL INPUT connector, J-203 and adjusting the ADJ trimmers; FINE and COARSE, C-1314 and C-1315, at the front panel until an accurate reading is obtained on the counters. The external frequency must be at least 10 mc for this adjustment to be made with the highest degree of precision. The standardizing procedure is described fully in this section.

GATING SECTION. Refer to paragraph 9-60. Same as for the FR-38/U, except as follows:

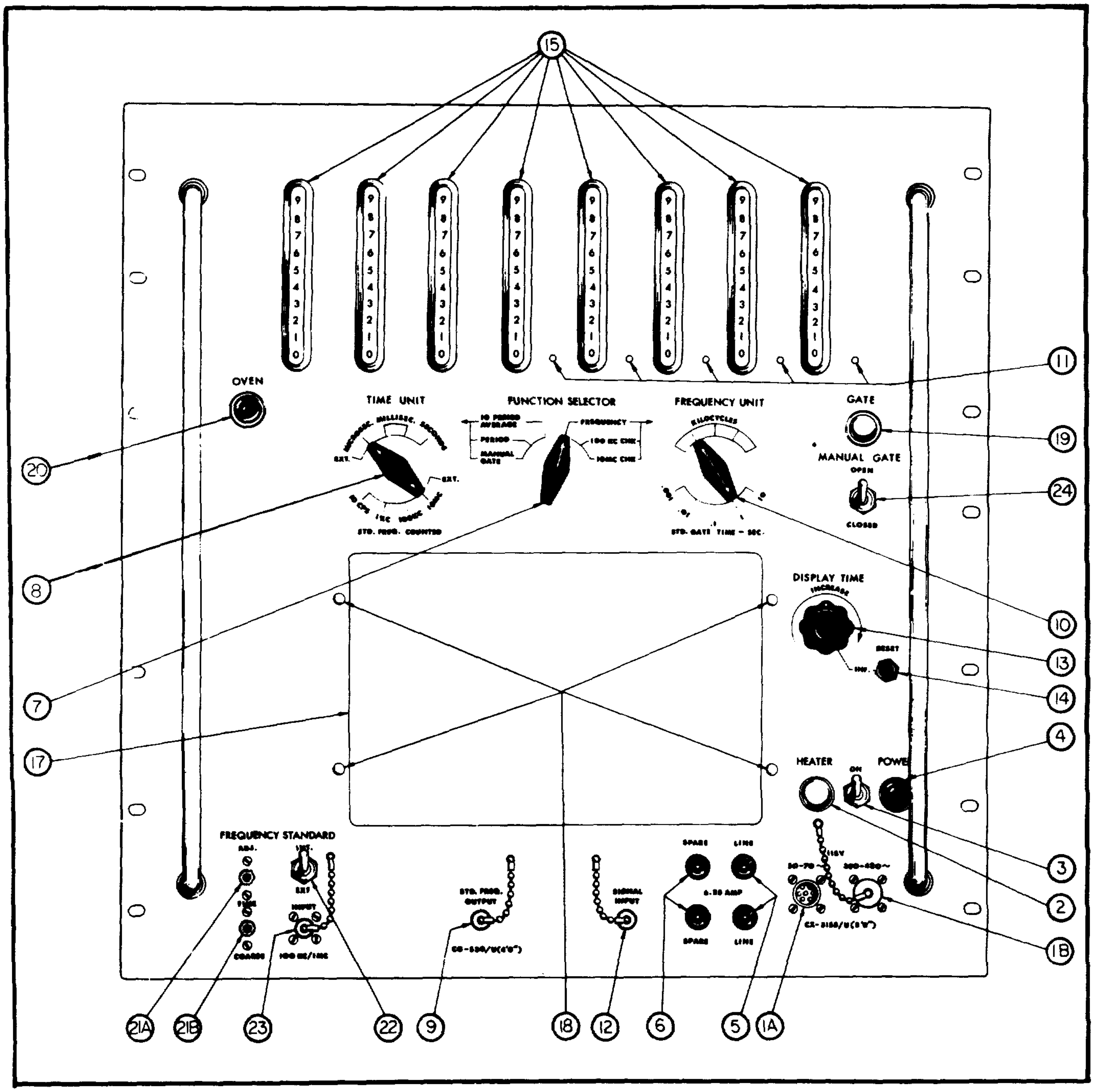


Figure 14-1. Frequency Meter FR-38E/U Controls Numbered

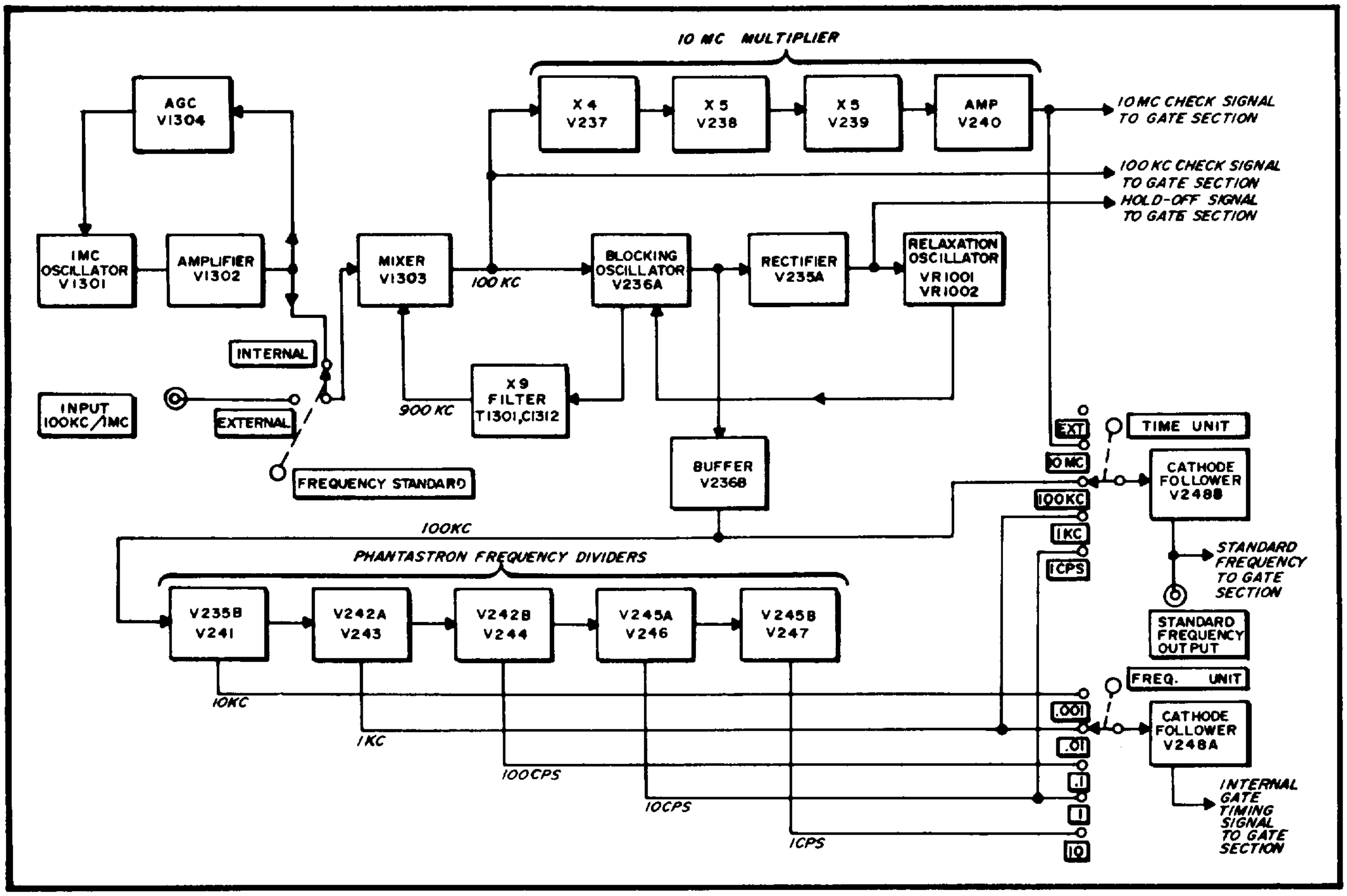


Figure 14-2. Block Diagram of Time Base of FR-38E/U

a. RESET CIRCUITS. Refer to paragraph 9-75Same as for the FR-38/U except that the reset of the counter system for the FR-38E/U is accomplished by the positive pulse from the cathode of reset thyratron V-209. The 10 mc decade is reset through the -2 volt bus grid clamp by the positive pulse from the cathode of V-209. All of the decade counting units are reset through their grid circuits. These reset circuits are shown on the schematic of the counter section.

b. TIME GATE CHANGE RESET. Refer to paragraph 981. Same as for the FR-38/U except that the decade divider is reset to a count of 8 in the FR-38E/U.

COUNTER SECTION. Refer to paragraph 9-92. Same as for the FR-38/U except as follows:

a. COUNTING CIRCUITS. Refer to paragraph 9-94. Same as for the FR-38/U except that the counter section of the FR-38E/U employs eight decade counters. The 10 mc decade is mounted on the chassis. The seven remaining decade counters are plug-in units. Six of these, Z-204 through Z-209 are decade counters with a maximum counting rate of 100 kcs. One decade counter, Z-1200, has a top counting rate of 1 mc. The residual count of all decades is displayed by means of neon lights.

DECADE COUNTERS. Refer to paragraph 9-110. Same as for the FR-38/U except as follows:

a. HIGH SPEED FEEDBACK GATE. Refer to paragraph 9-121 Same as for the FR-38/U, except as follows: A final factor in speeding up the counter is the use of a high speed feedback circuit that avoids the delays described before. The circuit used can be described by referring to figure 14-3 and figure 14-4. In figure 14-3 it is shown that in the interval between the second and the sixth applied pulses the second and the third binarys are in the same sense. This interval is the only time that the two binaries are aligned and thus would be susceptible to a feedback pulse. To accomplish this the binaries are coupled through a coincidence network (figure 14-4) which can only be opened when the second and the

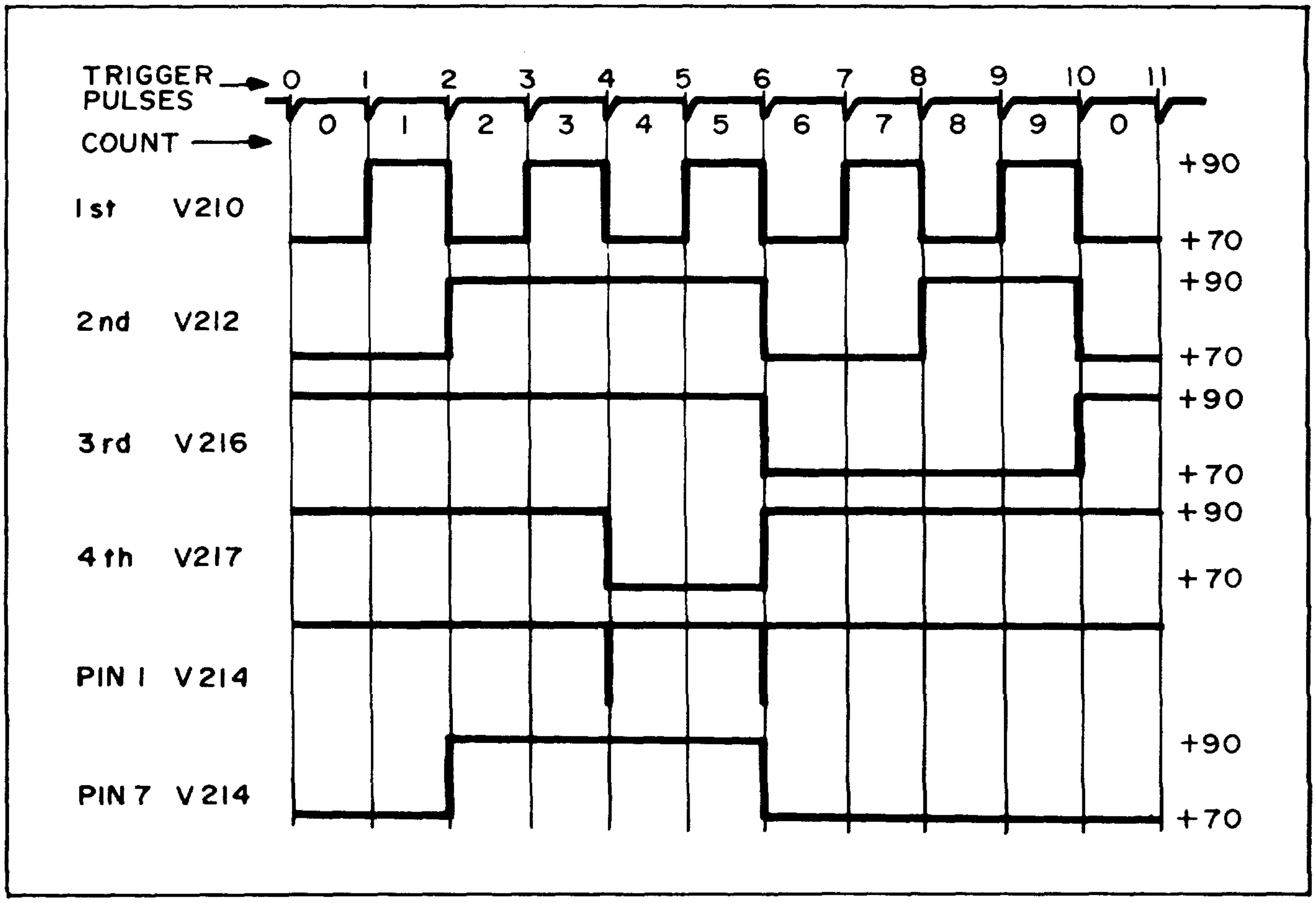


Figure 14-3. Plate Waveforms of 10 mc Section of FR-38/U

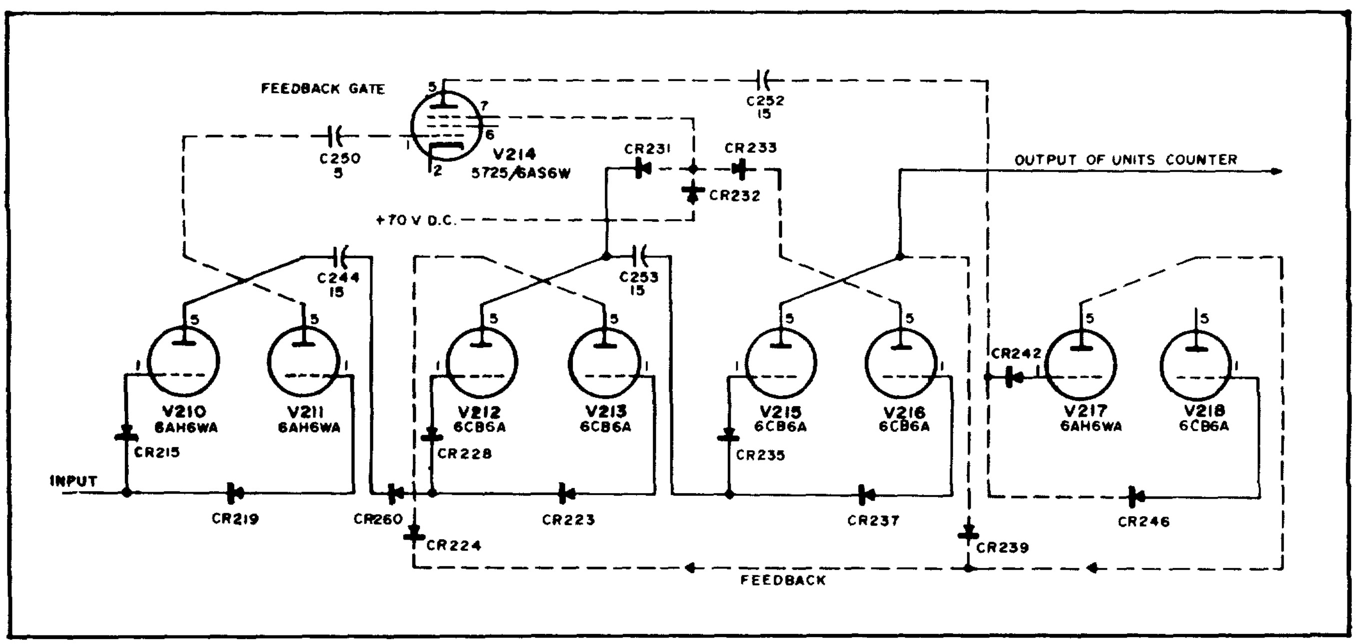


Figure 14-4. Simplified Schematic of 10 mc Section of FR-38E/U

third binaries are "up". The output of the gating tube V-214 is coupled to the 4th binary. On the fourth applied pulse, the sharp negative pulse from V-210 starts to trigger V-213. The positive pulse from V-211, is inverted by V-214 and triggers the 4th binary, V-218. The sharp negative pulse from V-217 is coupled back by a second feedback network to V-213, preventing V-212 from triggering. On the sixth input pulse the positive pulse from V-211 is inverted by V-214 and triggers the 4th binary, V-217, to its initial off position. The negative pulse from V-210 triggers the second binary putting V-212 in the "on" position. The negative pulse from V-212 triggers the third binary, V-215. Both feedback gates are inoperative from the seventh through the tenth applied pulses.

b. COINCIDENCE NETWORK. Refer to paragraph 9-124. Same as for the FR-38/U, except as follows: TableL4-4 shows the voltage levels for the 10 mc coincidence network. The gate is closed for the count of 0 and 1. The second input pulse operates V212 in the "up" position which opens the feedback gate V-214. The fourth input pulse causes a positive pulse from V-211 to be applied to the gate tube V214. The negative output pulse triggers the 4th binary. The sixth input pulse triggers V-211 in the correct direction to also trigger the 4th binary. At the same time the first binary triggers the 2nd which triggers the 3rd thus closing the feedback gate. The gate as shown by the table remains closed for the rest of the cycle.

c. It is apparent that the feedback gate V-214 is opened by the second pulse even though it is not needed until the fourth. When the fourth pulse enters the 1st binary the gate V-214 is already open and looks like a direct connection from the 1st to the 4th binary. This cuts down any circuit delay.

d. 1 MC DECADE. Refer to paragraph 9-126. Same as for the FR-38,/U, except that the 1 mc decade in the FR-38E U is a plug in self-contained unit.

READOUT CIRCUITS. Paragraph9-7 and subsequent paragraphs on the readout circuits for the FR-38 U are not applicable to the FR-38E/U.

a. The number of input pulses since the last output pulse is indicated on banks of neon lights for all counters. All of the counters are self contained plug in units with the exception of the 10 mc section.

b. The readout section for the 10 mc counter consists of four readout amplifiers, V-1200 through V1203, which drive the neon lamp display. These readout amplifiers sense the state of the counting binaries and provide the proper voltages necessary to drive the neon lamps.

ORGANIZATIONAL MAINTENANCE: Same as for the AN/USM-26,except as follows:

MINIMUM PERFORMANCE STANDARDS. Refer to paragraph 10-1. Same as for the AN/USM-26 except as follows.

a. SYSTEM ANALYSIS. Refer to paragraph 10-6. Same as for the AN/USM-26, except refer to 14-5 for the step-by-step analysis for the AN/USM26A.

b. Where reference to meter indication is made in table 10-1 through table 10-8 the indicated number is correct but the display in the FR-38E/U is by neon lamps.

c. Figure 10-1 is not applicable to the FR-38E/U.

SPECIAL PRECAUTIONS CONCERNING REMOVAL AND REPLACEMENT OF THE CABINET, INTERNAL PLUG-IN UNITS, TUBES AND CRYSTAL DIODES. Refer to paragraph 10-10. Same as for the AN/USM-26 except as follows:

SPECIAL PRECAUTIONS CONCERNING REMOVAL OF INTERNAL PLUG-IN UNITS. Refer to paragraphlo12. Same as for the AN/USM-26 except as follows:

a. Refer to Figures10-4and 14-5 for location of the retaining screws.

b. Z-201 Trigger Unit, Z-202 Amplitude Discriminator. Before removing the units release the captive screw from under the chassis and the captive screw at the back of the chassis. See Figure 14-5.

COUNT	V-212 (2nd Binary)	V-216 (3rd Binary)	OUTPUT OF COINCIDENCE NETWORK	V-214 FEEDBACK GATE
0 and 1	+70	+90	+70	Closed
2 thru 5	+90	+90	+90	Open
6 and 7	+70	+70	+70	Closed
8 and 9	+90	+70	+70	Closed

Table 14-4. Voltage Levels for 10MC Coincidence Network for FR-38E/U

c. Z-1200 Decade Counter Unit. Before removing the unit release the retaining screw on the front panel at the top of the number column. See Figure 14-5.

SPECIAL PRECAUTIONS WHEN REPLACING TUBES. Refer to paragraph 10-13. Same as for the AN/USM-26,except refer to Figure 10-3, Figure 10-4, and Figure 15 for tube locations for the AN/USM26A.

ALIGNING THE FR-38E/U. Refer to paragraph 10-16.Same as for the FR-38/U except as follows:

a. In Table 10-11 for the GATE SECTION the tubes used are as annotated for the FR-38C/U.

b. In Table 10-11 for the TIME BASE SECTION V-234 has been replaced with the 1mc oscillator and mixer circuitry, V-1301, V-1302, V-1303, and V-1304. Necessary adjustments required when these tubes are replaced are detailed in this section as revisions to paragraph 10-19. V-239 and V-240 are as annotated for the FR-38C/U.

c. In Table 10-11 for the POWER SUPPLY V249, V-250, V-251 and V-57 are not used.

ADJUSTING POWER SUPPLY VOLTAGES. Refer- to Paragraph 10-17. Same as for the FR-38/U except as follows:

a. Refer to Figure 14-6 for location of parts.

Table 14-5. Step-By-Step Analysis for the FR-38E/U

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Same as for FR-38/U. Table 10-1 thru Table 10/8, except as noted.		
Step 1a Turn power switch to ON	Blower operation can be heard	If blower does not operate, check blower. Make sure Power Cable is connected to INPUT connector for proper power frequency range.
Step 4 Same as Table 10-1	Same as table 10-1	The tubes to be checked should include V-1101, V-1102, and V-1103 as annotated for the FR- 3b'lt.
Step A1 Using a tube checker check all the tubes in the power supply section V-252-V-256 and V-258 - V-261 for emission and for internal shorts. Also using an ohm-meter check rectifier diodes CR-2001 - CR-2008 for an open or shorted condition..		Replace all tubes that are weak or otherwise defective. Replace all rectifier diodes which have a low back resistance or are otherwise defective.
Step A2 Turn the instrument on and measure the voltage at pin 2 of V-253	+325V dc Test Point (A)	If no voltage is present check the circuit of CR-2001 - CR-2008.
Step A3 Measure the voltage at pin 5 of V-258	135V dc Test Point (B)	If no voltage is present or if the voltage is low, check the circuit of CR-2005 - CR-2008 and V-260.
Step F1 Observe neon lamps VR-1001 and VR-1002 in 1mc-100kc divider	VR-1001, VR-1002 off	If VR-1001 and VR-1002 are pulsing at a slow visual rate V-1301, V-1302, or V-1304 in the 1mc oscillator circuit or V-1303 in the mixer circuit are not working. Proceed to Step F2.

Table 14-5. Step-By-Step Analysis for the FR-38E/U (contd)

PROCEDURE	CORRECT INDICATION	COMMON INCORRECT INDICATIONS AND THEIR CURES
Step F2 Set FREQUENCY STANDARD to EXT. Connect 1 volt rms 100kc or 1mc signal to 100 KC/IMC INPUT. Observe neon lamps VR-1001 and VR-1002.	VR-1001, VR-1002 off	If VR-1001 and VR-1002 are pulsing, circuit of V-1303, mixer is faulty. Replace V-1303. If replacement does not restore normal operation return the original tube and proceed to step F3. If the visual check is correct for F2 but not for F1 proceed to step F2A.
Step F2A Reset control settings to initial conditions.	VR-1001, VR-1002 off	Replace oscillator tubes V-1301, V-1302 and V-1304. If replacements do not restore to normal operation return original tubes. Crystal (Y-1301) may be inoperative. Replace crystal oven as described in section IX.
Step G1 Observe the displayed count	00100.000	If no count is obtained check V-210 and V-211 and associated crystal diodes. Return original parts if replacement does not restore normal operation.
		If count is erratic or otherwise wrong in each decade, proceed with Step G2.
		If the Units decade (right hand) operates normally and all other decades are wrong, proceed with Step G3.
		If the Units and Tens decades operate correctly, but all other decades do not, interchange decades until the defective decade is isolated. Replace tubes in the defective decade. If tube replacement does not restore operation service as described in paragraph 11-175.
Step G2 Set FUNCTION SELECTOR to MANUAL GATE, MANUAL GATE to OPEN, TIME UNIT to EXT. Check the counting sequence of the units decade	Units Decade should count 01234567890 123 etc.	Any other order of count is wrong. If the indication is wrong or erratic service as described in paragraph 11-152. If indication is correct proceed with Step G4.
Step G3 Set TIME UNIT to 1OCPS. Check the counting sequence of the tens decade, Z-1200.	Tens Decade should count 01234567890 123 etc.	Any other order of count is wrong. If the indication is wrong or erratic service as described in section XI
Step G4 Set FUNCTION SELECTOR to FREQUENCY, FREQUENCY UNIT to .01 SEC and MANUAL GATE to CLOSED. Connect a two volt rms signal of approximately 1mc to SIGNAL INPUT. Slowly increase frequency until counter indication begins to decrease, stop or becomes erratic.	Consistent readings should be possible at least as high as 10.6 mc.	If the units decade is operating erratically replace the tubes V-210 through V-218. In each case try several tubes. Service as described in paragraph 11-152.
Step G6 Set TIME UNIT to 10CPS. Check counting sequence of the tens decade.	Decade should count 012345 67890123 etc.	Any other order of count is wrong. Service as described in paragraph 11-162.

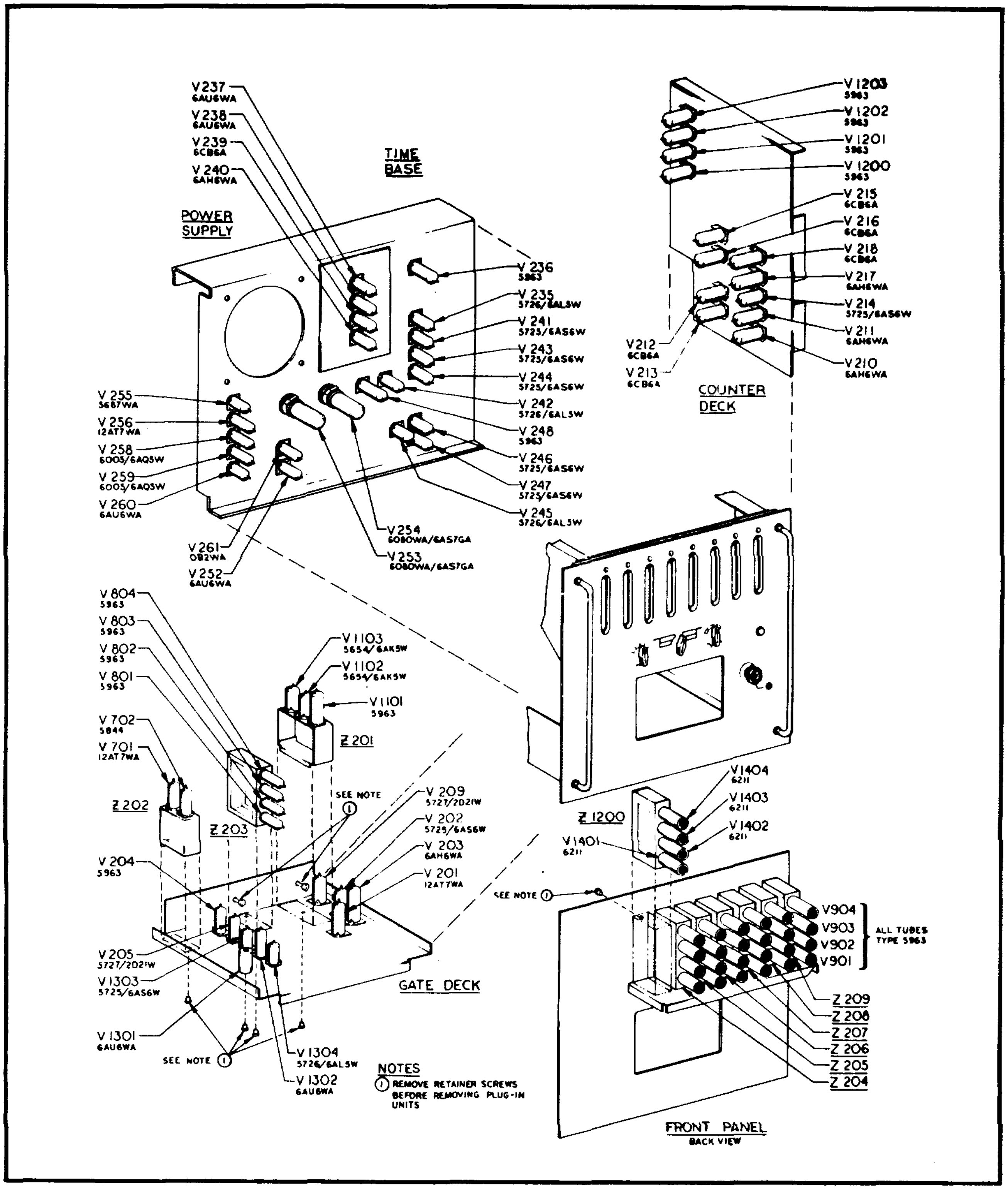


Figure 14-5. Frequency Meter FR-38E/U Tube Location Diagram

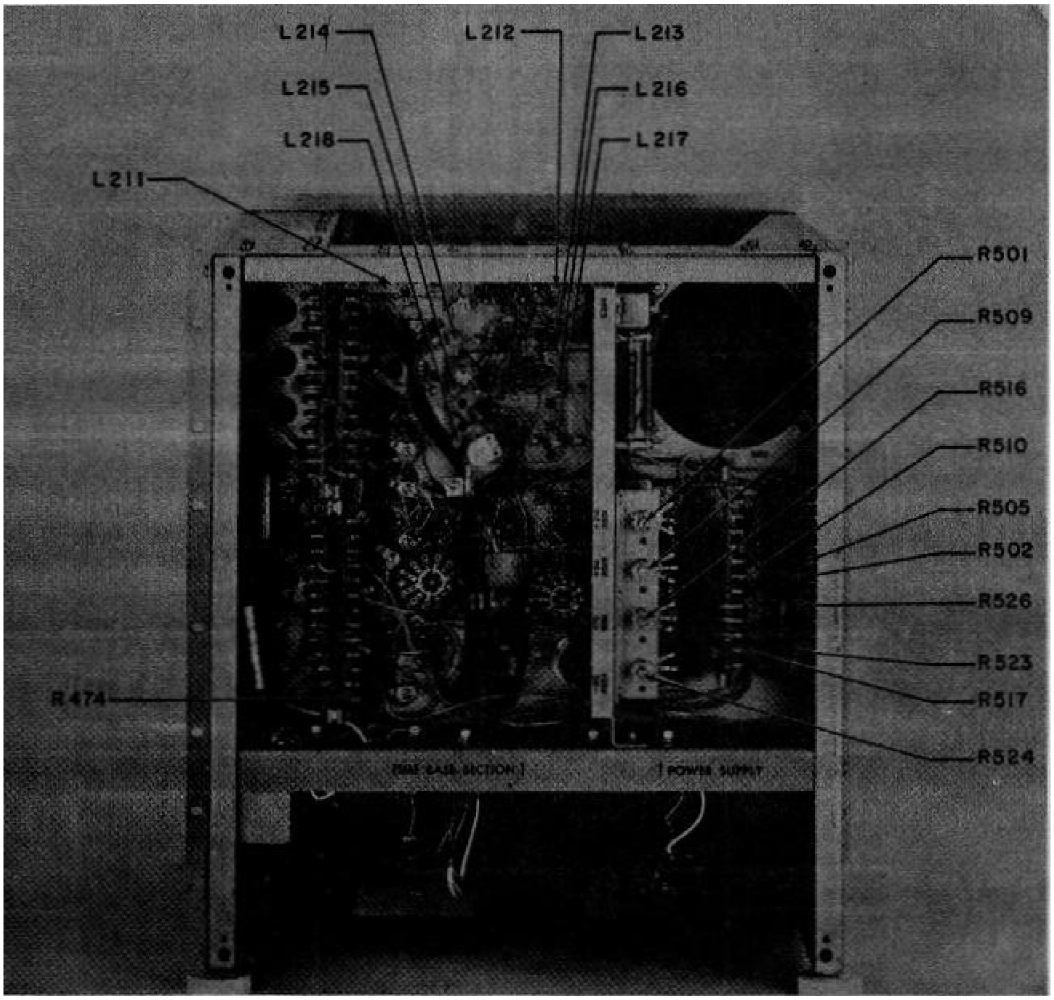


Figure 14-6. Frequency Meter FR-38E/U, Rear View

1 MC OSCILLATOR ADJUSTMENTS. Refer to Paragraph 10-19. Same as for the FR-38 U. except as follows:

a. Set ADJ FINE on the front panel so that the screwdriver slot is in the horizontal (mid) position.

b. Using ADJ COARSE on the front panel standardize the 1 mc oscillator by either method described in paragraph 10-36.

c. Adjust L-1301 for maximum negative voltage - about 5 or 6 volts as measured on dc probe of vacuum tube voltmeter connected to pin 2 of V-1304.

d. Now connect ac probe of vacuum tube voltmeter to the junction of C-290 and C-291., Tune L-211 and T-1301 for maximum voltage indication on the voltmeter.

e. Allow the FR-38E U to operate continuously for 24 hours and then standardize the 1 mc oscillator as described in paragraph 10-36.

TUNING THE 10 MC MULTIPLIER. Refer to paragraph 10-20. Same as for the FR-38,'U except, refer to Figure 14-6 for parts locations.

ADJUSTING 10 MC STD FREQUENCY INPUT. Paragraph 10-29 is applicable to the FR-38/U. The following procedure should be used for the FR-38E/U:

a. With the POWER switch off, remove the front panel plug-in unit and insert the test connector (Figure 14-7) into connector J-201. Turn the power on and allow the equipment to warm up thoroughly.

b. Connect the ac probe of a vacuum tube voltmeter (ME-26A/U or equal) to pin 8 of J-201.

c. Adjust L-224 for maximum reading on voltmeter. If the reading is between 85 and 100 volts proceed with step i.

d. If the reading is below 85 volts or above 100 volts check tuning of the 10 mc multiplier, paragraph 10-20.

e. If the reading is still below 85 volts or above 100 volts, adjust C-316.

f. Readjust L-218 as described in paragraph 10-20.

g. Readjust L-224 for maximum reading on ac voltmeter.

h. Repeat steps e through g until voltmeter reading at pin 8 of J-201 is between 85 and 100 volts.

i. Loosely couple voltmeter probe to 10 mc circuit by placing probe close to J-201.

j. Readjust L-224 for maximum reading on voltmeter.

ADJUSTING HARMONIC GENERATOR INPUT CAPACITY (C-74). Capacitor, C-74, has been set at the factory and should not normally require readjustment. In order to check its adjustment proceed as follows:

a. Check ADJUSTMENT OF 10 MC STD INPUT as detailed above for adjustment of C-316, L-218 and L-224. Leave Test Connector (Figure 14-7) installed in Connector J-201.

b. Remove cabinet from FR 38E/U. Refer to Figure 10-2.

c. Loosely couple ac voltmeter (ME-26A/U or equal)to blue lead from L-224. Do not connect ac probe directly to lead. Note voltage reading.

d. Remove Test Connector (Figure14-7 and install converter in FR-38E/U. Note whether voltage reading drops.

e. If voltage drops remove Converter and adjust C-74 slightly.

f. Repeat steps d and e until C-74 is adjusted to produce a maximum on the voltmeter.

PERIODIC CHECKS. Refer to paragraph 10-30. Same as for the FR-38/U except as follows:

a. Refer to paragraphs 10-3l. The lmc oscillator in the FR-38E/U should be standardized weekly for extreme accuracy. If equipment is not available for standardizing, however, the equipment can still be used but its accuracy may be reduced at the rate of 5 parts per 100 million per week.

b. The motor in the air blower is an ac type and requires no maintenance.

STABLIZING THE 1 MC CRYSTAL. Refer to paragraph 10-35. P as for the FR-38/U, except that the frequency of the oscillator is lmc and its specified stability is 5 parts per 100 million per week.

STANDARDIZING THE 1 MC CRYSTAL OSCILLATOR. Refer to paragraphs 10-36 through 10-43. Same as for the FR-38/U except as follows:

a. The frequency of the oscillator is lmc and its specified stability is 5 parts per 100 million per week.

b. In METHOD 1 and METHOD 111 the external standard should be accurate within 1 part in 100 million. In METHOD 1 the external frequency should have a frequency of approximately 10 megacycles.

c. In the FR-38E/U there are two external adjustments to the oscillator frequency available at the lower left of the front panel. A COARSE adjustment and a FINE adjustment. The FINE adjustment should be turned first and the results noted. If the FINE adjustment will not bring the oscillator on frequency the COARSE Adjustment should then be used. If neither the FINE nor COARSE adjustments will bring the oscillator on frequency refer to the revisions to paragraph 11-79.

GENERAL SUPPORT AND DEPOT MAINTENANCE. Same as for the AN/USM-26, except as follows:

a. Refer to Table 14-6 for SYSTEM ANALYSIS CHART for FR-38E/U.

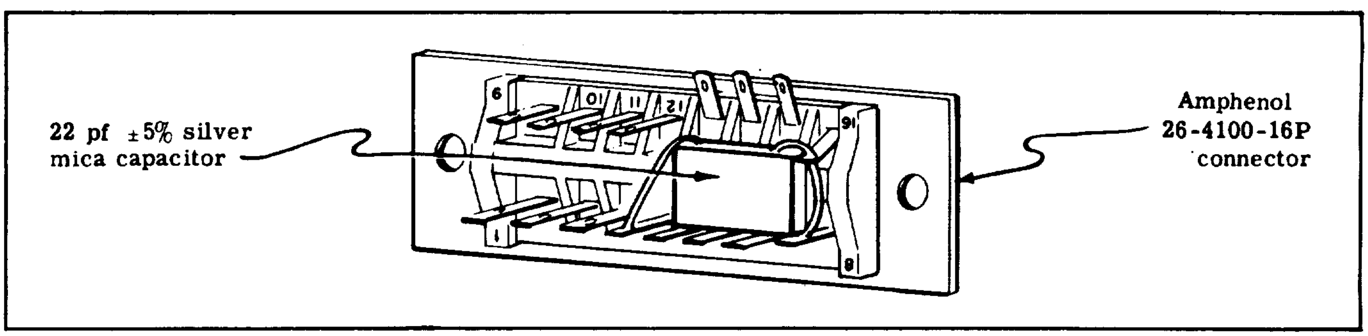


Figure 14-7. Test Connector for Adjusting 10-mc Drive

Table 14-6. Systems Analysis Chart for FR-38E/U

Same as for FR-38/U, Table 11-2, except as noted.

