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Field Manual FM 30-10, Military Geographic Intelligence (Terrain), March 1972

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FIELD MANUAL

MILITARY GEOGRAPHIC INTELLIGENCE (TERRAIN)

HEADQUARTERS, DEPARTMENT OF THE ARMY

MARCH 1972

FIELD MANUAL }
 No. 30-10 }

HEADQUARTERS
 DEPARTMENT OF THE ARMY
 WASHINGTON, D.C., 27 March 1972

**MILITARY GEOGRAPHIC INTELLIGENCE
 (TERRAIN)**

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CHAPTER 1

INTRODUCTION

Section I. GENERAL

1-1. Purpose and Scope

This manual serves as a guide in the production and use of military geographic intelligence. It defines military geographic intelligence and explains the process of collection, evaluation, and interpretation of information and the dissemination of finished intelligence. It discusses the characteristics of natural and man-made features of an area and the effects of terrain and weather on military operations. It discusses some of the sources of terrain information and provides guidance on the acquisition and use of military geographic intelligence at unit level in a theater of operations. Guidance is furnished for the preparation of the terrain study. The material presented is applicable to both nuclear and nonnuclear warfare.

1-2. Use of Terms

The correct use of terms, definitions, and nomenclature is extremely important in all activities associated with intelligence operations. Variants in terms, inconsistent descriptions, and incorrect definitions which may be permitted to occur in any phase of the intelligence cycle can cause confusion and delay, or may well result in the production of erroneous information. It is essential that all personnel engaged in the collection, processing, or use of intelligence information speak the same language. Therefore, where possible the terms used most frequently are defined within the appropriate subject matter of the chapters. For other pertinent terms, reference should be made to the manuals listed in appendix A.

1-3. Change and Comments

Users of this manual are encouraged to submit recommended changes and comments to improve the publication. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments will be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded direct to the Commandant, US Army Engineer School, Fort Belvoir, Virginia 22060.

1-4. Automated System

An automated system for the storage and dissemination of worldwide military geographic intelligence for all echelons of Army command is presently being developed. The present practice within the intelligence community follows most of the present and projected uses and techniques of the topographic data bank system with the exception of automation in data processing; i.e., everything is done by collectors, analysts, librarians, compilers, and draftsmen. Very little at this time is automated (computerized), and that which is, is not necessarily incorporated into a system compatible with other systems. Therefore, the collection, repository, and dissemination of military geographic intelligence should be accomplished in the manner presented, whether it is to be put into the automated system or handled as stated within the appropriate chapters of this manual.

Section II. CONCEPTS AND RESPONSIBILITIES

1-5. Purpose of Military Geographic Intelligence

The purpose of geographic intelligence is to obtain data about terrain and climate to assist command-

ers in making sound decisions and for utilization by the troops in executing their missions. In planning an operation, the commander and his staff analyze the effects that terrain and climatic condi-

tions will have upon the activities of both friendly and enemy forces. The commander must make the most effective use of the terrain occupied by his unit. If he is provided with adequate geographic intelligence, he will be able to exploit the advantages of the terrain and avoid or minimize its unfavorable aspects.

1-6. Scope of Military Geographic Intelligence

Geographic intelligence is classified according to the mission and level of the command at which it is used. These categories are broadly considered as strategic and tactical.

a. Strategic. Strategic geographic intelligence is concerned with large-scale plans and may include the military capabilities of nations. Strategic intelligence is produced continuously and requires the compilation and interpretation of information by specialized personnel. Included in strategic intelligence are descriptions and analyses of beaches, water terminals, inland waterways, urban areas, and other major terrain features; transportation and communication systems; soils and rock types; underground installations; climate; vegetation; and hydrography.

b. Tactical. Tactical geographic intelligence is produced for use in planning and conducting tactical or other operations. It is based on information secured locally or provided by higher headquarters and is concerned primarily with the effects of climate and terrain on the particular operations of the unit.

c. Objectives. The difference in the type of geographic intelligence required by strategic and tactical planners reflects their objectives. The strategic planner may consider an entire country or continent, while the tactical planner is concerned only with the terrain in his area of operations. Where the strategic planner often studies problems that may arise some years ahead and applies geographic intelligence in a wide variety of hypothetical situations, the tactical planner is primarily engaged with problems that currently involve his unit, although he will study the geographic and terrain factors in his entire area of possible operation.

1-7. Definitions

a. Terrain. A portion of the earth's surface including manmade and natural features. (In many uses no distinction can or should be made between

manmade and natural features because of man's influence on nature.)

b. Geographic or Terrain Intelligence. That terrain information which is independently meaningful and can be utilized directly in support of operations, or has potential value for future operations. It is produced from terrain information interpreted in relation to its effect on personnel, equipment and material. AR 310-25 defines terrain intelligence as processed information on the military significance of natural and manmade characteristics of an area.

c. Combat Intelligence. That knowledge of the opposing forces, climate, and the terrain used in the planning and execution of tactical operations within a given area.

d. Tactical Geographic or Terrain Intelligence. Tactical intelligence required by combat commanders and their staffs for planning and executing tactical operations, the majority of which is produced by engineers from technical terrain information interpreted in relation to its potential effect on tactical operations or plans.

e. Technical Geographic or Terrain Data. Terrain data requiring analysis and processing by engineers technically trained and equipped to handle such data. Collection is normally done by engineers.

f. Terrain Analysis. Terrain analysis is the process of analyses of a geographical area to determine the effect of the natural and manmade features on military operations. It includes the influence of climate on those features.

g. Terrain Study. A terrain study is the product derived from terrain analysis.

1-8. Responsibilities

On 1 January 1972, Department of Defense (DOD) Directive number 5105.40, established the Defense Mapping Agency (DMA), under the direction, authority, and control of the Secretary of Defense. The mission of DMA is to provide support to the Secretary of Defense, the Military Departments, the Joint Chiefs of Staff, and other DOD components, as appropriate on matters concerning mapping, charting and geodesy (MC&G). However, the details of the functional breakouts have not been received at this time.

1-9. Users of Geographic Intelligence

a. Troop Units. Geographic intelligence is essen-

tial to the unit commander in planning all phases of operations. This information must be disseminated to the individual soldiers concerned to enable them to properly conduct the mission.

b. Command Levels. Detailed and reliable geographic intelligence is required at all levels of command in planning the various phases of military operations. Special studies are essential in planning operations in mountains, in jungles or deserts, in snow and extreme cold, and for airborne, airmobile and amphibious operations.

c. Research and Development Agencies. All re-

search and development agencies are concerned with the conditions resulting from adverse climatic conditions and terrain. Detailed and accurate geographic intelligence is necessary to determine the requirements for new means of transportation, types of shelter and construction, weapons, food, and clothing. It is a basic requirement in the maintenance and modification of existing equipment as well.

d. Topographic Engineer Agencies. Current and accurate geographic intelligence is required by topographic engineer agencies for use in preparing or revising military maps and studies.

Section III. THE INTELLIGENCE CYCLE

1-10. Phases

The intelligence cycle described in FM 30-5, FM 30-16, and FM 5-30 is followed in the production of geographic intelligence. The activities associated with intelligence operations follow a four-step cycle (fig. 1-1) oriented to specific missions. The four steps are—

a. Planning the collection effort and preparing orders.

b. Collecting the information.

c. Processing the collected information.

d. Disseminating and using the resulting intelligence.

1-11. Planning the Collection Effort

a. The collection of geographic information is directed by the responsible intelligence officer. This direction involves the determination of requirements, preparation of a collection plan, issuance of orders and requests to appropriate collection agencies, and continuous check on the progress of collection. Four successive steps necessary in the direction of the collection effort are:

(1) Determining the intelligence required for the decisions and plans involved in an operation or specific mission.

(2) Determining the priority in which different intelligence items are required.

(3) Balancing the requirements with capabilities to arrive at an allocation of the available collection effort.

(4) Supervising the execution of orders to insure that required information is obtained in time to be of use.

b. In planning the collection effort, the general situation and mission requirements are determining factors. The gathering of geographic information in support of a tactical operation may not be as elaborately planned as that required to produce an area study. Since the time factor is critical in a tactical operation, information requirements can not usually be as detailed as those required for a construction mission or an urban area study. The responsible office must have a thorough knowledge of the available sources of information, the collection agencies, and the types of information each agency can provide.

1-12. Collection

Collection is the systematic exploitation of sources of information and the reporting of the information thus obtained to the proper intelligence agencies. A source is the person, object, or activity from which information is obtained. An agency is any individual or organization that collects or processes information. Sources of geographic information and collection agencies are discussed in paragraphs 1-15 through 1-24. Sources of information for specific purposes are discussed in the appropriate chapters of this manual.

1-13. Processing the Collected Information

a. Processing is the step in the intelligence cycle whereby information becomes intelligence. Processing consists of three steps:

(1) *Recording*: The reduction of information to writing or other graphical form of presentation and the grouping of related items to facilitate study and comparison.

(2) *Evaluation*: The appraisal of an item of information to determine its pertinence, the relia-

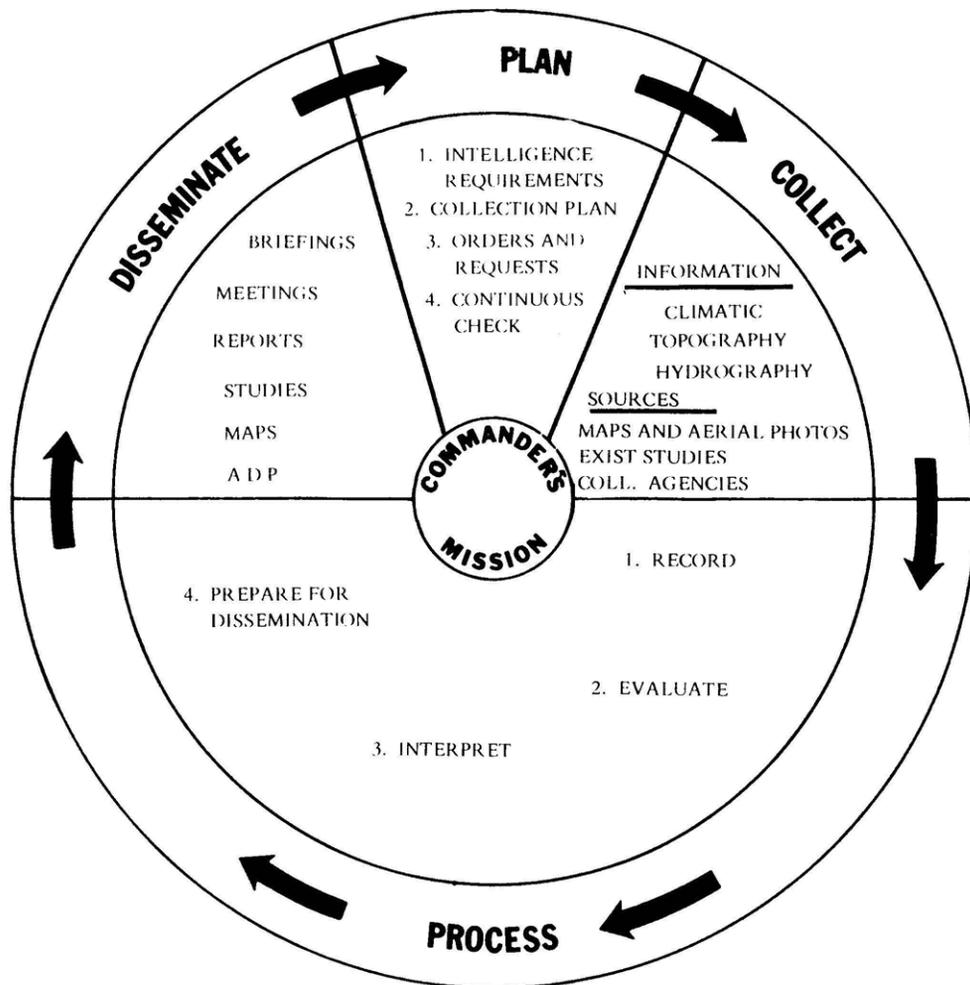


Figure 1-1. The intelligence cycle.

bility of the source or agency, and the accuracy of the information.

(3) *Interpretation*: The result of critical judgment involving analysis, integration, and deduction. Analysis is the sifting and sorting of evaluated information to isolate significant elements with respect to the mission and operations; integration is the combining of the elements with other known information; and deduction is the acquisition of a meaning from the material developed, tested, and validated.

b. The sequence in processing depends upon the nature and urgency of the information. Usually, recording is first. For urgent items, recording may occur simultaneously with evaluation and interpretation, or even later. Information needed immediately by higher, lower, or adjacent units is disseminated immediately. Information not of immediate concern, but of possible later value, is completely processed, usually before being disseminated.

c. The evaluation of each item of information is indicated by a standard system. The evaluation of reliability is shown by a letter, and the evaluation of accuracy by a numeral (fig. 1-2). Evaluation ratings are made at the lowest headquarters possible. If information is incomplete, a partial evaluation rating may be given.

d. Evaluation of the reliability of source and agency is shown as:

A—*Completely reliable*

Assigned only under unusual circumstances. For example, where the source has long experience and extensive knowledge of the information reported.

B—*Usually reliable*

Indicates a source of known integrity.

C—*Fairly reliable*

Ordinarily, collection agencies are rated A, B, or C; however where the source of an item and the reporting agency are evaluated differently, only the lower de-

INTELLIGENCE EVALUATION RATING SYSTEM

RELIABILITY - SOURCE

ACCURACY - INFORMATION

COMPLETELY RELIABLE -	A	1	- CONFIRMED BY OTHER SOURCES
USUALLY RELIABLE -	B	2	- PROBABLY TRUE
FAIRLY RELIABLE -	C	3	- POSSIBLY TRUE
NOT USUALLY RELIABLE -	D	4	- DOUBTFULLY TRUE
UNRELIABLE -	E	5	- IMPROBABLE
RELIABILITY CANNOT BE JUDGED -	F	6	- TRUTH CANNOT BE JUDGED

Figure 1-2. Intelligence evaluation rating system.

gree of reliability is assigned.

D—*Not usually reliable*

E—*Unreliable*

F—*Reliability cannot be judged*

Assigned when there is no adequate basis for estimating the reliability of source.

e. Evaluation of the accuracy of an item of information is shown as:

1—*Confirmed by other sources*

Assigned when it can be stated *with certainty* that the information originates from a source other than that which reported existing information on the same subject.

2—*Probably true*

Assigned if no proof can be established and if no reason exists to suspect that the reported information comes from the same source as information already available on the subject. This evaluation also applies to unconfirmed information contained in a report if the contents of the report are confirmed in essential parts by information already available.

3—*Possibly true*

Assigned if investigation reveals that the reported facts—on which no further information is available—comply with be-

havior of the target as observed up to now, or if the known background of a person leads to the conclusion that he might have acted as reported.

4—*Doubtfully true*

Unconfirmed information that contradicts the estimate of the development or the known behavior of the target, but cannot be disproved by available facts.

5—*Improbable*

Reported information which is not confirmed by data and which contradicts the experience hitherto assumed to be reliable with regard to the development of a case. The same classification is given to information that contradicts existing data on a subject originally rated "1" or "2."

6—*Truth cannot be judged*

Assigned when there is no basis for allocating a rating of "1" to "5." The statement that a report cannot be judged as to accuracy is always preferred to an inaccurate use of the ratings "1" to "5."

f. Although both letters and numerals are used to indicate the evaluation of an item of information, they are independent of each other. A completely reliable agency (A) may report information obtained from a completely reliable source

which, on the basis of other information, is judged to be improbable (5). In such a case, the evaluation of the information is A-5. A source known to be unreliable (E) may provide information that is confirmed by other sources (1) and is of undoubted accuracy. In such a case, a report is evaluated E-1. A report evaluated F-6 may be accurate and should not arbitrarily be discarded.

1-14. Dissemination

a. The procedure for dissemination depends upon the detail, pertinence, and urgency of the information as well as its intended use. Consideration is given to the needs of the user, his resources for handling the disseminated material, and the capabilities of available communications.

b. Dissemination may be accomplished by

means of briefings, messages, or such intelligence documents as the estimate, summary, periodic report, an analysis of area of operations, annex, maps, photointerpretation reports, and climatic summaries.

c. Each echelon disseminates to its subordinates only pertinent and usable intelligence information. Thus, the necessity to research large quantities of intelligence traffic for relevant material at successive lower echelons is avoided.

d. The timeliness and importance of each item of intelligence must be weighed carefully as a basis for selecting the dissemination means to be used. Intelligence must reach the users in time to permit further evaluation and interpretation, formulation of plans, and initiation of appropriate action.

Section IV. SOURCES OF INFORMATION

1-15. Maps and Terrain Models

a. Maps. Maps are a basic source of terrain information (FM 21-26). They are intelligence documents, not supply items. Accordingly, the intelligence officer usually is responsible for staff supervision over military maps and survey activities. The classification of US maps by type and scale is explained in AR 115-11. Foreign maps, (TM 5-248) or those copied from maps that were prepared by foreign agencies, often vary from US standards and specifications. Reliability information is indicated in the margin of US produced topographic maps. Foreign maps may not provide this. Portions of one map sheet may be fully reliable and yet other parts of the same sheet may be based on obsolete data, on US produced as well as foreign maps. The use of a map must be regulated by an estimate of the probable change in manmade features that have occurred since the date of the latest revision. All personnel must be impressed with the importance of reporting errors, changes, and omissions in existing maps, so that new editions may incorporate the necessary corrections. Maps prepared for a special purpose may not be reliable for information that is not related to that purpose. A railway map, for example, may be unreliable for data shown on roads or other features. Special maps and overlays may be prepared for a specific purpose or to show only particular characteristics of the terrain.

(1) Agricultural soil maps are prepared to show the potential of a soil for crop production. This type of map portrays soil types, indicating

their degree of acidity, nutrients, suitability for certain crops, and related information. Engineering terrain maps indicate qualities of soil composition for vehicle movement. Agricultural soil maps may be used for engineering purposes after they have been interpreted according to engineering nomenclature and requirements and criteria.

(2) Geologic maps (TM 5-545) portray the various kinds of geomorphological formations. Most geologic maps not prepared for intelligence purposes ignore soils, and the mapping may primarily show geologic age rather than rock type. Such maps are often accompanied by texts that do give information on kind of rock (lithology) and its physical properties. Geologic maps are important sources of information on natural construction materials, bedrock foundations, and ground water resources.

(3) Lines of communication maps include those that show railway systems, highway route information, navigable waterways, and the routes and stops of airlines. These may be considered as transportation maps.

(4) Hypsometric maps show differences in elevation by the use of various tints and shading patterns. An embossed or molded relief map is a standard topographic map printed on plastic and molded into a three-dimensional form with a vertical exaggeration in the relief. Because of the shrinkage characteristics inherent in plastic materials, there is considerable distortion of the features shown on this type of map. For example,

some stream lines may not be coincident with valley bottoms.

(5) Pictomaps are maps on which the photographic imagery of a standard photomosaic has been converted into interpretable colors and symbols. Desert sands, swamps, jungles, glaciers, and extraterrestrial topography are some of the features ideally portrayed of a pictomap. Shadows of features are emphasized on the pictomap. They accurately delineate many cultural features, and they lend a three-dimensional effect to buildings and vegetation. This effect symbolizes and establishes relative heights of features. The pictomap may be supportive in terrain analysis.

(6) Other special maps show the distribution of major vegetation types; water supply sources and distribution systems; structure of town and city plans; conditions affecting cross-country movement; and similar detailed information that can be presented most effectively in graphic form.

b. Terrain Models. A terrain model (TM 5-249) is a three-dimensional graphic representation of an area showing the conformation of the ground to scale. Usually it is colored to emphasize various physical features and the vertical scale is exaggerated to depict relief. Terrain models may be made for use in strategic or tactical planning, assault landings, airborne landings, and aerial target delineation.

1-16. Photographs and Remote-Sensor Imagery

a. General Features. Aerial and ground photographs provide an accurate visual record of the terrain. They furnish information that is not readily available or immediately apparent by ground reconnaissance or by visual observation from the air, especially of enemy-held areas. Photographs preserve information in a permanent form, so that it is available for later study and comparison. Remote-sensor imagery includes infrared photography and side-looking airborne radar. It provides imagery records of terrain, vegetation, and cultural features that may be obscured by atmospheric, natural, or artificial cover.

b. Applications. Properly interpreted, aerial and ground photography and airborne infrared and radar imagery will furnish detailed information concerning:

(1) *Surface configuration.* The physical characteristics of the earth's surface can be determined. These include surface relationship to surrounding area (higher or lower), arrangement and shape, boundary conditions (steep slopes, low

slopes, forest cover, barren), land-use pattern (trees, cultivation), maximum slope and slope breaks, and obstacle spacing and obstacle height.

(2) *Surface composition.* General classes of soil (e.g., coarse-grained versus fine-grained) and rock (hard versus soft, or massive versus layered) can usually be distinguished. Sometimes, specific soils or rock types can be identified as well as geologic structure.

(3) *Hydrologic pattern.* Certain surface and subsurface drainage characteristics may be determined from aerial photographs. Drainage patterns can sometimes be used to help identify both surface configuration and surface composition. Subsurface drainage can be predicted in general terms as, "well drained" or "poorly drained."

(4) *Vegetation.* Typical characteristics of the vegetation cover such as type (forest, shrub, grass, mixed, barren), density of stand and trees of forest (dense, scattered, sparse), and other characteristics of the cover (mixed types, uniform types) can be determined.

(5) *Suitability of terrain for construction of airfields, roads, and underground installations.* General characteristics, such as flat plain, predominately fine-grained soils, well-drained, forest cover, and deposits of gravel suitable for borrow can be determined.

(6) *Suitability of terrain for cross-country movement and airborne and airmobile operations.* Photographs and photomaps can be used advantageously in studying areas as to their suitability for movement, based on such terrain characteristics, as flat plain, grass-covered, silty soils, hedgerows and areas of poor drainage.

(7) *Manmade features.* Aerial and ground photographs, interpreted by skilled personnel, can give highly detailed information about all types of manmade features, from artificial obstacles to large industrial complexes.

(8) *Current information.* Photographs may depict more recent terrain features. Maps depict only what the mapmaker had available at the time the map was compiled.

c. Limitations. The amount of information that can be derived from interpretation of photography is limited by three major factors: natural, photographic, and human.

(1) *Natural.* The natural factors limiting interpretation are climate, season, and vegetation. Photo tones are influenced materially by the prevailing climatic conditions. For instance, a dry sand dune on a sand plain in a humid region will photograph light in color against a dark back-

ground because of the influence of climatic conditions. Furthermore, the time of year that the photography was taken might limit what can be obtained from it. Along with determining the season, vegetation is another limiting factor in that an analysis being conducted of a superhumid and tropical area will usually contain dense vegetation cover with individual trees being large and so closely spaced that details on the ground surface will often be obliterated. The interpreter, therefore, must be able to recognize the natural limitations before he can place much reliability in photo tones, vegetation, and surface features.

(2) *Photographic*. Limitations as they relate to photographic presentation are types of coverage and scale. The type of photographic coverage may limit the interpretation of features. In a high oblique photograph background features may not be as discernible as those in a low oblique photograph. Scale is another photographic factor which limits interpretation because the interpreter may not be able to obtain a satisfactory scale which would enable him to make clear interpretations.

(3) *Human*. The third major limitation is that influenced by the interpreter. Such items as background, vision, imagination, and knowledge of the area are of great importance in evaluating aerial photographs. The interpreter should be aware of the chief sources of literature in any of the natural science fields. This is important in obtaining background material about any particular area. The interpreter must develop a keen appreciation of the relationship between natural conditions and engineering problems and have a knowledge of the area. For the interpreter to gain the most from aerial photographs it is necessary that he be able to see stereoscopically and be able to perceive and interpret fine detail. One final factor limiting the amount of information which may be derived from interpretation of photography is the ability of the interpreter to possess or develop an intuitive grasp of natural features as presented by photographic detail, at once free of imaginative speculation.

d. Requirements. There should be sufficient aerial photographic coverage to enable the interpreter to determine the extent of local conditions and the expected variations. Stereoscopic vertical coverage is required for vertical measurements, although oblique photographs are more useful for specific purposes, such as in the study of dense forest areas and target avenues of approach. Scales of 1:5,000 to 1:20,000 are desirable for detailed geographic and terrain analysis. Photo-

graphs in this range provide good area coverage and stereoscopic perception of relief. They reveal such detail as major gully characteristics, and other outstanding terrain features.

(1) Photographs with scales smaller than 1:30,000 provide excellent area coverage in the broadest sense. Major physiographic details are easily seen and studied; however, relief must be great before stereovision is practicable because only major relief forms are clearly differentiated at these scales, and smaller details are minimized. Dissected terrain can be plotted, for example, but in some cases its characteristics cannot be determined. As a rule, landforms can be delineated only when there is a great contrast in pattern. Slopes associated with landforms may be difficult to see or be distinguished. While such manmade features as roads, railroads, bridges, and buildings can be identified, the interpreter may have difficulty in determining their structural details. Color or infrared, or other spectral film is frequently the most effective for identifying vegetation. The best scale depends on the data needed. Vegetation types can also be identified from differences in tone on black and white aerial photographs.

(2) Stereopairs, vectographs, and anaglyphs are particularly useful in making terrain studies.

(3) Controlled mosaics (TM 5-240) of an area provide a reasonably accurate map from which measurements of distances can be obtained. The amount of detail useful for terrain analysis is dependent upon the scale of the mosaic.

1-17. Books and Periodicals

Valuable geographic and terrain information can be found in a wide variety of books and periodicals. These include scientific and trade journals, economic atlases, tide tables, pilots' handbooks, tourist guides, and similar publications. Unpublished systematic records covering meteorological, hydrological, and similar scientific data prepared by government agencies, engineering firms, private societies, and individuals also contribute valuable terrain information. Although utilized chiefly for geographic and terrain studies made by higher headquarters, material of this type, when locally available, can be of considerable value to lower echelons.

1-18. Intelligence Reports

Strategic intelligence studies prepared by Department of Defense agencies provide detailed geographic and terrain information concerning major geographical areas. Such studies include—

Report title	Report utilization
1. Engineer recon report	(1) Preparation of target folders, (2) Preparation of engr. recon activity report, (3) Planning and execution of tactical operations, (4) Response to requests for technical data, (5) Planning of logistical support, (6) Preparation of terrain studies and intelligence estimates.
2. Engineer recon activity report	(1) Preparation of future collection plans, (2) Planning and supervising engineer recon activity.
3. Accelerated intelligence reports (spot/flash)	(1) Assessment of the tactical situation and execution of tactical operations, (2) Preparation of intelligence summaries, reports and estimates, (3) Updating of the situation map.
4. Engineer spot report	(1) Updating of situation map, (2) Preparation and execution of combat operations, (3) Preparation of summary, supplementary, situation reports, (4) Support to requests for combat terrain intelligence, (5) Preparation of intelligence summaries and estimates.
5. Intelligence summary report (intsum)	(1) Assessment of tactical situation and plans, (2) Preparation of plans for combat operations and logistic planning, (3) Preparation of intelligence estimates.
6. Engineer intelligence summary report	(1) Assessment of tactical situation, (2) Preparation of plans for combat operations and logistics planning, (3) Preparation of intelligence estimates.
7. Engineer supplementary intelligence report	(1) Assessment of tactical situation, (2) Preparation of plans for combat operations and logistics planning, (3) Preparation of intelligence estimates, (4) Updating situation map (5) Planning, supervising ADM operations.
8. Special intelligence report	(1) Preparation for and conduct of combat operations, (2) Preparation of plans for recon activity, (3) Support to combat support and services planning.
9. Front line trace	(1) Assessment of tactical situation, (2) Updating of situation map, (3) Preparation of summary, supplementary intelligence reports, (4) Planning tactical operations, logistical support, and long range rear activity.
10. Situation report (sitrep)	(1) Assessment of tactical situations, (2) Staff planning of tactical operations, recon activity, and logistic support.
11. Engineer situation report	(1) Assessment of results of combat support operations, (2) Planning and executing of combat operations, (3) Support to requests for combat terrain intelligence, (4) Updating of situation map, (5) Conduct of ADM operations.
12. Target folders (demolition)	(1) Updating of situation map, (2) Execution of assigned targets, (3) Support to requests for technical and tactical data, (4) Preparations of demolition reports, (5) Conduct of ADM operations.
13. Terrain estimates	(1) Preparation of plans for combat and combat support, (2) Planning of engineer recon activity.
14. Area of operations study (area analysis study)	(1) Preparation of plans for combat operations, (2) Planning of engineer recon activity, (3) Estimates of the situation, (4) Briefing the command staff, (5) Planning logistic support.
15. Tactical plans and objectives	(1) Planning and executing of combat operations, (2) Planning of engineer recon activity, (3) Briefing the command staff, (4) Preparation of operations orders for subordinate units.
16. Operations orders	(1) Planning combat operations, (2) Planning recon activities, (3) Support to logistic planning.
17. Imagery interpretation reports *	(1) Planning combat and support operations, (2) Planning recon activities, (3) Support to requests for terrain intelligence, (4) Analysis of area of operations, (5) Terrain studies.
18. Area damage assessment report	(1) Assessment of situation, (2) Planning of repair operations, (3) Preparation of area damage report, and damage assessment, (4) Monitoring of repair and logistic plans.

Figure 1-3. Summary of Army reports used in geographic and terrain intelligence.

19. Enemy minefield report	(1) Updating of situation map, (2) Preparation of plans to counteract minefield operations, (3) Preparation of engr. situation and minefield reports, (4) Preparation of target folders (demolition), (5) Support of tactical planning.
20. Engineer intention to lay minefield report	(1) Updating of situation map, (2) Preparation of request for supplies and report of intention to lay minefield, (3) Execution of ADM plans, (4) Preparation of target folders, (5) Preparation of barrier trace (6) Monitoring of barrier and denial operations.
21. Engineer minefield record	(1) Updating of situation map, (2) Preparation of minefield record report, (3) Preparation of target folders, (4) Preparation of barrier trace, (5) Monitoring of barrier and denial operations.
22. Demolitions report	(1) Coordination of ADM operations, (2) Updating of engineer situation map.
23. Terrain study on vegetation	(1) Selection of assembly areas and observation posts, (2) Execution of recon patrol activity, (3) Planning conducting of movement, maneuver operations, (4) Execution of camouflage operations, (5) Planning of engineer combat operations, (6) Support of artillery planning.
24. Terrain study on soils	(1) Support to communications planning, (2) Execution of movement, maneuver operations, (3) Planning of combat operation (construction of landing strips, maintenance of culverts), (5) Selection of avenues of approach.
25. Terrain study on rocks	(1) Planning of movement, maneuver operations, (2) Planning of combat operations (construction, maintenance, destruction of roads, bridges, culverts, defensive installations), (3) Selection of avenues of approach.
26. Terrain study on water resources	(1) Selection of location of water points and routes to water points, (2) Planning of combat operations (stream crossing, bridging), (3) Support to logistics planning.
27. Terrain study on drainage	(1) Selection of location of water points and routes to water points, (2) Planning of combat operations (construction of roads, fortifications, fords), (3) Support of river crossings and cross country movement.
28. Terrain study on surface configuration	(1) Support to communications planning, (2) Planning of observation posts and recon activity, (3) Planning of tactical operations and execution of tactical objectives, (4) Planning of barrier and denial operations, (5) Artillery support planning.
29. Terrain study on state of ground	(1) Planning for movement, maneuver operations, (2) Planning of ADM activity, (3) Planning of combat operations (construction, maintenance, repair of roads, fords, landing strips, fortifications), (4) Planning of logistics support.
30. Terrain study on construction suitability	(1) Planning of combat operations (construction of fortifications, landing strips, camouflage, obstacles, CP's supply installations), (2) Selection of construction supply point locations.
31. Terrain study on coasts and landing beaches	(1) Planning of amphibious operations (preparation and removal of obstacles, fortifications), (2) Planning of recon activity, (3) Planning of port construction.
32. Terrain study on cross-country movement	(1) Planning and execution of maneuver, movement operations, (2) Planning of logistics support, (3) Planning barrier and denial operations, (4) Planning of engineer combat operations.
33. Terrain study on lines of communication	(1) Planning, execution of combat operations (construction, repair, destruction of roads, bridges, railroads, culverts), (2) Selection of ADM placement, (3) Planning of recon activity, (4) Planning of logistics support.
34. Terrain study on defenses	(1) Planning of ADM placement, (2) Planning of recon activity, (3) Planning, execution of tactical objectives and obstacle emplacement or removal, (4) Support to artillery planning.
35. Terrain study on airborne landing areas	(1) Planning of area clearing support, (2) Planning of recon activity, (3) Planning of combat operations (construction, repair of landing strips), (4) Selection of helicopter landing zones.
36. Terrain study on urban areas	(1) Planning of recon activity, (2) Planning of combat operations (construction, repair, destruction of fortifications, roads, CP's, supply installations), (3) Selection of water points, (4) Planning of logistics support, (5) Transportation planning.

*Also produced by other services.

Figure 1-3—Continued.

a. National Intelligence Surveys (NIS). This is a series of documents covering the countries of the world, presenting a digest of the basic intelligence required for strategic planning and for the operations of major units. Each survey describes in general terms the terrain characteristics of a specific area or nation supported by descriptive material, maps, charts, tables, and with reliability ratings assigned to all data.

b. Lines of Communication (LOC). These studies, prepared on either medium-scale maps or single, small-scale foldup sheets, contain an analysis of transportation facilities with information on railroads, inland waterways, highways, airfields, pipelines, ports, and beaches.

c. Terrain Studies. These contain area intelligence depicted on maps with accompanying textual and graphic material.

d. Special Reports on Military Geography. These are designed primarily for strategic planning and are generally directed toward analysis of a major aspect of military geography such as cross-country movement, amphibious operations, and airborne operations.

e. Engineer Reconnaissance Reports. Reports that summarize data obtained by reconnaissance are a major source of geographic information. They are of particular value in providing current,

detailed information about lines of communication and availability of natural construction materials.

f. Army Geographic and Terrain Intelligence Reports. Figure 1-3 contains a list of geographic and terrain intelligence reports produced in the Army.

1-19. Captured Foreign Documents

Maps and other intelligence documents prepared by extranational or foreign sources often are of great value as sources of geographic information. Usually, foreign prepared military maps, geographic and terrain studies of foreign or enemy territory will be more up-to-date and detailed than our own. The processing of captured foreign or enemy documents is described in FM 30-15.

1-20. Interrogation

Interrogation personnel should be kept informed of the geographic and terrain information required by intelligence officers. Useful information about the area held by foreign forces frequently can be obtained from prisoners of war, deserters, liberated civilians, refugees, escapees, evadees, cooperative foreign nationals, and self-surrendered and apprehended foreign or enemy espionage agents.

Section V. COLLECTION AGENCIES

1-21. Units

Collection agencies include intelligence personnel, troop units, and special information services. FM 30-5 discusses the types and capabilities of these agencies. All units within a command may be employed by the intelligence officer to secure geographic and terrain information. In addition, he may request higher headquarters to use their units and facilities to secure the necessary information.

1-22. Troops

Reconnaissance missions to secure geographic and terrain information may be assigned to combat support units. Such missions may be accomplished by units specifically organized for reconnaissance or by other units assigned reconnaissance missions in addition to their normal duties.

1-23. Aircraft

In addition to ground reconnaissance, aircraft may be employed to secure information about the terrain. Although it may be limited by adverse weather or enemy air defense, air reconnaissance is the fastest means of gathering terrain information and, at times, may be the most practical means of reconnoitering enemy territory. Information on objects such as trees, structures, and communication lines is of great importance for airmobile and air landing operations.

1-24. Specialized Agencies

A Military Geographic Intelligence (MGI) detachment usually is assigned to each corps. The detachment is composed of personnel trained in various fields of engineering and the natural earth sciences who prepare special geographical and ter-

rain studies and evaluate all types of terrain information. MGI information may be provided by personnel whose normal duties are not primarily concerned with terrain intelligence. These include military intelligence personnel of the MI units at

field army, corps, and division. Civil Affairs area studies and surveys contain much information in considerable detail, particularly in the areas of agriculture, forestry and fishing, transportation, and other economic functions.

Section VI. CURRENT PRODUCTION TECHNIQUES

1-25. Requirements

Requirements for military geographic intelligence pertain to both foreign and domestic areas. They are generated at all echelons for purposes of long and short range planning and for execution of training, combat, combat support, and combat service support operations.

1-26. Collecting and Reporting

The second stage of the military geographic intelligence cycle is the systematic exploitation of sources of information and the reporting of information thus obtained to the proper intelligence agencies. In general terms, military geographic intelligence information is obtained in three ways: by the study of documents, including the interpretation of photographs; by aerial and ground reconnaissance; and by interrogation of individuals. The information collected is reported to the authority or agency who issued the collection order unless otherwise directed. Tactical situations may dictate that the information be utilized immediately without formal processing. MGI information collected by other than engineer troops eventually reaches the engineers through collection channels. Reporting is accomplished on various types of forms, and transmission media may include automatic digital means.

1-27. Analysis and Processing

The analysis and processing stage of the intelligence cycle involves the following steps:

a. Recording. The collected information is recorded on—

(1) *Intelligence journal*—a permanent, brief record of messages and events affecting the intelligence section.

(2) *Intelligence worksheet*—an indexed pad or looseleaf notebook in which information is recorded systematically and arranged by subject for ready reference and comparison.

(3) *Situation Map*—a temporary, graphic portrayal of current data.

(4) *Intelligence file*—an indexed and cross-referenced file of all information which may be of future value.

b. Evaluating. Each item of information is evaluated to determine—

(1) *Accuracy.* The intelligence officer judges the accuracy of each item (fig. 1-2).

(2) *Reliability.* Previous experience and a thorough knowledge of information requirements are the principal means of determining the reliability of collection agencies and sources of information (fig. 1-2).

1-28. Dissemination

a. Military geographic intelligence is transmitted to immediate potential users as well as to ZI agencies of collection and analysis. It is disseminated to commanders and staffs as one element of the overall intelligence report. It is transmitted through formal reports, documents, informal messages, briefings and other means such as—

(1) The Intelligence Annex to an operational plan or order.

(2) Intelligence estimates prepared at corps and higher headquarters.

(3) Technical intelligence bulletins and summaries made by technical service intelligence detachments.

(4) Tactical terrain studies.

(5) Photo interpretation reports.

(6) Maps.

(7) Map overlays.

(8) Terrain models.

(9) Staff briefings.

b. Unlike combat intelligence, which is screened to eliminate detailed items prior to upward transmission, military geographic intelligence is disseminated upward in the same technical detail as produced.

CHAPTER 2

CLIMATE AND WEATHER

Section I. CLIMATE

2-1. General

a. Increased Requirements. The wide dispersion of the Army forces on the modern battlefield and the complexity of current weapon systems have increased requirements for the systematic reporting and exploitation of all available sources of information on climate and weather. Climate and

weather affect operations of the various types of military units in different ways and are significant according to the type of mission performed by a particular unit.

b. Elements. Climate (fig. 2-1) refers to the general variation and pattern of the primary climatic elements which include temperature, pre-

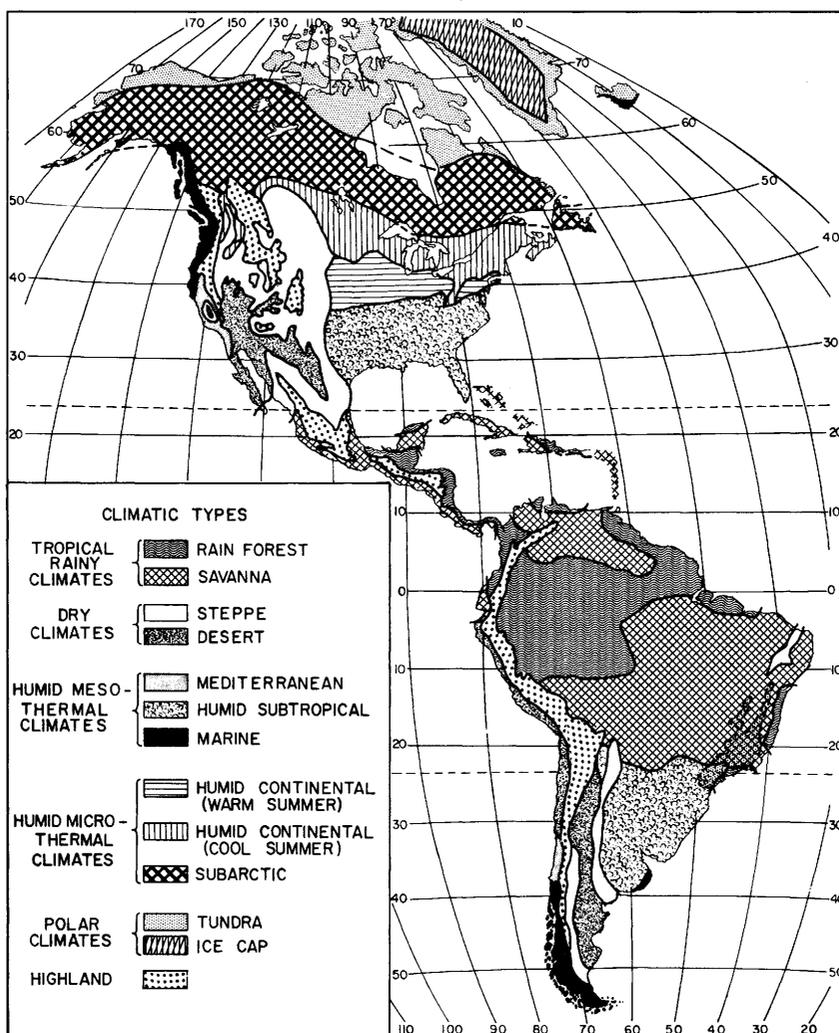


Figure 2-1. Major climate regions.

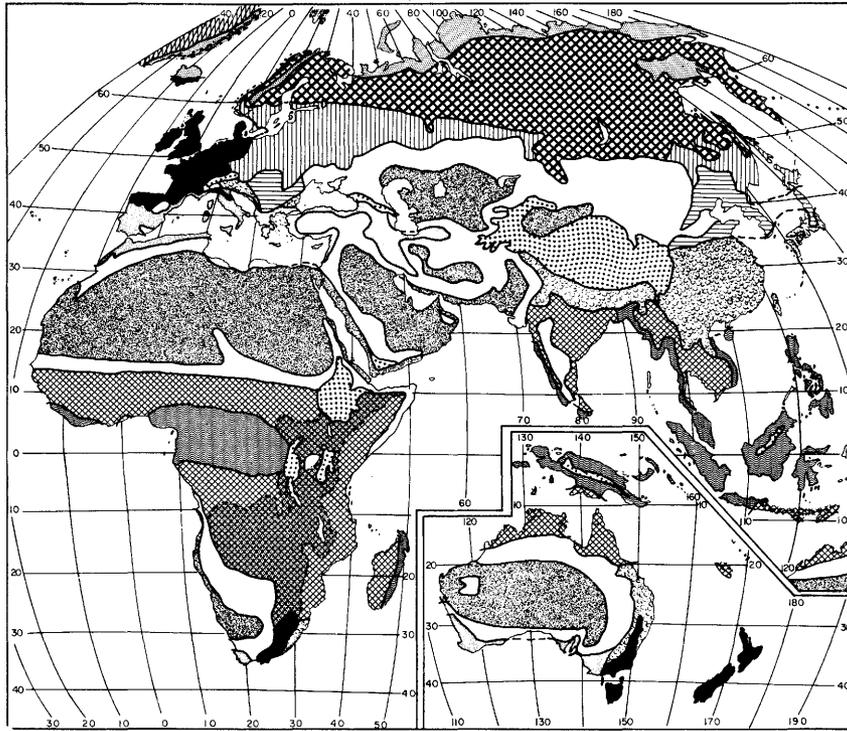


Figure 2-1.—Continued.

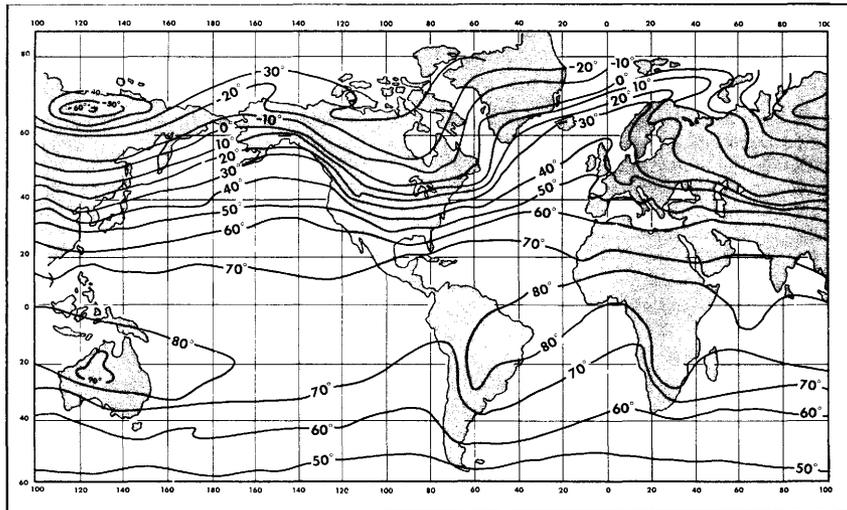


Figure 2-2. World temperatures in January.

precipitation, humidity, winds, and air pressure. It is a composite or generalization of the day-to-day weather at a given place or area over a long period of time. The strength and direction of winds, amount of precipitation, and average temperatures (fig. 2-2 and 2-3) that will prevail in an area can be approximated, based upon statistics compiled for previous years. These climatic elements may be described by graphs or charts in

terms of means, ranges, average maximums and minimums, extremes, and frequencies of occurrence.

c. Terrain. Although the heat transmitted by the sun to the earth and its atmosphere is the dominant factor in weather and climate, terrain is the most important modifier of climate in many regions. High mountains can block the movement of air masses and act as climatic divides. Terrain

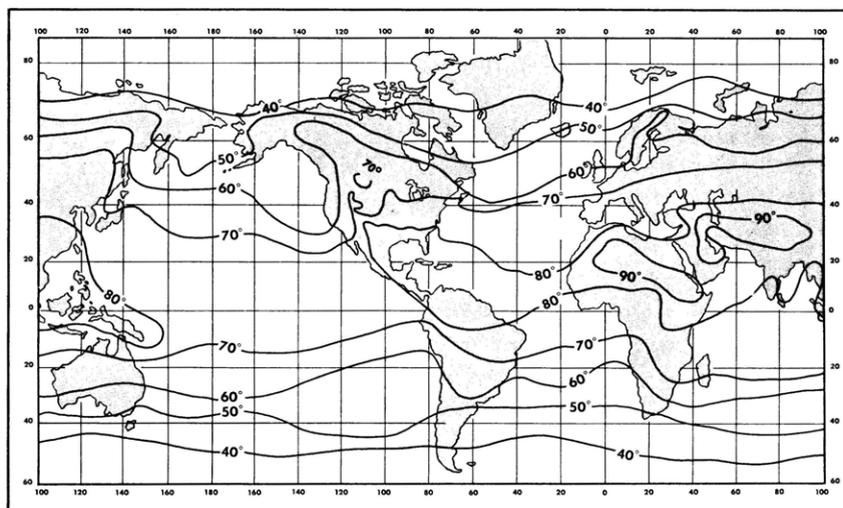


Figure 2-3. World temperatures in July.

can also effect differences in climate between land and ocean areas, where the land has higher summer temperatures and lower winter temperatures than the adjacent body of water. Local terrain influences may also be highly significant in military operations. The ground configuration often strongly affects the pattern of occurrence of fog, surface winds, and other conditions. Information about these local conditions frequently can be obtained only by the analysis of topographic maps, ground reconnaissance, and the interrogation of inhabitants.

d. Vegetation. The influence of climate on the growth of vegetation is a predominant factor in their distribution, and the relation between soil information and climate is so close that the pattern displayed by a soil map will provide an indication of the climatic conditions.

2-2. Tropical Rainy Climates

a. Rain Forest Climate. The tropical rain forest climate occurs in a belt generally extending from 5° to 8° on either side of the Equator. In some regions, such as the Amazon Basin and the Congo Basin, the air is always hot and damp, there are frequent torrential rains of short duration, and the winds are feeble or absent for long periods of time. This climatic type is also found on windward coasts, where, between latitudes of 5° and 25°, easterly trade winds blow almost constantly over hills or mountains. The cooling of these winds as they rise over the barriers produces an extremely heavy rainfall. This occurs, for example, in portions of Hawaii, the Philippines, the eastern coasts of Central America, Brazil, Mada-

gascar (Malagasy), and most of the islands in the southern Pacific Ocean. In this type of climate, the rays of the sun are nearly vertical most of the time, so that days and nights are practically equal in length throughout the year. Night temperatures usually are a few degrees lower than daytime temperatures. There are no clearly marked seasons. Relative humidity is high at all times, and cloudy weather may prevail at times. There are heavy rains on at least 4 or 5 days each week during the rainiest months, with the greatest amounts during the periods when the sun is most directly overhead. The rains are torrential, often accompanied by thunder and lightning. Ordinarily the rain begins in the afternoon, when the heated air is rising most rapidly, and ends before nightfall, although occasionally a light rain will continue into the night.

b. Savanna Climate. The tropical savanna climate occurs generally in the regions from 5° to 15° on either side of the Equator, between the dry climates and the tropical rain forest regions. Instead of the dense forests typical of the tropical rain forest climate, the savanna regions have more open forests and large areas covered with tall grasses. Savanna regions have high temperatures, with annual ranges (difference between mean temperature of the warmest and coldest months of the year) varying between 5° and 15° F. The total amount of rainfall is less than that of the tropical rain forest climate. There are distinct wet and dry seasons, and usually the rainy season begins and ends with squalls and violent thunderstorms. During the rainy season, periods of intensely hot sunshine also alternate

with brief, violent deluges of rain. The amount of rainfall varies considerably, so that there are years of drought and years of flood. In the dry season the weather resembles that of desert regions, with very little rainfall. Trees lose their leaves, many small streams are dry, and the soil becomes hard and cracked. Visibility is greatly reduced by dust and the smoke from grass fires.

c. Monsoon. In certain parts of southern and southeastern Asia, the climate is greatly influenced by monsoon winds. The wet and dry seasons coincide respectively with the onshore and offshore winds.

2-3. Dry Climates

a. Description. Dry climates are those in which the evaporation rate exceeds the precipitation rate. The dry climates are located on the leeward interior portions of continents. There are two subdivisions: the arid or desert type, and the semi-arid or steppe type. In general, the steppe is a transitional region surrounding the desert and separating it from the humid regions. Dry climates are characterized by extreme seasonal temperatures with large annual ranges. Daily ranges also are high. Humidity is relatively low, averaging from 12 to 30 percent around the middle of the day. Generally the skies are clear and cloudless. Because vegetation is meager, the barren surface of the dry earth becomes very hot during the day and cools rapidly at night. The vegetation offers little friction to the moving air, and accordingly, strong, persistent winds are typical of desert regions.

b. Low-Latitude Desert Climates. These occur in the vicinity of 20° to 25° north or south, with the average positions of their extreme margins at approximately 15° and 30°. The Sahara and Australian Deserts are typical examples of this type of climate. In these desert regions, rainfall is not only small in amount, but erratic and uncertain. However, infrequent heavy showers may turn dry streambeds into raging torrents. Often there is no rainfall for several years, and the skies are almost always clear and cloudless.

c. Low-Latitude Steppes. These are semiarid, having a short period of rain-bearing winds and storms each year. Precipitation, however, is meager and erratic. Steppe regions on the poleward sides of deserts have almost all their annual rainfall in the cool season. Those adjoining savannas on the equatorward sides of deserts generally

have a brief period of relatively heavy rains during the time when the sun is highest.

d. Middle-Latitude Dry Climates. These occur within the deep interiors of continents, in the regions surrounded by mountains or plateaus that block the humid maritime air masses. Rainfall is meager and undependable, as in the low-latitude deserts, but there is also a season of severe cold. In winter there may be a small amount of snow, frequently accompanied by strong winds. The temperature and weather characteristics are similar to those of humid continental climates in comparable latitudes, except that there is less rainfall. The western plains of the United States and Canada and the area immediately to the east and west of the Caspian Sea are typical examples of this climate.

e. Middle-Latitude Desert Climate. This climate is characterized by lower temperatures and precipitation than low-latitude desert climates. This climate occurs in the basinlike, low-altitude areas, surrounded by high-land rims, that exist in some continental interiors. The Great Basin of the US and the Turkestan Basin of Asia have this type of climate. Summer temperatures are high. Middle-latitude steppes occupy intermediate locations between deserts and humid climates. They have small amounts of rainfall, which is usually unpredictable in amount or time of occurrence.

2-4. Humid Mesothermal Climates

a. Description. These climates are characterized by moderate temperatures that occur in a seasonal rhythm. They are divided into three general categories—Mediterranean climate, humid subtropical climate and marine west coast climate.

b. Mediterranean Climate. This climate has hot, dry summers and mild winters, during which most of the annual precipitation occurs. Annual rainfall usually ranges from 38 to 64 centimeters (15 to 25 inches). In the winter months, the average temperature is usually between 40° and 50° F.; in the summer, it ranges generally from 70° to 80° F. This type of climate occurs in five regions—the borderlands of the Mediterranean Sea, central and coastal Southern California, central Chile, the southern tip of South Africa, and parts of southern Australia. Coastal areas often have a modified type of Mediterranean climate, with cool summers accentuated in some areas by the cool ocean currents offshore. There is apt to be a cool daily breeze along the seacoast and for a short distance inland. Relative humidity is high.

Fogs are frequent, but usually are dissipated by the heat of the sun in the early morning hours. Winters are mild and frost infrequent, and the annual change in temperature at some locations is uncommonly small. Summer days in Mediterranean climates are warm to hot, with bright sunshine, low relative humidity, and nearly cloudless skies. Daily weather becomes erratic and unpredictable in autumn. The winds are less regular and there is occasional rain. Temperatures remain relatively high. Winters are mild and warm, with occasional frosts and relatively abundant rainfall.

c. Humid Subtropical Climate. This climate occurs in regions located on the eastern sides of continents, generally from about latitude 25° poleward (north or south) to 35° or 40°. This type of climate is found, for example, in the American Gulf States. Temperatures are similar to those of the Mediterranean climate, with less contrast between regions on the coast and those located inland. Rainfall ranges from 75 to 165 centimeters (30 to 65 inches) a year at most locations. In the summer, humidity is high, temperatures average from about 75° to 80° F. in the hottest month, and there are frequent thundershowers. Nights are hot and sultry. There is no drought season, but normally there is less rain in winter than in summer. Severe tropical cyclones occur most frequently in the late summer and early fall. Winters are relatively mild in this type climate. Temperatures in the cool months usually average between 40° and 55° F. with the midday temperature around 55° to 60° F. and the night temperature from 35° to 45° F. The high humidity, however, makes the nights chilly and uncomfortable. Snow may fall occasionally, but it does not remain for more than 2 or 3 days. Daytime temperatures may be raised above 60° or 70° F. by the arrival of a tropical air mass, then be reduced by a subsequent polar wind as much as 30° F. in 24 hours, resulting in a severe freeze.

d. Marine West Coast Climate. This climate occurs on the western or windward sides of continents, poleward from about 40° latitude, and results from onshore westerly winds that blow over the land from adjoining oceans. It borders the Mediterranean type on its equatorward margins, extends into the higher middle latitudes and ends at the subarctic or tundra climate. Where mountains are closely parallel to the west coast, as in Scandinavia, this type of climate is confined to a relatively narrow region on seaward side of the highlands. In parts of western Europe, where there are extensive lowlands, the effects of the

ocean conditions have an influence on the climate for many miles inland. Summers are cool with occasional hot days but no severe or prolonged heat waves. Rainfall is fairly abundant. Winters are mild, particularly in western Europe, where a great mass of warm water known as the North Atlantic Drift lies offshore. Cloudy skies and a humid atmosphere are prevalent. There are frequent severe frosts. The midday temperatures of most winter days are relatively high. During unusually cold periods, temperatures may remain below freezing for several days. The winter season is marked by severe storms, fogs, and mist. Where the western coasts are bordered by mountain ranges, as in Norway and Chile, precipitation may reach a total of 250 to 380 centimeters (100 to 150 inches) a year. In areas consisting predominantly of lowlands, rainfall usually averages from 50 to 90 centimeters (20 to 35 inches) a year and may fall steadily for several days at a time. In mountainous regions, such as the Cascade Range or the Scandinavian Highlands, snowfall is very heavy. The marine west coast climate is cloudy, and has mist or fog for at least 40 days a year at many locations.

2-5. Humid Microthermal Climates

a. Types. The humid microthermal climate occurs in the Northern Hemisphere northward from the subtropical climatic regions and in leeward interior locations. Latitudinal spread is from about 40° N to 60° or 65° N. It has colder winters than the mesothermal type, with larger annual changes of temperature, longer frost seasons and snow cover that lasts for considerable periods. Humid continental and subarctic are the principal types of microthermal climate.

b. Humid Continental Climates. These climates border the marine west coast climatic regions. Where there are mountain barriers, as in North America, the change between the two types of climate is abrupt, but it is very gradual where there are no barriers, as in the lowlands of western Europe. Seasonal differences are extreme, with very cold winters and warm to hot summers. Along the seaboard, the summer heat is oppressive and sultry because of the higher humidity, and the winter cold is more raw and penetrating than in the drier interior regions. Along the interior margins, humid continental climates border upon the dry climates and have subhumid characteristics. The prairies of North America and interior Eurasia are examples of such climatic regions. In these areas, the maximum rainfall

usually occurs in late spring and early summer, rather than at the time of greatest heat. In winter, regions with a humid continental type of climate normally have a permanent snow cover that lasts a few weeks to several months. Summer rains usually occur in sharp showers accompanied by thunder and lightning. Winter in the prairie regions is characterized by frequent changes in weather conditions, with occasional blizzards, known as burans. A blizzard is marked by violent gales, drifting snow, and extreme cold. Although there may be no precipitation falling, the air is filled to a height of several hundred feet by swirling masses of dry, finely pulverized snow. Afternoon thunderstorms frequently occur during summer in prairie regions.

c. Southern Margins. Regions on the southern margins of microthermal climates have long, hot, and humid summers lasting from 150 to 200 days between the periods of frost. Winters are cold, with frequent intervals of mild, rainy weather.

d. Winter. Winter is the dominant season on the poleward side of regions with this type of climate. Summers are relatively short, usually comprising a period of about 5 months. Temperature changes of as much as 40° F. in 24 hours are common in spring and autumn.

e. Subarctic Climate. This climate occurs in latitudes of 50° to 60° in the Northern Hemisphere. The Eurasian region extends from Finland and Sweden to the Pacific coast of Siberia, and in North America, the subarctic stretches from Alaska to Labrador and Newfoundland. Long, extremely cold winters and very brief summers characterize this type of climate. Winter quickly follows summer, with only a short period of autumn intervening. A large part of these regions are frozen to a considerable depth, with only a few feet of the upper part thawing out in the summer. There is little precipitation in subarctic regions. No more than 40 centimeters (15 inches) a year falls over the greater part of the Siberian area. In most of subarctic Canada the precipitation is less than 50 centimeters (20 inches) annually. Precipitation exceeds 50 centimeters (20 inches) chiefly along the oceanic margins of Eurasia and North America.

2-6. Polar Climates

a. Location. The poleward limit of forest growth usually is considered the dividing line between polar climates and those of intermediate latitudes coinciding with a line (isotherm) con-

necting points having a temperature of 50° F. for the warmest month. A mean annual temperature of 32° F. or below is also a distinguishing feature of polar climates. In the Southern Hemisphere, the only large land area with a polar climate is the Antarctic continent. In the Northern Hemisphere, this climatic region includes the Arctic Sea, the borderlands of Eurasia and North America, with the island groups that are north of these continents, and ice-covered Greenland. The Arctic is almost a landlocked sea and the Antarctic is a seagirt land with important climatic differences between them. The climate has fewer wide variations in the Antarctic because it is a single land mass surrounded by oceans with a uniform temperature.

b. Temperature. Polar climates have the lowest mean annual and summer temperatures and although the sun remains above the horizon for 6 months of the year, the rays are too oblique to raise the temperature significantly. Much of the energy from the sun is reflected by snow and ice, and is consumed in melting the snow cover and evaporating the water. As a result neither the land surface nor the air adjacent to it becomes warm.

c. Precipitation. Precipitation averages less than 25 centimeters (10 inches) a year over large parts of the polar land areas. Because of the low evaporation and small amount of melting, permanent ice fields several thousand feet thick have accumulated on Greenland and the Antarctic continent.

2-7. Tundra and Icecap

a. Tundra. Polar climates usually are divided into two types—icecap and tundra. Icecap climates are those where the average temperature of all months is below 32° F., vegetation will not grow, and a permanent snow-and-ice cover prevails (fig. 2-4 and 2-5). When 1 or more months in the warm season have an average temperature above 32° F. but below 50° F., the ground is free from snow for a short period and low sparse vegetation is possible. This climate is designated as tundra. It is less rigorous than that of the icecap regions. The warmest month isotherms of 50° F. on the equatorward side and 32° F. on the poleward side are considered to be the boundaries. Over land areas, tundra climate is confined largely to the Northern Hemisphere. Ocean prevails in those Antarctic areas where the tundra climate



Figure 2-4. Arctic terrain.



Figure 2-5. Arctic tundra, showing warm-weather drainage.

normally would be found. Summers warm enough to develop a tundra climate occur only in the most northerly fringes of the Antarctic and on certain small islands of the region. The most extensive tundra areas are on the Arctic Sea margins of Eurasia and North America. Long, cold winters and brief, cool summers characterize the tundra climate.

b. Temperatures. Average temperatures usually are above freezing only for from 2 to 4 months of the year, and killing frosts may occur at any time. Fog is prevalent along the coast, frequently lasting for days at a time. Snow cover disappears for 1 or 2 months during the summer season, and the lakes usually are free from ice. Drainage is poor

because of the permafrost, resulting in many bogs and swamps. Summer temperatures do not differ greatly in the various tundra regions. There is, however, a considerable variation in winter temperatures. Average temperatures in the Arctic coastal areas of Siberia average about -35° to -40° F. in January and February, with even lower temperatures inland. Along the Arctic borders of North America, the temperature for comparable periods is higher, and winters are less severe.

c. Precipitation. Annual precipitation normally does not exceed 25 cm to 30 cm (10 to 12 inches) in the tundra regions, although larger amounts are received in parts of eastern Canada, particu-

larly in Labrador. Usually the most precipitation occurs in summer and autumn, the warmest seasons. Most of it is in the form of rain, with occasional snow. The winter snow is dry and powdery, forming a compact cover. Often it is accompanied by strong blizzard winds which pile up the snow on the lee sides of hills and in depressions, sweeping exposed surfaces bare. There is no vegetation to break the force of the wind and to hold the snow cover.

d. Icecap. This climate characterizes the permanent continental ice sheets of Greenland and Antarctica and the ocean in the vicinity of the North Pole. The average winter-month temperatures range from -35° to -45° F. Storms or violent winds do not occur as frequently in the inner portions of the icecaps as in other climatic regions, but in some marginal areas there are extreme gales caused by the precipitous descent of cold air from the continental ice plateau.

2-8. Climatic Studies

a. A climatic study is derived from the application of climatological information in a manner to reveal the probable effects of climate and weather elements on a specific operation of activity. Based on the records of past weather in a given area compiled over a long period of time, these studies range in scope from investigating a variety of weather conditions over a country to analyzing the local effects of a single atmospheric element on a particular operation or problem. For example, analyzing surface wind data for optimum runway orientation.

b. These studies are used in preliminary planning to provide knowledge of mean and extreme weather conditions which may be expected during the period of proposed operations. Studies for most of the strategic areas of the world are available in section 23, "Weather and Climate," of the National Intelligence Surveys (NIS). Studies for specific areas and problems are also prepared by Air Weather Service (AWS).

c. Although the weather elements presented in a climatic study of a specific area vary according to the needs of the user, the information generally includes, but is not limited to—

(1) Brief general description of prevailing weather for the period covered.

(2) Expected temperatures and temperature variations: including both the variations during a 24-hour day and of the daily average.

(3) Expected precipitation: rain or snow, total expected, frequency and intensity, frequency and duration of wet or dry spells, probability of cloudbursts, blizzards or droughts, and probable standing snow cover on level ground and in drifts.

(4) Expected winds: direction and intensity, maximum winds which might be expected with severe weather.

(5) Cloudiness: data on any seasonal periods of prolonged cloudiness or clear weather.

(6) Humidity.

(7) Severe weather: probability of hurricanes, typhoons, thunderstorms, tornadoes, dust storms, or blizzards.

(8) Effect of weather and atmospheric cloudiness on the transmission through the air of instantaneous nuclear and thermal radiation; the movement and concentration of contaminated clouds and dust; and the spread of surface fires and other phenomena connected with nuclear warfare and CBR agents.

d. Special climatic studies may be prepared to solve a specific engineering or logistics problem or to investigate in detail the effects of pertinent weather conditions on a particular operation. Such studies have been made, for example, to provide data for use in determining:

(1) Degradation in lift capability of helicopters.

(2) Optimum runway orientation.

(3) Planning factors for construction schedules.

(4) Wind chill factors for clothing requirements.

(5) Location of camps, training areas, and landing fields.

(6) Coastal areas most suitable for amphibious operations.

(7) Seasonal fuel requirements by weight, quantity, and type.

2-9. Climatic Summaries

a. A climatic summary (fig. 2-6) provides statistical data on normal weather conditions and variations from the normal at a specified place during a specified period. Climatic summaries are compiled from historical records of weather observations over long periods. They do not forecast day-to-day weather conditions, but they do provide a basis for estimates and plans. A summary emphasizes those features of the climate that may impose problems in a military operation, and it is indispensable to the field commander in preparing to meet such problems.

CLIMATIC SUMMARY FOR THE MONTH OF JULY - 3d CORPS AREA

1. GENERAL CIRCULATION

Generally air flows from the west and northwest. Occasionally warm, dry continental air from Russia causes a relatively intense, dry heat with temperature 90° or more.

2. TEMPERATURES

Afternoon temperatures generally are in the 70's and morning temperatures are in the 50's. There are occasional periods of hot, dry spells that last more than a week with temperatures in the 90's. The highest temperature ever recorded was 101° F.

3. THUNDERSTORMS

Occur frequently. They usually develop during the day and reach maximum intensity in the late afternoon and evening.

4. SURFACE WINDS

Average windspeed is 5 MPH. The most predominant direction is northeast, with a mean speed of 8 MPH. Calms are frequent, occurring 25.2 percent of the time, and usually in the early morning. Calms or near calms often last the whole day.

5. CLOUDINESS

Mornings frequently are clear. Clouds develop by noon and cloud cover reaches a maximum in the late afternoon, decreasing to nil just before sunset.

6. VISIBILITY

Normal visibilities are 7 to 13 miles and occasionally further. Occasionally haze may reduce visibility to about 3 miles.

7. PRECIPITATION

Thunderstorms are the usual cause of precipitation. Occasionally a southwesterly wind will cause continued drizzle and low, overcast skies for one to three days. This is the only time low visibilities occur. Occasional haze may reduce visibility to about 3 miles.

Figure 2-6. Example of a climatic summary.

b. Climatic summaries (and studies) supplement information contained in intelligence surveys. The summaries should be available to a commander whenever he is assigned command of a theater or area, and should contain items of information which he will require in planning an oper-

ation. Examples of such requirements are the relationship between precipitation, snow cover and thaw dates used by the engineers when they prepare charts of soil trafficability, or the wind and cloud patterns expected at the surface and aloft during a certain season used by staff sections in planning airborne operations.

	June	July	Aug.	Annual	Years Recorded
Mean precipitation (inches)	2.56	2.48	2.36	26.97	40
Mean number of days with thunderstorm	4	4	3	18	11
Temperature (°F)					
Absolute max	95	101	97		40
Absolute min	50	43	43		40
Mean daily max	71	74	73		40
Mean daily min	51	55	53		40
Mean number of days with fog	2	2	4	57	11

Surface winds for the month of July

DIRECTION:	S	SSW	SW	WSW	W	WNW	NW	NNW
Percentage frequency	2.1	2.0	8.6	1.0	0.7	0.3	0.4	0.0
Average speed (in knots)	5.6	9.4	8.8	7.6	6.8	8.3	3.2	0.0
DIRECTION:	N	NNE	NE	ENE	E	ESE	SE	SSE
Percentage frequency	1.2	2.1	19.5	10.5	12.2	2.7	9.6	1.0
Average speed (in knots)	5.0	6.3	8.4	10.0	7.1	6.6	6.0	4.0

Figure 2-6.—Continued

Section II. WEATHER

2-10. Definition

Weather comprises the day-to-day changes in atmospheric conditions. The physical properties and conditions of the atmosphere that must be measured or observed to describe the state of the weather are termed the weather elements.

2-11. Air Temperature

a. Measuring. Air temperature is the degree of hotness or coldness of freely circulating air as measured by a thermometer that is shielded from the sun. The thermometer is calibrated by using the melting point of ice and the boiling point of water at sea level as standard references. In most English-speaking countries, the Fahrenheit scale

is used, with the melting point of ice designated as 32° F above zero and the boiling point of water as 212° F above zero. Countries using the metric system employ the centigrade (Celsius) scale, with the freezing point of water designated as 0° C and the boiling point, 100° C. In the United States, surface air temperatures are indicated in degrees Fahrenheit and upper air temperatures in degrees centigrade. Temperatures may be converted from one of these scales to the other by use of the following formulas:

$$C = \frac{5}{9} (F - 32^{\circ})$$

$$F = \frac{9}{5} \times ^{\circ}C + 32^{\circ}$$

b. Recording. Temperature data may be recorded in the following forms:

(1) *Mean daily maximum temperature.* The average of the daily maximum temperatures for a month.

(2) *Mean daily minimum temperature.* The average of the daily minimum temperatures for a month.

(3) *Mean daily temperature.* Average of daily maximum and minimum temperatures for any specific day.

(4) *Mean monthly temperature.* Average of daily mean temperatures for any specific month.

(5) *Mean annual temperature.* Average of daily mean temperatures for any specific year.

(6) *Mean annual range.* Difference between the mean monthly temperatures of the warmest and coldest months.

(7) *Diurnal variation.* Difference between the maximum and minimum temperatures occurring in a day.

(8) *Normal values, or long-term mean.* The average of temperature values for the entire period of record. These values usually are used to evaluate the climate.

(9) *Extreme values.* Absolute maximum or absolute minimum or extreme values.

(10) *Length of freezing period.* Number of days with minimum temperature below freezing.

c. Use of Data. Monthly daily maximum and mean daily minimum temperatures usually are employed to provide a general definition of the type of climate, and the mean annual range to indicate its variability. Extreme values show the limits which must be anticipated in the climate being considered. Temperatures also are recorded at various altitudes above the ground level in order to provide data for estimating certain types of nuclear-weapon effects.

2-12. Atmospheric Pressure

a. Definition. Atmospheric pressure is the force exerted per unit of area by the weight of the atmosphere from the level of measurement to the top of the atmosphere. At sea level this pressure is approximately 6.66 kilograms per 6.45 square centimeter or 14.7 pounds per square inch. Mean sea level is used as a reference for surface weather observations, and pressure measurements are shown on weather maps and climatic charts as if the entire surface of the earth were at sea level. Atmospheric pressures are recorded at various al-

titudes to provide data for estimating nuclear-weapon effects.

b. Measurement. The standard device for measuring atmospheric pressure is a mercurial barometer which balances the weight of the atmosphere with a column of mercury. The standard atmospheric sea-level pressure is equal to that exerted by a 760 millimeter (29.92 inch) column of mercury at 32° F. and at standard gravity. For some scientific purposes, it is desirable to indicate atmospheric pressure in units of pressure (weight per unit of area) rather than in units of length (centimeters or inches). In the metric systems, a bar is the unit of measure. The millibar (1/1000 of a bar) is used in meteorology to designate the value of atmospheric pressure. The standard sea level pressure is 1013.2 millibars. One millibar equals .0762 centimeters or 0.03 inches of mercury. Most weather stations today observe pressure on an aneroid barometer, calibrated in both millibars and inches or millimeters of mercury. Barometer readings significantly below 760 millimeters usually indicate low-pressure areas and those significantly above 760 millimeters usually indicate high-pressure areas. In general, cold air, being heavy and dense, causes high barometric pressures, while hot air, which is light and thin, causes low pressures. (High-pressure systems usually are associated with fair, dry weather; low-pressure systems, with unsettled, cloudy conditions.)

2-13. Winds

a. Description. Wind is air in motion and results from differences in atmospheric pressure. A wind is described by its direction and speed. The direction of a wind is the direction from which it is blowing. A wind coming from the north, for example is termed a north wind. As reported in observations, wind direction is determined with reference to true north and is expressed to the nearest 10 degrees. Thus, a direction of 090 degrees (a wind from due east) would be reported as 09. Wind velocities are reported by the Air Weather Service in knots. A table of wind speeds and their specifications is given (table 2-1) to aid in estimating speeds. Over irregular terrain, a wind does not move with a steady force or direction, but as a succession of gusts and lulls of variable speed and direction. These eddy currents, caused by friction between air and terrain, are called gusts or turbulence. Turbulence also results from unequal heating of the earth's surface, the

Table 2-1. Weather Map Scale of Wind Velocity

Descriptive item	Knots	Meters/seconds	Specifications
Calm -----	less than 1	0-0.2	Calm; smoke rises vertically.
Light air -----	1-3	0.3-1.5	Direction of wind shown by smoke drift but not by wind vanes.
Light breeze -----	4-6	1.6-3.3	Wind felt on face; leaves rustle.
Gentle breeze -----	7-10	3.4-5.4	Leaves and small twigs in constant motion; wind extends light flag.
Moderate breeze -----	11-16	5.5-7.9	Raises dust and loose paper; small branches are moved.
Fresh breeze -----	17-21	8.0-10.7	Small trees in leaf begin to sway; crested wavelets form on inland waters.
Strong breeze -----	22-27	10.8-13.8	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
Near gale -----	28-38	13.9-17.1	Whole trees in motion; inconvenience felt when walking against wind.
Gale -----	34-40	17.2-20.7	Breaks twigs off trees; generally impedes progress.
Strong gale -----	41-47	20.8-24.4	Slight structural damage occurs (chimney pots, slates and shingles removed).
Storm -----	48-55	24.5-28.4	Seldom experienced inland; trees uprooted; considerable structural damage occurs.
Violent storm -----	56-63	28.5-32.6	Very rarely experienced; accompanied by widespread damage.
Hurricane -----	64 and over	32.7 and over	Very rarely experienced; accompanied by widespread damage.

cooler air of adjacent areas rushing in to replace the rising warm air from heated areas. Usually the turbulence produced by surface friction is intensified on a sunny afternoon.

b. Systems. Local pressure and wind systems are created by valleys, mountains, and land masses that change the weather characteristics of areas. Since land masses absorb and radiate heat more rapidly than water masses, the land is heated more than the sea during the day and cools more at night. In coastal areas, warm air over the land rises to a higher altitude and then moves horizontally out to sea. To replace this warm air, the colder air over the water moves on to the land, creating the so-called sea breeze. The circulation is reversed at night, so that the surface air moves from the land to the sea, resulting in a land breeze.

c. Valley Wind. Heated by the daytime sun, the air in contact with a mountain slope becomes lighter than the surrounding air and rises up the slope, being replaced by denser, colder air. This air movement is called a valley wind because it appears to be flowing up from the valley. At night the air in contact with the slope becomes colder

and more dense, sinking down along the slope to create a mountain breeze that seems to flow out of the mountain. Mountain breezes generally are stronger than valley winds, especially in the winter.

d. Chinook. A chinook (North America) or foehn (Europe) (fig. 2-7) is a phenomenon that occurs in winter and spring on the lee or downwind side of mountain ranges over which there flows a steady crosswind of moisture-laden air. As the air rises over the windward side of the mountain it expands and cools rapidly, producing clouds and precipitation. As the air moves down the lee side of the mountain range it compresses and warms. As a result, there are warm, dry winds on the lee side of the mountains.

e. Fall and Gravity. Fall and gravity winds are caused by the descent of downslope air through the action of gravity. They are typical of the Greenland coast, which is essentially a high plateau sloping abruptly to the sea along an irregular coastline cut by many fiords. The central plateau area remains ice-covered throughout the year, developing extremely cold air masses which frequently drain off through the fiords to the sea and

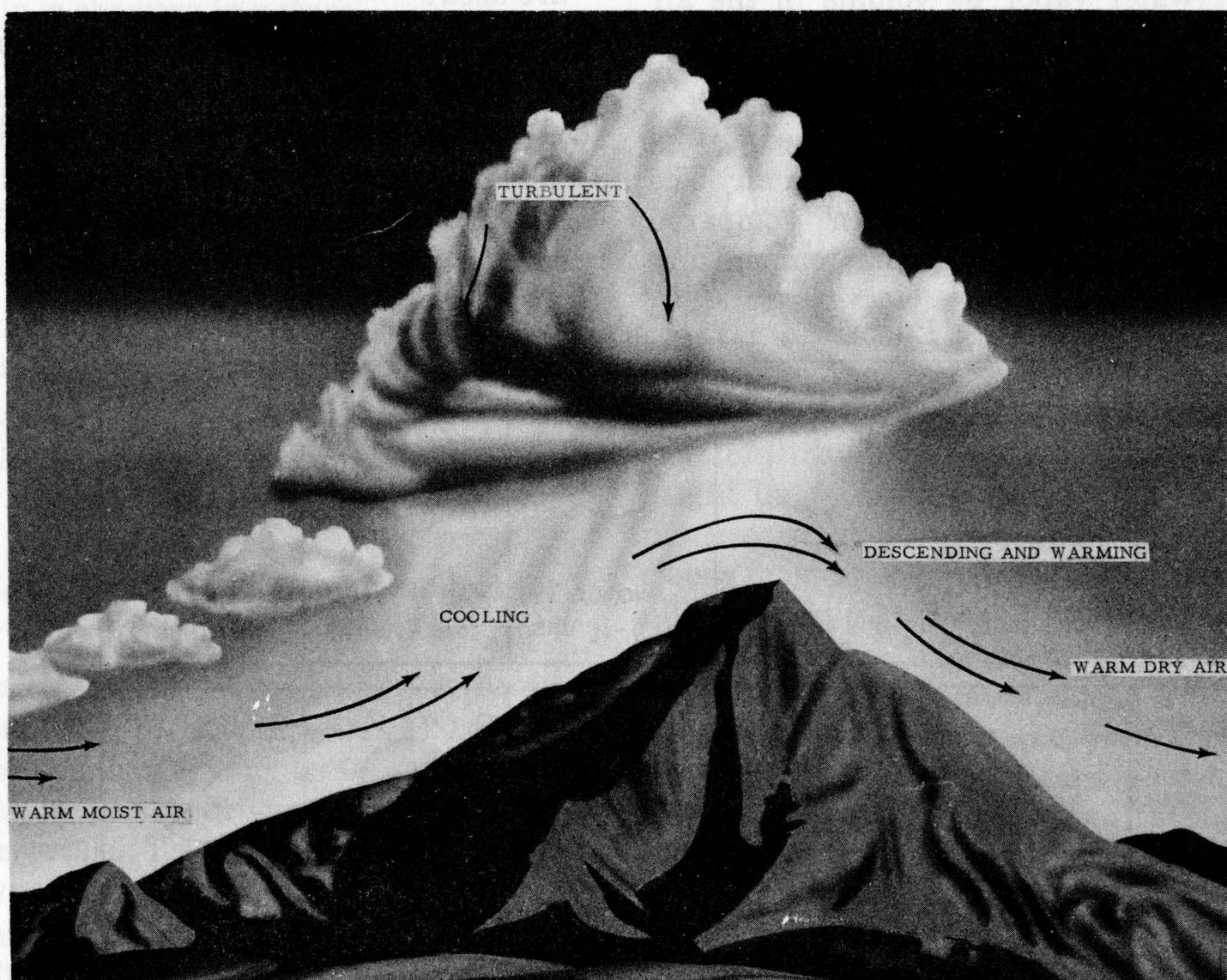


Figure 2-7. Chinook or foehn effect.

attain a near-hurricane speed. At sea level the winds remain relatively cold and very dry. Similar winds are the bora, which drain off the southern Alps and the Balkan Plateau into the Adriatic Sea, and the mistral of the Rhone Valley in France.

f. Monsoon. A monsoon wind is any seasonally changing or reversing wind. It is strongest and steadiest on the southern and eastern sides of Asia. It blows outward from high-pressure centers overland toward the sea in winter and inward toward low-pressure overland in summer. In most regions, the summer monsoon season is generally characterized by extensive cloudiness and frequent precipitation. The winter monsoon season is characterized by dry air and infrequent cloudiness except where the monsoon winds pick up moisture by moving over warm seas before striking an island or peninsular coastline.

2-14. Humidity

a. Vapor. Water vapor is the most important constituent of the atmosphere that determines weather phenomena. Although the oceans are the primary source, a limited amount of water vapor also is furnished to the atmosphere from lakes and rivers, snow, ice fields, and vegetation. The percentage of water vapor by volume in the air may vary from practically zero in deserts to 4 or 5 percent in humid tropical areas.

b. Amount. Humidity is the term used to describe the amount of water vapor in the air. The amount that the air actually contains compared with what it could hold at a given temperature

and pressure is termed the relative humidity. When a specific air mass holds all the moisture that it can at a given temperature, it is described as having a relative humidity of 100 percent.

c. Dew Point. The dew point is that temperature at which the air becomes saturated. The higher the dew point, the greater amount of water vapor the air can hold. The closer the dew point temperature is to the actual temperature, the greater the likelihood of condensation. Condensation results when the capacity of the atmosphere to hold water is reduced by cooling, so that the water vapor in the air is changed to visible moisture such as fog or clouds.

2-15. Clouds

a. Classification. Clouds are masses of condensed moisture suspended in air in the form of minute water droplets. They are classified according to their form or appearance and by the physical processes producing them. The Air Weather Service reports the type of clouds present, the heights of the cloud bases and cloud tops, the amount of cloudiness, and the direction in which the clouds are moving. Cloud amounts are reported in terms of the fraction of the sky that is covered by clouds (fig. 2-8). The following terms are used:

- (1) *Clear.* No clouds, or less than 0.1 of the sky covered.
- (2) *Scattered.* 0.1 to 0.5 of the sky covered.
- (3) *Broken.* 0.6 to 0.9 of the sky covered.
- (4) *Overcast.* More than 0.9 of the sky covered.

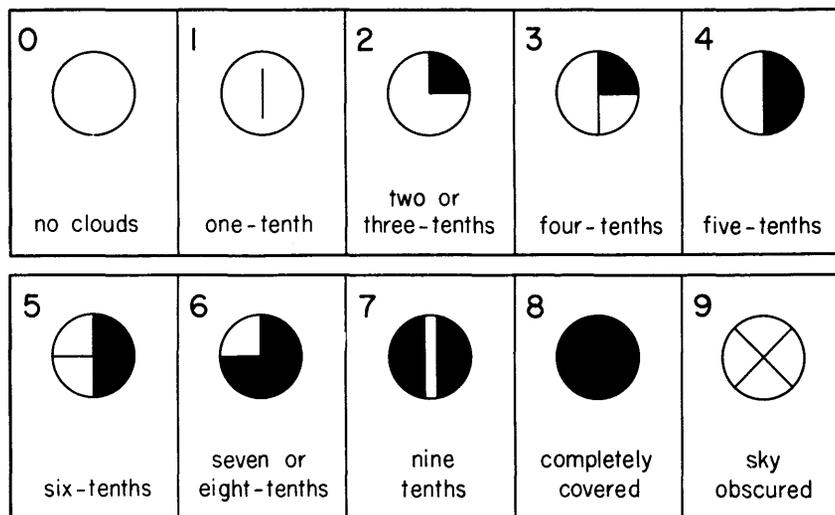


Figure 2-8. Cloud cover symbols.

b. Heights. Cloud heights are reported in meters above the ground. The heights of clouds below 1,500 meters (5,000 feet) are reported to the nearest 30 meters (100 feet); clouds from 1,500 to 3,000 meters (5,000 to 10,000 feet) are reported to the nearest 150 meters (500 feet), and clouds above 3,000 meters (10,000 feet) to the nearest 300 meters (1,000 feet). A ceiling is defined as the lowest layer of clouds that is reported as broken or overcast and not classified as thin. Heights of clouds are reported in meters or feet above the point of observation.

c. Direction. Cloud direction is the direction toward which the cloud bases are moving. It is reported according to the eight points of the compass.

d. Appearance. According to their appearance, clouds are either cumuliform or stratiform. Cumuliform clouds are formed by rising currents in unstable air. Stratiform clouds result from the cooling of air in stable layers.

(1) Cumuliform clouds are dense with vertical development. The upper surface of a cumuliform cloud is dome-shaped, while the base is nearly horizontal. Usually clouds of this type are separate from each other and rarely cover the entire sky. The precipitation from cumuliform clouds generally is showery in nature.

(2) Stratiform clouds usually occur in layers that may extend from horizon to horizon, without the vertical development of cumuliform clouds. Precipitation from this type of cloud usually is in the form of light continuous rain, drizzle, or snow.

e. Groupings. Clouds may be grouped into four families (fig. 2-9)—

- (1) *High.* Cirrus, cirrostratus, cirrocumulus.
- (2) *Middle.* Altostratus, altocumulus.
- (3) *Low.* Stratus, nimbostratus, stratocumulus.
- (4) *Vertical development.* Cumulonimbus for an example.

f. High Clouds. High clouds usually occur at heights of from 6,000 to 12,000 meters (20,000 to 40,000 feet), although they may be found at much lower altitudes in polar regions. They are composed of ice crystals. The characteristics of the major cloud types in this group are as follows:

(1) *Cirrus.* This is a delicate white fibrous cloud that often appears bright yellow or red from the reflection of light from a rising or set-

ting sun. Cirrus clouds may appear as isolated tufts, featherlike plumes, or streaks with up-turned ends often referred to as mare's tails. Because of their thinness, cirrus clouds do not blur the outlines of the sun or moon, and usually do not make an appreciable change in the appearance of the sky.

(2) *Cirrostratus.* These are thin, whitish veils of clouds that give the sky a milky look. Usually they can be distinguished from cirrus clouds by the halo which light from the sun or moon produces in them.

(3) *Cirrocumulus.* Clouds of this type consist of patches of small, rounded masses or white flakes arranged in groups or lines.

g. Middle Clouds. Middle clouds usually occur at altitudes of 1,800 to 6,000 meters (6,000 to 20,000 feet) in the lower limit of this range in the colder seasons, and at altitudes near the upper limit in the warmer seasons. The major types are—

(1) *Altostratus.* Clouds of this type appear as a veil of gray or bluish fibrous clouds, the thinner forms resembling the thicker forms of cirrostratus. Altostratus clouds are associated with smooth or stable air layers, and occasionally they produce light rain or snow.

(2) *Altocumulus.* This cloud type can appear as a layer or in patches, is white or gray in color, and the cloud elements appear as rounded masses or rolls. They occur in a variety of forms, and may exist at several levels at the same time.

h. Low Clouds. Low clouds usually have bases below 1,800 meters (6,000 feet) and include the following types:

(1) *Stratus.* These form a low layer resembling fog, although they do not rest upon the surface. They give the sky a hazy appearance. The base of this cloud is usually rather uniform in height but it often occurs in the form of ragged patches or cloud fragments. Layers of stratus clouds may cover hundreds of thousands of square miles. Usually they are thin, and range in thickness from a few hundred feet to several thousand feet. Frequently, stratus clouds are accompanied by fog, haze, or smoke between their bases and the ground. Visibility is very poor under stratus clouds, and precipitation from them usually is in the form of light snow or drizzle.

