NAVSHIPS 0967-053-7010

TECHNICAL MANUAL

for

FREQUENCY STANDARD AN/URQ-10

DEPARTMENT OF THE NAVY
NAVAL SHIP SYSTEMS COMMAND

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SECTION 1
GENERAL INFORMATION

1-1. INTRODUCTION.

This manual provides complete service instructions for Frequency Standard AN/URQ-10 (figure 1-1), referred to hereinafter as the frequency standard. The manual contains a functional description of the equipment, installation information, operating procedures, troubleshooting data, maintenance information, and a list of all replaceable parts.

1-2. GENERAL DESCRIPTION.

a. The frequency standard is a compact, highly stable, multiple-purpose frequency standard designed for continuous-duty use aboard ship and at shore facilities. It provides three output frequencies - 5.0 mc, 1.0 mc, and 100 kc.

b. The frequency standard can be used for laboratory frequency measurements and to drive precision timing devices such as a time comparator. It can also be used as a standby oscillator unit for other frequency/time-base standards such as Frequency-Time Standard AN/BSQ-2A.

c. The equipment is designed to operate from a nominal 115 volt, 50 to 400 cps, single-phase, alternating current, external power source. A battery, which is built into the equipment, is automatically switched into the circuit to maintain operation in the event the external power source fails or is disconnected. When fully charged, the battery is capable of operating the frequency standard for eight hours.

d. The frequency standard consists of the major assemblies listed in Table 1-1. Figure 1-2 identifies the major assemblies and shows their relative locations in the equipment.

e. The radio-frequency (r-f) oscillator consists of a crystal-controlled oscillator, 5-mc amplifier, and an inner and outer oven with control circuits. The r-f oscillator, with the voltage regulator, and two frequency dividers, comprises the frequency determining circuits and amplifiers.

f. The power supply is mounted at the lower rear of the unit. It converts 115 volts, 50 to 400 cycle input, to 11 and 21 vdc. The 21-volt output is supplied to the voltage regulator. The 11-volt output series connected with the 21-volt output, provides 32 volts for battery charging.

g. The battery power supply, mounted at the lower front of the unit, provides standby power to operate the frequency standard when ac input is not available. It consists of 13 nickel-cadmium cells that provide the standby power and one nickel-cadmium cell that acts as a discharge timer cell. It contains an indicator lamp which lights when the battery is being charged by either automatic or manual charging modes.

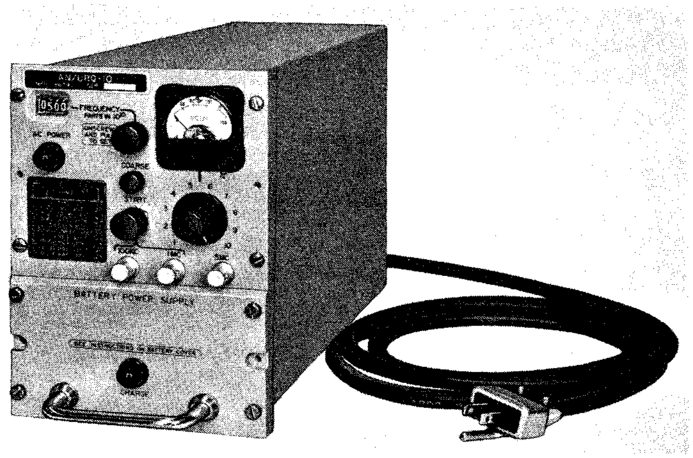


Figure 1-1. Frequency Standard AN/URQ-10

h. The frequency standard chassis contains the connectors and wiring necessary to interconnect the plug-in modules. It also mounts on both front and rear panels, the coaxial connectors through which 5 mc, 1 mc, and 100 kc are available. The front panel mounts the panel meter and metering switch which together select and monitor various circuits of the frequency standard. The front panel, which also mounts the fine frequency control and indicator,

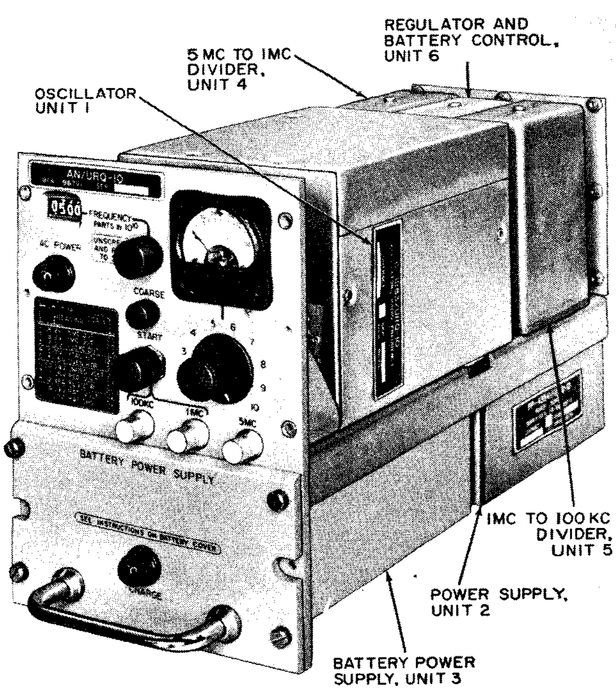


Figure 1-2. Frequency Standard AN/URQ-10, Cover Removed

provides access to the coarse frequency control. In addition, an AC POWER pilot lamp is mounted on the front panel of the chassis. The rear panel mounts an external alarm connector to provide a remote indication of an ac power interruption.

1-3. EQUIPMENT AND PUBLICATIONS SUPPLIED.

The frequency standard is a complete, self-contained, unit and is not supplied with accessory equipment or test fixtures. Table 1-1 lists the equipment and publications supplied. No additional equipment is required for normal operation of the set. Refer to Table 5-1 of this manual for a list of test equipment required.

1-4. QUICK REFERENCE DATA.

Refer to Table 1-2 for a listing of quick reference data.

TABLE 1-1. EQUIPMENT SUPPLIED

QTY PER EQUIP.	NOMENCLATURE		OVERALL DIMENSIONS (IN)			VOLUME	WEIGHT
	NAME	DESIGNATION	HEIGHT	WIDTH	DEPTH	(CU FT)	(LB)
	FREQUENCY STANDARD	AN/URQ-10	7-13/16	5-1/2	15-5/16	.38	22
	-including-						
1	Radio Frequency Oscillator	O-1283/URQ-10	4-7/16	4-7/16	6-3/8	.07	2
1	Power Supply	PP-4354/URQ-10	2-31/32	4-1/2	5-9/32	.04	5
1	Battery Power Supply	BB-605/URQ-10	3-3/16	5-1/2	9-1/8	.09	8
1	Frequency Divider Module, 5 mc to 1 mc		4-3/16	3	1-1/2	.011	.68
1	Frequency Divider Module, 1 mc to 100 kc		4-3/16	3	1-1/2	.011	.68
1	Regulator and Battery Control Module		4-5/16	3	1-1/2	.011	.68
	----*----						
1	Operating Instructions Chart for AN/URQ-10	NAVSHIPS 0967-053-7020	12	9			
2	Technical Manual for AN/URQ-10	NAVSHIPS 0967-053-7010	11	8-1/2			

TABLE 1-2. QUICK REFERENCE DATA

FREQUENCY STANDARD AN/URQ-10	
Input voltage	115 v rms 50 to 400 cps
Input power (battery fully charged)	15 watts (nominal)
Operating temperature range	0 to 50° C
Output frequencies	5 mc, 1 mc, and 100 kc
Output levels:	
50-ohm load	1 v rms (minimum) at all frequencies
1-megohm load	2 v rms (maximum) at all frequencies
Continuous operation time from battery after loss of primary power	8 hours (minimum, with fully charged battery)
Output spurious levels (50-ohm load)	0.1 mv rms (maximum)
Output harmonic levels (50-ohm load)	10 mv rms (maximum)

TABLE 1-2. (Continued)

RADIO FREQUENCY OSCILLATOR Q-1283/URQ-10, UNIT A1	
Output frequency	5 mc
Output levels:	
50-ohm load	1 v rms (minimum)
1-megohm load	2 v rms (maximum)
Spurious output level (50-ohm load)	0.1 mv rms (maximum)
Harmonic output level (50-ohm load)	10 mv rms (maximum)
Frequency adjustment range:	
Coarse	1000 parts per 10^9 (minimum)
Fine (readable within 1 part per 10^{10} on frequency indicator)	1000 parts per 10^{10}
Quartz Crystal Type	5 mc, fifth overtone, AT cut
Crystal excitation current: (agc controlled)	
Range	40 to 70 ua
Variation	±1 db (maximum)
Inner (crystal) oven temperature	Turning point temperature of crystal (65°C to 75°C)
Inner oven temperature variation	.01°C
Outer oven temperature	Approximately 5°C below inner oven temperature
FREQUENCY DIVIDER MODULE, 5 MC TO 1 MC, UNIT A4	
Input frequency	5 mc
Output frequency	1 mc
Input level	0.75 ± 0.3 v rms
Output level:	
50-ohm load	1 v rms (minimum)
1-megohm load	2 v rms (maximum)
Spurious output level (50-ohm load)	0.1 mv rms (maximum)
Harmonic output level (50-ohm load)	10 mv rms (maximum)
FREQUENCY DIVIDER MODULE, 1 MC TO 100 KC, UNIT A5	
Input frequency	1 mc
Output frequency	100 kc
Input level	0.75 ± 0.3 v rms
Output level:	
50-ohm load	1 v rms (minimum)
1-megohm load	2 v rms (maximum)
Spurious output level	0.1 mv rms (maximum)
Harmonic output level	10 mv rms (maximum)

TABLE 1-2. (Continued)

POWER SUPPLY PP-4354/URQ-10, UNIT A2	
Input voltage	115 v rms at 50 to 400 cps
Input power (output loaded as below)	16.5 ± 1 watts
Output voltage: Battery charge line (250-ohm load)	30.2 ± 0.5 vdc
Regulator input line (50-ohm load)	20.2 ± 0.5 vdc
Regulator input ripple (50-ohm load)	0.14 ± .02 - .08 v rms
BATTERY POWER SUPPLY, BB-605/URQ-10, UNIT A3	
Power battery voltage: Charged	18 vdc (nominal)
Discharged (battery disconnect voltage)	12.5 vdc
Discharged time (AN/URQ-10 load)	8 hours (minimum, with fully charged battery)
Battery charge current:	
Automatic	125 ma (nominal)
Manual	60 ma (nominal)
Trickle	20 ma (nominal)
REGULATOR AND BATTERY CONTROL MODULE, UNIT A6	
REGULATOR	
Input voltage	21 vdc ± 10%
Output voltage	12 + 0 - 0.5 vdc
Percent of output voltage change	
Input voltage variation 19 to 23 vdc (250 ma output load)	0.5% (maximum)
Output load variation 0 to 250 ma (21 vdc input voltage)	2.0% (maximum)
Output short circuit current	500 ma (maximum)
Input start voltage (200-ma load)	15 vdc (maximum)
BATTERY CONTROL	
Battery disconnect drop-out voltage	13.0 ± 0, - 0.5 vdc
Battery disconnect pull-in voltage	17.0 (maximum)
Status pull-in voltage (at ac input)	95 v rms (maximum)
Status drop-out voltage (at ac input)	60 v rms (minimum)
Battery charge to discharge time ratio	7.5 : 1

SECTION 2

INSTALLATION

2-1. GENERAL INFORMATION.

The frequency standard will be received by a calibration laboratory prior to being installed at the using activity. The calibration laboratory technicians will perform initial operation and calibration tests on the set and it will then be transferred to the using activity without being turned off (operating on the standby battery). When the set is received by the using activity, it must be plugged into the external power source as soon as possible to avoid completely discharging the battery. Do not wait until the equipment is permanently installed to connect it to the external power source.

CAUTION

Once the frequency standard is in operation and is calibrated, it must not be allowed to stop operating as this will cause the ovens to cool and will alter the operating frequency of the crystal. If the set does get turned off, it should be returned to the calibration laboratory for re-calibration; or, if the set is installed at a shore facility or aboard a ship that is in port, it may be allowed to run for one week and checked for stability and correct frequency before being placed in service. Refer to Chapter 5 for check-out procedure.

Note

When the frequency standard is plugged into the external power source, it will automatically switch from battery operation to ac operation.

2-2. UNPACKING AND HANDLING.

a. The frequency standard is shipped in a corrugated box which contains the set, an operating instruction chart, and two technical manuals.

b. No special precautions are necessary in unpacking the equipment.

c. After the equipment has been unpacked, check to see that all items have been supplied and that no external damage has been done to the equipment during shipment. If the frequency standard has been damaged, or any item is missing, reject the equipment.

2-3. POWER REQUIREMENTS.

The frequency standard requires a nominal 115-volt, 50 to 400 cps, 20 watt single-phase, ac power source available through a grounded female plug.

2-4. INSTALLATION LAYOUT.

The frequency standard may be used as a portable, bench-top instrument, or it may be installed in a mounting rack with mounting hole spacing as indicated in figure 2-1. Figure 2-1 also provides all other pertinent installation dimensions.

2-5. SITE SELECTION.

The frequency standard will perform within required stability limits over a range of temperatures of 0 to 50°C (32 to 122°F). For maximum stability, install the set in a convenient location where it will be adequately protected from temperature extremes and excessive moisture.

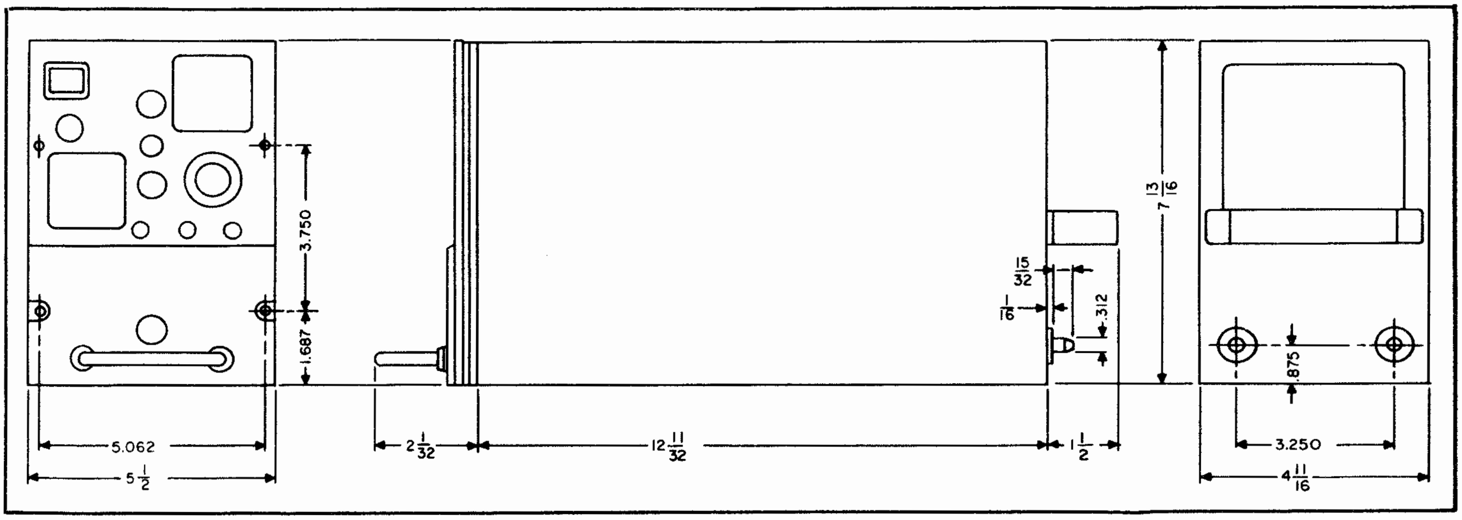


Figure 2-1. Frequency Standard AN/URQ-10, Dimensional Diagram

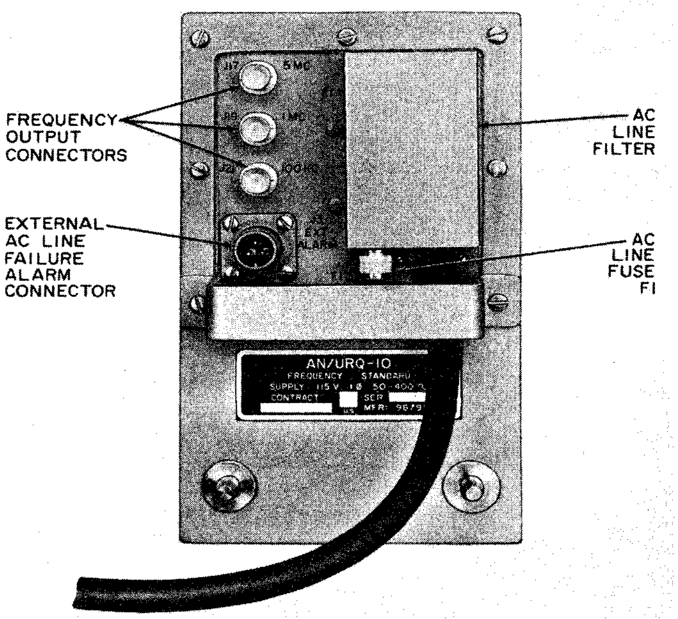


Figure 2-2. Frequency Standard, Rear View

2-6. INSPECTION.

a. The following over-all inspection should be made by calibration laboratory technicians before turning on the equipment for the first time.

b. Rotate the metering switch on the front panel to make sure the knob is properly secured and that the switch operates freely through all positions.

c. Check that the indicator lamps on the front panel are not cracked.

d. Check that the three coaxial connectors on both front and rear panels (figure 2-2) are in good condition.

e. Check that the pins of the external alarm connector on the back of the set are not bent or damaged.

f. Remove the four screws that secure the battery power supply to the frequency standard; remove the battery power supply. Remove the four screws that secure the cover to the battery power supply and check that battery cells, connections, and terminals are in good condition.

g. Remove the screws that secure the frequency standard cover to the front and rear panels; slide off the cover and check that all plug-in components are properly seated in their connectors and that all mounting screws are present and tight. Check all exposed wiring for good condition and firm connections. Install the cover on the frequency standard.

h. Before installing the battery power supply, operate the battery charge switch to the MANUAL CHARGE position. Install the battery power supply with four screws.

2-7. INITIAL OPERATION.

a. Instructions for initial operation at the calibration laboratory are contained in this paragraph.

b. Make sure the battery charge switch is in the MANUAL CHARGE position as described in paragraph 2-6h.

c. Insert the plug of the frequency standard power cord into a mating female connector that provides a nominal 115 volts, 50 to 400 cycle, single-phase ac.

WARNING

Make sure the ac outlet is properly grounded.

d. Since the frequency standard has no on-off switch, plugging in the power cord energizes the unit. As power is applied, the AC POWER lamp (figure 3-1) will light. Since the battery is being charged, the battery CHARGE lamp will also light.

e. Press the frequency divider START button momentarily to start operation of the 1-mc and 100-kc dividers.

Note

Output of the frequency standard does not become stable until the temperature of the crystal oven becomes stable. This requires approximately one week. Do not attempt to adjust the frequency of the unit until output does become stable.

f. After starting, check the output of the various circuits by use of the metering switch and panel meter (figure 3-1). This check will provide a general indication of the operation of the unit. Typical readings and the acceptable range of readings for each switch position are given in Table 3-2, along with an identification of the circuit being checked. Refer to the COMMENTS column for special considerations that could influence the output of the circuit.

Note

Full-scale deflection of the panel meter varies with the setting of the metering switch. Check the full-scale reading for the particular switch position by referring to the instruction chart on the front of the panel.

g. After five days of continuous operation with ac power being supplied continuously to the standard, remove the battery power supply and operate the battery charge switch (figure 3-2) to the AUTOMATIC CHARGE position. Install the battery power supply.

h. After a minimum of seven days of continuous operation, check and adjust the frequency output as directed in Chapter 5. Make daily checks of the frequency output until stable, properly adjusted output is attained.

i. When properly adjusted, the frequency standard can be assigned to the using organization. It must be provided to them while operating on standby battery and must be restored to ac operation as soon as practical (lapse time may not exceed 8 hours).

2-8. PREPARATION FOR RESHIPMENT.

a. To prepare the frequency standard for reshipment, thoroughly clean the unit with a dry cloth.

b. Disconnect primary power and allow the battery to discharge in the equipment until automatic disconnect of the batteries occurs.

c. Place the frequency standard in a plastic coated, metal lined, cloth barrier bag. Provide desiccant in the bag to assure proper moisture removal.

d. Pack in the shipping container with adequate crepe wadding or other resilient material to absorb shock during shipment. Tape the box securely with gummed or pressure-sensitive filament tape.

SECTION 3
OPERATOR'S SECTION

3-1. GENERAL.

The frequency standard is designed for continuous duty, unattended by an operator. It provides three fixed-frequency outputs (5.0 mc, 1.0 mc, and 100 kc). These frequencies are available at coaxial connectors located on the front and rear panels of the unit, and can be used to drive any impedance of 50 ohms or greater. This highly accurate and stable standard can be used to check frequencies of other equipment or to drive precision time comparators.

3-2. CONTROLS AND INDICATORS.

Table 3-1 identifies, illustrates, and explains the function of all controls and indicators of the frequency standard. Some of these controls are not operator controls and should be operated only by calibration laboratory technicians with the availability of frequency deviation meters and other precision equipment necessary to determine the accuracy of frequency output. Table 3-1 indicates which of the controls and indicators are provided for the use of the operator and which are provided only for the use of calibration laboratory personnel and higher echelon maintenance personnel.

CAUTION

Do not operate any controls unnecessarily. Unnecessary control manipulation can disrupt the output frequencies of the unit requiring calibration laboratory recalibration.

3-3. STARTING.

The frequency standard is provided to the using organization from the calibration laboratory in a properly calibrated condition, with operation being maintained by the standby battery. When the ac plug is inserted into a nominal 115-volt, 50 to 400 cycle, ac source, capable of supplying 20 watts, the set automatically reverts to ac operation and will continue to run with no control manipulation required. Battery charging, to restore the battery power supply to a full-charge condition, will proceed automatically if the battery charge switch (figure 3-2) is in the AUTO CHARGE position.

3-4. OPERATION.

a. Operating procedures for the frequency standard are limited to initial operation and emergency operation. When the set is operating normally, no operator is required.

b. Initial operation of the set is normally performed by the calibration laboratory technicians.

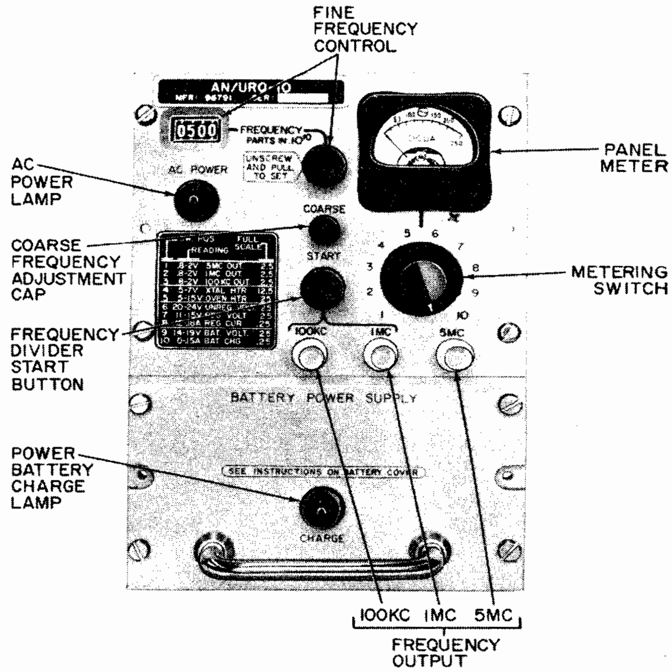


Figure 3-1. Front Panel Controls and Indicators

Refer to paragraph 2-7 for initial operation procedures.

c. Operation of the set will be maintained constantly, as long as the ac power plug is inserted in the ac power source. If the ac supply is interrupted, operation will be maintained by the standby battery for a minimum of 8 hours, provided the battery was fully charged at the start.

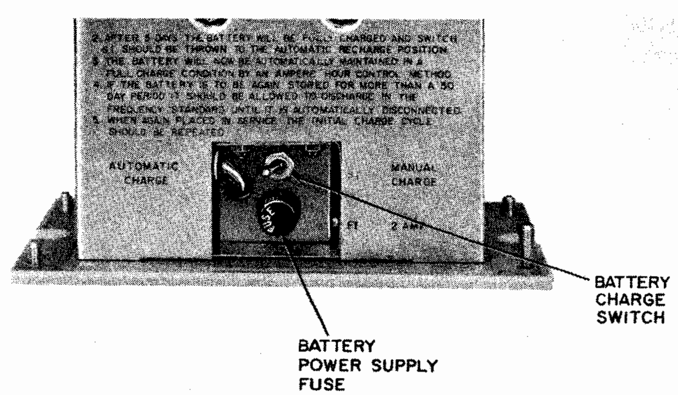


Figure 3-2. Battery Charge Switch

TABLE 3-1. CONTROLS AND INDICATORS

OPERATOR CONTROLS AND INDICATORS		
Control or Indicator	Function	Normal Status
AC POWER lamp (figure 3-1).	Lights when ac input is supplied to the frequency standard. Extinguishes when ac input is interrupted.	Remains lighted during normal operation.
Battery CHARGE lamp (figure 3-1).	Indicates that battery is being charged in the manual mode of operation or in the higher (not trickle) automatic charge mode.	Lamp remains extinguished during normal operation, except after interruption of ac input.
Battery charge switch (figure 3-2).	Selects either manual or automatic battery charging mode. MANUAL CHARGE position causes constant, higher rate charging. AUTO CHARGE position causes higher rate charging only when required to restore battery to full charge, automatically decreasing to trickle charge to maintain battery in full charge position.	Switch remains in AUTO position except at initial start or when battery power supply is replaced.
Frequency output connectors (figure 3-1).	Provides 5-mc, 1-mc, and 100-kc frequencies.	Frequencies are available at connectors whenever frequency standard is operating.
Panel meter (figure 3-1).	Indicates circuit conditions of circuit selected by metering switch.	Indicates zero when metering switch is set at normal unmarked position.
Metering switch (figure 3-1).	Selects circuit to be checked on panel meter.	Remains in unmarked, lower position.
CALIBRATION LABORATORY CONTROLS AND INDICATORS		
COARSE frequency adjustment cap (figure 3-1).	Provides access to coarse frequency control. Coarse frequency control provides coarse adjustment of oscillator output. This must be adjusted with special insulated tool. Tool is stored in clips mounted directly above battery power supply.	Screwed into panel to prevent adjustment of coarse control.
Fine frequency adjustment indicator (figure 3-1).	Indicates in parts per 10^{10} the amount of adjustment provided by the operation of the fine frequency control.	Varies for each unit.
Fine frequency control (figure 3-1).	Provides a fine frequency control, changing frequency of oscillator output by the amount, in parts per 10^{10} indicated on fine frequency adjustment indicator.	Screwed in to lock control and associated indicator.
Frequency divider START button (figure 3-1).	Starts operation of frequency dividers at initial operation or after shutdown.	Remains in undepressed position.

CAUTION

Do not allow the frequency standard to be shut off except in an emergency or unless it requires major repair. Cooling of the crystal will alter its frequency characteristics, making calibration laboratory adjustment necessary before the unit can be restored to service. Never remove the battery power supply from the unit unless the unit is plugged into a reliable source of ac.

d. Information on tuning and adjustment of the set is provided in Section 5.