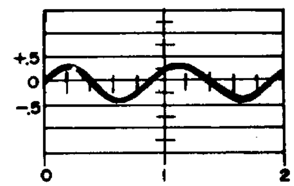
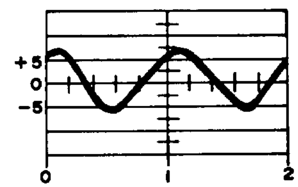
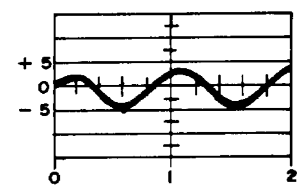
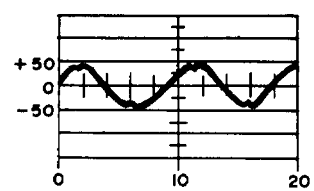
STEP	TEST POINT	CONTROL POSITION	TEST EQUIPMENT CONTROL POSITION	NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
1	Connect oscilloscope to pin 5 of V-1301 35	FREQUENCY STANDARD INT. Line voltage 115 v	Sync: +INT Sweep: 0.2 μsec/cm.		Check V-1301, V-1302, V-1304. If operation normal with external standard, check crystal oven assembly, Z-235
2	Connect oscilloscope to pin 5 of V-1302 36				Check V-1301, V-1302, V-1304
3	Connect oscilloscope to pin 1 of V-1303 37				Check V-1301, V-1302, V-1304
3A	Connect oscilloscope to pin 5 of V-1303 38		Sync.: +INT Sweep: 2 μsec/cm		Check V-1303, V-236 and associated circuitry

Table 14-6. Systems Analysis Chart for FR-38E/U (contd)

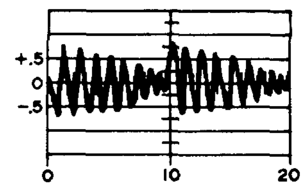
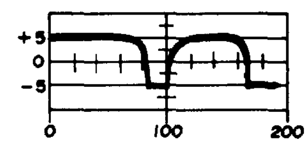
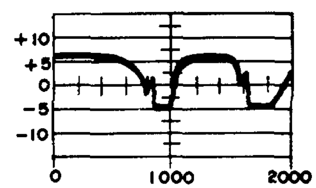
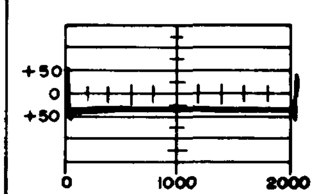
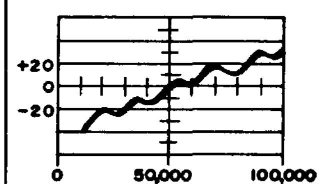
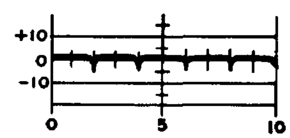
STEP	TEST POINT	CONTROL POSITION	TEST EQUIPMENT CONTROL POSITION	NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
4	Connect oscilloscope to pin 3 of V-236 39				Check V-236, T-1301 adjustment and associated circuitry
5	Connect oscilloscope to pin 7 of V-236 6	Same as Step 5 of Table 11-2	Same as Step 5 of Table 11-2	Same as Step 5 of Table 11-2	Same as Step 5 of Table 11-2
11	Connect oscilloscope to pin 7 of V-241 A_7		Sync: —EXT from pin 2 of V-243 Sweep: 20 μsec/cm		Check V-235, C-320, R-443, R-444, and R-442
17	Connect oscilloscope to pin 7 of V-243 B_4		Sync: —EXT from pin 2 of V-244 Sweep: 200 μsec/cm		Check V-242, V-243, C-322, R-452, R-453, and R-451
18	Connect oscilloscope to pin 5 of V-1303 38	See Step 1	See Step 1	See Step 1	See Step 1

Table 14-6. Systems Analysis Chart for FR-38E/U (contd)

STEP	TEST POINT	CONTROL POSITION	TEST EQUIPMENT CONTROL POSITION	NORMAL INDICATION	POSSIBLE CAUSE FOR MALFUNCTION
53	See Table 11-2	See Table 11-2	See Table 11-2	See Table 11-2	V-1101, V-1102, V-1103 are used in the FR-38E/U
62	Connect oscilloscope to pin 1 of V-209 (T)	Frequency Converter in place. Remove V-205 See control settings in Step 31 Table 11-2	Sync: —EXT pin 1 of V-209 Sweep: 200 μsec/cm		Check V-208, T-201
64	Not Used				
69	Connect oscilloscope to pin 6 of V-205 (V)	Install V-205. See control settings in Step 31 of Table 11-2	Sync: —EXT from pin 1 of V-208 Sweep: 10,000 μsec/cm		Check V-205 and associated elements, Check also V-209
71	Connect oscilloscope to pin 2 of V-204 (E7)	Same as Step 69	Same as Step 69	Same as Step 69	Check C-214, V-205 and associated elements.
80	Connect oscilloscope to junction of CR-223 and CR-228 (X)	Same as Step 77	Same as Step 77		Check V-210 and V-211, C-244
102 thru 122	Not used				

b. In Table 11-3 reference to readout meters should be deleted. Readout on the Units and Tens decade is by illuminated numerals.

c. In Table 11-3 reference to tubes V-223, V-249, V-250 and V-251 should be deleted. These tubes are not used in the FR-38E/U.

d. In Table 11-3 reference to the 100kc oscillator V-234 should be deleted and replaced with the lmc oscillator and mixer circuit V-1301, V-1302, V-1304 and V-1303. Adjustments to be checked would include L-1301, T-1301 and L-211 as well as replacing tubes V-1301, V-1302, V-1303, and V-1304.

e. In Table 11-4 for the FR-38E/U the crystal OVEN temperature is indicated by the on-off cycling of the OVEN indicator lamp.

f. In Table 11-4 step B for the FR-38E/U delete reference to V-234. Measure voltage at pin 1 of V-1301. The correct bias voltage is approximately -6 volts.

g. In Table 11-4 delete step G. The lmc counter in the FR-38E/U is a separate plug-in unit.

AIR FILTER. Refer to paragraph 11-33. Same as for the FR-38/U except that the air filter in the FR38E/U may be removed from the rear of the cabinet without removing the cabinet.

REMOVAL OF CRYSTAL OVEN ASSEMBLY. Paragraph 11-52 and 11-53 are not applicable to the FR-38E/U. The oven assembly used in the FR38E/U is a self contained unit. No disassembly of the oven should be attempted. To remove the oven from the FR-38E/U proceed as follows:

a. Remove bracket holding oven assembly in socket. Bracket mounting screws are located on the left side flange of the FR-38E/U.

b. Pull crystal oven from its socket.

1 TO 10 MC CHECK. Refer to paragraph 11-61. Same as for the FR-38/U except as follows:

a. Readout on the units and tens decade in the FR-38E/U is by illuminated numerals.

b. Paragraph 11-64 and paragraph 11-65 are not applicable to the FR-38E/U. If trouble is suspect in the units or tens decade proceed as outlined in paragraph 11-66 and paragraph 11-67.

TIME BASE SECTION. Refer to paragraph 11-77 and paragraph 11-78. These paragraphs are not applicable to the FR-38E/U. The procedures to be used are detailed below.

PEAKING THE OSCILLATOR. When the oscillator tube V-1301, amplifier tube V-1302 or rectifier tube V-1304 are replaced, peak L-1301 as described in this section under 1 MC OSCILLATOR ADJUSTMENT. The oscillator should then be standardized in accordance with paragraph 11-79.

ADJUSTING 1 MC-100 KC DIVIDER. When the mixer tube V-1303 or the blocking oscillator tube V-236 are replaced the divider will need realignment. Proceed as follows:

a. Turn off POWER switch and remove the cabinet from equipment.

b. Turn on Power. Set FREQUENCY STANDARD switch to EXT.

c. Connect accurate 100kc, 3 volt rms signal to 100KC/IMC INPUT connector.

d. Connect probe of oscilloscope OS-4(XN-1)/ AP or equal, to pin 5 of V-1303.

e. Adjust L-211 for maximum 100kc signal on oscilloscope.

f. Connect oscilloscope probe to pin 3 of V-236.

g. Adjust T-1301 for maximum 900kc signal on oscilloscope.

h. Set FREQUENCY STANDARD switch to INT.

i. Connect oscilloscope probe to pin 1 of V-237.

j. Adjust L-211 and T-1301 for maximum 100kc signal on oscilloscope.

SETTING FREQUENCY OF 1MC CRYSTAL OSCILLATOR. Refer to paragraph 11-79. Same as for the FR-38/U except as follows:

a. The primary frequency standard should have an accuracy of five parts per 100 million or better.

b. There are three adjustments available for setting the frequency of the lmc oscillator; ADJ FINE, C-1314 and ADJ COARSE C-1315 on the front panel, and coarse adjustment C-1318 in the crystal oven.

ADJ FINE C-1314 should be adjusted first. If this will not stop the pattern adjust ADJ COARSE C-1315. If neither ADJ FINE nor ADJ COARSE capacitors will stop the pattern it will then be necessary to adjust C-1318 located in the crystal oven. Access to C-1318 is made through the access hole in the front panel of the FR-38E/U after removing the button plug in the crystal oven. Adjustment of C-1318 is seldom necessary and should be needed only after several years of continuous operation of the oscillator.

PHANTASTRONS. Refer to paragraph 11-83. Same as for the FR-38/U, except that in Table 11-8 the value of the timing capacitors used in the FR38E/U are 39pf for C-320, 390pf for C-322, 3900pf for C-324, 39003pf for C-326 and 390,000pf for C-328.

FAST TRIGGER. Refer to paragraph 11-127. Same as for the FR-38C/U. The tubes used are V-1101, V-1102 and V-1103.

PROCEDURES FOR SETTING THE METERS. Paragraph 11-144 through paragraph 11-151 are not applicable to the FR-38E/U.

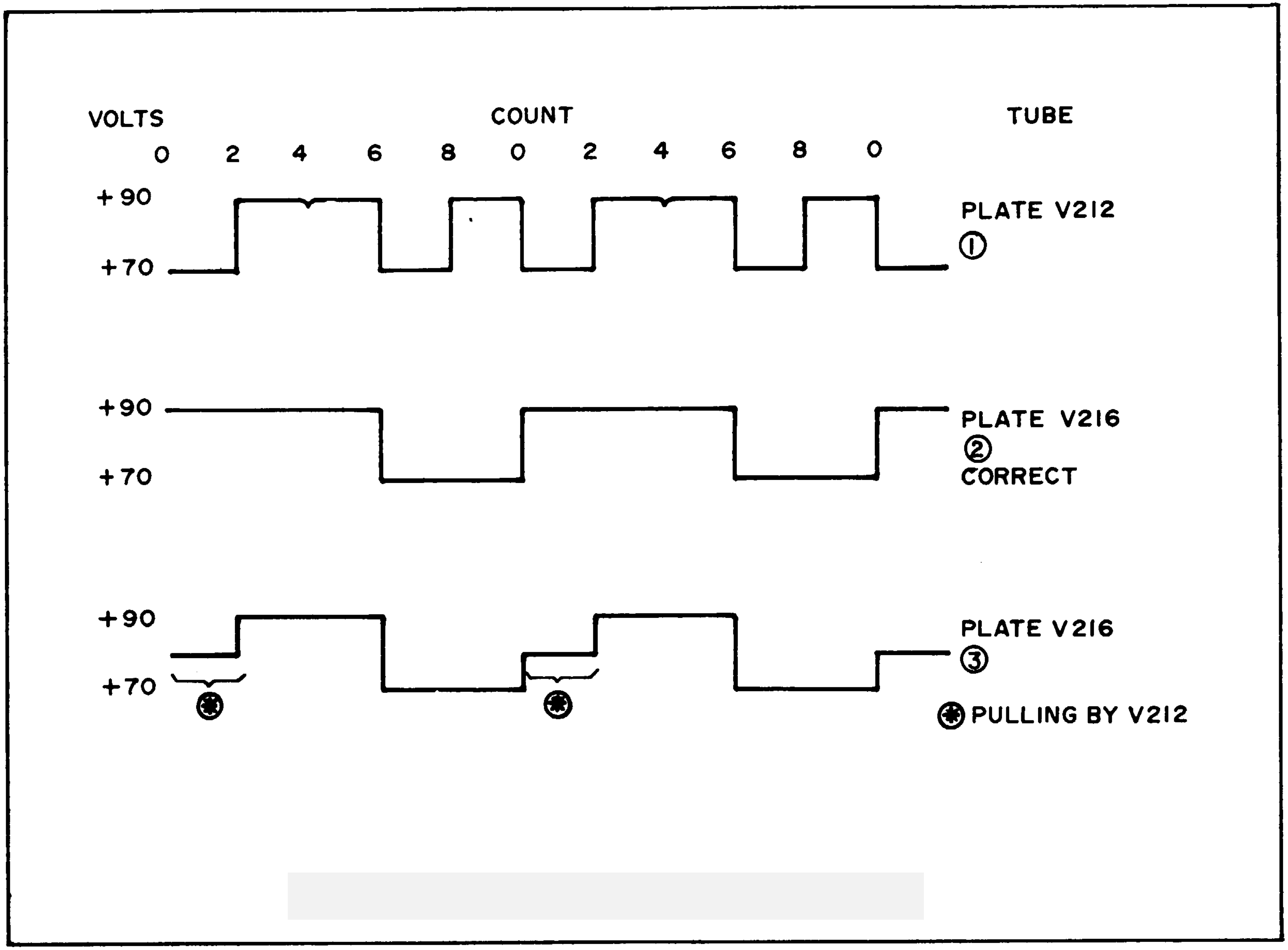


Figure 14-8. Waveforms in Coincidence Network of FR-38E/U

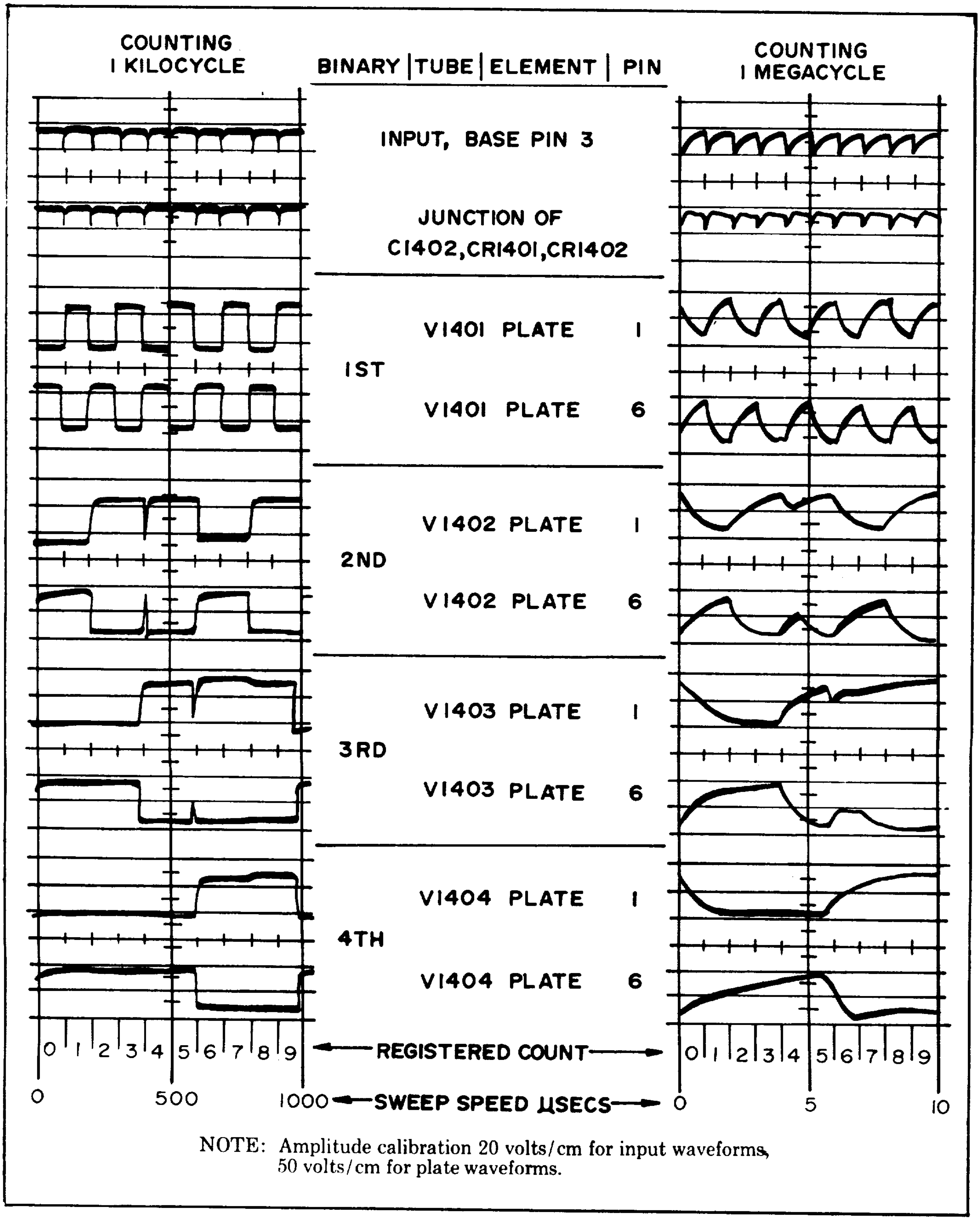


Figure 14-9. Plate Waveforms in 1 mc Decade Counter, Z-1200

TROUBLE-SHOOTING 10MC COUNTER SETION (V-210 to V-218). Refer to paragraph 11-152 thru paragraph 11-160. Same as for the FR-38/U except as follows:

a. Typical waveforms throughout the counters section of the FR-38E/U are shown in Table 14-16 in this section.

b. Refer to waveform 3 of Figure 14-8 for improper waveforms in the coincidence network caused by low back resistance diodes at CR-231 CR-233.

TROUBLESHOOTING 1 MC COUNTER SECTION, Z-1200. Refer to paragraph 11-161 thru paragraph 11-162. Same as for the FR-38/U except as follows:

a. The Imc counter in the FR-38E/U is a plug-in unit.

b. Refer to Figure 14-9 for waveforms for the Z-1200, Imc Decade Counter Unit.

MAINTENANCE OF DECADE COUNTERS, Z-204 THRU Z-209. Refer to paragraph 6-174 thru paragraph 6-190. Same as for the FR-38/U except as follows:

a. Decade counters Z-204 thru Z-209 are identical in the FR-38E/U.

b. Waveforms are identical to those shown for the FR-38A U in Figure 13-1.

DIAGRAMS. The diagrams given in Section XII for the FR-38/U are not applicable to the FR38E/U,except as detailed below. Refer to Figures 14-10 through 14-38 for Diagrams which apply to the FR-38E/U.

a. Parts layout of Decade Counters Z-204 through Z-209 used in the FR-38E/U are the same as appears in figure 13-3 and Figure 13-4 for the FR-38A/U except that R-949 through R-952 are not used.

b. For parts layout of the Imc decade counter, Z-1200, refer to Figures 14-10 and 14-11.

c. Z-210 in Figure 12-4 is correct for the FR-38E/U.

d. Z-213 in Figure 12-5 is correct for the FR-38E/U except that R-346 should be 82K, C-240 should be 15pf, R303 should be 68K and R-304 should be 5000.

e. Z-218 in Figure 12-9 is correct for the FR-38E/U except R-330 should be 68K and R-316 should be 5600.

f. Z-220 in Figure 12-10 is correct for the FR-38E/U.

g. Figure 12-12 is correct for the FR-38E/U.

h. Z-222 in Figure 12-13 is correct for the FR-38E/U except R-225 should be 82K.

i. Z-224 in Figure 12-13 is correct for the FR-38E U.

j. Z-225 in Figure 12-14 is correct for the FR-38E U except C-203 is not used, C-204 should be 4700 pf and C-235 should be .02 uf.

k. Z-226 in Figure 12-14 is correct for the FR-38E/U.

l. Z-229 is Figure 12-16 is correct for the FR-38E/U except R-298 is deleted and replaced with C-2:36 which has a value of 3300pf.

m. Z-2:31 in Figure 12-18 is correct for the FR-38E/U except R-526 and R-495 are interchanged.

n. Z-234 in Figure 12-20 is correct for the FR-38E/U except R-485 should be 18K and C-334 is replaced by C-207 with a value of .05uf.

o. Z-236 in Figure 12-21 is correct for the FR-38E U except that R-457, R-466 and R-476 are 110 K; C-323, C-325, and C-327 should be 270; R-459 should be 12K.

p. Figure 12-23 is correct for the FR-38E/U as annotated for the FR-38C/U.

q. Figure 12-31A is correct for the MX-1637A/U except R-39 should be 22K.

r. Figure 12-32 is correct for the MX-1636A/U except R-123 should be 22K.

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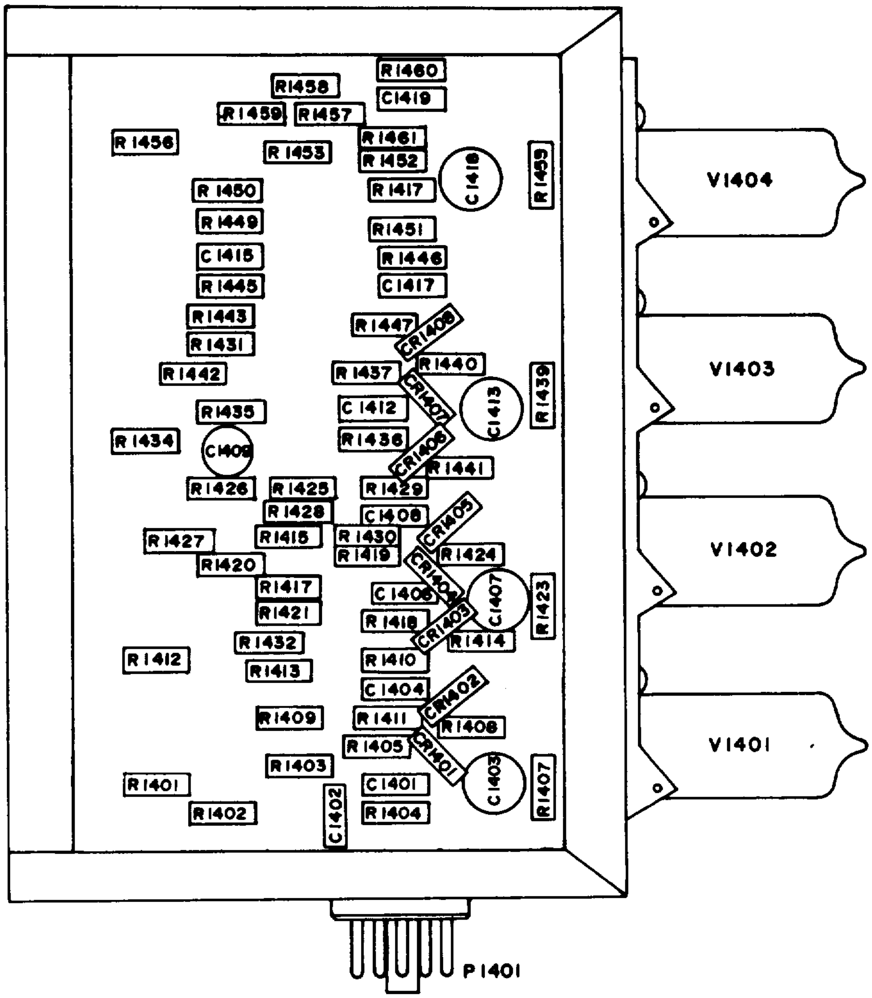


Figure 14-10. Right Side View Parts Layout of Decade Counter, Z-1200

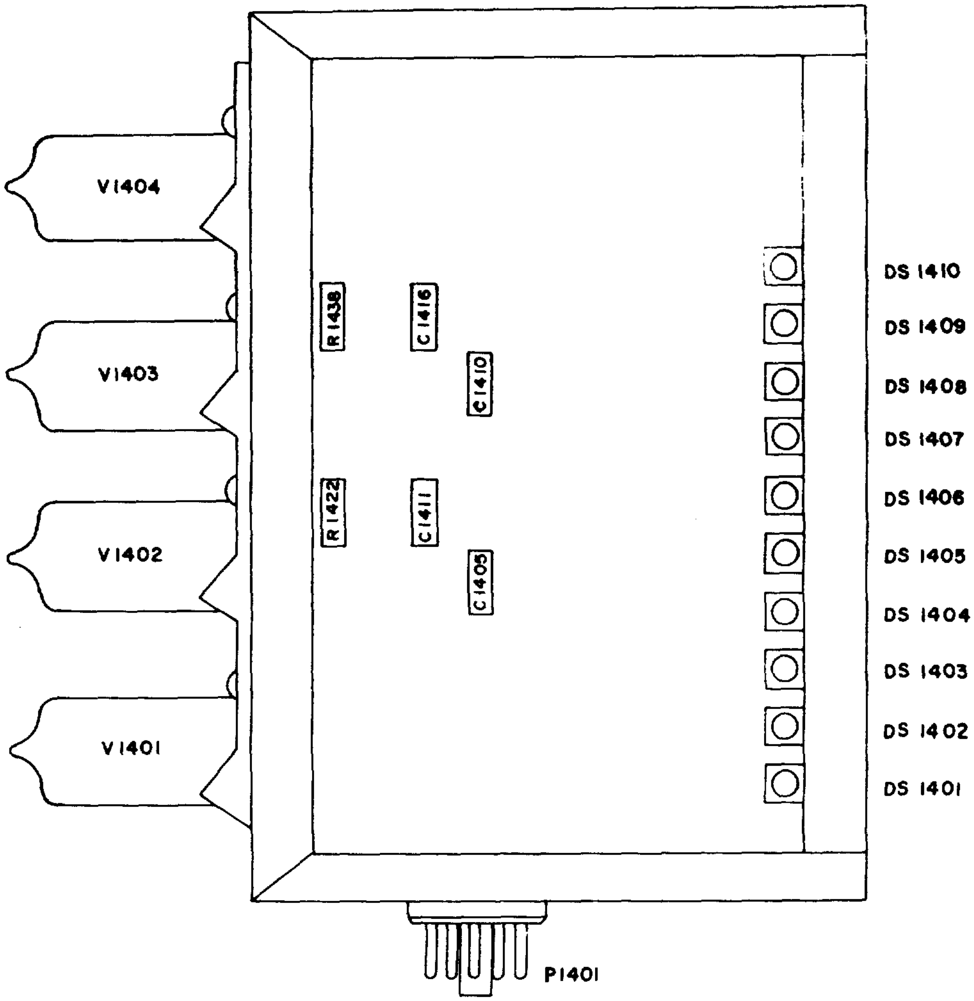


Figure 14-11. Left Side View Parts Layout of Decade Counter, Z-1200

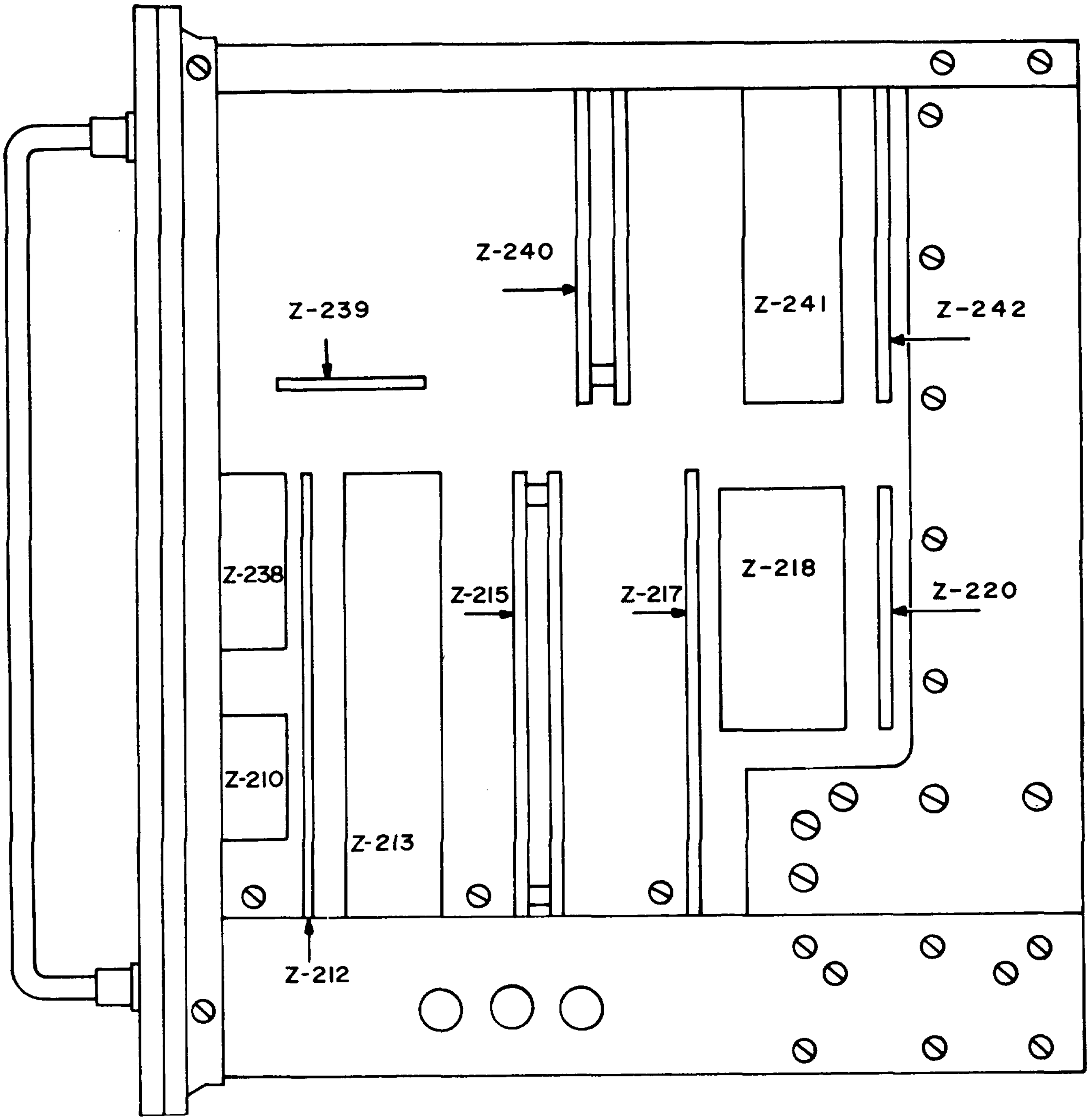


Figure 14-12. Counter Deck. Locating Resistor Boards Z-210, Z-212, Z-213 Z-215, Z-217, Z-218, Z-220, Z-238 through Z-242

