ORDER

SW 6012.3

ELECTRONICS INSTALLATION HANDBOOK

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Distribution: A-X-(AF)-3; F&E Employees (150) **Initiated By:** ASW-430

FOREWORD

This handbook provides basic technical information required by installation personnel to perform the work outlined in the work orders, engineering packages, FAA directives, and equipment manuals. The handbook is to be used in conjunction with SW 6000.24, F&E Administrative Procedures Handbook.

If any information in this handbook conflicts with any agency directive, the agency's directive is authoritative and overriding.

David F. Morse
David F. Morse
Manager, Airway Facilities Division

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CHAPTER 1. GENERAL

Section 1. INTRODUCTION

1. PURPOSE. This handbook delineates regional standards for all electronic installations. The placement of equipment (cabinets, associated junction boxes, relay boxes, control heads, and the innerwiring of these units), cable tray installations, and wiring shall be as specified in this handbook. Additionally, this handbook includes supporting data to the above, such as the acceptable methods of identifying cables and conductors, workmanship, installation practices, and precautionary measures for safety of personnel and equipment. This handbook is to be used in conjunction with current handbook and equipment instruction manuals for specific equipment and various types of FAA facilities.

2. DISTRIBUTION. This handbook is distributed to branch level in the Airway Facilities Division and to all F&E employees.

Section 2. INSTALLATION STAGES

3. ENGINEERING PACKAGE. The engineering package contains the instructions and drawings necessary to complete the installation of the project. It is important that the engineering package be studied by sector personnel, and that any questions be discussed with the project engineer at the preengineering survey.

4. PREENGINEERING SURVEY. The Project Engineer and the Assistant Manager of Technical Support (AMTS) will agree on the Preengineering Survey Meeting one week in advance. The purpose of this meeting is to discuss the project scope, gather applicable engineering data, and identify test equipment requirements. A Preengineering Survey Report will be completed by the project engineer, and a copy will be included with the engineering package and established in the project folder.

5. PHASE I MEETING. The project engineer and the AMTS will agree on Phase I meeting date. A letter written by the branch manager to the sector manager will confirm the Phase I meeting. The engineering package, drawings, and the confirmation letter will be sent such that two weeks time is allowed for review of the engineering package. At this meeting the engineering package will be discussed in detail; any suggestions or changes to the project scope will be resolved; and confirmation of test equipment required or excess equipment that will become available as a result of this project will be noted. A Phase I Meeting Report will be promptly completed by the project engineer and a copy filed in the project folder.

6. PHASE II MEETING. The purpose of the Phase II meeting is to coordinate the installation of the project with the local airway facilities and air traffic personnel. This will include scheduling any facility shutdowns (if required),

identifying any local assistance required from the air traffic or airway facilities personnel, determining estimated installation time stages, establishing Joint Acceptance Inspection (JAI) date if possible, and confirming commissioning date. Minutes of the Phase II meeting will be recorded on the Phase II Meeting Report, and promptly returned to the installation unit supervisor.

7. INVENTORY PSR AND RPML. The first step of the project installation phase is the inventory of the Project Status Report (PSR) and the Regional Project Material List (RPML). The installation unit supervisor shall be notified of all material shortages so that all needed project material may be ordered at one time.

8. INSTALLATION. The project will be installed in accordance with the engineering package. Any deviations from the engineering package shall first be coordinated with the project engineer.

9. DISCREPANCY PRE-PUNCH LIST. The F&E installation crew shall work closely with the local airway facilities and air traffic personnel, and have them identify any major or minor exceptions prior to completion of the project. Communications shall be maintained with the installation unit supervisor regarding project status via the telephone and completion of written weekly reports. The formal JAI shall be coordinated 10 days in advance for projects requiring 30 or more working days, 5 days in advance for projects requiring less than 30 working days, or at the Phase II meeting if the project will last less than 5 days. The F&E installation crew will actively participate in the completion of the JAI.

10.-15. RESERVED.

CHAPTER 2. INSTALLATION OF FACILITIES

16. <u>AIR ROUTE TRAFFIC CONTROL CENTER (ARTCC)</u>. The ARTCC is the agency's largest facility, both in physical size and magnitude of operation. Its primary duty is to provide separation of aircraft passing through its geographic boundaries. The ARTCC building is very large and contains a number of special purpose rooms. The equipment rooms for radar, communications, TELCO, and data equipment are in the basement. The control room is directly above the equipment rooms. The control room can contain as many as 60 positions (sectors), each position having radar, communications, and data equipment. Most of the ARTCC's communications are conducted over telephone lines to Remote Controlled Air/Ground (RCAG) facilities and radar data is received from remote Air Route Surveillance Radar (ARSR) via Radio Control Link (RCL). The amount of wiring within a ARTCC building is larger than many city telephone exchanges.

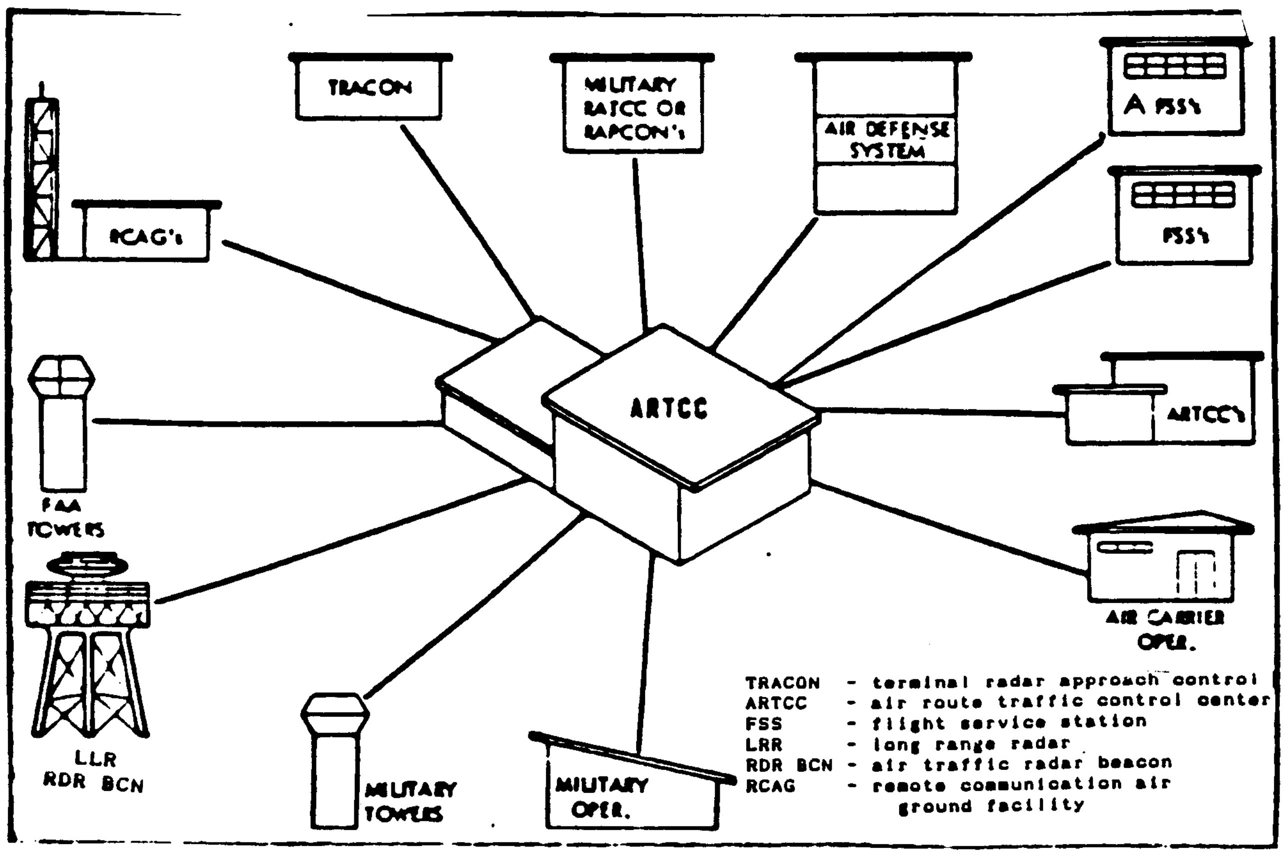


Figure 2-1. ARTCC Facility Operations

17. <u>AIRPORT TRAFFIC CONTROL TOWER (ATCT)</u>. The ATCT directs movement of aircraft in the vicinity of the airport, including all ground traffic on the runways and taxiways. Aircraft under the control of the ARTCC are directed to the airport control zone where they are "handed off" to the ATCT for landing instructions. Aircraft taking off are directed to the airport zone limits where the ARTCC assumes responsibility. The ATCT uses radio Remote Transmitter/Receiver (RTR) and Airport Surveillance Radar (ASR) for directing aircraft. The complexity of equipment and number of controller positions at the ATCT's vary with the amount of airport traffic. Many small towers are established without radar facilities, and without remote communications equipment.

