DEPARTMENT OF THE NAVY
BUREAU OF YARDS AND DOCKS
WASHINGTON 25, D. C.

This Bureau is responsible for the design, development, and construction of the structures and facilities required for all Navy shore-based communication systems.

In view of the responsibilities of the Bureau of Ships for technical equipment layout and for procurement and installation of the electronics equipment, criteria are developed jointly by the two Bureaus to govern this Bureau's design and construction of facilities to accommodate electronics equipment. Close coordination between the two Bureaus is maintained during the design, development, construction, and installation of communication systems.

This publication presents basic information for all Civil Engineer Corps officers and civilian personnel concerned with planning and providing the shore-based communication stations, inclusive of structures and facilities, that serve the Navy's radio communication systems.

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FOREWORD

This publication provides guidance for Bureau personnel concerned with the planning, site selection, design, construction, and maintenance of buildings, together with related services and installed facilities and/or radio towers, for shore-based radio communications at naval shore activities.

The criteria presented herein are not intended to limit or restrict initiative in design and planning, or to prevent the development of ideas arising from new communication practices or new materials, methods, and equipment used in radio communication facilities. Neither are they intended to limit or restrict the future planning or development of such practices as are consistent with the particular mission of an activity.

If there is doubt as to the application of, or deviation from, established policies and current criteria, clarification should be requested from this Bureau.

Part A presents the authority and responsibilities of this Bureau for providing the public works and public utilities that form the nonelectronic part of the Navy's shore-based radio communications, and defines related terms.

Part B covers general and specific site planning for the various types of radio communication stations.

Part C deals with radio receiver buildings, Part D with radio transmitter buildings, and Part E with radio communication centers and terminal equipment buildings.

Part F covers radio direction finder facilities, Part G control link facilities, and Part H antenna and ground systems.

CONTENTS

PART A. INTRODUCTION

Section 1. GENERAL

		Page
A1.01	Purpose and Scope	1
	1. Purpose	1
	2. Scope	1
A1.02	Authority and Responsibilities	1
A1.03	Design Policy	1
A1.04	Definitions	1
	1. Naval Communication Station (NCS)	1
	2. Naval Radio Station (NRS)	1
	3. Communication Center	1

Section 2. BUREAU OF YARDS AND DOCKS RESPONSIBILITIES

A2.01	General	2
A2.02	Field Responsibilities	2
	1. Bureau Representatives	2
	2. Public Works Officer	2
A2.03	Budget and Financial Responsibilities	2
A2.04	Relationships With Other Bureaus and Offices	3

PART B. SITE PLANNING

Section 1. GENERAL CONSIDERATIONS

B1.01	General	4
B1.02	Types	4
B1.03	Site Selection	4
	1. Evaluation	4
	2. Standard Layouts	4
	3. Zoning Regulations	4
	4. Strategic Considerations	4
	5. Isolation	4
	6. Security	4
	7. Terrain Characteristics	4
	8. Soil and Subsoil	5
	9. Receiving Qualities	5
	10. Noise Level	5
	11. Ground Conductivity and Uniformity	5

Page

B1.04 Gen ral Arrangement of Functional Ar as 5
1. General Planning 5
2. Receiver Station Planning 5
3. Th Plan 5

B1.05 Expansion 5

B1.06 Economy of Construction 5

B1.07 Em rgencies 5

B1.08 Cl arances 5

B1.09 Radio Interference Reduction Program 6

Section 2. RADIO RECEIVER STATIONS

B2.01 Site 6

B2.02 Clearances 6
1. Naval Radio Receiver Station 6
2. Nonnaval Transmitter Station 6

B2.03 Plan 6
1. Ability To Receive 6
2. Ant nna Area 6
3. Rec iver Building 7
4. Station Buildings 7
5. Service Area 7
6. Administration and Communal Area 7
7. Housing and Personnel Areas 7
8. Recreation Areas 7
9. Sewage Treatment Plant 7

Section 3. RADIO TRANSMITTER STATIONS

B3.01 Site 7
1. Acreage 7
2. Terrain Characteristics 7
3. Ground Conductivity and Uniformity 7
4. Utilities and Recreation 7

B3.02 Clearances 8

B3.03 Group Plan 8
1. Ant nna Park 8
2. Transmitter Building 8
3. Station Buildings 8

Section 4. COMMUNICATION CENTER

B4.01 Definition 8
1. M ssage Center 8
2. Relay Center 8
3. Radio Station, Control Link 8
4. Cryptographic Center 8
5. Other Activities 8

B4.02 Sit 8

Page

B4.03 Emergencies 8

B4.04 Group Plan 8

Section 5. DIRECTION FINDER (D/F) STATIONS

B5.01 General 9
1. Accuracy and Reliability 9
2. Importance 9

B5.02 Site 9
1. Selection 9
2. Ideal Site 9

B5.03 Site Considerations 9
1. Coastal Deviations 9
2. Deviations Caused by Local Conditions 9
3. Soil 9
4. Receiving Qualities 9
5. Anticipation of Encroachment 9
6. Stability of Electrical Characteristics 10
7. Power and Communication Facilities 10

B5.04 Minimum Site Requirements 10
1. Approval by Bureau of Ships 10
2. Clearance 10
3. Soil Specifications 10
4. Toleration of Close Elevation 10
5. Toleration of Distant Elevation 10
6. Clearance Specifications for Trees 10
7. Clearance Specifications for Fences 10
8. Rule-of-Thumb Spacing 10
9. Order of Error 10
10. Spacing 10

B5.05 Antenna Field 11
1. Antenna Array 11
2. Location 11

B5.06 Clearances 11
1. Antenna to Boundary Fence 11
2. Fence and D/F 11
3. HF and MF Band Antennas 11
4. Nearest D/F Antenna and D/F Building 11
5. Personnel Area and Nearest D/F Antenna 11

B5.07 Station Buildings 11

PART C. RADIO RECEIVER BUILDINGS

Section 1. REQUIREMENTS

C1.01 General 12

C1.02 Separation 12

C1.03 Space 12

Page

C1.04 Site Characteristics 13

C1.05 Qualifying Factors 13

Section 2. DESIGN

C2.01 General 13

C2.02 Criteria 13
1. Cellular Steel Floors 13
2. Filters 13
3. Grounding 13
4. Shielding 13
5. Cables 14
6. Access Areas 14

C2.03 Architectural Criteria 14
1. Floors 14
2. Walls, Partitions, and Ceilings 14
3. Doors and Door Openings 14
4. Roofs 14
5. Cable Trays 14

C2.04 Structural Criteria 15
1. Drawings and Specifications 15
2. Loads 15

C2.05 Power Requirements 15
1. Lighting 15
2. Utilities 15
3. Electronic Equipment 15
4. Emergency Power 15

C2.06 Mechanical Criteria 15
1. Circuit and Panel Requirements 15
2. Convenience Outlets 15
3. Heating and Ventilation 15
4. Plumbing and Sewerage 16
5. Underground Fuel Storage 16
6. Emergency Generator 16

PART D. RADIO TRANSMITTER BUILDINGS

Section 1. REQUIREMENTS

D1.01 General 17

D1.02 Composition 17

D1.03 Elements 17
1. Transmitter Room 17
2. Head House 17

D1.04 Site Suitability 17
1. Transmitting Qualities 17
2. Ground Conductivity and Uniformity 17
3. Isolation 17

Page

4. Terrain Characteristics . . . 17
5. Weather . . . 17
6. Utilities and Logistic Support . . . 18

D1.05 Total Cost . . . 18
1. Site . . . 18
2. Road . . . 18
3. Construction . . . 18
4. Security . . . 18
5. Engineering Standards . . . 18

Section 2. DESIGN

D2.01 Architectural Criteria . . . 18
1. Suitability Factors . . . 18
2. Expansion and Emergency Factors . . . 18

D2.02 Structural Criteria . . . 19
1. General . . . 19
2. Basement . . . 19
3. Transmitter Room Floor . . . 19
4. Loading Platforms . . . 19
5. Partitions . . . 19

D2.03 Air-Conditioning System . . . 19

PART E. RADIO COMMUNICATION CENTERS AND TERMINAL EQUIPMENT BUILDINGS

Section 1. REQUIREMENTS

E1.01 General . . . 20

E1.02 Communication Center Facilities . . . 20

E1.03 Terminal Equipment Building Facilities . . . 20

E1.04 Site Characteristics . . . 20

E1.05 Qualifying Factors . . . 20

Section 2. DESIGN

E2.01 General . . . 21

E2.02 Communication Centers . . . 21

E2.03 Terminal Equipment Buildings . . . 21
1. General . . . 21
2. Basement . . . 21
3. First Floor . . . 21
4. Second Floor (SupAct) . . . 21
5. Miscellaneous . . . 21

E2.04 Power and Ground Control Lines . . . 21

E2.05 Access Areas . . . 22

E2.06 Electronic Interference and Grounding . . . 22

Page

E2.07 Architectural Criteria 22
1. Floors 22
2. Walls, Partitions, and C ilings 22
3. Doors 22
4. Roofs 22

E2.08 Structural Criteria 22
1. Drawings and Specifications 22
2. Loads 22

E2.09 Power Requirements 22
1. Lighting 23
2. Utilities 23
3. Electronic Equipment 23
4. Emergency Power 23

E2.10 Mechanical Criteria 23
1. Electrical Bonding and Grounding 23
2. Circuit and Panel Requirements 23
3. Heating and Ventilation 23

E2.11 Communication Control Lines 23

PART F. RADIO DIRECTION FINDER (D/F) FACILITIES

Section 1. REQUIREMENTS

F1.01 Gen ral 25

F1.02 Method of Tracking 25

F1.03 Composition 25
1. Operations Area 25
2. Logistic Area 25

F1.04 Site Characteristics 25

F1.05 Qualifying Factors 26

Section 2. DESIGN

F2.01 G neral 26

F2.02 Operations Building 26
1. G neral 26
2. Cable Trough 27
3. Catwalk 27
4. Wiring, Pipes, and Fixtures 27
5. Entrance and Exits 27
6. Office and Emergency Berthing Room 27
7. Motors 27
8. Grounding 27
9. Electronic Equipment 27
10. Enclosure 27
11. Fire Protection 27
12. Floodlights 27

Page

F2.03 Auxiliary Power Building in Operations Area . . . 27

F2.04 D/F Antenna Array . . . 27

F2.05 Barracks and Messhall . . . 28

F2.06 Utility Building . . . 28
1. General . . . 28
2. Cable Trough . . . 28
3. Transformers . . . 29
4. Emergency Power Unit . . . 29
5. Grounding . . . 29
6. Antenna Lead-Ins and Insulators . . . 29
7. Fire Protection . . . 29

Section 3. CONSTRUCTION

F3.01 General . . . 29

F3.02 Antenna Array Cables and Trenches . . . 29

F3.03 Cables Within Operations Area . . . 29

F3.04 Antenna and D/F Array Monopoles . . . 29

F3.05 Installation of Electronic Equipment . . . 29

PART G. CONTROL LINK FACILITIES

Section 1. CONSIDERATIONS

G1.01 General . . . 30

G1.02 Operating Frequencies . . . 30

Section 2. INSTALLATION

G2.01 VHF Requirements . . . 30

G2.02 Microwave Requirements . . . 30

G2.03 Terrain . . . 30

Section 3. TOWERS

G3.01 General Requirements . . . 31

Section 4. BUILDINGS

G4.01 Radio Frequency (RF) House . . . 31

G4.02 Repeater Station Building . . . 31

PART H. ANTENNA AND GROUND SYSTEMS

Secti n 1. REQUIREMENTS

H1.01 General . . . 32

H1.02 Types of Antenna . . . 32

Section 2. DESIGN AND INSPECTION

		Page
H2.01	General	32
H2.02	Criteria	32
H2.03	Standard Design Drawings	34
H2.04	Clearance	34
H2.05	Guy Anchor Supports	34
H2.06	Winches and Ladders	34
H2.07	Lightning Protection	34
H2.08	Helix House and Ground System	34
	1. Construction of Helix House	34
	2. Ground System	35
	3. Drawings	35
H2.09	Inspection	35

ILLUSTRATIONS

Figure	Title	Page
1	D/F Operations Building—Floor Plan	26
2	D/F Utility Building—Floor Plan	28
3	Ground System for Transmitter Building	33
4	Vertical Radiator (Guyed) and Grounding System	36
5	Rhombic Antenna—Transmitting and Receiving	37
6a	Wide-Band Doublet—Transmitting Antenna	38
6b	Wide-Band Doublet—Receiving Antenna and Guying for Poles	39
7	Tilted Folded Doublet—Transmitting and Receiving	40
8	Vee—Transmitting and Receiving	40
9	Vertical Low Frequency—Transmitting and Receiving	41
10	Vertical Doublet—Transmitting and Receiving	42
11	Vertical Parasitic Array—Transmitting and Receiving	43
12a	Horizontal Parasitic Doublet—Transmitting	44
12b	Horizontal Parasitic Doublet—Receiving	44
13	Horizontal Two-Wire Doublet—Transmitting	45
14	Horizontal Three-Wire Doublet—Receiving	46
15	B verage (Three-Wire Wave)—Transmitting	46

PART A INTR DUCTI N

Section 1. GENERAL

A1.01 PURPOSE AND SCOPE

1. PURPOSE. This publication has been prepared by the Bureau of Yards and Docks as a technical and operational aid for all naval and civilian personnel concerned with this Bureau's design, construction, and maintenance of radio communication facilities at naval shore activities.

2. SCOPE. The technical criteria presented herein are used in the design, planning, construction, and maintenance of radio communication facilities at all naval shore activities. They are applicable to both permanent and temporary construction unless specifically indicated as being applicable to either one or the other.

Requirements and policies of other bureaus and/or offices are discussed herein insofar as they are important factors in this Bureau's performance of its mission with regard to radio communication facilities.

Radio communication facilities for naval air stations are described separately in *Aviation Facilities*, NAVDOCKS TP-Pw-25.

A1.02 AUTHORITY AND RESPONSIBILITIES

By authority vested in it by Navy Regulations, the Bureau of Yards and Docks is responsible for the planning, design, construction, alteration, cost estimates, and inspection of public works and public utilities, and the acquisition and disposal of real estate at all shore activities of the Naval Establishment. In addition, this authority extends to technical control of fire prevention and fire protection at all activities, and the alteration, repair, and upkeep of public works and public utilities, and the operating standards and procedures pertaining thereto.

A1.03 DESIGN POLICY

Because uninterrupted communications must be maintained, particularly in emergencies, it is the policy of this Bureau to design communication facilities that are functional to the highest degree; this requires construction that is of permanent type, and blast- and splinter-resistant whenever possible. Masonry and/or reinforced concrete construction is generally used, the end results being windowless buildings with mechanical ventilation or air conditioning.

A1.04 DEFINITIONS

1. NAVAL COMMUNICATION STATION (NCS). A naval communication station is an activity established by the Secretary of the Navy, including all communication facilities and ancillary equipment, however dispersed, required to provide essential interarea communication services for a specific area. It normally will include:

(1) A communication center
(2) Naval radio stations, as required
(3) A registered publications issuing office (RPIO)
(4) A fleet post office (FPO), if outside the continental United States

2. NAVAL RADIO STATION (NRS). A naval radio station is an activity of the Naval Communication System that performs radio transmitting, radio receiving, and/or radio link relay functions, or any combination thereof, at a location geographically distant from the communication center of a naval communication station. (Radio transmitter and/or receiver facilities located adjacent or proximate to the controlling components of the communication center are considered integral parts of the communication center.) A type designating letter, (T), (R), or (L), is added to indicate the functions performed. When special (supplementary or security) communication functions are performed, the letter (S) is added. The appropriate combination of these letters is used when applicable.

3. COMMUNICATION CENTER. A communication center is an agency charged with the receipt, transmission, and delivery of messages. It normally will include a message center, a cryptographic section, radio transmitter facilities, and radio receiver facilities. Transmitter, receiver, and relay stations are not necessarily located in the communication center, but facilities for their remote control must terminate there.

S cti n 2. BUREAU OF YARDS AND DOCKS RESPONSIBILITIES

A2.01 GENERAL

The responsibility of the Bureau of Yards and Docks for public works at naval shore activities extends to radio communication facilities.

In carrying out its over-all responsibility, this Bureau provides technical guidance to management control bureaus, to field activities, and to architectural-engineering contractors.

A2.02 FIELD RESPONSIBILITIES

1. BUREAU REPRESENTATIVES. The Chief of the Bureau has delegated certain specific phases of his authority to permanently established, authorized field representatives of the Bureau: Directors, Overseas Divisions, Bureau of Yards and Docks; Officers-in-Charge of Construction; and District Public Works Officers. The responsibilities of Public Works Officers also are described, insofar as they are related to those of the field representatives.

a. *Director, Overseas Division.* The Director of an Overseas Division is responsible to and acts for the Chief of the Bureau of Yards and Docks in all matters under the cognizance of this Bureau pertaining to construction, maintenance, and operation of all shore activities within his assigned area. Upon request he will furnish engineering s rvice, planning, administration of real estate matters, and assistance in the procurement and shipment of material and personnel from the Zone of the Interior for the Naval Construction Forces under Fleet, Force, Type, and Base Commands. On projects assigned to his cognizance, the Director will, after prior approval by the Chief of the Bureau of Yards and Docks, designate the Officer-in-Charge of Construction to be in charge of architectural-engineering and construction contracts. The Officer-in-Charge of Construction will thereafter report to the Director instead of the Chief of the Bureau.

b. *Officer-in-Charge of Construction.* Except in areas under cognizance of the Directors of Overseas Divisions, the Officer-in-Charge of Construction is designated by the Chief of the Bureau of Yards and Docks to administer the construction by contract of public works and public utility projects, including radio communication facilities. He is responsible for planning, directing, and carrying out, within his area of responsibility, the Bureau's technical program of design, construction, alteration, repair, upkeep, and inspection of public works and public utilities of the Shore Establishment, when accomplished by contract.

c. *District Public Works Officer.* The District Public Works Officer is responsible to the Chief of the Bureau of Yards and Docks for planning, directing, and carrying out, in accordance with Bureau policies and directives, this Bureau's technical program of design, construction, alteration, and inspection of public works, including radio communication facilities at shore activities within the boundaries of his naval district.

2. PUBLIC WORKS OFFICER. Maintenance and repair of radio communication facilities at an activity are the responsibility of the Commanding Officer or the Officer-in-Charge, under whom the Public Works Officer is responsible for assuring maximum performance of such facilities. When authorized by this Bureau, upon request of the management bureau, the Public Works Officer is responsible for awarding and executing short-form contracts both for new construction and for maintenance projects. When delegated authority by the District Public Works Officer, with the approval of the Commanding Officer, he acts as the Resident Officer-in-Charge of Construction for such projects constructed under long-form or cost-plus-a-fixed-fee contracts.

A2.03 BUDGET AND FINANCIAL RESPONSIBILITIES

The Bureau of Yards and Docks cooperates with the management bureaus and offices in preparing annual budgets for public works programs as required to provide for radio communication facilities. This involves the preparation of estimates and the provision of technical advice on all projected radio communication facilities, as well as the administrative work incurred in the numerous steps toward the approval of budgets or individual projects through higher authority in the Navy Department, the Department of Defense, the Bureau of the Budget, and the Congress. Following the authorization and appropriation of public works funds for radio communication facilities, this Bureau is responsible for the expenditure and accounting of such funds. When maintenance and repair work are beyond the capacity of the local

work force, this Bureau performs the work with funds supplied by the management control bureau.

A2.04 RELATIONSHIPS WITH OTHER BUREAUS AND OFFICES

Construction of radio communication facilities at shore activities, which is primarily the responsibility of the Bureau of Yards and Docks, must meet the requirements of the management control bureaus and offices. In general, management control bureaus at shore activities operate these facilities and finance their maintenance. The Chief of Naval Operations (Op 20) acts as the sponsor or management control office for facilities of the Naval Communication System. The Bureau of Ships exercises technical control of the electronic phases of radio communications.

PART B. SITE PLANNING

Section 1. GENERAL CONSIDERATIONS

B1.01 GENERAL

Thes are instructions for planning permanent and semipermanent naval shore radio communication facilities (except advanced bases), regardless of geographical location, and for replanning projects built during wartime so that they may be converted into improved, more efficient facilities.

B1.02 TYPES

All naval shore communication facilities in the Naval Communication System, and naval communication departments at certain naval stations, are under the management control of the Chief of Naval Operations and are classified according to their intended use. (Air station communication facilities are under the management control of the Bureau of Aeronautics.) It will be sufficient for planning purposes, however, to divide the naval sh re communication system into six major categories:

(1) Radio transmitter stations.

(2) Radio receiver stations.

(3) Communication centers.

(4) Direction finder (D/F) stations.

(5) Air station communication facilities (c ntained in *Aviation Facilities*, NAVDOCKS TP-Pw-25).

(6) Communication installations under the management control of other Navy bureaus.

NOTE: Facilities (1), (2), (3), and sometimes (4), when combined, become a naval communication station. Equipment employed by (5) and (6) may be installed in (1), (2), and (3) by approval of the Chief of Naval Operations.