3-5. EMERGENCY OPERATION.

a. No special precautions are necessary during temporary failure of ac input power. The battery power supply is provided in the unit to supply power instantly in case of failure of input power. The battery power supply, when fully charged, is capable of supplying power to operate the equipment for 8 hours minimum. Connect the unit to an alternate 115-volt, 50 to 400 cps, ac source before this time has elapsed.

Note

When the equipment is operating from battery, both indicator lights are off. Determine proper operation from meter readings. With the metering switch in positions 1 through 4 or 7, no change should occur in readings when operation is switched from normal to battery.

b. Each frequency output line is isolated from other outputs. A short circuit on one line will not interrupt other output frequencies.

c. The 5-mc crystal output is divided, in sequence, to 1-mc and 100-kc outputs. For this reason, 5-mc and 1-mc output will be available even though there is a failure in the 100-kc divider circuit. Similarly, 5-mc output will be available even though there is a failure of the 1-mc divider.

d. If frequency standard failure makes it necessary to stop the frequency standard, unplug it from the ac source and remove the battery power supply.

TABLE 3-2. TYPICAL PANEL METER READINGS

SWITCH POSITION	CIRCUIT FUNCTION MEASURED	UNIT METERED	TYPICAL READING	RANGE OF READING	FULL-SCALE DEFLECTION	COMMENTS
1	5-mc output level	A1	1v	0.8 - 2v	2.5v	Reading normally high with no load connected to 5-mc output.
2	1-mc output level	A4	1v	0.8 - 2v	2.5v	Reading normally high with no load connected to 1-mc output.
3	100-kc output level	A5	1v	0.8 - 2v	2.5v	Reading normally high with no load connected to 100-kc output.
4	Crystal (inner oven) heater voltage	A1	9v	8 - 10v	12.5v	Reading will be approximately 12v for a cold oven. After approximately an hour warmup, reading will drop to about 9v and thereafter remain constant within 1/2 volt.
5	Outer oven heater voltage	A1	5v	5 - 15v	25v	Reading may reach as high as 20v for a cold oven. After warmup, reading will decrease to about 5v. Reading will vary with ambient temperature changes.
6	Regulator input voltage	A2 or A3	21v	20 - 24v	25v	Typical reading and limits given are indicative of operation on primary power with a charged power battery. When battery is charging, reading will be 5v lower. When standard is operating on battery, reading will be battery voltage (13 - 19v).
7	Regulator output voltage	A6	12v	11 - 13v	25v	Component tolerances may cause a reading other than that given; however, reading should show no noticeable variation.
8	Current of voltage regulator	A6	0.15A	0.12 - 0.18A	0.25A	Reading may go as high as 0.23 amperes after equipment is turned on. After warmup, reading will range from 0.12 - 0.18A, depending on oven temperature corrections.

TABLE 3-2. (Continued)

SWITCH POSITION	CIRCUIT FUNCTION MEASURED	UNIT METERED	TYPICAL READING	RANGE OF READING	FULL-SCALE DEFLECTION	COMMENTS
9	Power battery terminal voltage	A3	18v	14 - 19v	25v	Reading given is typical of fully charged battery. Actual reading depends on battery state of charge.
10	Battery power charge current	A6	0.02A 0.06A 0.120A	0 - 0.15A .05 - .15A .095 - 0.15A	0.25A	Reading depends on battery charge mode. Typical readings and limits are given respectively for battery trickle charge, battery manual charge, and battery automatic charge.

3-6. OPERATING CHECKS.

a. Operating checks are limited to the use of the two indicator lamps on the front panel and to the use of the metering switch and panel meter.

b. The AC POWER lamp must remain lighted whenever ac power is connected to the set.

c. The power battery charge lamp must be lighted only when the battery charge switch is in the MANUAL CHARGE position or AUTO CHARGE position, at which time the battery is being charged at the higher charging rate. With the battery fully charged in the automatic mode of operation, the lamp must remain extinguished.

d. Rotate the metering switch through all 10 operating positions, carefully noting and recording the indication of the panel meter at each position. Check this indication against the normal reading range indicated on the front panel instruction plate. Table 3-2 provides normal reading ranges and permissible causes for variations from these readings. If there are unexplained deviations from indicated readings, report the condition to higher echelon maintenance.

3-7. FUSE REPLACEMENT.

a. If AC POWER lamp (figure 3-1) extinguishes during operation of the frequency standard, it indicates that ac input power has been lost, that ac line fuse F1 (figure 2-2) has blown, or that the AC POWER lamp is defective. Check first the ac source of supply. If ac is being supplied, rotate the metering switch through its range of positions. If the voltage drops below normal limits at positions 6 and 10, the fuse is probably faulty and requires replacement. Correct the cause of the fuse failure and replace the fuse by unscrewing the fuseholder cap, removing the old fuse, inserting a new fuse, and replacing the cap.

b. Low readings at metering switch positions 9 and 10 indicate that battery fuse F1 (figure 3-2) may have blown. To replace the fuse, remove the four screws that secure the battery power supply to the frequency standard. Unscrew the fuseholder cap, remove the blown fuse, insert a new fuse, and replace the fuseholder cap.

3-8. INDICATOR LAMP REPLACEMENT.

a. If the AC POWER lamp (figure 3-1) extinguishes during operation of the frequency standard, determine if the lamp is faulty as described in paragraph 3-6. If the lamp has burned out, unscrew the lampholder lens to remove it to provide access to the lamp. Remove the burned-out lamp and replace it with a new lamp. Install the lens.

b. If the power battery CHARGE lamp fails to light when the battery is being charged at other than the trickle rate, replace the lamp. Unscrew the lampholder lens to provide access to the lamp. Remove the lamp and replace it with a new one. Install the lens.

3-9. CLEANING.

Clean the exterior of the frequency standard and the ac input cable with a clean, dry cloth.

SECTION 4
TROUBLE SHOOTING

4-1. THEORY OF OPERATION.

a. This section provides maintenance personnel with a comprehensive description of the principles of operation of the frequency standard. These principles must be thoroughly understood before undertaking any trouble shooting procedures. Failure to understand the operation of the unit before attempting trouble shooting procedures may result in even more extensive trouble or misalignment than was originally noted. Refer to figure 4-2, the electrical schematic diagram, for a detailed circuit layout.

b. Frequency Standard AN/URQ-10 consists of two basic sections, the section which actually produces the frequency outputs, and the power supply section with its control circuits. Refer to figure 4-1. These two sections are comprised of three modules each, a total of six modules for the entire unit. The section which actually produces the frequency outputs consists of the oscillator module, unit A1; the 5-mc to 1-mc frequency divider module, unit A4; and the 1-mc to 100-kc frequency divider module, unit A5. The power supply section consists of the power supply module, unit A2; the battery power supply, unit A3; and the regulator and battery control module, unit A6.

c. The basic 5-mc signal, from which all other frequencies are derived, is generated in the oscillator module by the 5-mc crystal oscillator. The signal from the oscillator is amplified by the agc amplifier and then by the output amplifier. The output amplifier increases the signal to the level necessary for the 5-mc output signal and also provides the 5-mc internal signal which is utilized by the 5-mc to 1-mc frequency divider module. An inner oven and an outer oven, located within the oscillator module, maintain constant temperature control for the 5-mc crystal oscillator and the agc amplifier. The oven temperature circuits, the crystal oscillator, and the agc amplifier are a single potted assembly which is contained in the oscillator module along with the 5-mc output amplifier. The 5-mc to 1-mc frequency divider consists of the frequency divider proper and the 1-mc output amplifier. The 5-mc to 1-mc frequency divider circuit utilizes the internal 5-mc signal to produce two separate 1-mc outputs. One output is applied to the 1-mc amplifier and the other is applied to the 1-mc to 100-kc frequency divider module. The output amplifier increases the signal level to provide the 1-mc output signal. The 1-mc to 100-kc frequency divider module, which consists of a frequency divider and a 100-kc output amplifier, accepts the 1-mc internal signal to provide the 100-kc signal. The signal is then increased to the required level for the final 100-kc output signal.

d. The power supply module uses the primary ac power to provide unregulated dc for recharging the battery and for the operation of the other circuits in the frequency standard. The battery charging current passes through the battery charging control circuitry and the battery disconnect circuitry, located in the regulator and battery control module, before reaching the battery power supply. The battery charging control circuitry maintains a full charge for the battery power supply as long as primary ac power is present. The battery disconnect circuitry removes the battery from the load before its terminal voltage drops to a potential where the battery could be damaged. The other unregulated dc supply line provides power for the outer oven heater in the oscillator module and for the regulator which supplies all regulated operating power for the frequency generation circuits. The line status circuitry detects a loss of primary ac power.

4-2. OSCILLATOR MODULE, UNIT A1 (figure 4-3).

a. The oscillator module generates the 5-mc signal from which all other frequencies in the standard are derived. The module physically consists of two major assemblies: a pan assembly, which houses the 5-mc output amplifier circuit board, and a sealed outer oven assembly. The outer oven assembly houses the 5-mc crystal oscillator, the agc amplifier, the inner oven temperature control circuitry, and all of the outer oven temperature control circuitry with the exception of its output amplifier transistor Q19, which is mounted outside of the housing. The construction of these major assemblies provides isolation between the oscillator circuits and the output amplifier circuit. An inner oven assembly, contained within the sealed outer oven assembly, encloses the crystal and the coarse adjustment capacitor C1 of the 5-mc oscillator, thermistor RT1, and inner oven heater HR2. The 5-mc crystal oscillator also includes the fine frequency adjustment capacitor C6. Coarse and fine frequency adjustment points are accessible from the front of the frequency standard. A fine frequency indicator, calibrated in parts per 10^{10}, indicates the setting of the fine frequency control.

b. The 5-mc crystal oscillator is the heart of the frequency standard. The high degree of frequency stability is due primarily to the crystal and to the close temperature control which maintains inner oven temperature to within 0.01°C of the crystal turning point temperature over an ambient temperature range of 0°C to 50°C.

c. The two-stage oscillator configuration prevents loading of the crystal since it provides a high impedance to both ends of the feed-back loop. In addition, the crystal excitation current is controlled by the agc amplifier to further minimize frequency drift. The agc amplifier performs two functions. It amplifies the 5-mc signal for application to the output amplifier, and also detects the relative strength of the 5-mc signal and uses the detected signal to provide a dc agc voltage to control the amplitude of oscillator output. The agc voltage can be measured at TP1. The agc amplifier uses negative feedback to reduce transistor gain variations and to assist in obtaining a wide bandpass. The last transistor stage of the agc amplifier is a buffer stage which isolates the agc amplifier and oscillator from the output amplifier.

d. Q7 is a common emitter amplifier tuned to 5-mc by the tank in its collector circuit and couples its output to the base of Q8 through R32 and C29. A capacitive voltage divider in the collector circuit of Q7 provides a tap for the 5-mc internal signal.

e. The power amplifier is a common emitter stage. Although the collector load has a relatively wide bandwidth, selective negative feedback networks in the emitter ensure a high stage gain at 5 mc and a very low stage gain to all other frequencies. The feedback networks in the emitter circuit provide minimum feedback for the 5-mc input frequency, but provide maximum feedback at the second harmonic and at one-half of the input frequency. The frequency selective feedback networks consist of two parallel resonant LC circuits connected in series. The one LC circuit, L8 and C32 is resonant at 10 mc, the second harmonic of the input frequency. This circuit presents maximum impedance in the emitter circuit at the second harmonic frequency. The other LC circuit, consisting of L7, C31, and C34, is resonant at 2.5 mc and, therefore, presents maximum emitter impedance at this frequency. At the 5-mc input frequency, the first network appears inductive and the second network appears capacitive. The values of the two networks are such that the inductive and capacitive circuits are series resonant at 5 mc. Thus minimum impedance is presented in the emitter circuit to the 5-mc signal, allowing maximum amplification of this signal.

f. The 5-mc signal is coupled through T1 to the 5-mc output connectors at the front and rear of the frequency standard. A portion of the 5-mc output signal is sampled and detected by CR3 at the secondary of T1. This detected signal is fed to metering switch S2 to monitor the output signal on the front panel meter when the switch is in position 1.

g. The oven temperature control circuitry is similar for both the inner and outer ovens. Basically, a temperature-sensitive thermistor senses the oven temperature and controls the output signal level of an

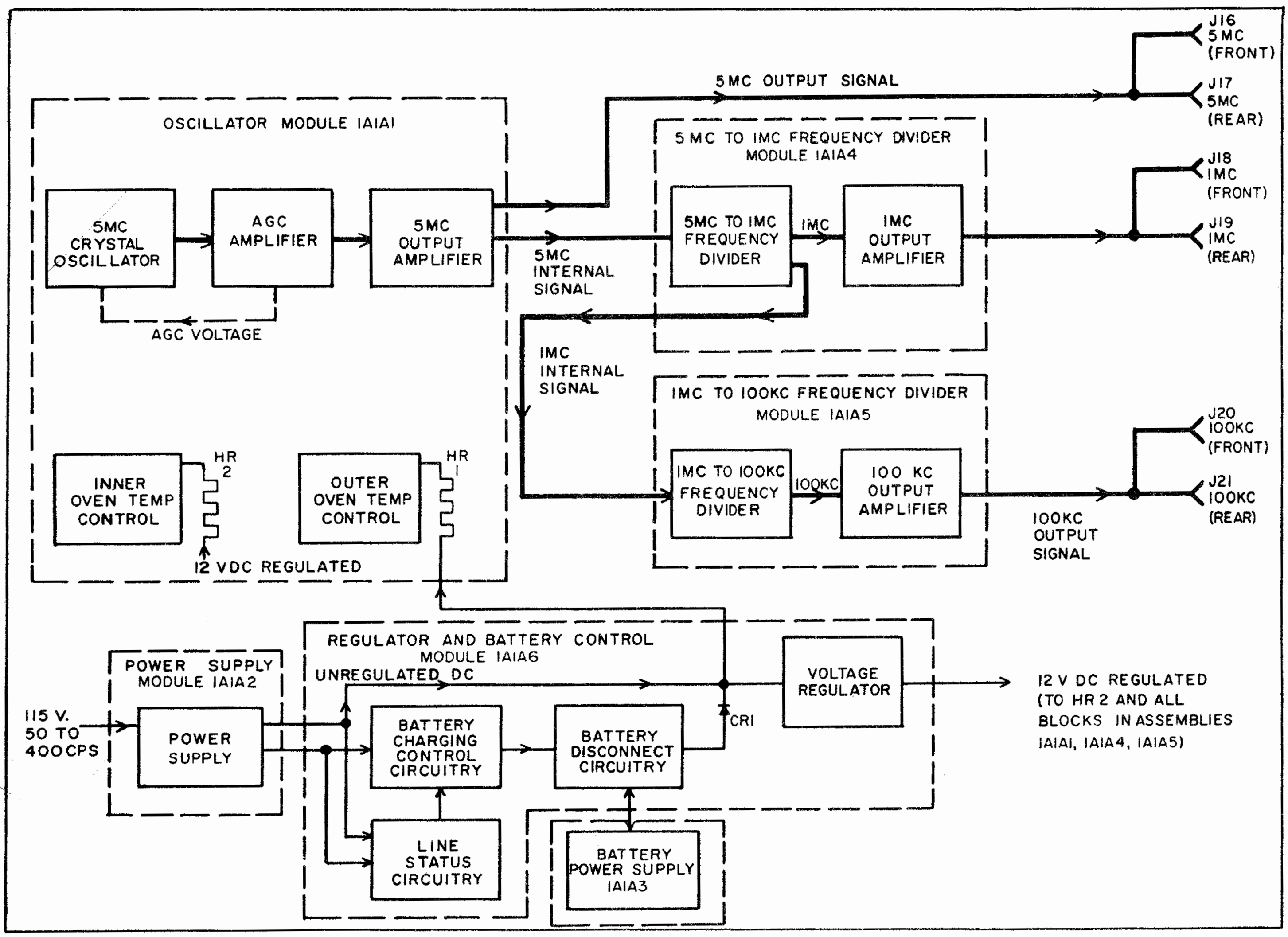


Figure 4-1. Frequency Standard AN/URQ-10, Block Diagram

Figure 4-2. Frequency Standard, AN/URQ-10, Schematic Diagram (1 of 2)

PARTS LOCATION INDEX

ASSEMBLY	REFERENCE DESIGNATION	LOCATION
1A1	J10	15D
	J11	15G
	J12	19, 20D
	J13	19, 20H
	J14	23B
	J15	23D, E
	J6	14B, C, D, E, F
	J7	14A, B
	J8	14B
	J9	15C
1A1A1A1	CR1	7D
	CR2	7D
	CR3	11B
	CR4	2E, F
	CR5	4G
	C1	2B
	C10	4C
	C11	4B
	C12	4B
	C13	6D
	C14	5B
	C15	5C
	C16	6C
	C17	6D
	C18	6C
	C19	7D
	C2	2B
	C20	7C
	C21	6B
	C22	7C
	C23	8C
	C24	9B
	C25	9B
	C26	9B
	C27	9C
	C28	9B
	C29	9B
	C3	2C
	C30	10B
	C31	10C
	C32	10C
	C33	10B
	C34	10C
	C35	11C
	C36	11C
	C37	11B
	C38	11C
	C39	12B
	C4	2C
	C40	12C
	C41	13C
	C42	2G
	C43	3E, F
	C44	4F
	C45	4G
	C46	4G
	C47	4F
	C48	5G
	C5	2, 3C
	C50	6G
	C6	3C
	C60	12F
	C61	6B
	C8	3B
	C9	3C
	HR2	6F
	J1	13,14B,C, D, E, F
	J5	13A, B
	J6	13B
	L1	2B
	L10	13F
	L11	11C
	L2	3B
	L3	4B
	L4	5B
	L5	8B
	L6	10B
	L7	10C
	L8	10C
	L9	13C
	Q1	2B, C
	Q10	3G
	Q11	3, 4G
	Q12	5F
	Q13	5F, G
	Q14	6G
	Q2	2C
	Q3	4B, C
	Q4	5B
1A1A1A1 (cont)	Q5	5B, C
	Q6	7B
	Q7	8C
	Q8	10B, C
	RT1	1G
	R1	2, 3B
	R10	4C
	R11	4C
	R12	4B
	R13	4C
	R14	5C
	R15	6D
	R16	6D
	R17	5A, B
	R18	5B
	R19	5C
	R2	2C
	R20	7D
	R21	6C
	R22	6B
	R23	6C
	R24	7A, B
	R25	7B
	R26	7C
	R27	7B
	R28	8B
	R29	8C
	R3	2C
	R30	8B
	R31	8C
	R32	9B
	R33	9C
	R34	10B
	R35	10C, D
	R36	11, 12B
	R37	11B
	R38	12B
	R39	12B
	R4	3A, B
	R43	1F, G
	R44	2F, G
	R45	2F
	R46	3F, G
	R47	3G
	R48	3E, F
	R49	3G
	R5	3D
	R50	3F
	R51	3, 4G
	R52	4G, H
	R53	4G
	R54	4E
	R55	5G
	R56	5G
	R57	5F
	R58	5G
	R59	6G
	R6	3A, B
	R7	3B
	R77	13E
	R8	3C
	R83	5E, F
	R84	5H
	R9	4B
	T1	11B
	T2	3, 4F
	Y1	2B
1A1A1A2	CR6	9, 10G
	C51	7G
	C52	8E, F
	C53	9F
	C54	9F, G
	C55	9G
	C56	9, 10F
	C57	10G
	C59	11G
	HR1	12F
	Q15	8G
	Q16	9G
	Q17	10F
	Q18	10, 11G
	Q19	11G
	RT2	7G
	R60	7G
	R61	7F, G
	R62	7F
	R63	8G
	R64	8G
	R65	8F
	R66	8G, H
	R67	8F, G
	R68	8, 9G
	R69	9G, H
	R70	9G
	R71	10E
	R72	10G
	R73	10G
	R74	10, 11F
	R75	10, 11G
	R76	11G
	R85	10, 11H
	T3	8, 9F
1A1A4	C13	19D
	C14	19D
	C27	20D
	C28	18D
	J1	15C
	J2	19, 20D
	J3	16D
	J4	23B
1A1A4A1TB1	CR2	18D
	C1	16C
	C10	18C, D
	C11	19C, D
	C2	16C
	C3	16B, C
	C4	17B
	C5	17B, C
	C6	17C
	C7	18B
	C8	18B, C
	C9	18B, C
	J5	16D
	J6	15B
	J7	17B
	J8	17B
	L1	16B, C
	L2	19B, C
	L3	19C
	Q1	16C
	Q2	16, 17C
	Q3	18C
	R1	15C
	R11	18C
	R12	18C, D
	R2	15C, D
	R3	16B
	R4	16C, D
	R5	16C
	R6	16C, D
	R7	17C, D
	R8	17C, D
	R9	18B
1A1A4A2TB2	CR1	22B
	C16	19, 20C
	C17	20C, D
	C18	21B
	C19	21B
	C20	21C
	C21	21C
	C22	21C
	C23	22C
	C24	21C, D
	C25	22C
	C26	22C
	J10	20, 21B
	J11	20, 21B, C
	J9	20, 21C, D
	L4	19C
	L5	21C
	L6	21C
	Q4	21C
	R13	20C
	R14	20B
	R15	20C
	R16	21C, D
	R17	22B
	R18	22C
	R19	22B, C
	T1	21, 22B, C
1A1A5	C13	19G
	C14	19G
	C27	21G
	C28	18, 19H
	J1	15, 16G
	J2	19, 20H
	J4	23D, E
1A1A5A1TB1	CR2	18G
	C1	16F
	C10	18G
	C11	19G
	C2	16, 17G
	C3	17F
	C4	17E, F
	C5	17F
	C6	17F
	C7	18E, F
	C8	18F
	C9	18, 19F
	J5	16G
	J6	16E
	J7	17F
	J8	18F
	L1	16E, F
	L2	19E, F
	L3	19G
	Q1	16G
	Q2	17G
	Q3	18, 19G
	R1	16F, G
	R11	18, 19F
	R12	18, 19G
	R2	16G
	R3	16F
	R4	16G
	R5	17F, G
	R6	17G
	R7	18G
	R8	17G
	R9	18E, F
1A1A5A2TB2	CR1	22E
	C16	20G
	C17	20G
	C18	21E
	C20	21E, F
	C21	21F
	C22	21F
	C23	22F
	C24	21F
	C25	22E
	C26	22F
	J10	20, 21E
	J11	20, 21E
	J9	20, 21F
	L4	19G
	L5	21E, F
	L6	21F
	Q4	21E
	R13	20F
	R14	20E
	R15	20F
	R16	21F, G
	R17	22E
	R18	22F
	R19	22E
	T1	21, 22E
1A1A9	J17	24B
	J19	24D
	J21	24F
1A1A10	J16	24A
	J18	24C
	J20	24D, E
	S1A	19D, E

TRANSISTOR FUNCTIONS

1A1A1	Q1	Emitter Follower
	Q2	Common Emitter
	Q3	Amplifier
	Q4	Amplifier
	Q5	Amplifier
	Q6	Buffer
	Q7	Emitter Follower Isolator
	Q8	Amplifier
1A1A1A1	Q10	Oscillator
	Q11	Oscillator
	Q12	Detector
	Q13	DC Amplifier
	Q14	Oven Output Amplifier
1A1A1A2	Q15	Oscillator
	Q16	Oscillator
	Q17	Detector
	Q18	DC Amplifier
	Q19	Oven Output Amplifier
1A1A4A1	Q1	Emitter Follower
	Q2	Mixer Amplifier
	Q3	Multiplier
1A1A4A2	Q4	Output Amplifier
1A1A5A1	Q1	Emitter Follower
	Q2	Mixer Amplifier
	Q3	Multiplier
1A1A5A2	Q4	Output Amplifier
1A1A6A1	Q1	Line Status
	Q2	Battery Charge Control
1A1A6A2	Q3	Battery Disconnect
	Q4	Regulator Driver
	Q5	Detector Amplifier
1A1A9Q1	Q1	Regulator

Figure 4-2. Frequency Standard, AN/URQ-10, Schematic Diagram (2 of 2)

PARTS LOCATION INDEX

ASSEMBLY	REFERENCE DESIGNATION	LOCATION
1A1	J1	4B
	J2	5, 6, 7F
	J4	8, 9, 10F
	J5	9, 10F
	S2	17, 18, 19C, D
1A1A2	CR1	3, 4B
	CR2	3, 4B
	CR3	3, 4B
	CR4	3, 4C
	C1	4B, C
	J1	4B
	L1	4B
	T1	3B, C
	XC1	4B, C
1A1A3	BT1	10G
	BT2 thru BT14	9G
	DS1	9G
	F1	9G
	J1	8, 9, 10F
	S1	8G
	XDS1	9G
	XF1	9G
1A1A6A1TB1	CR7	6C
	C1	6D
	C2	7D
	C3	7D, E
	J1	5, 6, 7F
	K1	6D
	K2	7D
	Q1	5D
	Q2	7E
	R1	5C
	R10	8C
	R2	5, 6C
	R3	6C, D
	R4	6, 7E
	R5	7, 8D
	R6	7, 8E
	R7	7C
	R8	8D, E
1A1A6A2TB2	CR1	9B, C
	CR2	10D
	CR3	11E
	CR4	12D
	CR5	13D
	CR6	12E
	C4	14D, E
	C5	14D
	J2	9, 10F
	K3	10C, D
	Q3	10, 11D
	Q4	12C
	Q5	13E
	R11	10C
	R12	11D
	R13	11, 12B
	R14	11C, D
	R15	11D
	R16	11D, E
1A1A6A2TB2 (cont)	R17	11E
	R18	12D, E
	R19	12E
	R20	12D
	R21	12D
	R22	12D, E
	R23	12, 13C
	R24	13E
	R25	13D
	R26	13E
	R27	13E
1A1A7	CR1	9E
	R1	6, 7B
	R2	9D, E
	TB1	8, 9, 10D, E
1A1A8	R5	17D
	R6	17D
	R7	18D
	R8	18D, E
	R9	18D
	TB2	17E
1A1A9	C1	2E
	C2	2F
	C3	2F
	C4	2E
	C5	2F
	FL1	1, 2, 3D, E, F, G
	F1	2F
	J3	5F, G
	L1	2E
	L2	2E
	Q1	12, 13B
	R3	9C
1A1A10	DS1	5B
	M1	16C
	S1B	19, 20A
	XDS1	5B

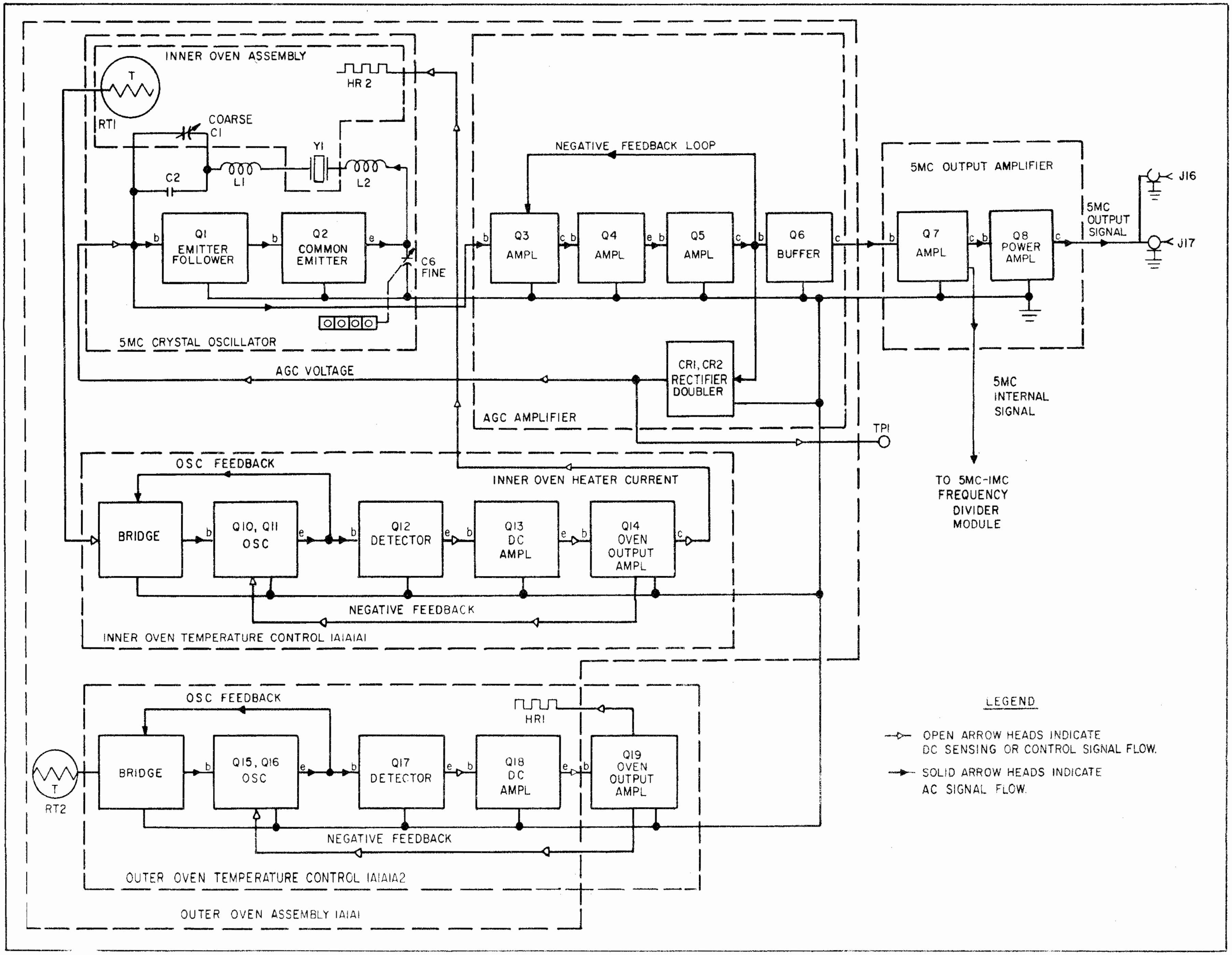


Figure 4-3. Oscillator Module, Unit A1, Block Diagram

oscillator. This oscillator signal strength is detected, amplified, and applied to the oven heater in order to maintain proportional oven temperature control. The temperature-sensitive thermistor is actually part of a bridge circuit in the feedback loop of a two-stage oscillator. When the oven temperature begins to drop below its predetermined setting, the thermistor resistance increases to further unbalance the bridge in a direction providing increased positive feedback for the oscillator. The signal increase from the oscillator is detected and amplified, providing more current to the oven heater. When the heater increases the oven temperature, the thermistor decreases the positive feedback of the oscillator, decreasing the oven heater current. Through this arrangement, the oven is maintained at a very nearly constant temperature. The inner and outer oven temperature control circuits are identical with the exception of the power handling capacity of the output amplifiers. The output amplifier for the outer oven is capable of more power output than the inner oven since the outer oven area is much larger. The output amplifier transistor for the outer oven is also mounted outside of the outer oven housing. All other temperature control circuits for both ovens are located within the sealed outer oven housing. TEMP ADJ control R62, under the module cover, provides an adjustment for the outer oven temperature, which is 5°C below that of the inner oven. The oven heater voltage for both ovens can be monitored on the front panel meter with the meter selector switch S2 in the proper position.

