

TECHNICAL MANUAL
for
MF/HF REMOTELY TUNED
HELICAL ANTENNA

CHU ASSOCIATES
LITTLETON, MASS.

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ADDENDUM 1 to NAVSHIPS

ADDENDUM 1 TO TECHNICAL MANUAL FOR
MF/HF REMOTELY TUNED HELICAL ANTENNA
NAVSHIPS

This addendum revises the associated manual to reflect the equipment supplied and the equipment required but not supplied with Chu Model CA118G-5 Helical Antenna installed on T-AGM-6 Class Ships.

Insert this temporary correction in the technical manual immediately after the front cover.

1. Make the following pen and ink corrections to the technical manual:

PAGE	PARA. FIG. OR TABLE	LINE OR LOCATION	ACTION
1-6	Table 1-1	Line 4 of table	Add under Qty Per Equip., Name, and Designation the following: 1, Line Section, Bird Model 471500.
1-7	Table 1-2	Line 4 of table	Add under Qty Per Equip., Name, Designation, and Required Use the following: 1, Safety Switch Box, RSD- and Control Interlock System.
1-7	Table 1-2	Line 5 of table	Add under Qty Per Equip., Name, Designation, and Required Use the following: 1, Inter- connecting Cabling, Per Figure 2-1.

SECTION I

GENERAL INFORMATION

1-1. SCOPE OF INSTRUCTION BOOK

This manual has been prepared to provide general information, operation, theory of operation and maintenance instructions for the MF/HF Remotely Tuned Helical Antenna. The complete installation consists of the Radome and Drive Assembly (figure 1-1), and the Remote Tuning Control Unit (figure 1-2).

1-2. PURPOSE AND FUNCTION OF EQUIPMENT

1-2.1 General

The MF/HF Remotely Tuned Helical Vertically Polarized Antenna is a high-Q, efficient antenna covering the 2 to 30 megacycle frequency band. The antenna consists of an antenna assembly (figure 1-3) that includes an antenna tuning drive mechanism, a remote tuning control unit, and interconnecting cabling. The antenna base flange is hinged to permit tilting of the antenna to facilitate servicing. The radome assembly is pressurized with 5 psi of dry air. Two antennas are required per installation.

1-2.2 Radome and Radiating Elements

a. Helix Assembly

The helix assembly consists of a 1-inch wide, 1/8-inch thick, copper ribbon helix uniformly wound over a series of ribs that are bonded to the outside of a 14-foot, laminated fiberglass cylinder. The copper ribbon is attached to the ribs with corrosion resistant type screws.

b. Feed Loop Assembly (Primary Feed)

The feed loop assembly consists of one turn of silver plated tubing supported by a fiberglass cylindrical structure. The feed loop assembly is located at the base of the helix.

c. Tuning Mechanism

The antenna tuning mechanism consists of a metal shorting ring which supports 22 individual shorting fingers, four stainless steel (constant tension spring) tapes nested in the shorting ring, and two rope drive assemblies with drive mechanism, and spring tensioned idler pulleys. The tapes provide continuous shorting of the adjacent turns of the helix when the shorting ring is moved along the length of the helix to the desired frequency position. The four tape take-up reels are housed within the shorting ring at 90 degree intervals on its circumference. The normal position of the tapes is coiled to the extent permitted by the position of the shorting ring assembly with respect to the helix. After being extended the tapes are returned to the coiled position by their spring