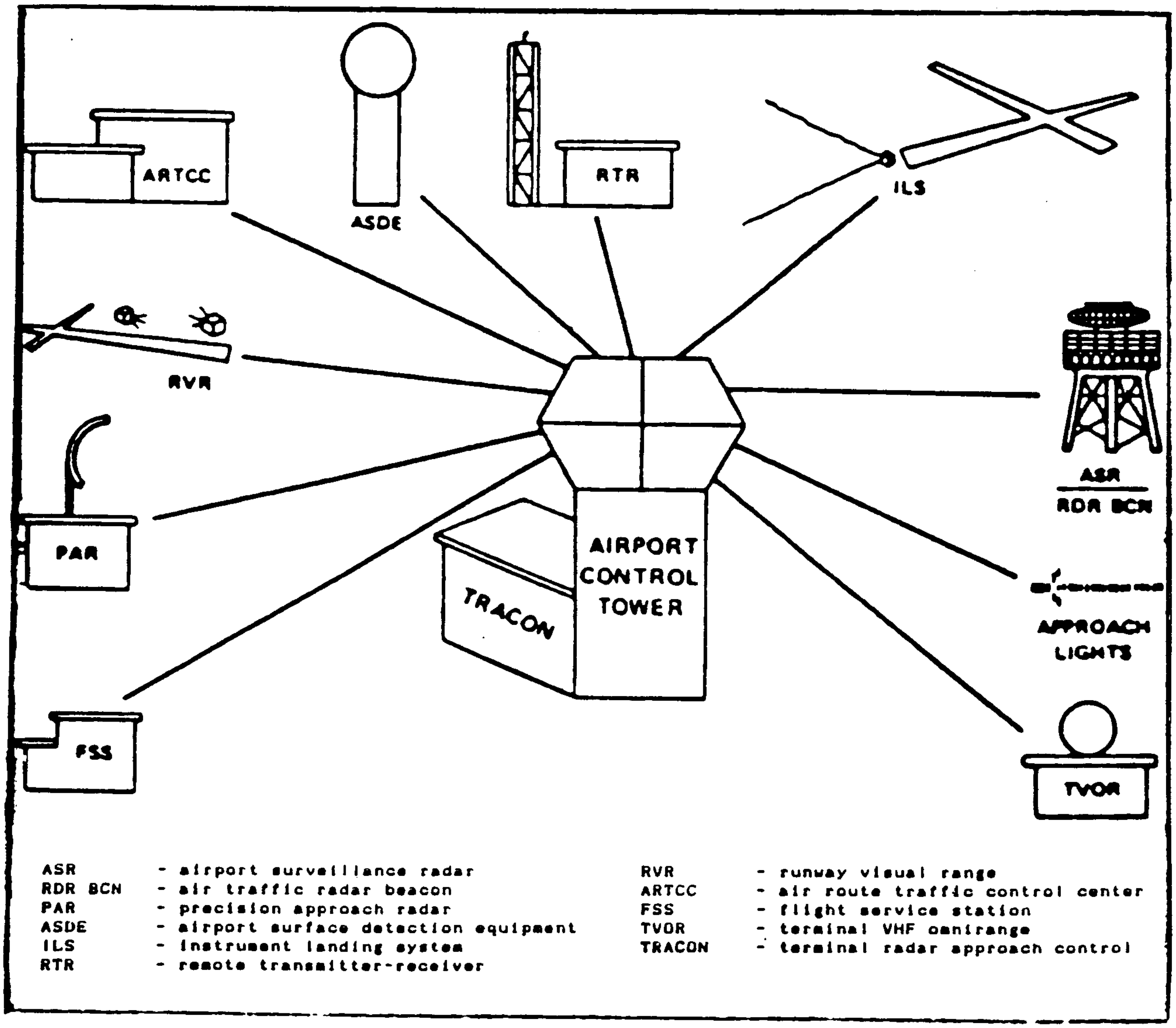
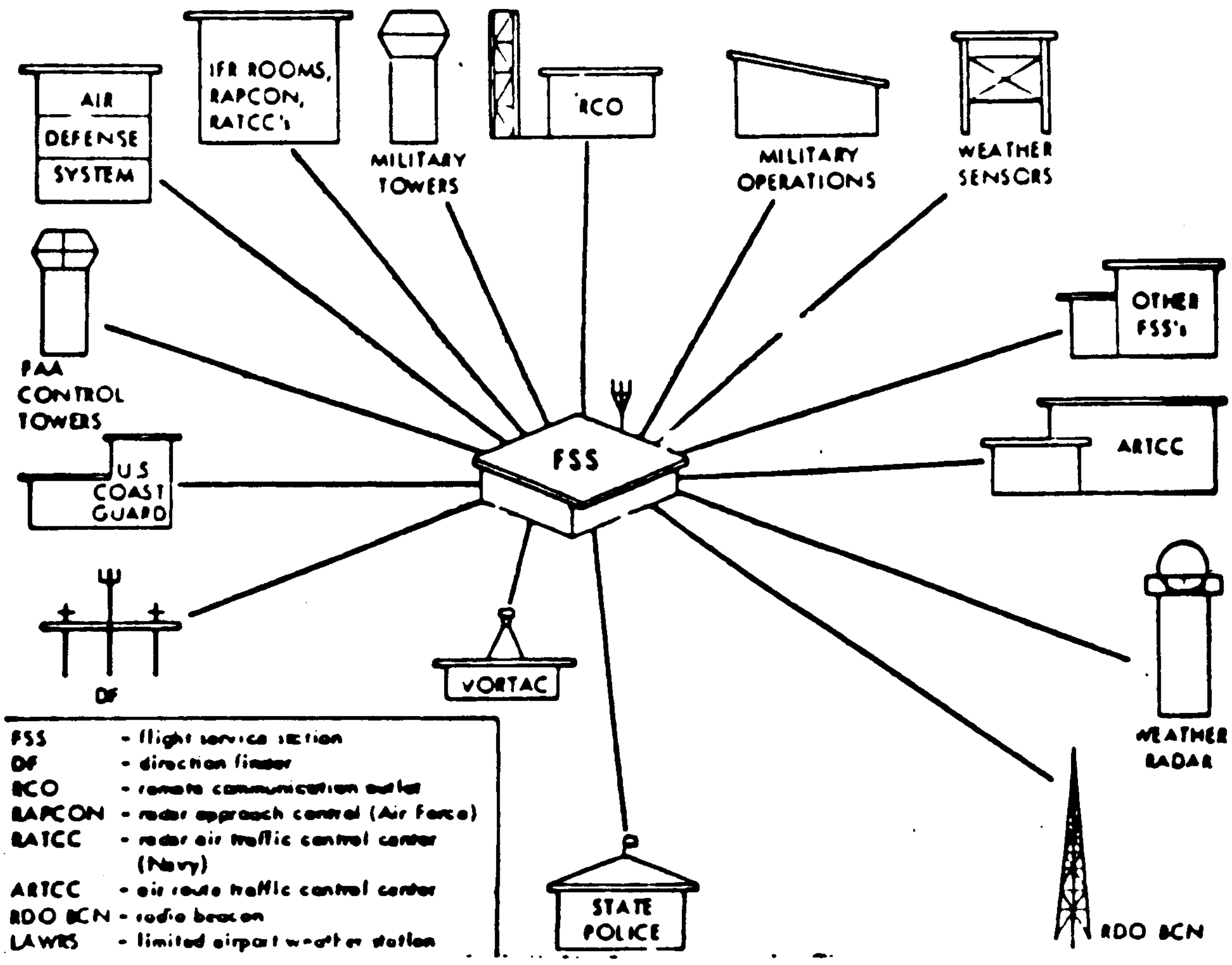


Figure 2-2. ATCT Facility Operations

18. <u>AUTOMATED FLIGHT SERVICE STATION/FLIGHT SERVICE STATION (AFSS/FSS)</u>. Automated Flight Service Stations/Flight Service Stations activities are primarily air traffic support functions. The AFSS/FSS is the main focal point for aviation weather acquisition and dissemination. Weather observations are gathered hourly from over 500 nationwide reporting stations. They are collected by the National Weather Service at Kansas City and distributed to the AFSS/FSS's via Leased Service A System (LSAS) from Western Union. Service A information is also distributed to AFSS's that have Model I equipment via the Flight Service Data Processing System (FSDPS) unit located at the appropriate ARTCC. AFSS/FSS's assist pilots in opening and closing flight plans, planning their flight routes, and advising them of navigation equipment shutdowns. Some AFSS/FSS's are equipped with Direction Finders (DF) for sensing the direction of received radio signals from lost aircraft.



<u>Figure 2-3. FSS Facility Operations</u>

19. REMOTE COMMUNICATIONS AIR/GROUND (RCAG). RCAG's are remotely operated air/ground radio channels located in selected areas to provide maximum communications coverage to the ARTCC. The units are unmanned and have either battery backup or generators which start automatically when commercial power to the facility fails. The facility has from one to twelve air-to-ground communication channels. A channel consists of companion VHF and UHF radio receivers and transmitters. The VHF and UHF transmitters may be keyed simultaneously (paired) or individually (split). Controlling functions (keying and changeover to standby equipment) are accomplished from the ARTCC via tone control equipment. RCAG sites are connected to the ARTCC by specially designed telephone circuits.

20. REMOTE TRANSMITTER/RECEIVER (RTR). Remote Transmitter/Receiver sites serve the air/ground communications needs of ATCT's. In many cases, the receivers are located in the tower equipment room with transmitters only at the remote site. Keying and audio signals are transmitted over buried cables or microwave links to the ATCT. Complete 1-for-1 backup equipment is provided, with changeover to the standby equipment accomplished by a control panel in the tower cab.

21. REMOTE CONTROLLED OUTLET (RCO). An RCO is an unmanned remotely operated, air/ground communication outlet controlled by air traffic operators from distantly located FSS/AFSS facilities. The equipment is controlled similar to an RCAG; keying and audio signals are transmitted via telephone lines.

22. LIMITED REMOTE CONTROL OUTLET (LRCO). LRCO equipment consists of one or two receivers installed at a VHF Omni-directional Range (VOR). They share the same TELCO line with the VOR monitor tones to the controlling FSS/AFSS. Two-way communication to an aircraft is provided when the FSS/AFSS operator transmits on the VOR transmitter.

23. INSTRUMENT LANDING SYSTEM (ILS). The ILS provides the means for safely landing aircraft under conditions of low cloud ceilings and limited visibility. The ILS system consists of separately housed transmitters whose simultaneous radiation signals combine in space to provide an "On Course" path to aircraft approaching the ILS runway. An indicator, consisting of two pointers, on the aircraft instrument panel gives the position of the airplane in relation to the Localizer (LOC) (lateral) and Glide Slope (GS) (vertical) courses. Other transmitters associated with an ILS system are the inner marker, middle marker, and the outer marker. These facilities are located along the approach path to the runway, giving the pilot an indication of his distance to "touchdown". The transmitting elements comprising an ILS are shown in Figures 2-4 through 2-7. There are three different categories of ILS systems dependant on the airport requirements, and are named CAT I, CAT II, and CAT III. CAT III has the most stringent tolerances with CAT I possessing the least stringent tolerances, and consequently, the CAT I ILS possesses the most precision.