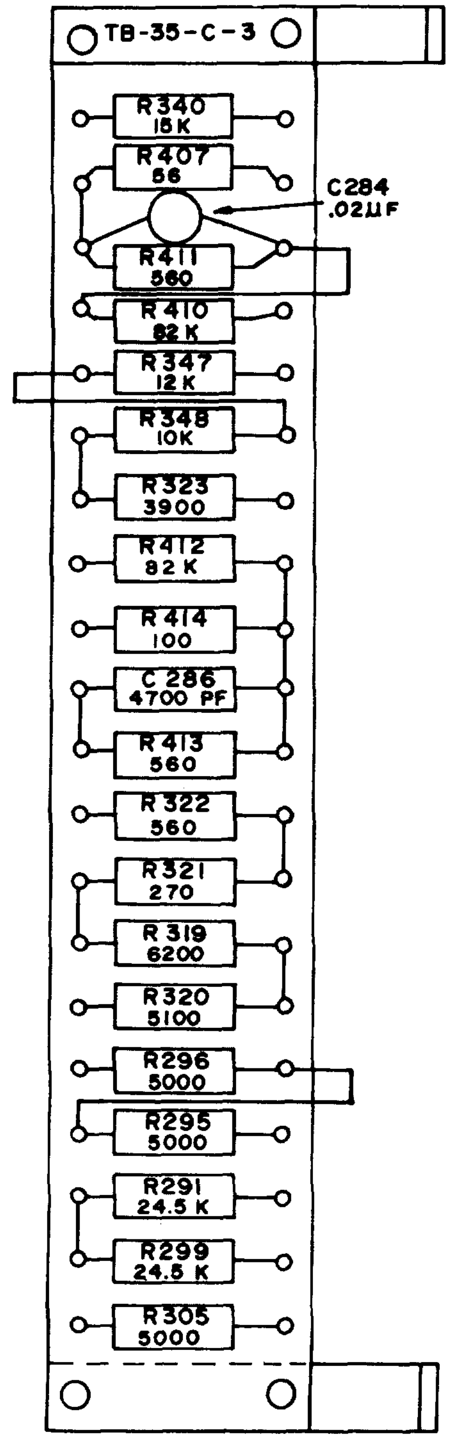


Figure 14-13. Resistor Board Diagrams, Z-212 for FR-38E/U

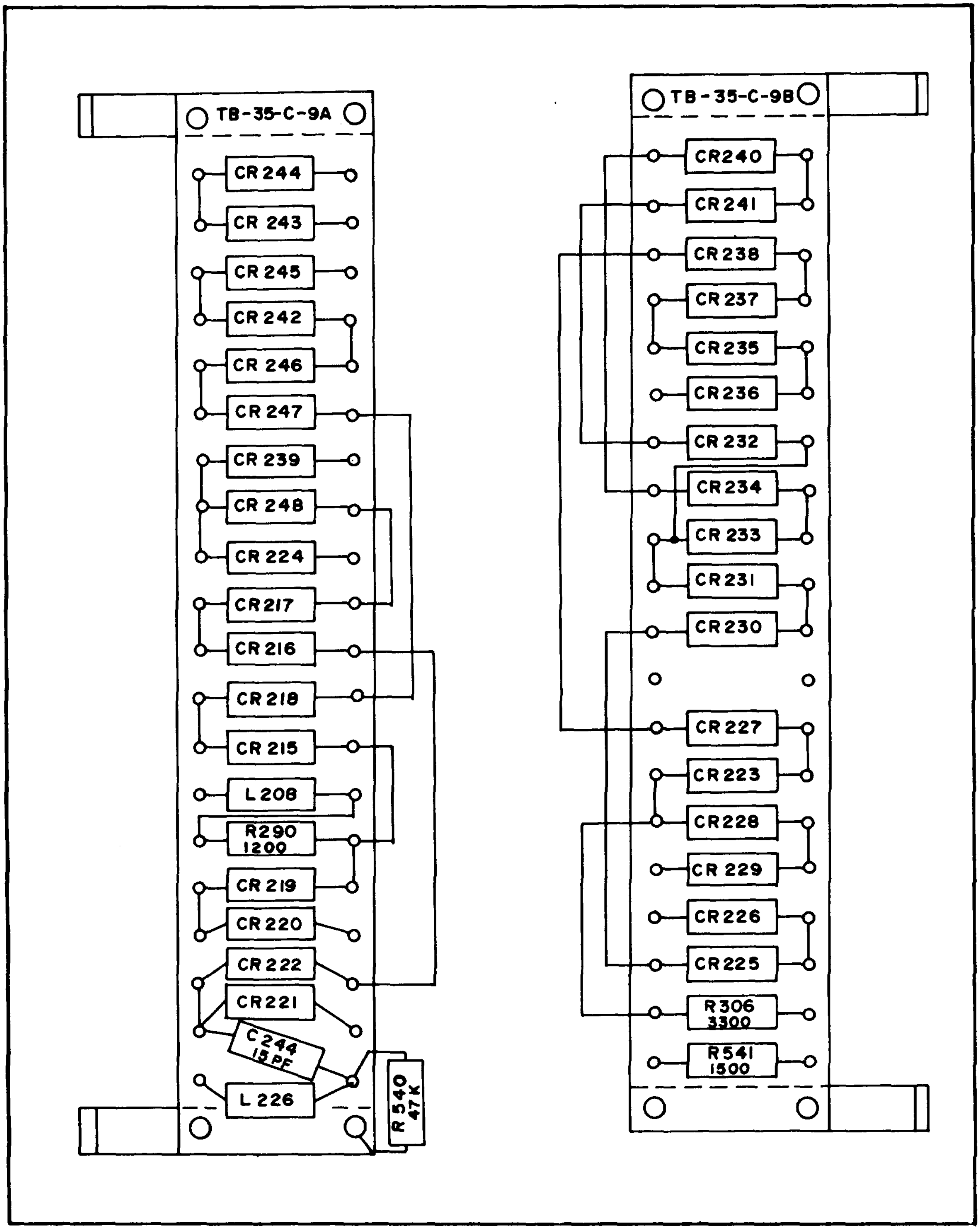


Figure 14-14. Resistor Board Diagrams, Z-215 for FR-38E/U

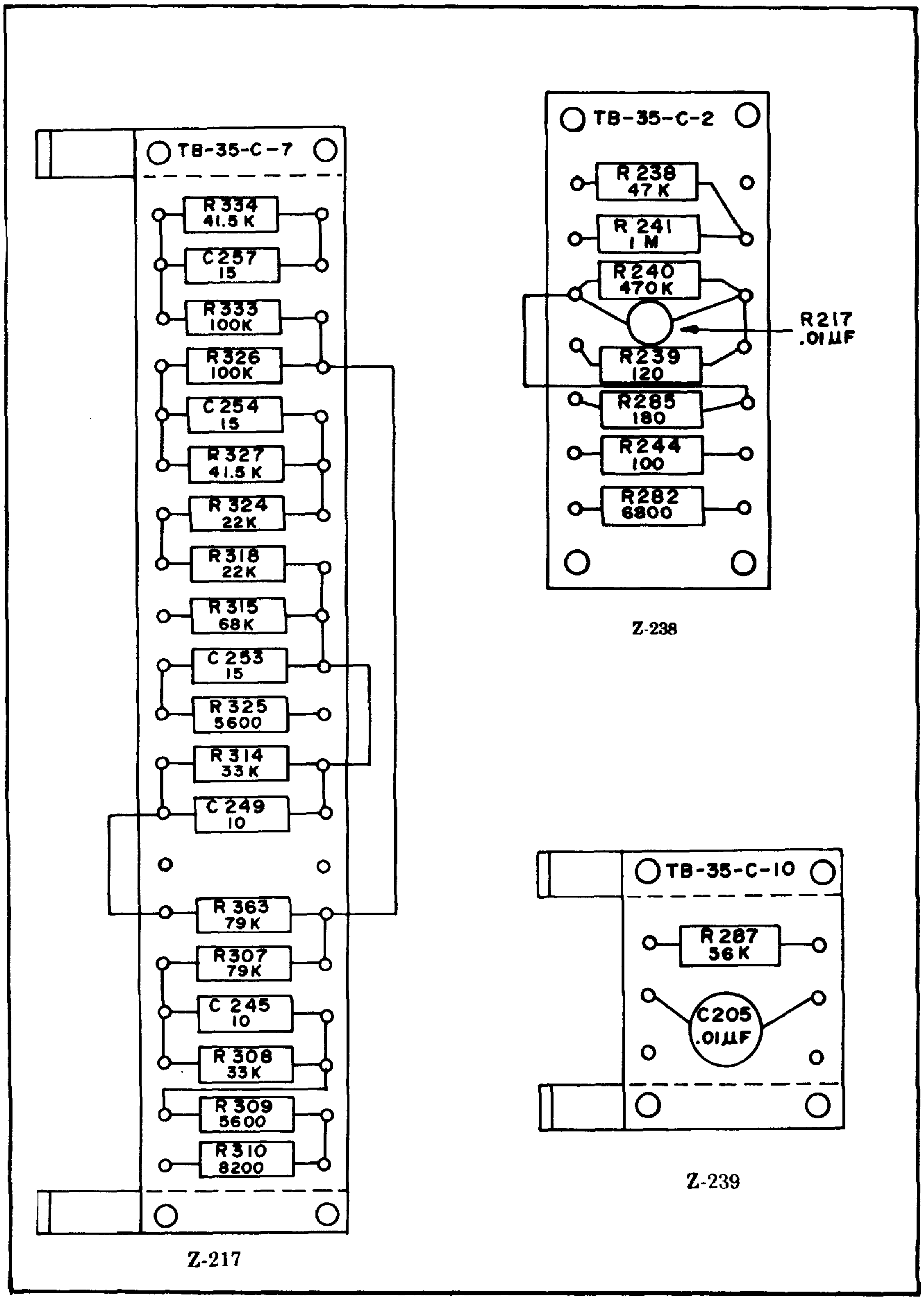


Figure 14-15. Resistor Board Diagrams, Z-217, Z-238 and Z-239 for FR-38E/U

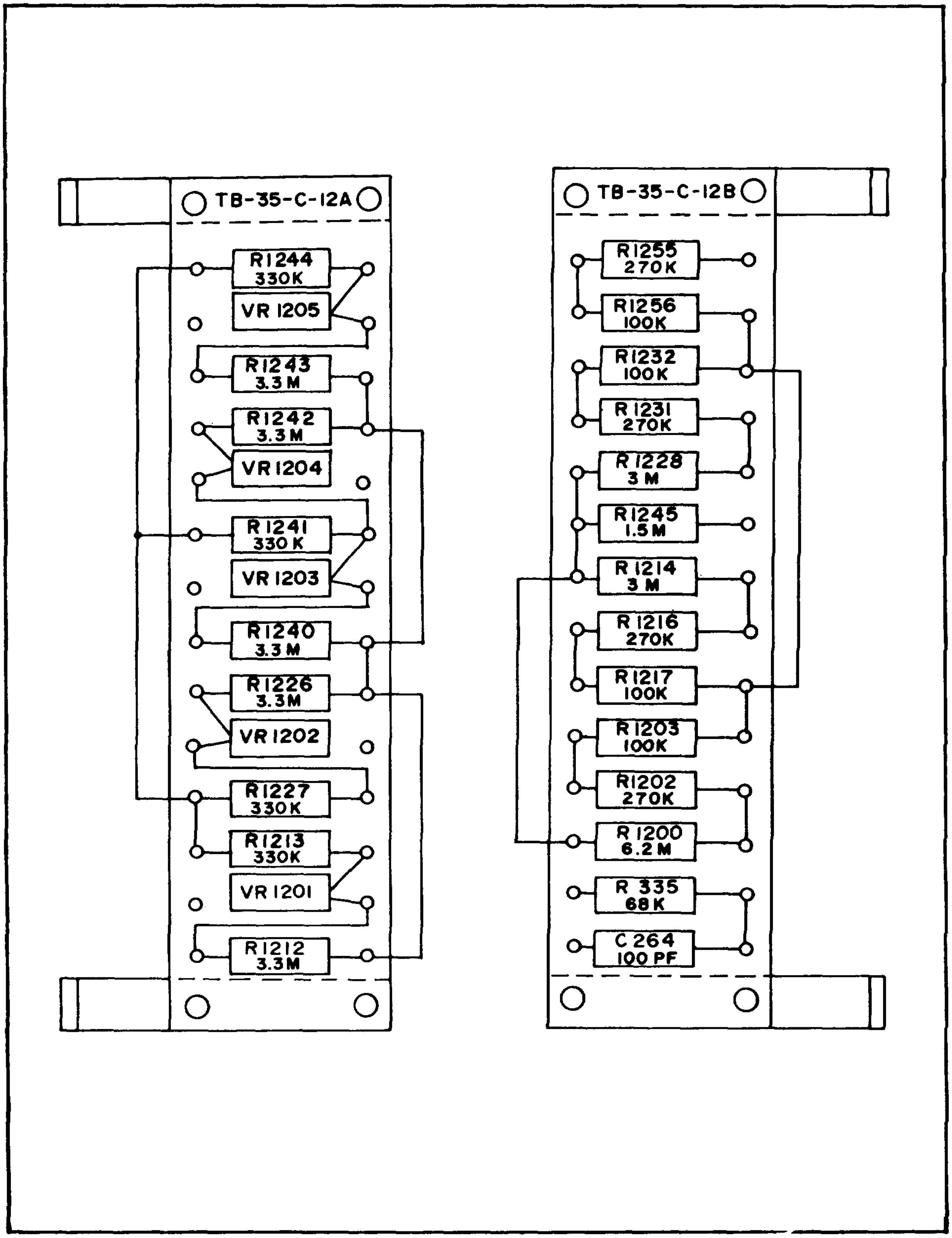


Figure 14-16. Resistor Board Diagrams, Z-240 for FR-38E/U

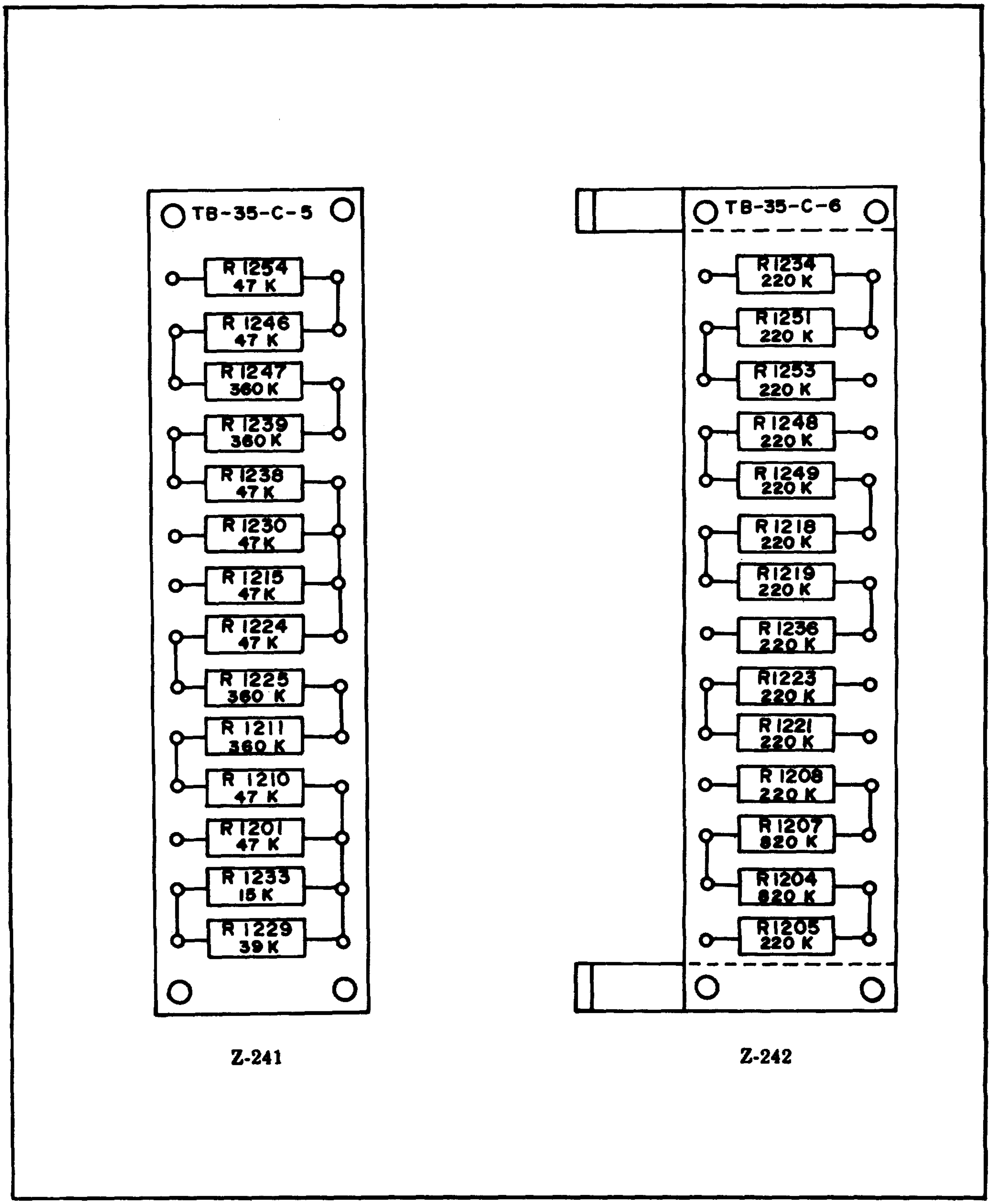


Figure 14-17. Resistor Board Diagrams, Z-241 and Z-242 for FR-38E/U

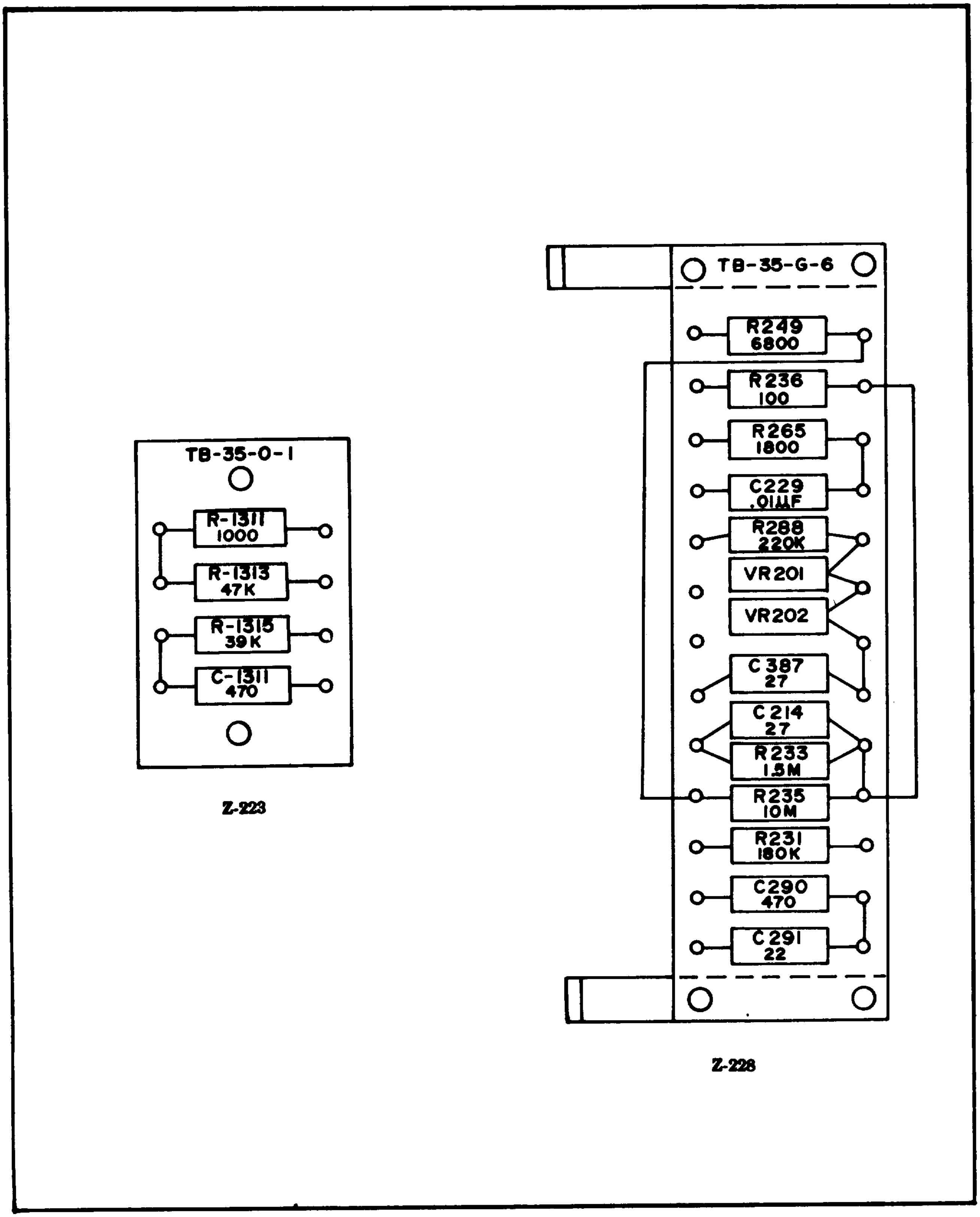


Figure 14-18. Resistor Board Diagrams, Z-223 and Z-228 for FR-38E/U

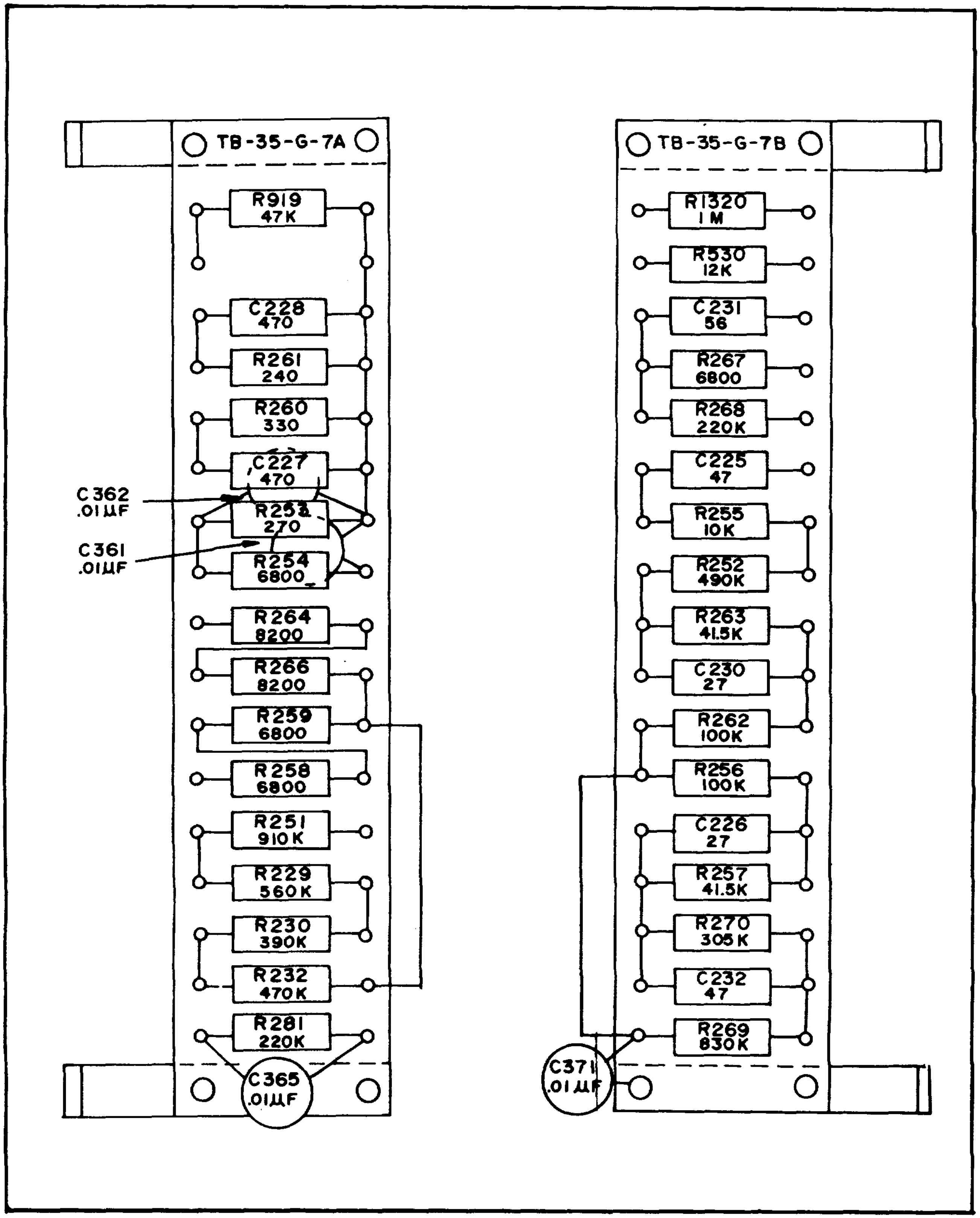


Figure 14-19. Resistor Board Diagrams, Z-227 for FR-38E/U

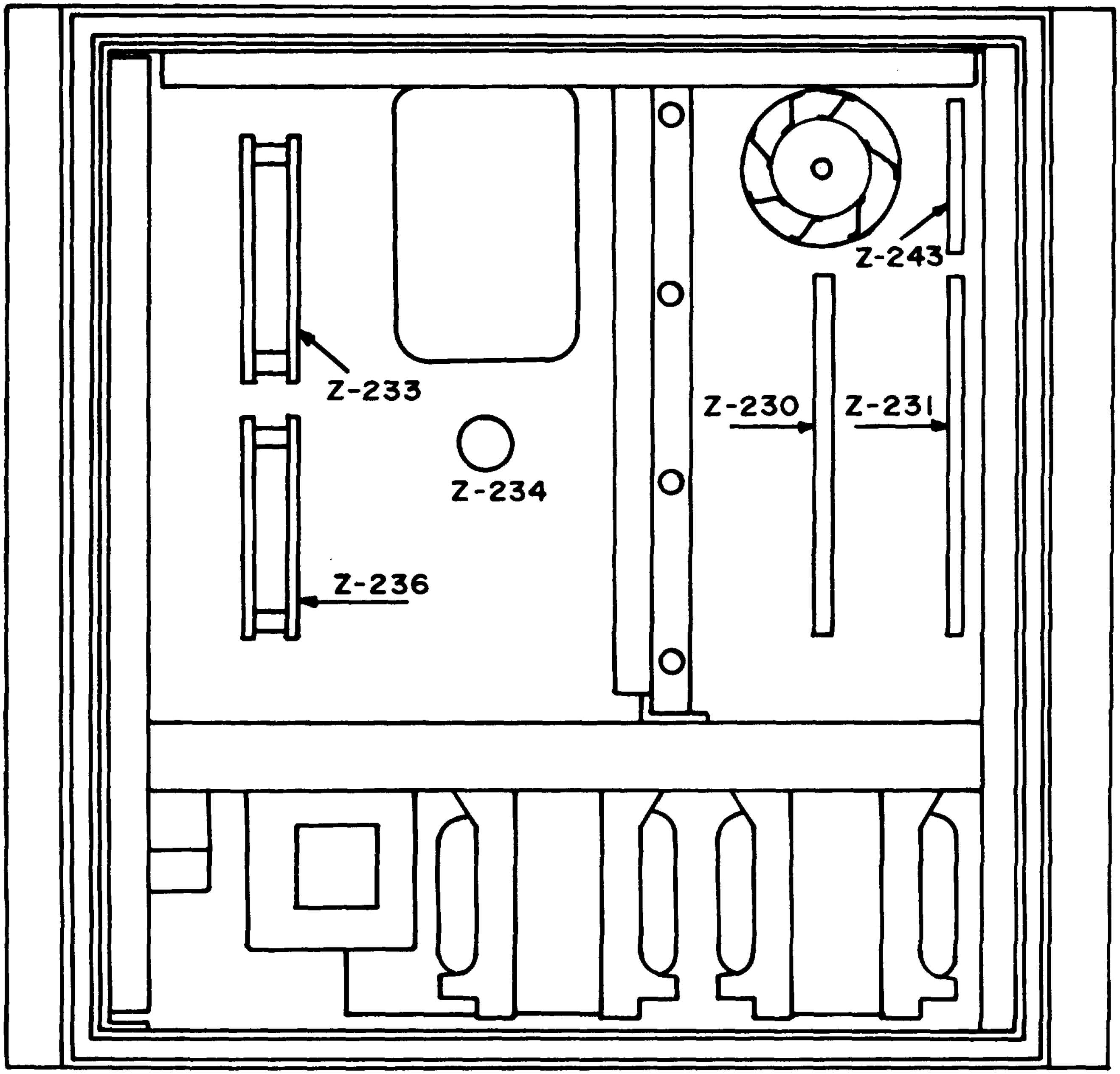
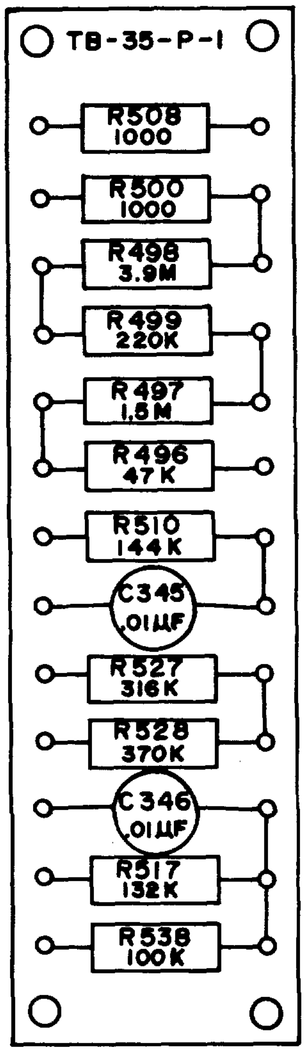
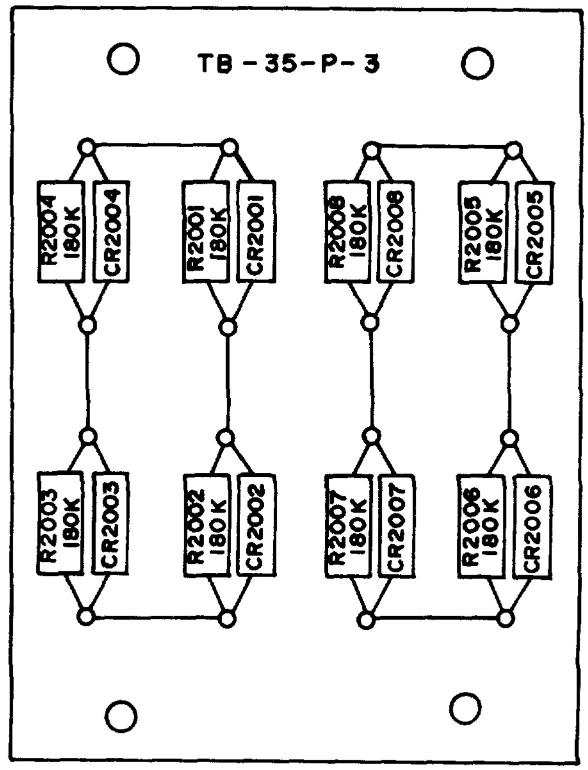


Figure 14-20. Time Base and Power Supply Deck, Locating Boards Z-230, Z-231, Z-233, Z-234, Z-236, and Z-243



Z-230



Z-243

Figure 14-21. Resistor Board Diagrams, Z-230 and Z-243 for FR-38E/U

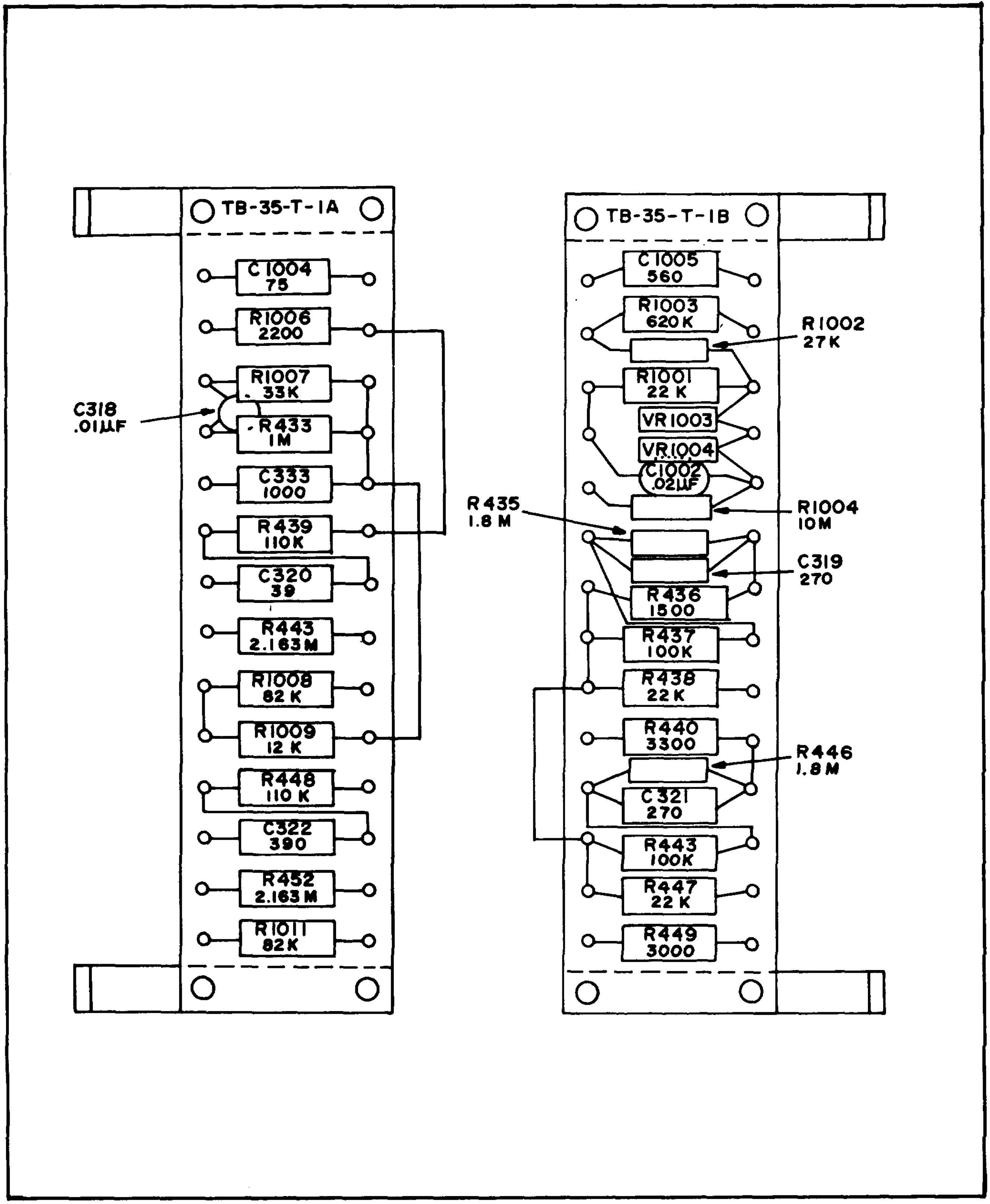


Figure 14-22. Resistor Board Diagrams, Z-233

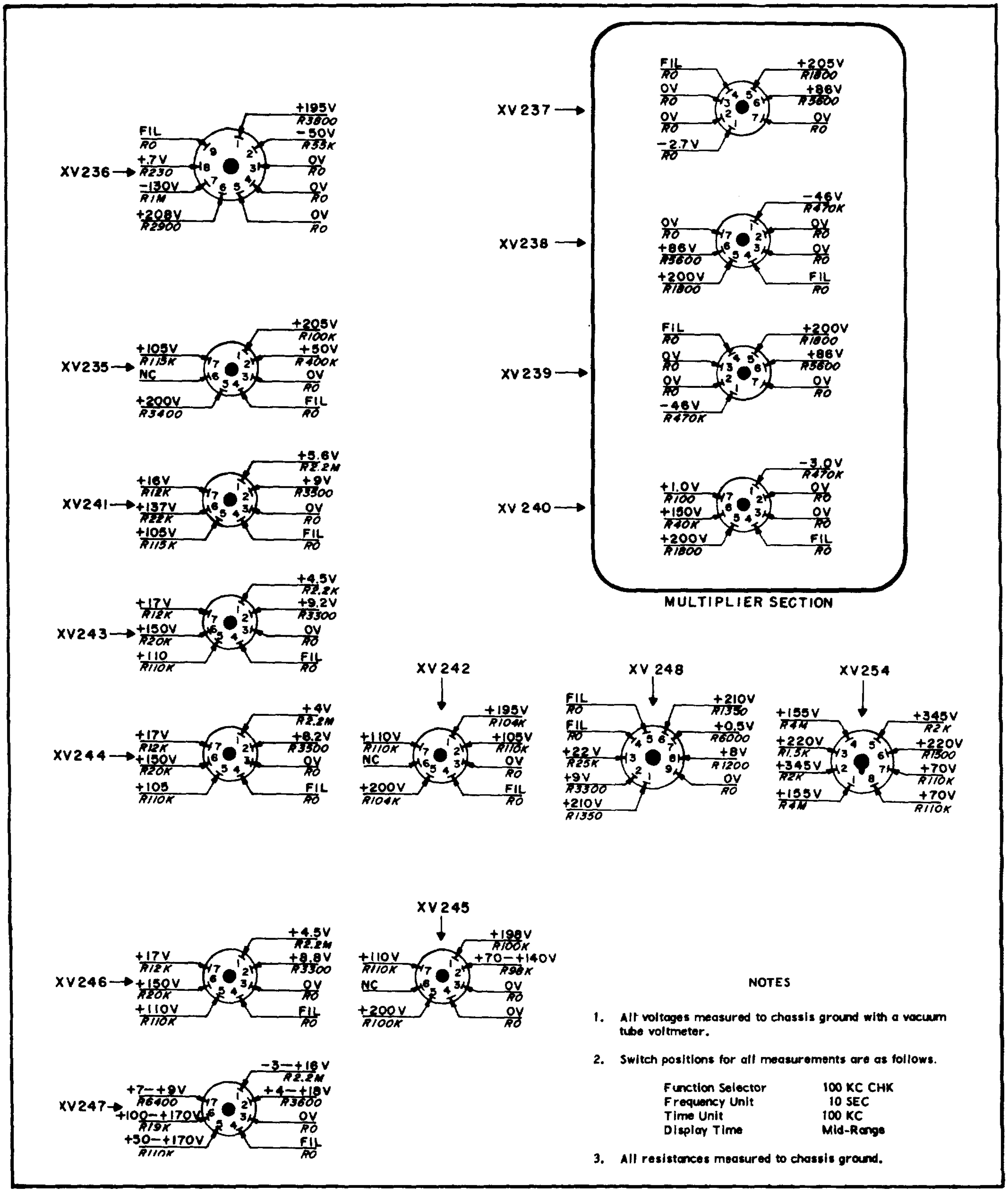


Figure 14-23. Voltage and Resistance Diagrams for Time Base Section of FR-38E/U

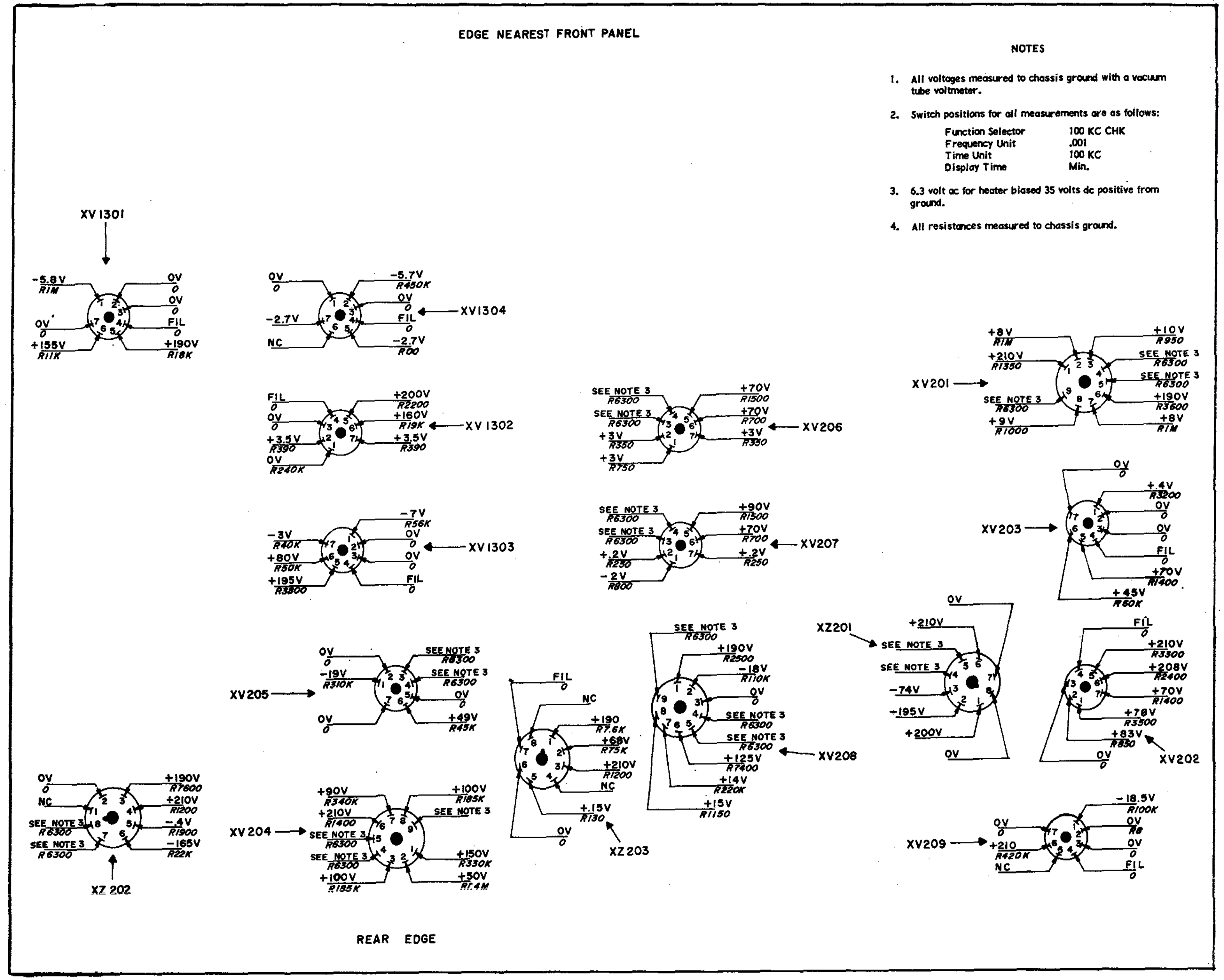


Figure 14-24. Voltage and Resistance Diagrams for Gate Section (.001 Second Gate) of FR-38E/U

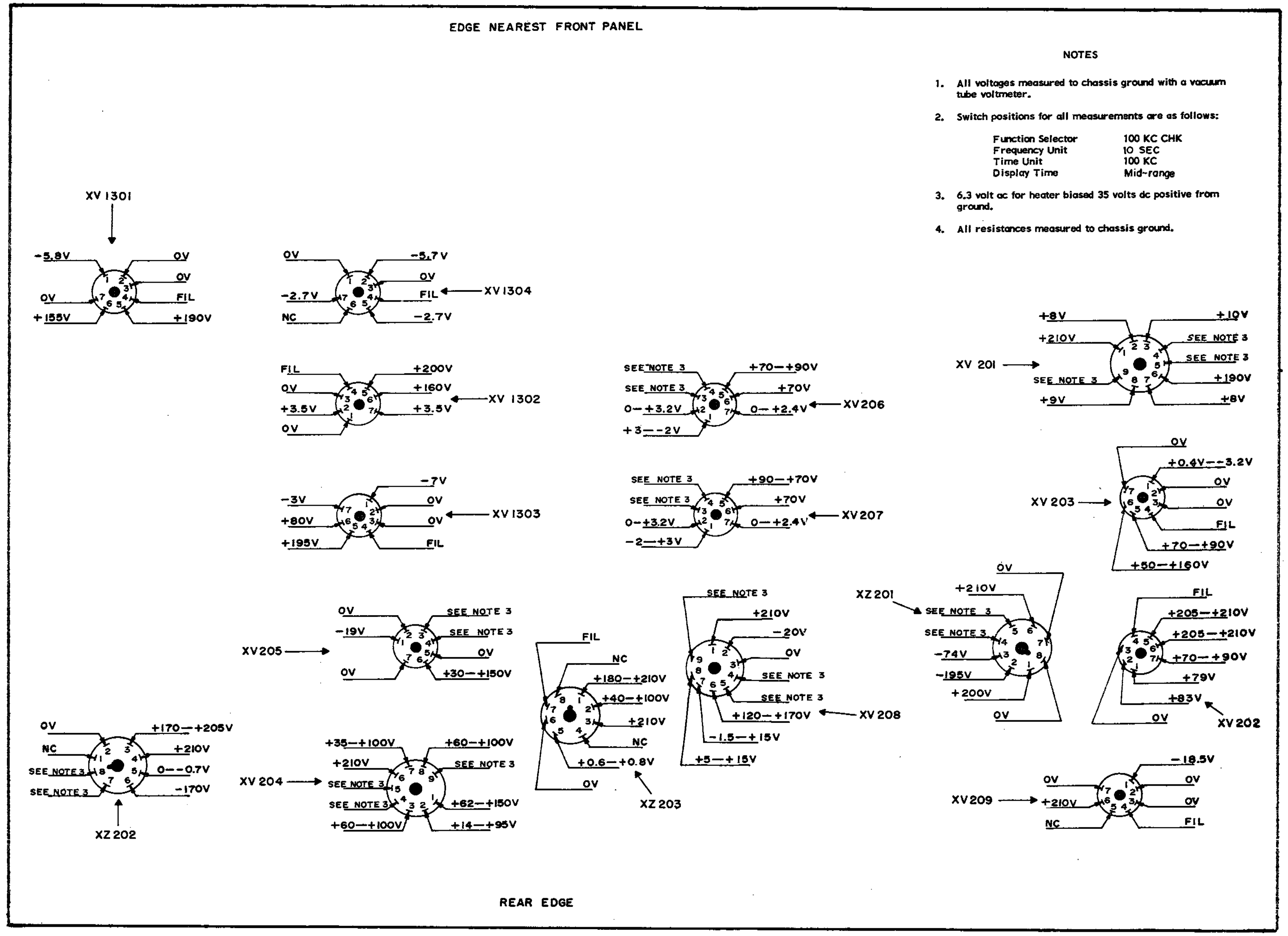


Figure 14-25. Voltage and Resistance Diagrams for Gate Section (10 Second Gate) of FR-38E/U

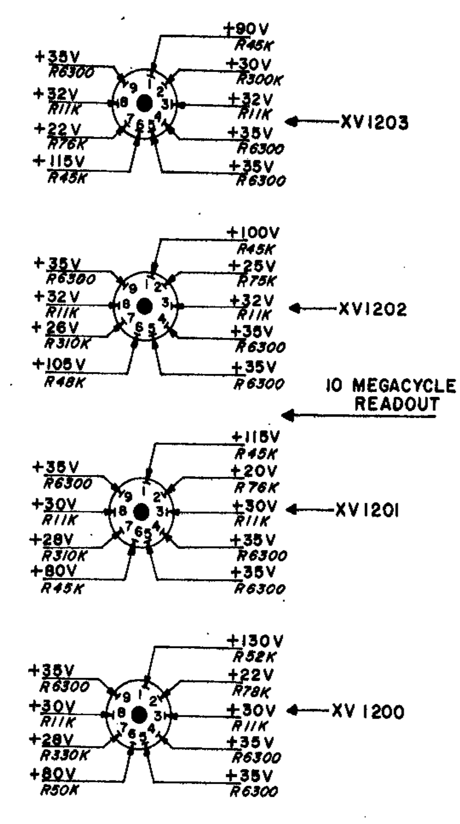
NOTES

1. All voltages measured to chassis ground with a vacuum tube voltmeter.
2. Switch positions for voltage measurements are as follows:

Function Selector	Manual Gate
Time Unit	100 KC
Manual Gate	OPEN

3. All resistances measured to chassis ground.
4. Switch positions for resistance measurements are as follows:

Function Selector	100 KC CHK
Frequency Unit	.001
Time Unit	100 KC
Display Time	Min.



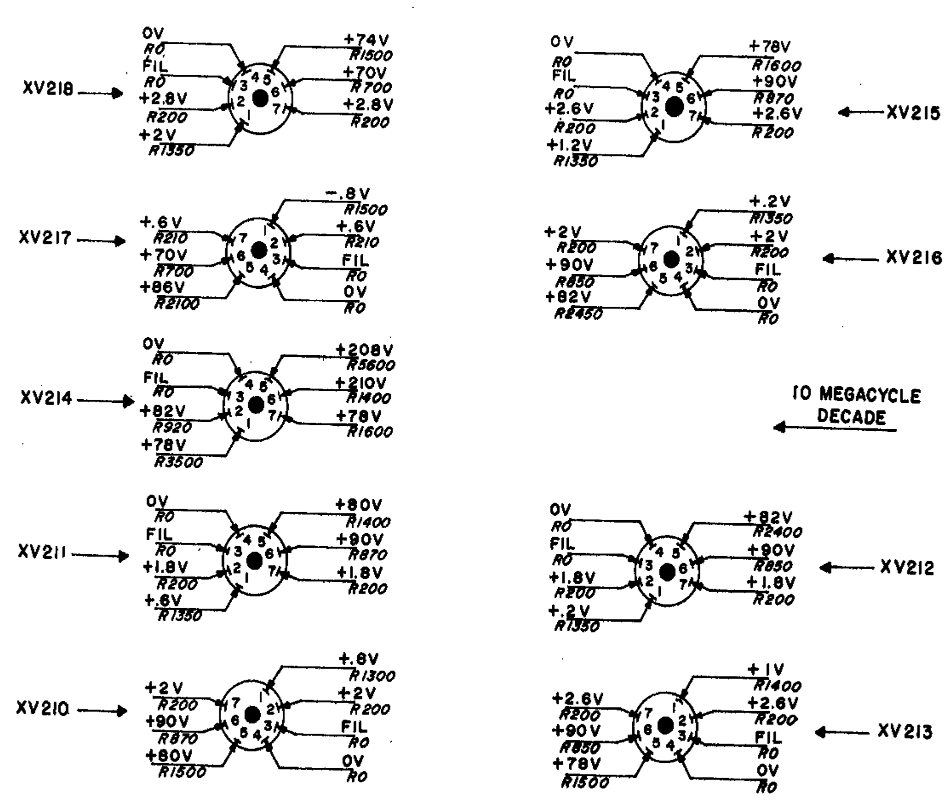


Figure 14-26. Voltage and Resistance Diagrams for Counter Section (100KC Input) of FR-38E/U

NOTES

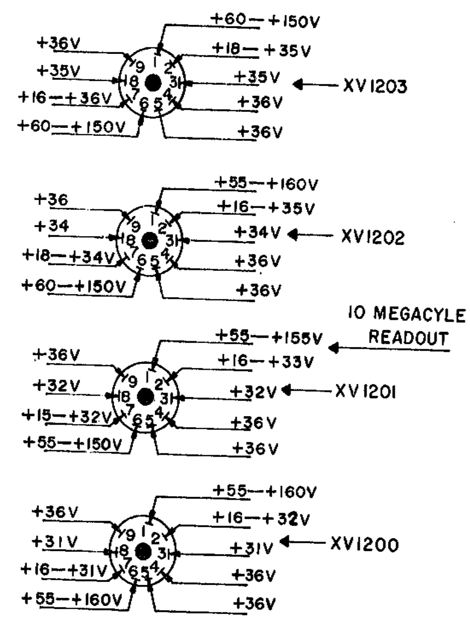
1. All voltages measured to chassis ground with a vacuum tube voltmeter.