4-3. FREQUENCY DIVIDER MODULE, 5 MC TO 1 MC, UNIT A4 (figure 4-4).

a. The 5-mc to 1-mc frequency divider module provides the 1-mc output signal and 1-mc internal signal for the frequency standard. The module consists of a 5-mc to 1-mc frequency divider circuit board and 1-mc output amplifier circuit board, enclosed by a can-type shield. Necessary adjustment points are accessible when the shield is removed.

b. The frequency divider circuit receives the 5-mc internal signal from the oscillator module and mixes it with a 4-mc signal in order to obtain the 1-mc signal. The 4-mc signal is obtained by multiplying a portion of the 1-mc signal by 4. Initially, a positive pulse must be applied to the times 4 multiplier in order to obtain enough 4-mc signal to start the mixing action and provide the 1-mc signal. Section A of START switch S1 is used to obtain this positive pulse. Once the circuit is started, the 1-mc signal is applied to the 1-mc output amplifier to obtain the required level for the 1-mc output signal. Another 1-mc signal, for internal use, is supplied to the 1-mc to 100-kc frequency divider module.

c. The first stage of the 5-mc to 1-mc frequency divider Q1 is an emitter follower amplifier which provides a high impedance to the incoming 5-mc internal signal. Capacitor C2 couples the 5-mc signal to the emitter circuit of mixer amplifier Q2. Q2 also receives the 4-mc signal on its base circuit from the times 4 multiplier Q3. Q2 mixes the two signals and amplifies the difference frequency of 1 mc. Capacitor C3 is adjustable to tune the tank circuit in the collector for the 1-mc difference signal. The capacitive voltage divider, consisting of C4, C5, and C6, provides taps for the 1-mc internal signal and the 1-mc signal which is applied to the output amplifier and times 4 multiplier. Times 4 multiplier Q3 is a common emitter stage biased class C. This amplifier configuration produces

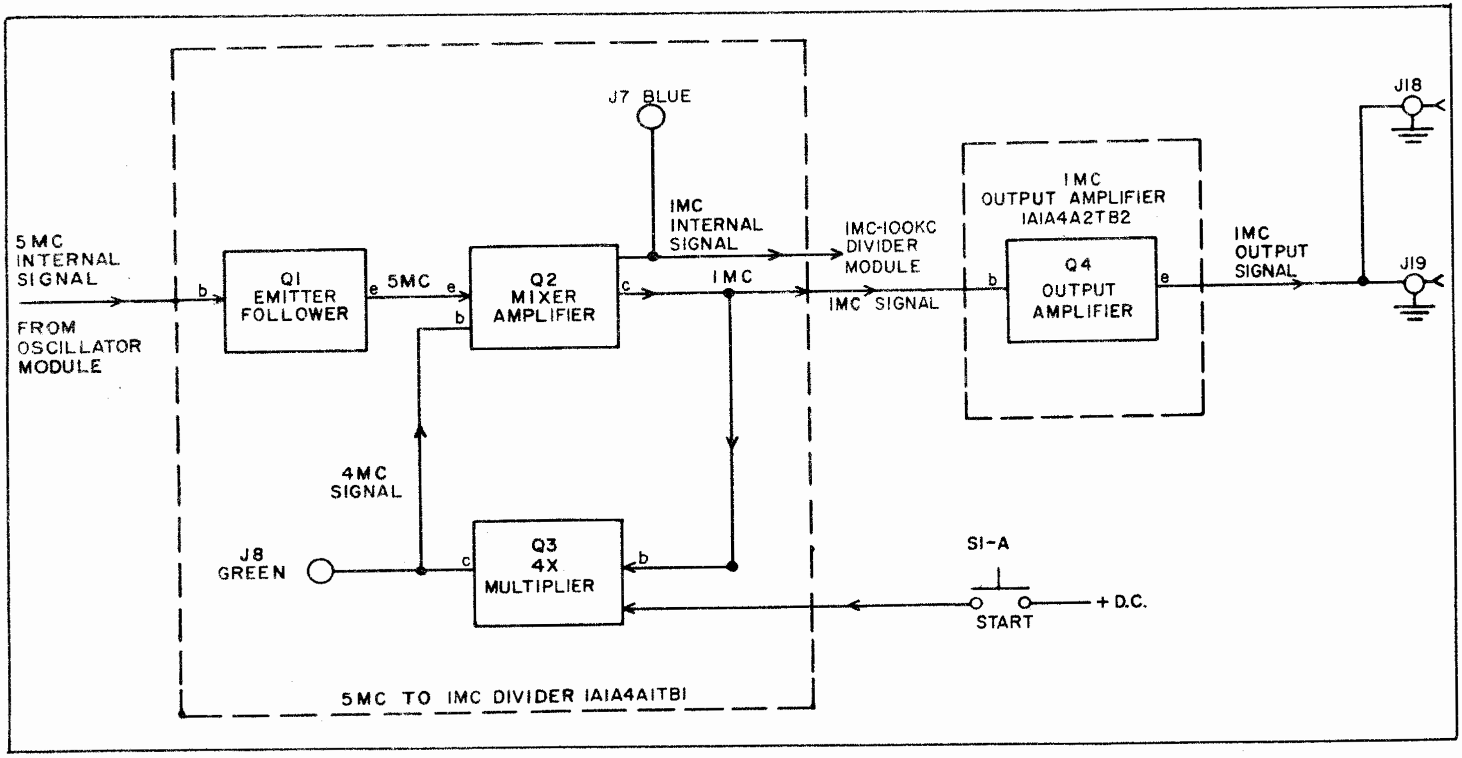


Figure 4-4. Frequency Divider Module, 5 Mc to 1 Mc, Block Diagram

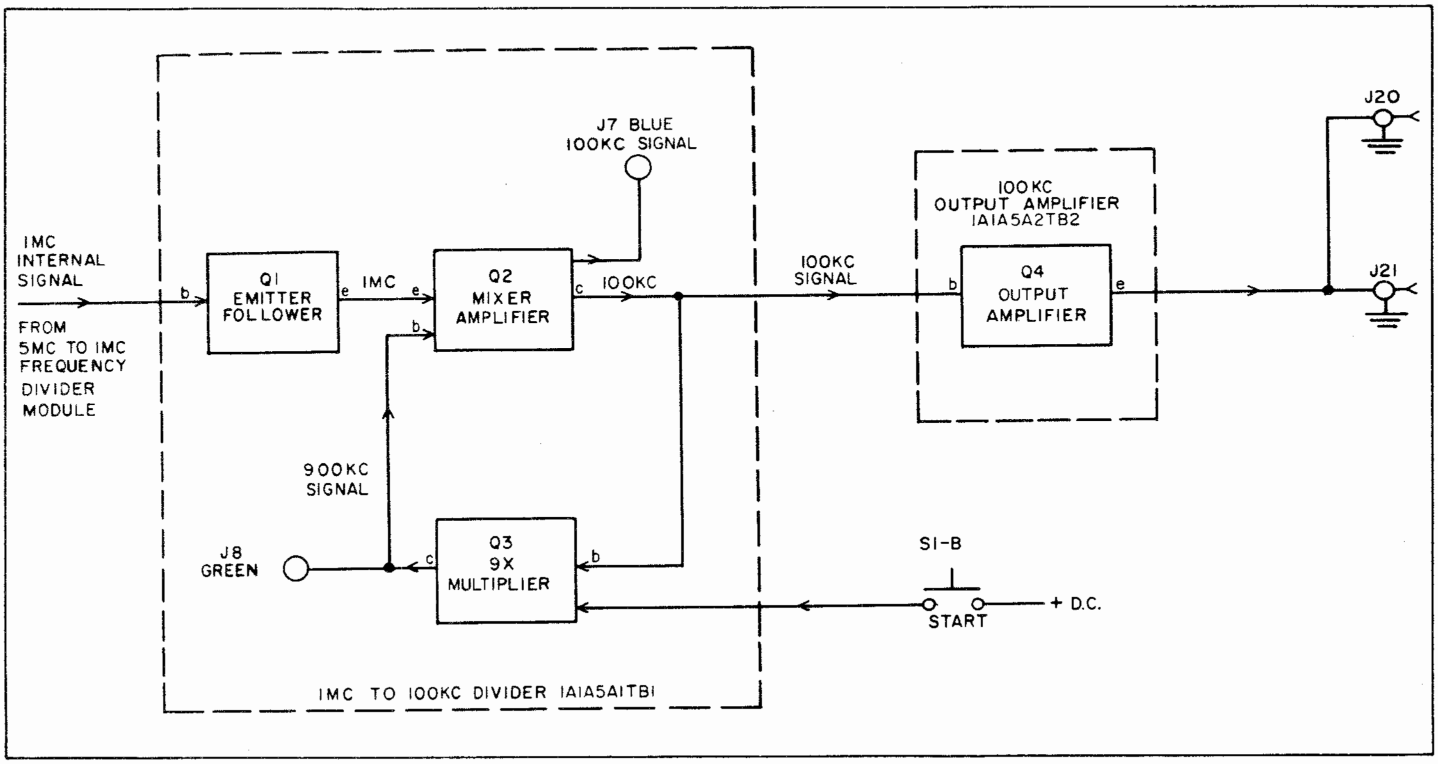


Figure 4-5. Frequency Divider Module, 1 Mc to 100 Kc, Block Diagram

signals rich in harmonics of the input frequency. Only the fourth harmonic is developed in the collector circuit of Q3, however, since the tank circuit is tuned to 4 mc.

d. Capacitor C9 provides a means of tuning the tank, and a capacitive voltage divider, consisting of C7 and C8, taps some of the 4-mc signal for application to mixer Q2. The 1-mc signal from mixer Q2 is applied through C17 and R13 to the base of output amplifier Q4. Output amplifier Q4 is a common emitter amplifier with frequency selective negative feedback. Although the collector load has a relatively wide bandwidth, the feedback networks in the emitter circuit ensure a high stage gain for the 1-mc signal and a very low stage gain for all other frequencies. Thus the 1-mc output signal is relatively free of harmonic distortion.

e. The frequency selective feedback networks consist of two parallel resonant LC circuits connected in series. The one LC network, consisting of L5 and C20, is tuned to approximately 2 mc, the second harmonic of the 1-mc input signal. This tank circuit presents maximum impedance in the emitter circuit for the second harmonic frequency and, therefore, also maximum negative feedback. The second LC network, consisting of L6, C21, C22, and C23, is resonant at approximately 500 kc, or about one-half of the 1-mc input signal. The second tank circuit provides maximum negative feedback at about 500 kc since, at this frequency, the tank presents maximum impedance. At the 1-mc input frequency, the first tank appears inductive and the second tank appears capacitive. The values are such that the two tank circuits are series resonant at the 1-mc input frequency. The emitter circuit presents minimum impedance to the 1-mc signal and, therefore, minimum negative feedback of this signal.

f. The 1-mc output signal is coupled through T1 to the 1-mc output connectors on the front and rear of the frequency standard unit. Some of the 1-mc output signal is sampled and detected at the secondary of T1 by CR1. This detected signal is then filtered and used to monitor the 1-mc output signal on the front panel meter when the metering switch is in position 2.

g. Test point J7 (blue) provides access to check the presence and quality of the 1-mc signal to the 1-mc to 100-kc divider module. Test point J8 (green) provides access to check the presence and quality of the 4-mc signal.

4-4. FREQUENCY DIVIDER MODULE, 1 MC TO 100 KC, UNIT A5 (figure 4-5).

a. The 1-mc to 100-kc frequency divider module provides the 100-kc output signal for the frequency standard from the internal 1-mc signal. The module consists of a 1-mc to 100-kc frequency divider circuit board and a 100-kc output amplifier circuit board. Both circuit boards are enclosed in a can-type shield. Necessary adjustment points for the frequency divider circuit card are accessible when the shell is removed.

b. The frequency divider circuit receives the 1-mc internal signal from the 5-mc to 1-mc frequency divider module and mixes it with a 900-kc signal in order to produce the 100-kc signal. The 900-kc signal is produced by multiplying a portion of the 100-kc signal by 9. Initially, a positive pulse must be applied to the times 9 multiplier in order to obtain enough 900-kc signal to start the mixing action and provide the 100-kc signal. Section B of START switch S1 is used to provide this initial positive pulse. This switch is under a protective cap located on the front panel of the frequency standard. Once the circuit is started, it is self sustaining. The 100-kc signal from the frequency divider circuit is then applied to the 100-kc output amplifier to obtain the required level for the output signal.

c. The first stage of the 1-mc to 100-kc divider circuit Q1 is an emitter follower amplifier which provides a high impedance to the incoming 1-mc internal signal. Capacitor C2 couples the 1-mc signal to the emitter circuit of mixer amplifier Q2. Transistor Q2 also receives the 900-kc signal at its base circuit from times 9 multiplier Q3. Q2 mixes the two signals and amplifies the difference frequency of 100 kc. Capacitor C2 is adjustable to tune the tank in the collector circuit of Q2 for 100 kc. A capacitive voltage divider taps the tank circuit for the 100-kc signal which is applied to the 100-kc output amplifier and the times 9 multiplier Q3. Q3 is a common emitter amplifier biased class C. This amplifier configuration produces signals rich in harmonics of the 100-kc input frequency. Only the ninth harmonic, however, is developed in the collector circuit of Q3, since the tank is tuned for 900 kc. C9 is adjustable to provide a means of tuning the tank, and a capacitive voltage divider taps some of the tank circuit signal for application to mixer Q2.

d. The 100-kc signal from mixer Q2 is applied through C17 and R13 to the base of output amplifier Q4. Output amplifier Q4 is a common emitter power amplifier with frequency selective negative feedback. Although the collector load has a relatively wide bandwidth, the feedback networks in the emitter circuit ensure a high stage gain for the 100-kc signal and a very low stage gain for all other frequencies. Thus the 100-kc output signal is relatively free of harmonic distortion. The frequency selective feedback networks consist of two parallel resonant LC circuits connected in series. The one LC network, consisting of L5 and C20, is tuned to approximately 200 kc which is the second harmonic of the 100-kc input signal. This tank circuit presents maximum impedance in the emitter circuit of Q3 for the second harmonic frequency and, therefore, also provides maximum negative feedback. The other LC circuit, consisting of L6, C21, C22, and C23, is resonant at approximately 50 kc or one-half of the input frequency. This tank circuit provides maximum negative feedback at about 50 kc, since at this frequency the tank provides maximum impedance in the emitter circuit. At the 100-kc input frequency, the first tank appears inductive and the second tank appears capacitive. The values are such that the two tank circuits are series resonant at 100 kc. The emitter circuit presents minimum impedance to the 100-kc signal and, therefore, also minimum negative feedback of this signal.

e. The 100-kc output signal is coupled through T1 to the 100-kc output connectors on the front and rear of the frequency standard unit. Some of the 100-kc output signal is sampled and detected by CR1 at the secondary of T1. This detected signal is then filtered and used to monitor the 100-kc output signal with the front panel meter when the metering switch is in position 3.

f. Test point J7 (blue) provides access to check the presence and quality of the 100-kc mixer output before it is fed to the output amplifier. Test point J8 (green) provides access to check the presence and quality of the 900-kc signal.

4-5. POWER SUPPLY MODULE, UNIT A2.

The power supply module (figure 4-1) converts ac primary power to dc operating power for the frequency standard circuits. Ac primary power, 115 volts at 50 to 400 cps, is applied to the power supply through a line filter and a 1-ampere fuse. The line filter and fuse are located on the rear panel of the frequency standard unit. The ac input is applied to the primary of step-down transformer T1. Transformer T1 has two secondary windings, one of which, with its diode rectifiers, produces 21 volts dc and the second which, with its rectifiers, provides 11 volts dc. The 21-volt output is supplied to the voltage regulator. The 21-volt output and the 11-volt output are series connected to provide 32 volts necessary for battery charging. The 21-volt output is filtered by L-type inductive input filters consisting of L1 and C1.

4-6. BATTERY POWER SUPPLY, UNIT A3.

a. The battery power supply (figure 4-1) provides standby power for operating the frequency standard for a period up to 8 hours in the event that primary ac power is interrupted. The battery power supply consists of a total of 14 sealed nickel-cadmium cells. The power battery consists of cells BT2 through BT14. Cell BT1 is a timing cell which is used in conjunction with the charging circuit in the regulator and battery control module to control the charge time of the power battery cells BT2 through BT14. A red charge lamp on the front of the battery power supply lights when the power battery is recharging.

b. Switch S1 selects the AUTOMATIC CHARGE or MANUAL CHARGE mode for the battery. The switch normally remains in the AUTOMATIC CHARGE position; however, when the battery has been out of service for extended periods of time, this switch is placed in the MANUAL CHARGE position. When S1 is in the MANUAL CHARGE position, the charge rate for the battery is approximately 60 ma. When the battery is charging in the automatic position, as determined by the battery control circuit, the charge rate is approximately 120 ma. When the battery is not being charged and primary power is present, the main battery receives a trickle charge of about 20 ma.

4-7. REGULATOR AND BATTERY CONTROL MODULE, UNIT A6.

The regulator and battery control module provides regulated 12-vdc for operating the frequency standard circuits. The module also controls the charge rate and protects the battery power supply. The battery control circuits consist of the line status circuit, the battery charge control circuit, and the battery disconnect circuit. The battery charge control circuit and the line status circuits are mounted on a common circuit board within the module. The battery disconnect and regulator circuits are mounted on another circuit board in the module. The regulator transistor of the voltage regulator, however, is mounted on the inside rear panel of the main chassis of the frequency standard. The last 5 positions of the metering switch allow various important circuit conditions of the regulator and battery control circuits to be monitored on the front panel meter.

4-8. VOLTAGE REGULATOR (figure 4-6).

a. The typical voltage regulator contains a voltage reference and a detector which sample some of the regulated output and compare it to the reference. The difference between the two is then amplified and used to control the passing resistance of a series element in order to correct for the detected difference. In addition, the regulator contains a self-starting feature and an overload current limiter. Zener diode CR5 provides a reference voltage by maintaining a fixed difference between the regulator output voltage and the emitter voltage of detector amplifier Q5. The output voltage of the regulator is sampled by voltage dividers R25, 26, and R27 and applied to the base of Q5. If the output voltage of the regulator decreases, due to an increased load current or a decrease in regulator input voltage, the emitter of Q5 becomes less positive by a greater amount than its base since the full output voltage change is felt at the emitter and only a part of the change is felt at the base. This causes the collector current of Q5 to increase because of the increased forward bias.

b. The increased collector current of Q5 drives the base of regulator driver Q4 more negative with respect to its emitter. The forward bias on Q4 causes an increase in its collector current which, due to the voltage drop across R23, forward biases regulator Q1.

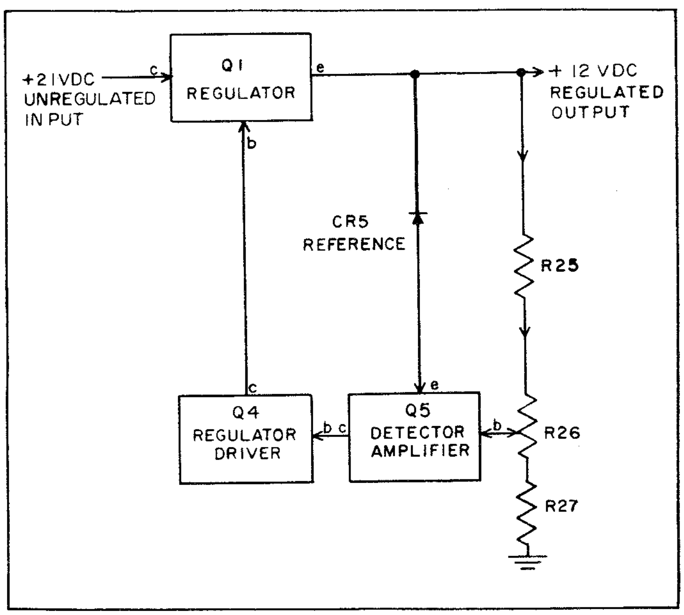


Figure 4-6. Voltage Regulator, Block Diagram

The forward bias on Q1 decreases its passing resistance, thereby increasing the output voltage to counter the effect of the increased load current or decreased input voltage. If the output voltage of the regulator were to increase, the regulator circuit would react similarly but opposite to the circuit action described above and, therefore, decrease the output voltage to maintain an output voltage very near 12 volts. Self-starting is provided by CR6. When power is first applied to the regulator circuit, regulator Q1 is virtually an open circuit and therefore the output voltage is zero vdc. Transistor Q5 must be conducting in order to turn on Q1 and, since Q5 receives its base voltage from the regulator output, the regulator would not function. To initially turn on Q5, diode CR6 provides a positive voltage at the base which is obtained from a divider connected to the regulator input line. Once regulator Q1 is turned on, the output voltage applied through voltage dividers R25, R26 and R27 reverse biases diode CR6, effectively taking it out of the circuit.

c. Overload protection for the regulator is provided by zener diode CR4. Normally, the voltage drop across R21 and the base emitter junction of Q4 is below the zener region of CR4, and therefore, CR4 does not affect the circuit. However, if the output load current of the regulator becomes excessive due to a short circuit, the output voltage of the regulator falls to a level far below normal. In an attempt to correct the output voltage, the increasing collector current of Q5 increases the voltage drop across R21. Once this voltage drop reaches the zener voltage of CR4, it can no longer increase since the zener diode has clamped at its zener voltage. Beyond this point Q4 can no longer increase conduction, and the passing resistance of Q1 will remain clamped, preventing any further attempt to correct the decreasing output voltage caused by an abnormal condition.

4-9. BATTERY CONTROL CIRCUITS.

The battery control circuits (figure 4-7) consist of the line status, battery disconnect, and battery charging circuits.

4-10. LINE STATUS CIRCUIT.

The line status circuit (figure 4-2), which consists primarily of transistor Q1 and relay K1, provides dry contact alarm points for indicating when primary power is lost. The circuit also provides relay contacts which are used in conjunction with the battery charge circuit. When primary ac power is present, the power supply module provides about 21 vdc on the voltage regulator supply line and 32 vdc on the battery charging line. The line status circuit and the AC POWER lamp DS1 are connected across the 11-volt output of the power supply. Relay K1 is energized and AC POWER lamp DS1 is lighted when ac input is applied. When primary ac power is lost, AC POWER lamp DS1 extinguishes and relay K1 deenergizes.

4-11. BATTERY DISCONNECT CIRCUIT.