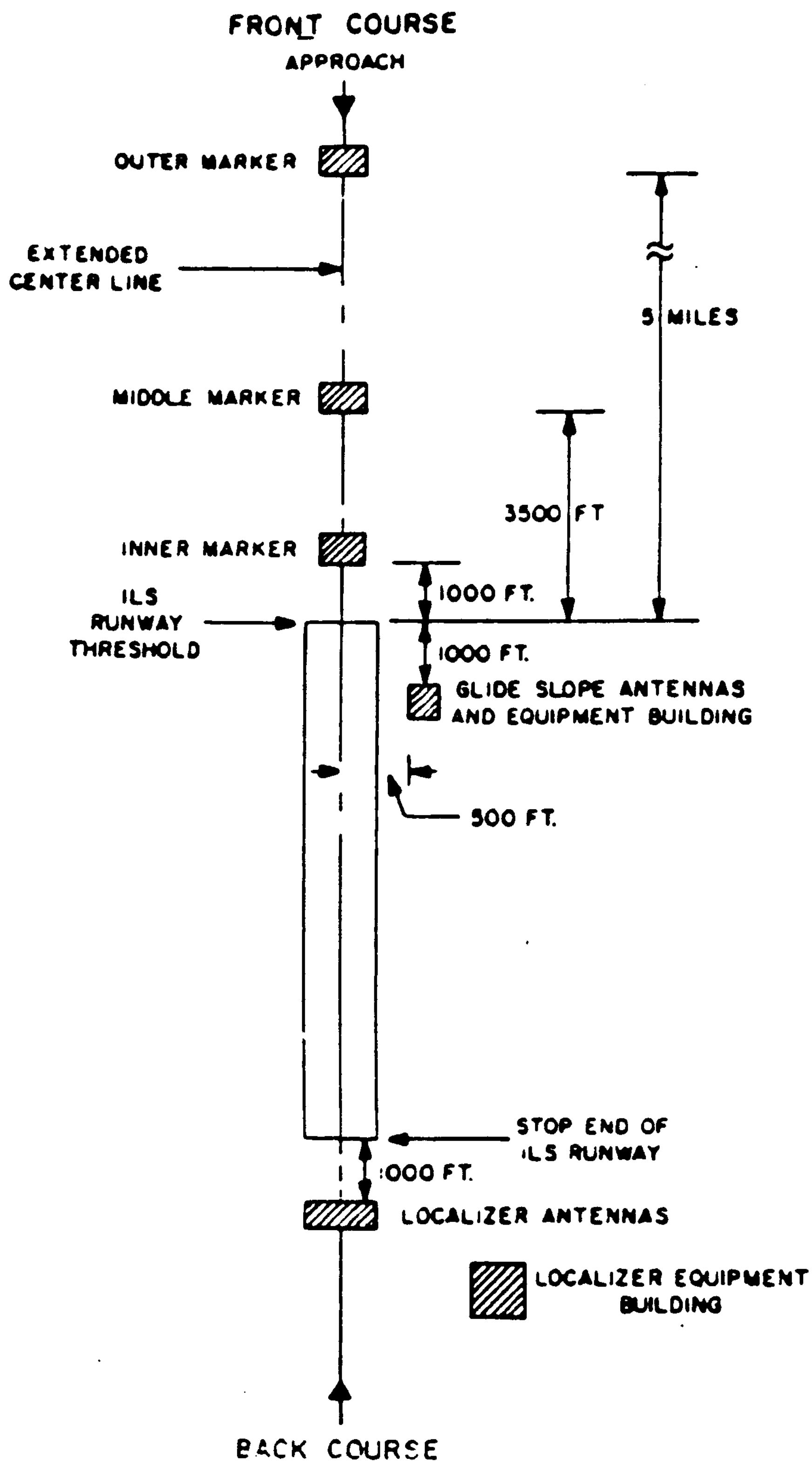


Figure 2-4. ILS Facilities

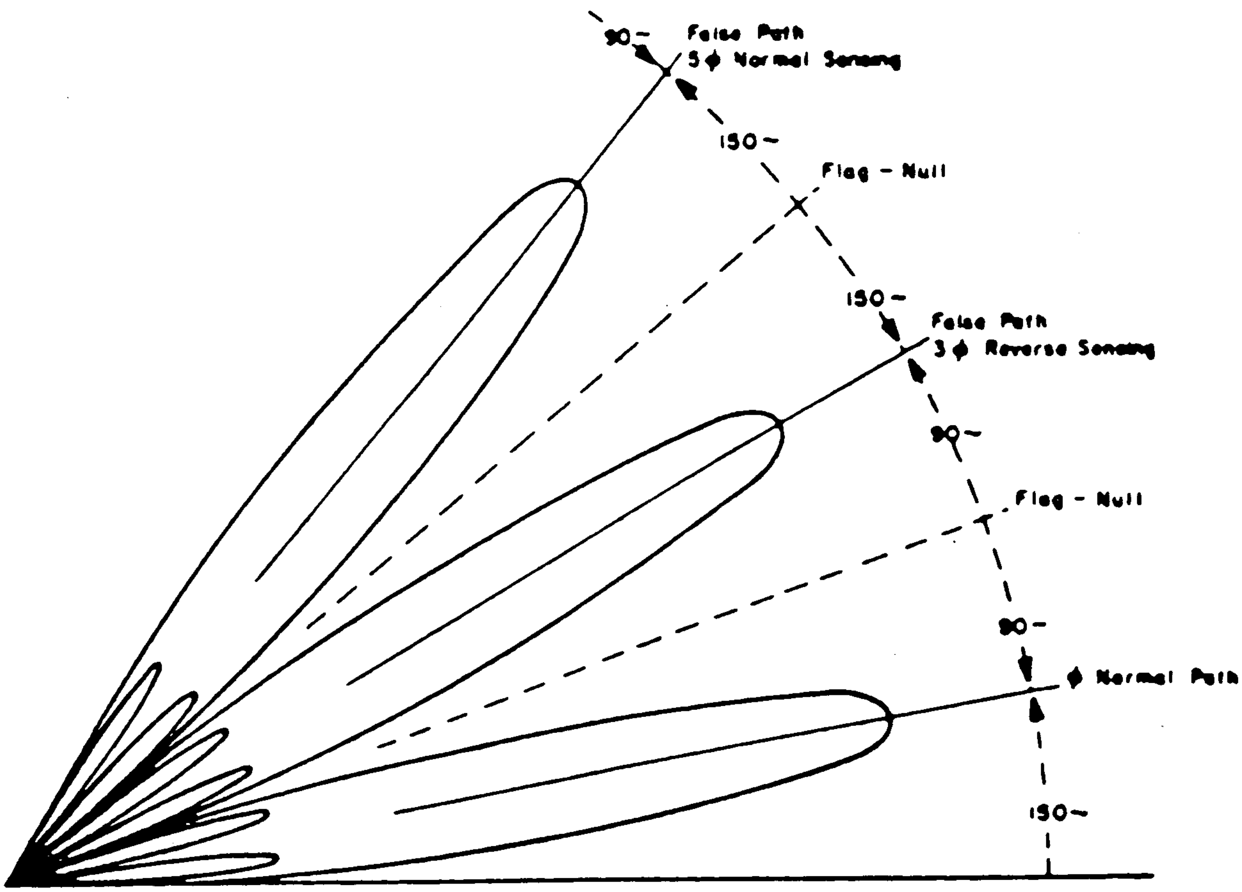


Figure 2-5. Null Reference Glide Slope Antenna Radiation Pattern

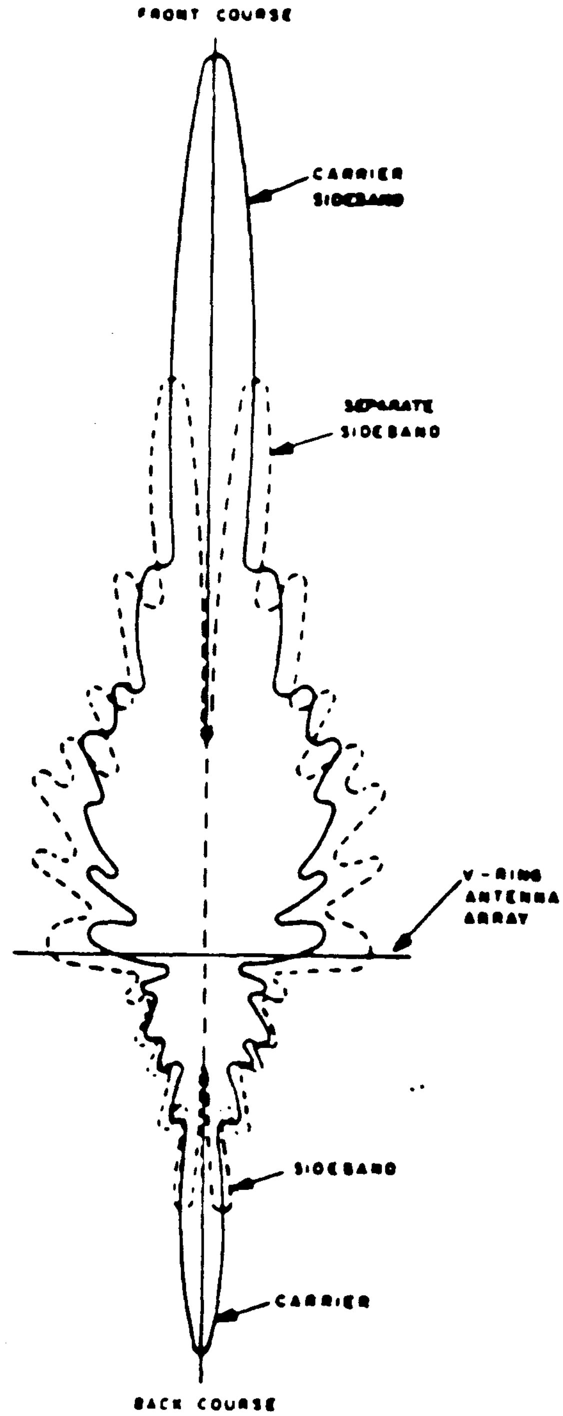


Figure 2-6. V-Ring Localizer Antenna Radiation Pattern

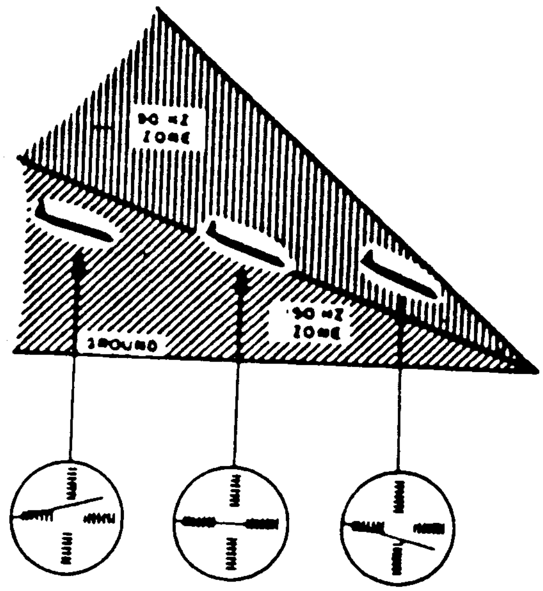


Figure 2-7a. Aircraft Glide Slope Indicator Deflection

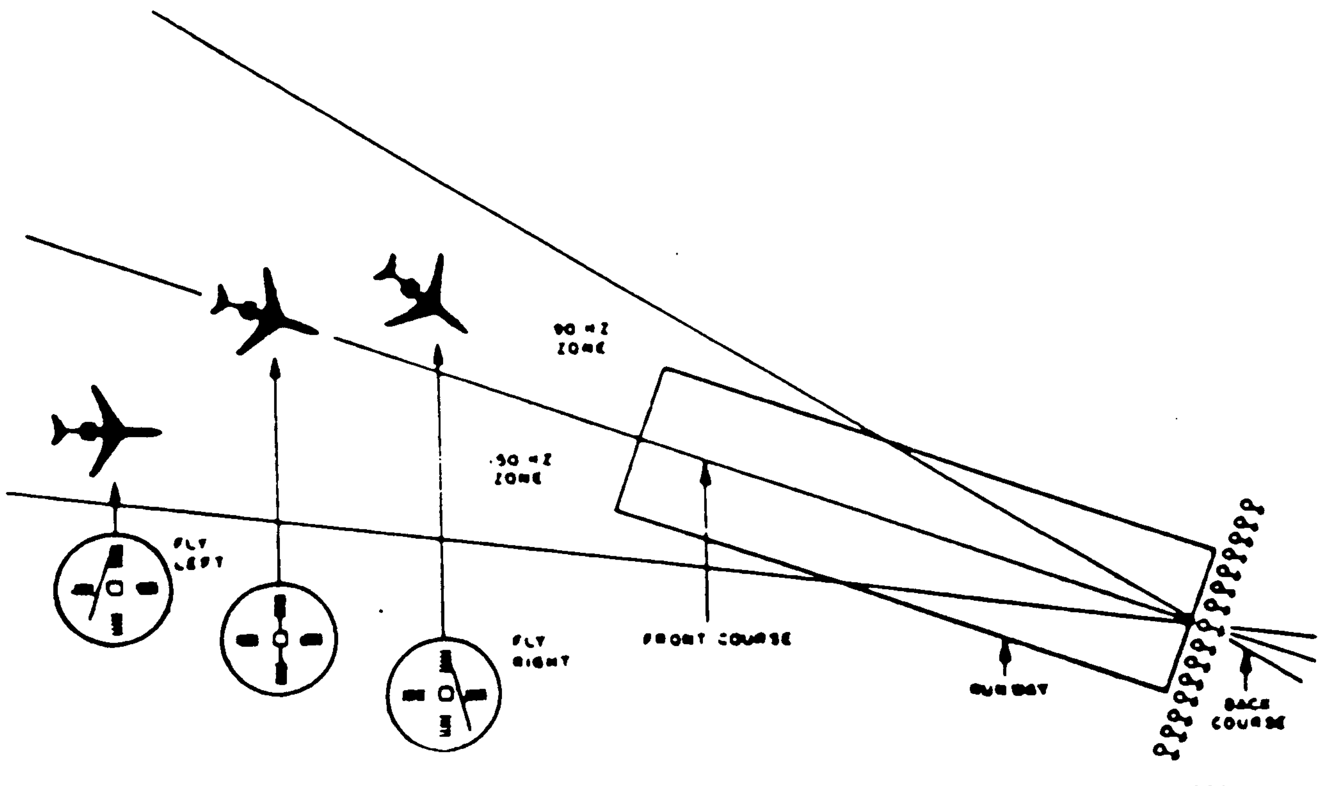


Figure 2-7b. Aircraft Localizer Indicator Deflection

24. MICROWAVE LANDING SYSTEM (MLS). The MLS has been adopted as the international standard for the replacement of the 40 year old Instrument Landing System (ILS). The azimuth (AZM) station is installed beyond the stop end of the runway and it provides horizontal guidance to an aircraft. The elevation (ELEV) station is placed alongside the runway at approximately the touchdown point and it provides vertical guidance to the aircraft. The Precision Distance Measuring Equipment (DME/P) is placed near the AZM and it provides distance information to the aircraft.

The AZM and the ELEV operate in the 5 GHz band of frequencies and the DME/P operates at approximately 1 GHz. Two hundred channels are provided for the MLS where the ILS only has 40 of which 20 are commonly used.

25. VHF OMNI-DIRECTIONAL RADIO RANGE (VOR). The VOR provides navigational signals to an aircraft receiver which will allow the pilot to determine the bearing of his aircraft relative to the VOR facility. The VOR operates on the principle of phase comparison of two audio signals, and this phase difference is designed to vary with azimuth. One signal, the "reference" is constant throughout 360 degrees of azimuth, while the second signal, the "variable", varies in phase with the azimuth. If there are no system errors, the variable signal will lag the reference signal one degree for every one degree of clockwise movement around the VOR. In addition to bearing signals, a VOR transmits a keyed identifier and is used for voice communications from the controlling FSS/AFSS to pilots tuned to the VOR frequency (see LRCO).

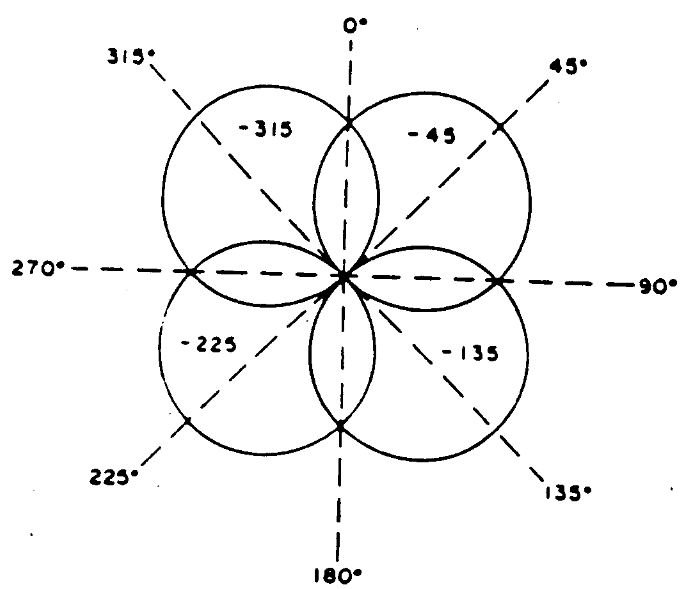


Figure 2-8. VOR Antenna's Audio Phase Relationships

a. VOR Antenna Space Modulation. The four phases illustrated below represent the audio relationship produced when each single antenna's sideband energy space modulates the carrier energy. This means in effect that the NE antenna's space modulation produces an audio signal which lags the reference signal by a fixed phase of 45 degrees. Similar audio phase relationships are at 135 degrees, 225 degrees, and at 315 degrees for the SE, SW, and NW antenna's respectively.

