SUPPORT ACTIVITIES TESTING AND MAINTENANCE

The location of the elements within the enclosure is important in achieving the desired final matched antenna impedance. The components must be mounted in such a manner as to keep interaction between the elements to a minimum. Inductors should be mounted on opposites sides of the enclosure not less than one diameter away from one side of the enclosure, and, if possible, with their axes at right angles. Capacitors should be mounted so no excessive strain will be placed on their envelopes. The output power of the transmitting equipment and the reactance values of the network will determine the voltage rating of the capacitor elements. Generally a rating of 10 kv is sufficient. Where low reactance is used, that is, a high value of capacitance, a lower voltage of 5 kv will be adequate.

Stray reactances within the enclosure, especially from interconnecting leads will have considerable effect on the final matched impedance. This is more pronounced as the operating frequency is increased. The connecting leads between elements should be one-inch copper strap to keep the inductance of these connections low. The connections should be routed as direct as possible. The mutual coupling between inductors and connecting leads must also be considered. Leads should be positioned to cross a minimum number of flux lines of an inductor; that is, leads should go directly away from the inductor to the next element.

The enclosure should be manufactured with seamless construction and a rectangular opening of sufficient size to permit installation of the components and adjustment. The cover must be gasketed to be watertight. A drain hole or tube is required in the bottom of the enclosure to prevent the collection of moisture within the unit due to cyclic temperature and humidity variations. Studs for mounting the element support plates should be welded to the inside of the enclosure. These studs will provide ground connections for the elements where required. The matching network enclosure should be welded to the ship's structure to assure a positive ground connection. If it is impracticable to weld the enclosure to the ship it should be bolted to the structure and fitted with a ground strap welded to the enclosure and to the nearest point of the ship's structure. The matching network should be installed as close as possible to the antenna terminal.

## 3.3 MODEL RANGE TESTING.

An antenna model range provides facilities to design, test and evaluate complete shipboard communications antenna systems for specific ships or classes, to determine the effects of topside structural changes on existing systems, to test multicouplers, matching networks, filters and RF distribution systems, and to perform research and development of antenna systems to meet specific needs. Model range tests involve determination of antenna impedance, pattern, gain, system EMI and EMC, and electromagnetic radiation hazards.

A scaled model study is the most useful and efficient method of determining the design and operational characteristics of a complete system in a shipboard environment. The greatest effect on the antenna system operational characteristics is from the environment in which the system must operate. The communications antenna system is not an isolated, independent system. As a matter of fact the entire ship from the top of the mast to the waterline is an antenna system. It is a whole complex of interacting antennas radiating and reradiating electromagnetic energy, some of which is unintentional and unwanted. Testing on the model under shipboard conditions is far more economical than on board ship. Years of experience at model ranges show that data gathered by model range testing will parallel very closely actual shipboard testing.

The U.S. Navy maintains an antenna model range at the Naval Electronics Laboratory Center (NELC), San Diego, California. This range is equipped and staffed to provide services for antenna system development, scale model testing and field engineering. The description of the physical plant and services related to scale model testing and field engineering services in this volume is based on the facilities and activities at NELC.

A model study requires the building of a scale model, usually to 1/48 scale, of the ship with complete topside configuration. This includes all communications antennas, fire control directors, ordnance, structures and other equipment that might influence the antenna patterns. Brass is normally used to model conducting surfaces since it is easy to machine, corrosion resistant, easily soldered and is a good conductor. All models are constructed from actual ship drawings with the topside reproduced only after verification of all structural details. Copies of plans, sketches and photos illustrating topside configuration should be forwarded to NELC. All measurement data from broadband antenna systems should be included. This data is used to update the model ships and aid NELC in providing quick responses to antenna problems encountered in the fleet.

The model range, Figure 3-17, consists of a 160-foot diameter cement base and a 22-foot diameter turntable in the center. The concrete base is coated with lead, and the turntable is covered with brass plate to simulate sea water. Reflections from the edge of the artificial ocean are reduced by triangular seriations of the outer edge of the lead surface. A large wooden arch located at the perimeter of the cement base is fitted with an antenna which can traverse the arch from 3 to 65 degrees above the horizontal.