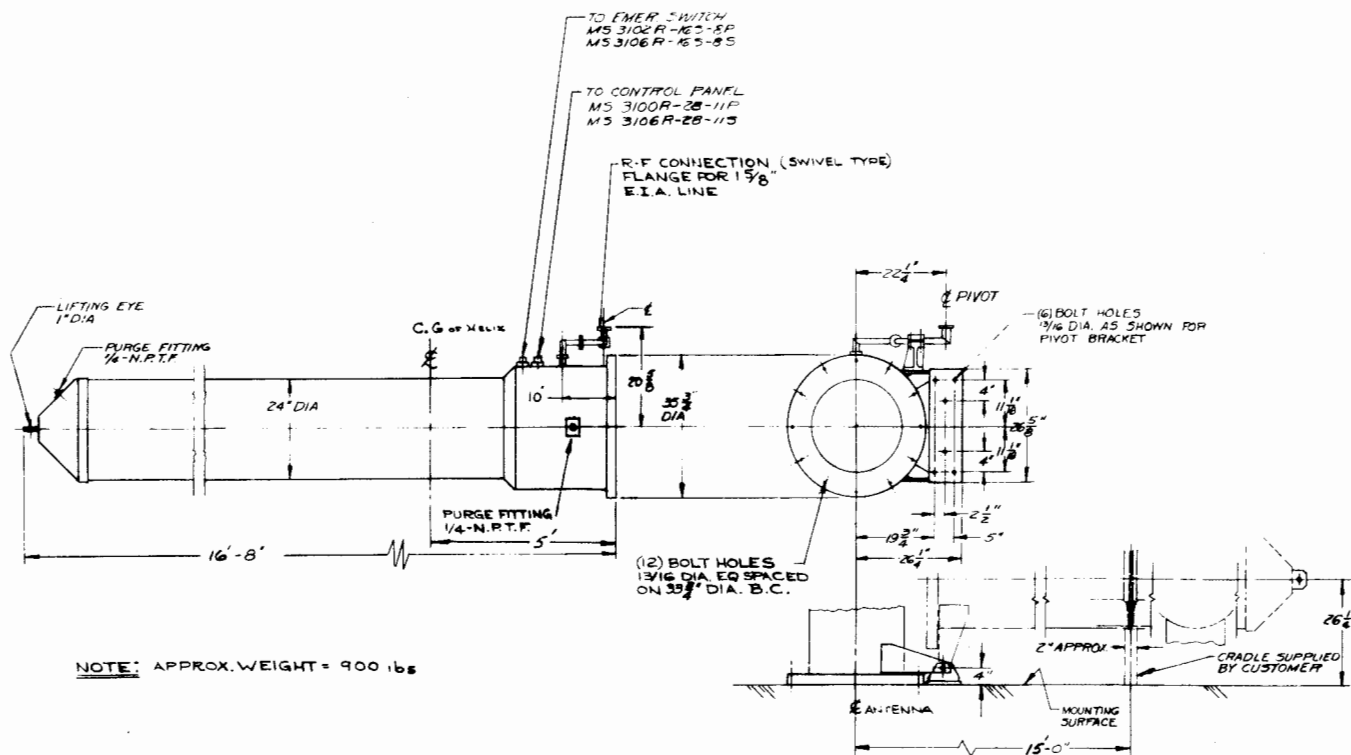


Figure 1-1. Installation Diagram, H.F. Helical Antenna

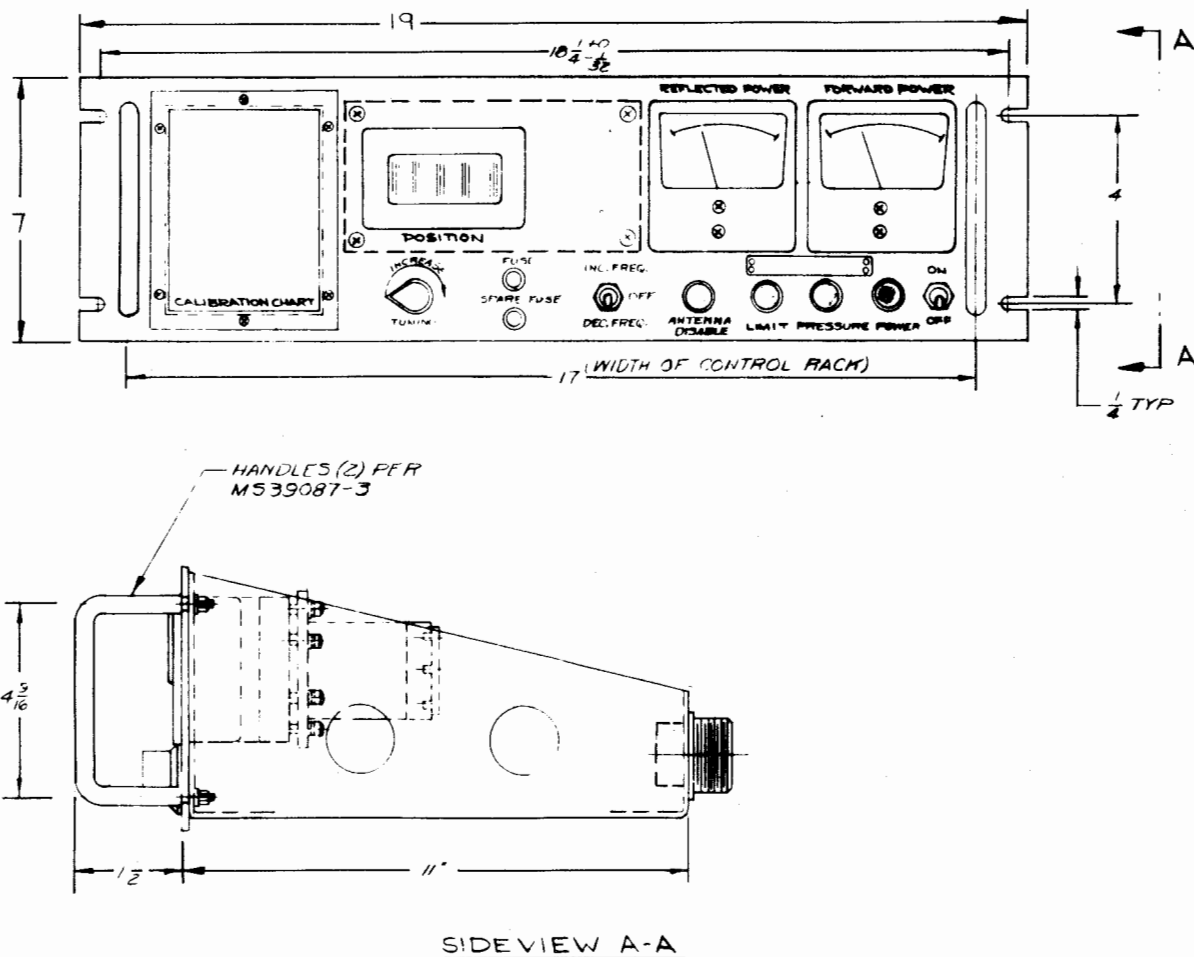


Figure 1-2. Helical Tuning Control Unit

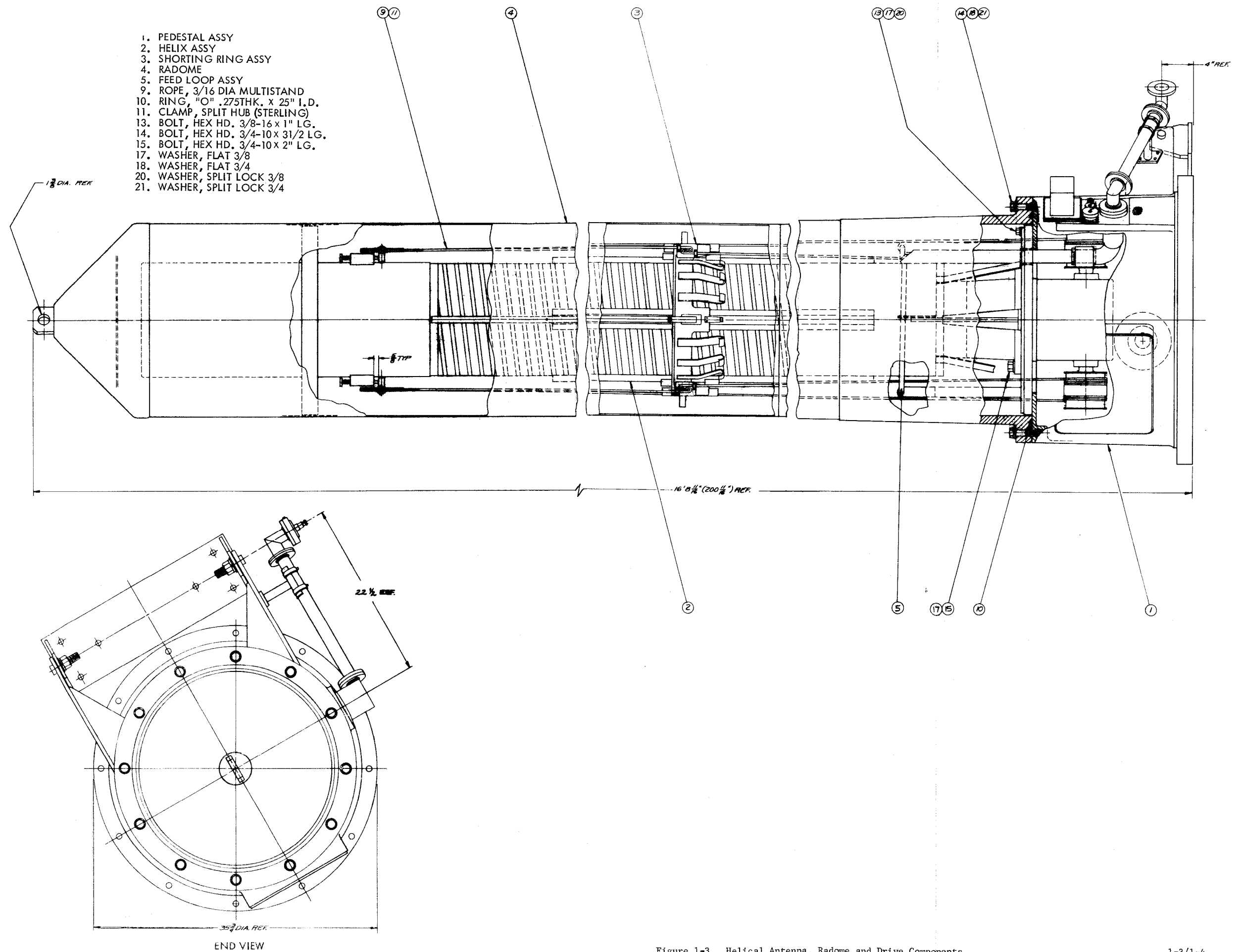


Figure 1-3. Helical Antenna, Radome and Drive Components

tension. The free end of the tape is electrically connected to a metal corona cap located at the top of the helix. The antenna is tuned by shorting out successive turns of the helix to achieve a resonant condition.

d. Shorting Ring (Antenna Tuning) Drive System

The drive for the antenna tuning system consists of a 1/6-horsepower, d-c, shunt motor; a speed reduction gear box; and two Mylar rope drive assemblies (see par. 1-2.2 c). The continuous duty type, adjustable-speed, drive motor is reversible. The motor drives the ropes at any pre-selected speed and direction through the reduction gear box. The ropes position the shorting ring to provide fine tuning of the antenna from a remote operation station.

e. Position Indicating Synchro Transmitter

The position indicating synchro transmitter supplies tuning position information to a synchro receiver and digital counter located on the tuning control unit front panel. The transmitter is driven through gearing to the drive pulley shaft of the of the shorting ring drive system.

f. Radome Assembly

The radome consists of a cylindrical fiberglass housing and flange assembly. The fiberglass radome, when installed, protects the radiating elements and other components of the antenna against the elements. The antenna structure is grounded through the base attaching bolts and flange surface contact.

1-2.3 Remote Tuning Control Unit

The antenna is tuned by the operator through the remote tuning control unit that is located in the radio room. The control unit chassis (figure 1-2) contains all control, power, and rectifier circuits; indicators; meters; fuses; and switches. The chassis is designed for installation in a standard, 19-inch, rack mounting type console.

1-2.4 Interconnecting Cabling

All interconnecting power, control, and RF coaxial cable is supplied and installed by the user. Refer to figure 2-1 for identification of connectors and number and type of cables.

1-2.5 Safety Interlock System

The antenna control system includes a safety interlock circuit that controls power to the antenna drive unit and transmitter through a relay closure.

The interlock system is actuated through a SAFETY SWITCH located on the safety switch box. The safety switch box is used in conjunction with, but is not considered part of this system. In the OPERATE position 120 vac, 60 cps power is supplied through the pedestal and control panels to the antenna drive starting relay and transmitter interlock relay. The antenna drive system and transmitter may be operated with the interlock switch in the OPERATE position.

In the SAFE position the antenna starting and transmitter relays are disengaged and the 120 vac, 60 cps power is applied to two amber lamps, one located on the safety switch box and one on the antenna control panel.

The antenna drive system and transmitter cannot be operated with the SAFETY SWITCH in the "Safe" position. This position should be used when working on the antenna assembly.

1-3. EQUIPMENT SUPPLIED

All equipment supplied is listed in Table 1-1.

TABLE 1-1. EQUIPMENT SUPPLIED

QTY PER EQUIP	NOMENCLATURE		UNIT NO.	OVER-ALL DIMENSIONS		WEIGHT LB
	NAME	DESIGNATION		HT	OTHER	
1	Antenna Ass'y MF/HF		1	16' 8"	35 3/4 in. base	900
1	Remote Tuning Control Unit		1	7 in.	19in. x 18in. long	30
1	Operators Manual		1	--	--	--

1-4. EQUIPMENT REQUIRED BUT NOT SUPPLIED

Test and other required equipment required but not supplied with the antennas is listed in Table 1-2.

TABLE 1-2. EQUIPMENT NOT SUPPLIED

QTY PER EQUIP	NOMENCLATURE		REQUIRED USE	EQUIP CHARACTERISTICS
	NAME	DESIGNATION		
1	Power Supply	General Radio or Equivalent 1203-B	Test Equipment	
1	Sig Generator	General Radio or Equivalent 1211-B	Test Equipment	0.5-50 MC
1	Receiver	Hammarlund or Equivalent HQ-100	Test Equipment	
1	RF Bridge	Chu Associates or Equivalent (B-21)	Test Equipment	0.5-50 MC

TABLE 1-2. EQUIPMENT NOT SUPPLIED (CONT)

QTY PER EQUIP	NOMENCLATURE		REQUIRED USE	EQUIP CHARACTERISTICS
	NAME	DESIGNATION		
1	Frequency Meter	LM-8 Bendix Radio Corp.	Test Equipment	
1	Multimeter 20,000 Ohms/Vlt	Simpson M-260 or Equivalent	Test Equipment	
1	R-F Bridge	General Radio type 1606-A	Test Equipment	400 kc - 60MC

1-5. TECHNICAL AND OPERATING CHARACTERISTICS

Refer to Table 1-3 for all required technical and operational reference data.

TABLE 1-3. REFERENCE DATA

	CHARACTERISTIC	RANGE OR TYPE
<u>System</u>	Frequency range	2-30 mc
	Input Impedance	50 ohms
	VSWR (Characteristic over operating range)	2.0:1.0 (50 ohm Transm. Line)
	Radiating Efficiency	50% (minimum)
	Bandwidth	15 kc (minimum)
	Minimum (at 2 mc)	
	Power Input, RF	10 KW PEP or 5 KW Avg.
<u>Antenna Assy</u>	Ambient Conditions	
	Temperature	-28°C to 65°C Continuous Duty
	Humidity	95%
	Wind Velocity	Up to 100 Knots
	Feed Loop Type	Unbalanced Feed Loop

TABLE 1-3. REFERENCE DATA (CONT.)

	CHARACTERISTIC	RANGE OR TYPE
<u>Antenna Assy</u>	Electromagnetic Compatability	25' Radius (size of area free from obstruction)
	Weight	900 lbs
<u>Tuning Control Unit</u>	Power Input	120 V, 60 cps, 10 amp
	Heat Dissipation	
	Ambient Conditions	
	Temperature	0°C to +50°C
	Humidity	95%

1-6. PREPARATION FOR RESHIPMENT

1-6.1 General

The packing procedure will depend on the material available and the condition under which the equipment is to be shipped or stored. Whenever possible, tape all cable ends to protect connectors and attach corrugated cardboard to all sharp corners and projections with masking tape. Place equipment in plywood containers with proper packing material to absorb shock and reduce equipment motion.

1-7. INSTALLATION

1-7.1 General

There are no special requirements for installing this system. Operating characteristics and power requirements are provided in Table 1-3.

CAUTION

Exercise care when uncrating, unpacking, and handling the equipment to avoid costly damage and possible equipment overhaul.

The antenna is bolted to a mounting plate, or base, (specified and designed by the user) and connected to the transmitter through a base installed connector and a 50-ohm r-f cable. The antenna is grounded through the base-attaching bolts and flange surface contact. Check that antenna-to-ground contact resistance is less than one ohm.

CAUTION

Do not paint mounting plate or base of the antenna.

A cradle is required to support the antenna when tilted for maintenance (figure 1-1).

The remote tuning control unit, a standard nineteen-inch rack-mounting type console, is installed in the radio room. The SAFETY SWITCH switch on the Safety Switch box must be in the OPERATE position (Amber Antenna Disable lamp, on control unit, will be out) otherwise the transmitter will not function.



SECTION II

THEORY OF OPERATION

2-1. FUNCTIONAL OPERATION

2-1.1 General

The model CA118G-5 remotely-tuned, self-resonant, helical antenna system (figure 2-1) consists of a helix assembly (which contains the radiating elements and the tuning system), a radome, a remote tuning control unit, and all required interconnecting cabling. The MF/HF antenna operates in two modes corresponding to the one-quarter and the three-quarter wavelength resonant modes of vertical antennas. The slow wave properties of a helical line are used to obtain a resonant condition without the aid of an r-f tuner. Radiation is vertically polarized with the radiation pattern similar to that obtained from a vertical antenna. The helical radiating structure is excited magnetically by a coupling (feed) loop which is located within the radome. The antenna is tuned by shorting out successive turns of the helix to achieve a resonant condition. Tuning is accomplished from a remote control unit usually located in the radio room.

2-2. BASIC PRINCIPLES OF OPERATION (figure 2-2)

2-2.1 Helix Feed Loop

The feed system employs an unbalanced coupling loop (1 turn) positioned axially about the center of the helix. Use of a fixed coupling loop position at the base of the antenna allows a relatively simple unbalanced loop design because the outer conductor is conveniently grounded to the ground plane.

2-2.2 Helical Radiator

The helical radiator is a self-resonant structure that utilizes the slow wave property of a helical transmission line. The antenna is made self-resonant over the 2- to 30-mc frequency range by varying its effective length. This is accomplished by shorting adjacent turns of the helix until the desired frequency is reached. This electromagnetically coupled antenna is capable of high power operation.

2-2.3 Equivalent Circuit

The equivalent circuit for the antenna is shown in figure 2-3. The antenna equivalent circuit values depend on the physical shape of the antenna which includes such factors as the height, the length of the helix winding, the circumference of the helix winding, and the number of turns per inch of helix winding.

The required L_2 for antenna resonance is inversely proportional to the antenna's capacitance to ground. Therefore as the capacitance loading of the antenna is increased the required L_2 is reduced. When the number of turns per inch winding of helix is decreased to reduce L_2 , the antenna