(2) *Nimbostratus.* Clouds of this type form a low, dark gray layer. Precipitation usually is in the form of continuous rain or snow of variable intensity. Because of its thickness, sometimes

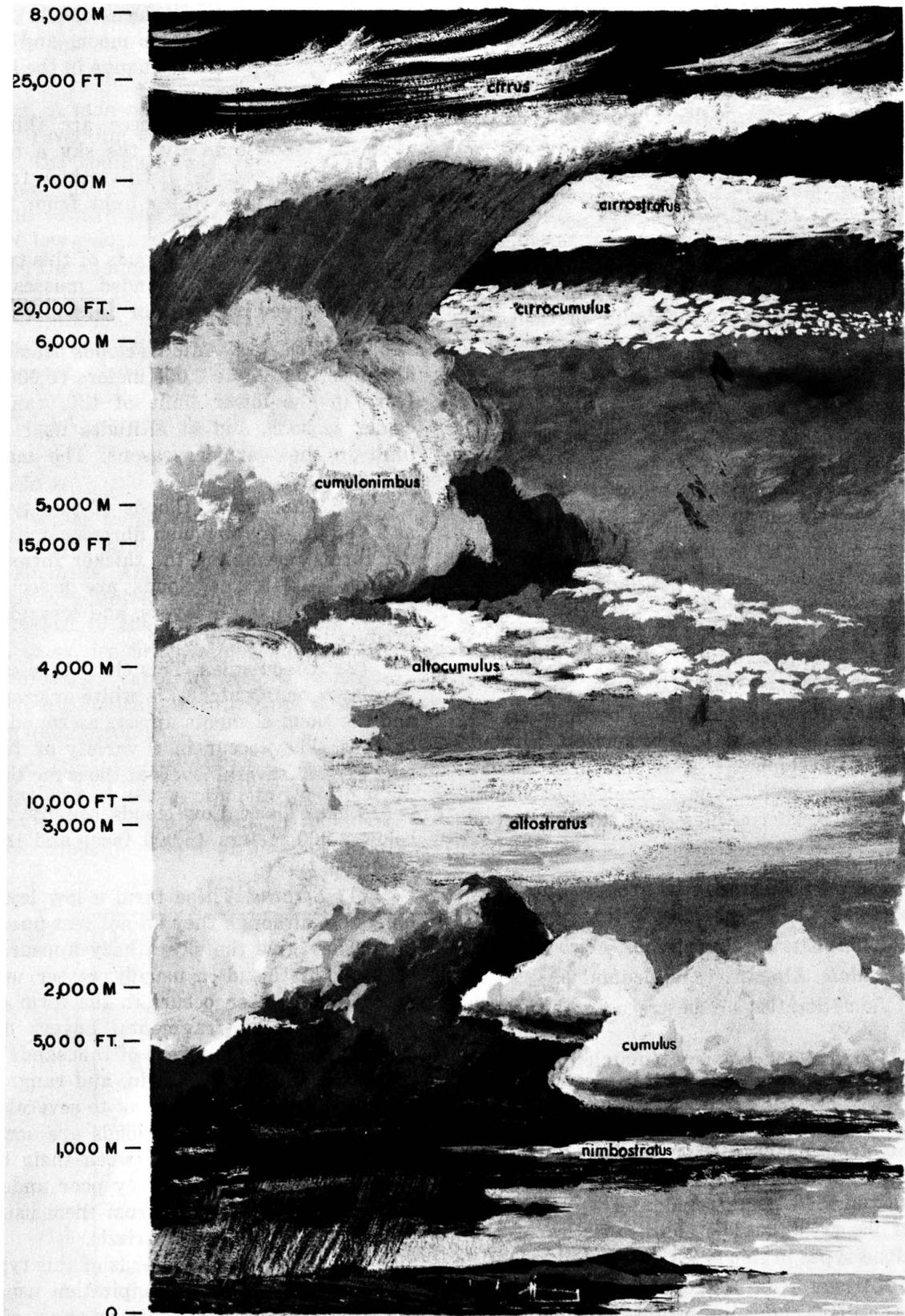


Figure 2-9. Major cloud types.

more than 4,500 meters (15,000 feet), the nimbostratus is frequently classified as a cloud of vertical development.

(3) *Stratocumulus*. This type of cloud forms a lower layer of patches of rounded masses or rolls. The base of the stratocumulus usually is larger and rougher than the stratus clouds. Frequently these clouds change into the stratus type.

i. Vertical. Vertical development clouds cannot be classified according to height, since they extend through all the levels assigned to other cloud groups. The bases vary from 150 to 3,000 meters (500 feet to 10,000 feet) or higher, while the tops may vary from 450 meters (1,500 feet) to more than 12,000 meters (40,000 feet). They all occur in relatively unstable air and frequently are associated with strong vertical currents and intense turbulence. In this category are the following:

(1) *Cumulus*. Clouds of the cumulus type are dense, with vertical development. The base is horizontal and uniform in height above the earth, with a top that is domed or cauliflower-like in shape. Cumulus clouds appear white when they reflect sunlight toward the observer, but when viewed from directly underneath or when they are between the observer and the sun, they may appear dark with bright edges. Over land, cumulus clouds tend to develop during the warming of the day, dissipating at night when the earth's surface cools. Over water, cumulus clouds tend to develop at night as the water surface remains warm while the air mass cools slightly.

(2) *Cumulonimbus*. Clouds of this type are heavy masses which extend to great heights. Their upper portions resemble mountains or towers capped with a fibrous texture. They develop only in unstable air. Cumulonimbus clouds are distinguished from cumulus clouds chiefly by the veil of ice crystal clouds which surrounds their upper portions. Thunderstorms, squalls, turbulence, and hail are characteristic of cumulonimbus clouds.

2-16. Precipitation

a. Description. Precipitation (fig. 2-10) is visible moisture that falls from the atmosphere, such as rain, sleet, snow, hail, drizzle, or combinations of these. As an air mass rises, its ability to hold moisture decreases and clouds form. When the cloud droplets become too large to remain in suspension, rain occurs or if the air temperature is below freezing, snow is formed. Sleet is frozen rain formed by droplets passing through a layer

of below-freezing air. Hail consists of rounded particles composed of layers of ice falling from cumulonimbus clouds with strong updrafts. Raindrops are carried to high altitudes and frozen into ice pellets. They then fall and are carried up again by the updraft until the weight of the pellet is greater than the force of the updraft, whereupon it falls to earth. Freezing rain falls from the air in liquid form but freezes upon contact with objects on the surface that are at a temperature below the freezing point. The ice formed on these surfaces is called glaze. Air Weather Service observations include information on the form of precipitation and its character, intensity, and amount.

b. Character. The character of precipitation refers to its duration and to changes in its intensity. It is reported as continuous, intermittent, or showery. Continuous precipitation is that in which the intensity increases or decreases gradually. Intermittent precipitation is characterized by a gradual change in intensity, but ceases and recommences at least once an hour. Showery precipitation is marked by rapid changes in intensity and by starting and stopping abruptly. The intensity of precipitation is determined on the basis of its rate of fall. It is described as follows:

(1) *Very light*. Scattered drops or flakes which do not completely wet an exposed surface, regardless of duration.

(2) *Light*. Not more than 0.25 millimeter (0.01 inch) in 6 minutes.

(3) *Moderate*. 0.26 to 0.75 millimeter (0.01 to 0.03 inch) in 6 minutes.

(4) *Heavy*. More than 0.75 millimeter (0.03 inch) in 6 minutes.

c. Intensity. The intensity of snow and drizzle is determined on the basis of the reductions in visibility which result, as follows:

(1) *Very light*. Scattered drops or flakes which do not completely wet an exposed surface, regardless of duration. Negligible effect on visibility.

(2) *Light*. Visibility 1 kilometer ($\frac{5}{8}$ statute mile) or more.

(3) *Moderate*. Visibility less than 1 kilometer ($\frac{5}{8}$ statute mile), but not less than $\frac{1}{2}$ kilometer ($\frac{5}{16}$ statute mile).

(4) *Heavy*. Visibility less than $\frac{1}{2}$ kilometer ($\frac{5}{16}$ statute mile).

d. Amount. The amount of precipitation is ex-

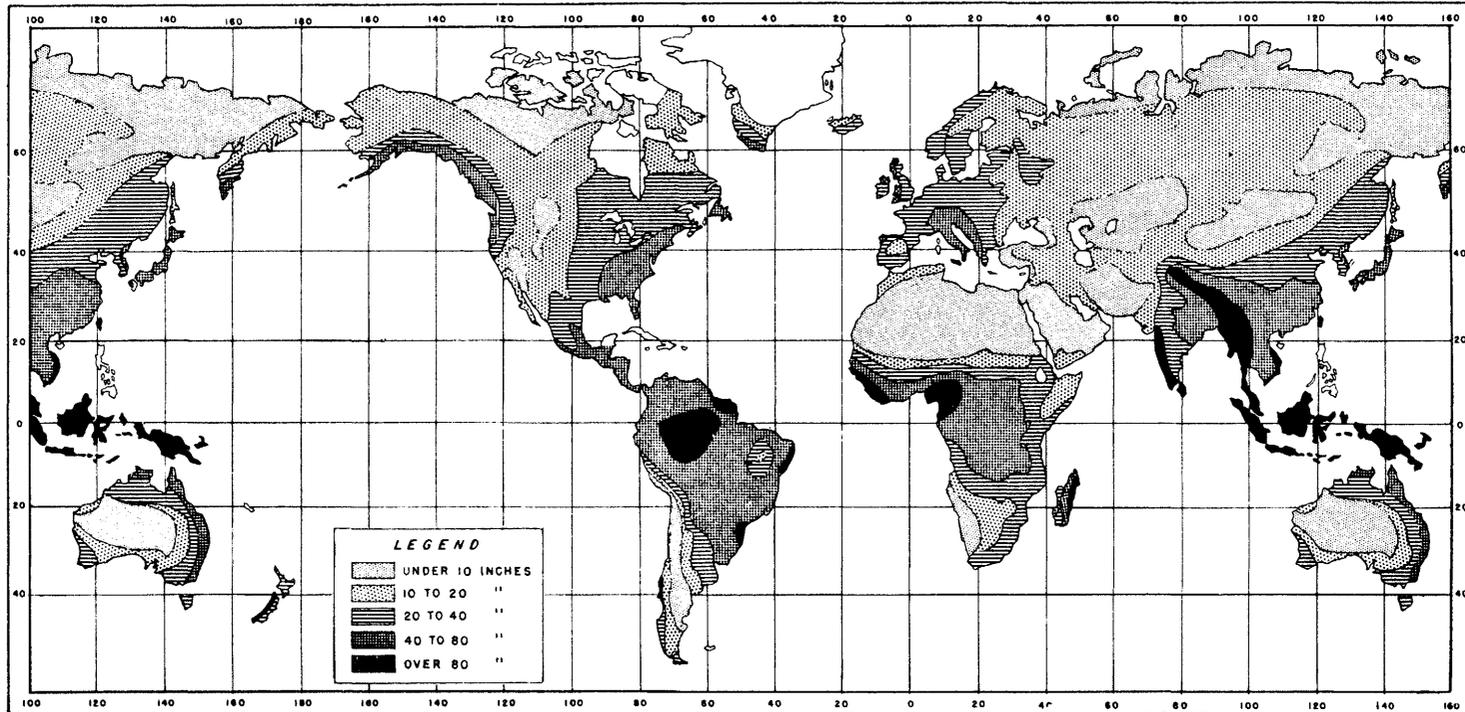


Figure 2-10. World rainfall.

pressed in terms of the vertical depth of water (or melted equivalent in the case of snow or other solid forms) accumulated within a specified time on a horizontal surface. This is expressed to the nearest 0.25 millimeter (0.01 inch). A depth of less than 0.13 millimeters (0.005 inch) is called a trace. In the case of snow, both the actual depth and the equivalent in water are required. Snow depth is measured to the nearest whole inch, and less than 1.3 centimeters (0.5 inch) is termed a trace. The water equivalent of snow is determined by melting a representative sample and measuring the resulting depth of water. As an average figure, 25 centimeters (10 inches) of snow are considered to be equivalent to 2.5 centimeters (1 inch) of water, although this is subject to wide variation. The depth of snow is of concern in estimating the trafficability and the water equivalent is significant for problems involving water supply, flood prediction, stream flow, and drainage.

2-17. Fog

Fog is defined as a mass of minute water droplets suspended in the atmosphere at the surface of the earth that reduces the horizontal visibility. It is formed by the condensation of water vapor in the air. The most favorable conditions for the formation of fog are an abundance of water vapor, high relative humidity, and a light surface wind. A light wind tends to thicken fog. Increasing wind speeds will usually cause a fog to lift or to dissipate. Fog usually is more prevalent in coastal areas than inland because there is more water vapor in the atmosphere. Inland fogs may be very persistent in industrial regions. In most areas of the world, fog occurs more frequently during the colder seasons of the year than it does in the warmer seasons.

2-18. Storms

a. Thunderstorms. A thunderstorm is a local storm accompanied by thunder, strong gusts of wind, heavy rain, and sometimes hail, usually lasting for no more than an hour or two. A thunderstorm is cellular, each of its many cells having violent up and down drafts in close proximity. The overall mass has a characteristic frontal zone with violent cool winds racing inward toward the storm in spite of its forward motion. When a thunderstorm reaches its mature stage and the rain begins, a downdraft starts in the lower and middle levels of the storm. The large body of descending air causes strong, gusty surface winds that move out ahead of the main storm area, often

resulting in a radical, abrupt change in wind speed and direction termed the first gust. In general, the strongest thunderstorm winds occur on the forward side of the storm where the downdraft first reaches the surface. These winds ascend upward at various rates, depending on the intensity and size of the storm. The actual storm has layers conducive to icing and hail formation depending on the altitudes obtained by updrafts and so on. The speed of a thunderstorm wind may reach 80 to 120 kilometers (50 to 75 miles) per hour for a short time.

b. Tornadoes. Tornadoes are circular whirlpools of air which range in size from about 30 meters to .8 kilometer (100 feet to $\frac{1}{2}$ mile) in diameter. A tornado appears as a rotating funnel-shaped cloud extending toward the ground from the base of a cumulonimbus. The low pressure and the high wind speeds encountered in the center of the tornado are very destructive. The paths of tornadoes over the ground usually are only a few miles long and the tornadoes move at speeds of 40 to 90 kilometers (25 to 55 miles) per hour. Although the maximum wind speeds associated with tornadoes never have been measured directly, property damage and other effects indicate that they may exceed 800 kilometers (500 miles) per hour. When they occur over water, tornadoes are termed *waterspouts*.

c. Tropical Cyclones. A tropical cyclone is a low-pressure system of cyclonic winds that forms over tropical water areas (fig. 2-11). Cyclones of great intensity are called hurricanes in the Atlantic and Eastern Pacific Oceans, typhoons in the Western Pacific Ocean, cyclones in the Indian Ocean, and *willi willi* in Australia. The average life span of a tropical cyclone is 6 days, although some last only a few hours and others as long as 2 weeks. Tropical cyclones of hurricane intensity are characterized by extremely strong and gusty surface winds, with speeds of 117 to more than 240 kilometers (73 to more than 150 miles) per hour; continuous intense rain in the central area, and a relatively calm area near the center known as the eye. These storms vary in size from 80 to 800 kilometers (50 to 500 miles) in diameter. The precipitation associated with tropical cyclones is extremely heavy. They are frequently accompanied by violent thunderstorms, with the heaviest rainfall usually occurring some distance ahead of the eye of the moving cyclone. Abnormally high tides are a common companion of hurricanes and are responsible for a great amount of damage.

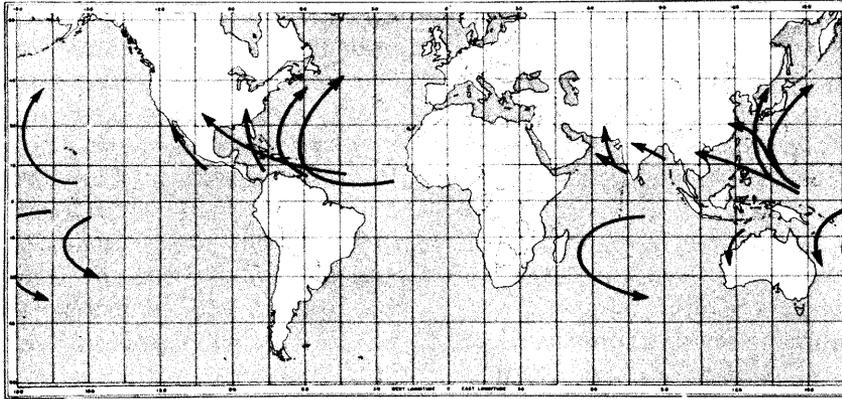


Figure 2-11. Tropical cyclones.

2-19. Weather Forecasts

A weather forecast is a statement of expected weather conditions at a point, along a route, or within an area at a specified future time, or during a specified period.

a. Forecasts are based upon weather charts and data, the application of forecasting rules, theories, and hypotheses, combined with the forecaster's training and experience and his knowledge of terrain and similar external factors. The current state of the meteorological science restricts most forecasts to a 48-hour period. In addition, a 3- to 5-day forecast also can be supplied to supplement the 48-hour operational forecast. Beyond 5 days, climatology is used, normally. Local area forecasts may depend on observations from the larger surrounding area; usually these are detailed enough to permit inferences of local conditions. Forecasts are prepared by AWS for the Army on both a routine and a special basis.

b. The accuracy of a forecast depends on many factors, including length of the forecast period, amount and reliability of weather data, location of the area, type of terrain, season, detail required, reliability of weather communications, and experience of the forecaster. When weather observations are few, or the meteorological situation is complex, a forecast of conditions 2 or 3 hours ahead may be inaccurate. When reports are complete and the meteorological situation is relatively simple or static, conditions may be forecast with reasonable accuracy for as long as 5 days; however, reliability of forecasts generally decreases as the forecast period increases. Because a forecast is issued for a specific time, usually beginning soon after issue, it rapidly loses its value unless promptly received by the user. Conse-

quently, forecasts are disseminated by electrical or other rapid means.

c. Forecasts are classified according to the length of the period or their specialized use. Classifications according to length of the periods covered are:

(1) Short-period forecasts give detailed values of the weather elements expected to occur during the period and the time of anticipated weather changes. They are sufficiently reliable for use in detailed short-range planning. The accuracy usually decreases as the period increases. Short-period forecasts also are referred to by the period covered; for example, 12-hour, 24-hour, or 48-hour forecasts.

(2) Extended period forecasts (fig. 2-12) are less detailed and less specific than short period forecasts. Usually the weather information is expressed in terms of departure from normal conditions and is suitable only for preliminary planning purposes. Extended period forecasts are also known as 3- to 5-day forecasts.

(3) Weather outlooks cover from 5 days to a month in advance and are based largely on climatic data. They predict future weather in general terms, expected departures from normal conditions, and expected times of significant changes. These predictions are normally useful only for preliminary planning and are classed as climatic studies.

d. Forecasts are also classified as general or special. The general forecast covers a wide range of weather elements while the special forecast covers a few elements in greater detail for a specific user.

(1) General forecasts are used by the majority of army units for day-to-day operations. They

EXTENDED PERIOD FORECAST CLYDESVILLE AND VICINITY VALID 01/0600Z TO 04/0600Z: 1 AUG: CEILING AND SKY CONDITION: 5000 FEET OVERCAST GRADUALLY LOWERING TO 1000 FEET OVERCAST BY SUNSET. VISIBILITY 5 MILES IN HAZE OCCASIONALLY LOWERING TO 2 MILES IN RAIN. WINDS NORTHEAST 3 TO 5 KNOTS. MIN TEMP RANGE 50 TO 60 DEG F, MAX 65 TO 75 DEG F. 2 AUG: CEILING AND SKY CONDITION: 500 TO 1000 FEET OVERCAST BECOMING 2000 FEET SCATTERED BY SUNSET. VISIBILITY 1 TO 2 MILES IN LIGHT RAIN AND FOG BECOMING 7 MILES BY NOON. WINDS NORTHEAST 5 TO 10 KNOTS BECOMING SOUTHWEST 10 TO 15 KNOTS BY MIDAFTERNOON. WARMER. MIN TEMP 55 TO 65 DEG F, MAX 70 TO 80 DEG F. 3 AUG: SKY CONDITION CLEAR, VISIBILITY 10 TO 15 MILES, WIND SOUTHWEST 15 KNOTS. LITTLE CHANGE MIN TEMP, MAX RANGE 75 TO 85 DEG F. LIGHT DATA: 1 AUG: BMNT 01/1151Z, EENT 02/0240Z. MOON: PHASE FULL, RISE 02/0230Z SET 02/1350Z. 2 AUG: BMNT 02/1152Z, EENT 03/0239Z. MOON: PHASE FULL, RISE 03/0320Z, SET 03/1440Z. 3 AUG: BMNT 03/1153Z, EENT 04/0238Z. MOON: PHASE FULL, RISE 04/0410, SET 04/1530Z. PLANNING WINDS FOR RADIOLOGICAL FALLOUT, HEIGHTS IN FEET, SPEED IN KNOTS. 0-12000 FEET SOUTH 10-20 KNOTS, 12000-24000 SOUTH TO SOUTHWEST 15 TO 30, 24000-36000 SOUTHWEST 20 TO 40, 36000-48000 SOUTHWEST 35 TO 55, 48000-60000 SOUTHWEST TO WEST 50 TO 70. 2 AUG: 0-12000 SOUTHWEST 15 TO 40, 12000-24000 SOUTHWEST 25 TO 55, 24000-36000 SOUTHWEST 40 TO 75, 36000-48000 SOUTHWEST TO WEST 30 TO 40, 48000-60000 SOUTHWEST TO WEST 25 TO 35. 3 AUG: 0-12000 WEST TO NORTHWEST 20 TO 30, 12000-24000 WEST TO SOUTHWEST 35 TO 50, 24000-36000 WEST TO SOUTHWEST 50 TO 80, 36000-48000 WEST 25 TO 35, 48000-60000 WEST 20 TO 30.

Figure 2-12. Typical extended period weather forecast.

are developed from reports received from a wide network of stations which make simultaneous observations at prescribed times. Data resulting from the observations are transmitted to specific users and to weather centers and weather teams for analysis. Forecasting techniques are applied to data to produce the forecast product, which is then forwarded to the operating units concerned. This type of forecast requires a dependable communications system, and observers located over a wide area, including, if possible, territory in possession of the enemy.

(2) Special contingency forecasts include forecasts for use of nuclear weapons, army aviation flights, employment of toxic chemicals and biological agents, and severe weather warnings. Forecasts of fallout winds are special forecasts of winds aloft to determine the area that would be covered by nuclear fallout. Severe weather warnings of tropical storms, hurricanes, thunderstorms, tornadoes, strong and gusty surface winds, heavy precipitation, and extremes of temperature are provided by AWS.

e. Weather forecasts may be presented in coded, graphic, or written format. Normally, those for use by Army units are issued in plain language form. Abbreviations, which are used extensively in weather messages, are contained in Joint-Army-Navy-Air Force Publications (JANAP) 169.

2-20. Weather Intelligence

a. *Dissemination.* Timeliness is the critical factor in disseminating weather reports and forecasts. Normally they are transmitted by radio or teletype. Weather information is incorporated in such documents as the intelligence estimate, periodic intelligence report, analysis of area of operations, and the intelligence summary.

b. *Responsibility of Intelligence Officer.* The intelligence officer at corps and lower levels is responsible for determining the weather information requirements and submitting them to the Air Weather Service personnel. He informs subordinate units of the weather data required by the Air

Weather Service and instructs them in the procedure for collecting and forwarding the data. He disseminates the received weather information and coordinates with G3/S3 in the weather training of subordinate units.

c. Requirements. Weather requirements are of two types—those established by the Army and passed to the Air Weather Service for action, and those established by the Air Weather Service and passed to the Army for action. The intelligence officer coordinates all activities directed toward satisfying these requirements. At division and higher levels this coordination is effected through the Air Force Staff Weather Officer, a special staff officer at those echelons. Below division, the intelligence officer requests Air Weather Service support through intelligence channels. Army weather requirements may include climatic information to be used in the planning phase of an entire campaign or operation, weather forecasts, reports of current weather, and weather summaries. Under conditions of nuclear warfare, timely and accurate weather data, particularly that concerning upper air wind speeds and direction, is essential in fallout predictions. Fallout predictions are required both for friendly and enemy employment of nuclear weapons.

d. Requests. Requests for specific weather information received by the intelligence officer are evaluated to determine whether or not the information can be secured by organic agencies before they are forwarded to the Air Weather Service. In all cases, before forwarding the request the intelligence officer insures that requests from various units do not overlap and that they cannot be fulfilled from information already available.

e. Information Sources. Weather data required by the Air Weather Service from Army units may be secured by artillery meteorological sections, Chemical Corps units, Army aviation, and forward combat troops. Artillery meteorological sections are capable of making winds-aloft observations and of determining upper air pressure, temperature, and humidity. In addition, they measure and report data for fallout prediction and use by the Air Weather Service. This information is transmitted every 3 hours. Chemical Corps smoke battalions can furnish information concerning surface winds and temperature. The pilots of army aircraft are capable of reporting weather conditions within their area of flight operations. Forward combat units can provide weather data obtained by visual observation, and if required,

they may be equipped with instruments for obtaining additional weather data.

f. Interpretation. An intelligence officer does not merely disseminate verbatim the weather forecast received from higher headquarters. He must interpret it in relation to particular operations. He also receives interpretations from such special staff officers as the chemical officer (toxic chemical interpretations and interpretations relative to fallout predictions and travel of fallout clouds), the aviation officer and the Staff Weather Officer. The weather information that he transmits to the command must be presented in its most usable form, with the operational aspects of the data indicated whenever applicable.

2-21. Effects of Temperature

a. Temperature. Periods of freezing temperatures will increase the trafficability of some soils, while with others it may create ice sheets on roads, making movement more difficult. Thawing temperatures may make frozen soils difficult to traverse and may damage roads with poor foundations. The ability of projectiles to penetrate the earth is decreased by frozen soil, but freezing increases the casualty effect of contact-fuzed shells. Melting snows may cause floods and in mountain areas result in avalanches.

b. Inversions. Temperature inversions create an exception to the normal decrease in temperature that occurs with increases in altitude. In a temperature inversion, the air nearest the ground is colder than the overlying air. The lower air remains stable. Dust and smoke remain near the ground, reducing visibility and air purity. Depending on wind direction, inversion conditions may be favorable to either enemy or friendly employment of toxic chemical or biological agents. Radar beams may also be refracted or ducted due to inversions.

c. Site Selection. In selecting sites to provide protection against low temperatures in the northern hemisphere, preference should be given to the southwesterly slopes of hills and mountains, where the temperature usually is higher than on other slopes. Cold air flows downslope and remains pocketed in inclosed drainage areas or is dammed by forests or other barriers. These cold air pockets have the lowest temperature of the terrain, and often are characterized by freezing or fog when adjacent areas are frost-free or clear. In areas of frequent calm or near calm conditions such cold air drainage areas should not be selected

for troop bivouacs or for such facilities as motor pools and hospitals. In hot climates, caution is required in utilizing cold air pockets, since they are likely areas for the formation of ground fog and excessive humidity. In windy areas, on the other hand, these pockets provide shelter from the chilling effects of the wind. Areas susceptible to cold air drainage can be readily located by ground reconnaissance or from topographic maps by visualizing the flow of cold and dense air over the terrain. In general, concave land surfaces facilitate the accumulation of cold air, and convex surfaces favor drainage of air from the surface. Toxic chemicals and biological aerosols also tend to collect in depressions and low places. In areas where heating is required, careful selection of the terrain in locating bivouacs and other installations will save fuel. If temperature data are available for various possible sites, or can be estimated by altitude factors and terrain configuration, fuel requirements may be closely ascertained. Toxic chemical agents vaporize more rapidly in high ambient temperatures than in low ambient temperatures. The effects of weather on toxic chemical and biological agents, and on radiological contamination, are discussed in FM 21-40 and TM 3-240. Temperature has no significant effects upon the intensity of blast or the thermal radiation of nuclear weapons.

2-22. Winds

a. Description. In arid or semiarid areas, strong winds frequently raise large clouds of dust and sand which greatly reduce observation. Similar effects result in snow-covered regions, where blowing snow may reduce visibility over wide areas. Observation aircraft may be grounded entirely during such periods. The speed and direction of the wind are prime considerations in areas contaminated by toxic chemical agents, biological agents, and radiological fallout. Winds of 5 to 16 kilometers (3 to 10 miles) per hour provide the most favorable conditions for the employment of contaminating agents. Winds below or above that range cause a loss of effectiveness in the use of gas, smoke, chemicals, radioactive clouds, and mists. The direction of the wind must be considered for the protection of friendly troops. In areas characterized by great turbulence and variable winds the use of contaminating agents is highly dangerous.

b. Projectiles. Winds tend to deflect projectiles from their normal paths, particularly when they are fired at long ranges. The effect that wind will

have on a projectile increases with an increase in the velocity of the wind and the size of the projectile. To obtain accuracy in artillery fires, the direction and velocity of the wind must be known in order to apply compensating corrections to firing data. Winds also affect the efficiency of sound-ranging equipment.

c. Parachute Landings. Parachute landings are feasible in winds up to 25 kilometers (15 miles) per hour. At higher velocities, the wind tends to scatter troop concentrations, to foul equipment, and increase the number of casualties from landing accidents. Strong winds also increase the time that parachutists must remain in the air, as well as the time required to secure equipment and prepare for combat after landing.

d. Amphibious. Strong winds hinder amphibious operations by creating high seas which will prevent landing craft from landing or retracting.

e. Nuclear. Wind speed and direction have no influence upon the blast or thermal radiation effects of nuclear weapons, nor upon the range of the initial nuclear radiation. Winds at all atmospheric levels are significant factors, however, in determining the location of radiological fallout resulting from the surface, subsurface or airburst of a nuclear weapon. Contaminated dirt and debris carried upon the column and cloud will be deposited downwind.

f. Aerosols. The effectiveness of toxic chemical and biological agent aerosols is influenced by the direction and speed of the wind. Such aerosols are dissipated rapidly in high winds. The use of toxic chemical agents in vapor form is most effective on clear or partially clear nights when the air usually is most stable.

2-23. Effects of Humidity

a. Ballistics. The effects of humidity upon ballistics are important because of the relationship of humidity and density. The amount of water vapor in the air affects the trajectory of projectiles by the influence that it has upon air temperature and density. Humidity also has an effect upon the distance that sounds travel, thus affecting sound-ranging operations. Humidity does not seriously decrease the effectiveness of most toxic agents and may increase the effectiveness of some, such as blister gas. The effectiveness of some biological agent aerosols may tend to be increased by moisture in the air since living organisms are affected adversely by dry air and direct sunlight.

b. *Smoke.* In the use of a screening smoke, a humidity of 90 percent will have twice the obscuring effect of a humidity of 40 percent. With this increase in relative humidity, only 1/4 of the amount of smoke-producing material need be used.

c. *Nuclear.* Humidity has no influence upon the blast effect or nuclear radiation of a nuclear weapon and no direct effect upon thermal radiation intensities. It will affect target vulnerability to a degree, because it will determine the moisture content of clothing, structures, equipment, and vegetation and their susceptibility to ignition. This effect is pronounced, however, only when a very high or low relative humidity has prevailed over a long period.

2-24. Cloudiness

a. *Effects.* Daytime cloudiness reduces the amount of heat received from the sun at the earth's surface, slowing down the drying of roads and affecting the trafficability of soils. Extensive night cloudiness prevents the loss of heat from the earth's surface due to radiational cooling and results in higher nighttime temperatures. Cloudiness chiefly affects air operations by limiting aerial observation and reconnaissance. Dense clouds above the camera level may reduce light intensity to the point that photography becomes difficult or impossible. A high, thin layer of clouds, on the other hand, may eliminate ground shadows and thus improve the quality of aerial photographs. In cloudy areas, close combat air support may be prohibited or restricted to aircraft equipped with suitable navigation instruments.

b. *Searchlights.* Low-lying clouds may be used to advantage by reflecting searchlight beams to illuminate the ground surface. Any considerable degree of night cloudiness reduces the amount of moonlight that reaches the ground. If the fullest utilization of twilight periods is desired, the extent of cloud cover must be considered.

c. *Nuclear.* Clouds have no influence upon the blast effect of nuclear weapons that are burst below them, nor do they affect nuclear radiation, but they may affect the intensity of thermal radiation reaching a target. If a weapon is burst above or within a continuous cloud layer over the target, a large portion or all of the thermal radiation may be attenuated, with a serious loss of effect. The amount of loss will depend upon the thickness and continuity of the cloud layer and the position of the burst with respect to it. If a weapon is burst below a continuous or nearly continuous cloud layer, some of the thermal energy may be reflected from the cloud layer downward on the target area, enhancing the total thermal effect.

2-25. Rainfall

a. *Amount.* When planning extended operations, the average amount of precipitation occurring in the proposed area must be considered. An area with 50 centimeters (20 inches) or less of rainfall in a year normally will not have adequate supplies of water for military purposes. Rainfall of 50 to 200 centimeters (20 to 80 inches) a year presents no serious problems in operations, other than those that occur in rainy seasons through localized flooding and poor soil trafficability. Annual

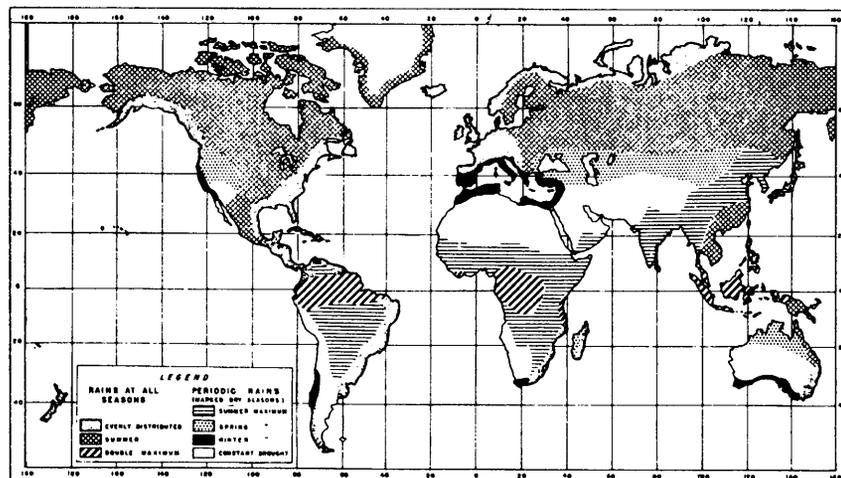


Figure 2-13. Seasonal distribution of rainfall.

rainfall in excess of 200 centimeters (80 inches) generally hinders normal operations during the seasons that the greater amount of this rainfall occurs. The seasonal and daily cycle of precipitation (fig. 2-13) affects the scheduling of military activities. Seasonal distribution may be uniform throughout the year or it may occur in distinct wet and dry periods. In the monsoon areas of southeast Asia, for example, the rains come suddenly and with such violent downpours that some military operations must cease almost entirely, and plans must be revised. During rainy seasons in most tropical or semitropical areas, there usually are predictable periods of maximum rainfall occurring at certain times of the day which must be considered when planning construction work or tactical activities. The maximum rate of precipitation expressed in inches per day or hour may also be critical in designing culverts or other facilities for draining excess water.

b. Trafficability. Precipitation affects soil trafficability and hence cross-country movement. In areas of seasonal precipitation, the cross-country movement characteristics of an area may change drastically each season. Seasonal floods may swell or flood streams, making fording and bridging operations difficult or impossible. Snow and sleet hamper movement on roads in winter, often making them impassable in mountainous areas. The snow that accumulates in mountains during the winter months frequently affords a water supply throughout the year to lower, drier regions.

c. Visibility. Precipitation usually has an adverse effect on visibility and observation, although rain sometimes may wash excessive impurities from the air. Rain and snow aid concealment, and may facilitate surprise attacks. Operation of lis-

tening and sound-ranging posts is often limited by precipitation.

d. Neutralization. Rain and snow normally reduce the effectiveness of toxic chemical and biological agents. Heavy or lasting rain washes away these agents and may neutralize them. Snow may cover liquid toxic agents so that little vapor or contamination hazard appears until the snow melts. Heavy precipitation will tend to dilute the concentration of biological agent aerosols.

e. Communication. Precipitation may have an adverse effect upon communications, reducing the range of field wire circuits and producing radar "clutter" which tends to obscure target echoes.

f. Nuclear. Precipitation has a significant influence upon the blast effect of a nuclear weapon, but no effect upon initial nuclear radiation. It affects the range of thermal intensity to the degree that it reduces visibility. Buildings, equipment, debris, vegetation, and other normally flammable elements will require higher thermal intensities for ignition, and the spread of primary or secondary fires will be limited. Residual radiation may be affected. If the radioactive particles formed in an air-burst are ingested into rain-bearing clouds, the nuclear cloud (if it does not rise above the rain-bearing clouds) will become so mixed with the rain cloud that it will become an integral part of the rain-producing system. The radioactive material will be deposited with the rain over a large area. Heavy rain over an area would wash away some of the material from a contamination burst, either air, surface or subsurface, possibly concentrating it in other areas where there are water-courses, low ground, drainage system, or flat undrained areas.

Section III. WEATHER EFFECTS ON TACTICAL OPERATIONS

2-26. Weather Information in Military Geographic Studies

Weather, climate, and terrain are so interrelated that they must be considered together when contemplating ground and air operations. Weather elements are capable of drastically altering terrain features and trafficability. Conversely, terrain features exert some influence on local weather. This relationship of weather and terrain must be carefully correlated in terrain studies in order to produce accurate terrain intelligence.

a. Terrain features are affected by such elements as visibility, temperature, humidity, precip-

itation, winds, clouds, and electrical phenomena. The specific factors described vary with the geographic area, time, and season. Terrain features also influence the climate of an area. A description of the climate of a large area can consider these terrain influences only generally, whereas a description of a small area, such as a single valley, can be quite specific.

b. The scheduled time of initiation of an operation determines the type of intelligence required in the study. Climatic data is used if the starting date is more than a week or two in the future (48-hour forecasts in conjunction with 3- to 5-day

extended period forecasts are used by G2 in the terrain estimate for periods of 5 days or less).

c. The type of operation planned determines the pertinent elements of climatological information to be furnished. Planning of airborne, amphibious, and other special operations requires knowledge of weather elements of somewhat different emphasis than that normal to ground operation.

d. Exact descriptions of humidity are not usually required, but the effects of humidity are described when significant, particularly its effect on the efficiency of personnel or on the storage and maintenance of supplies and equipment.

e. Data based on climatic records reflect the approximate number of days during a period when there will be a certain amount of cloud cover, and also the time of day or night cloud coverage can be expected. Related conditions such as storms and fog are also described when applicable.

f. Thunderstorms can have an important effect on proposed operations. The type, period of occurrence, severity, duration, and effect on planned operations are described when pertinent.

g. Winds at or near the surface of the earth have been classified and their characteristics are known and predictable. Some surface winds are deep. Some, such as the land breeze, are shallow, and may extend only a few hundred feet above the surface. Winds aloft may blow in a direction opposite that of surface winds, and the velocity may vary with different elevations. Sea, swell and surf are influenced by wind velocity, duration, and distance spanned.

h. Temperature forecasts based solely on climatic studies describe the range of temperatures in two ways. The first method describes the mean temperature, mean maximum, mean minimum, absolute maximum, and absolute minimum temperatures expected for the period. The mean temperature alone has little significance since it gives no indication of the range of the temperature variation. The second method tabulates the number of days during the period when the temperature can be expected to exceed or fall below the stated temperatures. The effect of temperature on soil trafficability and freezing or thawing of water bodies is particularly significant.

i. Precipitation is expressed in the type and amount which may be encountered during a particular period, the number of days within that

period on which certain amounts of precipitation can be expected, and the variability of precipitation from year to year. The effect of precipitation on terrain, particularly water bodies and the trafficability of soils, should be described.

j. Light data is necessary for determining courses of action. The beginning of morning nautical twilight (BMNT) and the end of evening nautical twilight (EENT) are the beginning and end, respectively, of enough light for limited visibility. The beginning of morning civil twilight (BMCT) and the end of evening civil twilight (EECT) are the beginning and the end, respectively, of adequate light for large scale operation. At BMNT, enough light, under ideal conditions, is available for infantry to effect close coordination among individuals while approaching an enemy position unobserved. EENT is the last time for enough light for such coordination. As a general rule, visibility at BMNT is about 366 meters (400 yards). At about halfway between BMNT and BMCT (or EECT and EENT), there is enough light for ground adjustment of close-in artillery fires and airstrikes. Visibility also is affected by factors such as weather; the position of the observer with respect to the object and sources of light; terrain configuration; and color and reflection quality of clothing, vehicles, and other material. Moon phases, atmospheric conditions, and star brilliance can influence both friendly and enemy courses of action such as attacking, patrolling, and changes in tactical disposition at night.

2-27. Importance of Restricted Commanders

a. Proper assessment of the weather presupposes a knowledge of how weather elements may affect operations. This knowledge not only increases the probability of success, but also helps in determining enemy courses of action.

b. The major weather elements affecting tactical operations are restricted visibility, winds, precipitation, cloud cover, temperature, and humidity. Only when the effects of these elements are understood and properly evaluated can the weather factor be judiciously weighed with other essential elements of information.

2-28. Effect of Restricted Visibility

Poor visibility normally aids both the ground offense and withdrawal. It restricts visual reconnaissance and surveillance. In the offense, it tends to conceal concentrations and maneuver of friendly forces from the enemy, thus enhancing

the possibility of achieving surprise. Poor visibility generally hinders the defense, because defensive cohesion and control are difficult. Target acquisition is less accurate with a consequent decrease in the ability to place aimed fire on the advancing force, although this disadvantage may be partially offset by extensive use of illuminants, radar, sound detection, and infrared devices. Poor visibility enhances patrol activities and guerrilla operations by masking and screening movement.

2-29. Effect of Wind

Wind velocity, both on the surface and aloft, almost invariably favors the upwind force in any type of operation. Chemical and biological weapons will saturate the low-level downwind atmosphere with contaminating aerosols. A defensive position is tactically stronger if it is upwind of the attacking force, because the wind itself permits the defenders a choice of either nuclear or nonnuclear weapons, a choice denied to the downwind force. Wind of sufficient speed reduces the tactical capability of the downwind force by blowing dust, smoke, sand, rain, or snow on personnel and equipment. The upwind force, with the wind at its back, has better forward visibility and can advance easier and faster.

2-30. Effect of Precipitation

The primary significance of precipitation is its effect on the state of the ground and trafficability, on the efficiency of personnel, and on visibility. The effects of restricted visibility caused by precipitation are just as important as those caused by airborne particles such as dust or smoke. Rain, snow, and fog mask patrol and guerrilla activities by decreasing the enemy's surveillance and detection capability. Precipitation (producing mud and causing floods) severely reduces trafficability; it alters the surface condition of different soils to varying extents. A heavy rain may make some types of unsurfaced roads impassable, but have little effect on others. Heavy or prolonged precipitation usually aids the protected defense by limiting the mobility of an offensive force. It can also drastically reduce the efficiency and effectiveness of exposed personnel. On the other hand, precipitation may aid the offensive operations by degrading the surveillance capabilities of radar, sound detection, and infrared devices. The force capable of operating in mud, or in deep snow, with the least loss of mobility, will naturally be at better advantage than a force of lesser capabilities, and

may exploit these conditions accordingly, in defensive, offensive, or withdrawal operations.

2-31. Effect of Clouds

The type and amount of cloud cover, as well as the height of cloud bases and tops, influence ground tactics because they affect the entire range of both friendly and enemy aviation. Extensive cloud cover reduces the effectiveness of air support, and provides a tactical advantage to the force lacking control of the battlefield airspace. This advantage is enhanced as cloud cover increases, as cloud bases lower, and with the increase of conditions frequently associated with clouds, such as icing, turbulence, and poor visibility aloft. Clouds further affect ground operation because they may limit illumination and visibility. They also determine the types, intensities, and amounts of precipitation. As solar radiation interceptors, clouds tend to reduce extremes of surface temperature. Clouds in relatively unstable air are associated with strong currents, turbulence, and poor visibility aloft. Clouds further affect ground operation because they may limit illumination and visibility. They also determine the types, intensities, and amounts of precipitation. As solar radiation interceptors, clouds tend to reduce extremes of surface temperature.

2-32. Effect of Temperature and Humidity

Temperature and humidity affect the density of the air. When temperature and humidity are high, the air will be less dense than when they are low. Thus, the efficiency of all aircraft is reduced in areas of high temperature and high humidity. Although temperature and humidity do not directly favor or disfavor a particular tactical operation, extremes will reduce personnel capabilities and may necessitate a reduction of aircraft payloads. Tactics devised for one climatic zone may require considerable revision if used in another. High temperature and humidity conditions found in the tropics are conducive to growth of dense foliage and jungles, which drastically affect operations. In temperate climates, cold weather periods create an almost constant need for heated shelter, cause difficulty in constructing fortifications, increase the amount of and dependence upon logistical support, and necessitate special clothing, equipment, and combat skills.

2-33. Effects of Weather on Specific Activities

Some of the effects of weather on certain selected

activities have been briefly condensed into a tabular format and are shown in table 2-2. This table is not intended to serve as a complete check list of

weather effects, but to point out some of the more significant factors which must be considered in planning an operation.

Table 2-2. Effects of Weather on Specific Activities

AERIAL OBSERVATION AND PHOTO RECONNAISSANCE (TM 1-300)

Restricted visibility. Hinders or prevents observation. May require use of indirect sensors and electronic devices.
Winds aloft. Affect routes and range of aircraft or drone.
Precipitation. Significantly affects visibility and photographic resolutions.
Clouds. May hinder or prevent observation. Density and height affect quality of photographs.

AVIATION AND AIRBORNE OPERATIONS (TM 1-300)

Restricted visibility. Seriously limits close air support and airborne operations. Army aviation operations may be limited. Creates hazard for high performance aircraft during takeoff and landing.
Wind. Parachute operations in winds over 15 mph can scatter personnel, supplies, and equipment, and hinder assembly and reorganization. High velocity increases injuries and damage to supplies and equipment, and may seriously limit Army aviation. Helicopter operations are adversely affected by gustiness. Winds aloft modify range and payload of all aircraft.
Precipitation. Effect on trafficability can limit or prohibit use of landing strips. Heavy rain or snowfall can reduce surface visibility.
Cloud cover. Aids helicopter and light aircraft in avoiding fighter aircraft and visually directed ground fire. Low clouds can prevent penetration of target areas by close air support aircraft.
Turbulence/icing aloft. Causes discomfort to personnel, strain or damage to airframes, difficulty in control, and decreases lift.
Temperature/humidity/pressure. Affects lift and load capabilities of aircraft. Of particular significance to helicopters.

ALTIMETRY AND SURVEY

Restricted visibility. May require use of magnetic needle, rather than visual means, for determining survey-starting direction. May require shorter distances between stations, necessitating more angle-turning stations.
Wind. Surface winds over 10 mph affect accuracy of angle observations, particularly those measured from observation towers.
Precipitation. Affects survey crew efficiency. Reduces visibility. Significant pressure changes may cause altimetry errors.
Temperature. Extreme conditions can reduce crew efficiency. Instrument maintenance is difficult, and may lead to inaccuracy.

AMPHIBIOUS OPERATIONS

Restricted visibility. Aids in protecting convoy from enemy observation. Offers some protection from air attack at landing area, and can be exploited during small-scale landings. Decreases effectiveness of close air and naval gunfire support and accuracy of artillery air spotting. Movement between ship and shore is difficult.
Wind. Ships are forced to slow down when moving through high waves. Convoys may be scattered. Deck gear and cargo may be lost or damaged. Ship-to-shore movement may be limited or made impossible. Troops may suffer from seasickness. When prevailing winds are on shore, surf may be too high to permit safe landing, may disrupt landing formations, and cause casualties. Retracting a landing craft from the beach in heavy surf is difficult and dangerous. Strong wind on tide at landing area may greatly alter width of beach. Strong offshore wind with ebbing tide may blow water to an extreme distance from the beach proper, requiring personnel and material to pass over wide exposed beach. Powerful onshore wind can increase the advance of high tide, flooding beach installations and activities.
Precipitation. Can restrict visibility and conceal approach to objective area. May affect coastal trafficability and delay onshore movement.
Cloud cover. May affect concealment of convoys, air support and defense, and aerial ship-to-shore discharge operations.
Temperature/humidity. No significant effect, other than on personnel comfort, and on possibility of ice formation at low temperatures.

Table 2-2. Effects of Weather on Specific Activities (Continued)

ARMOR AND ARMORED CAVALRY

Restricted visibility. Affects observation, control, and coordinated maneuver. May assist movement by reducing enemy observation and threat of air attack. Reduces effectiveness of gun firing.

Wind. Strong surface winds may produce dust or sand storms, decreasing visibility and impairing operation of engines and vehicles.

Precipitation. Lowers visibility. Mud or ice may seriously limit or prohibit mobile operations.

Cloud cover. Influences operation of both supporting and enemy aircraft.

Temperature. Affects viscosity of lubricants. Low temperatures affect engine-starting operations and necessitate longer warmup time. Sudden thaws may affect vehicle mobility.

ARTILLERY (FM 6-15)

Restricted visibility. Restricts visual ranging and target acquisition.

Wind. Tends to deflect projectile from normal path, particularly when fired at long range. Effect on projectile increases with increase in wind velocity and size of projectile. Reduces efficiency of sound-ranging operations by distorting sound propagation. Strong winds increase effectiveness of incendiary munitions. Turbulent winds in mountainous areas reduce effectiveness of meteorological messages and, therefore, the accuracy of fire.

Precipitation. Decreases effectiveness of incendiary munitions. Can limit mobility of prime mover or self-propelled artillery.

Cloud cover. Influences operation of manned and unmanned target acquisition aircraft.

Temperature/humidity. Frozen ground decreases capability of projectile to penetrate the earth but increases casualty effect of point-detonating shells. Powder temperature is a factor in computing muzzle velocity. Amount of water vapor in the air affects projectile trajectory. Humidity also affects sound-ranging. Temperature and humidity can reduce crew efficiency and increase instrument maintenance requirements.

BIOLOGICAL OPERATIONS (FM 3-8 and FM 3-10)

Restricted visibility. Attenuates ultraviolet radiation, decreasing decay rate of some biological agents. Makes observation of biological clouds more difficult; helps to achieve surprise in attack.

Wind. Biological agents are effective at various speeds. Downwind area coverage increases with increased wind speed.

Precipitation. Heavy rain or snow normally reduces effectiveness of agents.

Cloud cover. Reduces ultraviolet radiation, decreasing decay rate of some agents.

Temperature/humidity. Moderately cool temperatures are desirable for employment of wet biological agents because they favor the survival of micro-organisms in aerosols. Aerosols have high decay rate during periods of low relative humidity; increased moisture reduces decay rate.

COMMAND POST AND BIVOUAC SITE SELECTION

Restricted visibility. Ground fog and excessive humidity are likely to form in valley air (cold) drainage areas. Greater security measures may be required to reduce risk of surprise attack in such areas.

Wind. Sites with protection from strong surface winds should be considered. Downwind sides of hills are preferred.

Precipitation. Runoff drains into concave land surfaces; convex surfaces should be selected. Care should be used in selecting entrance and exit routes which will be passable after heavy precipitation.

Cloud cover. No bearing on choice of location, but may afford concealment and enhance camouflage measures.

Temperature/humidity. Basins or depressions normally have lowest temperature of the terrain. Pooling of colder air in valleys and depressions increases their vulnerability to chemical and biological attack. In the northern hemisphere, preference is given to southwesterly slopes of hills and mountains where temperature is usually higher than on other slopes.

CHEMICAL OPERATIONS (FM 3-8 and FM 3-10)

Restricted visibility. Makes observation of chemical clouds more difficult and helps in achieving surprise in a chemical attack.

Wind. High winds increase evaporation rate of liquid chemical agents and dissipate chemical clouds more rapidly than low winds. Effects of wind speed on persistent-effect agents are variable. Large area attacks with nonpersistent-effect agents are most effective in winds not exceeding 15 knots; small-area attacks with rockets or shell are most effective in winds not exceeding 5 knots. Wind direction must be considered for target coverage and for determining hazard to friendly troops.

Table 2-2. Effects of Weather on Specific Activities (Continued)

- Precipitation.* Normally reduces effectiveness of chemical agent. Heavy rains wash liquid contamination into low areas and stream beds, presenting a lingering hazard.
- Cloud cover.* Heavy cloud cover reduces surface heating and the resultant dispersion of agents is favorable for day-time chemical-agent employment.
- Temperature/humidity.* Blister Agent (HD) is highly effective in hot, humid weather because the body is more sensitive to both vapor and liquid under such conditions. High temperature increases evaporation rate of agents and decreases duration of effectiveness. The reverse occurs at low temperatures.
- Stability (temp gradient).* Stability of the air layer 0.5 to 2.0 meters above the surface has direct bearing on extent and effectiveness of chemical clouds. Under stable conditions, clouds persist with time, remain concentrated, and stay close to ground as they travel downwind.

COMMUNICATIONS AND RADAR

- Restricted visibility.* Limits all forms of visual communication.
- Wind.* Can damage or prevent use of radio and radar antennas.
- Precipitation.* May reduce talking range of field-wire circuits and produce radar clutter which can obscure target echoes. Wire communications are affected by heavy accumulation of snow and ice on wires and antennas.
- Cloud cover.* Little effect on communications, but electrical storms interfere with low-frequency radio reception. Drones cannot be radar-tracked in clouds of high moisture content.
- Temperature/humidity.* Large temperature variations necessitate special stringing of communication wire to allow for expansion and contraction. High humidity and temperature have adverse effect on wire insulation. Irregular distribution of temperature, pressure, and water vapor aloft refracts radar and very-high-frequency and ultra-high frequency radio waves. Refraction varies greatly with atmospheric changes.

EQUIPMENT AND SUPPLIES

- Restricted visibility.* Delays supply distribution, but increases passive security.
- Wind.* Can damage or destroy unprotected equipment. Blown sand and dust damage painted surfaces, engines, and weapons.
- Precipitation.* Can cause rotting or mildewing of rubber, leather, cloth, or rope. Heavy snow can cause roofs to collapse.
- Cloud cover.* Blocks out direct sunlight, reducing dehydration of exposed food, but accelerates growth of fungus and bacteria.
- Temperature/humidity.* Have direct influence on consumption rate of most supplies, notably fuel oil and food. High temperature and humidity cause rapid deterioration of some types of electrical insulating material, and corrosion of metal such as small arms and artillery pieces. Wood, paper, sugar, glue, and leather are sensitive to extremes of humidity. Food, medicine, film and photographic chemicals require special handling during extremes of temperatures or humidity. Evaporation losses of gasoline and other volatile stocks are high in fluctuating temperatures.

FLAME WEAPONS

- Restricted visibility.* Flame weapons have particularly demoralizing effects when used against enemy during poor visibility.
- Wind.* Affects range and accuracy. Crosswind or headwind breaks up fuel and decreases range; following wind increases range. Best results are obtained when it is calm or when flame throwers are positioned to take advantage of following wind. Firing into strong headwinds may cause fuel from portable flame throwers to be blown back on operator.
- Precipitation.* Rain has little effect on flame fuel in flight. Although fuel will float and burn on water, incendiary effect is diminished. Snow has little effect on fuel in flight, but tends to smother flame, reducing incendiary effect.
- Cloud cover.* No effect.
- Temperature/humidity.* High temperatures increase incendiary effect; fuels may have to be thickened to avoid excessive burning. Low temperatures decrease incendiary effect; more fuel may be required.

INFRARED

- Restricted visibility.* Infrared (IR) radiation is severely attenuated by heavy fog, with smaller haze particles affecting visible wavelengths. In light fogs, the near IR spectral region is superior to visible light; however as water droplets increase in size, and visibility decreases to about 1,000 yards near IR detection devices are virtually useless. Middle-to-far devices have from two-to-four times the detection range of visible light under these conditions.
- Wind.* High windspeed can reduce hot target vulnerability to passive IR detection because of increased cooling rate of target.
- Precipitation.* In rain, IR radiation has little advantage over visible light. Larger raindrops also affect certain radar wavelengths.

Table 2-2. Effects of Weather on Specific Activities (Continued)

Cloud cover. Radiation is attenuated in a cloud due to scattering by water droplets and selective absorption by liquid water. Sky background affects capability of IR homing-missile system to acquire and track target.

Temperature/humidity. During clear, dry conditions, IR transmittance is optimum. Only selective absorption, by water vapor and carbon dioxide, is important at low altitudes.

Note. Weather effects on an IR system depend upon characteristics of the particular system, IR target characteristics, and on a fairly detailed description of the transmission path.

ILLUMINANTS

Restricted visibility. Greatly reduces illuminants' effectiveness. Has more detrimental effect on searchlight than on flare, because searchlight beam is relatively close to the ground, and its intensity is affected by atmospheric conditions over the whole range, whereas flare is affected only by conditions in target area.

Winds. Flares may be blown rapidly away from target area, reducing time of effectiveness. Wind blowing toward friendly troops may illuminate positions or start fires in friendly territory. No effect on searchlight illumination.

Precipitation. Reduces visibility, although illumination is highly effective over snow-covered terrain because of surface reflection.

Cloud cover. Reflected illumination, almost equal to that of a full moon, may be obtained by directing searchlight beam against lowlying (500-3000 feet) clouds. Area beneath reflection point receives higher intensity illumination than it would from diffusion alone.

Temperature/humidity. No effect.

MINES

Restricted visibility. Affects rate of mine emplacement but, at same time, helps conceal mine-laying personnel.

Winds. In deserts or dry areas, wind may blow away dust or sand, exposing mines, or may deposit large quantities on the mines, preventing detonation.

Precipitation. Concealment of mines is difficult after a snowfall, and mines are revealed when snow melts. Rains may make mine-laying easier by softening the ground. Mines continually covered by water are not considered as reliable as those laid in well-drained areas.

Cloud cover. Low ceilings inhibit or prevent aerial observations or attacks, enhancing mine laying opportunities.

Temperature/humidity. Frozen ground greatly hinders mine emplacement.

MORTARS

Restricted visibility. Hinders visual target acquisition.

Wind. Can modify the normal trajectory of a projectile.

Precipitation. Affects visibility.

Temperature/humidity. Variation in air temperature causes variation in range. As temperature rises, velocity and range of projectile increase with no increase in powder charge.

Air resistance and density. At the same muzzle velocity, a heavier projectile travels farther because it is affected less by air resistance than a lighter projectile of the same size and shape. An increase in air density causes greater resistance to the projectile and decreases its range.

NUCLEAR OPERATIONS (TM 3-210)

Restricted visibility. Maximum thermal effect is realized on clear day. Smoke, haze, mist, or fog have pronounced influence on thermal radiation. Degree of visibility determines the distance to which personnel are subjected to temporary burst dazzle. Can also make poststrike analysis inaccurate or impossible.

Wind. Direction and speed have no significant influence on blast, thermal radiation, or initial nuclear radiation, but velocity affects movement and location of fallout from surface or subsurface burst by depositing contaminated dirt and debris downwind. Extent of contaminated area depends on velocity of winds between the ground and the nuclear cloud top.

Precipitation. Has significant effect on blast and also affects range of thermal intensity. Buildings, vegetation, and other flammable material require higher thermal intensities for ignition, and spread of fire is limited. Troops take shelter, giving themselves some degree of protection. Wet uniforms require much higher thermal intensities for ignition. Heavy rain can flush radioactive material from buildings, equipment, and vegetation, reducing intensities, and can deposit high concentrations in drainage systems, on low ground, and on flat, undrained areas.

Cloud cover. May affect intensity of thermal radiation reaching target. If burst is above or within cloud layer, a large portion of thermal radiation may be attenuated. In a burst below cloud layer, some of the thermal energy is reflected downward, intensifying the effect on target.

Temperature/humidity. Extremely low temperatures cause personnel to seek shelter, reducing their vulnerability to shock wave. Low temperatures also adversely affect stability and strength of certain materials, increasing a shel-

Table 2-2. Effects of Weather on Specific Activities (Continued)

ter's vulnerability to shock wave. Ambient temperature has no significant effect on thermal radiation; however, by influencing clothing requirements, it can increase or decrease vulnerability of troops. Prolonged high temperatures in dry weather make shelters more vulnerable to thermal radiation by lowering the kindling temperature of structural materials. Very high or low humidity has no direct effect upon thermal radiation, but can affect target vulnerability, to a degree, by the moisture content of clothing, structures, equipment, and vegetation. Temperature may significantly affect nuclear radiation, because relative air density affects initial nuclear radiation. Since climatic conditions usually determine the type of shelter occupied by personnel, temperatures indirectly affect the vulnerability of troops to nuclear radiation.

PERSONNEL

Restricted visibility. Increases probability of personnel becoming lost or having accidents. Detection and identification are more difficult. Field functions require more time.

Wind. Adverse effects usually increase with rising windspeed. The higher the windspeed, the more intense the resulting wind chill. Winds which produce blizzards or dust/sand-storms restrict visibility.

Snow cover. Rate of march for foot troops is decreased depending on nature and depth of snow. Normally, 12 inches or more of snow will prevent foot marches except with skis or snowshoes.

Precipitation. Affects morale and efficiency, especially in freezing rain or sleet. Prolonged rains may affect water supplies, causing conditions conducive to typhoid, dysentery, and other intestinal diseases, and creating breeding grounds for mosquitoes. Drought conditions create water supply problems and cause dust which induces throat irritations.

Cloud cover. Can help prevent sunstroke, but also inhibits drying of terrain after a rain. Prolonged exposure to sunshine or glare can cause conjunctivitis, sunburn, snowburn, or snow blindness, and create requirements for protective glasses, protective clothing, and medicines.

Temperature/humidity. Affects efficiency, physical well-being, and morale of personnel. Extreme conditions cause heat exhaustion and frostbite, and can lower the individual's level of resistance to many diseases. Water requirements of the human body vary with temperature and amount of exercise. In the jungle, where humidity is high, perspiration does not completely evaporate, but runs off the skin, increasing water losses. In desert regions, perspiration evaporates so rapidly that dehydration may result. At high desert temperatures, a man working hard may require as much as 3 gallons of drinking water per day. Low temperatures may produce cold weather injuries, and require use of clothing which reduces physical efficiency.

PSYCHOLOGICAL OPERATIONS

Restricted visibility. Major restriction is in delivery of leaflets by aircraft when pilot cannot see target.

Wind. Affects aerial and artillery delivery of leaflets and aerial or ground-based loudspeaker messages.

Precipitation. Causes deterioration of leaflets and posters. May force target audience indoors where it is not susceptible to leaflet drops or loudspeaker messages.

Cloud cover. May affect aerial loudspeaker and leaflet delivery by restricting visibility and access to the target. No effect on artillery delivery of leaflets.

Temperature/humidity. No effect.

RIFLE SIGHTING AND FIRING

Restricted visibility. Reduces target acquisition capability and accuracy.

Wind. Affects the flight of bullet.

Precipitation. May restrict visibility.

Cloud cover. Alternate patches of sunshine and shadow affect aiming.

Temperature/humidity. Together with improper lubrication may cause malfunctions.

ROCKETS

Restricted visibility. Affects target acquisition capability.

Wind. Low level winds affect rocket during entire burning phase; effects are greatest as rocket leaves launcher, and diminish rapidly to motor burnout. During powered flight, the thrust of a free rocket causes it to follow a path toward the direction from which wind is blowing. The magnitude of this deviation depends on the velocity of wind striking the fin surfaces of rocket. After burnout, rocket will still align itself with the relative wind; however, since no thrust is being applied, it is affected by wind in the same manner as an artillery projectile. High winds endanger controlling radars and rockets on their launchers.

Precipitation. At high speeds, the rocket collides with heavy precipitation which pits the rocket, damaging the smooth, aerodynamic surface with degradation of range and accuracy.

Cloud cover. No effect.

Table 2-2. *Effects of Weather on Specific Activities (Continued)*

Temperature/humidity. At high temperatures, propellant burns faster, more efficiently, and delivers greater thrust over shorter period of time, increasing velocity and range of missile. Exposure to direct rays of sun or to chilling wind can result in an improperly conditioned rocket.

SENTRY OR SCOUT DOGS

Restricted visibility. Little effect on use of sentry dogs.

Wind. Carries human scent to or away from the dog. Human scents from foxholes are borne by the wind as they rise and evaporate, and are not as strong as those from men in the open. During calm periods a dog's sense of hearing may be of more value than its sense of smell.

Precipitation. Causes scents to remain close to their sources.

Cloud cover. No effect.

Temperature/humidity. Human scent dissipates more rapidly in high temperature and low humidity than in higher humidity. Heat from sun causes scent to evaporate rapidly.

SMOKE OPERATIONS

Restricted visibility. May make screening-smokes unnecessary.

Wind. Windspeed and direction are vital factors in estimating amount of equipment, munitions, and fog oil required for a smoke operation. Windspeeds from 4 to 10 knots are ideal for production of smoke screens. At other speeds, more equipment may be needed.

Precipitation. Restricted visibility reduces need for smoke. In heavy rains or falling snow, smoke is rarely necessary to provide concealment.

Cloud cover. When sky is covered with clouds, the atmosphere is moderately stable and conditions are generally favorable for producing smoke.

Temperature/humidity. Temperature has no significant effect on smoke screens generated by hexachloroethane mixture (HC) smoke pots. At temperatures above 80°F. smoke screens produced by mechanical generators are dissipated more rapidly than at lower temperatures. Humidity has only slight effect on screens produced by smoke generators. In high humidity, HC smoke pots generate more effective smoke screens and produce denser concentrations than in low humidity.

SOUND-RANGING

Wind. May cause errors in plotting of sound waves. Noise produced by high winds may either decrease or increase audibility.

Precipitation. Heavy precipitation decreases audibility and reduces effectiveness of listening posts.

Cloud cover. No effect.

Temperature/humidity. Sound-ranging computations are based on corrections applied to a standard atmosphere. Temperatures and humidity corrections must be incorporated into this standard atmosphere to arrive at deviation amounts.

TRAFFICABILITY AND TRANSPORTATION

Restricted visibility. Increases vehicular accident rate. Impairs driver's ability to judge distances and speeds and to clearly distinguish other vehicles, persons, and objects. Enhances operations by providing passive security.

Wind. Blowing snow, sand, and dust may reduce visibility, create sand dunes or snowdrifts, or litter roadways with fallen trees and debris, blocking or delaying traffic.

Precipitation. Long exposure to moisture affects subsoil of even the best pavement. Saturated subsoil under poor surfaces can restrict or stop all movement. Highway transportation is restricted or halted by heavy snowfalls or icy road surfaces; in all cases, speeds are reduced. Mud can make unsurfaced roads impassable, and impede or stop cross-country movement. Flooding can immobilize a force or completely disorganize and endanger it. Both fixed and floating bridges may become unusable or swept away in high water. Maintenance problems may reduce vehicle availability.

Cloud cover. Can slow down drying of roads and affect soil trafficability.

Temperature/humidity. Freezing temperatures may increase trafficability of some soils, or create ice sheet making movement difficult. Thawing may make previously frozen soils impassable or damage roads with poor foundations. Melting snow can cause floods or avalanches in mountain areas. Temperature rise can turn trafficable snow into mud and slush. Midwinter thaws followed by subzero temperatures may freeze deep ruts and create dangerous ice conditions. Extreme temperatures can affect maintenance requirements and vehicle availability.

CHAPTER 3

NATURAL TERRAIN

Section I. INTRODUCTION

3-1. Significance

Natural terrain influences strategy and tactics. Intelligence on natural terrain is needed by most military units in a theater of operations. Hydrographic and hydrological intelligence on streams, lakes, marshes, estuaries and other bodies of water is needed for planning the maneuver of troops, the adaptation to tactical positions, the use of water as supply and for transportation, and the possible effects and uses of flooding on military operations. Data on the trafficability of soils, the presence of bedrock, and the kind and distribution of vegetation is needed when considering concealment and cover, cross-country movement, field fortifications and the establishment of denial positions.

3-2. Terrain Grouping

Natural environments are composed of many factors that affect military operations. A military activity can be simultaneously affected by factors acting either individually or in concert; systems used to describe these factors may be complex. This chapter treats four natural terrain factors: surface configuration, surface materials, hydrology and vegetation.

a. Surface Configuration. This group is concerned with the configuration of the earth's surface. Such things as slopes, ravines, embank-

ments, ditches, plowed fields, boulder fields and ricefield dikes are typical surface configurations that profoundly influence various military activities. The group is governed only by physical shape, size, and arrangement; it is not concerned with whether the feature is manmade or of natural origin. This group is simply the geometrical configuration of a three-dimensional surface or its profile.

b. Surface Materials. This group is concerned with the composition and physical properties of the materials of the earth's surface. It considers the classification and engineering properties of soil and rock as they apply to military operations and military construction.

c. Hydrology. This group is concerned with the shape, size and distribution of water bodies of all kinds. Temporal variance is a matter of great concern, since these shapes, sizes and distributions vary with time. There are also dynamic considerations, such as current volume and velocity. Both surface and ground waters are included in this group.

d. Vegetation. This group considers the various characteristics of vegetation such as structure, screening characteristics, and construction properties. Vegetation includes all flora growing on the surface of the earth, on other flora, and in or on the water.

Section II. SURFACE CONFIGURATION

3-3. Definitions

a. Topography. Topography refers to the configuration of the earth's surface, including its relief, and the positions of streams, roads, cities, etc. It refers to the earth's natural and physical features collectively. A single feature such as a mountain or valley is termed a topographic feature. Topography can be described in terms of

elevation (hypsography); positional relationships (planimetry); types of topography (landforms); drainage relationships (hydrography); and man-made alterations to the earth's surface.

b. Landforms. Landforms are the physical expression of the land surface. The principal groups of landforms are plains (plateaus), hills, and mountains. Within each of these groups are sur-

face features of a smaller size, such as flat lowlands, and valleys. Each type results from the interaction of earth processes in a region with given conditions as to climate and to kind and structure of rock. A complete study of a landform includes determination of its size, shape, arrangement, surface configuration, and relationship to the surrounding area.

c. *Relief.* The elevations or irregularities of a land surface are represented on graphics by contours, hypometric tints, shading, spot elevations, hachures, etc. Local relief is the differences in elevation between the different points in a given area.

3-4. Landform Classification

a. Surface configuration refers to the shape of the earth's land surface. The position of the earth's surface features combined with their size and shape are used to categorize surface configuration. These areas of similar topographies are spoken of as landforms.

b. A landform is indicated by its topographic position relative to the surrounding general area, general relief, general shape, and the distribution of its physical features. In certain patterns or

regions the term "landform" describes the general topography or relief such as in the case of a lake bed, a plain, a dissected plateau, a peneplane, rolling terrain, or rugged terrain. In others, where a specific deposit is being studied, the term "landform" describes the shape of the particular deposit such as: barchane dune; dome-like kame; snake-like esker; flat undissected terrace; rolling dissected terrace; hummocky kettle-kame; mesa; and others of a special nature. Table 3-1 lists the classifications of landform types in unconsolidated (soils) and consolidated (rock) materials.

c. For terrain intelligence purposes, major landforms are arbitrarily delimited on the basis of local relief and are classified as follows:

Plains: Less than 150 meters (500 feet)	
Flat	Less than 15 meters
Undulating	15 to 50 meters
Gently rolling	50 to 100 meters
Rolling	100 to 150 meters
Hills: 150 to 600 meters (500 to 2000 feet)	
Low	Less than 300 meters
High	300 to 600 meters
Mountains: More than 600 meters (2000 feet)	
Low	600 to 1500 meters
High	More than 1500 meters

Table 3-1. Classification of Landform Types

1. Formed in unconsolidated materials (soils) deposited by:
 - Eolian processes (stratified or nonstratified)
 - Dune fields
 - Loess surfaces
 - Glacial processes (nonstratified or very crudely stratified)
 - Ground moraines
 - Ridge moraines
 - Kettle-kame moraines
 - Drumlin fields
 - Eskers and kames
 - Fluvial processes (crudely to well stratified)
 - Alluvial fans and aprons
 - Outwash surfaces
 - Floodplains
 - Deltaic surfaces
 - Terraces
 - Coastal alluvial plains
 - Lacustrine processes (well stratified)
 - Beds of perennial lakes
 - Beds of ephemeral lakes
 - Littoral processes (crudely to well stratified)
 - Tidal flats
 - Beach ridges
 - Volcanic processes (well stratified)
 - Pyroclastic cones
2. Formed in consolidated materials (rock) of the following types:
 - Sedimentary rocks (stratified)
 - Plains or plateaus (bed horizontal or nearly so)

Table 3-1. Classification of Landform Types—(Continued)

- Limestone
- Shale
- Sandstone
- Limestone-shale
- Sandstone-shale
- Sandstone-shale-limestone
- Hills or mountains (beds inclined)
 - Limestone
 - Dolomite
 - Shale
 - Sandstone-shale
 - Limestone-shale
- Igneous rocks (stratified)
 - Basalt
- Igneous rocks (nonstratified)
 - Granitic
- Metamorphic rocks (stratified)
 - Slate
- Metamorphic rocks (nonstratified)
 - Gneiss
 - Schist

d. Smaller surface irregularities or minor relief features are described by various terms and include:

- High ground ----- Mesas, buttes, ridges, hillocks (knolls, mounds, hummocks), and dunes.
- Depressions ----- Basins, canyons, gorges, ravines, gullies, and wadis (arroyos).
- Breaks in high ground _ Passes (gaps, saddles, cols).
- Special features ----- Alluvial fans, talus slopes, and boulder fields.

3-5. Plains

a. Plains are flat to rolling areas with comparatively little change in elevation between high and low places. The continuity of a plain may be interrupted by hills or valleys, but flatness is the predominate characteristic. Plains may be tilted so that one extreme may be considerably elevated compared to the other. Plains have been classified as to origin and composition; descriptions of the various types are discussed in TM 5-545. In terrain analysis, the information required about plains is the extent of the area covered; surface, including elevation; general slopes and nature of the surface such as flat, undulating, rolling, or rugged in its surface expression. In figure 3-5, the such as hills or mountains rising above the plain; and river valleys, gullies, sinks or natural levees

cut into the plain. Plateaus are considered as elevated plains above adjacent lowlands, and no distinction is made between the two in this manual.

b. Figures 3-1 through 3-3 illustrate a variety of types of plains as seen in stereo pairs. They also illustrate the utility of aerial photographs in terrain analysis. In figure 3-1 the topography of the area is almost flat. One very broad gully wanders aimlessly across the area. The mottling and broad elongated streaks are characteristic of the fine textured lacustrine patterns. This plain is undissected and typical of a well-drained soil. This area would provide excellent cross-country movement, but relatively little cover and concealment. In figure 3-2, the general absence of vegetation and the crusted layer effect bordering the gullies places this plain in a semiarid region. It is high above the regional base level of erosion. A considerable portion of the original plain surface remains. In figure 3-3, much of the original plain surface has been removed by erosion and only remnants of the former plain surface remain. The gully pattern dissecting the area is fine in its arrangement. Should dissection progress to such an extent that all of the plain surface remnants disappear, then the area would be classed as hills.

3-6. Mountains and Hills

a. Mountains are characterized by high elevations, steep slopes, and small summit areas with local relief greater than 600 meters (2,000 feet). Normally, the summit area is extremely irregular with sharp peaks and jagged divides, and the land mass rises conspicuously above the surrounding

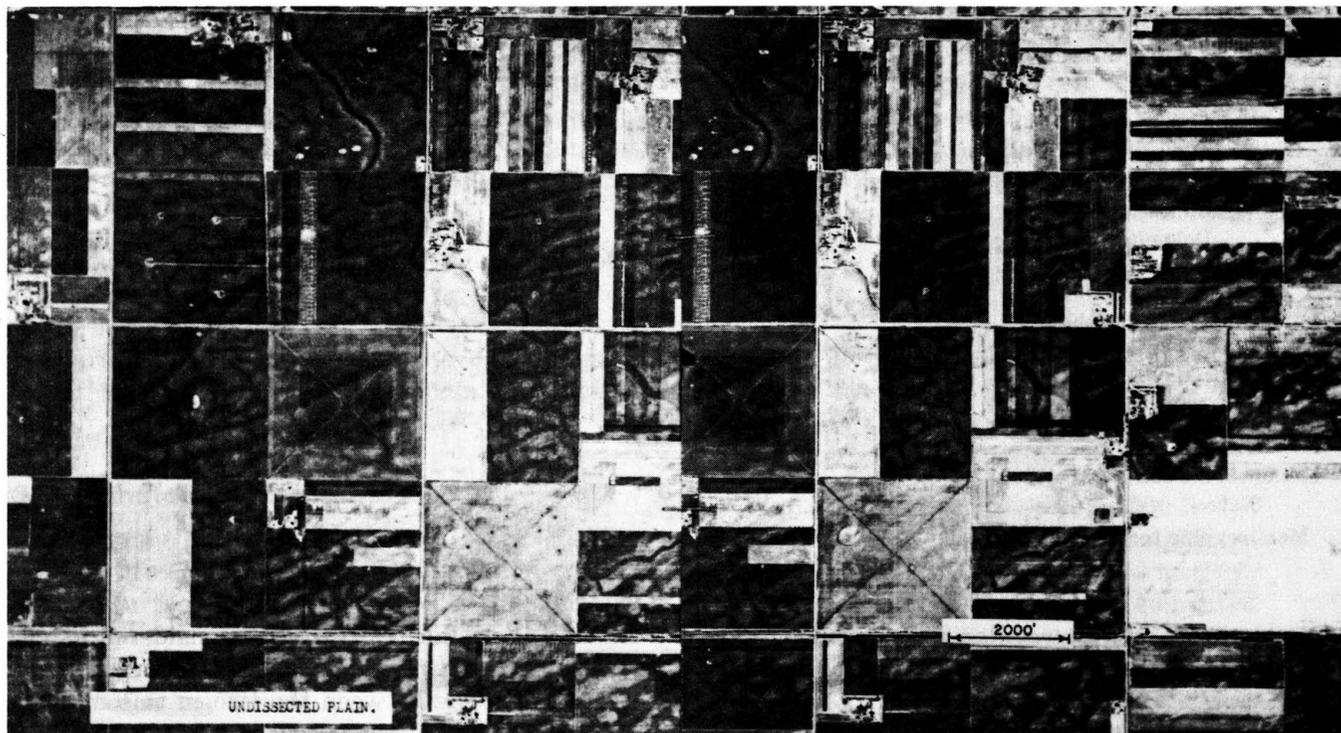


Figure 3-1. Undissected plain.



Figure 3-2. Elevated plain—moderately dissected.



Figure 3-3. Severely dissected plain.

area. Mountains are classified by extent and origin. Hills are characterized by moderately high local relief (150 to 600 meters) of limited extent with steep slopes, and small summit areas which rise above the surrounding area. Detailed descriptions on mountain and hill types are in TM 5-545.

b. The aerial photographs in figures 3-4 through 3-7 illustrate some common types of mountains and hills. The classifications are based on appearance rather than origin or composition as it is appearance which is most readily seen in the airphoto. In figure 3-4, the mountain is of extremely small summit area; it rises conspicuously above the surroundings and is extremely rugged in its surface expression. In figure 3-5, the mountain culminates in a single peak. It is of small summit area and rises conspicuously above the surroundings. In figure 3-6, local relief is not great. Rounded, or gently rolling topography prevails throughout the area. The summit area of such hills is rather broad with respect to their height. In figure 3-7, the area contains a series of hills which are elongated—axes in both directions are of different lengths. Such hills can either be gently rolling or sharply rolling.

3-7. Sources of Information

a. Government agencies produce the greatest amount of information on terrain features. Maps, particularly topographic and geologic maps, aerial charts and facility maps are basic sources of information. Publications containing topographic information include those of geographic societies and associations, engineering and scientific firms and societies, and government agencies. Much information can be obtained from atlases, aerial photography, tourist guides, and brochures.

b. Libraries, bookstores, universities, geographical societies, and mapping concerns are excellent sources. Information may also be derived from interviews with competent individuals, such as surveyors, foresters, engineers, mountaineers, explorers, and hunters. Personal reconnaissance may be used to fill specific information gaps.

c. Photographic coverage of surface configuration requires a great degree of selectivity to reduce the number of photographs to a practical level. The principal elements of concern are differences in elevation between tops and bottoms of adjacent topographic features, steepness of slopes,

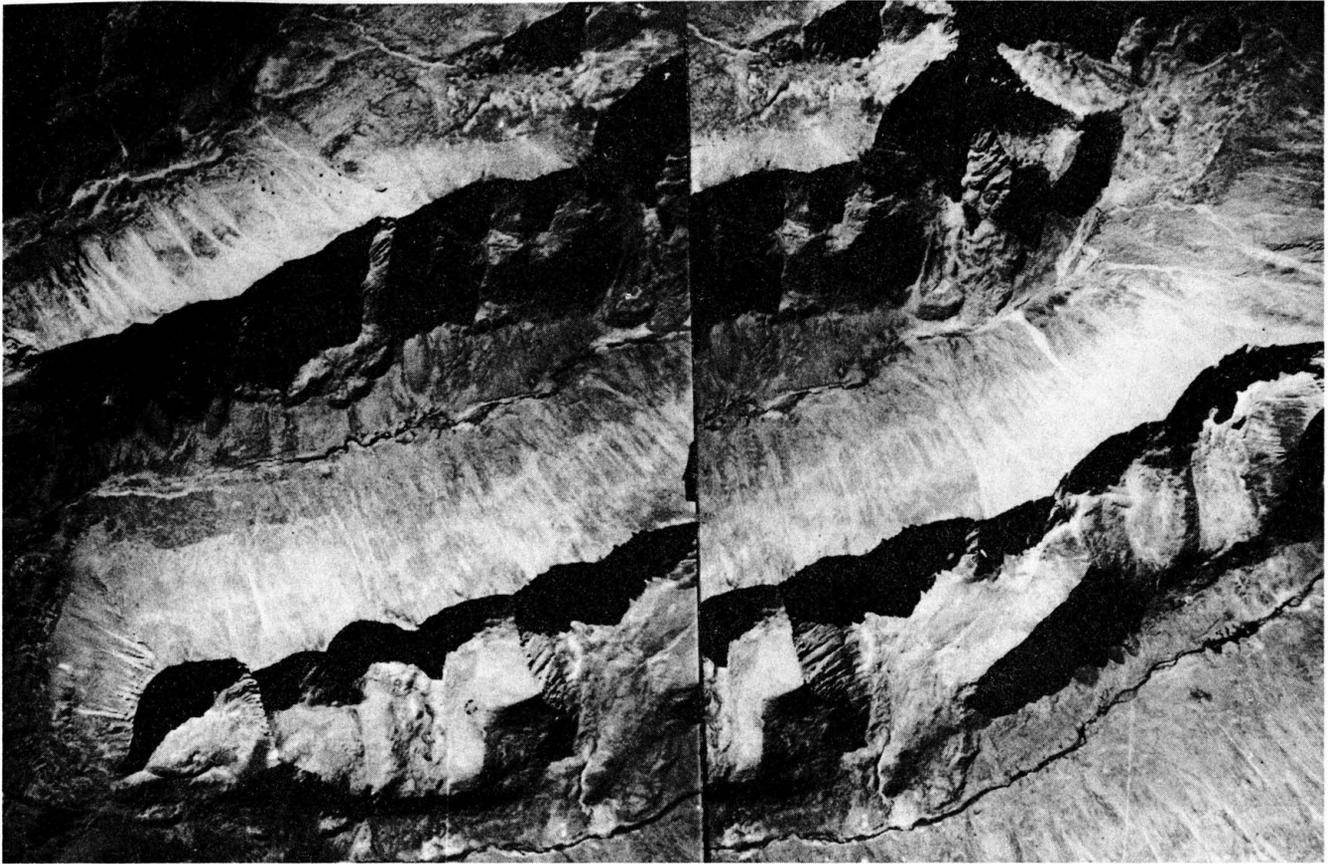


Figure 3-4. Serrated mountain.

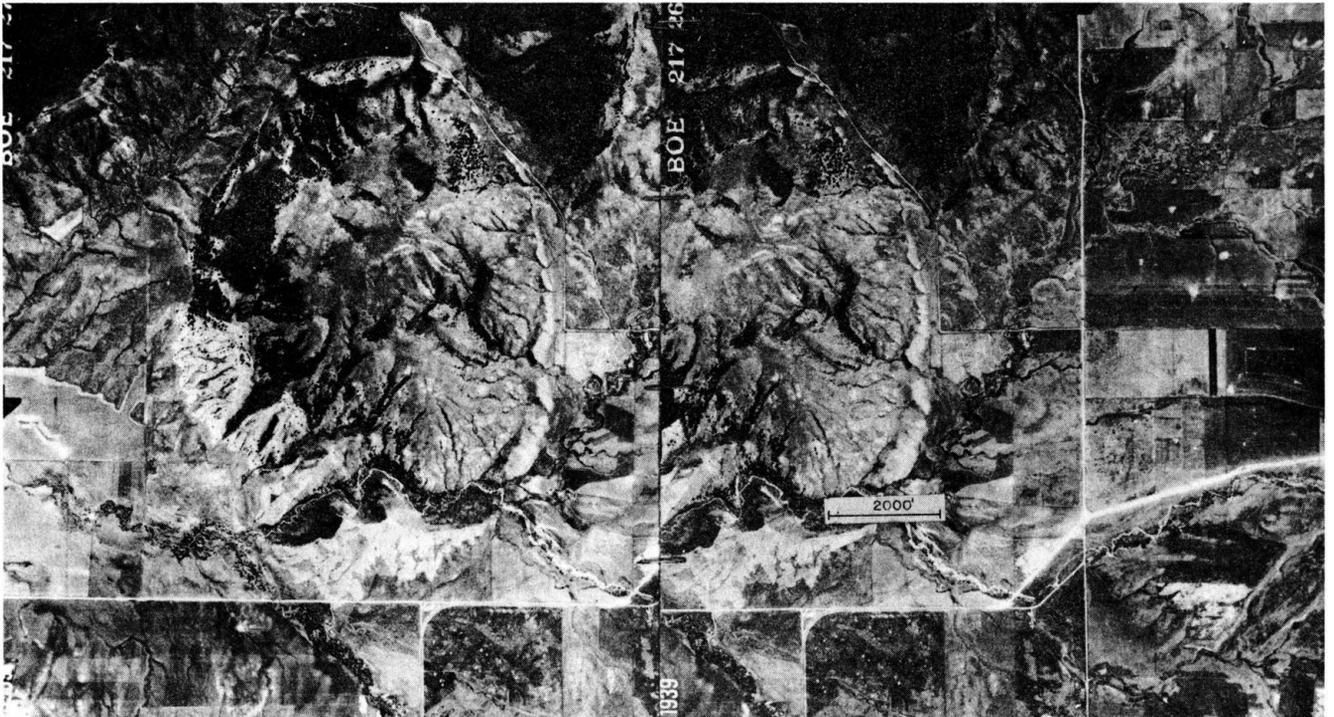


Figure 3-5. Single-peaked mountain.

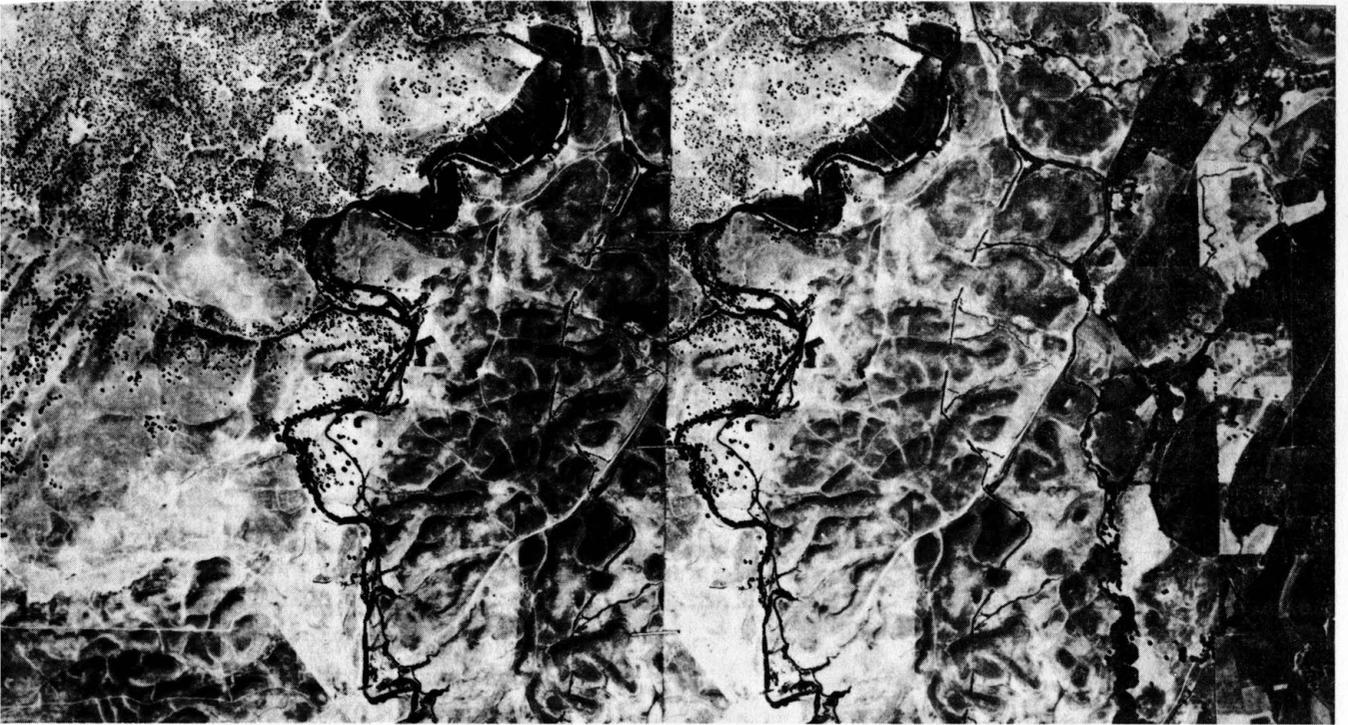


Figure 3-6. Gently rounded, rolling hills.