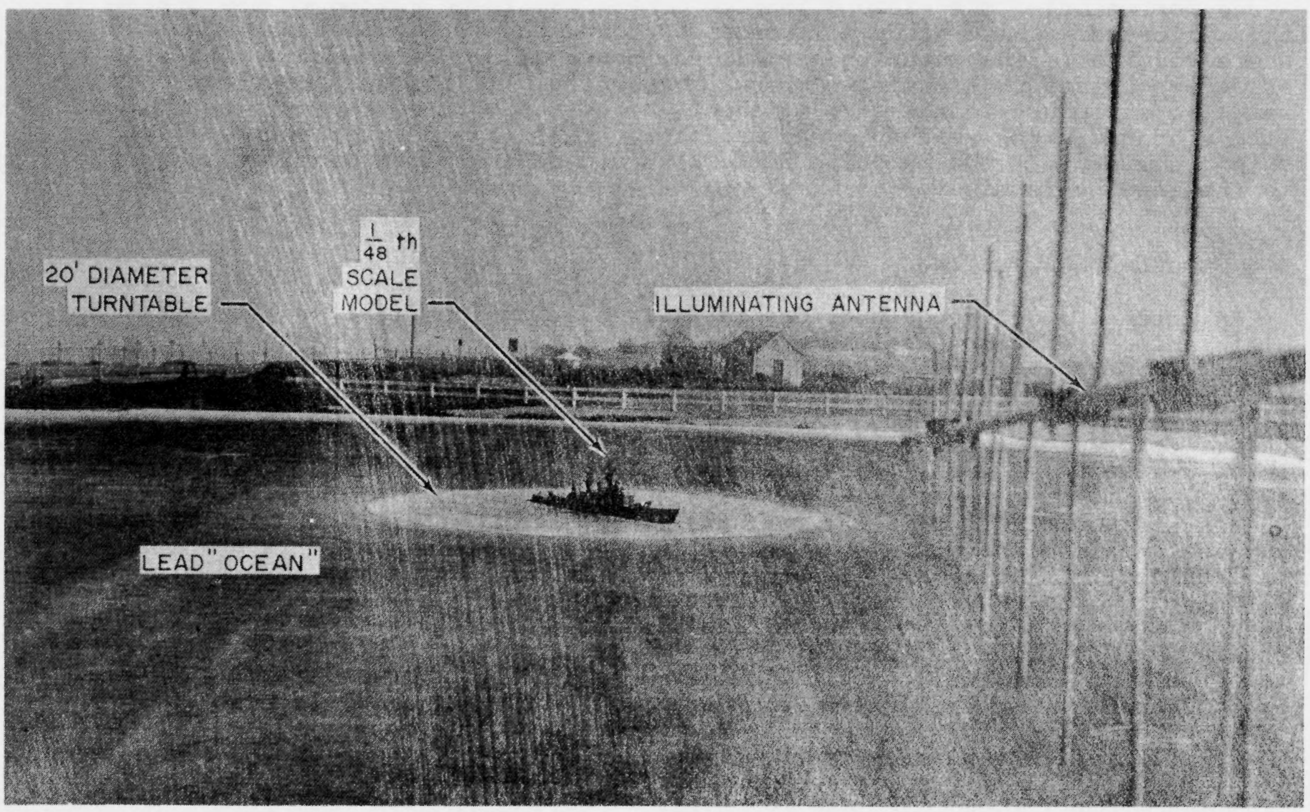


Figure 3-17. NELC Pattern Range

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Illumination of the range ( usually from 96 to 1440 MHz to simulate at 1/48 scale the 2- to 30-MHz band) is accomplished by the use of fixed monopoles inside parabolic reflectors at ground level and a planar log periodic antenna, Figure 3-18, mounted on a track attached to the inside face of the arch. The fixed monopoles excite the range for vertically polarized ground waves only. The arch mounted log periodic can be rotated remotely for vertically and horizontally polarized measurements in azimuthal and vertical planes.