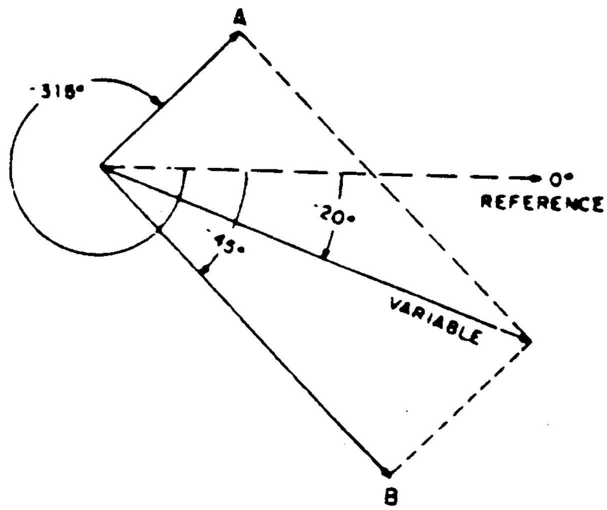


Figure 2-9. Two Audio Phasors Drawn to Derive an Omni-Course of 20 degrees

b. VOR Bearing Example. Using the VOR antenna's Audio Phase relationship illustrated on the previous page, the variable signal received by an aircraft at 20 degrees bearing from the VOR can be thought of as being composed of two fixed audio phasors whose resultant, the variable signal, lags the reference signal by 20 degrees.

As the aircraft position changes clockwise from 20 degrees, the length of phasor A (-315) will decrease while the length of phasor B (-45) will increase until at 45 degrees, the variable signal will be entirely due to the -45 degree audio phasor. At 90 degrees the variable signal will be the sum of two audio phasors, one at -45 and the other at -135.

26. DOPPLER·VOR. The Doppler VOR course forming signals received by an aircraft are compatible with the signals received from the conventional VOR. The primary difference being that the conventional VOR's 30Hz variable signal is AM produced, while the Doppler's variable signal is FM produced. The amplitude modulated variable signal of the conventional VOR is susceptible to reflection errors caused by uneven terrain or by large near-by buildings. These reflections make it possible for an aircraft to receive a reflected course bearing signal as well as the desired direct path course forming signal. The addition and subtraction of

these signals results in an Omni-Course error. The Doppler's FM produced variable signal is much less susceptible to reflection errors. Physical difference between the VOR's is apparent, since the Doppler has 50 antennas spaced 7.2 degrees apart around the edge of the counterpoise to achieve the "doppler effect".

27. DISTANCE MEASURING EQUIPMENT (DME). DME's are installed in selected VOR or Glide Slope facilities to give the pilot of an aircraft a direct readout of his distance from the navigational aid. DME ground equipment is interrogated by the aircraft on one of ten interrogation frequencies. The DME transmits a reply back to the aircraft. Circuits in the airborne equipment measure the time elapsed between interrogation pulse and reply pulse, and converts the time to distance measurement. The DME has only ten interrogation and ten reply frequencies; however, by varying the spacing between the pulses, each frequency operates in one of ten possible modes, making 100 usable channels.

28. TACTICAL AIR NAVIGATIONAL AID (TACAN). The TACAN facility combines azimuth information and distance measuring in one system. Distance data is computed in the aircraft by measuring the time for interrogation pulse pairs to be returned, via the TACAN reply frequencies. There are 126 receiver frequencies and 126 reply frequencies in the TACAN transponder equipment. As many as 100 aircraft may simultaneously obtain navigational information from a single transponder installation. The azimuth information received by an aircraft from a TACAN is the result of the rotation of the facility's antenna. Fundamental frequencies radiated are 15Hz and 135Hz which are detected in the aircraft's receiver. The 15Hz course phase measurement establishes the initial location of the aircraft indicator within a 40 degree sector, and the 135Hz fine phase measurement establishes the exact position within the 40 degree sector. This concept indicates that a small azimuth change will appear as a 9 fold electrical phase angle, which is the factor that makes the TACAN navigation system very accurate.

29. VHF OMNI-DIRECTIONAL RADIO RANGE AND TACTICAL AIR NAVIGATIONAL AID (VORTAC). The VORTAC facility has two air navigational systems installed in a single building, VOR and TACAN. The VOR system was developed to provide the necessary enroute navigational data for civil aviation. TACAN was developed by the military to provide a navigational system suitable to military needs. With the advent of the unified air traffic control concept, it was decided that the two navigational systems would be collocated. Thus, military aircraft can use the TACAN frequencies for azimuth and distance data, while civil aircraft may use the VOR for bearing data from the same facility.

30. RADAR. Many classes of radar systems are used in the FAA for detection of aircraft movements and measurement of the "target" range. In the basic radar system the transmitter sends out short bursts of radio energy. The voltage is then switched off while the system waits for echoes to be received. The system uses a common antenna which rotates 360 degrees of azimuth. The speed of rotation varies with the operational range of the system. The position of the antenna with respect to magnetic North is fed to the indicator so that targets presented may be seen in their relation to magnetic North. Radar systems are now combined with alphanumeric data systems, for identity of targets on the indicator, this is

commonly called beacon information. The controller can insert any data pertaining to the aircraft and it will be displayed in alphanumerics alongside the corresponding radar target as it progresses across the radar display. FAA designated radar systems are:

a. Air Route Surveillance Radar (ARSR). ARSR radars are located in geographically selected areas to provide the ARTCC's complete surveillance of the nations air route structure. The echoes returned to the remotely located radarsites are transmitted to the ARTCC over a Microwave Link (RML or RCL). At the ARTCC the information is presented on the controllers display. The ARSR transmitter RF output is approximately 4MW and the surveillance range is 200 miles.

b. Airport Surveillance Radar (ASR). The ASR system radar is installed at busier airports and serves the ATCT controllers directing approaches and departures from the airport. They operate at an radio frequency (RF) output of approximately 1.0 megawatt and have a range of 50 miles.

c. Airport Surface Detection Equipment (ASDE). The ASDE system is especially designed to provide surveillance of the ground features at an airport. The ASDE system allows the controller to direct ground movement of aircraft under very low visibility conditions.

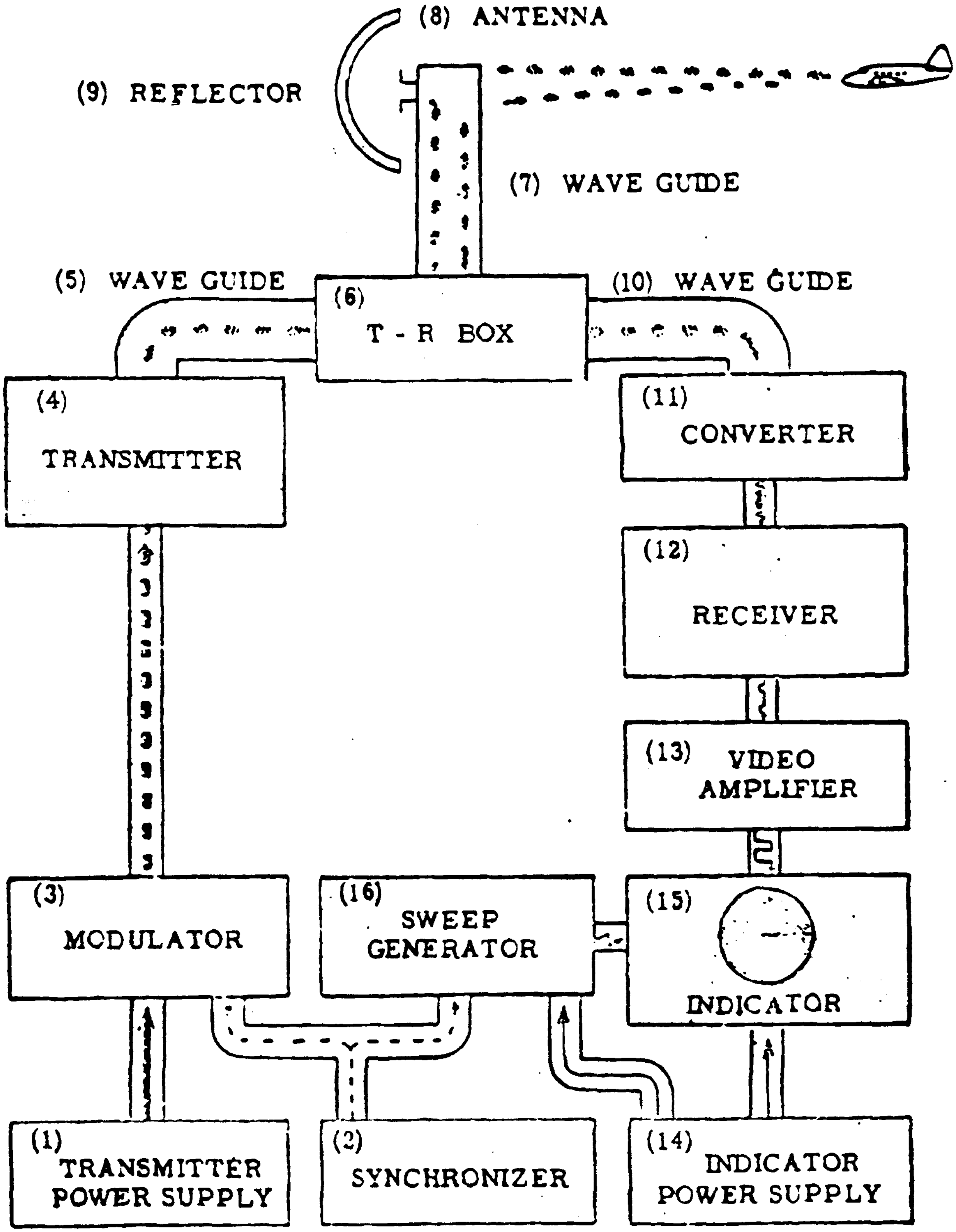
31. AIR TRAFFIC CONTROL BEACON INTERROGATOR (ATCBI). The ATCBI functions similar to the DME and TACAN facilities except in reverse form. The aircraft is interrogated from the ground by the controller. A transponder in the aircraft responds by sending replies back to the ground. The controller uses separate codes to obtain aircraft identification and altitude data. At ARTCC and ATCT facilities, beacon derived identification is automatically displayed adjacent to the aircraft target.

32. AUTOMATED RADAR TERMINAL SYSTEM (ARTS). The ARTS provides: (1) automatic and continuous association of an alphanumeric display to the controller of pertinent data of the controlled aircraft and its radar video, (2) the capability for automated transfer of information required for coordination between controllers by making simple keyboard entries, and (3) the ground facility effective utilization of the ATCBI.

33. BRIGHT RADAR INDICATOR TOWER EQUIPMENT (BRITE). The BRITE display was developed so radar targets could be viewed in bright light areas such as a tower cab. In the BRITE system, standard radar targets are presented on a miniature Plan Position Indicator (PPI). A camera in front of the PPI scans the image and transmits the picture to the BRITE monitor.

34. RADAR MICROWAVE LINK (RML). The RML relay facilities are the link between the remotely located long range radar sites and the ARTCC. The microwave link system operates in the 7125-8400 MHz frequency range, which requires a straight line path between terminals. The number of terminals between the radar site and the ARTCC depends on several factors, among these are the terrain, the path length for each hop, the antenna size, the transmitter power output, the receiver sensitivity and

Figure 2-10. Basic Radar System



the allowable path fade margin. The FAA RML has six channels, four operate from the radar to the ARTCC and two operate from the ARTCC to the radar site. One channel of the RML system carries voice communications.

35. RADIO COMMUNICATIONS LINK (RCL). The aging system of RML links is presently being replaced with a modern solid state radio link system, which will expand and modernize the functions of the RML. Operating in the same frequency bands as RML, RCL uses two radio frequency (RF) channels in each direction. These channels carry voice, data, and in a few cases, video communications from ARTCC to ARTCC and from radar to ARTCC.

36.-40. RESERVED.