B1.03 SITE SELECTION

1. EVALUATION. Site planning should begin when site selection studies are made. The site selection board must evaluate the relative advantages and disadvantages of each proposed site, determining its worth according to the procedures and consid rations outlined in the following paragraphs.

2. STANDARD LAYOUTS. Standard layouts are impracticable because each site presents a distinct design probl m as a location for a communication facility. No two sites and no two sets of local conditions are sufficiently alike to permit identical solutions. For example, climatic and topographic conditions of two areas may be similar, but their radio transmitting or receiving qualiti s may differ substantially. Each site, therefore, deserves a careful first analysis so that its own design criteria may be established.

3. ZONING REGULATIONS. The zoning regulations of areas surrounding the proposed site also must be considered. Zoning regulations either should exist or be instituted legally to limit future building outside the station, according to radio interference clearance standards.

4. STRATEGIC CONSIDERATIONS. Strategic considerations may force the selection of a site where topography, climate, and soil are not ideal for radio transmission or receiving. It may be necessary to select such a site for technical or tactical reasons or for training or other purposes.

5. ISOLATION. Naval shore communication facilities usually are isolated to minimize radio interference from urban areas, power lines, aviation and navigation aids, and similar sources. Accessibility, however, to good highways, electrical power, telephone, and other utilities is economically valuable and should be considered.

6. SECURITY. The site should be located so that defense against attack can be integrated with the general defense of the area. A minimum protective area of half a mile is desirable from the outermost antennas to the station boundary.

7. TERRAIN CHARACTERISTICS. The site for a communication facility should be slightly above the general level of flat country or on long easy slopes in hilly country. No rises or descents shall exceed 3½ feet per 100 feet in the antenna area. The ideal terrain should have no obstacles to the horizon, except the antennas and their supports. Clearance may be measured by a cone subtending a solid angle of 170 degrees, with the axis of th cone extending vertically and the vert x placed at any point in the antenna area.

8. SOIL AND SUBSOIL. Soil must be studied to determine its adequacy for structural foundations and radio communication reception, including ground conductivity and uniformity and transmitting and receiving qualities.

9. RECEIVING QUALITIES. To determine the receiving qualities of the site, reception should be checked from a number of fixed stations over wide ranges of distance, azimuth, frequency, and (if possible) time. Ground-wave and sky-wave transmissions should also be checked, if possible. The results should be paralleled with comparable data on similar sites so that a reasonable estimate of the reception characteristics of the proposed site may b obtained.

10. NOISE LEVEL. Because the ability to communicate depends on the ratio of signal strength to strength-of-noise level at the receiver, any undesirable noise peculiar to the site must be determined. The noise level (omitting atmospheric noise) of a good site should not exceed 2 microvolts per meter in the 10-kilocycle to 34-megacycle frequency range. This figure is the absolute maximum for an undeveloped site.

11. GROUND CONDUCTIVITY AND UNIFORMITY. The character of the soil at the site must be known. A highly conductive and uniform (homogeneous) soil, extensive in depth and area, is an ideal ground for most types of antenna in use at naval shore radio stations. According to instructions by the Bureau of Ships, soil conductivity shall not be less than 5 by 10^{-14} electromagnetic units (emu). Soil subject to glacial movement, erosion, and seasonal or other variations should be avoided.

B1.04 GENERAL ARRANGEMENT OF FUNCTIONAL AREAS

1. GENERAL PLANNING. The primary factors in planning a naval shore communication station are (a) efficiency of operation, (b) optimum radio reception or transmission, and (c) economy of construction (paragraph B1.06). In planning the arrangement of such functional areas as administrative and personnel, receiving, transmitting, and direction-finding areas, every effort should be made to assure convenience as well as efficiency of operation.

2. RECEIVER STATION PLANNING. The primary purpose of a receiver station is to receive radio signals, and that factor should govern the master plan and the type and methods of construction. The efficiency of a receiver station is a function of the minimum signal that can be received, as well as the station's operating and maintenance characteristics.

3. THE PLAN. The relationship between antenna field, operations and administration, maintenance, storage, and personnel areas should be studied to achieve the most convenient and efficient operation consistent with economical construction. Each area should be planned with regard to future expansion, and all planning should be considered in terms of units rather than details.

B1.05 EXPANSION

Provision for future expansion of radio communication facilities should be made at all stations. Determining factors include the type of station, its location, topographic limitations, and economics.

B1.06 ECONOMY OF CONSTRUCTION

The final layout of the site for radio communication facilities requires care and judgment in balancing the economic factors against operational efficiency. An ideal layout may have to be modified to avoid an excessive amount of grading, highway or railroad relocation, or other costly site preparation. After the general site has been carefully selected for minimum construction costs, the planning and exact locating of the individual facilities should utilize the natural topography with a minimum of grading.

B1.07 EMERGENCIES

A radio communication station must be capable of self-sustained operation for a considerable length of time. To this end, every facility vital to the station's continuous operation (inclusive of services such as power) should be pr vided with an emergency source of supply.

B1.08 CLEARANCES

Clearances from local transmitters should be viewed realistically, because rigid interpretation of minimum distances from sources of interference might hamper selection of a site for receivers. Certain transmitters for link and emergency communications must be tolerated on the receiver station. On the other hand, an overmodulated amateur transmitter close to the radio reservation can cause more interference than a 50-kw transmitter several miles away. A foreign nonregulated

and overmodulated broadcast transmitter just across the border can completely jeopardize the operation of a nearby receiver station by spurious radiations over a wide band. In evaluating the amount of anticipated interference, the effective transmitter power (beamed antenna, and so on), type and efficiency of emission, frequencies, and other factors should be considered. Actual field measurements should be made before final decision on the site is reached.

B1.09 RADIO INTERFERENCE REDUCTION PROGRAM

Th radio interference reduction program has revealed that high-frequency (HF) communications at air stations, even after all possible efforts at remedial suppression have been made, suffer from interference levels far in excess of those encountered at major naval communication stations. Yet, the requirements of Fleet Air Wing air-to-ground communications are as demanding as ship-to-shore circuits. Tower communications are also limited by interference that is often impracticable to eliminate, such as ignition interference from privately owned vehicles and other sources.

The solution at present is to place the receiver in a remote location free from interference. Furthermore, the receiver should be at least 1 mile from the operations building. The remote transmitter should also be located 1 mile from the operations building, and the distance between the receiver and transmitter should be at least 3 miles.

Section 2. RADIO RECEIVER STATIONS

B2.01 SITE

The site of a radio receiver station must be chosen for the best possible radio reception, even if the initial cost of the land is higher than for other sites. Its receiving qualities must be tested thoroughly to determine the basic requirements. Noise level *must not exceed* 2 microvolts per meter in th 10-kilocycle to 34-megacycle frequency range; the ground must be highly conductive, and the soil uniform and extensive in depth and area.

B2.02 CLEARANCES

1. NAVAL RADIO RECEIVER STATION. A naval radio receiver station must follow the Bureau of Ships requirements for minimum distance from sources of interference:

(1) High-power, VLF transmitter station ..... 25 miles
(2) Other transmitter stations ..... 5 miles
(3) Airfields and glide paths:
(a) For general communications, 5 miles
(b) For aeronautical receiving at air stations ..... 1,500 ft
(4) Teletypes and other electromechanical systems:
(a) Installed in shielded room, no requirement
(b) Installed in unshielded room:
Large installation (communication center), 1 mile from nearest antenna
Small installation (1 to 6 instruments), 2,000 ft from nearest antenna
(5) Main highways ..... 1,000 ft
(6) High-tension power lines (overhead):
(a) Receiver station feeders (not more than 4,400 v), 2,500 ft from nearest antenna
(b) Transmission lines and transformer substations ..... 3 miles
(7) Habitable areas (beyond limits of restriction) ..... 1½ miles
(8) Areas capable of industrialization (beyond limits of restriction) ..... 2 miles

2. NONNAVAL TRANSMITTER STATION. Clearances desired by the Bureau of Ships for a nonnaval transmitter station are:

(1) Distance between naval radio receiver station and nonnaval transmitter station .. 5 miles
(2) Maximum signal level from nonnaval station ..... 10 uv/m at Navy site
(3) Maximum harmonic or spurious radiations from nonnaval station .. 5 uv/m at Navy site

B2.03 PLAN

1. ABILITY TO RECEIVE. The ability to receive a radio signal depends on the ratio of desired signal strength to the strength of undesired noise in the system. All planning, therefore, should be done to minimize noise and increase effective signals.

2. ANTENNA AREA. The antenna area or park should be as near the center of the station as topography will permit, and no construction other than the receiver building and utility connections should be in the park. (Connections should be

buried, if possible.) Type, height, number, and layout of antennas required for each station are determined by the Bureau of Ships.

3. RECEIVER BUILDING. The receiver building is the terminal point of the antenna transmission lines and must be located near the center of the antenna park to reduce the length of the transmission lines. The transmission line should be 70-ohm solid dielectric coaxial cable, properly terminated, that can be buried to reduce the noise pickup usually caused by exposure.

4. STATION BUILDINGS. All buildings, except the operations building, should be near the station boundary to provide the greatest antenna area and the best noise and interference surveillance of the station. All these buildings should be wired to suppress interference, and all metal in the various structures thoroughly bonded and grounded. Expansion space allotted for administration and personnel should not invade the antenna area.

5. SERVICE AREA. As soon as the principal elements of the antenna area are established, the service area structures should be located. This area contains buildings and facilities for maintenance and repair of station equipment and structures, and should be free of everything not directly concerned with these functions. The service area generally includes maintenance and repair shops, storage facilities, garage, firehouse, public works building, antenna and cable storage, laundry, diesel oil storage, and a small administration building (if required).

6. ADMINISTRATION AND COMMUNAL AREA. The administration building and welfare and recreational facilities comprise the administration and communal area. This area usually should be close to the junction of the maintenance and storage area and the area for personnel, with the administration building easily accessible to the main gate.

7. HOUSING AND PERSONNEL AREAS. Separate housing areas are generally provided for enlisted personnel, married enlisted personnel, married officers, and civilians. In planning these areas, consideration should be given to prevailing breeze, view, orientation, winter winds, and accessibility to and from the main gate without crossing the antenna or maintenance areas.

Other considerations are:

(1) Enlisted personnel barracks and mess to be within easy walking distance of maintenance and storage area.

(2) Quarters for married personnel separated from the main arteries to protect children and for privacy, with easy access to the gate.

(3) Bachelor officers' quarters and women officers' quarters located near the married officers' quarters.

8. RECREATION AREAS. Recreation areas for enlisted men and officers shall be located within their respective areas.

9. SEWAGE TREATMENT PLANT. Sewage treatment plants should be located at a low elevation and planned so that prevailing breezes do not carry offensive odors to inhabited areas.

Section 3. RADIO TRANSMITTER STATIONS

B3.01 SITE

The site for a radio transmitter station must be chosen for best possible radio transmission, even if the initial cost of the land is higher than for other sites.

1. ACREAGE. Acreage is desirable for at least 25 percent expansion of initial facilities, plus additional space for clearances and protection from encroachment.

2. TERRAIN CHARACTERISTICS. The terrain for a radio transmitter station must be reasonably flat or rolling with no rises or descents exceeding 3½ feet per 100 feet in antenna area. (See paragraph 7 of B1.03.)

3. GROUND CONDUCTIVITY AND UNIFORMITY. A highly conductive and uniform soil, extensive in depth and area, approaches the ideal ground plane. (Soil conductivity must be 5 by 10^{-14} emu, or better.) Good conductivity is essential for transmitter sites and especially applicable to VLF, LF, and MF methods of communication.

4. UTILITIES AND RECREATION. A thorough survey should be made of the relative accessibility to transportation, electrical power, telephone, water, sewerage, and other facilities. For recreational purposes, the site should have transportation facilities to and from a large urban center.

B3.02 CLEARANCES

(1) Other transmitter stations . . . . . 3 miles
(2) Airfields and glide paths:
(a) For general communications transmitting . . . . . 3 miles
(b) For aerological transmitting at air stations . . . . . 1,500 ft
(3) Main highways . . . . . 1,000 ft
(4) High-tension power lines (overhead):
(a) Transmitter station feeders, 1,000 ft
(b) Transmission lines and transformer stations . . . . . 1 mile
(5) Habitable areas (beyond limits of restriction) . . . . . ½ mile
(6) Industrial areas (beyond limits of restriction) . . . . . 2 miles
(7) Separation from areas surrounding the site, according to zoning regulations (paragraph 3 of B1.03), to prevent obstructions to transmission and interference t radio and television reception in heavily populated areas.

B3.03 GROUP PLAN

1. ANTENNA PARK. The antenna park shall be as near the center of the station as topography will allow in order to permit expansion of the antenna area and easier observation of the required clearances. The transmitter building and antennas should be the only structures in this area.

2. TRANSMITTER BUILDING. The transmitter building is the terminal point of the open-wire transmission lines and should be as near as practicable to the center of the antenna park.

3. STATION BUILDINGS. Station buildings, such as those for maintenance, storage, administration, recreation and welfare, and housing, should be near the station boundary. Various supporting station structures are located as described in B2.03, paragraphs 4 through 9.

Section 4. COMMUNICATION CENTER

B4.01 DEFINITION

A communication center is the agency responsible for the receipt, transmission, and delivery of messages and normally includes several components.

1. MESSAGE CENTER. The message center is responsible for the acceptance, preparation for transmission, receipt, and delivery of messages.

2. RELAY CENTER. The function of the relay center is to relay messages with semiautomatic or automatic equipment.

3. RADIO STATION, CONTROL LINK. Control link equipment is required for keying transmitters from the communication center and transmitting signals from receivers to the communication center's receiving terminal equipment. Fewer circuits are required for keying transmitters from the receiver station.

4. CRYPTOGRAPHIC CENTER. The cryptographic center enciphers, deciphers, accepts, and delivers classified traffic.

5. OTHER ACTIVITIES. The communication center has other activities, such as wire and telephone rooms, a radio-photo unit, and a remote visual signal station, along with necessary facilities for administration, utility, maintenance, and personnel.

B4.02 SITE

The location of a communication center is seldom based on technical requirements but is indicated by the command or strategic considerations. Normally, the site is restricted to the confines of an existing naval base or station and must conform to the specified minimum separation for the receiver station.

If practicable, the site should be selected for a direct line of sight between the communication center and the transmitter and receiver stations, using the towers for link paths on a horizontal plane free of obstructions for a distance of 100 feet on either side of the center line. If repeaters are necessary because of unfavorable terrain, repeater sites should provide the required path, with a minimum of antenna heights.

B4.03 EMERGENCIES

A communication center should be capable of self-sustained operation for a considerable length of time. To this end, every facility should have power for continued operation in an emergency.

B4.04 GROUP PLAN

The communication center must be integrated with the layout of the naval base or station on which it is located and should be adjacent to, or part of, the base or station administration building for efficient pickup and delivery of messages.

Section 5. DIRECTION FINDER (D/F) STATIONS

B5.01 GENERAL

A fixed, shore-based radio direction finder station (DAJ) provides visual indications of received signals in the frequency range from 1.5 to 30 megacycles. The equipment consists of four independent direction finders, with four antenna arrays, placed within a minimum radius of 100 yards from the center of the operations room of the D/F operations building. All four pieces of equipment may be operated simultaneously. The DAL covers the 1.5- to 3.75-megacycle range; the DAM, the 3.75- to 7.5-megacycle; the DAN, the 7.5- to 15-megacycle; and the DAO, the 15- to 30-megacycle.

1. ACCURACY AND RELIABILITY. Model DAJ equipment is a visual-bearing, high-frequency direction finder system (HF/DF) capable of high bearing accuracy on practically all known types of radio transmission. For the best D/F performance from Model DAJ equipment, however, utmost care and supervision must be given to the choice of the D/F site and to those installations and associated factors on which accuracy and reliability depend.

2. IMPORTANCE. The importance of the radio D/F has long been recognized. The value of the D/F lies in its ability to locate the source of radio frequencies, information which may be used to aid friendly elements navigationally. It may also be used to determine the location of enemy units. Elaborate shore-type search and D/F facilities are planned for a number of strategic D/F centers to scan efficiently the pertinent radio-frequency spectrum and locate and monitor sources of enemy transmission.

B5.02 SITE

1. SELECTION. Selection of the proper site is most important for the use of any known D/F methods. All factors—instrumental, technical, and environmental—must be carefully judged, but the proper choice of site can reduce adverse effects to a tolerable value (from 2 to 3 degrees bearing error). If this is not done, accuracy and reliability of results are seriously threatened, particularly if a number of D/F equipments use the same site.

The D/F site area must be finally approved electronically by the Bureau of Ships, Shore Electronics Division.

2. IDEAL SITE. The ideal D/F site is absolutely flat with homogeneous and salt-saturated soil of high conductivity (not less than 10 by 10^{-14} emu). Flat land of the same elevation, removed from power lines, electrical noise generators, and other obstacles, should surround the site for a considerable distance. Such an ideal site can not always be obtained, and the D/F equipment must be located for best performance under existing conditions.

B5.03 SITE CONSIDERATIONS

1. COASTAL DEVIATIONS. D/F deviations are usually found whenever radio waves cross a coastal line at acute angles. In all instances of waves passing from sea to land, the direction of the deviation is indicated by the land wave bending normal to the coast line.

2. DEVIATIONS CAUSED BY LOCAL CONDITIONS. Certain local conditions (proximity of metalwork, buildings, overhead wires, trees, and other objects) can produce D/F deviations up to 22 degrees, and very few sites can be found with a maximum deviation of less than 2 degrees.

Deviations caused by local conditions are generally made up of several contributing causes that may be superimposed. Important deviations are caused by terrain, substrata, buried conductors, surface obstructions, resonance effect, transmitter station on the D/F site, and electrical interference that results in blurred minima.

3. SOIL. The conductivity and homogeneity of the soil are among the most important factors in determining the merit of a D/F site. A highly conductive soil, extensive in depth and area, approaches the ideal ground plane.

4. RECEIVING QUALITIES. A D/F site must have excellent receiving qualities. Poor reception limits the range of D/F equipment and may introduce considerable bearing error, particularly if poor reception is caused by an unsymmetrical absorbing area. Some preliminary determination of the reception must be made from a number of fixed stations over wide ranges of distance, azimuth, and frequency. Ground-wave and sky-wave transmission should also be employed with a suitable radio receiver, preferably the battery-operated type.

5. ANTICIPATION OF ENCROACHMENT. A good site may sometimes be adversely affected by

structures or other obstructions that are erected after the D/F equipment is installed. Encroachment of overhead power lines, highways, sewerage, buried cables, and so on, should be anticipated so that adequate clearances and spacings or modifications may be provided prior to the final choice of site, either by zoning regulations or written agreement.

6. STABILITY OF ELECTRICAL CHARACTERISTICS. Large vehicles moving close to the site, as well as rains, snows, and particularly tides, highly disturb electrical characteristics when nonhomogeneous ground conductivity occurs near the site.

7. POWER AND COMMUNICATION FACILITIES. Adequate power and communication facilities should be provided for proper operation of the D/F center. If possible, reliable and convenient service should be obtained, such as that provided by public utilities.

B5.04 MINIMUM SITE REQUIREMENTS

1. APPROVAL BY BUREAU OF SHIPS. The Bureau of Ships must approve the D/F site from the electronic standpoint. For further requirements, see Bureau of Ships Sketch 927B-7.

2. CLEARANCE. The site should have specified clearance from surrounding obstructions that may cause adverse D/F results, such as trees, metallic pipes, fences, and overhead lines. The best site slope is less than 1 degree with an elevation up to 5 (preferably 3) degrees to wooded areas or mountains, and the required leveled area in the immediate vicinity of each array should be about 10 times the array spacing. Legal action may sometimes be necessary to obtain site clearance.

3. SOIL SPECIFICATIONS. The following soil specifications of the Manufacturers Laboratory should be met, if possible:

(1) Flat, such as flat area behind a beach.

(2) Homogeneous, wet, capable of keeping grass r plants most of the year; no outcropping of rocks or large boulders less than 6 feet from the surface.

(3) No rocky seashores, rocky islands, or rocky hills.

4. TOLERATION OF CLOSE ELEVATION. An obstacle of 2-degree elevation can not be tolerated closer than 200 yards from any antenna array.

5. TOLERATION OF DISTANT ELEVATION. Distant obstacles, such as mountains, can be tolerated at 5 degrees at 5 miles, but they will also act as a perfect screen for direct ray shortwave reception from a transmitter located on the other side. Such obstacles may also affect the intensity and direction of low-angle sky waves (ground angle of 10 degrees or less) coming from long-distance transmitters. They will not generally affect the reception of sky waves with a ground angle of 25 degrees or more coming from medium-distance transmitters.

6. CLEARANCE SPECIFICATIONS FOR TREES. A clearance of 200 yards should be maintained between the antenna array and tall trees (from 40 to 50 feet high), thick forest, or jungle growth.