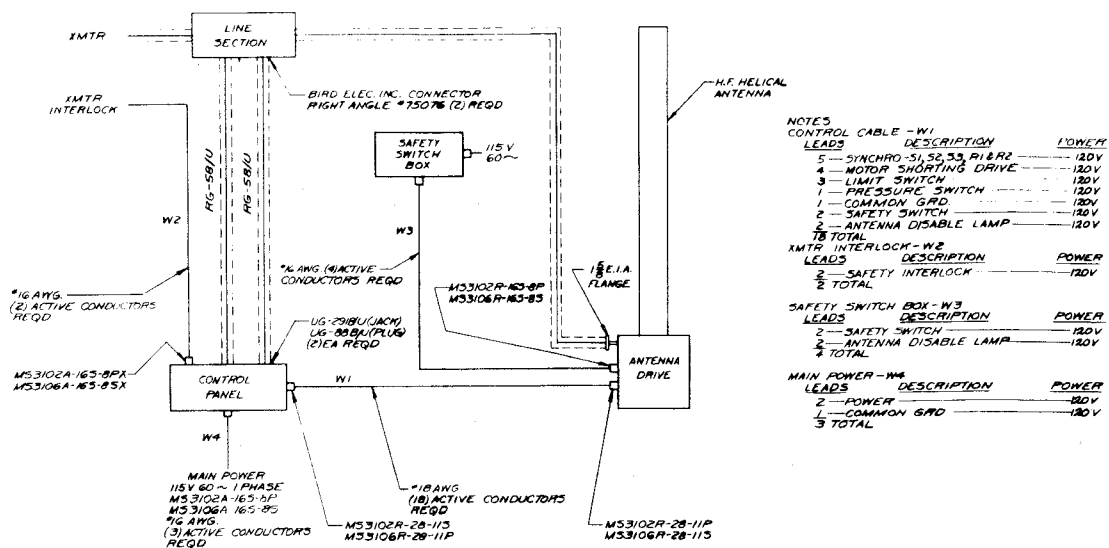


Figure 2-1. Block Diagram, H.F. Helical Antenna

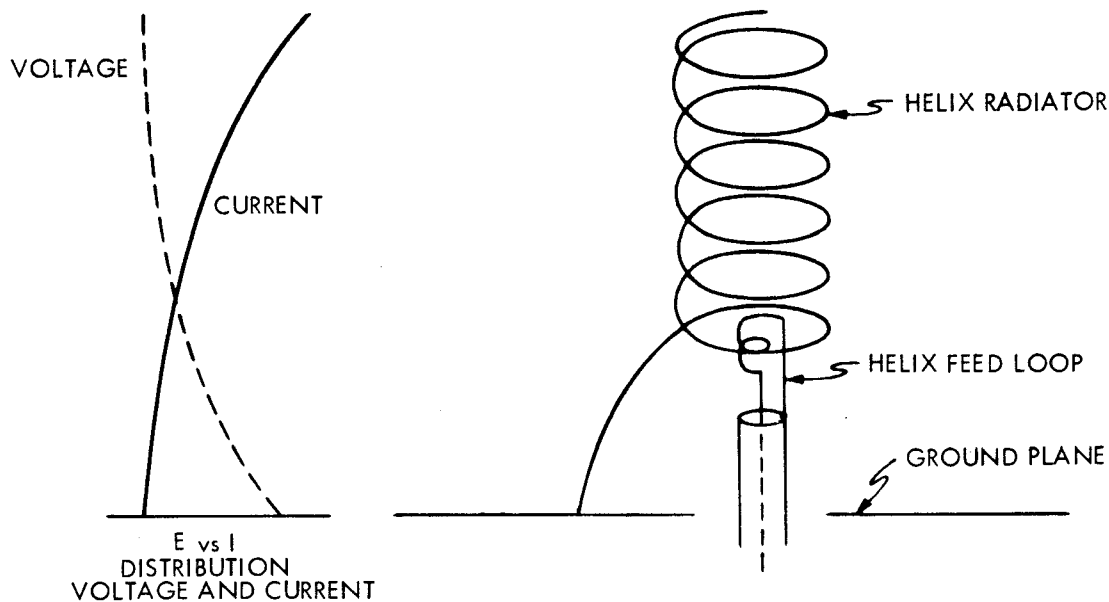


Figure 2-2. Line Schematic Basic Operation

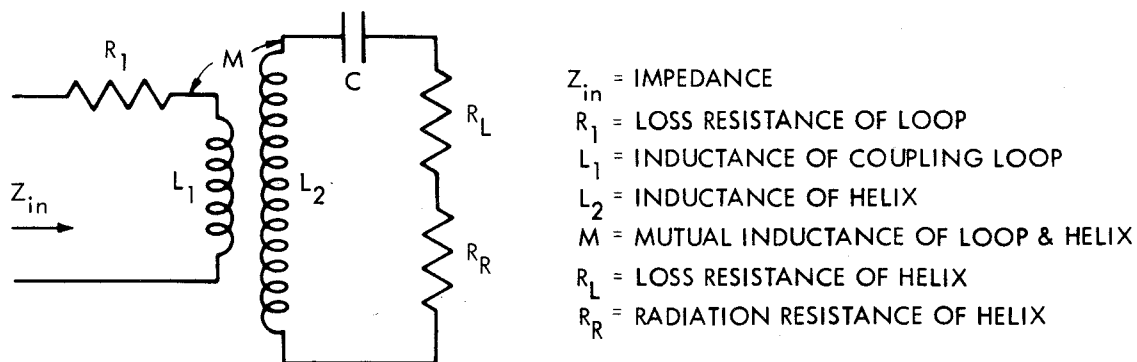


Figure 2-3. Equivalent Circuit

bandwidth increases and the antenna efficiency remains the same. However, if the number of turns of the helix is reduced the spacing between windings increases allowing the use of wider winding strip thereby reducing R_L the antenna loss resistance, and increasing the efficiency of the antenna. The efficiency of the helical antenna is at a maximum when the ratio of R_L to R_R is at a minimum.

2-2.4 Tuning Control System

a. General

The speed of the d-c shunt tuning drive motor is controlled by varying the armature voltage while keeping the field voltage constant. A simplified schematic diagram (figure 2-4) illustrates this method.

With a-c voltage supplied to terminals T_1 and T_2 the rectifier will conduct during the half cycle when terminal 1 is positive with respect to terminal 2. The rectifier will not conduct when terminal 1 is negative with respect to terminal 2. The shunting resistor is used to force high peak inverse voltages on to the diode rather than or in place of the silicone controlled rectifier (SCR).

b. Armature Loop Circuit

In order to control armature voltage for the above illustrated rectified power drives, it is necessary to control the time during the conducting half cycle at which the rectifier conducts. A pulse is applied to the SCR gate in order to "fire" the SCR. (See figure 2-5). The uni-junction transistor possesses a characteristic called the "stand-off ratio". The following will explain its operation.

For a given d-c voltage applied to B_2 , the junction E- B_1 will abruptly pass current when the d-c voltage from the cathode of CR_1 to E is increased from zero to a definite percentage (the stand-off ratio) of the voltage in B_2 . Capacitor C_1 charges exponentially through R_1 and dissipates its charge through the junction E- B_1 and primary of T_1 . The pulse on the secondary of T_1 is used for the SCR gate control. When R_1 is large, the time constant is high and the stand-off ratio is reached after a considerable time. During the next half cycle, the voltage across the SCR is negative and a firing pulse is not desired. The a-c power is so polarized that CR_2 conducts clamping the voltage on capacitor C_1 whenever the line voltage is negative for the SCR. Once the line voltage commences to go positive, the clamping of C_1 is removed and a firing pulse is obtained at some time interval set by R_1 and C_1 , following the clamp removal. This synchronizes the charging of C_1 with the line voltage alternations. Only one pulse is needed to fire the SCR, the subsequent pulses that are obtained due to the nature of the circuit are superfluous and cause no harm other than a slight increase in heating of the gate to cathode junction of the SCR.

c. Motor Field Circuit

Excitation of the motor field circuit is provided by the silicon diodes of the halfwave and back rectifier system (figure 2-6). The silicon diodes CR_1 and CR_2 form a halfwave and back rectifier system for supplying excitation to the motor field. During the portion of the cycle in which T_1 is positive, the electron flow is from T_2 to $F_2 - F_1$ field terminals, and

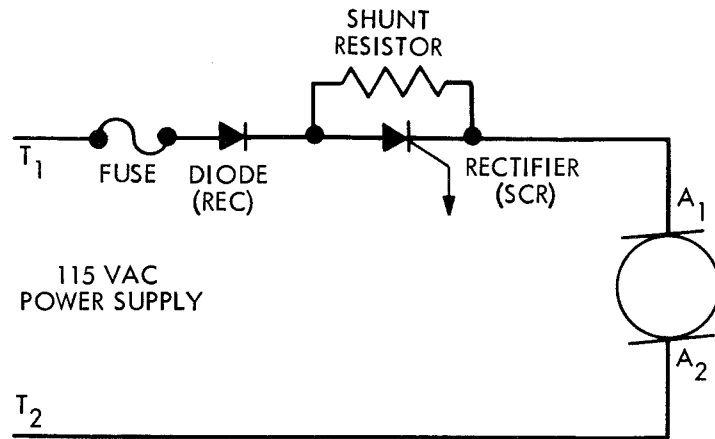


Figure 2-4. Simplified Schematic, Motor Control Circuit

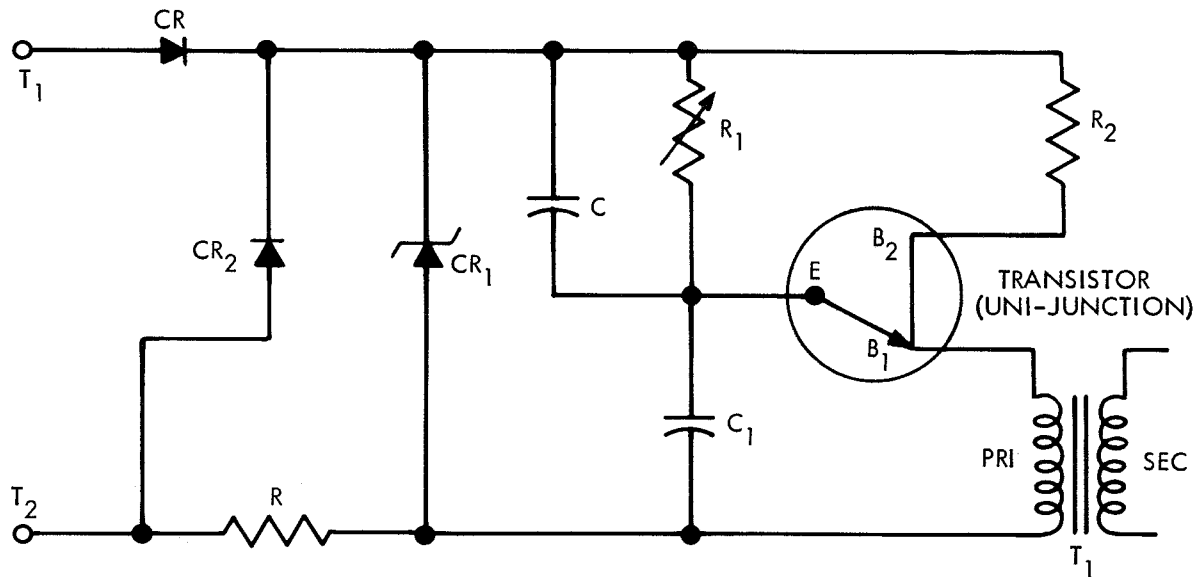


Figure 2-5. Simplified Schematic, Time Control - Armature Loop Circuit

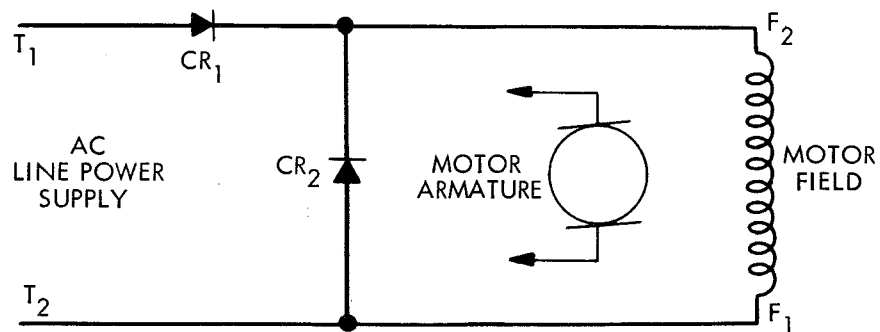


Figure 2-6. Motor Field Excitation

through rectifier CR_1 , to T_1 . Rectifier CR_2 does not conduct during this part of the cycle. With T_1 negative, CR_1 cannot conduct. The current in the field then tends to decrease causing a voltage due to field self-inductance to make T_2 positive with respect to the cathode of CR_1 . This causes CR_2 to conduct the field current for the remainder of the cycle. The current in the field is always uni-directional.

d. Reversing

Reversing of the motor is accomplished by the positioning of the INCREASE-DECREASE-OFF-FREQUENCY SWITCH, located on the Control Panel. The positioning of the switch selects the desired direction. When changing directions, the switch should be placed in the OFF position and the motor should be permitted to come to rest before placing the switch in the opposite direction of rotation.

2-2.5 Drive System

The drive motor actuates the antenna tuning mechanism through a gear reduction which in turn actuates the drive ropes. Refer to paragraphs 1-2.2c and 1-2.2d. A Selsyn position transmitter is geared to the motor. The position of the antenna is indicated on a corresponding selsyn indicator located on the control panel.

2-3. TYPICAL PERFORMANCE CURVES

Typical performance curves for the MF/HF antenna are illustrated in figure 2-7 VSWR vs Frequency, figure 2-8 Bandwidth vs. Frequency, and Calibration Tuning Curve figure 2-9.

2-3.1 VSWR vs. Frequency

Over its operating range the antenna has a VSWR of less than 2.0:1.0.

2-3.2 Bandwidth vs. Frequency

The bandwidth of the antenna is 15 kc at 2 mc. The bandwidth increases rapidly and is 725 kc at just below 8 mc.

2-3.3 Calibration Curve

The calibration of the antenna is plotted as frequency vs. setting numbers.