Figure 3-7. Elongated hills.

and shape, size, alinement, and surface characteristics of major features. Appropriate captions are extremely helpful in providing data that will permit the fullest exploitation of the photo. Of particular value are captions regarding locations, direction of view, distance and elevations, keying to other photography, and descriptive or explanatory matter not directly evident to an analyst.

3-8. Collection Checklist—Surface Configuration

1. *Identification.* Local name, geological name, and number.
2. *Location.*
 - a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b. Political unit, area, UTM and geographic coordinates of the geographic center.
3. *Dimensions.* Length, width, and profile.
4. *Type.*
 - a. Plains.
 - b. Mountains and hills.
5. *Classification.*
 - a. Plains.
 - b. Mountain and hills.
6. *Elevation.*
7. *Local relief (plains).*
 - a. Difference in elevation between highest and lowest points.
 - b. Major interruptions (hills, mountains, canyon, valleys, etc).
 - c. Minor interruptions (gullies, sinks, natural levees, etc).
8. *Surface water and drainage.*
 - a. Type (lakes, ponds, swamps, marshes, rivers, streams, etc).
 - b. Density (number of features per square mile).
 - c. Direction.
9. *Climate, weather, and seasonal effects.*
10. *Arrangement pattern.*
 - a. Alinement (N-S, E-W, etc).
 - b. Continuity (continuous, broken, etc).
11. *Slope.*
 - a. Shape (convex or concave).
 - b. Angle (in percent, degrees, or gradient).
 - c. Minor relief features (rough lava, boulder fields, gullies).
12. *Profile.* Transverse and/or longitudinal.
13. *Surface characteristic.* Soil, rock type, etc.
14. *Vegetation.*
15. *Cultural features.*
16. *Special phenomena.* Earthquakes, volcanoes, landslides, or permafrost.
17. *Ridge crests.*
 - a. Orientation.
 - b. Elevation (typical, highest, and lowest).
 - c. Height above adjacent valley flats (average, highest, and lowest).
 - d. Pattern (long, straight, parallel ridges, etc).
 - e. Skyline (flat-topped and broad, knifelike).
18. *Valley flats.*
 - a. Dimensions.
 - b. Tributary valleys.
 - c. Pattern (long, straight and parallel, branch-like and crooked).
 - d. Profile.
 - e. Border terraces (number of steps, width, continuity, elevation).
 - f. Slope.
 - g. Stream association.
19. *Intermontane basins.*
 - a. Dimensions (length and width).
 - b. Shape (round, oval, long and narrow, or irregular).
 - c. Flat bottom land (extent).
 - d. Profile.
 - e. Border terraces.
 - f. Elevation.
 - g. Slope.
 - h. Stream association.
20. *Passes.*
 - a. Total number.
 - b. Distance between.
 - c. Elevation (at pass crest, at bordering heights).
 - d. Dimensions (length and width).
 - e. Approaches (width, slope, and alinement).
 - f. Sides (type and slope).
 - g. Bottom (surface and slope).
 - h. Periods closed (dates and cause).
21. *Exceptional features.* Escarpments, glaciers, lava flows, karsts, etc.
 - a. Identification.
 - b. Dimensions.
 - c. Local relief and elevation.
 - d. Slope.
 - e. Unique characteristics.
22. *Movement aspects.*
23. *Observation aspects.*
24. *Cover and concealment.*
25. *Construction aspects.*
26. *Suitable drop sites.*
27. *Suitable assembly areas.*

Section III. SURFACE MATERIALS

3-9. Definitions

a. Soil is the unconsolidated material that overlies bedrock and is clearly distinguishable from bedrock.

b. Rock. Rock may be defined as the firm and coherent or consolidated material of the earth's crust. Bedrock is solid undisturbed rock either exposed at the surface or underlying the soil.

3-10. Soil

Soil is the accumulation of disintegrated and decayed rock and vegetation. This accumulation can be hundreds of feet thick or it may be absent in given areas. For field identification and classification, soils may be grouped into five principal types: gravel, sand, silt, clay and organic matter. These types seldom exist separately but are found in mixtures of various proportions, each type contributing its characteristics to the mixture. The classifications of soil and rock are shown in table 3-2.

Table 3-2. Classification of Surface Materials

Unconsolidated Parent Materials (SOIL)	
<i>Eolian materials</i> (stratified or nonstratified)	Coarse-grained sand Fine-grained silt (loess)
<i>Glacial materials</i> (mostly nonstratified)	Coarse-grained: gravel, sand Fine-grained: silt, clay
<i>Fluvial materials</i> (crudely stratified)	Coarse-grained, nonorganic: gravel, sand Coarse-grained, organic: sand Fine-grained, nonorganic: silt, clay Fine-grained, organic: silt, clay
<i>Lacustrine materials</i> (well stratified)	Coarse-grained, nonorganic: sand Coarse-grained, organic: sand Fine-grained, nonorganic: silt, clay Fine-grained, organic: silt, clay
<i>Littoral deposits</i> (crudely to well stratified)	Coarse-grained, nonorganic: gravel, sand Fine-grained, nonorganic: silt Fine-grained, organic: silt
<i>Volcanic deposits</i> (well stratified)	Coarse-grained Fine-grained
Consolidated Parent Materials (ROCK)	
<i>Sedimentary rocks</i> : limestone, dolomite, shale, sandstone, evaporite	
<i>Igneous rocks</i> : pyroclastics, rhyolites, basalt, granite-like, gabbro-like	
<i>Metamorphic rocks</i>	
Stratified: quartzite, slate, marble	
Nonstratified: quartzite, marble, gneiss, schist	

a. Gravel. Gravel is angular to rounded, bulky rock particles ranging in size from about 0.6 to 7.6 cm ($\frac{1}{4}$ to 3 inches) in diameter. It is classified as coarse or fine; well or poorly graded; and angular, flat, or rounded. Next to solid bedrock,

well-graded and compacted gravel is the most stable natural foundation material. Weather has little or no effect on its trafficability. It offers excellent traction for tracked vehicles; however, if not mixed with other soil, the loose particles may roll

under pressure, hampering the movement of wheeled vehicles.

b. Sand. Sand consists of rock grains ranging in diameter from about 0.6 cm (1/4 inch) down. It is classified as coarse, medium, or fine, and as angular or rounded. Well-graded angular sand is desirable for concrete aggregate and for foundation material. It is easy to drain, little affected by moisture, and ordinarily not affected by frost action. Care is required, however, to distinguish between a fine sand and silt. When wet enough to become compacted, or when mixed with clay, sand provides excellent trafficability. Very dry, loose sand is an obstacle to vehicles, particularly on slopes.

c. Silt. Silt consists of natural rock grains which will pass a US standard no. 200 sieve. It lacks plasticity and possesses little or no cohesion when dry. Because of silt's instability, water will cause it to become soft or to change to a "quick" condition. When ground water or seepage is present, silts exposed to frost action are subject to ice accumulation and consequent heaving. When dry, silt provides excellent trafficability, although it is very dusty. Silt absorbs water quickly and turns to a deep, soft mud which is a definite obstacle to movement.

d. Clay. Clay generally consists of microscopic particles. Its plasticity and adhesiveness are outstanding characteristics. Depending on mineral composition and proportion of coarser grains, clays vary from lean (low plasticity) to fat (high plasticity). Many clays which are brittle or stiff in their undisturbed state become soft and plastic when worked. When thoroughly dry, clay provides a hard surface with excellent trafficability; however, it is seldom dry except in arid climates. It absorbs water very slowly but takes a long time to dry and is very sticky and slippery. Slopes with a clay surface are difficult or impassable, and deep ruts form rapidly on level ground. A combination of silt and clay makes a particularly poor surface when wet.

e. Organic Matter. Chemically deposited and organic sediments are classified on the basis of mode and source of sedimentation.

3-11. Field Identification

Soils are classified according to particle-size distribution as coarse grained (gravels and sands), fine grained (silts and clays), and highly organic (peats). The location and extent of the various

types are an indication of the suitability of an area for military operations. In general, the coarse-grained soils are more favorable for cross-country movement and construction operations than are the silts and clays.

a. Coarse-Grained Soils. Identification can be made by spreading a dry sample of soil on a flat surface and estimating the grain size components.

b. Fine-Grained Soils. Silt and clay soils are further differentiated according to plasticity and the presence of organic materials. Plasticity can be determined by breaking and powdering a small, air-dried sample with the fingers. Highly plastic soils can be powdered only with great effort, while slightly plastic and nonplastic soils crumble and powder easily. Another method of determining plasticity is by rolling a small, moist sample in the hands and then squeezing it flat between the thumb and forefinger. In this test, highly plastic soils can be formed into long ribbons, whereas slightly plastic and nonplastic soils break into short length or cannot be formed into ribbons.

c. Highly Organic. Identification of highly organic soils is relatively easy as they contain partially decayed grass, twigs, leaves, etc, and have a characteristic dark brown to black color, a spongy feel, and fibrous texture.

3-12. Soil Depth

For terrain intelligence purposes, soils between 15 cm (6 in) and 2 meters (6 ft) in depth are the most important. Next in importance are the soils from 2 to 6 meters (6 to 20 ft). Soil depth can be measured directly from borrow pits, road cuts, building excavations, and streambanks. Where soil is so deep that bedrock cannot be located, it can be reported as exceeding a depth which can be determined with reasonable accuracy; i.e., where bedrock cannot be seen in gullies 5 meters (15 ft) deep, soil depth can be reported as exceeding 5 meters (15 ft).

3-13. Use of Gully Profile to Determine Soil Texture

The soil textural properties and profile development can be interpreted from the gully system and the individual gully shape or cross section (fig. 3-8). Deep uniform soils are reflected in uniform gully gradients, cross sections, and regularity of gully systems. Textures can be interpreted from gully shapes and drainage patterns. Well-drained, granular, noncohesive soils (sand, gravel,

and mixtures of the two) have V-shaped gullies with a short, steep gradient. Plastic, cohesive, poorly-drained soils (clays and silty clays) have broad, somewhat rounded U-shaped gullies and long, shallow gradients which extend some distance into the upland. Semicohesive, nonplastic soils (some clays and loessial silt) have U-shaped gullies with short, very steep gradients. Stratified soils, or soils with a strong profile development are indicated by changes in gully gradient and cross section. The absence of gullies may indicate porous soil conditions, particularly if timber occurs in the area. Gully profiles are best utilized with aerial photographs (when actual soil samples are not available).

3-14. Rock

The physical and engineering characteristics of rocks are significant factors in military operations, particularly in construction and in locating ground water. The three major classes of rock (table 3-2) are igneous, sedimentary, and metamorphic. Igneous rock (gabbro, granite, lava, etc.) formed by cooling and solidification from a molten or partly molten state; sedimentary rock (sandstone, shale, limestone, etc.) from material accumulated as a deposit from water or the air; and metamorphic rock (gneiss, schist, quartzite, etc.) by the recrystallization of igneous or sedimentary rock under the influence of heat, pressure, or both.

3-15. Reference Manuals

a. Four Army technical manuals contain specific data on soils. A general treatment of soils encountered in road and airfield construction is contained in TM 5-330; laboratory and field testing are covered in TM 5-530; a full description of soil testing equipment and improvisations are given in TM 5-330 and TM 5-545 contains information on soil formations, deposits and occurrence, and the use of deposits for construction material.

b. Details on rock classes and their respective engineering properties are discussed in TM 5-332 and TM 5-545. TM 5-545 also discusses the distribution and the primary landform structures associated with the three major rock classes.

c. Information contained in these manuals is generally helpful to personnel engaged in the collection of data on natural terrain.

3-16. Sources of Information

a. Information on soil and rock may be obtained from government agencies, book stores, libraries, geological and geographic societies, universities, museums, and mapping concerns. Interviews with geologists, surveyors, civil engineers, geographers, and naturalists can produce valuable data. When personal reconnaissance is necessary to fill gaps in information, road cuts, waterfalls, and rock quarries provide excellent opportunities for investigating rock types. The use of color film in photographing rocks and soils may enable analysts to make evaluations that otherwise would not be possible.

b. Among the many publications containing valuable information on soil and rocks are:

(1) Maps, particularly geologic, topographic, and soil maps, which show the distribution of specific rock types or geologic formations and the characteristic surface soils.

(2) Geologic and other scientific texts, journals, and reports published by professional scientific societies or by government agencies concerned with conservation, reclamation, mining, and civil engineering.

(3) Agricultural soil surveys, including maps and texts.

(4) Geological surveys, with maps and texts.

(5) Engineering surveys for construction projects such as roads, railroads and hydroelectric power developments.

(6) Surveys for irrigation projects.

(7) Agricultural reports in the field of agronomy.

(8) Vegetation surveys having supplemental soil information.

(9) Reports and manuscripts prepared by scientists and engineers in the field of agriculture.

3-17. Collection Check-List—Soil and Rock

SOILS:

1. *Identification.* Local name and military designation.

2. *Location.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

b. Political unit, area, UTM coordinates, and geographic coordinates.

3. *General terrain class.* Plain, desert, hill, or mountain.

4. *Boundaries*.
 - a. Type (geographic, political, geological).
 - b. General shape (circular, square, elongated, etc).
 5. *Dimensions*. Length and width.
 6. *Prevailing gradient*. Direction and slope.
 7. *Vegetative cover*.
 8. *Major soil classification*.
 - a. Grading (gravel, sand, silt, clay).
 - b. Composition (mineral, organic).
 - c. Consistency (plastic, friable).
 9. *Unified soil classification*. TM 5-330.
 10. *Parent material*. Limestone, coral, shale, sandstone, etc.
 11. *Dominant weathering process*. Chemical or mechanical.
 12. *Depth*.
 - a. Major surface soil (range and average).
 - b. Major subsurface layer (range and average).
 13. *Internal drainage*.
 - a. Water table (depth and stability).
 - b. Drainage rate (high, medium, low, or none).
 - c. Porosity.
 - d. Permeability.
 - e. Infiltration rate.
 14. *Surface drainage*.
 - a. Type.
 - b. Identification number.
 - c. Water table association.
 15. *Soil particle data*.
 - a. Size distribution (gravel, sand, silt, clay).
 - b. Maximum size.
 - c. Shape (angular, rounded, plate-like).
 16. *Soil cementing material*. Calcium, silicon, etc.
 17. *Soil color*.
 18. *Engineer test data*. TM 5-530.
 - a. Specific gravity (soil particles).
 - b. Moisture content (percent dry weight).
 - c. Density (expressed as lb/cu ft dry).
 - d. Void ratio.
 - e. Triaxial shear surcharge range.
 - f. Cone index.
 - g. Remolding index.
 - h. Airfield cone index.
 - i. Liquid limit.
 - j. Plasticity index.
 - k. Ph value.
 - l. Stickiness (complete, some, or none).
 - m. Slipperiness (all times, when wet, never).
 - n. California bearing ratio.
 - o. Modulus of subgrade reaction.
 19. *Bearing strength*.
 - a. Natural state.
 - b. Soil structure destroyed state.
 - c. Compacted state.
 20. *Compaction characteristics*.
 - a. Compacted dry density.
 - b. Optimum moisture for compaction.
 - c. Optimum method of compaction.
 - d. Ease of compaction.
 - e. Control (necessary or unnecessary).
 21. *Shrinkage and expansion of excavation material*.
 - a. Relative (high, medium, low, or none).
 - b. Percent shrinkage or expansion.
 22. *Special phenomena*.
 23. *Maximum stable slope*. Natural or cut.
 24. *Trafficability*. Foot, wheeled vehicle, and tracked vehicle.
 25. *Foundation conditions*.
 - a. Suitability for construction (light or heavy).
 - b. Known structural failures (faults, landslides, etc).
 26. *Excavation conditions*.
 - a. Ease, method, and rate of excavation.
 - b. Percent boulders, gravel, rock, by volume.
 27. *Suitability for subgrade*.
 28. *Suitability for borrow for fill*.
 29. *Suitability for fill and embankment*.
 30. *Suitability for airfields and helipads*.
 - a. Unsurfaced.
 - b. Surfaced.
 31. *Suitability for unsurfaced roads*.
 32. *Suitability for concrete aggregate*.
 33. *Suitability for bituminous aggregate*.
 34. *Suitability for binder*.
 35. *Suitability for top soil*.
- ROCKS:**
1. *Identification*. Local name and military designation.
 2. *Location*.
 - a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b. Political unit, area, UTM coordinates, and geographic coordinates.
 3. *General terrain class*. Plain, desert, hill, mountain, etc.
 4. *Boundaries*.
 - a. Type (geographic, political, formational).

- b. General shape (circular, square, elongated, etc).
- 5. *Dimensions*. Length and width.
- 6. *Prevailing gradient*. Direction and slope.
- 7. *Vegetative cover*.
- 8. *Major rock classification*.
- 9. *Overburden*. Type, depth, and seasonal conditions.
- 10. *Thickness of rock unit*. Range and average.
- 11. *Lithologic data*.
 - a. Bedded bodies (thickness of beds, variation in material, slope of beds, and continuity of beds).
 - b. Nonbedded bodies (shape, size, and geologic name).
 - c. Rock color.
 - d. Rock grain size.
 - e. Cementing (degree and kind).
 - f. Weathering (chemical or mechanical).
- 12. *Geologic structure*.
 - a. Major structure type (anticline, syncline, fault, etc).
 - b. Faults (type, slope, displacement, and activity).
 - c. Fractures (spacing, size, pattern, and slope).
 - d. Schistosity slope (amount and direction).
 - e. Foliation slope (amount, direction, and degree).
- 13. *Cavernous openings*. Dimensions and continuity.
- 14. *Engineer test data*. TM 5-530.
 - a. Specific gravity.
 - b. Solid unit weight.
 - c. Rock grain size (range, percent size distribution).
 - d. Porosity.
 - e. Absorption percentage (coarse, fine).
 - f. LART abrasion percent loss.
 - g. Soundness percent loss (coarse, fine).
 - h. Compressive strength.
- 15. *Shrinkage and expansion of excavation material*.
 - a. Relative amount (high, medium, low, or none).
 - b. Percent shrinkage or expansion.
- 16. *Special phenomena*.
- 17. *Maximum stable slope*. Natural or cut.
- 18. *Internal drainage*.
 - a. Water table (depth, stability, and range).
 - b. Drainage rate.
 - c. Permeability.
 - d. Infiltration.
- 19. *Trafficability*. Foot, wheeled vehicle, and tracked vehicle.
- 20. *Foundation conditions*.
 - a. Suitability for construction (light or heavy).
 - b. Known structural failures (faults, landslides, etc).
- 21. *Excavation conditions*.
 - a. Ease, method, and rate of excavation.
 - b. Break size (average and range).
- 22. *Tunneling conditions*.
 - a. Ease and method of tunneling.
 - b. Support required.
 - c. Water expected.
- 23. *Suitability for base course*. Degree and limiting factors.
- 24. *Suitability for binder*. Degree and limiting factors.
- 25. *Suitability for concrete aggregate*. Degree, conditions, reactivity, and processing required.
- 26. *Suitability for bituminous aggregate*. Degree, conditions, stripability, and processing required.
- 27. *Suitability for untreated surfacing*. Degree and limiting factors.
- 28. *Suitability for subbase, fill and embankment*. Degree and limiting factors.
- 29. *Suitability for rip rap*. Degree and limiting factors.
- 30. *Suitability for rubble masonry*. Degree and limiting factors.
- 31. *Suitability for cut stone masonry*. Degree and limiting factors.
- 32. *Suitability for roofing materials*. Degree and limiting factors.
- 33. *Potential quarry sites*.
 - a. Type of quarry material.
 - b. Associated roads and railroads.

Section IV. HYDROLOGY

3-18. Scope

Hydrology is concerned with the characteristics of surface and subsurface waters. This terrain group is closely associated with the other terrain groups because many of its characteristics are di-

rectly or indirectly influenced by them (fig. 3-9). Knowledge of the earth's topography (surface configuration) and geologic and soil formations (surface composition) will help find and evaluate supplies of water and determine how its occur-

rence and distribution will affect military operations. Surface water encompasses all inland waters: streams and canals, standing bodies of water (lakes and ponds), seasonally or perennially wet areas (swamps and marshes), and glaciers. Sub-surface water, or groundwater, is that located beneath the surface of the earth. Although more difficult to locate and develop than surface water, ground water sources are less susceptible to contamination and may be the only source of water in arid regions.

3-19. Drainage

a. The drainage pattern of an area indicates many physical features. Detailed study of the overall drainage pattern makes it possible to distinguish between flat lying sedimentary rocks and tilted sedimentary rocks in areas where the crustal soil is thin or absent. The drainage pattern of a horizontal limestone area is exhibited by a series of numerous sinkholes. The drainage pattern of most insoluble sedimentary rocks that are horizontally bedded is dendritic or a modified form thereof. In shale areas, the channels and gullies are more free to meander, therefore, a certain roundness of drainage plan results. In sandstone

regions (flat lying), the drainage pattern is also dendritic but has a noticeable angularity in many gullies and channels. Tilted rocks produce trellis-like drainage patterns or systems. In slightly tilted regions the channels flowing along the surface of the top sediments are usually parallel, delineating the direction of dip. Those flowing across the cross section of the strata are short and have steep gradients. In strongly tilted areas the drainage pattern is angular and approaches a true trellis-like appearance. In alternating layers of hard and soft rocks, the major streams flow in the valleys created in the softer rocks, leaving numerous wind and water gaps in the harder rocks where the streams once crossed.

b. Another important phase of the drainage pattern is that it is possible to predict the presence of underlying rocks by variations in the surface drainage. Each abrupt change in cross section, direction, or grade usually is accompanied by a change in material. The small upland gullies of an area will have the cross sections and patterns common to the soil in which they are flowing. When a gully is large enough to cut through the upper soil into the underlying rock, it will be controlled in shape, fall, and plan by the new materials encountered.

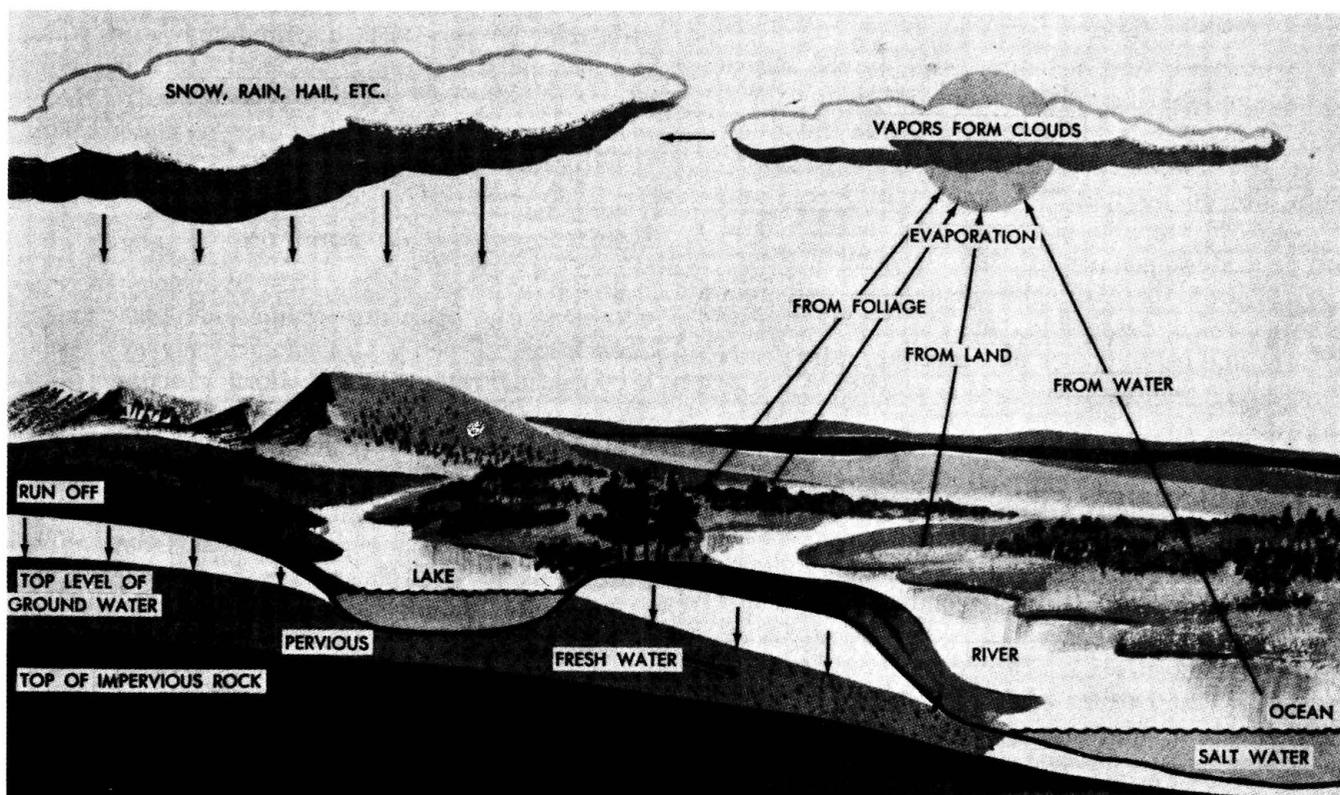


Figure 3-9. Hydrologic cycle.

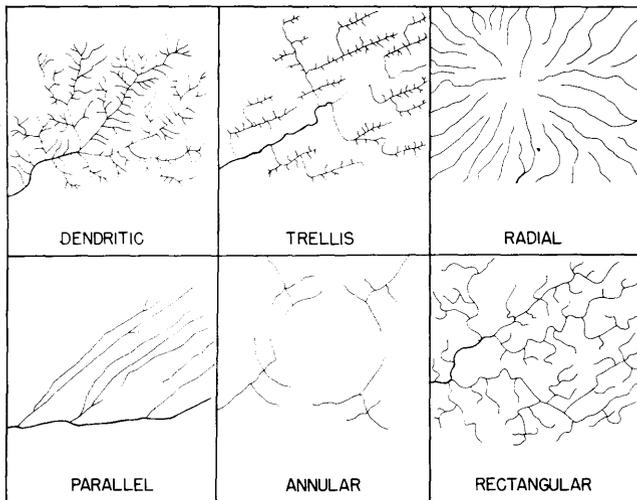


Figure 3-10. Sketches illustrating basic drainage patterns.

3-20. Drainage Patterns

Stream erosion reflects the surface configuration and composition by the type of drainage pattern it forms. These patterns (fig. 3-10) are recognizable on either topographic maps or aerial photographs. A knowledge of these drainage patterns is very helpful to the terrain analyst.

3-21. Watersheds

The watershed, or drainage basin, is the entire region contributing to the supply of water for a river or lake. It is the natural unit for the study of surface drainage, since surface drainage represents the end product of a number of forces and processes of variable character and location, and only in watersheds can all these elements be synthesized. Data on watersheds include the principal factors which determine the characteristics of streams and other bodies of water, and also focus attention on factors which are critical in military operations.

3-22. Watercourses and Water Bodies

Most military problems involving watercourses (streams, rivers, creeks, canals etc.) arise from the fact that stream drainage conditions vary not only from place to place but from time to time. Military planners are concerned with the flow and channel characteristics of these watercourses and their effect on military operations. Like watercourses of which they are normally a part, water bodies (lakes, inland seas, reservoirs, glaciers and snowfields) are involved in the hydrologic and

military aspects of surface drainage. They affect the characteristics of surface drainage by storing precipitation and runoff and by retarding or augmenting flood flows. Militarily, they constitute obstacles to cross-country movement or may provide avenues when sufficiently frozen. They determine the types of equipment to be used in an area. Figure 3-11 illustrates the method of determining bank heights and slopes of a watercourse.

3-23. Wet Areas

Wet areas are tracts of seasonally or perennially wet or water covered ground areas. These areas are treated separately in the collection of data because information requirements differ from other water bodies, especially in evaluation for cross-country movement.

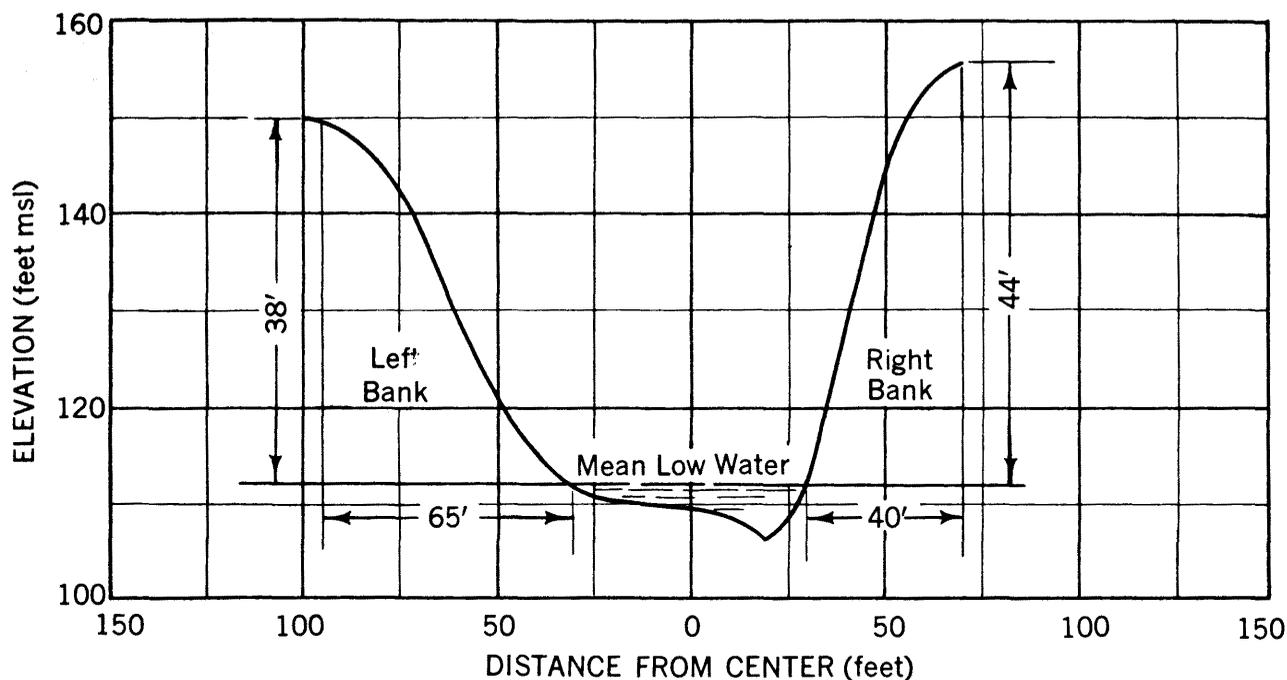
3-24. Groundwater

Groundwater is that water retained by the soil in the hydrologic cycle. When water fills the pores and crevices of soil and rock, a zone of saturation results. This is groundwater; the top of the saturated level is the water table. The depth of the water table beneath the surface varies according to topography, structure of the rock formations, amount of rainfall, and nature of pore spaces in the soil or rock. Groundwater is very significant militarily because it is a prime source of water supply, and the water table level has a profound effect on soil conditions for cross-country movement purposes and construction of underground installations.

3-25. Sources of Information

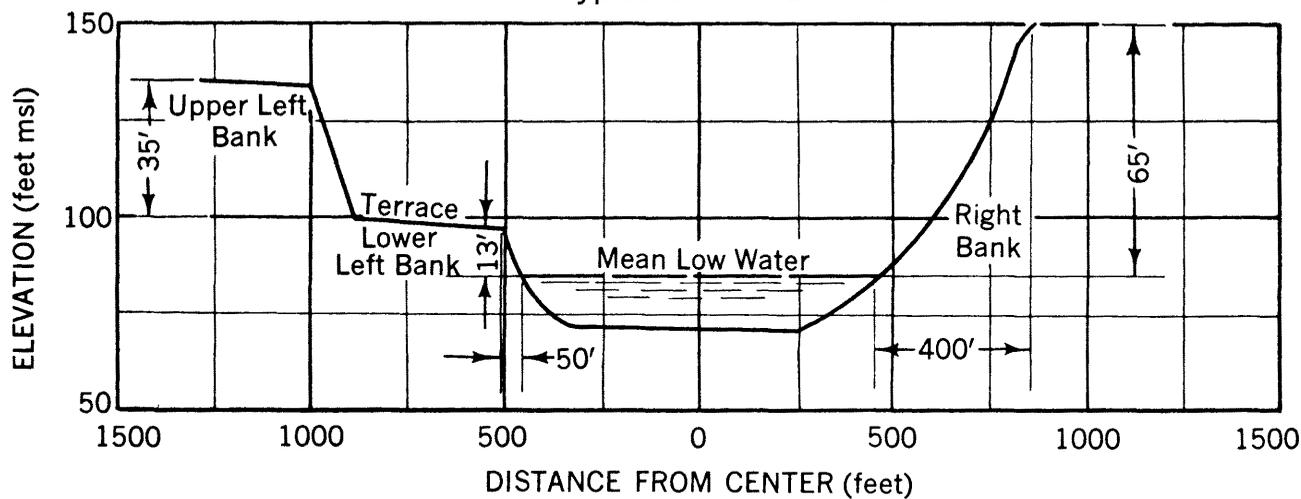
a. Publications dealing with hydrology may be obtained from book stores; libraries; government agencies concerned with geological surveys, reclamations, hydrology and natural resources; hydroelectric power agencies; civil engineering firms; universities; and mapping concerns. Topographic maps and geologic maps are very useful. Hydrologic yearbooks and precipitation records are excellent sources of information. Other publications include articles and reports of government and private organizations concerned with water supply, flood control, conservation and reclamation.

b. Useful information may be obtained from interviews with hydrologists, civil engineers and others concerned with water resources. Personal reconnaissance may be used to fill specific gaps in



	Left Bank	Right Bank
Height (ft.)	38'	44'
Slope:	$38/65=0.6$	$44/40=1.1$

a. Typical Stream Channel



	Upper Left Bank	Lower Left Bank	Right Bank
Height (ft.)	35'	13'	65'
Slope:	$35/100=0.35$	$13/50=0.26$	$65/400=0.16$

b. Stream Channel with Terraced Bank

Figure 3-11. Determination of stream bank heights and slopes.

information, particularly when photographic coverage can be obtained. Photographs may show both normal and extreme conditions, with a subject such as a person, boat, or structure included to indicate the scale of the photo. Data on depth, velocity, high water marks, etc. are important aspects that should be included in photo captions.

3-26. Collection Checklist—Hydrology

WATERSHEDS:

1. *Identification*. Local name and military designation.
2. *Location*.
 - a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b. Political unit, area, UTM coordinates, and geographic coordinates.
3. *Area dimensions*.
4. *Surface materials*. Soil and rock type distribution.
5. *Vegetation*. Cross reference to the vegetation collection file.
6. *Precipitation*. Cross reference to climatic summary collection file.
7. *Flooding*. Cross reference to climatic summary collection file.
 - a. Maximum flood history (dates, duration, extent, and effects).
 - b. Periods of high and low water (dates, extent, and effects).
8. *Ice conditions*.
 - a. Freezing and breakup dates (earliest, latest, and mean).
 - b. Extent and depth of frozen surface.
 - c. Bearing capacity of ice.
9. *Hydraulic developments*.
 - a. Location and purpose (flood control, water storage, irrigation).
 - b. Water control structures (dams, locks, canals, dikes, etc).
10. *Main stream*.
 - a. Name and location.
 - b. Length and pattern.
11. *Major tributaries*.
 - a. Names and location.
 - b. Length and pattern (type, texture, and alignment).
 - c. Drainage basins (area, slope, and shape).
12. *Standing bodies of water*. Lakes, reservoirs, snowfields, ponds, etc.
 - a. Name, location, and size (surface area).
 - b. Inlets and outlets.

13. *Glaciers*. Area and boundaries.
14. *Marshes and swamps*. Type and surface area.

WATERCOURSES AND WATER BODIES:

1. *Identification* (same as 1 above).
2. *Location* (same as 2 above).
3. *Type*. River, canal, lake, inland sea, glacier, etc.
4. *Pattern*.
5. *Direction of flow*.
6. *Crossings*. Cross reference to appropriate collection file.
7. *Navigability*. Cross reference to inland waterways collection file.
8. *Flooding*. Cross reference to climatic summary collection file.
 - a. Type and causes (normal, flash, or artificial).
 - b. Normal periods and duration.
 - c. Area extent and damage expected.
 - d. Key dams or structures.
 - e. Effects on movement and structures.
9. *Tidal effects*.
 - a. Tides (tidewater extent, variation, and datum).
 - b. Tidal currents (location, direction, velocity, and period).
10. *Banks*.
 - a. Composition and stability.
 - b. Height and slope.
 - c. Condition (eroded, turfed, improved, etc).
11. *Bottom*.
 - a. Composition and stability.
 - b. Occurrence of boulders and unusual conditions (type and location).
12. *Width, representative points*.
 - a. Mean high and low water.
 - b. Periods of occurrence.
13. *Depth, by sectors*. Mean high and low water.
14. *Velocity, at various locations*. Mean high and low water.
15. *Discharge*. Minimum and maximum; by season or month.
16. *Ice conditions*.
 - a. Freezing and breakup dates.
 - b. Extent of frozen surface and load capacity of ice.
 - c. Periods of drift ice and ice jam frequency and location.
17. *Nature of adjacent terrain*. Cross reference to appropriate collection file.
18. *Special considerations*. Cross currents, undertows, eddies, etc.

19. *Formations.* Islands, bars, shoals, rapids, falls, or atolls.
- Location and pattern.
 - Area extent and elevation.
 - Surface material and vegetation cover.
20. *Utilization of water body or watercourse.*
- Water supply.
 - Navigation.
 - Electric power production.
 - Drainage.
 - Irrigation.
 - Flood control.
 - Waste disposal.
21. *Channel data.*
- Length and slope.
 - Cross section at selected points.
 - Profile of bed.
 - Depth of bottom material.
 - Depth of bank material.
22. *Water surface profiles.* High, normal, and low water.
23. *Storage dams.*
- Identification and location.
 - Purpose (power, water supply, irrigation, flood control, etc).
 - Type (fixed, movable, gravity, etc).
 - Construction material (earthfill, rockfill, concrete, etc).
 - Security and safety features.
 - Dam dimensions (height, length, width, and thickness).
 - Operating characteristics.
 - Outlets (number, type, location, size, shape, length, etc).
 - Reservoir characteristics (dimensions, capacity, depth, etc).
 - Intake structures (location and type).
24. *Conduits.*
- Location, purpose, and type (canal, tunnel, pipe, within dam).
 - Alinement and length.
 - Related intake structures.
25. *Spillways.*
- Location and type (overflow, chute, side-channel, siphon, etc).
 - Length, width, and spacing of piers.
 - Gates (type, number, width, and height).
26. *Hydroelectric plants.* Location and layout.
27. *Drainage and irrigation structures.*
- Location and purpose.
 - Appurtenant works (canal, ditches, etc).
 - Related hydraulic structures (type, dimensions, characteristics).
28. *Navigation locks.*
- Location and number of chambers.
 - Length and width of chambers.
 - Height difference between upstream/downstream levels.
29. *Water treatment plants.*
- Location and type of treatment.
 - Capacity and source of water.
30. *Bank protection works.*
- Location and length of river reach concerned.
 - Material and type of construction (retaining walls, groins, etc).
31. *Flood protection structures, other than dams.*
- Location and terminal points.
 - Age (known or estimated) and condition.
 - Flood plain protected.
 - Alinement and type (levee, dike, flood wall).
 - Construction material (rockfill, masonry, wooden piles, etc).
 - Security and safety features.
 - Dimensions and elevation of structure.
 - Overtopping data (stream depth, discharge, and frequency).
 - Outlets (number, size, and characteristics).
- WET AREAS:**
- Identification.* (Same as 1 above.)
 - Location.* (Same as 2 above.)
 - Associated watercourses.*
 - Seasonal variations in wetness.*
 - Conditions causing inundation.*
 - Stream overflow.
 - Flooding by tides.
 - Rainfall/run-off imbalance.
 - Irrigation.
 - Type of area.* Swamp, marsh, bog, paddy field.
 - Transportation crossings.* Cross reference to appropriate collection file.
 - Flood data.* Frequency, duration, and periods of occurrence.
 - Water resources.*
 - Quantities (by season).
 - Quality (contamination, turbidity, taste, odor, color, chemical content, organic matter, dissolved mineral matter, etc).
 - Developments aspects (accessibility for intake points, water depth, availability of natural filtration materials, etc).
 - Ice conditions.*
 - Freezing and breakup dates.
 - Extent of frozen surface and load capacity of ice.

11. *Animal and vegetable life.* Kind and prevalence.

GROUND WATER:

1. *Identification.* (Same as 1 above.)

2. *Location.* (Same as 2 above.)

3. *Areal extent.*

4. *Wells.*

a. Distribution.

b. Relation to topography.

c. Characteristics.

d. Diameter and depth.

e. Casing or lining used (depth).

f. Materials and aquifers penetrated.

g. Yield of aquifers.

h. Static level of water (seasonal variations).

i. Rates of drawdown at specified yields.

j. Sustained yield (after prolonged pumping).

k. Rate of recovery after pumping.

l. Effects on yield of nearby wells.

m. Quality of water (color, odor, taste, temperature, dissolved solids, bacterial contamination, turbidity, and variation in quality).

5. *Springs.*

a. Locations and spacing.

b. Relation to topography.

c. Natural yield and seasonal variations.

d. Possible yield after development.

e. Method of development.

f. Quality of water (color, odor, taste, temperature, dissolved solids, bacterial contamination, turbidity, and variation in quality).

Section V. VEGETATION

3-27. Significance

Vegetation has a significant effect on many types of military activities, and it must be carefully considered in planning operations. To make reliable evaluations, data must be collected on the potential effect of vegetation on movement (both vehicular and foot), concealment, cover, observation, airdrops, and construction; the availability of fuel, shelter, food, and construction material; and an area's susceptibility to fire and blowdown.

3-28. Vegetation Types

The type of vegetation in an area gives an indication of the climatic conditions, soil, drainage, and water supply. For the purpose of terrain intelligence, vegetation is grouped into four general types with distinctive characteristics. These four types are trees, shrubs, grasses, and crops.

a. *Trees.* Trees are defined as perennial woody plants at least 10 feet in height, with single stems and definite crown shapes. A forest is an extensive area covered by trees. The area may be relatively open, or the trees may grow in close formation so that their crowns touch. Smaller areas covered by trees may be termed woods, groves or woodlots. On military maps, any perennial vegetation high enough to conceal troops or thick enough to be a serious obstacle to free passage is classified as woods or brushwood. Trees are classified as either deciduous or evergreen (coniferous). Deciduous trees drop all their leaves seasonally, while evergreen trees retain their leaves throughout the year. Although trees provide good cover

and concealment, they can present problems to movement of armor and wheeled vehicles. Individual large trees are seldom so close together that a tank cannot move between them, but the space between large trees is often filled by smaller trees or brush. Closely spaced trees usually are of relatively small diameter and can be pushed over by a tank; however, the resulting pileup of vegetation may stop the tank. Trees that can stop a wheeled vehicle usually are too closely spaced to be bypassed. The pileup effect from pushing over vegetation is greater for wheeled vehicles than for tanks. Woods also slow down the movement of dismounted troops.

b. *Scrub and Shrubs.* Scrub includes a variety of trees that have had their growth stunted because of soil or climatic conditions. Scrub growth includes cactus, stunted shrubs, sagebrush, mesquite, and similar plants found in arid or semiarid areas. Shrubs, like trees, are either deciduous or coniferous. Shrubs comprise the undergrowth in open forests; in arid and semiarid areas they are the dominant vegetation. Shrubs normally offer no serious obstacle to movement and provide good concealment from ground observation; however, they may restrict fields of fire.

c. *Grasses.* Grasses include all kinds of non-woody plants. A grassland is an extensive area where the natural vegetation consists primarily of grasses and forbs. (Forbs are herbaceous plants, and the dominant type in alpine and certain semidesert areas.) In low latitudes, grasslands often are termed savannas; in middle latitudes, they are called prairies (tall grass) and steppes (short

grass). Grasslands in wet or poorly drained areas are commonly called meadows. For terrain intelligence purposes, grass more than 1 meter (3 ft) high is considered tall, and below that height, short. Grass often improves the trafficability of some soils; very tall grass may also provide concealment for foot troops.

d. Crops. Field crops constitute the predominant class of cultivated vegetation. Vine crops and orchards are common but not widespread, and tree plantations are found in relatively few areas. The size of cultivated areas ranges from paddy fields covering a quarter of an acre to vast wheat fields extending for thousands of acres. In a densely populated agricultural area where all arable land is used for the crop that brings the highest yield, it may be possible to predict the nature of the soils from information about the predominant crops. Rice, for example, requires fine-textured soils. Other crops generally must have firm, well-drained land. An area of orchards or plantations usually consists of rows of evenly spaced trees, showing evidence of planned planting that can be distinguished on an aerial photograph. Usually such an area is free from underbrush and vines. Rice fields are flooded areas surrounded by low dikes or walls. Some crops, such as grain, improve the trafficability of soils while others, such as vineyards, present a tangled maze of poles and wires that are definite obstacles to vehicles and dismounted troops. Wheeled vehicles and some tracked vehicles are unable to cross flooded paddy fields, although they can negotiate them when the fields are drained and dry.

3-29. Sources of Information

a. Data on vegetation is available from a wide variety of publications. Vegetation and topographic maps, geographic periodicals and textbooks, scientific journals and agricultural yearbooks are useful. Private organizations as well as government agencies publish periodicals on agriculture, forestry, land reclamation and other subjects having a direct bearing on vegetation. Newspapers and magazines often provide data on crop production and failures and on forest fires, droughts; and reforestation programs.

b. Much information can be obtained from bookstores, libraries, government agencies concerned with forestry, agriculture and natural resources, geographic societies and natural history museums. Interviews with botanists, naturalist, lumbermen, forest rangers and agricultural

agents can provide useful data. Photography is especially helpful to an analyst; photo coverage of areas in which the types of vegetation are relatively uniform throughout, and detailed views of specific type plants comprising the area are desired.

3-30. Collection Checklist—Vegetation

1. *Identification.* Local name and military designation.
2. *Location.*
 - a.* Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b.* Political unit, area, UTM coordinates, and geographic coordinates.
3. *Terrain class.* Tropical rain forest, orchard, farm, meadow, etc.
4. *Boundaries.*
 - a.* General shape (circular, square, triangular, elongated, irregular).
 - b.* Azimuth (alinement).
5. *Area dimensions.* Longest, shortest, and hectares.
6. *Principal species.*
 - a.* Family.
 - b.* Common and botanical name.
 - c.* Percent of stand.
 - d.* Canopy (average height, depth, clearance beneath canopy, percent of area concealed by canopy, structure).
 - e.* Foliage (leaf type, color, density, and seasonal variations).
 - f.* Trunks, stems, or stalks (diameter and habit).
 - g.* Distribution pattern (random, clusters, clumps, grids, rows, strips, patches, and number of plants per cluster or clump).
 - h.* Distribution spacing (between clusters, rows, clumps, hills, etc).
 - i.* Roots (habit, height of emergence, spread above ground, spread below ground, and diameter above ground).
 - j.* Thorniness (location of thorns and length).
 - k.* Toxicity or irritants (location and reactions caused).
 - l.* Susceptibility to defoliating agents.
 - m.* Susceptibility to blowdown.
 - n.* Potential uses (food, fuel, posts, poles, piles, sawlogs, etc).
 - o.* Toughness of trunk (hard, soft, or pithy).
 - p.* Number of fallen plants per hectare.
 - q.* Rate of growth (trunk diameter, height, and crown diameter).

- 7. *Secondary species.* (Same as 6 above.)
- 8. *Ground cover.* Name, height, season, and area covered.
- 9. *Planting practices.* Method and period.
- 10. *Cultivation.* Method and period.
- 11. *Harvesting.* Product, method, period, yield, disposition, and distribution.
- 12. *Litter.* Type and depth.
- 13. *Through routes.* Cross reference to appropriate collection file.
- 14. *Run off factor.* Condition and seasonal variations.

- 15. *Susceptibility to fire.*
 - a. Type (controlled, accidental, and cause).
 - b. Seasonal aspects.
 - c. Degree of past burn off.
 - d. Characteristic of residue.
- 16. *Operational aspects.*
 - a. Cover and concealment.
 - b. Movement.
 - c. Observation.
 - d. Fields of fire (flat trajectory weapons).
 - e. Artillery fires (fusing and degradation effects).
 - f. Construction (suitability of plants for material).

CHAPTER 4

TACTICAL CONSIDERATIONS

Section I. MILITARY ASPECTS OF TERRAIN

4-1. General

Terrain is an important factor in the integration of fire and maneuver, in the generation of combat effectiveness, and in all military support operations. Terrain can usually be described in terms of its military aspects, which are used to determine the effect of terrain on the general courses of action available to both friendly and enemy forces. These aspects are key terrain features, observation and fields of fire, concealment and cover, obstacles, and avenues of approach (KOCOA). They are discussed in detail in FM 30-5.

4-2. Key Terrain

A key terrain feature is any area whose seizure or control affords a marked advantage to either opposing force. Key terrain features must be considered in formulating courses of action; their selection is based on the mission of the command. Terrain which permits or denies maneuver may be key terrain. Tactical use of terrain often is directed at increasing the capability for applying combat effectiveness and at the same time forcing the enemy into areas which reduce his capability. Terrain which permits this may also be key terrain. The effect of terrain on fire and maneuver, application of combat effectiveness and preservation of force integrity are considerations in selecting key terrain. A terrain feature may afford a marked advantage in one set of circumstances but little or no advantage under other conditions. The selection of key terrain varies with the level of command, the type of unit, and the mission of the unit.

a. Level of Command and Type of Unit. As an example of command level selection of key terrain, a field army commander may consider that the seizure and control of a given city would afford him control of a vital link in his line of communications; therefore, he might properly select the city as key terrain. On the other hand,

an infantry battalion commander within that field army would gain no advantage from seizing or controlling the city and, therefore, would not consider it key terrain. The structure of friendly and enemy units also influences the selection of key terrain. Types of terrain features frequently selected as key terrain for tactical units include high ground which affords favorable observation and fire; bridges over unfordable rivers; assigned or assumed objectives; and dominant terrain within a defensive sector. Although obstacles are rarely selected as key terrain, the same terrain feature may properly be considered as key terrain at one level of command and as an obstacle at another. For example, the city selected by the army commander as key terrain may be an obstacle to the battalion commander; it is not *both* key terrain and an obstacle to the *same* commander. Another example might be in the classification of an unfordable river. At the tactical unit level, in normal terrain, the river is classified as an obstacle because of its primary effect of stopping or impeding military movement; the adjacent high ground is key terrain because its seizure or control permits full utilization of the river as an obstacle, and this condition constitutes the tactical advantage.

b. Mission of the Unit. In the attack, key terrain features usually lie forward of friendly positions and are often assigned as objectives. Terrain features in adjacent zones may be key terrain if their control facilitates the conduct of the attack or accomplishment of the mission. Terrain in an adjacent zone which enables effective observation and fire of the enemy along an avenue of approach for friendly forces may be key terrain. Key terrain may be selected within friendly territory when its control is essential to the success of an operation. For example, if the enemy can seize a terrain feature which prevents or hinders the friendly force attack or withdrawal, then the control of that feature affords either force a marked

advantage and is key terrain. In the defense, key terrain is usually located within the battle area. Infrequently it may be forward of the defensive area or in adjacent sectors. A terrain feature forward of the battle area which gives the enemy a decided advantage of observation over defended localities, routes of communications, or enemy avenues of approach is key terrain. A terrain feature in an adjacent defensive sector which may give the same advantage may also be considered key terrain.

4-3. Observation and Fire

a. Observation relates to the influence of terrain on the ability of a force to exercise surveillance over a given area either visually or through the use of surveillance devices, both optical and electronic. The best observation generally is obtained from the highest terrain features in an area. Although the net effect of visibility and observation is manifest in the ability of a force to see (or its vulnerability to being seen), they are analyzed independently because visibility varies with weather conditions which are transitory, whereas observation varies with terrain conditions that are relatively permanent. For example, a high hill may provide excellent observation (an aspect of terrain) even though visibility (an effect of weather) is restricted by fog surrounding the hill at a given time.

b. Fire, a generic term, relates to the influence of terrain on the effectiveness of direct and indirect fire weapons. The fires of high-angle weapons such as mortars and howitzers are affected primarily by terrain conditions within the target area which may influence the terminal effect of the projectile. Fields of fire for direct fire weapons such as machineguns and automatic rifles may be affected by terrain conditions between the weapon and the target. The analyst identifies those terrain features within and adjacent to the area of operations which afford the friendly or enemy force favorable observation and fire.

4-4 Concealment and Cover

Concealment is protection from observation; cover is protection from the effects of fire. The analyst determines the concealment and cover available to both friendly and enemy forces.

a. Concealment may be provided by woods, underbrush, snowdrifts, tall grass, cultivated vegetation or by any other feature which denies observation. Concealment from ground observation

does not necessarily provide concealment from air observation or from electronic or infrared detection devices. Concealment may or may not provide cover as well.

b. Cover may be provided by rocks, ditches, quarries, caves, river banks, folds in the ground, shell craters, buildings, walls, railroad embankments and cuts, sunken roads, and highway fills. Areas that provide cover from direct fires may or may not protect against the effects of indirect fire; however, most terrain features that offer cover also afford concealment from ground observation.

4-5 Obstacles

An obstacle is any natural or artificial terrain feature that stops, impedes, or diverts military movement. Consideration of obstacles is influenced by the unit's mission. In defense, the intelligence officer identifies as obstacles those features that stop or impede movement within the battle area; in the attack he considers the obstacles within his unit's zone of action. An obstacle may constitute an advantage or disadvantage. Obstacles perpendicular to the direction of attack favor the defender by slowing or canalizing the attacker; obstacles parallel to the direction of attack may assist in protecting a flank of the attacking force.

4-6. Avenue of Approach

a. An avenue of approach is a route by which a force may reach an objective or key terrain. To be considered an avenue of approach, a route must provide enough width for the deployment of the size force for which it is being considered. Intelligence officers above corps level consider avenues of approach that are adequate for at least a division; at corps and lower levels, consideration is given to those adequate for the deployment of the major maneuver element directly subordinate to the headquarters. Thus, the corps G2 considers avenues of approach adequate for a division, the division G2 considers those adequate for a type brigade, the brigade S2 considers those adequate for a battalion and the battalion S2 considers those adequate for a company. The analysis of an avenue of approach at any level of command is based on:

(1) *Observation and fire.* Favorable for the force moving on the avenue of approach.

(2) *Concealment and cover.* This considera-

tion is frequently in conflict with the preceding one.

(3) *Obstacles*. Avoiding those that are perpendicular to the direction of advance and, whenever practical, taking advantage of those parallel to the direction of advance.

(4) *Utilization of key terrain*.

(5) *Adequate maneuver space*. This is based, in part, on consideration of deployment patterns, means of mobility, and sufficient space to avoid presenting advantageous targets for nuclear fires.

(6) *Ease of movement*. This includes relative length of the avenue of approach, directness of approach to the objective, soil trafficability, steepness of slopes, obstacles, direction of terrain compartments with respect to direction of movement, and other aspects of the terrain which enhance or restrict command and control.

b. The analysis of an avenue of approach is based solely on terrain considerations. The ability of an opposing force (existing or assumed) to interfere with the use of an avenue of approach has no influence on the analysis.

c. In the attack, avenues of approach leading from the line of departure to key terrain within the objective area are selected for analysis and the best one available to the friendly force is identified. In the defense, avenues of approach starting forward of the defensive position and leading to key terrain within the battle area are selected for analysis and the best one available to the enemy is identified. Avenues of approach available to the enemy are described as terminating within that key terrain in the battle area which, if seized by the attacker, could result in gross disadvantage to the defender. Such an avenue of approach begins a reasonable distance beyond the initial disposition of the forward forces of the unit for whom the analysis is being made. This distance is usually equal to the forward extent of the defense

sector. Avenues of approach may be either ridge, valley, or air.

(1) *Ridge approach*. The use of a ridge approach depends on the width and shape of the ridge, the size and deployment of the units involved, and the distance to, and elevation of, adjacent ridges. A ridge approach usually has the advantage of placing the axis of advance along good observation; however, there may be little protection from enemy fire on the ridge. The best axis of advance in a ridge approach is often slightly below the crest, with sufficient force on the crest to control it. Terrain appraisal should be made with this tactic given due consideration.

(2) *Valley approach*. A valley approach gives the advancing force some cover from enemy direct fire and some concealment from enemy observation. It includes the floor of the valley, the slopes of the ridges, and the military crests. Control of the military crests on each side of the valley is essential. The best axis of advance is one that offers the best observation, cross-country trafficability, road net, fields of fire, concealment and cover, and dispersion. In evaluating the use of a deep valley approach, the possible intensification of nuclear effects and resulting greater casualties on the valley floor are considered. At times, the best axis may be along the slopes of a ridge below the military crests rather than along a valley floor.

(3) *Air approach*. An air avenue of approach is a route that provides a suitable flight path for a specified number of aircraft to reach a drop or landing zone. To be considered an air avenue of approach, the flight path must afford some ease of movement for a force of sufficient size to produce a significant effect on the operation. The major considerations in selecting an approach are adequate air space for rapid movement of the aircraft to landing or drop zones, easily recognized terrain features, terrain corridors, length of the flight path and adequate landing zones to provide rapid deployment and dispersal from the aircraft.

Section II. CROSS-COUNTRY MOVEMENT

4-7. Definitions

a. *Cross-Country Movement*. This term, frequently abbreviated as CCM, means movement and maneuver without using roads. It includes movement by foot troops and by all military vehicles that move on the ground.

b. *Cross-Country Movement Study*. This is a study in which terrain information relevant to

cross-country movement is collected and interpreted, and the results are set forth on a graphic or series of graphics, with supporting texts, tables, etc. Interpretations on the map or graphic are for a specific vehicle, or for a group of vehicles alike in their movement capabilities. The text and related materials may include interpretations for other vehicles and for foot troops.

c. Soil Trafficability. This term means the capacity of soil to support traffic by military vehicles. It should not be used as a synonym for cross-country movement.

4-8. Terrain Factors Affecting Cross-Country Movement

Cross-country movement is affected by all physical components of the natural and cultural environment. It is affected by the configuration and geometry of the surface, the soils and rocks composing that surface, the vegetation cover, surface-water conditions, and all forms of cultural modifications. The most important components are the slope, and nature and condition of the soil. Movement must be considered in terms of the effects of both soil and slope. The obstacle factor also includes all slopes which exceed the maximum a vehicle can climb as well as the cultural modifications of the soil such as contour plowing, irrigation, and drainage which may alter the natural soil strength. In some areas one factor alone determines whether it is passable to vehicles, but more commonly it is the combination of two or more factors that determines whether vehicles can move across terrain with ease, with difficulty, or not at all.

4-9. Slope

Slope is the inclined surface of a hill, mountain, ridge, or any other part of the earth's surface. It is the inclination, not only of macrorelief features, such as hills and mountains revealed on topographic maps, but also microrelief features such as small gullies, mounds, low escarpments, small pinnacles and sinkholes which generally do not appear on topographic maps. Although some of the microrelief features might appropriately be considered as a roughness factor rather than slope, they are included in the general factor of slope because their obstacle value is due to the steepness of their slopes.

a. The angle that the inclined surface makes with the horizontal is commonly expressed as percent rather than degree. Percent of slope is the rise in elevation per 100 feet of horizontal distance. A slope of 100 percent would be the hypotenuse of a right triangle 100 feet long on the base and 100 feet high on the side. The angle made by the hypotenuse and the base is 45° ; therefore, a 45-degree angle is equivalent to a 100 percent slope. On a diagram of this right triangle the slope of the hypotenuse does not appear to be

particularly steep, but it is deceiving; actually, slopes greater than 80 or 90 percent are uncommon in nature unless they are rock escarpments or vertical slopes in loess or volcanic ash. Their occurrence as a manmade feature should not be overlooked.

b. Most Army vehicles are able to climb slopes of at least 60 percent. This limit, however, is too high for vehicles to negotiate in military operations. Slope has been related to soil strength and the generalized relationships are shown in figure 4-1. The vertical scale represents slope expressed in percent; the horizontal scale represents the soil strength required over that needed for movement on flat ground. Note that on slopes above approximately 45 to 50 percent for tracked vehicles and 30 to 40 percent for wheeled vehicles, the curves flatten out. On steeper slopes there is but little gain in climbing capability even if soil strength is increased substantially. Greater soil strength may, in fact, reduce climbing ability due to reduced traction. In evaluating terrain for cross-country movement 45 percent is commonly used as the reasonable upper limit for tanks and 30 percent for trucks. If other factors are highly favorable, they need to be reduced slightly. Short vertical or near-vertical slopes, such as those associated with rock ledges and gullies, may be deterrents or obstacles on terrain with a general slope much below 30 to 45 percent. Vertical heights above 0.8 to 1.3 meters ($2\frac{1}{2}$ to 4 ft) are generally considered to be the maximum for tanks and 15 to 30 cm ($\frac{1}{2}$ to 1 ft) the maximum for trucks. Foot troops can, of course, move over ground that is too steep and rough for either tanks or trucks; however, slopes of 60 percent are about the steepest that soldiers can climb by walking straight up slope. Above this limit they will normally have to zigzag. Above 100 percent, the going is very difficult, although not impossible.

c. Slopes too steep for the vehicle to climb constitute a barrier to vehicular movement; however, this is only the most obvious of the effects. A more subtle effect becomes evident when a vehicle attempts to climb a slope composed of a soil whose strength is close to that which is critical for that vehicle. In fine-grained soils the maximum slope negotiable for approximately 50 passes by a given vehicle is determined by subtracting the VCI from the RCI of the soil in question and relating this difference to the vehicle characteristics. For example, in a fine-grained soil with an RCI of 70, the M46 medium tank with a VCI of 60 could negotiate a maximum slope of 23 percent with the excess of 10 points in soil strength.

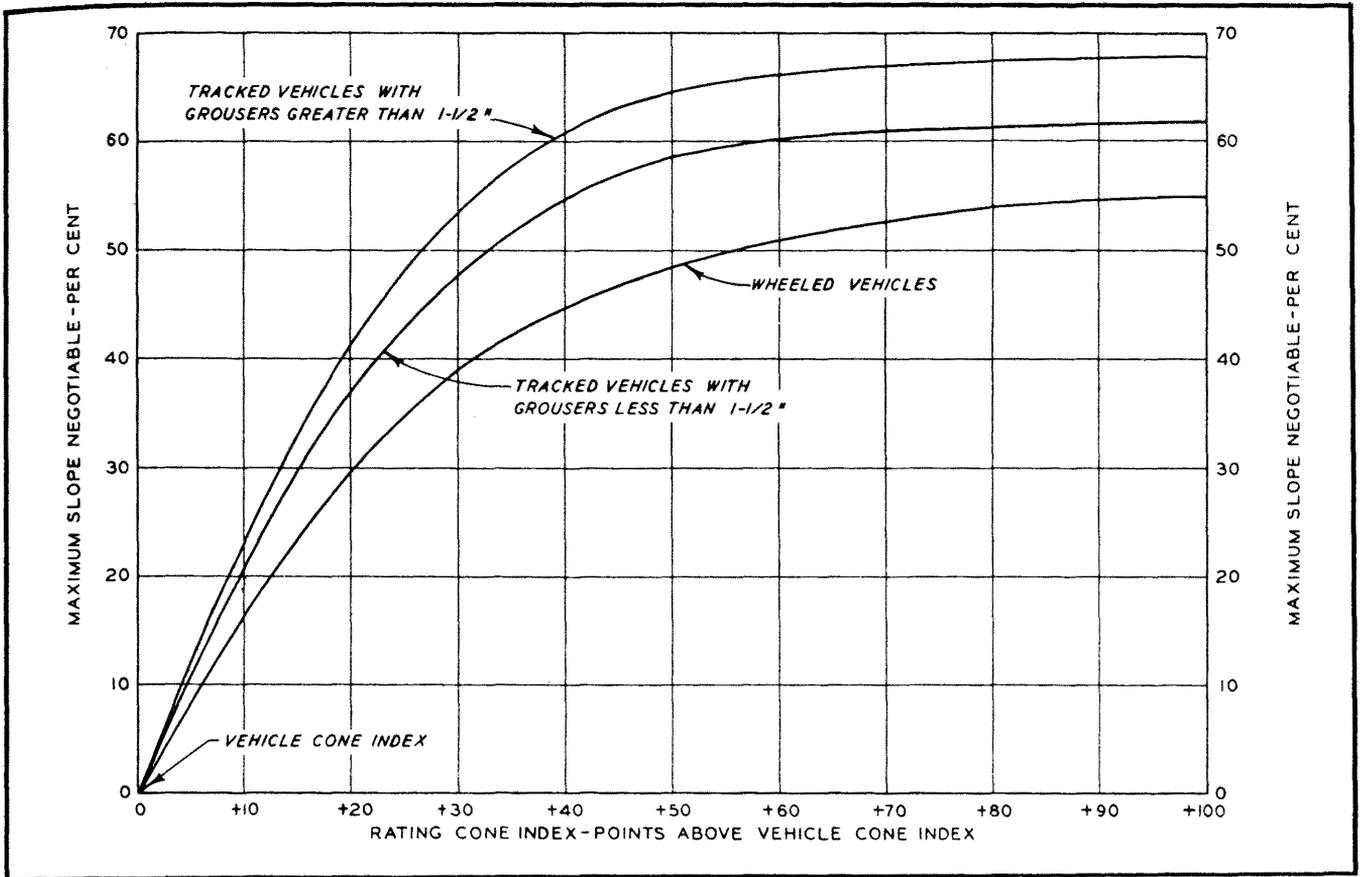


Figure 4-1. Criteria for self-propelled vehicles on fine-grained soils and sand with fines, poorly drained.

d. The relative direction at which a slope is negotiated must also be considered. The angle of movement of the vehicle with respect to the strike of the slope dictates the magnitude of the forces applied by the vehicle to the soil surface. For example, the downslope track or wheel has a greater load than the upslope and, as a result, deeper rutting occurs on the downslope side. This increases the effective slope.

e. The most reliable information about slopes, particularly short steep ones, is obtained by reconnaissance. In conducting reconnaissance, an instrument, such as an Abney level or clinometer, for measuring slope should always be used because slopes tend to appear much steeper than they actually are. At best, slope can be determined only on a small portion of the area by this procedure; therefore, heavy reliance must be placed on other sources, particularly topographic maps and airphotos.

f. Topographic maps are important sources of information on slope and landform. The percent of slope can be determined by dividing the con-

tour intervals by the horizontal distance between the contour lines and multiplying by 100. Devices have been developed for quickly determining slope by measurement of the distance between contour lines. One danger in relying on the distance between contour lines for determining slope is that much microrelief, or roughness, may be hidden, figuratively speaking, between the contour lines. If the contour interval is 20 meters, for example, a hill or depression 15 meters below or above the general land surface will not be shown. The larger the interval between contour lines and the smaller the scale of the map, the greater the amount of microrelief that may be hidden. Conversely, the smaller the contour intervals and the larger the scale of the map, the less microrelief will be hidden; but even on topographic maps at the large scale of 1:25,000 and a contour interval of 10 feet, there is always the possibility that some microrelief may not be revealed. Therefore, maps must be interpreted with caution and supplemented, if possible, by other information, such as geologic, geographic, and soil reports, and current aerial photography. Many of these contain landform de-

scriptions that reveal terrain characteristics and are also helpful in interpreting topographic maps. Soil maps contain information on slope and serve as useful supplements to topographic maps.

g. Aerial photographs are perhaps the best source of information for interpreting slope. From them, it is sometimes possible to obtain information not only on microrelief but also on important microrelief features. For example, small gullies, which can drastically slow movement, are not shown on topographic maps, but usually appear plainly on airphotos. Stereo pairs and a stereoscope are needed for making slope interpretations; for good results the photos themselves should be of high quality and reasonably large scale, 1:20,000 or larger. Slope interpretations must be done carefully; there is a danger of interpreting slopes to be steeper than they are because of inherent exaggeration in stereovision. Airphotos usually do not correctly reveal all relevant microrelief features.

4-10. Soil

Soil is a very important factor to deal with in evaluating cross-country movement. Obtaining the necessary information is difficult and time consuming, and a proper evaluation of the trafficability strength of soils is rather complicated. Therefore, users of this manual should become familiar with TM 5-330 which covers soils and soil trafficability in detail.

4-11. Soil Terms

a. Bearing Capacity. The ability of a soil to support a vehicle without undue settlement of the vehicle.

b. Traction Capacity. The ability of a soil to resist the vehicle-tread thrust required for steering and propulsion.

c. Critical Layer. The soil layer in which the rating cone index is considered a most significant measure of trafficability. Its depth varies with the weight and type of vehicle and the soil profile, but it is generally the layer located 15 to 30 cm (6 to 12 inches) below the surface.

d. Stickiness. The ability of a soil to adhere to vehicles.

e. Slipperiness. Low traction capacity of a soil's surface due to its lubrication by water or mud.

f. Fine-Grained Soil. A soil of which more than 50 percent of the grains, by weight, will pass a

No. 200 sieve (smaller than 0.074 mm in diameter).

g. Coarse-Grained Soil. A soil of which more than 50 percent of the grains, by weight, will be retained on a No. 200 sieve (0.074 mm and larger in diameter).

h. Sand With Fines, Poorly Drained. A sand in which water content greatly influences the trafficability characteristics. These soils react to traffic in a manner similar to fine-grained soils. They usually contain 7 percent or more of material passing the No. 200 sieve.

4-12. Trafficability Terms

a. Cone Index. (CI) An index of the shearing resistance of soil obtained with the cone penetrometer; a number representing resistance to penetration into the soil of a 30-degree cone with 1.27 square cm ($\frac{1}{2}$ square inch) base area (load in pounds on cone base area in square inches).

b. Remolding. The changing or working of a soil by traffic, or by a remolding test. Remolding may have a beneficial, neutral, or detrimental effect, resulting in a change of soil strength.

c. Remolding Index. (RI) The ratio of remolded soil strength.

d. Rating Cone Index. (RCI) The measured cone index multiplied by the remolding index; it expresses the soil-strength rating of a point subjected to sustained traffic.

e. Vehicle Cone Index. (VCI) The index assigned to a given vehicle that indicates the minimum soil strength in terms of rating cone index required for 50 passes of the vehicle.

f. Mobility Index. (MI) A number that results from a consideration of certain vehicle characteristics.

g. Maximum Tractive Effort. The maximum continuous towing force or pull a vehicle can exert expressed as a ratio or percentage of its own weight.

4-13. Instrument and Equipment Terms

a. Cone Penetrometer. A field instrument consisting of a 1 meter (39-in) shaft with a 30-degree cone of 1.27-sq-cm ($\frac{1}{2}$ -sq-in) base area mounted on one end and a proving ring with dial gage and handle mounted on the other end. The force required to move the cone at a rate of approximately 1.8 meters (6 ft) per min through a plane

of material is indicated on the dial inside the proving ring. This force is considered to be an index of the shearing resistance of the penetrated material and is called the cone index of the material in that plane. A capacity load of 150 lb deflects the ring 0.25 cm (0.1 in) and gives a cone index reading of 300.

b. Trafficability Sampler. A piston-type soil sampler for securing soil samples. Spacer bars permit cutting the sample to such a length that the density of the soil in pounds per cubic foot may be obtained by multiplying the weight of the sample in grams by 0.4.

c. Remolding Equipment. A cylinder of the same diameter as the trafficability sampler cylinder mounted vertically on a base, and a 2½-lb drop hammer that travels 30 cm (12 in) on a 46 cm (18 in) section of a cone penetrometer shaft fitted with a circular foot. A cone penetrometer equipped with a 1.27-sq-cm (½-sq-in) base area cone and a trafficability sampler are used to conduct a remolding test.

4-14. Remolding Tests

a. 100-Blow Remolding Test. This test is used to determine the remolding index of fine-grained soils. A sample is taken with the trafficability sampler, loaded into the remolding cylinder, and pushed to the bottom with the drop hammer. Cone indexes are measured at the surface of the soil and at 2.54 cm (1-in) vertical increments to a depth of 10.2 cm (4-in). Next, 100 blows of the hammer are applied and cone indexes are remeasured in the remolded soil. The remolding index is the sum of the five cone index readings made after remolding (a value of 300 is assigned to each depth that cannot be penetrated) divided by the sum of the five readings made before remolding.

b. Vibrated Remolding Test. This test is used to determine the remolding index of sand with fines, poorly drained, and is conducted in the same manner as the 100-blow test, with two exceptions. The cone index measurements are made with the 0.5-sq-cm (0.2-sq-in) cone instead of the 1.27-sq-cm (½-sq-in) cone, and the sample is remolded by placing the soil sample in the remolding cylinder and dropping the cylinder loaded with the soil sample by hand 25 times from a height of 15 cm (6 in).

4-15. Soil Factors That Affect Trafficability

a. Shear Strength. Soil trafficability is the abil-

ity of the soil to permit the movement of vehicles and personnel. The principal soil characteristic affecting trafficability is its shear strength. Shear strength is a function of the soil's moisture content, grain size, grain shape, mineralogical composition, organic content, plasticity and density. The principal factor affecting the shear strength of a soil is its moisture content. Any soil in a comparatively dry state may be trafficable to all military vehicles; but, at a higher moisture content, its strength and consequently its trafficability, may be such that only certain vehicles can pass. Shear strength is evaluated thru use of the cone penetrometer, as described in TM 5-330.

b. Bearing and Traction Capacity. Bearing and traction capacities of soil are primarily functions of the shear strength. The trafficability is considered adequate for a given vehicle if the soil has sufficient bearing capacity to enable it to develop the forward thrust necessary to overcome its rolling resistance. When the rolling resistance is equal to or greater than the forward thrust, the vehicle becomes immobilized.

c. Slipperiness and Stickiness. Slipperiness is a condition of deficient traction capacity in a thin layer of a soil that is otherwise trafficable. A vehicle immobilized solely because of slipperiness spins its wheels or tracks but neither moves forward nor sinks excessively. Stickiness is a condition that causes soil to cling to and build up on the wheels or tracks of vehicles. When this happens, the rolling resistance of the vehicle is increased and steering becomes difficult. In extreme cases, stickiness causes enough rolling resistance to "freeze" the running gear of the vehicle.

4-16. Soil Evaluation

a. The Army uses an empirical method for determining whether a soil will, in fact, support passage of a vehicle. This method and its application are described in TM 5-330. The key item in the method is the cone penetrometer.

b. The cone penetrometer determines an index of the shearing resistance of the soil. This is then used in computing the soil's trafficability. The cone penetrometer is a reliable device for quantitatively measuring the trafficability strength of a soil; however, the soil strength may change under traffic. For example, a soil may support three passes by a vehicle, but will give way on the fourth. This change in strength is called remolding.

c. Remolding may be positive as well as negative. That is, one soil may gain strength under traffic whereas another may lose; or the same soil may gain strength if its moisture content is high. To obtain a measure of the degree of remolding that a soil will undergo, it is necessary to simulate somewhat the action of vehicles in inducing remolding; a sample of soil is taken with a piston-type trafficability sampler and extruded directly into cylinder. First the cone index of the sample is determined; next, 100 blows are applied to the sample with an appropriate hammer, and the cone index of the sample is again determined.

d. Now that the cone index measurements have been made before and after remolding (before and after simulated traffic) the results are interpreted by introducing another term, the *remolding index*. This is simply the ratio obtained by dividing the cone index after remolding by the cone index obtained in the field before remolding.

$$\text{Remolding index} = \frac{\text{Cone index before remolding}}{\text{Cone index after remolding}}$$

If the soil loses strength upon remolding, the remolding index will be less than 1; if it gains strength, the remolding index will be greater than 1.

e. The third index is the *rating cone index*. This is simply the product of the measured cone index in the field and the remolding index for the same layer of soil.

$$\text{Rating Cone Index} = \text{Measured cone index (in natural soil)} \times \text{Remolding index.}$$

The rating cone index correlates with vehicles in such a way that it provides a reliable guide for predicting whether a soil will sustain repeated traffic.

f. Finally, there is the *vehicle cone index*. This is the minimum soil strength that will permit a given vehicle to complete about 50 passes. The vehicle cone index for the M-50 tank, for example, is 49. This means that if the rating cone index is less than 49, the tank will become mired to the point of immobilization before it has completed 50 passes; if the cone index is more than 49, the tank can make more than 50 passes, usually many more. Some other vehicle cone index values in round numbers are: for foot soldiers, about 20; for the D-7 Engineer tractor, 48; for the 2½-ton 6 X 6 cargo truck, 61; and for the APC M59, 44. Vehicle cone indices for most Army vehicles are listed in TM 5-330.

4-17. Estimating Soil Trafficability

The final estimate of soil trafficability is the estimate of the area's rating cone index. The process for determining the RCI is to first establish the soil type as categorized by the Unified Soil Classification System (TM 5-330). This permits an estimate to be made of the CI and RI, which in turn yields the final product, the RCI. Table 4-1 lists the characteristics of the four trafficability groups of soils in the wet season. Sources of soil information from which the RCI can be derived are:

a. *Terrain Reconnaissance*. There is no substitute for field examination of soils to determine whether or not they are trafficable. Although reconnaissance permits on-the-spot determination of trafficability characteristics, it requires considerable time, and such time is seldom available. Moreover, areas under study frequently may be difficult to reach. If the movement of traffic is to take place immediately after reconnaissance, it is necessary only to determine if the soil is strong enough to support the vehicles to be used, although this requires extensive experience and in any event is potentially subject to grave errors. In many places this determination can be made by simple inspection; in others, mainly in wet places, some soil trafficability testing will be necessary. If the reconnaissance is made to interpret trafficability conditions at some time in the future, then it is necessary to determine the kind of soil and its natural drainage condition. Does the soil lie on sloping terrain where excess water runs off, or is it in depressions where water will remain, and may also flow in from an adjacent slope? Is there evidence of seepage from upslope, or drainage impedance downslope? Is the soil permeable? Is there an impermeable layer below the surface foot? Is there evidence of a high water table? Answers to such questions, along with climatic data, are necessary to predict if and when the soil is likely to be wet.

b. *Maps and Reports*. If soils cannot be examined in the field, then the next best step leads to map studies and reports. Analysts should seek soil maps and studies, and accompanying reports; however, material of this type may be scarce. The search must not be limited to items labeled "soils"; frequently there is information about soils, or at least clues to their characteristics, on maps and in reports concerning geology, geography, ecology, forestry, agriculture, climate, vegetation, and other subjects.

c. *Aerial Photography*. The degree to which

Table 4-1. Trafficability Characteristics of Soils in Wet Season

Group	Soils	Unified soil classification system	Probable cone index range	Probable remolding index range	Probable rating cone index range	Slipperiness effects	Stickiness effects	Comments
A	Coarse-grained, cohesionless sands and gravels.	GW, GP, SW, SP	80 to 300	> 1	80 to 300	Slight to none	None	Will support continuous traffic of military vehicles with tracks or with high-flotation tires. Moist sands are good, dry sands only fair. Wheeled vehicles with standard tires may be immobilized in dry sands.
B	Inorganic clays of high plasticity, fat clays.	CH	55 to 165	0.75 to 1.35	65 to 140	Severe to slight	Severe to slight	Usually will support more than 50 passes of military vehicles. Going will be difficult at times.
C	Clayey gravels, gravel-sand-clay mixtures. Clayey sands, sand-clay mixtures. Gravelly clays, sandy clays, inorganic clays of low to medium plasticity, lean clays, silty clays.	GC SC CL	85 to 175	0.45 to 0.75	45 to 125	Severe to slight	Moderate to slight	Often will not support 40 to 50 passes of military vehicles, but usually will support limited traffic. Going will be difficult in most cases.
D	Silty gravels, gravel-sand-silt mixtures. Silty sands, sand-silt mixtures. Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. Organic silts and organic silty clays of low plasticity. Organic clays of medium to high plasticity, organic silts.	GM SM ML and CL-ML MH OL OH	85 to 180	0.25 to 0.85	25 to 120	Moderate to slight	Slight	Usually will not support 40 to 50 passes of military vehicles. Often will not permit even a single pass. Going will be difficult in most cases.

soils information can be interpreted from black and white airphotos varies with many factors, such as quality and scale of the photographs, the nature of plant cover, the nature of the soils themselves and, most important, the skill of the photo interpreter, not only in airphoto interpretation techniques, but also in a knowledge of soils and how they occur in nature. The primary requirement in black and white or color airphoto interpretation of a soil is to determine, so far as is possible, to which of the four trafficability groups the soil belongs. A skilled interpreter generally can determine where soils have good drainage and where they do not, but it must be remembered that airphotos reveal conditions at the time they were made. Airphotos made months or years ago can serve only to indicate the general drainage conditions, although this information alone is important, especially when used along with knowledge about the kinds of soil and moisture-climate relationships. The techniques for identifying soils from any airphotos are so complex that only well trained technicians can employ them to their fullest extent; however, many general facts may be interpreted by personnel with a minimum of training. For instance, orchards usually are planted in well-drained, sandy soils; vertical cuts are evidence of deep loessial (silty) soils; and tile drains in agricultural areas indicate poorly drained soils, probably silts and clays. Light tones on a black and white photo generally indicate higher elevations, sandier soils, and lower moisture content than do dark tones; however, it should be noted that the same tone will not signify exactly the same conditions throughout the same photo, and may have an entirely different significance on two separate photos. Also, natural tones are apt to be obscured and modified by tones created by vegetation, plowed fields, and cloud shadows.

4-18. Snow

a. Snow is considered along with soil because it substitutes partly or entirely for the soil, and because its trafficability behavior is similar to that of soils. Its strength can be measured with the cone penetrometer and its trafficability can be determined. Most snow behaves more like fine-grained soils than coarse-grained.

b. Snow is seldom a critical obstacle for tracked vehicles although it frequently may be a hindrance due to its slipperiness, especially on slopes. However, in spring and fall, it may cover saturated ground. On level or gently sloping terrain,

tracked vehicles, such as tanks, can function reasonably well in snow as deep as 0.9 meter (3 ft) and perhaps even a little deeper. Although there are many places where snow accumulates to depths greater than 0.9 meter (3 ft) such places are commonly forested or mountainous or both and, hence, generally unsuited for movement for reasons other than deep snow.

c. Snow is considerably more of a hindrance and hazard to wheeled vehicles. Light snow just covering the ground may create slipperiness that makes movement of wheeled vehicles difficult, although their capability can be enhanced by tire chains and by reduction of tire pressures. If the depth of snow exceeds 20 to 25 cm (8 to 10 inches), most wheeled vehicles are likely to become immobilized unless the snow is quite dense and hard, and again, depending on the use of high-flotation, low-pressure tires which enhance the capability of wheeled vehicles on snow just as on sand.

4-19. Climate

a. Climate has a unique relationship to cross-country movement, although most of its significant effects are indirect. To a large extent, climate controls the moisture and temperature in soils and thus greatly affects their strength; it also controls the water level and temperature of streams, thereby affecting their obstacle value. Climate also has some direct effects. Fog, a rather common weather phenomenon in some places, may obscure visibility enough to retard movement or even prevent it. Dust storms and snow storms may have the same effect. Also, there are places where extreme temperatures affect adversely the performance of men as well as vehicles.

b. Climatic summaries in which weather data are synopsized by months and years are generally available for most countries of the world, and daily weather records are available for many. Maps showing annual, seasonal or monthly distribution of rainfall or temperature are commonly available. Reconnaissance is of little or no value in obtaining climatic information; neither are airphotos, although some deductions about the general climate can be made from them.

4-20. Hydrology

A hydrologic factor is any surface or subsurface water. Such features become obstacles whenever the water becomes deep enough or turbulent enough to threaten the safety or operation of ve-

hicles and ground water affects soil moisture and, in respect to cross-country movement, is considered along with soil trafficability. Streams, ditches, and canals are linear features. They frequently constitute elongated obstacles in terrain that is otherwise suitable for movement. They have an important effect on direction of movement and, in many areas, make long detours necessary. Ponds, lakes, marshes, swamps, and bogs are areal obstacles rather than linear obstacles. They may impose circuitous routing, but a single pond or small lake commonly does not make long detours necessary.

a. Water bodies vary in their characteristics from time to time depending on weather and climate. Although streams are relatively low and slow during periods of low precipitation and high and rapid during periods of high precipitation, the relationship is not always this simple. Melting snow, for example, may cause high water downstream even in regions where rainfall is low. Continuous below-freezing weather can reduce stream flow even though precipitation may be high. Low temperatures may cause water to freeze over and form ice strong enough to carry vehicles; then, instead of being obstacles, water bodies may become the preferred avenues for movement. Foot troops in single file at a 2-pace interval may move on ice 7.6 cm (3 inches) thick, and lightly loaded 2½-ton trucks may move on ice 25 cm (10 inches) thick; however it must be recognized that movement on ice may entail considerable risk because of weak places such as those caused by water issuing from springs. Stream channels such as wadis also may become preferred avenues for movement during periods of little or no flow, although there may be quicksand or other soft places where vehicles bog down, and there is the danger of flash floods.

b. The ease of crossing streams usually is evaluated in terms of fordability. This depends on the characteristics of both the vehicles and the drainage features. The significant characteristics of drainage features are width of channel, depth and velocity of water, nature of bottom, and height, slope, and strength of banks. These characteristics may vary independently and fording, even of the smallest streams, requires selection of sites where favorable conditions coincide. Streams are no hindrance where fords are available and usable with little or no improvement; they are a hindrance if suitable fords are lacking, or if fording requires considerable preparation of approaches, reinforcement of bottoms, or the use of special

equipment on vehicles. Stream channels no wider than 2.4 meters (8 ft) are no obstacle to the medium tank; however, wheeled vehicles do not have this capability. Once the self-bridging capability of vehicles is exceeded, streams can be crossed only by bridging, ferrying, or fording. The width of a stream, although important to bridging, is of relatively little significance to ferrying and fording except that the wider the stream the greater the hazard involved. For fording, the maximum depth of water permissible for most tanks is between 0.9 to 1.3 meters (3 to 4 ft) and for trucks, about 0.6 to 0.9 meter (2 to 3 ft). Vehicles can be equipped with devices so they can cross water bodies considerably deeper than 1.3 meters (4 ft); but usually they are not so equipped. Unless otherwise instructed, analysts should assume that water-proofing kits are not used.

c. Stream velocities should be less than 1.5 meters (5 ft) per second for reasonably safe fording. The bottom of stream channels must be firm enough to support the vehicles. Bottoms made up of fine-grained material can prevent fording even though the water may be only a few centimeters deep. Suitable bottoms are restricted to those that are sandy, gravelly, or rock, but even sandy bottoms may give way to the weight of vehicles or boulders may prevent vehicular movement. The banks also are important. Hard, vertical banks will be obstacles to tanks if their height exceeds 1.3 meters (4 ft), and to trucks if their height exceeds about 0.3 meter (1 ft). Greater heights can be tolerated if the bank slopes are less than 45 percent and provided the vehicles can get adequate traction. The strength of the material composing the banks may be significant. Banks made up of fine-grained soils may give way under the weight of vehicles. Sandy and gravelly materials are likely to provide adequate strength, although exceptions can occur.

d. Reasonably adequate information is commonly available on large streams, but not for the small ones. Every stream is a potential obstacle and, as there are many more miles of small streams than of large, the problem of obtaining information pertains mainly to small streams, ditches and canals. Reconnaissance is the best source of information; for many areas it is the only reliable source. Topographic maps and geographic maps and reports, along with aerial photos, are often the best sources of information generally available, but occasionally useful data can be found in publications on geology, agriculture, soils, and forestry.