7. CLEARANCE SPECIFICATIONS FOR FENCES. Wood fences should be at least 40 yards from the array, and a clearance of 150 yards should be allowed for a steel or wire fence. This large clearance for a metallic fence is necessary because reliable data on error importance do not exist, and a conservative clearance estimate is therefore advisable.

8. RULE-OF-THUMB SPACING. A rule of thumb used by some D/F engineers to determine the spacing of obstructions from a set of D/F collectors is: For a single vertical or equivalent, spacing from the arrays should be at least 20 times the height. If the vertical has horizontal length, as well as height, above the earth's surface, the spacing should be more than 25 times the height.

9. ORDER OF ERROR. Experimental field tests verify that when a quarterwave tuned-vertical antenna is placed 90 degrees to the direction of arrival of waves on a D/F array, errors are recorded in the following order:

(1) 6 degrees at *two* wave-length spacing

(2) 3 degrees at *three* wave-length spacing

(3) 2 degrees at *four* wave-length spacing

(4) 1 degree at *ten* wave-length spacing

10. SPACING. The following spacing was prescribed and tested by a certain tactical group for installation of its shore HF/DF:

(1) High-tension power transmission lines (100-ft towers and above) . . . . . 6,000 ft

(2) Tuned receiving or transmitting aerials, 6,000 ft

(3) Large hangars, or a cluster of smaller hangars and of similar size, all-metal structures, 5,000 ft

(4) Railway lines, rivers, or similar, 2,500 ft

(5) Large nonmetallic buildings. . 1,500 ft

(6) Aircraft dispersal points. . . . . 1,000 ft

B5.05 ANTENNA FIELD

1. ANTENNA ARRAY.

a. *DAL Antenna.* The antenna of a DAL is a U-Adcock array consisting of four masts 35 feet high set in a square, with a diagonal distance of 66 feet and a 35-foot sense antenna at the center.

b. *DAM Antenna.* The antenna of the DAM is a U-Adcock array consisting of four masts 35 feet high set in a square, with a diagonal distance of 33 feet and a 35-foot sense antenna at the center.

c. *DAN Antenna.* The antenna of the DAN is a U-Adcock array consisting of four masts 17 f et high set in a square, with a diagonal distance of 19 feet and a 17-foot sense antenna at the center.

d. *DAO Antenna.* The antenna of a DAO, also a U-Adcock array, consists of four masts 17 feet high set in a square, with a diagonal distance of 12 feet and a 17-foot sense antenna at the center.

2. LOCATION. The four different D/F equipments, DAJ operations building, transmitting antennas, and other transmitting or receiving facilities, shall be placed as directed by the Bureau of Ships.

B5.06 CLEARANCES

1. ANTENNA TO BOUNDARY FENCE. The desired minimum distance from any antenna to the boundary fence line is 600 feet. No metallic fence of any kind shall be built on a D/F site.

2. FENCE AND D/F. An absolute minimum of 300-foot spacing shall be maintained between the fence and the D/F whenever a large spacing is impossible.

3. HF AND MF BAND ANTENNAS. The distance between any HF band (from 15 to 30 megacycles) antenna and any MF band (from 250 to 150 kilocycles) mast shall be 900 feet.

4. NEAREST D/F ANTENNA AND D/F BUILDING. The distance between the nearest D/F antenna and the D/F building shall be 300 feet.

5. PERSONNEL AREA AND NEAREST D/F ANTENNA. The distance between the personnel area and the nearest D/F antenna shall not be less than 1,800 feet, and 1 mile is preferable if emergency radio transmitting facilities are provided.

B5.07 STATION BUILDINGS

Except the DAJ operations building in the antenna field, all buildings shall be near the station boundary to allow the greatest antenna area and noise and interference surveillance of the station. Buildings should be wired to suppress interference, and any metal in the various structures should be thoroughly bonded and grounded. The earthgrounding, reinforcing steel, electrical and electronics wiring, and plumbing systems in the HF/DF operations building must be planned to avoid the formation, in free space above earthground, of closed electrical loop circuits that will resonate in the frequency range of D/F antenna arrays. In this respect, one good common earthground is usually less troublesome than several at random. Similarly, the nearer all metallic conductors are kept to earth level, the greater will be the reduction of reradiation from these conductors.

The maintenance and storage area, administrative, communal, housing, personnel, recreation, dispensary, and utilities areas shall be located as described in paragraph B2.03.

PART C. RADI RECEIVER BUILDINGS

Section 1. REQUIREMENTS

C1.01 GENERAL

A radio receiver building is the heart of a receiver station and should be remotely located. It is strongly recommended that a receiver station be located as far as possible from any other naval station or base or from any other facilities and obstructions that may limit radio reception by generation of electronic interference and/or shielding.

If the receiver station is remote, the receiver building (in the center of the antenna area) should be as far as possible from other areas and facilities at the station, including the administrative area and the terminal equipment building. All power lines, telephone lines, and control lines must be buried between the terminal equipment building and the receiver building, and overhead lines are prohibited within an area of 1,000 feet from the antenna area.

C1.02 SEPARATION

The usual separation requirements for a remote receiver station are:

(1) High-power, VLF transmitter station, 25 miles

(2) Other types of transmitter station, 5 miles

(3) Airfields and glide paths:

(a) For general service and supplementary activity (SupAct) communications, 5 miles

(b) For aeronautical receiving at air stations ..... 1,500 ft

(4) Main highways, 1,000 ft to nearest antenna

(5) Power lines:

(overh ad) ..... 1,000 ft to nearest antenna
(buried) . . the rest of the way to receiver building

(6) Habitable areas, including administrative areas at receiver station, 1½ miles to receiver building

(7) Areas capable of industrialization (beyond limits of receiver station reservation), 2 miles

C1.03 SPACE

Requirements for receiver buildings, including the activities to be accommodated, are established by the Chief of Naval Operations and the Bureau of Ships.

A receiver building is generally composed of one story and a basement, but another story may be added to furnish receiving facilities for supplementary activity (SupAct). Space requirements for various activities should include:

(1) Basement (joint use).
- (a) Mechanical equipment room.
- (b) Cable vault and wiring passageway.
- (c) Storage space (large).

(2) First floor (general service communications).
- (a) Operating room (large).
- (b) Security operating space (fairly large).
- (c) Security LAM space (frequency-measuring), small, double-shielded.
- (d) Teletype room, small, double-shielded.
- (e) Frame and multicoupler room (for use jointly with second floor).
- (f) Electronics repair shop, double-shielded.
- (g) Office.
- (h) Storage room.
- (i) Coffee mess.

(3) Second floor (SupAct).
- (a) Large operating area.
- (b) Special purpose room.
- (c) Office.
- (d) File room.
- (e) Teletype room, double-shielded.
- (f) Electronics repair shop, double-shielded.
- (g) Storage room.

(4) Toilets, stairways, halls, lobbies, cleaning gear storage, and elevator, as required.

(5) Stairway to roof and portion of roof designed for future installation of antenna and/or CCL gear.

C1.04 SITE CHARACTERISTICS

The terrain of the site for a receiver building and its attendant antenna system should be reasonably flat or rolling (paragraph 7 of B1.03), and the soil should be uniform with a high conductivity. Other characteristics of the site include:

(1) Good radio reception.

(2) Low electronic noise level (noise level, other than atmospheric, not to exceed 2 uv/m in the 10-kilocycle to 140-megacycle frequency range).

(3) Isolation as specified in paragraphs C1.01 and C1.02.

C1.05 QUALIFYING FACTORS

Principal factors in selecting a site for the receiver building and antenna system will include:

(1) Suitability of site for radio reception.

(2) Accessibility of utilities and logistic support.

(3) Cost of establishing and maintaining the site, receiver building and its auxiliaries, and operating personnel.

(4) Recreation: if possible, recreation facilities should be available within reasonable distance of a population center.

Section 2. DESIGN

C2.01 GENERAL

Permanent receiver buildings should be of masonry or reinforced concrete construction, generally rectangular in shape, the size established by the Chief of Naval Operations and the Bureau of Ships according to function and mission. Interior partitions (except those enclosing stairhalls, toilets, vaults, elevator hoistings, wiring passageways, and machinery rooms in basements) should be of metal or wooden studs and plaster or dry wall construction to allow rearrangement of operating space. Exterior walls (except doors, openings for ventilation and air conditioning, and cable entrances) are unpierced by windows. Such construction provides proper security without special scatterproof or bombproof design.

C2.02 CRITERIA

1. CELLULAR STEEL FLOORS. Cellular steel floors (where floors do not rest directly on the ground) must be installed to permit ready access to cable vaults, wiring passageways, frame and multicoupler rooms, raceways for wiring, and cable trenches.

2. FILTERS. The building should be wired to suppress radio interference as much as possible by providing space in the outlet boxes for a simple capacitor-resistor network filter. Such filters can be installed if field tests indicate their need.

3. GROUNDING. All metal structural members, such as reinforcing steel, flashings, casements, conduits, and piping raceways of cellular steel floors, must be electrically bonded and grounded to a buried ground system.

Electronic equipment must have a separate ground system that in some cases may b used to ground the building, if the connection to the building is below grade and a separate ground from the building to the common point is installed.

The buried ground system shall consist of No. 6 AWG copper wires about 100 feet long, radiating for 180 degrees from a common point, spaced about 10 degrees apart, and brazed to a ¼-inch thick copper plate, 24 inches square. The end of each radial is secured to a copper-clad steel ground rod, ¾ inch in diameter and 10 feet long. The ground system must be buried not less than 18 inches below grade and installed on each long side of the building, one system for the building ground and the other for electronic equipment.

4. SHIELDING. As already indicated, certain rooms (teletype rooms, frequ ncy-measuring spaces, and electronics repair shop) must be double shielded.

Shielded enclosures shall be provided with two layers of 16-mesh copper screening on floors, walls, and ceilings, each layer separated by the width of the stud or blocking. (Rather than two layers of copper screening, one layer of 16-ounce hard copper sheet may be used.) All joints between copper shall be locked and soldered continuously, and power lines entering these spaces shall enter through a power-line filter. (Navy type 53172 is acceptable for voltages of 250, and alternating and direct currents of 30 amperes.) Signal lines from teletype rooms must be shielded until they leave the building, and all power and signal cables must enter the room at one point, the only point at which the electrical connection is made between inner and outer wall screens of double-screened enclosures.

5. CABLES. Power and ground control cables to the receiver building must be buried to a point not less than 1,000 feet away from the nearest antenna and/or receiver building, and coaxial cables from the antenna to the receiver building are buried for the entire distance. Where cables enter the building, areaways or other means are used to trap water and prevent it from coming into the building.

Th cables are carried to the main power distribution panel or main frames (generally located in the basement) to be distributed properly throughout the building.

6. ACCESS AREAS. Parking and access areas of suitable size, including an area for maneuvering, shall be provided at entrances and loading platforms for motor vehicles.

C2.03 ARCHITECTURAL CRITERIA

1. FLOORS.

a. ***Basement.*** The basement should be reinforced concrete with dusted-on smooth-trowelled finish in storage spaces, vaults, and wiring passageways. Ceramic tile is used in toilets and asphalt tile for all other wearing surfaces. Slabs resting directly on the ground must have membrane waterproofing underneath, on a 6-inch porous fill.

b. ***First Floor.*** The first floor should be reinforced concrete or structural steel framing with cellular steel flooring. The floor finish should be cement underbed with dusted-on finish in vaults and unassigned spaces, and underbed for all other wearing surfaces.

c. ***Second Floor.*** The second floor should be the same as the first floor.

d. *Surface Treatment.* Concrete floors or floors finished with a cement topping must be sealed against dusting by surface treatment.

2. WALLS, PARTITIONS, AND CEILINGS.

a. *Walls and Partitions.* All partitions, except masonry, should be wooden studs faced with wallboard to permit easy rearrangement of rooms, and the joints should be properly pointed and painted. Metal lath and plaster partitions may be used in place of dry wall construction. Concrete and masonry walls and partitions should have joints smoothed and the surfaces neutralized and painted if this is practicable; if this is not practicable, they should be furred, plastered, and painted.

Glazed tile wainscots should be used for toilets and washrooms.

b. *Ceilings.* Where cellular steel floors are exposed on the underside, suspended ceilings are provided. All ceilings, except concrete slabs exposed in basements, are to be plastered and painted.

c. *Other Considerations.*

(1) Acoustical treatment should be provided as required on walls and ceilings of rooms and in all those accommodating electronic equipment (especially teletypewriters).

(2) Exterior surfaces of concrete walls must be smoothed where necessary and given one or two coats of cement water paint (walls below grade, a membrane waterproofing).

(3) Continuous, 6-inch diameter drain tiles in porous-fill envelope should be placed around the base of below-grade walls wherever there is a basement.

(4) Wire-mesh partitions should be used for enclosing basement rooms, such as repair shops and spare parts storage space.

3. DOORS AND DOOR OPENINGS. Hollow metal or metal-covered doors, frames, and bucks should be used when necessary for fire protection or operational security (doors leading to security spaces and SupAct areas), but all other doors and frames may be of wood. Operational security doors must have combination dial locks to prohibit entrance of unauthorized persons to security areas. Doors to shielded areas not having a double-entry system must have an interlocking switch to shut off power in all power outlets of the room when the door is opened. All such doors must be shielded and have inside locks, and double-door entries to shielded spaces shall have electrically operated interlocks to prevent simultaneous opening of both doors.

4. ROOFS. Roofs must be insulated as required, flat roofs covered with a 4-ply, built-up roofing in accordance with information in the latest edition of *Standard Specifications*, No. 7YG.

5. CABLE TRAYS. Cable trays are welded construction of light steel angles suspended from the underside of cellular steel floors and arranged vertically in three tiers. Wiring passageways, trenches, and cable vaults are equipped with cable trays to pick up the main services from the main frames and power-distribution panels for distribution to wiring raceways. (Wiring raceways are provided, by means of cellular steel construction, under the entire floor area except the basement floor slabs; cable and wiring to the raceways are fed from wiring passageways and/or trenches.)

Under the frame and multicoupler room, the edge of the cable tray is flush with the rectangular holes through the floors, thus allowing vertical clear space directly beneath these holes.

C2.04 STRUCTURAL CRITERIA

1. DRAWINGS AND SPECIFICATIONS. Prints of drawings and specifications for receiver buildings constructed at the Naval Communication Station, Guam, M.I., may be obtained from the Bureau. Drawings and specifications are also available for similar buildings constructed at the Naval Communication Facilities, Naval Station, Adak, Alaska, and at the Naval Air Activity, Port Lyautey, French Morocco. These may be used as guides for designing a receiver building for the Naval Communication System.

2. LOADS. Dead load, wind load, and seismic load shall conform to applicable Bureau of Yards and Docks requirements governing other buildings in the area. Live loads for receiver buildings are described in the following paragraphs.

a. *Floors.* Live loads for floors of receiver buildings are: 100 psf for stairs; 75 psf for toilets and washrooms; and 150 psf for all other areas.

b. *Roofs.* Roofs have a live load in accordance with this Bureau's criteria governing other buildings in the area, except that roof areas with installations of antenna and other electronic equipment are designed for 150 psf.

C2.05 POWER REQUIREMENTS

Power requirements for a receiver building should include the power loads necessary for all functions in the building under normal and emergency conditions. Loads for lighting, utilities (including air conditioning), and electronic equipment are based on the following:

1. LIGHTING. Under normal operating conditions, an illumination of from 30 to 40 foot-candles is required. Only incandescent lighting is used; no fluorescent lighting is permitted in receiver buildings.

2. UTILITIES. Utilities must be provided for convenience outlets, heating and ventilation, and other additional requirements. (See paragraph C2.06.)

3. ELECTRONIC EQUIPMENT. Electronic equipment must be calculated on the equipment schedule supplied by the Bureau of Ships or the District Electronics Officer.

Electronic equipment in a receiver building consists of receivers and multicouplers. At a 50-percent power factor, the power requirement for each receiver and each multicoupler is about 30 watts. For a teletypewriter, the requirement is 125 watts.

4. EMERGENCY POWER. In the event that the primary power source should fail, a receiver building should have quick-acting standby and/or emergency power capable of furnishing the following:

(1) 100 percent normal operation of electronic equipment.

(2) Illumination of from 20 to 25 ft-c.

(3) Blower ventilation (100 percent outside air; no cooling).

(4) Operation switchgear, 15-second rating.

C2.06 MECHANICAL CRITERIA

1. CIRCUIT AND PANEL REQUIREMENTS. Circuit and panel requirements shall be provided as follows:

(1) 50 percent additional circuits to known present requirements.

(2) Main distribution panel with space for 100 percent spare circuits.

(3) One 3-phase power panel.

2. CONVENIENCE OUTLETS. Convenience outlets, spaced 10 feet apart on centers, shall be on all walls of offices and operating spaces.

Power and control wiring distribution ducts from wiring passageways and/or trenches from basement to the second floor shall be provided as necessary.

3. HEATING AND VENTILATION. Receiver buildings are provided with heating and/or ventilation systems (including air conditioning, if required). In designing these systems, heat dissipation from electronic equipment should be considered. This will not amount to much, but such data can be secured from the Electronics Officer for Shore Installations or from the Bureau of Ships.

Heating and ventilation systems should maintain:

(1) A temperature of 70° F with maximum 85° F when outside temperature is 0° F.

(2) A relative humidity of 60 percent or below to minimize deterioration of electronic equipment.

Depending on climate, temperature and relative humidity may be maintained by one of the following systems: heating and ventilation without cooling or dehumidification; heating and ventilation

with summer cooling and dehumidification (m - chanical refrig ration pr ferred). If only cooling is required, vaporative cooling is advisable.

4. PLUMBING AND SEWERAGE. Plumbing and sewerag for r ceiv r buildings shall conform to applicabl requirements for other buildings in th area.

5. UNDERGROUND FUEL STORAGE. Underground fuel storage for a 15-day supply shall be provided for the standby or emergency generator plant.

6. EMERGENCY GENERATOR. The emergency generator should be in a separate building about 100 feet from the receiver building.

PART D RADIO TRANSMITTER BUILDINGS

Section 1. REQUIREMENTS

D1.01 GENERAL

The principal factors to be considered in arranging and constructing a radio transmitter building are: (a) suitability for conduct of efficient communications; (b) adaptability to normal expansion requirements; and (c) total cost of arranging and constructing the entire station.

These factors are not difficult to resolve if the scope of transmission to be conducted is determined, certain minimum conditions necessary for the desired transmission are evaluated with the arrangement and construction, and the advantages of each factor are weighed in relation to the minimum specifications.

There should be little choice in the matter of construction cost if the mission is kept in mind. The building should be constructed to *transmit radio signals*, and construction cost should be considered on the basis of cost per efficient transmitting circuit. It is false economy to sacrifice transmitting efficiency to economic expediency.

D1.02 COMPOSITION

The Chief of Naval Operations (Op 20) sets certain circuit requirements for transmitter facilities at communication stations. The Bureau of Ships (Code 910) interprets these requirements and formulates certain space and construction criteria used by the Bureau of Yards and Docks for designing the required buildings.

Transmitter buildings are designed for blast-resistant construction and are therefore windowless. All steel reinforcing material must be completely bonded together and grounded to prevent excessive heating and losses in the presence of high intensity radio-frequency (RF) fields.

D1.03 ELEMENTS

The transmitter building consists of two main elements:

1. TRANSMITTER ROOM. The transmitter room must be 50 feet wide to accommodate four rows of transmitters. Its length varies with the amount of equipment to be housed, and clear height, beneath the roof framing, should be about 16 feet. There must also be a full basement for tray- and cable-distribution floor sl eves under the rows of equipment.

2. HEAD HOUSE. The head hous is centrally located on one of the long sides of the transmitter room. On the main floor it generally contains shop and storage spaces, the communication control link (CCL) and switch gear, bunk and toilet facilities, office space, coffee mess, and the principal access to the transmitter room. The basement has space for air-conditioning equipment and storage.

D1.04 SITE SUITABILITY

Pertinent factors that affect the fundamental suitability of a site for radio transmission are:

1. TRANSMITTING QUALITIES. Some determination of the reception must be made from a number of fixed stations over wide ranges f distance, azimuth, frequency, and, if possible, time. Ground-wave and sky-wave transmission should also be checked. The results are compared with equivalent data from similar sites or sources and a reasonable estimate made of transmission capabilities.

2. GROUND CONDUCTIVITY AND UNIFORMITY. The character and homogeneity of soil at the site must be determined. A highly conductive and uniform soil, extensive in depth and area, approaches the ideal ground plane and must not be less than 5 by 10^{-14} emu.

3. ISOLATION. The site should be isolated by minimum distances specified for transmitter stations in paragraph B3.02.

4. TERRAIN CHARACTERISTICS. Terrain characteristics described in paragraph 7 of B1.03 apply to transmitter sites.

5. WEATHER. If great dissimilarity of weather conditions exists at prospective sites, and other factors are nearly equal, weather becomes a consideration in the reduction of construction expense and maintenance.