2. Control settings.

   Voltage measurements for 10 Megacycle Decade:

Function Selector	Manual Gate
Time Unit	EXT
Manual Gate	OPEN

   Connect a clip lead from Pin 2 of V-247 (R-474) to the STD. FREQ. OUTPUT connector. Any other 1 cps signal source of 2 to 10 volts rms will serve equally well.



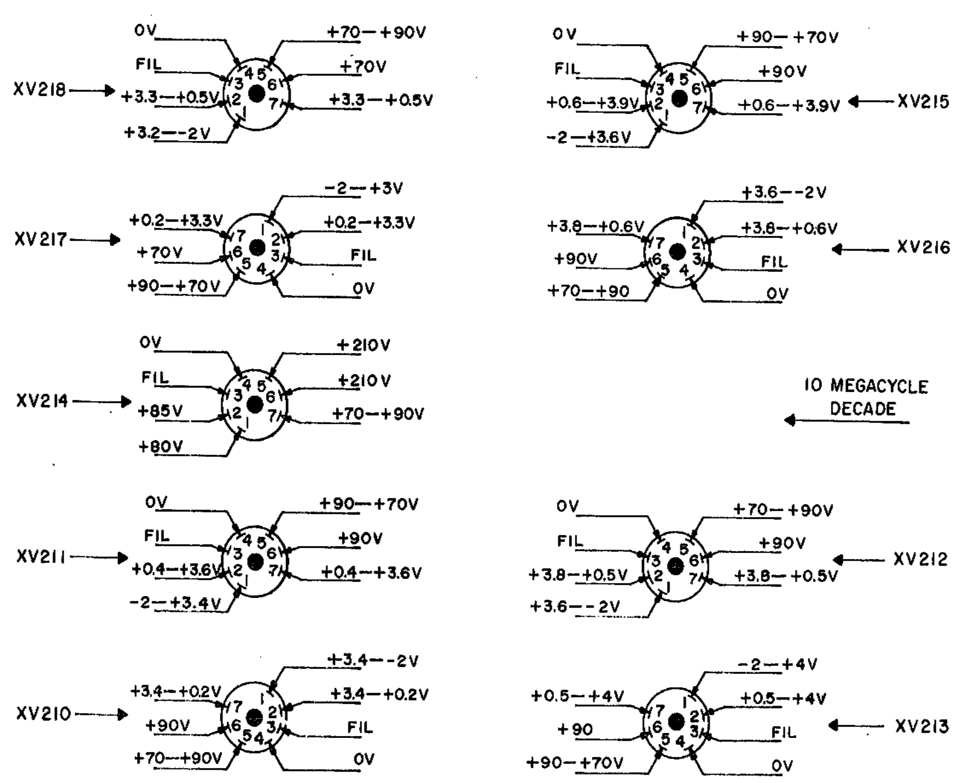


Figure 14-27. Voltage and Resistance Diagrams for Counter Section (1 CPS Signal Input) of FR-38E/U

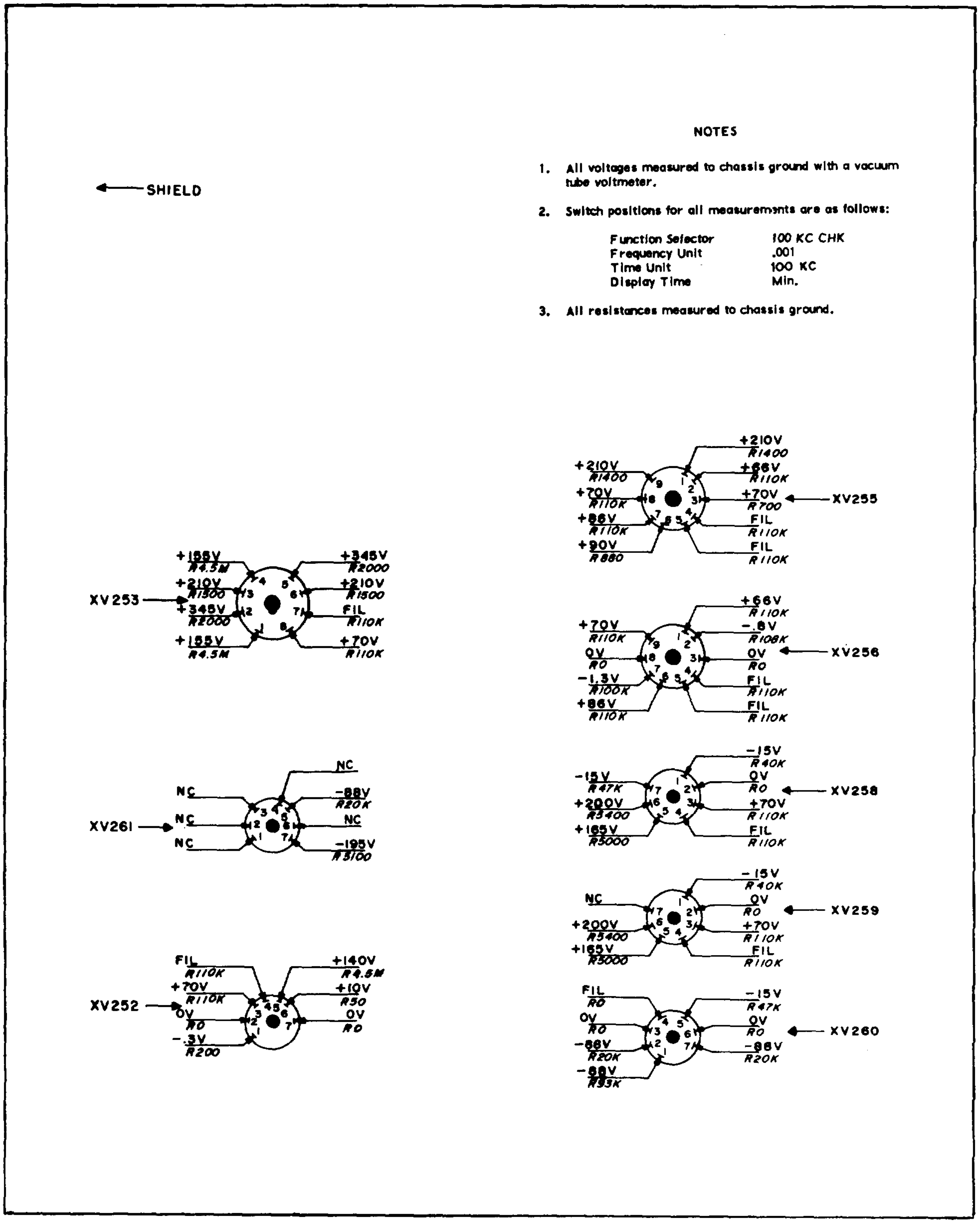


Figure 14-28. Voltage and Resistance Diagrams for Power Supply of FR-38E/U

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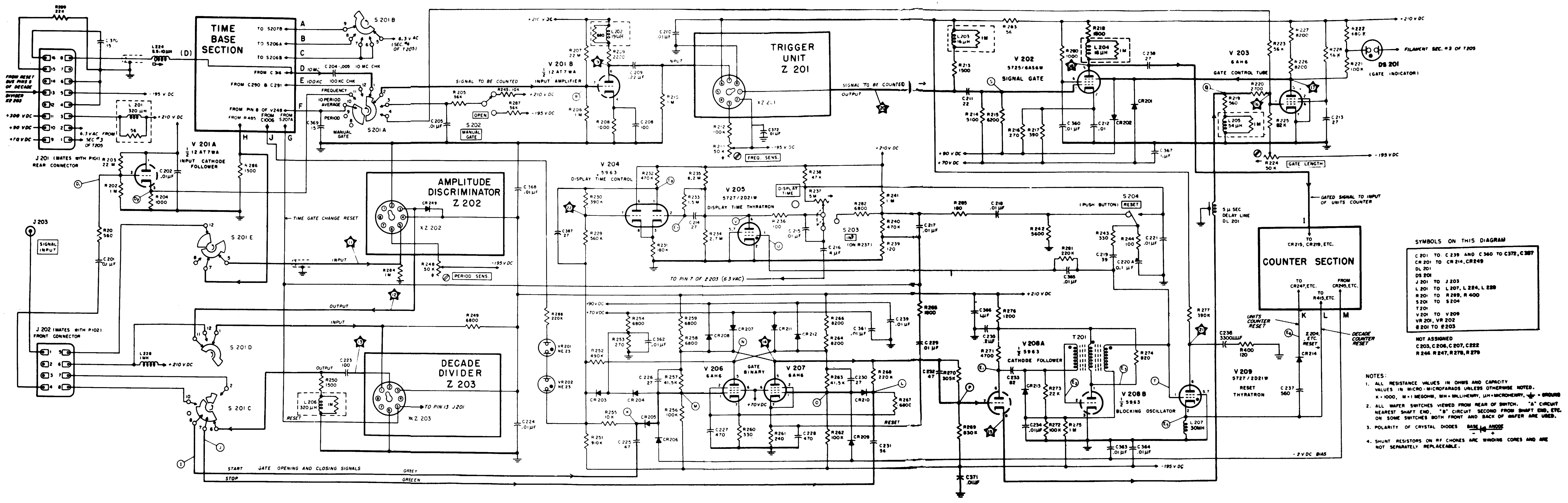


Figure 14-29. Schematic Diagram of Gate Section of Frequency Meter FR-38E/U

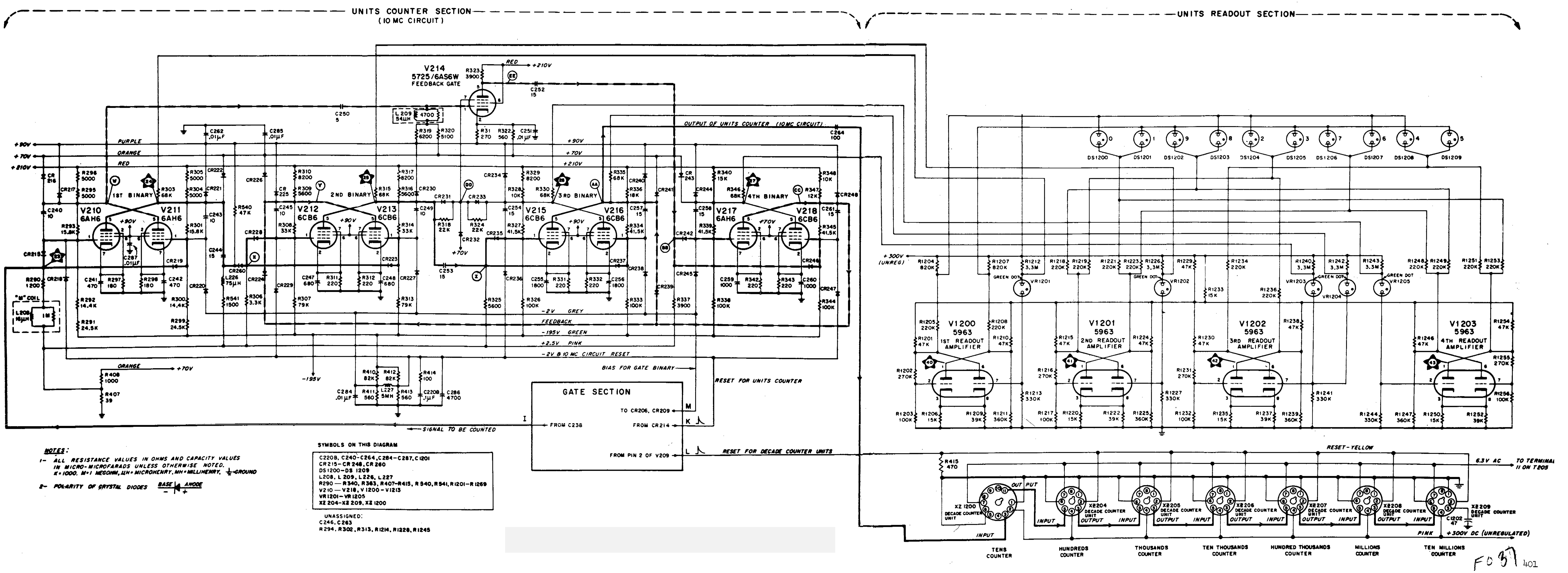


Figure 14-30. Schematic Diagram of Counter Section of Frequency Meter FR-38E/U

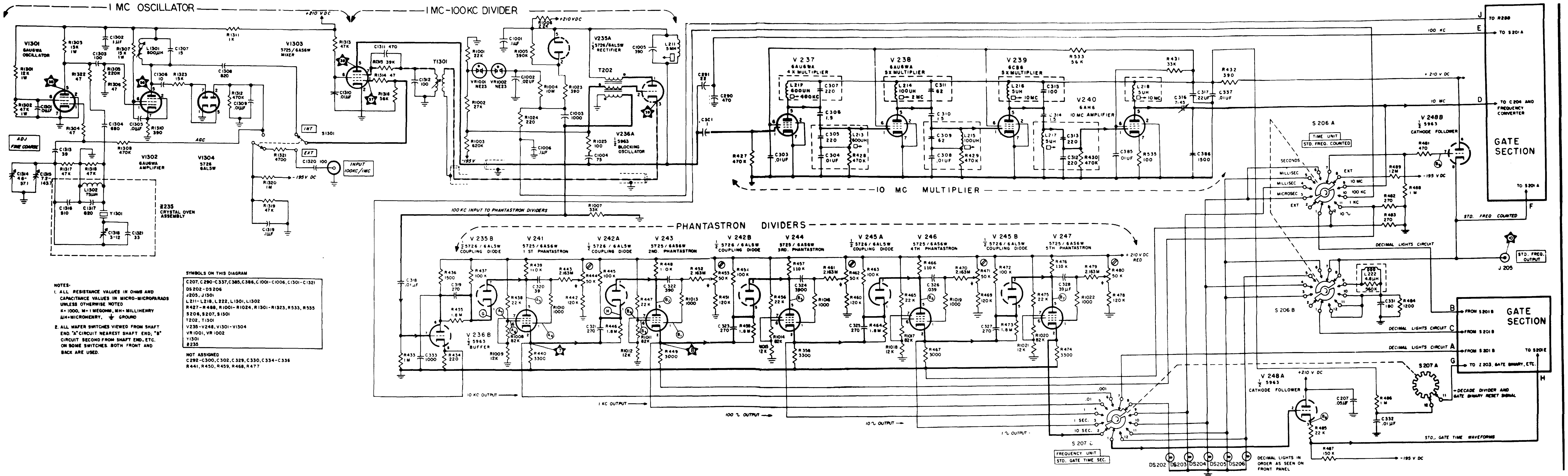


Figure 14-31. Schematic Diagram of Time Base Section of Frequency Meter FR-38E/U.

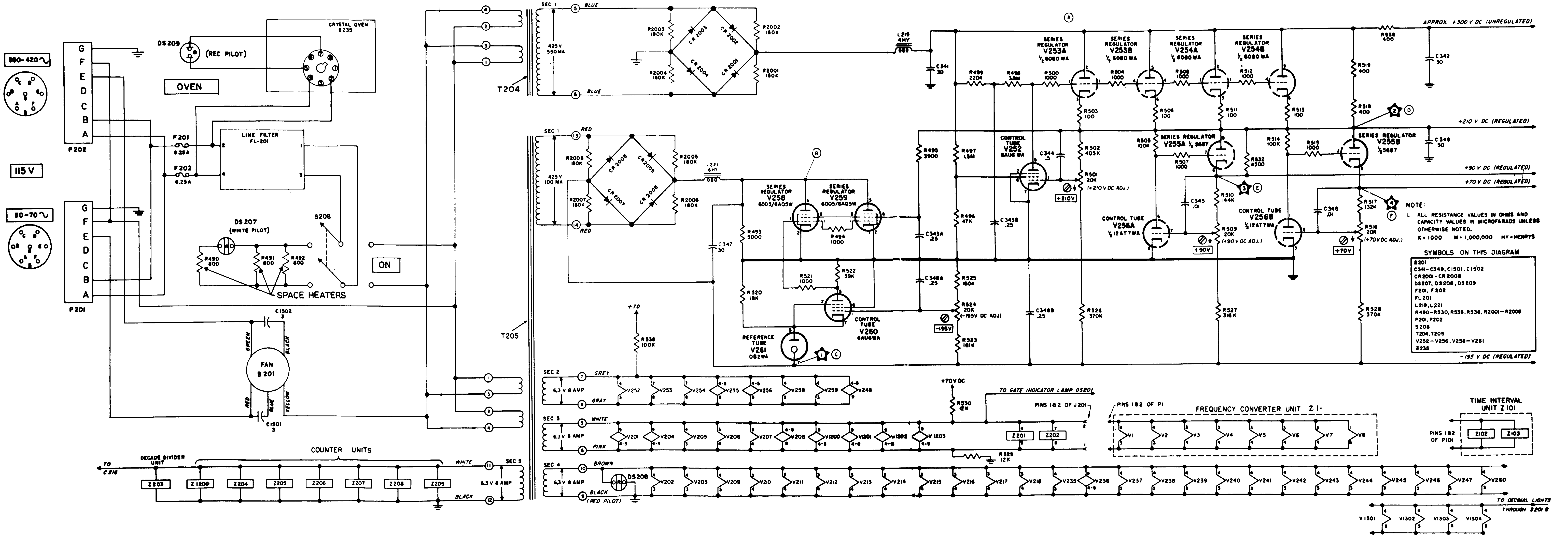


Figure 14-32. Schematic Diagram of Trigger Plug-In Unit for Frequency Meter FR-38E/U

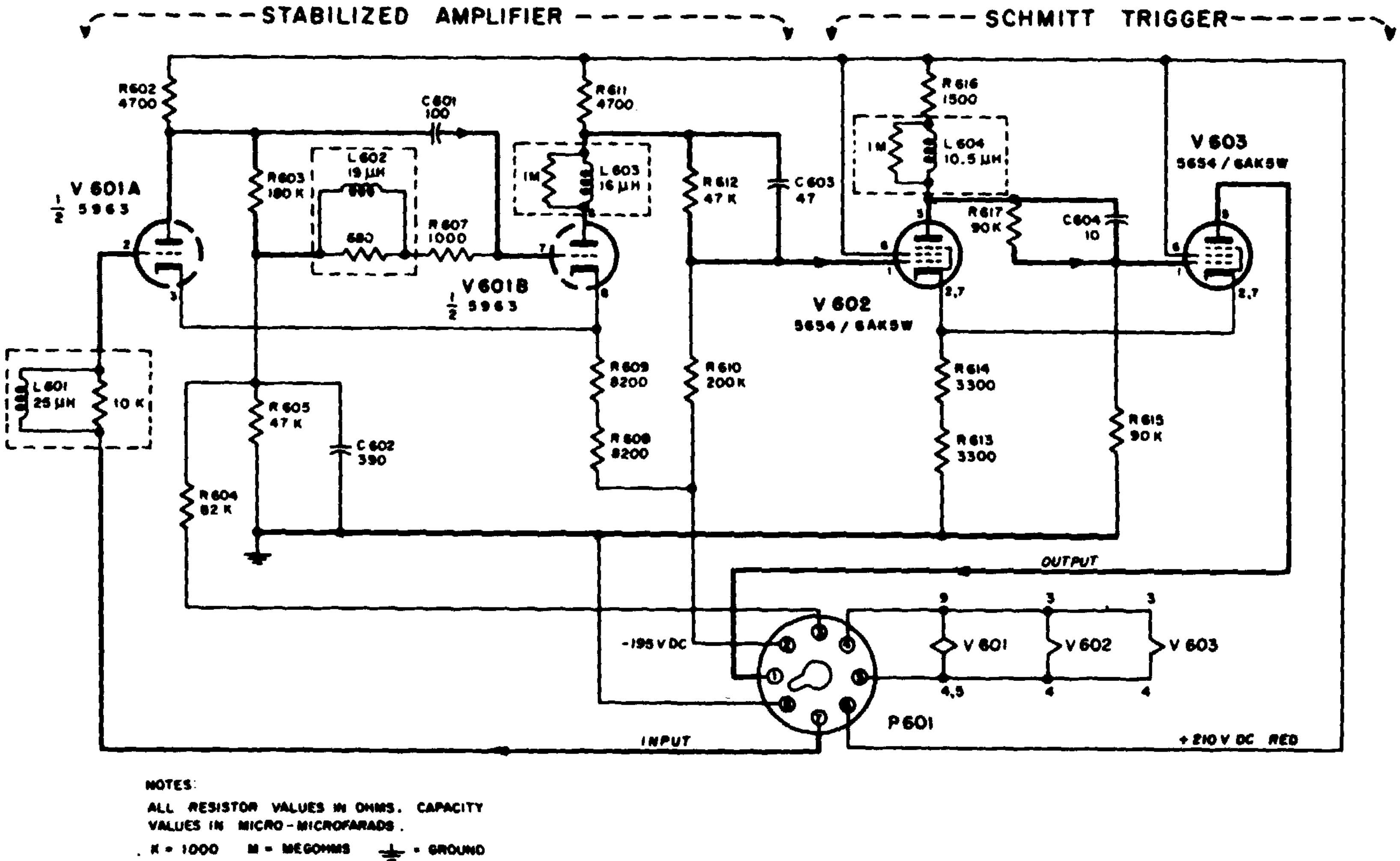


Figure 14-33. Schematic Diagram of Trigger Plug-In Unit for Frequency Meter FR-38E/U.

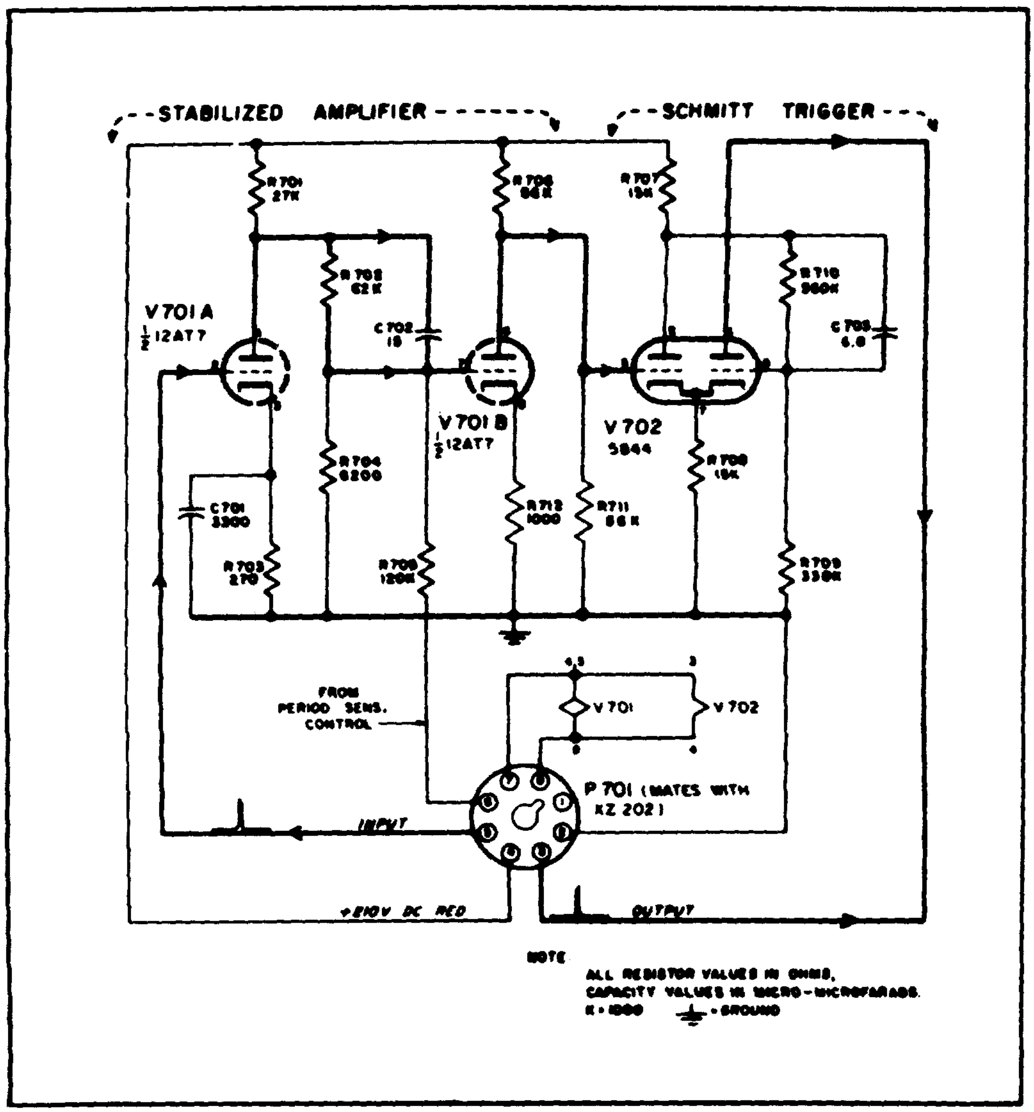
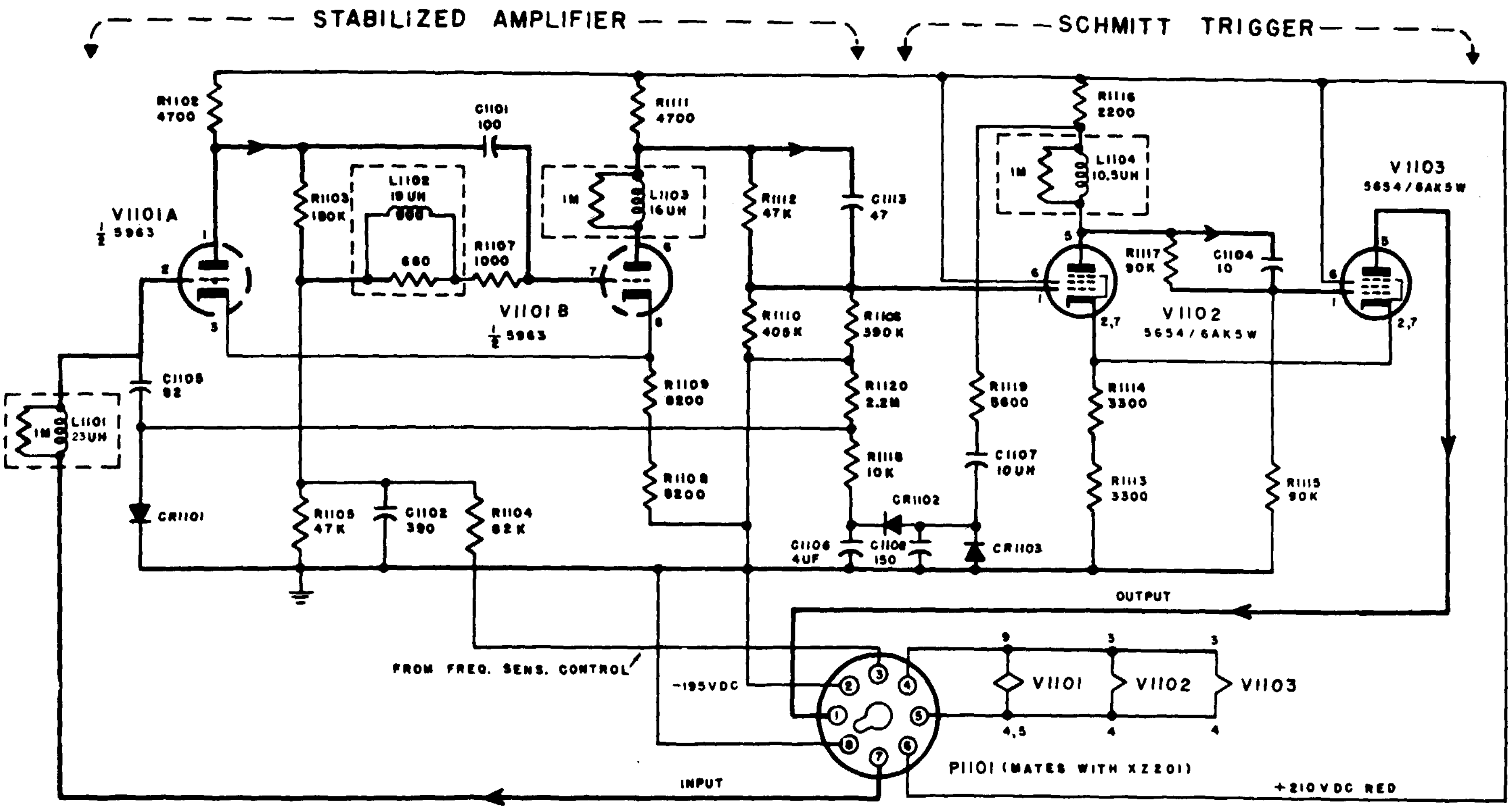


Figure 14-34. Schematic Diagram of Amplitude Discriminator Plug-In Unit for Frequency Meter FR-38E/U



NOTES

ALL RESISTOR VALUES IN OHMS,
CAPACITY VALUES IN MICRO-MICROFARADS UNLESS OTHERWISE SPECIFIED

K = 1000, M = MEGOHMS ⏚ = GROUND

Figure 14-35. -Schematic Diagram of Trigger Plug-In Unit Z-201 for Frequency Meter FR-38E/U

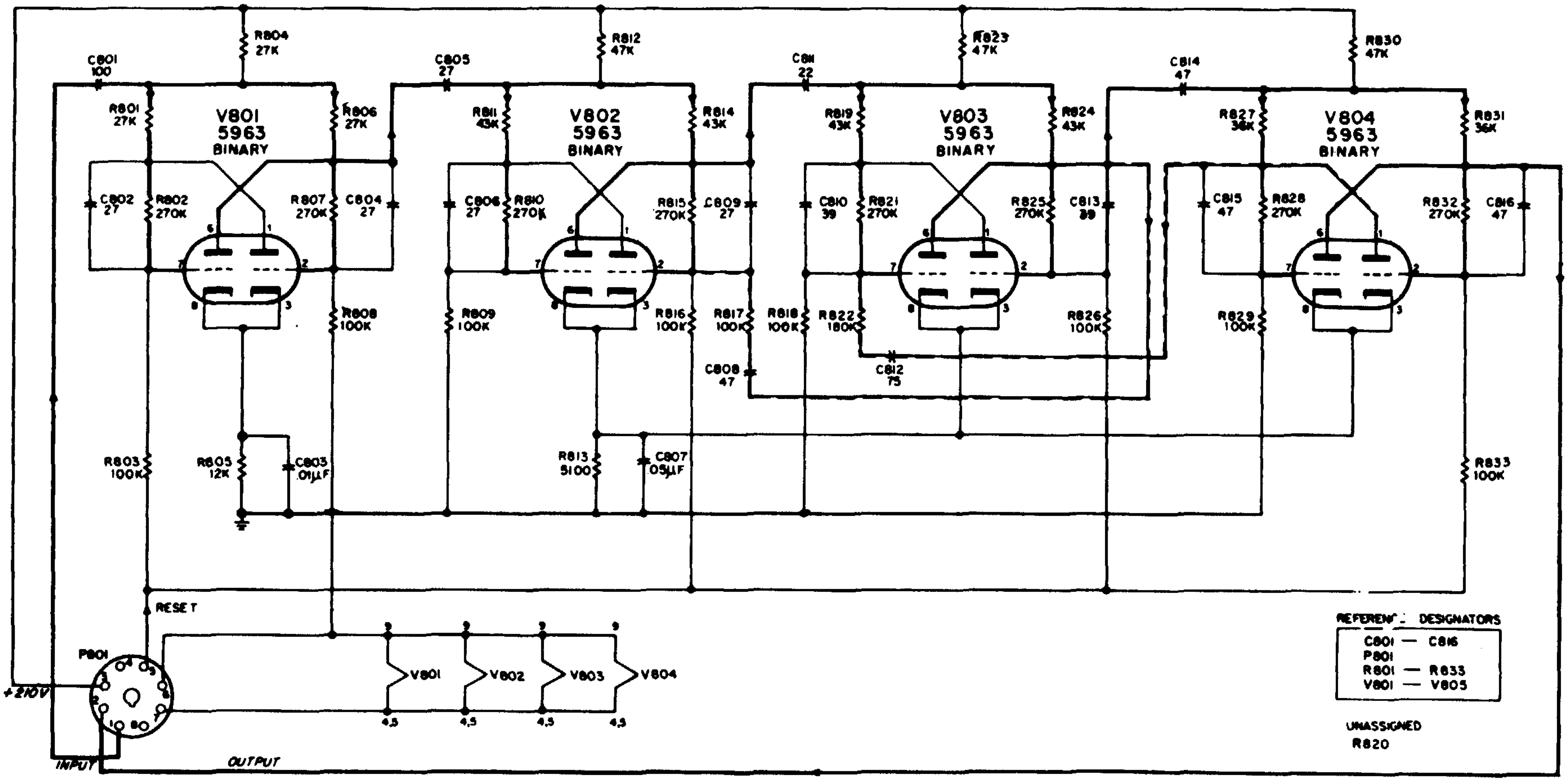


Figure 14-36. Schematic Diagram of Decade Divider Plug-In for Frequency Meter FR-38E/U

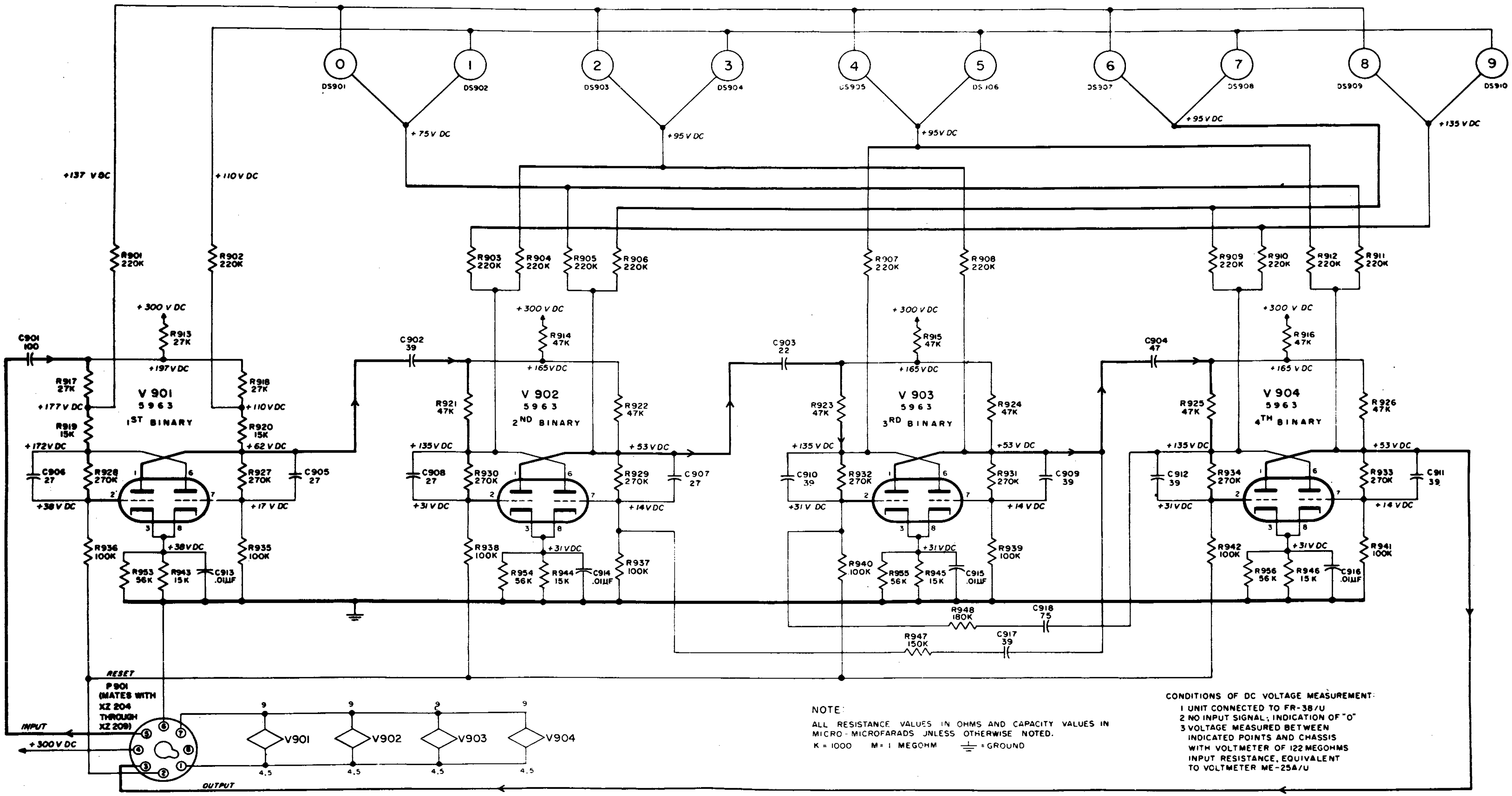


Figure 14-37. Schematic Diagram of Decade Counter Unit Subassemblies Z-204 through Z-209 for Frequency Meter FR-38E/U

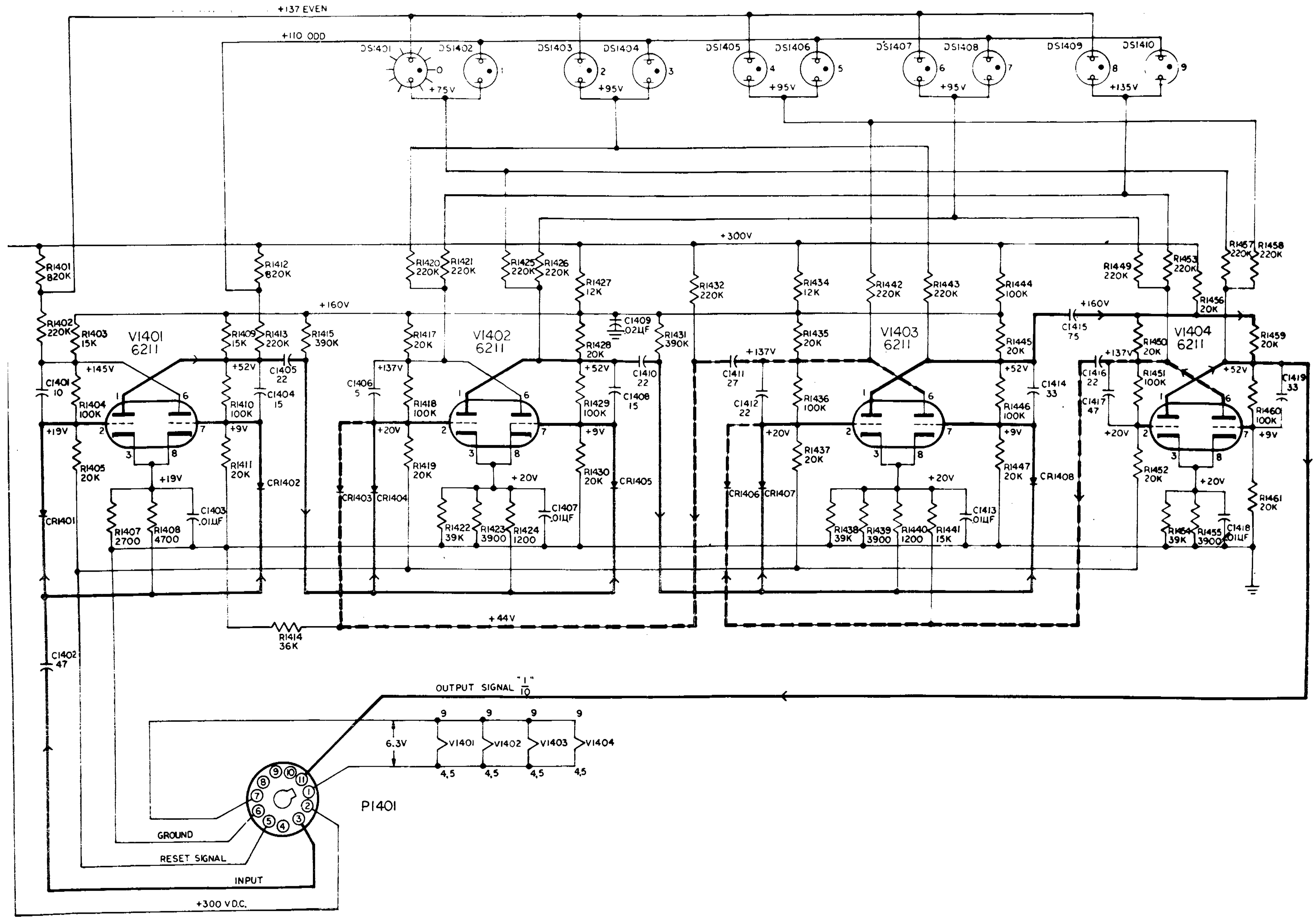


Figure 14-38. Schematic Diagram. Decade Counter Unit Subassembly Z-1200 for Frequency Meter FR-38E/U.