4-21. Vegetation

a. Vegetation includes not only the so-called natural vegetation but also crops grown by farmers. The primary concern in cross-country movement is with forest vegetation; trees are the principal obstacles to movement. Although grass and brush also have some effect, it is of relatively low significance. Nearly all forests have a slowing effect on movement. The problem is not whether forests will slow movement but whether they will slow movement slightly, drastically, or make it altogether impracticable.

b. Fully dependable criteria pertaining to the size of trees, and the significance of species and root systems have not been determined. Medium tanks, for example, have pushed over single trees as much as 30 cm (12 inches) in diameter, but this diameter is too large for use in a practical evaluation of forests. The overturning of trees within stands can also create complications; for example, if several trees are pushed over, some will not fall clear but will interlock with other trees to form a new obstacle to movement. Another difficulty can arise from the protruding root system of overturned shallow-rooted trees. The maximum diameter of trees practical for medium tanks to push over is considered to be between 15 and 20 cm (6 and 8 inches), although trees somewhat less than 15 cm (6 inches) in diameter may create problems if they are very close together. The maximum diameter of trees feasible for 2½-ton trucks to push over is considered to be between 2.5 and 5.0 cm (1 and 2 inches).

c. The critical average distance between trees in forests where the trees are too big to be pushed over is between 4.5 and 6.5 meters (15 and 20 ft) for both tanks and trucks. This distance is greater than the width of the vehicle but makes allowance for turning. In some managed forests where trees grow in rows the permissible distance between them may be considerably less than 6.5 meters (20 ft) but cannot be much less than 4.5 meters (15 ft).

d. Brush or tall grass may impair visibility for drivers of tanks and trucks and may obscure obstacles such as stumps and boulders. Brush that hinders or stops trucks will have little or no deterring effect on tanks; in fact, brush may enhance conditions for tanks by spreading the load over a greater ground surface. Low-growing vegetation less than 1 meter (3 ft) tall has no significant effect on movement except where it obscures obstacles or where there is a grass sod; the sur-

face of sod may be slippery enough to cause trouble, particularly where the slope is steep. Grassy sod does not add enough strength to the surface of weak soils to be of consequence because most military vehicles are so heavy that they simply cut through it.

e. Reconnaissance is especially important as a source of information about vegetation because two of the characteristics essential to sound evaluation, namely, the size of trees and the distance between them, are seldom recorded and frequently are difficult to determine from aerial photography. Maps and reports that are likely to be of most value are those dealing with vegetation, particularly forests; but useful information may also be found in publications that are not titled "vegetation" or "forest." Among these are agricultural reports and also reports on soils, geology, and geography. Maps and reports commonly provide information on the principal species of trees, grasses, etc., but less commonly do they provide information on diameter of trees; rarely do they contain data on the distance between trees. Foresters, botanists and ecologists are best prepared to interpret the probable spacing and the size of trees. Aerial photography is very useful, but even on photos the determination of spacing between trees is very difficult or even impossible. The problem of evaluating forests from literature and airphotos is obviously difficult and, for many areas, cannot be done reliably without some reconnaissance. Since forests may be, and frequently are, altered by thinning or cutting, or by burning, information must be recent if it is to be highly reliable.

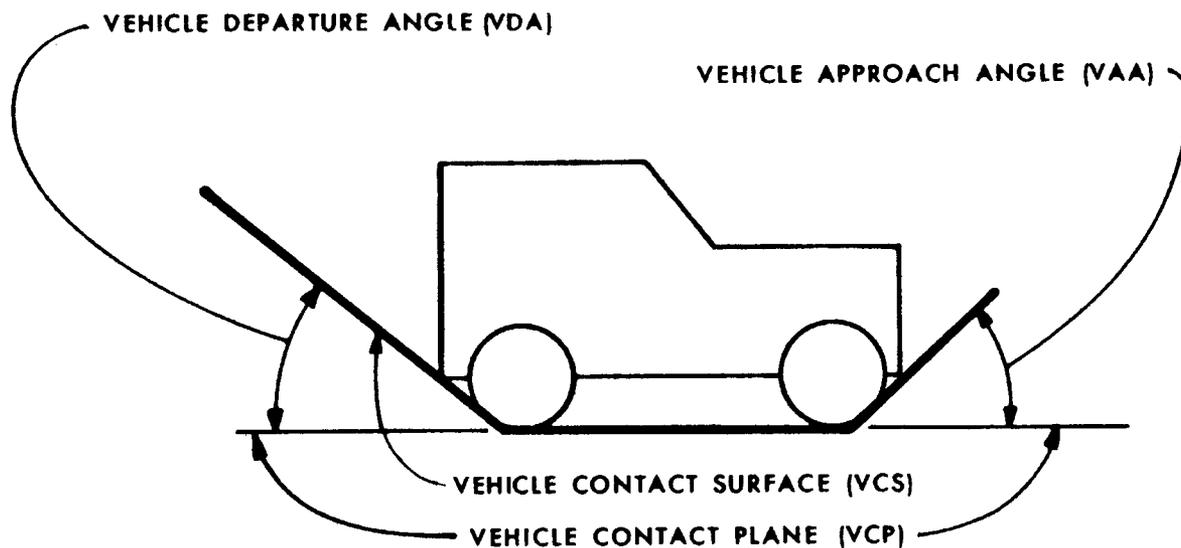
4-22. Culture Features

a. Culture features are the works of man, such as stone walls, hedgerows, dikes, canals, cuts, fills, built-up areas, etc. Some of these features are considered under the factor of slope, some under streams, and some, such as built-up areas, are usually not evaluated in cross-country movement studies. Nevertheless, culture features are treated as a separate factor to insure that they are not overlooked in evaluating terrain for cross-country movement.

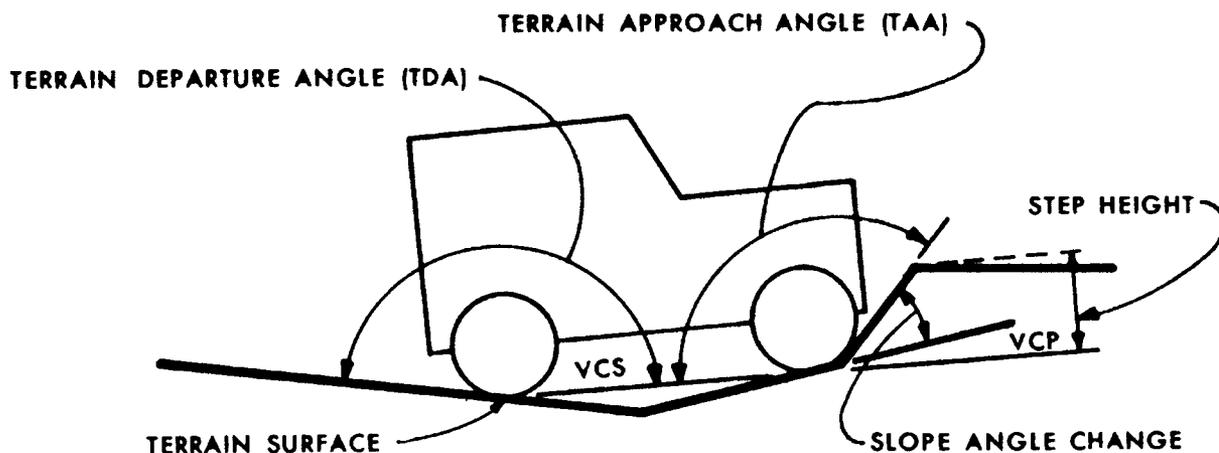
b. Many culture features act as deterrents or obstacles to movement. A stone wall may be a serious obstacle unless the sheer weight of a vehicle pushes it over; therefore the height and thickness of such walls may determine their obstacle value. The height of embankments as well as the

slope on either side determines their obstacle value. Embankments more than 3 meters (10 ft) high with side slopes greater than 45 percent are likely to be serious obstacles; cuts have similar significance. The critical values cited for streams apply to ditches and canals as well, but in addition, embankments of various heights may occur alongside these features and increase their obstacle value. Large gravel pits or areas where strip mining has taken place may present obstacles or traps for vehicles. These too must be evaluated, particularly on their slope and soil characteristics.

c. Information on culture features that may be relevant to cross-country movement is frequently difficult to obtain unless reconnaissance can be conducted. Some of the features can be interpreted from airphotos and some may be shown on topographic maps, but dimensions, which are highly important to cross-country movement, are frequently difficult to find or to estimate. Geographic reports may be helpful but no single kind of publication is likely to have the data needed as a consistent characteristic. Considerable resourcefulness is required in seeking out relevant information on culture features.



a. VEHICLE TERMS



b. TERRAIN - VEHICLE TERMS

Figure 4-2. Vehicle and terrain terms used in predicting obstacle effect of slope.

4-23. Vehicle Characteristics

a. Vehicle characteristics are those vehicle parameters and performance data that are important considerations when predicting the cross-country movement capability of a particular military unit. Each military vehicle has different characteristics that limit or enhance its capability to maneuver over various terrain situations.

b. Figure 4-2 shows the various vehicle terms and terrain-vehicle terms used in predicting the obstacle effect of slope on cross-country movement. The critical factor in a comparison of the terms is the change of slope of the terrain versus the maximum slope change a vehicle can negoti-

ate. If the change in slope angle is greater than the vehicle approach angle, then the vehicle cannot negotiate this change; thus the change in slope creates an obstacle for the vehicle in question. The step height or vertical change in elevation is also of primary importance. Step height is compared with the minimum vehicle clearance; step heights exceeding the vehicle clearance coupled with slope change create an obstacle for the vehicle. In many cases the microrelief features of an area (rice paddy dikes, ditches, etc.) are determining factors in cross-country movement.

c. Table 4-2 lists the seven vehicle categories according to a cone index range. These categories can be used when mapping soils trafficability.

Table 4-2. Vehicle Categories

Category	Vehicle cone index range	Vehicles
1	20-29	The M29 Weasel, M76 Otter, and Canadian snowmobile are the only known standard vehicles in this category.
2	30-49	Engineer and high-speed tractors with comparatively wide tracks and low contact pressures.
3	50-59	The tractors with average contact pressures, the tanks with comparatively low contact pressures, and some trailed vehicles with very low contact pressures.
4	60-69	Most medium tanks, tractors with high contact pressures, and all wheel-drive trucks and trailed vehicles with low contact pressures.
5	70-79	Most all-wheel-drive trucks, a great number of trailed vehicles, and heavy tanks.
6	80-89	A great number of all-wheel-drive and rear-wheel-drive trucks, and trailed vehicles intended primarily for highway use.
7	100 or greater	Rear-wheel-drive vehicles and others that generally are not expected to operate off roads, especially in wet soils.

Section III. WATER SUPPLY

4-24. Importance

An adequate supply of water for drinking, sanitation, construction, and vehicles is a fundamental requirement in any military operation. Entire campaigns in desert lands may be conducted solely to secure water sources or to deny them to an enemy. All feasible sources and methods for developing them must be considered when making plans for water supply. Development data are obtained from reconnaissance, map study, reports on runoff and rainfall average, and geological surveys. Detailed information concerning water supply is contained in TM 5-700.

4-25. Source

Water may be obtained from wells, streams, springs, lakes, and municipal or other supplies that are already developed. Investigations to

select a water source must consider the quantity and quality of the water, and the conditions at the proposed supply site.

a. *Quantity.* The quantity of water available in an area depends chiefly upon the climate. In temperate and tropical regions with less than 60 centimeters (25 inches) of annual precipitation, most streams become dry in drought periods. Streams usually flow throughout the year in temperate regions with more than 60 cm of annual rainfall and in tropical regions where the rainfall exceeds 90 to 100 centimeters (35 to 40 inches). Seasonal variations may reduce the flow below the required amount or result in water points being flooded by seasonal high water periods. Terrain studies should indicate alternate sources for use in case the selected primary sources dry up, become flooded, or cannot be used because of enemy action.

b. Quality. Color, turbidity, odor, taste, mineral content, and contamination determine the quality of water. TM 5-700 gives methods for estimating these characteristics and describes the use of standard test kits. Quality will vary according to the source and the season, the kind and amount of bacteria, and the presence of dissolved matter or sediment. Streams in inhabited regions commonly are polluted, with the sediment greatest during flood stages. Streams fed by lakes and springs, with a uniform flow, are usually clear and vary less in quality than do those fed mainly by surface runoff. Water in large lakes generally is of excellent quality, the purity increasing with the distance from shore. Very shallow lakes and small ponds are usually polluted.

c. Site Requirements. The ease with which a water source can be developed, operated, and maintained is determined largely by the location and the routes of communication. The design of the collecting system and the difficulties of development, operation, and maintenance are partially influenced by site conditions, topography, soils and vegetation. A military water point should be located as close as possible to a main route without interfering with traffic. In locating the water point, attention is given to concealment and cover, possible nearby targets which may attract enemy fire, drainage, road connections, condition of the banks and the bed if surface water is being drawn, and the facilities required to develop the source. Existing water supply systems are used when carefully checked by engineers and medical authorities. Purification units may have to be installed. The possibility of contamination by enemy agents also must be considered.

4-26. Surface Water

Surface water sources are generally more accessible and adequate in plains and plateaus than in mountains. Large amounts of good quality water normally can be obtained in coastal, valley, or alluvial and glacial plains. Although large quantities are available in delta plains, the water may be brackish or salty. Supplies are scarce on lacustrine, loess, volcanic, and karst plains. In the plains of arid regions, water usually cannot be obtained in quantities required by a modern army; much that is available is highly mineralized. In the plains and plateaus of humid tropical regions, surface water is abundant, but is generally polluted and requires treatment. Perennial surface water supplies are difficult to obtain in

Arctic regions; in summer it is abundant but often polluted.

a. Springs and Seeps. Springs or seeps originating at the base of steep slopes where the topography breaks abruptly, usually have a perennial flow of fresh, cold water. While spring water is generally clear, cool, and low in organic impurities, it may be hard because of fairly high mineral content. Those caused by the fracture or displacement of confining clay or rock layers above an artesian water-bearing formation (aquifer), often are thermal, and may contain excessive amounts of minerals. In regions where seasonal rainfall varies greatly, the spring flow often decreases during long periods of dry weather. Heavy infiltration of surface water causes some springs to become turbid, and may produce contamination.

b. Streams. Streams are the most common source of surface water supply. Streamflow may vary with precipitation, temperature, and the amount of vegetation. Turbidity and mineral content vary with the flow and with watershed conditions. Since large flows produce high dilution, they may be suitable sources of water supply although they receive raw or partially treated sewage; however, water from such streams must be settled, filtered, and chlorinated before use.

c. Lakes. Ordinarily, lakes are a satisfactory source of water supply. The water level and average yield in small lakes may vary. Many lakes receive sewage flow, have a high content of dissolved minerals, and may have considerable vegetative growth or contain vegetable or animal organisms. These can usually be removed by purification processes.

4-27. Ground Water

Ground water is obtained without difficulty from unconsolidated or poorly consolidated materials in alluvial valleys and plains, streams and coastal terraces, glacial outwash plains, and alluvial basins in mountainous regions. Areas of sedimentary and permeable igneous rocks may have fair to excellent aquifers, although they do not usually provide as much ground water as areas composed of unconsolidated materials. Large amounts of good-quality ground water may be obtained at shallow depths from the alluvial plains of valleys and coasts, and in somewhat greater depths in their terraces. Aquifers underlying the surface of inland sedimentary plains and basins also provide adequate amounts of water. Abundant quantities of good-quality water generally can be obtained

from shallow to deep wells in glacial plains. In loess plains and plateaus, small amounts of water may be secured from shallow wells, but these supplies are apt to fluctuate seasonally. Water from wells usually is clear and low in organic impurity, but may be high in dissolved mineral content.

a. Plains. Large springs are the best sources of water in karst plains and plateaus. Wells may produce large amounts if they tap underground streams. Shallow wells in low-lying lava plains normally produce large quantities of ground water. In lava uplands, water is more difficult to find, wells are harder to develop, and careful prospecting is necessary to obtain adequate supplies. In wells near the seacoast, excessive withdrawal of fresh water may lower the water table, allowing infiltration of salt water which ruins the well and the surrounding aquifer. Springs and wells near the base of volcanic cones may yield fair quantities of water, but elsewhere in volcanic cones the ground water is too far below the surface for drilling to be practicable.

b. Climate. Plains and plateaus in arid climates generally yield small, highly mineralized quantities of ground water. In semiarid climates, following a severe drought, there frequently may remain a flow of subsurface water under an apparently dry streambed that may yield considerable amounts of excellent water. Ground water is abundant in the plains of humid tropical regions, but usually it is polluted. In arctic and subarctic plains, wells and springs fed by ground water above the permafrost are dependable only in summer; some of the sources freeze in winter, and subterranean channels and outlets may shift in location. Wells that penetrate aquifers within or below the permafrost are good sources of perennial supply.

c. Hills. Adequate supplies of ground water are hard to obtain in hills and mountains composed of gneiss, granite, and granitelike rocks. They may contain springs and shallow wells that will yield water in small amounts.

Section IV. SPECIAL OPERATIONS

4-28. Amphibious Operations

Amphibious operations require detailed studies of hydrography, weather, climate, and terrain. A technical discussion of the requirements and preparation of these studies is beyond the scope of this manual. They are covered in detail in FM 60-30, FM 31-11, and FM 31-12, which also describe the characteristics, tactics, and techniques of amphibious operations.

a. Weather. All phases of an amphibious operation are directly influenced by weather conditions and climate. Weather affects the tides, beaching and unloading conditions, speed of vessels, air support, and visibility. Poor weather conditions may provide cover for the amphibious force, but favorable weather is essential for the actual landing and during the initial build-up that follows. Excessive sea and swell jeopardize the entire operation.

b. Location. The ideal beach for an amphibious landing is one with no obstructions in the sea approaches; deep water close inshore; nearshore gradients sufficiently deep for dry-ramp beaching of landing craft and ships; soil composed of firm sand with gentle gradients; small tides; and no currents, or surf. The beach terrain should be gently rising, relatively clear, and with a firm sur-

face that has adequate drainage. Flat or gently rising terrain, backed by a coastal range high enough to mask the landing area, is the most desirable for landing operations. Ideal conditions are rarely found, so suitable areas must be evaluated to determine those that come nearest to the optimum requirements.

c. Coastal Plain. A landing on a wide coastal plain provides unrestricted maneuver room and a subsequent advance from the beach can be made in any direction. Boundaries and objectives are hard to locate on this type of terrain, however, and there are few prominent registration points for artillery, naval gun fire, and aerial bombardment. Usually there is no good defensive terrain on the flanks of the beach head, so that more troops are required to protect the flanks. It is also important to remember that coastal plain beaches are often contiguous to marshy and swampy terrain which may hinder movement from the beach.

d. Coastal Ridge. Terrain that rises evenly to a considerable distance back from the beach gives the defender excellent observation and fields of fire. More commonly, the coastal area remains flat for some distance and then rises abruptly to a coastal ridge.

e. Dunes. Ground that is sharply broken by ex-

tensive dunes or a low coastal plateau provides the attacker with concealment from the defender's observation. The small compartments and corridors limit the range of defensive fire. Direction and control may be extremely difficult.

f. Mountains. Mountains located directly on the sea usually limit the number of beaches large enough to accommodate a landing force of effective size. Where steep ground is lightly defended or neglected by the defender, a small force may seize it and gain surprise. Airborne or airmobile troops may be used to block the movement of defensive reserves to the landing area, or to secure passes through the mountains and thus prevent the defender from interfering with the amphibious landing.

4-29. Collection Checklist—Beaches and Landing Areas

1. *Identification.* Local name and military designation.
2. *Location.*
 - a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b. Political unit, area, UTM coordinates and geographic coordinates of the end points of landing place.
 - c. Landmark reference—Description and location of landmark, and azimuth and distance from landmark to end point.
3. *Related water body or watercourses.* Cross reference to appropriate collection file.
4. *Length between end points.*
5. *Seashore form.* Concave, convex, or straight.
6. *Coastal terrain type.* Emergent, submergent, compound, coral reef, delta, volcanic, fault, man-made, etc.
7. *Alinement.* High water shoreline and low water shoreline.
8. *Beach width at low water.*
9. *Beach width at high water.*
10. *Backshore.*
 - a. Slope.
 - b. Material (composition, texture, and trafficability).
 - c. Obstacles.
 - d. Vegetation.
11. *Foreshore.* (Same information as 10 above.)
12. *Nearshore.* (Give alinement and distance from low water shoreline.)
 - a. 10 meters (5 fathoms) depth line at low water.
 - b. 6 meters (3 fathoms) depth line at low water.
 - c. 4 meters (2 fathoms) depth line at low water.
 - d. 2 meters (1 fathom) depth line at low water.
 - e. Obstacles (shoals, sandbars, rocks, fishtraps, etc).
 - f. Reefs (item 13 below).
13. *Reefs, nearshore and offshore.*
 - a. Type and location.
 - b. Distance from low water shoreline.
 - c. Length and width.
 - d. Slope (direction).
 - e. Depth to surface of reef at low tide.
 - f. Depth to surface of reef at high tide.
 - g. Height of surface above water at high and low tide.
 - h. Effects of surf.
 - i. Effects on tide.
 - j. Channel through reef (alinement, width, and depth at low water).
14. *Offshore conditions.*
 - a. Water depth.
 - b. Offshore islands (location and characteristics).
 - c. Reefs (item 13 above).
 - d. Sandbars (item 15 below).
 - e. Obstacles (type, location, and characteristics).
15. *Sandbars.*
 - a. Location and distance from low water shoreline.
 - b. Length and width.
 - c. Consistency.
 - d. Slope (seaward and landward).
 - e. Passages (alinement, width, and depth).
 - f. Depth at high and low water.
16. *Beach features.* Natural and manmade; cusps, runnels, stream mouths, groins, piers, out-fall pipes, etc.
 - a. Type and location.
 - b. Number and extent.
 - c. Bypass possibilities.
 - d. Influence on operations.
17. *Tide.*
 - a. Type (diurnal, semidiurnal, or mixed).
 - b. Type range (spring, tropic, and diurnal).
 - c. Range.
 - d. Meteorological effects.
18. *Surf.*
 - a. Breakers (type, average height, distance formed from shore, and number of lines).
 - b. Period.
 - c. Width of surf zone.

- d.* Direction from which swells approach coast.
- e.* Weather and seasonal effects.
- 19. *Currents.* Location, direction, and velocity.
- 20. *Beach exits.*
 - a.* Type and location.
 - b.* Number and condition.
- 21. *Coastal terrain.* Cross reference to appropriate collection file.
 - a.* Critical terrain features (location, type, bypasses, and influence on operations).
 - b.* Obstacles (location, type, extent, bypasses, and influence on operations).
 - c.* Cross country movement (troops, wheeled vehicles, and tracked vehicles).
- 22. *Support area cover and concealment.*
- 23. *Dispersal and storage area.* Location and description.
- 24. *Availability of fresh water.* Location and quantity.
- 25. *Defenses.* Location and type.

CHAPTER 5

TRANSPORTATION

Section I. INTRODUCTION

5-1. Significance of Transportation

a. The transportation facilities of an area consist of all highways, railways and waterways over which troops or supplies can be moved. The importance of particular facilities will, of course, depend on the units involved and the type of operations. The ability of an Army to carry out its mission depends greatly on its transportation capabilities and facilities.

b. One of the primary considerations in planning large-scale operations is the extent and general nature of the transportation network. Planners must consider the entire pattern of transportation facilities. An area with a dense transportation network, for example, is favorable for major offensives. One that is crisscrossed with canals and railroads, but possesses few roads, will limit the use of wheeled vehicles and the maneuver of armor and motorized infantry. Railroads extend-

ing along the axis of advance will assume greater importance than those perpendicular to the axis, and the direction of major highways and waterways assumes equal significance.

5-2. Transportation Intelligence

a. In preparing terrain studies and in planning military operations, all transportation facilities must be carefully evaluated to determine their effect on the proposed operations. Recommendations may be made to destroy certain facilities or to retain them for future use after the operation has been completed. Usually, each major facility is the subject of a detailed study by military intelligence personnel.

b. Transportation intelligence can be no better than the information from which it is derived. For a detailed discussion of transportation intelligence refer to FM 55-8.

Section II. HIGHWAYS

5-3. General

a. The term "highway" has a much broader meaning for intelligence purposes than for everyday usage. It includes all types of roads and trails, from multilane superhighways to ordinary pack trails and footpaths. All associated structures and facilities necessary for movement and for protection of the routes, such as bridges, ferries, snowsheds, tunnels, fords and the like, are considered as integral parts of the highway system.

b. An adequate highway system is a fundamental requirement in the conduct of any major military operation. Military interest in highway intelligence of a given area or country covers all physical characteristics of the existing road-track-trail system and the various administrative and operational aspects pertaining to construction and maintenance. Terrain studies must provide infor-

mation on the existing routes and any major repair or rehabilitation that may be required, as well as information on where new routes will be needed to support a planned operation.

c. Routes in the combat zone usually need meet only minimum standards, but those in rear areas, especially in the vicinity of water terminals, airfields, and supply installations must be well surfaced and capable of carrying heavy traffic without excessive maintenance. Operations on a wide front and the employment of nuclear weapons will require a large number of secondary routes in both forward and rear areas. The information presented in a terrain study should indicate the minimum maintenance and construction requirements that may be anticipated during a planned operation. In addition to the severe abuse given to roads by large volumes of heavy traffic, important bridges, intersections, and narrow defiles are pri-

mary targets for enemy bombardment. The maintenance of unnecessary routes must be avoided, and the construction of new routes held to a minimum.

5-4. Highway Classification

a. *Route Types.* Routes usually are classified as follows:

(1) *All weather route (type X).* Any route which with reasonable maintenance is passable throughout the year to a volume of traffic not less than its maximum capacity. A road of this type has a waterproof surface, adequate drainage, and is only slightly affected by precipitation or temperature fluctuations. At no time is it closed to traffic by weather effect other than snow blockage. These routes are paved with concrete, bituminous surfacing, brick, or paving stone.

(2) *All weather route (type Y).* Any route which with reasonable maintenance can be kept open in all weather, but sometimes only to traffic considerably less than maximum capacity. A road of this type does not usually have a waterproof surface and is considerably affected by precipitation or temperature fluctuations. Traffic may be halted completely for short periods. Heavy use during adverse weather conditions may cause complete collapse of the surface. Crushed or water bound macadam, gravel, stabilized soil, or sand clay, are typical surfaces on roads in this group class.

(3) *Fair weather route (type Z).* A route which quickly becomes impassable in adverse weather and cannot be kept open by maintenance short of major construction. This type of route is so seriously affected by weather that traffic may be brought to a halt for long periods. Roads in this class have surfaces of natural or stabilized soil, sand clay, shale, cinders, laterite, and/or other light aggregate.

b. *Military Route Classification.* Military routes are also classified according to their location and use:

(1) *Axial route.* A part of the military road network that leads toward the front and is generally perpendicular thereto. When designated as the principal traffic artery of a division or higher unit, such a route is termed a main supply route (MSR). When designated the principal traffic artery of a brigade or battalion, such a route is termed a supply route (SR).

(2) *Lateral route.* A route which generally parallels the front and leads into and across axial routes.

(3) *Reserved route.* A controlled route allocated exclusively to a command or unit, or intended to meet a particular requirement.

(4) *Supervised route.* A route over which control is exercised by means of traffic control posts, traffic patrols, or both.

(5) *Dispatch route.* A route over which full control, both priority and regulation of traffic, is exercised.

5-5. Design

For all classes of roads, the design includes cross-section elements, horizontal and vertical elements, and surface types. These data are of military significance because traffic capacity, load bearing capacity, maintenance, and reconstruction of a road depend on its original design and construction (TM 5-330).

a. *Cross-Section Elements.* The terms used to describe parts of a road cross section are illus-

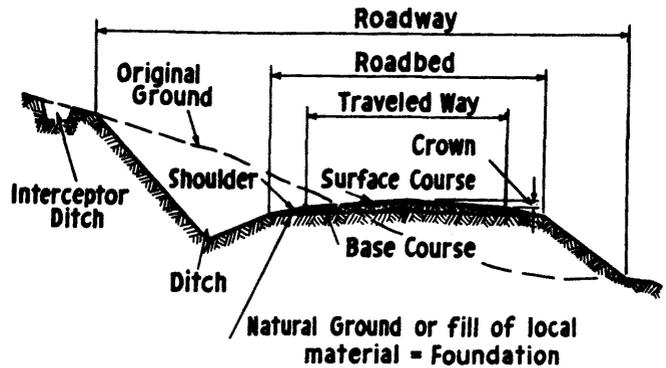


Figure 5-1. Typical cross section illustrating road nomenclature.

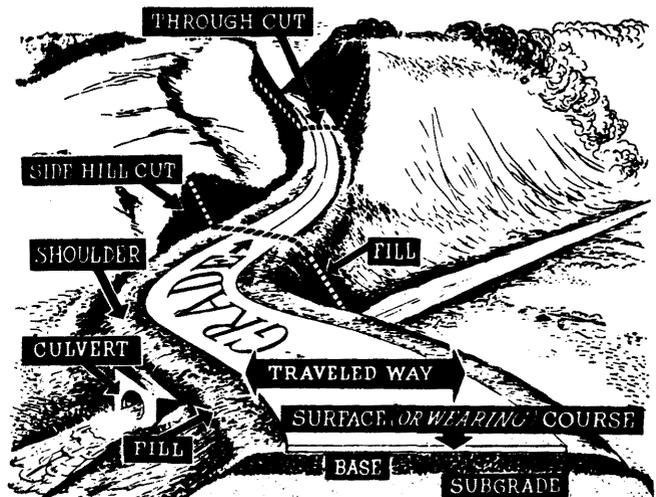


Figure 5-2. Perspective of road, illustrating nomenclature.

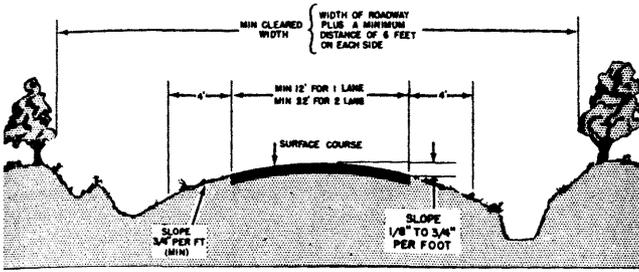
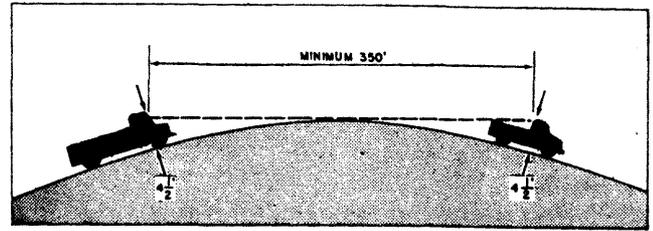
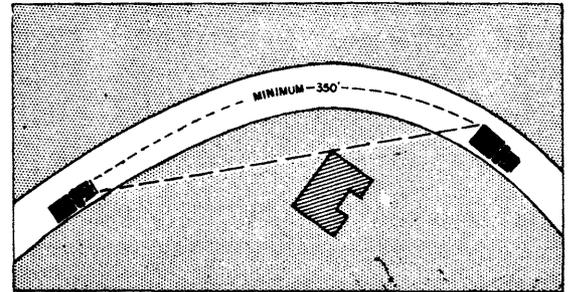


Figure 5-3. Typical cross section illustrating road design standards.



VERTICAL CURVE



HORIZONTAL CURVE

Figure 5-5. Minimum passing sight distances for vertical and horizontal curves.

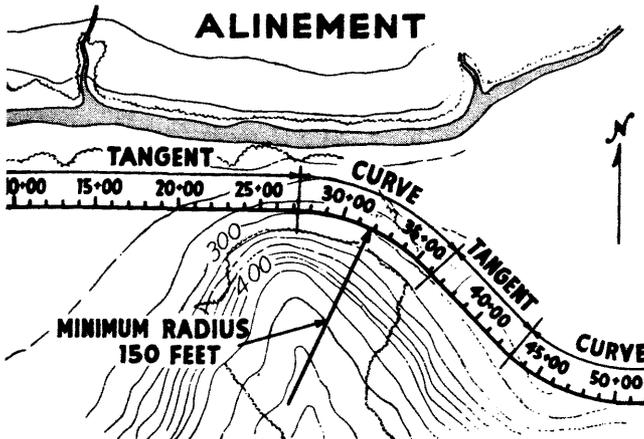


Figure 5-4. Alinement showing tangents and curves.

trated in figures 5-1 and 5-2. Typical road design standards are shown in figure 5-3. The following cross-section elements are basic information requirements.

b. Horizontal and Vertical Alinements. Curves (fig. 5-4 and 5-5) and grades (fig. 5-6) are major considerations in determining the traffic capacity of a road. Design standards of these elements provide valuable military data.

c. Road Surfaces. Surfaces are included in road design standards because they are basic to the overall usability of a road.

5-6. Construction and Maintenance

Problems which prevent effective highway maintenance, or which make it abnormally expensive and slow, are of military significance. Information on those factors which affect maintenance will also indicate the limitations or possibilities of new construction. Although the construction of new highways must be avoided whenever possible, there are times when it is necessary to accomplish the mission, and the same criteria applies in situations where there is no choice but to perform

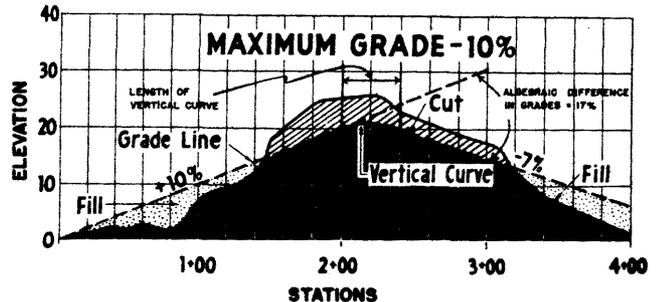


Figure 5-6. Profile of road.

major maintenance on existing roads. Therefore, all factors pertaining to construction and maintenance must be considered.

a. Terrain. Swamps, bogs, and lowlands such as delta areas may create special problems of drainage and may require added support to the roadbed or the construction of many bridges. Rugged topography may result in steep grades and sharp curves, tunneling, bridging, cuts, fills, and sidehill locations in laying out new roads. Sidehill locations, in turn, may require retaining walls, cribbing and snowsheds for protection against earth, rock, or snowslides. In the desert, sand fences and special crews may be required to keep the roads clear of drifting sands. Arctic terrain requires special techniques to build and maintain roads on permafrost and periodically frozen ground.

b. Weather and Climate. Sustained periods of freezing, heavy snowfall, and similar extreme weather conditions may seriously affect the construction, use, and maintenance of roads. Protection must be provided against snowdrifts, and provisions must be made to remove the snow and to repair damage due to frost heave and frost boils. Excessive rainfall can cause washouts and floodings in low areas, and earth and rock slides in rugged terrain. Continuous wet weather may make unsurfaced roads impassable. In dry periods, dust control becomes an important factor on unsurfaced roads.

c. Design and Construction. Terrain intelligence should include an engineering evaluation of the structural soundness of roads being considered for use. If the initial design did not provide for the increased loads and speed that accompany a military operation, or if the road was improperly constructed, it may prove to be a serious obstacle to movement. Unstable subgrade, inadequate drainage, sharp curves and loose or unsealed wearing surfaces may require major repairs and excessive maintenance.

d. Inadequate Maintenance. Poor maintenance of a road is shown by clogged culverts and ditches, potholes, bumpy and rutted surfaces, soft and uneven shoulders, and badly worn and cracked surfaces. Collectors of information should indicate where such conditions exist and the maintenance that would be required to bring the roads up to minimum military standards.

e. Trafficability. The trafficability of a road is affected in different ways by various types of soil. For example, sandstone affords excellent trafficability when dry, but is reduced to good trafficability when wet. A clay surface is rated as fair when dry, but it becomes impassable when wet.

5-7. Information Collection

a. The criteria for selecting highways on which information is collected and processed varies with the requirements of the producing command and from country to country. In areas with highly developed transportation systems, minor highways and tracks may be omitted, whereas, in undeveloped areas, every road and trail may be significant.

b. Highways are selected primarily for their suitability to serve as through routes or to provide connections to strategic points such as ports, airfields, railheads, and important cities. Included

also are other roads which can serve as connections between and alternates to portions of the through routes. In some cases it may be necessary to treat roads of the lowest classification in order to provide access to all parts of the study area. All physical features and installations that may limit or significantly influence movement on the selected routes should be treated.

5-8. Reporting Procedures

a. Detailed procedures for collecting, evaluating, and reporting data on highways are contained in FM 5-36, Route Reconnaissance and Classification. Also included are signs, markings, tables, sketches, diagrams, photographs and other illustrations which describe the procedures and reports used in route reconnaissance. The details presented in FM 5-36 are not repeated in this manual; therefore, personnel engaged in the collecting of information on transportation routes should refer to FM 5-36 for necessary administrative and technical details.

b. Standard terminology and methods of reporting, classifying, and marking highways have been approved for use by member nations of the North Atlantic Treaty Organization (NATO), the Southeastern Treaty Organization (SEATO) and the United States, United Kingdom, Canadian, and Australian Armies Nonmateriel Standardization Program. The format and symbols used in reporting this information are based on agreements between these organizations. In appropriate paragraphs of FM 5-36, applicable promulgating agreements—International Standardization Agreement (STANAG), SEATO Standardization Agreement (SEASTAG) and Standardization of Operations and Logistics (SOLOG)—are identified by short title and number. That manual also contains a compilation of related standardization agreements.

c. The principal tools used for the recording and reporting of highway information are maps and overlays, DA Form 1249 (Bridge Reconnaissance Report), DA Form 1250 (Tunnel Reconnaissance Report), DA Form 1251 (Ford Reconnaissance Report), and DA Form 1252 (Ferry Reconnaissance Report).

5-9. Sources of Information

The principal sources of information on highways are maps, route logs, aerial and ground photographs, publications, direct observation, and friendly natives.

a. Maps. Highway maps, topographic maps, town plans, and atlases contain much information on highway types, basic road patterns, international connections, mileages, number of traffic lanes and road surfaces. Up-to-date maps may be obtained from map making organizations, agencies in charge of public works and transportation, bookstores, motor clubs, travel bureaus, oil companies, and service stations.

b. Route Logs. A route log is the basic intelligence instrument for highways. It provides detailed route descriptions using mile or kilometer post locations; the width, and other characteristics of highway surfaces; bridges, tunnels, fords, ferries, snowsheds and galleries; bottlenecks of all types; clearances; curves; gradients; and repair and servicing facilities. Documents of this type are usually available at government agencies responsible for public works or transportation. Partial information may be obtained from engineering publications available in bookstores.

c. Photographs. Both aerial and ground photographs are valuable sources for supplementing detailed information on highways, especially for structures. They may be obtained from government highway departments, construction organizations, photography companies, technical publications, and manufacturing brochures.

d. Publications. Many publications which can be found at bookstores, government agencies, libraries, bus terminals, travel bureaus and private organizations, are valuable sources of information. The following types are most readily available to the collector.

(1) Newspapers and magazines often contain articles dealing with new construction and maintenance.

(2) Technical publications such as engineer textbooks, technical reports, serial periodicals, and brochures contain information on highway plans and projects, construction and maintenance, design specifications, structures, and construction equipment.

(3) Traffic regulations, and the related booklets and pamphlets, provide information on traffic rules, road guidance, warning and regulatory signs and signals, and other traffic control means.

(4) Statistical yearbooks contain mileages by types of roads; number of structures; equipment inventories; vehicles; data on traffic carried by various modes of transportation; and labor statistics on administration, construction and maintenance.

(5) Bus timetables, guidebooks, and other tourist literature contain information and photographs on routes and terminals.

(6) Construction plans and projects give data for the development of new highways or describe expansion, reconstruction, or improvement of existing highways. They may also contain route logs of individual highways, diagrams showing typical cross-sectional views of the roadway, and drawings of principal structures.

(7) Manufacturing catalogs, brochures, and advertising documents contain information on construction equipment and methods, and engineering procedures.

e. Direct Observation. Direct observation may be used to fill specific gaps in information. Normally, however, it should be undertaken only after all other means of gathering data have been exploited. In countries where security restrictions prohibit or restrict access to published material, direct observation may be the only reliable method of obtaining information. Personnel charged with such collection should prepare detailed collection plans. Reconnaissance trips should be concentrated on roads that carry the heaviest traffic, connect key urban areas, or have other strategic importance. In an underdeveloped country, the highways selected may include all existing roads. FM 5-36, Route Reconnaissance and Classification, is the guide for collecting highway information by direct observation.

f. Native Citizens. Cooperation with the citizens of friendly foreign countries and with refugees from unfriendly foreign countries can help the collector, either by advising him on sources of information or by supplying the required information. Prior to such contacts, the collector should consult with the senior US official in the country.

5-10. Information Requirements

As explained in the introductory chapter of this manual, major developments now underway are designed to improve the handling and production of geographic and terrain intelligence through the use of automatic data systems. In keeping with these developments, information requirements on highways, as well as all other transportation facilities, are reflected in the same detailed format to be used in the automated systems. These requirements, or data tags, provide a uniform, Army-wide checklist for the collection of information in any country or locality, either by manual or auto-

mated methods. They should also provide commanders and other users of information a better understanding and greater appreciation for the magnitude of data which will be available within the system.

5-11. Collection Checklist—Highways

1. *Identification.* Route designation (native, military or other) and segment being studied.
2. *Route type.* Type X-all weather; type Y-all weather, limited traffic due to weather; type Z-fair weather; track; or trail.
3. *Location.*
 - a. Map reference—Include series and sheet number(s) on both tactical and air-ground series.
 - b. End points of segment—Political unit, area, UTM coordinates, and geographic coordinates.
4. *Length of segment in kilometers.*
5. *Load class of lowest class bridge.*
6. *Road classification formula (FM 5-36).*
7. *Grades.*
 - a. Number exceeding 7 percent.
 - b. Maximum grade in percent.
 - c. Location of grades exceeding 7 percent (kilometer distance from end points; direction from end points; and UTM coordinates of top and bottom of grade).
8. *Bridges.* Any structure spanning gaps greater than 6 meters.
 - a. Total number on segment.
 - b. Number greater than 18 meters.
 - c. Cross reference to bridge collection file (para 5-24).
9. *Culverts.* Any structure spanning 6 meters or less. Include location (UTM Coordinates), total number, type, construction material and bypasses (easy, difficult, impossible).
10. *Median strip or divider (Yes or No).* Material and Width.

11. *Traveled way.* Width (average, widest point, narrowest point); surface material (thickness and condition); base course (material and thickness); subgrade material; maximum wheel loading (FM 5-36); crown; and maximum superelevation.
12. *Shoulders.* Material, width, slope, and condition.
13. *Ditches.* Depth, width, side slope, lining, condition, and structures (weirs, gratings, etc.).
14. *Curves, radius less than 30 meters.* Location (UTM) and radius.
15. *Off-road parking areas.* Location (UTM), vehicle capacity and facilities.
16. *Fords.* (Cross reference to ford collection file, paragraph 5-30.)
17. *Ferries.* (Cross reference to ferry collection file, paragraph 5-28.)
18. *Tunnels, Galleries, and Snow Sheds.* (Cross reference to TGSS collection file, paragraph 5-26.)
19. *Underpasses.* (Cross reference to bridge collection file, paragraph 5-24.)
20. *Sections subject to blockage.* Location of end points and bypasses.
21. *Obstacles.* Type (crater, washout, road block, ditched, mines, damaged structures) and effort required to remove.
22. *Civilian use.*
 - a. Type of traffic (volume by type and periods).
 - b. Importance to economy.
 - c. Possible rerouting.
 - d. Method of traffic control.
23. *Significant junction or grade crossings.*
 - a. Identification of joining or crossing route.
 - b. Location of junction or grade crossing.
24. *Prominent features along route which can be used for convey check points.*
 - a. Description of feature.
 - b. Location (UTM).

Section III. RAILWAYS

5-12. Definitions

a. The term "railway" includes all fixed property belonging to a line, such as land, permanent way, and facilities necessary for the movement of traffic and protection of the permanent way. It also includes bridges, tunnels, snowsheds, galleries, ferries, and other structures which are discussed in paragraphs 5-18 through 5-32. Railway intelligence covers all physical characteristics of

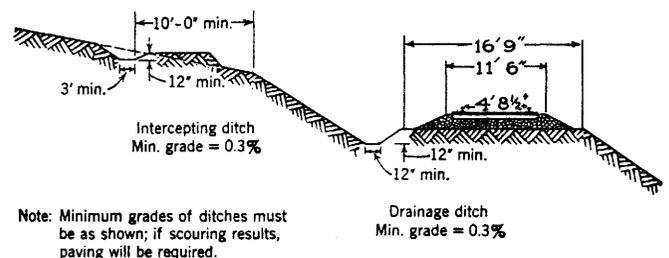


Figure 5-7. Typical roadbed cross section.

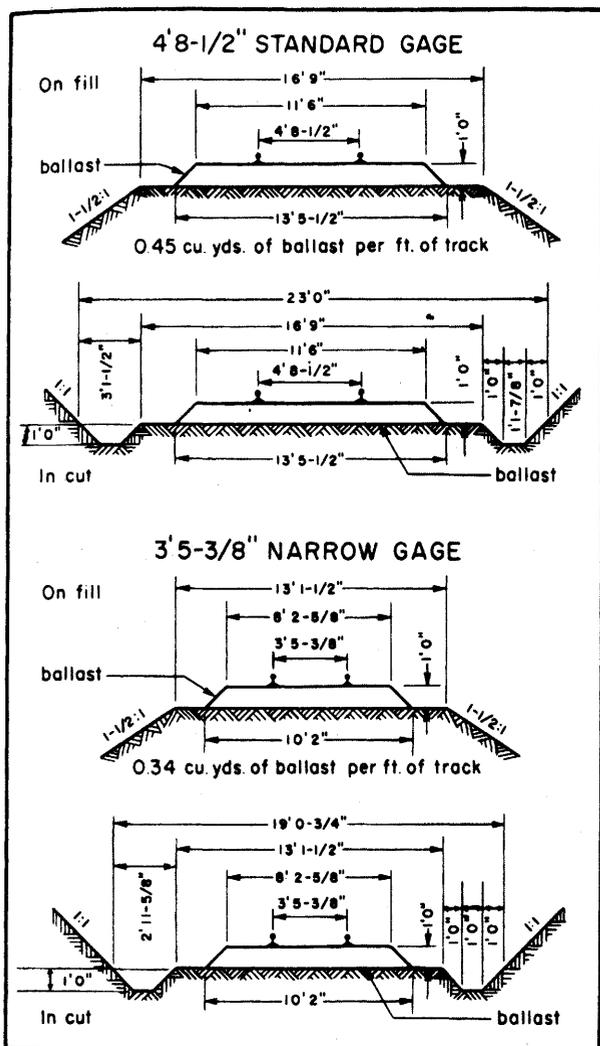


Figure 5-8. Diagram of standard gage and narrow gage roadbed cross section.

the existing system and all available information pertaining to development, construction, and maintenance.

b. The term "physical characteristics" describes the roadway and all its component parts (roadbed, ballast, track, rails, etc.), its horizontal and vertical alinement, as well as critical features. Information on physical characteristics is necessary for determining capacities and maintenance or rehabilitation requirements of railways. Diagrams of roadbed cross sections and rail fastenings are shown in figures 5-7 through 5-9. Figure 5-10 is an illustration of steam locomotive wheel arrangements.

5-13. Significance of Rail Transportation

a. Today, and for the immediate future, railways constitute the backbone of the transporta-

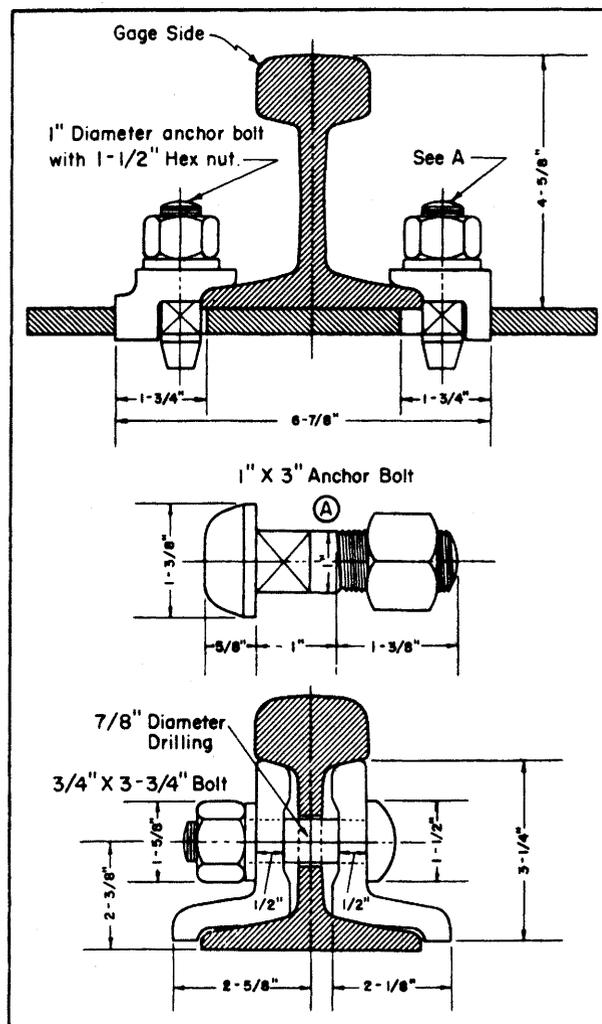


Figure 5-9. Diagram of rail fastenings.

tion system in countries where no complementary road system has been extensively developed. Their suitability for long distance mass movement and low susceptibility to the vagaries of the weather make them particularly useful for logistics support. The present concept of warfare, with its emphasis on dispersal and the requirement for more and smaller rear installations, also lends importance to secondary and feeder lines. Railways assume increased military importance in areas where the soils are generally untrafficable, roads are poor, and rail transportation facilities are extensive. Frequently railways can be used as substitute roads for vehicles. Most railway bridges will carry tanks without reinforcement.

b. Railways are a highly desirable adjunct to extended military operations. Their capabilities are of primary concern, and are the subject of continuing studies by personnel at the highest levels. Detailed intelligence about the railways in an

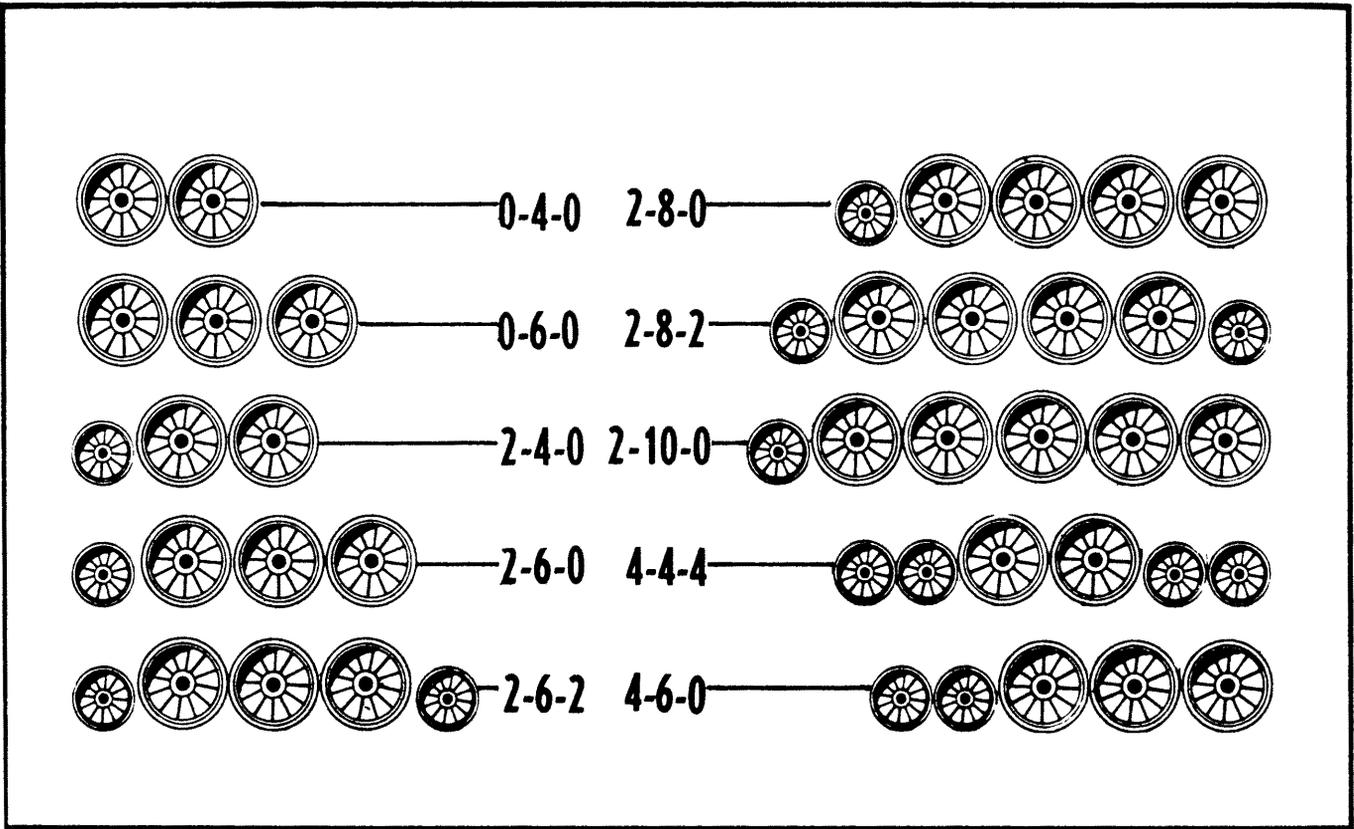


Figure 5-10. Steam locomotive wheel arrangements.

area of operations is produced by specialists of transportation and engineer units.

5-14. Vulnerability

a. Railways and their associated facilities are highly vulnerable to enemy attack, particularly to sabotage and guerrilla operations. Since the routes are relatively straight and are limited to certain types of terrain, camouflage and protection are extremely difficult and, in many cases, impossible. The requirement for large, open facilities located in broad, flat areas adds to the difficulty of protection. Keeping a railroad in operation requires trained security forces and extensive protective measures.

b. Aside from bridges and bottlenecks on a rail route, perhaps the most vulnerable points in a railway system are the terminals, classification yards, repair shops, and other necessary facilities where trains are assembled and where major maintenance and repair are performed. Diagrams of typical classification yards are shown in figures 5-11 through 5-13. Freight stations are shown in figure 5-14. Figure 5-15 is a diagram of a typical locomotive repair layout.

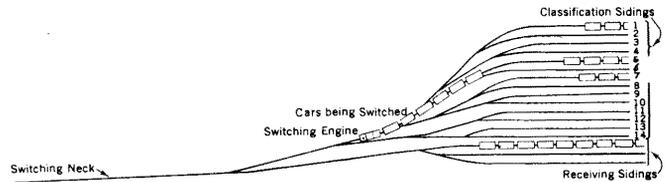


Figure 5-11. Flat classification yard.

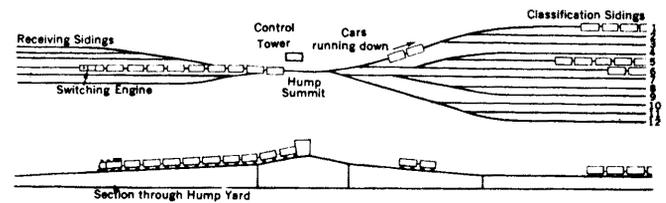


Figure 5-12. Gravity or hump classification yard.

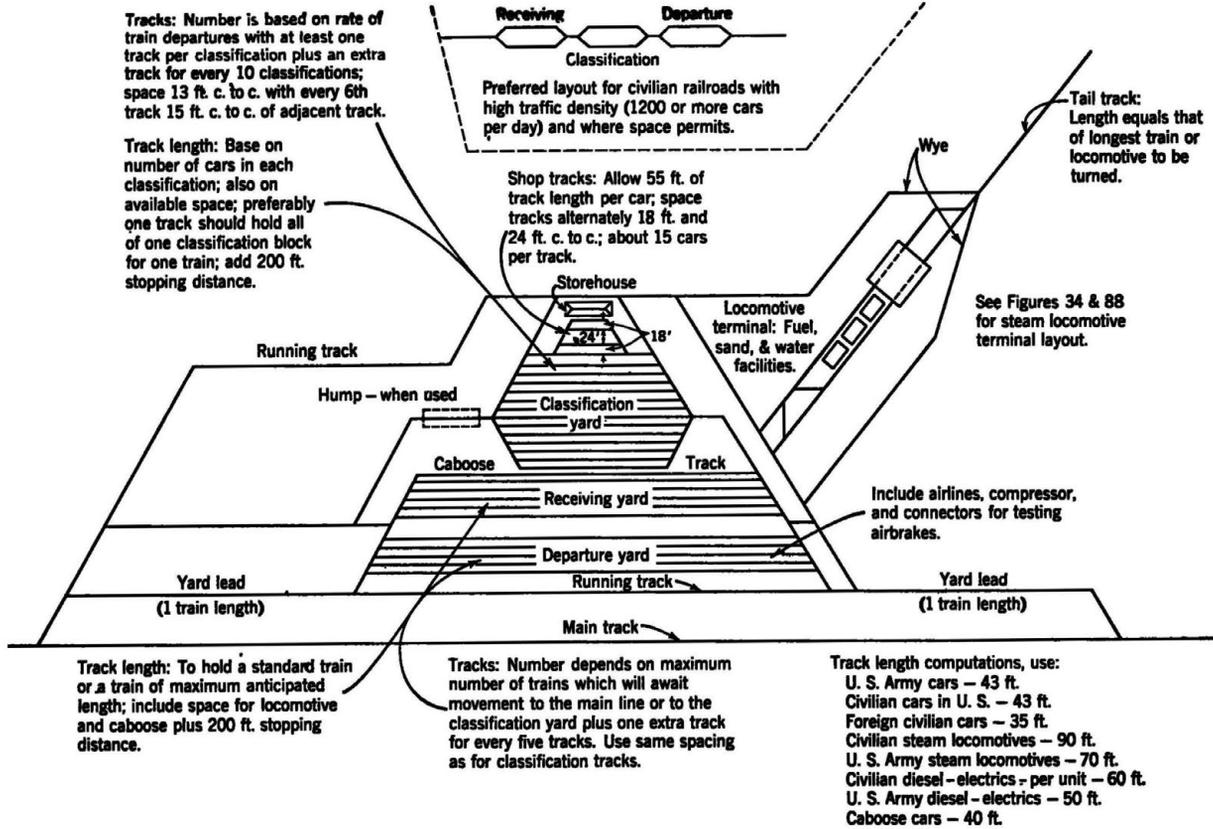


Figure 5-13. General layout of a major classification yard.

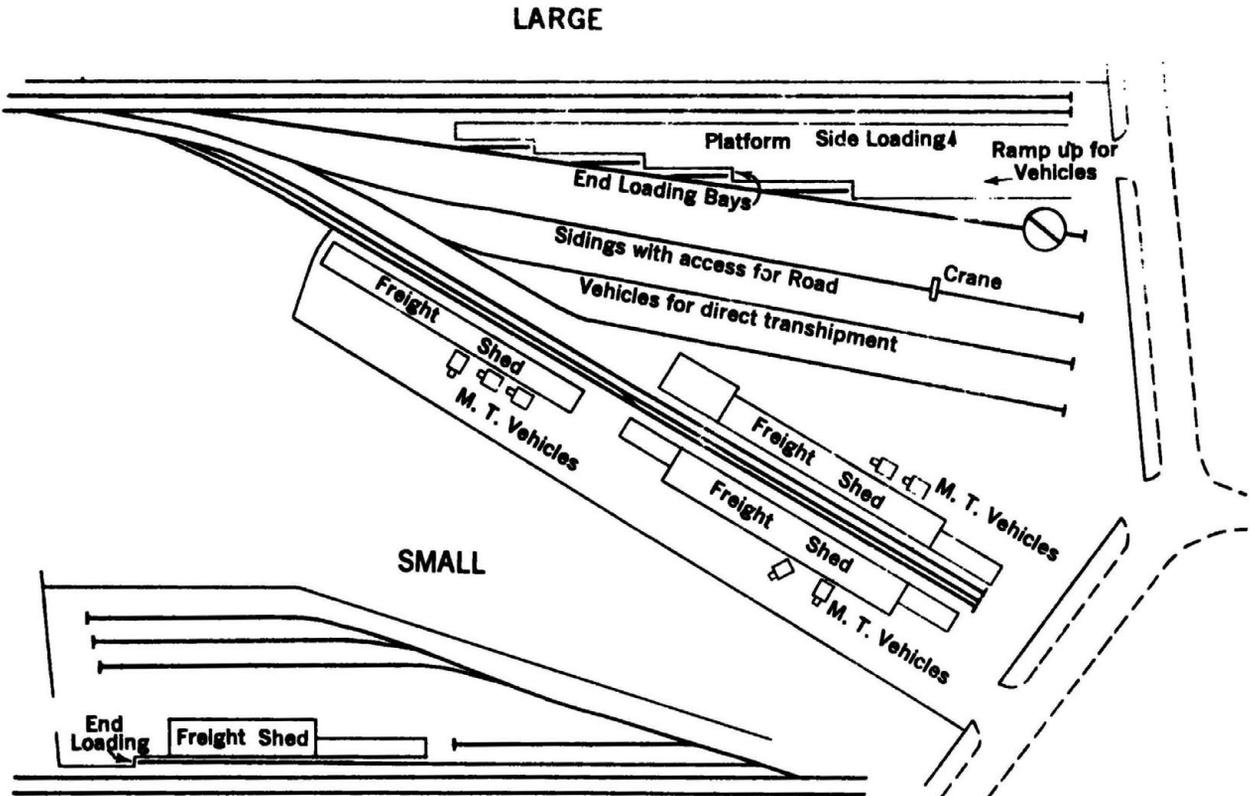


Figure 5-14. Simplified diagram of a large and small freight station.

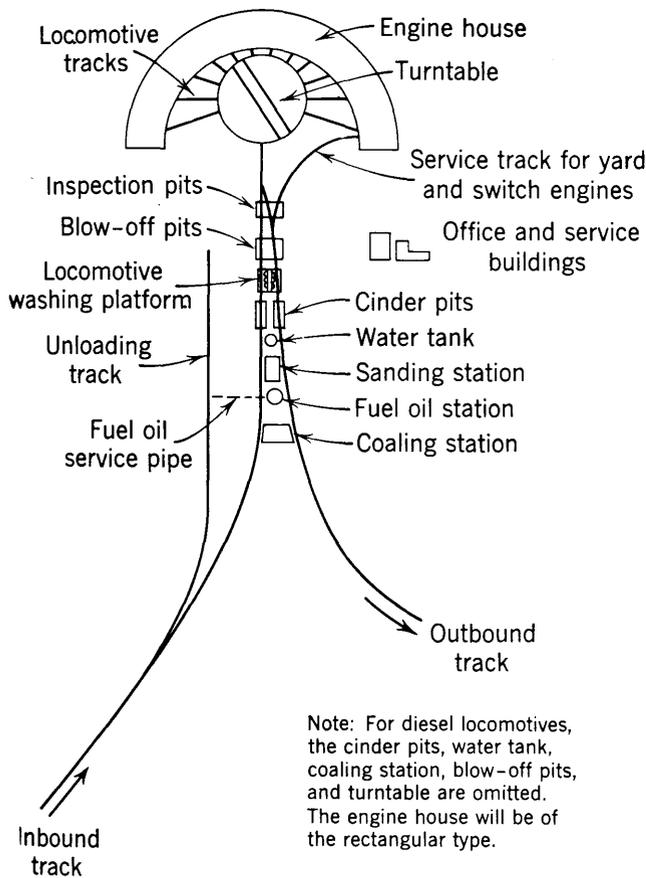


Figure 5-15. Typical locomotive repair layout.

5-15. Construction and Maintenance

a. The development and extent of a railway system largely reflect the topography of the region that it traverses. In desert regions, a single railroad may extend on a straight line across vast barren waste. In hill regions and mountain areas it will run through valleys, with short lines leading off into other terrain. On plains, railways will have few curves but may be subject to the effects of poor drainage conditions. Generally, railways tend to follow rivers because of the more uniform grades, the availability of straight routes, and the concentration of resources, industries, and population centers along the waterway. The terrain characteristics of an area can be determined to a considerable degree by a study of the railway routes, since the rail lines almost invariably follow the topography that offers the fewest obstacles. TM 5-370 serves as a guide and standard in the location, construction, rehabilitation and maintenance of military railroads.

b. In evaluating a railway for geographic intelligence purposes, consideration should be given to the effects of adverse terrain, weather and cli-

mate, and the overall design and construction of the system.

(1) *Adverse terrain.* Railroads passing over swamps, bogs, and delta terrain may encounter special problems of drainage, ditching, and roadbed maintenance. In mountainous areas, steep grades, sharp curves, and tunnels are common. Because of sidehill locations and deep cuts, protection should be provided against earth, rock, and snow slides. In the desert, provisions must be made for the removal of drifting sand.

(2) *Adverse weather and climate.* Severe winter conditions seriously retard operation and maintenance of railways, requiring protection against drifting snow, provisions for snow removal, and repairs because of damage caused by frost heaves. Excessive rainfall may result in washouts and flooding in low areas and cause earth and rock slides in rugged terrain.

(3) *Design.* A railway may prove inadequate because the initial design did not provide for the increased loads and speeds or heavy volume of traffic needed. As a result, a railway might require either considerable reconstruction and repair or extensive maintenance. Among the more common defects are unstable subgrade, lack of adequate drainage, light rail, poor ballast and untreated ties. Improper maintenance is evidenced by such conditions as an uneven roadbed, improperly tamped ties, loose fastenings, badly worn rail, and uncleared drains.

5-16. Sources of Information

The principal sources of information on railways are similar to those on highways (para 5-9). They include maps, route logs, track charts and profiles, aerial and ground photographs, trade publications, direct observation, and friendly foreign representatives. In addition to these sources, much valuable information is contained in the following:

a. *Track Charts and Profiles.* These include diagrams, blueprints, and other drawings picturing alinement and profiles of lines; locations of stations; main and secondary tracks; structures; crossings; signal and other facilities; connecting lines; length or capacity of yards, passing tracks and sidings; details on grades; degree of track curvature; weight of rails; and other information.

b. *Book of Operating Rules.* These books, designed for the use of railway companies, usually define railway terms and set forth the rules and

procedures affecting train operations, the use of timetables, train orders, and signals.

c. Books of Standard Plans. These books contain the railroad standards for rails, ties, ballast and other track material, roadbed construction, and switches.

d. Bridge and Tunnel Books, Lists, and Tables. These are comprehensive listings of bridges and tunnels, including data on type, length, location, construction details, clearances, capacity, and other features affecting rail operations.

e. Operating Timetables. Timetables (not to be confused with passenger timetables) are issued for operational use. They generally contain speed and maximum weight limits, vertical clearances for all overhead structures, small scale maps showing locations of servicing facilities, line profile diagrams and other operating data.

5-17. Collection Checklist—Railways

1. *Identification.* Route designation (native, military, or other) and segment being studied.
2. *Location.*
 - a. Map reference—Include series and sheet number(s) on both tactical and air-ground series.
 - b. End points of segment—Political unit, area, UTM coordinates, and geographic coordinates.
3. *Ownership.*
4. *Total track length.* Double and single tracks in kilometers.
5. *End points of double track sections.* Location (UTM) and area name.
6. *Track.*
 - a. Gage (millimeters).
 - b. Rails.
 - c. Roadway (total width and double or single track).
 - d. Ditches (depth, width, side slope, lining, condition, cross section, and structures).
7. *Roadbed.* Material, total width and width of shoulders.
8. *Subballast.* Material and thickness.
9. *Ballast.* Material, size, thickness, and condition.
10. *Spacing of tracks.* Center line to center line.
11. *Ties.* Material, length, width, depth, and spacing.
12. *Radius of tightest curve.* Location (UTM) and radius.
13. *Maximum grade.* Direction of travel and location (UTM).
14. *Bridges.* (Cross reference to bridge collection file, paragraph 5-24.)
 - a. Total number of bridges in segment.
 - b. Total length of bridging in segment.
15. *Ferries.* (Cross reference to ferry collection file, paragraph 5-28.)
16. *Tunnels, Galleries, and Snow Sheds.* (Cross reference to TGSS collection file, paragraph 5-26.)
17. *Underpasses.* (Cross reference to bridge collection file, paragraph 5-24.)
18. *Minimum clearances.* Horizontal and vertical.
19. *Ax'le load limit.* Metric tons.
20. *Cu'verts.* Location (UTM), total number, type, construction material, and bypasses.
21. *Electrification.*
 - a. End points of electrified sections (UTM).
 - b. Power feed (overhead or third rail).
 - c. Current characteristics (AC or DC).
 - d. Source of power.
22. *Mainline junctions.* Location (UTM), identification of connecting line, and type switch.
23. *Crossovers.* Location (UTM) and type of switch.
24. *Passing sidings.* Locations (UTM), number, double end or single end, length, and type of turnout.
25. *Stations.*
 - a. Location (local name and UTM coordinates).
 - b. Function (passenger, freight or both).
 - c. Facilities.
26. *Freight handling facilities.*
 - a. Location (local name and UTM coordinates).
 - b. Side loading platforms (number and length).
 - c. End loading bays.
 - d. Sidings with access roads.
 - e. Freight sheds.
 - f. Turntables (number and diameter).
 - g. Cranes (type, number, and capacity).
27. *Yards.*
 - a. Location (local name and UTM coordinates).
 - b. Function (receiving, classification, departure, storage, etc.).
 - c. Hump or flat.
 - d. Number of tracks.
 - e. Fuel facilities (type of fuel, quantity normally on hand, and maximum storage capacity).
 - f. Other facilities (water, sand, compressed air, etc.).
 - g. Electrification (overhead or third rail).
28. *Repair shops/locomotive terminals.*
 - a. Location (local name and UTM coordinates).

- b. Engine house and turntable.
- c. Service facilities.
- 29. *Fuel facilities.*
 - a. Location (local name and UTM coordinates).
 - b. Type of fuel.
 - c. Type of storage and capacity.
 - d. Quantity of fuel normally on hand.
 - e. Method of loading.
- 30. *Watering facilities.*
 - a. Location (local name and UTM coordinates).
 - b. Source and type of storage.
- 31. *Signals and train control.* Location (UTM) and type.
- 32. *Critical points.*
 - a. Type (points subject to rock slides, snow slides, flooding or subject to interdiction and ambush).
 - b. Location (local name and UTM coordinates).
- 33. *Use.* Average number of trains per day (both passenger and freight).
- 34. *Sections in need of repair.* Location, nature of repair, and effort required to repair.
- 35. *Construction, maintenance, and repair equipment.*
 - a. Type and characteristic of equipment.
 - b. Location of park where kept (UTM coordinates).
- 36. *Maintenance schedule.*
- 37. *Planned extension and improvements.*
- 38. *Maintenance and construction standards.*
- 39. *Safety and security features.*
- 40. *Rolling stock.*

Section IV. STRUCTURES AND CROSSINGS

5-18. General

a. Structures and crossings on highways or railways include bridges, culverts, tunnels, galleries, ferries and fords. Also, for the purpose of terrain intelligence, they include cableways, tramways and other features which may reduce or interrupt the flow of traffic on a transportation route. Bridges and culverts are the structures most frequently encountered; however, any feature that may present a potential interdiction is of significance in a military operation.

b. Detailed information on structures and crossings is essential to the intelligence analyst and to the engineers who may be required to repair or restore a structure or to provide a bypass. All personnel engaged in collecting and reporting of information should follow carefully the collection checklists contained in this chapter and the appropriate references listed in appendix A.

5-19. Sources of Information

Any type of structure or crossing on a transportation route is an important portion of the route regardless of the mode of transportation. Therefore, information on such structures may be derived from the same sources listed for highways and railways (para 5-9 and 5-16). Maps, charts, publications, photographs, and other sources contain valuable information which should be exploited by collectors. Due to the critical nature of structures and crossings, they may be the subject of considerable study by collectors and analysts.

The evaluation of information on key bridges, tunnels, and other critical points on a transportation route are usually performed by highly skilled engineers.

5-20. Bridges

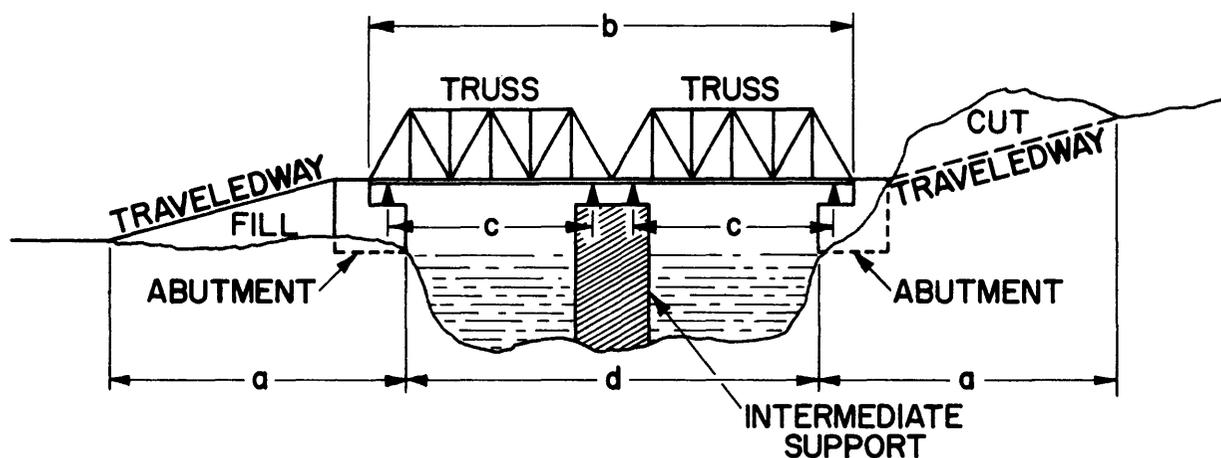
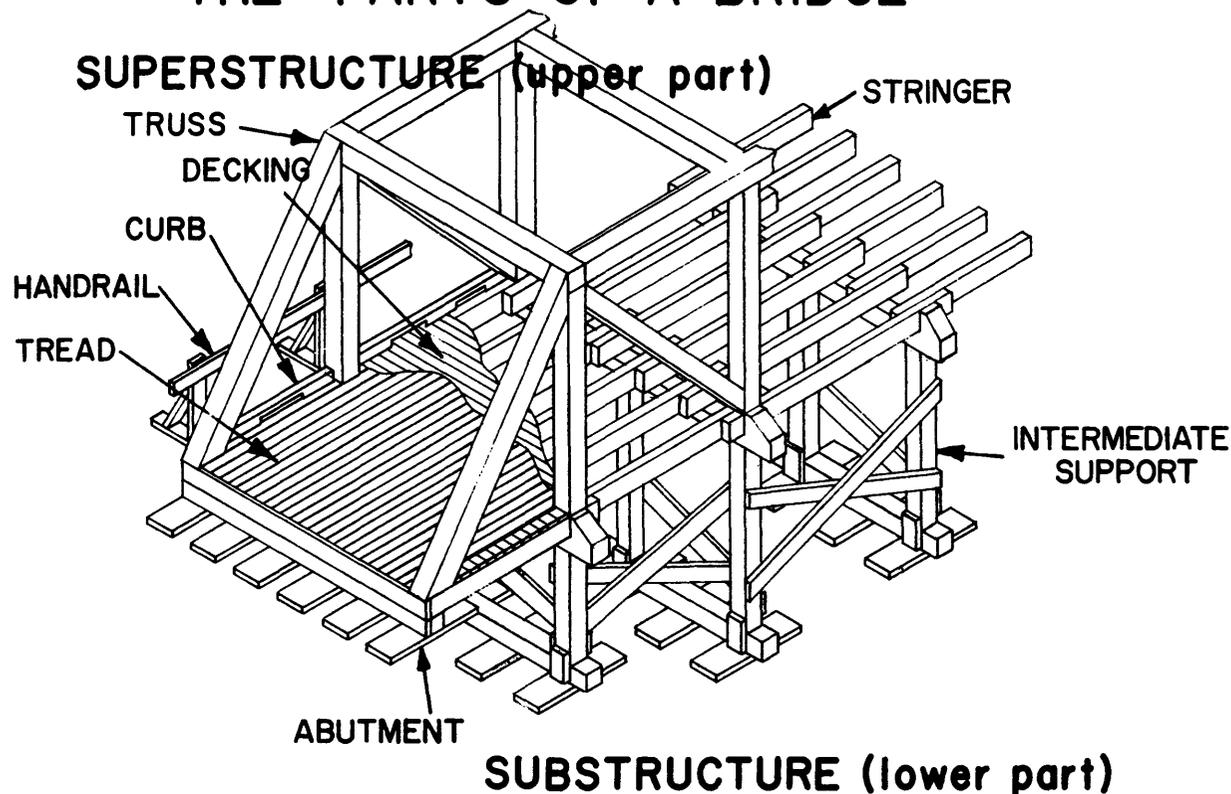
a. Highway and railway bridges and tunnels are vulnerable points on a line of communications. Timely preservation, destruction, or repair of a bridge may be the key to an effective defense or to the successful penetration of an enemy area. A bridge seized intact has great value in offensive operations, since even a small bridge facilitates the movement of troops over a river or stream. Information on bridge type and classification is contained in TM 5-312 and FM 5-36.

b. Detailed information other than length about bridges cannot be obtained from topographic maps, but measurements from aerial photographs usually permit an approximate determination of the bridge length, width, clearance and height above water. Necessary details concerning a bridge should be obtained from engineer reconnaissance as described in FM 5-36. Basic information requirements for a bridge include a summary of its structural characteristics, critical dimensions (length, usable width, overhead clearance), an estimate of capacity, and general condition.

5-21. Bridge Design

A bridge has two main parts; the substructure and the superstructure. The substructure com-

THE PARTS OF A BRIDGE



- a= APPROACH
- b= OVERALL LENGTH
- c= SPAN LENGTH, BEARING TO BEARING
- d= LENGTH, ABUTMENT TO ABUTMENT

Figure 5-16. Bridge nomenclature.

prises the foundation and supporting elements of a bridge; the superstructure is the assemblage which rests on the substructure and spans the gaps between ground supports. The parts of a bridge are shown in figure 5-16.

a. *Substructure.* The substructure consists of the ground supports at the shore ends of a bridge (abutments) and the intermediate ground supports (bents, or piers). Materials used in substructures include concrete, masonry, steel, and

wood. Concrete and masonry are the most common.

b. Superstructure. Bridge superstructures take many forms, ranging from short trestle spans built into wooden stringers to large multiple cantilever spans of several thousand feet. Most have two basic components, the main supporting members and a floor or deck system. The primary exception is the concrete slab design in which the supporting member also serves as the floor. The type of superstructure used depends on the type of loads to be carried, required span lengths, the time available for erection, the availability of construction materials, manpower and equipment, and the characteristics of the site. Based on their superstructures, bridges may be divided into two general classes, fixed and movable.

(1) *Fixed bridges* (fig. 5-17). Fixed bridges fall into five major groups: beam, slab, girder, truss, and arch bridges. These types may occur

alone or in combination. In addition, bridges may require special adaptations.

(2) *Movable bridges* (fig. 5-18). A movable bridge has at least one span that can be moved from its normal position to allow passage of vessels. The four general types of movable bridges are swing, lift, bascule, and retractile.

c. Principal Measurements. Measurements of intelligence significance include the length and width of the bridge and its component spans; vertical, horizontal, and underbridge clearances; and other measurements concerning the bridge site. Figure 5-19 shows the principal bridge measurements.

d. Bridge Capacity. The load capacity is the most critical factor of a bridge. The most reliable capacity data are derived from the so-called standard design loadings according to which most countries design their bridges. Usually a country has a number of standard design loadings for dif-

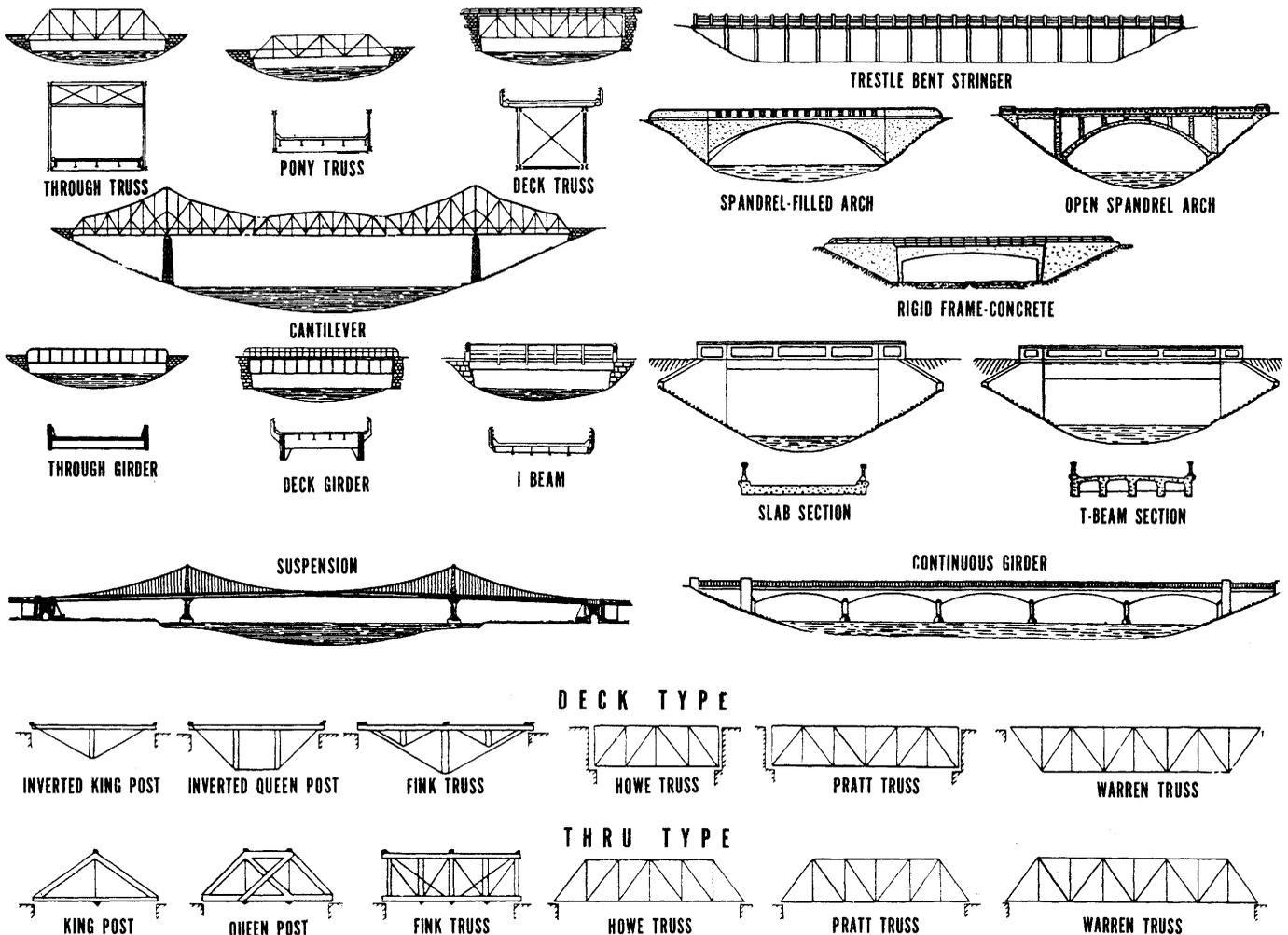


Figure 5-17. Fixed bridges.

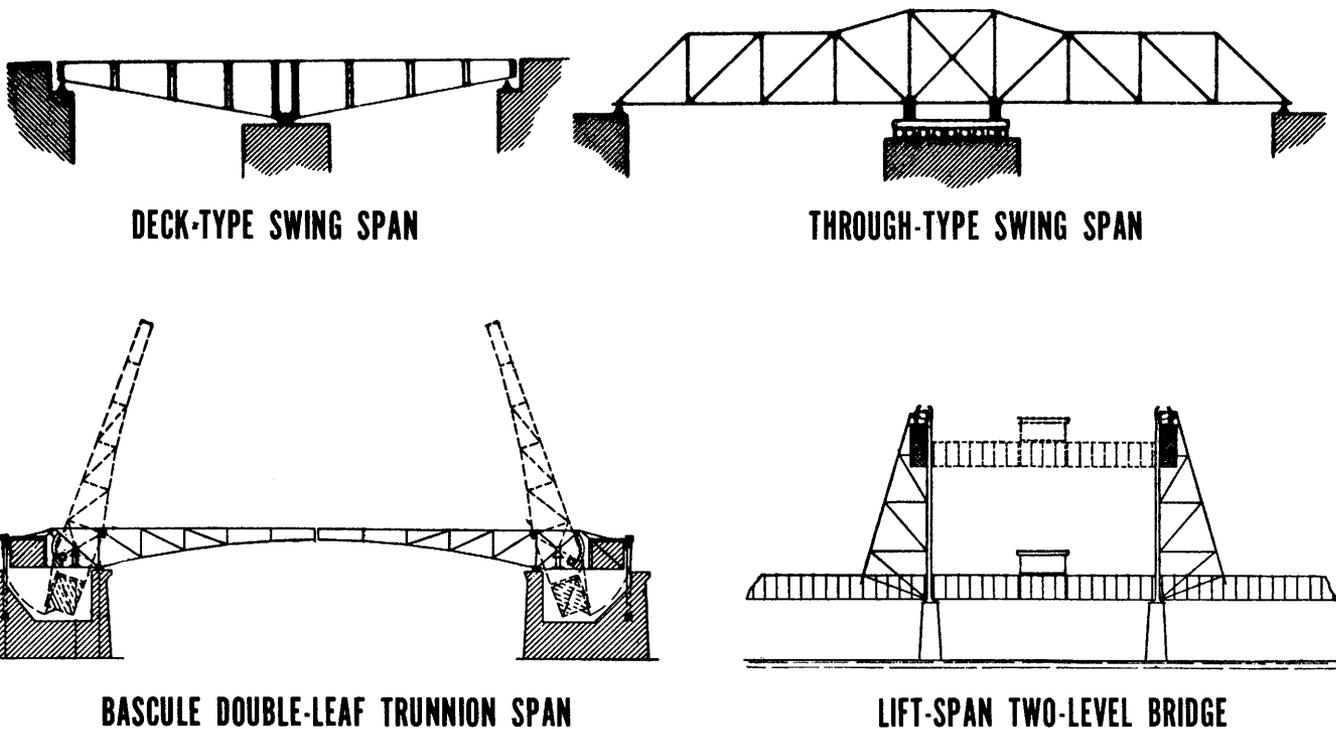


Figure 5-18. Movable bridges.

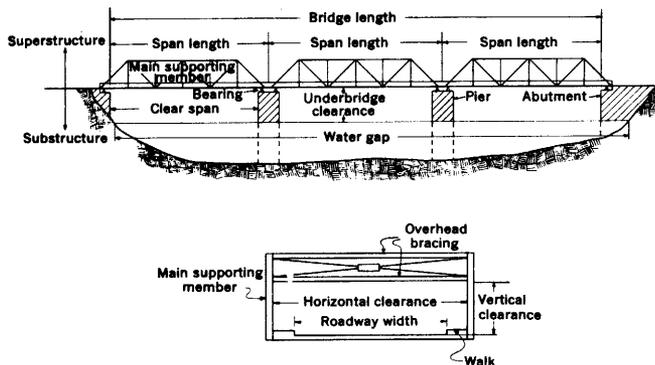


Figure 5-19. Principal bridge measurements.

ferent capacity classes. Standard design loadings may be expressed by a letter, number, symbol, and so forth. In the United States they are given in Coopers E units. In some countries, bridge capacities may be expressed in tons per axle.

e. Culverts. Culverts can be grouped into four main categories: pipe, box, arch, and rail girder spans.

(1) *Pipe culverts.* Pipe culverts are the most common. They are usually made of concrete, but corrugated metal and cast iron pipe are also used. The pipes have different shapes and range from 12 inches to several feet in diameter.

(2) *Box culverts.* Box culverts are used to a great extent in modern construction. They are

rectangular in cross section and usually of concrete. A large box culvert is similar to a slab bridge.

(3) *Arch culverts.* Arch culverts were frequently used in the past but are rarely constructed now. They are made of concrete, masonry, brick or timber.

(4) *Rail girder spans.* On lightly built railways or in case of emergency on any line, rails laid side by side and keyed head to base may be used for spans of 3 meters (10 feet) or less.