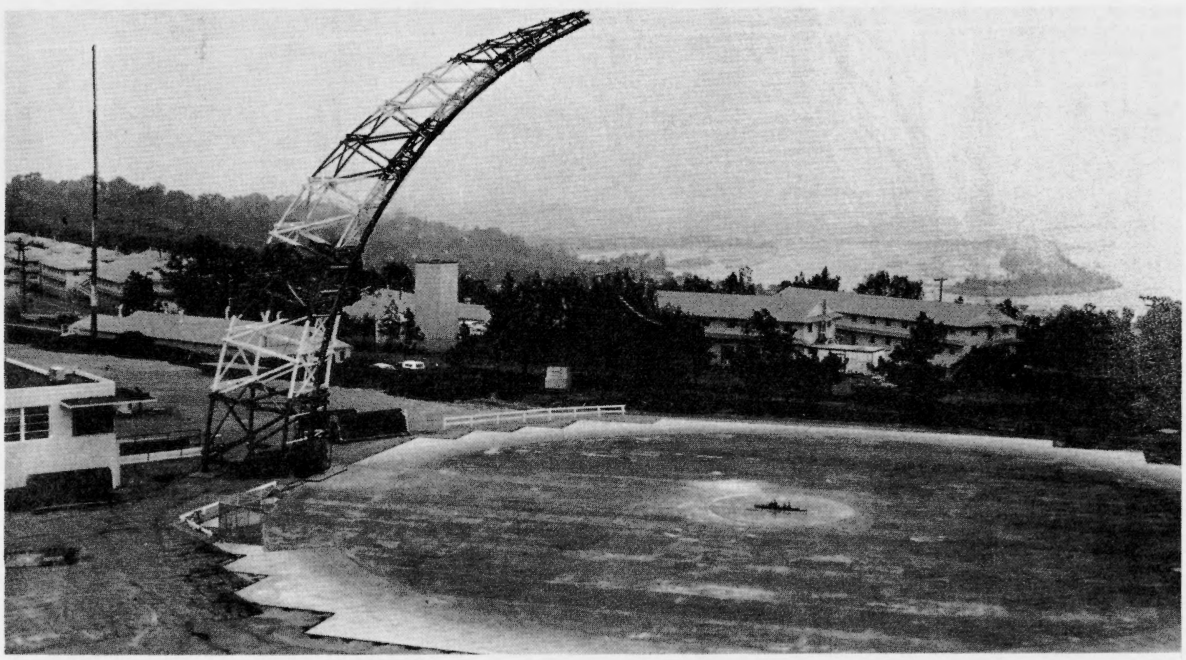

Figure 3-18. NELC Model Range

Brass plate ships, Figure 3-19, modeled to the waterline are placed over a slot in the turntable for measurements. Access to the model ship's antennas is from underneath.

The receiving equipment, located in a nearby control room, Figure 3-20, is connected by coaxial cable to the antennas on the model. A polar plotter or a radiation distribution printer is used to record the data. Data gathered is stored on paper and magnetic tape for use in the center's computer. This information is retained for future use in comparing and evaluating any subsequent changes to the particular system.

The model range has four underground test rooms available, and they are equipped to measure full or reduced scale antennas to determine functional characteristics such as susceptance and mutual coupling at frequency ranges from 2 to 12 GHz. The model ship and antenna under test are placed directly over the test equipment on a wire mesh screen which forms a continuous ground plane or counterpoise. The antenna is connected to the test equipment in the room below by low-loss coaxial cable. This configuration permits antenna measurements without disturbing the electrical field of the antenna.