APPENDIX A

REFERENCES

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), and Supply Bulletins, and Lubrication Orders.
DA Pam 310-7	U.S. Army Equipment Index of Modification Work Orders.
TM 11-6625-200-15	Operator, Organizational, DS, GS, and Depot Maintenance Manual: Multimeters ME-26A/U, ME-26B/U, ME-26C/U, and ME-26D/U.
TM 38-750	Army Equipment Records Procedures.

APPENDIX B

BASIC ISSUE ITEMS LIST (BIIL) AND ITEMS TROOP INSTALLED OR AUTHORIZED LIST (ITIAL)

Section I. INTRODUCTION

B-1. Scope

This appendix lists only basic issue items required by the crew/operator for installation, operation, and maintenance of Frequency Meters AN/USM-26 and AN/USM-26A.

B-2. General

This Basic Issue Items and Items Troop Installed or Authorized List is divided into the following sections:

a. Basic Issue Items List -Section II. A list, in alphabetical sequence, of items which are furnished with, and which must be turned in with the end item.

b. Items Troop Installed or Authorized List - Section III. Not applicable.

B-3. Explanation of Columns

The following provides an explanation of columns found in the tabular listings:

a. Illustration. This column is divided as follows:

(1) *Figure Number*. Indicates the figure number of the illustration in which the item is shown.

(2) *Item Number*. Not applicable.

b. Federal Stock Number. Indicates the Federal stock number assigned to the item and will be used for requisitioning purposes.

c. Part Number. Indicates the primary number used by the manufacturer (individual, company, firm, corporation, or Government activity), which controls the design and characteristics of the item by means of its engineering drawings, specifications standards, and inspection requirements, to identify an item or range of items.

d. Federal Supply Code for Manufacturer (FSCM). The FSCM is a digit numeric code used to identify the manufacturer, distributor, or Government agency, etc., and is identified in SB 708-42.

e. Description. Indicates the Federal item name and a minimum description required to identify the item.

f. Unit of Measure (U/M). Indicates the standard of basic quantity of the listed item as used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation, (e.g., ea, in., pr, etc.). When the unit of measure differs from the unit of issue, the lowest unit of issue that will satisfy the required units of measure will be requisitioned.

g. Quantity Furnished with Equipment (Basic Issue Items Only). Indicates the quantity of the basic issue item furnished with the equipment.

Section II. BASIC ISSUE ITEMS LIST

(1) ILLUSTRATION (A) FIG. NO.	(B) ITEM NO.	(2) FEDERAL STOCK NUMBER	(3) PART NUMBER	(4) FSCM	(5) DESCRIPTION USABLE ON CODE	(6) UNIT OF MEAS	(7) QTY FURN WITH EQUIP
1-1		6625-603-9082			CASE, TEST SET CY-1424/USM-26	EA	1
1-1		6625-605-5459			CASE, TEST SET CY-1563/USM-26	EA	1

APPENDIX C

MAINTENANCE ALLOCATION

Section I. INTRODUCTION

C-1. General

This appendix provides a summary of the maintenance operations covered in the equipment literature for Frequency Meters AN/USM-26 and AN/USM-26A. It authorizes categories of maintenance for specific maintenance functions on repairable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

C-2. Maintenance Functions

Maintenance functions will be limited to and defined as follows:

a. INSPECT. To determine serviceability of an item by comparing its physical, mechanical, and electrical characteristics with established standards.

b. TEST. To verify serviceability and to detect incipient electrical or mechanical failure by use of special equipment such as gages, meters, etc. This is accomplished with external test equipment and does not include operation of the equipment and operator type tests using internal meters or indicating devices.

c. SERVICE. To clean, to preserve, to charge, and to add fuel, lubricants, cooling agents, and air. If it is desired that elements, such as painting and lubricating, be defined separately, they may be so listed.

d. ADJUST. To rectify to the extent necessary to bring into proper operating range.

e. ALIGN. To adjust two or more components or assemblies of an electrical or mechanical system so that their functions are properly synchronized. This does not include setting the frequency control knob of radio receivers or transmitters to the desired frequency.

f. CALIBRATE. To determine the corrections to be made in the readings of instruments or test equipment used in precise measurement. Consists of the comparison of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared with the certified standard.

g. INSTALL. To set up for use in an operational environment such as an encampment, site, or vehicle.

h. REPLACE. To replace unserviceable items with serviceable like items.

i. REPAIR. To restore an item to serviceable condition through correction of a specific failure or unserviceable condition. This function includes, but is not limited to welding, grinding, riveting, straightening, and replacement of parts other than the trial and error replacement of running spare type items such as fuses, lamps, or electron tubes.

j. OVERHAUL. Normally, the highest degree of maintenance performed by the Army in order to minimize time work in process is consistent with quality and economy of operation. It consists of that maintenance necessary to restore an item to completely serviceable condition as prescribed by maintenance standards in technical publications for each item of equipment. Overhaul normally does not return an item to like new, zero mileage, or zero hour condition.

k. REBUILD. The highest degree of materiel maintenance. It consists of restoring equipment as nearly as possible to new condition in accordance with original manufacturing standards. Rebuild is performed only when required by operational considerations or other paramount factors and then only at the depot maintenance category.

Rebuild reduces to zero the hours or miles the equipment, or component thereof, has been in use.

l. SYMBOLS. The uppercase letter placed in the appropriate column indicates the lowest level at which that particular maintenance function is to be performed.

C-3. Explanation of Format

a. Column 1, group number. N/A.

b. Column 2, functional group. Column 2 lists the noun names of components, assemblies, subassemblies and modules on which maintenance is authorized.

c. Column 3, maintenance functions. Column 3 lists the maintenance category at which performance of the specific maintenance function is authorized. Authorization to perform a function at any category also includes authorization to perform that function at higher categories. The codes used represent the various maintenance categories as follows:

Code	*Manufacturer*
C	Operator/Crew
O	Organizational Maintenance
F	Direct Support Maintenance
H	General Support Maintenance
D	Depot Maintenance

d. Column 4, tools and test equipment. Column 4 specifies, by code, those tools and test equipment required to perform the designated function. The numbers appearing in this column refer to specific tools and test equipment which are identified in Table I.

e. Column, 5, Remarks. Self explanatory.

C-4. Explanation of Format of Table I, Tool and Test Equipment Requirements

The columns in Table I, Tool and Test Equipment Requirements are as follows:

a. Tools and Equipment. The numbers in this column coincide with the numbers used in the tools and equipment column of the Maintenance Allocation Chart. The numbers indicate the applicable tool for the maintenance function.

b. Maintenance Category. The codes in this column indicate the maintenance category normally allocated the facility.

c. Nomenclature. This column lists tools, test, and maintenance equipment required to perform the maintenance functions.

d. Federal Stock Number. This column lists the Federal stock number of the specific tool or test equipment.

e. Tool Number. Not used.

SECTION II MAINTENANCE ALLOCATION CHART AN/USM-26, AN/USM-26A

GROUP NUMBER	COMPONENT ASSEMBLY NOMENCLATURE	INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	TOOLS AND EQUIPMENT	REMARKS
	FREQUENCY METER AN/USM-26; AN/USM-26A	C												
			H										2,3,4,5,6,9, 10 ,12	
				C										
					H								1,2,3,4,5,6, 7 ,9,10,12	
						H							1,2,3,4,5,6, 7,9,10,12	
										O			13	Replace items allotted to organization
										H			11	
											D		1,2,3,4,5,7, 8,10,11,12	
	CABLE ASSEMBLIES									H			11	
	CASES, TEST SET									H			11	
	FREQUENCY METER FR-38A, C, D, E/USM-26													Same maintenance function, tools, and equipment as end item
	COUNTERS, ELECTRICAL								H	H			11	
	DISCRIMINATOR ASSEMBLIES								H	H			11	
	DIVIDER ASSEMBLIES								H	H			11	
	MOTOR								H	H			11	
	TRIGGER CIRCUIT								H	H			11	
	FREQUENCY METER SUBASSEMBLY MX-1636/U; MX-1636A/U													Same maintenance functions, tools, and equipment as end item
	TRIGGER CIRCUIT								H	H			11	

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C-1

SECTION II MAINTENANCE ALLOCATION CHART (cont)

GROUP NUMBER	COMPONENT ASSEMBLY NOMENCLATURE	MAINTENANCE FUNCTIONS											TOOLS AND EQUIPMENT	REMARKS
		INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD		
	FREQUENCY METER SUBASSEMBLY MX-1637/U; MX-1637A/U													Same maintenance functions, tools, and equipment end item

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TABLE 1 TOOL AND TEST EQUIPMENT REQUIREMENTS AN/USM-26, AN/USM-26A

TOOLS AND EQUIP	MAINT. CATEGORY	NOMENCLATURE	FEDERAL STOCK NUMBER	TOOL NUMBER
1	H,D	GENERATOR, PULSE AN/PPM-1A	6625-504-9603	
2	H,D	GENERATOR, SIGNAL AN/URM-25D	6625-649-5193	
3	H,D	GENERATOR, SIGNAL AN/USM-44A	6625-539-9685	
4	H,D	MULTIMETER ME-26D/U	6625-360-2493	
5	H,D	MULTIMETER TS-352B/U	6625-553-0142	
6	H,D	OSCILLOSCOPE AN/USM-281	6625-053-3112	
7	H,D	TEST SET, CRYSTAL RECTIFIER TS-268E/U	6625-669-1215	
8	D	TEST SET, ELECTRON TUBE TV-2C/U	6625-669-o263	
9	H	TEST SET, ELECTRON TUBE TV-7D/U	6625-820-0064	
10	H,D	TEST SET, POWER, ELECTRICAL TS-914/U	6625-542-1289	
11	H,D	TOOL KIT, ELECTRONIC EQUIPMENT TK-100/G	5180-605-0079	
12	H,D	TRANSFORMER, VARIABLE CN-16B/U	5950-235-2086	
13	O	TOOLS AND TEST EQUIPMENT AVAILABLE TO REPAIRMAN-USER BECAUSE OF HIS ASSIGNED MISSION		

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APPENDIX D

ORGANIZATIONAL, DS, GS, AND DEPOT REPAIR PARTS

Section I. INTRODUCTION

D-1. Scope

This appendix contains a list of repair parts required for the performance of organizational maintenance and a list covering the corresponding requirements for general support and depot maintenance for Frequency Meters AN/USM-26 and AN/USM-26A.

NOTE

No special tools, test and support equipment are required.

D-2. General

The repair parts list is divided into the following sections:

a. Prescribed Load Allowance (PLA), Section II. The PLA is consolidated listing of repair parts allocated for initial stockage at organizational maintenance category. This is a mandatory minimum stockage allowance.

b. Repair Parts for Organizational Maintenance, Section III. Repair parts authorized for organizational maintenance are included in this section.

c. Repair Parts for Direct Support, General Support and Depot Maintenance, Section IV. Repair parts authorized for general support, and depot maintenance are included in this section. No parts authorized at direct support.

NOTE

All indexes noted below are cross. referenced to index numbers. The index numbers appear in ascending sequence in column 1 of the repair parts list (para D-3*a*). The index number for the particular item will be the same for the item in all sections of this appendix.

d. Federal Stock Number Cross-Reference to Index Number, Section V. This is a cross-reference index of Federal stock numbers to index numbers. Where applicable, when the same reference designation is used on different models, the usable code (para D-3*c*) is identified after the reference designation (e.g., CR-805-1, CR-805-2).

e. Reference Designation Cross-Reference to Index Number, Section VI. This is a cross-reference index of reference designations and/or item numbers to index numbers. Where applicable, when the same reference designation is used on different models, the usable code (para D-3*c*) is identified after the reference designation (e.g., CR-805-1, CR-805-2).

D-3. Explanation of Columns

An explanation of the columns is given below.

a. Source, Maintenance, and Recoverability Codes (SMR) and Index Numbers Column. The first line in this column lists the applicable SMR codes for the part. Listed in ascending order directly below the SMR codes is the index number assigned to the repair part.

(1) *Source code (S).* The selection status and source for the listed item is noted here. Source code and its explanation is as follows:

Code	*Explanation*
P	applies to repair parts that are stocked in or supplied from the GSA/DSA, or Army supply system, and authorized for use at indicated maintenance categories.

(2) *Maintenance code (M).* The lowest category of maintenance authorized to install the listed item is noted here.

Code	*Explanation*
C	Operator/Crew
O	Organizational Maintenance
H	General Support Maintenance

(3) *Recoverability code (R).* The information in this column indicates whether unserviceable items should be returned for recovery or salvage. Recoverability code and its explanation is as follows:

NOTE

When no code is indicated in the recoverability column, the part will be considered expendable.

Code	*Explanation*
R	Applies to repair parts and assemblies which are economically repairable at DSU and GSU activities and normally are furnished by supply on an exchange basis.

b. Federal Stock Number Column. The Federal stock number for the item is listed in this column.

c. Description Column. This column includes the Federal item name and any additional description of the item required, the manufacturer's part number (reference number), and the applicable five-digit Federal Supply Code for Manufacturers (para D-5). Also included in this column are the designators 1, 2, 3, 4, etc., listed under the heading *Usable on Code*. The designators, which are explained at the beginning of the description column in the repair parts list, indicate that the part is used on the model or serially numbered groups so identified. For subsequent appearances of the same item, the manufacturer's code and part number (reference number) are omitted. The words "same as" followed by the index number assigned to the item when it first appeared in the list will follow the item name, e.g., "RESISTOR, FIXED, COMPOSITION: SAME AS A 298."

d. Unit of Measure Column. The unit used as a basis of measure (e.g., ea, pr, ft, yd, etc.) is indicated in this column.

e. Quantity Incorporated in Unit Column. The quantity of repair parts in an assembly is given in this column.

f. Maintenance Allowances Column.

(1) The maintenance allowance columns are divided into subcolumns. Indicated in each subcolumn opposite the first appearance of the item is the total quantity of items authorized for the number of equipments supported. Subsequent appearances of the same item will have no entry in the allowance columns, but will have a reference in the description column to the first appearance of the item. Items authorized for use as required, but not for initial stockage, are identified with an asterisk (*) in the allowance column.

(2) The quantitative allowances for organizational category of maintenance represents one initial prescribed load for a 15-day period for the number of equipments supported. Units and organizations authorized additional prescribed loads will multiply the number of prescribed loads authorized by the quantity of repair parts reflected in the appropriate density column to obtain the total quantity of repair parts authorized.

(3) Subsequent changes to organizational allowances will be limited as follows: No change in the range of items is authorized. If additional items are considered necessary, recommendations should be forwarded to Commanding General, U.S. Army Electronics Command, ATTN: AMSEL-ME-NMP-TB, Fort Monmouth, N.J. 07703, for exception or revision to the allowance list. Revisions to the range of items authorized will be made by the USA ECOM. National Maintenance Point based upon engineering experience, demand data, or TAERS information.

(4) The quantitative allowances for GS categories of maintenance will represent initial stockage for a 30-day period for the number of equipments supported.

g. One-Year Allowances Per 100 Equipments/ Contingency Planning Purposes, Column. Opposite the first appearance of each item, the total quantity required for distribution and contingency planning purposes is indicated. The range of items indicates total quantities of all authorized items required to provide for adequate support of 100 equipments for one year.

h. Depot Maintenance Allowance Per 100 Equipments Column. This column indicates the total quantity of each item authorized depot maintenance for 100 equipments. Subsequent appearances of the same item will have no entry in this column, but will have a reference in the description column to the first appearance of the item.

i. Illustrations Column.

(1) *Figure number (a).* Not used.

(2) *Item No. or reference designation (b).* The callout number or reference designation used to reference the item appears in this column.

D-4. Location of Repair Parts

a. This appendix contains two cross-reference indexes (section V and VI), to be used to locate a repair part when either the Federal stock number, reference number (manufacturer's part number), or reference designation is known. The first column in each cross-reference index is prepared, as applicable, in numerical or alphanumerical sequence. The last column of each cross-reference index lists the index number assigned to the part.

b. Refer to the appropriate cross-reference index (para D-2 d, e), and note the index number in the last column; then refer to the repair parts list to locate the index number which is listed in ascending order in column 1 of the repair parts list.

D-5. Federal Supply Codes

This paragraph lists the Federal supply code with the associated manufacturer's name.

Code	*Manufacturer*
00346	Crescent Communications Corp.
05621	Alpha Instrument Inc.
07497	Amphenol Corp. Amphenol Cable Div.
11237	Chicago Telephone of California Inc.
18714	Radio Corp. of America Solid State and Receiving Tube Div.
24446	General Electric Co.
28480	Hewlett-Packard Co.
56289	Sprague Electric Co.
62119	Universal Electric Co.
71400	Bussman Mfg Div. of McGraw Edison Co.
71590	Globe-Union Inc. Centralab Div.
71785	Cinch Mfg. Co. & Howard B Jones Div.
72619	Dialight Corp.
72656	Indiana General Corp. Electronics Div.
72982	Erie Technological Products Inc.
74545	Hubbell Harney Inc.
75376	Kurz-Kasch Inc.
75915	Littlefuse Inc.
78488	Stackpole Carbon Co.
80045	Avco/Electronics Div.
80058	Joint Electronic Type Designation System
80667	Northeastern Engineering Inc.
81349	Military Specifications
82893	Vector Electronic Co.
82903	Okonite Co.
84979	Independent Cordage Co.
90201	Mallory Capacitor Co.
91662	Elco Corp.
99800	Delevan Electronics Corp.

SECTION II PRESCRIBED LOAD ALLOWANCE

(1) FEDERAL STOCK NUMBER	(2) DESCRIPTION	USABLE ON CODE	(3) 15-DAY ORG MAINT. ALW (A) 1-5	(B) 6-20	(C) 21-50	(D) 51-100
	NOTE: Usable on Code 1 refers to FR-38A/USM-26; 2 refers to FR-38C/USM-36: 3 refers to FR-38D/USM-26; 4 refers to FR-38E/USM-26					
5355-579-3175	KNOB: S-308-64-SL-B-522; 75376	1,2,3,4	*	*	*	2
	NOTE: Usable on Code 1 refers to MX-1637/U; 2 refers to MX-1637A/U					
5960-188-3968	ELECTRON TUBE: 6E5; 81349	1,2	*	2	3	5
	NOTE: Usable on Code 1 refers to FR-38A/USM-26; 2 refers to FR-38C/USM-36; 3 refers to FR-38D/USM-26; 4 refers to FR-38E/USM-26					
5960-193-5111	ELECTRON TUBE: 5R4WGY; 81349	1,2,3	2	2	4	8
5960-230-5307	ELECTRON TUBE: 6CB6; 81349	1,2,3	2	5	13	25
		4	2	5	13	25
5960-237-6917	ELECTRON TUBE: 5725/6AS6W; 81349	1,2,3,4	2	2	3	6
5960-262-0167	ELECTRON TUBE: 12AT7WA; 81349	1,2,3,4	*	*	2	2
5960-284-9285	ELECTRON TUBE: 5725/2D21W; 81349	1,4	2	3	9	12
		2,3	2	3	9	12
5960-542-7004	ELECTRON TUBE: 6AH6WA; 81349	1,2,3,4	2	3	9	16
5960-669-6861	ELECTRON TUBE: 6005/6AQ5W; 81349	1,2,3,4	2	2	3	5
6240-155-8706	LA14P, INCANDESCENT: 47; 24446	1,2,3	2	2	3	5
		4	2	2	3	5
6685-605-7192	THERMOMETER, SELF-INDICATING: BI-METALLIC:	1,2,3	*	*	*	2
	ELECTRON TUBE: 5Y3WGT; 81349	1,2,3	*	2	2	3
	ELECTRON TUBE: 5963; 18714	1,2,3	13	25	59	114
		4	3	10	25	47
	ELECTRON TUBE: 6080WA; 81349	1,2,3,4	2	2	3	6
	FUSE CARTRIDGE: MDF 6.25; 71400	1,2,3,4	2	2	6	11
	KNOB: A-17872; 80667	1,2,3,4	*	*	*	2

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SECTION III REPAIR PARTS FOR ORGANIZATIONAL MAINTENANCE

(1) SMR CODE INDEX	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 15-DAY ORGANIZATIONAL MAINTENANCE ALW (a) 1-5	(b) 6-20	(c) 21-50	(d) 51-100	(7) ILLUSTRATION (a) FIG NO.	(b) ITEM NO. OR REF. DESIG
1	6625-543-1356	FREQUENCY METER AN/USM-26, and AN/USM-26A: (This item is nonexpendable)									
		NOTE: Usable on Code 1 refers to AN/USM-26; 2 refers to AN/USM-26A									
P-C-- 2	5935-201-3090	ADAPTER, CONNECTOR, ELECTRICAL UG-201A/U;	1,2	ea	2	*	*	*	*		E201, E202
P-C-- 3	5935-149-3914	ADAPTER, CONNECTOR, ELECTRICAL UG-255/U:	1,2	ea	2	*	*	*	*		
P-C-- 4	5935-149-3534	ADAPTER, CONNECTOR, ELECTRICAL UG-273A/U:	1,2	ea	2	*	*	*	*		
P-C-- 5	6625-603-9082	ADAPTER, CONNECTOR, ELECTRICAL UG-282A/U:	1,2	ea	2	*	*	*	*		
P-C-- 6	5935-201-3091	ADAPTER, CONNECTOR, ELECTRICAL UG-394A/u:	1,2	ea	2	*	*	*	*		
P-C-- 7	5935-280-1454	ADAPTER, CONNECTOR, ELECTRICAL UG-914/U:	1,2	ea	2	*	*	*	*		
P-C-- 8	5935-204-5098	ADAPTER, CONNECTOR, ELECTRICAL UG-103A/U:	1,2	ea	2	*	*	*	*		
		FREQUENCY METER FR-38A ,C ,D, E/U									
		NOTE: Usable on Code 1 refers to FR-38A/USM-26; 2 refers to FR-38C/USM-36; 3 refers to FR-38D/USM-26; 4 refers t o FR-38E/USM-26									
P-O-- 28		CAP, ELECTRICAL: 62119; 14A5	1,2,3	ea	2	*	*	*	*		
P-O-- 29	5920-583-5057	CAP, ELECTRICAL: 75915; 342003-SA-2	1,2,3,4	ea	2	*	*	*	*		
P-O-- 168	5960-193-5111	ELECTRON TUBE 81349; 5R4WGY	1,2,3	ea	3	2	2	4	8		V249, V250, V251
P-O-- 169		ELECTRON TUBE: 81349; 5Y3WGT	1,2,3	ea	1	*	2	2	3		V257
P-O-- 170	5960-542-7004	ELECTRON TUBE: 81349; 6AH6WA	1,2,3,4	ea	5	2	3	9	16		V210, V211, V217
P-O-- 172	5960-230-5307	ELECTRON TUBE: 81349; 6CB6	1,2,3	ea	5	2	5	13	25		V212, V213, V215 V216, V216
			4	ea	5	2	5	13	25		V212, V213, V215, V216, V218
P-O-- 173	5960-262-0167	ELECTRON TUBE: 81349; 12AT7WA	1,2.3,4	ea	1	*	*	2	2		V201
P-O-- 176	5960-237-6917	ELECTRON TUBE: 81349; 5725/6AS6W	1.2,3,	ea	2	2	2	3	6		V202. V214
P-O-- 178	5960-284-9285	ELECTRON TUBE: 81349; 5727/2D21W	1,4	ea	2	2	3	9	12		V205, V209
			2,3	ea	1	2	3	9	12		V205
P-H-- 180		ELECTRON TUBE: 18714; 5963 (Item. Nos. V204, V219, V220, V221, V222, V223, V236, V801 thru V804, V991 thru V904, V2101 thru V2104, V3101 thru V3104)	1,2,3	ea	23	13	25	59	114		See Desc. Column
			4	ea	10	3	10	25	47		V204, V236, V801 thru V804, V901
P-O-- 181	5960-669-6861	ELECTRON TUBE: 81349; 6005/6AQ5W	1,2,3,4	ea	2	2	2	3	5		V258, V259
P-O-- 182		ELECTRON TUBE: 81349; 6080WA	1,2,3,4	ea	2	2	2	3	6		V253, V254
P-O-- 187		FUSE, CARTRIDGE: 71400; MDF6.25	1,2,3,4	ea	2	2	2	6	11		F201, F202

SECTION III REPAIR PARTS FOR ORGANIZATIONAL MAINTENANCE (CONTINUED)

(1) SMR CODE INDEX	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF NUMBER & MFR CODE	(3) USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 15-DAY ORGANIZATIONAL MAINTENANCE ALW (a) 1-5	(6) (b) 6-20	(6) (c) 21-50	(6) (d) 51-100	(7) ILLUSTRATION (a) FIG NO.	(7) (b) ITEM NO. OR REF. DESIG
P-O-- 193		KNOB: 80667; A-17872	1,2,3,4	ea	1	*	*	*	2		
P-O-- 194	5355-559-3891	KNOB: 80667; A-17871	1,2,3,4	ea	2	*	*	*	*		
P-O-- 195	5355-579-3175	KNOB: 75376; S-308-64-SL-B-522	1,2,3,4	ea	1	*	*	*	2		
P-O-- 199	6240-155-8706	LAMP, INCANDESCENT: 24446; 47	1,2,3	ea	7	2	2	3	5		1202 thru 1208
			4	ea	7	2	2	3	5		DS202 thru DS208
P-O-- 202		LENS, INDICATOR LIGHT: 00346; 25P-323C	4	ea	1	*	*	*	*		XDS201B
P-O-- 203		LENS, INDICATOR LIGHT: 00346; 25P-323W	4	ea	1	*	*	*	*		XDS207B
P-O-- 204		LENS, INDICATOR LIGHT: 00346; 25P-323R	4	ea	2	*	*	*	*		XDS208B
P-O-- 206	6210-243-0056	LENS, INDICATOR LIGHT: 72619; 81-117	1,2,3	ea	2	*	*	*	*		X1201A thru X1207A
P-O-- 207	6210-247-1778	LENS, INDICATOR, LIGHT: 72619; 81-111	1,2,3	ea	1	*	*	*	*		X1208A
P-O-- 211	5955-583-1875	OVEN, CRYSTAL ASSEMBLY: 80667; C-18463	1,2,3	ea	1	*	*	*	*		
P-O-- 378	5960-272-9094	SHIELD ELECTRON TUBE: 81349; TS102UO2	1,2,3	ea	2	*	*	*	*		E11, E702
P-O-- 379	5960-264-3004	SHIELD ELECTRON TUBE: 81349; TS103U02	1,2,3	ea	1	*	*	*	*		E703
P-O-- 409	6685-605-7192	THERMOMETER, SELF-INDICATING: BI-METALLIC: 80667; B-17397	1,2,3	ea	1	*	*	*	2		
		FREQUENCY METER SUBASSEMBLY MX-1636/U; and MX-1636A/U:									
C-R-- 420		FREQUENCY METER SUBASSEMBLY MX-1636/U; MX-1636A/U:									
		NOTE: Usable on Code 1 refers to MX-1636/U; 2 refers to MX-1636A/U									
P-O-- 440	5355-579-3175	KNOB: SAME As 195		ea	4						
		FREQUENCY METER SUBASSEMBLY MX-1637/U; and MX-1637A/U:									
--C-R	6625-553-4006	FREQUENCY METER MX-1637/U; MX-1637A/U: NOTE: Usable on Code 1 refers to 6X-1637/U; 2 refers to MX-1637A/U									
P-H-- 505	5960-542-7004	ELECTRON TUBE: SAME AS 170	1,2	ea	5						V1, V2, V5, V6, V7
P-O-- 506	5960-188-3968	ELECTRON TUBE: 81349; 6E5	1,2	ea	1	*	2	3	5		V8
P-O-- 508		KNOB: SAME AS 193	1,2	ea	2						012, 0367
P-O-- 509	5355-579-3175	KNOB: SAME AS 195	1,2	ea	1						
P-O-- 540	5960-272-9094	SHIELD, ELECTRON TUBE: SAME AS 378	1,2	ea	1						

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SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1)	(2)	(3)		(4)	(5)	(6)			(7)			(8)	(9)	(10)	
SMR CODE INDEX NO	FEDERAL STOCK NUMBER	DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	UNIT OF MEAS	QTY INC IN UNIT	30 DAY DS MAINT ALLOWANCE (a) 1-20	(b) 21-50	(c) 51-100	30 DAY GS MAINT ALLOWANCE (a) 1-20	(b) 21-50	(c) 51-100	1-YR ALWPER EQUIP CNTGY	DEPOT MAINT ALWPER 100 EQUIP	ILLUSTRATION (a) FIG. NO.	(b) ITEM NO.
1	6625-543-1356	FREQUENCY METER AN/USM-26, and AN/USM-26A: (this item is nonexpendab le NOTE: Usable On Code 1 refers to AN/USM-26; 2 refers to AN/USM-26A													
P-C-- 2	5935-201-3090	ADAPTER, CONNECTOR, ELECTRICAL: UG-201-A/U	1,2	ea	2				*	*	2	10	6		E201, E202
P-C-- 3	5935-149-3914	ADAPTER, CONNECTOR, ELECTRICAL: UG-225/U	1,2	ea	2				*	*	2	10	6		
P-C-- 4	5935-149-3534	ADAPTOR, CONNECTOR, ELECTRICAL: UG-273A/U	1,2	ea	2				*	*	2	10	6		
P-C-- 5	6625-603-9082	ADAPTER, CONNECTOR, ELECTRICAL: UG-282A/U	1,2	ea	2				*	*	2	10	6		
P-C-- 6	5935-201-3091	ADAPTER, CONNECTOR, ELECTRICAL: UG-394A/U	1,2	ea	2				*	*	2	10	6		
P-C-- 7	5935-280-1454	ADAPTER, CONNECTOR, ELECTRICAL: UG-914/U	1,2	ea	2				*	*	2	10	6		
P-C-- 8	5935-234-5098	ADAPTER, CONNECTOR, ELECTRICAL: UG-1034A/U	1,2	ea	2				*	*	2	10	6		
P-H-- 9	6145-504-0942	CABLE, POWER, ELECTRICAL: 82903; Type SJO 2 COND. No. 16	1	ft	6				*	*	6	60	60		
P-H-- 10		CABLE, POWER, ELECTRICAL: 81349; CO-03MGF(3/16)0350	1	ft	6				*	*	6	65	60		
P-H-- 11		CABLE, RADIO FREQUENCY RG-62A/U	1,2	ea	4				*	*	4	170	170		
P-H-- 12	6145-606-8539	CABLE, SPECIAL PURPOSE, ELECTRICAL: 80667; A-177 82-2	1,2	ft	2				*	*	*	20	20		
P-H-- 13		CLAMP, ELECTRICAL: 81349; AN3057-4	1		1				*	*	2	8	5		
P-H-- 14		CLAMP, CABLE: 81349; AN3057-8	1	ea	1				*	1	2	8	5		
P-H-- 15		CONNECTOR, PLUG, ELECTRICAL: UP-121-M	1	ea	1				*	*	2	8	5		
P-H-- 16	5935-404-8015	CONNECTOR, PLUG, ELECTRICAL: 81349; 3106A-10SL-3S	1	ea	1				*	*	2	8	5		
P-H-- 17		CONNECTOR, PLUG, ELECTRICAL: 81349; MS3106A-160-1S	1	ea	1				*	*	2	8	5		
P-H-- 18	5935-149-4013	CONNECTOR, PLUG, ELECTRICAL: 74545; 7057	1	ea	1				*	*	2	8	5		
P-H-- 19	5935-201-2774	CONNECTOR, PLUG, ELECTRICAL: 74545; 7084	1	ea	1				*	*	2	8	5		
P-H-- 20	5935-173-5895	CONNECTOR , PLUG, ELECTRICAL: 2G-260/U	1,2	ea	2				*	*	2	10	6		
P-H-- 21	5935-027-9424	CONNECTOR, RECEPTACLE, ELECTRICAL: 07497; 26-4100-8P	1,2	ea	1				*	*	2	13	9		
P-H-- 22	5935-283-3383	CONNECTOR, RECEPTACLE, ELECTRICAL: 07497; 26-4100-16P	1,2	ea	1				*	2	2	13	9		
		FREQUENCY METER FR-38A, C, D, E/U													
--C-R 23	6625-605-7189	FREQUENCY METER FR-38A, C, D, E/U NOTE: Usable On Code 1 refers to F-308A/USM-26; 2 refers to Fr-38C/USM-36; 3 refers to FR-38D/USM-26; 4 refers to FR -38E/USM-26													
P-H-- 24	6625-605-7198	AMMETER: 80667; B-17390	1,2,3	ea	2				*	*	2	13	10		M201, M202

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SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	(3) USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H--25		RAFFLE, BLOWER: 52667; B-17579	1,2,3	ea	1				*	*	*	5	3		
P-H--26		BLOWER: 00346; V5H0-M1-1	4	ea	1				*	*	2	8	5		B201
P-H--27	5977-295-8063	BRUSH, ELECTRICAL CONTACT: 62119; 25A9A-7	1,2,3	ea	1				*	*	*	5	3		
p-O--28		CAP, ELECTRICAL: 62119; 14A5	1,2,3	ea	2				*	*	2	6	10		
P-O--29	5920-583-5057	CAP, ELECTRICAL: 75915; 342003-SA-2	1,2,3,4	ea	2				*	*	2	5	8		
P-H--30		CAPACITOR, FIXED CERAMIC: 00346; 821-011	4	ea	1				*	*	*	5	3		C284
P-H--31		CAPACITOR, FIXED CERAMIC DIELECTRIC: 20346; 5HK-S20	4	ea	4				*	2	2	16	12		C207, C235, C807 C1002
P-H--32	5910-577-6859	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 81349; CC21CH050C	1,2,3,4	ea	1				*	*	2	10	6		C250
P-H--33		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 81349; CC21CH100D	2, 3	ea	1				*	*	2	10	6		C1124
			4	ea	2				*	*	2	10	6		C1104, C1401
P-H--34	5910-112-7908	CAPACITORS, FIXED, CERAMIC DIELECTRIC: 81349; CC30CH470J	1,2,3	ea	8				*	2	2	28	24		C801, C802, C804 thru C808, C812 C814
P-H--35	5910-270-9214	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 81349; CC26TH750J	1,2,3	ea	1				*	*	*	5	3		
			4	ea	1				*	*	*	5	3		C1004
P-H--36	5910-578-5533	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 81349; CC26UJ101J	2,3	ea	1				*	*	*	5	3		C815
P-H--37		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 81349; CK61Y102Z	2,3	ea	2				*	2	2	21	18		C2119, C3119
P-H--38	5910-857-2123	CAPACITOR, FIXED, CERAMIC DIELECTRI C: 81349; CK70AW152M	2,3,4	ea	1				*	2	2	19	15		C386
P-H--39		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 81349; CK63AW103M													
		Item Nos. C202, C205, C206, C207, C210, C212, C215, C217, C218, C221, C224, C229, C234, C235, C239, C251, C266, C271, C276, C280, C284, C298, C303, C304, C308, C318, C332, C334, C337, C345, C346, 0360 thru C365, C368, C385, C813, C903, C907, C915)	1	ea	43				2	5	10	114	129		See Desc. Column
		(Item Nos. C202, C205, C206, C207, C208, C210, C212, C215, C217, C21 8, C221, C224, C229. C234, C235, C239, C251, C262, C266, C271, C276, C280, C294, C285, C292, C293, C298, C303, C304, C308, C318, C332, C334, C337, C345, C346, C360 thru C365, C368, C385, C813, C2104, C2108, C2112, C2116, C3104, C3108, C3112, C31164	2,3	ea	52				2	6	11	134	156		See Desc. Column
		(Item Nos. C202, C204, C205, C210, C212, C215, C217, C218, C221, C224, 0229, C234, C251, C262, c285, C287, C303, C304, C308, C318, C332, C337, C345, C346, C360 thru C365, C368. C371, C372, C38 5, C803, C913, C914, C915, C916, C1301, C1305, C1309, C1310, C1403, C1407, C1413, C1410)	4	ea	46				2	6	12	143	168		See Desc. Column
P-H--40	5910-578-1645	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 72982; 817-.02	2,3	ea	1				*	*	*	5	3		C339

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAI NT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H 41	5910-666-8197	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 71590; DD-203	4	ea	1				2	2	3	30	27		C1409
P-H-- 42	5910-578-5536	CAPACITOR, FIXED, ELECTROLYTIC: 56289; Type 101D, 4UF,6V	1,2,3,4	ea	1				*	2	2	12	10		C1106
P-H-- 43	5910-519-6668	CAPACITOR, FIXED, ELECTROLYTIC: 81349; CE31C100N	1,2,3,4	ea	1				*	2	2	12	10		C107
P-H-- 44	5910-112-7800	CAPACITOR, FIXED, ELECTROLYTIC: 81349; CE41P300R	1,2,3,4	ea	3				*	2	2	13	9		C341, C342, C347
P-H-- 46	5910-615-9519	CAPACITORS, FIXED, ELECTROLYTIC: DIELECTRIC 81349; CM15C050JN1	1,2,3,4	ea	1				*	*	*	13	10		C349
P-H-- 47		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C100KN1	4	ea	1				*	*	*	5	3		C1306
P-H-- 48		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20 B100KN1	2	ea	6				*	2	2	21	18		C240, C243, C245, C249, C21 C703
			3,4	ea	3				*	2	2	13	9		C243, C245, C249
P-H-- 49		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15B150KN1	4	ea	2				*	*	2	10	6		C1404, C1408
P-H-- 50		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C150JN1													
		(Item Nos. C252, C258, C261, C244, C252, C258, C261, C253, C254, C257, C269)	1	ea	3				*	*	2	10	6		See Desc. Column
		(Item Nos. C282, C369, C370, C151 thru C383, C702)	2,3	ea	16				2	2	3	48	45		See Desc. Column
		(Item Nos. C240, C244, C252, C253, C254, C257, C258, C261, C369, C370, C702, C1307)	4	ea	12				2	2	3	39	36		See Desc. Column
P-H-- 51		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C220JN1	2,3	ea	1				*	*	2	13	6		C316
			4	ea	5				2	2	3	18	15		C811, C1405, C1410, C1412, C1416
P-H-- 52		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E220JN1	4	ea	1				*	*	*	5	3		C903
P-H-- 53		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM205220KN1	1	ea	2				*	*	2	10	6		C268, C274
			2,3	ea	3				*	2	2	13	9		C211, C268, C274
			4	ea	2				*	*	2	10	6		C211, C291
P-H-- 54		CAPACITOR, FI XED MICA DIELECTRIC: 81349; CM15B270KN1 (Item Nos. C204, C213, C214, C226, C230, C238, C265, C267, C270, C272, C273, C2715 C277, C278)	1,2,3	ea	14				2	3	5	43	42		See Desc Column
			4	ea	5				*	2	2	19	15		C213, C214, C226, C230, C387
P-H-- 55		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C270JN1	4	ea	6				*	2	2	21	18		C802, C905, C906, C907, C908,C1411
P-H-- 56		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C330JN1	4	ea	2				*	*	2	10	6		C1414, C1419
P-H-- 57	5910-100-8141	CAPACITOR, FIXED , MICA DIELECTRIC: 81349; CM20B330K	2,3	ea	1				*	*	*	5	3		C338
P-H-- 58		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E390GN1	4	ea	1				*	*	*	5	3		C320
P-H-- 59		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E390JN1	4	ea	9				2	2	3	31	27		C810, C813, C902. C909 thru C912, C917, C1313

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1 Nov 68 6048 (Previous edition is obsolete) AN/USM-26, AN/USM-26A ESC-FM 4534-68