2-4. SPECIFIC DESIGN CHARACTERISTICS

Since this antenna is a self-resonant structure with a nominal 50 ohm input impedance, high voltages normally inherent at the antenna input in the Hf antenna systems are eliminated.

The simplicity of design reduces the number of parts, thus increasing the system reliability under all types of environmental conditions.

The slow wave properties of a helical line are used to obtain resonance without the aid of an r-f tuner.

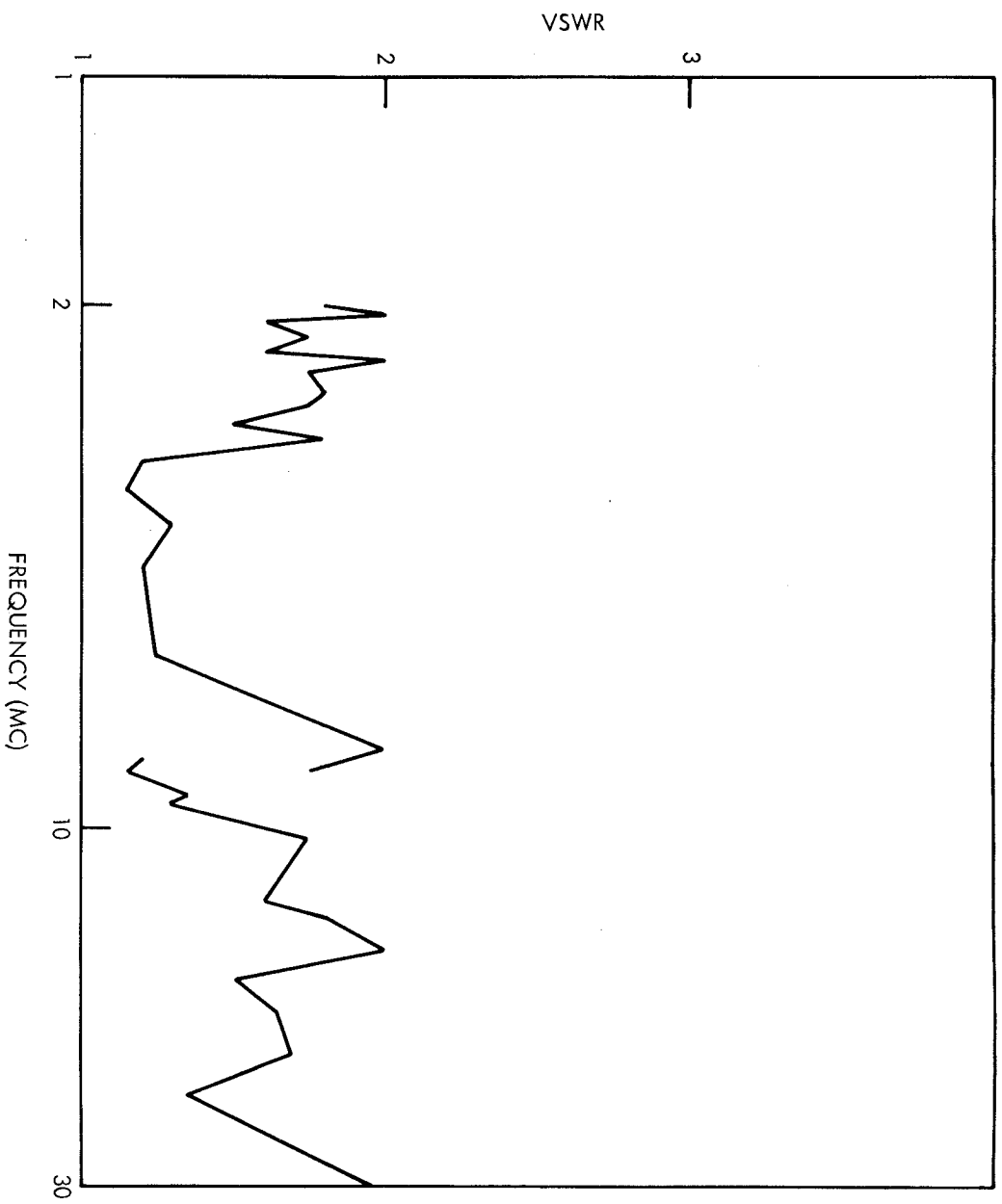


Figure 2-7. VSWR vs Frequency

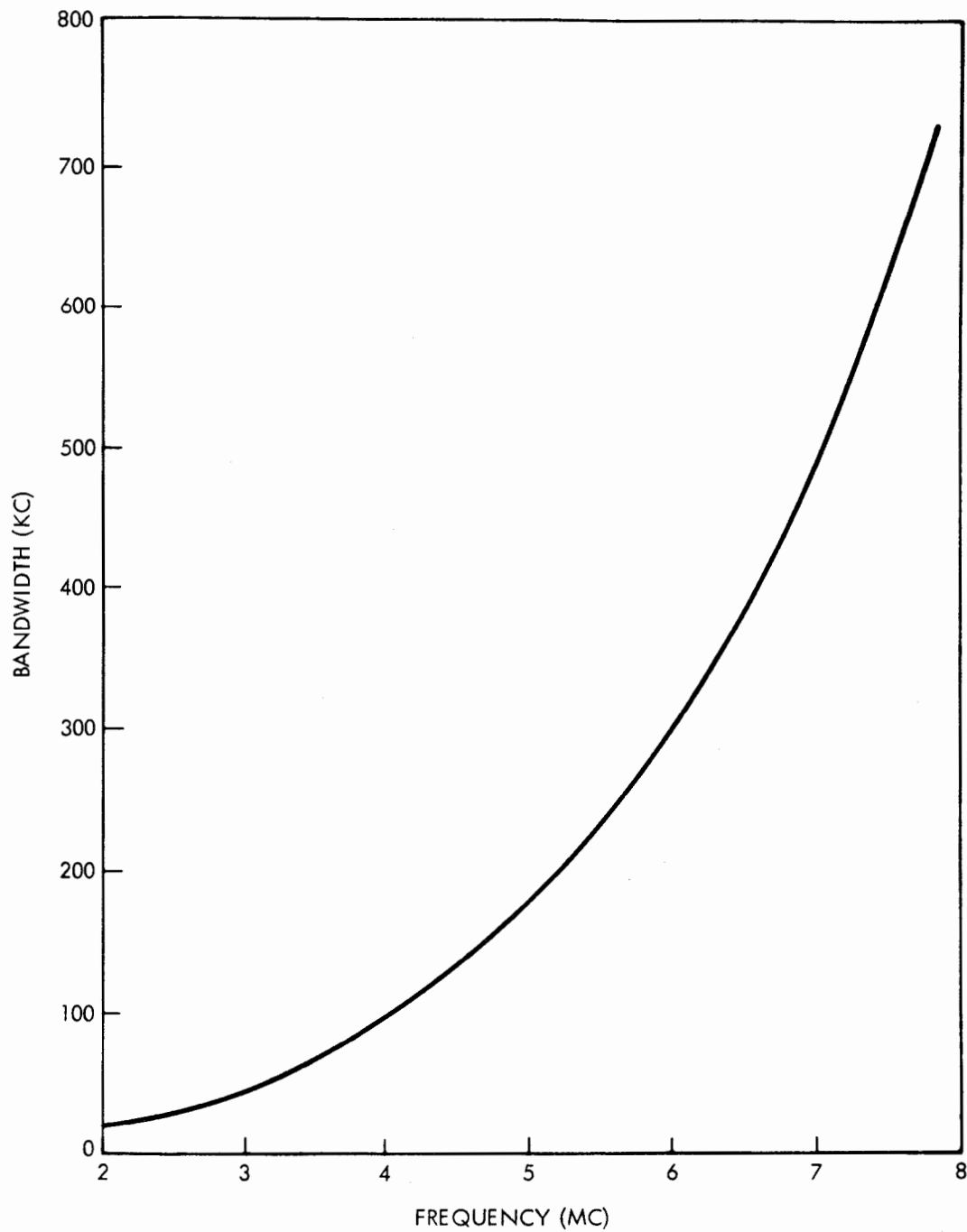


Figure 2-8. Bandwidth vs Frequency

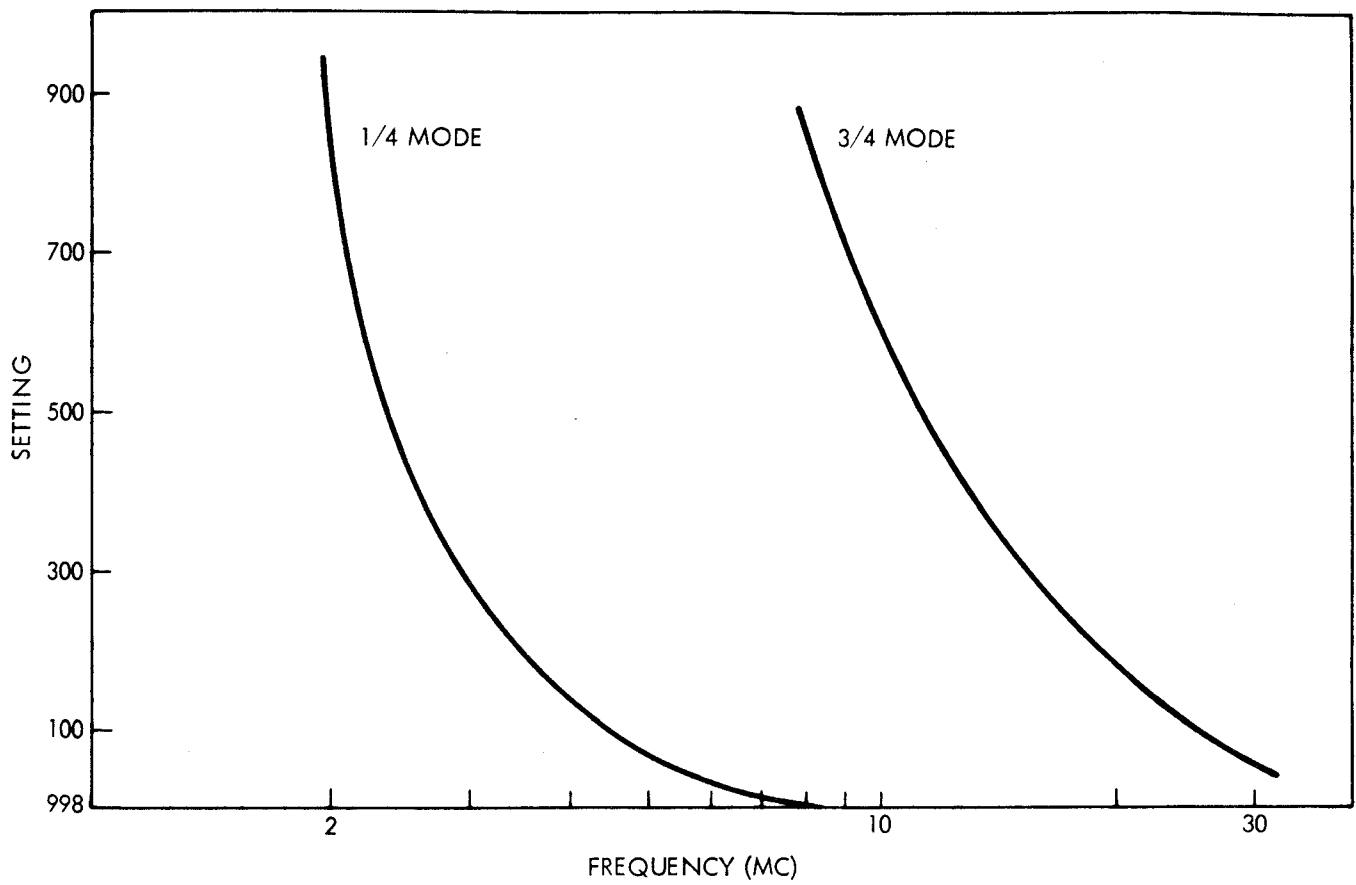


Figure 2-9. Calibration (Tuning) Curve

SECTION III

OPERATION

3-1. OPERATING PROCEDURES

3-1.1 General

Placing the antenna in operation, selecting the operating frequency (tuning), and discontinuing operation of the antenna are simple procedures. This becomes evident as the operator familiarized himself with the controls and indicators and learns to operate and maintain the equipment. This section identifies all front panel operating controls and indicators (Table 3-1) and briefly describes their function. The operating procedures are given in a standard recommended sequence. Calibration procedures are performed only following initial installation and routine maintenance. Major repairs, if required, should be referred to and performed at depot level only. Field replacement of parts other than those specified in Tables 4-2 and 4-3 is not recommended and should not be attempted.