5-22. Bridge Planning

Because of the time and labor involved, new bridges are erected only when an existing bridge, ford, or detour cannot be used. There are, however, times when the erection of a bridge is essential to the accomplishment of a mission. Therefore, all personnel engaged in the collection of information must observe and report any terrain details that will assist their own unit or higher echelons in planning for bridges.

5-23. Information Reporting

a. In collecting and reporting information on bridges, it is necessary in most areas to treat only those bridges longer than a specified length.

Structures less than 6 meters (20 feet) long are considered to be culverts; all others are treated as bridges. This cut-off length is flexible according to the prevalence of bridging in the study area.

b. All bridges have the common characteristic of presenting a potential restriction to traffic, and all items reflected in the collection checklist (para 5-24) are important information. Some of the basic requirements for information on any type of bridge are:

(1) *Location*. Kilometer stations from origin of section. Nearest kilometer should be given unless close spacing requires use of nearest 0.1 kilometer for separate identifications.

(2) *Obstacle crossed*. Name of stream when known. Other possible entries include "gorge," "railroad," "canal," etc.

(3) *Coordinates*. UTM coordinates to six places and geographic coordinates to the nearest second.

(4) *Overall length*. Length, to the nearest meter. Overall length should generally be the sum of the span lengths, but should not include approaches.

(5) *Roadway width*. Width, to nearest 0.1 meter, of that portion of deck over which vehicles normally run. This excludes sidewalks, curves, parapets, truss superstructure, etc.

(6) *Horizontal clearance*. Limiting width to nearest 0.1 meter at a point 30 centimeters above the edge of roadway. This normally includes widths of curbs and sidewalks but excludes parapets and trusses.

(7) *Vertical clearance*. Minimum distance between roadway and any obstruction immediately over the roadway, to the nearest 0.1 meter.

(8) *Standard class*. Normal class as described in TM 5-312. For bridges wide enough for two lanes of traffic, both one-way and two-way classes should be given, e.g. 50/30.

(9) *Spans*. The number and length of spans. Lengths are given to the nearest 0.1 meter and represent the distance between supports (centers of bearing).

(10) *Span construction*. The construction material such as concrete, steel, masonry, or timber, and the construction type, such as suspension, cantilever, truss, slab, beam, girder, arch, trestle, or ponton.

(11) *Bypassability*. "Easy," "difficult," or "impossible" as defined in FM 5-36.

5-24. Collection Checklist—Bridges

1. *Identification*. Local and military designation.
2. *Location*.
 - a. Map reference—Include series and sheet number(s) on both tactical and air-ground series.
 - b. Center of bridge—Political unit, area, UTM coordinates, and geographic coordinates.
3. *Obstacle crossed*. (Cross reference to appropriate collection file.)
4. *Route designation*. (Cross reference to appropriate collection file.)
5. *Bridge reconnaissance symbol*.
6. *Landmark reference*. Description and location (UTM) of landmark, and azimuth and distance from landmark to center of bridge.
7. *Military load classification*.
8. *Condition*. Effort required to repair.
9. *Bypasses*. Location (UTM) and condition.
10. *Approaches*. Characteristics, surface, grade, curves, turnouts and parking areas.
11. *Obstacle characteristics at crossing point*.
 - a. Total width of gap spanned.
 - b. Width of water gap (if appropriate).
 - c. Depth of water (if appropriate).
 - d. Current velocity (if appropriate).
 - e. Bottom.
12. *Banks*. Height, slope, material, and vegetative cover.
13. *Overall bridge length*. Between bearing points of abutments, if unable to determine bearing points measure from shore ends of abutments.
14. *Structure type*. Simple stringer, slab, T beam, truss, girder, arch, suspension, cantilever, swing, lift, bascule, retractile, floating, combination, aqueduct.
15. *Military nomenclature*. (Standard military bridges only.)
16. *Number of spans*.
17. *Abutments*. Type (straight, wing, U, T, box, pier), dimensions, material, soil type, and shore (direction).
18. *Width of traveled way*. (Curb to curb clearance of narrowest span, channel width if aqueduct.)
19. *Horizontal clearance*.
20. *Channel depth (aqueducts on'y)*.
21. *Walkways*.
22. *Spans*.
 - a. Identification (number consecutively from

north or west, indicate which by preceding number with N or W).

b. Length (between bearing points of supports).

c. Structural type.

d. Vertical clearance.

e. Horizontal clearance.

f. Width between curbs.

g. Curbs.

h. Wearing surface (lining if aqueduct).

i. Flooring.

j. Truss type.

k. T beams or stringers.

l. Plate girders.

m. Under bridge clearance (height and width).

23. *Suspension system.*

a. Towers.

b. Main cables.

c. Suspenders.

d. Anchors.

24. *Movable spans.*

a. Type (swing bridge, trunnion or counterweight, bascule, single or double leaf trunnion type, rolling lift bascule, or vertical lift).

b. Open width.

c. Open height.

d. Operating machinery.

e. Hand operation.

f. Open state frequency.

g. Structural details.

25. *Arches.*

a. Type.

b. Materials.

c. Arch rings.

d. Roadway fill.

e. Spandrels.

f. Arch factors.

26. *Intermediate supports.*

a. Identification (22a above).

b. Distance from abutment or preceding support bearing point.

c. Material.

d. Type.

e. Footings or foundations.

f. Trestle bents.

g. Pile bents.

h. Trestle bent piers.

i. Pile piers.

j. Crib piers.

k. Steel trestle piers (provide data on each bent).

l. Concrete or masonry piers.

27. *Floating bridges.*

a. Military nomenclature.

b. Provisions for swinging.

c. Bank at which hinged.

d. Time required to swing.

e. Time required to replace.

28. *Demolition requirements.*

a. Type and amount of explosives.

b. Placement.

c. Equipment required.

d. Man-hours required.

e. Probable effect of demolition.

29. *Safety and security features.*

30. *Traffic control markings.*

31. *Effects of weather and climate.*

a. Floods.

b. Snow.

c. Icing.

d. Wind.

5-25. Tunnels, Galleries, Snowsheds

Features on a transportation route where it would be relatively easy to block traffic, or that affect the traffic capacity of the road, are considered to be critical. Such features include tunnels, snowsheds, galleries, mountain passes, terrain gaps, gorges and defiles, deep cuts, steep grades and sharp curves. Any obstructions to traffic flow which limit the physical dimensions of vehicles utilizing a specific route are important aspects of transportation intelligence. Reductions in traveled way widths, such as narrow streets in built up areas, drainage ditches, embankments, and war damage, limit vehicular movement. Underpasses and other covered traveled ways may restrict traffic flow not only as to width but also as to height.

a. *Tunnels.* A tunnel is an underground section of the route which has been made by cut-and-cover or bored for the passage of a route. It consists of the bore(s), a liner (optional) and portals. Common shapes of tunnel bores are semicircular, elliptical, horseshoe, and square with arched ceiling. Bores may be lined with brick, masonry or concrete or they may be unlined. Some very long tunnels on steam operated railroad lines are artificially ventilated by blowers at the portals or in ventilating shafts above the bore. Alinement of tunnels may be straight or curved.

b. *Snowsheds and Galleries.* Built in rugged, mountainous terrain, these protective structures are not as common as bridges or tunnels. Snowsheds offer protection against snow accumulations as well as drifts and slides on exposed sections of the permanent way. Galleries offer

protection against snow and rock avalanches. They may be cut into the side of a cliff and have a natural overhang, or the cover may be a concrete slab, either of which guides the avalanche across the track or road. One side of a gallery is usually open.

c. Retaining Walls. These are built to support embankments, either on the uphill or downhill side of the roadway. Retaining walls also are necessary where an embankment requires support against the pressure of water.

5-26. Collection Checklist—Tunnels, Galleries, and Snowsheds

1. *Identification.* Native name, military designation and tunnel number.
2. *Location of portals.*
 - a.* Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b.* Political unit, kilometer points, UTM coordinates, and geographic coordinates.
 - c.* Landmark reference. Description and location of landmark, and azimuth and distance from landmark to nearest portal.
3. *Length.* (Portal to portal.)
4. *Type.* Tunnel, gallery or snowshed.
5. *Cross section.*
 - a.* Shape (semicircular, elliptical, horseshoe, square with arched ceiling).
 - b.* Width of traveled way.
 - c.* Width at widest point.
 - d.* Height of widest point.
 - e.* Height of ceiling at center.
 - f.* Height of ceiling at edge of traveled way.
 - g.* Rise of arch.
6. *Constrictions, horizontal and vertical.* Type, least clearance, and location (meters from nearest portal).
7. *Railroad tracks.*
 - a.* Number for which tunnel was designed.
 - b.* Number in use.
 - c.* Gage.
 - d.* Center to center spacing.
 - e.* Cross reference to railway collection file, paragraph 5-17.
8. *Highway.*
 - a.* Wearing surface (material, thickness, and condition).
 - b.* Base course.
 - c.* Subgrade.
 - d.* Cross reference to highway collection file, paragraph 5-11.
9. *Channel (water tunnels).*
 - a.* Cross section, dimensioned.
 - b.* Sides (material and thickness).
 - c.* Bottom (material and thickness).
 - d.* Normal depth.
 - e.* Normal current velocity.
10. *Alinement.*
 - a.* Horizontal (position, curve radius, and curve location).
 - b.* Vertical (grade percent, length, and location).
11. *Number of manways.* Dimensions and spacing.
12. *Obstacle tunneled.*
13. *Portal.* Design and material.
14. *Lining material.* Type, thickness, condition, and points of change.
15. *Shoring and bracing.*
 - a.* Location or spacing.
 - b.* Design.
 - c.* Materials.
 - d.* Dimensions of members.
 - e.* Arrangement and spacing of members.
16. *Structural design, materials, and dimensions of galleries and snowsheds.*
17. *Geological data.*
 - a.* Material through which tunnel passes.
 - b.* Geology of adjacent area.
18. *Overhead cover.* Material and depth.
19. *Demolition chambers.* Location and dimensions.
20. *Ventilation.* Description and adequacy.
21. *Drainage.* Description, location, and adequacy.
22. *Lighting facilities.* Type, locations, and power source.
23. *Year completed.*
24. *Bypasses.* Location, condition, effort, required to establish.
25. *Alternate routes.* (Cross reference to highway collection file, paragraph 5-11.)
26. *Traffic control markings.*
27. *Approaches.* Characteristics, grade, surface, curves, turnouts and parking areas.
28. *Surface features over tunnels.* Vegetation, structures, and surface configuration.
29. *Effects of climate and weather.*
 - a.* Snow blockage (probable occurrence, effects, and duration).
 - b.* Flooding (periods of occurrence, effects, and duration).
30. *Special geophysical phenomena.*
31. *Susceptibility to above ground demolitions.*

32. *Camouflage and defenses.*

33. *Present use.*

5-27. Ferries

A ferry site is that place where traffic and cargo are conveyed across a river or other water barrier by a vessel called a ferry or ferry boat. Ferry boats or vessels vary widely in physical appearance and capacity depending on the depth, width, and current of the stream, and the characteristics of traffic to be moved. Propulsion of ferries may be by oars, cable and pulleys, poles, stream current (trail and flying ferries), or by steam, gasoline, and diesel engines. Construction of ferry boats varies widely from expedient rafts to ocean going vessels.

a. Usually, the capacity of a civil ferry boat is expressed in tons and total number of passengers. In addition, it is often assigned a military load classification number. When more than one ferry is employed for a given site, the capacity of each should be reported.

b. Ferry slips or piers are generally provided on the shore to permit easy loading of passengers, cargo and vehicles. The slips may vary from simple log piers to elaborate terminal buildings. A distinguishing characteristic of a ferry slip is often the floating or adjustable approach ramp which accommodates to variations in ferry deck level.

c. Approach routes to ferry installations have an important bearing on the use of the ferry. The condition of the approaches, including the load carrying capacity of landing facilities, should be reported.

d. The limiting characteristics of ferry sites must be considered. Necessary information includes the width of the water barrier from bank to bank, the distance and time travelled by the ferry boat from one side to the other side, and the depths of the water at each ferry slip.

e. Climatic conditions have a marked effect on ferry operations. Fog and ice substantially reduce the total traffic moving capacity and increase the hazard of the water route. Therefore, data on tide fluctuations, freezing periods, floods, excessive dry spells, and their effects on ferry operation are important considerations.

5-28. Collection Checklist—Ferries

1. *Identification.* Local name and military designation.

2. *Location of terminals.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

b. Political unit, area, UTM coordinates and geographic coordinates.

c. Landmark reference. Description and location of landmark, and azimuth and distance from landmark to nearest ramp.

3. *Stream crossed.* Cross reference to appropriate collection file.

4. *Route designation.* Cross reference to appropriate collection file.

5. *Ferry reconnaissance symbol.* STANAG 2274.

6. *Type of ferry.* AF—vehicular ferry; PF—pedestrian ferry; and MF—military ferry.

7. *Propulsion method.* Inboard power, outboard power, trail ferry, flying ferry, towed, or poled.

8. *Vessel features.*

a. Construction type and material.

b. Capacity (vehicles, railroad cars, passengers, and tonnage).

c. Parking area dimensions (length, width, and height).

d. Tracks (gage, number, length, and spacing).

e. Length.

f. Draft (loaded and unloaded).

g. Beam.

h. Free board (loaded and unloaded).

i. Number of each type.

j. Military load class.

k. Condition.

9. *Terminal features.* Include dimensions, number, type, condition, clearance, and load class.

a. Slips.

b. Piers/docks.

c. Landing.

d. Ramps.

e. Moorings.

f. Fender or bumper piles.

g. Shore facilities.

h. Approaches.

10. *Water body.*

a. Width at crossing point.

b. Depth of water within slip (high, low, and mean).

c. Current velocity, meters per second (maximum, minimum, and normal).

d. Bottom (material and profile).

e. Banks (height, material, grade, condition, and approaches).

f. Obstacles (type, location, azimuth and distance from nearest landing, and effort required to neutralize).

11. *Course traveled in crossing.* Alinement and distance.
12. *Timing.*
 - a. One way crossing time.
 - b. Loading time.
 - c. Unloading time.
 - d. Turnaround time.
13. *Navigation aids.*
 - a. Aboard vessel.
 - b. Route and channel markers (type and location).
 - c. Depth markers.
14. *Adjacent terrain.* Cross reference to appropriate collection file.
15. *Effects of climate and weather.*
 - a. Flooding (periods of occurrence, effects, and depths).
 - b. Snow (probable occurrence, maximum depth, effects, and facilities for removal).
 - c. Icing (periods of occurrence, maximum thickness on water, and effects on operations).
 - d. High winds.
16. *Possible hazards.* (Mines, logs, snags, debris, ice, etc.)
17. *Ownership.*
18. *Principal traffic.*
19. *Importance to local economy.*
20. *Current operation.*
 - a. Schedule.
 - b. Personnel.
 - c. Maintenance.
21. *Anchors (trail and flying ferries only).* Type, location, azimuth and direction from nearest ramp.
22. *Cables (trail and flying ferries only).* Material, diameter, number of strands, and number of wires or ropes per strand.
 - a. Track or anchor cables.
 - b. Maneuver lines.
 - c. Haul lines.

5-29. Fords

A ford is a location in a water barrier where the physical characteristics of the current, bottom, and approaches permit the passage of personnel or vehicles and other equipment where they cross under their own propulsion (or assisted) and where their wheels or tracks remain in contact with the bottom, and in the case of personnel, little or no swimming is required. The physical characteristics of a ford are:

a. *Trafficability.* Fords are classified according to their crossing potential for foot or wheeled and tracked vehicles. Fordable depths for vehicular traffic can be increased by suitable waterproofing or, in the case of modern tanks, by the addition of deep water fording kits which permit fording of depths up to 4.3 meters (14 feet).

b. *Approaches.* Approaches may be paved with concrete or bituminous surface material but are usually unimproved. The composition and the slope of the approaches to a ford should be carefully noted to permit determination of its trafficability in inclement weather and after fording vehicles have saturated surface material.

c. *Bottom.* The composition of the stream bottom determines its trafficability. It is important to determine if the bottom is composed of sand, gravel, silt, clay, or rock, and in what combination. In some cases, the natural river bottom of a ford may have been improved to increase load bearing capacity and to reduce the water depth. Improved fords may have gravel or concrete surfacing, layers of sandbags, metal screening or matting, timber or wooden planking. Bottom conditions are determined by checking the stability and composition of the bed.

d. *Climatic Conditions.* Seasonal floods, excessive dry seasons, freezing, and other extremes of weather materially effect the fordability of a stream.

e. *Current.* The velocity of the current and the presence of debris have an effect on the condition and passability of a ford. Current is estimated as swift (more than 1.5 meters per second), moderate (1 to 1.5 meters per second), and slow (less than 1 meter per second).

f. *Low Water Bridges.* During high water periods, low water bridges may be easily confused with paved fords as both are completely submerged. This type of bridge consists of two or more intermediate supports with concrete decking and located wholly within ravines or gullies. It is important to differentiate between this type of bridge and a paved ford because of corresponding military load limitations.

5-30. Collection Checklist—Fords

1. *Identification.* Local name and military designation.
2. *Stream name.*
3. *Route.* Cross reference to appropriate collection file.

4. *Location, entrance and exit.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

b. Political unit, area, UTM coordinates, and geographic coordinates.

c. Landmark reference. Description and location of landmark, and azimuth and distance from landmark to nearest ford exit.

5. *Approaches.* Separate entries for each side and identify sides as northern, eastern, southern, or western.

a. Usable width in meters.

b. Condition (wet, dry, and reaction to heavy traffic).

c. Length (distance from nearest road, track, or trail).

6. *Banks.* Separate entries for each bank and specify as northern, eastern, southern, or western.

a. Height (above normal water level).

b. Slope.

c. Surface material.

d. Condition (wet, dry, and reaction to heavy traffic).

7. *Azimuth of crossing.* Specify exit from which azimuth is taken.

8. *Length of crossing.* At high water, low water, and normal water.

9. *Width of ford.*

10. *Depth of ford at deepest point.* At high water, low water, and normal water (specify probable periods and duration).

11. *Bottom slope at exits.*

12. *Bottom.* Material, thickness, and trafficability.

15. *Fixed obstacles.* Description, location, and azimuth and distance from nearest exit.

14. *Possible hazards.* (Mines, logs, snags, debris, ice, etc.)

15. *Effort required to remove obstacles or to improve crossing.*

16. *Ford reconnaissance symbol.* STANAG 2274.

17. *Stream velocity, meter per second.* Normal, maximum, and minimum.

18. *Direction of flow.*

19. *Military load class.*

20. *Bypasses and alternate crossings.* Cross reference to appropriate collection file.

a. Direction.

b. Distance.

c. Markers.

21. *Nearest depth gage location.* Cross reference to appropriate collection file.

22. *Site plan and cross section.*

5-31. Cableways and Tramways

Cableways, tramways and other facilities of this nature are not usually major factors in a military operation; however, they may be encountered in rugged mountainous regions and beach areas or used as connections between two primary supply routes. In some cases they may extend for several miles, and may be the best available method of moving many tons of supply. Accurate data on these facilities are necessary to evaluate and determine their effect on military operations.

5-32. Collection Checklist—Cableways/Tramways

1. *Identification.* Local name and military designation.

2. *Location of terminals.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

b. Political unit, area, UTM coordinates, and geographic coordinates.

c. Landmark reference. Description and location of landmark, and azimuth and distance from landmark to specified terminal.

3. *Obstacle crossed.* Cross reference to appropriate collection file.

4. *Total length.*

5. *Single lift capability (metric tons).*

6. *Daily capacity (metric tons).*

7. *Traverse time (minutes).*

8. *Base stations (terminals).*

a. Motive power (type, capacities, and delivery train).

b. Towers (material, type, height, and anchors).

c. Facilities for passengers and freight.

9. *Intermediate towers.*

a. Material and type.

b. Height (overall, top of track cable saddle).

c. Type of saddle used for power cable.

d. Type of support used for power cable or haul rope.

e. Foundations.

f. Guylines and anchors.

g. Condition.

10. *Track cable.*

a. Material and number.

b. Diameter.

c. Strands and wires.

d. Condition.

e. Fastenings at terminals.

f. Sag or bow.

11. *Power cable.*
 - a. Material and number.
 - b. Diameter.
 - c. Strands and wires.
 - d. Condition.
12. *Carriage data.*
 - a. Type.
 - b. Capacity (passengers or metric tons of freight).
 - c. Dimensions (interior and exterior).
 - d. Condition.
 - e. Method of fastening the power cable.
 - f. Trolley type.
13. *Approaches.* Cross reference to appropriate collection file.
14. *Effects of climate and weather.*
15. *Maintenance.* Type of equipment used and frequency.
16. *Route connecting.* Cross reference to appropriate collection file.
17. *Adjacent terrain.* Cross reference to appropriate collection file.
18. *Ownership.*
19. *Principal uses.*
20. *Importance to local economy.*
21. *Profile.*
22. *Operating personnel at stations.*
23. *Security and safety features.*

Section V. PIPELINES

5-33. General

The pipelines which carry petroleum and natural gas represent an important mode of transportation. While rail, water, and road transport are used extensively for transport of fluids and gases, the overland movement of petroleum and refined products is performed most economically and expeditiously by pipeline. Crude oil pipelines are used only for the transportation of crude oil, while many refined products pipelines carry more than one type of product (multiple products pipelines). These products are sent through the pipeline in tenders (batches) in such a way as to reduce the amount of mixing at the interface of successive tenders to a minimum. Because of their large capacity, pipelines are generally the most vital link in an industrialized country's energy supply system. A 25-cm (10-inch) pipeline under pressure can deliver over 47,500 barrels of gasoline per day, or as much as 200 railroad tank cars, 400 tank trucks or 100 standard size river barges. Coal and ore are also carried in pipelines as slurry.

5-34. Components of a Pipeline System

a. *Pipe.* The pipe used in long distance pipelines, and in many local lines, is of welded steel with diameters varying from 15 cm to more than 1 meter (6 to more than 40 inches), depending upon the economies of the lines construction. The pipe may be laid either underground or above ground (fig. 5-20) and may extend cross country or follow the alignment of roads and railroads. Stream crossings are generally effected by laying the pipe on the stream bottom. Where streams are

swift or where beds may shift rapidly, the pipe is attached to existing bridges (fig. 5-21), or special pipeline suspension bridges are built. Siphon type crossings are used where necessary.

b. *Pumps and Compressors.* Where increases or reduction of pressure are required, regulating features such as pumps or compressors are used. Pumping stations for liquid fuels, and compressor stations for gas, are similar in appearance; the



Figure 5-20. Pipeline laid above ground.

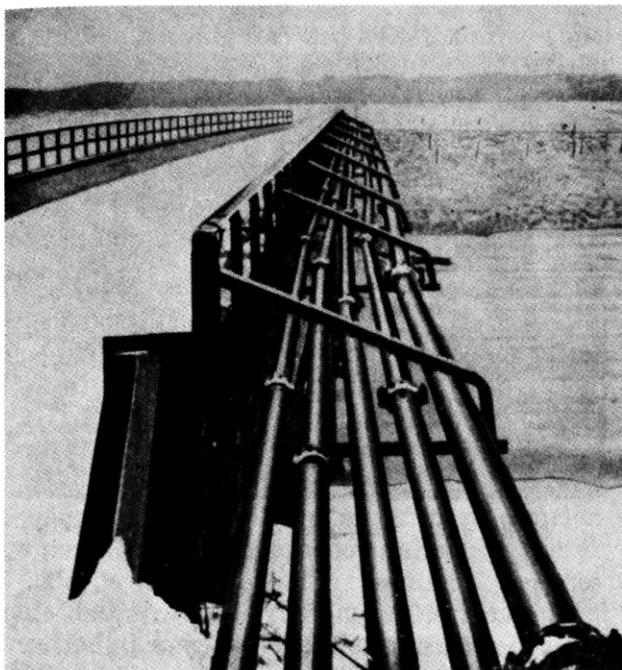


Figure 5-21. Pipeline crossing stream on existing bridge.

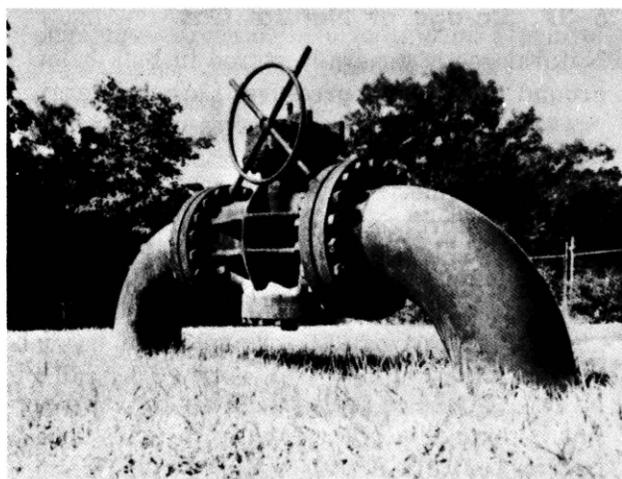


Figure 5-22. Cutoff valve.

distinguishing features are the cooling towers present at compressor stations.

c. *Other Components.* Integral parts of any pipeline system are valves, manifolds, and meters. These are located at frequent intervals along the pipeline and at terminals. Valves protruding from the ground (fig. 5-22) are often the only indicators of the alignment of a pipeline.

5-35. Terminal Facilities

a. Crude oil receiving terminals receive oil directly from oil fields by means of a number of

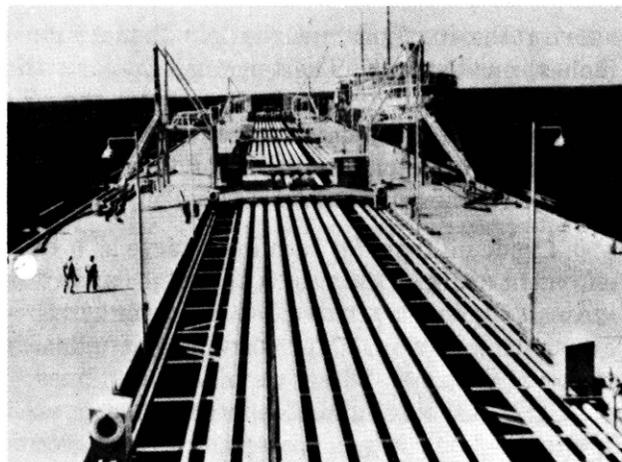


Figure 5-23. Oil loading lines.

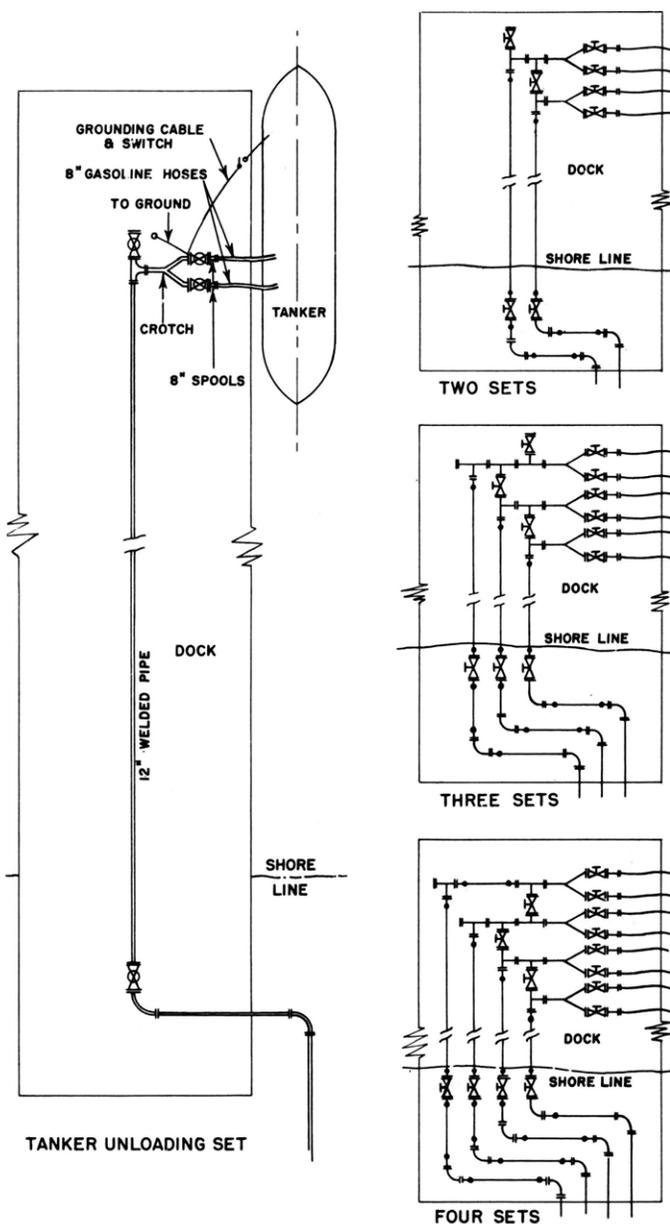


Figure 5-24. Layout of dock set for tanker unloading.

short gathering lines, usually less than 15 cm (6 inches) in diameter. The terminals have settling tanks and other facilities for purifying the oil as it comes from the ground. Once purified, the oil is dispatched to a truck pipeline or to other terminals for further shipment.

b. Crude oil transfer terminals serve as a transshipment point between a pipeline and other means of transportation. Most transfer terminals are marine terminals for loading and unloading tankers. Figure 5-23 shows oil-loading lines for simultaneous loading of several tanker vessels. Figure 5-24 is a typical layout of dock set for tanker unloading. Characteristics of such terminals are the numerous pipelines laid along the piers and extending to tanker berths. In shallow waters, loading facilities may lie a considerable distance from the shore and pipe is generally laid on the water bottom.

c. Refinery terminals consist of numerous tanks for the separate storage of crude oil and refined products. The size and type of facilities will depend on whether the refinery is located near the source of supply or consuming center.

d. Refined products transfer terminals may be marine receiving terminals or loading points for railroad tank cars and tank trucks for the bulk shipment of individual products.

e. Refined products dispensing terminals contain a variety of products for final distribution.

f. Natural gas receiving terminals are located at the producing field and contain facilities for conditioning the gas for pipeline transmission.

g. Natural gas dispensing terminals are located at consuming centers and include dispatching and metering facilities and sufficient storage facilities to meet peak demands.

5-36. Storage of Petroleum and Petroleum Products

Storage tanks, found in varying numbers at all petroleum installations, constitute an easy recognition feature. Areas of great extent and capacity are called tank farms. Products with different characteristics are stored in different types of tanks. Generally, volatile products, such as gasoline and kerosene, are stored in floating roof tanks, i.e., tanks which have roofs that float on the liquid in order to reduce space in which vapor might form. Nonvolatile products such as fuel oils and crude oil are stored in fixed roof tanks. Petro-

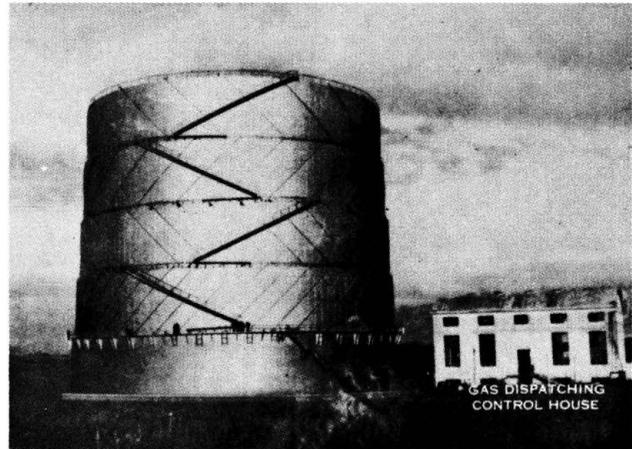


Figure 5-25. Gas holder at dispensing terminal.

leum gases are generally liquified and stored under pressure in spherical tanks or in horizontal cylindrical tanks. The number and variety of tanks in a storage installation indicate the quantity and type of each product stored.

5-37. Storage of Natural Gas

Natural gas is generally stored in bulk below the ground under high pressure. Large underground gas storage pools, usually caves or quarries near consuming centers, are often used to store gas for seasonal or emergency needs. Above ground, natural gas is stored mostly under pressure in spherical tanks, but large telescoping tanks (fig. 5-25) are sometimes used for low pressure storage.

5-38. Military Pipelines

Military pipelines are used chiefly to transport jet fuel and gasoline. Occasionally they are used also to transport diesel fuel and kerosene. Ordinarily, a 15cm (6 inch) pipe is used. A 20cm (8 inch) pipe is employed for ship unloading or trunk lines. The pipeline follows the most direct level route, within 6 to 9 meters (20 to 30 feet) of all-weather roads so as to facilitate construction, patrol, repair, and security of the line. Cross-country cutoffs are used where roads wind excessively. A military pipeline is diverted around difficult terrain, such as marshes, swamps, or land that is subject to periodic flooding. It also avoids populated areas and military installations that have a high element of hazard, such as ammunition dumps. Base terminals are located in rear areas, at or near theater ports of embarkation or other tanker unloading points, but pipehead terminals are located at the forward end of a mili-

tary pipeline, moving forward with the army supply point to support the advancing forces. Details on planning, design and maintenance of military pipeline systems are contained in TM 5-343, "Military Petroleum Pipeline Systems."

5-39. Civilian Pipelines

Civilian pipelines are important for potential military support. They are generally permanently installed cross country along the most economical route. These pipelines may range from about 10cm (4 inches) to more than 100cm (40 inches) in diameter. Pipe of extremely large diameter is ordinarily used only for natural gas or crude oil. Pipelines for crude oil are much more common than those for refined products, although use of the latter is rapidly growing. Crude oil pipelines can be converted for handling refined products; however, this is a costly and time consuming undertaking, particularly if aviation grade fuels are to be transported.

5-40. Sources of Information

The primary sources of information on pipelines are publications, personal contacts, direct observation and photography.

a. Publications. Technical publications on individual installations, fields and facilities contain information on the location, size, and capacity of transportation installations and describe the methods of distribution. Company publications and annual reports provide statistical data on production and plans for the expansion of pipelines. Trade journals and economic periodicals analyze the effects of changes of fuel supply on the country's economy and provide technical and engineering data. Government publications deal with the administration and operation of fuel supply systems. Equipment manuals give specific details on the operation and maintenance of equipment and pipelines.

b. Personal Contacts. The principal purpose in making personal contacts is to obtain data not available from publications. Hence, the ideal subject for interrogation would be a person engaged in the activities with which publications are concerned. In countries friendly to the United States, much information may be obtained from local oil company employees.

c. Direct Observation. Generally, direct observation should be undertaken only after documentary exploitation and personal interviews have

been attempted, thereby limiting personal reconnaissance to specific gaps in information. Some of the requirements which may be met by direct observation are the capacity and types of storage tanks, number of loading and unloading lines at terminals, pipeline stream crossings, and pipeline alinement.

d. Photography. Good photography is a valuable source of information. Photographs of pipelaying operations should be taken, if possible, from a slight eminence overlooking the site so as to show all the construction equipment available. The best photographs of above ground pipelines are close-ups with common, well known objects placed against the pipeline to offer a size comparison. In most countries storage tanks and refinery equipment are coated with colored paint. Generally, units performing the same type of processing are painted the same color, as are tanks and pipes containing the same type of product. The use of color film in photographing such installations is of great assistance in determining their layout. To be of maximum intelligence value, all photographs should be accompanied by captions telling what was being photographed, and where and when it was taken.

5-41. Collection Checklist—Pipelines

1. *Identification.* Local name, number and military designation.
2. *Location.* Base terminal, pipehead or port of entry.
 - a.* Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b.* Political unit, area, UTM coordinates, and geographic coordinates.
3. *Total length of pipeline in kilometers.*
4. *Status.* Operative, inoperative, damaged, under repair, abandoned.
5. *Ownership.*
6. *Materials normally carried.*
7. *Importance to local economy.*
8. *Rated capacity (cubic meters per hour).*
9. *Actual throughput (cubic meters per hour).*
10. *General condition.*
11. *Capability for flow reversal (yes or no) time required to reverse flow.*
12. *Horizontal alinement.*
13. *Ship to shore unloading/loading facilities.*
 - a.* Dockside connection or submarine lines.
 - b.* Dockside connections (pier identification).

c. Discharge hoses (type, number, diameter, length, and connectors).

d. Pipeline from dockside to trunk terminal (number, type, diameter, material, length, and type of coupling).

14. *Other input sources.* Describe or cross reference to petroleum collection file.

15. *Trunk line segments.*

- a. Identification.
- b. Location of end points (UTM coordinates).
- c. Facility connected to at end point.
- d. Length of segment.
- e. Number of lines.
- f. Material and type.
- g. Diameter.

h. Operating and maximum pressure.

i. Type of coupling.

j. Capacity.

k. Pumping/compressor stations (location, distance from end points, function, and type of pumps).

l. Construction details.

16. *Branch lines.*

a. Connection with trunk line (number and location).

b. Pipehead and facility.

17. *Operation and maintenance.*

18. *Security and safety features.*

19. *Repair requirements.*

Section VI. INLAND WATERWAYS

5-42. General

The term inland waterways is applied to the rivers, canals, lakes, and inland seas which are used as avenues of transport. It also includes the inter-coastal waterways, usually running parallel to the coastline of a land mass and sheltered enough to permit the navigation of small vessels. The term includes all the fixed structures which affect the movement of vessels carrying passengers or freight.

a. *Classification.* Inland waterways can be classified according to their depths:

(1) *Very shallow.* Depths less than 1.4 meters (4½ feet).

(2) *Medium.* Depths between 1.4 and 2 meters (4½ and 6½ feet).

(3) *Deep.* Depths greater than 2 meters (6½ feet).

b. *Advantages.* Inland waterways provide an economical form of transportation for bulk supplies, freeing faster modes for shipments of a higher priority. Frequently, large or very heavy items that cannot be handled by truck and rail can be shipped by waterway. One of the major uses of waterways in an active theater is the transportation of supplies for the rehabilitation of the economy in liberated areas, thus reducing the demands upon military transportation facilities.

c. *Limitations.* Waterway transport is slow. It is also inflexible since new waterways cannot be constructed during military operations. The depths of rivers and streams used as waterways

fluctuate with maximum and minimum rainfall. Streams with fairly direct courses commonly are interrupted by falls and rapids. Streams of low and uniform gradients usually meander and their channels shift constantly, depositing sandbars which are a menace to navigation. Unless ice breaking operations can be conducted, traffic is halted completely during a freezing period. The thaw following a freeze may cause floods. Periods of drought may result in insufficient water for the movement of vessels. The locks, bridges, cuts, dams, and other fixed facilities are vulnerable to enemy action.

5-43. Individual Waterways

a. The inland waterway network of a country usually is comprised of a number of individual waterways or waterway systems that may or may

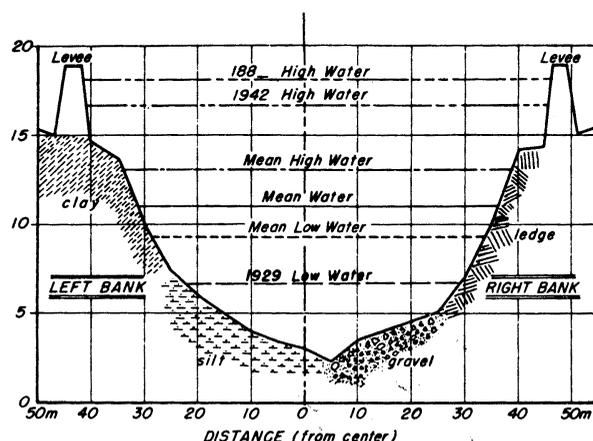


Figure 5-26. Typical river cross section.

not be interconnected. Rivers and lakes, if navigable either in their natural or improved states, may be used or canals may be dug. Navigability of a waterway may be facilitated by construction of locks, dredging of shoals, and other channel improvements. Figure 5-26 shows a typical river cross section.

b. Detailed information is needed on the distinctive characteristics of each individual waterway to determine its capacity for transport and to define its repair and maintenance requirements. A site on an inland waterway is considered critical or hazardous if it can be easily blocked or has characteristics that tend to restrict traffic. Critical sites include gorges, narrows on rivers, deep cuts on canals, potential landslide areas, narrow navigable channels, and passages between sandbars or islands that may be blocked by debris, sunken vessels or mining, and locks, dams, bridges, levees, and other structures whose destruction might affect traffic.

5-44. Principal Ports

Inland waterway ports vary from large well-equipped port complexes to small simple landings. Some inland waterway complexes are larger in size, and handle greater tonnages yearly than many maritime ports. Facilities for loading, unloading and transshipping inland waterway cargo are often important features of maritime ports. Interest in principal inland waterway ports parallels that in maritime ports and is concerned with administration, traffic, operating practices, and physical features of the harbors, terminals, storage, and clearance facilities that pertain specifically to inland waterway operations. The guidance on maritime ports contained in paragraphs 5-50 through 5-61, *Ports and Harbors*, can be applied to inland waterway ports.

5-45. Secondary Ports and Landing Facilities

Secondary ports are those located, in most cases, farther upstream or inland from the coast than are maritime ports or the more complex inland river ports. Such ports may be little more than stops or points of call on steamer service routes, and may consist of but a single small landing or merely a point at which craft tie up along an unimproved section of the river bank. Climatic factors exert greater influence on the characteristics of waterway terminals than on maritime ports. Where seasonal variations in water levels

are great and where winter freezes are a common occurrence, pontoons with movable shore connections are sometimes employed as berthing platforms. Collection of information on secondary ports and landing facilities is often deficient because of a lack of appreciation of their importance in inland waterway transport. Although the facilities of an individual port may be limited, the combined volume of traffic handled by a number of such minor ports may represent a significant portion of the total water transport capabilities of an inland waterway system.

5-46. Facilities and Installations

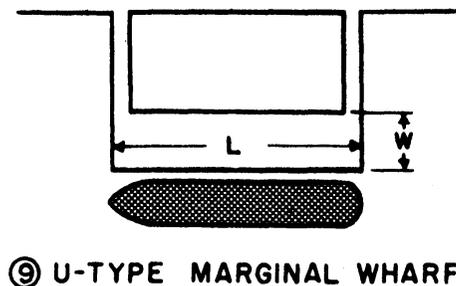
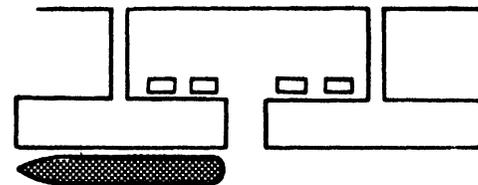
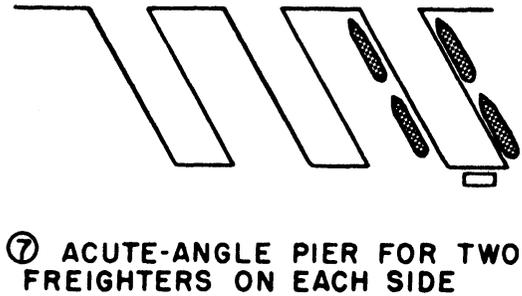
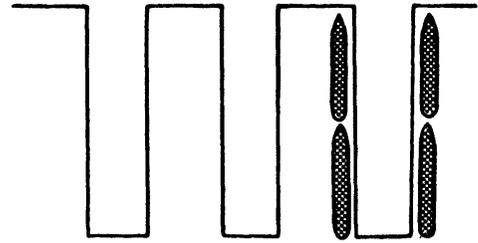
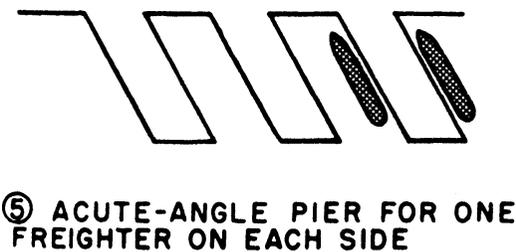
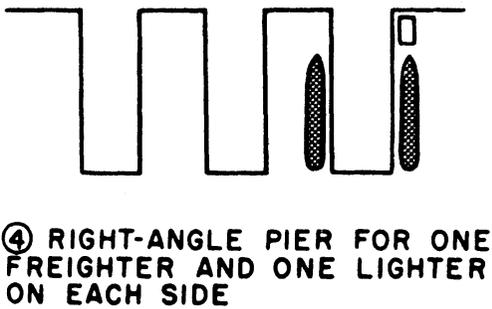
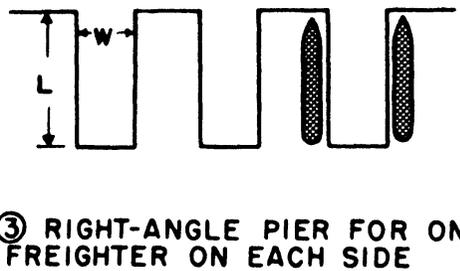
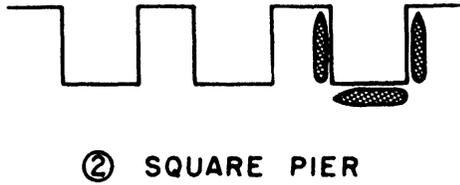
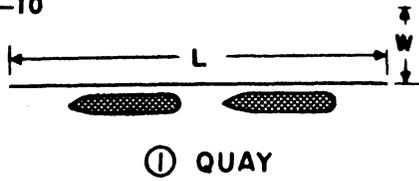
a. *Wharves*. A discussion of wharves is contained in paragraphs 5-50 through 5-61. Figure 5-27 shows types of wharf layout. A wharf reference diagram is shown in figure 5-28.

b. *Locks*. Locks (fig. 5-29) are structures in a waterway with gates at each end, used in raising or lowering vessels as they pass from one level to another. Common types of locks are single- and multiple-chamber. An auxiliary gate is sometimes installed near the center of a lock to economize on the volume of lockage water for a single ship or short tows. Two identical locks side by side are called twin or parallel locks. A tandem lock consists of two or more chambers in series, locking being accomplished in two or more steps. Intermediate gates are common so that three gates (instead of four) are sufficient for a two-step tandem lock. To relieve the pressure on the regular lock gates when repair work is being done, a guard gate may be constructed in a waterway. To shorten the time to fill and empty lock chambers, filling or lock basins are built either as multiple basins or basins parallel with the lock chamber. These side basins serve as "thrift" basins to conserve lockage water by storage of part of the water. The gates are the most vulnerable features of a lock. Common types of gates are:

(1) *Double-leaf miter gates* (fig. 5-30). A pair of hinged gates that form a "V" or angle across the end of the lock when closed. The apex is always upstream to utilize the head of water to keep the gates closed.

(2) *Single-leaf miter gates*. Hinged gates that pivot into a recess in the lock wall.

(3) *Vertical-lift gates*. Lock gates that move in a vertical plane. This type of gate is usually suspended from an overhead frame and counterbalanced.



W = WHARF WIDTH L = WHARF LENGTH

NOTE: NOT TO SCALE. FOR EXPLANATION OF LAYOUT TERMINOLOGY ONLY

Figure 5-27. Types of wharf layout.

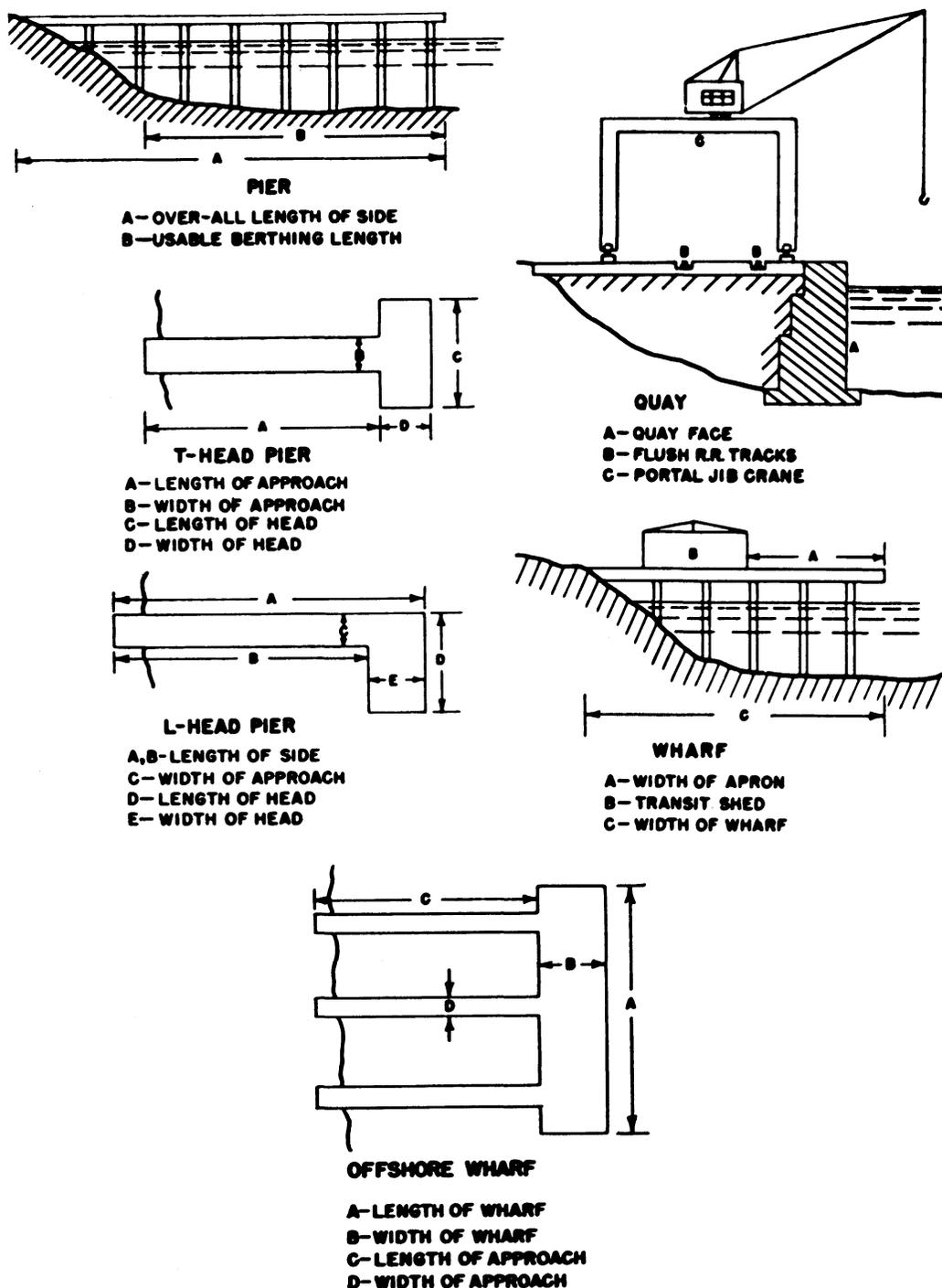


Figure 5-28. Wharf reference diagram.

(4) *Caisson or sliding (retractile) gates.* This type of gate moves horizontally into wells or caissons when in an open position.

(5) *Segmental gates* (fig. 5-31). A pair of gates shaped like sectors of a cylinder. They are hinged at the sides and rotate into wells.

c. Dams. Dams are barriers across the water-course to prevent, divert, or regulate the flow of

water. They are built for navigation, hydroelectric power, flood control, irrigation, water supply, or a combination of purposes. They may be either movable or fixed. Movable dams are low weirs topped by relatively large movable gates that can be opened or closed to regulate the water level. Fixed dams are of three basic types: gravity, arch, or buttress dams. In a gravity dam, the forces acting on the structures are directed verti-

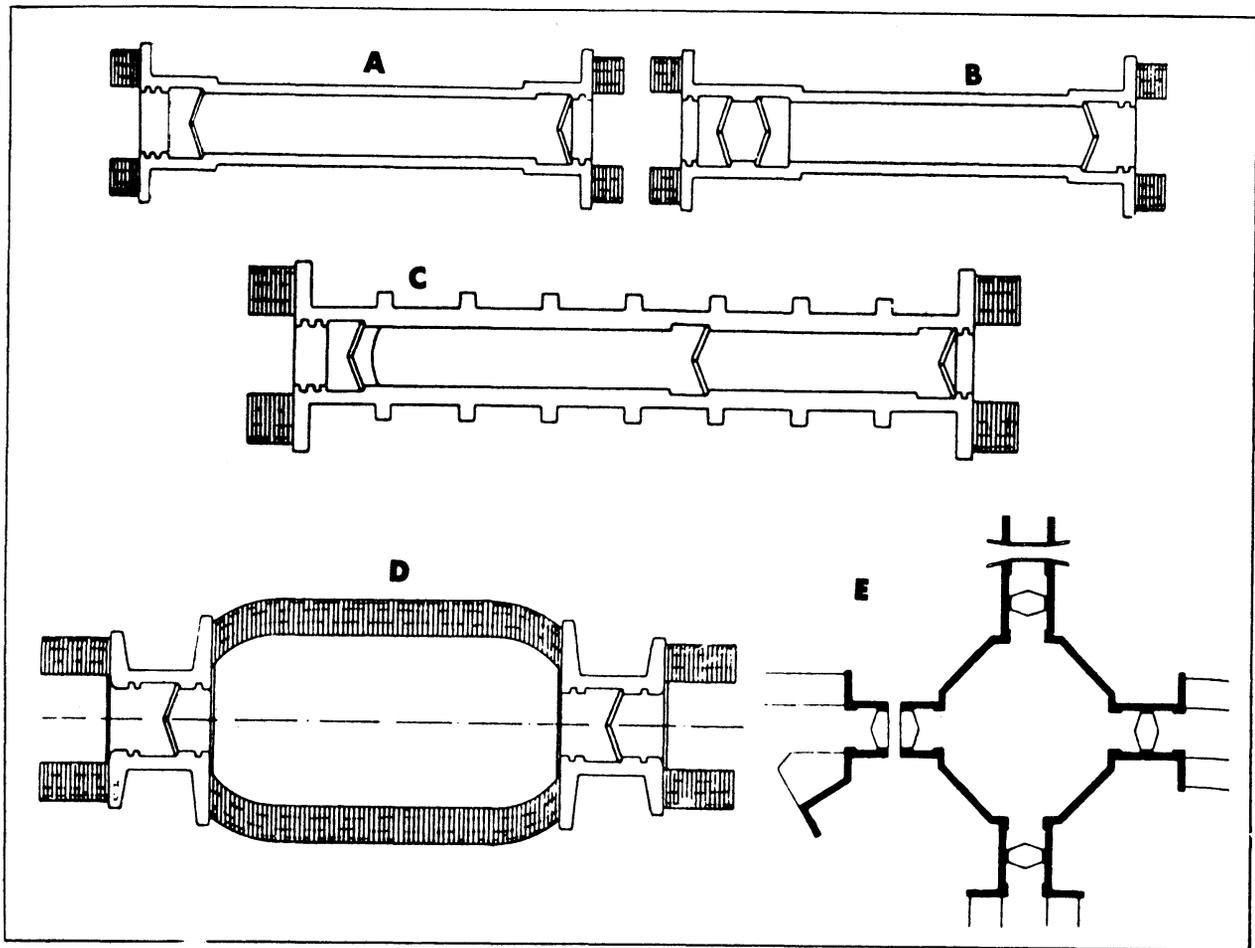


Figure 5-29. Common types of locks. A. Chamber lock with double-leaf miter gates. B. Chamber lock with double-leaf miter gates and, at one end, opposing or tidal gates. C. Chamber lock with intermediate gates. D. Basin lock with double-leaf miter gates at either end. E. Switch kettle or four-square lock with opposing double-leaf miter gates.

cally downward to the bed of the channel; in an arch dam, they are mainly horizontal to the banks or the sides of a gorge; and in a buttress dam they are directed to an auxiliary structure. Water may be discharged over a spillway located at or near the dam or elsewhere along the reservoir, or through pipes or tunnels beneath or bypassing the dam or abutments. Locks may be provided at the dam or on bypass canals to permit passage of waterway traffic.

d. Bridges. Bridges may have restrictive effects on navigation because of limited vertical and horizontal underbridge clearances which determine the height and width of craft that can pass under the structure. Bridges may be highway, railroad, or pedestrian.

e. Aqueducts. An aqueduct (fig. 5-32) is a bridge that carries a waterway or water conduit over another waterway, ravine, or depression.

Like other bridges, aqueducts have a substructure and a superstructure. Spans may be built of steel, concrete or masonry.

f. Tunnels. Waterway tunnels are uncommon structures on inland waterway canals. They are usually preceded by locks with short lifts to overcome local irregularities in surface configuration or they may have the same level as the canal. In some tunnels, a railroad tow engine is used to pull the barges and vessels.

g. Shiplifts (fig. 5-33). When lockage water is difficult to obtain or where lift requirement is very great, ships may be lifted by elevators operated hydraulically or mechanically, although the size of vessels which can be handled is limited.

h. Inclined Planes. In some cases where a great difference in elevation is involved or where transfer of vessels is required across a ridge between waterways, inclined tracks may be provided on

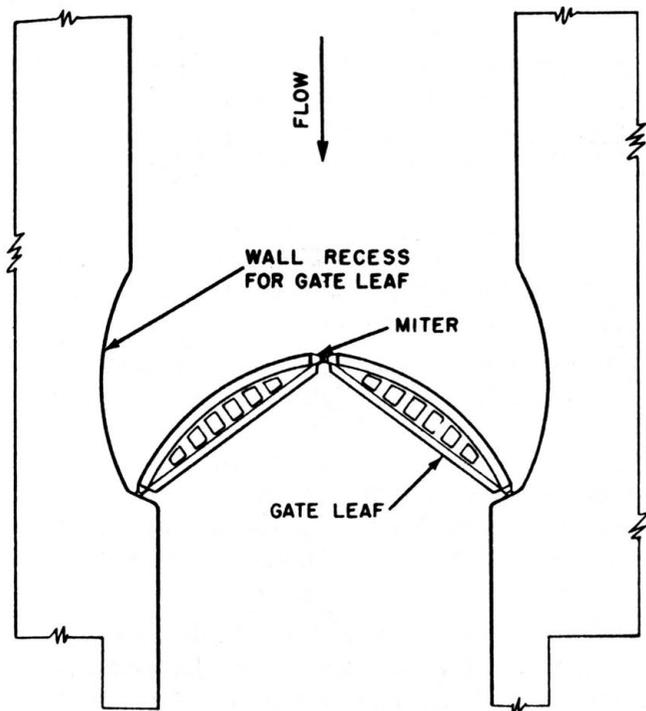


Figure 5-30. Schematic drawing of miter lock gate in closed position.

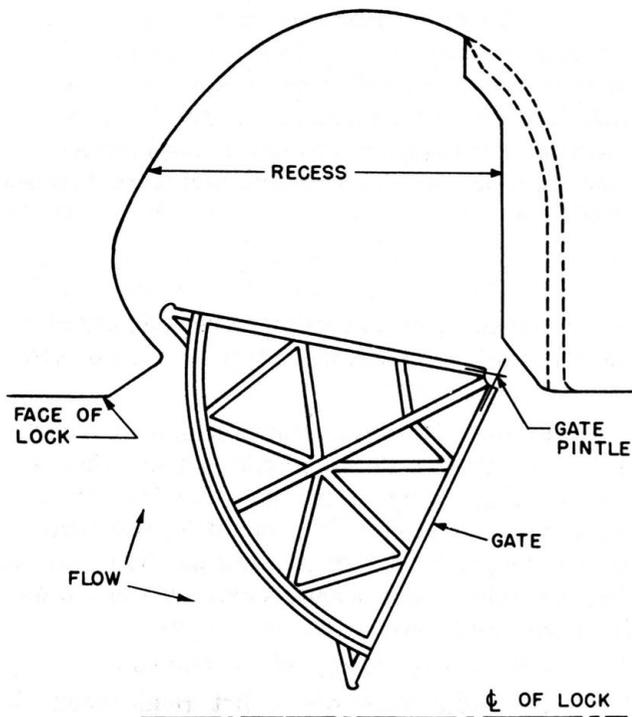


Figure 5-31. Schematic drawing of sector gate leaf.

which vessels are drawn on special carriages. Such devices are cheaper to construct than locks or shiplifts, but usually are restricted to handling small- or medium-sized craft.

i. Safety Gates. Single safety or guard gates,

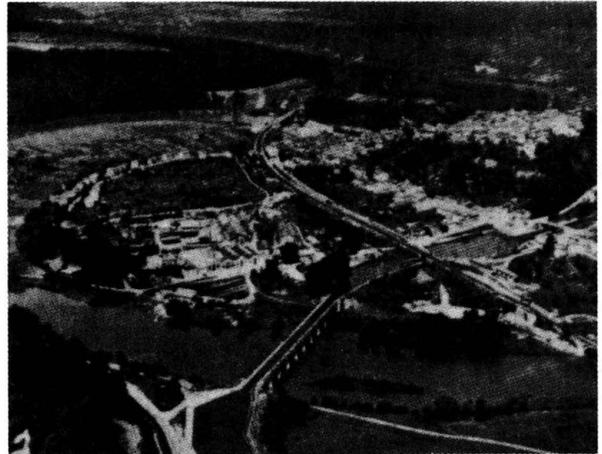


Figure 5-32. Aqueduct carrying a waterway over a river.

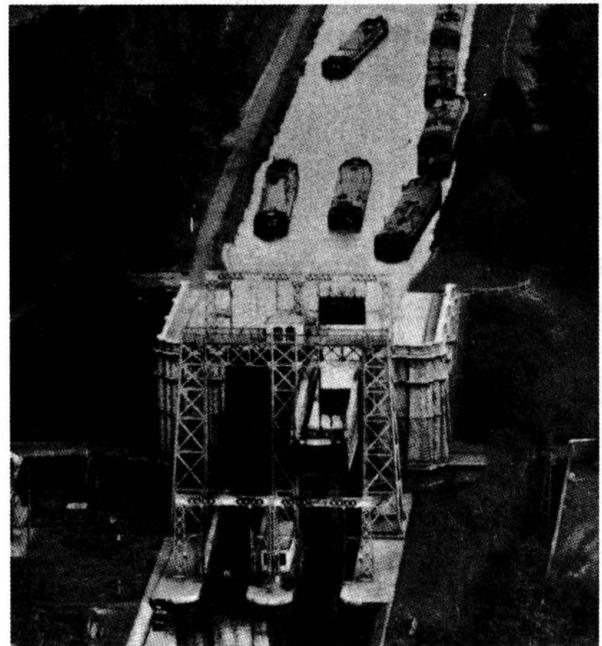


Figure 5-33. Shiplift.

similar to a lock gate, may be installed to seal off sections of a waterway from loss or entry of water if a vulnerable structure (such as lock) is damaged or if flood water, floating ice, or high tides must be diverted from a section of a waterway.

j. Ferry Crossings. In many countries, ferries are frequently used to cross rivers and lakes. They often provide vital links in the rail or highway net and thus are significant components of inland waterway transport. The ferry craft may represent appreciable portions of the inland waterway fleet capacity. Ferry sites may also be im-

portant locations for military stream-crossing operations.

5-47. Construction and Maintenance

a. Data on construction and maintenance are important in any study of inland waterways. Construction includes the building of canals, the extension of navigation facilities, and the building of protective, regulating, or navigational works on any waterway, natural or artificial. Maintenance and repair are continuing services required to keep channels, facilities, and navigation aids in operational condition.

b. Construction and maintenance depend upon the availability and quality of material, equipment, and labor forces. Ordinary land based equipment may be used in some phases of waterway maintenance and improvements; however, specialized floating equipment is required for dredging navigable channels, installing and maintaining waterway facilities, and clearing snags, ice, and debris that hinder navigation. This specialized equipment includes dredges, derrick boats, floating cranes, and pile drivers.

5-48. Source of Information

There is no worldwide standard of waterway classification. Collection of inland waterway information can be difficult. The principal sources of information are documents, direct observation, photographs, trade journals, and government agencies for trade and commerce.

a. Documents. The following types of source material may be obtained from agencies dealing with public works or transportation, engineer contractors, shipping companies, hydrographic offices, mapping organizations, manufacturers brochures, or from magazines and technical publications found in book stores and libraries:

(1) Waterway maps, large scale topographic maps, and city plans are among the principal sources of information. They contain information on navigability of rivers, lakes, and canals, occasionally including periods of navigability, allowable craft sizes, navigational aids, hazards, principal ports, and landing places.

(2) Hydrographic charts show navigational depths throughout the length of a waterway, tidal information, topography of the shore, channels, islands, character of the bottom, and hazards to navigation.

(3) Hydrographic discharge graphs, charts,

and tables indicate the volume of discharge (volume of water passing a given point over a given period of time), usually expressed in cubic feet or cubic meters per second. Composite hydrographs showing monthly discharge averages and water level averages over a period of years are preferable.

(4) Waterway profiles are scaled drawings showing the sectional differences in elevation along the course of a waterway from a vertical datum point, usually a sea level reference.

(5) Route guides describe the navigational characteristics of a waterway route, including class (based on traffic movement or ship size), and type (canal, canalized river, etc). They also provide details on the maximum size or type of craft that can use waterways, lock size and bridge passage restrictions, and the number of lockages and ports.

(6) Lock tables contain tabulations of locks on individual waterways giving location, length and width of chamber, depth over sill, amount of lift, type of gates and number, and other descriptive data.

(7) Terminal plans are large-scale drawings or representations showing the general layout with details on berthing, cargo-handling, and storage facilities; feeder canals and tidal creeks; rail, road, and waterway connections and structures; and location of important servicing and repair facilities.

(8) Construction plans and progress reports may contain information on improvement policies and programs, cross-section views of rivers and canals, and drawings of principal locks, dams, bridges, levees, and other structures.

(9) Aerial and ground photographs are accurate sources for detailed information on structures such as locks, dams, port facilities, floating equipment, cargo-handling facilities, road and rail clearance facilities and equipment, and vessels. Picture postcards at bookstores and news stands at major terminals often provide excellent views of structures and sections of waterways.

(10) Ship diagrams or blueprints show the features or design characteristics of a particular craft.

(11) Traffic flow charts may be either actual maps or schematic diagrams. They generally show tonnage movement over individual waterways or in ports by means of color changes or various types of lines.

(12) Traffic tables and graphs are usually concerned with freight, passenger, and vessel movement, and may show total or directional movement over an individual waterway.

(13) Structure plans are scaled engineering drawings giving structural details and dimensions of construction projects, such as locks, dams, and ports.

(14) Rules of the road are usually in the form of handbooks which describe rules and procedures for ship operation. They include whistle signal systems and other ship navigation data such as right-of-way rules, buoyage, lights, and navigational aids in general.

b. Direct Observation. Personal observation should be undertaken as a supplement to or substitute for other sources. Normally, direct observation should be used to fill specific requirements and to provide a general verification of available data as a whole.

c. Photographs. Photographs not only supplement information obtained by direct observation, but often provide much additional technical data. Photographs should be taken of port facilities, locks, bridges, and waterway craft from several angles and distances to show both the relation between the various elements in an installation and the details of critical features. It is important that complete explanations of the photographs accompany the pictures. Water level may be read from a gage if one is located in the vicinity; if no gage is available, a general statement of water conditions (such as high or low tide, high or low water, etc.) should be included. An indication of scale and dimensions should be provided by including people, vehicles or objects of known size in the photograph.

5-49. Collection Checklist—Inland Waterways

1. *Identification.* Local name and military designation of the overall route and segments thereof.
2. *Location.*
 - a. Map reference—Include series and sheet number(s) of both tactical and air ground series.
 - b. Political unit, area, UTM coordinates, and geographic coordinates.
3. *Total length of overall route and segments thereof in kilometers.*
4. *Vessel tonnage class of segment.*
5. *Type of waterway (terrain classification).*

6. *Controlling characteristics of open reaches.*
 - a. Channel depth and width.
 - b. Current velocity, meters per second.
 - c. Overhead clearance.
 - d. Sharpest bend (degree of bend and location).
7. *Safe draft.*
8. *Navigational seasons.*
9. *Alinement of channel.*
10. *Alinement of banks.*
11. *Sources of water.* Primary sources, adequacy, and alternate sources.
12. *Water characteristics (potability).*
13. *Approaches and entrances to waterway.*
 - a. Nature of approach.
 - b. Identification and location.
 - c. Conspicuous objects or landmarks.
 - d. Approach channel (controlling width and depth, location of obstacles, and alternate channels).
14. *Junctions with other waterways.*
15. *Aqueduct bridges.* Cross reference to bridge collection file, paragraph 5-24.
16. *Crossings.* Cross reference to bridges, cableways/tramways, tunnels, fords, and ferries collection files.
17. *Waterway profile and cross sections.*
18. *Intermediate points.* Cross reference to ports and harbors collection file.
19. *Locks.* Identification, location, type, controlling dimensions, time required to fill, time required to clear, demolition chambers, filling basins, and condition.
20. *Lifts.* Identification, location, construction design, dimensions, transit time (minutes), power source, demolition chambers, and condition.
21. *Inclined planes.* Identification, location, construction design, hoisting device, transit time (minutes), and condition.
22. *Dams and reservoirs.*
23. *Levees and retaining walls.*
24. *Channel obstructions.* Type, location, effect on navigation, by-passes methods, and effort required to remove.
25. *Upper limits of tidal influence.*
26. *Towage system.*
27. *Passing basins and anchorages.* Locations, size, depth, bottom material, berth locations and controlling clearances.
28. *Jetties and groins.* Locations, function, and construction design and materials.

29. *Pumping stations.* Location, function, power source, and type of pumps (rated capacity).
30. *Banks.*
31. *Bottom.*
32. *Design standards for canals.*
33. *Navigational aids.*
34. *Planned development.*
35. *Maintenance and repair requirements, dredging.*
36. *Heavy floating machinery.*
37. *Vessel repair facilities.*
38. *Loading and unloading facilities.*
39. *Tonnage moved by commodity (daily, monthly).*
40. *Vessels using waterways.* Type, number, dimensions, capacity, and propulsion.
41. *Major traffic interruptions.* Type, cause, location, and number of occurrences.
42. *Major transport organizations.*
43. *Importance to local economy.*
44. *Movement capability, metric tons per day.*
45. *Effects of climate and weather.*
 - a. Flooding (probable occurrence, extent, duration and effects).
 - b. Winds (probable occurrence, extent, duration, and effects).
 - c. Icing (probable occurrence, extent, duration, and effects).
 - d. Drought (probable occurrence, extent, duration, and effects).
46. *Special geophysical phenomena.*
47. *Adjacent terrain.* Cross reference to appropriate collection file.
48. *Critical points.* Points at which traffic may be easily blocked.
 - a. Nature of point.
 - b. Location.
 - c. Method of causing blockage.
49. *Operational features.*
50. *Security and safety features.*

Section VII. PORTS AND HARBORS

5-50. General

a. Information on ports, naval bases, and shipyard facilities is essential for estimating capacities, capabilities, vulnerability, and other items of military significance. Ports are classified on an area rather than worldwide basis, and a principal port in a small maritime nation may be about equivalent to a much lesser port in the more extensive port system of another country. In wartime, principal and secondary ports and bases are prime targets for destruction, and the relative importance of minor ports increases.

b. Modern trends in cargo handling and transport methods will decidedly affect future port development, and the use of new types of equipment will permit greater flexibility of movement and application in maritime transportation. The enormous increase in bulk cargo carrying capacity of ships (especially oil tankers and ore-carrying ships) has necessitated construction of more massive and complicated pier and wharf structures and offshore terminals. The use of specialized transport, such as container ships, trailer ships, conveyor equipped bulk carriers, and dual purpose bulk cargo ships may result in a shift to a limited number of specially equipped ports, or require major reconstruction of existing ones.

c. The need for detailed information on ports and maritime facilities is of a continuing nature. Collectors and users of such information should become familiar with the details contained in TM 5-360, Port Construction and Rehabilitation.

5-51. Harbors

Only when a harbor has been developed for transacting business between ship and shore does it become part of a port. A port, therefore, normally consists of a harbor plus terminal facilities. Harbors are classified according to location: coastal, bay and estuary, and river/harbors. Although they vary greatly in size, shape, and situation, individual harbors in the same category have common characteristics and problems. Harbors associated with ports may be natural, improved natural, or artificial. The natural harbor is one that can be used without harbor works or improvements of any kind. The improved natural harbor is a natural harbor whose utility has been enhanced by the addition of artificial works and improvements. An artificial harbor is one that is created and maintained largely or entirely by human efforts. The great majority of harbors associated with ports are either artificial or improved natural harbors.

a. Harbor Works. Harbor works, including protective works, are the structures designed to provide shelter, to control water flow, and to regulate erosion for the improvement of the navigability of a harbor. The principal categories and types of structures are breakwaters, jetties, groins, sea walls, bulkheads, dikes, locks, and moles. Harbor works do not include port facilities that are designed specifically for the transfer of cargo and the servicing of ships.

b. Depths. Depths are an important element in such port topics as harbor, entrance, anchorage, wharves, and dry docks. Depths are computed in terms of established reference planes which are based on, but do not necessarily coincide with, tidal levels. The particular reference plane on which depths on a hydrographic chart are based is called chart datum and is defined on the chart. Precise datums are established for most ports and are a basis for soundings. The reference plane should be clearly indicated when depths are reported.

c. Basins and Docks. Basins are artificially enclosed bodies of water that form a harbor or part of a harbor. They may be tidal basins in which the water is subject to tidal influences, or controlled-level basins, in which the water level is maintained irrespective of tidal change. Controlled-level basins are of two types: wet docks and half-tide basins. The wet dock is enclosed by a gate, caisson, or lock. It may be filled by naturally impounding water at each high tide or at spring tides only. Pumping plants may be provided for initial filling or for elevations of the water above that achieved by natural impounding. The half-tide basin has gates at each end and is used in much the same manner as a large lock to increase the length of time for entry and exit. Owing to the enormous amount of water required to raise the water level it cannot be used at all states of the tide; hence its name, half-tide basin.

d. Navigable Fairways. The navigable fairways through the approach and the entrance to the harbor and the harbor itself frequently determine the size of ships that can be accommodated in the port. Any fairway with controlling dimensions that limit the size (draft, length, beam, height above water) of ships that can traverse it should be described in detail. Reports on the experiences of ships with critical dimensions that have entered are most helpful.

e. Anchorage. Much of the anchorage data can best be shown on large scale charts and plans. All

available information of an operational nature should be reported, including anchorage designations and berth assignments by local authorities, normal anchoring practices, and ship experiences.

f. Moorings. Fixed moorings are provided in harbors where space restrictions prohibit free-swinging anchorage, where the number of accommodations is limited, and as a more secure berth than can be provided by a ship's own anchors. Fixed moorings may consist of anchored buoys or mooring posts:

(1) *Buoy moorings.* Several types of berths can be provided by mooring buoys: free-swinging (one buoy), ship's head secured to buoy, bow and stern (one buoy), ship secured ahead by own anchors and astern to buoy, or ship secured ahead to buoy and astern to bollards ashore; bow and stern (two buoys), ship secured to buoys ahead and astern. Buoys may be held by a single anchor but, generally, two or more anchors laid at varying angles are used for greater holding capacity and more precise positioning of the buoy. When more than one anchor is employed each may connect independently with the buoy, but generally ground chains from each anchor converge at a heavy sinker to which the buoy is secured by a pendant chain. Mooring buoys (particularly those used by naval craft) may be fitted with submarine cable connections for telephone, electricity, and water. It is important to know the holding capacity of the buoy.

(2) *Mediterranean moorings.* Ships may lie in fixed moorings without buoys in a variety of ways. The simplest method, that of mooring with one or both anchors ahead and stern lines to bollards ashore, is used where wharf facilities are limited, and is commonly employed in Mediterranean ports. In the Mediterranean moorings, ships lie stern to off and at right angles to a quay wall or wharf.

(3) *Dolphin moorings.* In many ports the dolphin is used as a mooring device. It usually consists of a cluster of piles lashed together at the top. Dolphins are located off the shore and are used singly for breasting into or hauling out of a berth, and in a series for mooring a ship fore and aft alongside. Dolphin moorings conserve space in the stream and are used either for idle berthing or for working cargo by lighter. Dolphins are often associated with a wharf either as a protective device at wharf corners and face, or as a means of increasing the length of berthing space provided by a wharf face. Mooring piles have the

same functions as dolphins but occur as individual piles rather than as clusters.

g. Sea and Swell. Sea is a term referring to waves and other disturbance of the surface of a body of water under the direct influence of winds, while a swell is an unbroken wave which may be the result of a storm at some distant place, regular tidal action along cotidal lines, or a combination of both of these forces. Swells are usually several hundred feet long (between successive crests), and their direction of travel may differ from that of the wind. Harbors are usually subject to these conditions, and navigation and port operations are consequently affected. Frequency, duration, and seasonal variation in the occurrence of sea and swell conditions are important information as are specific effects on lighterage and boat work, on anchoring and mooring, and on movement into and about the harbor.

5-52. Wharves

Wharves form the pivot point for port operations, and detailed information concerning them is necessary to evaluate a port's capabilities. Wharf design is determined largely by the use for which the wharf is intended and by local conditions and local engineering practice. Variations in the nomenclature of landing structures are a cause of considerable confusion, and care should be taken to use the proper term. The term "dock" is properly used in northwestern European countries to designate a water area; in the US, however, "dock" is applied generally but erroneously to any and all types of landing structures. The pier type of structure is commonly called a "jetty" in British and other foreign ports, and all marginal structures are referred to as "quay." Improper classification will often be embodied in the proper name of a wharf, and the name should not arbitrarily be changed by the reporting officer. In describing the structure, however, the type wharf should be correctly indicated.

a. Wharf Types. The majority of landing structures fall into two classes: piers and wharves (illustrated in paragraph 5-42 through 5-49). The pier type of structure projects into the water at an angle with the shore line. Berthage is usually available on the two sides of the pier, and, if the structure is sufficiently wide, at the head as well. Variations of the simple straight pier are the T-head pier and the L-head pier. These latter types are commonly used for the transfer of bulk petroleum, and berthage is generally confined to the pierhead.

(1) The term wharf is used in two ways. In its broader sense, wharf is the general designation for all landing structures, including piers. Specifically, the wharf is the type of structure that parallels the shore line and provides berthage at its face only. It occurs in three variations: the marginal wharf, the quay, and the offshore wharf. The marginal wharf and quay are both built parallel to and against the shore and differ only in type of construction. The marginal wharf is of open piling construction, and the quay is a solid wall of masonry or other material. The offshore wharf is a structure of open piling built parallel to, but in an insular position off the shore line. The offshore wharf may be connected with the shore by one or more approaches or gangways or pipelines. A variation of the offshore wharf in common use in the Far East is the pontoon wharf, which consists of pontoons of various types of construction moored in a fixed position offshore and connected with the shore by one or more adjustable gangways. This type is used where there is considerable fluctuation in water level.

(2) Two special wharf types are the mooring platform and the breasting platform. The mooring platform is a small offshore wharf with a square platform or deck. It provides berthage for a ship but is too small for cargo transfer. Mooring platforms commonly are provided in series of two or more, and ships are berthed across the faces. One or more of a group of mooring platforms is generally connected with the shore by a narrow approach or trestle and individual platforms may be interconnected by catwalks. The breasting platform is a small platform structure projecting from the face of a wharf bulkhead. Breasting platforms are usually provided in series of two or more, and ships are berthed across the heads.

(3) An offshore pipeline berth is an offshore berth that is connected to shore solely by submarine or floating pipeline which permits the transfer of cargo directly (without the use of lighters, barges, or other intermediate means) to storage installations on shore.

(4) In a terminal buoy system the terminal buoy is somewhat similar in appearance to the standard mooring buoy but is substantially larger. It is positioned offshore in deep water with three or more chains attached to heavy anchors. The terminal buoy has a revolving platform or swivel to which the tanker is secured as are the floating hose lines for cargo, bunker oil, and fresh water. When the buoy's flexible hoses are coupled to the ship's system this permits ship and hose lines to

swing together a full 360° with the wind or sea. Product transfer proceeds through submarine pipelines connecting the buoy and a shore installation.

b. Wharf Construction. Great variety exists in types of wharf construction and materials used; however, most structures fall into two categories: open construction and solid construction. Great variety exists in types of wharf construction and materials used; however, most structures fall into two categories: open construction and solid construction.

(1) Open construction is used for marginal wharves, offshore wharves, and most piers. In its simplest and least permanent form it consists of open-spaced wooden piling supporting a wooden deck. Variations designed to contribute to the strength and permanence of the open structures are numerous. Substructures may consist of steel or precast concrete piling. The superstructure or decking may vary from wooden joints and flooring to concrete and steel construction with an asphalt or other paved surface.

(2) Solid construction is used in quays and occasionally in piers, and consists of a solid wall backed by fill surmounted by a surfaced decking. Quay walls may be a simple facing of interlocking sheet steel piling, a monolithic concrete wall, or a masonry structure built of stone or precast concrete blocks. Many quays abroad consist of large concrete caissons sunk in line to form a wall, and then filled with concrete or rubble and capped with a reinforced concrete deck.

c. Wharf Dimensions. Several basic dimensions are required for a wharf, and careful measurement and precise identification of reference points is essential. Measurement may be in either feet or meters, but conversion from one unit of measure to another should not be attempted unless accurate conversion tables are available.

(1) The length of one side of a pier may differ from that of the other, and both should be reported. The side of a pier or face of a wharf may be irregular or stepped, and a dimension should be reported for each segment. Usable berthing space may or may not coincide with the overall length; shoals or other obstructions may decrease the usable length of a wharf.

(2) The width of a marginal-type wharf may be difficult to determine, since the inner limit may not be defined. In such cases the measurement points should be clearly identified. Width of apron is not to be confused with width of wharf. The apron is the working part of the wharf deck at

shipside and terminates at the transit shed or other obstruction.

d. Wharf Surface. The type and condition of the deck surface has an important bearing on the usability of a wharf. Indication should be made of the layout of wharf railroad tracks with respect to the wharf deck.

e. Berthing Capacity. Particular care should be given to reporting berthing capabilities of a wharf. Special or unusual berthing conditions would include the breasting of ships off the wharf by means of pontoons, the presence of surge or swell that might require special mooring precautions, and draft limitations.

5-53. Cranes

The variety of cranes through ports of the world is so great that it is not easy to classify them systematically. In many instances identical cranes in different localities are called by different names (table 5-1).

a. Jib Cranes (fig. 5-34 through 5-39). The jib crane consists of the primary arm on which is mounted a shorter arm (jib) extending at an angle. At the end of the jib are sheaves through which run the fall from which the load is suspended. The fall is raised and lowered by a hoisting mechanism built into the crane. Because of their versatility jib cranes are the most common type of cranes and have a wide range of uses. Wharf cranes for handling general cargo are of this category as are many types used in shipyards. They are usually electric powered and range in capacity from 3 to 5 tons. Other types of jib cranes may range up to 100 tons or more. The working radii of a jib crane are measured on a horizontal line between the center of its vertical axis and the hoisting hook. It is customary to report the capacity at minimum working radius and at maximum radius. For wharf cranes it is also important to indicate the maximum height of lift above the wharf deck. Jib cranes are frequently mounted on gantry, bridge, or trestle bases, where they are capable of transverse movement. The various types of jib cranes are portal jib, semiportal jib, tower jib, and locomotive and automotive.

b. Cantilever Cranes (fig. 5-40 through 5-42). The cantilever crane consists of a base or tower structure on which is mounted a counterbalanced horizontal arm or jib. A trolley that can be racked along rails on the cantilevered jib carries the

Table 5-1. Variants in Crane Terminology

Local or national variants in nomenclature often are misleading and difficult or impossible of precise identification. For the purposes of reference, the following list of variants in crane nomenclature is included.

A-frame derrick	Same as sheer legs.
Car dumper	Same as loading tower (car-dumping type).
Cargo crane	Functional term for crane used for general-cargo handling at shipside; may be of any type but usually a traveling jib crane of the portal or the semiportal type.
Also: Quay crane	
Wharf crane	
Dockside crane	
Caterpillar crane	Same as automotive crane (crawler type).
Fitting-out crane	Functional term for crane used for fitting out in shipyards; usually a hammerhead crane, tower cantilever crane, or tower jib crane.
Foundry crane	Functional term for overhead traveling crane.
Also: Shop crane	
Gantry crane	This term is often erroneously used to designate a portal jib crane.
Goliath crane	British term for gantry crane.
Hand crane	Any hand operated crane; usually fixed.
Also: Hand derrick	
Mast and boom derrick	Same as guyed derrick.
Portable crane	Any type of movable crane; generally refers to automotive crane.
Railroad crane	A specialized locomotive crane of heavy construction and large capacity; used for salvage and construction work on railroad.
Also: Wrecker crane	
Shipyard crane	Functional term for cranes employed in shipyards; usually a hammerhead crane, tower cantilever, or tower jib crane.
Stationary crane	Any type of fixed crane; but usually a fixed jib crane.
Straight-line crane	Same as tower transporter.
Tractor crane	Same as automotive crane (wheeled type).
Also: Truck crane	
Whirley crane	Any slewing crane; usually a type of jib crane.

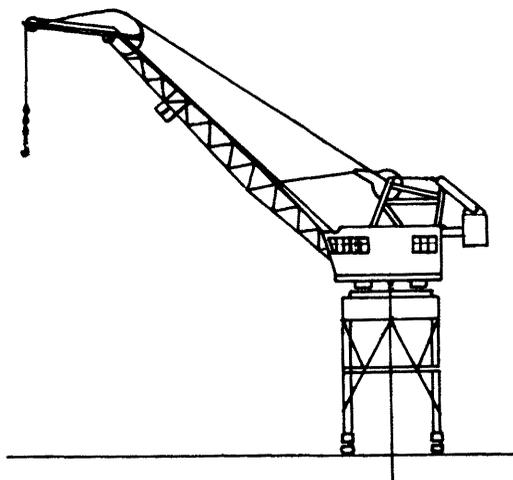


Figure 5-34. Portal jib crane.

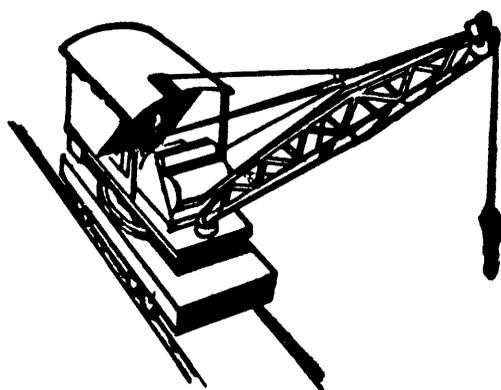


Figure 5-37. Locomotive crane.

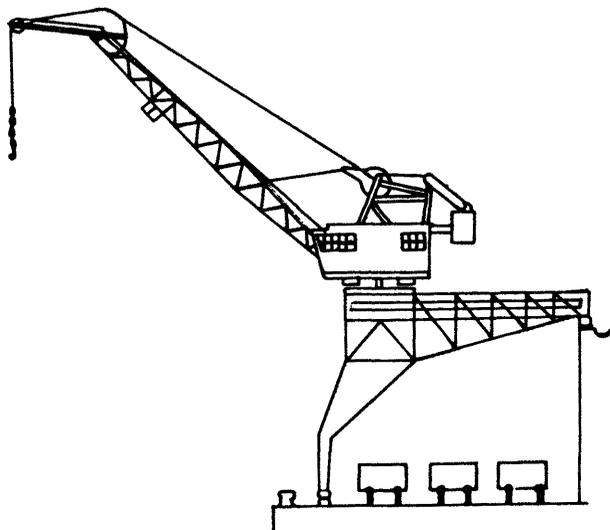


Figure 5-35. Semiportal jib crane.

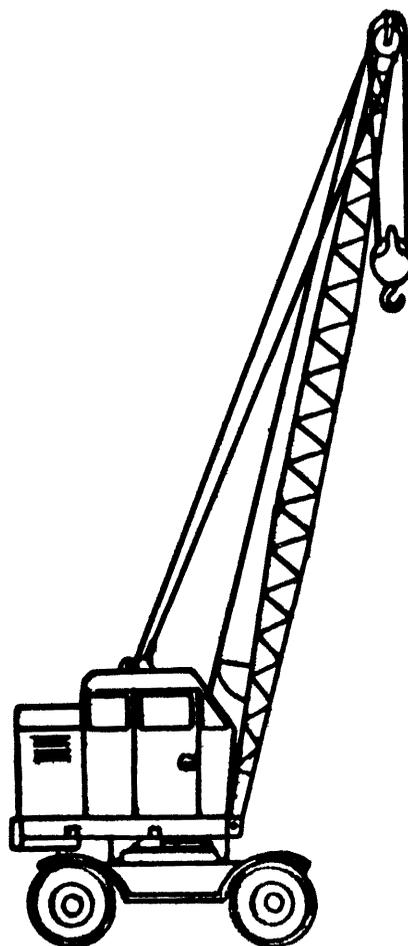


Figure 5-38. Automotive crane (wheeled type).