The battery disconnect circuit (figure 4-2) disconnects the power battery from its load when the battery terminal potential drops to a level where the battery

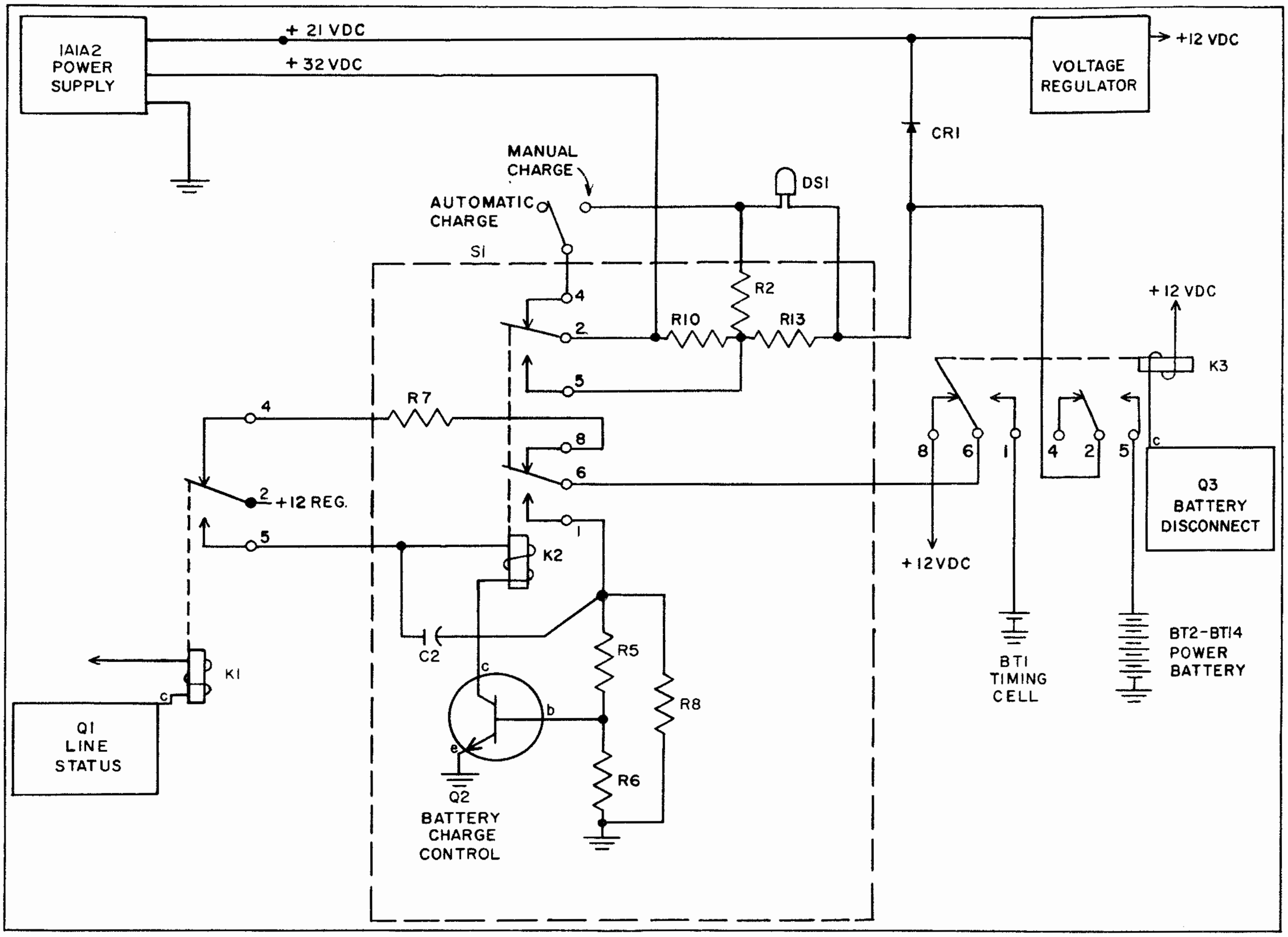


Figure 4-7. Battery Control Circuits, Simplified Schematic Diagram

could be damaged. Since all cells in the battery are not exactly the same ampere hour rating, the cells with the lower rating become discharged first and their polarity reversed by remaining cells if the battery is allowed to discharge completely. The battery is connected to the voltage regulator line through diode CR1 and contacts 2 and 5 of relay K3 which is held energized. Normally, when ac power is present, diode CR1 is reverse biased since it is connected between the regulator input line and the battery, and the input line will be more positive than the battery potential. However, when ac power is lost, the regulator input line voltage will drop until it reaches the battery terminal potential. At this point, CR1 will become forward biased and connect the battery to the regular input line. As long as ac power is present or as long as the battery potential does not fall below a preset value, relay K3 will remain energized. This is because relay K3, in the collector circuit of Q3, is connected to the regulated source and the base circuit for the transistor is tied through a voltage divider to the input side of the regulator, providing forward bias. After the battery discharges to a preset value at the input of the regulator where the bias on Q3 is no longer sufficient to hold relay K3 energized, the battery will be disconnected from the circuit. Resistor R15 is adjustable to set the point at which K3 will deenergize and disconnect the battery. Diode CR2 provides protection from high voltage kickback as the relay is deenergized. Relay K3 deenergized, will energize again when primary ac power is restored. Diode CR3 provides temperature compensation for Q3.

4-12. BATTERY CHARGE CIRCUITS.

a. The battery charge circuit (figure 4-2) regulates battery charging and maintains a fully charged battery when primary power is available. The circuit utilizes a set of relay contacts in the battery disconnect and line status circuits in addition to the timing cell in the battery power supply. The power battery is fully charged when the timing cell is discharged. Under normal conditions, with the power battery fully charged, the frequency standard is operating from the primary power source and therefore relays K1 and K3 will be energized. Relay K2 will be deenergized and will provide a trickle charge (approximately 20 ma) for the power battery. This charge path is from the positive battery terminal through K3 contacts 2 and 5, R13 in parallel with DS1 and R2, and R10 to the positive terminal of the power supply 32-volt line. If the primary power is interrupted, K1 will deenergize, K2 will remain deenergized, and K3 will remain energized. The trickle charge current is now lost since it was obtained from the primary power source, and the power battery begins to supply operating power for the frequency standard through K3 contacts 2 and 5 and diode CR1.

b. Immediately when K1 deenergizes, a charging path is completed for the timing cell. This path is from the positive terminal of the timing cell through K3 contacts 1 and 6, K2 contacts 6 and 8, R7, and K1 contacts 4 and 2 to the regulated supply voltage being provided by the power battery. Timing cell BT1 will continue to charge until primary power is restored or until the battery disconnect circuit deenergizes relay K3, at which time BT1 will approach full charge. When power is restored, K1 will energize and K3 will energize if it has deenergized due to operation of the battery disconnect circuit. When K1 energizes, a positive pulse is applied through K1 contacts 2 and 5, capacitor C2, and resistor R5 to the base of Q2. This positive pulse forward biases the transistor and momentarily energizes K2. When K2 energizes, contacts 6 and 1 close, completing a circuit to the timing cell.

c. The timing cell begins to discharge through K3 contacts 1 and 6, K2 contacts 6 and 1, and resistor network R5, R6, and R8. The voltage developed across R6, caused by BT1 discharging, holds Q2 forward biased and relay K2 remains energized. With K2 energized, a charge current of approximately 125 ma is supplied to the power battery. This charge path is from the positive terminal of the power battery, through K3 contacts 5 and 2, resistor R13, and K2 contacts 5 and 2 to the positive 32-volt line of the power supply. When BT1 discharges to the point where it can no longer hold Q2 sufficiently forward biased, K2 will deenergize and open the charge path to the power battery and restore the trickle charge current. The discharge circuit for BT1 is designed to provide a charge to discharge ratio of about 7.5 to 1 for the power battery. That is, if the power battery is discharged for one hour, it will be recharged at a 125-ma rate for about 7.5 hours after primary power is restored.

d. The battery charge switch S1 on the battery power supply provides a charge current for the power battery of approximately 60 ma. This charge rate will not damage the power battery if the switch is left in the MANUAL CHARGE position for extended periods of time. This switch is used to initially charge the battery since the battery power supply is shipped in a discharged state. Instructions for its use are provided on the cover of the battery power supply and in Section 3 of this instruction manual. Charge lamp DS1 lights when the battery power supply is being automatically charged or manually charged. It will not light when the power battery is being trickle charged.

4-13. TROUBLE SHOOTING PROCEDURE.

a. The AN/URQ-10 Frequency Standard, after initially put into operation, normally does not require further adjustment or attention other than the routine operational checks described in paragraph 3-6. However, as with all electronic equipment, an occasional fault can develop and interrupt operation. When such a fault does occur, it is often essential to diagnose the fault and correct the difficulty in a minimum amount of time. The objective of this section is to provide the necessary trouble shooting information.

b. The ability to diagnose and rapidly correct a difficulty requires first, a good working knowledge of the principles of operation of the equipment at both the block and component levels, and secondly, a certain amount of practical experience with the equipment. Paragraph 4-15 below is provided to assist the technician in gaining experience by developing his ability to decide which checks to make and where to make them. Figure 4-1, a block diagram of the frequency standard, should be used in conjunction with this paragraph to help isolate a fault to a particular unit. Paragraphs 4-16 through 4-21 provide the same type of assistance at the component level within a unit. Refer to the block diagrams of this section and the schematic diagram of the equipment (figure 4-2) when isolating a fault within a unit. Paragraphs 5-6 through 5-17 provide adjustment information for each unit. These adjustments may be necessary after servicing.

4-14. TEST EQUIPMENT REQUIRED.

The test equipment required for trouble shooting the frequency standard is listed in Table 4-1.

TABLE 4-1. TEST EQUIPMENT FOR TROUBLE SHOOTING

NAME	DESIGNATION	USE
Multimeter	AN/USM-116	Check various dc voltages, resistances, and amperages.
Vacuum tube voltmeter	AN/USM-143	Check ac voltages.

4-15. LOCALIZING TROUBLE TO THE UNIT LEVEL.

The frequency standard indicator lights and the panel meter simplify trouble shooting to unit level. A comprehensive investigation of the symptoms at this level is necessary to avoid disassembly of unrelated units later. It is suggested that when failure does occur, all of the circuits in the frequency standard be metered with the panel meter, in order not to overlook a possible conspicuous reading. Table 3-2 in the operation section provides a list of typical panel meter readings and points out conditions where out-of-limit readings are acceptable. Readings which are out of limits with no logical explanation should be further investigated. Table 4-2 provides trouble symptoms and suggests causes for them.

TABLE 4-2. BASIC TROUBLE SHOOTING CHART

SYMPTOM	SUGGESTED CHECK CIRCUIT	CIRCUIT LOCATION
AC POWER lamp out, all frequencies normal	1. Ac line circuits	-
	2. Power supply	A2
AC POWER lamp out, no frequency output signals	1. Ac line voltage	-
	2. Power supply	A2
	3. Battery power supply	A3
	4. Voltage regulator	A6
	5. Oscillator	A1
AC POWER lamp on, no frequency output signals	1. Voltage regulator	A6
	2. 5-mc output amplifier	A1
	3. 5-mc oscillator	A1
No 5-mc output signal, other frequencies present	1. External 5-mc load	-
	2. 5-mc output amplifier	A1
No 1-mc output signal, other frequencies present	1. External 1-mc load	-
	2. 1-mc output amplifier	A4
	3. 5-mc to 1-mc divider	A4
No 100-kc output signal, other frequencies present	1. External 100-kc load	-
	2. 100-kc output amplifier	A5
	3. 1-mc to 100-kc frequency divider	A5
No 1-mc or 100-kc output signals, 5-mc output signal present	1. 5-mc to 1-mc frequency divider	A4
Abnormal frequency drift	1. Inner oven heater	A1
	2. Outer oven heater	A1
	3. Agc amplifier voltage	A1
	4. 5-mc oscillator	A1

4-16. LOCALIZING TROUBLE WITHIN A UNIT.

When the investigation of a malfunction reaches this stage, disassembly of the frequency standard is necessary only to the extent of gaining access to the suspected circuitry. Most test points and other monitoring points for the frequency dividers, units A4 and A5, and for the regulator and battery control circuits are accessible upon removing the module cover for the unit. When a unit must be removed from the frequency standard, external power, input signals, and loads should be provided as necessary to maintain actual operating conditions.

WARNING

When operating the frequency standard with the cover removed, take care not to touch points where ac input is available. This 115-volt input is high enough to cause injury or death.

4-17. OSCILLATOR, UNIT A1.

Most of the oscillator module circuits are sealed within the outer oven assembly. Only the 5-mc output amplifier circuits and the output amplifier for the outer oven are readily accessible. If a fault is traced to the circuitry within the outer oven assembly, the entire assembly is usually replaced. A high agc voltage at TP1 (figure 5-11) and/or no signal output from Q6 indicate a faulty oscillator. Also, a varying output frequency or output level is normally cause for replacement. The output voltage of the oven heaters, as indicated by the panel meter, provides a good indication of the condition of the oven temperature control circuits. An improper outer oven heater voltage could be due to a faulty output amplifier, Q19, which is accessible for replacement. Faults in the 5-mc output amplifier can be located by checking the dc operating voltages and the signal voltages of the transistor stages. Typical readings for each stage are provided in Table 4-3. Difficulties such as excessive harmonic distortion or spurious signal content in the output signal could be caused by a faulty transistor, especially Q8 and its associated feedback circuitry.

4-18. FREQUENCY DIVIDERS, UNITS A4 AND A5.

a. The 5-mc to 1-mc frequency divider is nearly identical to the 1-mc to 100-kc frequency divider with the exception of the input and output frequencies. Likewise, the 1-mc output amplifier is similar to the 100-kc output amplifier, and therefore trouble shooting procedures for both units are the same. Once the trouble is isolated to a frequency divider unit, the faulty component can be located through dc voltage and ac signal measurements. Tables 4-4 and 4-5 give typical voltages for the divider units. Low output levels from the frequency divider circuit could be caused by a faulty transistor or bad component in a tank circuit. Normally, a bad component in a tank circuit will completely stop circuit operation since the dividers are the fail-safe type.

TABLE 4-3. PERTINENT TROUBLE SHOOTING VOLTAGES FOR OSCILLATOR MODULE, UNIT A1

TEST POINT	VOLTAGE MEASURED	NORMAL VOLTAGE (Nominal)	NO SIGNAL VOLTAGE
TP1	AGC VOLTAGE	0.25 vdc	0.86 vdc

5-MC OUTPUT AMPLIFIER TRANSISTOR TERMINAL VOLTAGES

TRANSISTOR	TYPE VOLTAGE	EMITTER		BASE		COLLECTOR	
		No Signal Input (Nominal)	*Normal Signal Input (Nominal)	No Signal Input (Nominal)	*Normal Signal Input (Nominal)	No Signal Input (Nominal)	*Normal Signal Input (Nominal)
Q7	vdc	2.5	2.1	3.2	3.3	10.8	10.6
	vac	--	0.38	--	0.38	--	.6
Q8	vdc	2.0	2.6	2.7	2.8	11.5	11.5
	vac	--	0	--	0.38	--	4.5

*Input signal of 5 mc at 0.4 ± .05 v rms

NOTES

1. All dc voltages are positive with respect to ground.
2. Output signal of 5 mc at 1.15 ± 0.15 v rms (across 50 ohms).
3. Output signal to divider of 5 mc at 1 ± 0.5 v rms.

Note

If there is reason to believe that the input signal to either frequency divider was interrupted, try to restart the frequency divider with the START button on the front panel of the standard before attempting to locate a fault.

b. Excessive harmonic distortion or spurious signal content in the 1-mc or 100-kc output signal could be caused by a faulty output amplifier transistor. High harmonic output could also result from a faulty emitter feedback network.

4-19. POWER SUPPLY, UNIT A2.

Once it is assured that primary power is present and fuse F1 at the rear of the frequency standard is good, check for ac voltage at the secondary terminals of T1. No secondary output indicates a faulty transformer. Ripple voltage greater than 0.18 volts on the regulator input line could indicate a faulty filter circuit.

4-20. BATTERY POWER SUPPLY, UNIT A3.

If the power battery is completely dead, check the battery fuse F1. A low power battery voltage is more likely caused by a fault in the battery control circuit located in unit A6 than by a fault of the battery. However, check the voltage output of the power battery across pins 1 and 7 of battery power supply. Volt should be 17 volts minimum when the battery is fully charged.

4-21. REGULATOR AND BATTERY CONTROL, UNIT A6.

a. Faults in the regulator circuit can be located through voltage and resistance checks. Table 4-6 provides typical transistor voltages for the regulator under no-load and full-load conditions. The battery control circuits consist of three transistor stages, each driving a relay. This circuitry is probably the most difficult to trouble shoot since the various functions of the control circuitry are interrelated and depend upon each other for final battery control. However, with a knowledge of the operation of the control circuits and through continuity checks between relay circuits, a trouble can be located. The first indication of a battery control circuit failure is usually a zero indication on the panel meter for battery charge current and battery voltage or by failure of the CHARGE lamp to light when the battery should be charging.

b. The first item to check is the battery fuse and then

TABLE 4-4. PERTINENT TROUBLE SHOOTING VOLTAGES
FOR 5-MC TO 1-MC FREQUENCY DIVIDER, UNIT A4

TEST POINT VOLTAGES

TEST POINT	VOLTAGE MEASURED	NORMAL VOLTAGE
J6, RED	Frequency divider supply voltage	12 ± 0.5 vdc
J7, BLUE	1-mc signal developed in Q2 collector tank	0.5 vac (Nominal)
J8, GREEN	4-mc feedback signal to Q2	0.35 vac (Nominal)
J10, RED	Output amplifier supply voltage	12 ± 0.5 vdc
J11, BLUE	1-mc signal at primary of T1	4.7 vac (Nominal)

TRANSISTOR TERMINAL VOLTAGES

TRANSISTOR	TYPE VOLTAGE	EMITTER		BASE		COLLECTOR	
		No Signal (Nominal)	*Normal Signal (Nominal)	No Signal (Nominal)	*Normal Signal (Nominal)	No Signal (Nominal)	*Normal Signal (Nominal)
Q1	vdc vac	2.3 --	2.3 0.74	2.9 --	2.9 0.8	10.2 --	10.1 0.003
Q2	vdc vac	2.7 --	2.2 0.74	2.6 --	2.0 0.35	11.7 --	11.7 5.8
Q3	vdc vac	0 --	3.2 0.13	0 --	1.8 1.35	12.4 --	11.5 3.5
Q4	vdc vac	4.4 --	4.4 0.18	5.1 --	5.1 0.2	12.3 --	12.3 4.7

*Input signal of 5 mc at 0.75 v rms ± 0.3 v rms

NOTES

1. All dc voltages are positive with respect to ground.
2. Output signal of 1 mc at 1.35 v rms ± 0.3 v rms (into 50-ohm load).

the battery disconnect circuit since these are in series with all battery connections to the frequency standard. If the battery does not automatically recharge when primary power is restored after an interruption, also check the line status circuit since this circuit must provide contact closure to supply the battery charge circuit (Q2 and K2) with operating power. Next check the battery charge circuit, particularly transistor Q2, capacitor C2, and the timing cell discharge path.

TABLE 4-5. PERTINENT TROUBLE SHOOTING VOLTAGES FOR 1-MC TO 100-KC FREQUENCY DIVIDER, UNIT A5

TEST POINT VOLTAGES

TEST POINT	VOLTAGE MEASURED	NORMAL VOLTAGE
J6, RED	Frequency divider circuit supply voltage	12 ± 0.5 vdc
J7, BLUE	100-kc signal developed in Q2 collector tank	0.5 v rms (Nominal)
J8, GREEN	900-kc feedback signal to ampli-mixer Q2	0.42 v rms (Nominal)
J10, RED	Output amplifier supply voltage	12 ± 0.5 vdc
J11, BLUE	100-kc signal at primary of T1	6.4 v rms (Nominal)

TRANSISTOR TERMINAL VOLTAGES

TRANSISTOR	TYPE VOLTAGE	EMITTER		BASE		COLLECTOR	
		No Signal (Nominal)	*Normal Signal (Nominal)	No Signal (Nominal)	*Normal Signal (Nominal)	No Signal (Nominal)	*Normal Signal (Nominal)
Q1	vdc vac	2.1 --	2.1 0.37	2.8 --	2.8 0.38	10.3 --	10.3 .01
Q2	vdc vac	1.3 --	1.2 0.38	1.5 --	1.3 0.42	12.0 --	12.0 5.8
Q3	vdc vac	0 --	2.2 0.19	0.1 --	0.6 1.9	12.4 --	11.7 4.3
Q4	vdc vac	4.5 --	4.0 0.76	5.3 --	5.3 0.8	12.4 --	12.4 6.4

*Input signal 1 mc at 0.75 ± 0.3 v rms.

NOTES

1. All dc voltages are positive with respect to ground.
2. Output signal of 100 kc at 1.35 ± 0.3 v rms (into 50-ohm load).

TABLE 4-6. TYPICAL VOLTAGES FOR REGULATOR CIRCUIT, PART OF UNIT A6

TRANSISTOR TERMINAL VOLTAGES

	EMITTER		BASE		COLLECTOR	
	No Load	Full Load	No Load	Full Load	No Load	Full Load
Q1	12 v	12 v	12.75 v	12.8 v	30.3 v	19.5 v
Q3	0 v	0 v	0.74 v	0.725 v	0.175 v	0.21 v
Q4	30.3 v	19.5 v	29.5 v	18.9 v	12.75 v	12.8 v
Q5	6 v	5.9 v	6.5 v	6.45 v	26.25 v	11.5 v

NOTES

1. All voltages are positive dc with respect to ground and are measured under the following conditions:
   a. No Load - input voltage 21 vdc with infinite ohm load.
   b. Full Load - input voltage 21 vdc with 48 ohm load.
2. Q1 is not part of unit A6 but is located on inside rear panel of main chassis. (Located in 1A1A9.)

TABLE 4-7. TYPICAL VOLTAGE FOR STATUS-BATTERY CHARGE, PART OF UNIT A6

TRANSISTOR TERMINAL VOLTAGES

	EMITTER		BASE		COLLECTOR	
	No Load	Full Load	No Load	Full Load	No Load	Full Load
Q1	20.7 v	19.1 v	21.1 v	19.4 v	20.5 v	18.8 v
Q2	0 v	0 v	0 v	.6 v	0 v	12 v

NOTE

1. All voltages are positive dc with respect to ground.

SECTION 5
MAINTENANCE

5-1. PREVENTIVE MAINTENANCE.

The frequency standard is designed to operate for long periods of time, supplying highly accurate outputs at three frequencies, while requiring minimum maintenance. As long as output remains stable and the equipment is operating properly, do not disturb the set any more than is necessary to assure that it is functioning correctly without progressive deterioration of certain of its functions.

5-2. ROUTINE PREVENTIVE MAINTENANCE.

Routine preventive maintenance is limited to performing the operating checks described in paragraph 3-6. The readings attained in these checks should be recorded and each reading compared to those obtained in previous checks to assure that no particular reading is varying progressively in the same direction. If this condition does exist, the reason for the variation should be determined and the condition corrected before it causes malfunction of the equipment.

5-3. SPECIAL PREVENTIVE MAINTENANCE.

a. Output Frequency Check. If the equipment is available, it is desirable to check frequency of the 5-mc output on a monthly basis. By comparing the reading with previous readings, the direction and amount of drift can be determined and adjusted. The procedure for checking and adjusting output frequency is described in paragraph 5-8.

b. Battery Check (Preferred Method). Check the battery as follows:

(1) Remove the battery cover and connect a 0.25 ± 0.1 ohm resistor across each nickel cadmium cell.

(2) After each cell has been discharged to a terminal voltage of 0.8 ± 0.2 volt, remove the 0.25 ohm resistors and recharge the battery for 16 hours at a constant current of 350 ma, ambient temperature 25°C, 5.6 ampere hours charge.

(3) Allow the cells to rest for 24 to 48 hours at 25°C while completely disconnected from the charging circuit. This step is to detect and eliminate cells with a high self-discharge rate. Check individual cells with a voltmeter and replace cells with low voltage output.

(4) Discharge the cells into a 0.5 ohm resistor and measure the time required for the terminal voltage to drop to 1.1 volts.

(5) Minimum acceptable discharge time into a 0.5 ohm resistor is 85 minutes. The curve should be reasonably flat and should not display an early drop in potential to less than 1.1 volt.

(6) After this test, recharge the battery for 16 hours at a 350 ma rate and return to service.

c. Battery Check (Alternate Method).

(1) Discharge the individual cells of the battery to 0.8 ± 0.2 volts and recharge the complete 13 cell battery for 16 hours at a 350 ma rate. Clip separate 1 ohm resistors across the 13 cells in series, and allow the battery to discharge.

(2) Sample the terminal voltage of each cell during the discharge using a voltage recorder at each cell for approximately one minute. Continue until the terminal voltage of each cell drops to 1 volt. Examine the record and replace individual cells that drop to less than 1.1 volt in less than 180 minutes.

(3) After this test, recharge the battery for 16 hours at a 350 ma rate and return it to service.

5-4. ADJUSTMENT AND REPAIR.

The adjustments described in this section are not to be performed on a routine basis, but only when component replacement has been made or when comprehensive trouble shooting indicates the need for the adjustment. The frequency standard has been carefully aligned by the calibration laboratory prior to installation. Any attempt to adjust circuits, when something else is at fault, will result in wasted time and may require the return of the equipment to the calibration laboratory when the true difficulty is determined. If component removal is required to make tests or adjustments, refer to paragraphs 5-18 through 5-25 of this section for removal and replacement instructions.

5-5. TEST EQUIPMENT REQUIRED.

Test equipment required to check and adjust the frequency standard is listed in Table 5-1.

TABLE 5-1. TEST EQUIPMENT REQUIRED FOR ADJUSTMENT

NAME	DESIGNATION	USE
Frequency Deviation Meter	AN/URM-115	Checks frequency output of frequency standard against output of known accuracy.
Frequency Standard	AN/URQ-9 (or Equivalent)	Provides a known frequency output against which 5-mc output can be checked.
Multimeter	AN/USM-116	Checks various dc voltages, resistances, and amperages.
Oscilloscope	AN/USM-105A	Checks ratio of frequency outputs.
Vacuum Tube Voltmeter	AN/USM-143	Checks ac voltages.

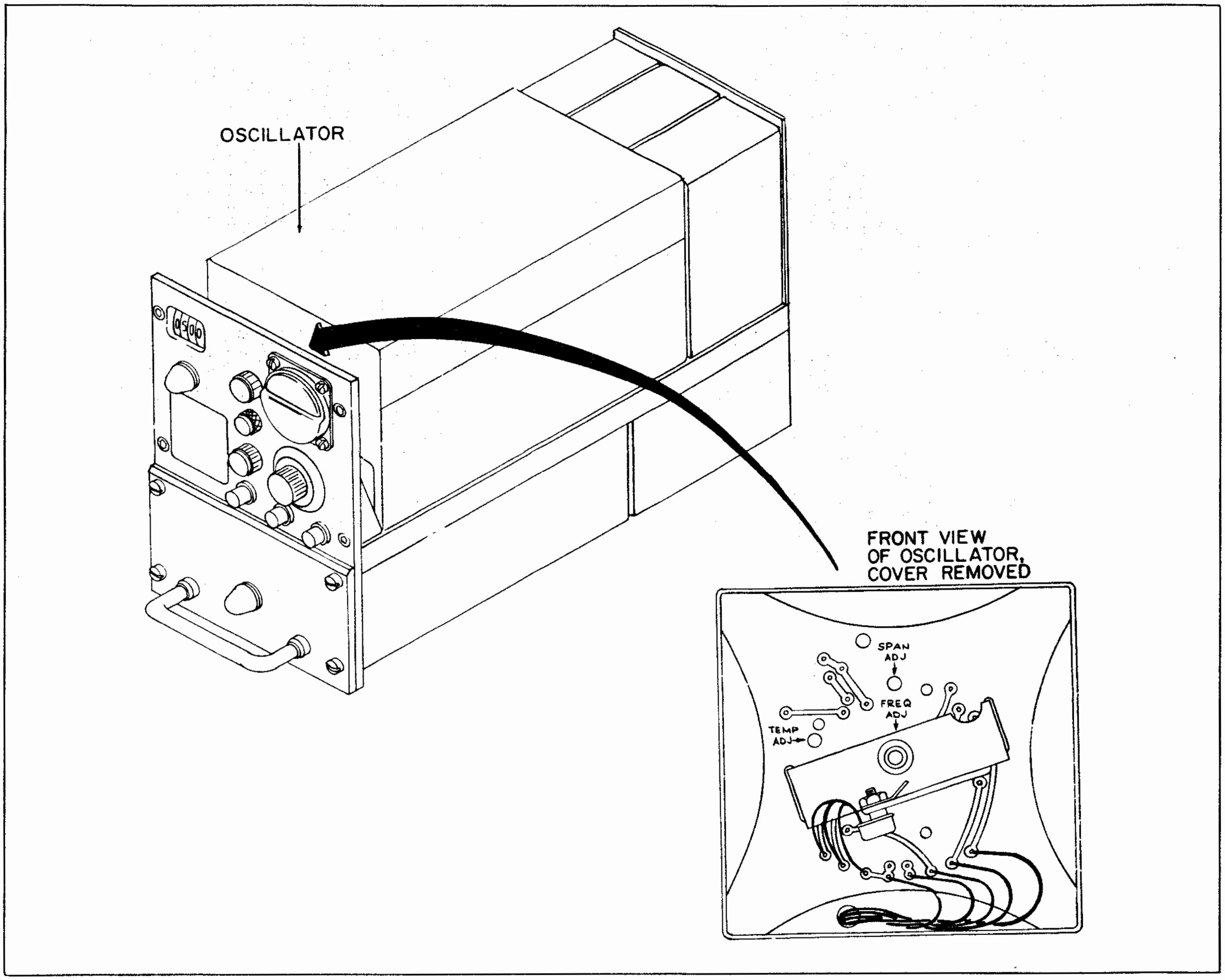


Figure 5-1. Oscillator, Unit A1, Adjustment Points

5-6. OSCILLATOR, UNIT A1, ADJUSTMENT.