WARNING

All calibration and inspection procedures performed on the antenna must be made only when the antenna SAFETY SWITCH has been turned to SAFE (Amber ANTENNA lamp light). This disconnects all r-f power at the transmitter and all motor control voltage at the pedestal. Otherwise SAFETY SWITCH must remain in OPERATE position.

CAUTION

Disconnect or temporarily turn off all line 120 vac power while working on the motor or control panel.

3-1.2 Operating Controls and Indicators

Table 3-1 provides the nomenclature, function, and initial position or indication of all front panel controls and indicators.

Table 3-1. Operating Controls and Indicators

Index No.	Control or Indicator	Initial Position or Indication	Function
1.	POSITION Indicator, Antenna	1000	Relates the position of the tuning system to the frequency.

3-1.3 Placing the Equipment in Operation

With the equipment installed and all preliminary checks, tests, and calibration procedures completed, assure that all controls on the tuning control unit (figure 1-2) are positioned as specified in Table 3-1. and the SAFETY SWITCH is in the OPERATE position as indicated by the ANTENNA DISABLE Indicator Light being OFF. Then proceeds as follows.

a. Place the ON-OFF Power switch in the ON position. Observe the POWER and LIMIT Indicator lights, to see that they go on.

b. Set INCREASE TUNING selector to the midway position.

c. Place the INC. FREQ.-OFF-DEC. FREQ. selector in the INC. FREQ. position. The motor will start to drive the tuning mechanism and the LIMIT indicator will go out.

d. With the motor running, slowly increase or decrease the INCREASE TUNING selector as desired for the particular set of operating conditions.

e. Place the INC. FREQ.-OFF-DEC. FREQ. selector in the desired position and observe the POSITION indicator. When the reading on the POSITION indicator reaches the desired frequency setting (obtain relationship from the calibration curve prior to starting operation) place the selector in the OFF position.

WARNING

Do not tune antenna under high r-f power.

f. Apply r-f transmitter power (not more than 500 watts) to the antenna. Observe the REFLECTED and FORWARD POWER meters, and adjust the power to the desired level. If the ratio is unfavorable, turn the r-f power off and re-tune.

g. Jog the INC. FREQ.-OFF-DEC. FREQ. selector to obtain either maximum FORWARD POWER or minimum REFLECTED POWER as indicated by the meters.

h. When the antenna is tuned to its desired frequency, the power can be increased to its maximum.

3-1.4 Turning the Equipment OFF

To discontinue operation, proceed as follows:

a. Decrease applied transmitter power and turn off.

b. Place the ON-OFF power switch in the OFF position.

WARNING

Make sure the antenna SAFETY SWITCH is on SAFE before working on the antenna or the controls.

3-2. Setup, Test, and Calibration Procedures (Operators)

The described setup, test, and calibration procedures always should be performed following initial installation of the equipment. Therefore, under

normal operating conditions it should not be necessary to make any adjustments in the control unit or limit switch assembly. If, however, there are indications of malfunctioning, the following steps should be performed.

a. With the system installed and fully assembled and the control unit connected to the antenna, but not to 120 vac, see that the following are in the position indicated:

1. Radome removed for visual inspection of antenna.
2. ON-OFF Power Switch in the OFF position.
3. INC. FREQ-OFF-DEC. FREQ. Switch in DEC. FREQ. position.
4. INCREASE TUNING control in extreme CCW position.

b. Connect the control unit to 120 vac.

c. Place the ON-OFF Power Switch to ON. Observe that the POWER and LIMIT Indicator Lights go on.

d. Turn INCREASE TUNING control approximately 20 % CW. Place the INC. FREQ-OFF-DEC. FREQ. selector to INC. FREQ. The motor should start and drive the shorting ring out from its initial position. The LIMIT Indicator Light will extinguish. If not, set ON-OFF Power to OFF, disconnect the 120 vac, and check wiring. Reconnect 120 vac, set ON-OFF Power to ON, and re-adjust limit switch as required.

e. With the motor running, slowly rotate the INCREASE TUNING control CW until the limit of travel is reached. Check that the motor speed increases to its maximum. Return to previous setting.

f. Place ON-OFF Power Switch in OFF position. Check that motor stops, then return ON-OFF to ON position.

g. Place INC. FREQ-OFF-DEC. FREQ. Selector in INC. FREQ. position and check travel of shorting ring assembly. Place switch in OFF position until motor stops, then place in DEC. FREQ. and again check travel. See that all mechanical drives operate properly and both extremes of travel are reached.

h. Check POSITION Indicator readings while performing step "g" against calibration chart.

i. Proceed with frequency calibration by determining the frequency at all designated points. Use this data to plot a calibration chart. It is advisable to recalibrate by using a signal generator and a SWR bridge. Follow procedure as described in paragraphs 4-5 through 4-6.

NOTE

Increasing frequency lowers the shorting ring assembly.
Decreasing frequency raises the shorting ring assembly.

Radiation is vertically polarized with the radiation pattern similar to that obtained from a vertical antenna.

Table 3-1. Operating Controls and Indicators (Cont)

Index No.	Control or Indicator	Initial Position or Indication	Function
2.	ON-OFF Power Switch	OFF	When in ON position, energizes the antenna system.
3.	INC. FREQ-OFF-DEC. FREQ Selector Switch	OFF	Tuning control. Permits selection of desired frequency.
4.	INCREASE TUNING Selector Control	Fully CW	Controls speed of drive motor thus permitting fast or slow tuning of the antenna.
5.	REFLECTED POWER Meter	ZERO	Indicates reflected power.
6.	FORWARD POWER Meter	ZERO	Indicates forward power.
7.	POWER Indicator Light	OFF	When ON, indicates that the antenna system is energized.
8.	LIMIT Switch Indicator Light	OFF	When ON, indicates that the tuning mechanism has reached its limit of travel.
9.	PRESSURE Indicator Light	OFF	When ON, indicates loss of radome pressurization.
10.	ANTENNA DISABLE Indicator Light	OFF	When ON, indicates all r-f power and operating current has been shut off by SAFETY SWITCH on Safety Switch control box.

SECTION IV

MAINTENANCE

4-1. PREVENTIVE MAINTENANCE

4-1.1 General

Preventive maintenance is performed on equipment, usually idle, to keep it in good working order thereby minimizing breakdowns and interruptions in service. Preventive maintenance differs from trouble shooting and repair, since its object is to prevent certain troubles from occurring. Unless otherwise stated, preventive maintenance should be performed every 1000 hours of operation.

a. Corrosion

Use No. 0000 sandpaper to remove corrosion.

CAUTION

Do not use emery cloth

b. Cleaning

1. Use a clean, dry, lint-free cloth or a dry brush for cleaning. If necessary, except for electrical contacts, moisten the cloth or brush with solvent, then wipe the parts dry with a cloth.

2. Clean connector pins with an approved type solvent, then wipe with a dry cloth.

NOTE

To remove dust, vacuum cleaning is the preferred method. If available, dry compressed air may be used at line pressure of 30 psi max.

4-1.2 Exterior Preventive Maintenance

Perform the following:

- (a) Check antenna installation for condition, completeness, and security of attachment.
- (b) Clean dirt and moisture from radome, control unit, and inter-connecting cable connection.
- (c) Inspect connectors for condition and security of attachment.
- (d) Inspect cabling for cuts, breaks, deterioration, and strain.
- (e) Clean nameplate and calibration curve.
- (f) Check condition of antenna ground. Resistance must be within permissible tolerance.

4-2. INTERNAL PREVENTIVE MAINTENANCE

4-2.1 Failure and Performance and Operational Reports

NOTE

The Bureau of Ships requires the submission of failure reports and performance and operational reports for equipments designated in Electronics Installation and Maintenance Book, NAVSHIPS 900,000. All failures shall be reported for those equipments requiring the use of failure reports.

4-2.2 Test Equipment and Special Tools

a. Use of Electrical Test Instruments

Make sure that selector switch of a combination meter is set to type of measurements being made, and that proper binding posts and range settings are used. Keep readings within middle three-fourths of scale and re-zero meter for each range.

CAUTION

Use only designed mating connector when making connections to plugs or receptacles for test purposes. Test leads may be clipped to solder pots or lugs on wiring side of mating connectors.

b. Continuity Check

CAUTION

All power must be "OFF" prior to performance of this check.

1. Use either an ohmmeter or continuity checker in accordance with specific test procedure when making continuity tests.

2. Connect instruments leads to remotest parts of circuit accessible in order to check all connections in circuit.

3. Check suspected malfunctioning switches and potentiometers with ohmmeter or continuity checker. If the device is accessible, actuate manually and check for proper operation.

c. Insulation Resistance Measurements

Tests may be performed in one of several ways: (a) between specifically indicated circuits; (b) between circuits (from each circuit to each other individual circuit following it in its respective group of circuits); and (c) from circuits to ground and shield (from each individual circuit or group of circuits to ground, with all other wiring not under test grounded).

CAUTION

When testing, include only those circuits designated in test procedure. Do not exceed voltage ratings and current-carrying capacities of components on the circuit under test.

d. Voltage Measurements

Instrument used must be of a range and type comparable to the magnitude and type of voltage being measured. If in doubt, start with a high range and work down to proper range in steps.

e. Special Items of Test Equipment

Check manufacturer's recommendations and follow provided instructions.

4-2.3 Inspection and Replacement

CAUTION

Disconnect all power before performing any of the following operations. Upon completion, reconnect power and check for satisfactory operation.

a. Drive Motor

1. Lubrication is limited to the motor drive assembly and is extremely important for satisfactory operation, therefore, proper oil level must be maintained in the gear case at all times. The correct level is indicated by the brass or red plug. Frequent inspections with the motor not running, and preferably when warm, should be made by removing the plug to see that the level is being maintained. If the level oil is low, additional lubricant must be added through one of the upper openings until it comes out the oil level hole, which must be kept open during this operation.

Lubricant should be drained and gear case refilled every 750 hours of operation when in normal daily use; every 500 hours if operated continuously or in excessively high temperatures. Use only lubricants recommended by the motor manufacturer and listed in Table 4-1.

When the gear end motor or upper shaft bearing is provided with a zerk fitting, lubricate with ball bearing grease at the same time that the gear lubricant is changed. If no zerk fittings are provided on the gear case, bearings are lubricated by gear lubricant. The rear motor bearing is always grease lubricated; to regrease, remove plug from bearing hub.

CAUTION

Do not over lubricate grease packed bearings.

Check vent plugs to see that they are not plugged. Without proper air vents in the gear case the increase in air pressure, caused by heat, may force gear lubricant through the oil seals.

Table 4-1. Recommended Lubricants

AMBIENT TEMP.	LUBRICANT VISCOSITY GROUP					
	UP TO 300 R.P.M.			OVER 300 R.P.M.		
-65°F. to -20°F.	Group 10			Group 10		
-20°F. to +20°F.	Group 12			Group 12		
10°F. to 55°F.	Group 15			Group 15		
45°F. to 90°F.	Group 17			Group 17		
80°F. to 120°F.	Group 19			Group 16		
110°F. to 160°F.	Group 20			Group 17		
VISCOSITY GROUP	15	16	17	18	19	20
Atlantic Ref. Co. PREMIER GEAR OIL		#12		#15	#19	
Cities Service Oil Co. TROJAN COMP.	L-00	L-0	L-2	L-3	L-4	L-5
Continental Oil Co. MILGEAR OIL	50-L	75-L	100-L	135-L	150-L	
Humble Oil & Ref. Co. PEN-O-LED EP	1	2	3	5	6	8
Fiske Bros. Ref. Co. LUBRIPLATE	3	4	APG 140	8	APG 250	
Gulf Oil Corp. GULF E.P. LUBR	55	75	95	115	145	500
E. F. Houghton & Co. SPEC. M.E. WORM GEAR OIL	Light	80	90	140	EP 140	Vital Oil 500
Keystone Lubr. Co. KEYSTONE LUBR.	WG-5X	WG-3X	WG-1X	WG-A	WG-B	WG-E
N.Y. & N.J. Lubr. Co. NON-FLUID OIL EPW	D-61	D-62	D-63	D-64	D-65	D-66
Pure Oil Co. POCO PB	5		8	12	15	25
Shell Oil Co. SHELL MACOMA OIL	33	68	73	76	978	
Sinclair Ref. Co. PENNANT EP	1	2	3	5	6	8
Socony Mobil Oil Co. GARGOYLE VACTRA OIL	2	3	4			
Std. Oil Co. of Cal. CHEVRON GEAR COMP.	80		100	130	150	
American Oil Co. AMOGEAR COMP.	1	2	3	5	6	8
Std. Oil Co. of Ohio FACTOLUBE	1	2	3	5	6	8
Sun Oil Co. SUNEP	50	70	90	110	150	430
Texaco Inc. MEROPA THUBAN	1 80	2	3 90	5 140	6	8 250
Tidewater Oil Co. TYCOL APRESLUBE	71	80	86	90	95	98
Union Oil Co. of Cal. REDLINE WORM GEAR LUBRS.		90	140		250	
Whitmore Mfg. Co. WORM GEAR LUBR.		33	23		2	
Master Electric Co. MASTER 318	15	16	17	18	19	20
Group 10—Dilute Group 15 Lubricant with 50% kerosene.						
Group 11—Dilute Group 15 Lubricant with 30% kerosene.						
Group 12—Dilute Group 15 Lubricant with 20% kerosene.						
Group 13—Dilute Group 15 Lubricant with 10% kerosene.						
Group 14—Dilute Group 15 Lubricant with 5% kerosene.						