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6)(b) 21-50	(6)(c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7)(b) 21-50	(7)(c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10)(b) ITEM NO.
P-H--60	5910-100-8130	CAPACITOR. FIXED MICA DIELECTRIC: 81349; CM20B390K	1,2,3	ea	4				*	2	2	16	12		C219, C264, C279, C281
P-H-61	5910-636-2104	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C470J	2,3	ea	6				2	4	7	83	90		C2102, C2103, C2106, C2107, C2110, C2111
P-H-62		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E470JN1	4	ea	7				*	2	2	26	24		C808, C814, C815. C816, C904, C1402, C1417
P-H--63		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B470JN1	1	ea	6				*	2	2	16	12		C222, C225, C231, C232, C320, C1103
			2,3	ea	5				*	2	2	28	24		C222, C225, C232, C320, C1103
			4	ea	3				*	2	2	16	12		C225, C232, C1103
P-H--64	5910-270-4828	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C510J (Item Nos. C3102, C3103, C3106, C3109, C3110, C3111, C3113, C3114, C3115, C3118)	2,3	ea	10				3	7	13	153	198		See Desc. Column
P-H--65		CAPACITOR, FIXED, MICA DIELECTRICAL: 81349; CM15B560KN1	2,3	ea	2				*	*	2	10	6		C231, C330
			4	ea	1				*	*	*	5	3		C231
P-H--66	5910-666-8898	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C560J	2,3	ea	10				2	2	3	33	30		C2114, C2115
P-H-67		CAPACITOR, FIXED. MICA DIELECTRIC: 81349; CM20C620JN1	1,2,3,4	ea	2				*	*	2	10	6		C309, C311
P-H-68	5910-636-2155	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C680J	1,2.3	ea	5				2	2	3	41	39		C609, C810, C811, C2105, C2109
P-H--69		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C750JN1	1	ea	1				*	*	*	5	3		C917
			2	ea	1				*	*	2	10	6		C3105
			3	ea	1				2	2	3	39	36		C3107
			4	ea	2				*	2	2	10	6		C812, C918
P-H--70		CAPACITOR. FIXED, MICA DIELECTRIC: 81349; CM15B820KN1	1.2,3	ea	3				*	2	2	13	9		C223, C300, C1105
			4	ea	2				*	*	2	10	6		C223, C1105
P-H--71		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CH15C820J	2,3	ea	2				2	2	3	33	30		C2117, C2118
P-H--72	5910-174-9967	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15B101K	1.2,3	ea	1				*	*	*	5	3		C315
P-H--73		CAPACITOR. FIXED, MICA DIELECTRIC: 81349; CM15C101J	1	ea	1				*	*	*	5	3		C901
			2	ea	2				2	2	3	35	33		C2101, C2103
P-H--74		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E101JN1	1	ea	6				*	2	2	21	18		C315, C801, C804, C805, C806, C809
P-H--75	5910-951-7074	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E101JP3	1	ea	7				*	2	2	28	24		C208, C295, C319, C321, C323, C325, C1101
			2,3	ea	9				2	2	3	33	30		C208, C299, C319, C321, C323, C325, C327. C1101
			4	ea	3				*	2	2	13	9		C208, C264, C1320
P-H--76		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E111JN1	4	ea	1				*	*	*	5	3		C1312
P-H--77		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B151KN1	1,2,3,4	ea	1				*	*	*	5	3		C1108

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	(3) USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALW PER EQUIP CNTGY	(9) DEPOT MAINT ALW PER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H--78	5910-112-7712	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM25D151J	1,2,3	ea	1				*	*	*	5	3		C336
P-H--79	5910-101-5582	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B181K	2,3	ea	2				*	*	2	10	6		C331, C803
			4	ea	1				*	*	*	5	3		C331
P-H--80		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15E221JN1	1	ea	1				*	*	*	5	3		C305
			2,3,4	ea	4				*	2	2	16	12		C305, C307, C312. C313
P-H--81		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B271KN1	4	ea	5				*	2	2	19	15		C319, C321, C323, C325, C327
P-H--82		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B391KN1	2,3	ea	1				*	*	2	10	6		C1102
P-H--83		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20E391GN1	4	ea	1				*	*	*	5	3		C322
P-H--84		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B471KN1 (Item Nos. C227, C228, C241, C242, C263, C290, C297, C322, C333, C340)	1,2,3	ea	10				2	2	3	33	30		See Desc, Column
			4	ea	5				*	2	2	19	15		C227, C225, C241, C242, C290
P-H--85		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30B561KN1	1,2,3	ea	1				*	*	*	5	3		C237
			4	ea	2				*	*	2	10	6		C237, C1005
P-H--86		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B681KN1	4	ea	1				*	*	*	5	3		C1304
P-H--87		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30B681K	1,2,3,4	ea	2				*	*	2	10	6		C247, C248
P-H--88		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM20B821JN1	4	ea	1				*	*	*	5	3		C1308
P-H--89		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30B102KN1	1,2,3	ea	2				*	*	2	10	6		C259, C260
			4	ea	3				*	2	*	13	9		C259, C263, C1003
P-H--90		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30E102FN1	4	ea	1				*	*	*	5	3		C333
P-H--91	5910-101-3984	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30B182K	1,2,3,4	ea	2				*	*	2	10	6		C255, C256
P-H--92		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30B332KN1	1,2,3	ea	1				*	*	*	5	3		C701
			4	ea	1				*	*	2	10	6		C236
P-H--93		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30E392GN1	4	ea	1				*	*	*	5	3		C324
P-H--94		CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM30B472KN1	1.2.3,	ea	3				*	*	2	13	9		C236, C256, C324
			4	ea	1				*	*	*	5	3		C286
P-H--95	5910-578-5527	CAPACITOR, FIXED, OXIDE DIELECTRIC: 78488; GAO.47UU	1,2,3	ea	1				*	*	*	5	3		C301
P-H--96		CAPACITOR, FIXED, OXIDE DIELECTRIC: 00346; JM1.0	4	ea	1				*	*	*	5	3		C301
P-H--97	5910-578-5528	CAPACITOR, FIXED, OXIDE DIELECTRIC: 78488; GA3 1.5UU	1,2,3,4	ea	3				*	2	2	13	9		C306, C310, C314
P-H--98	5910-578-5530	CAPACITOR, FIXED, OXIDE DIELECTRIC: 78488; CA-42.2UU	2,3	ea	1				*	*	*	5	3		C329

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H--99		CAPACITOR, FIXED, OXIDE DIELECTRIC: 00346; JN6.8	4	ea	1				*	*	*	5	3		C703
P-H--100		CAPACITOR, FIXED PAPER DIELECTRIC: 81349; CP05A1EF332KN1	4	ea	1				*	*	2	8	5		J701
P-H--101		CAPACITOR, FIXED, PAPER DIELECTRIC: W0346; 22A1PE393G	4	ea	1				*	*	2	8	5		C326
P-H--102	5910-196-2501	CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP54B1FF503K	1,2,3	ea	1				*	*	*	5	3		C326
P-H--103		CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP04A1KE104K	4	ea	1				*	*	2	8	5		C1001
P-H--104	5910-543-9502	CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP05A1KF104K3	4	ea	3				*	2	2	18	15		C1006, C1302, C1319
P-H--105		CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP05A1KF104K1	4	ea	1				*	*	2	8	5		C201
P-H-106	5910-112-7643	CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP26A1EF104M	1,2,3	ea	2				*	*	2	10	6		C201, C352
P-H-107		CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP54B4EG104V	1,2,3,4	ea	1				*	*	*	5	3		C220AB
P-H--108	5910-822-2579	CAPACITOR, FIXED. PAPER DIELECTRIC: 81349; CP05A1KE224K3	1,2,3,4	ea	2				*	*	2	10	6		C209, C317
P-H-109		CAPAC ITOR, FIXED, PAPER DIELECTRIC 81349; CP54B6EF254V	1,2,3	ea	4				*	2	2	16	12		C343AB, C348AB, C350AB, C351
			4	ea	2				*	*	*	10	6		C343, C348
P-H-110		CAPACITOR, FIXED, PAPER DIELECTRIC: 00346; 22A1PE394G	4	ea	1				*	*	2	8	5		C328
P-H--111		CAPACITOR, FIXED, PAPER DIELECTRIC: 00346; P150F424	4	ea	2				*	2	2	13	10		C1501, C1502
P-H--112	5910-112-7117	CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP54B1FF504K	1,2,3	ea	2				*	*	2	10	6		C328, C344AB
P-H--113		CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP61B1EF105K	1,2,3	ea	2				*	*	2	10	6		C366, C367
P-H--114	5910-129-9237	CAPACITOR, FIXED, PAPER DIELECTRIC: 81349; CP41B1FF405K	1,2,3,4	ea	1				*	*	*	5	3		C216
P-H--115	5910-126-1584	CAPACITOR, VARIABLE, AIR DIELECTRIC: 81349; CT1C025	1,2,3	ea	1				*	*	*	5	3		C204
P-H--116		CAPACITOR, VARIABLE, AIR DIELECTRIC: 81349; CT1C100	1,2,3	ea	2				*	*	2	10	6		C295, C196
P-H--117		CAPACITOR, VARIABLE, AIRDIAL ELECTRIC: 81349; CT13E057J	4	ea	1				*	*	*	5	3		C1314
P-H-118		CAPACITOR, VARIABLE, AIR DIELECTRIC: 81349; CT13E143J	4	ea	1				*	*	*	5	3		C1315
P-H-119	5910-578-1623	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: 81349; CV11C450	1,2,3	ea	1				*	*	*	5	3		C335
			4	ea	1				*	*	*	5	3		C316
P-H-120	5950-615-3262	CHOKE, RADIO FREQUENCY: 99800; 3500-38	2,3	ea	1				*	*	*	5	3		L225
P-H--121		COIL, RADIO FREQUENCY: 00346; 524B-S-412-8	1,2,3,4	ea	1				*	*	2	13	10		L201, L1101
P-H-122		COIL, RADIO FREQUENCY: 00346; 524B-S-412-9	1,2,3,4	ea	2				*	2	2	13	10		L202, L110
P-H-123		COIL, RADIO FREQUENCY: 00346; 524B-S-446-1	1,2,3,4	ea	4				*	2	2	21	20		L203. L204, L208, L1103
P-H--124		COIL, RADII FREQUENCY: 00346; 524-B-S-412-7	1,2,3	ea	2				*	*	2	13	10		L205, L209

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1)	(2)	(3)		(4)	(5)	(6)			(7)			(8)	(9)	(10)	
SMR CODE INDEX NO	FEDERAL STOCK NUMBER	DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	UNIT OF MEAS	QTY INC IN UNIT	30 DAY DS MAINT ALLOWANCE (a) 1-20	(b) 21-50	(c) 51-100	30 DAY GS MAINT ALLOWANCE (a) 1-20	(b) 21-50	(c) 51-100	1-YR ALWPER EQUIP CNTGY	DEPOT MAINT ALWPER 100 EQUIP	ILLUSTRATION (a) FIG. NO.	(b) ITEM NO.
P-H-- 125		COIL, RADIO FREQUENCY 00346; 524B-S-412-4	1,2,3,4	ea	1				*	*	2	8	5		L206
P-H-- 126		COIL, RADIO FREQUENCY: 00346; 50M-S-494	1,2,3	ea	2				*	*	2	13	10		L207, L210
			4	ea	1				*	*	2	8	5		L207
P-H-- 127		COIL, RADIO FREQUENCY: 00346; 524B-S-412-3	4	ea	1				*	*	2	8	5		L209
P-H-- 128	5950-607-3845	COIL, RADIO FREQUENCY: 80667; A-17497-2	1,2,3	ea	1				*	*	*	5	3		L211
P-H-- 129		COIL, RADIO FREQUENCY : 00346; 50M-S-524	4	ea	1				*	*	2	8	5		L211
P-H-- 130	5950-556-1795	COIL, RADIO FREQUENCY: 80667; A-17497-4	1,2,3	ea	2				*	*	2	10	6		L212, L213
P-H-- 131		COIL, RADIO FREQUENCY: 00346; 50M-S-524-4	4	ea	3				*	2	2	18	15		L212, L213, L1301
P-H-- 132	5950-556-1796	COIL, RADIO FREQUENCY: 80667; A17497-1	1,2.3	ea	2				*	*	2	10	6		L214, L215
P-H-- 133		COIL, RADIO FREQUENCY: 00346; 50M-S-524-1	4	ea	2				*	2	2	13	10		L214, L215
P-H-- 134	5950-556-1787	COIL, RADIO FREQUENCY: 80667; A-17497-3	1,2,3	ea	2				*	*	*	5	3		L216, L217
P-H-- 135		COIL, RADIO FREQUENCY: 00346; 50M-S-524-3	4	ea	2				*	2	2	13	10		L216. L217
P-H-- 136	5950-578-5674	COIL, RADIO FREQUENCY: 80667; A-17190	1,2.3	ea	2				*	*	2	10	6		L218, L224
P-H-- 137		COIL, RADIO FREQUENCY: 00346; 509-S-524-5	4	ea	2				*	2	2	13	10		L218, L224,
P-H-- 138		COIL, RADIO FREQUENCY: 00346; 524B-S-413-6	1,2,3,4	ea	1				*	*	2	8	5		L222
P-H-- 139	5950-578-5676	COIL. RADIO -FREQUENCY 80667; A- 17792	1,2,3	ea	1				*	*	*	5	3		L223
P-H-- 140		COIL, RADIO FREQUENCY: 00346; 524B-S-412-13	4	ea	1				*	*	2	8	5		L226
P-H-- 141		COIL, RADIO FREQUENCY: 00346; 524B-S-412-11	4	ea	1				*	*	2	8	5		L227
P-H-- 142		COIL, RADIO FREQUENCY: 00346; 524B-S-412-12	4	ea	1				*	*	2	8	5		L228
P-H-- 143		COIL, RADIO FREQUENCY: 00346; 524B-S-413-3	1,2,3,4	ea	1				*	*	2	8	5		L1104
P-H-- 144	5935-082-0481	CONNECTOR; RECEPTACLE, ELECTRICAL 07497; 26-4200-165	1,2,3, 4	ea	1				*	*	2	10	6		J201
P-H-- 145	5935-666-4791	CONNECTOR, RECEPTACLE, ELECTRICAL 07497; 26-4200-8S	1,2,3,4	ea	1				*	*	2	10	6		J202
P-H-- 146	5935-201-3511	CONNECTOR RECEPTACLE ELECTRICAL: UG-290/U	1,2,3	ea	1				*	*	*	5	3		J204
P-H-- 147	5935-149-2726	CONNECTOR RECEPTACLE ELECTRICAL: UG-291/U	1,2,3	ea	2				*	*	2	10	6		J203, J205
P-H-- 148	5935-565-0067	CONNECTOR RECEPTACLE, ELECTRICAL: 80058; UG-910/U	4	ea	2				*	*	2	10	6		J203, J205
P-H-- 149	5935-843-9008	CONNECTOR, RECEPTACLE, ELECTRICAL: 80058; UG-1094A/U	4	ea	1				*	*	2	5	3		J1301
P-H-- 150	5935-149-3466	CONNECTOR, RECEPTACLE, ELECTRICAL: 81349; MS3102A16S-1P	4	ea	2				*	2	2	10	6		P201, P202
P-H-- 151	5935-187-0624	CONNECTOR, RECEPTACLE ELECTRICAL: 07497; 86-CP8T	1,2,3	ea	3				2	2	3	33	30		P701, P801, P901
			4	ea	1				*	2	2	16	12		P1101

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(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALW PER EQUIP CNTGY	(9) DEPOT MAINT ALW PER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 152		CONNECTOR, RECEPTACLE ELECTRICAL: 00346; 86CP-11T	4	ea	1				*	*	*	5	3		P1401
P-H-- 153	5935-169-2962	CONNECTOR, RECEPTACLE ELECTRICAL: 81349; AN3102A-10SL-3P	4	ea	1				*	*	*	5	3		J206
P-H-- 154	6680-605-7224	COUNTER, ELECTRICAL: 80667; D-18418	1,2,3	ea	1				*	*	2	5	3		Z204
P-H-- 155		COUNTER, ELECTRICAL: 00346; 35-Z-204	4	ea	6				*	2	2	21	18		Z204 thru Z209
P-H-- 156		COUNTER, ELECTRICAL: 80667; D-19148	1,2	ea	5				*	2	2	19	15		Z205 thru Z209
P-H-- 157	3010-629-7045	COUPLING, SHAFT, FLEXIBLE 80667; A-17573	1,2,3	ea	2				*	*	*	5	4		
P-H-- 158	6625-031-0991	COVER, CRYSTAL OVEN: 80667; B-19606	1,2	ea	1				*	*	*	5	3		
P-H-- 159	5935-252-6340	COVER, ELECTRICAL CONNECTOR CW-123/U:	1,2,3	ea	5				*	2	2	12	10		
P-H-- 160	5955-605-5476	COVER, OVEN BODY: 80667; A-19598	1	ea	1				*	*	*	5	2		
P-H-- 161	5955-605-7200	CRYSTAL UNIT, QUARTZ: 00775; 74G	2,3	ea	1				*	*	2	8	5		Y201
P-H-- 162		DELAY LINE: 80667; B-17394	1,2,3	ea	1				*	*	2	8	5		DL201
P-H-- 163		DELAY, LIRE: 05621; 35-DL-201	4	ea	1				*	*	*	2	5		DL201
P-H-- 164		DISCRIMINATOR ASSEMBLY, AMPLITUDE: 80667; C-17823	1,2,3	ea	1				*	*	*	5	3		Z202
P-H-- 165		DISCRIMINATOR ASSEMBLY, AMPLITUDE: 00346; 35-Z-202	4	ea	1				*	*	*	5	3		Z202
P-H-- 166		DIVIDER ASSEMBLY, DECADE: 10346; 35-Z-203	4	ea	1				*	*	*	5	3		Z201
P-H-- 167	5960-262-3763	ELECTRON TU BE: 81349; OB2WA	1,2,3,4	ea	1				2	3	6	63	100		V261
P-O-- 168	5960-193-5111	ELECTRON TUBE: 81349; 5R4WGY	1,2,3	ea	3				3	9	16	233	300		V249, V250, V251
P-O-- 169		ELECTRON TUBE: 81349; 5Y3WGT	1,2,3	ea	1				2	3	5	54	100		V257
P-H-- 170	5960-542-7004	ELECTRON TUBE: 81349; 6AH6WA	1,2,3	ea	7				10	25	47	585	1200		V203, V206, V207, V210, V211, V217, V239
			4	ea	7				10	25	47	505	1200		V203, V016, V207, V210, V211, V217,
P-H-- 171	5960-262-0152	ELECTRON TUBE: 81349; 6AUGWA	1,2,3	ea	5				3	9	16	179	500		V234, V237, V238, V252, V260
			4	ea	6				4	10	10		600		V237, V238, V252, V260, V1301, V1302
P-O-- 172	5960-230-5307	ELECTRON TUBE: 81349; 6CB6	1,2,3	ea	6				20	22	42	508	600		V212, V213, V215, V216, V218, V240
			4	ea	6				20	22	42	508	600		V212, V213, V215 V216, V218, V239
P-O-- 173	5960-262-0167	ELECTRON TUBE: 01349; 12AT7WA	1,2,3,4	ea	3				2	6	11	138	300		V201, V256, V701
P-H-- 174	5960-262-1357	ELECTRON TUBE: 81349; 5654/6AK5W	1,2,3	ea	2				5	12	22	269	600		V1102, V1103
			4	ea	2				2	6	11	142	200		V1102, V1103
P-H-- 175	5960-827-8781	ELECTRON TUBE: 81349; 5687WA	1,2,3,4	ea	1				2	2	4	46	100		V255

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(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOW ANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-O 176	5960-237-6917	ELECTRON TUBE: 81349; 5725/6AS6W	1,2,3	ea	7				4	11	20	252	700		V202, V214, V241, V243, V244, V246 V247
			4	ea	8				5	13	25	287	800		V202, V214, V241, V243, V244, V246, V247, V1303
P-H- 177	5960-879-5078	ELECTRON TUB E: 81349; 5726/6AL5W	1,2,3,4	ea	3				3	9	16	233	300		V235, V242, V245
P-O 178	5960-284-9285	ELECTRON TUBE: 81349; 5727/2L21W	1,4	ea	2				5	13	25	344	200		V205, V209
			2,3	ea	1				5	13	25	344	200		V205
P-H-- 179	5960-272-8548	ELECTRON TUBE: 81349; 5844	1,2,3,4	ea	1				2	3	6	63	100		V702
P-H-- 180		ELECTRON TUBE: 18714; 5963													
		(Item Nos. V204, V208, V219, V220, V221, V222, V223, V236, V248, V801 thru V804 V901 thru V904, V1101, V2101 thru V2104, V3101 thru V3 104)	1,2,3	ea	39				39	92	179	2052	4110		See Desc. Column
		(Item Nos. V204, V098, V236, V248, V801 thru V804, V901 thru V904, V1101, V1200 thru V1203)	4	ea	17				16	37	71	901	1700		see Desc. Column
P-O 181	5960-669-6861	ELECTRON TUBE: 81349; 6005/6AQ5W	1,2,3,4	ea	2				2	4	8	100	200		V258, V259
P-O 182		ELECTRON TUBE: 81349; 6080WA	1,2,3,4	ea	2				2	6	11	130	200		V253, V254
P-H-- 183	5960-296-3371	ELECTRON TUBE: 81349; 6211	4	ea					6	16	29	320	400		V1401, V1402 V1403 V1404
P-H-- 184	4140-555-8322	FAN ASSEMBLY: 80667; D-17734	1,2,3	ea	1				*	*	*	5	3		
P-H-- 185	5915- 605-5487	FILTER, RADIO INTERFERENCE: 80667; C-17828	1,2,3	ea	1				*	*	2	8	5		FL201
P-H-- 186		FILTER, NETWORK: 00346; FA-9836	4	ea	1				*	*	2	8	5		FL201
P-O 187		FUSE, CARTRIDGE: 71400; MDF6.25	1,2,3,4	ea	2				4	11	20	242	200		F201, F202
F-H 188		FUSEHOLDER: 00346; HKP-H	1,2,3,4	ea	2				*	*	2	10	6		XF201A; XF202A
P-H-- 189	4140-555-8321	IMPELLOR, FAN, CENTRIFUGAL: 90667; B-17578	1.2,3	ea	1				*	*	*	4	2		0318A
P-H-- 190	5970-175-2736	INSULATOR, STANDOFF: 72656; 1023-04-3/4	1,2,3	ea.	11				*	2	2	20	22		
P-H-- 191		INSULATOR: 00346; NS5W106	4	ea	3				*	*	2	13	9		E274 thru 9276
P-H-- 192	5970-578-4018	INSULATOR, STANDOFF: 80667; A-17281	1,2,3	ea	4				*	*	2	10	8		
P-O 193		KNOB: 80667; A-17872	1,2,3,4	ea	1				*	2	2	13	9		
P-O 194	5355-559-3891	KNOB: 80667; A-17871	1,2,3,4	ea	2				*	*	2	10	6		
P-O 195	5355-579-3175 75376; s-308-64-SL-D-522	KNOB:	1,2,3,4	ea	1				*	2	2	13	9		
P-H-- 196	6240-223-9130	LAMP, GLOW: 24446; NE-S1	1,2,3	ea	1				*	2	2	19	100		I201
			4	ea	1				*	2	2	19	100		DS201
P-H-- 197	6240-179-1811	LAMP, GLOW: 24446; NE-2	1,2,3	ea	10				*	2	2	19	100		D0901B thru DL910B

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P-H-- 198		LAMP, GLOW: 00346; NE-23	4	ea	30				6	16	29	352	1500		DS901 thru DS910 DS1200 thru DS1209 DS1401 thru DS1410
P-O-- 199	6240-155-8706	LAMP, INCANDESCENT: 24446; 47	1,2,3	ea	7				2	5	10	95	50		I202 thru I208
			4	ea	7				2	5	10	95	50		DS202 thru DS208
P-H-- 200	6250-283-9741	LAMPHOLDER: 81349; LH22XX0	1,2,3	ea	5				*	2	2	26	21		X1202 thru- X1206
P-H-- 201		LAMPHOLDER: 00346; 7-06	4	ea	5				*	2	2	19	15		XDS202, XDS203, XDS204, XDS205, XDS206
P-O-- 202		LENS, INDICATOR LIGHT: 00346; 25P-323C	4	ea	1				*	*	*	5	3		XDS201B
P-O-- 203		LENS, INDICATOR LIGHT: 00346; 25P-323W	4	ea	1				*	*	*	5	3		XDS207B
P-O-- 204		LENS, INDICATOR LIGHT: 00346; 25F-323R	4	ea	2				*	*	2	10	6		XDS208B
P-H-- 205		LIGHT, INDICATOR: 00346; 422-000	4	ea	4				*	2	2	16	12		XDS201A, XDS207A, XDS208A, XDS209A
P-O-- 206	6210-243-0056	LENS, INDICATOR LIG HT: 72619; 81-117	1,2,3	ea	2				*	*	*	5	4		X1201A thru X1207A
P-O-- 207	6210-247-1778	LENS, INDICATOR, LIGHT: 72619; 81-111	1,2,3	ea	1				*	*	*	4	3		X1208A
P-H-- 208	6210-036-2564	LIGHT, INDICATOR: 72619; 81410-1	1,2,3	ea	3				*	2	2	16	12		X1201, C1207, X1208
P-H-- 209	6105-557-8999	MOTOR, DIRECT CURRENT 80667; A-17560	1,2,3	ea	1				*	*	2	8	5		B201A
P-H-- 210	5955-605-5455	OVEN BASE ASSEMBLY, CRYSTAL: 80667; C-08607	1,2,3	ea	3				*	*	2	8	5		
P-O-- 211	5955-583-1875	OVEN, CRYSTAL ASSEMBLY: 80667; C-18463	1,2,3	ea	1				*	*	*	5	3		
P-H-- 212	5952-570-5545	REACTOR: 80667; C-17402	1,2,3	ea	1				*	*	2	8	5		L219
P-H-- 213		REACTOR: 00346; 50M-L-572	4	ea	1				*	*	2	8	5		L219
P-H-- 214		REACTOR: 80667; B-17396	1,2,3	ea	1				*	*	2	8	5		L221
P-H-- 215		REACTOR: 00346; 50M-M-240	4	ea	1				*	*	2	8	5		L221
P-H-- 216	6130-557-8955	RECTIFIER, METALLIC: 84979; 4N26-5B1-AC	1,2,3	ea	1				*	*	2	8	5		F60
P-H-- 217	6625-676-1322	REFLECTOR: 80667; A-17535	1,2,3	ea	7				*	2	2	15	14		
P-H-- 218	5905-086-3008	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF1O1K	1	ea	2				*	2	2	21	20		R434, R535
			2,3	ea	2				*	2	2	21	20		R535, R1134
			4	ea	2				*	2	2	21	20		R535, R1025
P-H-- 219	5905-279-3513	RESISTOR, FIXED, COMPOSITION: 81349; RC200F221J	4	ea	1				*	*	2	8	5		R434
P-H-- 220	5905-185-6966	RESISTOR, FIXED, COMPOSITION: 81349; RC20CF271K	1,2,3,4	ea	1				*	*	2	8	5		R703
P-H-- 221	5905-279-1890	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF391J	4	ea	1				*	*	2	8	5		R1023
P-H-- 222	5905-170-2005	RESISTOR, FIXED, COMPOSITION: 81349; RC200F471K	1,2,3,4	ea	1				*	*	2	8	5		R481

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P-H-- 223	5905-195-6817	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF102K	1,2,3	ea	9				2	3	6	46	50		R204, R494, R500 R504, R507, R508, R512, R515, R1107
		(Item Nos. R204, R494, R500, R504, R507, R508, R512, R515. R712, R1010, R1013, R1016, R1019, R1022, R1107, R1311)	4	ea	16				2	3	6	69	80		See Desc. Column
P-H-- 224	5905-195-5514	RESISTOR, FIXED, COMPOSITION: 81349; RC 200F152K	1,2,3	ea	2				*	*	2	13	10		R246, R286
			4	ea	2				*	*	2	13	12		R286, R541
P-H-- 225	5905-279-1876	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF222J	1,2,3,4	ea	1				*	*	2	8	5		R209
P-H-- 226	5905-060-2326	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF562K	1,2,3,4	ea	2				*	2	2	13	10		R242, R1119
P-H-- 227	5905-279-2673	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF622J	4	ea	1				*	*	2	8	5		R704
P-H-- 228	5905-185-8510	RESISTOR, FIXED , COMPOSITION: 81349; RC20GF103J	4	ea	3				*	2	2	21	20		R287, R489, R1118
			2,3	ea	4				*	2	2	27	25		R287, 8489, R1118, R3424
P-H-- 229	5905-279-3502	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF123J	1,2,3	ea	2				*	2	2	13	10		R3111, R3137
			4	ea	6				2	2	6	30	30		R805, R1009, R1012, R1015, R1018, R1021
P-H-- 230	5905-107-5445	RESISTOR, FIXED, COMPOSITION: 81349;RC20GF153J	1,2,3	ea	8				2	2	3	39	40		R919, R920, R943, thru R946, R1206, R3148
		(Item. No. R919, R1920, R943 thru 8946, 81206, 81220, 81235, 81250, 81323, R1441)	4	ea					2	3	5	54	60		See Desc. Column
P-H-- 231	5905-279-3500	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF183J	2	ea	4				2	4	7	90	110		R2111, R2124, R3106
			3	ea	2				*	2	2	30	30		R3106, R3107
P-H-- 232	5905-171-2004	RESISTOR, FIXED, COMPOSITION: 81349, RC20GF2231	1	ea	1				*	*	2	8	5		R289
			2,3	ea	3				*	2	2	18	15		R289, R3104, R3105
			4	ea	3				*	2	2	21	20		R289, R318, R1101
P-H-- 233	5905-279-3499	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF273J	1	ea	12				2	3	5	54	60		R901 thru R312
			2,3	ea	2				2	2	3	31	30		R2106, R2107
			4	ea	5				*	2	2	21	20		R801, R806, R917 R918, R1102
P-H-- 234	5905-249-4256	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF363J	4	ea	3				*	2	2	18	15		R287, R831, R1414
P-H-- 235		RESISTOR, FIXED, COMPOSITION: 81349; RC20GF393J	2,3	ea	1				2	2	3	30	30		R3151
			4	ea	5				*	2	2	27	25		R1209, R1222, R1315 R1422, R1438
P-H-- 236	5905-279-3498	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF473J	4	ea					*	2	2	21	20		R811, R814, R819
P-H-- 237	5905-254-9201	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF473J	1,2,3	ea	1				*	2	2	13	10		R1112
		(Item Nos. R540, R921 thru R926, R1112, R1201, R1210, R1215, R1224, R1230, R1238, R1246, R1254, R1317, R1318, R1319)	4	ea	19				2	4	7	83	100		See Desc. Column

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 238	5905-171-1986	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF563J	2	ea	2				2	3	6	65	75		R21014, R2105
			4	ea	8				2	2	3	65	75		R205, R287, R711, R953, R954, R955, R956, R1316
P-H-- 239	5905-853-412 3	RESISTOR, FIXED COMPOSITION: 81319; RC20GF683J	4	ea					*	*	2	8	5		R335
P-H-- 240	5905-254-7097	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF823K	2,3,4	ea	1				*	2	2	13	10		R1104
P-H-- 241	5905-254-7100	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF913J	1,2,3	ea	9				2	2	3	42	45		R803, R807. R814, R815, R821, R824, R828, R3110 R3112
P-H-- 242	5905-195-6761	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF104J	1	ea	7				2	3	5	54	61		R913, R917, R926, R930, R937, R941, R950
			2	ea	9				2	3	6	72	85		R2110, R2112, R2123, R3135, R3136, R3138, R3147, R31149, R3150
			3	ea	6				3	7	13	160	210		R3123, R3125, R3138, R3147, R3149, R3150
		(Item Nos. R538, R803, R808, R809, R817. R818, R826, 8828, R833, R935 thru R942, R1203, R1203, R1217, R1232, 91256. R1404, R1410, R1418, 921429, R1436, R1446, R1451, R1460)	4	ea	30				2	5	10	118	150		See Desc. Column
P-H-- 243	5905-192-3981	RESISTOR, FIXED, COMPOSITION: 81349; RC20CF124J	1	ea	1				*	*	2	8	5		R831
			2, 3	ea	3				2	3	5	54	61		R831, R3101, R3102
P-H-- 244	5905-279-2522	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF154J	2	ea	8				3	7	13	153	200		R2101, R2102, R2103, R2125, R2136, R2138, R2147, R2149
			4	ea	1				*	*	2	8	5		R947
P-H-- 245	5905-192-0660	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF184J	4	ea	1				*	*	2	8	5		R948
P-H-- 246	5905-192-0667	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF224J	1	ea	1				*	*	2	8	5		R830
		(Item Nos. R2114, R2115, R2117, R2118, R2127, R2128, R2130, R2131 R2140, R2142, R2150, R3114, R3115, R3110. R93118. R3127, R3128, R3130, R3131. R3140, R3142, 9830)	2	ea	2				3	7	13	169	198		See Desc. Column
		(Item Nos. R335, R3114, R3115, R3117, R3118, R3127, R3128, R3130, R3131, R3140. R3142)	3	ea	10				3	7	13	169	198		See Desc. Column
		(Item Nos. R288, R901 thru R912, R1024, R1205. R1208, R1218, R1219, R1221, R1223, R1234, R1236, R1248, R1249, R1251, R1253. R1305, R1402, R1413, R1420, R1421, R1425, R1426, R1432, R1442, R1443, R1449, R1453. R1457, R8158)	4	ea	10				3	7	13	153	200		See Desc. Column
P-H-- 247	5905-279-2521	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF244J	1,2.3	ea	9				2	2	3	42	45		R802, R806, R809, R813, R816, R820, R823, R827, R830
P-H-- 248	5905-190-8865	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF274J	1,2,3	ea	6				2	2	3	39	40		R3108, R3109, R3121. R3122, R3145, R3146
		(Item Nos. R802, R807, R810, R815, R821, R822, R825. R828, R832, R927 thru R934, R1202, R1216, R1231, R1255)	4	ea	21				2	4	7	87	105		See Desc. Column

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SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H--249	5905-279-2519	RESISTOR, FIXED, COMOSITIOR: 81349; RC20GF334J	2	ea	8				3	7	13	153	200		R2108, R2109, R2121, R2122, R2134, R2135, R2145, R2146
			4	ea	5				*	2	2	18	15		R709, R1213, R1227, R1241, R1244
P-H--250	5905-279-2520	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF364J	4	ea	3				*	2	2	13	10		R1211, R 1225. R1247
P-H--251	5905-185-6944	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF394K	1,2.3	ea	1				*	*	2	8	5		R1106
			4	ea	5				*	2		27	25		R230, R1005. R1106 R1415, R1411
P-H--252	5905-279-2515	RESISTOR, FIXED, COMPOSITIOR: 81349; RC20GF474J	1,2,3	ea	2				*	2	2	27	25		R429, R430
			4	ea	7				*	*		34	35		R232, R240, R428, R429, R430, R1308, R1312
P-H--253	5905-221-5848	RESISTOR, FIXED, COMPOSITION: 81349; RC2 0GF824K	4	ea	4				*	2	2	21	20		R12.4, R1207, R1401, R1412
P-H--254	5905-192-0390	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF105J	1	ea	6				2	2	3	42	45		R202, R206, R210, R419, R486, R488
			2,3	ea	5				2	2	3	42	45		R202, R206, R210, R419, R488,
			4	ea	6				2	2	3	42	45		R202, R210, R241, R284, R486, R488
P-H--255	5905-190-8874	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF125J	4	ea	1				*	*	2	8	5		R489
P-H--256	5905-279-1873	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF185J	1,2,3	ea	4				*	2	2	27	25		R435, R455, R464, R473
			4	ea	5				*	2	2	27	25		R435, R446, R455 R464, R473
P-H--257	5905-295-3403	RESISTOR, FIXED, COMPOSITION: 81349; RC20OF225K	1,2,3,4	ea	1				*	*	2	8	5		R1120
P-H--258	5905-279-1883	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF335J	4	ea	5				*	2	2	21	25		R1212, R1226, R1240, R1242, R1243
P-H--259	5905-279-1749	RESISTOR, FIXED, COMPOSITION: 81349; Rc20GF625J	4	ea	1				*	*	2	8	5		R1200
P-H--260	5905-279-1865	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF106K	4	ea	1				*	*	2	8	5		R1004
P-H--261	5905-259-2990	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF226i	1,2,3,4	ea	2				*	2	2	13	10		R203. R207
P-H--262	5905-279-1686	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF5603	1,2,3	ea	2				*	2	2	13	10		R283, R407
			4	ea	1				*	*	2	8	5		R407
P-H--263	5905-279-2643	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF101J	1.2.3	ea	4				*	2	2	21	20		R236, R244, R278. R414
			4	ea	3				*	2	2	18	15		R236, R244, R414
P-H--264		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF121K	1,2,3,4	ea	1				*	*	2	8	5		R239
P-H--265	5905-299-2055	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF181K	1,2,3	ea	3				*	2	2	18	15		R285, R297. R298
			4	ea	1				*	*	1	8	5		R285
P-H--266		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF221K	1,2,3	ea	7				2	2	3	34	35		R311, 9312, R331, R332, 9342, R343, R400
			4	ea	6				2	2	3	30	30		R311, R312, R331, R332, R342, R343
P-H--267	5905-279-1725	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF241J	2,3,4	ea	1				*	*	2	8	5		R261

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 268	5905-279-2628	RERISTOR, FIXED, COMPOSITION: 81349; RC32GF271J	1	ea	4				*	2	2	21	20		R253, R321, R482, R483
			2,3,4	ea	5				*	2	2	27	25		R216, R253, R321, R482, R483
P-H-- 269	5905-279-2645	RESISTOR, FIXED, COMPOSITION: 81349; RC320F331K	1,2,3,4	ea	2				*	2	2	13	10		R243, R260
P-H-- 270	5905-279-2642	RESISTOR. FIXED, COMPOSITION: 81349; RC320F391J	1	ea	1				*	*	2	8	5		R432
			2.3,4	ea	2				*	2	2	13	10		R217, R432
P-H-- 271		RESISTOR, FIXED, COMPOSITION: 81349; RC32CF471J	1,2,3,1	C	1				*	2	2	13	10		R415
P-H-- 272	5905-299-2049	RESISTOR, FIXED, COMPOSITION: 81349; RC32CF561J	1,2,3,4	ea	5				*	2	2	28	25		R201, R219, R322, R411, R413
P-H-- 273	5905-107-4126	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF821K	1,2,3,4	ea	1				*	*	2	8	5		R274
P-H-- 274	5905-473-5251	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF102J	1,2,3	ea	4				*	2	2	27	25		R118, R208, R280, R521
			4	ea	4				*	2	2	21	20		R118, R208, R280, R521
P-H-- 275		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF152K	1,2,3	ea	3				2	2	3	31	30		R213, R250, R436
			4	ea	2				*	2	2	13	10		R250, R436
P-H-- 276	5905-552-5057	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF182K	1,2,3	ea	1				*	*	2	8	5		R218
				ea	1				*	*	2	8	5		R265
P-H-- 277	5905-299-2044	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF222K	1,2,3	ea	2				*	2	2	13	10		R265, R116
				ea	2				*	2	2	13	10		R1006, R116
P-H-- 278		RFSISTOR, FIXED, COMPOSITION: 81349; RC32GF272K	1,2,3,4	ea	1				*	2	8	5			R220
P-H-- 279	5905-299-2041	RESISTOR, FIXED, COMPOSITION: 81319; RC32GF32 J	1,2,3,4	ea	2				*	2	2	13	10		R449, R467
P-H-- 280	5905-299-2042	RESISTOR, FIXED, COMPOSITION: 81349; RC320F332K	1,2,3	ea	5				*	2	2	27	25		RP36, R110, R458. R170, R859
			4						*	2	2	21	20		R306, R440, R458, R474
P-H-- 281	5905-299-2039	RESISTOR, FIXED, COMPOSITION: 81349; RC320F392K	1,2,3,0	ea	5				*	2	2	27	25		R323, R337, P403, R422, R495
P-H-- 282	5905-299-2037	RWISTOR, FIXED, COMPOSITION: 81349; RC320F472K	1,2,3,4	ea	1				*	2	2	18	15		R271
P-H-- 283	5905-279-2591	RBSISTOR, FIXRD, COHPOSITIOR: 81349; RC32CF512J	1,2,3	ea	2				*	2	2	13	10		R214, P320
			4	ea	2				*	2	2	13	10		R320, R813
P-H-- 284	5905-299-2038	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF562K	1,2,3,4	ea	3				*	2	2	13	10		P325, R360, R368
P-H-- 285	5905-299-2035	RESISTOR, FIXED, COMPOSITION: 81319; RC32GF622J	4	ea	1				*	*	2	8	5		R319
P-H-- 286	5905-299-2033	RESISTOR, FIXED, COMPOSITION: 81349; RC32CF682K	1,2,3	ea	6				2	2	3	30	30		R282, R441, R450, R459, R468, R477
			4	ea	1				*	2	2	13	10		R282