6. UTILITIES AND LOGISTIC SUPPORT. A survey of accessibility to transportation, electrical power, telephone, water, sewerage, and other facilities should be made. Requirements for logistic support of the proposed station should also be surveyed and related to the capacity of naval or other logistic establishments in the vicinity.

D1.05 TOTAL COST

1. SITE. The site should be located on Government-owned property if its suitability (paragraph D1.04) approaches that of an alternate, non-Government-owned site. Precautions should be taken at the time of transfer, purchase, or lease to provide sufficient area not only for expansion, such as might be occasioned by national emergency, but for a legally restricted surrounding zone to prevent building encroachment. Such precautionary procedure is far more economical than the relocation of a station that has had its communication efficiency impaired by overshadowing construction.

2. ROAD. Road building should be consistent with the clearance requirements in paragraph B3.02. If a road is constructed for access to the site, its use should be restricted to prevent exploitation, encroachment by building, or later conversion to a main highway.

3. CONSTRUCTION. Availability of construction facilities and labor supply in the area is important in computing the construction cost of a building, because maintenance and alteration costs often make a temporary structure more expensive than a permanent one.

4. SECURITY. Planning and cost estimates should include a suitable fence and patrol service for safeguarding the station from trespass and sabotage.

5. ENGINEERING STANDARDS. This Bureau's engineering standards for design and form of specifications will be used wherever practicable when the engineering is performed under an architectural-engineering services contract.

Section 2. DESIGN

D2.01 ARCHITECTURAL CRITERIA

The architectural arrangement and construction of a radio transmitter building must be suitable for the conduct of efficient communications and adaptable to normal expansion and emergency requirements.

1. SUITABILITY FACTORS. Factors pertaining to the suitability of architectural arrangement and construction for efficient transmission are:

a. *Arrangement.* Arrangement and construction should be such as to permit maximum transmitter and antenna flexibility, and to eliminate noise and interference.

b. *Location.* The transmitter building, or the terminal point of the transmission lines, should be as near the center of the station as terrain will allow, providing maximum antenna area and reducing the length of the lines.

c. *Concentration.* All buildings, except the transmitter building, should be near the station boundary for greatest antenna area and noise and interference surveillance.

d. *Construction.* No construction, other than utilities connections, should be located in the antenna park.

e. *Common Features.* Features common to all transmitter buildings (construction details varying with climate and protective or defensive measures) are:

(1) All metal thoroughly bonded and grounded.

(2) Full basement for cable trays under the operating space to distribute signal and power cables.

(3) Ignition systems of gasoline engines, automatic furnaces, and so on, appropriately suppressed to prevent noise radiation.

(4) All buildings and quarters wired to suppress interference.

f. *Signal-Energy Distribution.* Arrangement and construction should be done for ease of signal-energy distribution and equipment maintenance and operation (efficiency being a function of the speed with which frequency changes can be made).

2. EXPANSION AND EMERGENCY FACTORS.

a. *Expansion.* Expansion of transmitter buildings involves additional transmitting equipment, antennas, housing, subsistence for personnel, and utilities. Considerable space can be provided for expansion if the need is observed during the planning stage.

(1) *Operating Space.* Additional transmitting equipment requires more operating space. Plans for the transmitter buildings should therefore contain provision for additions that will not disrupt initial installation.

(2) *Additional Antennas.* Space for additional antennas is provided for by the Bureau of Ships in the initial plans of the antenna field (unless space is at a premium).

(3) *Quarters Area.* The quarters area should be concentrated on a boundary of the station, but expansion space that does not invade the antenna area should be provided.

(4) *Utilities.* Utilities should be assured in the planning stage and sufficient allowance made for expansion requirements.

b. *Emergencies.* A transmitter station should be provided with the following emergency supplies:

(1) *Standby Power Supply.* A standby power supply capable of handling the station electronic load should be provided. An automatic start and change-over system is required.

(2) *Emergency Water Supply.* If available, a commercial source of water may be used. If not, there should be a well, equipped with automatic pumps, on the station. Adequate storage facilities to ensure sufficient water for protection and sustenance should also be provided.

(3) *Fire Protection.* Firefighting facilities should exist for controlling all types of fire (brush, fuel supply, building, and electrical). Reliance on city fire departments is to be discouraged.

(4) *Subsistence.* Adequate storage facilities should be furnished for station subsistence during emergency periods.

D2.02 STRUCTURAL CRITERIA

1. GENERAL. The structure of the transmitter building may be a rigid concrete frame with reinforced concrete walls. The clear span in the transmitter section must be 50 feet, with column faces within the section flush with the interior walls.

The foundation should be concrete spread footings, or piles (if required), and the roof should be well insulated and covered with built-up roofing sloped at least ½ inch to the foot.

2. BASEMENT. A basement must extend under the entire building with a removable masonry wall at each end of the operating space to permit expansion. The basement area under the transmitter room should afford easy working space and accessibility to the system of cable trays carrying cables up through floor sleeves to the transmitters. The basement may also be used as a plenum chamber for the transmitter room air conditioning.

3. TRANSMITTER ROOM FLOOR. The floor of the transmitter room must be reinforced concrete, designed for a live load of 200 psf, with a hatchway for lowering spare parts to the basement and sleeves in the equipment rows for bringing cables up easily from the basement trays to the transmitters. Sleeve apertures must be closed with an easily removable plug covered with a cement wearing surface.

4. LOADING PLATFORMS. A loading platform must be provided at each end of the transmitter room, with roll-up doors and facilities for lifting large transmitters in and out of the building.

5. PARTITIONS. Partitions are masonry around stairhalls, toilets, and in the basement. Other partitions throughout the building are plaster on metal lath and wood or metal studs, easily movable and (if possible) demountable.

D2.03 AIR-CONDITIONING SYSTEM

The air-conditioning system should maintain a relative humidity of 60 percent and a maximum ambient temperature of 90° F. The air-conditioning supply is introduced at the first-floor level of the transmitter room, exhausted through vents in the roof, and recirculated through return grilles in the side walls.

PART E. RADI COMMUNICATI N CENTERS AND TERMINAL EQUIPMENT BUILDINGS

Section 1. REQUIREMENTS

E1.01 GENERAL

The general service Naval Communication System (transmitting and receiving) at any station is controlled by a communication center located either at base or station headquarters, or in a position remote from the base. If a supplementary activity exists, however, the communication center may be included in the terminal equipment building, which is the control center for SupAct. Requirements for the various activities of a communication center and/or terminal equipment building are established by the Chief of Naval Operations (Op 20) and the Bureau of Ships (Code 910).

E1.02 COMMUNICATION CENTER FACILITIES

A communication center for general service includes:

(1) Message center
(2) Teletype relay
(3) Radio receiver
(4) Radio control
(5) Radio photo
(6) Communications, security activity
(7) Communications, operations and administrative

E1.03 TERMINAL EQUIPMENT BUILDING FACILITIES

A terminal equipment building generally includes control and terminal equipment facilities for radio SupAct and (if directed) a communication center for general service. General service is usually on the first floor and SupAct on the second floor, with the basement for joint use. SupAct operations are classified, but space will generally be furnished to accommodate:

(1) Offices for the commanding and executive officers
(2) Administration
(3) Equipment area (operating)
(4) Security
(5) Code room
(6) Electronics test room
(7) Supplies and duplicating
(8) Mail room

E1.04 SITE CHARACTERISTICS

If not at a base or station proper, communication centers and terminal equipment buildings should be separated a minimum of 1½ miles from radio receiving facilities because they contain so much electronic equipment (such as teletypewriters) that generates radio interference. Because these facilities contain communication control link equipment, including receivers and transmitters operating at ultra-high or super-high radio frequencies, site characteristics applicable to receiver buildings (paragraph C1.04) also may apply to communication centers and terminal equipment buildings.

E1.05 QUALIFYING FACTORS

Principal factors in selecting a site for a communication center and a terminal building will include:

(1) Suitability for radio reception.
(2) Accessibility to utilities and logistic support.
(3) Cost of establishing and maintaining the site, its auxiliaries, and operating personnel.

Secti n 2. DESIGN

E2.01 GENERAL

Permanent buildings for communication centers and terminal equipment buildings should be masonry and/or reinforced concrete construction. Interior partitions (except those enclosing stairhalls, toilets, vaults, elevator hoistways, and machinery rooms in basements) should be metal or wood studs and plaster or dry wall construction for easy rearrangement of operating spaces. Exterior walls (except doors and openings necessary for ventilation and air-conditioning systems) are unpierced by windows. This type of construction provides proper security without special scatterproof or bombproof design.

E2.02 COMMUNICATION CENTERS

Communication centers are designed in accordance with applicable requirements specified for terminal equipment buildings.

E2.03 TERMINAL EQUIPMENT BUILDINGS

1. GENERAL. Terminal equipment buildings are designed for ready access to frame room, multicouplers, raceways for wiring, cable trenches, and wiring passageways. This may be done with cellular steel floors (where floors do not rest directly on the ground), trenches, and overhead wiring racks or ladders. The building is wired to suppress radio interference by providing space inside the outlet boxes for capacitor-resistor network filters. The building should also have the required loading platforms and an elevator if it is higher than one story.

The following design requirements are general, and it should be understood that the functions of a terminal equipment building will vary in different locations according to Chief of Naval Operations directives.

2. BASEMENT.
   (1) Security room.
   (2) Photo-radio room.
   (3) Agitator room.
   (4) Conference room.
   (5) Cable-terminating and frame room.
   (6) Spare parts storage.
   (7) Repair shop for general service.
   (8) Teletype repair shop.
   (9) Electronic equipment repair.
   (10) Incinerator for classified papers and tapes (if required).
   (11) Transformer vault (if located inside building).
   (12) Machinery room, including machinery necessary for ventilation and/or complete air conditioning (if required).
   (13) General storage.
   (14) Wiring tunnel or passageway and/or trench, accessible to frame room and to cellular steel floors above.

3. FIRST FLOOR.
   (1) Office for commanding officer.
   (2) Administration.
   (3) CNO space and radio room.
   (4) NYX relay.
   (5) Cryptoroom with vault.
   (6) Room for CCL and local VHF Ratt (if required).
   (7) Receiving room opening upon loading platform.
   (8) Elevator (if more than one story).
   (9) Storage room.
   (10) Main frame and line-testing room.

4. SECOND FLOOR (SupAct).
   (1) Control (frame) room.
   (2) OIC office.
   (3) Mail room.
   (4) Duplicating.
   (5) Electronics testing room.
   (6) Code room.
   (7) Vault.
   (8) Equipment area (operating, large).
   (9) Communications (outgoing).
   (10) Administration.
   (11) Storage.

5. MISCELLANEOUS. Room or space for halls, lobbies, stairs, toilets, cleaning gear, and a small coffee mess should be provided as required.

E2.04 POWER AND GROUND CONTROL LINES

Power and ground control lines can be overhead in the vicinity of the terminal equipment building. Where they enter the building, however, they must be below grade to allow proper distribution throughout the building from the main power distribution panel and main terminal equipment frames.

E2.05 ACCESS AREAS

Parking and access areas of suitable size, including an area for maneuvering and paved areas at entrances and unloading platforms, should furnish easy access for motor vehicles.

E2.06 ELECTRONIC INTERFERENCE AND GROUNDING

General requirements for suppressing electronic interference are outlined in paragraph E2.03, and the subject of grounding is covered in paragraph 1 of E2.10.

E2.07 ARCHITECTURAL CRITERIA

In addition to the general information in paragraph E2.01, architectural criteria for a terminal equipment building include the following:

1. FLOORS.

a. *Basement.* The basement should be reinforced concrete, dusted-on smooth-trowelled finish in storage spaces, vaults, and wiring passages; ceramic tile in toilets, and asphalt tile for all other wearing surfaces. Slabs resting directly on the ground must have membrane waterproofing underneath on a 6-inch porous fill.

b. *First Floor.* The first floor should be reinforced concrete or structural steel framing with cellular steel flooring. The floor in vaults and unassigned spaces should be a cement underbed with dusted-on finish; it should be underbed and ceramic tile in the toilets, and asphalt tile on a suitable underbed for all other wearing surfaces.

c. *Second Floor.* The second floor is the same as the first.

d. *Surface Treatment.* Concrete floors or floors finished with cement topping must be surface treated and sealed against dusting.

2. WALLS, PARTITIONS, AND CEILINGS.

a. *Walls and Partitions.* All partitions, except masonry, are wood studs faced with wallboard to permit rearrangement of rooms, with the joints properly pointed and painted. (Metal lath and plaster partitions may be used in place of dry wall construction.) Concrete and masonry walls and partitions should have smoothed joints and neutralized and painted surfaces if practicable. If this is not practicable, they should be furred, plastered, and painted. Glazed tile wainscoting may be used in toilets.

b. *Ceilings.* If the underside of cellular steel floor is exposed, suspended ceilings are used, and all ceilings except concrete slabs in basements must be plastered and painted.

c. *Other Considerations.*

(1) *Acoustical Treatment.* Walls and ceilings must be acoustically tr ated in rooms containing electronic equipment, especially teletypewriters.

(2) *Exterior Walls.* Exterior surfaces of concrete walls should be smoothed where necessary and given one or two coats of cement water paint. Walls below grade must be waterproofed with membrane waterproofing.

(3) *Base of Walls.* Continuous 6-inch diameter drain tiles in a porous fill envelope must be provided at the base of walls around buildings wherever there are basements.

(4) *Wire-Mesh Partitions.* Wire-mesh partitions should enclose certain basement rooms (repair shops and spare parts storage).

3. DOORS. All doors leading to SupAct spaces must have combination dial locks for security. The same condition pertains for doors leading to other security rooms to prohibit entrance of unauthorized persons.

4. ROOFS. Roofs are insulated as required, and flat roofs must be sloped at least ½ inch to the foot and covered with 4-ply, built-up roofing according to the latest edition of *Standard Specifications*, TY9. Roofs supporting antennas or other electronic equipment must be designed for 150 psf.

E2.08 STRUCTURAL CRITERIA

1. DRAWINGS AND SPECIFICATIONS. Drawings of the terminal equipment building, including the communication center, designed and constructed at the Naval Communication Station, Guam, M.I., may be obtained from the Bureau. Drawings of similar buildings at the Naval Communication Facilities, Naval Station, Adak, Alaska, and at the Naval Air Activity, Port Lyautey, French Morocco, are also available for use as guides.

2. LOADS. Dead load, wind load, and seismic load must conform to applicable Bureau of Yards and Docks requirements governing other buildings in the area. Live loads for a terminal equipment building are the same as for a receiver building. (See paragraph 2 of C2.04.)

E2.09 POWER REQUIREMENTS

Power requirements for a terminal equipment building should include the power loads necessary

for all functions in the building, including loads for lighting, utilities, and el ctronic equipment.

1. LIGHTING. Normal operating conditions require an illumination of from 30 to 40 ft-c; emergency conditions, from 20 to 25 ft-c. Only incandescent lighting is used.

2. UTILITIES. Power supply must be provided for the convenience outlets, air conditioning, and additional requirements for repair rooms, cable-terminating frame rooms, telephone exchange, and electronic-equipment testing.

3. ELECTRONIC EQUIPMENT. The load for electronic equipment is calculated in the equipment schedule supplied by the Bureau of Ships or the District Electronics Office. Terminal equipment buildings and communication centers include the following electronic equipment.

Item	*Type*	*Power requirements at 50% power factor*
(1) Teletypewriters	Model 14	125 w ea
Teletypewriters	Model 15	160 w ea
Teletypewriters	Model 19	85 w ea
(2) Duplex units	Each unit consisting of a set of Model 14, 15, and 19; or 14, 28, and 19 teletypes	
(3) ANFGC5 (multiplex)		1.4 kw ea
(4) ANFGC3	CCL equipment	1 kw ea
(5) Facsimiles		200 w ea
(6) ANFGC6	NTX relays, 3 circuits each of 3 transmitter distributors, 4 type reperforators, sending, receiving, and monitoring	2 kw
(7) Tape factories	2 receiving, 1 sending	1,540 w
(8) Boehme circuits	CW	500 w ea
(9) CW, circuits	2 receivers	250 w
(10) Repeaters	Teletype	1 kw
(11) Message center	Duplicating NTX routing, teletype routing	

4. EMERGENCY POWER. Standby and/or emergency power is also required for a terminal equipment building. In the event that the primary source of power faiis, the emergency source should furnish power for: (a) normal operation of electronic equipment; (b) lighting for office and operating spaces, from 20 to 25 ft-c; (c) blower ventilation (100 percent outside air), no cooling; and (d) switchgear, 15-second rating.

E2.10 MECHANICAL CRITERIA

1. ELECTRICAL BONDING AND GROUNDING. No bonding is required for metal structural members, such as reinforcing steel, flashings, and door frames, but copper grounding bus bars are electrically bonded to conduits, piping, and cellular steel floors. These bars are grounded outside to a moderate, buried ground system in locations where ground conductivity is poor. Otherwise, grounding to the water piping system is sufficient.

If required, buried ground consists of 40 No. 6 AWG bare copper wires, each 50 feet long, brazed or welded to a copper plate and radiating from this common point.

2. CIRCUIT AND PANEL REQUIREMENTS.

(1) 50 percent extra circuits in addition to those necessary.

(2) 100 percent spare circuits in main distribution panel.

(3) One 3-phase power panel.

(4) Power-distribution riser ducts at end of wiring passages or trenches from basement to second floor (if structure has two stories and a basement); additional power-distribution panels on first and second floors at this riser.

(5) Convenience outlets spaced 10 feet on centers on all walls in offices and operating spaces.

3. HEATING AND VENTILATION. Terminal equipment buildings, including communication centers, are provided with heating and/or ventilation systems (air conditioning, if required). In designing them, heat dissipation from electronic equipment is a consideration. The dissipation will not amount to much, but such data may be procured from the Electronics Officer for Shore Installations or from the Bureau of Ships. Heating and ventilation systems should maintain: (a) a temperature of 70° F with a maximum of 85° F when the outside temperature is 0° F; and (b) a relative humidity of 60 percent or below to minimize deterioration of electronic equipment.

Depending on the climate, one of the following systems is used: heating and ventilation without cooling and dehumidification; heating and ventilation with summer cooling and dehumidification; ventilation without heating or cooling; ventilation only. If cooling and dehumidification are required, mechanical refrigeration is preferred; if only cooling is required, evaporative cooling is acceptable.

E2.11 COMMUNICATION CONTROL LINES

Communication control lines for communication centers and terminal equipment buildings are generally provided by telephone companies in the area

under contract with the Navy Department. If no t lephone company lines ar availabl , ground control cables ar provided by Bureau of Yards and Docks or Bur au of Ships contracts, as the case requires.

The ground control syst m is th primary control for communication facilities. If funds do not permit installation of such lines, however, the secondary system (VHF or UHF) communication control links should be utilized for primary control. The number of pairs requir d in ground control cabl s is established by th Bureau of Ships. Local tel phone (control) installations ar fulfill d by Bureau of Yards and Docks contract, and long haul installations by Chief of Naval Operations contract (DCO).

PART F. RADI DIRECTI N FINDER (D/F) FACILITIES

Section 1. REQUIREMENTS

F1.01 GENERAL

A radio direction finder (D/F) facility is an important and vital component of the basic Naval Communication System. Its primary mission is to determine the exact location of any transmitted radio signal, and it is highly effective in:

(1) Antisubmarine warfare

(2) Search and rescue efforts

(3) Location of unfriendly transmitter stations

F1.02 METHOD OF TRACKING

To determine the exact origin of a transmitted radio signal, a control center instructs two or more D/F facilities to take a fix (true bearing) on a radio signal of a certain frequency and located in a definite sector. The more D/F facilities taking a fix on a questionable signal, the more accurate will be the determination of its location. Each D/F facility advises the control center of its fix, which is then plotted. The point of intersection of all fixes is the source of the questionable signal.

F1.03 COMPOSITION

A self-supporting D/F facility consists of two distinct areas about 3½ miles apart. One is called the operations area, and the second the logistic or transmitter area. Both areas shall be served with the following public utilities, if available: telephone, electric power, water, and sewerage.

1. OPERATIONS AREA. The operations area consists of approximately 180 acres containing: (a) the operations building with its attendant D/F antenna arrays, (b) auxiliary power building, (c) necessary rhombic receiving antennas, and (d) access road with a parking area.

If public utilities are not available, the auxiliary power plant becomes the primary power with auxiliary power backup. Water must be obtained by the most economical method. A communication line must be installed between the operations area and the logistic area.

2. LOGISTIC AREA. The logistic area consists of approximately 60 acres containing: (a) a utility building (including transmitter facilities when required), auxiliary power, workshop, storage, and garage; (b) barracks building with galley and messhall for 24 enlisted men and 1 officer; (c) transmitting rhombic antennas; and (d) road with parking area.

If public utilities are not available, the auxiliary power becomes the primary power with auxiliary backup, and water is obtained by drilling a well or any other appropriate means.

F1.04 SITE CHARACTERISTICS

The site for the operations building and the D/F arrays should be as flat as possible and meet the following requirements:

(1) Good ground conductivity.

(2) Low noise level.