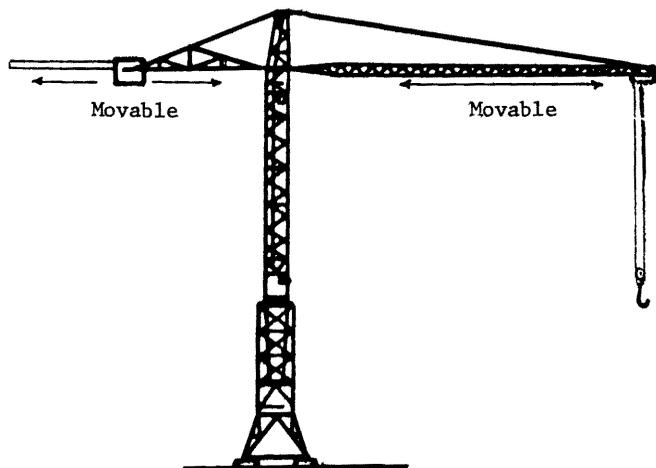


Figure 5-36. Tower jib crane.

hoisting sheaves. The trolley does not carry the hoisting mechanism but merely serves to support the fall, and its transverse movement is controlled by a system of sheaves and ropes. Cantilever cranes are most commonly found in shipyards, although they may be occasionally used for cargo handling in special instances where large working

radius is required. They are normally electrically powered and range up to 250 tons or more in capacity. The working radii are measured on a horizontal line between the center of the vertical axis and the hoisting hook. The trolley carrying the hoisting sheaves can move to any position along the length of the jib, and hoisting capacity varies with the distance of the trolley from the vertical axis. Capacities should be reported at maximum and minimum radii. Types of cantilever cranes are tower cantilever, hammerhead, and block setting (titan).

c. *Gantry Type Cranes* (fig. 5-43 through 5-46). The gantry type crane is a traveling crane consisting of a horizontal cross section (bridge) supported by uprights at either end. Hoisting is performed by a trolley or crab which moves transversely along the bridge. Gantry type cranes occasionally serve as a base for a jib crane, the latter being mounted on and capable of transverse movement along the bridge member. They are used extensively in shipyards for hull erection

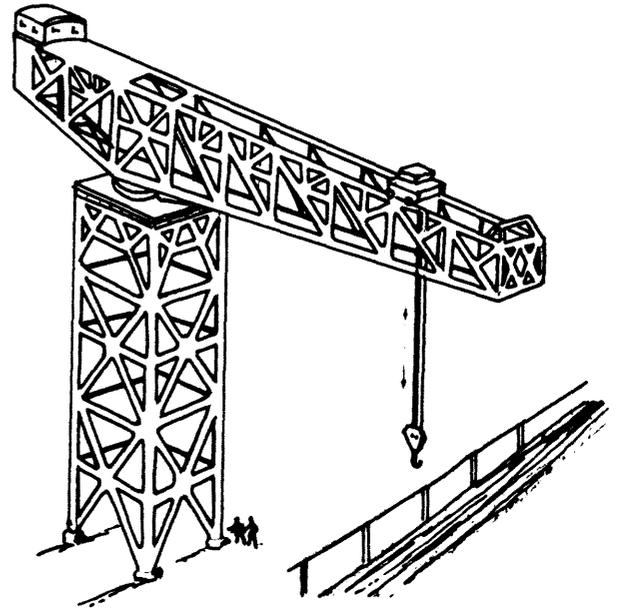


Figure 5-41. Hammerhead crane.

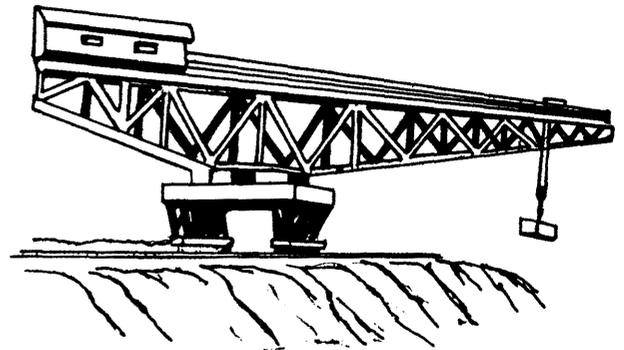


Figure 5-42. Block setting crane.

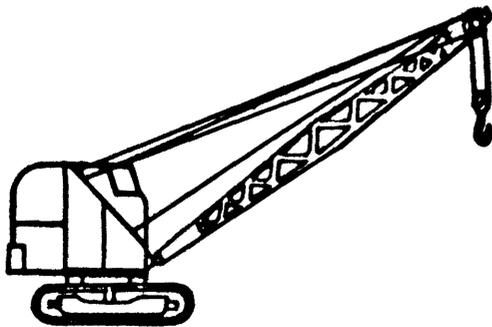


Figure 5-39. Automotive crane (crawler type).

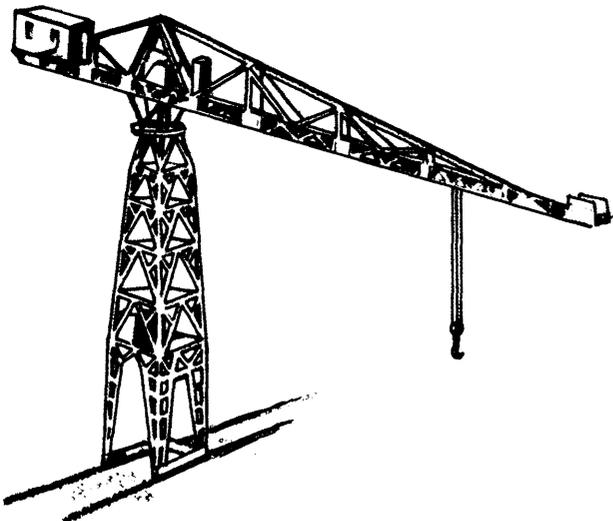


Figure 5-40. Tower cantilever crane.

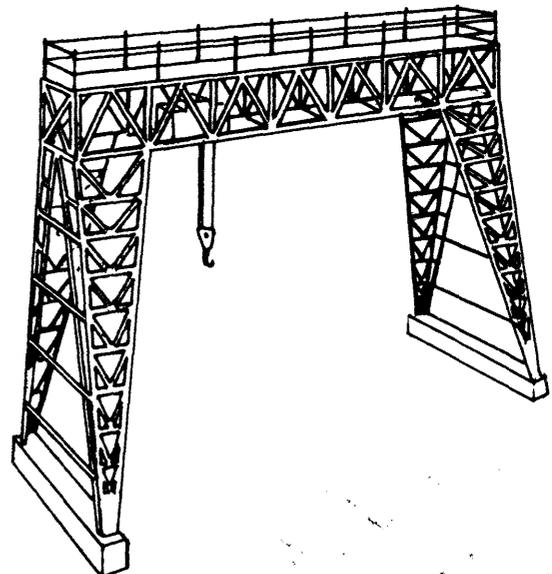


Figure 5-43. Gantry crane.

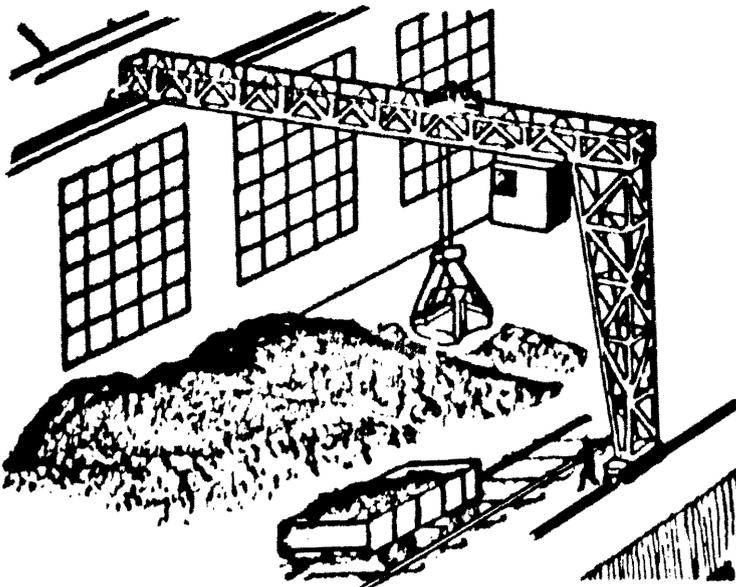


Figure 5-44. Semigantry crane.

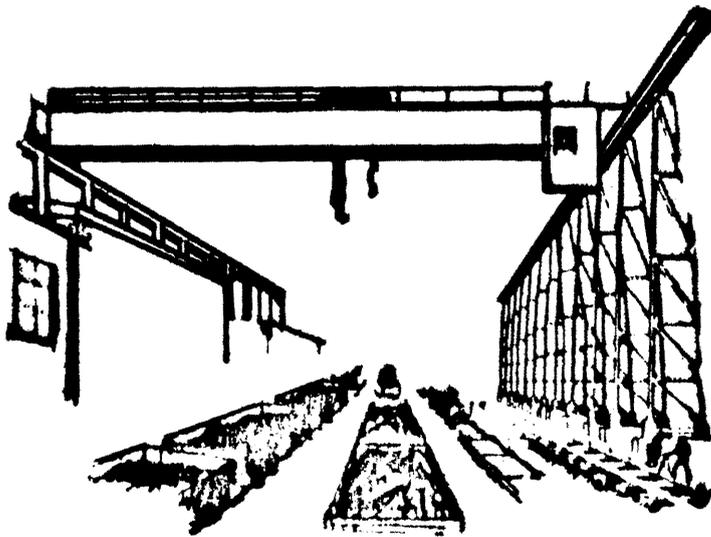


Figure 5-45. Bridge crane.

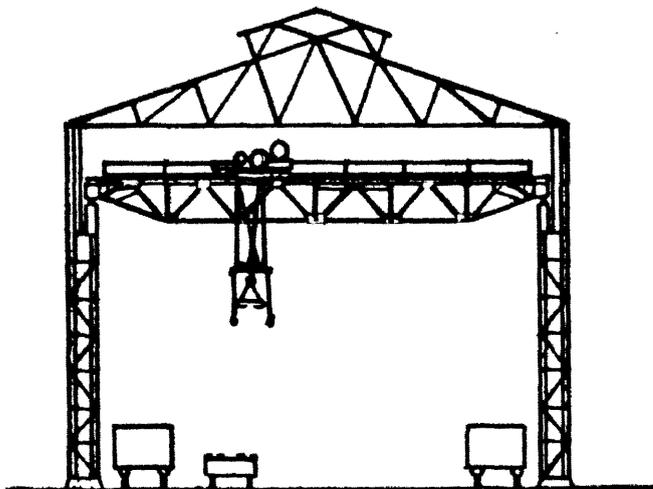


Figure 5-46. Overhead traveling bridge crane.

and in various industrial yards and shops for heavy lifting. They are almost always electrically operated. Depending on use, they may range up to 250 tons capacity. Hoisting capacity is constant regardless of the position of the crab or trolley on the bridge. Types of gantry cranes are gantry, semigantry, bridge, and overhead traveling.

d. *Derricks* (fig. 5-47 and 5-48). The derrick consists of a vertical mast supporting a pivoting jib or boom. The mast may be stayed by cable or beams anchored to the ground. The fall runs through sheaves at the end of the jib. Large derricks are used for miscellaneous heavy lifting tasks, and smaller ones for simple cargo handling. Derricks and shearlegs are normally the simplest and least expensive type of cranes. The larger derricks are steam, gasoline, diesel, or electric powered and the smaller types may be driven by gasoline/diesel engine or operated manually. Depending on size and type they may range from 1 to 40 tons capacity. The jib of a derrick functions similarly to that of a jib crane, and operating dimension should be reported the same. Types of derricks are guyed derrick and stiffleg derrick.

e. *Sheer Legs* (fig. 5-49). The sheer legs is an A-shaped frame consisting of two rigid, standing

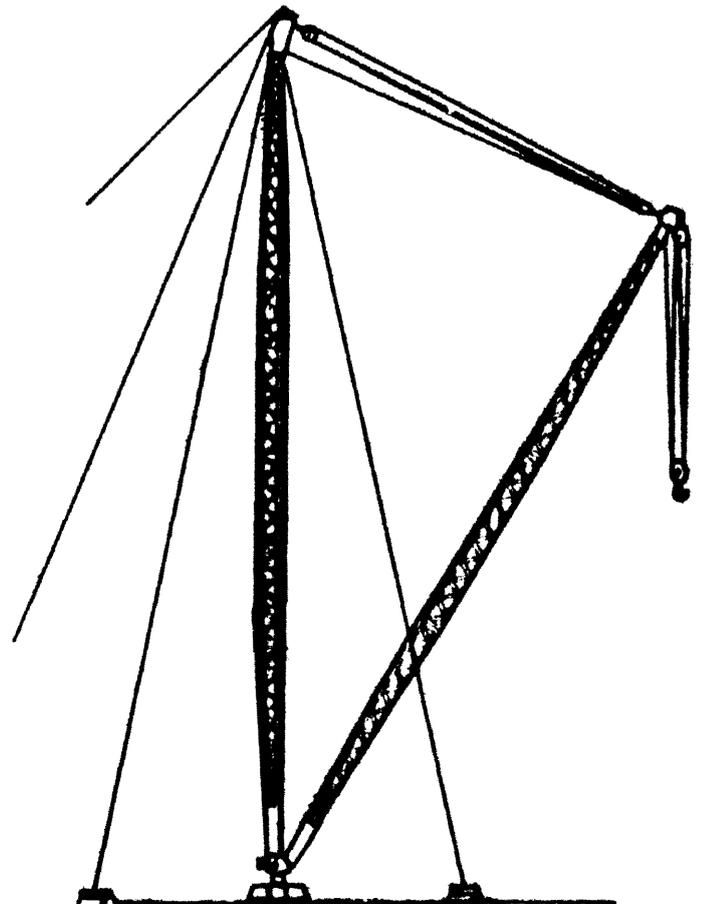


Figure 5-47. Guyed derrick.

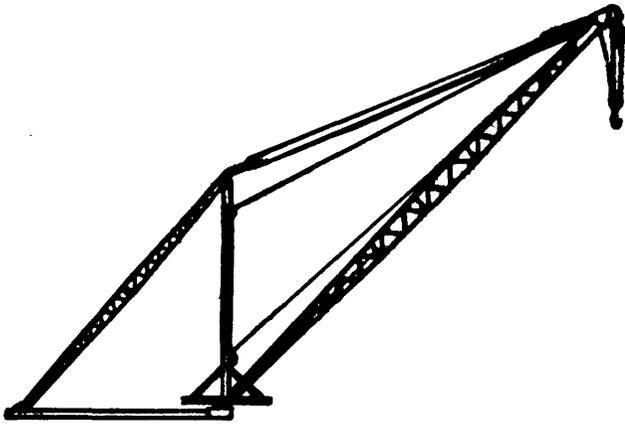


Figure 5-48. Stiffleg derrick.

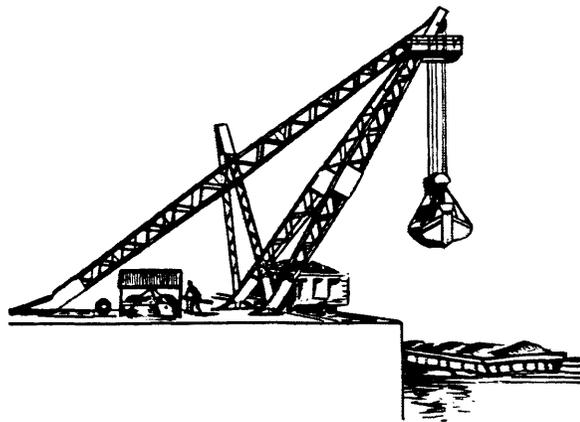


Figure 5-49. Sheer legs crane.

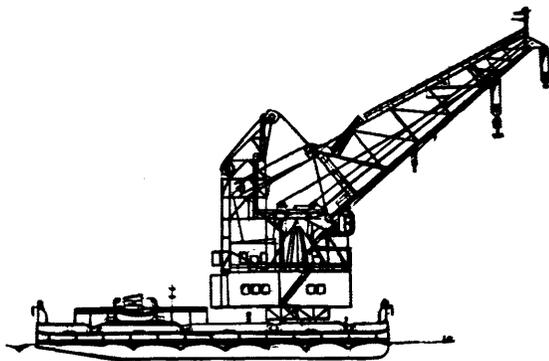


Figure 5-50. Floating jib crane.

legs converging at the top and fixed to a base, but usually pivoted at the bottom. It is generally capable of being luffed and is supported in a standing position in various ways; by a tackle leading to a guyed vertical mast behind the sheer legs, by a tackle sloping directly to the ground behind the sheer legs, and by a long adjustable rigid leg sloping to the ground behind the sheer legs. Heavy

sheer legs may range up to 150 tons capacity. In hoisting and luffing motions the operating dimensions are comparable to those of the jib crane.

f. *Floating Cranes* (fig. 5-50). For greater mobility, cranes are often mounted on pontoons or barges. Almost any type of crane can be used. The float may range from a simple wooden barge to an elaborately constructed steel hull with built-in balancing tanks and pumps. The larger floating cranes are usually steam powered and are commonly employed in harbor construction work, salvage operations, or the transfer of heavy items of cargo to and from ships. Capacities may range up to 400 tons or more. Smaller floating cranes, driven by internal combustion engine or operated manually, are used in all sorts of lifting tasks about a port. The operating dimensions are similar to those for the cranes counterpart ashore, except that reach beyond the ponton should be substituted for radius. Dimensions of the ponton including length, beam, and draft forward and draft aft should be reported.

5-54. Basic Motions of Cranes (fig. 5-51)

According to their structures and uses, cranes are capable of various basic motions:

- a. *Hoisting*. Lifting the load.
- b. *Slewing*. Rotation of the jib about a vertical axis.
- c. *Luffing*. Alteration of angle of jib which carries hoisting rope, and thus of radius from within which load can be raised or lowered. Level-luffing cranes are fitted with compensating gear to maintain suspended load at constant height while luffing is in progress, thus making for more precision in operation.
- d. *Traveling*. Longitudinal movement of crane on tracks, or of bridge or gantry within limits of crane structure.
- e. *Racking*. Movement of hoisting trolley or hoisting crab transversely on bridge of traveling crane, or on jib of cantilever crane.

5-55. Special Handling Devices

- a. *Coal and Ore*.
 - (1) *Unloading devices*. The unloading of coal or ore from ships is normally done by bridge transporters and occasionally by conventional types of cranes fitted with automatic grabs. The transporter consists of a straight horizontal beam along which runs a trolley or crab carrying the

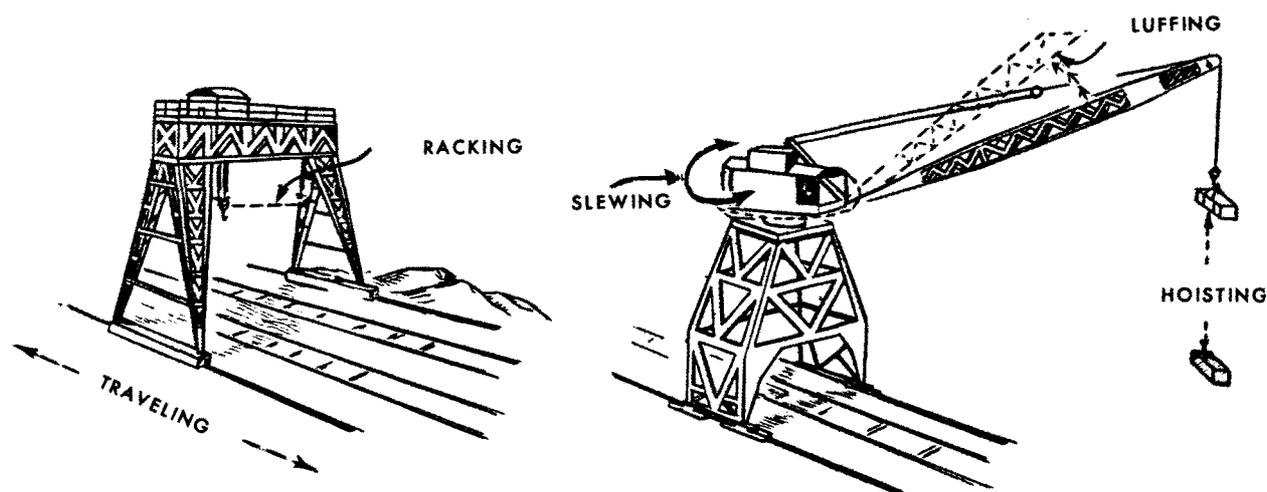


Figure 5-51. Basic motions of cranes.

hoisting gear. The end projecting over the water is often pivoted so that it can be raised while the ship is being berthed. Because of the type of commodity handled, the hoist is fitted with an automatic grab or bucket (skip) instead of a hook. The overall handling rate is specified in tons per hour. The transporter is almost always electric powered. Its load capacities are moderate, generally ranging between one and six tons.

(2) *Loading devices.* Coal, ore, etc. are usually received for shipment in railroad cars and, in order to avoid rehandling, most loading devices load directly from the cars. A loading tower is an upright structure located on a wharf at shipside. Coal, ores, etc. are elevated by mechanical means to a hopper at top of tower and then dropped into ships through gravity chutes. A loading trestle is an elevated structure occupying a wharf parallel to ship berths. Coal, ores, or other such bulk cargoes are loaded through gravity chutes projecting from trestle at intervals over berths. The trestle may be equipped with railroad tracks or fitted with a conveyor belt, or both.

(3) *Transfer facilities.* Conveyors, telfers, aerial cableways, and aerial ropeways are not usually directly associated with the loading of cargo but are the transporting part of an integrated handling system that moves the cargo to or from the loading or unloading berth. Conveyors may be either bucket or belt type, the latter being the more common. In the case of telfer the track consists of a rail which can be fitted with junction and transfer points, giving the system great flexibility. The aerial cableway is a device for hoisting, lowering, and transporting a single load in

either direction on a steel cable suspended overhead in a single clear span between two supporting towers. The aerial ropeway in its monocable form consists of an endless cable, passing around the sheave at each end station, from which buckets are suspended and which is supported along the intermediate stretch by towers placed at appropriate intervals. In the bicable form, two ropes are used: one as a track on which the buckets travel and one as a hauling rope to which the power is applied.

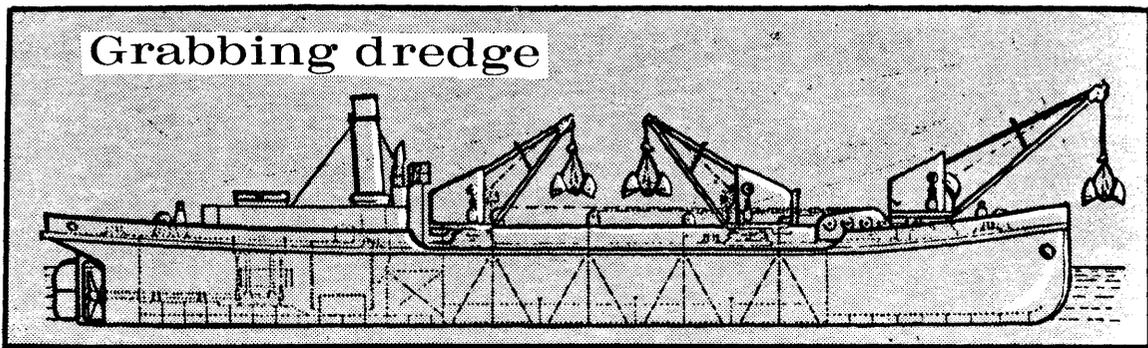
b. Grain.

(1) *Unloading devices.* Bulk grain unloading wharves are generally fitted with a system of conveyor galleries similar to that of the loading wharf. Unloading is accomplished by unloaders that raise the grain from the ship's hold to the conveyor gallery. The unloaders may be mechanical or pneumatic. The mechanical unloader is usually fixed in position, but the pneumatic unloader may be capable of traveling along the wharf. Grain loading machinery, usually of the pneumatic type, may be mounted on floats and used for discharging ships in the stream into lighters.

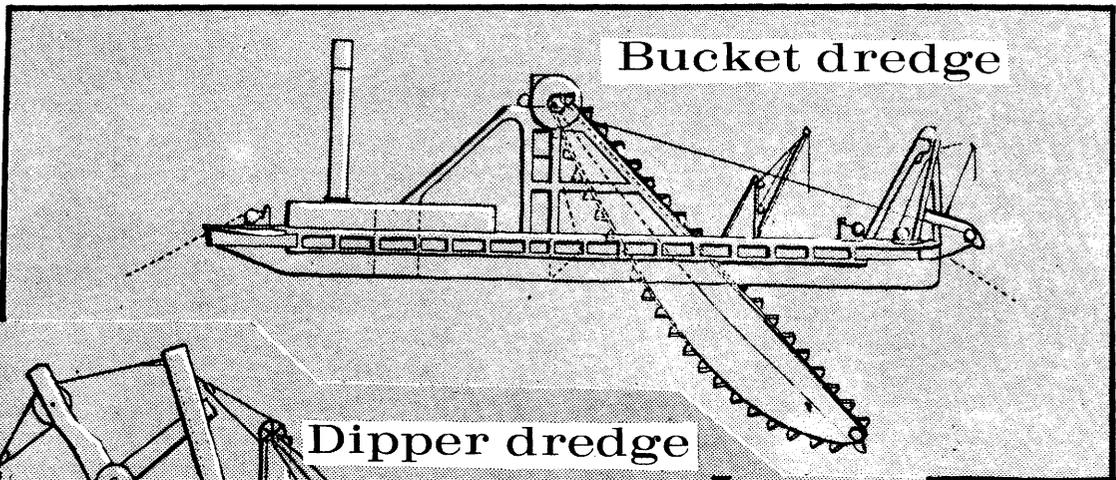
(2) *Loading devices.* Bulk grain loading wharves are usually fitted with elevated covered galleries containing belt conveyors. A main longitudinal conveyor gallery parallels the berth at shipside and lateral conveyor galleries connect with the adjacent granary. Loading spouts fed by the conveyor belt are installed at intervals along the gallery face.

5-56. Harbor Craft

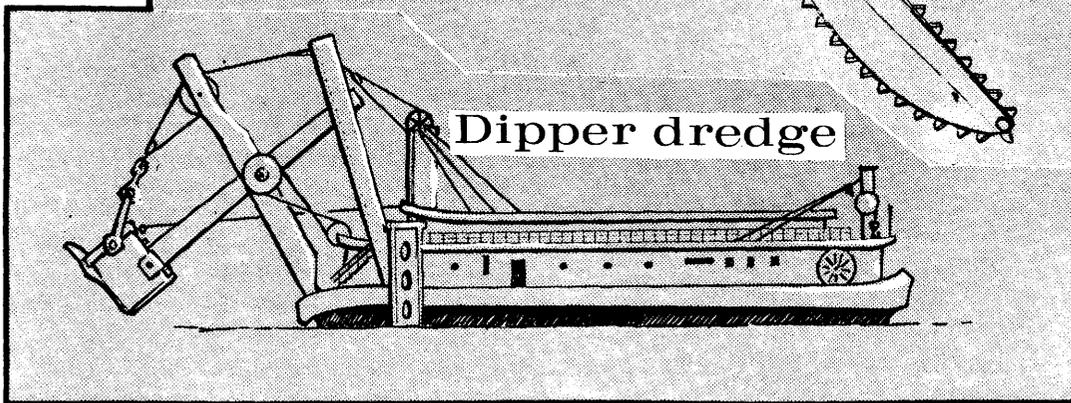
The operation of most ports requires a fleet of



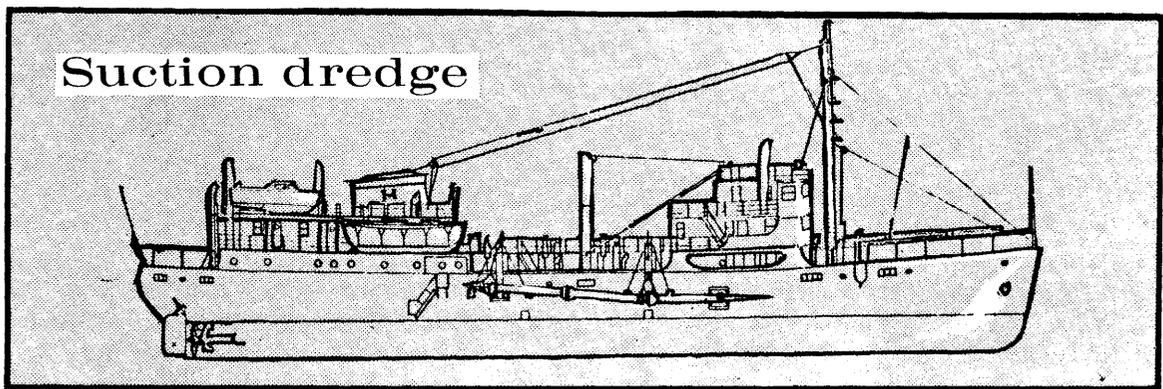
Grabbing dredge



Bucket dredge



Dipper dredge



Suction dredge

Figure 5-52. Dredges.

harbor craft of various types. Although in large ports the composition of the fleet may undergo frequent changes, information on the types, gen-

eral numbers, and operating characteristics of harbor craft is essential.

a. *Tugs and Launches.* Tugs may be divided into

two broad general classes, seagoing tugs and harbor tugs. The horsepower, type of power, and any special equipment, such as salvage or firefighting equipment, should be given. The operating ranges of seagoing salvage tugs should be indicated. Launches achieve importance when there are no tugs; they may be grouped by horsepower and type of power.

b. Cargo Craft. Lighters may be broken down by size and type (self-propelled and dumb), and in large ports their numbers may be given in round figures. Information requirements include such details as capacity, construction, type of power, and specialized lighters for handling ammunition.

c. Bunkering and Watering Craft. The more important data includes capacities, pumping rates, type of power, and any special equipment.

d. Dredging Equipment. Harbor dredging operations employ dredges, hopper barges, and rock breakers. Rock breakers, as the name implies, are special craft used in cases where loosening of rock from the harbor floor is required. Hopper barges are self-propelled or dumb barges, fitted with self-emptying hoppers, which haul material recovered by a dredge. Dredges (fig. 5-52) vary in type and mechanism, depending on the nature of the bottom sediments to be worked.

5-57. Shipyards

Complete up-to-date information is required on shipyard facilities and on all firms capable of making marine repairs but lacking dry docking facilities. Valuable information is contained in maps, yard plans, individual facility plans, shop layouts, photographs of yard facilities, and dock-

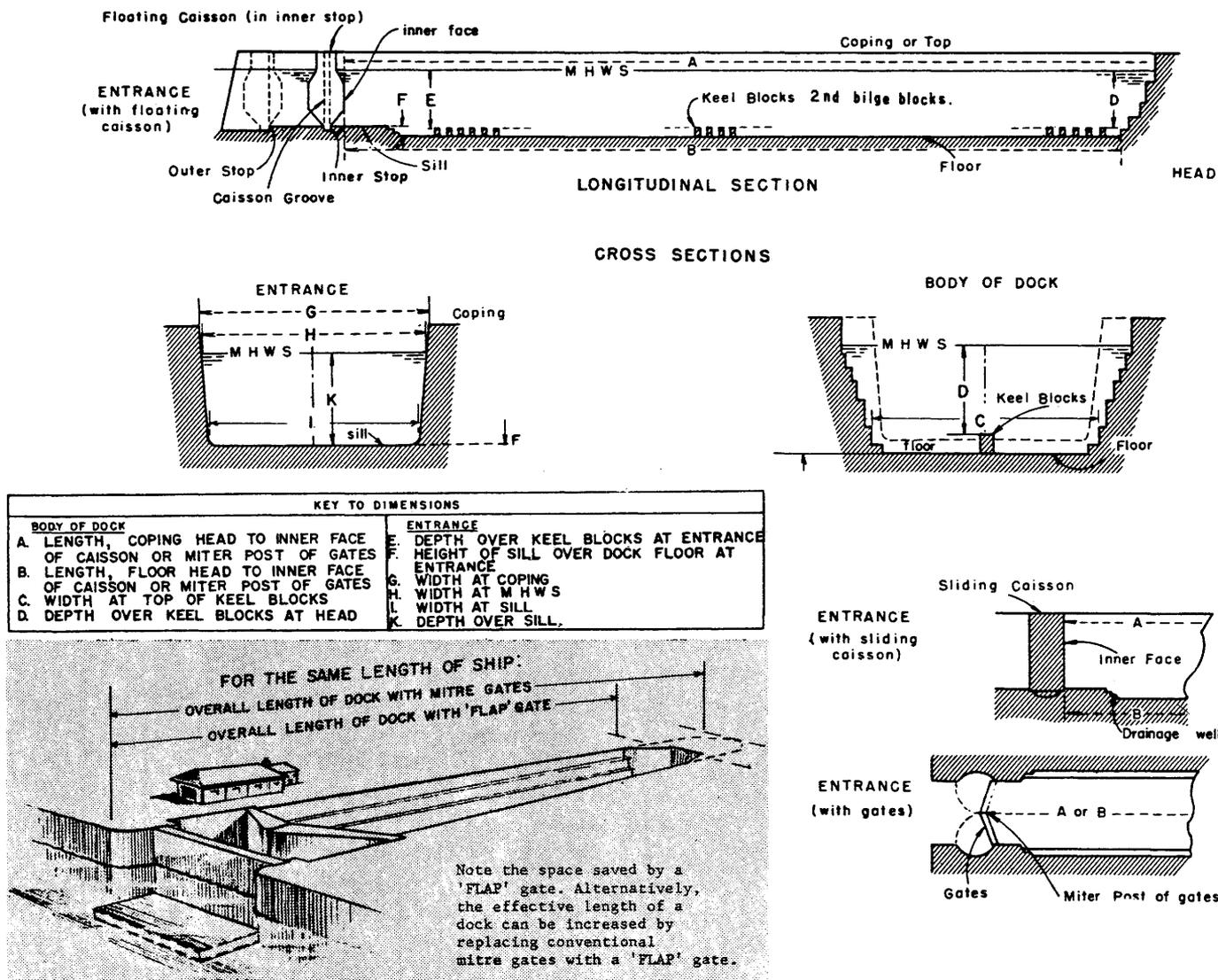
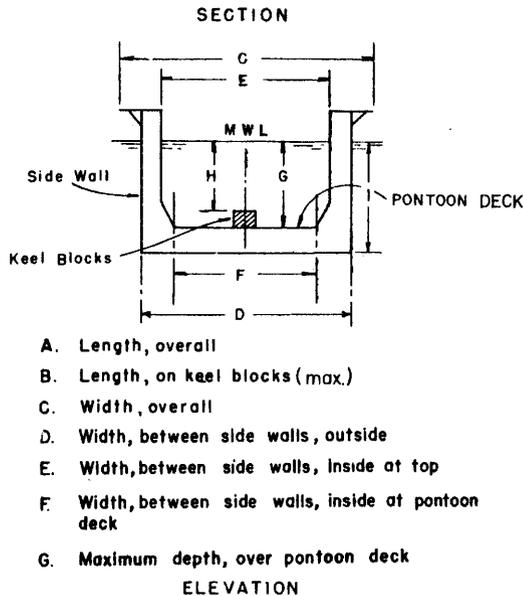
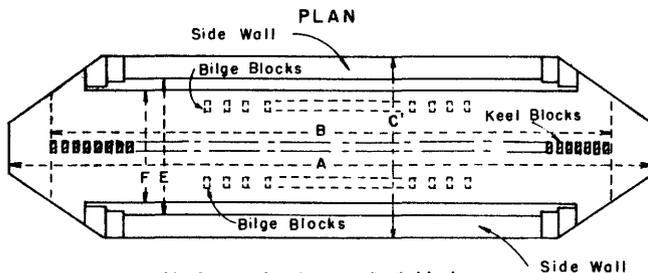
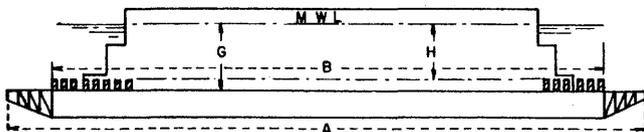


Figure 5-53. Graving dock.



ELEVATION



- H. Maximum depth, over keel blocks
 I. Maximum draft, of dock

M.W.L. Maximum water level to which dock can be lowered for docking

Figure 5-54. Floating drydock.

ing manuals. Each shipyard should be positively located by position within a city or port, and with reference to outstanding landmarks on waterfront, rivers, and tributaries.

a. Dry Docking Facilities. The three principal types of dry docking facilities are the graving dock (fig. 5-53), floating dry dock (fig. 5-54), and marine railway. Four types of gates are provided for graving docks: leaf gates, flap gates, sliding caisson, and floating caisson. Leaf gates are hinged swinging gates that fold back into recesses in the walls of the entrance when the dock is open. Flap gates are hinged at the bottom and are lowered outward to a horizontal position in the

approach to the dock. The sliding caisson rolls or slides on a trackway on the dock sill.

b. Shipyard Shops. Ship construction and conversion are not treated in detail in port studies dealing with terrain intelligence; however, information on the physical facilities used in construction and repair are valuable to the intelligence analyst. It includes the types of structural, engineering, electrical and miscellaneous shops in which various shipbuilding and ship repair processes are performed; the types of ships constructed and the largest of each type constructed to date; whether repairs can be effected without dry docking by means of caissons; the yard's reputation for speed in accomplishing repair work; and the general capabilities of the yard as to hull, engineering and electrical repairs. Shipyard shops standards are shown in figure 5-55.

5-58. Naval Bases

Natural features required of a good naval base site include a harbor with deep water approaches, protected and spacious deep water anchorages, position capable of being easily defended, sufficient land for expansion, elevation of approximately 1.5 to 3 meters (5 to 10 feet) above mean high water at the water front, and ground of a suitable character for the foundation of dry docks, buildings and heavy equipment. An ample supply of safe, fresh water should be available. Local labor, materials, and transportation system must be adequate to support the operation. Secondary stations of the shore establishment are necessary to the operation of a fleet.

a. Base Components. Although they will vary in both size and relative importance, there are certain functional components common to given types of naval bases. Submarine bases will almost invariably contain a torpedo shop, battery repair shop, electrical battery charging equipment and high pressure air charging equipment. The medical component of a large activity may contain, in addition to the normal medical and dental equipment, specialized equipment and resuscitating gear for underwater personnel. If a particular component is not included among the base installations, this negative information should be reported.

b. Base Defenses. The base defense provides effective protection, the detection and identification of all craft transiting the harbor entrance, and a capability for the attack and destruction of enemy craft attempting penetration. Defense mea-

SHIPYARD SHOPS STANDARDS				
Type	Alternate Names	Equipment	Operations & Functions	Remarks
Structural: Mold loft.	<u>none</u>	Primarily hand tools.	Making full-sized templates for all hull, framing, & irregularly curved parts of ship for use in forming and shaping plates and shapes.	Large smooth floor area, usually wood, unobstructed by columns or supporting structures in working area of floor.
Plate shop.	Shipfitter shop.	Presses, rollers, shears, cutters, reamers, punches, bending slabs, furnaces, and welding and riveting equipment.	Bending, rolling, and cutting of plates and shapes to suit templates provided by mold loft; preparation and fabrication of other structural members and structural foundations; prefabrication of vessel parts, depending on size of shop & available space.	
Shape shop.	<u>none</u>	<u>do</u>	Same as plate shop, except only shapes worked. Shape shop usually with plate shop.	
Sheet-metal shop.	Tin shop.	Equipment similar to plate shop's, minus reamers, bending slabs, and furnaces; much lighter capacities.	Making sheet-metal bulkheads, partitions, furniture, lockers, bins, sheathing, etc.	
Welding shop.	<u>none</u>	Electric, autogenous, acetylene welding equipment; occasionally acetylene or carbide production equipment.	Prefabrication and/or subassembly of sections of hull, foundations, and other items welded before installation aboard ship; miscellaneous welding.	Usually sufficient space for prefabrication or subassembly.
Riggers loft.	<u>none</u>	Wire-rope cutters, splicers, workbenches with vises, hand tools.	Cutting and splicing of wire rope and lines; weaving fenders of manila, cane, or similar material.	Usually with runway or long corridor for laying out cables.
Carpenter shop	Woodworking shop.	Lathes, drills, saws, sanders, planes, miscellaneous hand tools, etc.	Structural woodworking.	
Joiner shop.	Cabinet shop.	<u>do</u>	Making wood furniture, cabinets, lockers, etc.; installing light wood and composition bulkheads and partitions.	
Engineering: Pattern shop.	<u>none</u>	<u>do</u>	Precision woodworking; making full-sized wood patterns for molds used in foundry.	
Foundry	<u>none</u>	Smelting furnaces, molds, mold-drying machines, sand-mixing machines, sandblasting machines.	Making molds; casting metal parts; sandblasting castings.	
Coppersmith and tinsmith shop (may be either or both).	<u>none</u>	Anvils, punches, small forges or heating torches, riveting machines, hand tools.	Making and forming irregularly shaped copper and/or tin pipes, connections, tanks, etc.	
Machine shop.	Lathe shop; turning shop.	Lathes, drills, grinders, milling machines, boring machines, planing machines, screw and small-bolt machines.	Machining and finishing of metal parts.	
Forge shop.	Blacksmith shop; smithy.	Hammers, anvils, forging furnaces, annealing furnaces.	Stamping, shaping, and heat-treating of various metal parts.	
Engine shop.	<u>none</u>	Frequently same as machine shop, plus dynamometers, test beds and other testing equipment.	Machining of engine parts; assembling and testing of engines.	
Boiler shop.	<u>none</u>	Hammers, presses, drills, forges, tube benders, welding equipment.	Assembly and repair of boilers.	Do not confuse with boilerhouse where steam is generated.
Pipe shop.	Plumbing shop; tube shop.	Machines for cutting, bending, and threading of pipe; welding equipment.	Cutting, bending, threading, and welding together of pipe.	
Galvanizing shop.	<u>none</u>	Tanks, spraying equipment, melting pots.	Dip and spray galvanizing.	
Ordnance shop.	<u>none</u>	Same as machine shop.	Machining and finishing of guns, gun mounts, miscellaneous ordnance equipment.	
Refrigeration shop.	<u>none</u>	Testing equipment, hand tools.	Testing and repairing of refrigerating machinery.	Storage area for spare parts.

Figure 5-55. Shipyard shops standards.

SHIPYARD SHOPS STANDARDS				
Type	Alternate Names	Equipment	Operations and Functions	Remarks
Electrical and Instrument: Electrical shop.	<u>none</u>	Small machine tools, coil winder, baking oven or other equipment for drying insulation, testing equipment.	Maintenance and repair of electrical equipment.	
Battery shop.	<u>none</u>	Charging equipment, washing tanks, melting pots, hand tools.	Charging and maintenance of batteries.	Battery shop usually with electrical shop.
Instrument shop.	Optical shop.	Small machine tools, paint-baking and/or drying equipment, gas-charging equipment, specialized testing equipment.	Maintenance and repair of optical and precision instruments, i.e., rangefinders, gunsights, binoculars, etc.	
Periscope shop.	<u>none</u>	<u>do</u>	Maintenance and repair of periscopes.	Periscope shop usually with instrument shop.
Gyrocompass shop.	<u>none</u>	Small machine tools, jeweler's tools, testing equipment.	Maintenance and repair of compasses, chronometers, clocks, watches.	
Electronics shop.	Radar shop; sonar shop; fathometer shop; radio shop.	Hand tools, testing equipment.	Maintenance and repair of radar and/or sonar and/or fathometers and/or radios.	Electronics shop may be with electrical shop.
Miscellaneous: Sail loft.	<u>none</u>	Sewing machines, eye-punching machines, light riveting machines.	Working of canvas, bunting, leather, upholstery.	
Paint shop.	<u>none</u>	Spraying equipment, brushes, scrapers, etc.	Housing of paint and painting and caulking equipment; mixing of paint.	May have special washroom for painters.
Tool shop.	<u>none</u>	Small machine tools, hand tools.	Maintenance of equipment of other shops.	

Figure 5-55—Continued.

asures may be designed for protection against underwater, surface, or air attacks. There may be active or passive defense measures for the protec-

tion of base and port installations and for ships in the harbor area and anchorages.

5-59. Landings

Landings may be defined as structures that are usable for landing although primarily designed to serve some other function, and as beaches in the harbor on which landings are possible. Landings assume particular importance when a port is rendered unusable by damaged or sunken vessels through military action or other cause, and when they must serve as the supplemental or principal medium of transfer between ship and shore. These structures include breakwaters, sea walls, bulkheads, seaplane ramps, and beaching hardstands. In wall-type structures the length, depth alongside as referred to chart datum, height of the top above chart datum, and batter of face wall are significant. For all structures, the type of construction, the condition of the sea and current alongside, and the clearance facilities are desirable data.

5-60. Sources of Information

The primary sources of information on ports and harbors are personal contacts, publications, maps and charts, photographs, and direct observation.

a. Contacts. Normally, the best sources for general port information will be: the port engineer for constructional details of harbor works and port facilities; the port captain (or harbormaster) for details of port operations and berth dimensions; the pilotage organization for navigational and fairway limitations; and, in the case of marine petroleum terminals, the terminal manager or the yard superintendent. Other general sources include military and civilian personnel of the technical services of the Armed Forces; military police personnel; representatives of construction and engineering firms, export-import firms and steamship lines; public utilities; major oil companies; tourist, statistical, and census bureaus; and government transportation officials.

b. Publications. Articles in technical books and journals, and official or commercial handbooks on trade and shipping will yield useful data. Port authority publications, foreign issue tide tables, and sailing directions are valuable sources of information. Construction drawings showing cross-sections, elevations, plan views of breakwaters, wharves, storage buildings, ship channels, and repair installations are utilized to a maximum to supplement studies. Dredging and boring records, and development and reconstruction plans and sketches are invaluable to engineering planners.

c. Maps and Charts. Good maps are indispensable to proper coverage of many topics. The informational value of maps may often be improved by annotations identifying important features or by inserting additional details. All annotations should be specific and details inserted to scale. The classes of map material desired are—

(1) *Hydrographic charts.* Large-scale nautical charts covering harbor and approaches.

(2) *Port plans.* Accurate, large-scale (1:10,000 or greater if possible) plans of port with details drawn to scale on wharves, transit sheds and warehouses, railroad spurs and sidings, roadways, layout of shipyards and naval bases, soundings, mooring buoys and dolphins.

(3) *Special maps and plans.* Special-purpose map material such as geological maps of port area, bottom sediment charts, yard diagrams of tank farms, shipyards, naval bases, and built-up area density maps.

(4) *Transportation maps.* Medium or large-scale maps of transportation facilities serving the port.

(5) *Topographic maps.* Large-scale maps of port and vicinity with relief indicated by contour lines.

(6) *City plans.* Large-scale maps of city covering details of streets, buildings, and other installations.

d. Photographs.

(1) *Surface photographs.* Panoramic photographs, closeup photographs of port sections, and detailed photographs of port, specific installations, and operations.

(2) *Aerial photographs.* Vertical coverage of port, town bases, and important installations providing stereo coverage at a desired scale of 1:10,000 or larger. High oblique encompassing the entire port at a scale of 1:10,000 or smaller. Close-in, low obliques with a scale of 1:5,000 or larger, showing details of individual berthing areas, specific port facilities, petroleum storage areas, shipyards, and naval installations.

5-61. Collection Checklist—Ports and Harbors

1. *Identification.* Local name and military designation.

2. *Location.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

- b. Political unit, area, nearest city, reference point (UTM coordinates).
3. *Importance* (economic and strategic).
4. *Type*. Natural, improved natural, or artificial.
5. *General condition*.
6. *Estimated military port capacity, metric tons per day*.
7. *Largest vessel accommodated*.
 - a. Approaches (depth and width).
 - b. Alongside berths (depth, length, and clearance).
 - c. Anchorage and free-swinging berths (diameter and depth).
8. *Major operating problems*.
9. *Hydrographic conditions*. Types of tides and tidal ranges.
10. *Unusual geophysical conditions*.
11. *Principal port activities*.
12. *Harbor data*.
 - a. Approaches and entrances (location and width and depth).
 - b. Protective works (type, location, alinement, dimensions, and construction design).
 - c. Total harbor area (hectares).
 - d. Harbor divisions (designation, location, area, principal uses, characteristics, controlling depth, width, and length).
 - e. Fairways (location, alinement, radius of tightest turn, shortest tangent, controlling depth, width, overhead clearance, and susceptibility to silting).
 - f. Turning basins (location, dimensions, and controlling depth).
13. *Anchorage and free-swinging mooring areas*.
 - a. Location.
 - b. Range of depths.
 - c. Holding ground.
 - d. Protection afforded.
 - e. Type and number of berths.
14. *Fixed mooring berths*. Give locations, numbers, types, buoys, dolphins, etc—for each class.
 - a. General commercial berths.
 - b. Tanker berths.
 - c. Naval berths.
15. *Wharfage summary*. Alongside berth class, use class standards in 14 above.
 - a. General cargo wharves (number, location, and linear meters).
 - b. Bulk cargo wharves (type, location, use, number, and linear meters).
 - c. Supplementary wharves (type, locations, normal use, number, and linear meters).
16. *Principal wharves*.
 - a. Identification.
 - b. Location.
 - c. Normal use.
 - d. Type and construction.
 - e. Berth length (meters).
 - f. Depth alongside.
 - g. Height of deck.
 - h. Total length of structure (meters).
 - i. Standard berth class (number).
 - j. Transit sheds.
 - k. Fueling facilities.
 - l. Cargo handling cranes.
 - m. Specialized handling equipment.
 - n. Clearance.
 - o. Utilities.
17. *Offshore pipeline berths*.
 - a. Location.
 - b. Number.
 - c. Mooring and berthing facilities.
 - d. Exposure.
 - e. Maximum safe draft.
 - f. Cross reference to pipeline collection file.
18. *Hards and unimproved sites usable for cargo*. Identification, locations, length, width, surface composition, and offshore bottom.
19. *Miscellaneous cranes*. Type, locations, number, normal use, owner, motive power, and size.
20. *Stevedore gear*. Type, location, quantity, and condition.
21. *Storage facilities*.
 - a. General cargo storage.
 - b. Individual covered storage structures.
 - c. Summary of refrigerated storage.
 - d. Individual refrigerated structures.
 - e. Summary of open storage areas (hectares).
 - f. Individual open storage areas.
 - g. Summary of bulk cargo storage, dry products.
 - h. Individual storage sites, dry products.
 - i. Bulk cargo storage, coal.
 - j. Bulk cargo storage, petroleum products.
 - k. Miscellaneous tank storage.
22. *Clearance facilities*. Cross reference to appropriate collection file.
 - a. Railroads.
 - b. Roads.
 - c. Inland waterways.
 - d. Pipelines.
23. *Shipbuilding and repair facilities*.
 - a. Identification, location, capabilities, and ownership.
 - b. Shipyard category (I, II, or III).

- c. Principal activities.
 - d. Graving docks (location, type of construction, condition, type of lock, crane service, and power required).
 - e. Shipbuilding ways (location, type, condition, length, and width).
 - f. Floating drydocks (location, dimensions, crane service, and owner).
 - g. Marine railroads (location, owner, type, length of track, gage, hauling capacity, power system, handling equipment, and condition).
 - h. Machine shops (locations, owners, capacity, and normal activity).
 - i. Foundries (locations, owner, capability, normal activity, and condition).
24. *Fire protection.*
- a. Fireboats (type, power, normal location, number, pumping capacity and condition).
 - b. Shore firefighting equipment (locations, type of equipment, number of pieces, and condition).
 - c. Water supply (source, adequacy, distribution system).
25. *Harbor maintenance.*
- a. Present routine maintenance.
 - b. Equipment available.
 - c. Dredging requirements.
 - d. Rehabilitation requirements.
26. *Navigation aids.*
27. *Pilotage data.*
28. *Obstructions.*
- a. Overhead obstructions.
 - b. Surface and underwater obstructions.
29. *Water Supply.*
- a. Source.
 - b. Potability.
 - c. Methods of distribution and capacity and adequacy of system.
 - d. Storage facilities (location, type, and capacity).
30. *Electricity.* Cross reference to electric power collection file.
- a. Sources (primary and alternate) and current characteristics.
 - b. Substations (location and description).
31. *Medical facilities.*
- a. Hospitals (name, location, type, number of beds, and service).
 - b. Infirmaries and clinics.
 - c. Doctors and dentists in vicinity.
 - d. General sanitary condition of port.
 - e. Port pratique granted.
32. *Features vulnerable to nuclear or CBR attack.*
33. *Expansion potential.*
- a. Developments and improvements underway.
 - b. Planned improvements.
34. *Construction data.*
- a. Materials (sources, quality, location, and quantities).
 - b. Equipment and labor available.
 - c. Foundation condition.
35. *Operating data.*
- a. Average tonnages (annual, monthly).
 - b. Administration.
 - c. Labor resources.
36. *Communication facilities.* Cross reference to communication collection file.
37. *Military housing and messing facilities.*
- a. Location.
 - b. Type of facility.
 - c. Capacity of facility.
38. *Military transportation facilities.* Cross reference to appropriate collection file.
39. *Ordnance facilities.* Cross reference to appropriate collection file.
40. *Military training facilities.*
41. *Adjacent terrain.* Cross reference to appropriate collection files.
42. *Defenses.* Cross reference to appropriate collection file.

Section VIII. AIRFIELDS

5-62. Scope

The characteristics, tactics, and techniques of airborne operations are discussed in many publications including FM 17-36 and FM 61-100, and are not within the scope of this manual. It is limited, primarily, to airfields which, whether military or civilian, are closely linked to the nation's transportation system, and are important factors in any study of transportation intelligence.

a. *Civil Aviation.* Civil aviation embraces all commercial, private, and nonmilitary governmental flying, and the control, regulation, and administrative support of such activities.

b. *Air Facilities.* Air facilities are the military and civilian installations upon which a nation's air operations depend. The fundamental air facilities are airfields, seaplane stations, and heliports (TM 5-330). Ancillary facilities are radio aids to

navigation, the airspaces for control of air traffic, airways, and special use airspaces. An airfield, heliport, or seaplane station has its own facilities such as runways, hangars, fuel systems, maintenance shops, crash, fire and service equipment, and many other features. At some small foreign



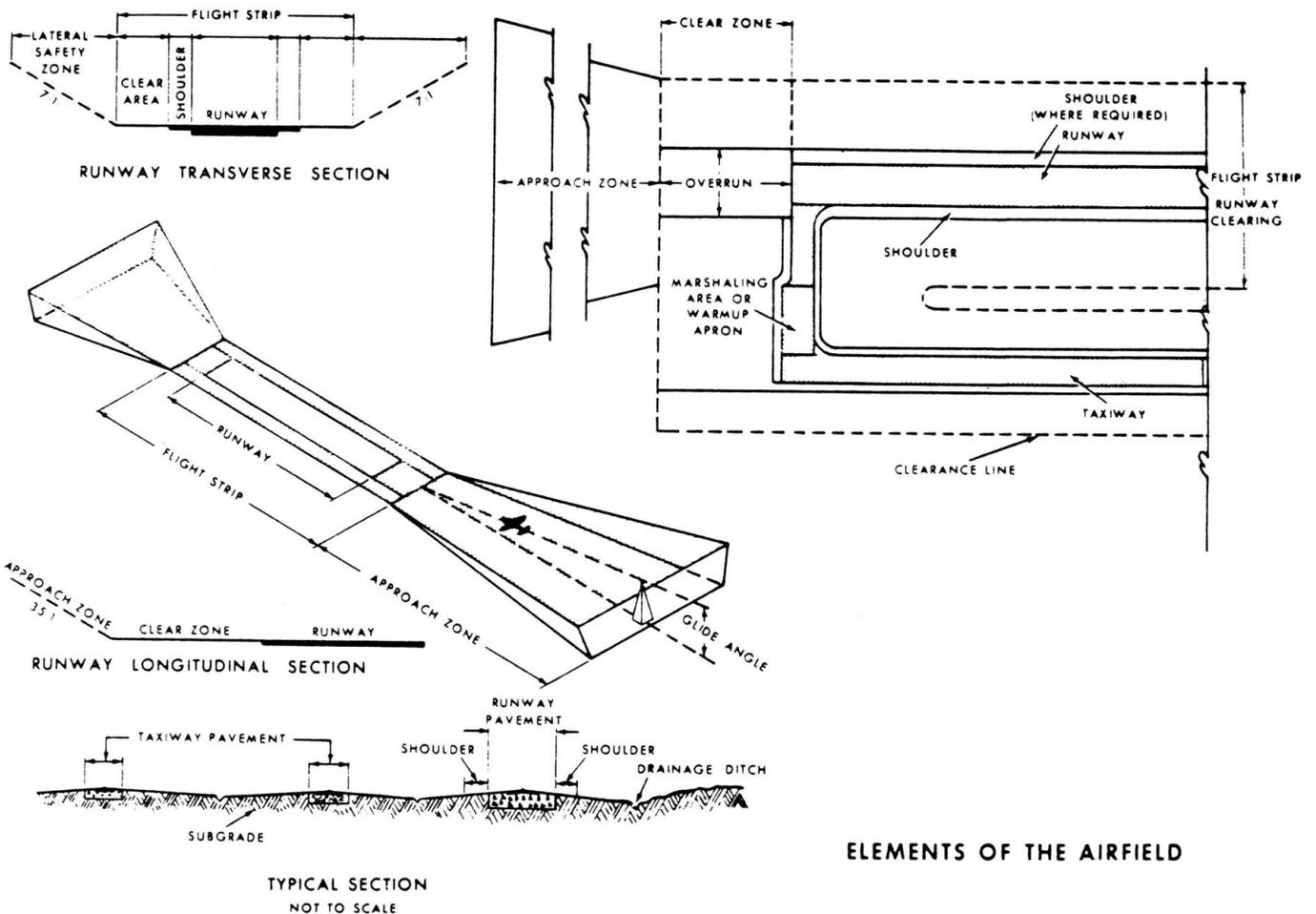
Figure 5-56. Control tower, operations, administration, and passenger terminal at small airfields.

airfields (fig. 5-56), many functions may be combined in one or two centrally located buildings.

5-63. Airfield Location

a. The most advantageous location for an airfield (fig. 5-57) is an area free from natural and cultural impediments to operations. An elevated rather than low area is preferred because of the absence of terrain obstructions and, generally, more favorable local weather conditions. Low areas are frequently exposed to adverse wind conditions, fog, and occasional flooding. Another important factor in airfield location is its intended utilization. Major civil airfields almost invariably will be located near the cities they serve. Major military installations, which normally require more land area because of their usual vast complex of fixed facilities, are more often constructed some distance away from large cities.

b. Auxiliary airfields are normally located near major operational or training bases. Their pur-



ELEMENTS OF THE AIRFIELD

Figure 5-57. Elements of the airfield.



Figure 5-58. Runways at a major US airfield.

pose is to supplement the operational capacity of a primary airfield during periods of peak activity. Very often these facilities are on caretaker status during part of the year when their additional capacity is not needed.

c. Air facilities of increasing significance are heliports and helistops. Heliports are considered as major helicopter facilities and may contain helipads, maintenance and service facilities, hangars, administration or operations office, control tower, communications facilities, and other accommodations similar to an airfield. A helipad is an area specifically designated and marked for helicopter landings and takeoffs. The surface of the pad may be natural, temporary, or permanent. A helistop refers to a helipad with little or no facilities, and is used for en route on and off loading of cargo or passengers.

5-64. Controlling Agency

The identity of the controlling agency can provide a clue to an airfield's character in terms of its mission, volume and variety of facilities, services, and the course of possible future developments. Controlling agencies may be civil, military, joint, or private. Information regarding the controlling agency may be secured from a variety of sources such as the manager, the commanding officer or the caretaker. If no source is available, observation of the airfield and its activities may reveal the controlling agency.

5-65. Runways, Taxiways, and Parking Areas

a. Runways (fig. 5-58) are the most significant features of an airfield, and detailed information

concerning them, as well as taxiways and parking areas, is essential in order to properly evaluate an airfield's capabilities. The length, width, load bearing capacities and pavement condition have a direct influence on the type and amount of traffic an airfield can accommodate.

(1) An airfield runway is a flat landing surface, with a true or magnetic heading, normally taking advantage of prevailing winds. The number of runways or "runs" may vary from one to several, and are usually oriented in different directions. Some airfields will have parallel runways, i.e., two runways with the same headings—not to be confused with a parallel taxiway.

(2) Taxiways are access paths to parking aprons, hangar aprons, hardstands, and revetted hardstands (revetments). A "parallel" taxiway parallels the runway but is usually narrower. Under emergency conditions it may be used as a runway, but it should not be reported as a runway. "Link" taxiways connect the runways with other taxiways, parking and hangar aprons, hardstands or revetments. A "perimeter" taxiway usually starts at one end of the runway and ends at the other, and is normally, in an oval shape. "Loop" taxiways are normally located at one or both ends of the runway, forming a loop. The "alert" taxiway is located at the end of the runway with clear access to the runway for a "scramble" by fighter interceptors.

(3) Parking aprons are generally found near the administration, passenger and freight terminals. Hardstands, normally circular in shape, are usually dispersed around the perimeter of the airfield and linked by taxiways. Revetted hardstands are surrounded by either earth or concrete walls to protect aircraft from strafing or shrapnel, or to prevent destruction of one aircraft to spread to

others. General field parking is any other area that can be used for aircraft parking.

b. Runways, taxiways, aprons, and revetment surfaces may be permanent, temporary, or natural. Permanent surfaces such as concrete or asphalt have distinct edges and ends, whereas temporary surfaces such as mixed-in-place macadam or oiled earth have ragged and uneven edges and ends. Permanent surfaced runways are easily discernible, and may have jet barriers or arrester gear. Jet barriers are located on the overrun, whereas the arrester gear is normally flush with the runway and located approximately 500 meters from the end of the runway. This 500 meters is usable runway and should not be confused with an overrun.

c. There should be no great difficulty in measuring permanent or temporary surfaced runways. The major difficulties will be in locating and arriving at the measurements of natural surface runways (fig. 5-59) which may, or may not, be marked with painted barrels, rocks, or broken white lines. Runway lengths and surfaces vary according to the use or intended use of the airfield.

d. The weight or load bearing capacity of a runway, taxiway, or apron is a determining factor in its capability to accept aircraft without damage to the aircraft or the facility. The engineering factors involved in determining weight bearing capacity are complicated; however, other methods of obtaining this information are Route Manuals, Air Information Publications, airfield managers, and engineering documents. If these sources are not available, information on the type and weight of aircraft (partially or fully loaded) operating out of a given airfield will enable the analyst to

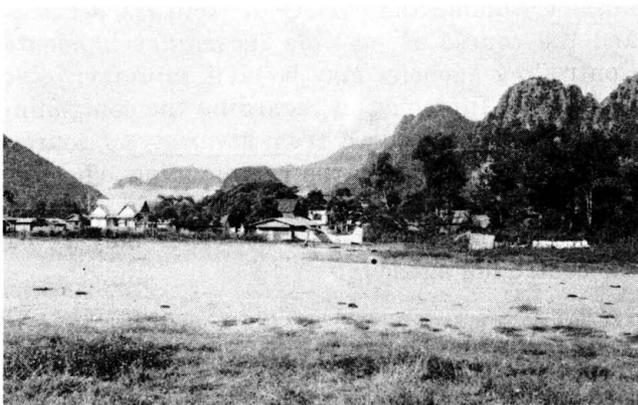


Figure 5-59. Natural surface runway of small airfield for light aircraft.



Figure 5-60. Hangars and hardstand at light aircraft airfield.

estimate the weight bearing capacity of the runway.

5-66. Hangars

Hangars are perhaps the most easily recognized features of an airfield since they are relatively large structures of distinctive design. Information on the number and types of hangars provides a general indicator as to the extent and type of operations and the availability of repair and maintenance facilities (fig. 5-60). In some areas, special underground hangars have been constructed to provide maximum protection against bomb damage.

5-67. Lighting

Airfield lighting facilities provide necessary operational aids for operating aircraft both on the ground and in the air in the vicinity of the airfield (fig. 5-61). They are especially critical during approach, landing, and takeoff.

a. Airfield Beacons. Rotating beacons are usually located on the control tower or in that general vicinity. They flash alternate white and green signals or all green with code.

b. Obstruction Lights. A system of red lights is used to define vertical or horizontal limits of natural or manmade objects which are a hazard to air navigation. The arrangement of lights and characteristics of signals depend on objects to be defined.

c. Approach Lights. A system of lights dispersed symmetrically about and along the extended center line of the runway. The system has its origin at the threshold of the usable landing area and, for a primary instrument approach, extends outward for 900 meters. For approaches other than a primary instrument approach, the system will extend only 460 meters. At some locations, terrain conditions prevent the installation of the entire length of either the 900 meter or 460 meter system. Where such is the case, the maximum possible length will be installed.

d. Threshold and Terminating Lights. Threshold lights are a line of lights placed at the end of each runway, outward from the end of usable landing area at a distance of not more than 3 meters, to denote the longitudinal limits of the runway. These green, bidirectional lights are usually spaced at equal intervals between runway lights. There may also be a threshold light line on each side of the runway, extending outward approximately 12 meters. The terminating light bar

will be located beyond the threshold light line or in the overrun area to denote end of usable landing area.

e. Landing Area Flood Lights. A group of large white flood lights elevated on standards, and located at the ends of runways, to each side and outside the approach area. These lights are located so as to aid in illuminating the landing area and not create shadow pools.

f. Runway Lights. Runway lights are white lights used to indicate the location of the runway and assist aircraft in landing and takeoff. They are placed along the length of the runway between the threshold lights in two straight lines at the edge of the runway equidistant from the runway centerline. Flush white centerline lights may be found at some large modern airports.

g. Taxiway Lights. These are placed on both sides, or on both sides and center, of taxi route. When the lights are on both sides of taxiway, color is either blue on both sides of taxiway, or blue on one side and yellow on the other side. When the centerline is used, the lights will be green.

h. Maintenance Ramp Lights. These are white flood lights placed either on buildings or on elevated poles at edge of area. The purpose is to aid in night maintenance or unloading of aircraft.

i. Flares. A temporary type lighting used when no electric lighting is available in an emergency. Flares are usually open flame wick burners utilizing a flammable liquid, and usually are weather-proof.

j. Boundary Lights. Boundary lights outline the entire available landing area of the airport and are spaced to give the pilot a definite picture of the size and shape of the field. These are usually cone-mounted lights, white in color.

5-68. Ground Equipment

Aircraft and their associated ground equipment are becoming more and more complex. Ground equipment is divided into two categories, powered and nonpowered; however, some equipment, such as auxiliary power units, falls into both categories. Some are mounted on jeeps or pickup trucks, and become powered; others supply their own motive power.

a. Oxygen Service. Dry Aviator's Breathing Oxygen is stored in steel air bottles under 1,800 to 2,200 pounds of pressure. The color of the bottle



Figure 5-61. Runways and approach lighting at a major US airfield.

varies from country to country. Many airfields have oxygen service for High Pressure (HPOX), Low Pressure (LPOX), and Replacement Bottle (R.B.) by simply keeping one or two bottles of oxygen, a regulator, and adapters on hand. Liquid oxygen (LOX) is found primarily on a military airfield and is, when not associated with missiles, generated in a 5-ton capacity plant. The LOX cart, a large thermos type vessel, resembles an air compressor tank on wheels, and holds approximately 50 gallons. The LOX cart and its sister, the dry oxygen bottle cart, are usually stored on the operational or preflight portion of the parking area of the airfield.

b. Auxiliary Power Unit. All jet and turboprop engines, and many of the heavier reciprocating engined aircraft require an external source of

power for ground maintenance, passenger loading and debarking, and engine starting. Most reciprocating engined aircraft use an auxiliary power unit for engine starts. Some of the jets have a one-start, aircraft-contained, high pressure air bottle for ground starts. This bottle has to be recharged from a high pressure compressor or from other high pressure air bottles. Normally, an air starter unit will be employed, with its attendant ducting, to ground start the engines. The presence of 115 volt, 400 hertz current would indicate the presence of aircraft carrying radar on other electromagnetic devices.

c. Air-Flow Starters. Some jet engines require a high volume of air to start, and others require a high pressure to start. The low pressure, high flow can usually be adapted to start a high pres-

sure engine; but the high pressure unit cannot be adapted to start the low pressure starting engine. Air flow starters are usually hooked to the aircraft by a 10-cm (4-inch) reinforced duct somewhere near the outboard engine that is first in the starting sequence.

d. Ancillary Equipment. Other equipment may be essential or ancillary, depending on the major use of the airfield. This includes, but is not limited to: air compressors, test stands, sanitation trucks, water trucks, high lift trucks, fork lifts, heaters, air conditioners and towbars.

5-69. Special-Purpose Vehicles

In many respects, airports resemble a self-contained community and are largely independent of outside sources. They must remain operational under the most adverse conditions. An airport must have equipment to clear snow, slush and debris from runways, taxiways and other areas on which aircraft move. Jet engines are easily damaged by ingestion of stones and other foreign objects. The airport must make provision for cleaning those areas where jet aircraft move under their own power. To satisfy such needs there is a variety of ground equipment from hand sweepers to modern vacuum runway sweepers, snow plows, tractors, and graders.

a. Cargo Handling Equipment. Cargo handling capabilities vary throughout the world, depending on the equipment employed. Special loading and unloading devices include elevators and forklifts of varying capacities, loading ramps and specially designed elevators and ramps.

b. Fire and Crash Equipment (fig. 5-62). The principal purpose of crash and firefighting services is to save lives and minimize damage in the event of an accident or enemy action. The type of facilities will vary depending on the largest type



Figure 5-62. Firefighting equipment at a major airfield.

aircraft using the aerodrome, density of traffic, and size of the aerodrome. The location of the equipment generally will be in the proximity of the operations area where quick access to taxiways, runways, parking and revetment areas is afforded. Hydrants and special water tanks distributed throughout the area indicate the existence of some type of fire protection system.

c. Wreckage Removal Equipment. To keep runways, taxiways, etc., clear and operational in case of crashed aircraft, or those damaged by enemy action, wreckage removal equipment should be immediately available. Included in this category are mobile cranes, shearlegs, crash dollies, hoists, wreckers, and pneumatic lifting bags. Some vehicles used for cargo handling may be used in a dual role as wreckage removal equipment.

5-70. Maintenance

Aircraft maintenance is divided into three distinct echelons: depot, intermediate, and organizational.

a. Use of Maintenance Equipment.

(1) *Maintenance work stands* are work platforms constructed in various heights, sizes, and shapes to aid in performance of maintenance duties and allow personnel to work at various extended heights in relative safety and comfort.

(2) *Tugs* are vehicles used for ground movement of aircraft. Sizes and description vary in relation to the aircraft they have to move.

(3) *Engine stands* are used to mount an engine that has been removed from an aircraft, or engines that are being built-up for replacement in aircraft. These are on wheels to facilitate mobility.

(4) *Engine shipping cans* are large cylindrical containers split in two sections, and bolted together. They are used to transport engines to and from depot or from manufacturer.

(5) *Portable ground heaters* are used to provide large amounts of heated air for many uses in aircraft servicing. Designed specifically to preheat engines and cabins, they may also be used to thaw carburetors, fuel lines, batteries, brakes, and all types of aircraft parts. They are gasoline driven engines, mounted on truck beds or dollies, coupled to a heater unit with large blower opening and tube to direct heat where needed.

(6) *Aircraft jacks.* A large number and variety of jacks are needed in the maintenance field. In appearance, they will have a vertically mounted cylinder on a tripod with caster wheels

fixed to the base for mobility. Some will have an adjustable extension at top.

(7) *Engine hoists* are used in removal or replacement of aircraft engines. They are mounted on a truck bed or tractor, or can be mounted on a base with small wheels for mobility. They resemble cranes, but are of smaller construction.

(8) *Instrument test sets* may be stationary or portable. The portable sets consist of various master indicators, gauges and devices which actuate aircraft instruments to be tested without removal from the instrument panel. The stationary test equipment is used in shops when instruments have been removed from the aircraft.

(9) *Hydraulic test stand* is a portable electric motor or gasoline engine-driven test stand designed to supply a source of hydraulic pressure for testing the hydraulic system of the aircraft in the field or in a location where electrical power may not be available.

(10) *Aft fuselage cradle* is an adjustable cradle, mounted on wheels for mobility, and designed to hold the tail section of the aircraft during engine change or maintenance requiring access to engine, tail pipe or rear section of the fuselage of aircraft serviced in this manner. The cradle has two semicircular padded sections to support the fuselage without damage.

b. Location of Maintenance Equipment. All equipment used in aircraft maintenance will normally be found within or near the hangars, or in a maintenance equipment storage area near the line where work is normally performed.

5-71. Petroleum, Oils, and Lubricants (POL)

The availability of aircraft fuel, oil, and lubricants are items of major significance in the evaluation of the operational capability of an airfield. Advance planning for strategic air missions or tactical exercises requires sufficient quantities of specific types of fuel and proper dispensing and servicing equipment.

a. Storage Facilities. The general design of area reserve bulk storage and airfield bulk storage will be similar except for the number and quantity of fuels handled (automotive gasolines, diesel fuel and commercial heating fuels are held, in addition to aircraft fuels, in the area reserve storage). Area reserve bulk storage will normally be on or adjacent to primary transportation lines, and the storage tanks will be above ground. Airfield bulk storage will usually be on or adjacent to the air-

field, and the storage tanks may be underground or above ground. Individual above ground tanks are normally inclosed within a diked area that has a capacity at least equal to that of the tank. Underground storage tanks, while not so obvious, may be identified by inlet and outlet pipes; manholes or pits located over the tank for purposes of fuel measurement and tank cleaning; tank breather vents; and tank truck fill stands. Drum storage may be utilized at small remote airstrips. Types of aviation fuel, size and types of tanks, operators, transportation facilities, method and rate of resupply, and average stock levels should be reported.

b. Fuel Transfer Equipment. Distribution of fuel from the storage facility may be by truck, railroad tank car, barrel fill stands, barge or marine tankers, pipelines, or airfield hydrant-type refueling systems. Of specific interest is the number and capacity of pipelines, trucks and trailers (including turn around time), fill stands and types of fuel processed by each system.

c. Fuel Dispensing Equipment. Equipment used to move fuel from storage to aircraft ranges from elaborate hydrant systems at modern international airports, to hand pumping from barrels at remote landing sites. Airfield operating storage may be located underground, adjacent to or beneath the aircraft parking area, or above ground, usually within the confines of the airfield. Multiple-outlet hydrant-type refueling systems deliver fuel to the aircraft at its normal parking position from fuel ports flush mounted in the parking apron. Tank-truck or trailer combination is the traditional equipment for over-the-wing refueling. Hand pump units may be used to dispense small quantities of fuel. The overall refueling capability of the system for each type of fuel, capacity and normal stock level of the operating storage, type of equipment, and number of refueling outlets are details which should be reported.

d. Aircraft Fuels. Aviation gasoline is identified internationally by octane rating. To provide a visual identification, AVGAS produced to US specifications is color coded, i.e., 80/87 red, 91/96 blue, 100/130 green, and 115/145 purple. Commercial and foreign military organizations may color code fuel, fuel lines or dispensing equipment to provide visual fuel grade identification. It is important that these local use designations and their source be reported.

e. Lubricating Oil. In reporting on lubricants,

specific identification of product by brand and grade is desired. Usability of certain oils is enhanced by the addition of additives; i.e., the addition of cyclohexanone to grade 1100 will make this oil suitable for use in US reciprocating engines. Information on kind of additives used is of value.

f. Thrust Augmentation. Thrust or power augmentation at takeoff is achieved in some types of jet engine aircraft by injection of a demineralized water, methyl alcohol, or a water and methyl alcohol mixture into the engine-fuel supply system. While facilities for the storing of materials and blending equipment will vary in design, they all consist of an underground tank for the storage of straight alcohol, an underground tank for mixing and blending the alcohol with water, a small tank with provisions for the introduction of additives, a pump house, and a truck fill stand. The water-alcohol blending facility will normally be located in the POL operating storage area. The extremely toxic and explosive nature of methyl alcohol may cause unusual safety precautions and isolation of these facilities.

5-72. Ordnance Storage (Conventional)

Evidence of ordnance storage gives a clue to the operational capability of an aerodrome. A storage dump or magazine is generally located some distance from the operating area. Bunkers, igloos, magazines, or buildings are generally revetted or barricaded with a mound of earth on three sides; they may be completely covered, except the entrance, and isolated from each other by a few hundred feet in all directions.

5-73. Meteorology

Weather data is required to insure safe and efficient aviation activities. In time of war the meteorological factor is particularly critical, especially in aviation training, airborne operations, and reconnaissance. Climatic summaries and studies consisting of data accumulated over periods of months and years, are used in preparing plans, estimates and recommendations. They are a vital element in determining soil trafficability for possible airfield construction sites.

a. Weather observation and forecast facilities are normally located near the flight line and operations building. Visible external features indicating some form of weather collection facilities will be the anemometer (wind speed indicator) and



Figure 5-63. Weather radar.

direction vane mast usually located on top of a building; rain gauge/temperature recording instruments, normally housed in a small ventilated structure in an open unobstructed area; periodic release of balloons; and the tracking of objects through a theodolite or radar unit. A vertical beam of light visible at intervals during hours of darkness when cloud cover exists would be evidence of the existence of a ceilometer, a photoelectric device for determining the height of clouds. Radar units—portable, fixed, and airborne—are also used extensively in weather equipment which may be found on some installations (fig. 5-63).

b. Teletype and other electronic communications facilities are usually associated with weather stations in accumulating and disseminating meteorological data.

5-74. Seaplane Stations

The location of a seaplane station is expressed in terms of its physical relationship to prominent landmarks, such as a bay, gulf, river, lake, harbor, or a direction and distance from a metropolitan area. The operating area will generally be the body of water adjacent to the station. Elevations are normally expressed as "sea level" for all coastal installations, but this would not hold true on inland rivers and lakes where the elevation

may be considerably above sea level. Sealanes are the seaplane runways in the operating area. These are usually marked by permanently moored can-type buoys which may or may not be lighted. In areas where no marked sealanes are available, the safe operating area dimensions, minimum depth, and direction of longest run available are desirable information.

a. Operational Factors.

(1) *Shelter.* Swell, tide, and winds should be considered in determining the degree of shelter prevailing in the operating and anchoring areas. Swells and their direction of travel may differ from that of the wind. Heavy swell conditions can render an operating area unusable. Wind directly affects the operating and anchorage areas, and is considered the primary element governing their operational capability. Strong winds can produce heavy seas, rough water, surface chop and hazardous conditions, not only in the landing and takeoff area, but also in the launch and anchoring areas. Prevailing winds, unusual wind conditions, and seasonal availability of landing areas should be reported.

(2) *Obstructions.* As applied here, obstructions pertain to known surface and submerged objects that are hazardous in both the operating and anchoring areas. These could be in the form of below-surface rocks, reefs, sand bars, breakwaters, shallow water areas, or piers. Most will be marked or depicted on local area charts. Other types of obstruction would include small boats and shipping, land contours, and other air navigation hazards in the approach and climbout areas.

b. Anchorage.

(1) *Depth of water.* In the mooring area, depth of water is subject to tidal influence. Therefore, the tidal level should be considered in reporting a minimum usable depth. The value for the overall anchorage area should reflect a range, in feet, from this minimum to the greatest depth.

(2) *Type of bottom.* Knowledge of the characteristics of the bottom in the mooring area is desirable from the standpoint of safe and efficient operations. Mud, clay and sand provide a firm anchoring bed, but a rocky bottom presents a snagging hazard.

(3) *Ice conditions.* Operations in low temperature areas must be concerned with ice conditions. Floating masses of surface ice are hazardous and could render the operating area unusable. This condition would also affect the seasonal utility of a station and should be reported.

(4) *Tidal range.* All water in a seaplane area is affected by the tides. It has little significance in the operating area due to the greater depths involved except for shoal areas at low tide; however, in the anchorage and beaching areas where minimum depths are critical, it is a prime element to be taken into consideration. In addition to varying the depth, tides induce a current which must also be considered. Its movement should be measured, and the value expressed in knots.

5-75. Sources of Information

The best sources of information on airfields are personal contacts, documents and publications, maps and charts, and photographs.

a. Personal Contacts. Generally, at airfields open to civil aviation, the airport employees are good sources of information for details of airfield construction, operational capabilities and limitations, and associated support facilities. Personnel who regulate and control air navigation aids, communications, weather services, and related subjects often yield much useful information. Other personnel who may serve as useful contacts are employees of major oil companies, representatives of tourist bureaus, scheduled and nonscheduled airline operators, foreign attaches accredited to the area of interest, commercial air line pilots, private pilots, aero club representatives, travelers, and other observers having access to airfield or adjacent areas.

b. Documents. The numerous facilities used for present day aerial navigation and traffic control normally require the publication of a large mass of operational aeronautical information. This is presented on charts in booklets, documents and notices. Examples of such documents are NOTAM (Notice to Airmen), Aeronautical Information Publications (AIP), commercial air publications such as airline route manuals, aviation periodicals and trade journals, annual reports and handbooks, and newspaper and press reports.

c. Maps and Charts. Good maps are invaluable sources of information which contribute greatly toward proper coverage of some subjects. The informational value of maps may be improved by additional notations identifying significant features, or by updating. Highly desirable charts are planning, airway and route, radio facility, radio navigation, instrument approach, visual approach, and terminal area. Valuable information is contained in plans which include details on runways

and taxiways, including lighting information, parking areas, hangars, control structures, terminal buildings, railroad spurs and sidings, layout of maintenance areas, POL bulk storage areas, and other related facilities such as sewage treatment, trash and garbage disposal, drainage, quarters, and medical facilities.

d. Photography. The high yield of information possible from aerial and ground photographs makes it essential that they be used extensively as a reporting medium supplementing textually reported observation, maps, news articles, publications and other sources of information. The most useful is aerial photography; however, ground photography is needed to supplement the vertical and the oblique photography.

5-76. Collection Checklist—Airfields

1. *Identification.* Local name (both romanized and ideograph) and military designation.
2. *Location.*
 - a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.
 - b. Political unit, area, nearest town, and specified reference point (both UTM and geographic coordinates).
3. *Airfield category.* Liaison, surveillance, light lift, medium lift, tactical, or heavy lift.
4. *Status.*
5. *Type.* Civilian, military or joint.
6. *Principal use.*
7. *Layout.*
8. *Elevation (feet and meters).*
9. *Number of runways.*
10. *Each runway.*
 - a. Identification.
 - b. Azimuth.
 - c. Length and width.
 - d. Surface, base, subbase course (material, thickness and condition).
 - e. Longitudinal grade (minimum and maximum change per 100 feet).
 - f. Transverse grade (maximum).
 - g. Shoulders, clear area, and overrun (width, transverse grade, and surface material).
 - h. Lateral safety zone (width, transverse slope, and obstacles).
 - i. End clear zones (length, width, and maximum slope).
 - j. Approach zones (length, width, glide slope, and obstacles).
 - k. Condition.
11. *Each taxiway.*
 - a. Identification.
 - b. Azimuth.
 - c. Length and width.
 - d. Grade (maximum longitudinal and transverse).
 - e. Surface, base, subbase material (thickness).
 - f. Bearing capacity (pounds per square inch).
 - g. Shoulders and clear area (width, transverse grade, surface, and obstacles).
 - h. Turn radii.
 - i. Condition.
12. *Parking and warm up aprons.*
 - a. Number.
 - b. Total area and individual area.
 - c. Description of each apron.
 - d. Total capacity (specify aircraft type).
13. *Hardstands.*
 - a. Total number.
 - b. Aircraft capacity (specify).
 - c. Description of each hardstand.
14. *Petroleum, oil, and lubricants.* Describe facilities and storage.
 - a. Jet fuel by type (J rating).
 - b. Aviation gasoline.
 - c. Jet oil.
 - d. Aviation oil.
 - e. Lubricants.
 - f. Pipelines (cross reference to pipeline collection file).
15. *Navigation facilities.* Describe the type of facility.
16. *Lighting facilities.* Describe all lighting at airfield.
17. *Communication facilities.* Cross reference to communication collection file.
18. *Maintenance facilities (aircraft).*
19. *Oxygen availability.*
20. *Special equipment.*
 - a. Crash and fire.
 - b. Construction and ground maintenance.
21. *Covered storage.*
22. *Sanitation.*
23. *Hangars.*
 - a. Number and locations.
 - b. Type and material.
 - c. Condition.
24. *Housing facilities.*
 - a. Type, location, and number.
 - b. Capacity and condition.
25. *Munition storage.*
 - a. Type and location.
 - b. Cubage, normal use, and condition.

- 26. *Administration buildings (identify).*
- 27. *Electricity.* Cross reference to electric power collection file.
 - a. Sources.
 - b. Current characteristics.
- 28. *Jet starting units.*
- 29. *Auxiliary power units.*
- 30. *Anti detonation fluid/water-alcohol.*
 - a. Type and location.
 - b. Quantities.
- 31. *Defenses.*
- 32. *Adjacent terrain.* Cross reference to appropriate collection files.
- 33. *Medical facilities.*
 - a. Type and location.
 - b. Capacity and characteristics.
- 34. *Weather facilities.* Cross reference to weather collection file.
 - a. Type and location.
 - b. Characteristics and condition.

CHAPTER 6

TELECOMMUNICATIONS

Section I. INTRODUCTION

6-1. Scope of Telecommunications

Telecommunications refers to all forms of civil and military telecommunications systems, facilities and equipment. It also refers to the related governmental and commercial organizations that regulate and operate the systems. Telecommunications services include telephone, telegraph, teleprinter, facsimile, data transmission, radio broadcast and television. These services are provided by various types of transmission media, such as wire lines, cables, radio-relay links, tropospheric scatter links, satellite communications, and high frequency radio communications stations. Telecommunications facilities serve the armed forces, police, railways, airways, and other public and special purpose organizations.

6-2. Collecting Information

The collection of information on foreign telecommunications activities and facilities is a continuing requirement. Although each major facility is often the subject of a detailed study by highly skilled telecommunications personnel, the information gathered by nontechnically trained field collectors is of vital importance to the intelligence effort. There is a continuing need for the systematic exploitation by field collectors of available sources of information on telecommunications in a country or region and for reporting such information to the proper command or intelligence agency.

Section II. MILITARY COMMUNICATIONS ESTABLISHMENT

6-3. Organization

The level of organization of its telecommunications elements is a good indication of the potential of a foreign armed service. It is of prime interest in intelligence information collection. The organization may be a separate arm or service, or it may be subordinate to or integrated into other arms or services. It may be responsible for a wide range of functions or it may be responsible only for operations, with other functions being handled by central agencies or services. Sizeable assets may be assigned to training. In any case there will be some type of organization for providing military telecommunications services, no matter how small. Refer to FM 32-20, Electronic Warfare (Ground Based).

6-4. Functions

Any major military establishment will have a large telecommunications unit. A typical central headquarters for communications service would

contain the usual staff sections found in a US military organization. The most important sections would probably be research and development, procurement, training, operations and plans. The size and scope of the staff elements will vary greatly depending upon the size and effectiveness of the nation's military forces.

6-5. Personnel Requirements

A small military establishment, such as that serving one of the South American Republics, probably will have one or two battalion size units to provide tactical communications. It will depend upon public communications facilities for transmission of its administrative telephone and telegraph traffic. It may even have a radar unit, or one or two special communications units. On the other hand, a large military establishment requires a huge complex of telecommunications and electronic systems in order to accomplish its mission. Such a military force would need special units to provide fixed communications over areas

including several countries. Depending upon the level of the headquarters served, this equipment might range from several vehicles (aircraft and ships) forming a complete telecommunications complex, to a single vehicle that can accommodate all of the communications equipment necessary to a unit commander. The number and type of personnel assigned would differ greatly. In addition to telecommunications units, a large military establishment requires the support of many types of special units such as depot and maintenance, radar, intercept jamming, surveillance and other types.

Section III. RADIO

6-7. General

Since its introduction, radio has assumed ever increasing importance in telecommunications. Radio is used at every level of command in a modern military operation.

Note. When working around certain types of radio/telecommunication equipment care must be taken because of clearly defined hazards that exist. Refer to the appropriate TM where available for the particular equipment being used or examined.