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 287	5905-279-1719	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF103K (Item- No R255, R340, R341, 1348, R354, R1372, R380, R384, R393, R399, 8401, R426)	1,2.3	ea	12				2	3	5	58	65		See Desc. Column
			4	ea	2				*	2	2	13	10		R255, R348
P-H-- 288	5905-299-2027	RESISTOR, FIXED, COMPOSITION: 81349; RC32CF123K	1,2,3	ea	4				*	2	2	21	20		R347, R365, R529, R530
			4	ea	4				*	2	2	21	20		R3471, 529, R530, R1301
P-H-- 289	5905-299-2025	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF153K	1,2.3	ea	2				*	2	2	13	10		R707, R708
			4	ea	4				*	2	2	21	20		R707, R708,
P-H-- 290	5905-299-2023	RESISTOR, FIXED, COMPOSITION: 81349; RC320F183K	1,2,3	ea	1				*		2	8	5		R1303, R520
			4	ea	2				*	2	2	13	10		R485, R520
P-H-- 291	5905-299-2019	RESISTOR, FIXED, COMPOSITION: 81349; RtC32GF223K	1,2,3	ea	5				*	2	2	30	31		R273, R390, R416, R485, R1204
			4	ea	1				*	*	2	8	5		R273
P-H-- 292	5905-299-2020	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF273J	1.2,3	ea	4				2	2	3	46	50		R405, R701, R706. R3103
			4	ea	3				*	2	2	18	15		R701 , R804, R913
P-H-- 293	5905-279-1716	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF333K	4	ea	1				*	2	2	27	25		R107
P-H-- 294	5905-299-2015	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF393J	1,4	ea	1				*	2	2	13	10		R522
			2,3	ea	4				2	4	7	67	95		R522, R2103, R3119, R3120
P-H-- 295	5905-299-2013	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF473J (Item Nos. 8238, R496, R804, R805, R808, 8810, R812, R817, R818, R819, R822, R825, R826, 8921, R933)	1	ea	15				2	3	6	67	80		See Desc. Column
		(Item Nos. R238, R43 1, R496, R801, R814, R805, 8811, R812, R817, 9818, R819, R822, R825, R826, R1105, R3116. R3129, R3132, R3133, R3141)	2,3	ea	20				3	9	16	179	240		See Desc. Column
		(Item Nos. R238, 8431, R496, R812, R823, R830, R914, R915, R916, R1105, R1312. R1313)	4	ea	12				2	3	5	54	60		See Desc. Column
P-H-- 296	5905-299-2011	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF5637	1	ea	6				*	2	2	30	32		R223, R228, R363, R375, R397, R533
			2,3	ea	8				2	3	6	76	90		R223, R228, R363, R375, R397, R533, R3134, R3144
			4	ea	4				2	2	2	21	20		R223, R228, R533, R706
P-H-- 297	5905-299-2009	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF623J	4	ea	1				*	*	2	8	5		R702
P-H-- 298	5905-299-2010	RESISTOR, FIXED, COMPOSITION: 81349; RC32CF683J	1,3	ea	3				*	2	2	21	20		R225, R402, R702
		(Item Non. R225, R402, R702, R2119, R2120, 82132, R2133, R2143, R2144, R2151)	2	ea	10				2	6	11	129	175		See Desc, Column

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 299	5905-29 9-2005	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF823J	1,3	ea	2				*	*	2	13	10		R410, R412
			2	ea	5				2	3	6	65	75		R410, R412, R2116, R2129, R2141
			4	ea	8				2	2	21	20	R346,		R110, R412, R1008, R1011, R1014, R1017 R1020
P-H-- 300	5905-299-2004	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF104K													
		(Item Nos. R212, R221, R272, R437, R439, R445, R446, R448., R454, R457, R463, R472, R476, R505, R514)	1	ea	15				2	3	6	65	75		See Desc. Column
		(Item Nos. R212, R221, R272, R437, R445, R454, R463, R472, R505, R515)	2,3,4	ea	10				2	3	6	46	50		See Desc. Column
P-H-- 301	5905-279-2644	RESISTOR, FIXED, COMPOSITION: 81349; C32GCF114J	2,3,4	ea	5				*	2	2	28	25		R439, R448, R457 R466, R476
P-H-- 302	5905-299-2012	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF24K	1,2,3	ea	7				2	2	3	34	35		R391, R442, R451, R460, R469, R478, R705
			4	ea					2	2	3	31	30		R442, R451, R460, R69, R478, R705
P-H-- 303		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF154K	1,2,3,4	ea	1				*	2	2	13	10		R487
P-H-- 304	5905-279-4317	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF184K	1,2,3	ea	3				*	2	2	21	20		R231, R425, R103
			4	ea	9				2	2	3	42	45		R231, R2001 thru R2008
P-H-- 305	5905-279-4301	RESISTOR, FIXED, COMPOSITION: 81349, RC32GF154K	1,2,3	ea	5				2	2	3	34	35		R315, R346, R371 R387, R404
P-H-- 306	5905-299-2000	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF184K	1,2,3,4	ea	3				*	2	2	18	15		R268, R281, R499
P-H-- 307	5905-120-0487	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF334K	1,2,3	ea					*	*	2	8	5		R709
P-H-- 308	5905-279-2618	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF394J	1,2,3	ea	4				*	2	2	21	20		R230, R277, R303, R359
									*	*	2	8	5		R277
P-H-- 309	5905-299-1994	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF47K	1,2,3	ea	3				*	2	2	18	15		R232, R240,R427'
			4	ea	1				*	*	2	8	5		R427
P-H-- 310		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF564K	1,2,3	ea	3					2	2	18	15		R229, R421, R710
			4	ea	2				*	2	2	13	10		R229, R710
P-H-- 311	5905-279-4303	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF684J	4	ea	1				*	*	2	8	5		R1003
P-H-- 312		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF684J	1,2,3	ea	2				*	2	2	13	10		R222, R433
			4	ea	1				*	2	2	18	15		R222
P-H-- 313	5905-299-1985	RESISTOR, FIXED, COMPOSITION: 81319; RC32GF105K	1,2,3	ea	3										R241, R270, R420
			4	ea	2				*	2	2	13	10		R275, R433
P-H-- 314		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF155K	1,4	ea	1				*	2	2	13	10		R233
			2,3	ea	4				2	2	3	30	30		R247, R318, R323, R377

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 315		RESISTOR, FIXED, COMPOSITION: 81349; RC32GF185K	2,3	ea	1				*	*	2	8	5		R446
P-H-- 316	5905-279-4309	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF275J	1,2,3	ea	6				2	2	3	30	30		R234, R443, R452, R461, R470, R479
			4	ea	1				*	*	2	8	5		R234
P-H-- 317	5905-299-1987	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF395K	1,2,3,4	ea	1				*	*	2	8	5		R498
P-H-- 318	5905-116-9821	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF475K	1,2,3	ea	1				*	*	2	8	5		R235
P-H-- 319	5905-299-1990	RESISTOR, FIXED, COMPOSITI ON: 81349; RC32GF106K	4	ea	1				*	*	2	8	5		R235
P-H-- 320	5905-279-19T6	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF101K	2.3,1	ea	4				*	2	2	21	20		R503, R506, R511 R513
P-H-- 321	5905-195-5507	RESISTOR, FIXED, COMPOSITION: 81349; RC43GF122K	2,3	ea	3				*	2	2	18	15		R276, 0290, R484
P-I- 322	5905-257-0926	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF332J	1,2,3,4	ea	2				2	2	3	30	30		R1113, R1114
P-H-- 323	5905-257-0937	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF472J	1,2,3,	ea	9				2	3	5	54	64		R295, R296, R301, R305, R339, R316, R409, R1102, R1111
			4	ea	2				*	2	2	13	10		R1102, R1111
P-H-- 324	5905-249-4190	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF562J	1,2,3	ea	8				2	2	3	39	40		R353, R358, R362, R370, R374, R302. R386, R395
			4	ea	3				*	2	2	13	10		R309, R316, R358
P-H-- 325	5905-279-2528	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF682J	1	ea	3				*	2	2	18	15		R249, R254, R267
			2,3,4	ea	5				*	2	2	27	25		R249, R254, R258, R259, R0267
P-H-- 326	5905-192-4504	RESISTOR, FIX ED, COMPOSITION: 81349; RC42GF822J	1,2,3,4	ea	9				2	2	4	49	55		R226, R227, R264 R266, R340, R317 R329, R1108, R1109
P-H-- 327	5905-185-8521	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF013K	1,2,3,4	ea	1				*	*	2	8	5		R328
P-H-- 328	5905-279-1949	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF2113J.	1,2,3	ea	4				2	2	3	22	20		R335, R366, R379, R389
P-H-- 329	5905-249-1227	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF183K	1,2,3,4	ea	1				*	*	2	8	5		R336
P-H-- 330	5905-279-2527	RESISTOR, FI XED, COMPOSITION: 81349; RC42GF223J,	1,2,3,4	ea	5				*	2	2	28	25		R943, R447, R456, R465, R475
P-H-- 331		RESISTOR, FIXED, FILM: 00346, LP1-3-5	1	ea	4				*	2	2	21	20		R295, R296, R304, R305
P-H-- 332		RESISTOR, FIXED, FILM: 81349; RN75B1442F	1,2,3,4	ea	2				*	2	2	13	10		R292, R309
P-H-- 333	5905-552-6049	RESISTOR, FIXED, FILM: 81349; RN75B1582F	1,2,3,1	ea	2				*	2	2	13	10		R293, R031
P-H-- 334		RESISTOR, FIXED, FILM: 81349; RN7502452F	1,2,3,1	ea	2				*	2	2	13	10		R291, R299
P-H-- 335	5905-729-0433	RESISTOR , FIXED, FILM: 81349; MP75Xi3302f	1,2,3,4	ea	2				*	2	2	13	10		R308, R314
P-H-- 336		RESISTOR, FIXED, FILM.: 81349; RN75X3302F	1,2,3,4	ea	6				2	2	3	30	30		R257, R263, R327, R334, R339, R345
P-H-- 337	5905-578-0301	RESISTOR, FIXED, FILM 81349; RN75X6202F													
		(Item Nos. R294, R351, R352. R357, R361, 0364, R367, 0369, R373, R376, 0379, 0301, R305, R388, R392)	1,2,3	ea	15				2	3	6	69	90		See Desc. Column

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 338		RESISTOR, FIXED, FILM: 81349; RN75B7092F	1,2,3	ea	2				*	2	2	13	10		R307, R313
			4	ea	2				*	2	2	13	10		R307, R363
P-H-- 339		RESISTOR, FIXED, FILM: 81319; RN75X9002F	2.3	ea	2				2	2	3	30	32		R3115, R1113
			4	ea	2				2	2	13	10			R615, R361
P-H-- 340		RESISTOR, FIXED, FILM: 81349; RN75X9002F	4	ea	2				*	2	2	13	10		R1115, R1117
P-H-- 341	5905-542-8837	RESISTOR, FIXED, FILM: 81349; RN75B1003F	1,2,3	ea	8				2	2	3	39	40		R256, R262, R326, R330, R133, R338. R366, R383
			4	ea	6				2	2	3	30	30		R256, R262, R326, R333, R338, R344
P-H-- 342		RESISTOR, FIXED, FILM: 81349; RN75B1323F	1,2,3,4	ea	1				*	*	2	8	5		R517
P-H-- 343		RESISTOR, FIXED, FILM: 81349; RN7501443F	1,2,3,4	ea	1				*	*	2	8	5		R510
P-H-- 344		RESISTOR, FIXED, COMPOSITION: 81439; LP1-3-15K	4	ea	4				*	2	2	21	20		R340, R123, R103,
P-H-- 345		RESISTOR, FIXED, FILM: 81349; RK75B1603F	1,2,3,4	ea	1				*	*	2	8	5		R525
P-H-- 346		RESISTOR, FIXED, FILM: 81349; RN75B1813F	1,2,3	ea	1				*	*	2	8	5		R523
			4	ea	2				*	2	2	13	10		R523, R1103
P-H-- 347		RESISTOR, FIXED, FILM: 81349; R175B3053F	1,2.3,4	ea	1				*	*	2	8	5		R270
P-H-- 348	5905-502-9080	RESISTOR, FIXED, FILM: 81349; RN75B3163F	1,2,3,4	ea	I				*	*	2	8	5		R527
P-H-- 349	5905-828-6300	RESISTOR, FIXED, FILM: 81349; RN75B3703F	1,2,3,4	ea	2				*	*	2	8	5		R526, R528
P-H-- 350		RESISTOR, FIXED, FILM: 81349; RN75B4053F	1,2,3	ea	1				*	2	2	13	10		R502
			4	ea	2				*	2	2	13	10		R502, R1110
P-H-- 351		RESISTOR, FIXED, FILM: 81349; RN75B4903F	2,3,4	ea	1				*	*	2	8	5		R252
P-H-- 352		RESISTOR, FIXED, FILM: 81349; RN75B 8303F	1,2,3,4	ea	1				*	*	2	8	5		R269
P-H-- 353	5905-578-0275	RESISTOR, FIXED, FILM: 81349; RN75X9803F	2,3	ea	1				*	*	2	8	5		R251
P-H-- 354		RESISTOR, FIXED, FILM: 81349; RN70D3004F	4	ea	2				*	2	2	13	10		R1214, R1228
P-H-- 355		RESISTOR, FIXED, FILM: 81349; RN75B2164F	4	ea	5				*	2	2	27	25		R443, R452, R661, R470, R479
P-H-- 356	5905-878-8643	RESISTOR, FIXED, WIREWOUND: 81349; RW21V391	1,2,3,4	ea	3				*	2	2	18	15		R518, R519., R536 R518, R519, R536
P-H-- 357	5905-846-8152	RESISTOR, FIXED, WIREWOLND: 81349; RW21V921	1,2,3,4	ea	3				*	2	2	18	15		R493, B491, R492
P-H-- 358		RESISTOR, FIXED, WIREYOLND: 81349; RW32C152	4	ea	1				*	*	2	8	5		R408
P-H-- 359	5905-157-2131	RESISTOR, FIXED, WIREWOUND: 81349; RW2CO202	1,2,3	ea	1				*	*	2	8	5		R408
P-H-- 360	5905-839-5931	RESISTOR, FIXED, WIREWOUND: 81349; RW32G352	4	ea	1				*	*	2	8	5		R532
P-H-- 361	5905-264-7153	RESISTOR, FIXED, WIREWOUND: 81349; RW21C452	1,2,3	ea	1				*	*	2	8	5		R532

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H 362	5905-807-3314	RESISTOR, FIXED , WIREWOUND: 81349; RW21G512	1, 2.3,4	ea	1				*	*	2	8	5		R493
P-H 363		RESISTOR, VARIABLE: 81349; RV4LAXA203B	4	ea	4				*	2	2	21	20		R501, R509, R516 , R524
P-H- 364	5905-578-0293	RESISTOR, VARIABLE: 80667; A-17874-4	1, 2, 3	ea	8				2	2	3	39	40		R211, R224, R248 , R444, R453, R462 R471, R480
P-H 365		RESISTOR,. VARIABLE: 81349; ERV4LAXSA503A	4	ea	8				2	2	3	39	40		R211, R224, R248, R444, R453, R462 R471, R480
P-H 366	5905-578-0292	RESISTOR, VARIABLE: 80667; A17874-5	1, 2, 3	ea	2				*	2	2	13	10		R350, R396
P-H 367	5905-578-0290	RESISTOR, VARIABLE: 80667; A-17874-6	1, 2, 3	ea	6				2	2	3	30	30		R349, R39, R501 , R509, R516, R524
P-H 368	5905-518-9422	RESISTOR, VARIABLE: 81349; RV4NATRD254A	1, 2, 3, 4	ea	2				*	*	2	8	5		R110, R122
P-H 369	5905-578-4278	RESISTOR, VARIABLE: 11237; AW8908	1, 2, 3	ea	1				*	2	2	13	10		R237
P-H 370		RESISTOR , VARIABLE: 81349; RV2TRD505B	4	ea	1				*	*	2	8	5		R237
P-H 371	5910-643-8590	RETAIN, CAPACITOR: 81349; CP065A5	1, 2, 3	ea	2				*	*	*	10	6		
P-H 372	5910-666-7959	RETAINER, CAPACITOR: 90201; TH-23	1, 2, 3	ea	1				*	*	*	5	3		
P-H 373	5340-526-3944	RING, RETAINING: 07497; 2-104-02	1, 2, 3	ea	10				2	2	3	33	30		
P-H 374	5961-296-0162	SEMICONDUCTOR, DEVICE DIODE: 22480; 212-011A	1, 2, 3	ea	59				4	11	20	230	315		CR201 thru R259
P-H 375		SEMICONDUCTOR, DEVICE DIODE: 81349; IN198 (Item Nos. CR201 thru CR249 CR260, CR1101, CR1102, CR1103, CR1401 thru CR1408, CR2001 thru CR2008)	4	ea	69				4	11	20	249	355		See Desc. Column
P-H 376	5306-315-3680	SCREW, CAPTIVE: 28480; 618B-S-332-1	1, 2 , 3	ea	4				*	2	2	16	12		0286
P-H 377	5950-578-5551	SHIELD, ASSEMBLY, COIL: 80667; B-17493	1, 2, 3	ea	2				*	*	2	10	6		
P-0- 378	5960-272-9094	SHIELD, ELECTRON TUBE: 81349; TS102U02	1, 2, 3	ea	2				*	*	2	13	9		E11, E702
P-0- 379	5961-264-3004	SHIELD, ELECTRON TUBE: 81349; TS103U02	1, 2, 3	e-	1				*	*	*	5	3		E703
P-H- 380	5935-160-1364	SOCKET, ELECTRON TUBE: 81349; TS102U02	4	ea	1				*	*	2	8	5		XZ235
P-H 381	5935-063-5789	SOCKET, ELECTRON TUBE: 81349; TAS101C01	4	ea	11				2	2	3	35	33		XV253, XZ254, XZ201 thru XZ209
P-H 382	5935-129-9358	SOCKET, ELECTRON TUBE: 81349; TS101P01 (Item Nos. XV249 thru XV251 X7253, XV254, XZ257, 71102, XZ103, XZ201 thru XZ209, XZ235)	1, 2, 3	ea	18				2	3	5	54	54		See Desc. Column
P-H 383	5935-260-0516	SOCKET, ELECTRON TUBE: 81349; TS102P01	4	ea	2				*	2	2	13	9		XV1301, XV1304

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H 384	5935-617-2849	SOCKET, ELECTRON TUBE: 81349; TS102P03 (Item Nos. XV202, XV203, XV205, XV206, XV207, XV209, XV211 thru XV218, XV234, XV235, XV23 thru XV247, XV252, XV258 thru XV261, XV1102, XV1103)	1, 2, 3	ea	34				2	4	8	97	108		See Desc. Column
		(Item Nos. XV202, XV203, XV205, XV206. XV207, XV209 thru XV218, XV235. XV237 thru 35247, XV252, XV258 thru XV261, XV702, XV1102, XV1103, XV1302, XV1303)	4	ea	37				2	4	8	100	11		See Desc Column
P-H 385	5935-594-2059	SOCKET, ELECTRON TUBE: 81349; TS103P03 (Item Nos. XV201, XV204, XV208, XV236, XV255, XV256. XV701, XV801 thru XV804, XV901 the. X7904, XV01O0, XV1200 thru XV1203, XV1401 thru XV1404)	4	ea	20				2	3	6	59	60		See Desc. Column
P-H 386	5935-666-4565	SOCKET, ELECTRON TUBE: 91662; BR316PHSPTD	1, 2	ea	1				*	2	2	26	21		XV210
			3	ea	6				2	2	3	39	36		XV1 thru XV6
P-H 387	5935-201-3113	SOCKET, ELECTRON TUBE: 82893; 8-N-9TJG	1, 2, 3	ea	1				*	*	*	5	3		XV248
P-H 388	5935-721-0124	SOCKET ELECTRON TUBE: 71785; 44F16388 (Item Nos. XV801 thru XV804, XV1101, XV2101 thru XV2104, XV3101 thru XV31014)	1, 2, 3	ea	13				2	4	7	84	93		See Desc. Column
P-H 389		SOCKET, ELECTRON TUBE: 81349; 77MIP-11MT	4	ea	1				*	*	2	8	5		XZ1200
P-H 390	5935-259-0337	SOCKET, ELECTRON TUBE: 71785; 16112 (Item Nos. .V201, XV204, XV208, XV219 thru XV223, XV236. XV255, XV256)	1, 2, 3	ea	11				2	2	3	35	33		See Desc. Column
P-H 392	5915-578-5553	SUPPRESSOR, PARASITIC: 80667; A-17773-2	1, 2, 3	ea	1				*	2	2	21	20		L602
P-H 393	5915-578-5556	SUPPRESSOR, PARASITIC: 80667; A-17777	1, 2, 3	ea	2				2	2	3	32	30		L603, L1101
P-H 396	5915-578-5558	SUPPRESSOR, PARASITIC: 80667; A-17773-1	1, 2, 3,4	ea	2				*	2	2	13	10		L601
P-H 397	5915-578-5552	SUPPRESSOR, PARASITIC: 80667; A-17774-3	1, 2, 3	ea	1				*	2	2	13	10		L604
P-H 398	5915-578-5554	SUPPRESSOR, PARASITIC: 80667; A-17774-6	1.2, 3	ea	1				*	*	2	8	5		L607
P-H 399	5930-578-4267	SWITCH, PUSH: 80667; A-17875	1, 2, 3,4	ea	1				*	*	2	8	5		S204
P-H 400	5930-578-3097	SWITCH, ROTARY: 80667; A-17606	1, 2, 3	ea	1				*	*	2	8	5		S206
P-H- 401	5930-548-5744	SWITCH, ROTARY: 80667; A-17607	1, 2, 3	ea	1				*	*	2	8	5		S201
P-H 402	5930-578-0972	SWITCH, ROTARY: 80667; A-17608	1, 2, 3	ea	1				*	*	2	8	5		S207
P-H 403		SW ITCH, ROTARY: 00346; 310-39	4	ea	1				*	*	2	8	5		S206
P-H 404		SWITCH, ROTARY: 00346; 310-126	4	ea	1				*	*	2	8	5		S207

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-405		SWITCH, ROTARY: 00346; 310-128	4	ea	1				*	*	2	8	5		S201
P-H-406	5930-578-3167	SWITCH, THERMOSTATIC: 80667; A-19596	1, 2, 3	ea	1				*	*	2	8	5		
P-H 407	5930-296-9725	SWITCH, TOGGLE: 81349; ST-12D	1, 2, 3,4	ea	1				*	*	2	8	5		S202
P-H 408	5930-050-2638	SWITCH, TOGGLE : 81349; ST-22N	1, 2, 3.,	ea	2				*	2	2	13	10		S205, S208
P-O-409	6685-605-7192	THERMOMETER, SELF-INDICATING; B1-METALLIC: 80667; B-17397	1, 2, 3	ea	1				*	*	2	8	5		
P-H 410	5950-578-1715	TRANSFORMER, POWER, STEP-UP: 80667; C-17400	1, 2, 3	ea	1				*	*	2	8	5		T204
P-H-411		TRANSFORMER, POWER, STEP-UP: 00346; 50M-L-531	4	ea	1				*	*	2	8	5		T204
P-H-412	5950-578-1717	TRANSFORMER, POWER, STEP-UP AND STEP-DOWN: 80667; C-17401	1, 2, 3	ea	1				*	*	2	8	5		T205
P-H 413		TRANSFORMER, POWER, STEP-UP AND STEP-DOWN: 80346; 50M-L-532	4	ea	1				*	*	2	8	5		T205
P-H 414	5950-605-5465	TRANSFORMER, PULSE: 80667; B-17614	1, 2, 3	ea					*	*	2	13	10		T201, T202
P-H 415		TRANSFORMER, PULSE: 00346; 50MY-S-495	4	ea	2				*	2	2	13	10		T201, T202
P-H-416		TRANSFORMER, PULSE: 00346; 50M-S-533	4	ea	2				*	*	2	8	5		T1301
P-H-417	6625-605-5453	TRIGGER CIRCUIT: 30667; C-17825	1, 2, 3	ea	1				*	*	2	8	5		Z201
P-H-418		TRIGGER CIRCUIT: 80346; 35-Z-201	4	ea	1				*	*	2	8	5		Z201
P-H 419	6625-605-5460	WINDOW DIAL: 80667; B-17643	1, 2, 3	ea	1				*	*	*	5	3		
		FREQUENCY METER SUBASSEMBLY MX-1636/U and MX-1636A/U													
-C-R 420		FREQUENCY METER SUBASSEMBLY MX-1636/U: MX-1636A/U NOTE: Usable on code 1 refers to MX-1636/U: 2 refers to MX-1636A/U													
P-H-421	5935-252-6340	COVER, ELECTRICAL CONNECTOR CW-123/U; SAME AS 159	1, 2	ea											
P-H-422		CAPACITOR, FIXED, CERAMIC DIELECTRIC: SAME AS 33	1, 2	ea	1										C604
P-H-423		CAPACITOR, FIXED, CERAMIC DIELECTRIC: SAME AS 39	1, 2	ea	1										C108
P-H-424		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 48	1, 2	ea	2										C101, C114
P-H-425		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 50	1, 2	ea	4										C102, C104, C109, C113
P-H-426		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 51	1, 2	ea	1										C107
P-H-427		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 54	1, 2	ea	2										C103, C110
P-H-428		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 63	1, 2	ea	3										C105, C112, C603
P-H-429		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 70	1, 2	ea	2										C106, C111
P-H-430		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 75	1, 2	ea	1										C601

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H 431		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 82	1, 2	ea	1										C602
P-H- 432	5950-578-5276	COIL, RADIO FREQUENCY: 80667; A-17209	1, 2	ea	2				*	*	2	10	6		L101, L102
P-H 433	5935-201-3511	CONNECTOR, RECEPTACLE. ELECTRICAL: SAME AS 146	1, 2	ea	2										J101, J102
P-H- 434	5935-027-9424	CONNECTOR RECEPTACLE, ELECTRICAL: SAME AS 21	1, 2	ea	1										P102
P-H 435	5935-283-3383	CONNECTOR, RECEPTACLE, ELECTRICAL: SAME AS 22	1, 2	ea	1										P101
P-H 436	5355-559-6287	DIAL, CONTROL: 80667; A-17171	1, 2	ea	2				*	*	2	10	6		0124, 0125
P-H 437	5355-559-6285	DIAL CONTROL: 80667; A-17172	1, 2	ea	2				*	*	2	10	6		0126, 0127
P-H- 438		ELECTRON TUBE: SAME AS 180	1, 2	ea	1										V601
P-H 439	5960-262-1357	ELECTRON TA BE: SAME AS 174	1, 2	ea	2										V602, V603
P-O- 440	5355-579-3175	KNOB: SAME AS 195	1, 2	ea	4										
P-H 441	5905-195-6817	RESISTOR, FIXED, COMPOSITION: SAME AS 223	1, 2	ea	1										R607
P-H- 442	5905-249-4248	RESISTOR9 FIXED, COMPOSITION: 81349; RC20GF333K	1, 2	ea	4				*	2	2	21	20		R105, R106, R115, R116
P-H 443	5905-254-9201	RESISTOR, FIXED, COMPOSITION: SAME AS 237	1, 2	ea	1										R612
P-H 444		RESISTOR, FIXED, COMPOSITION: 81349; RC20GF683K	1, 2	ea	2				*	2	2	13	10		R101, R117
P-H 445		RESISTOR, FIXED, COMPOSITION: 81349; RC20GF823K	1, 2	ea	1				*	*	2	8	5		R604
P-H 446	5905-195-6761	RESISTOR, FIXED, COMPOSITION: SAME AS 242	1, 2	ea	3										R108, R120, R123
P-H 447	5905-249-9468	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF534J	1, 2	ea	2				*	2	2	13	10		R102, R112
P-H- 452	5905-279-2522	RESISTOR, FIXED, COMPOSITION: SAME AS 244	1, 2	ea	2										R109, R121
P-H 449	5905-171-2003	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF204J	1, 2	ea	1				*	*	2	8	5		R610
P-H- 450	5905-190-8865	RESISTOR, FIXED, COMPOSITION: SAME AS 248	1, 2	ea	2										R103, R113
P-H 451	5905-221-5840	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF564K	1, 2	ea	2				*	2	2	13	10		R104, R114
P-H 452	5905-299-2046	RESISTOR, FIXED, COMPOSITION: SAME AS 275	1, 2	ea	1										R616
P-H- 453		RESISTOR, FIXED COMP OSITION: SAME AS 278	1, 2	ea	1										R111
P-H- 454	5905-299-2013	RESISTOR, FIXED, COMPOSITION: SAME AS 295	1, 2	ea	1										R605
P-H- 455	5905-279-4317	RESISTOR, FIXED, COMPOSITION: SAME AS 304	1, 2	ea	1										R603
P-H- 456	5905-257-0926	RESISTOR, FIXED, COMPOSITION: SAME AS 322	1, 2	ea	2										R613, R614
P-H 457	5905-257-0937	RESISTOR, FIXED, COMPOSITION: GATE AS 323	1, 2	ea	2										R602, R611
P-H- 458	5905-192-4504	RESISTOR, FIXED. COMPOSITION: SAME AS 326	1, 2	ea	2										R608, R609

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALWPER EQUIP CNTGY	(9) DEPOT MAINT ALWPER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 459		RESISTOR, FIXED FILM: SAME AS 339	1.2	ea	2										R615, R617
P-H--- 460	5905-578-0293	RESISTOR, VARIABLE: SAME AS 364	1,2	ea	2										R107, R119
P-H-- 461	5935-129-9358	SOCKET, ELECTRON TUBE: SAME AS 382	1,2	ea	2										XV102, XV103
P-H-- 462	5935-617-2849	SOCKET, ELECTRON TUBE: SAME AS 384	1,2	ea	2										XV602, XV603
P-H-- 463	5935-721-0124	SOCKET, ELECTRON TUE: SAME AS 388	1,2	ea	1										XV601
P-H-- 464		SWITCH, ASSEMBLY: 80667; B-17636	1,2	ea	2				*	2	2	13	10		
P-H-- 465		SWITCH, ROTARY: 80667; A-17605	1,2	ea	2				*	2	2	13	10		S101, S103
P-H-- 466	5930-296-9725	SWITCH, TOGGLE: SAME AS 407	1,2	ea	3										S102, S105,S106 0106
P-H-- 467	5930-050-2638	SWITCH, TOGGLE: SAME AS 407	1,2	ea	1										S104
P-H--R 468	6645-605-5454	TRIGGER CIRCUIT: 80667; C-17821	1	ea	2				*	2	2	13	10		Z102, Z103
P-H--R 469		TRIGGER CIRCUIT: 00346; 35-T1-6A	2	ea	2				*	2	2	13	15		Z102, Z103
		FREQUENCY METER SUBASSEBLY MX-1637/U and MX-1637A/U													
--C-R 470	6625-553-4006	FREQUENCY METER SUBASSEMBLY MX-1637/U; MX-1637A/U NOTE: ;Usable on code 1 refers to Mx-1637/U: 2 refers to MX-1637A/U													
P-H-- 471	5910-577-6859	CAPACITOR, FIXED, CERAMIC DIELECTRIC: SAME AS 32	1,2	ea	1										C15
P-H-- 472		CAPACITOR, FIXED, CERAMIC DIELECTRIC: SAME AS 33	1,2	ea	1										C16
P-H-- 473	5910-270-9214	CAPACITOR, FIXED, CERAMIC DIELECTRIC: SAME AS 35	1,2	ea	1										C2
P-H-- 474	5910-715-6135	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 72982; 327-1000	1,2	ea	3				*	2	2	13	9		C6, C11, C13
P-H-- 475	5910-857-2123	CAPACITOR, FIXED, CERAMIC, DIELECTRIC: SAME AS 38	1,2	ea	4										C3, C22, C23 C40
P-H-- 476		CAPACITOR, FIXED, CERAMIC: DIELECTRIC: SAME AS 39 (Item Nos. C1, C4, C5. C7 thru C10, C19. C20, C58, C63, C70, C73. C77)	1,2	ea	14										See Desc. Column
P-H-- 477	5910-666-8197	CAPACITOR, FIXED CERAMIC DIELECTRIC: SAME AS 41	1,2	ea											C61, C62, C65, C66, C618, C75 C76, C78
P-H-- 478	5910-284-4045	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15B050M	1,2	ea	2				*	2	2	21	20		C29, C31, C46 C48
P-H-- 479		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 51	1,2	ea	2										C39, C56
P-H-- 480	5910-284-4049	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15C390J	1,2	ea	2				*	*	2	10	6		C37, C54
P-H-- 481		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 63	1,2	ea	1										C59
P-H-- 482	5910-951-7074	CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 75	1,2	ea	1										C57

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALW PER EQUIP CNTGY	(9) DEPOT MAINT ALW PER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 483	5910-284-4430	CAPACITOR, FIXED, MICA 81349; CM15C111J	1.2	ea	2				*	2	2	13	10		C35, C52
P-H- 484	5910-829-3730	CAPACITOR, FIXED MICA DIELECTRIC: 83149; CM15D221JN1	1,2	ea	1				*	*	2	5	3		C61
P-H-- 485		CAPACITOR, FIXED, MICA DIELECTRIC: SAME AS 82	1,2	ea	1										C67
P-H-- 486	5910-284-4046	CAPACITOR, FIXED, MICA DIELECTRIC: 81349; CM15D391J	1,2	ea	2				*	*	2	10	6		C33, C50
P-H-- 487	5910-578-5527	CAPACITOR, FIXED, OXIDE, DIELECTRIC: SAME AS 95	1,2	ea	2										C18, C21
P-H-- 488	5910-578-5530	CAPACITOR, FIXED, OXIDE, DIELECTRIC: SAME AS 98	1,2	ea	2										C27, C44
P-H- 489		CAPACITOR, FIXED PAPER DIELECTRIC: 81349; CP04A1KF103K	1.2	ea	1				*	*	2	8	5		C69
P-H-- 490	5910-578-5544	CAPACITOR, VARIABLE, AIR DIELECTRIC: 80045; 465	1,2	ea	2				*	*	2	10	6		C32, C49
P-H-- 491	5910-649-2949	CAPACITOR, VARIABLE, AIR DIELECTRIC: 80667; B-17188	1,2	ea	1				*	*	*	5	3		C12
P-H-- 492	5910-556-9440	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: 81349; CV11A070	1,2	ea	8				*	2	2	28	24		C24, C25, C26, C28, C10, C42, C43, C45
P-H-- 493	5910-578-5543	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: 813b9; CV11B200	1,2	ea	4				*	2	2	16	16		C30, C38.C47, C55
P-H-- 494	5910-578-1623	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: SAME AS 119	1,2	ea	5										C34, C36, C51, C53, C74
P-H-- 495	5950-556-1797	COIL AS8EMBLY, RADIO FREQUENCY: 80667; A-17757	1,2	ea	1				*	*	2	8	5		Z8
P-H-- 496		COIL RADIO FREQUENCY: 80667; A-17496	1,2	ea	1				*	*	2	8	5		L1
P-H-- 497		COIL RADIO FREQUENCY: 80667; A-17191	1,2	ea	2				*	*	2	8	5		L3, L6
P-H-- 498	5950-578-1460	COIL, RADIO FREQECY OG: 80667; B-17192-2	1,2	ea	1				*	*	2	8	5		L4
P-H-- 499	5950-578-1461	COIL, RADIO FREQUENCY: 90667; B-17192-1	1,2	ea	1				*	*	2	8	5		L5
P-H-- 500	5950-578-5268	COIL RADIO FREQUENCY: 80667; A-17189	1,2	ea	2				*	*	2	8	5		L10, L11
P-H-- 501	5950-578-5674	COIL, RADIO FREQUENCY SAME AS 136	1,2	ea	1										L12
P-H-- 502	5935-027-9424	CONNECTOR, RECEPTACLE. ELECTRICAL: SAME AS 21	1,2	ea	1										P102
P-H-- 503	5935-283-3383	CONNECTOR, RECEPTACLE, ELECTRICAL: SAOE AS 22	1,2	ea	1										P101
P-H-- 504	5355-605-7248	DIAL, CONTROL: 8066; A-17509	1,2	ea	1				*	*	*	5	3		07
P-H-- 505	5960-542-7004	ELECTRON TUBE: SAME AS 170	1,2	ea	5										V1, V2, V5, V6, V7
P-O-- 506	5960-188-3968	ELECTRON TUBE: 81349; 6E5	1,2	ea	1				2	4	8	100	100		V8
P-H-- 507	5960-237-6917	ELECTRON TUBE: SAME AS 176	1,2	ea	2										V3, V4
P-O-- 508		KNOB: 1,2 SAME AS 193	1,2	ea	2										012, 0367
P-O-- 509	5355-579-3175	KNOB: SAME AS 195	1,2	ea	1										
P-H-- 510	5905-279-1752	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF120J	1,2	ea	4				*	2	2	13	10		R13, R17, R18, R21

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALW PER EQUIP CNTGY	(9) DEPOT MAINT ALW PER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 511		RESISTOR, FIXED, COMPOSITION: 81349; RC20GF470K	1,2	ea	1				*	*	2	8	5		R14
P-H-- 512	5905-279-1898	RESISTOR, FIXED COMPOSITION: 81349; RC20GF560K	1,2	ea	2				*	*	2	8	5		R40
P-H-- 513	5905-186-3008	RESISTOR, FIXED COMPOSITION: SAME AS 218	1,2	ea	2										R3, R8
P-H-- 514	5905-252-5434	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF121K	1,2	ea	2				*	2	2	13	1		R28, R32
P-H-- 515	5905-196-7242	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF151K	1,2	ea	2				*	2	2	13	10		R2, R7
P-H-- 516	5905-190-8880	RESISTOR, FIXED,COMPOSITION: 81349; RC20GF122J	1	ea	1				*	*	2	8	5		R30
P-H-- 517	5905-195-6502	RESISTOR, FIXED, COMPOSITION: 81349; RC20GF332K	1.2	ea	1				*	*	2	8	5		R43
P-H-- 518	5905-185-8510	RESISTOR, FIXED, CONPOSITIOY: SAME AS 228	1,2	ea	1										R44
P-H-- 519	5905-171-2004	RESISTOR, FIXED, COMPOSITION: SAME AS 232	2	ea											R39
P-H-- 520	5905-195-6761	RESISTOR, FIXED COMPOSITION: SAME AS 242	1	ea	4										R1, R6, R3, R39
			2	ea	3										R1, R6, R23
P-H-- 521	5905-279-2515	RESISTOR, FIXED, COMPOSITION: SAME AS 252	1,2	ea	2										R12, R16
P-H-- 522	5905-192-0390	RESISTOR, FIXED, COMPOSITION: SAME AS 254	1,2	ea	3										R27, R31, R34
P-H-- 523	5905-101-7856	RESISTOR, FIXED, COMPOSITION: 81349; RC32GF100K	1,2	ea	1				*	*	2	8	5		R11
P-H-- 524		RESISTOR, FIXED, COMPOSITION: SAME AS 271	1,2	ea	1										R36
P-H-- 525	5905-473-5251	RESISTOR, FIXED, COMFOSITION: SAME AS 271	1,2	ea	2										R10, R33
P-H-- 526	5905-299-2045	RESISTOR, FIXED, COMPOSITION: 81349; RC320F122J	2	ea	1				*	*	2	8	5		R30
P-H-- 527		RESISTOR, FIXED, COMPOSITION: SAME AS 275	1,2	ea	1										R25
P-H-- 528	5905-299-2037	RESISTOR, FIXED, COMPOSITION: SAME AS 282	1,2	ea	2										R22, R29
P-H-- 529	5905-279-1719	RESISTOR, FIXED, COMPOSITION: SAME AS 287	1,2	ea	1										R26
P-H-- 530	5905-299-2019	RESISTOR, FIXED, COMPOSITION SAME AS 291	1,2	ea	1										R42
P-H-- 531	5905-279-1716	RESISTOR, FIXED, COMPOSITION: SAME AS 293	1,2	ea	4										R4, R9, R19, R20
P-H-- 532	5905-299-2015	RESISTOR, FIXED, COMPOSITION: SAME AS 294	1,2	ea	1										R37
P-H-- 533	5905-299-2010	RESISTOR, FIXED, COMPOSITION: SAME AS 298	1,2	ea	1										R24
P-H-- 534		RESISTOR, FIXED, COMPOSITION: SAME AS 303	1,2	ea	1										R38
P-H-- 535	5905-171-1978	RESISTOR, FIXED, COMPOSITION: 81349; RC42GF104K	1,2	ea	2				*	2	2	13	10		R35, R41
P-H-- 536	5905-578-0289	RESISTOR, VARIABLE: 91667; A-17874-7	1,2	ea	1				*	2	2	13	10		R15
P-H-- 537	5905-503-5817	RESISTOR, VARIABLE: 81349; RV4NATSD502A	1,2	ea	1				*	*	2	8	5		R5
P-H-- 538	5961-170-4430	SEMI-CONDUCTOR DEVICE: 81349;	1	ea	4				*	2	2	21	20		CR1 thru CR4