The percentage of kerosene is by volume, example: Group 12 lubricant is 1 qt. Group 15 plus 2/5 pt. kerosene.

CAUTION: All of the lubricants listed above contain extreme pressure additives. UNDER NO CONDITIONS should unapproved substitutes be used since a lubricant with an unsuitable additive may cause serious trouble.

For information on additional approved lubricants, write factory.

2. Remove inspection strip and check that commutator is shiny and light brown. If it looks sooty, it may be cleaned with canvas while running at low speed. Thoroughly wipe out oil, grease, or wet dirt to prevent further contamination. If the surface is very rough, it may be cleaned with a very fine white sandpaper. Never allow the brushes to wear so short that spring tension is lost. The resultant sparking will seriously damage the commutator.

If frequent dressing is required, the cause should be found and corrected. A very rough commutator should be turned at high speed on a lathe with a sharp too. Never remove more copper than is necessary. The mica segments between the commutator bars should be undercut about 1/32 to 1/16 inch to prevent brush wear. It is recommended that this work be done by an authorized service shop.

3. Check condition of brushes. Give complete motor nameplate data when ordering replacement brushes, to ensure they are identical to original equipment. New brushes are fitted by inserting a strip of fine white sandpaper between commutator and brush and sliding it back and forth along the commutator surface until the brush fits the curvature of the commutator. Blow out the resulting carbon dust. Short brush life and poor commutation may be due to a rough commutator, a shorted armature, or poor undercutting of mica. Also, dirt and chemicals in the air are common causes of trouble.

NOTE

Multimeters having a sensitivity of 100 ohms per volt on ac and 10,000 ohms on dc, or better, are satisfactory for all voltage measurements. (Examples: Triplet, Simpson, and Weston.)

b. Fuses and Protective Devices

1. Check condition of all fuses.

Overload protection for the system is supplied by the panel mounted current limit type fuse. This fuse should be replaced upon failure by one of identical rating and type.

NOTE

Consistent overloading will radically reduce the system's life. It is definitely advisable to stay within the specified operating range. Under some overload conditions, the motor may not be able to reach base speed.

4-3. TROUBLE SHOOTING PROCEDURES

4-3.1 General

A corrective adjustment following careful analysis of the trouble symptom usually takes only a few minutes. The ability and experience of the operator in making this analysis and resulting adjustments, repairs, or replacements, is reflected in the reduced equipment down-time.

4-3.2 Methods of Trouble Shooting

Trouble shooting procedures are based on the following five steps:

a. Symptom Recognition

A good knowledge and understanding of the operating characteristics of the antenna is required. (Refer to Section I, para 1-5 and Section II, para 2-2). Since all equipment malfunctions are not the direct result of component failure, the normal and peak performance of equipment must be well known and understood. Trouble resulting from other than component failure is usually discovered while accomplishing preventive maintenance procedures.

b. Definition and Positive Identification of Trouble or Malfunction

Following recognition of the nature of malfunction, as differentiated from normal or peak performance, all available aids built into, or associated with, the equipment (meters, gages, indicating devices, front panel controls, etc.) should be used. Also, checking or otherwise manipulating the operating controls should provide better identification of the original malfunction and, possibly, eliminate the trouble. (Refer to Section III, paras 3-1 and 3-2.)

c. Determination of Possible Causes of Antenna Malfunction

Determine several alternate causes of malfunction and relate to functional circuit or part. The over-all functional descriptions (Section II) and operation (Section III) provide information on which to base the selection of possible causes. Alternate possibilities can be determined from the equivalent circuit diagram (figure 2-3), schematic diagram (figures 2-4 and 2-5), and the mechanical make-up of the equipment (figure 1-3).

d. Localizing and Identifying the Malfunctioning Antenna Part or System

The selected circuit or part (step c) must be checked and tested to determine if it is one of the possible causes of malfunction. A list of test equipment (Section I, para 1-3), test procedures, and calibration curves (figures 2-7, 2-8, and 2-9) are provided to aid in localizing this trouble.

e. Repair and Replacement

After the malfunction has been positively isolated an appropriate corrective action must be taken. Replace parts, repair circuitry, perform alignment procedures, etc. as required.

4-3.3 Typical Control Unit and Drive Motor Operating Voltages

Refer to table 4-2 for values of all operating voltages. Use a voltmeter of proper range and sensitivity.

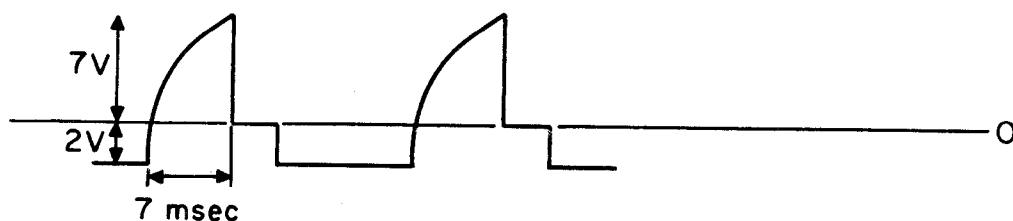
Table 4-2. Typical Control Unit and Drive Motor Operating Voltages

Use Meter Type	Approx Voltage	Comments
A-C	120 60 cps	A-C input to control panel. W4 Pin A and B
A-C	120 60 cps	A-C power for relay K1. W1 Pin W and X
D-C	50	Motor field supply voltage. W1 Pin F and G
D-C	5.5	Available reference voltage across CR7 and CR8.
D-C	0-75	Armature voltage supply - depends on speed pot setting. W1 Pin I and H.

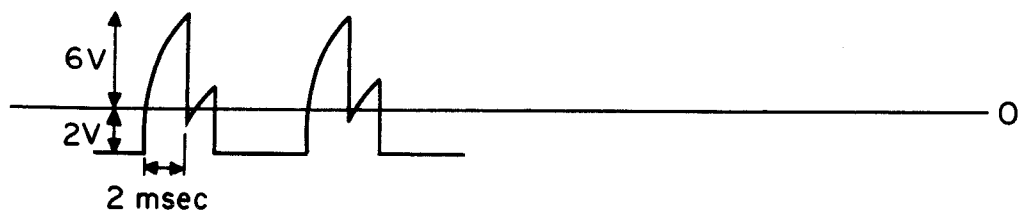
Oscilloscope

Firing pulses formed on 0.22MFD capacitor. If correct, uni-junction 2N1671A is functioning.

Low Speed



High Speed



4-3.4 Trouble Shooting Charts

Perform all checks as specified.

Table 4-3. Control System and Drive Motor

Condition	Probable Cause and Check
1. Drive motor will not run	(a) No a-c power at terminals A and B or L and M (b) Blown panel fuse. (1) Overload condition. (2) Grounded armature or field circuit. (c) Defective SCR (d) Defective diode. (e) Motor brushes worn or sticking in brushholder. (f) No reference voltage. (1) Open control Transformer T1. (2) Defective speed control pot. (3) Shorted capacitor C1 or C2. (4) Open resistor R1, R2, R3. (5) Defective rectifier CR1, CR2, CR3. (g) Defective uni-junction 2N1671A.
2. Drive motor runs at high speed with no control	(a) Defective speed control pot or wiring (b) Defective SCR. (c) Defective transistor 2N526 (d) Defective resistor R4
3. Drive motor runs but cannot obtain top speed	(a) Defective transistor 2N526. (b) Defective capacitor C2. (c) Defective SCR. (d) Brushes in drive motor worn or improperly seated. (e) Defective speed control pot. (f) Drive motor overloaded.
4. Short SCR life and/or frequent panel fuse failure	(a) Line voltage not within range. (b) Overload drive. (1) Constant overload. (2) Peak overload. (3) Excessive load during acceleration. (c) Excessive load during acceleration due to defective capacitor C2, resistor R3. (d) Ambient temperature excessive or ventilation of control cabinet obstructed. (e) Grounded (possibly intermittent) armature, or field circuit. (f) Defective diode CR6
5. Motor overheats and/or sparks excessively at brushes . .	(a) Motor overloaded. (b) Brushes worn, improperly seated, or sticking in brushholders. (c) Wrong grade of brushes.

Table 4-3. Control System and Drive Motor (Cont)

Condition	Probable Cause and Check
6. Motor speed oscillates	(a) Brushes worn, improperly seated, or sticking in brushholders. (b) Machine load demand varies (check motor speed with motor decoupled from machine to verify).

NOTE

When installing any components marked with proper polarity, be sure that it is wired in the same direction as the original part.

Table 4-4. Radome Assembly

1. High VSWR	Poor tape to helix contact Faulty transmission line Faulty connector Poor ground contact	Check condition of tapes, for accumulation of lubricant or other materials. Check installation, contact, etc.
2. Change in frequency	Condition of input connector Condition of ground contact High resistance	Check input connector Check for proper grounding and contact.
3. Voltage breakdown between helix windings	Excessive input power Moisture accumulation	Check VSWR Check VSWR

NOTE

The actual loads connected to the feed loop contain both the resistive and reactive components. The result is the formation wave. Considering the standing wave of voltage, the ratio of maximum to minimum voltage is the standing wave ratio. This ratio can also be obtained by measuring the maximum and minimum currents. The standing wave ratio provides a measure of the reflected energy.

4. Resonant frequency setting off	Inoperative or defective POSITION INDICATOR	Check indicator by tuning and checking indicated frequency response at 20 points of POSITION indicator spacing.
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4-4, DISASSEMBLY AND ASSEMBLY

4-4.1 General

Disassembly and assembly procedures required to properly remove and replace defective items is accomplished by performing the following steps.

4-4.2 Disassembly

a. Removal of Radome

Remove the twelve hex head bolts, washers, and lock washers from the pedestal assy. Lift radome clear of the antenna helix assembly using the lifting eye.

CAUTION

When lifting radome clear of the antenna helix, be sure radome does not bump or scrape the helix and feed loop.

b. Removal of Motor Drive

Remove the radome as previously described. Loosen the four screws on the right angle R-F feed line located adjacent to the tilting pivot. Disconnect the two cable connectors at the pedestal. The antenna assembly now may be tilted to a horizontal position.

CAUTION

When lowering the antenna assembly, the antenna must be restrained by connecting a guy line to the spacer wheel located at the top of the helix.

When the antenna is in the horizontal position remove the bottom plate by unscrewing the 1/4-20 screws. Remove the drive cables from the idler pulleys at the top of the helix. This will allow for sufficient cable slack to withdraw the drive housing. Remove the drive housing by unscrewing the four hex head bolts on the drive housing flange. The drive cable end may be disconnected from the wind up drum by loosening the retaining screw located on the outside shoulder diameter of each wind up drum.

c. Removal of Shorting Ring

Run the shorting ring to the top of helix by actuating the INC. FREQ-OFF-DEC. FREQ. switch in the DEC. FREQ. mode. Remove radome, tilt antenna assembly and disconnect cables from idler pulleys as previously described. Remove the no. 8 flat head screws holding the corona cap to the helix mast and slide corona cap and idler pulley assembly free from the mast. Remove the no. 8 screw which fastens the tape end to the helix at four stations.

CAUTION

When the tape is released make sure that it rewinds evenly on the drum.