(3) Homogeneity of soil, free of all conductors, such as pipes, cables, wires, rails, and so on.

(4) Obstructions (buildings, trees, or mountains) not exceeding an angle of 5 degrees above the horizontal, with the center of the operations building the apex of the angle.

(5) Preferred minimum separation from:

(a) VLF and LF transmitter station (500 kw or over) ..... 50 miles

(b) VLF and LF transmitter station (50 kw) ..... 25 miles

(c) VLF and LF transmitter station (10 kw) ..... 10 miles

(d) Any other transmitter ..... 5 miles

(e) Aviation and navigation aids (transmitting type up to MGS) ..... 5 miles

(f) Receiver station ..... 1,000 ft

(g) Power lines (aerial)

(1) 11,000 v or over ..... 3 miles

(2) 2,200 to 11,000 v ..... 1 mile

(3) 440 to 2,200 v ..... 2,500 ft

(all lines at a lesser distance to be buried)

(h) Transformer substations over 11,000 v ..... 3 miles

(i) Industrial area:

(1) Non-Navy ..... 1½ miles

(2) Navy ..... 1,000 ft

(j) Communication center (command) ..... ½ mile

(k) Terminal building (station) . . . . . ½ mile

(l) Any highway or parking area, 1,000 ft

(m) Any other activity . . . . . 1,000 ft

(6) Ready availability of utilities (sewers, water, electric, telephone).

(7) Easy access to roads.

F1.05 QUALIFYING FACTORS

The site characteristics enumerated in paragraph F1.04 pertain to an ideal site. Certain modifications may be required, however, to obtain a satisfactory facility at an economical cost, in lieu of an excellent facility at a very high cost or of one entailing excessive maintenance. Excellent conductivity and low noise level, for example, would be obtained by locating the site in a swamp, but the construction cost would be excessive and the maintenance of a facility at such a location would be very uneconomical. In this case, a site without such excellent conductivity and low noise level would be more economical to construct, maintain, and operate.

Section 2. DESIGN

F2.01 GENERAL

The design of a radio D/F facility is a relatively simple matter from the standpoint of design loading because the main problems concern the equipment to be used and its placement.

All structures are permanent, single-story, without a basement, and of either frame or nonferrous masonry construction, whichever type is more economical in first cost and maintenance for the particular locale. Footings and foundations of the building can be reinforced concrete. This kind of construction is specified for the extremely sensitive electronic equipment installed and operated at this facility.

F2.02 OPERATIONS BUILDING

1. GENERAL. The operations building is usually a gable-roofed structure in the shape of an off-center T. The approximate dimensions of the top of the T are 25½ ft x 61 ft, and this section contains the operations room (25½ ft x 37½ ft), workshop (10 ft 6 in. x 19 ft 4 in.), storage room (10 ft 4 in. x 13 ft), boiler room (13 ft x 15 ft 2 in.), and a passage. The stem of the T is approximately 18 ft x 18½ ft and houses the toilet (6 ft x 11 ft 2 in.), office and emergency berthing (12 ft 6 in. x 17 ft 2 in.), and the entrance passage. The stem of the T shall be affixed to the top of the T opposite the area housing the workshop, boiler

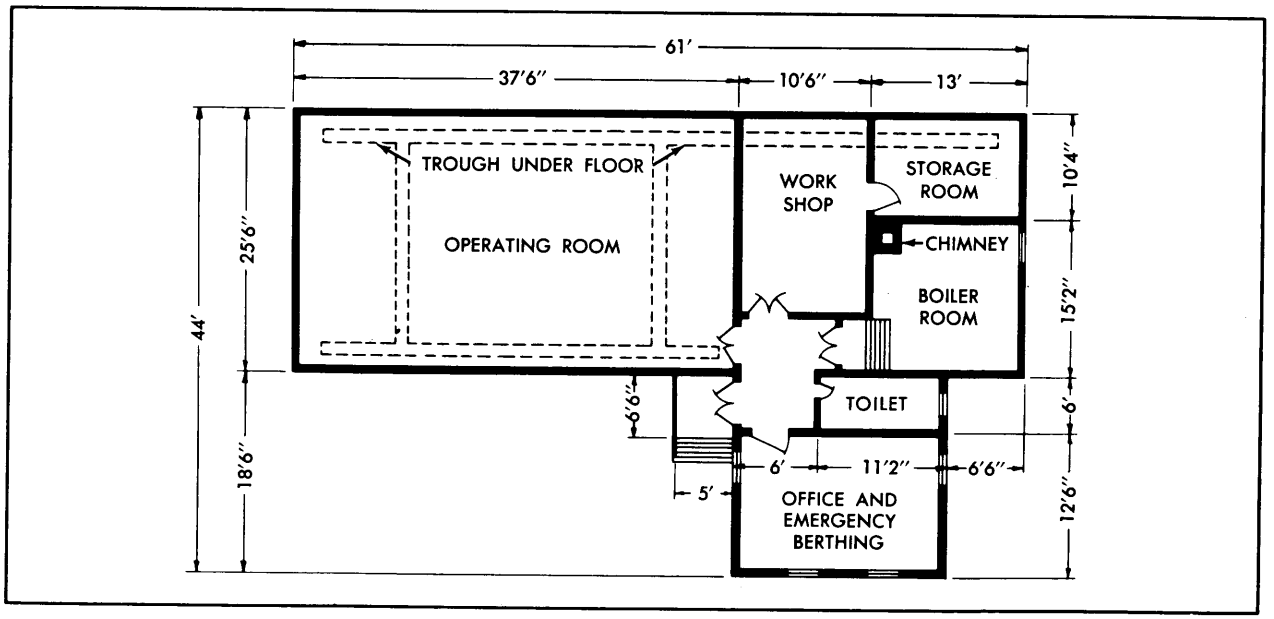


FIGURE 1

D/F Op rati ns Building—Floor Plan

room, and storage room, with one outside wall in line with the inner end of the operations room.

The finished floor level is approximately 3½ ft above the finished grade around the building, except the floor level of the boiler room, which is approximately at grade.

The finished floor surface is asphalt tile, except the finished concrete floor in the boiler room.

2. CABLE TROUGH. A wooden cable trough (inside dimensions, 6 in. deep x 10 in. wide) must be suspended from the floor joists along each side and extend the full length of the building, except for the area of the boiler room. The center of the trough is located about 3½ ft from the inside face of the foundation wall, and the bottom of the trough 3 ft below the finished floor level. Trough lengths terminate within 2 ft of the inside face of the foundation walls. The two side cable troughs are connected by two cross cable troughs of the same dimension and at the same elevation. Centers of the cross cable troughs are located about 8 ft and 30½ ft, respectively, from the inside face of the exterior foundation wall of the operations room. Access doors are provided to the cable trough area, and the area is illuminated whenever personnel are inside.

3. CATWALK. A catwalk with an access shall be provided in the attic.

4. WIRING, PIPES, AND FIXTURES. No metal is to extend above 4½ ft from the finished floor of the building, and all soil vents, pipes, heating, and air-conditioning ducts, that are over 4½ ft above the finished floor, must be nonmetallic. All wiring and electric light fixtures are to be wall-mounted with indirect lighting in the operations room.

5. ENTRANCE AND EXITS. The operations building has only one main exterior entrance consisting of two doors (2½ ft x 7 ft) equipped with magnetic lock and warning buzzer. An emergency exit may be provided and the door equipped with a panic bolt. The building is windowless except, possibly, for windows in the office and emergency berthing area.

6. OFFICE AND EMERGENCY BERTHING ROOM. The office and emergency berthing room is equipped with a small electric refrigerator, electric range or 2-burner hot plate, small sink, and bunks to accommodate four persons under emergency conditions, such as severe snowstorm or hurricane.

7. MOTORS. All motors are induction type.

8. GROUNDING. The building must have a copper bar ground (1 in. x ⅛ in.) around the inside of the foundation, 1 ft above grade, with each corner connected by a No. 6 bare copper wire to a copper-clad ground rod (¾ in. x 10 ft).

9. ELECTRONIC EQUIPMENT. Installation of all electronic equipment is the responsibility of the Electronics Officer.

10. ENCLOSURE. A wooden fence with a gate must be located about 50 ft from each side of the building to enclose the building area.

11. FIRE PROTECTION. Internal fire protection is by CO_2 hand extinguishers.

12. FLOODLIGHTS. A floodlight shall be placed at grade at each corner of the fence around the operations building and directed along the fence.

F2.03 AUXILIARY POWER BUILDING IN OPERATIONS AREA

The auxiliary power generator unit must be housed in a building constructed of the same material as the operations building, at a minimum distance of 300 feet from the operations building along the access road, and large enough to take care of the auxiliary power generator unit, switchgear, and automatic starting unit.

The auxiliary power unit should be ample to handle the full electronic load of the operations building in addition to its minimum power load requirements. It should be quick-starting, conforming in all respects to *Military Specifications*, MIL-R-16165 (Bureau of Ships) of 15 March 1951, regarding radio-interference shielding.

Any transformers required on the primary power are located adjacent to the building and enclosed by a wooden fence.

Wiring, pipes, and fixtures shall conform to the requirements of the operations building. (See paragraph 4 of F2.02.)

F2.04 D/F ANTENNA ARRAY

Installation of DAJ-type D/F equipment requires four antenna arrays (DAM, DAN, DAL, and DAO) for effective operation and coverage. Arrays are spaced symmetrically about the longitudinal center line of the operations room of the operations building, DAM and DAL arrays with a 450-foot radius from the center of the opera-

tions room, and DAN and DAO arrays with a 300-foot radius from the same center. The spacing between arrays is 300 feet. Each array consists of five monopoles, and the exact spacing and arrangement of the monopoles in each array is to be obtained from the Electronics Officer.

Footings of the pedestals for the antenna array monopoles are to be designed to remain rigid under a 20,000-pound vertical load, and foundations of the guy anchors for the monopoles must withstand an axial pull of 700 pounds per guy. Footings, pedestals, and guy anchor foundations are reinforced concrete.

In the event that grazing is to be permitted in the area, each antenna array shall be enclosed by a wooden fence located 90 feet, from the center of the array.

F2.05 BARRACKS AND MESSHALL

Barracks and messhall should be designed to accommodate 1 officer and 24 enlisted men in accordance with this Bureau's design crit ria.

F2.06 UTILITY BUILDING

1. GENERAL. This building is often constructed in the shape of an L. The approximate dimensions of the long side of the L are 28 ft x 69 ft, and it houses the transmitter room (11 ft x 24½ ft), emergency generator room (11 ft x 20 ft), workshop and storage (17 ft x 24½ ft), boiler room (17 ft x 20 ft), toilet (5 ft 6 in. x 8 ft 9 in.), and two-car garage (24 ft 6 in. x 28 ft 4 in.). The base of the L, approximately 17 ft x 20 ft 4 in., contains the well pump with water storage tanks, and is attached to the rear of the garage.

The finished floor surface of the transmitter room and the workshop and storage room is asphalt tile; the remaining floor is finished concrete.

2. CABLE TROUGH. A trough (1 ft 6 in. wide x 6 in. deep), covered with removable sections of checkered steel floor plates, is constructed

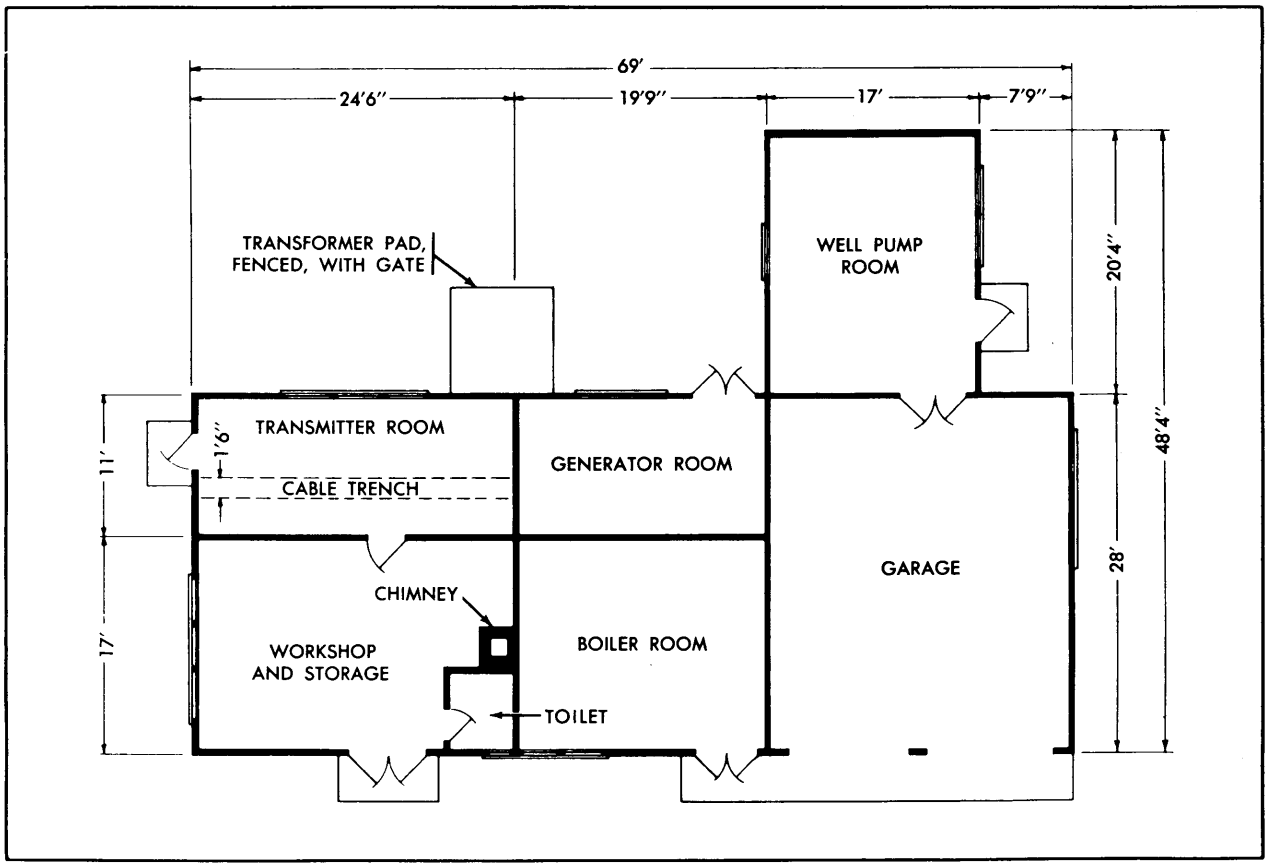


FIGURE 2

D/F Utility Building—Fl r Plan

in and across the width of the transmitter room floor from the generator room. Transmitters are located over this trench, which contains all the necessary power, radio-frequency, and audio-frequency cables.

3. TRANSFORMERS. Any transformers required on the primary power source are adjacent to the building and enclosed by a woven-wire fence.

4. EMERGENCY POWER UNIT. The emergency power unit should be ample to handle the full electronic load of the transmitters in addition to the minimum power load required by the utility building and the barracks and galley.

5. GROUNDING. The utility building must be grounded, encompassed by an external No. 2/0 copper ground girdle to which are attached No. 6 AWG soft-drawn bare copper ground wires 50 feet long and buried 1 foot below grade. These wires are spaced approximately 10 feet apart and terminate on a ¾-inch copper-clad ground rod. The transmitters, all the metal in the transmitter room, and the emergency generator are grounded inside the building to an electrical bus connected to the external ground girdle.

6. ANTENNA LEAD-INS AND INSULATORS. Adequate provision must be made for installation of antenna lead-ins and insulators around the exterior walls and near the ceiling of the transmitter room.

7. FIRE PROTECTION. Internal fire protection is by portable CO_2 system.

The well pump house must have water-storage capacity to meet minimum fire regulations in addition to normal personnel requirements.

Section 3. CONSTRUCTION

F3.01 GENERAL

The buildings composing a radio D/F facility are described in Part F, Section 2, Design. Any special features discussed there pertain to both design and construction.

F3.02 ANTENNA ARRAY CABLES AND TRENCHES

Cable trenches are 2 feet wide by a depth of 1 foot below the average water table. A 10-inch bed of select backfill, preferably sand, is laid on the bottom of the cable trench, and cables are laid there approximately 4 inches from the bottom of the fill. A suitable 2-inch plank covers the backfill containing the cables, and the remainder of the trench is filled with the original earth.

Cables are cut to length and laid under supervision of Navy electronics personnel and are connected to the tee-junction and field-junction boxes, array monopoles, and to equipment in the operations building.

F3.03 CABLES WITHIN OPERATIONS AREA

For a minimum distance of 1,000 feet from the operations building, all cables, wiring conductors, and pipes within the area must be buried 5 feet deep or 1 foot below the average water table (or deep enough to avoid damage by agriculture, if such is required).

Minimum distance of the cable pole of any rhombic antenna in the operations area must be 1,800 feet from the nearest D/F antenna array. The cable (RG-85U) from the operations building to the rhombic antenna is buried the entire distance, according to instructions in the preceding paragraph.

F3.04 ANTENNA AND D/F ARRAY MONOPOLES

All antennas are constructed in conformance with Bureau of Ships drawings and specifications applicable to the particular type of antenna. Drawings and specifications are furnished either by that Bureau or the Industrial Manager of the naval district in which the project is located.

Each D/F antenna array must be erected on an absolutely level circular area with a 90-foot radius from the center of the array. Array monopoles are erected by the Industrial Manager.

F3.05 INSTALLATION OF ELECTRONIC EQUIPMENT

Installation and connection of all electronic equipment at the operations area and transmitter site must be done by Navy electronics personnel.

PART G. C NTR L LINK FACILITIES

Section 1. CONSIDERATIONS

G1.01 GENERAL

The various components of a naval communication station [naval radio station (R), (T), (S), and communication center] are interconnected by communication control circuits for keying circuits and passing information between units. These circuits may be telephone-type cable pairs (either leased or Government-owned), or special short-range (from 25 to 30 miles) radio equipment commonly known as CCL (communication control links).

Present procedure is to use cables only for short distances where cables lie entirely within Government-owned property. In practice, cables are primarily useful between a receiver building and a terminal building, because both are on the receiver station site. If longer distances are involved, the use of CCL is preferable.

G1.02 OPERATING FREQUENCIES

CCL equipment may be defined roughly by its operating frequencies. Presently installed equipment is almost entirely within the VHF range (from 132 to 152 megacycles). Some equipment operates in the 80- to 100-megacycle and the 360- to 400-megacycle bands. Because the installation problems for these bands are almost identical, they will be considered as VHF for present purposes of discussion.

All CCL installations must be carefully and fully coordinated with electronics personnel.

For practical reasons, no new major installation will be made in the VHF range except, possibly, at overseas locations in isolated areas. VHF equipment now installed is to be replaced, on a planned basis, with equipment operating in the 1,700- to 1,850-megacycle range, known as microwave.

Section 2. INSTALLATION

G2.01 VHF REQUIREMENTS

Installation of VHF equipment, including antennas, requires a location free from radio noise, with particular attention paid to isolation from vehicular traffic. (An interference survey must be conducted by electronics specialists prior to installation.) Antennas should be located to provide an optical line of sight between the antennas on both ends. Under favorable conditions, this requirement may be minimized, but the decision is to be made by qualified electronics personnel and based upon actual measurements. Connection between the antenna and other equipment, however, is to be of minimum length.

Ordinarily, the connection between antenna and equipment will be solid, dielectric coaxial cable, such as RG-17/U and RG-8/U, and antenna supports will be rigid.

G2.02 MICROWAVE REQUIREMENTS

Installation requirements for microwave CCL equipment are much more stringent than for VHF. Each RF path (site-to-site) must be determined individually, and only general rules can be given here. Over a path of broken terrain reasonably consistent in height, a First Fresnel Zone clearance of all obstacles over a 4/3 earth-radius profile is required. If this can not be obtained on a direct site-to-site basis, one or more intermediate stations, known as repeaters, must be used.

Profile charts, prepared by the Public Works Officer, for each path will show the geographical location of each antenna in degrees, minutes, and seconds, and the bearing between the end points in degrees, minutes, and seconds. This profile must also identify the nature of the terrain (wooded, cultivated, water, and buildings). Tree and building heights should be estimated and noted carefully for possible future tree growth or probable new building construction.

G2.03 TERRAIN

Over a path of terrain of substantially flat earth or water, antenna heights other than those in the preceding paragraph may be required. Such devia-

tions represent difficult, technical decisions to be made only by the Bureau of Ships or its designated representative.

Antennas, coaxial cables, transmission lines, and associated fittings will be furnished by the Bureau of Ships and installation is to be carefully made to that Bureau's drawings and specifications. Connection between antennas and RF equipment will ordinarily be made by air-pressurized coaxial transmission line.

Section 3. TOWERS

G3.01 GENERAL REQUIREMENTS

Towers for microwave systems must be rigid structures that will not permit more than a 2-degree center-line deviation of the antennas.

NOTE: Antennas will be either 6-foot or 10-foot diameter parabolas and several may be on one tower.