One of the underground test rooms is used primarily for full scale antenna testing. Testing is normally limited to 2 to 400 MHz with facilities to measure up to 12 GHz. This room has been used for analysis of full scale VHF

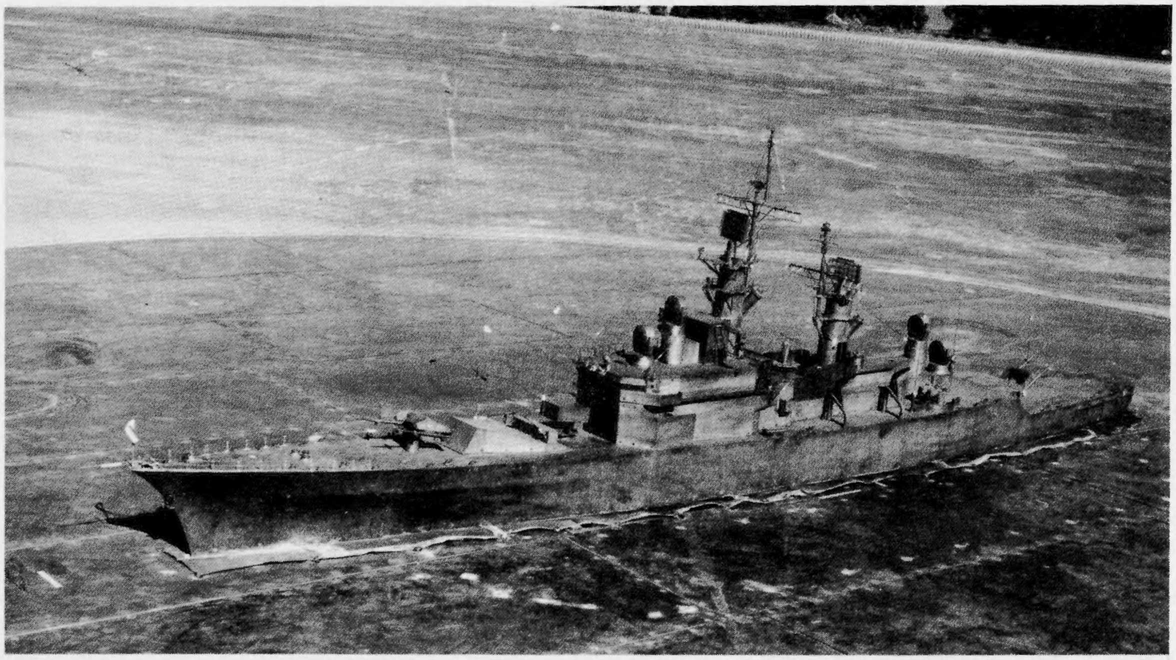

Figure 3-19. Model on Turntable

Figure 3-20. Model Range Control Room

broadband dipoles, checking wire fan antennas and in the design of 35-foot fiberglass whip antennas.

The ship models, stored at the facility, are updated periodically to reflect changes to the actual ship. They are readily available for use in determining the effects of structural changes or new topside installations and providing solutions to antenna problems that may be experienced in the field. All data accumulated during tests is retained for future reference.

### 3.3.1 IMPEDANCE MEASUREMENTS.

The impedance of an antenna at the input terminal affects the interaction between the antenna and its associated equipment. Antenna impedance is an important factor in the consideration of power transfer, noise, and bandwidth. In broadband antenna systems it is the antenna impedance that limits the useful bandwidth of the antenna. Since shipboard broadband antennas are limited to presenting a 3:1 VSWR to the transmitting equipment it is essential that the impedance be known for use in the design of matching networks. The antenna is modified by the environment in which it operates, especially from nearby structures and antennas. For this reason the antenna is placed in a replica of its operating environment. When the model has been configured to conform with the specifications for the test it is placed on the test platform and connected to the test equipment. Figure 3-21 shows a typical test instrumentation setup for determining antenna input impedance. There may be variations in the instrument setup depending on test requirements.