Three major Oscillator, Unit A1, adjustments can be made without major disassembly of the unit. These include the outer oven temperature adjustment, the 5-mc oscillator frequency adjustment (both coarse and fine adjustments), and the 5-mc output amplifier adjustment. Another adjustment that affects oscillator frequency is the SPAN ADJ control. However, this is normally a factory adjustment and is used to calibrate the fine frequency control to within ±20 percent of the frequency indicator reading.

5-7. OUTER OVEN TEMPERATURE ADJUSTMENT.

This adjustment is primarily a factory adjustment but may be necessary after replacing output transistor Q19 in the outer oven temperature control circuit. The TEMP ADJ control (figure 5-1), located under the front cover of the module, is provided for the adjustment. Adjust this control to provide a voltage of 9 ± 1 vdc on the panel meter in position 4. When the inner oven heater is at this reading, the outer oven temperature will be set about 5°C (9°F) less than the inner oven temperature. The affect of the adjustment will not be immediate since it takes about an hour for the change in outer oven temperature to affect the inner oven temperature control circuit.

5-8. 5-MC OSCILLATOR FINE FREQUENCY ADJUSTMENT.

a. Check the output of the 5-mc oscillator using a test setup as shown in figure 5-2. Make sure the output of the frequency standard, which is being used as a reference, is accurate.

b. If it is determined that the frequency has drifted, determine the extent of drift in parts per 10^{10}.

c. To adjust the frequency, unscrew the fine frequency control and pull it out to engage the gears which link it to the fine tuning capacitor in the oscillator.

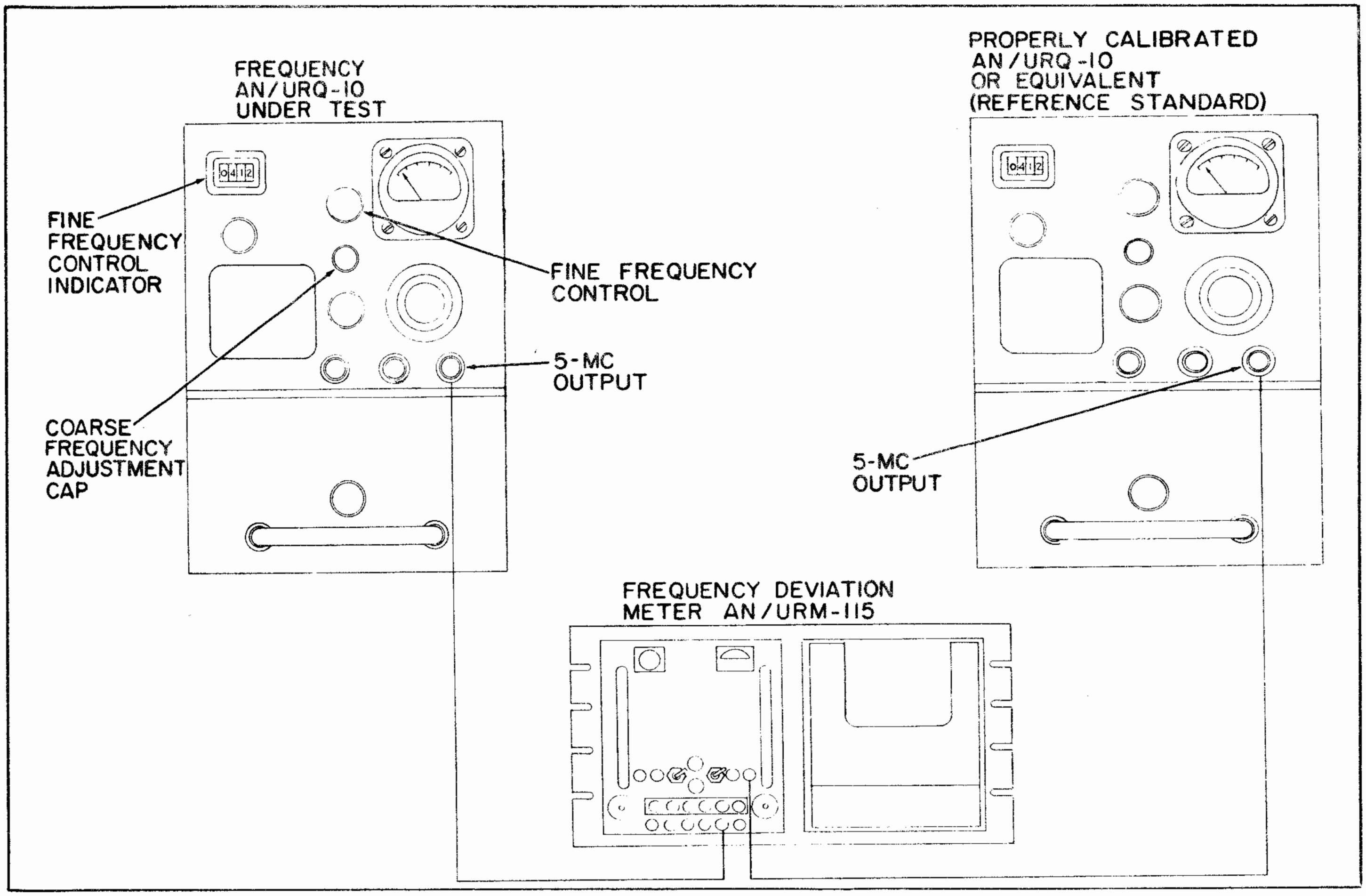


Figure 5-2. Test Setup for Checking Frequency Drift

d. If the frequency rate is fast, rotate the control counterclockwise to decrease the reading on the fine frequency control adjustment indicator by the parts per 10^{10} of determined deviation. Since one unit or count on the indicator represents a frequency change of one part per 10^{10}, the knob should be rotated 10 indicator units for each part per 10^{9} parts of frequency error.

e. If the frequency rate of the oscillator is slow, rotate the fine frequency control until the fine frequency control indicator advances by the required amount.

f. If the error rate cannot be corrected with the fine frequency control, rotate the control until 500 is displayed on the indicator and perform the adjustment with the COARSE frequency adjustment.

5-9. 5-MC COARSE FREQUENCY ADJUSTMENT.

a. If the error rate cannot be adjusted as directed in paragraph 5-8, using the fine frequency control, rotate the fine frequency control until 500 is displayed on the fine frequency control indicator.

b. Check that the ac power supply is being provided by a reliable source and remove the battery power supply. At the top of the battery power supply cavity,

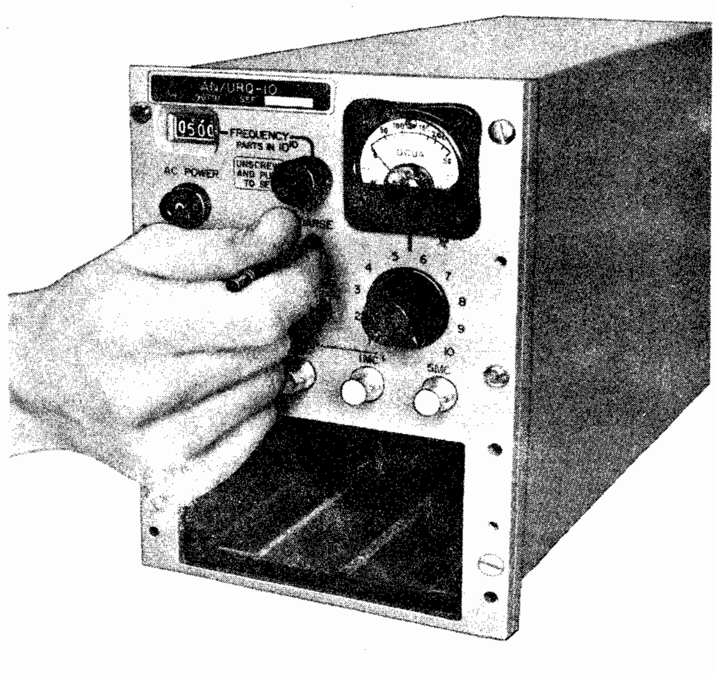


Figure 5-3. Coarse Frequency Adjustment

the special coarse adjustment tool is mounted in clips. Remove the tool.

c. Remove the COARSE frequency adjustment cap and insert the end of the special tool as shown in figure 5-3 into the COARSE adjustment point and rotate the control in the direction necessary to correct the deviation. Rotating the tool counterclockwise increases oscillator frequency. Rotating the tool clockwise decreases the frequency. 1/2 turn will change frequency approximately 10 parts in 10^9.

d. Remove the tool and install it in the clips in the top of the battery power supply opening, with the handle to the rear of the frequency standard. Replace the battery power supply.

e. Replace the COARSE frequency adjustment cap.

5-10. 5-MC OUTPUT AMPLIFIER ADJUSTMENT.

Two tank circuit adjustments are provided for the 5-mc output amplifier. Capacitor C29 (figure 5-4), at the rear of the oscillator in the tank circuit of Q2, may require adjusting when Q2 or components in its collector circuit are replaced. This control is adjusted for maximum 5-mc output signal at the output amplifier as indicated on a Ballantine Model 314 VTVM. Capacitor C34 (figure 5-4), in the emitter circuit of Q3, may require adjusting if Q3 or any of its associated components are replaced. This control should also be tuned for maximum 5-mc output signal as indicated on the VTVM. Final output must be 1.15 ± 0.15 volts.

Note

The adjustment of capacitors C29 and C34 for maximum 5-mc output signal may increase harmonic distortion above the 10-mv maximum. If this occurs, C34 should be readjusted slightly, trading maximum output signal for less distortion. Output must not be less than 1.0 volt.

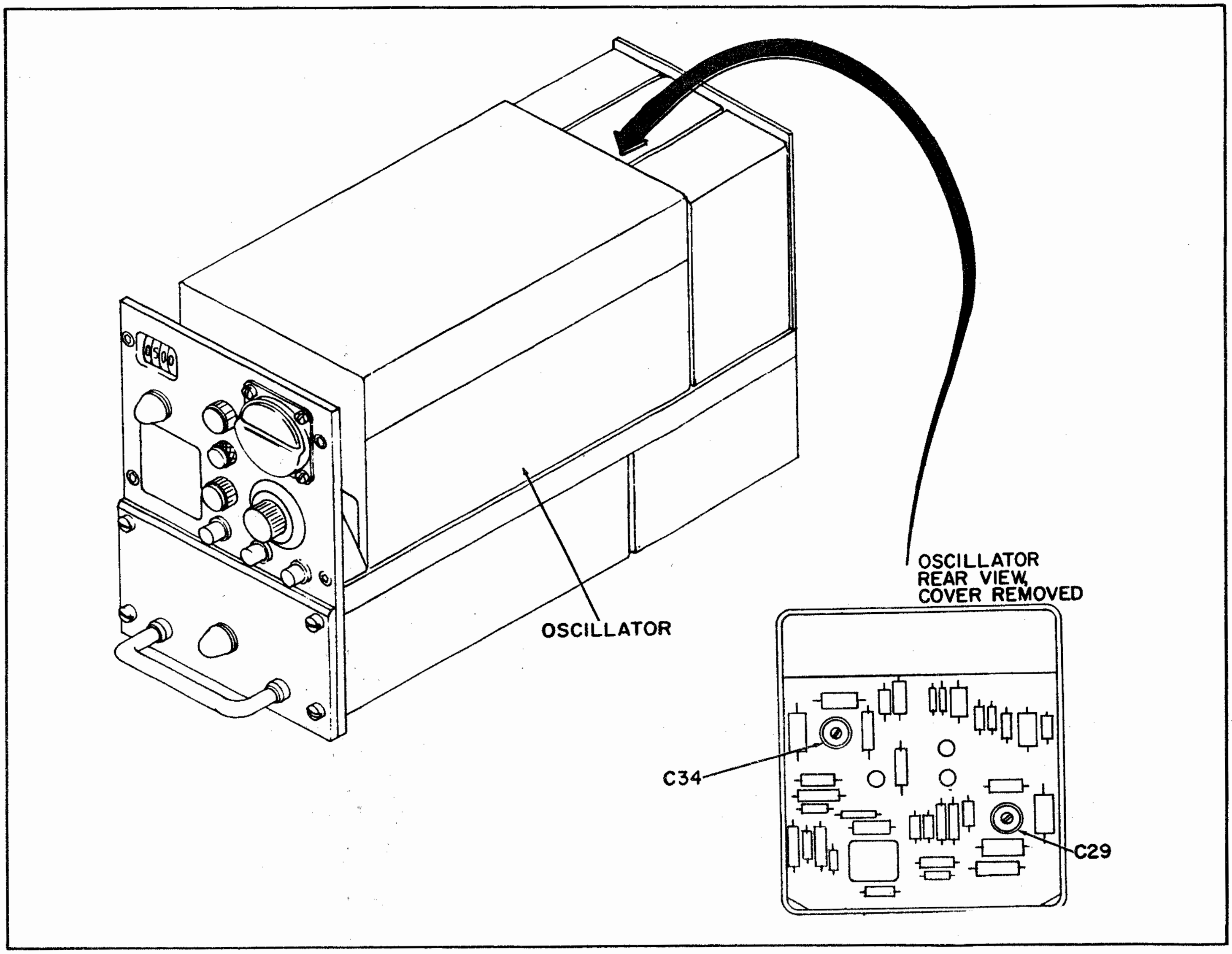


Figure 5-4. 5-Mc Output Amplifier Adjustment

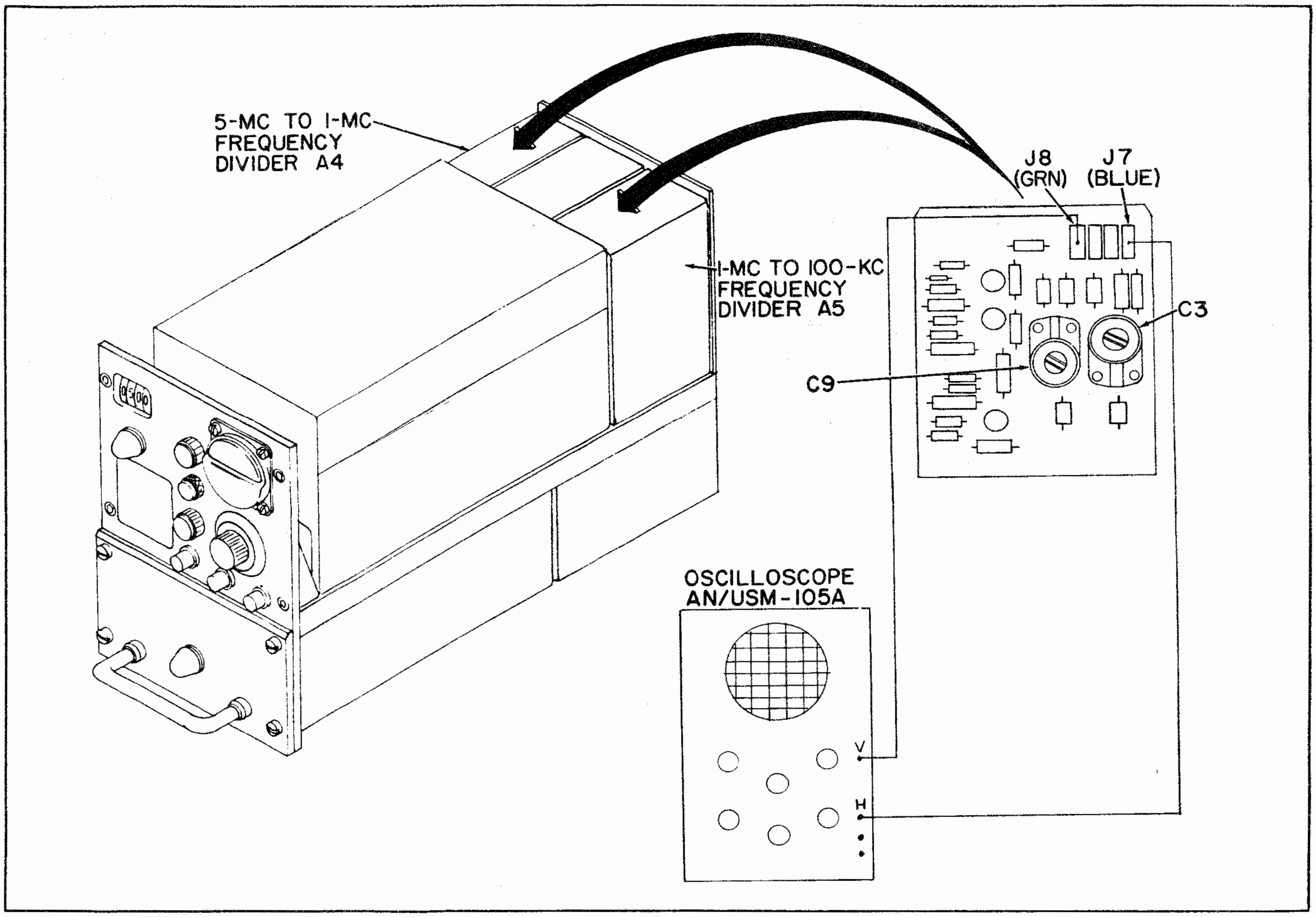


Figure 5-5. Checking Ratio of 4-Mc and 1-Mc Outputs of Unit A-4

5-11. ADJUSTMENT OF 5-MC TO 1-MC FREQUENCY DIVIDER, UNIT A4.

Adjustment points are provided to align the frequency divider circuits of unit A4. Refer to paragraph 5-12. If components have been replaced in the 1-mc output amplifier of unit, realignment may be necessary by selective replacement of components. Refer to paragraph 5-13.

5-12. FREQUENCY DIVIDER OUTPUT ADJUSTMENT.

Two tank circuit adjustments are provided for the frequency divider. Capacitor C3 (see figure 5-5) adjusts the tank circuit of Q2 for 1-mc output, and C9 adjusts the tank circuit of Q3 for 4-mc output. These adjustments may be required if a transistor is replaced or if a component in the circuit is replaced. Each capacitor is adjusted for maximum signal at the tank circuit frequency, as indicated on the Oscilloscope AN/USM-105A connected to the tank circuit test point. Blue test point J7 is in the 1-mc circuit. Green test point J8 is in the 4-mc circuit. When the circuit is tuned, its frequency can be checked on Oscilloscope AN/USM-105A by obtaining Lissajou patterns. These oscilloscope patterns are obtained by applying one tank circuit frequency to the vertical input and another to the horizontal input. A stationary pattern should appear on the oscilloscope which shows the ratio of the two frequencies.

5-13. ADJUSTMENT OF 1-MC OUTPUT AMPLIFIER.

No adjustment points are provided on the output amplifier. If the output transistor or a tank circuit component is replaced and proper output is not attained, it may be necessary to selectively replace capacitors C22 and C23 or resistor R13 until proper output is attained.

5-14. ADJUSTMENT OF 1-MC TO 100-KC FREQUENCY DIVIDER, UNIT A5.

The adjustments for the 1-mc to 100-kc frequency divider are the same as those for the 5-mc to 1-mc frequency divider described in paragraphs 5-12 and 5-13 and illustrated in figure 5-5, except for the tank circuit frequencies. The tank circuit of Q2 is tuned for 100 kc and the tank circuit from Q3 is tuned for 900 kc. If the inductor L1 is replaced it may be necessary to select L1 to obtain sufficient range of adjustment with Q3. Blue test point J7 is in the 100-kc circuit. Green test point J8 is in the 900-kc circuit. The output amplifier normally requires no adjustment after replacement of a component. However, if proper output is not attained, selectively replace capacitors C21, C22, or C23 or resistor R13 to get proper output.

5-15. POWER SUPPLY CIRCUITS.

Two power supply adjustments may be required after replacement of components. These are the voltage regulator adjustment (paragraph 5-16) and the battery disconnect adjustment (paragraph 5-17).

5-16. VOLTAGE REGULATOR ADJUSTMENT.

The output voltage of the regulator is adjusted through the use of R26 (figure 5-6). This adjustment is usually required after replacing a component in the regulator circuit. The adjustment should be performed with normal input voltage and normal output load current for the regulator. Adjust to an output voltage of 12 + 0 - 5 vdc as indicated on the panel meter when the metering switch is in position 7.

5-17. BATTERY DISCONNECT ADJUSTMENT.

Resistor R15 (figure 5-6) sets the battery dropout voltage of relay K3. This control may require resetting if Q3 or a component in its base circuit is replaced. In order to set R15, it is necessary to disconnect the ac primary power and remove the battery power supply. Use a variable dc power supply to provide voltage directly to the regulator input line, pins H and J of jack J2. (Apply negative input to pin J.) Set R15 to deenergize K3 when the variable power supply voltage is decreased to 13 + 0 - 0.5 vdc. As voltage is increased, relay K3 must pull in at or before input reaches 17 volts.

5-18. COMPONENT REMOVAL AND REPLACEMENT.

The following paragraphs describe the replacement of all major components of the frequency standard. Replacement of components is easily done, since extensive use has been made of plug-in type connectors to eliminate the requirement for unsoldering of wire

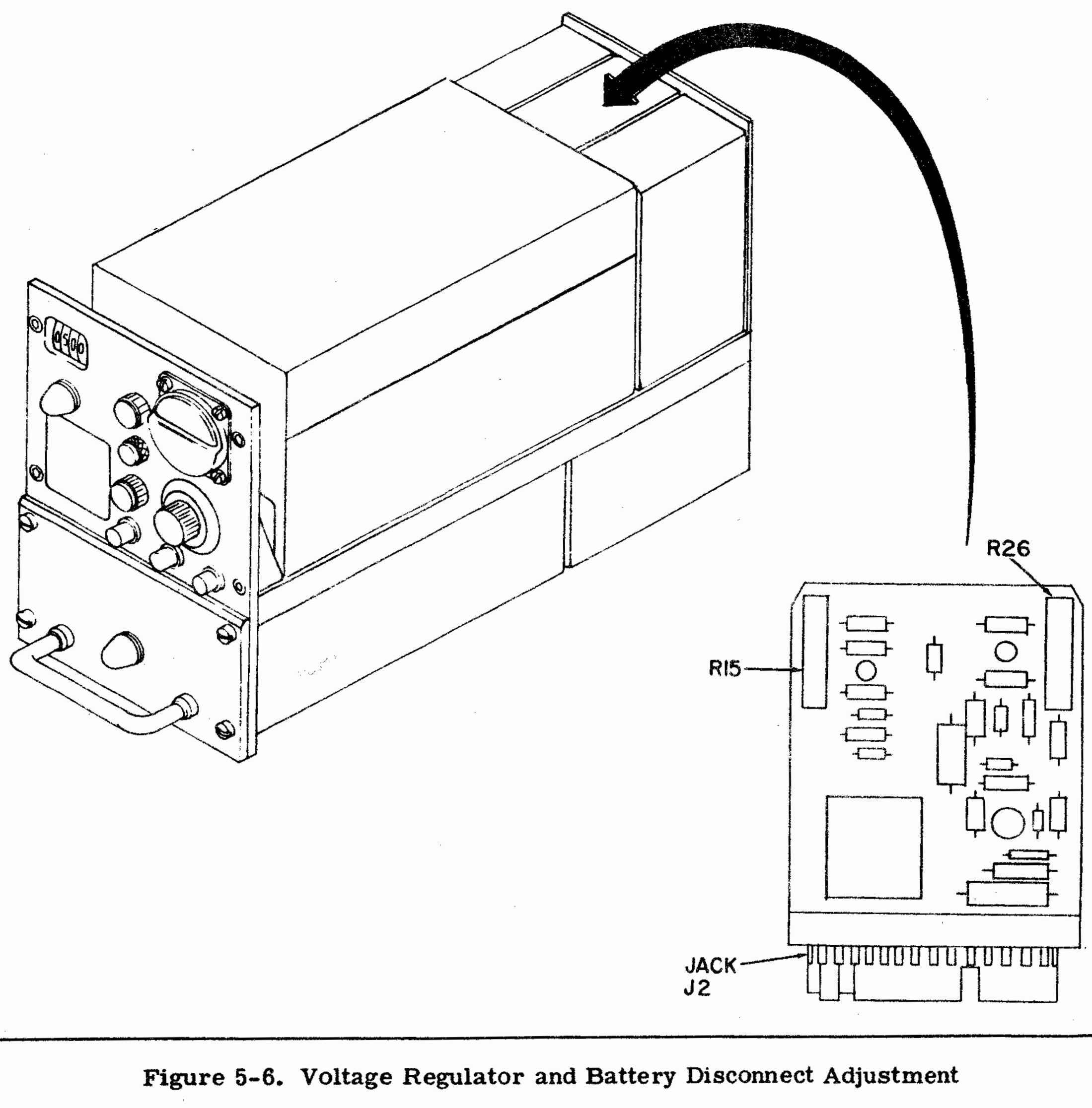
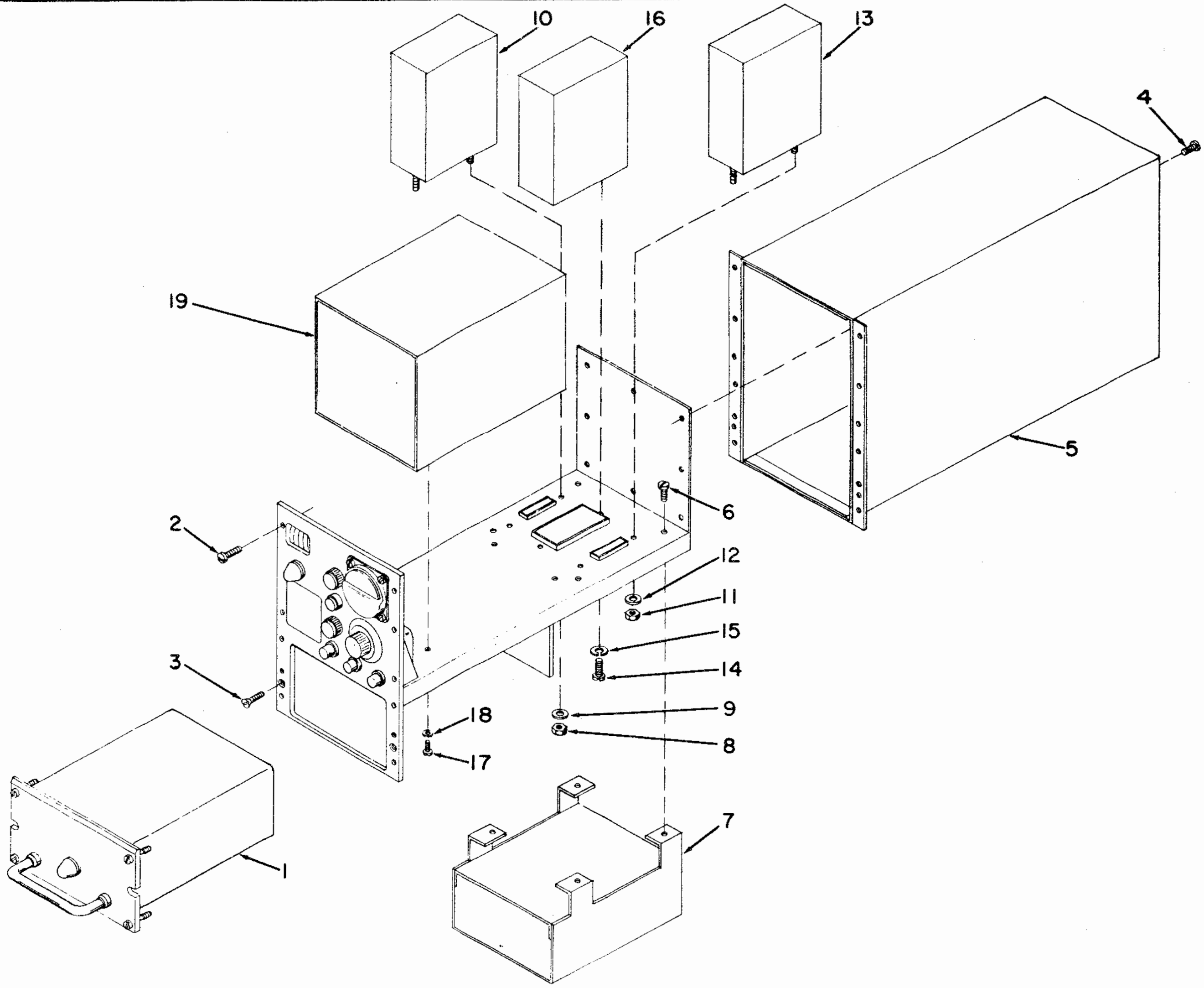


Figure 5-6. Voltage Regulator and Battery Disconnect Adjustment



1. Battery power supply
2. Pan head screw
3. Flat head screw
4. Pan head screw
5. Cover
6. Fillister head screw
7. Power supply
8. Nut
9. Lockwasher
10. 5-mc to 1-mc frequency divider
11. Nut
12. Lockwasher
13. 1-mc to 100-kc frequency divider
14. Screw
15. Lockwasher
16. Regulator and battery control
17. Pan head screw
18. Lockwasher
19. Oscillator

Figure 5-7. Major Components of Frequency Standard, Exploded View

connections. Individual electronic parts that make up components are mounted on circuit boards which greatly facilitate parts replacement. Remove and replace parts only as necessary to make necessary adjustments and calibration checks.