Until more experience is gained in the problems of maintaining air-pressurized lines, the tower must not be used to support lower-frequency antennas, strongbacks, or other attachments. The Bureau of Ships, however, will consider such supports in individual cases upon request.

There is no requirement for location of microwave towers, antennas, and equipment in a radio-noise-free area.

Section 4. BUILDINGS

G4.01 RADIO FREQUENCY (RF) HOUSE

A small building, about 10 ft x 12 to 18 ft, to house the RF equipment must be provided at the base of each microwave tower (on the side of the tower toward the distant point, if possible) if the tower is more than 50 ft from the operations building and more than 200 ft high.

One run of buried RG-85/U cable is to be provided for each microwave transmitting or receiving circuit between the tower RF house and the operations building, and one 7-to-11 pair of telephone cable. Emergency a-c power is to be provided the RF house from the operations building emergency supply. Spare or alternate RG-85/U cable, telephone cables, and power lines are to be furnished as required by site considerations.

G4.02 REPEATER STATION BUILDING

A microwave repeater station installation at an operating point is similar to the RF house and tower. At the repeater station, however, the RF building should be about 20 ft x 20 ft and contain a 10 ft x 20 ft equipment space, a 10 ft x 10 ft storage battery locker, and a 10 ft x 10 ft automatic-start engine generator space. It should also have a battery-driven dynamotor, an automatic-start engine generator, and the necessary chargers, switchgear, and so on. Separation between antennas and RF building, without special approval of the Bureau of Ships, is not to exceed 300 ft, and 1,500 ft between RF building and operations building.

RF houses and repeater station buildings are windowless structures with 2-hour fire-resistance underwriters rating. Temperature in these buildings must be held between 55° F and 85° F, with a relative humidity of 50 percent or below. The equipment will require 115-volt, 60-cycle, I-phase power, and the load depends on station requirements.

Normally, both types of buildings will be occupied only for short maintenance periods.

PART H ANTENNA AND GR UND SYSTEMS

Section 1. REQUIREMENTS

H1.01 GENERAL

Naval radio communication facilities use various types of antenna for transmission and reception of radio signals, each type for an intended and specific purpose. The Bureau of Ships determines the type and size of antenna to be used and furnishes the Bur au of Yards and Docks or the District Public Works Officer with the design and working drawings. Designs for vertical radiators or self-supporting towers, however, are furnished by this Bureau.

Many structures at a radio transmitter station require a comprehensive and intricate ground system. Structures requiring such grounding area are: transmitter building (Figure 3), helix house, vertical radiators, and extensive suspended antenna syst m. The Bureau of Ships informs this Bureau of the type and extent of ground system.

At a radio receiver station or a D/F facility, certain buildings (receiver, terminal equipment, and D/F operations) have a less extensive electronics ground.

H1.02 TYPES OF ANTENNA

The following types of antenna are used at radio communication facilities (Figures 4 through 15, which appear at the end of this Part):

(1) Antenna system supported between self-supporting or guyed towers, transmitting and receiving.

(2) Vertical radiator, transmitting.

(a) Self-supporting.

(b) Guyed.

(3) Rhombic, transmitting and receiving.

(4) Wide-band doublets, transmitting and receiving.

(5) Tilted folded doublet, transmitting and receiving.

(6) Vee, transmitting and receiving.

(7) Vertical LF, transmitting and receiving.

(8) Vertical doublet, transmitting and receiving.

(9) Vertical phased doublet, transmitting and receiving.

(10) Horizontal parasitic doublet, transmitting and receiving.

(11) Horizontal two-wire doublet, transmitting.

(12) Horizontal three-wire doublet, receiving.

(13) Beverage (three-wire wave), transmitting.

(14) Various UHF and VHF antennas.

Section 2. DESIGN AND INSPECTION

H2.01 GENERAL

The design furnished by this Bureau must cover the structural design of the supporting structures (usually towers). The exception is the vertical radiator, either self-supporting or guyed, which is both antenna and supporting structure.

The antenna design is furnished by the Bureau of Ships, which in turn furnishes this Bureau the information as to desired arrangement, sag, and size and weight of material in the antenna system. From this data, the resulting forces applied to the tops of the towers are computed. District Public Works Officers should be sure that the towers are not subjected to antenna forces in excess of those for which they are designed.

Similarly, the electronic design of the grounding mats for vertical radiators, transmitter buildings, helix houses, and grounding system for suspended transmitting antenna is produced by the Bureau of Ships. Foundation design is made by the Bureau of Yards and Docks or the District Public Works Office.

H2.02 CRITERIA

The design of the supporting tower and vertical radiators (self-supporting and guyed) is based on this Bureau's design criteria, and their height is determined by the Bureau of Ships.

The Bureau of Yards and Docks provides for the galvanizing of all structural steel towers or

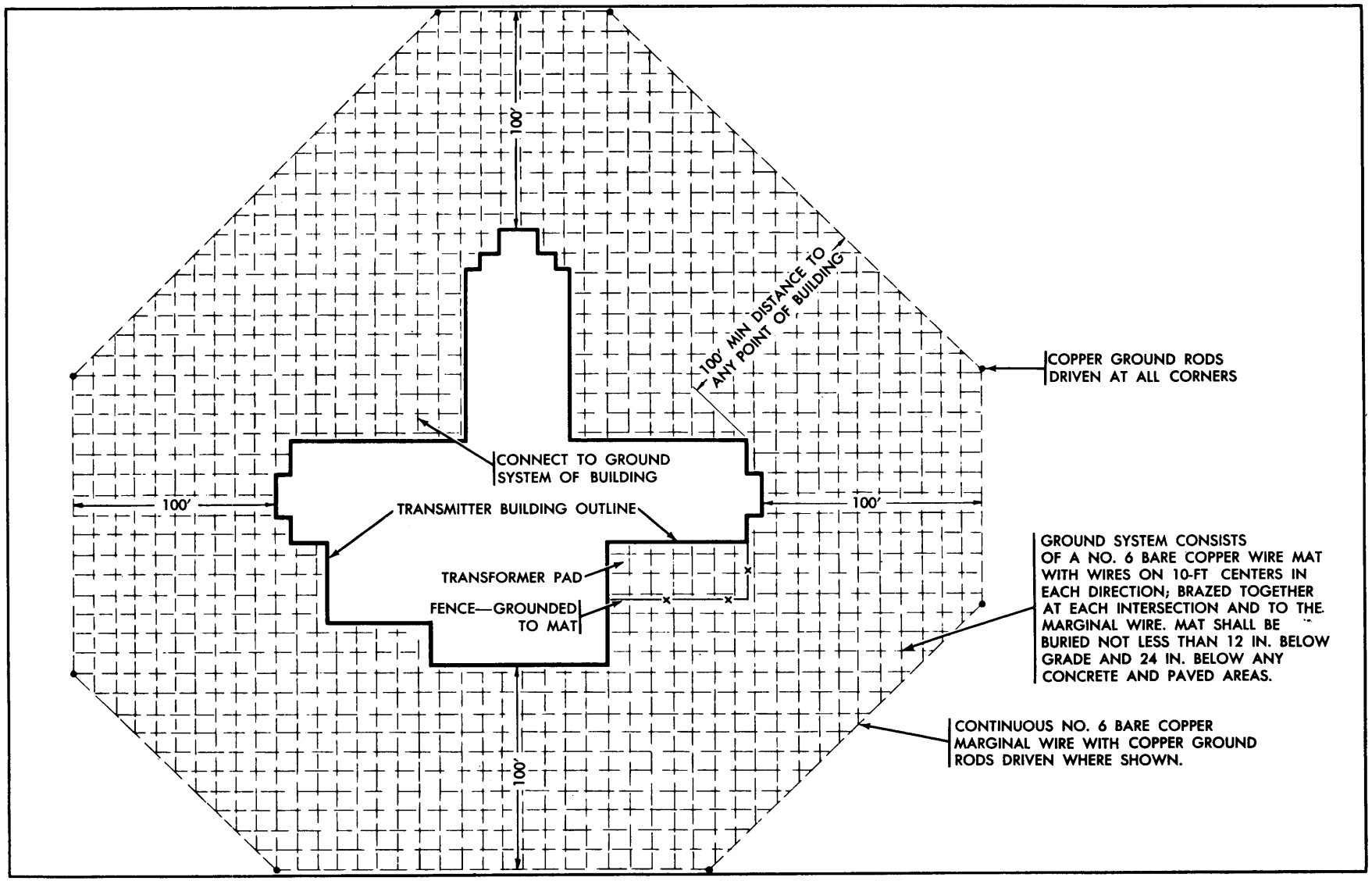


FIGURE 3

Ground System for Transmitter Building

v rtical radiat rs, r gardless of th purpose f r which they are er cted.

H2.03 STANDARD DESIGN DRAWINGS

The Bureau of Yards and Docks has standard design drawings c vering guyed vertical radiators of th following heights: 800 feet, 600 feet, 300 feet, and 250 feet; also standard design drawings f r self-supporting towers 300 feet and 450 feet high.

VERTICAL RADIATORS (GUYED)

Height, in ft	*Design condition*	*Standard drawing numbers*
800	Wind 90 mph	558,993 to 559,000 incl.
800	Wind 125 mph, or 90 mph with ½-in. ice	559,001 to 559,009 incl.
600	Wind 125 mph, or 90 mph with ½-in. ice	559,010 to 559,017 incl.
300	Wind 90 mph	559,018 to 559,020 incl.
300	Wind 125 mph, or 90 mph with ½-in. ice	559,021 to 559,023 incl.
250	Wind 100 mph with ½-in. ice	559,024 and 559,025

SELF-SUPPORTING TOWERS

300	Wind 150 mph with ½-in. ice and two 3,500-lb antenna pulls	559,026 to 559,028 incl.
300 and 450	Wind 90 mph and two 3,500-lb antenna pulls	559,029 to 559,035 incl.

The Bureau of Ships or the Industrial Manager of the naval district has standard working drawings for the antennas (3) through (13) listed in paragraph H1.02.

A typical grounding system for a helix house and a guyed vertical radiator is shown in Yards and Docks drawing No. 479, 245; typical grounding system for a transmitter building is shown in Yards and Docks drawing No. 512,614.

H2.04 CLEARANCE

All proposed towers or vertical radiators in the vicinity of any airfield or airpath must be approv d for air obstruction clearance by the Bureau of A ronautics.

H2.05 GUY ANCHOR SUPPORTS

Guy anchor supports are usually concrete. The type of bas and guy anchor supports for an 800-foot v rtical radiator are shown in Yards and Docks drawing No. 537, 535, but th se supports must be specifically d signed for each installation.

H2.06 WINCHES AND LADDERS

A winch with a snatch block and halyard is necessary to facilitate handling antenna n a radio tow r. Winches may be install d on towers at the top of the portal secti n, or at th base. Th latt r location is preferable because: (a) there is more room for operation, (b) climbing to operate winches is eliminated, (c) winches and halyards are more accessible, and (d) repairs can be accomplished more readily in bad weather. A hand-operated winch is usually installed, but motor drive is good for towers over 300 feet high if current is readily available; and a truck- or tractor-mounted winch also may be used in special cases.

A ladder with guards and resting platforms should be installed on one of the legs of each tower.

H2.07 LIGHTNING PROTECTION

Steel towers should be electrically grounded as a protection against lightning and accumulation of static charges, and a spark gap for insulated towers and vertical radiators serves the same purpose.

H2.08 HELIX HOUSE AND GROUND SYSTEM

Transmitting antennas of the low-frequency type are provided with electronic tuning devices, including coils (helices) and variometers furnished and installed by the Bureau of Ships. For high power LF or VLF transmitting antennas 50 kw or higher, the tuning equipments are installed in a helix house generally located near and below its particular antennas. The helix house is design d and constructed by the Bureau of Yards and Docks.

1. CONSTRUCTION OF HELIX HOUSE. Helix houses for 50-kw and higher LF antennas should be masonry and/or reinforced concrete construction (preferably reinforced concrete), with interior (floor, trenches, walls, and ceiling) completely copper lined. Entrances to helix houses must have double doors completely copper covered, of sizes permitting equipment installation. Linings (shielding) shall be 16-ounce copper sheets for LF antennas of the 50-kw type, and heavier (as determined by the Bureau of Ships) for antennas of higher power with continuous brazed or soldered joints.

Reinforcing st el, in walls and ceiling of helix hous s for 50-kw transmitters, shall be w ld d at joints between longitudinal and transverse rods

along lines 10 feet apart both ways, forming buses that shall be carried and grounded to the buried ground system surrounding the helix house. Reinforcing steel, in walls and ceilings of helix houses for transmitters of more than 50-kw power, must be welded at every joint where transverse rods pass longitudinal rods. This reinforcing is also carried and grounded to the buried ground system.

2. GROUND SYSTEM. The ground system for a helix house serving a vertical radiator (antenna for a 50-kw ANFRT4 transmitter) consists of a buried rectangular mat about 100 feet wide by 130 feet long. The mat is a grid of No. 6 AWG bare copper wires spaced 12 inches on the centers, both ways. The wires are brazed at each intersection, and to copper bar or zero-gage bare copper wire buses running continuously around the outer perimeter of the helix house and of the rectangular mat. The ground mat should not extend under the helix house.

The ground mat also will provide the grounding for the copper shielding on the pedestal for the isolating transformer that is between the helix house and the vertical radiator, and for the copper shielding over the pedestal supporting the vertical radiator. The radial ground system for the radiator, consisting of 240 radials of No. 6 AWG bare copper wire 1,000 feet long, does not terminate at the outer perimeter of the ground mat but is carried over the mat and brazed to the buses around the helix house, the isolating transformer, and the base of the vertical radiator.

The ground system for VLF antenna serving transmitters of the 500- or 1,000-kw variety is very extensive and should be specially designed for each particular project.

3. DRAWINGS. Bureau of Yards and Docks drawings and specifications for helix houses, isolating transformers, and vertical radiators constructed for the 50-kw LF (ANFRT4) transmitters installed at NCS, Adak, Alaska, at NCS, Kodiak, Alaska, and at Naval Air Activity, Transmitter Station, Port Lyautey, French Morocco, are available for use as guides. Also available are the drawings of the helix house and ground system provided for the 1,000-kw VLF ANFRT3 transmitter at the Navy Radio Station (T), Snohomish County, Arlington, Washington. In addition, this Bureau has standard drawings for a 50-kw helix house and vertical radiator installation.

H2.09 INSPECTION

Towers and radiators must be thoroughly inspected every two years by competent personnel to obviate any serious structural defect and to determine the necessity for structural repair.