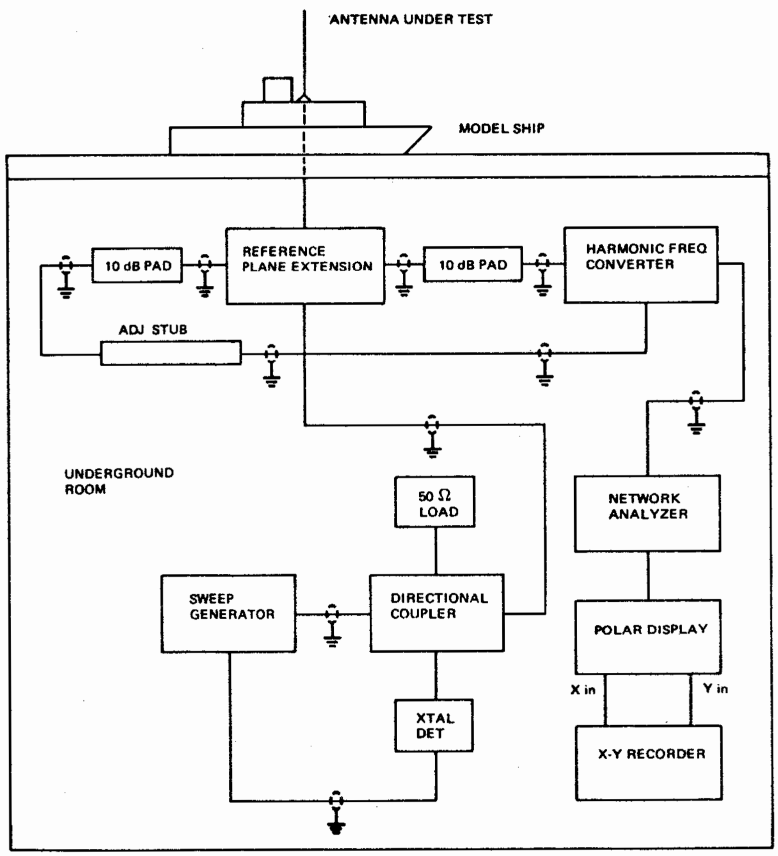


Figure 3-21. Model Range Test Setup for HF Impedance Measurements

The antenna is tested over its design bandwidth. From the data it can be determined if the antenna can be satisfactorily matched to the system transmission line over its bandwidth. If the antenna does not provide an adequate match the data can be used in the design of matching networks to improve the match. The data may also be used in determining the practicality of modifying the ship's structure or relocating antennas or other equipment to bring the impedance within specified boundaries. The impedance data obtained from model tests will assist in the alignment of the shipboard system.

### 3.3.2 PATTERN AND GAIN MEASUREMENTS.

Scale model radiation pattern and gain measurements provide important information that may be used in determining some of the expected operational characteristics of the shipboard antenna system. This information includes radiation distribution which predicts the expected coverage of the antenna, gain, depth of nulls for a given set of conditions, mismatch losses, and statistical data that may be used to determine other system losses such as whether the system will become noise limited. Since it is more economical and convenient to perform model measurements in the receive mode, the tests are conducted with the model being illuminated from an external source. The information recorded in this mode is applicable to transmitting antennas by the principle of reciprocity.

The radiation pattern measurements are conducted on the pattern range. The model is positioned on the turntable and the interconnecting cables terminated to the model and the control room. A typical test setup for measuring antenna patterns is shown schematically in Figure 3-22.