6-8. Ground Communications Systems

a. In military operations, particularly air defense, one of the major problems is the rapid transmission and processing of data. Radio equipment and systems, especially those employed in the ground-support portion of ground-air operations involving command and liaison communications nets, include low frequency (LF), medium frequency (MF), and high frequency (HF) sets (table 6-1). Multichannel, highly directional radio links, most commonly known as microwave communications systems, are also used. Ground radio communications equipment may be used in conjunction with other types of electronic equipment. For example, radio communication is an integral phase of early warning radar networks. Early warning (EW) and air surveillance radars (ASR) are used to detect aircraft and visually provide their bearing and distance.

b. Collection indicators are the installation of multiconductor lines, coaxial lines, and radio relay facilities. The ground-support portion or link in ground-air control-type systems usually is located at air fields and may be either a fixed or mobile unit. In ground-controlled intercept installations, communications with interceptor aircraft is carried on by means of radio. Missile-testing installations may use radio communications equipment

6-6. Research and Development

Usually, military forces will develop the need for a new type of equipment or system. This need will be transformed into a plan, and then passed to the research and development organization for actual prototype development of the necessary equipment or system. Some military establishments have their own research and development facilities whereas some depend entirely upon the local electronics industry.

for the control of the missile as well as for normal communications purposes. Other installations which might be expected to include communications equipment are all types of ground based radar, radio navigation, and electronic counter-measure equipment.

6-9. Radio Communications

a. The two basic components of radio communication installations are transmitters and receivers. Transmitters are generally bulkier and more characteristic in appearance than receivers, and normally easier to observe. Fixed transmitters may be quite large with elaborate and extensive antenna fields, or they may be small in size and area with a single antenna. Leads to the transmitting antenna are insulated, often with porcelain sheaths, against high voltages, whereas the leads from the receiving antenna are plastic or rubber insulated. No insulation, however, will be present on openwire transmission lines. Fixed transmitters require a tremendous amount of electrical power. This power may come from generators or commercial power sources.

b. High frequency (HF) fixed radio facilities carry the bulk of worldwide communications traffic. The rhombic antennas (para 6-11*d*) usually employed by these facilities are easily identified. The type of rhombic antenna may provide further identification—all receiving rhombics and some transmitting rhombics are single curtain (single wire), but some transmitting rhombics are three-curtain (fig. 6-1). Thus, a three-curtain rhombic positively identifies a transmitting facility. Relatively large and readily observable transmitters are characteristic of a high frequency fixed radio facility.

c. Land based radio communications equipment

Table 6-1. Radio Frequency Spectrum

Frequency -----	3 KHz*	30 KHz	300 KHz	3 MHz	30 MHz	300 MHz	3 GHz	30 GHz	300 GHz
Wave length -----		10m	1 km	100 m	10 km	1m	10cm	1cm	.1cm
Band Designation -----	VLF	LF	MF	HF	VHF	UHF	SHF	EHF	
Band number -----	4	5	6	7	8	9	10	11	12
Corresponding Metric Subdivision -----	Myria- metric waves	Kilo- metric waves	Heco- metric waves	Deca- metric waves	Metric waves	Deci- metric waves	Centi- metric waves	Mille- metric waves	Decimilli- metric waves

LEGEND:

VLF — Very Low Frequency
 LF — Low Frequency
 MF — Medium Frequency
 HF — High Frequency

KM — Kilometers
 M — Meters
 CM — Centimeters
 VHF — Very High Frequency
 UHF — Ultra High Frequency
 SHF — Super High Frequency
 EHF — Extremely High Frequency

ABBREVIATIONS:

Hz — Hertz (internationally accepted +c/s)
 K — Kilo (10³)**
 M — Mega (10⁶)
 G — Giga (10⁹)
 T — Tera (10¹²)

* Frequencies below 3 KHz have been referred to as ELF—Extremely Low Frequencies.

** (10³ indicates 10 to the third power).

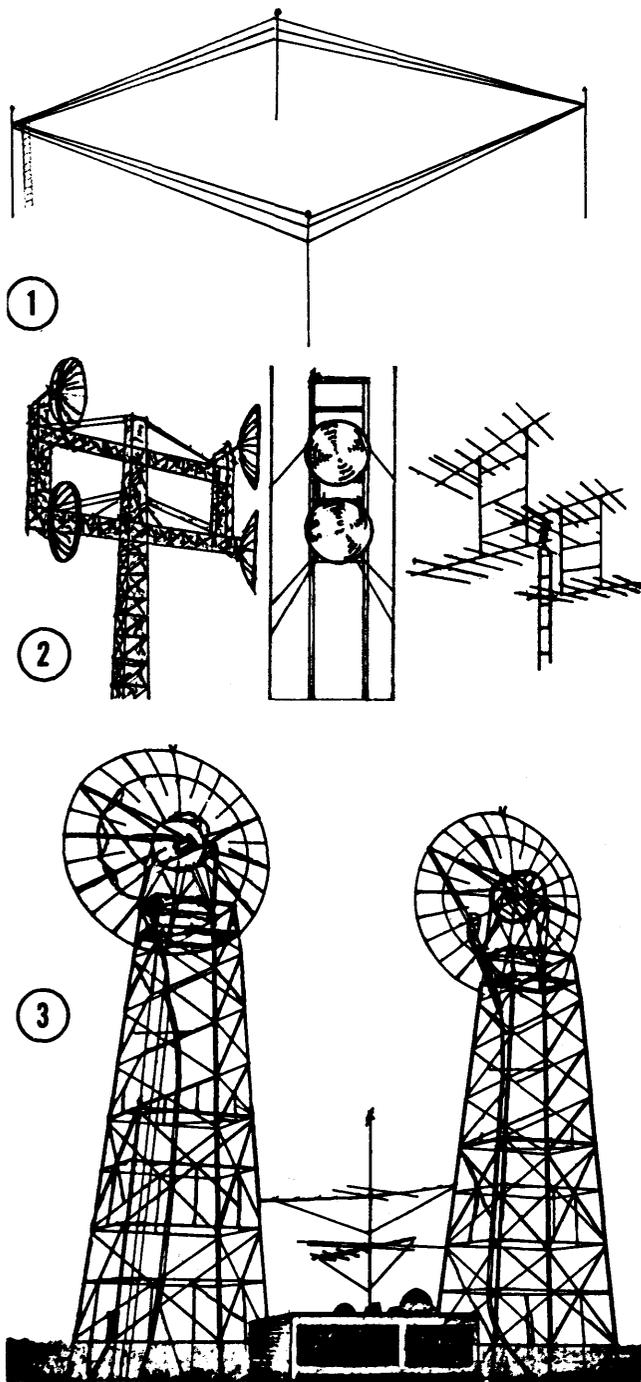


Figure 6-1. VHF and microwave antennas.

which supports naval operations takes the form of large scale, high power, permanent transmitter sites. Because the VLF and ELF operation uses extremely long wave lengths, extensive antenna installations are required. Recognition features for these include massive high towers supporting complex wire patterns, heavy conducting cables, and the use of large, heavy duty transmitting components. Tubes may be on the order of 6 feet high and require water jackets for cooling. Tun-

ing coils may be room size. In this type of installation, as in fixed HF installations, transmissions ordinarily originate at central command locations and are conveyed to the transmitter by land line or radio link.

d. Recent developments in the field of radio communications include microwave radio-relay and radio scatter techniques. Transmitters of these types are more special purpose and less widely in use than HF. Microwave radio-relay, employing frequencies in the upper very high frequency (VHF) through ultrahigh frequency (UHF) and super high frequency (SHF) bands is used for high capacity multichannel links of up to 50 kilometers (30 miles) in length (table 6-2). In radio scatter communications, the output of a high powered transmitter (usually microwave) is directed to the troposphere or the ionosphere, where the signal is scattered, mostly in a forward direction. Usable signals can be picked up at great distances. Although scatter transmission is effective over difficult terrain and water barriers, the size and cost of scatter equipment limits its application. The important and readily identifiable feature of a scatter transmitter is the antenna, which is a parabola or a sector of a parabola, very large in area, and supported by an elaborate steel structure.

e. Radio communications receiver sites may be large and located at a distance from the transmitter sites, or they may be combined. Receiver equipment is generally more compact than transmitters and may be contained in a single metal box or mounted on a rack with several other receivers. In HF communications, however, the number of receivers required to provide for the large number of channels may necessitate a sizable station. In contrast a small station may employ only a single receiver. No clear distinctions between transmitter and receiver facilities at radio relay and scatter communications sites can be observed, since receivers and transmitters may share the same antenna or use similar antennas fastened to the same support. The great variety of radio receivers, from the tiniest transistor set to the most elaborate, is well known from everyday broadcast equipment, but communications types are readily recognizable if a collector is aware of unique designs and controls.

6-10. Radio and Television Broadcasting

Collection of information on radio and television broadcasting transmitters and receivers is also es-

Table 6-2. Radio Frequency Transmission Characteristics

Band	Range (note)		Power required	Antenna required
	Day	Night		
VLF -----	Long	Long	Extremely high	Very long
LF -----	Long	Long	Very high	Long
MF -----	Medium	Long	High to medium	Long
HF (3 to 10 MHz) -----	Short	Medium to long	Medium	Medium
HF (10 to 30 MHz) -----	Long	Line of sight	Low	Short
VHF -----	Line of sight	Line of sight	Low	Very short
UHF, SHF, and EHF -----	Line of sight	Line of sight	Low	Very short

Note. Long range: over 1,500 miles
 Medium range: 200 to 1,500 miles
 Short range: under 200 miles
 Line of sight: under 50 miles

sential. Broadcasting transmitter antennas differ significantly by being higher powered, fewer in number, and often so large as to be landmarks. Distinguishing features of AM or FM radio and television broadcasting stations are generally easy to identify. In most countries no attempt is made to conceal the equipment or data concerning them, and the task of collection is made easier.

6-11. Radio Antennas

a. In general, antennas are grouped according to the services they perform—broadcast, communications, point-to-point, FM and TV broadcast, and radio relay. The transmitting antenna is essential to all types of radio facilities. The antenna receives the radio frequency energy from the transmitter and directs it into the atmosphere (or beyond) as electromagnetic waves. There is a direct relationship between the physical dimensions of the antenna and the operating frequency. The smaller the antenna the higher the operating frequency. As directivity increases, so does the number of elements in the antenna system. The two criteria most important in determining the use and operating frequency of an antenna are the appearance (configuration) and the dimensions.

b. The length of a halfwave radiator can be used to determine its operating frequency. Thus, in figure 6-2, the formula $f = \frac{468}{L}$ can be used. In this formula, f is the operating frequency in kHz and L is the length of the halfwave in feet. The transmission line carries the energy from the transmitter to the radiator. In figure 6-2 the transmission line is shown as coaxial cable, but instead, it could be a two-wire (open wire) feeder. Halfwave HF dipoles are used by airlines, railroads, police, military and international commer-

cial radio facilities. In general, the radiators of antennas used with VHF or UHF point-to-point communications are dipoles consisting of short metal rods. Usually there will be a reflector element behind the radiator and one or more directors in front of the radiator. This whole unit, framed with dipoles, is connected to the transmitter with a tow-wire or single cable feeder. Except for the greater majority of those VHF type antennas used in shipborne radio communications, dipoles almost always have a reflector behind them. Such reflectors, which may be another dipole, or wire mesh, or a solid metal dish, direct or focus the radiated energy in one direction like the beam of a searchlight.

c. Particular attention should be directed to an-

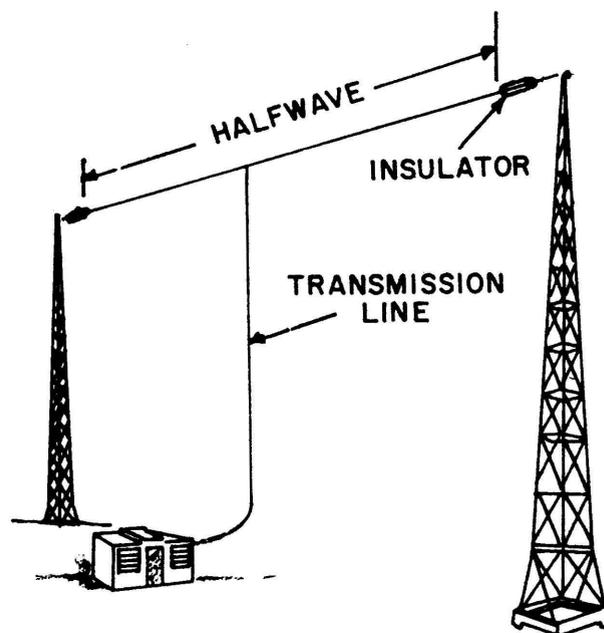


Figure 6-2. Halfwave antenna measurements.

tenna fields where a variety of large antennas is installed. It is not necessary to identify or describe each individual antenna in a large complex; however, the collector should try to determine the approximate numbers and describe them as rhombic, "V," curtain, etc. (fig. 6-3). Such antenna fields are always large and important communications installations, and their location and identification as such will suffice. Single, unusually large antennas associated with ELF, and VLF are of utmost interest, and all information as to shape, length, number of elements, construction, and orientation should be reported. Figure 6-4 illustrates the standard method of dimensioning antennas as set forth in AR 105-24.

d. Certain installations contain a large number of parabolic, horn, dipole, and possibly lens type antennas pointed in various directions. These installations are radio relay terminals or repeater points, and no attempt need be made to describe each individual antenna. The collector should count or estimate the number of each type on the structure and the general direction (azimuth) in which most are pointed.

e. The collector should report all antennas observed. Technical knowledge is not required to place an observed antenna into its proper category. A properly described and/or identified antenna will disclose enough information to establish the function of any radio type installation.

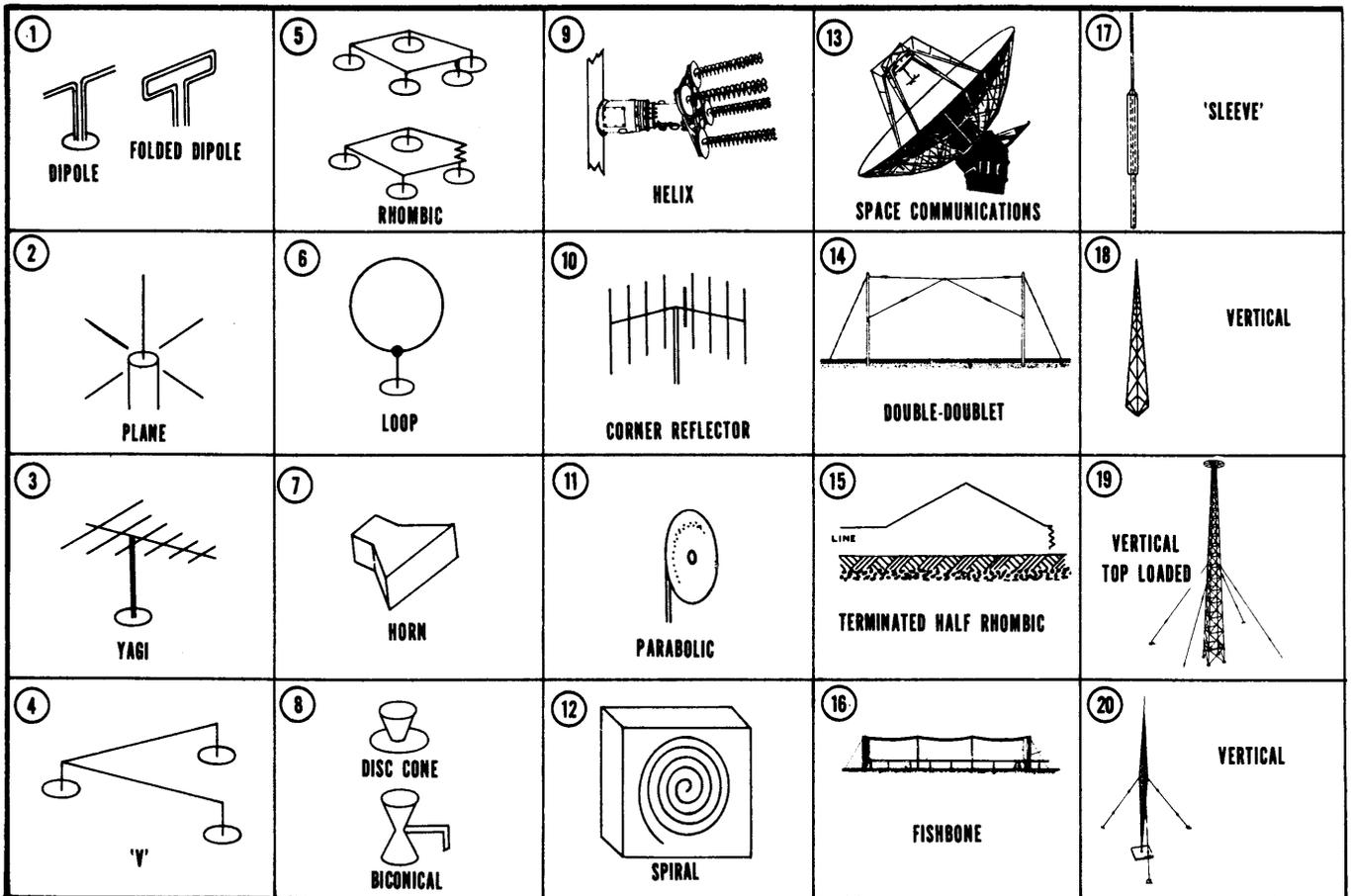


Figure 6-3. Radio antennas.

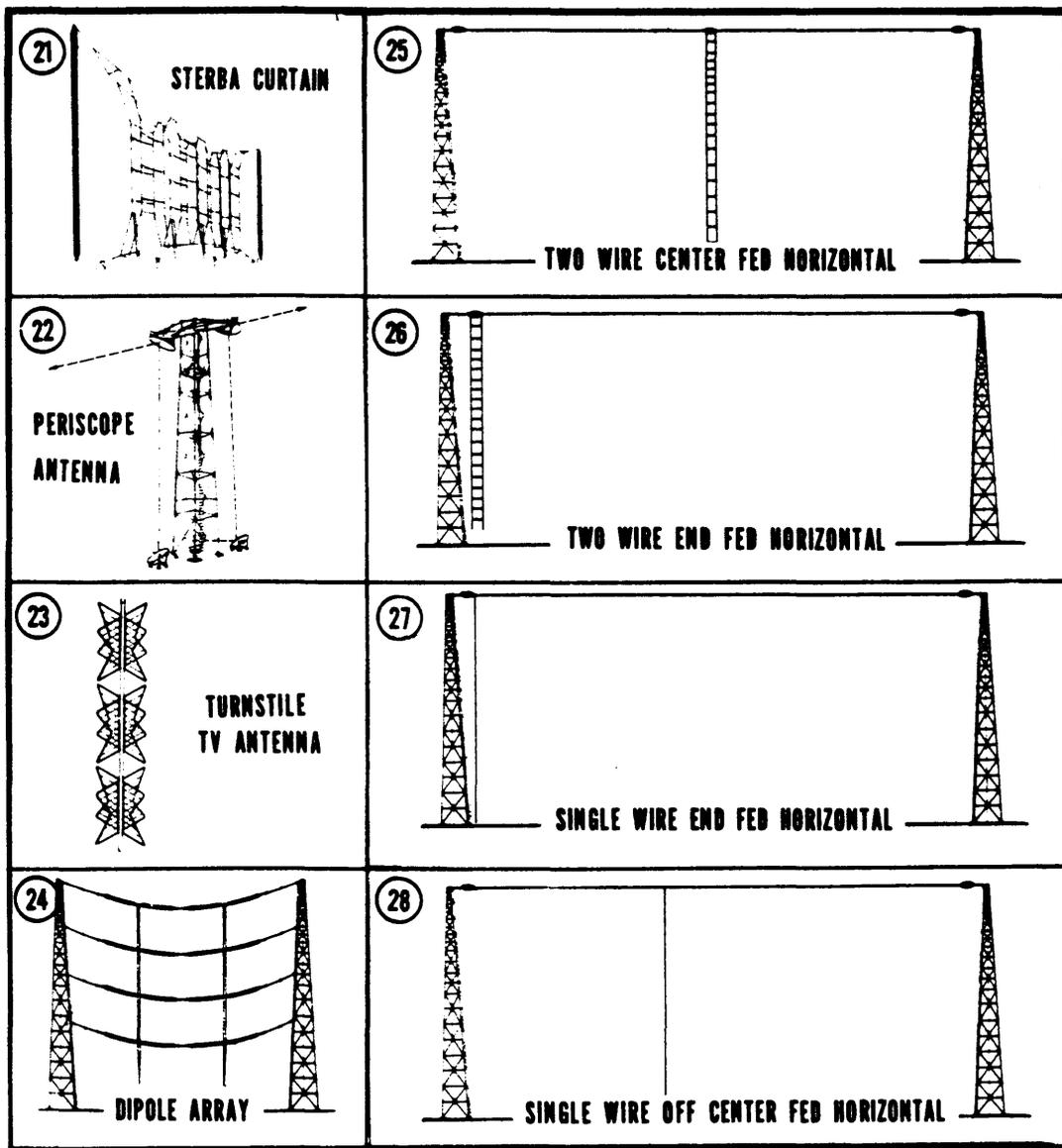


Figure 6-3—Continued

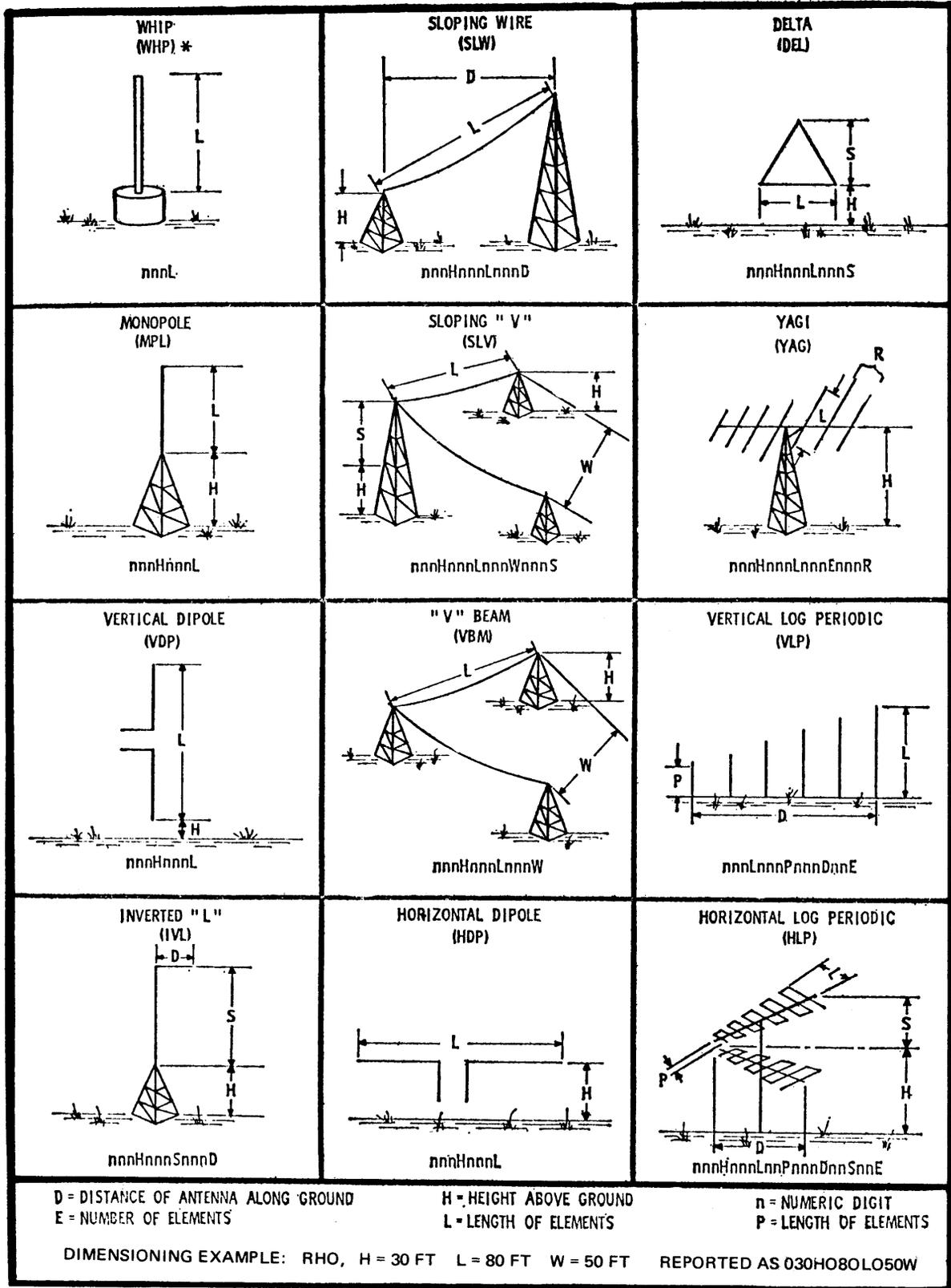


Figure 6-4. Standard method of dimensioning antennas.

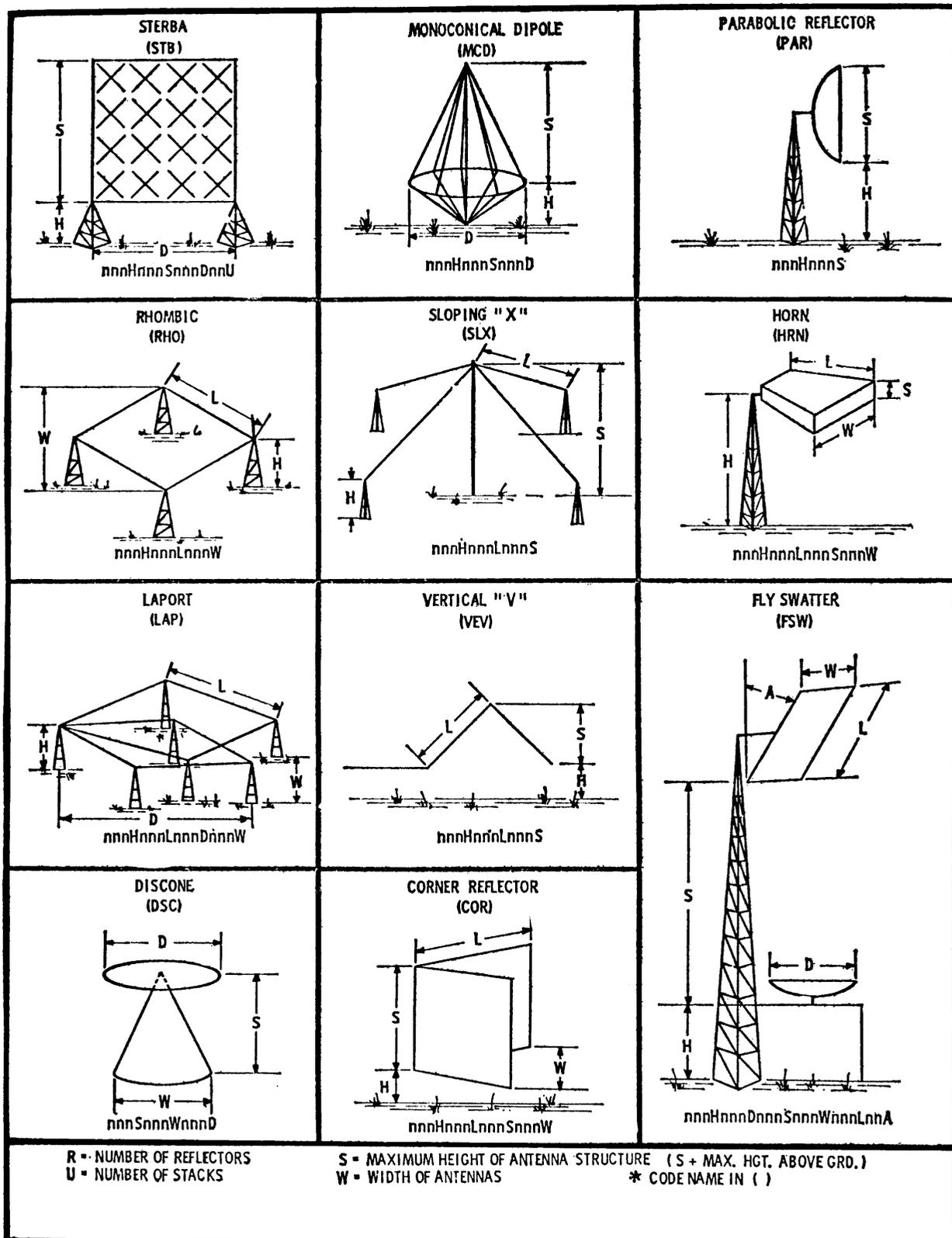


Figure 6-4—Continued

Section IV. WIRE

6-12. Wire Communications Systems

Wire communications are considered to be one of the most reliable and secure means of carrying messages. Wire systems include telephone, telegraph, wire line radio broadcasts, and associated equipment such as teleprinter and telephoto. Telephone transmission equipment has developed to the stage where it can handle blocks of several hundred circuits. New systems are being developed and well established systems are being continually improved by the addition of new components and by using new techniques and developments. Data transmission systems are being increasingly used for both the switched network for general subscriber use and for point-to-point communications on rented circuits, telephone, or wider-band channels for high-speed transmission. Other facilities provided by line transmission systems are circuits for broadcasting and both picture and sound channels for television transmission. In the field of telegraph, modern teleprinter apparatus is replacing obsolete Morse and Boudot equipment.

6-13. Telephone

A telephone system is comprised of the instruments, all connecting wires and cables, the switchboards, test equipment, and power sources (batteries, generators, repeaters and amplifiers).

a. Repeater Stations. The range of the unaided human voice is limited. Even when aided electrically and put on wires, the distance the voice can travel is reduced by the internal resistance of the wire. For this reason, when the signal fades on long distance wires, it is equalized and amplified at intervals along the line at repeater or amplifier stations, which may or may not be attended. Repeaters are used to amplify the attenuated signals at regular intervals along the lines. In large cities, the station will commonly be found in a separate building; in smaller cities in the same building as the telephone office; and, in many small villages, in the municipal administration office. Repeater and amplifier stations are important links in long distance telephone networks. When a station fails, or if service is interrupted for any other reason, all communications along that line are curtailed or even halted. Quite often, lines which feed into it or otherwise depend upon it are also affected.

b. Line Construction.

(1) Telephone lines or open-wire lines are

usually strung along and run parallel to railroads and highways that are passable both winter and summer. Lines may be constructed of steel since great strength is required to withstand the weight of snow, ice, and strong winds; however, the attenuation of voice frequencies on steel is considerably greater than on copper. Bimetallic (copper clad steel) wires have been developed as a compromise for minimum tensile strength. The lines must be inspected frequently and require considerable maintenance, especially during winter months when the ice and snow cause wires and poles to break.

(2) Poles (fig. 6-4) are usually of wood; however, wooden poles may be replaced by reinforced concrete poles as the wooden ones deteriorate. Crossarms are fastened at right angles to the poles to support the wires.

(3) A basic long distance network consists of an underground cable capable of simultaneously carrying telephone messages, telegraph, and wire broadcast programs. Underground cables may be composed of as many as 200 pairs of wire or as few as 12. Route markers (fig. 6-6), generally placed above the ground, show the important routes, splicing and loading points, ownership, and crossing points of other utilities. These route markers should be examined as closely as possible to determine structure material, any inscription on the marker, the direction the numbers increase, and where the underground cables cross rivers or other bodies of water. Collectors should also note how water crossings are indicated. Much of this information may be obtained from technical publications on telecommunications.

c. Principal and Branch Exchanges. An important part of any telephone or telegraph network are the principal and branch exchanges. There are three types of exchanges: automatic (dial), semi-automatic (dial plus operator) and manual (hand operated). Principal exchanges are usually found in the nation's capital, other large cities, and in transit centers. Branch exchanges may also be found in large cities. The collector should attempt to locate and identify the trunk lines between exchanges and to obtain the trunking diagrams, usually from the telephone company or from a map. He should ascertain how the principal exchanges are bypassed during emergencies, the route used, and how the routes are indicated above ground. Another type of exchange is the private branch exchange, or PBX. These may be owned by a telephone company and leased to rail-

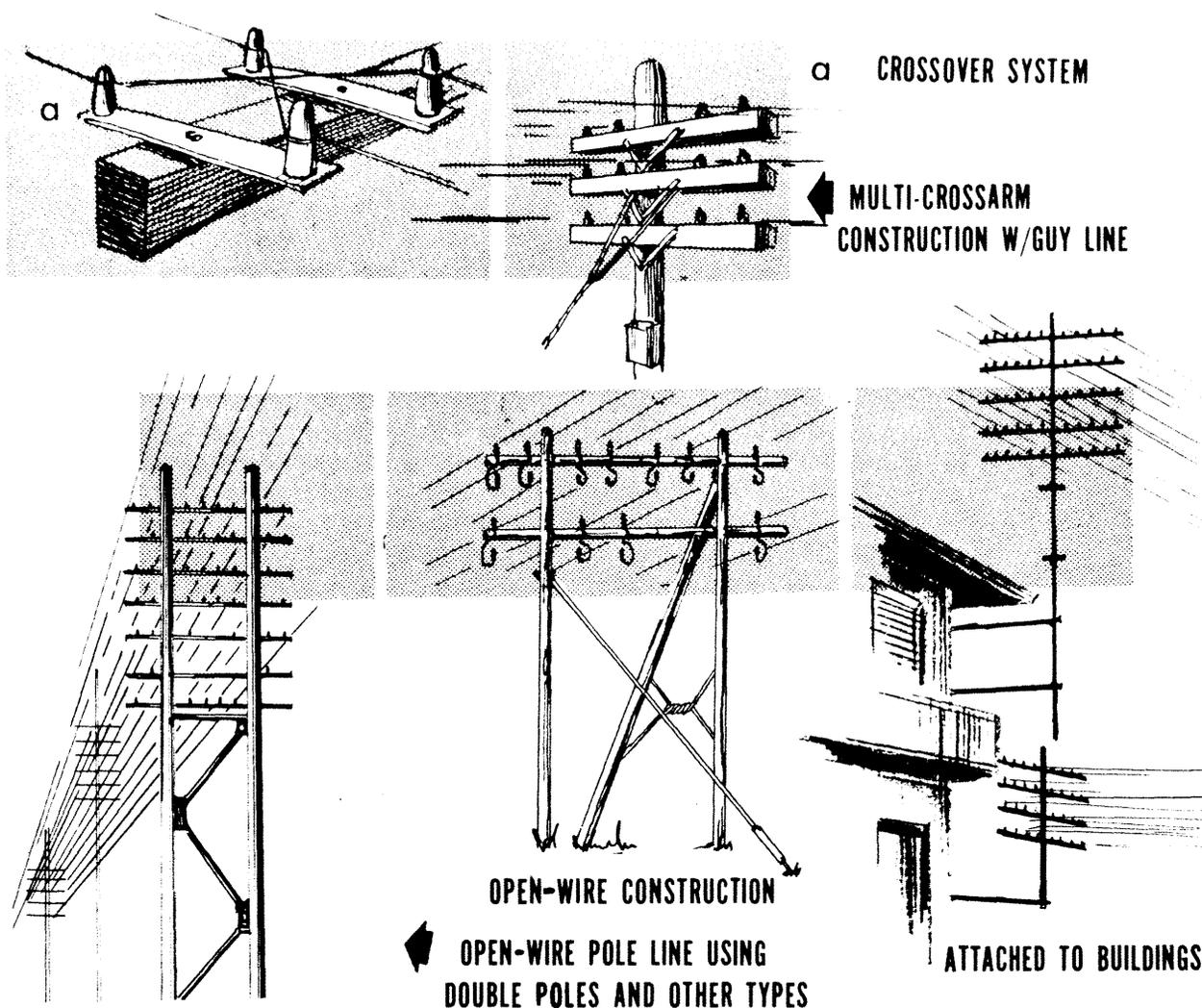


Figure 6-5. Types of telephone poles.

roads, public utilities and oil companies and other customers for their exclusive use. PBXs may also be manufactured, installed, and serviced by other commercial telephone enterprises.

d. Symmetrical-Pair Cable. Telephone cables have either paired or quadded conductors. Local cables are commonly paired, and long distance cables are multiple-twin quadded cables. These cables use frequencies up to about 500 kilohertz (KHz), making possible the application of 60-channel 2-wire systems, or 120-channel 4-wire systems when two cables are used. Limitations of these systems are those of cross talk control between like systems in the same cable; separate "go" and "return" cables are needed, and one repeater is required for each cable pair at a repeater station. Relatively large repeater stations are required. An advantage of this type of system is that a large number of circuits may be spread

over a number of systems in the same cable, thus limiting the circuit outages due to equipment failure. The equipment needed to terminate one or more 12-channel groups at any intermediate point is simpler than for the coaxial system.

e. Coaxial Cable. The use of coaxial cable is increasing rapidly. It consists of one or a series of metal tubes or pipes used for the transmission of messages by electrical means. Each tube surrounds a conducting wire supported concentrically by insulators. The space in the tube normally contains nitrogen gas under pressure. Generally, coaxial cable is used for the transmission of information in complex form, such as radar images, computer data, or television signals, or for the carrying of telephone channels and telegraph sub-channels. A single tube usually carries information in only one direction at a time. The capacity of a tube depends in part upon the distance be-

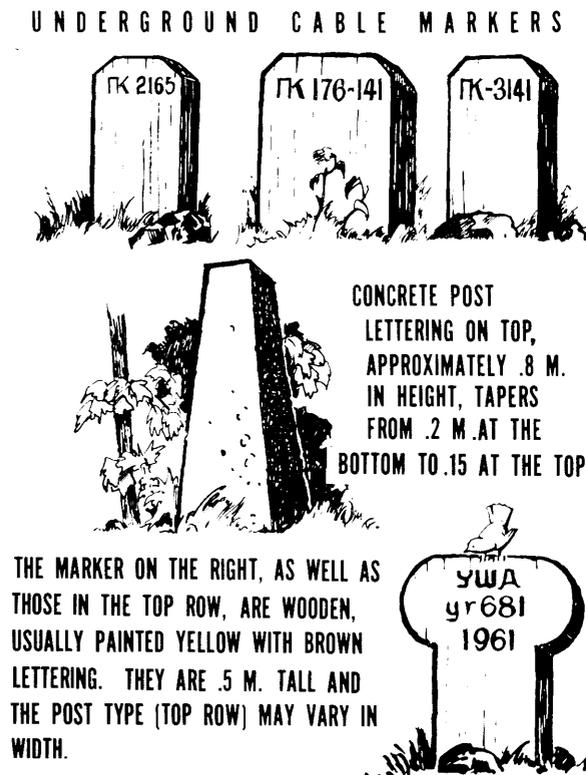


Figure 6-6. Cable markers.

tween repeater stations. In the standard facility, which may have from 2 to 8 tubes in a cable, a single tube carries a lane of up to 1800 telephone channels or one television channel, for which the repeater station spacing is about 11 kilometers (7 statute miles). New developments in coaxial cable design permit a single tube to carry a total of 1800 telephone channels or three television lanes, with a repeater station spacing of about 5 kilometers (3 statute miles). Coaxial cables have proved to be more economical than most other types of cables systems, both from the point of view of initial cost and the subsequent cost of operation. This is because the go and return circuits in the coaxial system can be in one cable whereas symmetrical pair cable systems need two cables. Another advantage of coaxial cables is that cross talk coupling between pairs decreases with increase of frequency instead of increasing as occurs between pairs in the balanced cable. Cables can be identified by information printed on the sides of the reels. Considerable detail can be realized by taking photographs during construction.

f. International Facilities. International tele-

phone facilities are made up of landlines and submarine cables. The landlines may be either separate from or independent of the existing telephone facilities, especially the long distance lines, or a part of the existing system. Submarine cables that cross oceans differ from those used within a country. The transocean cables are heavier and are better protected against the corrosive effects of salt water. They are stronger in order to withstand the pressure of shifting ocean currents, and are of such high technical quality as to require only a minimum of maintenance and repair work. An important phase of submarine cable construction is the connection to existing landlines. Submarine cable systems have a great advantage over any other intercontinental or continental method of communication from the standpoint of reliability and maintenance. Circuits compare favorably with radio systems using satellite repeaters in relation to propagation time. The circuits are considerably superior to those obtained on a high frequency radio system.

6-14. Telegraph

The telegraph network of a country is closely allied to or an integral part of the telephone network, because telegraph companies transmit most of their messages over telephone lines. Therefore, any investigation into the technicalities of one will involve the other. In telegraph networks, as in telephone, repeaters must be installed in long distance lines. If the telegraph company uses telephone lines, the telegraph repeaters may be in the telephone repeater and amplifier stations. Telegraph companies, however, may use their own lines, especially on secondary networks. In this case, they most likely have their own repeater stations. International telegraph facilities, like those of telephone, are divided into submarine cables and landlines.

a. Submarine Cables. International wire telegraph messages travel over landlines and over deep sea submarine cables and, in some instances, over submarine telephone cables. If the latter have been investigated under the telephone system, the number of telegraph circuits, the type of cable installed, and the beaching point should already be known. If, however, there are international facilities and cables that do not utilize the submarine telephone cable, the telegraph cable should be located in the same manner used for locating a telephone cable.

b. Landlines. International telegraph landlines

usually form a part of the international telephone landlines. They are considered major routes and occupy a number of circuits in the underground network.

6-15. Wire Broadcast Systems

a. Wire broadcast systems (sometimes identified as wired radio) are similar to the music distribution systems known in the United States as MUZAK. The wire broadcast station is composed of a radio broadcasting station, except that the transmission of the program is carried out through telephone wires to receiver sets in the subscribers installation rather than through the air. The location of such station, the headquarters and business offices, the studios, transmitters, and power supply equipment may be marked on maps.

It is important to determine how the interconnections are made between it and existing telephone communications facilities.

b. When rough terrain and large bodies of water preclude the economical construction of wire lines, wired radio may overcome this difficulty by resorting to line-radio couplers. These are similar in purpose and operation to microwave radio relay links, although they may operate on low frequencies. The couplers consist of a transmitter and antenna which transmit programs to a receiving antenna and receiver that put the program back on the wires to continue its journey. When such line-radio couplers are located, the technical information about them should be secured in the same manner as that given for radio and microwave relay links, the antennas, and the transmitters.

Section V. GROUND FORCES COMMUNICATIONS

6-16. General

a. The effectiveness of any military operation is directly dependent on its communications links. Although these links may vary from foot messengers to laser beams, wire and radio still predominate. The use of wire is generally preferred over radio wherever possible; however, the speed and wide deployment of modern armed forces are forcing greater reliance upon various forms of radio communications. Extensive knowledge of tactical communications capabilities of a foreign military organization provides significant advantages to an opponent. The value of such knowledge increases in proportion to the dependence of a military force on one form of communications, for example, the radio control associated with a missile system.

b. A clear understanding of the technical and operational capabilities of a unit's radio equipment and its location may give valuable clues to the organization and disposition of the military force. The complexity of a major unit requires large quantities of tactical wire and radio equipment. Smaller unit operations also require tactical communications for effective action.

6-17. Equipment Characteristics

Despite the great variety of tactical communications means, several general characteristics should be considered for all types of equipment.

Physical appearances—shape, size, construction materials—are always pertinent, as is any data on controls and meters in the equipment. Information on circuitry and components, and characteristics can be most valuable. Details on cipher devices, antijamming circuitry, restricted transmission paths, and communications security, even if fragmentary, should be reported by the most expeditious means. The operational reliability of an item in realistic combat environments is one of its most vital characteristics. Basic design features, quality of components, climate and signal vulnerability, maintenance, and antenna configuration are extremely important and contribute to a more accurate assessment of military potential.

6-18. Radio Equipment

Types of tactical radio equipment range from tiny transistorized helmet radios to large stations transported by two or more trucks. Tactical radios may be divided into several classes: man-packed (carried by one man), portable, vehicle mounted, mobile, and transportable. Radio equipment is flexible in its applications, so that one basic set may be used in more than one of the above classes. Generally, when this occurs, the radio set uses a different power unit or power source for each application. Tactical radios will not be discussed in this manual; refer to the appropriate technical manual for the type of radio being used.

6-19. Wire Equipment

Telephone, telegraph, and facsimile equipment are essential components in most tactical communications, yet they are often ignored in intelligence information collection efforts. This neglect may be due to the commonplace nature of the equipment, slow changes in design, and the absence of detectable emissions.

a. Switchboards. Tactical switchboards vary from simple 6-line boxes to elaborate central office equipment mounted in large trailer vans. In smaller sizes, telephone switchboards in many armed forces are similar in that they provide switching for 6 to 15 local battery (handcrank) lines, and have provisions for stacking units to provide service for additional lines.

b. Teleprinter. Teleprinter message traffic comprises a large portion of the total tactical commu-

nications traffic, especially at and above division level.

c. Facsimile. Facsimile equipment is used principally to transmit maps and photographs. Transmission of such material is made by scanning the subject with a focused beam of light and a properly placed photocell.

d. Carrier Equipment. Carrier telephone and telegraph equipment is used in conjunction with field cable or radio relay equipment to provide multichannel circuit capabilities from battle group level upward through all signal centers.

e. Field Wire and Cable. The types of field wire and cable are similar in all modern armed forces. The most common type of field wire is an insulated, twisted pair of wires, although single conductor wire still is preferred for forward areas by some armed forces. The wires consist of several strands of copper and/or steel and the insulation is normally a black flexible plastic.

Section VI. INFORMATION COLLECTION

6-20. General

a. The collection of information on telecommunications activities is a matter of concern at each level of command; however, much of the collection effort necessary to produce adequate communications intelligence must be accomplished by special units organized to perform a particular type of mission. These communications intelligence units require highly skilled personnel and specialized equipment designed to perform specific functions.

b. These units may be trained and equipped to operate at the tactical level or they may be engaged solely in strategic intelligence activities. The functions vary according to the level of the supported command and may consist of direction finding, traffic analysis, signal analysis, countermeasures, communications security, and other tasks which are not normally within the capability of combat units. Information collected by these units is passed through G2 channels to commanders who have a need-to-know. By the same token, the information collected by nontechnically trained personnel is placed in G2 channels where it is processed with that produced by the special units and later disseminated in a finished intelligence product.

c. The collection of information on telecommunications is normally accomplished by technically trained personnel; however, information obtained

by field collectors is extremely valuable. It may provide important leads to initial sources of information or it may be used to confirm other sources. The special communications intelligence units are also equipped to provide technical assistance where necessary; requests for such assistance should be forwarded through G2 channels.

6-21. Sources of Information

a. Information on telecommunications is collected through personal contacts, direct observation, maps, publications, and photographs. The relative value of any one means employed depends on the time, area and other circumstances. Usually several methods may be employed, one complimenting the other.

b. In some areas, reliance must be placed on nontechnical sources. In these instances, the collector may obtain information which is hearsay; however, intensive exploitation of such sources (refugees, defectors, escapees, prisoners of war, and repatriates) can provide valuable information. In situations where highly knowledgeable sources such as skilled scientists, project engineers, testing personnel, and laboratory technicians are available, the collector should request technical assistance to exploit these sources.

c. Photographs are invaluable assets in providing information on communications equipment,

materials, and structures. Sketches drawn by the collector, particularly of antenna arrays, can also produce valuable information.

d. The ability of intelligence researchers to follow technological advances in foreign countries depends to a large extent upon foreign publications, both official and private. Collectors should be as selective as possible in obtaining publications; but, if there is any doubt as to the value of a publication it should be forwarded. The following list constitutes an overall guide for the collector in the procurement of publications:

(1) Technical and scientific periodicals, books, magazines, and trade journals.

(2) Budgetary and financial data of research facilities. Reports and statistical data issued by government bureaus and private enterprises.

(3) Maps, official documents, technical orders, maintenance handbooks, specifications, drawings, patents, flow charts and organization charts.

(4) Equipment catalogues and training manuals.

(5) Advertising brochures, pamphlets from industrial fairs and exhibitions, literature and lectures of scientific meetings and symposiums.

(6) Directories of all types: telephone, telegraph, engineering and other professional societies.

(7) Published articles. Collectors should always endeavor to associate authors with facilities, or their relationship to the actual research conducted.

6-22. Collection Checklist— Telecommunications

1. *Identification.* Local name and military designation.

2. *Location.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

b. Political unit, area, nearest town, UTM coordinates, and geographic coordinates.

c. Landmark reference—Description and location of landmark, and azimuth and distance from landmark to specified point.

3. *Importance.* Economic and strategic.

4. *Government administration.*

a. Agencies involved.

b. Functions.

c. Location of offices.

5. *Military communications establishment.*

a. Background.

b. Staff control of communications services.

c. Types of communications in use.

d. Other facilities under military control.

e. Source of equipment and materials.

f. Key personnel.

g. Training.

6. *Research and development.*

a. Installations.

b. Projects (type, purpose, location).

c. Performance data.

d. Progress.

e. Foreign contributions (personnel, funds, and equipment).

f. Training of local personnel in foreign schools.

7. *Intercept and direction-finding stations.*

a. Location (UTM coordinates).

b. Lines of communications (roads, railroads, etc).

c. Type of shelter.

d. Antenna layout (type, number, description, and pattern).

e. Rotating antennas (degree of rotation and direction of rotation).

8. *Power sources.*

a. Type and location.

b. Design.

c. Voltage and hertz.

d. Batteries.

e. Generator engine (gasoline, diesel, etc).

9. *Telephone and telegraph.*

a. Line routes (locations).

b. Construction type.

c. Exchanges and offices.

d. Repair facilities.

10. *Line construction.*

a. Open-wire lines (material, spacing, conductors, etc).

b. Poles (materials, treatment, spacing, number of crossarms, etc).

c. Underground and underwater cables (method, type, location, etc).

11. *Submarine cable facilities.*

a. Cable (type, length, location, and description).

b. Terminal and operating equipment (type, dimensions, power requirement, technical characteristics, land line connections).

12. *Fixed installations.*

a. Strength.

b. Housing facilities.

c. Defenses.

d. Administration facilities.

e. Primary mode of transportation (cross reference to appropriate collection file).

f. Terrain features (cross reference to appropriate collection file).

g. Acreage in antenna field.

h. Security and safety features.

13. *Technical details.*

a. Equipment identification.

b. Frequency range.

c. Function.

d. Operator's requirements.

e. Operational status (manned or unmanned).

f. Maximum reliable range.

g. Power source requirements.

h. Transmitter specifications.

i. Receiver specifications.

j. Antennas (item 14 below).

14. *Antennas.*

a. Location (UTM coordinates).

b. Dimensions (length, height, diameter, etc).

c. Type of feed system (single wire, open wire, cable, etc).

d. Orientation (direction).

e. Ownership or control (military, government, or private).

f. Use (transmitter, receiver or both).

g. Security at site.

h. Type of service (FM, AM, TV, satellite, radio astronomy, etc).

i. Polarization (horizontal, vertical, or circular).

j. Mounting position (fixed or rotatable).

k. Bandwidth capability (broadband or narrow band).

l. Operating frequency (table 6-1).

m. Type of installations.

n. Mounting structure (building, pole, tower, etc).

o. Single or multiple elements.

p. Number of antennas on structure.

q. Radiation pattern (omnidirection, 360° coverage; unidirectional, 1 direction; or bidirectional, 2 directions).

CHAPTER 7

URBAN AREAS

Section I. IMPORTANCE OF URBAN AREAS

7-1. Introduction

a. Urban area intelligence is important in the planning of tactical and strategic operations, in targeting for nuclear or air attack, and in planning the logistical support for operations. Knowledge of the characteristics of urban areas may also be important in the conduct of civil affairs and in intelligence and counterintelligence operations. Although information is frequently somewhat more accessible than in other fields, the amount of detail required necessitates a substantial collection effort in the field.

b. Urban area intelligence consists of data on both country-wide and individual urban areas. The first aspect includes the physical dimensions, geographic location, and relative economic and political importance of urban areas in the national structure. The second aspect includes the physical composition, vulnerability, accessibility, productive capacity, and military resources of individual urban areas. Urban areas are significant as military objectives or targets and as bases of operations. They may be one or a combination of: power centers (political, economic, military); industrial production centers; population centers; transportation centers; service centers (distribution points for fuels, power, water, raw materials, food, manufactured goods); or cultural and scientific centers (seats of thought and learning, and focal points of modern technological developments).

c. In planning geographic intelligence collection operations in urban areas, considerations on a strategic level include the effects which destruction of the principal urban centers of a country would have on the national economy. On a logistical level are such considerations as the suitability of urban centers for base development, for communications, and for utilization of local manpower, material resources, and production facilities. On a tactical level are such considerations as

the potential of urban areas for operational bases or defensible points and their vulnerability as targets.

7-2. Decentralization

The vulnerability of large urban areas and the growth of metropolitan centers have contributed to new planning concepts which would decentralize population and industry, and at the same time effectively reduce the territorial expansion of large cities. In some countries this has resulted in the construction of satellite towns with populations as large as 100,000. They are generally developed in the environs of a central city and are related to it by common features that serve their combined population. Many satellite towns have important industrial installations or scientific research institutes and other educational establishments which give the town additional significance.

7-3. Classification

Urban areas are classified as key strategic, secondary, or minor according to their general position in the country's economy and according to their military importance. In general, importance in the national economy will be the primary concern of the collector; however, location, size, complexity, and specialized function also are significant factors in classifying cities.

a. *Key Strategic Urban Areas.* These include urban areas that, because of their size, location, and function, economically or sociologically dominate large sectors of a country and are significant in regional or world-wide trade and culture, and also cities that comprise the lesser focal points within the national structure. Examples of cities of the first type are London, Paris, Moscow, Buenos Aires, Calcutta, New York and Tokyo. Cities of the second type generally are ports or manufacturing centers, such as St. Louis and Cleveland. Sometimes cities are placed in this category that

have minor economic importance but which are national or international centers of social or religious significance, such as Mecca.

b. Secondary Urban Areas. These are urban areas which do not have sufficient importance to be classified as key strategic urban areas; however, they have major significance in at least three of the categories listed in *a* above.

c. Minor Urban Areas. These are urban areas which do not have sufficient importance to be classified as secondary urban areas. They have mainly local importance but contain some particular feature or facility that gives the town additional significance.

7-4. Location

The importance of individual urban areas, in many cases, is based on location. Locations conducive to development of cities possess a combination of elements that encourage settlement, promote exchange of goods, interrupt or limit movement, or provide transit between hinterland areas and ports.

7-5. Components of Urban Area Intelligence

The complexity of urban area intelligence requires its division into several components.

a. Importance. On a country-wide basis, intelligence must provide a specific indication of the geographic, political, economic, and military importance of urban areas within the national structure. On an individual basis, the intelligence must indicate the salient factors that determine the importance of each urban area within its setting and its place in the national structure.

b. Physical Characteristics. On a country-wide basis, intelligence must cover the characteristic urban pattern as influenced by tradition, terrain, climate, construction material, and type of construction. On an individual basis, information must cover the details of site, shape, density, and limits of built-up areas, and of the functional composition and structural features of the urban area.

c. Accessibility and Communications Lines. On an individual basis, data must indicate the accessibility to the city from surrounding areas and include a thorough description and analysis of main transportation lines by type and general capacity.

d. Utilities, Services, Facilities and Construction Resources. On a country-wide and on an individual basis, information must cover the specific characteristics and adequacy of supply systems and alternate sources for peacetime and wartime use.

(1) *Utilities.* Extent and adequacy of transit systems, and means of supply, distribution, and collection of water, gas, electricity, and sewerage, as well as the extent and adequacy of the telecommunications system.

(2) *Facilities.* Size, location, and capacity of hospitals, transfer and storage facilities, billeting and other accommodations, and ice making facilities.

(3) *Services.* Equipment and organization for coping with emergency problems of fire and other disasters, for policing, for health and sanitation, and for civil defense.

(4) *Construction resources.* Type and quality of construction materials, and manpower and construction equipment available in individual urban areas, as well as an evaluation of the capability of the local construction industry to support base development or urban rehabilitation.

e. Industrial, Military, and Other Important Installations. For each important industry or individual plant, data include an indication of type, amount, and quality of products and the number of people employed. Also included are wholesale and other major distribution facilities which serve the local population. Information should cover identification, function and number of personnel at all military installations, such as headquarters, camps, and training facilities, underground installations and semipermanent and permanent defense installations. Data should also cover important installations such as principal education and research facilities.

Section II. PHYSICAL CHARACTERISTICS

7-6. Composition

a. Knowledge of the physical composition of an urban area is necessary to collect information on

the importance of the city the nature of its facilities, and its value as a target.

b. The type of functions and degree of develop-

ment in each area are determined from the specific types of construction and the layout of facilities. Types of construction in industrial, port, or railway areas reflect the needs and capacity of the industrial production or of the transportation media.

7-7. Functional Divisions

For military purposes, the functional divisions of urban areas are classified as industrial, commercial, residential, governmental and institutional, military and open.

a. Industrial. Within the industrial area are located two types of plants: heavy manufacturing (those requiring distinctive structures, such as blast furnaces, which could be readily recognized), and medium and light manufacturing (those housed in general loft buildings from which the machinery could be removed). The specific type of light or medium manufacturing is not usually apparent from the type of building. Included in the industrial areas are limited storage and transportation facilities normally associated with the operation of industrial plants. The city

of Liege, Belgium is the center of an industrial settlement which extends for many miles (fig. 7-1).

b. Commercial. The central commercial area (fig. 7-2) comprises the congested "commercial core" of a city, and includes retail and wholesale establishments, financial institutions, office buildings and hotels. Modern multistory office buildings are typical of commercial sections of large cities. In most of Europe the commercial area is the old core of the city and is usually the most densely built-up part of the town. In the larger cities of the Near and Far East, the old core is usually the native commercial area; the more modern commercial areas have developed away from the core. There may be more than one commercial area, particularly in cities composed of a number of towns which have merged. Transportation facilities generally are found in commercial areas, and may include rail-freight yards, ports, truck depots, pipeline terminals, and airports, as well as associated repair and maintenance facilities. Storage facilities also are generally located in commercial areas and include warehouses, refrigera-



Figure 7-1. Industrial area.



Figure 7-2. Central commercial area.

tor plants, grain and bulk storage elevators for holding goods and materials and facilities for bulk storage of petroleum, coal, and ores. Extensive railroad facilities, including yards and storage installations, are typical features of industrial cities (fig. 7-3).

c. Residential. Residential areas of a city include many types of dwelling structures. Buildings vary from one- and two-story single family dwellings to multistory apartment houses and may be built of any materials available locally. Type and size of residential areas often indicate the number of people and the varying living standards throughout the city. Figure 7-4 shows the multistory residential buildings predominant in this section of a European city.

d. Governmental and Institutional. Governmental and institutional areas may include buildings such as the capitol or other administrative center,

ministries, departments, legislative buildings, courts, embassies and police headquarters; educational, cultural, and scientific institutions such as schools, universities, libraries, museums, theaters, and research institutions and laboratories; and religious and historic structures, such as churches, monuments, and shrines.

e. Military. Military areas usually include transportation, billeting, storage, and administration facilities. Since these are of strategic as well as tactical importance, they require as accurate a description as possible for urban area intelligence.

f. Open. Both developed and undeveloped land is considered as an open area. Included are parks, beaches, recreation areas, farms, wooded areas, swamps, and vacant land in general. Extensive open areas within the city may be a valuable military asset, particularly if these areas have roads and railroad lines nearby and have readily availa-



Figure 7-3. Transportation facilities.

ble electric and water supply facilities. Open areas on the outskirts of cities are the most immediately available land for military use. Often, very useful supply depots, storage areas, and other facilities can be established adjacent to transportation lines without affecting normal city life. For temporary use, however, any open area can be used if it is reasonably dry and accessible.

7-8. Homogeneous Tracts

The structure pattern within the urban functional divisions is represented by smaller, relatively homogeneous tracts according to building occupancy, building construction and height, and building density.

a. Occupancy. The groupings of warehouses, apartment houses, single-family residences and specific industrial installations form the principal subtypes within the general functional pattern. They afford a broad basis for estimating work and storage space, production capacity, and resident population.

b. Building Types and Construction Materials. Types of building construction are identified by height (number of stories), whether wall-bearing or framed, wall and roof materials, and crane capacity (if equipped with one or more traveling cranes). Wall materials may be wood, masonry, adobe, sheet or corrugated metal, and possibly other materials. The following are examples of the principal types of buildings:

- (1) Single-story *or* multistory wood framed.
- (2) Single-story *or* multistory wall-bearing.
- (3) Single-story *or* multistory log or timber (a type of wall-bearing building).
- (4) Single-story adobe (a type of wall-bearing building).
- (5) Single-story light steel framed—no cranes, or equipped with cranes of less than 10 tons.
- (6) Single-story light reinforced concrete framed—no cranes, or equipped with cranes of less than 10 tons.
- (7) Single-story heavy steel framed—



Figure 7-4. Residential area.

equipped with 10-ton or larger cranes (crane size is important).

(8) Single-story heavy reinforced concrete framed—equipped with 10-ton or larger cranes (crane size is important).

(9) Single-story stressed skin.

(10) Multistory steel framed—conventional design or earthquake-resistant design (number of stories is important).

(11) Multistory reinforced concrete framed—conventional design or earthquake-resistant design (number of stories is important).

7-9. Density

The term “density” refers to the ratio of roof area of buildings to total ground area, including streets and small open spaces. There are four significant categories of density:

Open—5 percent or less.

Sparse—5-20 percent.

Moderate—20-40 percent.

Dense—40 percent and over (fig. 7-5).

7-10. Building Arrangement and Streets

a. Street Patterns. There are six basic patterns of streets: rectangular, radial, concentric, contour conforming, medieval irregular, and planned irregular (in the new residential suburbs of some countries, irregularly patterned streets have been constructed in order to control the speed of vehicular traffic). These patterns may exist singly, in combination, or in juxtaposition, and may have a sparse, moderate, or dense degree of development. A street pattern is divided into arterial, feeder, and bypass routes. Arterial streets carry the main flow of traffic between various sections of the city. Feeder streets generally are narrower than the arterial streets, and often end at watercourses. Bypass streets are through streets which avoid central areas. For most military purposes, information is required only for through and bypass streets.

b. City Block and Building Arrangement. The pattern of streets and the types of buildings that occupy each block are closely related. There are



Figure 7-5. Densely built-up section of a Japanese city.

four main types of block arrangement, each of which reflects a specific type of land ownership and type of dwelling.

(1) *Hollow square building arrangement.* The hollow square city block, composed of adjacent buildings forming a continuous wall around the block and having a central service courtyard, served by alleys and narrow streets, is the most common and oldest form of urban dwelling arrangement. In European cities, this arrangement is indicative of multiple dwelling areas. The interior courtyard is the service area for the entire block; garbage and sewage (where interior plumbing has not been installed) are placed in bins for removal by the city sanitation department. A square street pattern is generally formed by this arrangement. In North Africa, South Asia, and China, the central courtyard is the common cooking and eating area and the enclosure for animals belonging to several families. No regular street pattern exists.

(2) *Row building arrangement.* Row dwellings consist of adjacent dwellings forming a continuous wall facing the long side of an elongated

rectangular block. Row dwellings are indicative of single- or two-family dwellings. Row dwellings provide the greatest density of small dwellings for a given area.

(3) *Detached dwellings.* Detached dwellings, each on a separate plot of ground, are common where land values are low or where high family income permits greater living space. Blocks may be rectangular or contour conforming.

(4) *Ribbon pattern.* The ribbon pattern consists of buildings situated close together (although usually detached) along a main road, with open land to the rear; no block pattern with streets paralleling the main road has developed. Such an area in cities usually is representative of urban expansion.

c. Firebreaks. Open spaces, such as streets, parks, and canals, may serve as firebreaks. The effectiveness of streets and other open spaces in stopping the spread of fire depends on their width and the size, construction material, occupancy, and density of the buildings on each side of the open space, as well as on prevailing wind condi-

tions, although these can be counted of no value in fire control if construction is of a type to support "fire storm" conditions.

7-11. Topography

The physical setting of an urban area has a great influence on the shape and functional development of a city. Industries need tracts of dry, flat land for the best layout of their facilities. Drainage features play an important part in the selection and development of an urban area. Many cities are situated where conditions for crossing rivers or marshy valleys are good. In towns which use navigable waterways as trade routes, the need for facilities to load and unload ships gives added importance to sites that offer both shelter from

stormy weather and suitable water frontage on a deep channel. Many large industrial plants use water in large quantities and seek sites near sources of fresh water.

7-12. Geology

Geology is another site element affecting the development of an urban area. The presence of coal or other minerals in the vicinity of an urban area is of great economic significance. Also noteworthy is the presence of caves which might be used for storage or shelter. The availability of construction materials in the area is important, as is the depth of the water table and the existence of subterranean streams, which could be used to supplement the existing water supply for military operations.

Section III. ACCESSIBILITY AND LINES OF COMMUNICATION

7-13. Avenues of Approach

The lines of communication which connect a city with its hinterland and with other urban areas are vital to its existence. These are discussed in greater detail in chapter 5. Three basic features of the lines of communication require consideration within the context of urban area intelligence: general accessibility of a city by established overland routes of approach; significance of a city in the national transportation network; and availability of bypass, through, and dispersal routes.

7-14. Accessibility

Urban accessibility is a general evaluation of the approaches to a city for tactical and logistical purposes. The evaluation must consider direction, traffic capacity, vulnerability of routes to interdiction, bypass possibilities at points of interdiction, and possibilities for cross-country movement. Detailed data should be collected where approach weakness exists and general information must be collected in order to provide a clear understanding of approach accessibility.

a. Tactical Aspects. The tactical aspects of urban accessibility include the potential of cross-country access, as well as access along established arteries. In ground warfare, the successful assault or defense of a city has often hinged upon overland approaches. Ridges, ravines, and wooded areas, as well as streams, lakes, and swamps near a city have an important bearing on the location of roads and railroads and greatly influence their vulnerability.

b. Logistical Aspects. The logistical aspects of urban accessibility are concerned with the quantities of supplies that can be cleared through cities serving as bases, transshipment points, and producing centers. Poor road, rail, and water approaches reduce the clearance capacity of a city.

7-15. Significance in National Transportation Network

The importance of a city as an operating center in the country's transportation network must be carefully reported. Dispatch, repair, maintenance, and headquarters facilities for railway and waterway traffic are not easily moved. The need to operate and maintain such facilities is essential for the operation of the transportation system. For the same reason, these points represent strategic targets.

7-16. Through, Bypass, and Dispersal Routes

Considerable information is required on city streets and local roads to meet requirements for maintaining movement of military traffic through a city; bypassing a city to avoid congestion, to reduce target potential, and to screen military movement; estimating the vulnerability of routes; connecting dispersed military base installations; and evacuating the military and civilian population. The selection of routes requires detailed information on the location, width, condition, and bearing capacity (limiting) of all main streets. Information is also required on existing or poten-

tial bottlenecks, such as narrow or weak bridges, ferries, fords, or overhead obstructions, and on the general effects of heavy rain and snow on selected routes.

a. Through Routes. Through routes are those which afford a continuous flow of military traffic in a city. These routes should avoid congested industrial, residential, and commercial areas.

b. Bypass Routes. Military traffic frequently avoids congested areas in a city by using bypass routes. In the United States and in other Western countries, such routes are part of a city's normal

roadway system. They have the added value of separating through traffic from local traffic, thereby reducing congestion. In Germany, the autobahn system, a network of wide, dual highways, that bypasses cities entirely, was constructed to enable military traffic to move rapidly between the eastern and western borders of the country.

c. Dispersal and Other Local Roads. Routes that connect the local transportation network to open areas suitable for the development of military bases also are important. Other routes might be usable for the evacuation of the military and civilian populations.

Section IV. UTILITIES, SERVICES, FACILITIES AND CONSTRUCTION RESOURCES

7-17. General

Utilities, services, facilities, and construction resources comprise the essential internal supply systems and installations used to protect and maintain the life of the city. Military interest in this field is primarily logistical. Although installations, equipment, and services of supply for large concentrations of population can be used by military forces, maximum use of these facilities can be made only if the specific adequacy and quality are known.

7-18. Water Consumption

Water is the most extensively used commodity in the urban habitat. Maintaining an adequate supply and controlling the quality of the water are the main functions of an urban water supply system. Civilian consumption of water is divided among domestic, industrial, commercial, firefighting and other public uses. In the United States about 35 percent is for domestic use, about 40 percent for industrial and commercial use, about 15 percent for other public uses, and about 10 percent is lost in distribution. Water consumption is rated on a daily per capita basis, which is determined by dividing the overall consumption by the population. The overall daily per capita consumption of water is about 155 gallons in the United States, about 60 gallons in Europe, and about 20 gallons in South Asia.

a. Industrial Water Consumption. Water has many uses in industry: as an ingredient in the product, as a cooling agent, for boiler feed, and for sanitary purposes. Industrial water consumption is enormous. Over 2200 tons of water are used in the making of one ton of synthetic rubber,

over 200 tons of water to produce one ton of copper, and over 80 tons of water for one ton of steel.

b. Domestic Water Consumption. Potability is the primary requirement for domestic water use. Most central supply systems attempt to provide safe water, but often poor treatment facilities and poor maintenance of distribution lines makes water supplies in many areas unsafe for Americans or Europeans. Local populations often develop tolerances for water which would be dangerous for American troops without further treatment. The per capita domestic use of water is related directly to the standard of living. In high standard countries, such as the United States, domestic daily consumption ranges up to 60 gallons per capita, of which only about 35 percent is used for cooking, washing, and sanitary purposes; the remainder is used for appliances, gardens, and similar uses. In low standard countries, domestic water uses are more nearly limited to personal consumption.

c. Firefighting and Public Uses. Water pressures for firefighting are classed in three separate pressure systems according to the different needs of various parts of a city. High pressure systems are designed to supply water for firefighting in central areas. Medium and low pressure systems are used in dense and moderately dense residential areas. Water for firefighting is rated in gallons per capita and differs according to the size of the city. In large cities, the water requirement for firefighting is lower than the domestic or industrial requirements, which are the controlling factors in the size of mains and water pressures. In smaller cities, water requirements for firefight-

ing are sometimes larger than domestic requirements, and these requirements may determine the size of mains and water pressures. Large industrial plants often have their own firefighting facilities.

7-19. Military Water Requirements

Data on the adequacy and capacity of an urban water supply system and the quality of the water are essential for military evaluation of an urban area. Vast quantities of water are required primarily for base development and operation, firefighting, and for radiological decontamination in the event of atomic attack. In the field, a soldier normally requires about 3 gallons of water daily, whereas in a base camp the requirement per man may increase to 50 gallons per day. This large amount includes that used in laundries, ice plants, hospitals, and other installation and transportation facilities. Where existing water supplies can be used to a considerable extent, the whole process of base development is generally simplified. Most cities have central water supply systems but few can provide all the water needed for large military bases. It is essential therefore, to assess the adequacy not only of the existing water supply system, but of raw water sources, and to examine the local consumption statistics to determine the amount of water that could possibly be diverted to military use without affecting essential activities of the city.

7-20. Water Supply Systems

Urban water supplies are obtained from surface and ground water sources. Surface sources may be relatively pure sources, such as river headwaters and upland lakes that require only limited treatment, or relatively polluted and turbid sources, such as the lower and middle reaches of rivers that require considerable treatment. In areas of low, uncertain, or seasonal rainfall, impounding reservoirs are constructed to contain surface runoff. Ground sources are used by tapping natural springs and by drilling wells.

a. Collection. There are different facilities for collection of surface and ground water. Collection of surface water from rivers, lakes, and reservoirs is generally done by means of intakes, which withdraw water from levels with the least turbidity, odor, algae, floating debris, or ice. For small water supply systems, the intake may be a simple pipe with a coarse screen extending into the water, or it may be a submerged crib of concrete or timber. Larger water systems make use of in-

take towers, vertical concrete or steel tubes having gates at different levels which are opened according to the depth from which water is to be withdrawn. A reservoir is normally equipped with intake towers either in the center of the water or as part of the dam. Where the source is a swift-flowing stream, a canal may be constructed to a reservoir or to a pool in which the intake is situated. Instead of intakes, infiltration galleries are sometimes laid under the body of water or onshore below the ground water level to collect seepage from the river. Infiltration galleries usually consist of a series of perforated pipes surrounded by gravel and sand. The number of wells that can be sunk depends upon the extent of area that each well can effectively tap. The yield of a well is dependent on the porosity of the water-bearing formation and the rate of underground flow. From each well, a pipe connects with some central collecting point.

b. Storage. Extensive storage facilities are an integral part of most water supply systems. The storage facilities are designed to maintain raw water adequate to cover prolonged periods of drought, and reserve supplies of treated water to offset interruptions in flow in various parts of the distribution system. Systems based on headwater sources almost invariably have extensive facilities to contain surface runoff from the watershed or catchment basin. The catchment basin includes the runoff or drainage area and the impounding reservoir area. For protection of the water supply, natural vegetative cover is carefully maintained over the entire watershed area. Impounding reservoirs may be enlarged natural lakes or ponds, or lakes artificially created by damming stream valleys. Such storage areas are generally of very large size and may contain more than a year's normal water requirement. Middle and lower stream courses provide a more certain water supply, but because of great seasonal fluctuations in stream flow, impounding reservoirs are frequently used.

c. Treatment. The treating of water from its raw state to a finished potable product involves a sequence of processes. Mechanical cleaning comprises the use of coarse and fine screens in series to strain the water and remove debris, ice, vegetation, fish, and algae, and of desedimentation basins to allow suspended solids to settle to the bottom. Chemical purification comprises the removal or neutralization of bacteria and other fine organic particles, and the use of flocculents to remove colloids. Objectionable dissolved chemicals

are removed by precipitation to reduce water hardness, corrosiveness, and discoloration. In the final treatment stage, minute quantities of several chemicals may be introduced to improve the quality of water. This includes protection of water in transit after treatment and reduction of excessive alkalinity or corrosiveness.

(1) *Facilities* (fig. 7-6). The facilities provided at a water treatment plant depend on the water source. Water from polluted middle or lower courses of rivers generally requires all treatment processes, whereas, upland water sources require less treatment to remove bacteria. A large city could conceivably utilize all the various sources of water supply, but most cities usually have only one or two main sources.

(2) *Filtration*. Filtration is the heart of the water treatment process. Filtration processes dif-

fer in the use of slow and rapid sand filter systems.

(a) The slow sand filter consists of a series of rectangular basins about 1.8 to 3 meters (6 to 10 feet) deep, in which water is passed over beds of sand and then seeps through to collector basins below, leaving impurities in the sand. This system is commonly used in Asia and in many parts of Eastern Europe where published data on capacity is not available or difficult to obtain. Direct observation is usually needed to determine capacity. Capacity may be estimated with reasonable accuracy if the size of the filter beds and the nature of the water can be determined. Filter beds are most frequently of quarter-acre size, about 62 meters by 15 meters (205 feet by 50 feet). Turbid river water without preliminary settlement filters at a rate of about 3 million gallons per acre of

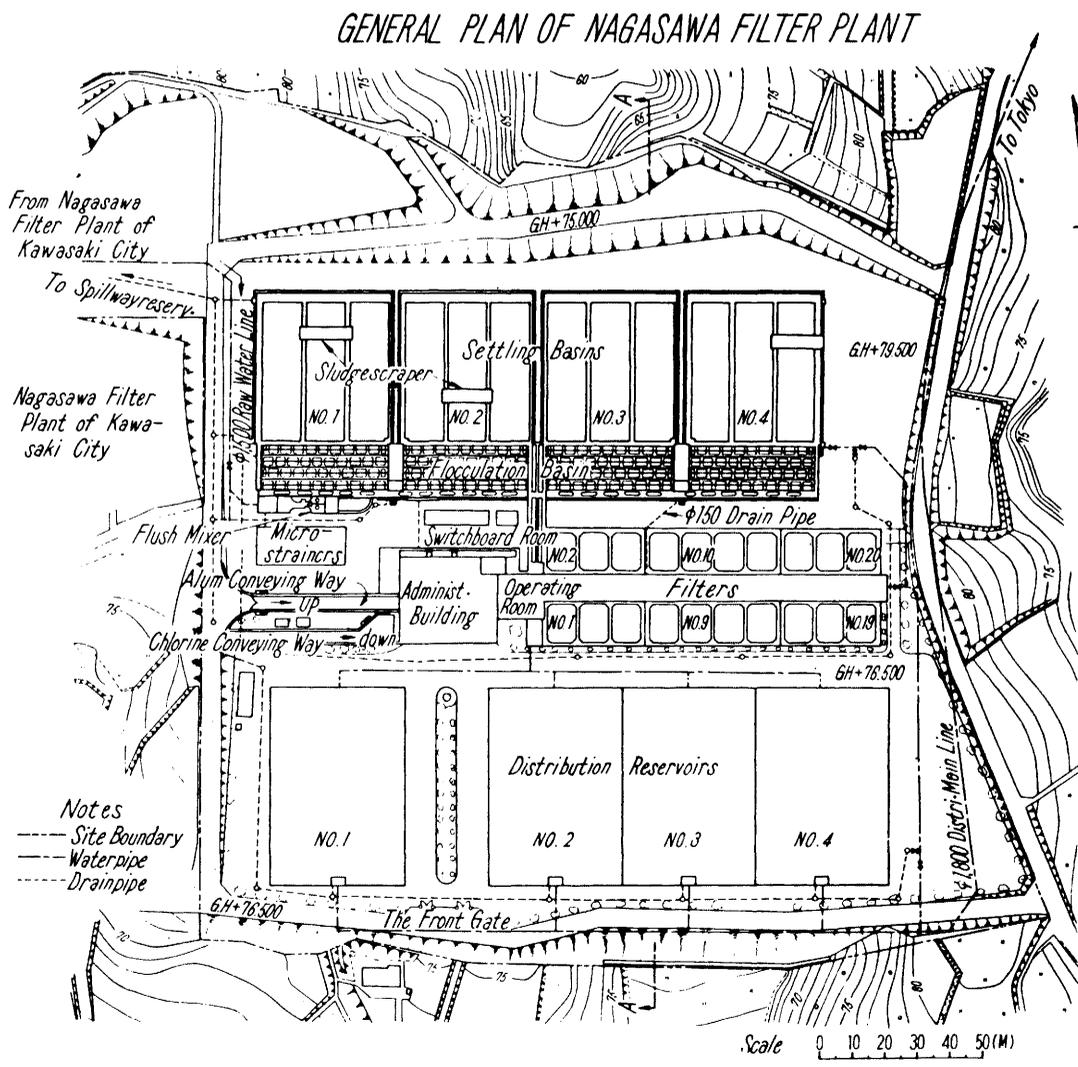


Figure 7-6. Plan of water treatment facility in Japan.

d. Voltage is a measure of electrical potential or volume of the electrical energy transmitted. High voltage is used for transmission of power to transformers, which reduce the voltage for consumption. Within urban areas, transmission voltages vary from 22,000 to 66,000 volts (22 to 66 kilovolts). Higher voltages are used for long distance transmission.

7-25. Gas

In many cities of the world, industries, as well as the bulk of the population, are dependent on a gas supply system. Huge gas works form prominent features on the urban skyline and are key elements in the urban economy. Natural gas is supplied to cities from gas fields, oil fields, or petroleum refineries. Manufactured gas is produced from coal, petroleum, and oil shale, with coal being by far the most important source. Coal gas is produced by heating coal in closed containers which separates the more volatile gaseous and liquid hydrocarbons from the solid residue known as coke. Various processes of separation and blending with oil, water, and air produce a number of gases with different properties and different industrial uses. Manufactured gas is stored in huge telescoping low pressure tanks, which rise or fall depending on volume stored to maintain a constant pressure, and in high pressure tanks which store great quantities of gas in comparatively small containers. Natural gas is ordinarily stored in underground reservoirs, usually away from cities. In urban areas, spherical tanks are generally used for the storage of gas under high pressure. The distribution of gas is primarily by pipeline, similar to water supply distribution. The key point in this system is the dispatching office, where control of flow and pressure throughout the system is maintained. In suburban areas of cities, gas is sometimes distributed in small tanks, and is commonly termed "bottled" gas.

7-26. Transit Facilities

Urban transit facilities fall into two general categories: railway and roadway transit systems. Collection guidance and requirements on these facilities are contained in chapter 5; however, there are several important ways in which they differ from regional railway and highway systems.

a. Urban railway transit systems include street, elevated, and subway lines. Elevated lines and subways operate on an intensive train and station basis using relatively few lines; street level systems usually operate on a single-car basis and use

many routes. Urban railroads carry heavy traffic and operate on schedules that require exacting dispatch, control, and maintenance. Even a short interruption can immobilize an entire system. Extended delays in some cities can disrupt industrial production almost as effectively as destruction of power facilities. Almost all urban railways are electrified, making them dependent on the city power supply. The capacity of street railways or street cars is considerably lower than that of a train and station systems, but because costs are lower, street level lines can be extended to many areas of a city. Street railways are electrically operated, receiving power from overhead, open wire cables, or third rail systems laid in a narrow channel below roadway surfaces between the main rails. They may rarely have the third rail placed beside one of the running rails, above ground.

b. Roadway transit systems include busses, taxis, and private vehicles. Bus systems operate on a multiline, single vehicle basis similar to street railways. Busses, although generally of slightly lower capacity, are not dependent upon a central power source (except in the case of trolley buses) and can use almost any surfaced street. Bus systems would be the first municipal transit service capable of resuming operation after an attack on a city. The trolley bus is a road vehicle which operates by electricity supplied from overhead wires. It has the same limitations as the street railway in that routes cannot readily be changed and it is dependent on a central power source.

c. Transit facilities in themselves have little direct military value, since military forces normally have adequate organic mobile equipment; nevertheless, secondary considerations make it important to collect detailed information. Continued operation of the transit system in many cities is vital to the continuance of the urban economy. Subways have great potential for use as shelter and storage areas. Busses, taxis, and even private vehicles could be commandeered for many transit chores, freeing military vehicles for specific duties. Facilities such as repair shops, yards, and garages could be used to maintain military vehicles.

7-27. Telecommunications

Collection guidance and requirements for data on telecommunications are contained in chapter 6, Telecommunications.

vacuums which could interfere with the free flow of water. Service connections consist of the piping from street mains to the consumer plumbing system.

f. Measurement and Computation. Although it is common for water consumption to be stated in terms of thousands of gallons per day, month, or year, the rate of flow (volume passing in a unit of time), or its total volume, is often expressed in predetermined units for specific purposes. The following units and equivalents usually are used:

Cubic feet per second (cfs), used to measure rate of flow (1 cfs = 448.83 gpm = 646,315 gpd).

Gallons per minute (gpm) and gallons per day (gpd), used to express pump output, pipe flows, and fixture requirements.

Millions of gallons per day (mgd), used to express total daily flow or rate of flow.

Cubic feet, used in measuring storage volume (1 cu. ft = 7.48 gallons).

Acre feet, used in measuring storage volumes (1 acre ft = 43,560 gals).

7-21. Sewerage

Sewerage is a process of urban waste removal using water as a carrying medium. A sewerage system includes all the facilities for collection, transportation, treatment, and disposal of sewage. Domestic sewage includes bathroom, laundry, and kitchen wastes. Industrial sewage includes wastes from manufacturing processes and food preparation, as well as water used for cooling. Street wastes include refuse, debris, greases, and oils which wash off buildings and street surfaces during rains, and also include storm water runoff. The ability to use existing sewage disposal facilities appreciably reduces a major problem in base development planning. Although other methods are possible, waterborne sewage disposal is the most efficient for base installations. Requirements for water, as well as for facilities for disposal, are large. For airfields, cantonments and similar facilities the flow of sewage ranges from 25 to 50 gallons per capita daily. For military hospitals, the daily flow amounts to 50 to 85 gallons per capita daily.

a. Sewage Collection. The use of water as an agent for disposal of sewage is relatively new. Although it is used in the western world, waterborne sewage systems elsewhere are rudimentary, limited in extent, or nonexistent. Even in in-

dustrial countries such as Japan, waterborne sewerage is limited. In the cities of China and India, the situation is much worse, and disastrous epidemics frequently occur. European cities provide much better disposal facilities, but even these are generally below common American urban standards.

(1) Sewer mains form a network of lines paralleling the water distribution system. Where street wastes and storm waters, and domestic and industrial sewage are carried in the same drains or sewers, the system is called a combined system. Where they are carried in separate sewers, the terms "dual" or "separated" systems are used. The pattern of mains may be dendritic, grid, or belt, as with the water supply system, but with several important differences. Water flowing under pressure supplied by a high head or by pumping from a central point can overcome minor differences in relief and can more readily follow the road pattern. Sewage collector lines must more closely follow drainage lines to various sub-central collecting stations where pumps maintain the flow of sewage to the treatment plant. These stations are critical features in the water supply system. Because the quantity of sewage flow approximates the flow of water supply, any disruption in the sewerage system would require an immediate curtailment of water to prevent sewage backup or bursting of sewage and water mains.

(2) Waterborne sewerage is but one means of waste collection. In many parts of the world, collection of domestic wastes is made from individual houses or from interior courtyard bins by carts or trucks. In many cities, waterborne sewerage is limited to commercial and wealthy residential areas. The sewerage may empty into community cesspools, which are pumped out periodically for final disposal.

b. Treatment and Disposal. The purification of sewage is essentially an oxidation process in which organic matter is reduced by bacterial action into its basic mineral constituents. When the sewage flow is heavy, natural purification by stream water must be assisted by prior treatment of sewage. Municipal treatment facilities (fig. 7-7) may provide limited or full treatment, depending on the capacity of the stream for self-purification, the type of sewage discharged, and the degree of civic interest in sanitation.

(1) *Natural purification.* In the simplest form, sewage discharged into a stream is separated into solid and liquid components by sedimentation. A stream can act as a purifying plant

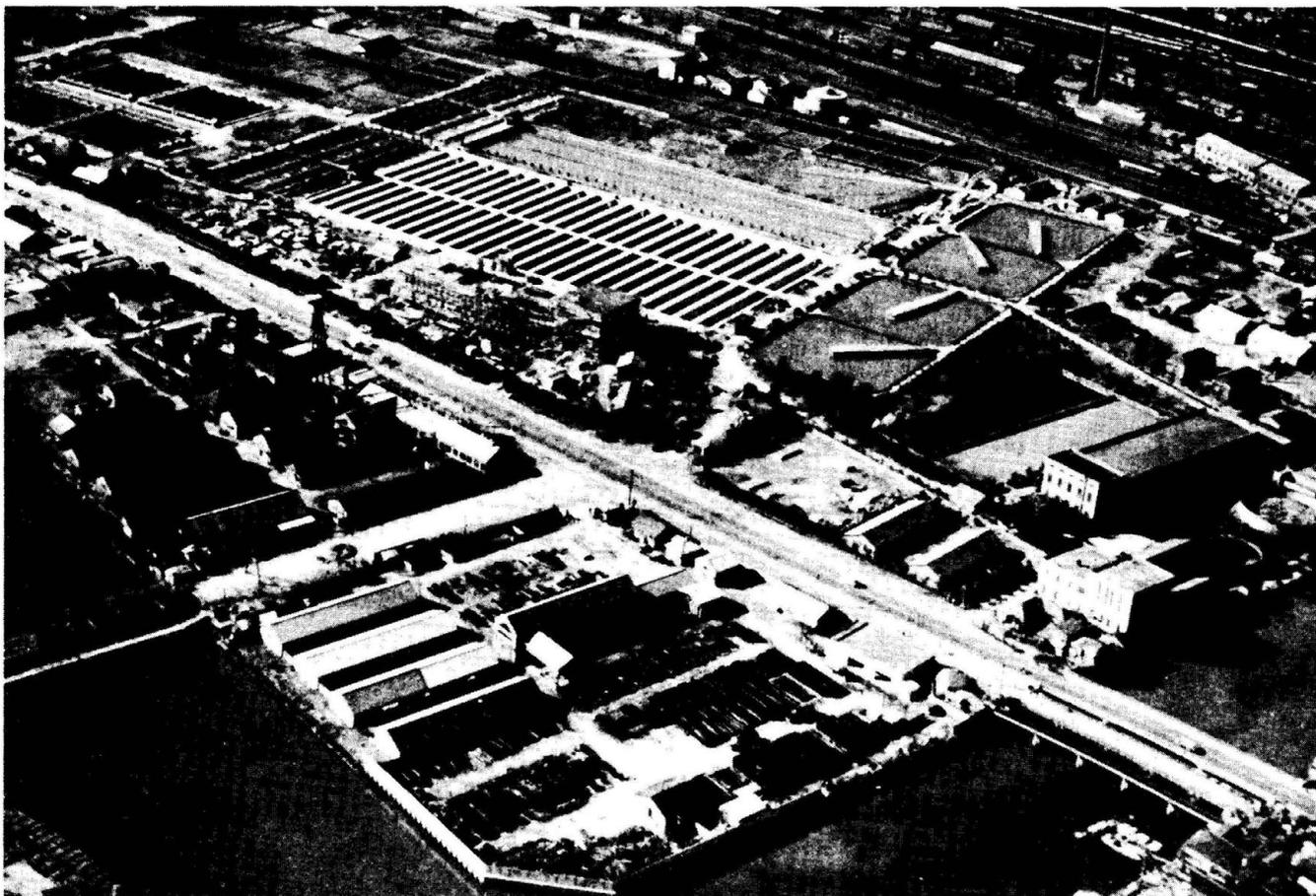


Figure 7-7. Sewage treatment plant in Tokyo.

provided the balance of aerobic and anaerobic bacteria is sufficient to decompose the volume of sewage entering the stream.