5-19. REMOVAL AND REPLACEMENT OF BATTERY POWER SUPPLY.

a. Removal. Loosen the four captive screws that secure the battery power supply (1, figure 5-7) to the frequency standard; pull the battery power supply from the unit.

b. Replacement. Slide the battery power supply into the frequency standard. Secure by tightening the four captive screws.

5-20. REMOVAL AND REPLACEMENT OF COVER.

a. Removal. Remove the battery power supply (paragraph 5-19). Remove the four pan head screws (2, figure 5-7), and the two flat head screws (3) that secure the frequency standard cover (5), to the front panel of the frequency standard. Remove the eight pan head screws (4), that secure the cover to the rear of the unit. Slide the cover from the unit.

b. Replacement. Inspect gasket seal then position the cover on the frequency standard. Secure to the front panel with four pan head screws and two flat head screws. Secure to the rear panel with eight pan head screws.

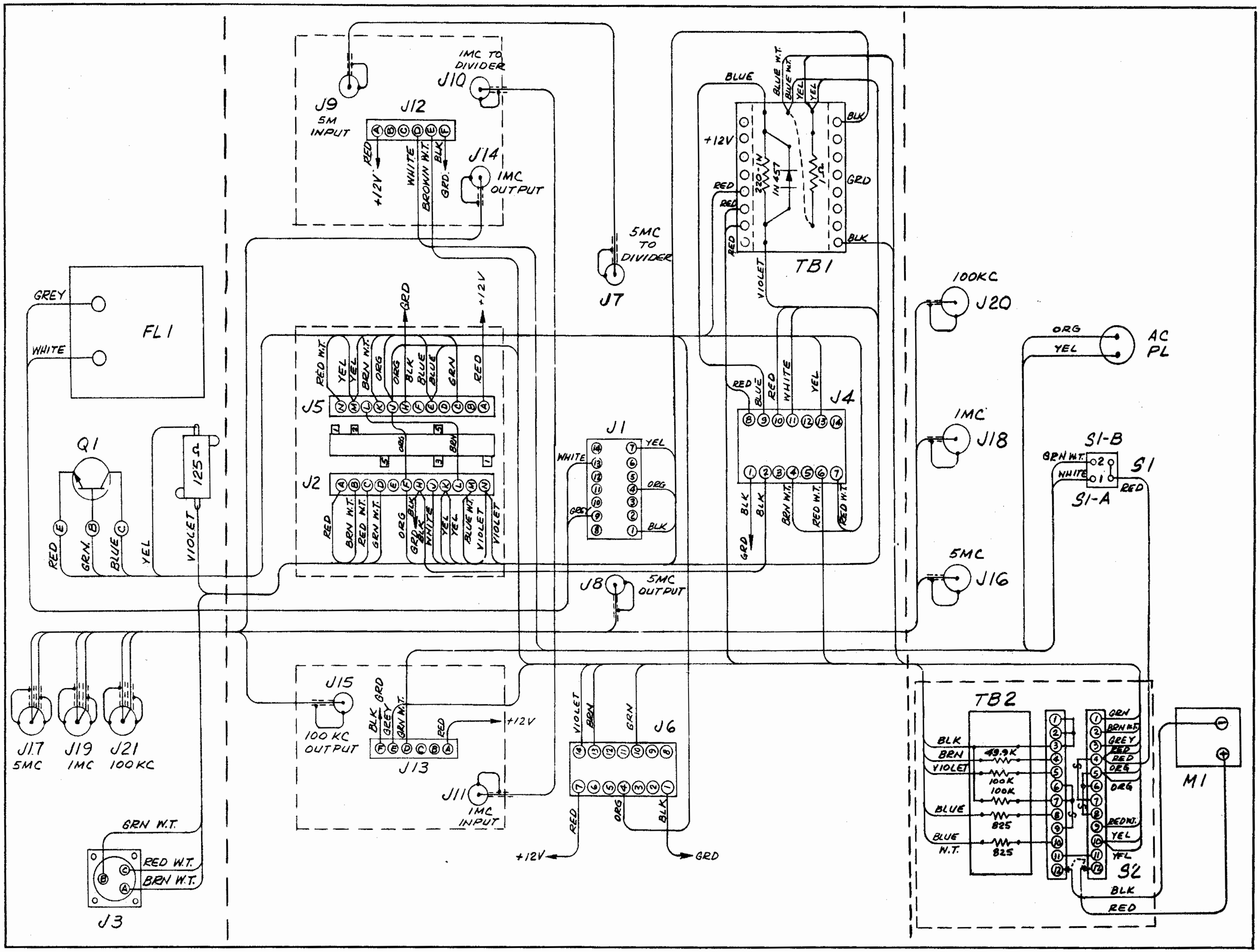


Figure 5-8. Frequency Standard Chassis, Wiring Diagram

5-21. REMOVAL AND REPLACEMENT OF POWER SUPPLY.

a. Removal. Remove the frequency standard cover (paragraph 5-20). Remove the four fillister head screws (6, figure 5-7) that secure the power supply (7) to the frequency standard; remove the power supply by pulling straight out of the connector.

b. Replacement. Position the power supply so that the connector is fully seated in the mating connector. Secure with four fillister head screws. Install the frequency standard cover (paragraph 5-20).

5-22. REMOVAL AND REPLACEMENT OF FREQUENCY DIVIDERS.

a. Removal. Remove the power supply from the frequency standard (paragraph 5-21). Remove the two nuts (8 or 11, figure 5-7) and lockwashers (9 or 12) that secure the frequency divider (10 or 13) to the chassis; remove the frequency divider by pulling straight out of the connector.

b. Replacement. Position the frequency divider in its connector, making sure it is fully seated. Secure with two nuts and lockwashers. Install the power supply on the frequency standard (paragraph 5-21).

5-23. REMOVAL AND REPLACEMENT OF REGULATOR AND BATTERY CONTROL.

a. Removal. Remove the power supply from the frequency standard (paragraph 5-21). Remove the two screws (14, figure 5-7) and lockwashers (15) that secure the regulator and battery control (16) to the frequency standard. Pull straight out to remove the regulator and battery control from the connector.

b. Replacement. Position the regulator and battery control on the connector on the chassis, making sure it is fully seated. Secure with two screws and lockwashers. Install the power supply (paragraph 5-21).

5-24. REMOVAL AND REPLACEMENT OF OSCILLATOR.

a. Removal. Remove the power supply from the frequency standard (paragraph 5-21). Disconnect the linkage between the fine frequency adjustment control on the chassis and the shaft on the oscillator. Remove the four pan head screws (17, figure 5-7) and lockwashers (18) that secure the oscillator assembly (19) to the main chassis; pull straight out on the oscillator to remove it from its connector. Remove the pan head screws and lockwashers that secure the covers to the oscillator and remove the covers.

CAUTION

Do not rotate the fine frequency control on the frequency standard front panel or the control shaft on the oscillator when connecting linkage is disconnected. The two shafts are so oriented that C7 is at midposition when the frequency indicator is at 500.

b. Replacement. Position the covers on the oscillator; secure with pan head screws and lockwashers. Position the oscillator on the main chassis, making sure it is fully seated in the connector; secure with four pan head screws and lockwashers. Connect the fine adjustment linkage between the shaft of the oscillator and the fine adjustment control. Install the power supply on the frequency standard (paragraph 5-21).

5-25. CHASSIS REPAIR.

Chassis repair consists primarily of replacement of components mounted on the chassis. When replacing components, tag leads to facilitate reassembly. Refer to figure 5-8 for wiring information for the chassis.