CHAPTER 3. SAFETY

41. GENERAL. Safety is the responsibility of all personnel. It is essential that safe working practices outlined in agency directives and OSHA handbooks be followed. It is incumbent on all personnel that they develop safe working practices, be aware of potential unsafe conditions, report and/or correct potential hazards, and use appropriate safety equipment while on the job. If the installation cannot be performed in a safe manner, notify the installation supervisor immediately.

42. SAFETY EQUIPMENT. Safety equipment is to be used whenever applicable on the job. Some of the most common types of safety equipment are as follows.

a. Safety Belt. It is imperative that a safety belt be used when work requires climbing and working on towers, poles, or other high structures. These belts can normally be obtained from the local AF sector. Precaution should be taken to examine the safety belt before it is used. When the belt has not been used for some time, there is a possibility of mildew or leather fatigue. If either of these conditions is found, a replacement belt should be obtained.

b. Hard Hats. Hard hats will be issued to all field electronics installation personnel. These hard hats are to be worn at all construction or installation areas where overhead work is in progress. Personnel on the ground are to be advised when overhead work is being performed.

c. First Aid Kits. Personnel should ascertain that a first aid kit is at the facility where work is in progress. A quick check of contents should be made. On new facilities being established, the project crew chief will obtain a first aid kit from the appropriate F&E section office for use on the project.

d. Ear Plugs. Ear plugs or other noise suppression devices are to be used to prevent hearing damage when working near runways, on flight lines, or on engine generators. These can be obtained from the appropriate F&E section office when required.

e. Safety Glasses. Safety glasses are provided by the Technical Support Services and should be used at any phase of the installation where the possibility of eye injury exists.

43. OPERATIONAL EQUIPMENT. It is imperative to recognize that equipment commissioned into the NAS system is used constantly to ensure the safety of the flying public; therefore, extreme caution should be exercised when working in or around operational equipment.

44. POWER. The equipment and/or components being installed will normally be accomplished under power-off conditions. When this is not possible, or when working with high voltages, personnel shall work in pairs and use insulated floormats and gloves. Furthermore, all personnel shall be familiar with techniques

for administering artificial respiration, including the use of respirators. When working with equipment containing high voltages, it is well to remember the following simple but important rules.

a. If at all possible, power should be turned off prior to accomplishing work in high voltage and/or adjacent component areas.

b. When "shutdown" is not feasible, personnel should remain conscious of the high voltage areas at all times.

c. When possible, work with one hand, (preferably the right hand) thereby reducing the possibility of full-body exposure to shock.

d. Locate high-voltage terminals in equipment and make a mental note or, if practical, mark the location. When working with equipment having filter capacitors, extreme care should be exercised to short the capacitor terminals with a ground stick after equipment has been "shut off." The residual charge on a capacitor can result in serious injury.

e. Tools utilized should be insulated when possible. Great care should be exercised in selecting the proper tool for the job.

f. Polarized AC receptacles shall be installed in racks to minimize possible "above ground" voltage potentials.

45. <u>TRAINING</u>. It is the supervisor's responsibility to be certain each employee is trained in first-aid practices and defensive driving. Training records are to be reviewed annually to assure new employees are trained and other employees retrained, if required.

46. <u>USE OF POWER TOOLS</u>. Tools must be used with care as they may be harmful to the user or dangerous to fellow employees. Every common safety precaution shall be exercised when using any tool. Use of the following requires special instructions.

a. The Ramset gun is a powerful hand tool which should be handled with extreme care. The principle of operation is to drive a stud by means of an exploding blank cartridge. Due to its makeup, the normal utilization of this tool can be very dangerous. This tool is supplied in kit form and includes an operational instruction book. It is imperative that employees using the Ramset tool be familiar with the instructions contained in this booklet.

b. An electric drill is a commonly used tool; however, it can be a dangerous device if not properly utilized.

(1) Make sure stock to be drilled is secured or properly fastened. Do not hold material in hand when drilling.

(2) If at all possible, drilling should be accomplished below eye level.

(3) Provide grounding for drill motors or any electrical power tool when working in moist areas. It is an excellent practice to provide this safety feature at all times regardless of the working environment.

(4) When drilling thick material, a pilot hole of small diameter should be drilled, then followed by the drill size required.

(5) Check the area behind the material being drilled to ensure that no obstacles or electrical circuits are present.

(6) When drilling thick "hard steel" stock with a 1/2-inch or larger high-torque drill, make a special attempt to keep the drilling pressure minimized to reduce the "biting" effect. A small amount of cutting oil will assist in making this type of drilling easier.

(7) If skin burns are experienced when drilling, an application of tannic acid will reduce the chance of infection.

47. ON-THE-JOB INJURIES. Personnel injured while on duty shall promptly obtain treatment from a physician or medical facility of their choice, shall report any injury as soon as possible to the supervisor, and shall initiate the required accident forms within 48 hours where possible. Procedures and examples of these forms are contained in Order SW 6000.24, F&E Administrative Procedures.

48.-53. RESERVED.

CHAPTER 4. TOOL SETS

54. GENERAL. This chapter outlines procedures for procurement, care, and disposition of tool sets issued to installation personnel.

55. ISSUANCE OF TOOL SETS. All personnel engaged in installation work shall be issued a standard set of tools and test equipment upon entry on duty. The sets will be invoiced to the employee on FAA Form 4650-12, Materiel Requisition/ Issue/Receipt. This invoice will be an itemized inventory which will carry the tool set number. The employee will be held responsible for this equipment, and every reasonable effort should be made to protect it against loss, theft, or accidental damage. However, when such losses do occur, the employee should report the loss immediately to the Technical Support Staff, ASW-431.

56. SPECIAL TOOLS. Installation personnel may have a need, from time to time, for a special tool which was not included in the original tool set. A request should be made to the Technical Support Services, ASW-431, and if it is considered necessary, the tool will either be furnished to you, or you will be given authority to rent or purchase it locally. Prior approval for purchase of tools is mandatory.

57. CARE AND REPLACEMENT OF TOOLS. When a particular tool in a set becomes damaged or unserviceable, it should be replaced by making a request to the Technical Support Staff, ASW-431. Some tools become worn and unserviceable through normal usage, and this is expected. However, each tool set contains at least one item of electronic test equipment which is subject to serious damage due to improper application or rough handling. You are urged to give these instruments the protection they require for continued service. It is also suggested that upon completion of every major project, a physical inventory be taken at that time and action initiated to replace all lost, damaged, or otherwise missing or unserviceable items.

58.-63. RESERVED.

CHAPTER 5. INSTALLATION OF EQUIPMENT

ENCLOSURES AND JUNCTION BOXES

64. GENERAL. There are varying sizes and types of equipment racks, wall-mounted cabinets, and junction boxes involved in electronic installations.

65. ENCLOSURE TYPES. All equipment enclosures and junction boxes will be installed in accordance with the floor plan provided in the engineering package.

a. Enclosed-type equipment cabinets are generally referred to as "relay racks." These come in a variety of heights and in the case of specialized equipment, a variety of widths and depths. The standard rack usually used measures 22" x 22" x 83" (or 76"). In many instances, equipment will be housed in racks with varying dimensions supplied by the manufacturer. The front edges of standard racks will have holes tapped at regular intervals allowing standard 19-inch wide equipment or panels to be mounted.

b. Junction boxes are usually installed as part of the construction project on new facilities; however, installation or relocation of junction boxes may be necessary in modernization projects. Currently, some equipment is now provided in wall-mounted enclosures. These junction boxes and enclosures come in a variety of sizes and weights which must be taken into account during installation.

66. INSTALLATION OF ENCLOSURES. This paragraph contains general instructions for alignment and anchoring of various types of equipment enclosures.

a. When installing equipment racks, align the fronts of adjacent racks flush and level in both the horizontal and vertical dimensions. Shims shall be used to compensate for uneven floor surfaces. If required, bolts to hold the racks together should be installed at the top and bottom of the racks.

b. Position the racks or cabinets in accordance with the floor and equipment layout drawings in the engineering instructions when anchoring equipment enclosures.

(1) Equipment cabinets with pull-out drawers must be floor anchored regardless of size.

(2) Floor anchoring of racks is of major concern, and effective methods and devices shall be used.

(a) Lag bolts are utilized when anchoring racks to wooden floors. Examine the floor structure and position racks so that lag bolts will connect to the supporting structure under the floor where possible. Utilize the correct size lag bolts for the job.

(b) Lead anchors are used when floor material is of concrete or concrete-mesh structure. Many sizes are available, and emphasis should be placed on utilizing the correct anchors. A Carboloid drill or impact hammer and star bit may be used to drill the hole. Personnel should check the floor layout prior to drilling as some floors contain Q-cells or under-surface ducts. Damage to the Q-cells or under-surface ducts may cause an electrical hazard.

(c) Anchoring in concrete may be accomplished with a Ramset gun. If this method is used, extreme caution and thorough familiarization with the operation of the gun are necessary. Personnel should know the load or charge size to properly select the correct stud size. Inspect the area to which equipment is to be anchored for type of material, thickness, and location of reinforcing bars. After the stud has been positioned, always check for firmness in the set and what is located behind the area prior to using the Ramset gun. Some cement surfaces tend to peel or chip when studs are driven in, thereby reducing strength of the set. What do we do in this case? Appropriate epoxy patches should be accomplished to repair this damage. Always use this gun with CAUTION as it has the destructive power of a .22-caliber rifle.

(3) Wall mounting of cabinets or equipment may cause variable difficulties. Wall construction and space within the wall are to be examined for possible conduits or electrical circuits which may be damaged by fastening devices used to support units. A suitable method should be selected for the attachment utilizing proper tools and fastening devices consistent with the wall construction and the weight to be supported.

67.-71. RESERVED.

CHAPTER 6. INSTALLATION OF CABLE ENCLOSURES

72. GENERAL. Several types of cable supports and enclosures are in use throughout National Airspace System (NAS) facilities. The types most used are cable ladders/trays, cable ducts, and conduits. On larger facilities, cable trays, square ducts, and most conduit installations are installed as part of the construction contract. Usually, F&E personnel install cable tray drops and conduits required to interface power, control, and other circuits between equipment racks. At times, installation personnel must extend cable enclosures in order to accommodate additional equipment in existing facilities. In these cases, the installation should conform to existing techniques. On smaller projects, installation crews may be required to install the entire cable tray and conduit systems.

73. CABLE TRAYS. Cable trays are used where large volumes of wiring must be installed. When modernization of a system is required and an additional cable tray is to be installed, techniques compatible with the existing site will be used. Routing of additional cable enclosures will usually be detailed on the project drawings.

74. CABLE DUCT. When cable trays (more commonly identified by the trade name "square ducts") are extended in existing facilities, the installation and support of these cable trays will conform to existing techniques at the facility. Horizontal cable tray runs over equipment racks are adequately supported by connecting vertical cable tray drops to the racks. On long horizontal runs, the cable trays will usually be supported by special brackets, which are usually suspended from the equipment room ceiling using a 3/8-inch threaded rod. Supports are to be installed at not more than 5-foot intervals. Cable trays along walls or floors are to be secured using approved fastening devices consistent with the material used in the walls or floors.

75. CABLE LADDERS. Cable ladders are used where large volumes of cable must be installed. Preformed curves, risers and straight runs of cable ladders are available. Cable ladders are a long lead time item. They should be ordered as early as possible.

76. CONDUITS. Normally, three types of conduits are utilized in electronic installations. These are thin-wall, flexible, and watertight flexible conduits. Usually, rigid conduits are not installed by the installation personnel due to special tool requirements. Reference should always be made to the National Electrical Code (NEC) for type and size of conduits to be used.

a. A flexible conduit is normally used between power distribution panels and equipment racks. This conduit is usually supported by commercially available straps which are attached to walls, ceilings, or existing cable trays. It is preferable to install a conduit in an unexposed location to ensure a neat looking facility.

b. A flexible conduit is usually installed in trays or floor ducts to shield and separate control, audio, video, and data cables from AC power wiring. Usually the support of the flexible conduit is provided by the cable tray or duct system. Where required, support is provided in the same manner as the flexible or rigid conduit. Flexible conduit is also used in equipment racks to interface power outlets when multiple circuits are required. Only compression or set screw type fittings shall be used with flexible conduit. This method should be employed only when it is not practical to install separate conduit or square duct runs; as if installed within an AC duct run, the AC conductors may require derating in accordance with the NEC.

c. A liquid-tight flexible conduit is normally used in outdoor or other locations where moisture problems exist. Installation and support are the same as for other types of conduit. A liquid-tight conduit usually has a shorter bending radius and may be used in locations where space is limited. Liquid-tight conduit shall not be used where it will be subject to physical damage.