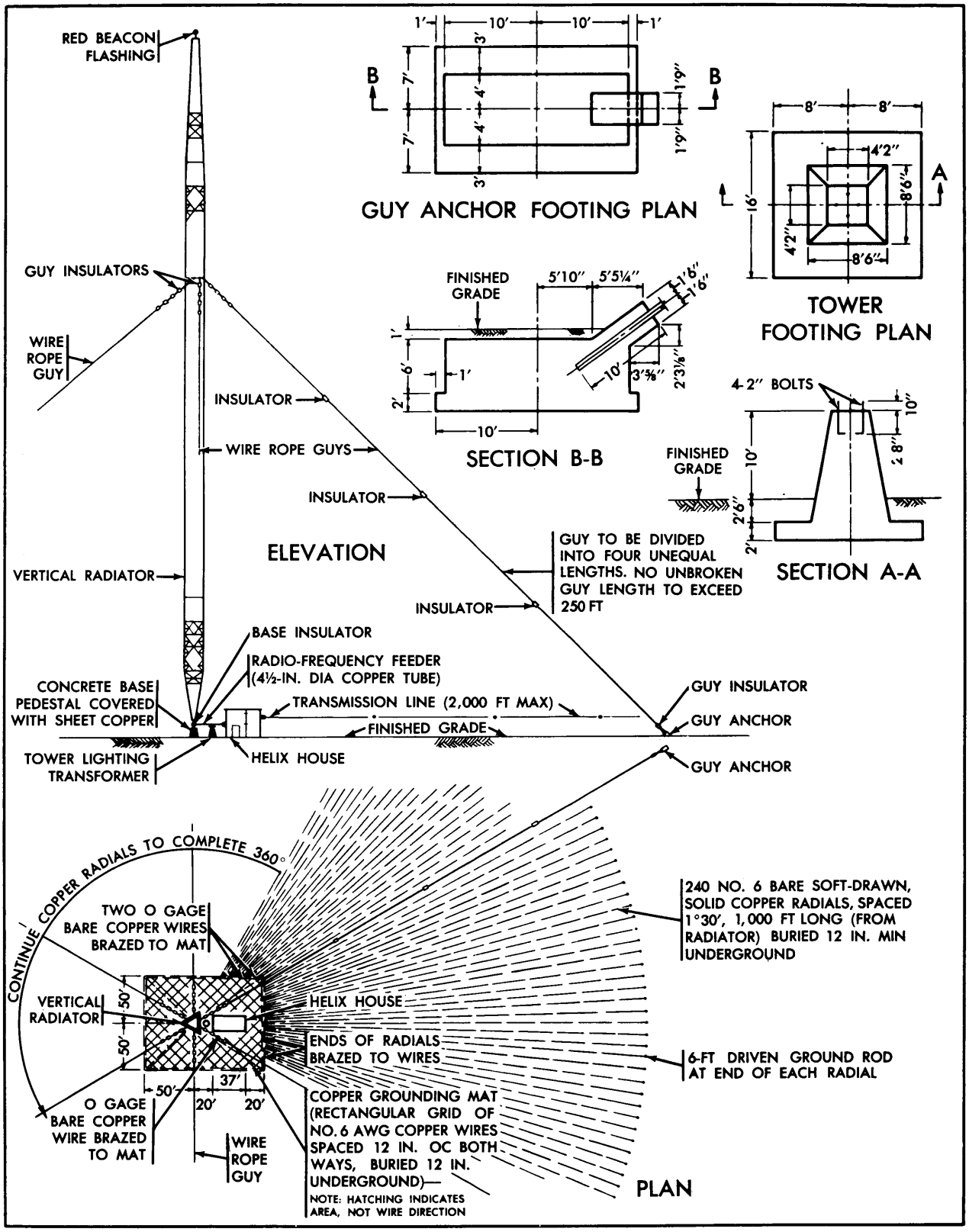


FIGURE 4

V rtical Radiat r (Guyed) and Gr unding Syst m

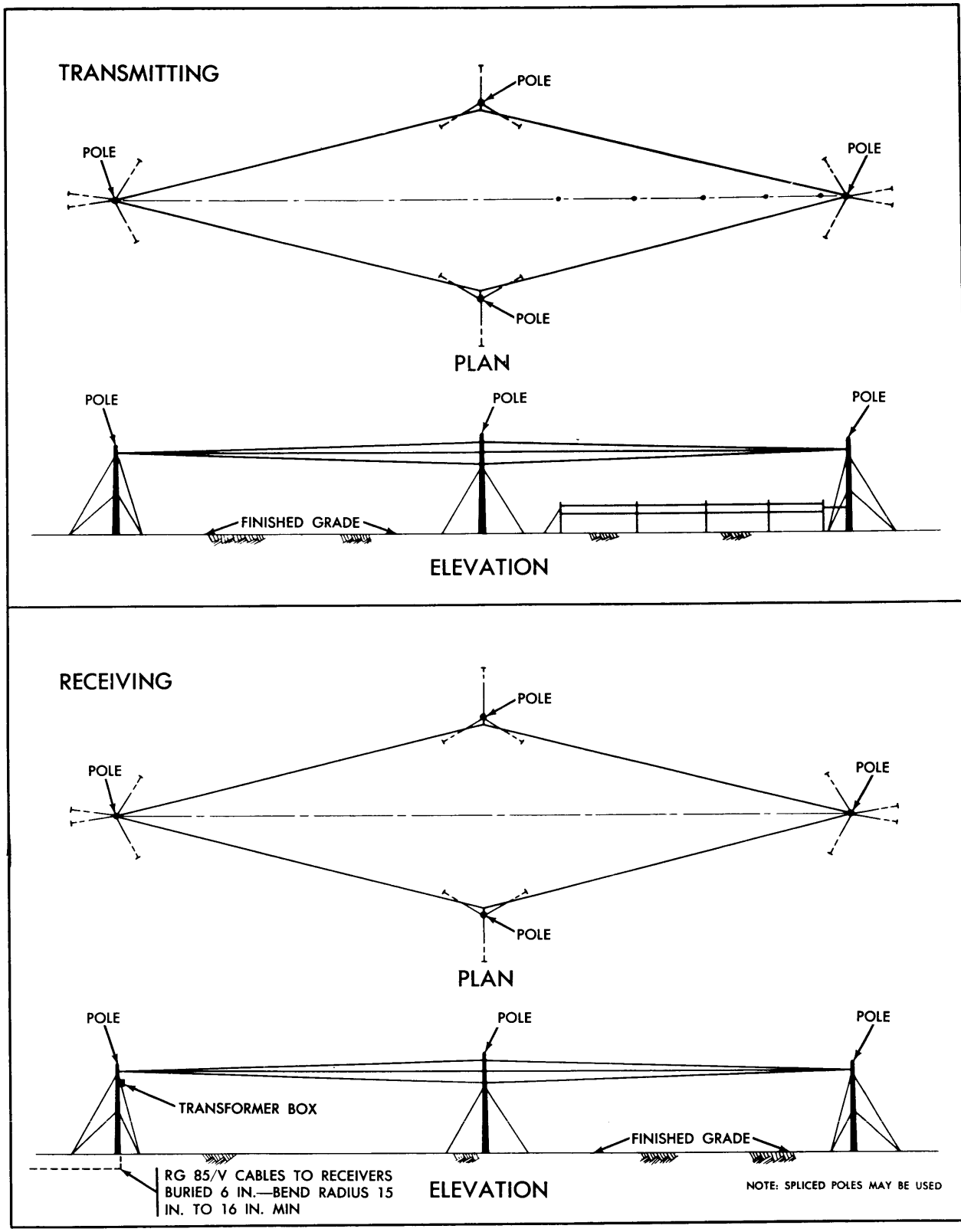


FIGURE 5

Rh mbic Ant nna—Transmitting and R c iving

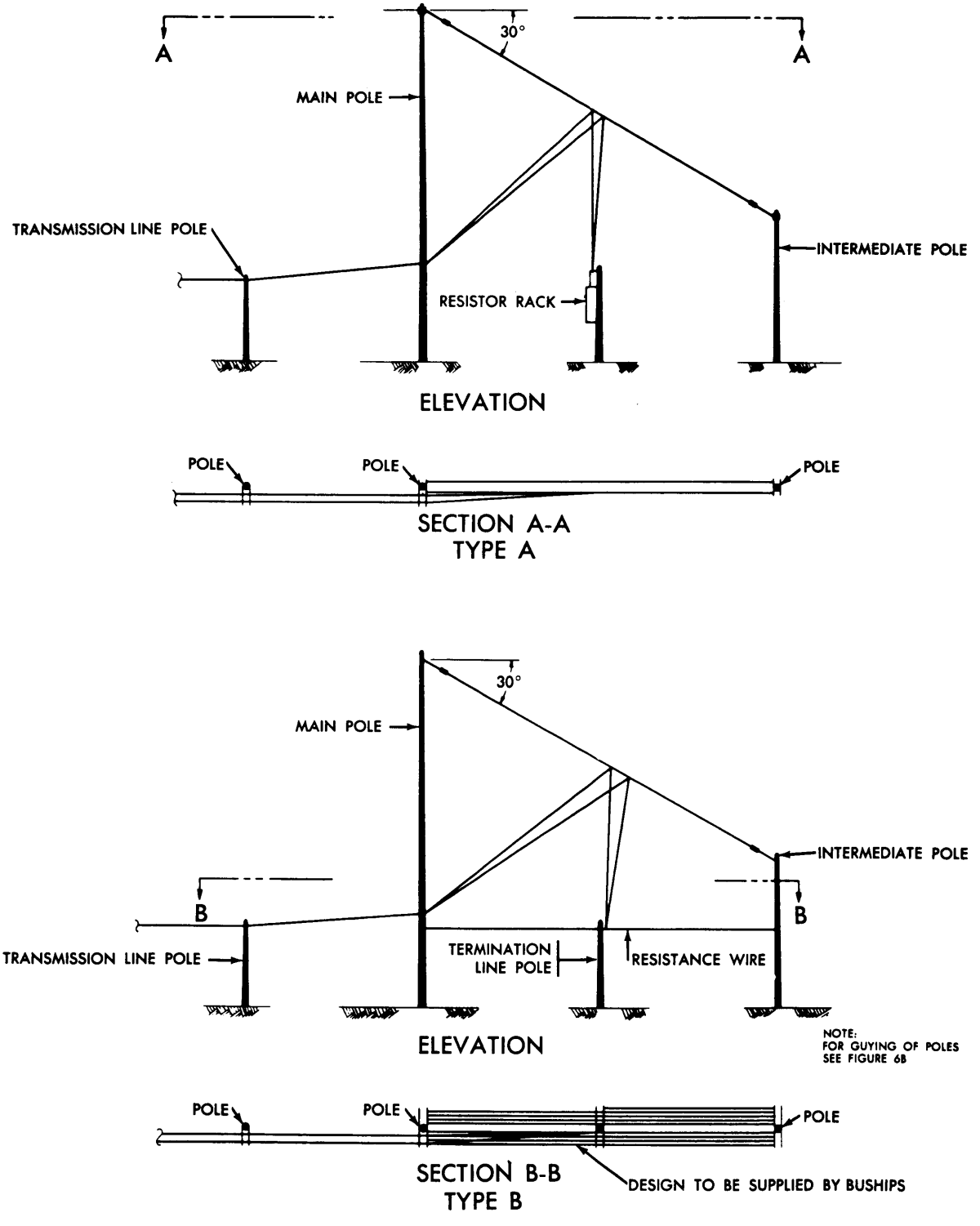
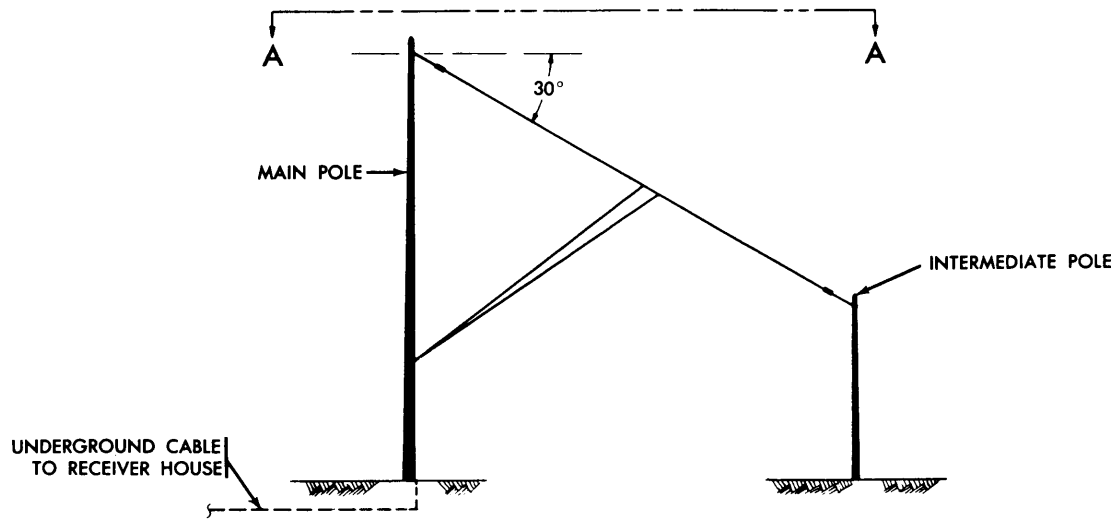
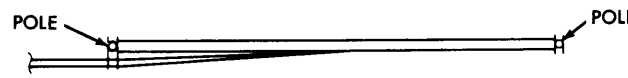


FIGURE 6a

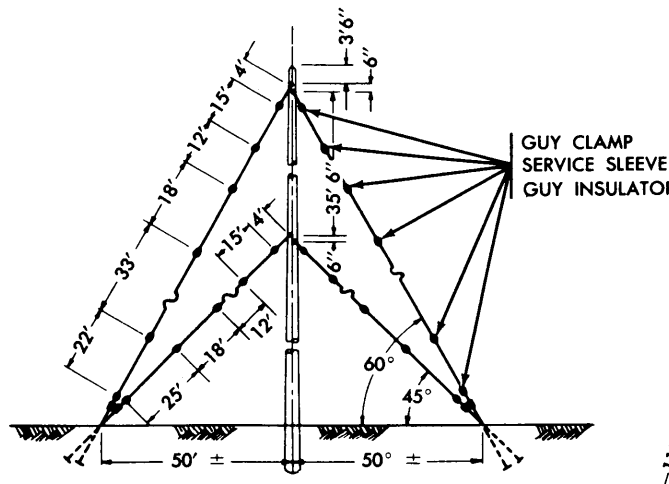
Wid -Band D ublet—Transmitting Ant nna



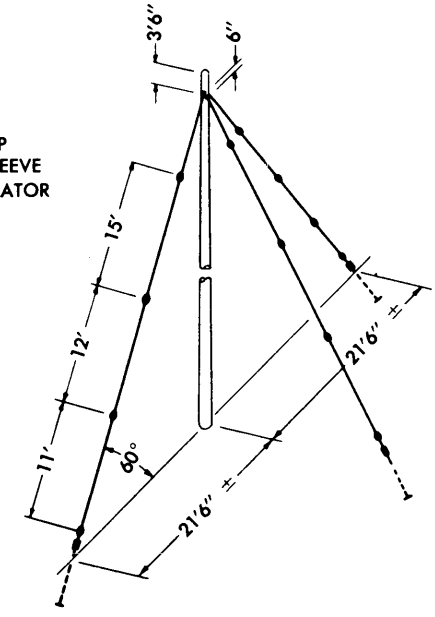
ELEVATION



SECTION A-A



GUYING AT MAIN POLE



GUYING AT INTERMEDIATE POLE

NOTE:
DIMENSIONS SHOWN ARE TYPICAL. DESIGN CAN CHANGE WITH LOCAL CONDITIONS.