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE

TO INDEX NUMBER AN/USM-26: AN/USM-26A

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
3010-629-7045	157	5905-192-3981	243	5905-279-1890	221
4140-555-8321	189	5905-192-4504	326	5905-279-1898	512
4140-555-8322	184	5905-195-5507	321	5905-279-1949	328
5306-315-3680	376	5905-195-5514	224	5905-279-1976	320
5340-526-3944	373	5905-195-6502	517	5905-279-2515	252
5355-559-3891	194	5905-195-6761	242	5905-279-2519	249
5355-559-6285	437	5905-195-6817	223	5905-279-2520	250
5355-559-6287	436	5905-196-7242	515	5905-279-2521	247
5355-579-3175	195	5905-221-5840	451	5905-279-2522	244
5355-605-7248	504	5905-221-5848	253	5905-279-2527	330
5905-060-2326	226	5905-249-4190	324	5905-279-2528	325
5905-101-7856	523	5905-249-4227	329	5905-279-2591	283
5905-107-4126	273	5905-249-4248	442	5905-279-2618	308
5905-107-5445	230	5905-249-4256	234	5905-279-2628	268
5905-116-9821	318	5905-249-9468	447	5905-279-2642	270
5905-120-0487	307	5905-252-5434	514	5905-279-2643	263
5905-157-2131	359	5905-254-7097	240	5905-279-2644	301
5905-171-1978	535	5905-254-7100	241	5905-279-2645	269
5905-171-1986	238	5905-254-9201	237	5905-279-2673	227
5905-171-2003	449	5905-257-0926	322	5905-279-3498	236
5905-171-2004	232	5905-257-0937	323	5905-279-3499	233
5905-171-2005	222	5905-259-2990	261	5905-279-3500	231
5905-185-6944	251	5905-264-7153	361	5905-279-3502	229
5905-185-6966	220	5905-279-1686	262	5905-279-3513	219
5905-185-8510	228	5905-279-1716	293	5905-279-4301	305
5905-185-8521	327	5905-279-1719	287	5905-279-4303	311
5905-186-3008	218	5905-279-1725	267	5905-279-4309	316
5905-190-8865	248	5905-279-1749	259	5905-279-4317	304
5905-190-8874	255	5905-279-1752	510	5905-295-3403	257
5905-190-8880	516	5905-279-1865	260	5905-299-1985	313
5905-192-0390	254	5905-279-1873	256	5905-299-1987	317
5905-192-0660	245	5905-279-1876	225	5905-299-1990	319
5905-192-0667	246	5905-279-1883	258	5905-299-1994	309

SECTION IV REPAIR PARTS FOR DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE (CONT)

(1) SMR CODE INDEX NO	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION REF. NUMBER & MFR CODE	USABLE ON CODE	(4) UNIT OF MEAS	(5) QTY INC IN UNIT	(6) 30 DAY DS MAINT ALLOWANCE (a) 1-20	(6) (b) 21-50	(6) (c) 51-100	(7) 30 DAY GS MAINT ALLOWANCE (a) 1-20	(7) (b) 21-50	(7) (c) 51-100	(8) 1-YR ALW PER EQUIP CNTGY	(9) DEPOT MAINT ALW PER 100 EQUIP	(10) ILLUSTRATION (a) FIG. NO.	(10) (b) ITEM NO.
P-H-- 539		SEMICONDUCTOR DEVICE, DIODE: SAME AS 375	2	ea	4										CR1 thru CR4
P-O- 540	5960-272-9094	SHIELD, ELECTRON TUBE: SAME AS 378	1,2	ea	1										
P-H-- 541	5935-260-0516	SOCKET, ELECTRON TUBE: SAME AS 383	1,2	ea	1										XV5
P-H-- 542	5935-256-2103	SOCKET, ELECTRON TUBE: 07497; 77-MIP-6TM	1,2	ea	1										XV8
P-H-- 543	5935-666-4565	SOCKET, ELECTRON TUBE: SAME AS 386	1,2	ea	6										XV1 thru XV4, XV6, XV7
P-H-- 544		SWITCH ASSEM8LY: 80667; B-17635A	1,2	ea	1				*	*	2	8	5		
P-H-- 545		SWITCH, ROTAMY: 80667; A-17604	1	ea	1				*	*	2	8	5		S2
P-H-- 546		SWITCH ROTARY: 81349; A-17609	1	ea	1				*	*	2	8	5		S1
P-H-- 547		SWITCH, ROTARY: 00346; 310-134	2	ea	1				*	*	2	8	5		S1
P-H-- 548		SWITCH, ROTARY: o0346; 31D-125	2	ea	1				*	*	2	8	5		S2
P-H-- 549		WINDOW. DIAL: 80667; A-17278	1,2	ea	1				*	*	*	4	2		08

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
5905-299-2000	306	5905-578-0289	536	5910-543-9502	104
5905-299-2004	300	5905-578-0290	367	5910-556-9440	492
5905-299-2005	299	5905-578-0292	366	5910-577-6859	32
5905-299-2009	297	5905-578-0293	364	5910-578-1623	119
5905-299-2010	298	5905-578-0301	337	5910-578-1645	40
5905-299-2011	296	5905-578-4278	369	5910-578-5527	95
5905-299-2012	302	5905-729-0433	335	5910-578-5528	97
5905-299-2013	295	5905-807-3314	362	5910-578-5530	98
5905-299-2015	294	5905-828-6300	349	5910-578-5533	36
5905-299-2019	291	5905-839-5931	360	5910-578-5536	42
5905-299-2020	292	5905-846-8152	357	5910-578-5543	493
5905-299-2023	290	5905-853-4123	239	5910-615-9519	45
5905-299-2025	289	5905-878-8643	356	5910-636-2104	61
5905-299-2027	288	5910-100-8130	60	5910-636-2155	68
5905-299-2033	286	5910-100-8141	57	5910-643-8590	371
5905-299-2035	285	5910-101-3984	91	5910-649-2949	491
5905-299-2037	282	5910-101-5582	79	5910-666-7959	372
5905-299-2038	284	5910-112-7117	112	5910-666-8197	41
5905-299-2039	281	5910-112-7643	106	5910-666-8898	66
5905-299-2041	279	5910-112-7712	78	5910-715-6135	474
5905-299-2042	280	5910-112-7800	44	5910-822-2579	108
5905-299-2044	277	5910-112-7908	34	5910-829-3730	484
5905-299-2045	526	5910-126-1584	115	5910-857-2123	38
5905-299-2049	272	5910-129-9237	114	5910-951-7074	75
5905-299-2055	265	5910-174-9967	72	5915-578-5552	397
5905-473-5251	274	5910-196-2501	102	5915-578-5553	392
5905-502-9080	348	5910-270-4828	64	5915-578-5554	398
5905-503-5817	537	5910-270-9214	35	5915-578-5556	393
5905-518-9422	368	5910-284-4045	478	5915-578-5558	396
5905-542-8837	341	5910-284-4046	486	5915-605-5487	185
5905-552-5057	276	5910-284-4049	480	5920-583-5057	29
5905-552-6049	333	5910-284-4430	483	5930-050-2638	408
5905-578-0275	353	5910-519-6668	43	5930-296-9725	407

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
5930-548-5744	401	5935-617-2849	384	5960-262-3763	167
5930-578-0972	402	5935-666-4565	386	5960-264-3004	379
5930-578-3097	400	5935-666-4791	145	5960-272-8548	179
5930-578-3167	406	5935-721-0124	388	5960-272-9094	378
5930-578-4267	399	5935-843-9008	149	5960-284-9285	178
5935-027-9424	21	5950-556-1787	134	5960-296-3371	183
5935-063-5789	381	5950-556-1795	130	5960-542-7004	170
5935-082-0481	144	5950-556-1796	132	5960-669-6861	181
5935-129-9358	382	5950-556-1797	495	5960-827-8781	175
5935-149-2726	147	5950-578-1460	498	5960-879-5078	177
5935-149-3466	150	5950-578-1461	499	5961-170-4430	538
5935-149-3534	4	5950-578-lT15	410	5961-296-0162	374
5935-149-3914	3	5950-578-1717	412	5970-175-2736	190
5935-149-4013	18	5950-578-5268	500	5970-578-4018	192
5935-160-1364	380	5950-578-5276	432	5977-295-8063	27
5935-173-5895	20	5950-578-5545	212	6105-557-8999	209
5935-187-0624	151	5950-578-5551	377	6130-557-8955	216
5935-189-2962	153	5950-578-5674	136	6145-504-0942	9
5935-201-2774	19	5950-578-5676	139	6145-606-8539	12
5935-201-3090	2	5950-605-5465	414	6210-243-0056	206
5935-201-3091	6	5950-607-3845	128	6210-247-1778	207
5935-201-3113	387	5950-615-3262	120	6210-836-2564	208
5935-201-3511	146	5955-583-1875	211	6240-155-8706	199
5935-204-5098	8	5955-605-5455	210	6240-179-1811	197
5935-252-6340	159	5955-605-5476	160	6240-223-9100	196
5935-256-2103	542	5955-605-7200	161	6250-283-9741	200
5935-259-0337	390	5960-188-3968	506	6625-031-0991	158
5935-260-0516	383	5960-193-5111	168	6625-543-1356	1
5935-280-1454	7	5960-230-5307	172	6625-553-4006	470
5935-283-3383	22	5960-237-6917	176	6625-603-9082	5
5935-404-8015	16	5960-262-0152	171	6625-605-5448	164
5935-565-0067	148	5960-262-0167	173	6625-605-5453	417
5935-594-2059	385	5960-262-1357	174	6625-605-5460	419

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
6625-605-7189	23	CM15C270JN1	55	CP54B4EG104V	107
6625-605-7198	24	CM15C330JN1	56	CP54B6EF254V	109
6625-676-1322	217	CM51C750JN1	69	CP61B1EF105K	113
6645-605-5454	468	CM15C820J	71	CT1C100	116
6680-605-7224	154	CM1SE101JN1	74	CT13E057J	117
6685-605-7192	409	CM15E111JN1	T6	CT13E143J	118
REF	INDEX	CM15E220JN1	52	D-19148	156
NUMBER	NUMBER				
		CM15E221JN1	80	FA-9836	186
A-17191	497	CM51E390CN1	58	HKP-H	188
A-17278	549	CM15E39WJN1	59	JM1.0	96
A-17496	496	CM15E470JN1	62	JM6.8	99
A-17604	545	CM20B100KN1	48	1P1-3-15K	344
A-17605	465	CM20B101KN1	77	1P1-3-5	331
A-17609	546	CM20B220KN1	53	MDF6.25	187
A-17872	193	CM20B271KN1	81	MS3106A-163-1S	17
AN3057-4	13	CM20B391KN1	82	NE-23	198
AN3057-8	14	CM20B470JN1	63	NS5W106	191
B-17394	162	CM20B471KN1	84	P150F424	111
B-17396	214	CM20B681KN1	86	RC20GF393J	235
B-17579	25	CM20B821JN1	88	RC20GF470K	511
B-17635A	544	CM20C620JN1	67	RC20GF683K	444
B-17636	464	CM20E391GN1	83	RC20GF823K	445
CC21CH100D	33	CM30B102KN1	89	RC32GF121K	264
CK61Y102Z	37	CM30B332KN1	92	RC32GF152K	275
CK63AW103M	39	CM30B472KN1	94	RC32GF154K	303
CM15B150KN1	49	CM30B561KN1	85	RC32GF155K	314
CM15B270KN1	54	CM30B681K	87	RC32GF185K	315
CM15B560KN1	65	CM30E102FN1	90	RC32GF221K	266
CM1SB820KN1	70	CM30E392GN1	93	RC32GF272K	278
CM15C050JN1	46	C0-03MGF(3/16)0350	10	RC32GF471J	271
CM15C100KN1	47	CP04A1KF103K	489	RC32GF564K	310
CM15C101J	73	CP04A1KE104K	103	RC32GF684J	312
CM15C1S0JN1	50	CP05A1EF332KN1	100	RN70D3004F	354
CM15C220JN1	51	CP05A1KF104K1	105	RN70D9002F	340

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
RN75B1323F	342	35-Z-202	165	821-011	30
RN75B1442F	332	35-Z-203	166	86CP-11T	152
RN75B1443F	343	35-Z-204	155		
RN75B1603F	345	4228-000	205		
RN75B1813F	346	5HK-S20	31		
RN75B2164F	355	5Y3WCT	169		
RN75B2452F	334	50M-1-531	411		
RN75B3053F	347	50M-1-532	413		
RN75B4053F	350	50M-1-572	213		
RN75B4152F	336	50M-M-240	215		
RN75B4903F	351	50M-s-494	126		
RN75B7902F	338	50M-S-495	415		
RN75B8303F	352	50M-S-524	129		
RN75X9002F	339	50M-S-524-1	133		
RV2TRDS0SB	370	50M-s-524-3	135		
RV4LAXSA203B	363	50M-s-524-4	131		
RW320152	358	50M-s-524-5	137		
V5H0-M1-1	26	50M-S-533	416		
1N198	375	524B-S-412-11	141		
14A5	28	524B-S-412-12	142		
22A1PE393G	101	524B-S-412-13	140		
22A1PE394G	110	524B-S-412-3	127		
25P-323C	202	524B-S-412-4	125		
25P-323R	204	524B-S-412-7	124		
25P-323W	203	524B-S-412-8	121		
310-125	548	524B-S-412-9	122		
310-126	404	524B-S-413-3	143		
310-128	405	524B-S-413-6	138		
310-134	547	524B-S-446-1	123		
310-39	403	5963	180		
35-D1-201	163	6080WA	182		
35-T1-6A	469	7-06	201		
35-Z-201	418	77M1P-11MT	389		

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
B201	26	C39	479	C103	427
B201A	209	C40	475	C104	425
C1	476	C41	492	C105	428
C2	473	C42	492	C106	429
C3	475	C43	492	C107	426
C4	476	C44	488	C108	423
C5	476	C45	492	C109	425
C6	474	C46	478	C110	427
C7	476	C47	493	C111	429
C8	476	C48	478	C112	428
C9	476	C49	490	C113	425
C10	476	C50	486	C114	424
C11	474	C51	494	C201--1	106
C12	491	C52	483	C201--2	106
C13	474	C53	494	C201--3	106
C15	471	C54	480	C201--4	105
C16	472	C55	493	C202	39
C18	487	C56	479	C204--1	54
C19	476	C57	482	C204--2	54
C20	476	C58	476	C204--3	54
C21	487	C59	481	C204--4	39
C22	475	C60	477	C205	39
C23	475	C61	484	C206	39
C24	492	C62	477	C207	39
C25	492	C63	476	C208	75
C26	492	C65	477	C209	108
C27	488	C66	477	C210	39
C28	492	C67	485	C211	53
C29	478	C68	T477	C212	39
C30	493	C69	489	C213	54
C31	478	C70	476	C214	54
C32	490	C73	476	C215	39
C33	486	C74	494	C216	114
C34	494	C75	477	C217	39
C35	483	C76	477	C218	39
C36	494	C77	476	C219	60
C37	480	C78	477	C220 AB	107
C38	493	C79	424	C221	39

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
C222	63	C256	91	C291-2	48
C223	70	C257	50	C291-4	53
C224	39	C258	50	C292	39
C225	63	C259	89	C293	39
C226	54	C260	89	C294	115
C227	84	C261	50	C295	116
C228	84	C262	39	C296	116
C229	39	C264--1	60	C297	84
C230	54	C264--2	60	C298	39
C231--1	63	C264--3	60	C299	75
C231-2	65	C264--4	75	C300	70
C231--3	65	C265	54	C301--1	95
C232	63	C266	39	C301--2	95
C234	39	C267	54	C301--3	95
C235	39	C268	53	C301--4	96
C236--1	94	C269	50	C303	39
C236--2	94	C270	54	C304	39
C236--3	94	C271	39	C305	80
C236--4	92	C272	54	C306	97
C237	85	C273	54	C307	80
C238	54	C274	53	C308	39
C239	39	C275	54	C309	67
C240--2	48	C276	39	C310	97
C240--4	50	C277	54	C311	67
C241	84	C278	54	C312	80
C242	84	C279	60	C313	80
C243	48	C280	39	C314	97
C244	50	C281	60	C315--1	72
C245	48	C282	50	C315--2	72
C247	87	C283	8,	C315--3	72
C248	87	C284--1	39	C315--4	74
C249	48	C284--2	39	C316--2	51
C250	32	C284--3	39	C316--3	51
C251	39	C284-4	30	C316-4	119
C252	50	C285	39	C317	108
C253	50	C286	94	C318	39
C254	50	C287	39	C319-1	75
C255	91	C290	84	C319-2	75

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
C319--3	75	C329	98	C382	50
C319--4	81	C330	65	C383	50
C320--1	63	C331	79	C385	39
C320--2	63	C332	39	C386	38
C320--3	63	C333--1	84	C387	54
C320--4	58	C333--2	84	C601	430
C321--1	75	C333--3	84	C602	431
C321--2	75	C333--4	90	C603	428
C321--3	75	C334	39	C604	422
C321--4	81	C335	119	C701	100
C322--1	84	C336	78	C702	50
C322--2	84	C337	39	C703--2	48
C322--3	84	C338	57	C703--4	99
C322--4	83	C339	40	C801--1	34
C323--1	75	C340	84	C801--2	34
C323--2	75	C341	44	C801--3	34
C323--3	75	C342	44	C801--4	74
C323--4	81	C343AB	109	C802--1	34
C324--1	94	C344AB	112	C802--2	34
C324--2	94	C345	39	C802--3	34
C324--3	94	C346	39	C802--4	55
C324--4	93	C347	44	C803--2	79
C325--1	75	C348AB	109	C803--3	79
C325--2	75	C349	45	C803--4	39
C325--3	75	C350AB	109	C804--1	34
C325--4	81	C351	109	C804--2	34
C326--1	102	C352	106	C804--3	34
C326--2	102	C360	39	C804--4	74
C326--3	102	C365	39	C805--1	34
C326--4	101	C366	113	C805--2	34
C327--1	75	C367	113	C805--3	34
C327--2	75	C368	39	C8O5--4	74
C327--3	75	C369	50	C806--1	34
C327--4	81	C370	50	C806--2	34
C328--1	112	C371	39	C806--3	34
C328--2	112	C372	39	C806--4	74
C328--3	112	C380	50	C807--1	34
C328--4	110	C381	50	C807--2	34

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
C807--3	34	C904	62	C1309	39
C807--4	31	C905	55	C1310	39
C808--1	34	C906	55	C1312	76
C808--2	34	C907--1	39	C1313	59
C808--3	34	C907--4	55	C1314	117
C808--4	62	C908	55	C1315	118
C809--1	68	C909	59	C1319	104
C809--2	68	C910	59	C1320	75
C809--3	68	C911	59	C1400	33
C809--4	74	C912	59	C1402	62
C810--1	68	C913	39	C1403	39
C810--2	68	C914	39	C1404	49
C810--3	68	C915	39	C1405	51
C810--4	59	C916	39	C1406	46
C811--1	68	C917--1	69	C1407	39
C811--2	68	C917--4	59	C1408	49
C811--3	68	C918	69	C1409	41
C811--4	51	C1001	103	C1410	51
C812--1	34	C1002	31	C1411	55
C812--2	34	C1003	89	C1412	51
C812--3	34	C1004	35	C1413	39
C812--4	69	C1005	85	C1414	56
C813--1	39	C1006	104	C1416	51
C813--2	39	C1101	75	C1417	62
C813--3	39	C1102	82	C1418	39
C813--4	59	C1103	63	C1419	56
C814--1	35	C1104	33	C1501	111
C814--2	35	C1105	70	C1502	111
C814--3	35	C1106	42	C2101	73
C814--4	62	C1107	43	C2102	61
C815--2	36	C1108	77	C2103--2	61
C815--3	36	C1301	39	C2103--3	61
C815--4	62	C1302	104	C2103--3	73
C816	62	C1304	86	C2104	39
C901	73	C1305	39	C2105	68
C902	59	C1306	47	C2106	61
C903--1	39	C1307	50	C2107	61
C903--4	52	C1308	88	C2108	39

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
C2109	68	CR204	374	CR242	374
C2110	61	CR205	374	CR243	374
C2111	61	CR206	374	CR244	374
C2112	39	CR207	374	CR245	374
C2114	66	CR208	374	CR246	374
C2115	66	CR209	374	CR247	374
C2116	39	CR210	374	CR248	374
C2117	71	CR211	374	CR249	374
C2118	71	CR212	374	CR249--1	374
C2119	37	CR213	374	CR249--2	374
C3102	64	CR214	374	CR249--3	374
C3103	64	CR215	374	CR201	375
C3104	39	CR216	374	CR202	375
C3105	69	CR217	374	CR203	375
C3106	64	CR218	374	CR204	375
C3107	69	CR219	374	CR205	375
C3108	39	CR220	374	CR206	375
C3109	64	CR221	374	CR207	375
C3110	64	CR222	374	CR208	375
C3111	64	CR223	374	CR209	375
C3112	39	CR224	374	CR210	375
C3113	64	CR225	374	CR211	375
C3114	64	CR226	374	CR212	375
C3115	64	CR227	374	CR213	375
C3116	39	CR228	374	CR214	375
C3118	64	CR229	374	CR215	375
C3119	37	CR230	374	CR216	375
CR1--1	538	CR231	374	CR217	375
CR1--2	539	CR232	374	CR218	375
CR2--1	538	CR233	374	CR219	375
CR2--2	539	CR234	374	CR220	375
CR3--1	538	CR235	374	CR221	375
CR3--2	539	CR236	374	CR222	375
CR4--1	538	CR237	374	CR223	375
CR4--2	539	CR238	374	CR224	375
CR201	374	CR239	374	CR225	375
CR202	374	CR240	374	CR226	375
CR203	374	CR241	374	CR227	375

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
CR228	375	CR1102	375	DS909	198
CR229	375	CR1103	375	DS910	198
CR230	375	CR1401	375	DS901B	197
CR231	375	CR1402	375	DS902B	197
CR232	375	CR1403	375	DS903B	197
CR233	375	CR1404	375	DS904B	197
CR234	375	CR1405	375	DS905B	197
CR235	375	CR1406	3T5	DS906B	197
CR236	375	CR1407	375	DS907B	197
CR237	375	CR1408	375	DS908B	197
CR238	375	CR2001	375	DS909B	197
CR239	375	CR2002	375	DS910B	197
CR240	375	CR2003	375	DS1200	198
CR241	375	CR2004	375	DS1201	198
CR242	375	CR2005	375	DS1202	198
CR243	375	CR2006	375	DS1203	198
CR244	375	CR2007	375	Ds1204	198
CR245	375	CR2008	375	DS1205	198
CR246	375	DL201--1	162	DS11206	198
CR247	375	DL201--2	162	DS1207	198
CR248	375	DL201--3	162	DF1208	198
CR249	375	DL201--4	163	DS1209	198
CR249--4	375	DS201		DS1401	198
CR250	374	DS202	199	DS1402	198
CR251	374	DS203	199	DS1403	198
CR252	374	DS204	199	DS1404	198
CR253	374	DS205	199	DS1405	198
CR254	374	DS206	199	DS1406	198
CR255	374	DS207	199	DS1407	198
CR256	374	DS208	199	DS1408	198
CR257	374	DS901	198	DS1409	198
CR258	374	DS902	198	DS1410	198
CR259	374	DS093	198	E11	378
CR260--1	216	DS904	198	E201	2
CR260--2	216	DS905	198	E202	2
CR260--3	216	DS906	198	E274	191
CR260--4	375	DS907	198	E275	191
CR1101	375	DS908	198	E276	191

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
E702	378	L11	500	L216--1	134
E703	379	L12	501	L216--2	134
F201	187	L101	432	L216--3	134
F202	187	L102	432	L216--4	135
F1201--1	185	L201	121	L217--1	134
F1201--2	185	L202	122	L217--2	134
F1201--3	185	L203	123	L217--3	134
F1201--4	186	L204	123	L217--4	135
I201	196	L205	124	L218--1	136
I202	199	L206	125	L218--2	136
I203	199	L207	126	L218--3	136
I204	199	L208	123	L218--4	137
I205	199	L209--1	124	L219--1	212
I206	199	L209--2	124	L219--2	212
I207	199	L209--3	124	L219--3	212
I208	199	L209--4	127	L219--4	213
J101	433	L210	126	L221--1	214
J102	433	L211--1	128	L221--2	214
J201	144	L211--2	128	L221--3	214
J202	145	L211--3	128	L221--4	215
J203--1	147	L211--4	129	L222	138
J203--2	147	L212--1	130	L223	139
J203--3	147	L212--2	130	L224--1	136
J203--4	148	L212--3	130	L224--2	136
J204	146	L212--4	131	L224--3	136
J205--1	147	L213--1	130	L224--4	137
J205--2	147	L213--2	130	L225	120
J205--3	147	L213--3	130	L226	140
J205--4	148	L213--4	131	L227	141
J206	153	L214--1	132	L228	142
J1301	149	L214--2	132	L6o1	396
L1	496	L214--3	132	L602	392
L3	497	L214--4	133	L603	393
L4	498	L215--1	132	L6o4	397
L5	499	L215--2	132	L607	398
L6	497	L215--3	132	L1101	393
L10	500	L215--4	133	L1101	121

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
L1102	122	R12	521	R104	451
L1103	123	R13	510	R105	442
L1104	143	R1'4	511	R106	442
L1301	131	R15	536	R107	460
M201	24	R16	521	R108	446
M202	24	R17	510	R109	448
07	504	R18	510	R110	368
08	549	R19	531	R111	453
012	508	R20	531	R112	447
0124	436	R21	510	R113	450
0125	436	R22	528	R114	451
0126	437	R23	520	R115	442
0127	437	R24	533	R116	442
0286	376	R25	527	R117	444
0318A	189	R26	529	R118	274
0367	508	R27	522	R119	46o
P101--1	435,503	R28	514	R120	446
P101--2	435,503	R29	528	R121	448
P102--1	434,502	R30--1	516	R122	368
P102--2	434,502	R30--2	526	R123	446
P201	150	R31	522	R201	272
P202	150	R32	514	R202	254
P701	151	R33	525	R203	261
P801	151	R34	522	R204	223
P901	151	R35	535	R205	238
P101	151	R36	524	R206	254
P1401	152	R37	532	R207	261
R1	520	R38	534	R208	274
R2	515	R39--1	520	R209	225
R3	513	R39--2	519	R210	254
R4	531	R4o	512	R211	364
R5	537	R41	535	R212	300
R6	520	R42	530	R213	275
R7	515	R43	517	R214	283
R8	513	R44	518	R216	268
R9	531	R101	444	R217	270
R10	525	R102	447	R218	276
R11	523	R103	450	R219	272

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
R220	278	R241--3	313	R276	321
R221	300	R241--4	254	R277	308
R222	312	R242	226	R278	263
R223	296	R243	269	R280	274
R224	364	R244	263	R281	306
R225	298	R246	224	R282	286
R226	326	R247	314	R283	262
R227	326	R248	364	R284	254
R228	296	R249	325	R285	265
R229	310	R250	275	R286	224
R230--1	308	R251	353	R287--1	228
R230--2	308	R252	351	R287--2	228
R230--3	308	R253	268	R287--3	228
R230--4	251	R254	325	R287--4	238
R231	304	R255	287	R288	246
R232--1	309	R256	341	R289	232
R232--2	309	R257	336	R290	321
R232--3	309	R258	325	R291	334
R232--4	252	R259	325	R292	332
R233	314	R260	269	R293	333
R234	316	R261	267	R294	337
R235--1	318	R262	341	R295--1	323
R235--2	318	R263	336	R295--2	323
R235--3	318	R264	326	R295--3	323
R235--4	319	R265--1	277	R295--4	331
R236	263	R265--2	277	R296--1	323
R237--1	369	R265--3	277	R296--2	323
R237--2	369	R265--4	276	R296--3	323
R237--3	369	R266	R264	R296--4	331
R237--4	370	R267	325	R297	265
R238	295	R268	306	R298	265
R239	264	R269	352	R299	334
R240--1	309	R270	347	R300	332
R240--2	309	R271	282	R301	333
R240--3	309	R272	300	R303	308
R240--4	252	R273	291	R304--1	323
R241--1	313	R274	273	R304--2	323
R241--2	313	R275	313	R304--3	323

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
R304--4	331	R330	341	R360	284
R305--1	323	R331	266	R361	337
R305--2	323	R332	266	R362	324
R305--3	323	R333	341	R363--1	296
R305--4	331	R334	336	R363--2	296
R306	280	R335--1	328	R363--3	296
R307	338	R335--2	328	R363--4	338
R308	335	R335--3	328	R364	337
R309--1	323	R335--4	239	R365	288
R309--2	323	R336	329	R366	328
R309--3	323	R337	281	R367	337
R309--4	324	R338	341	R368	284
R310	326	R339	336	R369	337
R311	266	R340--1	287	R370	324
R312	266	R340--2	287	R371	305
R313	338	R340--3	287	R372	287
R314	335	R340--4	344	R373	337
R315	305	R341	287	R374	324
R316--1	323	R342	266	R375	296
R316--2	323	R343	266	R376	337
R316--3	323	R344	341	R377	3114
R316--4	324	R345	336	R378	328
R317	326	R346--1	305	R379	337
R318--2	314	R346--2	305	R380	287
R318--3	314	R346--3	305	R381	337
R318--4	232	R346--4	299	R382	324
R319	285	R347	288	R383	341
R320	283	R348	287	R384	287
R321	268	R349	367	R385	337
R322	272	R350	366	R386	324
R323	281	R351	337	R387	305
R324	314	R352	337	R388	337
R325	284	R353	324	R389	328
R326	341	R354	287	R390	291
R327	336	R357	337	R391	302
R328	327	R358	324	R392	337
R329	326	R359	308	R393	287

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
R395	324	R434--1	218	R456	330
R396	366	R434--4	219	R457--1	300
R397	296	R435	256	R457--2	301
R398	367	R436	275	R457--3	301
R399	287	B437	300	R457--4	301
R400	266	R438	330	R458	280
R401	287	R439--1	300	R459	286
R402	298	R439--2	301	R460	302
R403	281	R439--3	301	R461--1	316
R404	305	R439--4	301	R461--2	316
R405	292	R440	280	R461--3	316
R407	262	R441	286	R461--4	355
R408--2	359	R442	302	R462	364
R408--3	359	R443--1	316	R463	300
R408--4	358	R443--2	316	R464	256
R409	323	R443--3	316	R465	330
R410	299	R443--4	355	R466	301
R411	272	R444	364	R467	279
R412	299	R445	300	R468	286
R413	272	R446--1	300	R469	302
R414	263	R446--2	315	R470--1	316
R415	271	R446--3	315	R470--2	316
R416	291	R446--4	256	R470--3	316
R419	254	R447	330	R470--4	355
R420	313	R448--1	300	R471	364
R421	310	R448--2	301	R472	300
R422	281	R448--3	301	R473	256
R425	304	R448--4	301	R474	280
R426	287	R449	279	R475	330
R427	309	R450	286	R476--1	300
R429	252	R451	302	R476--2	301
R430	252	R452--1	316	R476--3	301
R431	295	R452--2	316	R476--4	301
R432	270	R452--3	316	R477	286
R433--1	312	R452--4	355	R478	302
R433--2	312	R453	364	R479--1	316
R433--3	312	R454	300	R479--2	316
R433--4	313	R455	256	R479--3	316

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
R479--4	355	R509--1	367	R536	356
R480	364	R509--2	367	R538	242
R481	222	R509--3	367	R540	237
R482	268	R509--4	363	R541	224
R483	268	R510	343	R602	457
R484	321	R511	320	R603	455
R485--1	291	R512	223	R604	445
R485--2	291	R513	320	R605	454
R485--3	291	R514	300	R607	441
R485--4	290	R515	223	R608	458
R486	254	R516--1	367	R609	458
R487	303	R516--2	367	R610	449
R488	254	R516--3	367	R611	457
R489--2	228	R516--4	363	R612	443
R489--3	228	R517	342	R613	456
R489--4	255	R518	356	R614	456
R490	357	R519	356	R615	459
R491	357	R520	290	R616	452
R492	357	R521	274	R617	459
R493	362	R522	294	R701	292
R494	223	R523	346	R702--1	298
R495	281	R524--1	367	R702--2	298
R496	295	R524--2	367	R702--3	298
R498	317	R524--3	367	R702--4	297
R499	306	R524--4	363	R703	220
R500	223	R525	345	R704	227
R501--1	367	R526	349	R705	302
R501--2	367	R527	348	R706--1	292
R501--3	367	R528	349	R706--2	292
R501--4	363	R529	288	R706--3	292
R502	350	R530	288	R706--4	296
R503	320	R532--1	361	R707	289
R504	223	R532--2	361	R708	289
R505	300	R532--3	361	R709--1	307
R506	320	R532--4	360	R709--2	307
R507	223	R533	296	R709--3	307
R508	223	R535	218	R709--4	249

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
R710	310	R811--2	295	R823--1	247
R711	238	R811--3	295	R823--2	247
R712	223	R811--4	236	R823--3	247
R801--2	295	R812	295	R823--4	295
R801--3	295	R813--1	247	R824--1	241
R801--4	233	R813--2	247	R824--2	241
R802--1	247	R813--3	247	R824--3	241
R802--2	247	R813--4	283	R824--4	236
R802--3	247	R814--1	241	R825--1	295
R802--4	248	R814--2	241	R825--2	295
R803--1	241	R814--3	241	R825--3	295
R803--2	241	R814--4	236	R825--4	248
R803--3	241	R815--1	241	R826--1	295
R803--4	242	R815--2	241	R826--2	295
R804--1	295	R815--3	241	R826--3	295
R804--2	295	R815--4	248	R826--4	242
R804--3	295	R816	247	R827--1	247
R804--4	292	R817--1	295	R827--2	247
R805--1	295	R817--2	295	R827--3	247
R805--2	295	R817--3	295	R827--4	234
R805--3	295	R817--4	242	R828--1	241
R805--4	229	R817--1	295	R828--2	241
R806--1	247	R818--2	295	R828--3	241
R806--2	247	R818--3	295	R828--4	248
R806--3	247	R818--4	242	R829--1	280
R806--4	233	R819--1	295	R829--2	280
R807--1	241	R819--2	295	R829--3	280
R807--2	241	R819--3	295	R829--4	242
R807--3	241	R819--4	236	R830--1	247
R807--4	248	R820	247	R830--2	247
R808--1	295	R821--1	241	R830--3	247
R808--4	242	R821--2	241	R830--4	295
R809--1	247	R821--3	241	R831--1	243
R809--2	247	R821--4	248	R831--4	234
R809--3	247	R822--1	295	R832	248
R809--4	242	R822--2	295	R833	242
R810	248	R822--3	295	R901	233
R811--1	295	R822--4	248	R901	246

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
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R903	233, 246	R932	248	R1012	229
R904	233, 246	R933--1	295	R1013	223
R905	233, 246	R933--4	248	R1014	299
R906	233, 246	R934	248	R1015	229
R907	233, 246	R935	242	R1016	223
R908	233, 246	R936	242	R1017	299
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R913--1	242	R941	242	R1022	223
R913--4	292	R942	242	R1023	221
R911	295	R943	230	R1024	246
R915	295	R944	230	R1025	218
R916	295	R945	230	R1102	323
R917--1	242	R946	230	R1103--1	304
R917--4	233	R947	244	R1103--2	304
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R919	230	R950	242	R1103--4	346
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R921--1	295	R954	238	R1105	295
R921--14	237	R955	238	R1106	251
R922	237	R956	238	R1107	223
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R924	237	R1002	233	R1109	326
R925	237	R1003	311	R1110	350
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R927	248	R1006	277	R1113	322
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R929	248	R1008	299	R1115--2	339
R930--1	243	R1009	229	R1115--3	339
R930--2	248	R1010	223	R1115--4	340
				R1116	277

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.	FEDERAL STOCK NUMBER	INDEX NO.
R1117--2	339	R1228	354	R1323	230
R1117--3	339	R1230	237	R1401	253
R1117--4	340	R1231	246	R1402	246
R1118	228	R1232	242	R1403	344
R1119	226	R1233	344	R1404	242
R1120	257	R1234	246	R1409	344
R1134	218	R1235	230	R1410	242
R1200	259	R1236	246	R1412	253
R1201	237	R1238	237	R1413	246
R1202	248	R1240	258	R1414	234
R1203	242	R1241	249	R1415	251
R1204--1	291	R1242	258	R1418	242
R1204--2	291	R1243	258	R1420	246
R1204--3	291	R1244	249	R1421	246
R1204--4	253	R1246	237	R1422	235
R1205	246	R1247	250	R1425	246
R1206	230	R1248	246	R1426	246
R1207	253	R1249	246	R1429	242
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R1209	235	R1251	246	R1432	246
R1210	237	R1253	246	R1436	242
R1211	250	R1254	237	R1438	235
R1212	258	R1255	248	R1441	230
R1213	249	R1256	242	R1442	246
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SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

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R2105	238	R2147	244	R3140	246
R2106	233	R2149	244	R3141	295
R2107	233	R2150	246	R3142	246
R2108	249	R2151	298	R3144	296
R2109	249	R3101	243	R3145	248
R2110	242	R3102	243	R3146	248
R2111	231	R3103	292	R3147	242
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R2114	246	R3105	232	R3149	242
R2115	246	R3106	231	R3150	242
R2116	299	R3107	231	R3151	235
R2117	246	R3108	248	R3424	228
R2118	246	R3109	248	S1--1	546
R2119	298	R3110	241	S1--2	547
R2120	298	R3111	229	S2--1	545
R2121	249	R3112	241	S2--2	548
R2122	249	R3114	246	S101	465
R2123	242	R3115	246	S102	466
R2124	231	R3116	295	S103	465
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SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

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S207--3	402	V211	170	V256	173
S207--4	404	V212	172	V257	169
S208	408	V213	172	v258	181
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T201--2	414	V215	172	V260	171
T201--3	414	V216	172	V261	167
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T202--1	414	V218	172	V602	439
T202--2	414	V219	180	V603	439
T202--3	414	V220	180	V701	173
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SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

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X1203A	206	XV5--2	541	XV221	390
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X1204A	206	XV6--1	543	XV223	390
X1205	200	XV6--2	543	XV234	384
X1205A	206	XV6--3	386	XV235	384
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SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

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XV255--3	390	XV1202	385	XZ208	381
XV255--4	385	XV1203	385	XZ209--4	381
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XV256--2	390	XV1302	384	XZ235--2	382
XV256--3	390	XV1303	384	XZ235--3	382
XV256--4	385	XV1304	383	XZ235--4	380
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XV259	384	XV2103	388	Z8	495
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XV261	384	XV3101	388	Z102--2	469
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XV602	462	XV3103	388	Z103--2	469
XV603	462	XV3104	388	Z201--1	417
XV701	385	XV1401	385	Z201--2	417
XV702	384	XV1402	385	Z201--3	417
XV801	388	XV1403	385	Z201--4	418
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XV804--2	388	XZ201	382	Z202--4	165
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XV902	385	XZ208	382	Z205--2	156

SECTION V INDEX-FEDERAL STOCK NUMBER CROSS REFERENCE TO INDEX NUMBER (CONTINUED)

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Z206--1	156				
Z206--2	156				
Z206--4	155				
Z207--1	156				
Z207--2	156				
Z207--4	155				
Z208--1	156				
Z208--2	156				
Z208--4	155				
Z209--1	156				
Z209--2	156				
Z209--4	155				

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11-97	29-247
11-98	29-500
11-117	32-56
11-127	32-57
11-155	32-67
11-157	32-77
11-158	32-78
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KA,RL,RO,RR,RV)	32-56
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29-85	32-500
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29-105	44-12
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	55-457
	55-458
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	57-100
	67
	77-100

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The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*	*To change*	*To*	*Multiply by*
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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