Release the cable clamps on the side of the shorting ring and slide the shorting ring off the helix mast.

d. Removal of Feed Loop Assembly

Remove radome, lower antenna assembly to a horizontal position, remove corona cap and shorting ring assembly as previously described. Remove six no. 10 screws which fasten the feed loop assembly to the helix mast base flange. Remove pedestal access cover on bottom plate. Disconnect the right angle connector, located in the pedestal, which is connected to the extended feed loop outer conductor. Remove the hose type clamp which grounds the outer conductor of the feed loop to the end of the helix winding. Carefully remove the feed loop assembly over the length of the helix mast.

4-4.3 Assembly

a. Motor Drive

Fasten the drive housing casting and wind up drums to the pedestal with four 3/8 hex head bolts observing correct orientation provided by the roll pins. Mount the gear head motor to the drive housing castings with four 1/4 hex head bolts. Orientation and correct gear mesh is insured by the locating pins in the motor flange.

b. Shorting Ring Cable

Fasten one end of the cable to the wind up drum diameter nearest the drive housing by wrapping the cable around the drum one and a half turns. Extend the cable through the pedestal slot and over the idler pulley at the top of the helix and back down to the adjacent windup drum diameter. Wrap cable over pulley diameter six times before fastening the cable to the drum diameter. Repeat this procedure for the drum on the opposite side.

c. Shorting Ring

To facilitate assembly separate the shorting ring into two sections by removing three screws on each side of the shorting ring. Remove the four tape carriers and engage them in the tracks on the helix. Fasten the end of each tape to the helix winding with a no. 8 screw. Reassemble the shorting ring sections around the helix enclosing the tape carriers. The shorting ring must be placed so that the cable clamps are aligned with the cable on the helix mast. Clamp the cable to the shorting ring.

d. Corona Cap

NOTE

The corona cap assembly consisting of a spacer type wheel and idler pulleys should only be installed after the feed loop shorting ring are assembled on the antenna.

The corona cap slides on the end of the helix mast and is fastened in place by eight flat head screws.

CAUTION

Make sure that the idler pulleys are in line with the cable slots at the top of the pedestal.

e. Radome

The radome is assembled when the antenna is in the vertical position. Use the lifting eye for support while aligning and lowering the radome over the helix mast.

CAUTION

While lowering the radome, make sure it does not bump or scrape the feed loop.

Before lowering radome make sure O-ring is in its groove. Silicone type grease may be applied to the groove to retain the O-ring in the groove. Orientation of the radome should allow the lifting eye to be in the tilt direction of the antenna. Before bolting the radome in place check the base of the radome to insure that the O-ring is properly seated.

4-5. PERFORMANCE TEST - TUNING

4-5.1 General Information

a. The purpose of this test is to check the frequency calibration of the antenna and, if required, to plot a new calibration curve. The test is accomplished by selecting some representative frequencies, obtaining the corresponding POSITION indicator settings from the calibration chart, and then checking the setting against an external signal source.

The approximate time required to perform this test is 10 to 15 minutes.

WARNING

- a. Dangerous r-f voltages exist during this test.
- b. Report all malfunctions for corrective action.

4-5.2 Test Equipment Required

a. Oscillator, variable LC, GR 1211B or equivalent. Used as a signal source to provide the antenna stimulus that, in turn, creates the response to be measured.

b. Bridge, R-F, Chu Associates Model B-21 or equivalent.

Used to measure low values of impedance. Measures directly the VSWR of antenna and feed loop.

c. Power Supply, GR 1203B or equivalent. Unregulated, general purpose 300 V dc and 6.3 V ac. Required for plate and heater voltage supply for all unit instruments.

d. Frequency Meter LM-8 Bendix. Provides a means of measuring and monitoring the frequency setting of the oscillator.

e. R-F Voltmeter used to measure existing r-f potentials.

4-5.3 Tuning Calibration Curve

a. A tuning calibration curve provides the operator with the required relationship between the desired frequencies and numerical position indications on the POSITION indicator.

NOTE

There are NO OTHER tuning controls or adjustments than those mentioned above.

b. The calibration curve is installed on the front panel of the Control Unit (figure 1-2).

c. Following the initial installation of the antenna, a new calibration curve is made. This curve is used to determine the resonant frequency for the various readings of the POSITION indicator.

4-6. FREQUENCY CALIBRATION PROCEDURE

During this test, the antenna is tuned by the operator from the radio room, where the test equipment is also located. If this method is not feasible, the operator will have to improvise. Perform the following tests at convenient frequency settings. Proceed as follows:

WARNING

Disconnect transmitter, if possible, prior to test

Beware of Dangerous R-F Voltages.

a. Connect test equipment as shown in figure 4-1.

b. Disconnect the r-f power cable from the line section and connect to the bridge (figure 4-1).

c. Operate the control unit and set POSITION indicator to within 10 KC of desired frequency. This relationship is obtained from the calibration curve.

d. Set and adjust test equipment as follows:

1. Oscillator

Set to selected frequency.

2. Power Supply

Connect power supply to oscillator and to ship's power supply.

3. Bridge

Connect to the transmission line between the oscillator and the antenna. (VSWR is read directly from bridge meter).

- e. Tune the antenna to the exact frequency and obtain test readings.
- f. Set the antenna to next selected frequency and repeat step "e".
- g. Repeat for remaining frequencies.

h. Disconnect test setup and re-install the r-f power cable on the line section.

NOTE

To obtain data for the calibration curve, repeat above procedure taking readings at every 5 points of the POSITION indicator for both 1/4 and 3/4 MODE of operation.

4-7. BANDWIDTH VS FREQUENCY TEST

4-7.1 To perform bandwidth vs frequency tests, connect equipment as shown in figure 4-2. Compare with typical curve (figure 2-8). The antenna has a minimum bandwidth of 15 kc at 2 mc. This bandwidth increases rapidly to approximately 725 kc at a point just below 8 mc.

4-7.2 VSWR vs Frequency Test

Connect test equipment as shown in figure 4-1. The VSWR characteristic of this antenna is less than 2 to 1 on a 50 ohm transmission line. A characteristic VSWR curve for this antenna is shown in figure 2-7.