77.-82. <u>RESERVED</u>.

CHAPTER 7. GROUNDING, SHIELDING, AND LIGHTNING PROTECTION

83. GENERAL. The earth electrode system establishes the electrical connection between the facility and the body of the earth. This connection is necessary for lightning protection, power fault protection, and the minimization of noise between interconnected facilities. The system should be tailored to reflect the characteristics of the site and the requirements of the facility. It must be properly installed and steps must be taken to assure that it continues to provide a low resistance connection throughout the life of the structure.

The main purpose of grounding is to maintain all portions of a system at the same potential at all times by providing low-impedance paths for any excess energy to equalize throughout the system and simultaneously drain to earth. This is accomplished by insuring that all equipment configurations, antennas, and support structures, as well as all metal structures, frames, armored cables, control equipment enclosures, and conduits, are at ground potential; thereby, reducing the possibility of electrical shock to personnel, improving the operation and continuity of service of all equipment configurations, and reducing Radio Frequency Interference (RFI).

84. CABLE ENCLOSURE, JUNCTION BOX AND GROUNDING. A continuous No. 6 bare copper ground wire shall be run from the station ground along the inside of each duct with branch runs connected to it using pressure-type connectors. Each section of the duct or tray shall be connected to the ground wire by a pressure-type connecting lug using a nut, bolt, and lock washer or the split-bolt technique. Paint shall be scraped from the point of attachment to ensure a good metal-to-metal contact. Where expanded or punched metal cable trays are used, a ground wire need only be run from one end of the cable tray system to the station ground.

85. EQUIPMENT ENCLOSURE GROUNDING. A short No. 6 bare copper wire will be connected between the ground wire in the cable ladder or duct and the equipment racks using pressure-type connectors and lugs. For a row of racks, connect the first rack to the duct or tray ground with a No. 6 bare copper wire. Adjacent racks will be grounded to this ground. Within the racks, No. 6 bare copper wire can be used for grounding the equipment chassis to the rack ground when separate chassis grounds are not required.

86. SIGNAL GROUNDS. Signal grounds are connected to the equipment terminal blocks or multi-pin connectors. The other end will be connected to a terminal block which is grounded to the signal ground. To prevent ground loops, all terminal blocks for a signal path are connected in a series back to the main signal grounding point. Sufficient ground terminals shall be provided on each terminal block to ensure spare ground connection points for future expansion. The conductor used between the terminal blocks and the main signal ground will be an insulated, stranded wire.

87. SPECIAL GROUNDING SITUATIONS. Special grounding techniques are used at facilities with automated air traffic control data processing equipment such as

ARTCC's, high-density ATCT's, RAPCON's, and TRACON's. Care is to be taken when working in these facilities to ensure that the individual grounding systems are not compromised. The following provides some general details concerning grounding at ARTCC's and high-density terminal facilities.

a. ARTCC's have separate power grounds for critical, essential, and non-essential power sources. It is important that power grounds on these circuits are not cross-connected except at the station ground. In addition, primarily in the data processing systems, separate cabinet, chassis, and signal grounds are required.

b. High-density terminal facilities at this time have only the essential and nonessential power systems. Care must be taken to keep the system grounds separated. The data processing equipment in these facilities has its own grounding system completely separate from other systems. Again, separate cabinet, chassis, and signal grounds are provided, and care is to be taken to ensure the integrity of these grounds.

88. SHIELDING. As a general rule, all active or receptive cables should be shielded in addition to maintaining maximum separation between cable runs. When circuits require shielded cable, GROUND ONLY ONE END OF THE SHIELD to reduce circulating current. All audio circuits are to be run in twisted, shielded-pair cables. For purposes of determining the need for shielding or not shielding conductors or groups of conductors, three categories of cabling have been established.

a. Active cables are any conductors or cables carrying levels of current or voltage of sufficient level to radiate.

b. Receptive cables are any conductors or cables carrying very low signal levels of audio, data, or RF energy. Maximum protection must be provided for this class of cable.

c. Passive cables are any conductors or cables for DC control lines, remote control circuitry, or multiconductor cables providing remote control. Passive cables do not require shielding unless collocated with unshielded power wiring.

89. LIGHTNING PROTECTION. Lightning arresters or suppression equipment is being installed on the main power feeder circuits of new NAS facilities. Special transient suppression devices are used on control and signal lines for communications, radar, and NAVAID facilities.

a. Lightning arresters are normally installed on the main power input lines of the new facility under the construction contract. On existing solid state equipment facilities, the lightning arrestors should have been installed by the Airway Facilities sector as part of the modification program.

Some electronics equipment modifications (EEM) have been issued for facilities which require transient suppression devices in control and signal landings. Check at the start of each project to determine if a modification is required and, if applicable, the modification kits are on hand or have been ordered. Installation of these devices must be accomplished in accordance with the modification directives.

b. TELCO Circuits. Many component failures of equipment have been traced to high voltage transients induced in control lines by lightning strikes. Damage can be minimized by installing lightning protection circuits (LPC) between FAA equipment and the TELCO demarcation terminal strip. Care must be taken not to install LPC's on TELCO lines having automatic sensing and switching LSAS equipment or other facilities that have landline inputs passing through TELCO solidstate amplifiers before interfacing with FAA equipment.

c. The recently furnished communications antennas are provided with an internal spark gap and need only have the mast securely grounded. Older type antennas are not provided with this gap; therefore, one will have to be fabricated. A 1/16" x 3/4" x 4" copper strap pointed on one end may be used for this purpose. A 1/8-inch spark gap spacing is required between the pointed end of the copper strap and the antenna with the other end of the strap bonded to the antenna support. The earth-ground connection will be made to a ground rod at the base of the antenna tower or mast or to lightning rod grounds.

The outer conductors of both halves of each DC pole of the antenna are the same DC ground potential. The base of the antenna shall be tied to the antenna tower grounding system via No. 6 copper ground wire. Lightning rods shall provide a cone of protection relative to the top of the antenna element not less than 45 degrees from normal.

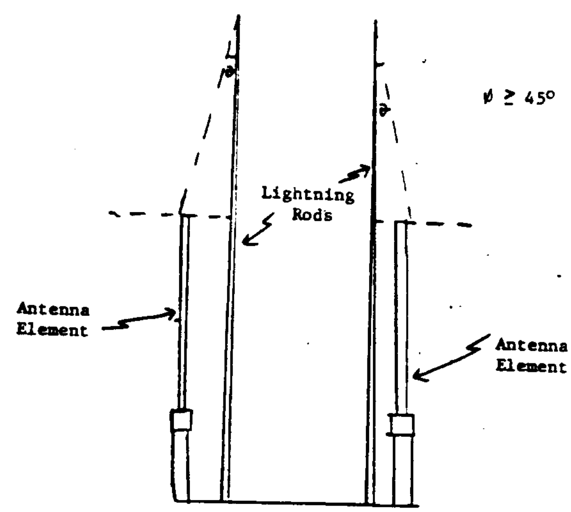


Figure 2-11. Lightning Protection of Communication Antennas

90.-94. RESERVED.

CHAPTER 8. POWER CIRCUIT INSTALLATION

95. GENERAL. All power circuits shall be installed in accordance with the latest issue of the National Electrical Code (NEC) and FAA specification FAA-C-1217 (Electrical Work, Interior) and its applicable addendums. Normally, power circuit drawings are provided as part of the engineering package and should be designed to provide equal-phase loading. Therefore, it is important that if any changes or additional circuits are required, care is to be taken to balance the phase loading to the maximum extent possible.

96. POWER DISTRIBUTION PANELS. Power distribution panels are usually contractor installed before the start of the project. If it becomes necessary for installation personnel to install an additional panel to provide more circuits, factors such as power distribution panel rating, ampere rating of main circuit breaker and feeder breaker, and length of the feeder cable must be considered to determine the size of the feeder cable. In addition to the main feeder cables, a neutral conductor of the same size as the phase conductors is to be installed into the new panel and terminated to the panel's neutral bus. Most power panels supplied from a vendor do not contain a ground bus. Therefore, a ground bus is to be procured and installed in the power panel and connected to the building service panel or, if a direct commercial power feed is provided to the panel, both the ground and neutral buses are to be grounded to the main station ground using separate insulated cables. The ground wire size will conform to the NEC, but will be no smaller that size No. 6 American Wire Gage (AWG). All circuit breakers will be identified as to their functions. Likewise, all neutral, ground, and hot conductors will be labeled with wire markers to identify the circuit breaker they are respectively associated with.

97. BRANCH CIRCUITS.

a. There are several types of branch circuits used in FAA facilities. The most commonly used is a three-wire, single-phase circuit. Others are a four-wire, three-phase, and a three-wire, three-phase circuit.

(1) The three-wire, single-phase circuit consists of a hot phase, neutral, and ground conductors.

(2) The four-wire, three-phase circuit has three-phase conductors, each on a different phase and one neutral conductor. This type of branch circuit is used as a main power feeder for data processing equipment or three-phase power supplies.

(3) The three-wire, three-phase circuit consists of the three-phase cables and is used for motor systems such as those used to drive radar antennas.

b. The size of the phase and neutral conductors is determined by the load and circuit breaker size, but no smaller than No. 12 AWG solid. Normally, the ground conductor is the same size as the other conductors, but no smaller than No. 12 AWG.

c. When installing branch circuits, care will be taken to ensure that the capacities of the conduit and/or power ducts, as specified in the NEC, are not violated. If necessary, on the 120-volt, single-phase circuits, a single neutral and ground conductor can be used for three separate circuits provided that the three circuits are of different phases and from the same power distribution panel.

d. Circuit breakers used for branch circuits will not be rated at less than 15 amperes.

98. RACK AND EQUIPMENT POWER WIRING. The number of branch circuits in a single equipment rack will depend on the equipment to be installed in the rack. A separate circuit will be provided for main and standby equipment. For communications facilities where multiple main and standby equipment are in the same rack, a separate circuit on separate phases is to be installed for the main and standby equipment. On all new equipment installations, strip and convenience outlets of the grounding-pin type are to be used. Since some equipment is polarized, each outlet and associated plug should have the "hot" lead identified with a red dot. The convenience outlets of three racks may be connected to the same branch circuit.

99. COLOR CODING. All branch circuit and feeder conductors shall be color coded as specified hereinafter. The color coding shall be continuous throughout the facility on each phase conductor to its point of utilization so that the conductor phase connection is readily identifiable in any part of the installation. The equipment grounding conductor shall be covered with green insulation or shall be bare copper as specified hereinbefore. Conductors covered with green insulation with yellow tracers shall be used for other grounding systems. Neutral conductors shall be continuous white unless more than one system is run in the same raceway, box, or other type enclosure. The neutral of the other systems shall be white with identifiable colored tracers (not green). Where color coding is not available in the larger size conductors, the conductors shall be color coded by use of color coded tape, half lapped for a minimum length of 3 inches. Where conductors are color coded in this manner, they shall be color coded in all junction and pull boxes, accessible raceways, panelboards, outlets, and switches, as well as at all terminations. Conductors in accessible raceways shall be coded in such manner that by removing or opening any cover, the coding will be visible.

Phase conductors shall be color coded as follows:

Single Phase	Three Phase	
120/240 Volts	120/208 or 240 Volts	240/480 Volts
Line A - Black	Phase A - Black	Phase A - Yellow
Line B - Red	Phase B - Red	Phase B - Brown
	Phase C - Blue	Phase C - Orange

Color coding for conductors in control cables shall be in accordance with NEMA standard WC-5.

100.-104. RESERVED.

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CHAPTER 9. CABLE TYPES AND INSTALLATION

105. GENERAL. Several types of coaxial and multiconductor cables are used in FAA facilities. Multiconductor cables are generally connected to terminal blocks, terminal strips, or plugs. Coaxial cables are used for radio frequency (RF), data, pulse, and video transmissions in the NAS facilities. Most cables are secured by means of clamps, spiral wraps, or cable ties.