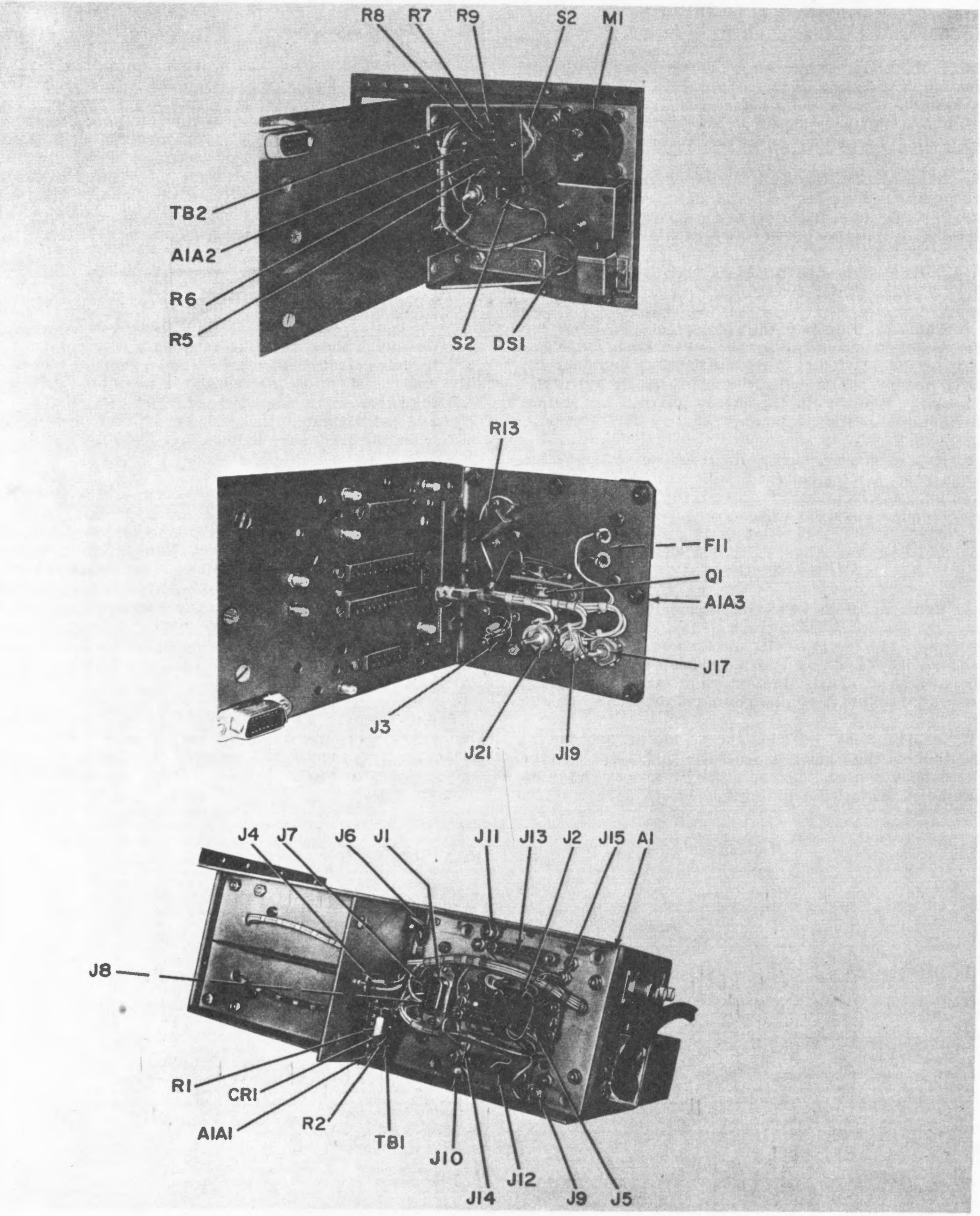


Figure 5-9. Chassis Assembly Internal Parts

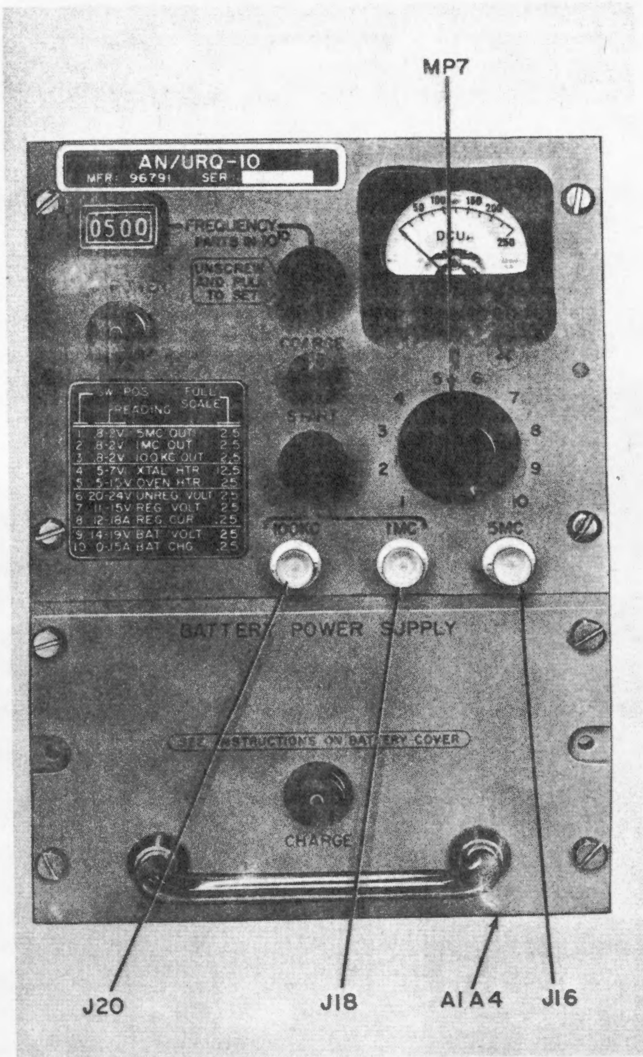


Figure 5-10. Chassis Assembly External Parts

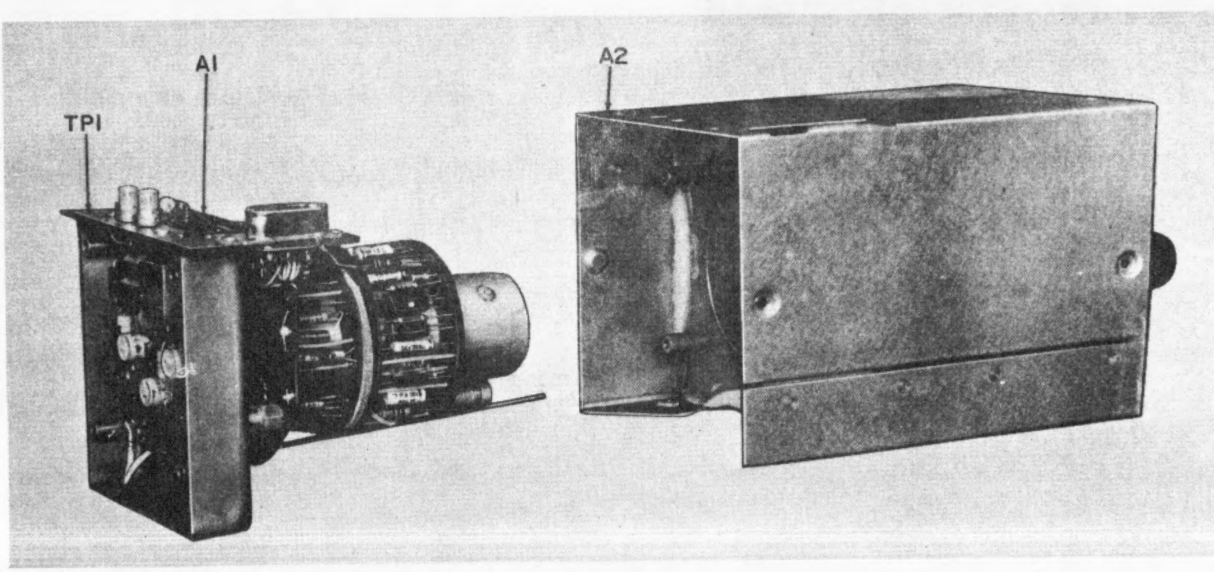


Figure 5-11. Oscillator Assembly Parts

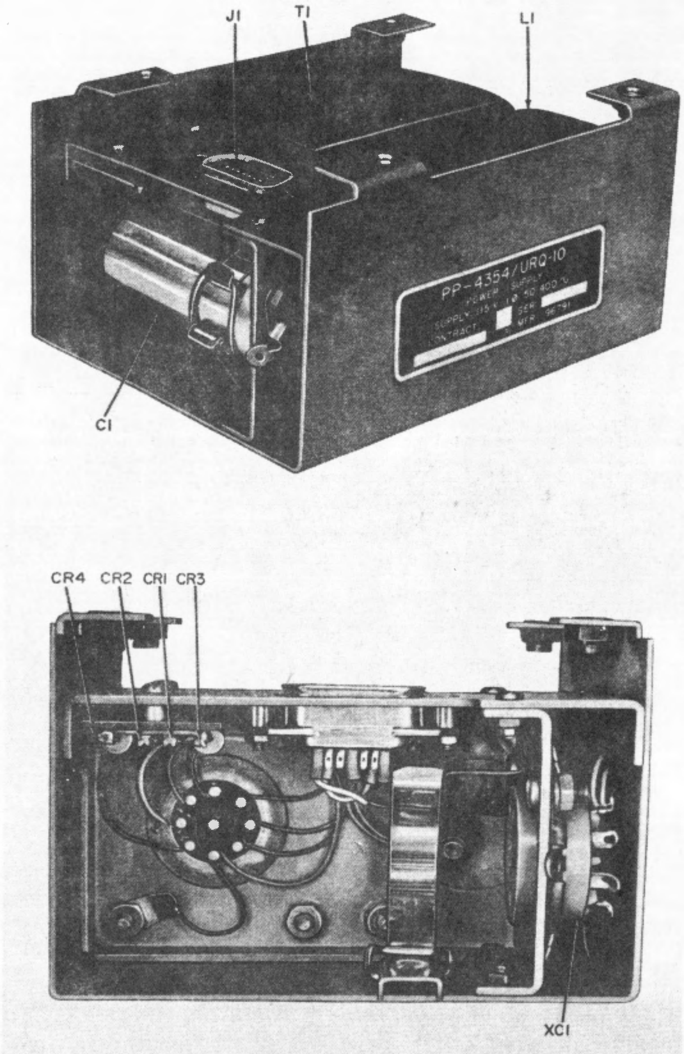


Figure 5-12. Power Supply Assembly

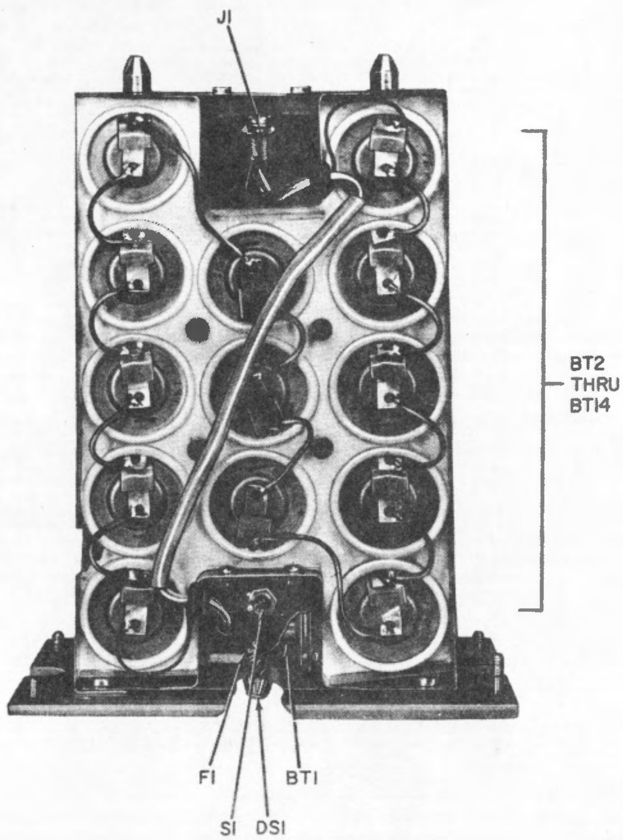


Figure 5-13. Battery Assembly

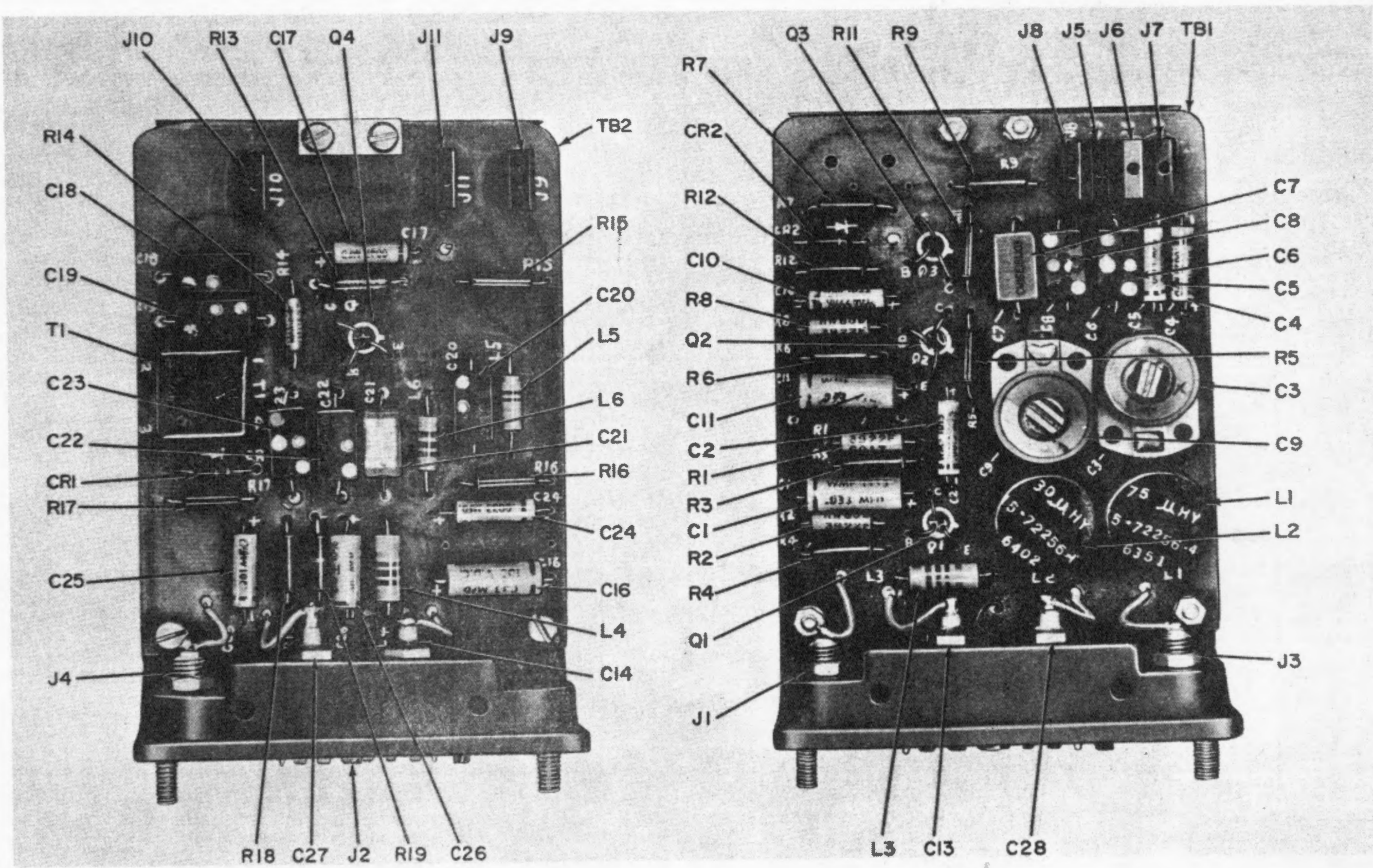


Figure 5-14. Divider, 5 Mc to 1 Mc

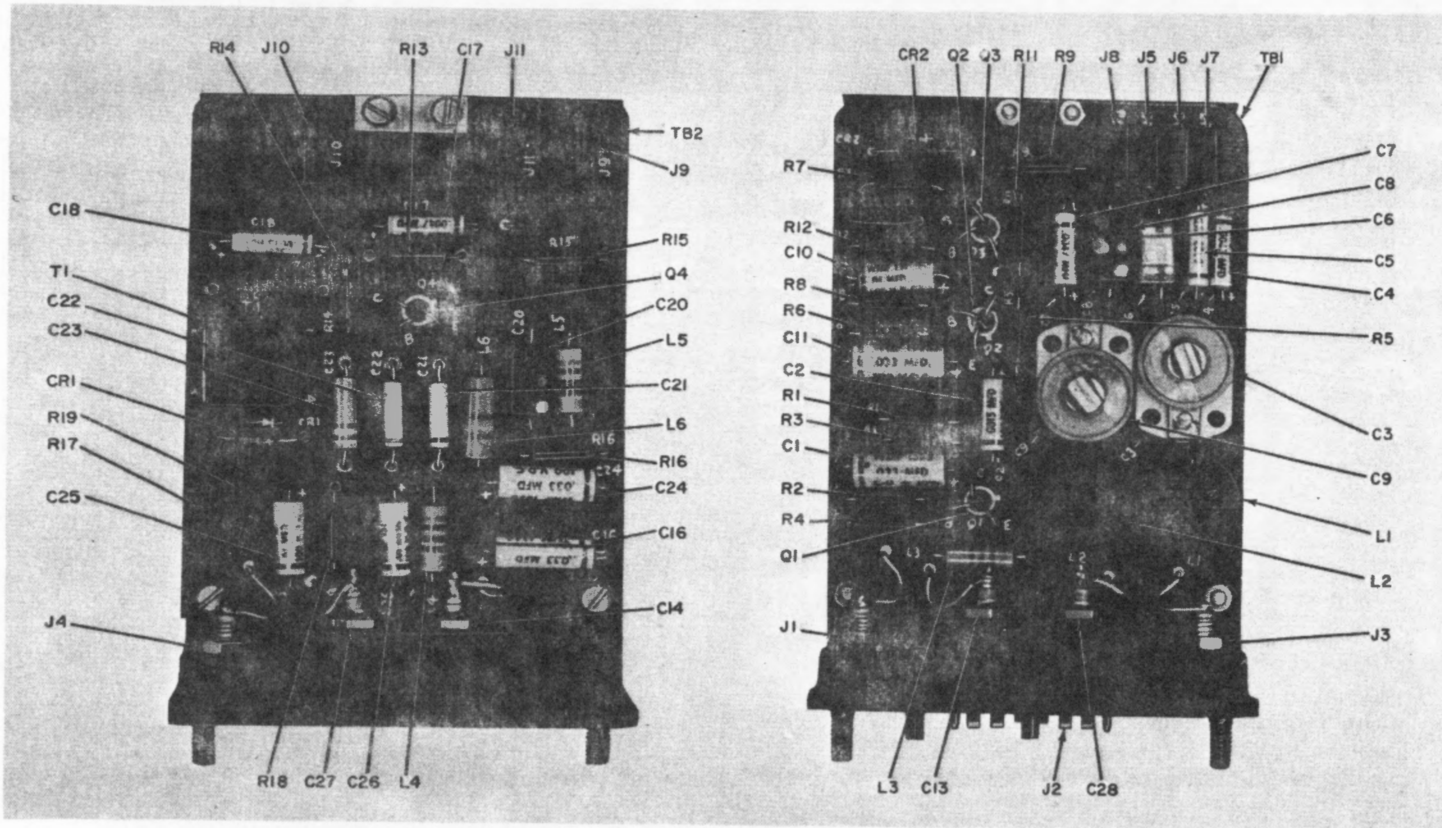


Figure 5-15. Divider, 1 Mc to 100 Kc

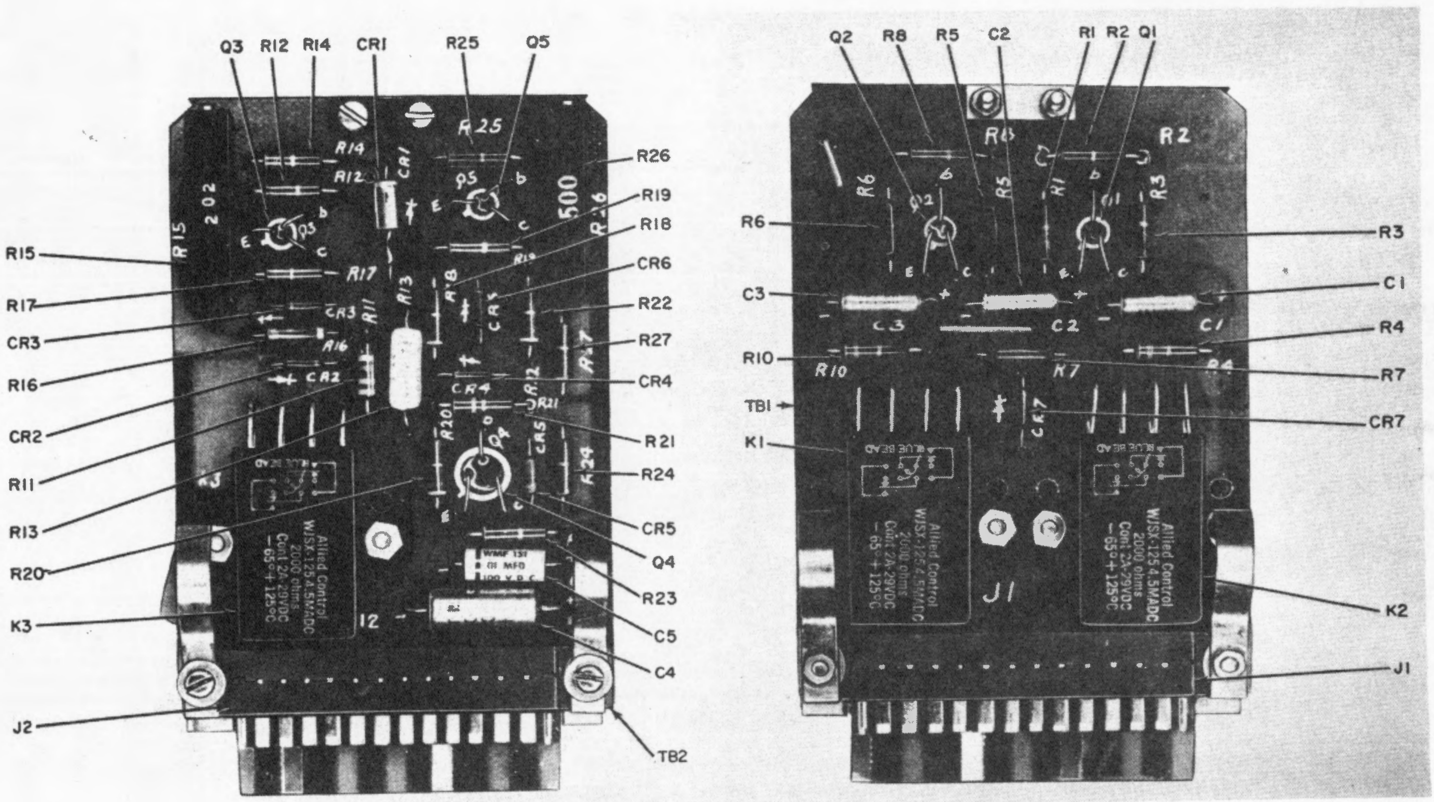


Figure 5-16. Voltage Regulator and Status

SECTION 6A
SUPPLEMENTARY REPAIR PARTS LIST

6A-1. INTRODUCTION.

This parts list has been corrected by means of the following supplementary table. For any given item, always refer first to the appropriate supplementary table, since it completely supersedes any corresponding listing in the basic table. If no information is shown for a given item, refer to the basic table for the required information.

Table 6A-1. Repair Parts List

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A4A1 L1	INDUCTOR, 82 uh, 0.155 dia, 0.375 in. lg	15-63317-19	(99800) 1537-72	5-14
1A1A4A1 L2	INDUCTOR, 30 uh, 0.155 dia, 0.375 in. lg	15-63317-1	(99800) 1537-50	5-14
1A1A4A1 Q1	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-502062-5	(01295) 2N706 Selected	5-14
1A1A4A1 Q2	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-502062-5	(01295) 2N706 Selected	5-14
1A1A4A1 Q3	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-502062-5	(01295) 2N706 Selected	5-14
1A1A4A2 C19*	CAPACITOR, MIL type CM15E151J		(81349) CM15E151J	5-14
1A1A4A2 Q4	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-502062-5	(01295) 2N706 Selected	5-14
1A1A5A1 CR3	DELETED			5-15
1A1A5A1 L1	INDUCTOR, 3.65 mh, 0.225 dia, 0.570 in. lg	15-502196	(99800) 2500-54	5-15
1A1A5A1 L2	INDUCTOR, 82 uh, 0.155 dia, 0.375 in. lg	15-63317-19	(99800) 1537-72	5-15
1A1A5A1 Q1	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-502062-5	(01295) 2N706 Selected	5-15
1A1A5A1 Q2	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-502062-5	(01295) 2N706 Selected	5-15
1A1A5A1 Q3	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-502062-5	(01295) 2N706 Selected	5-15
1A1A5A2 C18**	CAPACITOR, Fixed, plastic dielectric, 2200 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-1	(14655) WMF1D22E	5-15

*Units having CM15E241J replaceable with new value CM15E151J
**Units having WMF1D33E replaceable with new value WMF1D22E

Table 6A-1. Repair Parts List - (Cont'd.)

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A5A2 L4	COIL, Radio frequency, 1000 uh, 0. 200 dia, 0. 450 in. lg	15-63978-1	(99800) 2500-28	5-15
1A1A5A2 L5	COIL, Radio frequency, 1000 uh, 0. 200 dia, 0. 450 in. lg	15-63978-1	(99800) 2500-28	5-15
1A1A5A2 L6	COIL, Radio frequency, 2400 uh, 0. 225 dia, 0. 570 in. lg	15-63978-2	(01295) 2500-46	5-15
1A1A5A2 Q4	TRANSISTOR, 0. 195 dia, 0. 205 in. lg	15-502062-5	(01295) 2N706 Selected	5-15
1A1A6A1 K1	RELAY, 4. 5 ma, 2000 ohms, 0. 453 x 1. 281 x 1. 328 in.	15-64000	(70309) WJSX125	5-16
1A1A6A1 K2	RELAY, 4. 5 ma, 2000 ohms, 0. 453 x 1. 281 x 1. 382 in.	15-64000	(70309) WJSX125	5-16
1A1A6A1 Q1	TRANSISTOR, 0. 195 dia, 0. 205 in. lg	15-502062-5	(01295) 2N706 Selected	5-16
1A1A6A1 Q2	TRANSISTOR, 0. 110 dia, 0. 295 in. lg	15-502062-5	(01295) 2N706 Selected	5-16
1A1A6A2 K3	RELAY, 4. 5 ma, 2000 ohms, 0. 453 x 1. 281 x 1. 328 in.	15-64000	(70309) WJSX125	5-16
1A1A6A2 Q3	TRANSISTOR, 0. 195 dia, 0. 205 in. lg	15-502062-5	(01295) 2N706 Selected	5-16
1A1A6A2 Q5	TRANSISTOR, MIL type 2N929		(01295) 2N929	5-16
1A1A6A2 Q6	DELETED			5-16
1A1A6A2 R21	DELETED			5-16
1A1A9 Q1	TRANSISTOR	15-73335	(12672) 2N2339 Selected	5-9

SECTION 6

REPAIR PARTS LIST

6-1. INTRODUCTION.

The unit numbering method of assigning reference designations has been used to identify the frequency standard unit and its various subassemblies. Unit and subassembly reference designations are as follows:

1	FREQUENCY STANDARD UNIT
1A1	CHASSIS ASSEMBLY
1A1A1	OSCILLATOR
1A1A1A1	INNER OVEN AND OUTPUT ASSEMBLY
1A1A1A2	OUTER OVEN AND HOUSING ASSEMBLY
1A1A10	FRONT PANEL ASSEMBLY
1A1A2	POWER SUPPLY ASSEMBLY
1A1A3	BATTERY ASSEMBLY
1A1A4A1TB1	PRINTED CIRCUIT BOARD ASSEMBLY
1A1A4A2TB2	PRINTED CIRCUIT BOARD ASSEMBLY
1A1A5	1-MC TO 100-KC DIVIDER
1A1A5A1TB1	PRINTED CIRCUIT BOARD ASSEMBLY
1A1A5A2TB2	PRINTED CIRCUIT BOARD ASSEMBLY
1A1A6	VOLTAGE REGULATOR AND STATUS
1A1A6A1TB1	BATTERY CHARGING AND STATUS ASSEMBLY
1A1A6A2TB2	REGULATOR - BATTERY DISCONNECT ASSEMBLY
1A1A7	JUNCTION BOARD ASSEMBLY
1A1A8	METER SWITCH BOARD ASSEMBLY
1A1A9	REAR PANEL ASSEMBLY

6-2. REPAIR PARTS LIST.

The Repair Parts List identifies all subassemblies and repair parts in the frequency standard. The subassemblies are listed in alpha-numerical sequence as outlined in paragraph 6-1. Repair parts are listed in alpha-numerical sequence immediately following the subassembly to which they belong. The following information is provided in the Repair Parts List: (1) the complete reference designation of each part, (2) noun name and brief description, (3) prime contractor part number, (4) manufacturer's code and part number, (5) the figure number of the illustration which will pictorially locate the part.

NOTE

Parts in accordance with a Government Specification or Standard are so identified in the Description column, but otherwise are not described in detail.

6-3. VENDOR CODES.

Following the Repair Parts List is a numerical listing of the Manufacturers' Codes which appear in the Repair Parts List, with the manufacturer's name and address corresponding to each.

Table 6-1. Repair Parts List

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1	CHASSIS ASSEMBLY, 5.625 x 7.969 x 14.563 in.	15-81891		5-9
1A1A1	OSCILLATOR, 4-1/2 x 4-1/2 x 6-1/8 in.	15-81840		1-2
1A1A1A1	INNER OVEN AND OUTPUT ASSEMBLY, Inner, 3.406 x 4.157 x 5.281 in.	15-82075		5-11
1A1A1A2	OUTER OVEN AND HOUSING ASSEMBLY, Outer, 4.453 x 4.453 x 6.188 in.	15-82078		5-11
1A1A10	PANEL ASSEMBLY, Front, 1.500 x 5.500 x 8.000 in.	15-81918		5-9
1A1A10 DS1	LAMP, MIL type MS25237-327		(96906) MS25237-327	5-9
1A1A10 J1 thru 1A1A10 J15	NOT USED			
1A1A10 J16	CONNECTOR, MIL type MS27035-625B		(96906) MS27035-625B	5-9
1A1A10 J17	NOT USED			
1A1A10 J18	CONNECTOR, MIL type MS27035-625B		(96906) MS27035-625B	5-9
1A1A10 J19	NOT USED			
1A1A10 J20	CONNECTOR, MIL type MS27035-625B		(96906) MS27035-625B	5-9
1A1A10 M1	AMMETER, 0 to 250 microamps dc	15-64147	(38315) HS1	5-9
1A1A10 S1A	SWITCH, Start, 0.790 dia, 1.260 in. lg	15-63991	(81073) 35DPST	5-9
1A1A10 S1B	SWITCH, Start, 0.790 dia, 1.260 in. lg	15-63991	(81073) 35DPST	5-9
1A1A10 XDS1	SOCKET ASSEMBLY, Red indicator light, 0.625 dia, 1.699 in. lg	15-64316-1	(72619) 177-8430-931	5-9
1A1A2	POWER SUPPLY ASSEMBLY, 3.313 x 4.250 x 5.297 in. lg	15-81892		1-2
1A1A2 CR1	SEMICONDUCTOR, MIL type 1N645		(01295) 1N645	5-12
1A1A2 CR2	SEMICONDUCTOR, MIL type 1N645		(01295) 1N645	5-12
1A1A2 CR3	SEMICONDUCTOR, MIL type USN1N3611		(04713) USN1N3611	5-12
1A1A2 CR4	SEMICONDUCTOR, MIL type USN1N3611		(04713) USN1N3611	5-12
1A1A2 C1	CAPACITOR, MIL type CE51C401F		(81349) CE51C401F	5-12
1A1A2 J1	CONNECTOR, Receptacle, electrical, 14 male cont, 0.600 x 0.600 x 1.750 in.	15-63309	(02660) 57-10140	5-12
1A1A2 L1	INDUCTOR, 47.5 to 420 cps, 2.062 x 2.312 x 3.563 in.	15-72172	(70674) TF4RX04FA	5-12
1A1A2 T1	TRANSFORMER, Power step down, 2.062 x 2.312 x 3.500 in.	15-72813		5-12
1A1A2 XC1	SOCKET, MIL type TS101P01		(91662) TS101P01	5-12
1A1A3	BATTERY ASSEMBLY, 5-1/2 x 6-1/2 x 9.000 in.	15-81893		1-2
1A1A3 BT1	CELL, Timing, 1.22 v, 0.988 dia, 0.230 in. thk	15-64321	(86638) 100B	5-13

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A3 BT2 thru BT14	CELL, Battery, 1.343 dia, 2.395 in. lg	15-64283		5-13
1A1A3 DS1	LAMP, MIL type MS25237-327		(96906) MS25237-327	5-13
1A1A3 F1	FUSE, 2 amp, 0.250 in. dia, 0.348 in. lg	15-63862-1	(75915) 273002-2AMP	5-13
1A1A3 J1	CONNECTOR, Receptacle electrical, 14 female cont, 0.600 x 0.600 x 1.417 in.	15-63330	(02660) 57-20140	5-13
1A1A3 S1	SWITCH, Toggle, 5 amp, 115 vac	15-64315	(81640) T2104	5-13
1A1A3 XDS1	SOCKET, Light, red, 5/8 dia, 1.000 in. lg	15-64316-1	(72619) 177-8430-931	5-13
1A1A3 XF1	HOLDER, Fuse, 0.578 dia, 1.063 in. lg	15-63996	(75915) 281002	5-13
1A1A4	DIVIDER, 5 mc to 1 mc, 1.375 x 3.000 x 4.750 in.	15-81875		1-2
1A1A4A1 TB1	BOARD ASSEMBLY, Printed circuit, 0.578 x 2.844 x 3.672 in.	15-72859		5-14
1A1A4A1 CR1	NOT USED			
1A1A4A1 CR2	SEMICONDUCTOR, MIL type 1N662		(01295) 1N662	5-14
1A1A4A1 C1	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.218 dia, 0.625 in. lg	15-63310-7	(14655) WMFIS33E	5-14
1A1A4A1 C10	CAPACITOR, Fixed, plastic dielectric, 2200 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-1	(14655) WMFID22E	5-14
1A1A4A1 C11	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.218 dia, 0.625 in. lg	15-63310-7	(14655) WMFIS33E	5-14
1A1A4A1 C2	CAPACITOR, Fixed, plastic dielectric, 1500 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-4	(14655) WFMID15E	5-14
1A1A4A1 C3	CAPACITOR, MIL type CV11D450		(81349) CV11D450	5-14
1A1A4A1 C4	CAPACITOR, Fixed, plastic dielectric, 2200 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-1	(14655) WMFID22E	5-14
1A1A4A1 C5	CAPACITOR, Fixed, plastic dielectric, 1500 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-4	(14655) WMFID15E	5-14
1A1A4A1 C6	CAPACITOR, MIL type CM15E431J		(81349) CM15E431J	5-14
1A1A4A1 C7	CAPACITOR, MIL type CM15E181J		(81349) CM15E181J	5-14
1A1A4A1 C8	CAPACITOR, MIL type CM15E390J		(81349) CM15E390J	5-14
1A1A4A1 C9	CAPACITOR, MIL type CV11D450		(81349) CV11D450	5-14
1A1A4A1 J1 thru 1A1A4A1 J4	NOT USED			
1A1A4A1 J5	JACK, Tip, black, 0.203 dia, 0.410 in. lg	15-501787-2	(74970) 105-753	5-14
1A1A4A1 J6	JACK, Tip, red, 0.203 dia, 0.410 in. lg	15-501787-1	(74970) 105-752	5-14
1A1A4A1 J7	JACK, Tip, blue, 0.203 dia, 0.410 in. lg	15-501787-9	(74970) 105-760	5-14
1A1A4A1 J8	JACK, Tip, green, 0.203 dia, 0.410 in. lg	15-501787-3	(74970) 105-754	5-14
1A1A4A1 L1	INDUCTOR, 75 uh, 0.6885, 0.375 in. thk	15-63317-19	(99800) 1537-72	5-14
1A1A4A1 L2	INDUCTOR, 30 uh, 0.688 dia, 0.375 in. thk	15-63317-1	(99800) 1537-50	5-14
1A1A4A1 L3	COIL, Radio frequency, 1000 uh, 0.190 dia, 0.440 in. lg	15-63978-1	(99800) 2500-28	5-14
1A1A4A1 Q1	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-1
1A1A4A1 Q2	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-14
1A1A4A1 Q3	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-14

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A4A1 R1	RESISTOR, MIL type RN60D3922F		(81349) RN60D3922F	5-14
1A1A4A1 R10	NOT USED			
1A1A4A1 R11	RESISTOR, MIL type RC20GF102J		(81349) RC20GF102J	5-14
1A1A4A1 R12	RESISTOR, MIL type RN60D2741F		(81349) RN60D2741F	5-14
1A1A4A1 R2	RESISTOR, MIL type RN60D3922F		(81349) RN60D3922F	5-14
1A1A4A1 R3	RESISTOR, MIL type RC20GF471J		(81349) RC20GF471J	5-14
1A1A4A1 R4	RESISTOR, MIL type RN60D4750F		(81349) RN60D4750F	5-14
1A1A4A1 R5	RESISTOR, MIL type RC20GF102J		(81349) RC20GF102J	5-14
1A1A4A1 R6	RESISTOR, MIL type RN60D2741F		(81349) RN60D2741F	5-14
1A1A4A1 R7	RESISTOR, MIL type RC20GF393J		(81349) RC20GF393J	5-14
1A1A4A1 R8	RESISTOR, MIL type RN60D3922F		(81349) RN60D3922F	5-14
1A1A4A1 R9	RESISTOR, MIL type RC20GF104J		(81349) RC20GF104J	5-14
1A1A4A2 TB1	NOT USED			
1A1A4A2 TB2	BOARD ASSEMBLY, Printed circuit, 0.453 x 2.848 x 3.750 in.	15-72860		5-14
1A1A4A2 CR1	SEMICONDUCTOR, MIL type 1N662		(01295) 1N662	5-14
1A1A4A2 C1 thru 1A1A4A2 C15	NOT USED			
1A1A4A2 C16	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.218 dia, 0.625 in. lg	15-63310-7	(14655) WMFIS33E	5-14
1A1A4A2 C17	CAPACITOR, Fixed, plastic dielectric, 4700 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-6	(14655) WMFID47E	5-14
1A1A4A2 C18	CAPACITOR, MIL type CM15E511J		(81349) CM15E511J	5-14
1A1A4A2 C19	CAPACITOR, MIL type CM15E241J		(81349) CM15E241J	5-14
1A1A4A2 C20	CAPACITOR, MIL type CM15E221J		(81349) CM15E221J	5-14
1A1A4A2 C21	CAPACITOR, MIL type CY15C681J		(81349) CY15C681J	5-14
1A1A4A2 C22*	CAPACITOR, MIL type CM15E500J		(81349) CM15E500J	5-14
1A1A4A2 C22*	CAPACITOR, MIL type CM15E101J		(81349) CM15E101J	5-14
1A1A4A2 C22*	CAPACITOR, MIL type CM15E151J		(81349) CM15E151J	5-14
1A1A4A2 C22*	CAPACITOR, MIL type CM15E201J		(81349) CM15E201J	5-14
1A1A4A2 C22*	CAPACITOR, MIL type CM15E251J		(81349) CM15E251J	5-14
1A1A4A2 C23*	CAPACITOR, MIL type CM15C100J		(81349) CM15C100J	5-14
1A1A4A2 C23*	CAPACITOR, MIL type CM15C200J		(81349) CM15C200J	5-14
1A1A4A2 C23*	CAPACITOR, MIL type CM15E300J		(81349) CM15E300J	5-14
1A1A4A2 C23*	CAPACITOR, MIL type CM15E390J		(81349) CM15E390J	5-14
1A1A4A2 C23*	CAPACITOR, MIL type CM15E430J		(81349) CM15E430J	5-14
1A1A4A2 C23*	CAPACITOR, MIL type CM15E510J		(81349) CM15E510J	5-14
1A1A4A2 C24	CAPACITOR, Fixed, plastic dielectric, 3300 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-8	(14655) WMFID33E	5-14
1A1A4A2 C25	CAPACITOR, Fixed, plastic dielectric, 1000 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-3	(81349) WMFIDIE	5-14

*Capacitor selected and exact value determined by equipment test.

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A4A2 C26	CAPACITOR, Fixed, plastic dielectric, 10,000 uuf, 100 v, 0.200 dia, 0.500 in. lg	15-63310-2	(14655) WMFISIE	5-14
1A1A4A2 J1	NOT USED			
1A1A4A2 J10	JACK, Tip, red, 0.203 dia, 0.410 in. lg	15-501787-1	(74970) 105-752	5-14
1A1A4A2 J11	JACK, Tip, blue, 0.203 dia, 0.410 in. lg	15-501787-9	(74970) 105-760	5-14
1A1A4A2 J2 thru 1A1A4A2 J8	NOT USED			
1A1A4A2 J9	JACK, Tip, black, 0.203 dia, 0.410 in. lg	15-501787-2	(74970) 105-753	5-14
1A1A4A2 L1 thru 1A1A4A2 L3	NOT USED			
1A1A4A2 L4	COIL, Radio frequency, 1000 uh, 0.190 dia, 0.440 in. lg	15-63978-1	(99800) 2500-28	5-14
1A1A4A2 L5	INDUCTOR, 30 uh, 0.155 dia, 0.375 in. lg	15-63317-1	(99800) 1537-50	5-14
1A1A4A2 L6	INDUCTOR, 200 uh, 0.155 dia, 0.375 in. lg	15-63317-17	(99800) 1537-90	5-14
1A1A4A2 Q1 thru 1A1A4A2 Q3	NOT USED			
1A1A4A2 Q4	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-14
1A1A4A2 R1 thru 1A1A4A2 R12	NOT USED			
1A1A4A2 R13*	RESISTOR, Mil type RN60D3321F		(81349) RN60D3321F	5-14
1A1A4A2 R13*	RESISTOR, MIL type RN60D4021F		(81349) RN60D4021F	5-14
1A1A4A2 R13*	RESISTOR, MIL type RN60D5111F		(81349) RN60D5111F	5-14
1A1A4A2 R13*	RESISTOR, MIL type RN60D6041F		(81349) RN60D6041F	5-14
1A1A4A2 R13*	RESISTOR, MIL type RN60D7151F		(81349) RN60D7151F	5-14
1A1A4A2 R13*	RESISTOR, MIL type RN60D8061F		(81349) RN60D8061F	5-14
1A1A4A2 R13*	RESISTOR, MIL type RN60D9091F		(81349) RN60D9091F	5-14
1A1A4A2 R13*	RESISTOR, MIL type RN60D1003F		(81349) RN60D1003F	5-14
1A1A4A2 R14	RESISTOR, MIL type RN60D1002F		(81349) RN60D1002F	5-14
1A1A4A2 R15	RESISTOR, MIL type RN60D1002F		(81349) RN60D1002F	5-14
1A1A4A2 R16	RESISTOR, MIL type RN60D2740F		(81349) RN60D2740F	5-14
1A1A4A2 R17	RESISTOR, MIL type RN20GF101J		(81349) RN20GF101J	5-14
1A1A4A2 R18	RESISTOR, MIL type RN60D5621F		(81349) RN60D5621F	5-14
1A1A4A2 R19	RESISTOR, MIL type RC20GF751J		(81349) RC20GF751J	5-14
1A1A4A2 T1	TRANSFORMER, 1 mc, 0.555 x 0.625 x 0.625 in.	15-72548		5-14
1A1A4 C1 thru 1A1A4 C12	NOT USED			
1A1A4 C13	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-14
1A1A4 C14	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-14

*Resistor selected and exact value determined by equipment test.