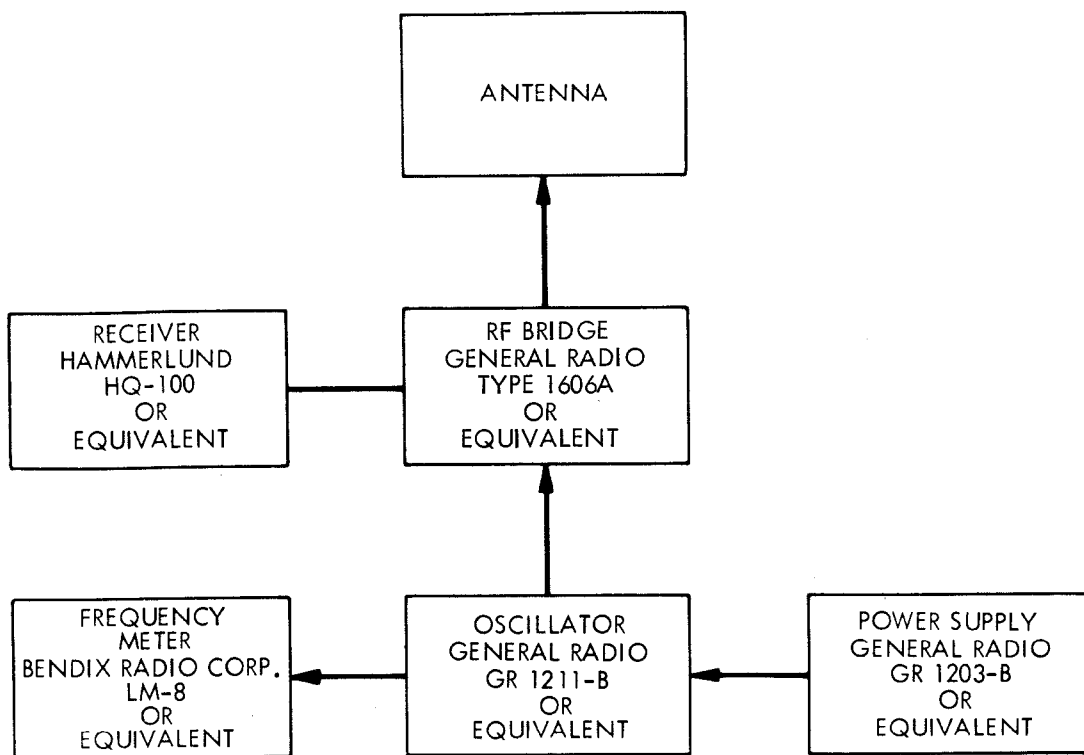


Figure 4-1. Tuning (Frequency) Tests, Test Equipment Arrangement

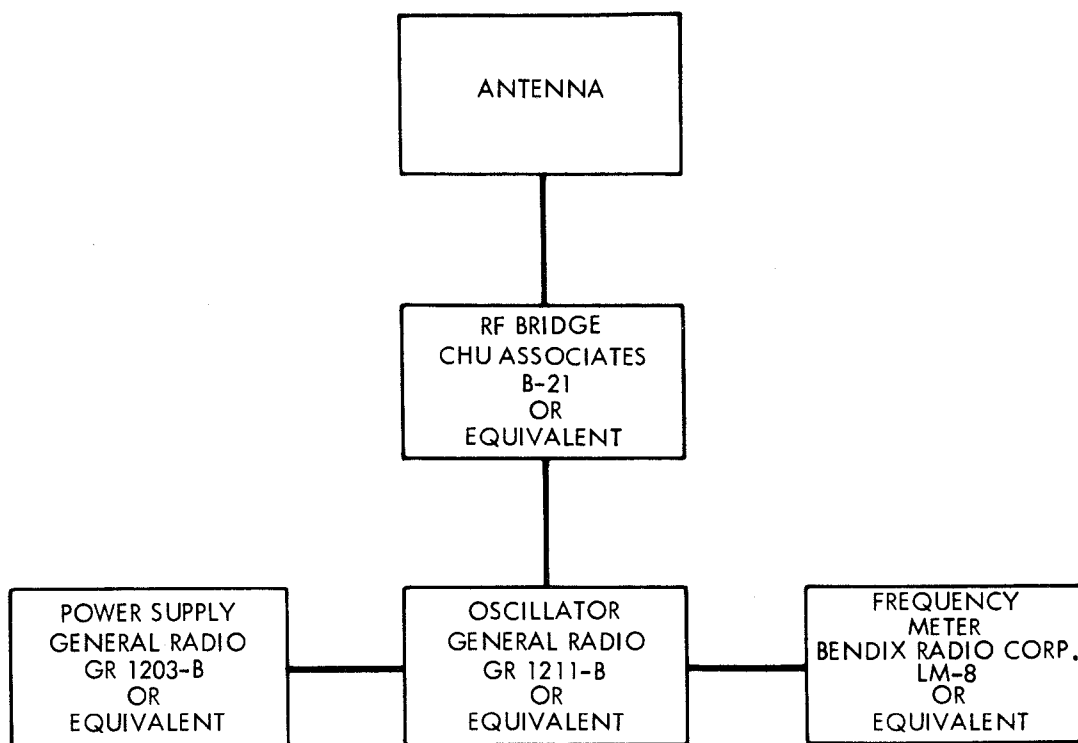


Figure 4-2. Bandwidth Measurement

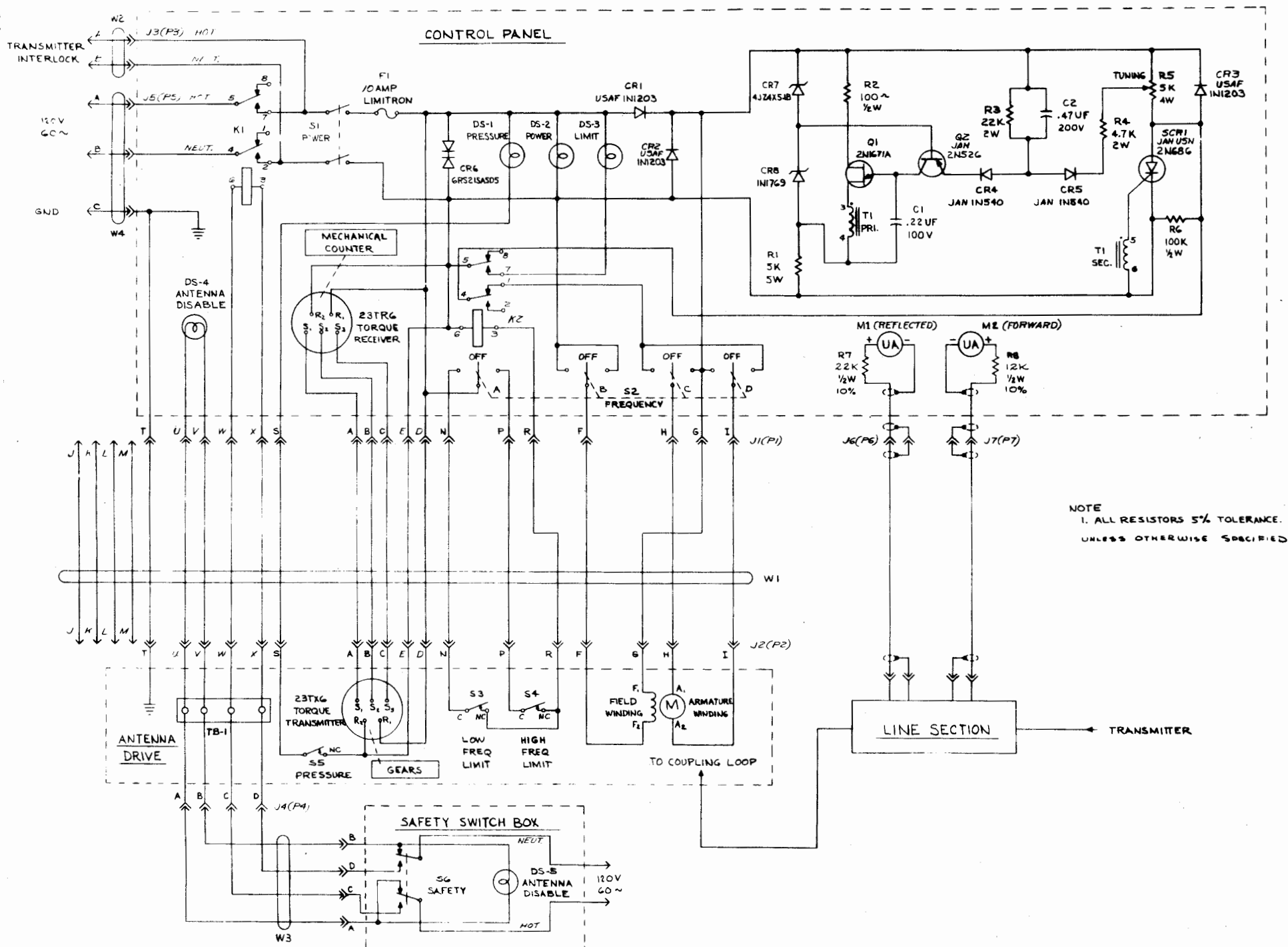


Figure 4-3. Schematic Diagram, Control Unit

SECTION V

PARTS LIST

RADOME ASSEMBLY

PART NO.	DESCRIPTION	QTY
4286	Top Cap Assembly	1
4150	Cap, Top	1
4151	Eye-Lifting Assembly	1
4156	Sleeve	1
4155	Bushing, Threaded	1

HELIX ASSEMBLY

4144	Mast Assembly	1
4326	Feed Loop Assembly	1
4285	Feed Loop	1
4283	Base	1
4324	Short, Flanged	1
4284	Support	4
4282	Bracket	8
	Clamp for 1 5/8 une (Ideal #64 Series)	2
4339	Shorting Ring Assembly	1
4173	Sector Shorting Ring	2
4163	Block Sector	1
4175	Block Sliding	2
4164	Block Sector	1
4161	Block Sliding	2
4343	Tape Shorting	4
4341	Shorting Strap	
4181	Side Plate	8
4182	End Plate	4
4335	End Plate	4
4179	Shoe	8
4342	Spacer	4

SECTION V

PARTS LIST (Cont)

HELIX ASSEMBLY (Cont)

PART NO.	DESCRIPTION	QTY
4162	Tape Guide	
4187	Tape Retainer	
4288	Strip, Sponge Rubber	
4269	Corona Cap Assembly	1
4143	Corona Cap	1
4154	Spacer Bearing	1
4270	Block, Shaft	2
4271	Block, MTG	2
4272	Shaft, Pulley	2
4273	Shaft	4
4274	Block, Pulley	2
4275	Retainer, Spring	4
4276	Pulley	2
4278	Thrust Washer	2
	Spring 1 1/2 Free Lgth. x 3/4 O.D x 0.094 W/D (Hardware Prod. Co.)	4
	Retaining Ring (Waldes-Truarc External Series #5100-62)	2

CONTROL UNIT ASSEMBLY

4178	Front Panel - Engraving	1
4174	Front Panel Fabrication	1
4172	Chassis Fabrication	1
4176	Mounting Plate Fabrication	1
	Meter, Weston Panel, Model 301, 50 D-C Micro-Ammeter, 2.5 KW	1
	Meter, Weston Panel, Model 301, 50 D-C Micro-Ammeter, 5 KW	1
MS39087-3	Handle	2
4286	Torque Receiver and Counter Assembly	1
3414	Plate, Synchro	1
3402	Block, Standoff	2
3406	Clamp, Synchro	1

SECTION V

PARTS LIST (Cont)

CONTROL UNIT ASSEMBLY(Cont)

PART NO.	DESCRIPTION	QTY
23TR6	Torque Receiver	1
4-D-8861R	Counter (Dialco)	1
4289	Gear-Rework	1
SBG-150-36-187	Gear, Mitre Bevel (Dynaco)	2
	Teflon Spaghetti for #22 Buss Wire	1 ft.
HKP	Fuse Holder (Bussmann)	2
MS25068-27	Switch,Toggle (JBT)	1
2TL1-2	Switch,Toggle (Microswitch)	1
4153	Plate, Identification	1
95408x-931	Pilot Light-Red (Dialco)	1
95408x-933	Pilot Light - Amber (Dialco)	3
MS3102R-28415	Connector, Recptical (Bendix)	1
MS3102A-165-8P	Connector, Receptical (Bendix)	1
UG-291B/U	Jack, Panel	2
GBB10	Fuse, "Limitron" (Bussmann)	2
BOHRO-6A	Relay, Power (Allied Control)	2
	Resistor, 100 , 1/2 W, 5%	1
	Resistor, 5.5K, 1/2 W, 5%	1
	Resistor, 15 K, 1/2 W, 5%	1
	Resistor, 100 K, 1/2 W, 5%	1
	Resistor, 4.7K, 2 W, 5%	1
	Resistor, 22K, 2 W, 5%	1
	Resistor, 5K, 5 W, 5%	1
RA30NASD-502A	Potentiometer, 5K, 4W (IRS-CTS)	1
CP05AIKD224K3	Capacitor, .22MF, 100V (Sprague)	1
CP05A1KC474K3	Capacitor,0.47 MF, 200V(Sprague)	1
6RS21SA505	Thyrector (G.E.)	1
USAF1N1203	Diode, Rectifier(G.E.)	3
JAN1N540	Diode, Silicon Rectifier (G.E.)	2
4J24x5.1B	Diode, Zener (G.E.)	1
1N1769	Diode, Zener	1

SECTION V
PARTS LIST (Cont)

CONTROL UNIT ASSEMBLY (Cont)

PART NO.	DESCRIPTION	QTY
JANUSN2N686	Rectifier, Silicon Control	1
2N1671A	Transistor, Unijunction (G.E.)	1
JAN2A526	Transistor	1
PE2229	Transformer, Pulse (Pulse Eng. Inc.)	1
77-M1P8	Socket, Relay (Amphenol)	2
106-312-1	Clip, Transistor (Atlee)	2
ET-145-2	Bezel (Jan Hdw. Mfg. Co.)	1
4911-3-05-19	Terminal, Insulated (Cambion)	28
3935-11	Standoff, Metal (Cambion)	6
NAS1464B-046-10C	Clip, Spring Tension (Augat)	1
NAS1464B-062-10C	Clip, Spring Tension (Augat)	1
90-5-2G	Knob, Control (Raytheon)	1
4340	Meter, Board	2
AN931-A3-5	Grommet, Rubber	2
NE-51	Lamp, Neon Glow	4
4367-1	Relay Clamp	1
4287	Washer, Shoulder	3
4320	Washer, Shoulder	1
MS3102A-165-8PX	Connector, Receptical (Bendix)	1
4367-2	Relay Clamp	1

PEDESTAL ASSEMBLY

4166	Winding Drum	2
4193	Retaining Washer	2
	Rope	
5008-206	Retaining Ring (Waldes)	2
Z99505	Bearing, Ball (N.D.)	2
	Motor	1
4165	Motor Mount	1
4169	MTG. Plate	1
4167	Shaft	1
4170	Gear and Hub Assembly	1

SECTION V

PARTS LIST (Cont)

PEDESTAL ASSEMBLY

PART NO.	DESCRIPTION	QTY
G43-96	Gear (Pic)	1
4319	Limit Switch and Gear Train Assembly	1
4290	Limit Switch Assembly	1
3825-1	Plate, Cam Housing	1
3825-2	Plate, Cam Housing	1
3366	Cover, Cam Housing	1
3596	Cam	2
3368	Worm Gear Shaft	1
3369	Cam Shaft	1
3600	Standoff	1
3599	Spacer	1
3598-1	Spacer, Locking	1
3598-2	Spacer, Locking	1
3457	Bracket, Switch	2
3597	Post, Switch Adjust.	1
33K5	Bearing, Ball (Fafnir)	4
Q1-12	Gear, 120 teeth, 64P-Bronze (Pic)	1
G7-72	Gear, 72 teeth, 48 P (Pic)	1
G7-32	Gear, 42 teeth, 48 P (Pic)	1
	Spring, Helical Comp. 1" Lg. x 1/4 O.D. x 0.031 wire Music Wire, CAD PLT.	2
1SA1-T	Micro-switch (Honeywell)	2
JS-5	Actuator (Honeywell)	2
4191	Support Plate	1
4189	MTG. Plate - Rear	1
4190	MTG. Plate - Front	1
4192	Gusset	2
3406	Clamp, Synchro	1
3370	Worm Shaft	1
3371	Drive Gear Shaft	1
3602	Spacer, Shaft	1
3459	Spacer Post	4

SECTION V

PARTS LIST (Cont)

PEDESTAL ASSEMBLY (Cont)

PART NO.	DESCRIPTION	QTY
G43-112	Gear, 112 Teeth, 32 P (Pic)	1
23TX6	Torque, Transmitter	1
Q2-2	Worm, 0.500 P.D., 64P (Pic)	1
G43-26	Gear, 26 Teeth, 32P. (Pic)	1
G43-128	Gear, 128 Teeth, 32P. (Pic)	1
G43-88	Gear, 88 Teeth, 32P. (Pic)	1
51K7	Bearing, Ball (Fafnir)	1
33K5	Bearing, Ball (Fafnir)	3
4349	Pedestal-Weldment	1
4134	Pedestal	1
4346	Support, Conductor	1
4135	Hinge - Weldment	1
4317	Bracket (Terminal Board)	1
4318	Bracket MTG. (Terminal Board)	1
4280	Gasket, Connector	1
4279	Gasket, Connector	1
4152	Plate, Identification	1
4140	Cover, Access Hole	1
4338	Flange Assembly	1
4141	Flange, Adapter	1
4337	Conductor Assembly	1
300-925	Flange, Fixed	2
4334	Plate, Switch MTG.	1
4321	Cover	1
4333	Gasket, Cover	1
4267	Bevel Gear	1
PA6412Y-G	Bevel Gear (Boston Gear)	1
4266	Pinion Gear	1
PA6412Y-P	Bevel Gear (Boston Gear)	1

SECTION V

PARTS LIST (Cont)

PEDESTAL ASSEMBLY (Cont)

PART NO.	DESCRIPTION	QTY
4137	Pin, Hinge	2
4139	Screw, Captive	14
4177	Base, Plate	1
4138	Cover, Bottom	1
	"O" Ring, 0.070 thk. x 13 3/4 I.D. - Buna - N	1
	"O" Ring, 0.070 thk. x 30 13/16 I.D. - Buna - N	1
MS25043-16C	Dust Cap	1
MS25043-29C	Dust Cap	1
MS3102A-28-11P	Connector, Receptical (Bendix)	1
MS3102R-165-8P	Connector, Receptical (Bendix)	1
4136-2	Hinge Bracket, Weld (Left)	1
4136-1	Hinge Bracket, Weld (Right)	1
20-141	Terminal Board (Cinch - Jones)	1
MS20-A1	Marker Strip (Cinch - Jones)	1