106. MULTICONDUCTOR CABLE. Most multiconductor cables are color coded to ensure that individual wires or pairs are easily identified. Multiconductor cables may be unshielded, have an overall shield, or contain individually shielded pairs. Shielded-pair cables are used for audio and data circuits, and unshielded cables are normally used for control functions. Overall shielded cables are used for control functions when included in the same duct with unshielded power cables. The color codes for various multiconductor cables are included in Appendix 4. The cable butt is the point at which the sheath or covering is terminated and the wires are left protruding for later connection. Cables butted in dry, heated locations need not be waterproofed. Cables approaching terminal strips at right angles should be butted 3 inches back from the terminal strip. Cables are to be supported immediately back of the butting point by tying or clamping to a frame member or to the side of a cabinet.

a. Cables having a plastic sheathing need only have the plastic cut and stripped to expose the wires. This is efficiently done with a tool designed for such work which prevents cutting too deeply and provides a true cut.

b. When butting individually shielded-pair cable, cut and remove the outer sheath at the point the cable breaks out of the cable harness to expose the twisted-pair cable. Shielding may be either braided copper or aluminum foil with a bleeder wire enclosed. Push the outer sheath back approximately 1 inch and separate the braid or bleeder wire from the twisted pair. Remove the aluminum foil, if applicable. If the shield is to be terminated in a termination cabinet to provide a ground or to provide continuity of the shield, push the outer sheath down and tape. Since only one end of the shield is to be grounded at the last termination point, remove the shield or bleeder wire, push the outer sheath down over the ends of the shield, and tape or use heat-shrink tubing.

c. Generally, individual pairs should be butted as near as practicable to where the wires break out of the main cable harness or plastic slotted duct which is sometimes used in equipment racks. In cases where a comparatively large number of cables enter an equipment rack or terminal cabinet, space can be conserved and a neater installation made by butting all cables at the same point. This should be 4 inches to 6 inches from the point where the wires break out to the first terminal strip.

d. Several methods of securing multiconductor cables or many individual conductors together are in use.

(1) Spiral wrap is a flexible plastic strip which comes wrapped in a tight spiral. It can be obtained in 1/8-inch to 3/4-inch widths that can secure wiring bundles ranging from 1/4 inch to 5 inches in diameter.

(2) Cable ties or tyraps are used extensively to secure or bundle cables. They are readily available in several sizes and composition for either indoor or outdoor use.

(3) Plastic duct or conduit with slots and snap-on lids is preferred to secure cables within equipment racks.

107. FIBER OPTICS. The official specification for fiber optic cables is FAA-E 2761 and has been recently issued.

The recommended optical cable for "trunk" applications, whether direct-earth-burial (DEB) or duct, is a six-fiber cable built around a central strength member of steel wire or structural fiberglass. Each optical fiber has its own little "mini-duct", called a "loose buffer tube", in which the fiber, as the name implies, lies loosely. The loose buffer tube is about the same diameter as a piece of spaghetti; approximately two millimeters or so. Most such cables being built today have the buffer tube filled with a gel having the approximate consistency of petroleum jelly. This lubricates the fiber, and allows it to "float" in the buffer tube. The gel also retards the intrusion of water into the buffer tube in the event of a breach in the cable.

In the recommended cable, there is only one fiber in each buffer tube. The buffer tubes are wound helically around the central strength member. A common design practice is to use multiples of six buffer tubes per cable. Around the helically wrapped buffer tubes, there is usually a tape wrapping, over which is extruded an inner jacket of plastic. Over this inner jacket is armor of corrugated aluminum or passivated steel tape (for direct-earth-burial installations), or a braid of kevlar or other yarn (for duct installations). The outer jacket, also of plastic, is extruded over the armor or braid.

Regarding cable installation, as long as the maximum allowable pulling tension and minimum bending radii under tension are observed, there is no basic difference between pulling fiber optic cables and any other cable. Because they are so much lighter in weight, and more flexible than metallic cables, fiber optic cables are actually much easier to install than an equivalent number of coaxial cable channels. Minimum recommended bending radii (static, no tensile load), which are less than those for the loaded cable, should also be observed. Lubricants commonly used for aiding duct installation (pulling) of ordinary metallic cables may also be used for fiber optic cables.

The recommended optical connector is an Amphenol-906-compatible SMA connector. The reason for recommending this connector is that it has become a "de facto" industry standard, being used very widely, although admittedly not exclusively, by manufacturers of optical transmitters and receivers.

108. COAXIAL CABLE. Lower voltage standing wave ratio (VSWR), phase compensation, lower attenuation, and better RF shielding are some of the desired qualities in coaxial cable used in the FAA systems. Coaxial cables are extensively used in communications, NAVAIDS, radar, and data systems. The most commonly used RF coaxial cables and connectors are listed in Appendix 3.

a. As a general rule, the minimum bending radius of coaxial cable is 10 times the diameter of the cable; i.e., a 1/2-inch coax should not be bent sharper than a 5-inch radius or a 10-inch diameter circle. Where possible, a larger bending radius is recommended. Many types of coaxial cable, especially those using a solid-sheath or armored jacket, require a much larger bending radius. The minimum bending radius of cables will usually be given in the manufacturer's specifications.

b. Generally, coaxial cable is supported by the same method used for other types of cable and should never be supported on a sharp edge. Where coaxial cable breaks out of a rack, a piece of rounded wood or fairing must be used on the edge of the tray or ladder. When tying or clamping the cable, use very light pressure to hold the cable in place. If several cables are to be tied to a support, use flat "ribbon" type ties. When coaxial cables are supported outside the building, special consideration must be given to wind flexing, temperature effect, etc., to prevent damage.

c. To provide the most efficient transfer of energy, the cable must terminate in its characteristic impedance. This may be an antenna or a tuned RF circuit, fed at the proper point, or resistor of the proper value. In case of doubt as to the termination point or method, a confirmation should be obtained from the project engineer before actual termination is made. Require termination of spare or unused cables where RF is present.

109. TERMINATION METHODS. Many varieties of terminating devices and methods are used in electronic systems. The most popular types are punch block circular, multi-pin, and termination strips. Approximate termination tool should be provided for maintenance after initial installation.

110. CABLE REMOVAL. When performing modernization or improvement at a facility, unused cable and wire in a cable tray or conduit not required for near future projects shall be removed. The unused cable or wire installed for future use shall be marked on both ends.

111.-115. <u>RESERVED</u>.

CHAPTER 10. INTERFACILITY TRANSMISSION METHODS

116. GENERAL. Besides the normal telephone services, TELCO circuits are mainly used for remote air/ground communications audio and control, NAVAIDS monitor and control, narrow-band radar data, and flight plan data. FAA control lines are used principally for on airport remote transmitter/receiver audio and control circuits, radar control, and control and/or monitoring of airport NAVAIDS equipment.

117. TELCO LINES. Due to the various types of TELCO lines used, signal level tolerances and specifications are not included in this handbook. Reference should be made to leased service orders for the type of circuit requested and to Order 6000.22, Maintenance of Two-Point Private Lines, for line specifications and signal levels. It is essential that performance checks on TELCO lines be conducted by sector personnel as soon as possible after the lines are installed and while telephone personnel are on site. Line audio runs with appropriate forms completed will be accomplished by sector personnel at the time of acceptance from TELCO. It is imperative that the Interfacility Planning and Telecommunications Section, ASW-422, be notified as soon as the lines are accepted from TELCO.

118. FAA LINES. The FAA makes extensive use of multiconductor and coaxial cables between adjacent facilities which are in close proximity. These lines are generally contractor installed and checked under a construction contract and may be installed in duct banks, but more often by the direct earth-burial method.

a. Commonly used multiconductor cables currently in use are 12-, 26-, and 52-pair No. 19 AWG for control, audio, and monitoring circuits. Line checks for these cables are usually made with a megger to verify that the lines are usable. Normal checks include leakage resistance from individual conductors to ground, isolation between paired conductors, and loop resistance of individual pairs. Insulation resistance between conductors, and conductor and ground, must be checked and meet the tolerance in accordance with Order 6950.22, Maintenance of Electrical Power and Control Cables. Loop resistance is dependent on the conductor size and length.

b. Direct buried coaxial lines are used for NAVAIDS, A/G communications, and terminal radar facilities. These cables are to be checked with a time domain reflectometer (TDR) prior to and after burial to ensure that the line meets specifications and was not damaged when buried.

119. RCL. The FAA operates a system of FAA-owned terrestrial microwave links to transmit voice and data between ARTCC's, other ARTCC's, and ARSR's. This system is known as the Radio Communications Link (RCL) system. The RCL provides the capability of adding voice/data information at any site along its route through drop and insert (D/I) equipment. When it is necessary to add a voice or data channel to the RCL network, D/I equipment is utilized to accomplish this function.

a. The voice/data signal level tolerances vary according to the particular application, but the signal levels presented to the RCL channel interface is always the same: -16 dBm transmit and +7 dBm receive for voice; and -29 dBm transmit and -6 dBm receive for data. Adjustment to these levels is accomplished by adding attenuation at the point of interface between the RCL and the incoming signals.

b. Placing voice/data on the RCL requires the use of channel modems to interface low frequency voice/data signals to the radio frequency (RF) equipment in the RCL. The channel modem will require setting of the assigned channel frequency and adjustment of the transmit and receive levels. Order 6350.13A, Maintenance of Radar Microwave Link Equipment, RML-1A, -2, -3, -4, specifies the levels and tolerances for the RCL system.

120.-125. RESERVED.

CHAPTER 11. EQUIPMENT INSTALLATION AND ADJUSTMENT

126. GENERAL. Due to the wide variety of FAA equipment and the continual updating oI equipment, equipment alignment or performance data will not be included in this order. Reference to the appropriate instruction manuals and maintenance handbooks will be required to obtain this information. All equipment performance data shall be completed and distributed before commissioning of a system.

127. EQUIPMENT ALIGNMENT. In most cases, the FAA has developed an order outlining the alignment procedure for the installation of equipment. Compliance of these specific levels in these orders are mandatory. However, in instances where the FAA has not yet developed directives for the equipment, the alignment procedure outlined in the manufacturer's instruction manual will be used.

128. RECORDING PERFORMANCE DATA.

a. Technical Reference Data Criteria. At the time of commissioning a facility, system, or equipment, the measured values of parameters recorded on FAA Form 6030-17, Technical Reference Data Record, shall be within the upper and lower INITIAL tolerance limits listed in Chapter 3, Standards and Tolerances (blue sheets), of the applicable maintenance technical handbooks (or as otherwise authorized by other appropriate directives). Initial tolerances may be referred to as AUTHORIZED TOLERANCES in some maintenance technical handbooks. If a measured parameter value is not within the initial tolerance limits at the time of commissioning and cannot be brought within those limits through proper corrective and/or optimization procedures, an approved FAA Form 1800-49, NAS Configuration Control Decision, shall be required before the facility, system, or equipment is commissioned for use in the National Airspace System.

b. Facility Technical Reference Data. FAA Form 6030-16, Technical Reference Data Records Cover/Transmittal Sheet, and FAA Form 6030-17, replace the FAA Form 198 series in its entirety. FAA Form 6030-16, serves as the control sheet for all applicable facility, system, and equipment, and FAA Form 6030-17, serves as the transmittal for these records. FAA Form 6030-17 shall be used at the time of commissioning and shall be updated as necessary. Separate FAA Forms 6030-17 shall be completed for each facility, system, and unit of equipment covered by an individual maintenance technical handbook. The data recorded on this form shall be the specific standards and tolerances, of applicable maintenance technical handbooks. When maintenance technical handbooks have not been published at the time of commissioning, the program manager, shall prescribe the interim technical data which will be recorded until the maintenance technical handbooks are received. FAA Forms 6030-16 and 6030-17 shall be filed together in the Facility Reference Data File (FRDF). All superseded sheets shall be retained as a historical record.

c. FAA Form 198 Issuances by Manufacturers. Equipment instruction books have occasionally been issued by manufacturers with data lists called Technical Performance Data, FAA Form 198 (usually without an actual FAA Form 198 number assigned), and similar terminology. These data lists are very similar to the discontinued FAA Form 198 series. The purpose of these lists is to assist the regions in developing interim technical reference data (formerly preliminary FAA Form 198 data) and/or for use by establishment personnel to document technical performance when transferring a facility, system, or equipment to Airway Facilities sector personnel. The Airway Facilities Division may prescribe the use of such lists for establishing interim FAA Form 6030-17 when the applicable maintenance technical handbook has not been issued at the time of commissioning.

129. FLIGHT INSPECTION CHECK. Many facilities require flight inspection prior to commissioning. The facilities that require flight inspection include electronic and visual navigational facilities and radar facilities. Generally, the most involved flight inspection a facility undergoes is the commissioning flight inspection.

Flight inspection is very expensive, with the cost now exceeding $1,000 per hour. It is essential that proper planning be done prior to flight inspection to prevent costly delays. Installation personnel communicate with flight inspection on aircraft type AM radios using frequencies 135.85 MHz and 135.95 MHz. The radios should be checked before flight inspection and a spare radio should be available so that radio failure does not waste expensive flight check time.