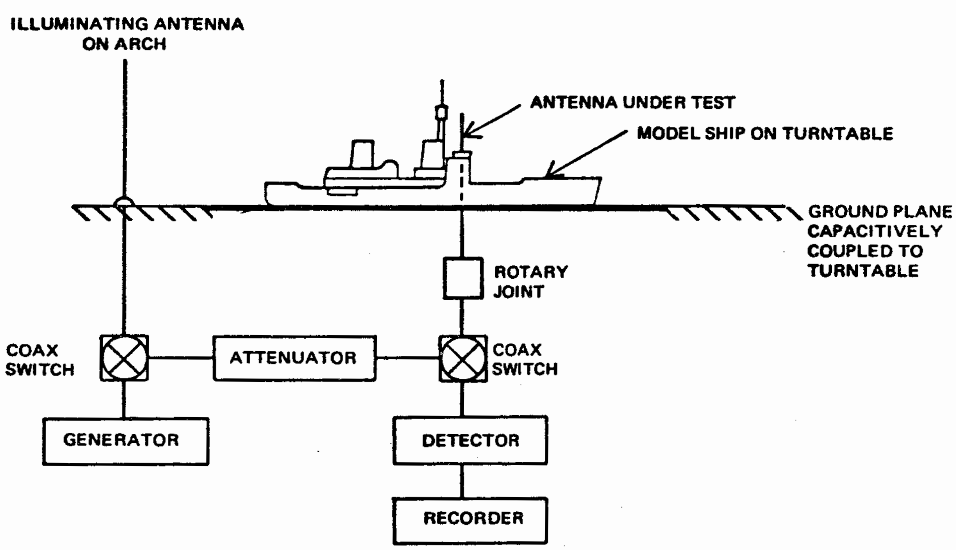


Figure 3-22. Model Range Test Setup for Antenna Radiation Patterns

The model is illuminated by the antennas at ground level and on the arch. The patterns are recorded over full 360 degrees in azimuth and the illuminating antenna on the arch is capable of furnishing angles of incidence from 3 to 65 degrees from the horizontal. The illuminating frequencies are determined by the bandwidth of the antenna under test. Patterns are recorded on a polar recorder and statistical data recorded on a radiation distribution printer. Radiation pattern measurements may be on either a relative or an absolute field intensity basis.

A typical polar recorder pattern is shown in Figure 3-23; variations in power levels and azimuth coverage for various angles of incidence are clearly shown. Since the model data is closely duplicated on board ship this will be the expected coverage when the full scale antenna is installed on the specific ship. Energy levels are determined by comparing the level of the received signal with the output level of the illuminating antenna. The reference levels are determined by measuring the levels of a quarterwave monopole.

Once the initial radiation pattern measurements have been recorded for the complete system, the data is analyzed to ascertain whether the configuration may be expected to fulfill the operational requirements. If there are discrepancies, such as lack of coverage, excessive radiation losses, or mutual interference with other antennas, the model is reconfigured and additional patterns are made. This process is continued until the best possible design, within the constraints imposed by the ship's structure, has been obtained. The design is then considered satisfactory for full scale installation.

The data obtained from these measurements is retained for future use and is especially useful in determining the effects on the antenna system of future structural changes on a specific ship or class.

## 3.4 SHIPBOARD TESTING AND MAINTENANCE.

Engineering and technical personnel assigned to laboratories and industrial activities are available to support the fleet in the installation and maintenance of shipboard communications antenna systems. These services include initial adjustments of the antennas and matching devices, calibration and adjustment after structural or other changes that affect antenna operation, inspections, and response to requests for assistance in solving specific problems beyond the capabilities of the ships force on an emergency or "quick fix basis." The support activities are equipped to provide instrumentation not normally available on ship to conduct specific tests.

### 3.4.1 IMPEDANCE MEASUREMENTS.

The most important characteristic of a shipboard antenna is the input impedance. The impedance will determine the bandwidth of the antenna, the design and adjustment of matching and coupling devices and the VSWR on the transmission line. The impedance of an antenna may be measured on board ship by the use of an RF bridge to measure the antenna input admittance from which the impedance can be calculated. Figure 3-24 shows a typical setup of the equipment required for this measurement.

The accuracy and repeatability of data and the safety of personnel and test equipment are dependent on the control of the topside area during the measurements. Strict attention must be given to the following:

a. The ship must be docked in a clear location with no other ships nested alongside.

b. All RF emissions in the immediate area must be eliminated.

c. Stack and exhaust emissions must be controlled.

d. All nearby hf antennas should be shorted to ground at their feedpoint. Tuned probes such as the AS-1857/SRA-43 used with the AN/SRA-43 Antenna Group are exempted from this requirement.