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A4 C15 thru 1A1A4 C26	NOT USED			
1A1A4 C27	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-14
1A1A4 C28	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-14
1A1A4 J1	CONNECTOR, Plug, electrical, 0.281 hex, 0.703 in. lg	500433-2	(98278) 32-42	5-14
1A1A4 J2	CONNECTOR, Receptacle, electrical, 6 male cont, 0.600 x 0.600 x 1.825 in.	15-63864-1	(02660) 133-006-23	5-14
1A1A4 J3	CONNECTOR, Plug, electrical, 0.281 hex, 0.703 in. lg	15-64748-2	(02660) 5116-054300	5-14
1A1A4 J4	CONNECTOR, Plug, electrical, 0.281 hex, 0.703 in. lg	15-64748-2	(02660) 5116-054300	5-14
1A1A5	DIVIDER, 1 mc to 100 kc, 1.375 x 3.000 x 4.750 in.	15-81876		1-2
1A1A5A1 TB1	BOARD ASSEMBLY, Printed circuit, 0.445 x 2.891 x 3.734 in.	15-72861		5-15
1A1A5A1 CR1	NOT USED			
1A1A5A1 CR2	SEMICONDUCTOR, MIL type 1N662		(01295) 1N662	5-15
1A1A5A1 CR3	SEMICONDUCTOR, MIL type 1N702		(13480) 1N702	5-15
1A1A5A1 C1	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.218 dia, 0.625 in. lg	15-63310-7	(14655) WMFIS33E	5-15
1A1A5A1 C10	CAPACITOR, Fixed, plastic dielectric, 10,000 uuf, 100 v, 0.200 dia, 0.500 in. lg	15-63310-2	(14655) WMFISIE	5-15
1A1A5A1 C11	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.218 dia, 0.625 in. lg	15-63310-7	(14655) WMFIS33E	5-15
1A1A5A1 C2	CAPACITOR, Fixed, plastic dielectric, 1500 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-4	(81349) WMFID15E	5-15
1A1A5A1 C3	CAPACITOR, MIL type CV11D450		(81349) CV11D450	5-15
1A1A5A1 C4	CAPACITOR, Fixed, plastic dielectric, 4700 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-6	(81349) WMFID47E	5-15
1A1A5A1 C5	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-8	(14655) WMFID33E	5-15
1A1A5A1 C6	CAPACITOR, MIL type CY15C102J		(81349) CY15C102J	5-15
1A1A5A1 C7	CAPACITOR, Fixed, plastic dielectric, 4700 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-6	(14655) WMFID47E	5-15
1A1A5A1 C8	CAPACITOR, MIL type CM15E431J		(81349) CM15E431J	5-15
1A1A5A1 C9	CAPACITOR, MIL type CN11D450		(81349) CN11D450	5-15
1A1A5A1 J1 thru 1A1A5A1 J4	NOT USED			
1A1A5A1 J5	JACK, Tip, black, 0.203 dia, 0.410 in. lg	15-501787-2	(74970) 105-753	5-15
1A1A5A1 J6	JACK, Tip, red, 0.203 dia, 0.410 in. lg	15-501787-1	(74970) 105-752	5-15
1A1A5A1 J7	JACK, Tip, blue, 0.203 dia, 0.410 in. lg	15-501787-9	(74970) 105-760	5-15
1A1A5A1 J8	JACK, Tip, green, 0.203 dia, 0.410 in. lg	15-501787-3	(74970) 105-754	5-15

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A5A1 L1	INDUCTOR, 3.6 mh, 0.688 dia, 0.375 in. thk	15-63978-3	(99800) 2500-54	5-15
1A1A5A1 L2	INDUCTOR, 82 uh, 0.688 dia, 0.375 in. thk	15-63317-19	(99800) 1537-72	5-15
1A1A5A1 L3	COIL, Radio frequency, 1000 uh, 0.190 dia, 0.440 in. lg	15-63978-1	(99800) 2500-28	5-15
1A1A5A1 Q1	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-15
1A1A5A1 Q2	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-15
1A1A5A1 Q3	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-15
1A1A5A1 R1	RESISTOR, MIL type RN60D3922F		(81349) RN60D3922F	5-15
1A1A5A1 R10	NOT USED			
1A1A5A1 R11	RESISTOR, Fixed, composition, 1000 ohms ± 5%, 0.5 watt		(81349) RC20GF102J	5-15
1A1A5A1 R12	RESISTOR, Fixed, film, 2740 ohms ± 1%, 0.25 watt		(81349) RN60D2741F	5-15
1A1A5A1 R2	RESISTOR, Fixed, film, 39.2 Kohms ± 1%, 0.25 watt		(81349) RN60D3922F	5-15
1A1A5A1 R3	RESISTOR, Fixed, composition, 470 ohms ± 5%, 0.5 watt		(81349) RC20GF471J	5-15
1A1A5A1 R4	RESISTOR, Fixed, film, 475 ohms ± 1%, 0.25 watt		(81349) RN60D4750F	5-15
1A1A5A1 R5	RESISTOR, Fixed, composition, 1000 ohms ± 5%, 0.5 watt		(81349) RC20GF102J	5-15
1A1A5A1 R6	RESISTOR, Fixed, film, 2740 ohms ± 1%, 0.25 watt		(81349) RN60D2741F	5-15
1A1A5A1 R7	RESISTOR, Fixed, composition, 39 Kohms ± 5%, 0.5 watt		(81349) RC20GF393J	5-15
1A1A5A1 R8	RESISTOR, Fixed, film, 39.2 Kohms ± 1%, 0.25 watt		(81349) RN60D3922F	5-15
1A1A5A1 R9	RESISTOR, Fixed, composition, 220 Kohms ± 5%, 0.5 watt		(81349) RC20GF224J	5-15
1A1A5A2 TB1	NOT USED			
1A1A5A2 TB2	BOARD ASSEMBLY, Printed circuit, 0.461 x 2.859 x 3.734 in.	15-72862		5-15
1A1A5A2 C1 thru 1A1A5A2 C15	NOT USED			
1A1A5A2 C16	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.218 dia, 0.625 in. lg	15-63310-7	(14655) WMFIS33E	5-15
1A1A5A2 C17	CAPACITOR, Fixed, plastic dielectric, 4700 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-6	(14655) WMFID47E	5-15
1A1A5A2 C18	CAPACITOR, Fixed, plastic dielectric, 3300 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-8	(14655) WMFID33E	5-15
1A1A5A2 C19	NOT USED			
1A1A5A2 C20	CAPACITOR, MIL type CM15E511J		(81349) CM15E511J	5-15
1A1A5A2 C21*	CAPACITOR, Fixed, plastic dielectric, 2200 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-1	(14655) WMFID22E	5-15
1A1A5A2 C21*	CAPACITOR, Fixed, plastic dielectric, 1500 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-4	(14655) WMFID15E	5-15

*Capacitor selected and exact value determined by equipment test.

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A5A2 C22*	CAPACITOR, Fixed, plastic dielectric, 1500 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-4	(14655) WMFID15E	5-15
1A1A5A2 C22*	CAPACITOR, Fixed, plastic dielectric, 1000 uuf, 100 v, 0.156 dia, 0.500 in. lg	15-63310-3	(14655) WMFIDIE	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15C200J		(81349) CM15C200J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E390J		(81349) CM15E390J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E620J		(81349) CM15E620J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E820J		(81349) CM15E820J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E101J		(81349) CM15E101J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E121J		(81349) CM15E121J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E151J		(81349) CM15E151J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E181J		(81349) CM15E181J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E201J		(81349) CM15E201J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E221J		(81349) CM15E221J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E241J		(81349) CM15E241J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E271J		(81349) CM15E271J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E301J		(81349) CM15E301J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E331J		(81349) CM15E331J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E361J		(81349) CM15E361J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E391J		(81349) CM15E391J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E431J		(81349) CM15E431J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E471J		(81349) CM15E471J	5-15
1A1A5A2 C23*	CAPACITOR, MIL type CM15E501J		(81349) CM15E501J	5-15
1A1A5A2 C24	CAPACITOR, Fixed, plastic dielectric, 33,000 uuf, 100 v, 0.218 dia, 0.625 in. lg	15-63310-7	(14655) WMFIS33E	5-15
1A1A5A2 C25	CAPACITOR, Fixed, plastic dielectric, 10,000 uuf, 100 v, 0.200 dia, 0.500 in. lg	15-63310-2	(14655) WFMISIE	5-15
1A1A5A2 C26	CAPACITOR, Fixed, plastic dielectric, 10,000 uuf, 100 v, 0.200 dia, 0.500 in. lg	15-63310-2	(14655) WFMISIE	5-15
1A1A5A2 CR1	SEMICONDUCTOR, MIL type 1N662		(01295) 1N662	5-15
1A1A5A2 J1	NOT USED			
1A1A5A2 J10	JACK, Tip, red, 0.203 dia, 0.410 in. lg	15-501787-1	(74970) 105-752	5-15
1A1A5A2 J11	JACK, Tip, blue, 0.203 dia, 0.410 in. lg	15-501787-9	(74970) 105-760	5-15
1A1A5A2 J2 thru 1A1A5A2 J8	NOT USED			
1A1A5A2 J9	JACK, Tip, black, 0.203 dia, 0.410 in. lg	15-501787-2	(74970) 105-753	5-15
1A1A5A2 L1 thru 1A1A5A2 L3	NOT USED			
1A1A5A2 L4	COIL, Radio frequency, 1000 uh, 0.190 dia, 0.440 in. lg	15-63978-1	(99800) 2500-28	5-15
1A1A5A2 L5	COIL, Radio frequency, 1000 uh, 0.190 dia, 0.440 in. lg	15-63978-1	(99800) 2500-28	5-15

*Capacitor selected and exact value determined by equipment test.

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A5A2 L6	COIL, Radio frequency, 2400 uh, 0.215 dia, 0.560 in. lg	15-63978-2	(01295) 2500-46	5-15
1A1A5A2 Q1 thru 1A1A5A2 Q3	NOT USED			
1A1A5A2 Q4	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-15
1A1A5A2 R1 thru 1A1A5A2 R12	NOT USED			
1A1A5A2 R13*	RESISTOR, MIL type RN60D3321F		(81349) RN60D3321F	5-15
1A1A5A2 R13*	RESISTOR, MIL type RN60D4021F		(81349) RN60D4021F	5-15
1A1A5A2 R13*	RESISTOR, MIL type RN60D5111F		(81349) RN60D5111F	5-15
1A1A5A2 R13*	RESISTOR, MIL type RN60D6041F		(81349) RN60D6041F	5-15
1A1A5A2 R13*	RESISTOR, MIL type RN60D7151F		(81349) RN60D7151F	5-15
1A1A5A2 R13*	RESISTOR, MIL type RN60D8061F		(81349) RN60D8061F	5-15
1A1A5A2 R13*	RESISTOR, MIL type RN60D9091F		(81349) RN60D9091F	5-15
1A1A5A2 R13*	RESISTOR, MIL type RN60D1002F		(81349) RN60D1002F	5-15
1A1A5A2 R14	RESISTOR, MIL type RN60D1002F		(81349) RN60D1002F	5-16
1A1A5A2 R15	RESISTOR, MIL type RN60D1002F		(81349) RN60D1002F	5-16
1A1A5A2 R16	RESISTOR, MIL type RN60D2740F		(81349) RN60D2740F	5-16
1A1A5A2 R17	RESISTOR, MIL type RC20GF101J		(81349) RC20GF101J	5-16
1A1A5A2 R18	RESISTOR, MIL type RN60D5621F		(81349) RN60D5621F	5-16
1A1A5A2 R19	RESISTOR, MIL type RC20GF821J		(81349) RC20GF821J	5-16
1A1A5A2 T1	TRANSFORMER, 0.559 x 0.625 x 0.625 in.	15-72354		5-16
1A1A5 C1 thru 1A1A5 C12	NOT USED			
1A1A5 C13	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-16
1A1A5 C14	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-16
1A1A5 C15 thru 1A1A5 C26	NOT USED			
1A1A5 C27	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-16
1A1A5 C28	CAPACITOR, Feed thru, 2300 pf, 500 v, 0.313 hex, 1.156 in. lg	15-63308-1	(71590) FT2300	5-16
1A1A5 J1	CONNECTOR, Plug, electrical, 0.281 hex, 0.703 in. lg	15-64748-2	(02660) 5116-054300	5-16
1A1A5 J2	CONNECTOR, Receptacle, electrical, 12 male cont, 0.600 x 0.600 x 2.762 in.	15-63864-1	(02660) 133-006-23	5-15
1A1A5 J3	NOT USED			
1A1A5 J4	CONNECTOR, Plug, electrical, 0.281 hex, 0.703 in. lg	15-64748-2	(02660) 5116-054300	5-15

*Resistor selected and exact value determined by equipment test.

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A6	REGULATOR AND STATUS, Voltage, 1.375 x 3.000 x 4.750 in.	15-81870		1-2
1A1A6A1 TB1	CHARGING AND STATUS ASSEMBLY, Battery, 0.625 x 2.844 x 4.719 in.	15-72879		5-16
1A1A6A1 C1	CAPACITOR, MIL type CS13AD220K		(81349) CS13AD220K	5-16
1A1A6A1 C2	CAPACITOR, MIL type CS13AD220K		(81349) CS13AD220K	5-16
1A1A6A1 C3	CAPACITOR, MIL type CS13AD220K		(81349) CS13AD220K	5-16
1A1A6A1 CR1 thru 1A1A6A1 CR6	NOT USED			
1A1A6A1 CR7	SEMICONDUCTOR, MIL type 1N457		(01295) 1N457	5-16
1A1A6A1 J1	CONNECTOR, Receptacle, electrical, 12 male cont, 0.600 x 0.600 x 2.762 in.	15-63864-2	(02660) 133-012-43	5-16
1A1A6A1 K1	RELAY, 4.5 ma, 2000 ohms, 0.800 x 1.281 x 1.328 in.	15-64000	(70309) WJSX125	5-16
1A1A6A1 K2	RELAY, 4.5 ma, 2000 ohms, 0.800 x 1.281 x 1.382 in.	15-64000	(70309) WJSX125	5-16
1A1A6A1 Q1	TRANSISTOR, 0.195 dia, 0.205 in. lg	15-501758	(01295) 2N706	5-16
1A1A6A1 Q2	TRANSISTOR, 0.110 dia, 0.295 in. lg	15-501758	(01295) 2N706	5-16
1A1A6A1 R1	RESISTOR, MIL type RC20GF681J		(81349) RC20GF681J	5-16
1A1A6A1 R10	RESISTOR, MIL type RC20GF332J		(81349) RC20GF332J	5-16
1A1A6A1 R2*	RESISTOR, MIL type RC20GF752J		(81349) RC20GF752J	5-16
1A1A6A1 R2*	RESISTOR, MIL type RC20GF822J		(81349) RC20GF822J	5-16
1A1A6A1 R2*	RESISTOR, MIL type RC20GF912J		(81349) RC20GF912J	5-16
1A1A6A1 R2*	RESISTOR, MIL type RC20GF103J		(81349) RC20GF103J	5-16
1A1A6A1 R2*	RESISTOR, MIL type RC20GF113J		(81349) RC20GF113J	5-16
1A1A6A1 R3	RESISTOR, MIL type RC20GF101J		(81349) RC20GF101J	5-16
1A1A6A1 R4	RESISTOR, MIL type RC20GF332J		(81349) RC20GF332J	5-16
1A1A6A1 R5	RESISTOR, MIL type RN60D5620F		(81349) RN60D5620F	5-16
1A1A6A1 R6	RESISTOR, MIL type RN60D1001F		(81349) RN60D1001F	5-16
1A1A6A1 R7	RESISTOR, MIL type RN60D1001F		(81349) RN60D1001F	5-16
1A1A6A1 R8	RESISTOR, MIL type RC20GF682J		(81349) RC20GF682J	5-16
1A1A6A1 R9	NOT USED			
1A1A6A2 TB1	NOT USED			
1A1A6A2 TB2	DISCONNECT ASSEMBLY, Regulator-battery, 0.625 x 2.844 x 4.719	15-72880		5-16
1A1A6A2 C1 thru 1A1A6A2 C3	NOT USED			
1A1A6A2 C4	CAPACITOR, MIL type CS13AD680K		(81349) CS13AD680K	5-16
1A1A6A2 C5	CAPACITOR, Fixed, plastic dielectric, 10,000 uuf, 100 v, 0.200 dia, 0.500 in. lg	15-63310-2	(14655) WMFISIE	5-16
1A1A6A2 CR1	SEMICONDUCTOR, MIL type USN1N3611		(04713) USN1N3611	5-16
1A1A6A2 CR2	SEMICONDUCTOR, MIL type 1N457		(01295) 1N457	5-16

*Resistor selected and exact value determined by equipment test.

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A6A2 CR3	SEMICONDUCTOR, MIL type 1N457		(01295) 1N457	5-16
1A1A6A2 CR4	SEMICONDUCTOR, MIL type 1N754		(01295) 1N754	5-16
1A1A6A2 CR5	SEMICONDUCTOR, MIL type 1N821		(04713) 1N821	5-16
1A1A6A2 CR6	SEMICONDUCTOR, MIL type 1N457		(01295) 1N457	5-16
1A1A6A2 J1	NOT USED			
1A1A6A2 J2	CONNECTOR, Receptacle, electrical, 12 male cont, 0.600 x 0.600 x 2.762 in.	15-63864-2	(02660) 133-012-43	5-16
1A1A6A2 K1	NOT USED			
1A1A6A2 K2	NOT USED			
1A1A6A2 K3	RELAY, 4.5 ma, 2000 ohms, 0.800 x 1.281 x 1.328 in.	15-64000	(70309) WJSX125	5-16
1A1A6A2 Q1	NOT USED			
1A1A6A2 Q2	NOT USED			
1A1A6A2 Q3	TRANSISTOR, 0.195 dia, 0.205 in. thk	15-501758	(01295) 2N706	5-16
1A1A6A2 Q4	TRANSISTOR, MIL type 2N1131		(01295) 2N1131	5-16
1A1A6A2 Q5	NOT USED			
1A1A6A2 Q6	TRANSISTOR, MIL type 2N929		(01295) 2N929	5-16
1A1A6A2 R1 thru 1A1A6A2 R10	NOT USED			
1A1A6A2 R11	RESISTOR, MIL type RC20GF332J		(81349) RC20GF332J	5-16
1A1A6A2 R12	RESISTOR, MIL type RC20GF221J		(81349) RC20GF221J	5-16
1A1A6A2 R13	RESISTOR, MIL type RW69V1RO		(81349) RW69V1RO	5-16
1A1A6A2 R14	RESISTOR, MIL type RC20GF752J		(81349) RC20GF752J	5-16
1A1A6A2 R15	RESISTOR, Variable, 0 to 5000 ohms, 0.280 x 0.360 x 1.280 in.	15-64367-5000		5-16
1A1A6A2 R16	RESISTOR, MIL type RC20GF820J		(81349) RC20GF820J	5-16
1A1A6A2 R17	RESISTOR, MIL type RC20GF561J		(81349) RC20GF561J	5-16
1A1A6A2 R18	RESISTOR, MIL type RC20GF472J		(81349) RC20GF472J	5-16
1A1A6A2 R19	RESISTOR, MIL type RC20GF102J		(81349) RC20GF102J	5-16
1A1A6A2 R20	RESISTOR, MIL type RC20GF472J		(81349) RC20GF472J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF103J		(81349) RC20GF103J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF113J		(81349) RC20GF113J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF123J		(81349) RC20GF123J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF133J		(81349) RC20GF133J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF682J		(81349) RC20GF682J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF752J		(81349) RC20GF752J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF822J		(81349) RC20GF822J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF912J		(81349) RC20GF912J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF143J		(81349) RC20GF143J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF153J		(81349) RC20GF153J	5-16
1A1A6A2 R21*	RESISTOR, MIL type RC20GF163J		(81349) RC20GF163J	5-16

*Resistors selected and exact value determined by equipment test.

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A6A2 R22	RESISTOR, MIL type RC20GF472J		(81349) RC20GF472J	5-16
1A1A6A2 R23	RESISTOR, MIL type RC20GF221J		(81349) RC20GF221J	5-16
1A1A6A2 R24	RESISTOR, MIL type RC20GF152J		(81349) RC20GF152J	5-16
1A1A6A2 R25	RESISTOR, MIL type RC20GF152J		(81349) RC20GF152J	5-16
1A1A6A2 R26	RESISTOR, Variable, 0 to 500 ohms, 0.280 x 0.360 x 1.280 in.	15-64367-500		5-16
1A1A6A2 R27	RESISTOR, MIL type RC20GF152J		(81349) RC20GF152J	5-16
1A1A7	BOARD ASSEMBLY, Junction, 1.625 x 4.750 x 6.375 in.	15-72705		5-9
1A1A7 CR1	SEMICONDUCTOR, MIL type 1N457		(01295) 1N457	5-9
1A1A7 R1	RESISTOR, MIL type RW69V1RO		(81349) RW69V1RO	5-9
1A1A7 R2	RESISTOR, MIL type RC32GF221J		(81349) RC32GF221J	5-9
1A1A7 TB1	BOARD, Printed circuit, 0.063 x 1.200 x 1.600 in.	15-72878		5-9
1A1A8	BOARD ASSEMBLY, Meter switch, 0.063 x 2.844 x 3.594 in.	15-72896		5-9
1A1A8 R1 thru 1A1A8 R4	NOT USED			
1A1A8 R5	RESISTOR, MIL type RN60D4992F		(81349) RN60D4992F	5-9
1A1A8 R6	RESISTOR, MIL type RN60D1003F		(81349) RN60D1003F	5-9
1A1A8 R7	RESISTOR, MIL type RN60D8250F		(81349) RN60D8250F	5-9
1A1A8 R8	RESISTOR, MIL type RN60D1003F		(81349) RN60D1003F	5-9
1A1A8 R9	RESISTOR, MIL type RN60D8250F		(81349) RN60D8250F	5-9
1A1A8 TB1	NOT USED			
1A1A8 TB2	BOARD, Metering circuit, 0.063 x 1.531 x 1.531 in.	15-72877		5-9
1A1A9	PANEL ASSEMBLY, Rear, 1.500 x 4.438 x 4.469 in.	15-72890		5-9
1A1A9 F1	FUSE, 1 amp, 0.250 in. dia, 0.348 in. lg	15-63862-3	(75915) 273001	--
1A1A9 FL1	FILTER, line, 115 vac, 47.5 to 420 cps, 0.5 amp	15-72830		5-9
1A1A9 J1	NOT USED			
1A1A9 J10 thru 1A1A9 J16	NOT USED			
1A1A9 J17	CONNECTOR, MIL type MS27035-625B		(96906) MS27035-625B	5-9
1A1A9 J18	NOT USED			
1A1A9 J19	CONNECTOR, MIL type MS27035-625B		(96906) MS27035-625B	5-9
1A1A9 J2	NOT USED			
1A1A9 J20	NOT USED			
1A1A9 J21	CONNECTOR, MIL type MS27035-625B		(96906) MS27035-625B	5-9
1A1A9 J3	CONNECTOR, MIL type MS3102A10SL3P		(96906) MS3102A10SL3P	5-9

Reference Symbol	Description	Prime Contractor Part Number	Manufacturers Code and Part Number	Fig. No.
1A1A9 J4 thru 1A1A9 J9	NOT USED			
1A1A9 Q1	TRANSISTOR, MIL type 2N2339		(12672) 2N2339	5-9
1A1A9 R1	NOT USED			
1A1A9 R2	NOT USED			
1A1A9 R3	RESISTOR, MIL type RE65G1240		(81349) RE65G1240	5-9
1A1 J1	CONNECTOR, Receptacle, electrical, 14 female cont, 0.563 x 0.600 x 1.531 in.	15-63330	(02660) 57-20140	5-9
1A1 J10	CONNECTOR, Receptacle, electrical, 9/32 hex, 23/32 in. lg	15-64748-1	(02660) 5116-054325	5-9
1A1 J11	CONNECTOR, Receptacle, electrical, 9/32 hex, 23/32 in. lg	15-64748-1	(02660) 5116-054325	5-9
1A1 J12	CONNECTOR, Receptacle, electrical, 6 male cont, 0.340 x 0.458 x 1.785 in.	15-64057-1	(02660) 143-006-01	5-9
1A1 J13	CONNECTOR, Receptacle, electrical, 6 male cont, 0.340 x 0.458 x 1.785 in.	15-64057-1	(02660) 143-006-01	5-9
1A1 J14	CONNECTOR, Receptacle, electrical, 9/32 hex, 23/32 in. lg	15-64748-1	(02660) 5116-054325	5-9
1A1 J15	CONNECTOR, Receptacle, electrical, 9/32 hex, 23/32 in. lg	15-64748-1	(02660) 5116-054325	5-9
1A1 J2	CONNECTOR, Receptacle, electrical, 12 male cont, 0.340 x 0.458 x 2.722 in.	15-64057-2	(02660) 143-012-01	5-9
1A1 J3	NOT USED			
1A1 J4	CONNECTOR, Receptacle, electrical, 14 male cont, 0.562 x 0.600 x 1.750 in.	15-63309	(02660) 57-10140	5-9
1A1 J5	CONNECTOR, Receptacle, electrical, 12 male cont, 0.340 x 0.458 x 2.722 in.	15-64057-2	(02660) 143-012-01	5-9
1A1 J6	CONNECTOR, Receptacle, electrical, 14 female cont, 0.563 x 0.600 x 1.531 in.	15-63330	(02660) 57-20140	5-9
1A1 J7	CONNECTOR, Receptacle, electrical, 9/32 hex, 23/32 in. lg	15-64748-1	(02660) 5116-054325	5-9
1A1 J8	CONNECTOR, Receptacle, electrical, 9/32 hex, 23/32 in. lg	15-64748-1	(02660) 5116-054325	5-9
1A1 J9	CONNECTOR, Receptacle, electrical, 9/32 hex, 23/32 in. lg	15-64748-1	(02660) 5116-054325	5-9
1A1 MP1 thru 1A1 MP6	NOT USED			
1A1 MP7	KNOB, MIL type MS91528-1F2B		(96906) MS91528-1F2B	5-10
1A1 S1	NOT USED			
1A1 S2	SWITCH, Rotary, 2 pole, 12 position, 2 sections, nonshorting	15-64582	(71590) PA2000 Special	5-9

TABLE 6-2. LIST OF MANUFACTURERS

MFR CODE	NAME	ADDRESS
01295	Texas Instruments, Inc. Semiconductor-Components Division	Dallas, Texas
04713	Motorola, Inc. Semiconductor Products Division	Phoenix, Arizona
06813	Industrial Enterprises, Inc.	New York, New York
12672	Radio Corporation of America Commercial Receiving Tube and Semiconductor Division	Woodridge, New Jersey
13480	Hughes Electronics Company	Los Angeles, California
14655	Cornell-Dubilier Electronic Corporation	Newark, New Jersey
38315	Honeywell, Inc. Precision Meter Division	Manchester, New Hampshire
70309	Allied Control Company, Inc.	New York, New York
70674	ADC Products, Inc.	Minneapolis, Minnesota
71590	Centralab Division of Globe-Union, Inc.	Milwaukee, Wisconsin
72619	Dialight Corporation	Brooklyn, New York
74970	Johnson, E. F., Company	Waseca, Minnesota
75915	Littlefuse, Inc.	Des Plaines, Illinois
81073	Grayhill, Inc.	Chicago, Illinois
81349	Military Specifications	
81640	Hetherington, Inc.	Folcroft, Pennsylvania
86638	Nicad Division of Gould-National Batteries, Inc.	East Hampton, Massachusetts
91662	Elco Corporation	Philadelphia, Pennsylvania
95794	Anaconda American Brass Company	Torrington, Connecticut
96906	Military Standards	
98278	Microdot, Inc.	South Pasadena, California
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