The flight check for some facilities is quite involved, especially for some navigational facilities such as VOR's and ILS's. Insure that the facility is ready for flight check before scheduling one. If possible, simulate some of the adjustments that the flight inspection will require to insure that the equipment is ready for flight check.

All flight inspections that are associated with installation projects are scheduled by the regional flight check coordinator. Contact the unit supervisor for your section if you are unsure who the flight check coordinator is. Only after the flight inspection has been formally scheduled by the flight check coordinator is it permissible to contact the Flight Standards District Office (FSDO) to discuss specifics about a flight check.

130.-135. RESERVED.

CHAPTER 12. CONTRACT INSTALLATIONS

136. GENERAL. Normally, the region's responsibility during turnkey or contract installations is limited to site preparation, monitoring, and acceptance of equipment installation and testing. Final commissioning of the system is the responsibility of the FAA. The regional office designates the technical officers representative (TOR).

137. TECHNICAL ONSITE REPRESENTATIVE (TOR) RESPONSIBILITIES.

a. The function of the TOR is to provide regional coordination, direction, and guidance necessary for effective and timely accomplishment of site preparation, installation, testing, evaluation, and precertification during implementation. A detailed set of instructions and a work order will be provided by the regional office to the TOR.

b. The TOR is the principal interface between the region and the program technical officer.

c. The TOR is responsible for monitoring the work of the contractor and participating in testing of the system during the onsite implementation.

d. A weekly narrative report on the status of the project and problems encountered is required to be submitted to the program technical office by the TOR.

138. MONITORING OF CONTRACT INSTALLATIONS.

a. Contract acceptance is accomplished by completing FAA Form 256, Inspection of Material and/or Services, through line 24 and signing the "inspected by" block. The FAA Form 256 is then routed to the regional office for distribution. The Washington technical officer signs block 25 of FAA Form 256 to accept the system.

b. The TOR does not have the authority to approve changes that affect the contract price, delivery schedule, or end-use requirement of the equipment. These changes can be authorized only by the technical officer. It is essential to ensure that all contract specifications, performance measurements, and tests have been satisfactorily completed in accordance with installation and test plans before the FAA Form 256 is prepared.

139.-144. RESERVED.

CHAPTER 13. MAINTENANCE ORDERS AND INSTRUCTION BOOKS

145. GENERAL. An instruction book provides detailed, descriptive installation, operation, maintenance, and logistic information regarding a particular type of electronic or plant equipment, subsystem, or system. A maintenance technical directive provides supplementary system-oriented policy, descriptions, standards/tolerances/limits, maintenance schedules, and maintenance procedures. The information in maintenance technical directives and instruction books tie together the various parts of equipment that comprise a system. They may cover a single category of equipment and/or they may be applicable to several "generations" or categories of systems and equipment. In the absence of a maintenance technical directive the applicable instruction book should be used.

146. MAINTENANCE ORDERS. Maintenance orders identify the required maintenance intervals, critical parameters, parameter tolerances, and detailed maintenance procedures for FAA equipment. A current listing of all orders and directives may be found in the current issue of Order SW 0000.42L, Airway Facilities Field Offices Directives Checklist as of November 30, 1987.

147. INSTRUCTION BOOKS. Instruction books will be provided with all equipment or will be available at appropriate facilities. They will be used to augment FAA maintenance orders and directives. In the event of a discrepancy between FAA orders and manufacturer's instruction book, procedures or parameter tolerances identified in the FAA orders will take precedence.

148.-153. RESERVED.

CHAPTER 14. JOINT ACCEPTANCE INSPECTION

154. GENERAL. A Joint Acceptance Inspection/Acceptance Inspection (JAI/AI), as appropriate, is required for each F&E project completed in the Southwest Region. The Airway Facilities Sector (AFS) Manager or his designee will act as onsite JAI or AI board chairperson. The chairperson will be identified on or before the Phase II/preconstruction meeting. The designated AFS representative will observe the installation project and represent the sector throughout the entire project, including the JAI/AI.

When appropriate and necessary, the JAI/AI should be performed in increments (partial JAI's/AI's) of a planned series. The use of partial JAI's/AI's should be outlined at the beginning of the project through a cooperative effort between the AFS and F&E representatives. As a minimum, the electronics and environmental phases should have separate JAI's. Once agreed upon, the partial JAI's must be signed and dated by the AFS and F&E representatives. All partial JAI's shall be attached to the final JAI.

155. COORDINATION. It is incumbent on the F&E representative to coordinate the scheduling of the formal JAI with AFS personnel, the installation supervisor, and the project engineer. Coordination with AFS personnel will be made 10 days in advance for projects requiring 30 or more working days, 5 days in advance for projects requiring less than 30 working days or at the Phase II meeting if the project will last less than 5 working days. The F&E installation crew will actively participate in the completion of the JAI.

a. Exceptions. Conditions which do not meet FAA standards of acceptability are referred to as exceptions. Acceptance of a facility, system, or equipment can be made with exceptions provided the exceptions do not derogate personnel safety, maintainability, reliability, or operational services to the extent that the facility, system, or equipment cannot be used to properly satisfy the intended functions. Where exceptions exist, such that the facility cannot be used to provide the intended function, a JAI report shall be prepared defining the actions necessary for acceptance of the facility for operation and/or assumption of maintenance responsibility. As directed by the responsible regional office divisions, notice of an exception which precludes a facility from being accepted for operation shall be transmitted to the next higher level supervisor by the joint acceptance representatives.

(1) Categories of Exceptions. The two categories of exceptions are:

(a) Minor. A condition which has no appreciable effect on facility, system, or equipment operation or has only a slight effect on operational or maintenance workload. A minor exception does not prevent the facility, system, or equipment from being commissioned and placed into service.

(b) Major. A condition which has an adverse effect on facility, system, or equipment reliability of service, safety of personnel, or will result in excessive operational or maintenance workload. A facility, system, or equipment with a major exception cannot be commissioned or placed in service until the exception is resolved.

(2) Determination of Exception Category. The joint acceptance representatives shall evaluate each identified exception and determine whether it is a major or minor exception based on the criteria prescribed in paragraph 405h(1) and paragraph 406 of Order 6030.45, Facility Reference Data File.

(3) Documentation of Exceptions. All identified exceptions shall be indicated on FAA Forms 6030-19 through 6030-24, Joint Acceptance Inspection Report Checklist, and fully documented on FAA Form 6030-25, Joint Acceptance Inspection Report Exceptions List and Clearance Record. Partial JAI reports may be processed individually or the exceptions reported on the partial JAI reports not cleared at the time of the final JAI may be transferred to and documented on the final JAI report at the option of the regional Airway Facilities Division. The authority (order, handbook, specifications, NEC, OSHA requirements, etc.) shall be provided for each exception. The required actions for correcting exceptions shall be included on the JAI report exception list and clearance record. Each major exception shall be listed on a separate FAA Form 6030-25 with a full description of the major exception and the recommended corrective action.

(4) Assignment of Exception Clearance Actions. The joint acceptance representative, in consultation with the resident engineer (RE), work order carrier (WOC), or technical onsite representative/contracting officer's technical representative (TOR/COTR) and, as appropriate, other representatives, shall assign an action office and an estimated completion date for each exception identified during the JAI. The action offices shall be limited to the Airway Facilities Division's branches and sectors. All pertinent factors should be carefully considered in assigning clearance actions. The sector representative and the RE, WOC, or TOR/COTR should cooperatively strive to assign action items to the office which can accomplish them in the most expeditious and efficient manner. If sector resources are available, significant cost savings may be realized if the sector accomplishes clearance actions that would require the regional office personnel to remain at or return to the project site at a later date. In some cases, portions of an action should be assigned to both the responsible Airway Facilities Division's branches and sectors to expedite completion. The action office is responsible for notifying and coordinating with other organizations to accomplish the clearance actions.

(5) Resolution of Disagreements. Exceptions on which joint acceptance representatives cannot reach a mutual agreement shall be itemized on a separate FAA Form 6030-25. The dissenting representatives shall state their positions and recommendations in the REMARKS section of the form and, if necessary, additional sheets of plain bond paper. The JAI report shall be forwarded through appropriate channels for resolution. The JAI report shall be amended by the deciding official to reflect the final decision rendered on items of disagreement.

(6) <u>Determination of Nonacceptability</u>. A facility, system, or equipment with a major exception cannot be recommended for acceptance by the joint acceptance representative. An identified exception which will prevent a facility, system, or equipment from being accepted for maintenance and/or operation shall be referred by telephone to the responsible Airway Facilities Division's branch prior to the completion of the JAI so that every effort can be made to resolve the problem. The Manager, Airway Facilities Division, or his/her designee, shall be immediately notified of the nonacceptance of a facility, system, or equipment. The joint acceptance representative shall document each major exception on a separate FAA Form 6030-25 as described in paragraph 405h(3). The Airway Facility Sector Manager shall forward copies of the JAI report containing a major exception to the Manager, Airway Facilities Division, and the designated division branches within 5 workdays following a determination of nonacceptability.

(7) <u>Design Deficiencies and Recommendations for Improvements</u>. Items pertaining to design deficiencies and recommended facility, system, or equipment improvements which are identified during the JAI, but cannot be classified as exceptions, shall be listed on plain bond paper or entered on FAA Form 1800-2, NAS Change Proposal, and atttached to the JAI report. A full description should be provided for each item along with a recommended corrective action. These items shall not be treated as exceptions but will be reviewed by the Airway Facilities Division and a determination will be made. The Airway Facility Sector Manager shall be notified of the determination.

b. <u>Certification and Commissioning</u>.

(1) Certification normally occurs concurrent with commissioning. However, under certain circumstances, it is necessary to conduct lengthy testing and evaluation of new or improved systems/subsystems. In these instances, it is necessary to provide interim certification for the test systems/subsystems. This certification shall be based upon applicable standards and tolerances. In the event that certification standards and tolerances have not been fully developed, interim standards will be based upon the demonstrated ability of the system/subsystem to perform its intended function. Software diagnostics will be used whenever practical. The use of interim standards shall be fully coordinated with appropriate airway facilities engineering branch in Washington headquarters.

Only personnel issued appropriate certification authority and specifically assigned certification responsibility in writing may certify specified systems, subsystems, and equipment. For further details refer to Order 3400.3, Airway Facilities Maintenance Personnel Certification Program. However, preventive and/or corrective maintenance activities, which do not affect any of the certification parameters (e.g., observation of meters or monitors, replacement of fuses, etc.), may be accomplished by personnel who do not possess certification authority and/or who have not been assigned certification responsibility, provided the limitations of these duties are clearly identified in writing. Such activities are to be documented in the FAA Form 6030-1, Facility Maintenance Log, but no certification statement shall be made.

Certification is (1) the technical verification that a system, subsystem, or equipment is providing the required or advertised services to the user (Air Traffic personnel or the aviation public) at any given time subsequent to commissioning followed by (2) the insertion of the prescribed written entry in the official facility maintenance log. It includes independent determination as to when a system, subsystem, or equipment should be continued in, restored to, or removed from service.

(2) Certification Parameter. Certification parameters are selected critical indicators of the quality of the required or advertised services being provided to the user of systems, subsystems, and equipment.

(3) Commissioning. Before any equipment can be incorporated into NAS and used in the Air Traffic Control System, it must be commissioned. Commissioning is the formal exercise of incorporating a new facility, system, subsystem, or equipment into the NAS. This term has legal and budgetary significance and has been used to justify logistic and manpower operational support as an FAA obligation under public law. After the equipment has been commissioned, the appropriate airway facilities sector assumes formal maintenance responsibility for the equipment.

(4) Commissioning Requirements. A facility, system, subsystem, or equipment shall be commissioned only after the following actions have been completed:

(a) The joint acceptance representatives have determined the conditions of acceptability in accordance with established standards and specifications and signed the JAI report for their respective offices.

(b) Certification and commissioning statements have been entered in the appropriate facility maintenance log by responsible Airway Facilities sector personnel.

(c) Flight inspection, when required, has certified the facility for operation in the NAS and issued any required restrictive NOTAM.

(d) Required Instrument Approach Procedures (IAP) have been developed by the Aviation Standards National Field Office (AVN).

(e) Commissioning Notice to Airmen (NOTAM) has been issued (if required).

(f) The FRDF has been completed.

(g) A change to the FMF has been initiated, where required, to place the facility in a commissioned status. The facility may be commissioned if the action has been initiated, even if the FMF action has not been completed.

156.-161. RESERVED.