FIGURE 6b

Wid -Band D ubl t—R ceiving Ant nna and Guying for P l s

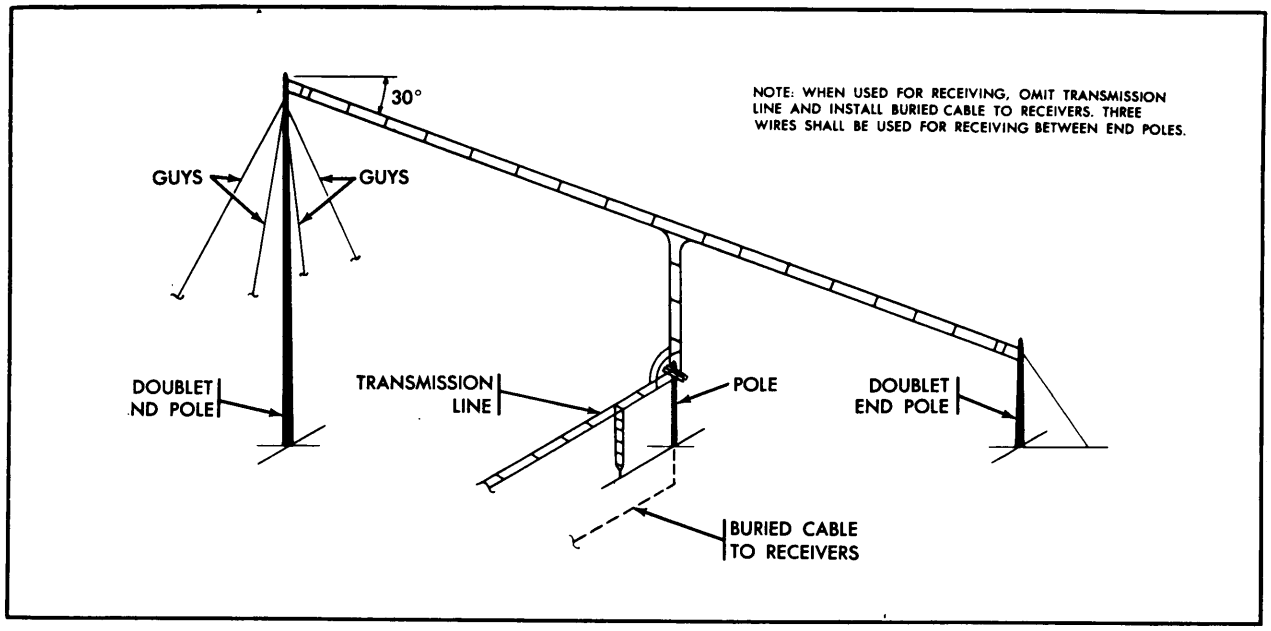


FIGURE 7

Tilted Folded Doublet—Transmitting and Receiving

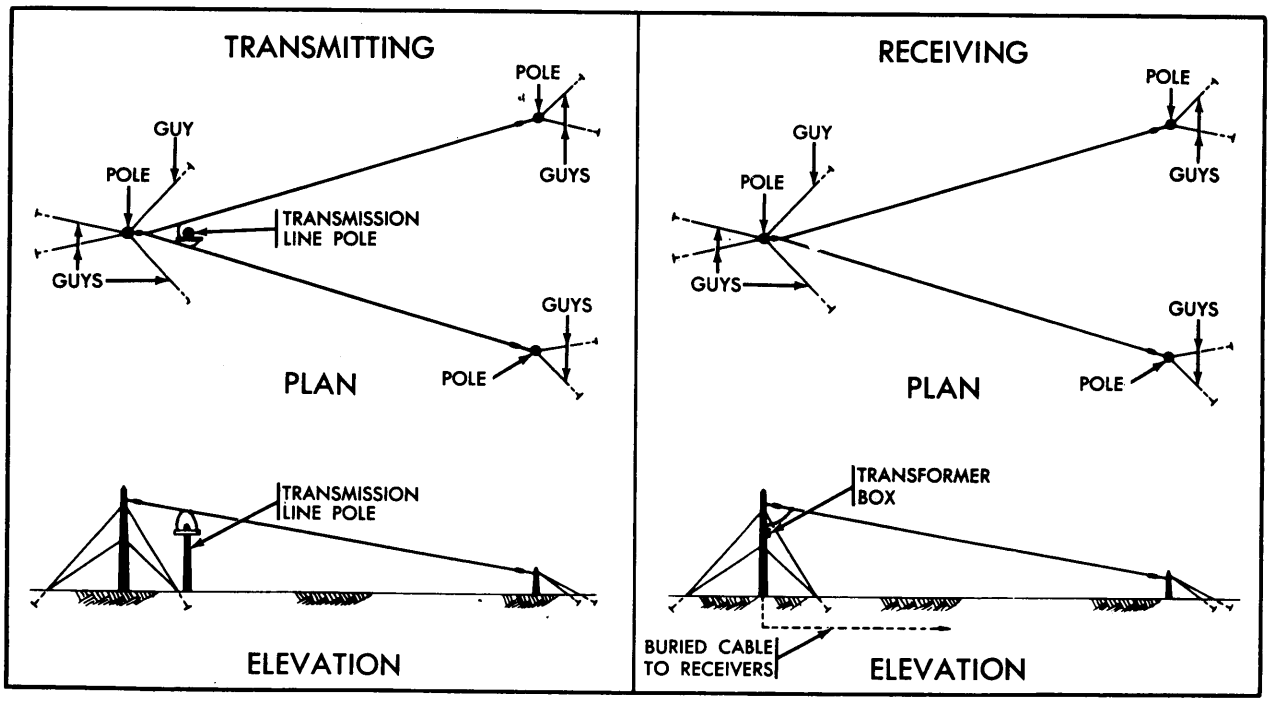


FIGURE 8

Vee—Transmitting and R c iving

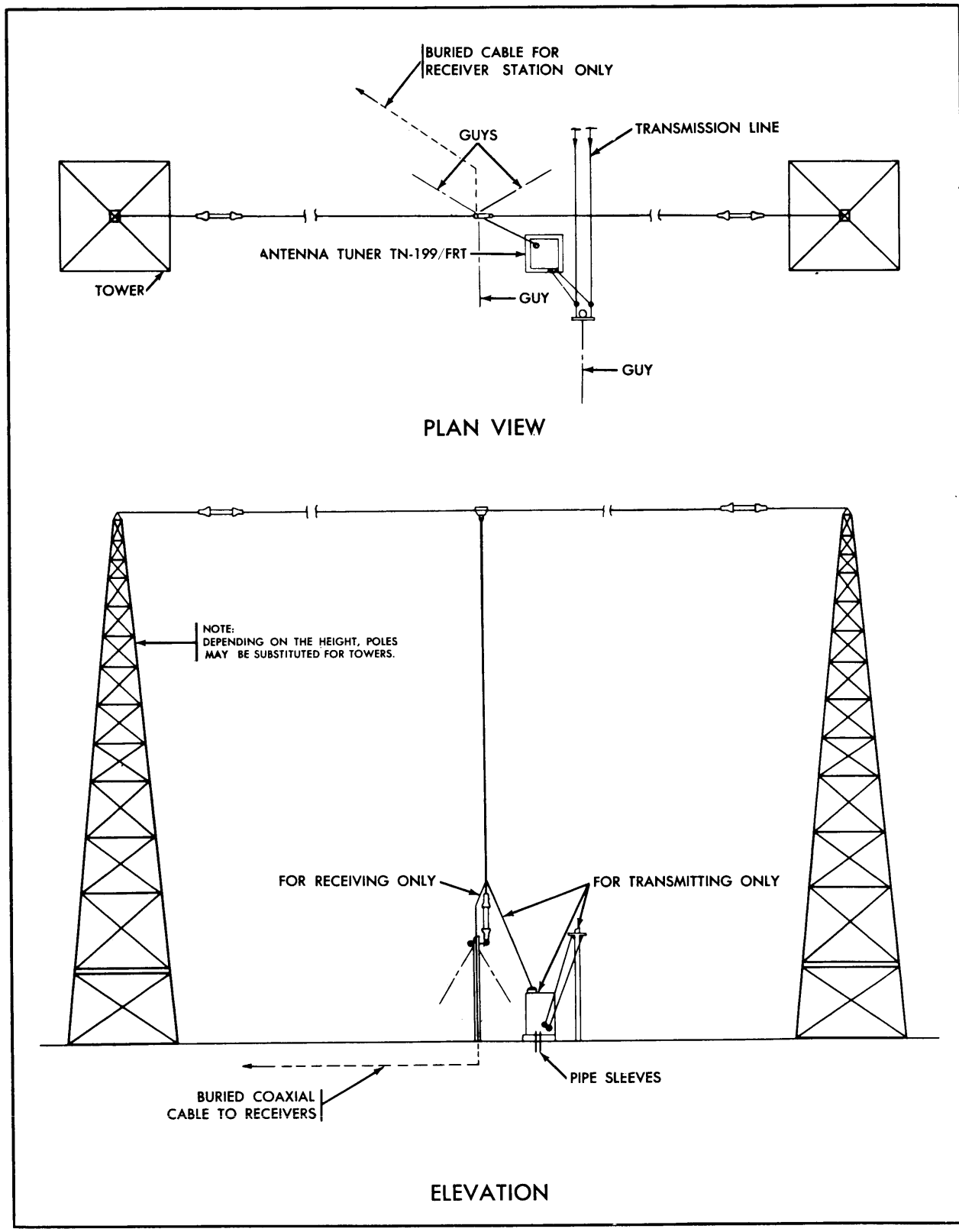


FIGURE 9

V rtical L w Fr qu ncy—Transmitting and R c iving

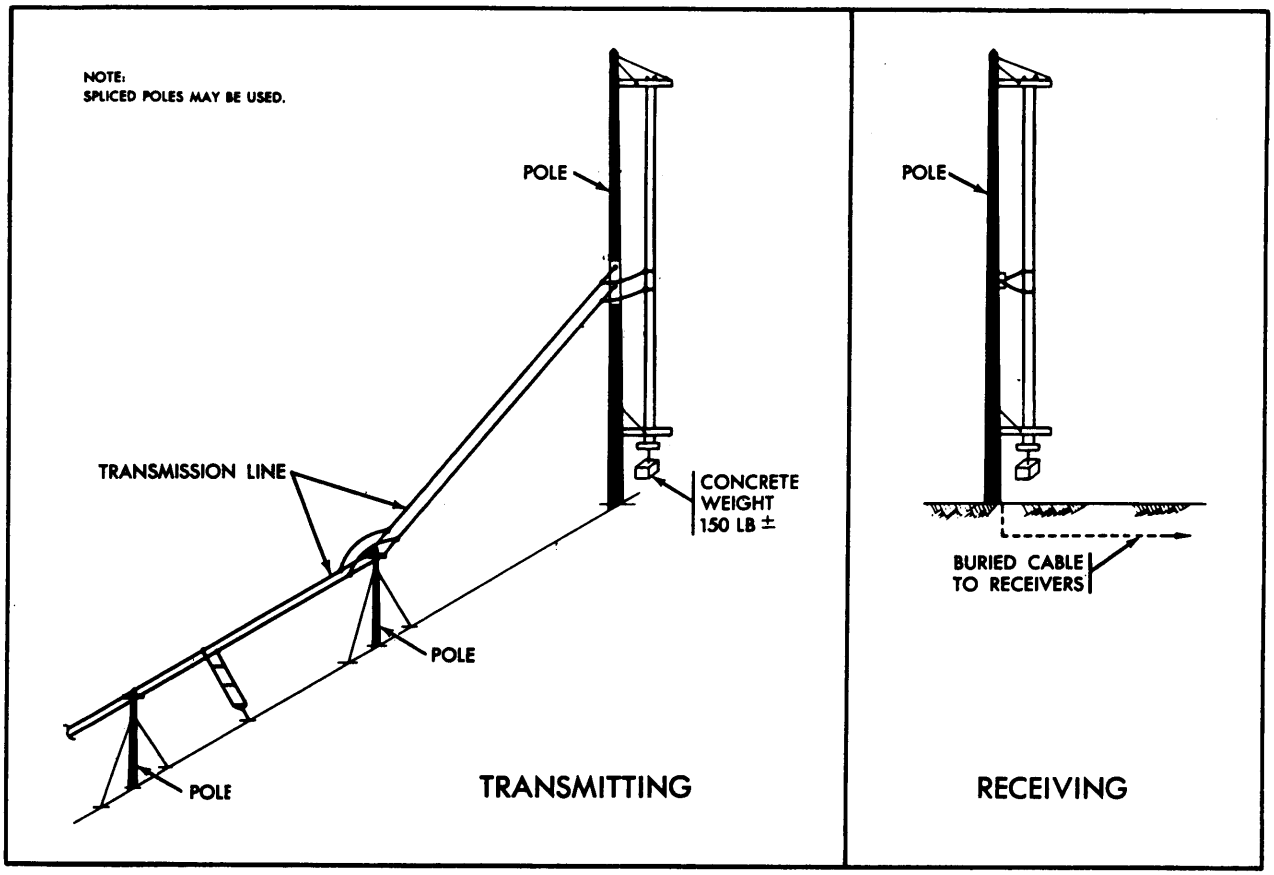


FIGURE 10

Vertical Doublet—Transmitting and Receiving

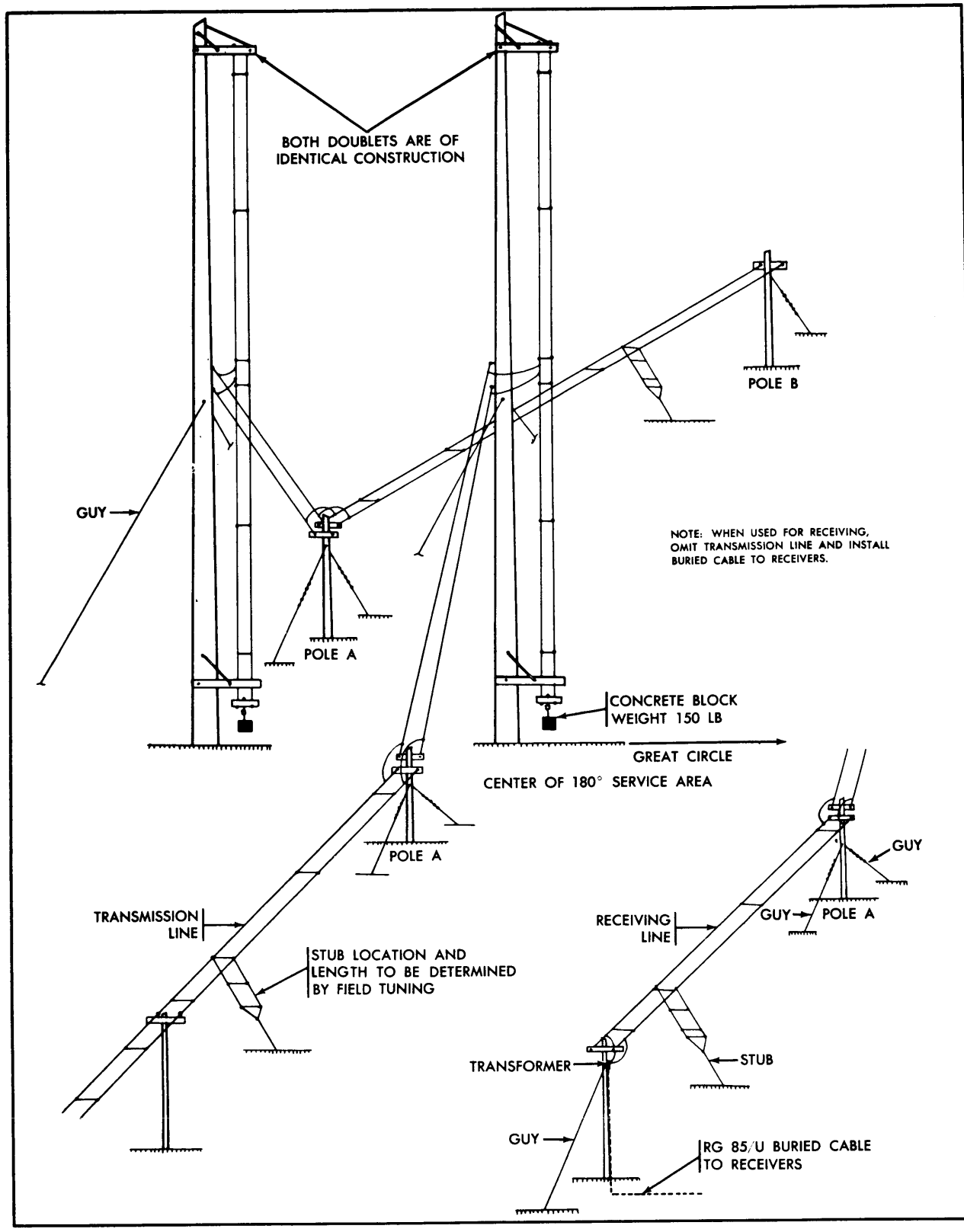


FIGURE 11

Vertical Parasitic Array—Transmitting and R c iving

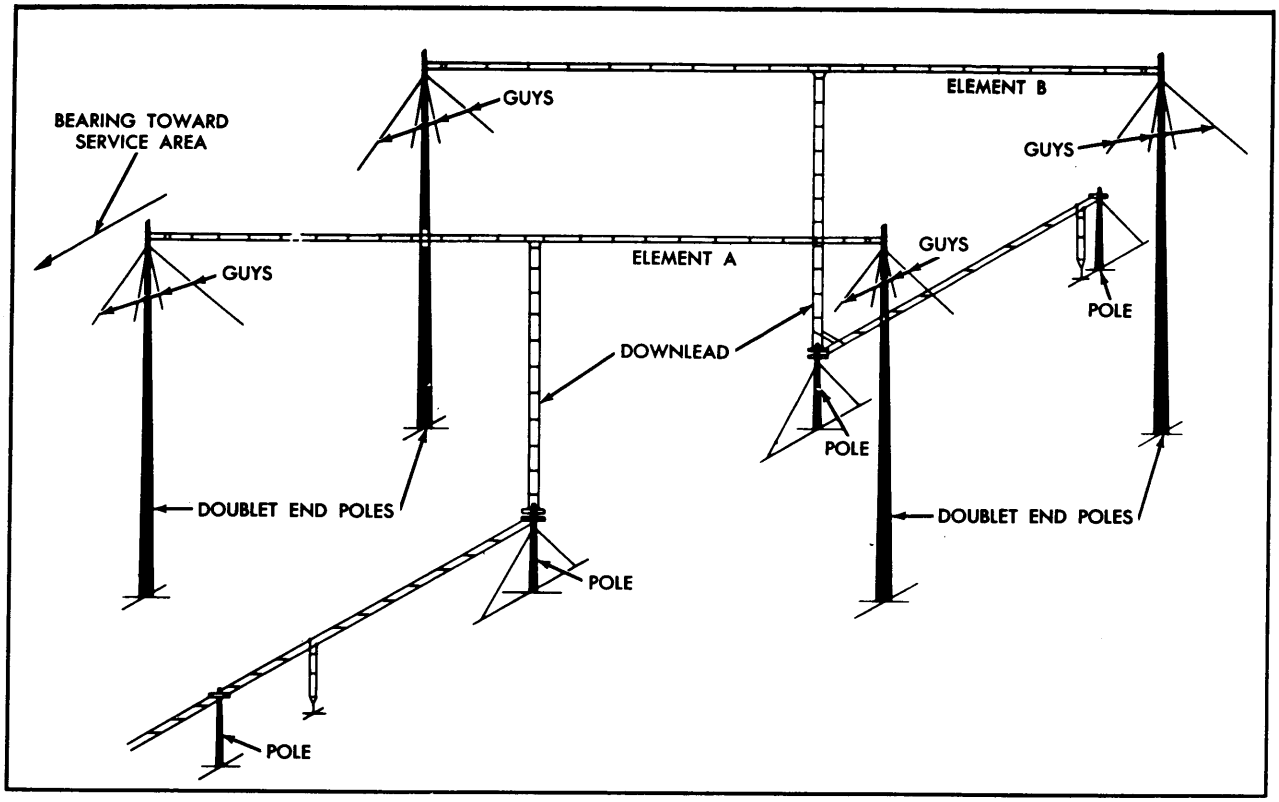


FIGURE 12a

Horizontal Parasitic Doublet—Transmitting

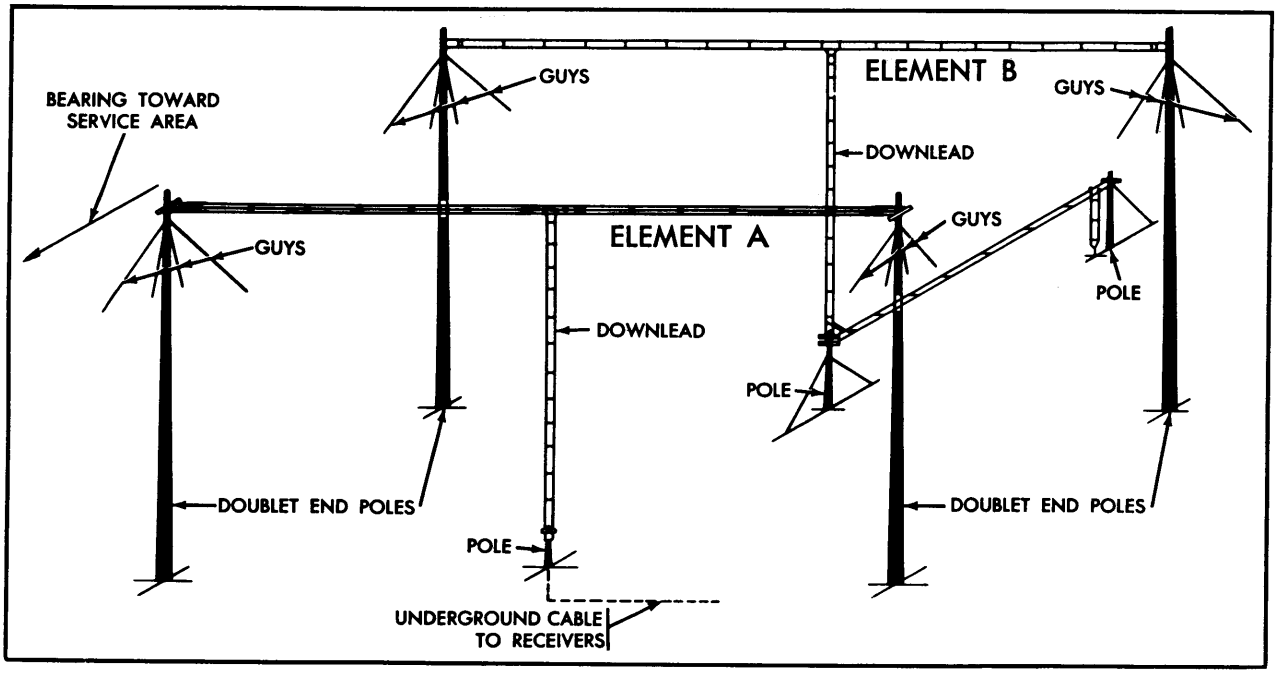


FIGURE 12b

Horizontal Parasitic Doublet—Receiving

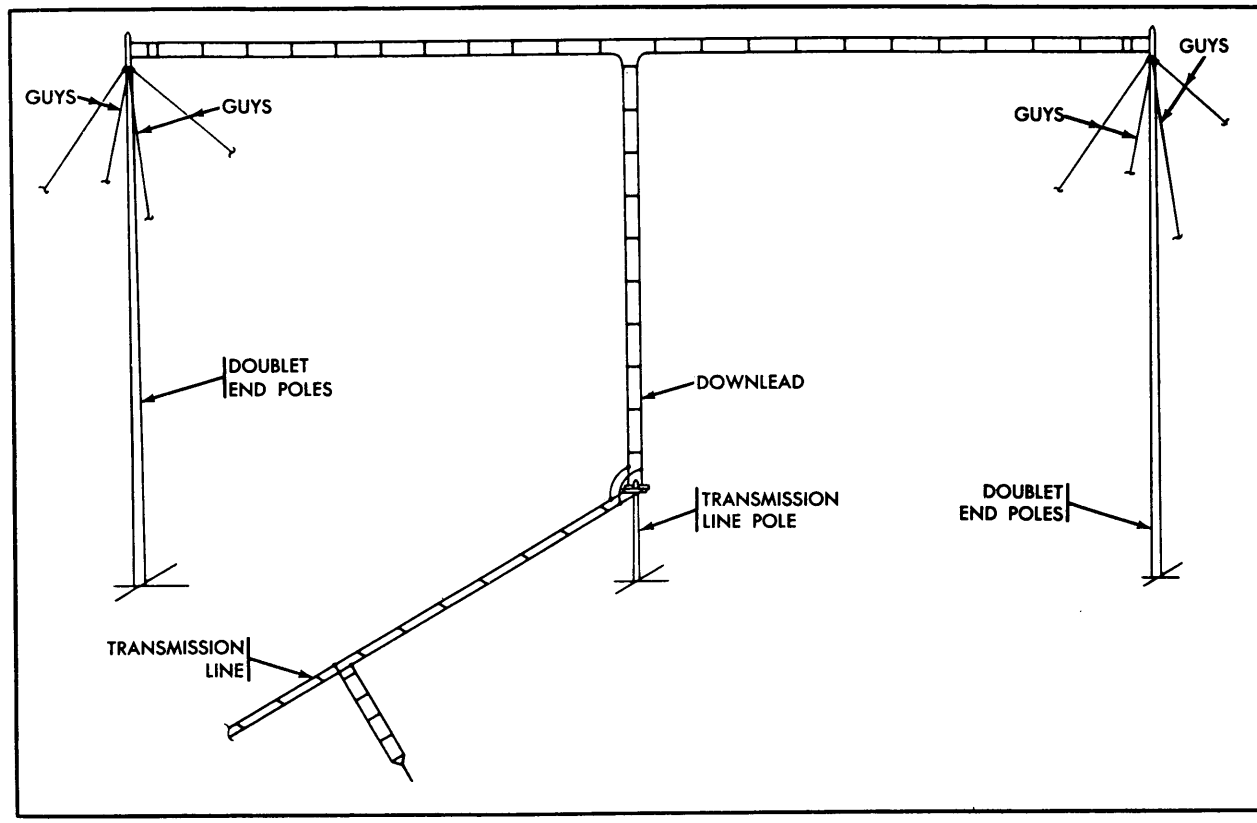


FIGURE 13

Horizontal Two-Wire Doublet—Transmitting

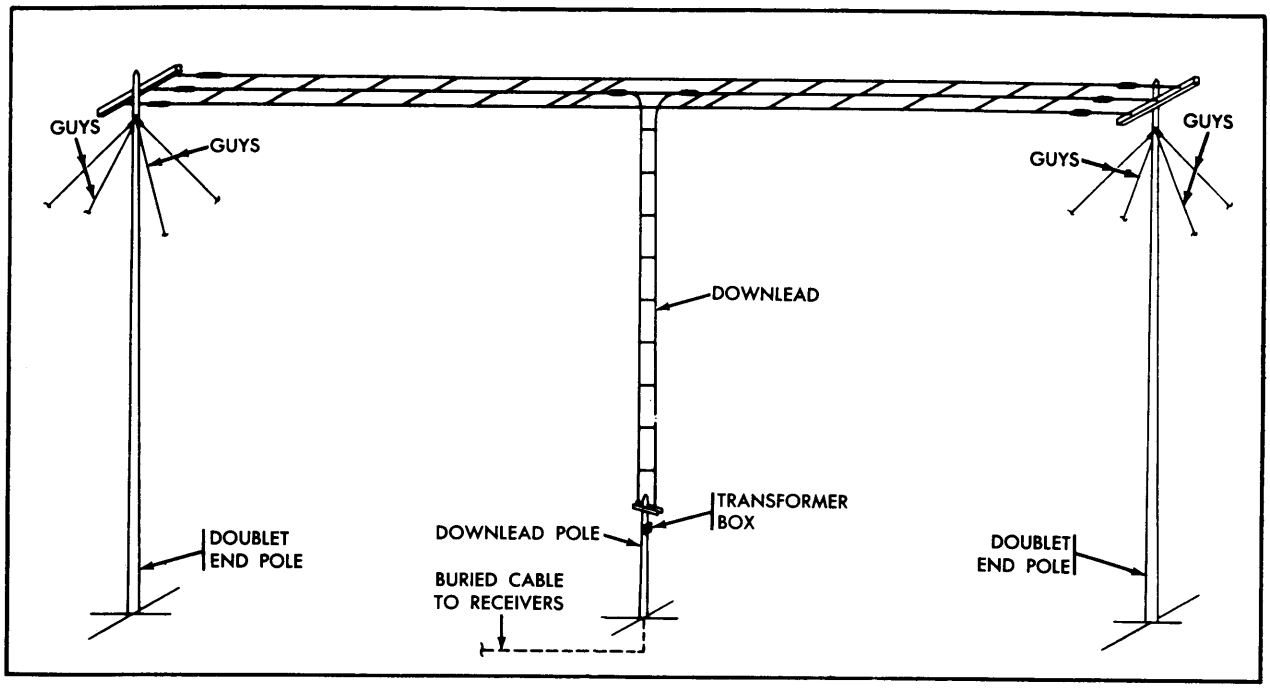


FIGURE 14

Horizontal Three-Wire Doublet—Receiving

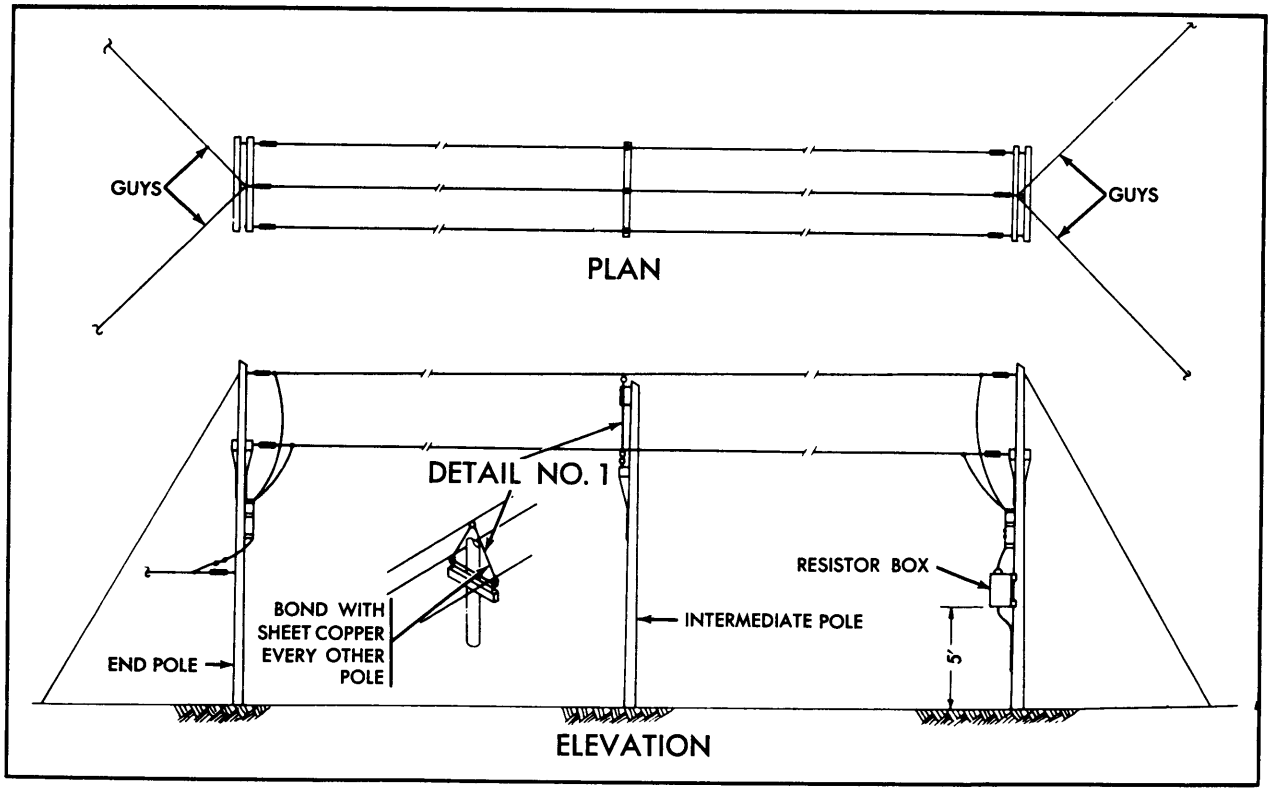


FIGURE 15

B v rag (Thr -Wir Wav)—Transmitting