(2) *Purification by treatment.* For small towns or small military camps, direct dumping of sewage is feasible, but for cities of any appreciable size, sewage must have some treatment to prevent stream pollution. Mechanical, chemical, and biological means are employed to reduce the unstable organic content of sewage water prior to discharge, by removing solids, by speeding the bacterial action, and by chemically neutralizing contaminants.

c. Treatment Methods. Two stages of sewage treatment are employed. Primary treatment is designed to reduce the discharge of contaminants to a point where the stream can continue self-purification. Primary treatment consists of separating the suspended solids from the liquid sewage by stabilizing the solids or sludge. Secondary treatment consists of disposal or treatment of sewage liquids or effluent by processes similar to water purification.

(1) *Primary treatment.* Screens are used to withdraw debris and grease which are gathered in sedimentation tanks. Sedimentation basins aid the settling of sewage solids. The separated solids are termed sludge. Sludge is withdrawn for further settling and digestion through the use of septic and Imhoff tanks. After digestion, sludge may be further dried for disposal as earthy material. Sludge drying beds may be open or, in moist climates, under glass and are distinctive features of sewage plants. Gas produced in sludge digestion is sometimes collected for use as a fuel. In large cities, sufficient gas may be collected for the operation of small electric power plants.

(2) *Secondary treatment.* Raw effluent may be disposed of by discharging it into streams or by irrigation. Effluent also may be treated by oxidation, filtration, and chlorination processes similar to water treatment. When disposed of by irrigation, effluent is distributed over porous ground and allowed to evaporate and to percolate into the soil. Grasses are usually planted in these areas to speed the disposal. This method is used primarily

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7-28. Storage Facilities and Warehousing

Urban storage facilities are important both as targets and as facilities for receiving, handling, and forwarding supplies. These facilities are eminently suitable for military supplies. They hold and protect a variety of commodities temporarily while in transit or permanently in stock piles, which may be drawn upon regularly or held in reserve against future demand. Warehousing is a combination of services and equipment for stock control and handling as well as loading, unloading, packaging, crating and delivering supplies to loading points for shipment.

a. Open Storage. Protection in open storage is generally limited to canvas covering and to fencing to prevent sabotage. These areas are identified by readily recognizable handling facilities, such as overhead conveyor belts, and rail mounted cranes or transporters using hooks, slings, scoops and clamshell buckets. Open storage areas may also include established transit areas, such as rail- and port-side transfer yards where commodities are placed temporarily in the course of loading or unloading.

b. Covered Storage. Covered storage facilities include warehouses, sheds, bins, silos, elevators and dry tanks which provide shelter and protection for commodities. Covered storage warehouses often comprise large clusters of buildings within a transportation area, or may be integral units within industrial or wholesale commercial establishments. Warehousing comprises the services essential to the operation of storage facilities. A variety of equipment such as bucket loaders, conveyor belts, transporters, aerial ropeways and forklift trucks are used for handling bulk and packaged commodities. Box making, wrapping, bottling, canning, waterproofing and labeling are all essential warehousing services in preparing supplies for shipment. Such facilities are normally used at the point of origin of supplies but, in operating theaters, similar facilities are needed for recrating or repackaging supplies, and preparing and forwarding locally available products and salvaged items.

c. Refrigerated Storage. Cold storage facilities used to handle fresh foods for a short period of time in a moderately cool atmosphere are usually found in wholesale food dealer establishments near railroad freight yards, and in large market areas. Temperatures maintained range from 32° to 40° F. *Quick-freeze storage* is used primarily for packing and processing of foods, usually

meats and produce. Ice cream plants also are in this category. Temperatures below freezing are used in the preparation and packaging of products. *Frozen storage* is used for stockpile storage of foods, blood plasma, and medicines. Usually these facilities exist in association with other food storage facilities. Temperatures are generally maintained at about 10° F.

d. Explosives Storage. Heavily earth covered (igloo) or revetted buildings are generally used to store explosives and ammunition. A heavy layer of earth is designed to prevent or reduce the spread of the blast effect in event of ignition.

e. POL Storage. Storage and handling facilities for petroleum, oil, and lubricants are important installations in any type of military operation. They are discussed in greater detail in chapters 5 and .

f. Bin and Tank Storage. Grain, cement, and various dry industrial chemicals are normally stored in cylindrical or rectangular silo type bins. Tank storage is common for various industrial liquids and gases. Tanks may also be used for dry storage. Dry tanks make use of the same equipment used for large petroleum tanks, but the difference can be recognized by the absence of manifold and other piping normally present in petroleum installations and because there is elevator equipment beside or on top of the dry storage facility.

g. Underground Storage. Underground storage is particularly important because of the protection it affords against aerial bombardment. In and around urban areas there normally are numerous underground structures which may be readily used for military storage. Vaults and cellars may be highly useful storage areas. Subways, tunnels, and aqueducts are generally well constructed underground installations that could provide considerable protection against bombardment. Subways probably are the most readily available; however, they vary in depth and construction to meet different needs. In areas where the subways lie just below the surface, blast protection would be limited. Quarries, mines and caves are often found on the outskirts of cities. Quarries are not underground structures strictly speaking, but they are below ground installations that are relatively safe from all but a direct hit. Quarries normally have good road or railroad access, making them highly suitable places for the storage of items that can withstand weather exposure; however, most quarries quickly fill with water when not pumped con-

tinuously. Mines may provide extensive storage areas and normally have good access facilities; however, there may be structural weaknesses that must be carefully analyzed before they are used for storage. Caves also have extensive potential storage capacity, but the same problems of structural safety apply as with mines. The use of caves requires consideration of the potential construction of access roads and the provision of lights and amenities for supply personnel. Both mines and caves require assessment as to pumping requirements.

7-29. Potential Storage Areas

General information on open, concealed and underground installations which may be suitable for storage and warehousing are almost as important as details of existing storage facilities. Economic and defense considerations may limit the use of existing storage facilities. In friendly areas, the need for stepped-up industrial war production competes with military requirements for storage space and warehousing facilities. In occupied enemy areas, a considerable amount of the existing storage facilities will probably have been destroyed by attacking or retreating forces. In addition, the need for protective measures against widespread blast and fire effects of nuclear weapons requires dispersing depots beyond probable target areas; scattering and duplicating facilities; and concealing supplies in factories, schools and other public buildings.

7-30. Fire Protection and Rescue Service

a. Although the military is not concerned with normal firefighting problems, fires, if not suppressed, may burn out vast areas of a city thereby greatly reducing its value, hence adequate protective measures must be taken on a city wide basis. In planning the use of a city as a military base, overall fire susceptibility must be heavily weighed in the selection of installation sites. The capability of both civilian and military firefighting forces must be evaluated.

b. Civilian firefighting organization differs widely from city to city, but the general plan of urban firefighting is similar. Fire stations are located at convenient points throughout the city. Each station copes with small fires independently within its own area. If the fire is too large for the equipment on hand, other fire stations are called upon.

c. Firefighting equipment consists of high pres-

sure water main systems and mobile firefighting trucks. Trucks generally are specially constructed vehicles with powerful motors; however, in some cities, ordinary trucks may be fitted with hose, pumps and ladders. Pumper trucks consist basically of a stock of hose and a powerful pump to draw water and to provide added water pressure. Tankers contain their own supply of water, and generally carry chemicals that are mixed with the water to form a foam which smothers flames more efficiently than plain water. Service vehicles include ladder trucks, hose trucks, mobile command posts, floodlight and rescue trucks and ambulances. In addition to equipment, special water tanks designed expressly for firefighting to supplement normal water sources may be located in various parts of the city.

7-31. Population Protection and Controls

a. Urban protective services normally deal with the policing and protection of population and property from such crimes against persons and property as vandalism, assault, robbery, looting, and natural disasters. During wartime, protective services are also concerned with passive defense measures against high explosive and nuclear blast; with radioactive, biological, chemical, and fire hazards; with the provision of shelters for the population; with the protection of industry and the restoration of damaged utilities; and with other essential services and facilities. The concern here primarily is with wartime protective services, which are considered under military area damage control and civil defense, fire protection and rescue services, and police and other population controls.

b. Police and other population controls, such as rationing and curfews, are very real features of urban life and are of particular interest to military police and to civil affairs/military government. They lie beyond the scope of this manual; however, data are required on physical facilities such as police stations; armories; barracks; communications centers; and headquarters of civil defense, paramilitary or gendarmarie auxiliary police and other security forces. Data on location and general type of structures are all that are required.

7-32. Billeting and Accommodation

a. The quartering of military forces in urban areas involves much more than the problem of finding places where men can sleep and eat. It has

been estimated, for example, that hospital space sufficient to take care of from 3 to 5 percent of a command must be provided even for units which are not in combat. Of buildings suitable for military use, hospitals have first priority, followed by administration buildings, and storage facilities for perishables. Facilities must be provided for the maintenance and repair of vehicles, weapons, and equipment, and space suitable and sufficient for the storage of all types of supplies. Personnel must have facilities for recreation and relaxation. The numbers and types of urban buildings and installations used by military units are almost limitless. Gasoline storage tanks, bakeries, breweries, athletic areas and fields, hotels, railway stations, dock yards, auditoriums, slaughterhouses, and machine shops all serve their purposes.

b. Modern war, with its tremendous destruction of structures and property, also affects the lives of civilians living in the combat area. The military commander must, of necessity, do what he can for the bombed out, the displaced, and the dispossessed. For the collector, the principal requirement is the location and general condition of facilities that could be used for billeting or accommodation. The potential use of a building is determined by the immediate military need and cannot be predetermined by any specific use except in general terms.

c. For quartering purposes, the urban area is classified in four categories:

(1) Buildings or areas suitable for general military use without major dislocation of the local population or industry. These include hotels, schools, many commercial buildings, and various institutions not used for residence.

(2) Buildings suitable with displacement of local population or industry. These include private residences, factories, local government and commercial offices, and institutions such as old age homes and orphanages.

(3) Buildings unsuitable for quarters. These include areas where sanitary conditions are poor.

(4) Special facilities for feeding, laundering, and various recreational purposes.

7-33. Health and Sanitation

Where substantial military forces are stationed, the health and sanitation of the adjacent civilian community are a matter of vital concern to military forces in order to combat the spread of disease. In past wars, disease has taken greater toll

of military lives than combat. For the collector, the principal requirement is the location of and all pertinent data on the public health facilities in the area. This should include the number, type, and bed capacity of hospitals as well as on number and adequacy of medical personnel.

7-34. Construction Resources

a. Data on the availability of construction materials, facilities, equipment, organization, and manpower are important factors in planning military operations in any area. Construction resources are required for facility construction, for improvement of transportation capabilities, for repair and restoration of utilities, and for repair of structures used for hospitals, storage, administration and billeting. Large amounts of resources are normally available in cities both for urban construction and for distribution to surrounding regions. In most cities, plants for the manufacture of construction materials are located on the outskirts, and warehouses and dumps are located in the center near transportation terminals. The materials include bulk items, such as lumber, cement, structural steel, railroad ties and rails, and sand and gravel; manufactured items such as plumbing and electrical supplies, hardware, paint, and camouflage materials; and repair parts for nonstandard items, such as local powerplants, water supply systems, and machine shops.

b. The procurement of construction materials may require operation or administration of plants which produce these materials (table 7-1). Other facilities which may be utilized include facilities for printing, drafting, photostating and map reproduction, as well as plants producing chemicals used in water purification. In addition, stocks of construction equipment in contractors' or sales agents' yards, and display areas could be taken over.

c. Private contractors and public construction organizations, such as public works, highway, railway, and port maintenance departments can be utilized for military construction. Required information on these organizations includes size, experience, and ability to function with military personnel and equipment. Where existing construction organizations are inadequate or do not exist, it is necessary to recruit skilled and unskilled labor from the population at large. Some data on their physical capacity, general education and ability to work with tools and machinery is needed.

Table 7-1. *Representative Construction Materials and Equipment Normally Available in Urban Areas*

Brick	-----	Bricks, tile.
Cement, concrete	-----	Cement, cement and cinder blocks, prefabricated structural concrete products.
Ceramic	-----	Plumbing fixtures, plumbing supplies, building and roofing tile, electrical insulators.
Chemical	-----	Acids, industrial gases, oxygen, nitrogen, acetylene, pitch, road oils.
Cordage	-----	Rope, nets, slings and rigging, both natural and metallic.
Iron and steel	-----	Wire, structural pieces, beams, hardware, tools, sheets, flat and round bars, nails, pipe, sheet and tube piling and bulkheads.
Machinery and equipment	-----	Cranes, shovels, concrete mixers, tractors, and all earth-moving equipment, sawmill machinery, lathes, grinders, cutters, crushers.
Nonferrous metals	-----	Electrical wire, welding rods, sheets, rods, tubes.
Paper and pulp	-----	Pulp wood.
Quarries	-----	Sand, gravel, crushed rock, cut stone, and natural asphalt and bitumen.
Woodworking	-----	Soft woods, hard woods, cut lumber.

Section V. IMPORTANT INSTALLATIONS

7-35. Industrial Targets

a. Modern armies are entirely dependent upon the materials and equipment produced by industry. A successful attack on the industrial structure can disintegrate warmaking capacity to a point where a country no longer retains the ability or will to resist. Cities as centers of industry bear the brunt of this attack.

b. In the past, industrial targeting was based primarily upon pinpoint bombing of individual components in critical industries, such as an aircraft engine plant or a blast furnace. Post-World War II strategic bombing surveys of Germany and Japan revealed that the decisive effect of the attacks had been achieved more by disruption of the total war economy (primarily by fire bombing of urban areas) than by destruction of individual components in certain industries. For example, despite repeated attacks on ball-bearing works in Germany, bearings were always in sufficient supply for the engines produced as long as the general industrial structure and its ability to recuperate and improvise remained relatively undamaged. Greater effect was felt in industries not directly attacked. For example, medical supplies, such as surgical instruments, pharmaceuticals, and even bandages, were in critically short supply because bombing effects were felt in a great number of supporting industries. With the increased mass destruction capability of atomic weapons, the entire socio-economic structure of the urban area must be considered as a single component in the national war production.

7-36. Protection of Urban Area

Military protection of national borders can no longer guarantee against surprise attack by missile and supersonic aircraft armed with nuclear weapons. It has become a strategic necessity for each nation to ring its principal urban centers with various defensive weapons and warning systems, and to develop an active defense (anti-aircraft and rocket missile systems) which will minimize the effect of such attack. Because of secrecy usually surrounding these installations, this data may be difficult to obtain; however, the need for data on defensive installations is as compelling as for that covering industrial and other important installations.

7-37. Importance of Industrial Installations

In any manufacturing center, the large number and variety of industries make it virtually impossible to do more than collect general information. Some selection is necessary in order to make possible the detailed reporting of those installations having the greatest immediate military logistical importance, the most significant role in the regional or national economy, and the greatest effect upon the urban civilian economy. The collector should determine the relative importance of industrial installations in the following classifications sufficiently to estimate the degree of effort to be expended in collecting detailed information.

a. *Direct Producers of Materials for Support of Military Forces.* Destruction of fabricating plants

cuts off immediate sources of supply of finished goods, but these installations may be readily repaired and restored to operation if adequate supporting industry exists. Steel mills are among the most important industrial installations and should be reported in detail (fig. 7-8). Direct production is classified as follows:

(1) Fabrication of finished goods, such as tanks, munitions, trucks, or canned foods.

(2) Processing of raw materials into intermediate form, such as steel sheets and tubes, copper wire, or lumber.

(3) Producing basic materials, such as steel and copper ingots.

b. Supporting Industries. Industries in this category support current production, and also determine the capability for expansion, development of new products, and restoration of plants after attack. These industries include:

(1) Equipment producers, which manufacture such items as machine tools, and construction and rail transportation equipment.

(2) Research and development facilities where new products are conceived, developed, or tested.

(3) Utilities, services, and facilities, such as power, water, and waste removal.

(4) Transportation of all types.

(5) Consumer essentials, such as food and clothing needed to supply urban populations.

c. Importance of Industry in the Economy. The particular features that the urban area supplies in support of industry include pools of labor and skills; a variety of urban services; transportation facilities; proximity of related industries; economic channels to raw materials and markets (wholesaling, financing); technological skills and research facilities; and plant maintenance and equipment repair facilities. Weakness in any of these elements creates vulnerability in the industrial structure. Specific elements for targeting will be those which would have the greatest immediate and the most lasting effect on production if attacked. For example, destruction of factories which provide a livelihood for a large percentage of the working population can upset the economy of the city; conversely, disruption of water or electric power supply can halt production in many industrial plants simultaneously. The largest centers of production are obviously important, since practically all industry plays some direct or indirect role in a war effort. So also are urban areas whose total volume of production is small but whose only industrial installations may be produc-



Figure 7-8. Iron and steel plant.

ers of critical items, such as electronic components of guided missiles.

d. Individual Installations. Often, only a few or even a single plant may produce items which affect virtually an entire industry. A particular electronic computer or gyrostabilizer may be produced in only one plant in a country; its loss could affect the production of many types of radar, artillery, or missiles. By way of general identification, industrial installations can be divided into two broad groups comprising fixed or housed facilities. Fixed facilities consist of large pieces of equipment which are constructed on the site and comprise the structure of the producing component, such as a blast furnace, a cooling water tower, an oil refinery, or a cement plant. Housed facilities consist of machinery placed inside a building; these can be dismantled and moved. Housed industry is mainly for processing, fabricating, and assembling products, such as electronic equipment or automobiles. While types of fixed industry can readily be recognized, housed industry is difficult to classify from observation alone.

7-38. Active Defense Installations

Active defense installations accommodate weapons systems, including interceptor aircraft, missiles, and antiaircraft artillery, designed to interdict attack forces and/or weapons before they reach the urban area, as well as warning systems, comprising radar, other search devices, and communications. Although many of these installations are a considerable distance from an urban area, they are designed primarily for its defense. In a defended urban area, the various active defense installations may be pictured as forming a series of concentric rings. Requirements in connection with urban area intelligence are limited to location, number, and identification of the type of active defense installation within or near the urban area.

7-39. Passive Defense Installations

Passive defense installations are designed, not to accommodate the entire urban population or all industry, but to protect a hard core that will insure a given level of military retaliatory and industrial recuperative capability.

a. Military Retaliation. Industrial support of military retaliation is achieved through protective construction, dispersal of plants, or other means which, despite surprise attack, could insure con-

tinued production of essential items required for initial military retaliation. Data on the type of industry protected and the type and amount of protection given can be highly useful in assessing a country's military intentions and its industrial mobilization capability.

b. Industrial Recuperation. Recuperative capability lies mainly in the construction and industrial equipment industries, and in spare parts stocks that can be drawn upon to restore industrial production. During World War II, even after losing control of the air, the Germans were able to maintain a production level not less than 60 percent of initial capacity so long as the recuperative elements were not consistently attacked. When attacks on industry were directed to neutralize recuperation capability, the industrial structure quickly fell apart. Elements of recuperation capability include: reduction of the vulnerability of industrial installations by dispersal, duplication of plants, and protective construction; a build-up of reserve supplies of essential parts, tools, and finished products to cover the period required for reconstruction; and rehabilitation of industry through mobilization of construction and equipment industries and by improvisation. In Japan, considerable production was farmed out on a cottage industry basis, in which thousands of producers in separate locations were making individual parts or assembling components of aircraft or other essential equipment.

7-40. Passive Defense Methods and Protective Systems

Three main systems of protection determine the specific type of installation employed. These systems include dispersal, duplication, and protective construction.

a. Dispersal. With this system, only a small part of the total industrial potential would be destroyed by any single attack. It is also designed to reduce the target potential of the urban area to a level where the less dangerous pinpoint attack against individual plants rather than the massive attack would be used.

b. Duplication. This is a further extension of dispersal. The objective is to insure that no single attack would destroy all of any given type of operation or production. This is achieved by breaking up plants into small components; several of each type are placed in widely dispersed locations.

c. Protective Construction. This is undertaken

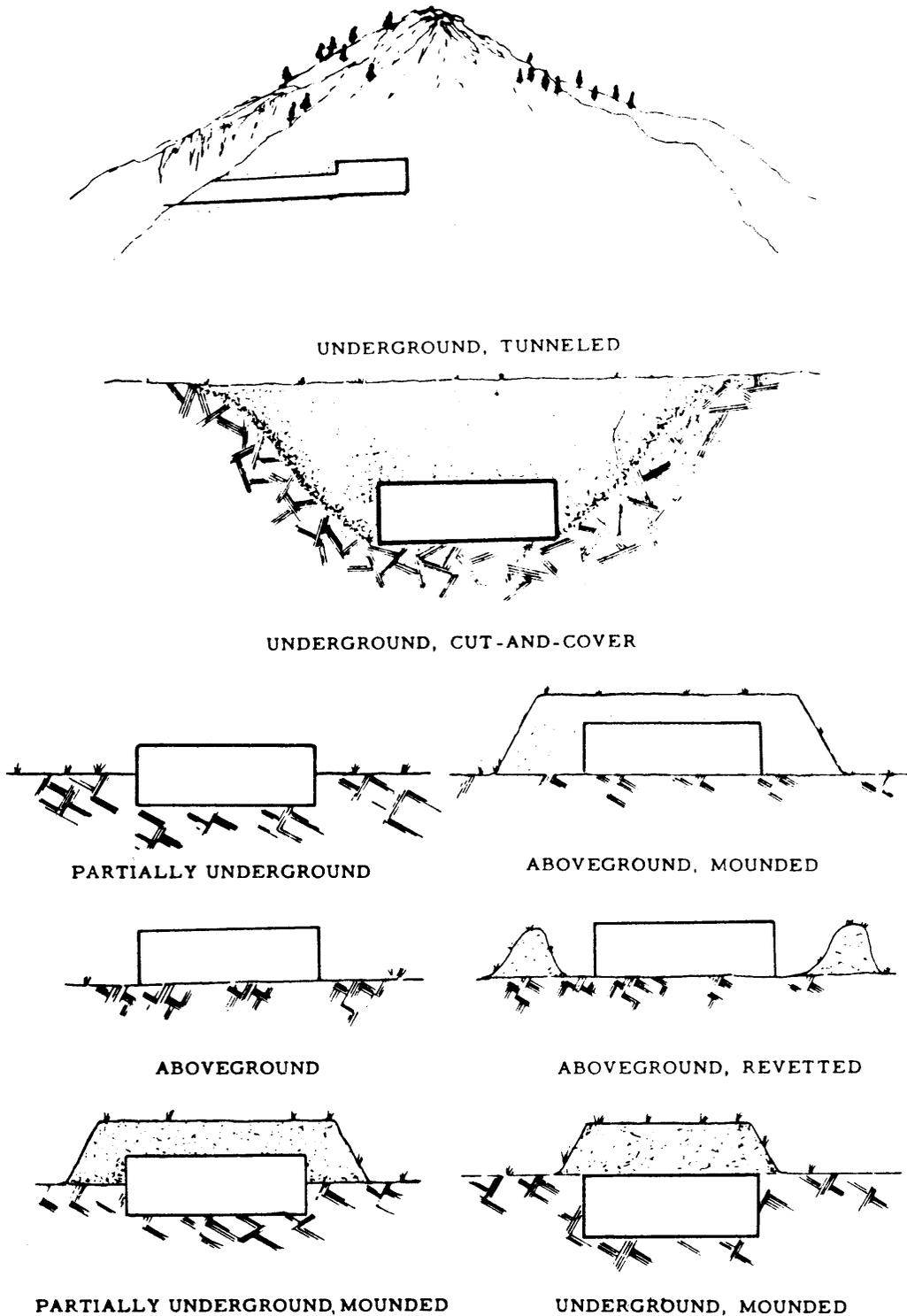


Figure 7-9. Structure situations.

to provide sufficient structural strength to installations to withstand attack. This is probably the most important class of defensive installation. Cost of construction and requirements in manpower and materials is so large that only the most essential facilities are protected in this manner.

Protective construction may be above ground, partially underground, cut-and-cover, or deep underground. Properly constructed, the latter may be capable of providing complete protection against nuclear weapons; construction near or on the surface can offer only limited protection. For

analysis of the vulnerability of protective construction to blast and ground shock, detailed information is needed as to dimensions and all structural features, type of soil or rock, depth of water table, and depth of burial or cover. Terminology and schematic illustrations for protective installations are given in figure 7-9.

(1) *Above ground protective installations.* These comprise mainly reinforced existing installations. The object is to reduce the amount of damage to equipment through construction of interior blast, radiation, and fire protection walls, and the shoring of foundations and roofs. Massive aboveground construction, because of great expense and tremendous consumption of material, is resorted to only as an extreme measure.

(2) *Cut-and-cover protective construction.* There are two main types of cut-and-cover protective construction. Shallow cut-and-cover is used

mainly for storage. Its chief advantage lies in speed and economy of construction. Storage buildings are erected in shallow cuts, then the entire area is covered with a thick layer of earth. Vegetation assists in camouflaging these areas. Deep excavations are used for such installations as power plants, petroleum storage, and water reservoirs. These are roofed with heavily reinforced concrete and then covered with earth.

(3) *Underground construction.* Underground construction consists of tunneling into rock or using existing tunnels, caves, and mines for placement of industrial and military installations. During World War II, the Germans placed many of their synthetic petroleum plants in mines and caves; none were permanently, disruptively damaged despite repeated attacks. Figure 7-10 shows a tunnel factory located in Italy that produced war materials during World War II.

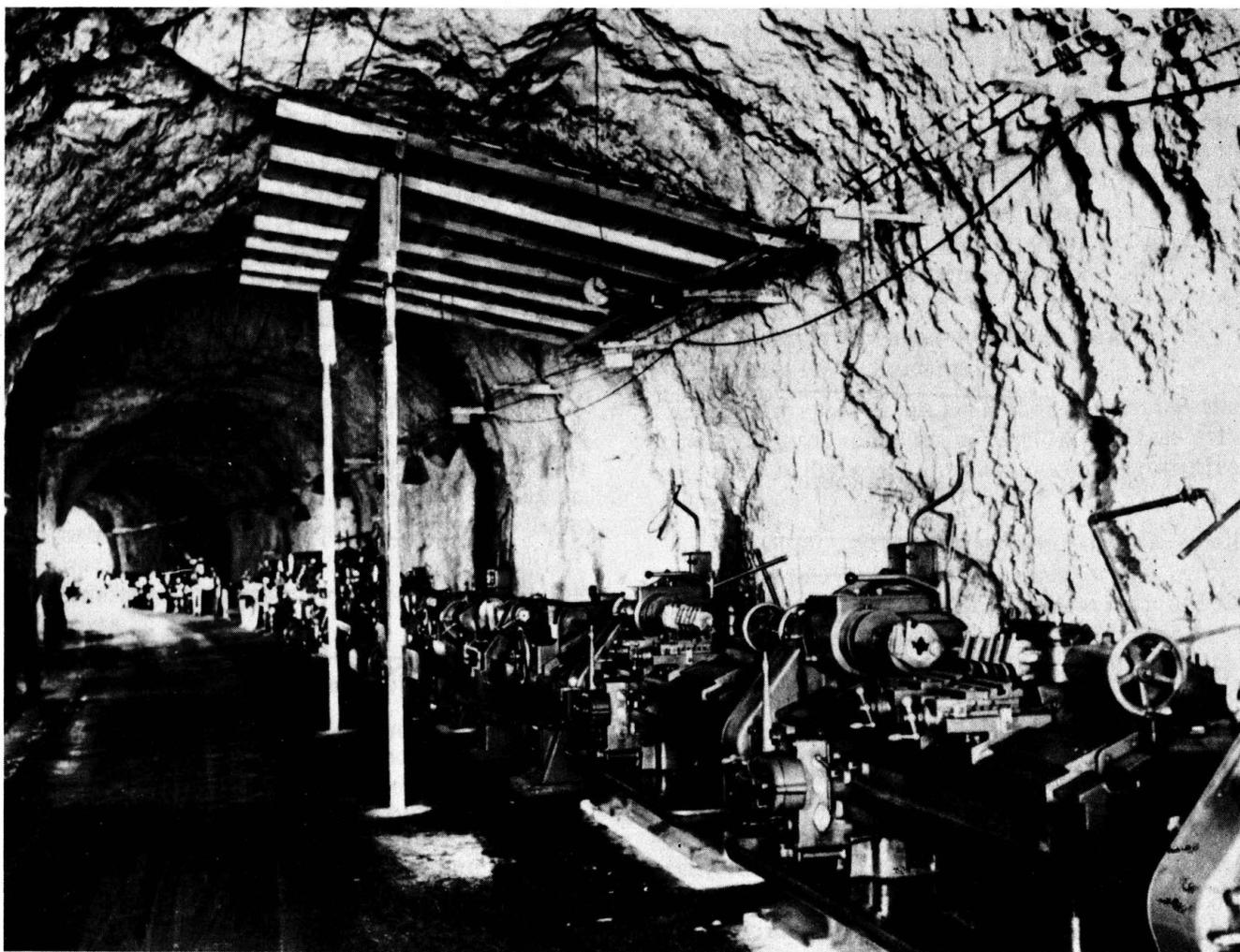


Figure 7-10. Tunnel factory.

7-41. Hazardous Installations

These are industrial storage or other facilities that, if destroyed, could have some widespread dangerous effect on the structure or population of the urban area. Industrial plants whose products may cause great fires or severe explosions, or which may release or generate noxious chemical liquids and gases are definite problems. Many examples of this occur in peacetime. In wartime, installations of this type are even greater hazards because of the increased industrial and target potential. Examples of hazardous installations include oil refineries and tank farms; basic chemical plants; paint, plastic, and cellulose products plants; and liquefied petroleum gas bottling and oxygen plants. Biochemical and nuclear research and manufacturing installations if damaged could spread harmful biological and radiological agents. Nuclear reactors in universities and in power

plants are obvious dangers, as are biological research facilities on communicable diseases.

7-42. Irreplaceable Installations and Institutions

Those installations impossible or difficult to replace or restore need to be identified and located in order to reduce damage if possible. These include religious shrines, national monuments, and museums.

7-43. Landmarks and Unidentified Installations

This category includes structures that form important reference points to other features of the city, and those installations which cannot be identified, but appear to be important because of size or observable security measures.

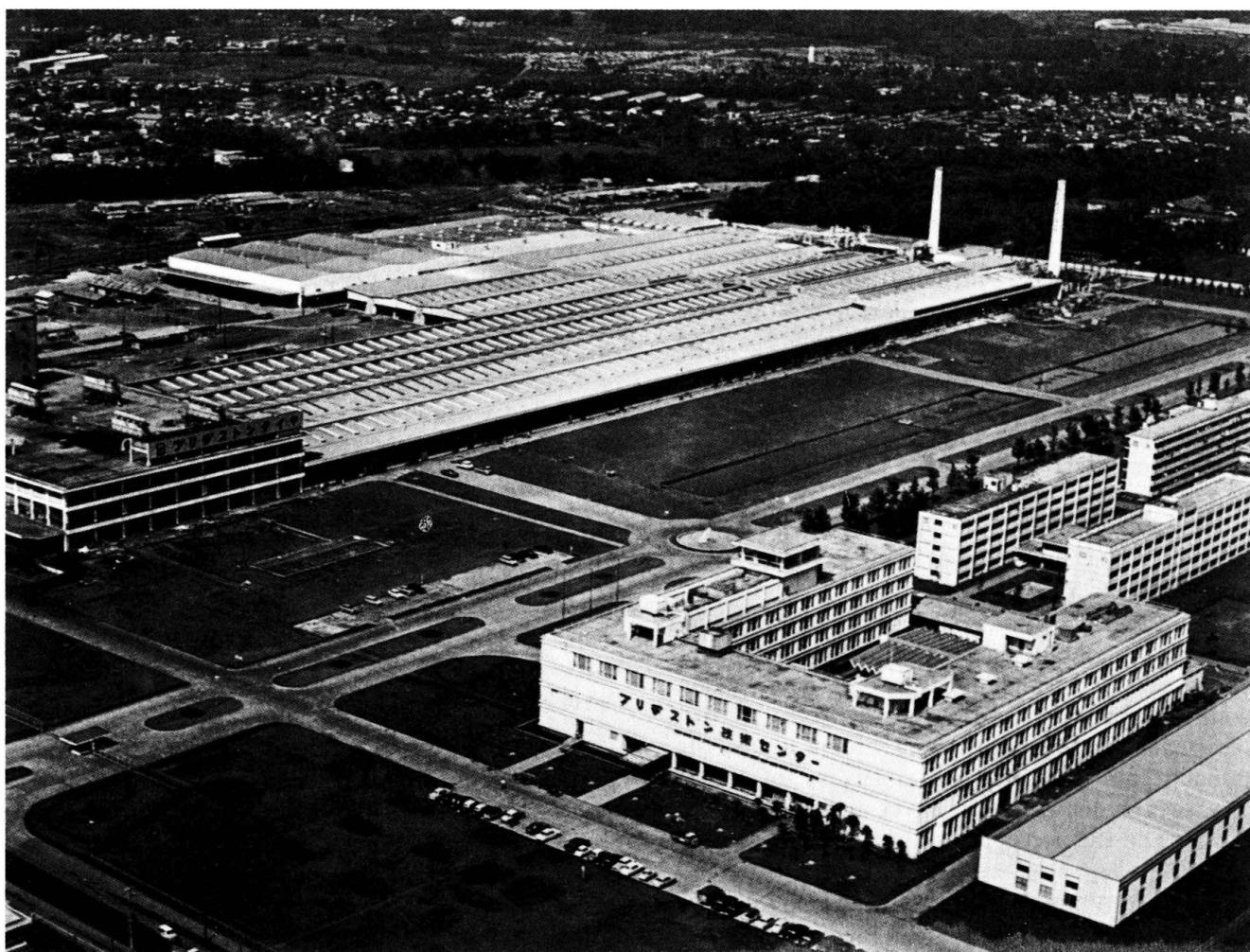


Figure 7-11. Research facility collocated with tire manufacturing plant.

7-44. Special Research Installations

Research facilities (fig. 7-11), such as national health, agricultural, forestry, geologic, and archeological research institutes should be identified to prevent the destruction of long-range scientific

studies that are of little military importance. Also in this category are those installations where special research is being conducted on weapons and other equipment which, if taken intact, could reveal valuable military information.

Section VI. INFORMATION COLLECTION

7-45. Sources of Information

The primary sources of information on urban areas are documents and photography. Personal contacts and direct observation afford some verification data. The information from these sources will vary greatly depending on the amount and accuracy of the sources and the size and complexity of the urban area.

a. Documents. Documents are the most valuable single source of urban area data. They include not only written material, but also drawings and sketches, voice recordings, photographs, and exposed film. Sources of documents include foreign government agencies, international conferences, fairs and exhibitions, libraries, research foundations, universities, professional societies, publishing houses, retail book stores, photography shops, and private collectors. Following are only a few of the various types of documents which contain valuable information:

(1) Annual administrative reports, surveys, statistical assemblies, and departmental reports discuss operations for an annual or other specified period. These are almost always valuable for statistical data on capacity and quality of urban services and facilities. They also cover physical accomplishments for the period and provide valuable comment on general conditions of utilities, services, and facilities; street and road construction, repair and maintenance; and growth of new areas of the city.

(2) Planning studies are particularly valuable sources of data. Characteristically, these have detailed and often elaborate graphic material on the current situation and proposed future growth of the urban area. In surveying future needs, the comments on current conditions are of great value, as are details on location and capacity of facilities and the performance of services.

(3) From the standpoint of technical accuracy and thoroughness, the most valuable documentary sources are technical reports made by various consultants and engineering departments on the feasibility of new projects, the progress of

new construction, and details on the cost, mechanics, and operation of new equipment and facilities. These are however, very narrow and specific. In a similar class of reliability, but less complete, are the technical papers appearing in official journals of engineering and professional societies, and technical trade magazines. These generally present reports on details and progress of construction of new installations and facilities; frequently diagrams and photographs are included. Typical publications are concerned with city administration, planning, construction, architecture, highway traffic and construction, water and sewerage systems, and coal, oil, gas and electric power.

(4) Maps and town plans are among the best sources of information for locating installations, for describing the street pattern, for locating transportation facilities and through routes, and for use as a frame of reference for all the other data collection. Specific locations require detailed maps showing all street names and building and house numbers.

(5) Guide books and other tourist literature nearly always contain valuable statistical and photographic data, as well as maps. Since the availability and quality of these differ from place to place, it is generally desirable to collect and forward a liberal amount of such material.

(6) Newspapers and magazine articles which comment on future plans and present conditions of physical, social, and economic facets of the urban area are important sources. Material in such sources is generally voluminous, but may have a low reliability, since they often are assembled to express a particular editorial viewpoint. On the other hand, the photography may be excellent and can often supply useful information.

(7) Telephone directories are a most valuable source of information. In conjunction with a numbered street map, it would be possible to locate every important installation in the city. Trade directories also provide a means for locating plants. In addition, the directories advertise the types of products manufactured and provide use-

ful information on processes, facilities, and quantities.

(8) Graphic material often can supply required data more clearly, concisely, and comprehensively than words alone. In many instances, a report can consist largely of such material. As far as possible, all photographs, drawings and sketches should be clearly marked to show exactly what they represent, from what position they were taken, and the date the photos were taken or sketches made. Whenever possible, actual negatives or positive prints should be submitted in preference to the half-tone reproduction in printed matter.

b. Human Sources. Almost any resident of an urban area can provide some information on the area. The most valuable information from such sources will come from someone associated with the municipal administration or from someone associated with a particular installation or facility under study. For example, if a report is being made on the telephone installations of an urban area, an employee of the telephone company would be the most logical source.

c. Direct Observation. Direct observation is concerned principally with reporting details on specific installations. In general, direct observations should be undertaken only after full documentary exploitation, thereby limiting the reconnaissance to specific gaps in information. Important points of identification and location to be considered in reporting on specific installations include:

(1) *Name and number.* The proper name of the installation should be given whenever possible, for example "General Chemical Company, Plant #2."

(2) *Functional description.* The functional description is the most important feature of the identification. This description should be carefully and concisely made to describe the functions of the installations, e.g., rare-earth reduction plant, telephone exchange, cotton storage area. Careful distinction should be made between fabrication, processing, and production. A steel plant should be further described as to whether it is a producer of basic metals and has a blast furnace; a processor, such as a steel rolling mill; a fabricator of items, such as automobile body parts; or an assembly plant, such as a prefabricated bridge parts assembly plant.

(3) *Location.* The location of the installation must be indexed to a map. In the text of the

report, the installation will be further located by city and region and its position relative to landmarks.

(4) *Structural information.* Physical data on installations should not be overlooked. Information is required on the physical characteristics of individual structures, the contents of buildings, and of plants and installations as a whole to permit thorough analysis and appraisal of their capacity and vulnerability. The size, shape, general layout, and terrain features of the overall installation, and the size, shape, and exact locations of its vital components must be determined to make such an appraisal. In addition to buildings, other features such as railroads or pipelines, conveyors, water towers and tanks, loading platforms, and other component features should be identified and described.

d. Priorities of Collection. The wide variety of subject matter required for urban area intelligence precludes an inflexible order of collection. In general it should be as follows:

(1) Data of a locational and descriptive nature such as town plans and street maps, guide books, tourist literature, diagrams, and aerial and ground photography.

(2) Data on size and capacity of individual installations and facilities, such as those data found in general commercial, transportation, and utilities statistics.

(3) Data on adequacy and condition of streets, facilities, and utilities, as well as plans for future development, such as those data available in town planning reports, development proposals, and comments in the local press.

(4) Data on the potential of the area for occupation as an offensive base or defensive point; these data may require direct observation by the collector.

7-46. Collection Checklist—Urban Areas

1. *Identification.* Local name and classification (major, secondary, etc).

2. *Location.*

a. Map reference—Include series and sheet number(s) of tactical, air-ground, and city plans.

b. Political unit, area, boundaries, UTM coordinates, and geographic coordinates.

3. *Population.*

a. Present.

b. Trend.

c. Significant segments (ethnic, religious).

4. *Importance.*
 - a. International.
 - b. National.
 - c. Regional.
5. *Suburban areas.*
 - a. Names and locations.
 - b. Boundaries and areal extent.
 - c. Population.
6. *Climate and weather.* Cross reference to climatic summary file.
7. *Landmarks.* Natural and manmade.
8. *Extent of built-up areas.*
9. *Functional areas.*
 - a. Type (industrial, commercial, residential, military, governmental and institutional, etc).
 - b. Location.
 - c. Areal extent.
 - d. Structures (predominant type buildings include characteristics and construction type).
 - e. Vulnerability (nuclear, artillery, and/or air attack).
10. *Damaged or destroyed areas.*
11. *Road nets.* Cross reference to road collection file.
 - a. Through routes (entering, leaving, and general direction).
 - b. Bypasses (direction, name, and characteristics).
12. *Railway nets.* Cross reference to railway collection file.
 - a. Through routes (entering, leaving, terminals, and general direction).
 - b. Bypasses (direction, name, characteristics, and terminals).
 - c. Facilities (stations, yards, sidings, repair shops, and turntables).
13. *Waterways.* Cross reference to appropriate collection file.
 - a. Identification and characteristics.
 - b. Relationship to urban area.
 - c. Nearest ports (names, distances, and directions).
 - d. Waterway significance.
 - e. Structures.
14. *Airfields.* Cross reference to airfield collection file.
 - a. Name, type and location.
 - b. Utilizing airlines and/or military.
 - c. Characteristics and aircraft using.
15. *Sites suitable for military purposes.*
 - a. Location, type, and purpose.
 - b. Structural data.
 - c. Repairs and improvements needed.
 - d. Vulnerability.
16. *Military installations.*
 - a. Location and type.
 - b. Facilities.
17. *Engineer facilities and equipment.*
 - a. Plants and fleets.
 - b. Location and type.
 - c. Stocks of construction equipment.
 - d. Stores and warehouses.
 - e. Associated facilities (map reproduction, lithographing, etc).
18. *Billeting and accommodations.* Hotels, motels, bakeries, laundries, recreation, etc.
 - a. Location, type, and capacity of each.
 - b. Repairs and improvements needed.
 - c. Vulnerability.
19. *Central steam heating.*
 - a. Area and installations served.
 - b. Sources (fuel, equipment, and water).
20. *Water supply.* Cross reference to appropriate collection file.
 - a. Area, population, and installations served.
 - b. Type and location.
 - c. Capacity, adequacy, characteristics, and seasonality.
 - d. Delivery methods.
 - e. Treatment plants (number, type, location, capacity, and condition).
 - f. Storage (type, location, capacity, and condition).
 - g. Consumption (minimum and average).
 - h. Total capacity of system.
21. *Electricity.* Cross reference to appropriate collection files.
 - a. Area, population, and installations served.
 - b. Location and type of source.
 - c. Fuel and equipment.
 - d. Transformer system.
 - e. Output (average, peak, and seasonal variations).
 - f. Transmission (lines, voltages, and transformer stations).
 - g. Ties with outside sources.
 - h. Capacity of system (normal, peak, and seasonal variations).
22. *Illuminating gas.* Cross reference to appropriate collection file.
 - a. Area, population, and installations served.
 - b. Location, type, and sources (capacity and characteristics).
 - c. Storage (location, type, capacity, and characteristics).

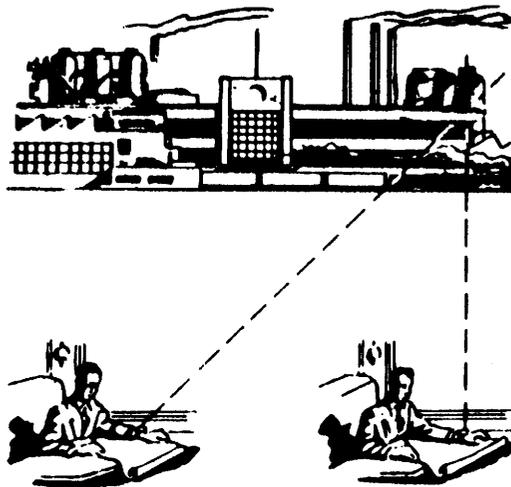
- d.* Distribution system (pipelines, mains, tanks, controls, and auxiliary installations).
 - e.* Output (average, peak, and seasonal variations).
 - f.* Annual consumption.
23. *Telecommunications.* Cross reference to telecommunication collection file.
- a.* Type and location.
 - b.* Important structures and apparatus.
 - c.* Operating features.
24. *Sewage disposal.*
- a.* Area, population, and installations served.
 - b.* Location and type (sanitary, storm, industrial).
 - c.* Treatment plants (location, type, equipment, capacity, and type of collection).
 - d.* Disposal (sludge, effluent, dumps, and/or incinerators).
25. *Garbage and trash disposal.*
- a.* Area, population, and installations served.
 - b.* Methods and schedules.
 - c.* Equipment.
 - d.* Disposal and treatment plants (location, type, and capacity).
26. *Public transportation.*
- a.* Area, population, and installations served.
 - b.* Type, routes, schedules, and capacity.
 - c.* Terminals (type and location).
 - d.* Equipment (type, quantity, storage location, motive power, and condition).
 - e.* Maintenance facilities.
27. *Fire protection.*
- a.* Area, population, and installations served.
 - b.* Organization.
 - c.* Stations (number, locations, and description).
 - d.* Manpower and equipment (number, type, quantity, and condition).
 - e.* Hydrants and key valves.
 - f.* Water source (location, adequacy, and pressure).
 - g.* Alarm, communications, and dispatching system.
28. *Police protection.*
- a.* Area, population, and installations served.
 - b.* Organization.
 - c.* Manpower.
 - d.* Stations (number, locations, and description).
 - e.* Equipment (type, quantity, and condition).
 - f.* Detention and security areas (name, location, capacity and condition).
29. *Civil Defense.*
- a.* Area, population, and installations served.
 - b.* Organization and manpower.
 - c.* Equipment.
30. *City government.*
- a.* Type and facilities.
 - b.* Locations.
31. *Storage facilities.* Cross reference to appropriate collection files.
- a.* Name and location.
 - b.* Type of facility (open, covered, grain elevator, petroleum tank farm, underground, etc).
 - c.* Product stored (type, normal stock level, and capacity).
 - d.* Construction details (type, material, dimensions, layout, physical condition, and cargo facilities).
 - e.* Transportation connections (road, rail, air, water, and/or pipeline).
 - f.* Security features (guards, fencing, etc).
 - g.* Refrigeration and ice-making facilities (purpose, equipment, and capacity).
 - h.* Utilities (water supply, fire protection, electric power, gas).
32. *Industry.* Cross reference to appropriate collection files.
- a.* Major industrial activities (type, location, plants, and importance).
 - b.* Significant manufacturing plants (type, location, buildings, facilities, product, and condition).
33. *Hospitals.*
- a.* Name, location, and capacity.
 - b.* Specialization, adequacy, and condition.
34. *Other important installations (location and characteristics).*
- a.* Churches and schools.
 - b.* Post offices and banks.
 - c.* Cultural centers (museums, theaters, cinemas, etc).
 - d.* Research laboratories.
 - e.* Others.
35. *Streets.*
- a.* General pattern.
 - b.* General overall condition.
 - c.* Numbering and naming system.
 - d.* Traffic control system.
 - e.* Classification and prevailing width.
 - f.* Repairs and improvements needed.
36. *Underground installations.*
- a.* Type (plants, hospital, shelter, storage, etc).
 - b.* Name and location.
 - c.* Original use (mine, cave, tunnel, vault, etc).
 - d.* Construction data.
 - e.* Protective cover.
 - f.* Vulnerable features.
 - g.* Protective construction features.

- h. Operating equipment.
 - i. Accessibility to transportation.
 - j. Utilities.
37. *Underground openings.*
- a. Type, name, and location.
 - b. Operational status (active, inactive, abandoned).
 - c. Accessibility to transportation.
 - d. Utilities.
 - e. Dimensions.
 - f. Vulnerable features.
 - g. Adaptability for use.
38. *Defenses.*

- a. Fortified areas (location, extent, purpose, and description).
- b. Individual fortification (location, extent, type, camouflage, armament, design, purpose, and description).
- c. undefended areas (location, extent, and probable reason for no defense).
- d. Possible and probable invasion routes.

7-47. Aids to Observation

Through the use of simple devices and methods a number of important measurements and directions can be determined. Figures 7-12 through 7-17 are provided as aids to assist the collector in



To determine bearing, distance, or map location of an installation:

The map location of an installation viewed from a moving train, ship, or vehicle can be determined by a simple bow-and-beam reading. The only equipment required is a watch, compass, or protractor.

- a = Angle of bearing at first sighting.
 - B = Distance along route between first sighting and abeam position.
 - C = Distance along route from abeam position to next known location.
- Unknown: A = Distance abeam from route to object.

Procedure:

- a. Take a bow watch bearing at first sighting of object.
- b. Measure B from position of first sighting to position abeam of object.
- c. Measure C from abeam position to next known location.

NOTE

To measure distance by rail, count route markers or count rail clicks and measure rail lengths during train stops. On highways, use speedometer readings, telephone-pole distances, or other standard distance markers. Aboard ship, calibrate speed.

- d. Make a map plot showing rail, highway, or waterway distances, C and B, back from known location.
- e. Plot line of abeam sighting and line of first sighting.
- f. The intersection of the lines of sight is the map location of the object. Distance and direction can now be determined from the map, or by formula: $\tan/a = A/B$.

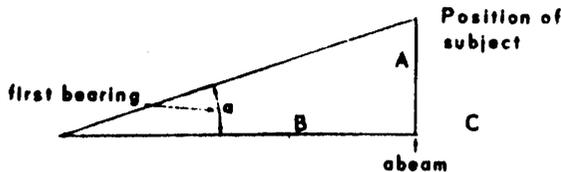
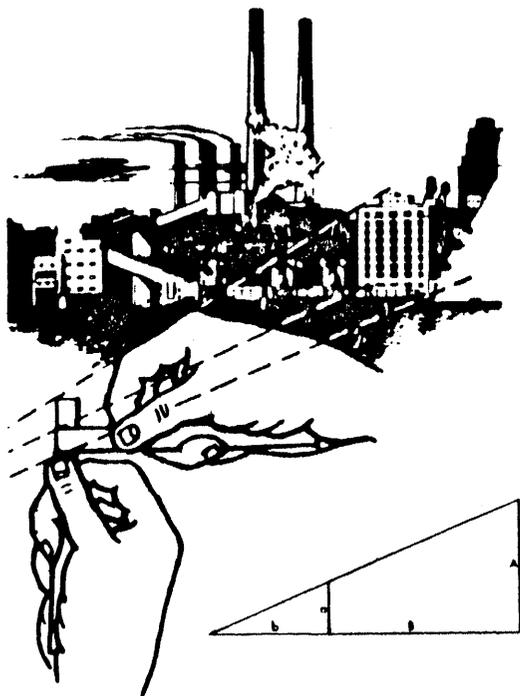


Figure 7-12. Determining bearing, distance, or map location.



To determine an unknown measurement:

By using simple proportions, an unknown measurement can be determined if the three other values in the proportion are known or measurable. This method is useful in determining heights and widths of inaccessible objects. However, if a measurement of the object is known, it can be used instead to determine distance. The only equipment required is a 6-inch scale or other measuring unit. Known or measurable:

a = Length sighted on measuring unit in inches,
 b = Distance from eye to sight on measuring unit in inches.

B = Distance in feet from observer to object
 (or A = Measurement of object in feet)

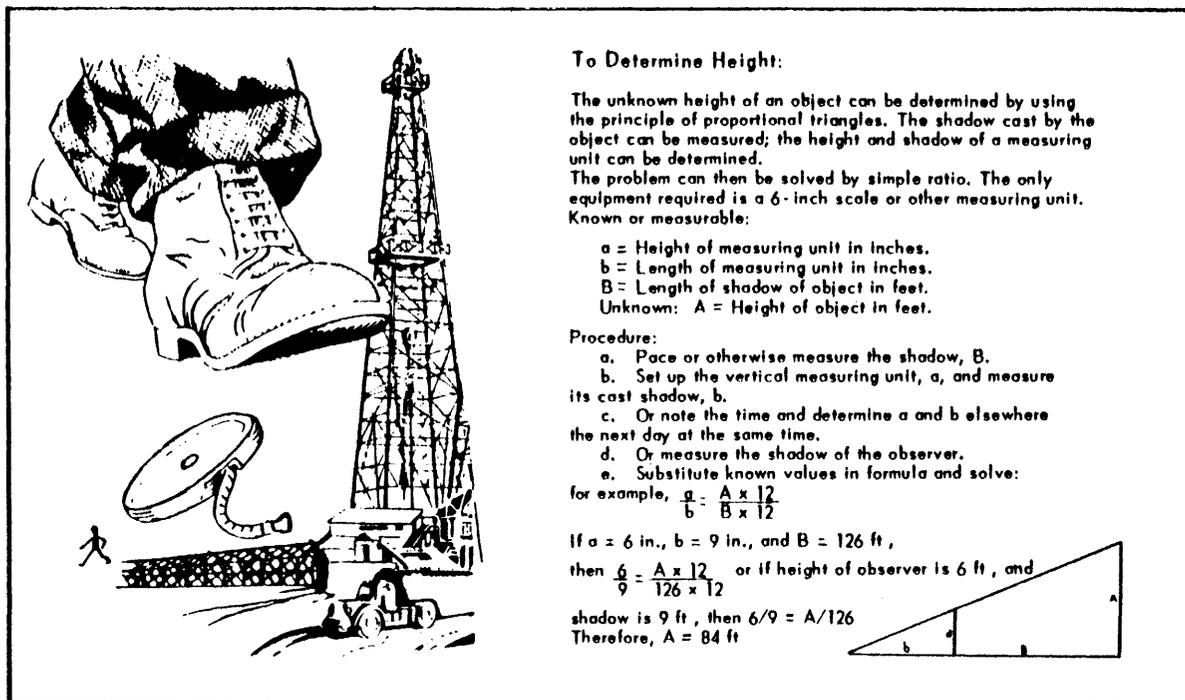
Unknown: A = Measurement of object in feet
 (or B = Distance in feet from observer to object)

Procedure:

- a. Sight object as shown in sketch and determine a.
- b. Pace, or otherwise measure B, e.g., use map of area.
- c. Substitute known values in formula and solve; for example, $\frac{a}{b} = \frac{A \times 12}{B \times 12}$

If a = 1.5 in., b = 21 in., and B = 980 ft,
 then $\frac{1.5}{21} = \frac{A \times 12}{980 \times 12}$
 therefore, A = 70 ft

Figure 7-13. Determining an unknown measurement.



To Determine Height:

The unknown height of an object can be determined by using the principle of proportional triangles. The shadow cast by the object can be measured; the height and shadow of a measuring unit can be determined.

The problem can then be solved by simple ratio. The only equipment required is a 6-inch scale or other measuring unit. Known or measurable:

a = Height of measuring unit in inches.
 b = Length of measuring unit in inches.
 B = Length of shadow of object in feet.
 Unknown: A = Height of object in feet.

Procedure:

- a. Pace or otherwise measure the shadow, B.
- b. Set up the vertical measuring unit, a, and measure its cast shadow, b.
- c. Or note the time and determine a and b elsewhere the next day at the same time.
- d. Or measure the shadow of the observer.
- e. Substitute known values in formula and solve:

for example, $\frac{a}{b} = \frac{A \times 12}{B \times 12}$

If a = 6 in., b = 9 in., and B = 126 ft,
 then $\frac{6}{9} = \frac{A \times 12}{126 \times 12}$ or if height of observer is 6 ft, and

shadow is 9 ft, then 6/9 = A/126
 Therefore, A = 84 ft

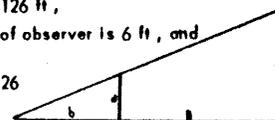
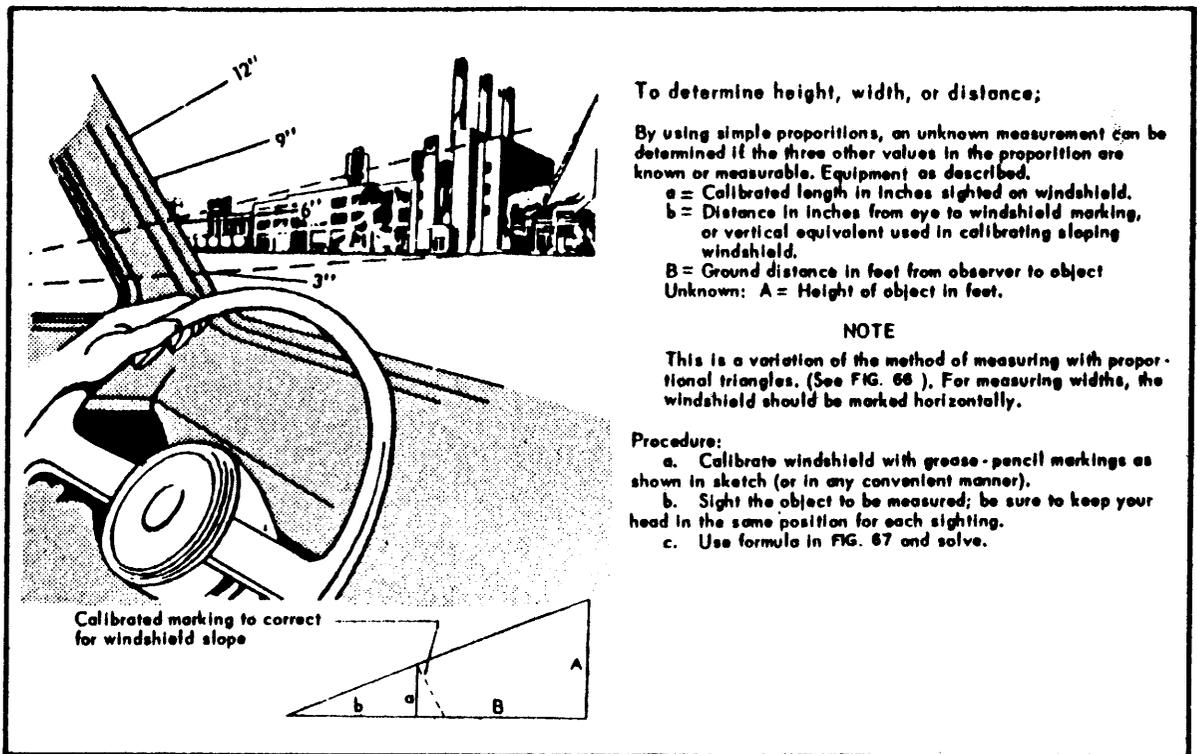


Figure 7-14. Determining height.



To determine height, width, or distance;

By using simple proportions, an unknown measurement can be determined if the three other values in the proportion are known or measurable. Equipment as described.

- a = Calibrated length in inches sighted on windshield.
- b = Distance in inches from eye to windshield marking, or vertical equivalent used in calibrating sloping windshield.

B = Ground distance in feet from observer to object
 Unknown: A = Height of object in feet.

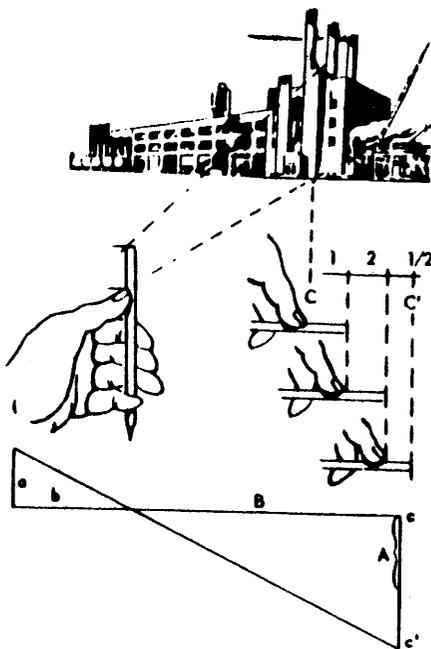
NOTE

This is a variation of the method of measuring with proportional triangles. (See FIG. 66). For measuring widths, the windshield should be marked horizontally.

Procedure:

- a. Calibrate windshield with grease-pencil markings as shown in sketch (or in any convenient manner).
- b. Sight the object to be measured; be sure to keep your head in the same position for each sighting.
- c. Use formula in FIG. 67 and solve.

Figure 7-15. Windshield measurements.



To determine distance, height, or width:

The distance from an observer to a reference object can be determined if a dimension of the object is known from previous observation, or from a map or other source. The only equipment required is a pencil or other small straight object.

- a = Distance between the pupils of the eyes.
- b = Distance from eye to hand-held pencil.
- r = b/a used as a constant. An approximation of 10 is often used.

A = Height or width of reference object.
 c - c' = The numerical relation between the height (or width) of the reference object and the distance it appears to move during sighting (as shown in sketch), when observer changes his sighting eye.

Unknown: B = Distance from observer to reference object.

Procedure:

- a. Using right eye, sight pencil on reference object.
- b. Slide thumbnail along pencil until the distance between it and the pencil end intercepts the known height or width of the reference object. The distance on the pencil is your measuring unit.
- c. Without moving the pencil, close right eye and sight with left eye.
- d. The pencil will appear to move to the right from c to c'.
- e. Turn pencil and estimate c - c' in terms of the measuring unit. (In the sketch, c - c' is shown as 2½ units.)
- f. Substitute known values in formula and solve; for example;

$r = b/a$, usually 10; $B = Ar(c - c')$
 If $a = 84$ ft, $c - c' = 2.5$, and $r = 10$,
 then $B = 84$ ft. $\times 10 \times 2.5$

Therefore, B = 2100 ft

Figure 7-16. Determining distance, height, or width.

To determine bearing of an object from known azimuth:

If the map location of a route or direction is known, a bearing can be taken with reference to it. The only equipment required is a watch and bent clip.

B = Route or direction used as a reference line.

Unknown: a = Angle of bearing.

Procedure:

- a. Align watch as shown in sketch, the numeral 12 lying along B.
- b. Sight object in line with the upright prongs of the bent paper strip.
- c. Note the number of minutes marked off to the left or right of 12. Each minute equals 6° of bearing.
- d. Read bearing in degrees.

By taking bearings at both ends of B, and measuring B, the position of the subject can be plotted on a map.

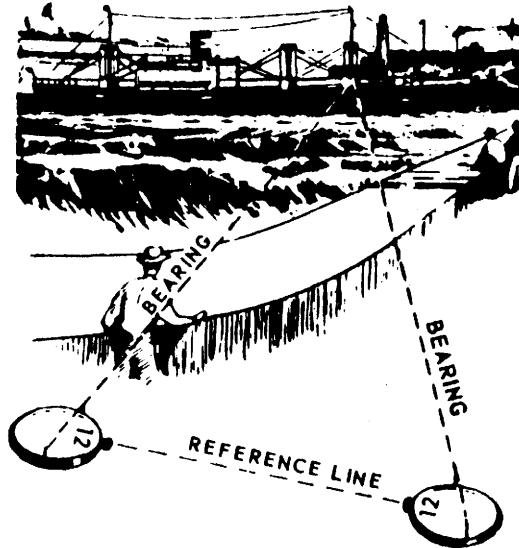
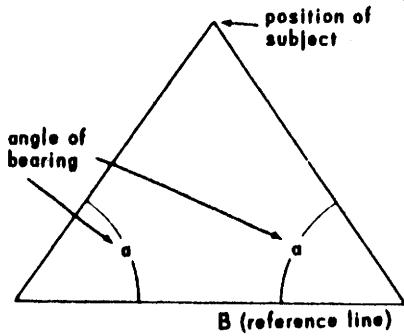


Figure 7-17. Taking a watch bearing.

CHAPTER 8

RURAL AREAS AND RESOURCES

Section I. RURAL AREAS

8-1. Importance

a. Information on all areas of a country is important in the planning of tactical and strategic operations, in targeting for nuclear or air attack, and in planning logistic support for operations. Knowledge of the characteristics of rural areas may be extremely important in the conduct of civil affairs, and in intelligence and counterintelligence operations. Accurate information on the availability of resources is essential to the adequate planning of military operations.

b. In planning operations in rural areas, consideration must be given to the effects they will have on the national economy and on those areas outside the principal urban centers of a country. Planning must take into consideration the suitability of small settlements for base development, for communications, for utilization of local manpower and material resources, and for production facilities. Farmlands, villages, natural resources, and other nonurban features are important considerations on a strategic level as well as for tactical operations.

c. This chapter will deal predominantly with cultural features in rural areas; for natural features refer to chapter 10.

8-2. Rural Features

Rural, or nonurban settlements are all those not inhabited by an urban population. These settlements include farms, hamlets, villages, small towns, and buildings of various sizes, types, and materials. Rural areas may also include transmission features such as telephone, telegraph, and electric power distribution lines, as well as miscellaneous nonurban topographic features such as open and deep mines, slag heaps, tailings, salt pans and evaporators, fire and observation towers, grave mounds, etc.

8-3. Population Distribution

Population distribution is a large and complex

area of study and is based on many variables, such as climate, environment, education, etc. Therefore no attempt will be made to discuss population distribution, except for short general statements. Each country will have its own special and unique influences that will have to be used by the collector of geographic intelligence data.

a. Populated areas outside towns and cities usually consist of farmsteads (fig. 8-1) and settlements (fig. 8-2). A farmstead is the dwelling and adjacent buildings associated with an individual farm. The characteristics of a farmstead reflect the climate of the area and the type of agriculture.

b. In rainy tropical climates, most of the inhabitants dwell along streams and waterways; settlements are often located on the banks above the high water mark.

c. In temperate climates, the buildings of a farmstead are detached from each other, while in areas with extremely cold winters the house, barn, and other outbuildings commonly are under one roof. The outbuildings of a farmstead in the tropics normally are few and small, because the animals remain outdoors all year.

8-4. Military Significance

a. Small settlements may be of greater relative importance when they dominate routes of communication at fords, bridges, railway lines, or defiles. Villages that are small in size may have considerable military significance because of a particular industry, mine, or other unique economic feature. They may be local markets and distribution centers serving a wide area and representing an important source of foodstuffs and other supplies in guerrilla type operations. A village with a small local population may be a resort area or the site of a university or similar large institution, capable of providing quarters and other facilities for large numbers of troops.



Figure 8-1. Aerial photograph of farmsteads.



Figure 8-2. Aerial view of small town in agricultural area.

b. In tactical operations, it is occasionally necessary to neutralize small villages that have no direct military value but are used to provide concealment, supplies, and other support to guerrillas. The buildings of a farmstead furnish quarters for troops and shelter for storage and maintenance facilities. Stone buildings may be suitable for weapons emplacements and defensive strong points. Nearly all rural dwellings are within a short distance of a reliable source of water. Cross country movement frequently is hampered by such obstacles as hedgerows, stone fences, retaining walls, irrigation ditches, and paddy fields. Such features as high fences, hedgerows, embankments, and ditches may offer limited cover and/or concealment to individuals and small units.

8-5. Sources of Information

One of the best sources of information on rural areas is aerial photography. Aerial reconnaissance can provide information in greater detail on buildings, facilities and other features of small settlements and farmsteads which may not be reflected on available maps. Ground photography is also helpful in providing information on small towns and villages which may be of tactical significance. Ground reconnaissance with direct observation are valuable sources of information when time permits and size of the area to be covered makes collection feasible. Interrogation of the local populace may also produce information which, in some cases, may not be available through any other source.

8-6. Collection Checklist—Rural Areas

1. *Identification.* Local name and military designation (if applicable).

2. *Type.* Farmstead, village, or small settlement.

3. *Location.*

a. Map reference—Include series and sheet number(s) of tactical, air-ground series, and city plan if available.

b. Political unit, area, UTM coordinates, and geographic coordinates.

c. Nearest predominant terrain feature (azimuth and distance).

4. *Importance* (i.e., dominates bridge 23 or prime food supplier, etc).

5. *Billeting and quartering.* Available, yes or no.

6. *Cover and concealment.*

7. *Cross-country movement.*

8. *Water supply.* Source, quantity, and characteristics.

9. *Maintenance and repair facilities.* Type, capacity, and condition.

10. *Adjacent terrain.* Cross reference to appropriate collection file.

11. *Population.* Permanent, nomadic, or seminomadic.

12. *Areal extent.*

13. *Streets/roads.* Entering, pattern, and characteristics.

14. *Buildings.* Number, type, characteristics, and building materials.

15. *Utilities.* Type, characteristics, and condition.

16. *Important features.*

a. Type (fences, walls, ditches, canals, retaining walls, etc).

b. Location (azimuth and distance from specified point).

c. Characteristics.

Section II. ELECTRIC POWER

8-7. Military Significance

Electricity is used to operate nearly all of the industrial machinery in most countries of the world. Since there is a direct relationship between industrial development and war-making potential, the military significance of electric power is apparent. At present, there is no practical way to store industrially significant amounts of electricity as such, and therefore damage to a power system yields instant results.

8-8. Generation of Power

For primary identification purposes, powerplants are classified into two major categories: hydroelectric (hydro) and thermoelectric (thermal).

Hydro powerplants use falling water as their primary source of energy for the operation of turbines, which, in turn, operate generators. Thermal powerplants, on the other hand, use a variety of energy sources, all of which are fuels. In conventional thermal powerplants, some type of fuel is burned to turn the water in boilers into steam, which is used to operate turbines. In nuclear powerplants, the heat resulting from a nuclear chain reaction is used to create the steam. Gas turbine powerplants use hot gases in lieu of steam to operate the turbines. Powerplants that use internal combustion engines to operate generators also are included in the thermal category although they do not have the characteristics common to most thermal powerplants. Generating capacity is measured

in kilowatts (Kw) and actual production is measured in kilowatt hours (Kwh).

8-9. Transmission of Power

a. Transmission systems are designed and constructed to transfer electrical energy from powerplants to consumers. To transmit large quantities of power for considerable distances, high voltage power lines are required. Generally, high voltage is considered to be 45,000 volts (45 Kv) or more. Nearly all high-voltage transmission is of 3-phase current, using one conductor per phase. A high-voltage powerline therefore usually has three heavy "wires" supported by large insulators for each "circuit." Powerlines often comprise two circuits (six "wires") on the same poles, which also carry above the main conductors one or two smaller wires, attached without insulators, to protect main circuits from lightning. The voltage is reduced at various substations in the transmission system until it reaches the level that can be used by the consumer. The level for most domestic consumption in the world is from 110 to 120 volts and from 220 to 380 volts.

b. There are two types of electrical current: alternating (ac) and direct (dc). Voltage is a characteristic of both types; alternating current also has characteristics of phase and frequency. Knowledge of the type and characteristics of current is important because electrical equipment designed for one type of current will not usually function with or be adaptable to the other type. In fact, there is a grave danger of damage to the equipment and a possible short circuit.

8-10. Classification of Powerplants

Powerplants are classified according to the amount of service they are expected to provide as base load, peak load, and standby. A base load powerplant usually operates 24 hours a day. A peak load powerplant operates daily during the times when consumption needs exceed the maximum capacity of the base load plant. A standby powerplant operates only during emergencies. Powerplants are further classified according to the consumers they serve: public utility, industrial, or combination. A public utility powerplant serves all kinds of consumers—residential, commercial, transportation, and industrial; an industrial powerplant serves an industrial installation or area and is not connected to the public power network; and a combination plant primarily serves an industrial installation or area, but it also serves some other consumers and usually is connected to the public power network.

8-11. Thermal Powerplants, Conventional Steam

Most steam powerplants have certain basic elements that are fairly easy to recognize: large fuel storage areas, usually containing huge mounds of coal; mechanical fuel handling devices, generally some type of conveyor; cooling towers or cooling ponds (if not located next to a natural body of water); tall smoke stacks; and an adjacent transformer and switching yard.

a. *Boilers.* Boilers in most steam powerplants are installed in a building that usually is several stories high; however, in some modern powerplants where climatic conditions are favorable, boilers are installed in open air frameworks. Most boilers are of the water-tube type; hot gases resulting from the burning of fuel, circulate around water filled tubes in which steam is generated.

b. *Cooling Facilities.* Immediately after steam leaves the turbine it is condensed into water. The cooling water used to speed the condensing process in many powerplants comes from a stream or lake and is returned to its original source. Where water is in short supply, however, the cooling water must be reused. Cooling towers and cooling ponds are the most common types of facilities used to reduce the temperature of the water that has been used in the condensing process so it can be reused for condensing. A cooling tower (fig. 8-3) is a large wooden or sheet-metal structure open at the top and bottom.

8-12. Thermal Powerplants, Nuclear Steam

Nuclear powerplants do not resemble conventional steam powerplants; they look more like modern industrial buildings or technical laboratories. Fuel storage facilities such as coal yards or oil tanks are missing; however, cooling towers, smoke stacks, and adjacent substations are common characteristics of nearly all commercial nuclear powerplants. Nuclear powerplants are remote from population centers, as a safety precaution.

8-13. Thermal Powerplants, Internal Combustion

Powerplants that have internal combustion engines are different from other types of thermal powerplants. In addition to the adjacent substation, the principal recognition feature is an exhaust stack, one of which is provided for each engine. Most of these powerplants have capacities of less than 10,000 kilowatts.

8-14. Hydro Powerplants

Hydro power is dependent upon the pressure exerted by a column of water, or head, directed against the rotor buckets, vanes, or blades of a hydro turbine, which, in turn, activate the rotor of an electric generator. Three principal types of facilities are foot-of-dam, separated dam, and powerhouse (diversion).

8-15. Substations

a. Substations are located at key points in the transmission system, and their functions depend

on the type of equipment installed. This equipment is used for switching (transferring electrical energy from one circuit to another of the same voltage), transforming (changing the voltage received to a higher or lower voltage), converting (changing alternating current to direct current), or inverting (changing direct current to alternating current). Switching, converting, and inverting equipment is almost always located inside a building; however, transformers, most of which resemble large metal boxes into which slots have been cut and are capped by three or more Christmas tree shaped groups of insulators, generally are out

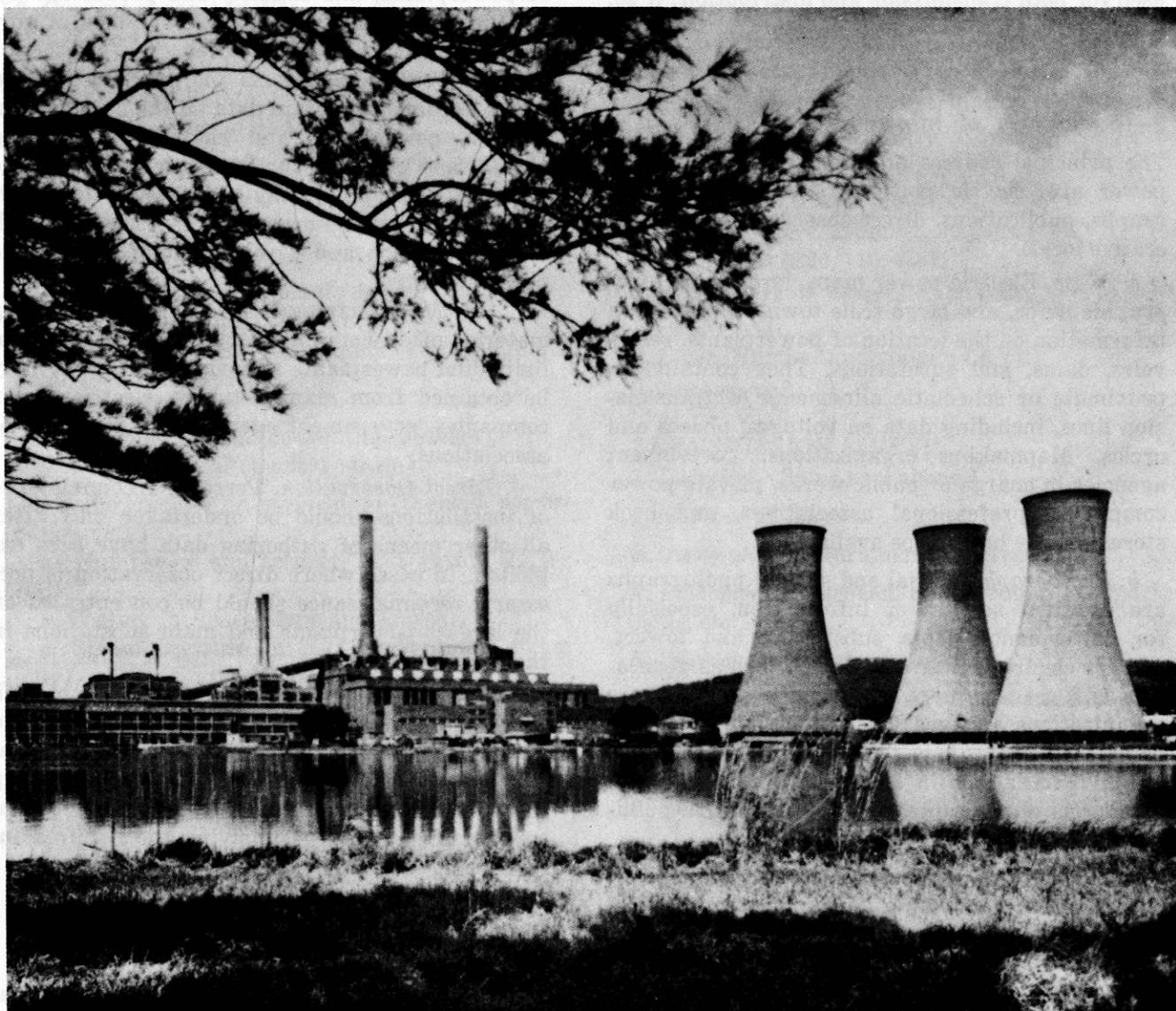


Figure 8-3. Thermal powerplant (cooling towers on right).

in the open and relatively easy to recognize. Usually the capacity and voltage ratio of a transformer is shown on its nameplate.

b. There are three types of substations: transmission, distribution, and industrial. Transmission substations are designed to help move the electrical energy along the powerlines; they usually are located at powerplants or in areas remote from consuming centers. Distribution substations are designed to transform, convert, invert, or subdivide the electrical energy for general use; they generally are situated in a commercial or residential area or at a railroad station. Industrial substations are designed to change the current of the primary distribution system into current that can be used by the equipment in an industrial installation; they are always located near an industrial plant. Many substations are used for both transmission and distribution; if so, they will contain both switching and transforming equipment.

8-16. Sources of Information

The principal sources of information on electric power are electric power system maps, photographs, publications, direct observation and cooperative locals.

a. *Maps.* Electric power maps, large scale topographic maps, and large scale town plans contain information on the location of powerplants, reservoirs, dams, and substations. They contain approximate or schematic alignments of transmission lines, including data on voltages, phases and cycles. Mapmaking organizations, government agencies in charge of public works, private power companies, professional associations, and book stores usually have maps available.

b. *Photographs.* Aerial and ground photographs are excellent sources of information, especially for powerplants, dams, substations and towers, and for electric power equipment, such as generators and transformers. Government and private organizations engaged in construction of powerplants generally have photographs of electric power installations in all stages of construction. Numerous photographs appear in technical publications and manufacturers' brochures.

c. *Publications.* Publications are extremely valuable sources of information. Following are only a few of the types most readily available:

(1) *Newspapers and popular magazines.* News media often contain articles dealing with the construction of powerplants, dams, transmis-

sion lines and substations. They contain statistics on monthly or annual production and consumption of power, and on power imports and exports. Articles are often illustrated with photographs, charts, and graphs.

(2) *Technical publications.* Handbooks, manuals, booklets, serial periodicals, and technical reports contain excellent information on electric power plans and projects. They contain details on construction as well as statistics on the capacity and production of individual powerplants. They may be obtained at government agencies, libraries, bookstores and professional societies concerned with the construction and maintenance of electric power installations.

(3) *Statistical yearbooks.* These volumes contain total power capacity, production, and consumption figures as well as the number and types of powerplants, and capacity and production figures for each type. They may be obtained at government agencies and bookstores.

(4) *Construction plans and progress reports.* These documents contain data on the construction of new powerplants; on changes to existing plants; and on plans for development of electric power systems. They may be obtained from government and private organizations concerned with the construction and development of the electric power industry.

(5) *Manufacturers' brochures.* Advertising material often contains detailed information on individual powerplants and equipment. They may be obtained from manufacturers, electric power companies, government agencies and professional associations.

d. *Direct Observation.* Personal reconnaissance of installations should be undertaken only after all other means of gathering data have been exploited. In cases where direct observation is necessary, reconnaissance should be concentrated on the largest powerplants and main substations in the country.

e. *Foreign Representatives.* Cooperation with representatives of friendly foreign countries and with refugees from unfriendly foreign countries may be very profitable. Such personnel can help the collector either by advising about potential sources of data or by supplying the required information.

8-17. Collection Checklist—Electric Power

POWERPLANTS:

1. *Identification.* Local name and military designation.

2. *Location.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

b. Political unit, area, nearest town, UTM coordinates, and geographic coordinates.

3. *Type.* Conventional-steam thermal, nuclear-steam thermal, internal combustion thermal, hydro-turbine storage, hydro-turbine run-of-river, solar, wind, tidal, etc.

4. *Ownership.* Government or private.

5. *Function.* Public utility, industrial, or both.

6. *Area served.*

7. *Purpose.* Base load, peak load, or stand-by.

8. *Statistics.*

a. Total capacity (KW or KVA) and annual production (KW hrs).

b. Generators (number, type, and rating of each).

9. *Current characteristics.*

a. Type (dc; ac).

b. Generating voltage.

c. Phase and hertz.

10. *Overall condition and age.*

11. *Powerhouse construction.* Material, number of stories, windows, etc.

12. *Transmission line connections.* Number and voltage.

13. *Fuel data (thermal plants only).*

a. Type (by grades).

b. Quantity used per annum (tons, gallons, cubic feet, pounds, etc).

c. Sources.

d. Calorific content (conventional-steam).

e. Waste disposal (nuclear-steam).

14. *Boiler, reactor or engine data (thermal powerplants only).*

a. Number, manufacturer, and rating (KW; HP).

b. Cooling facilities (type and source).

c. Steam pressure in psi (conventional-steam only).

d. Efficiency (calories; BTU/KW-hr) (conventional-steam only).

e. Operating temperature (conventional-steam only).

f. Neutron flux (nuclear-steam only).

g. Shielding and control mechanism (nuclear-steam only).

15. *Water source, hydro-turbine powerplants.*

a. Identification.

b. Flow, cubic feet per second (average, minimum, and maximum).

c. Reservoirs (location, volume, area, head, etc).

d. Dams (name, location, dimensions, diversion canal).

16. *Hydro-turbines (hydro-turbine powerplants only).*

a. Type, number, and rating (HP).

b. Heat (ft; meters) and Flow (cubic meters per second).

SUBSTATIONS:

1. *Identification.* Local name and military designation.

2. *Location.*

a. Map reference—Include series and sheet number(s) of both tactical and air-ground series.

b. Political unit, area, UTM coordinates, and geographic coordinates.

3. *Type.* Transmission, distribution, or industrial.

4. *Function.* Switching, transforming, converting or inverting.

5. *Ownership.* Government or private.

6. *Transformers.* Number, capacity (KVA), and voltage ratio (220/110, etc).

7. *Converters or inverters.* Number and capacity (KW; KVA).

8. *Lines.* Number and voltage (KV).

9. *Area served.*

TRANSMISSION LINES:

1. *Location.* (Same as 2 above.)

2. *Number of lines.*

3. *Ownership.* Government or private.

4. *Placement.* Overhead, underground, submarine cable, etc.

5. *Wire characteristics.*

6. *Type of tower.* Metal, wood, or concrete.

7. *Alinement and length.*

8. *Voltage (KV).*

9. *Phase.*

10. *Maintenance.* Failures causes, effects, and frequency.

Section III. PETROLEUM AND NATURAL GAS

8-18. Significance

Information on the petroleum and natural gas resources of a nation is significant to any modern military operation. It provides a means for evaluating the capacity of a nation to produce, process and supply fluid or gaseous hydrocarbons for military purposes, and the vulnerability of its economy to attack on its petroleum supply system.

8-19. Sources

a. Petroleum, or crude oil, is a combination of fluid hydrocarbon compounds found in pools in the ground. It comprises mixtures of gaseous, liquid, and semisolid compounds, the proportion of which vary from pool to pool. The gaseous compound is called natural gas, and is usually considered to be a fuel apart from the other petroleum compounds. Sources of crude oil are relatively difficult to discover and exploit, even though their distribution is fairly widespread. They are found in sedimentary rocks at varying depths in the ground in the form of pools trapped between impervious rock formations (fig. 8-4) in such structures as anticlines, salt domes, faults, and stratigraphic traps.

b. Synthetic oils are petroleum-like hydrocarbons produced from oil shale or coal in areas where these materials are available and where crude oil resources are inadequate. Their production involves extensive processing and, in many countries, is only in the experimental stage. The existence of even pilot or experimental synthetic oil plants may be highly significant in determining a nation's capability for producing fuels.

c. Natural gas occurs together with crude oil or by itself. Exploration methods are the same for natural gas as for crude oil.

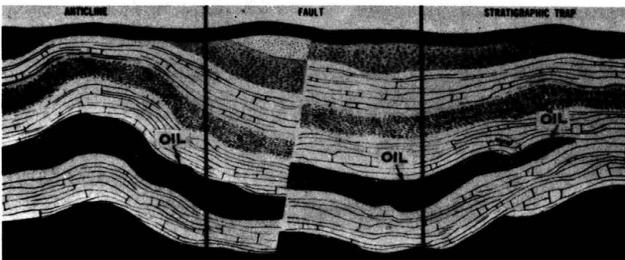


Figure 8-4. Geologic formations in which oil is found.

8-20. Methods of Extraction

a. The extraction of petroleum and natural gas is a complex operation which involves the drilling of a number of wells to tap underground basins. In some fields, crude oil is forced to the surface by the pressure of underground gases; in others, gas pressures are insufficient, in which case pumps are installed to raise the crude oil to the surface.

b. There are three methods of well drilling now in use: cable tool, rotary, and turbine. In cable tool drilling, the cable rig raises and drops a weight bit which chips away at rock to form a hole; this method is no longer employed in the United States. Rotary drilling (fig. 8-5) is performed by means of a drill assembly connected to

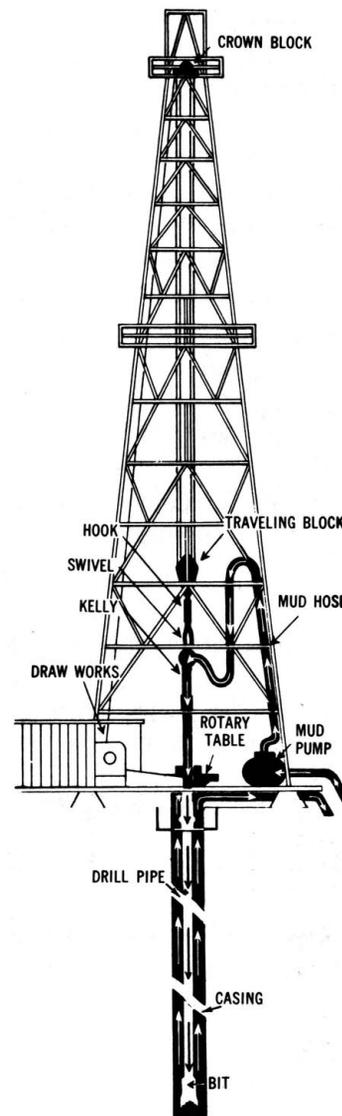


Figure 8-5. Rotary drilling.

in the types and relative amounts of hydrocarbons in each component fraction. Consequently, no two refineries employ exactly the same processes; each employs only those processes which produce the most profitable commercial products at the least cost from base stock available to them. In general, the principal recognition features of a refinery are the oil heating furnaces, the distillation towers, and the coolers. Although many different processes are used in refining, the major ones can be broken down into two large groups, namely separation and conversion.

a. Separation. Separation processes are used to segregate the hydrocarbons in crude oil according to either boiling range or hydrocarbon types. This is achieved with the aid of heat, or heat and pressure.

b. Conversion. Conversion processes are used to alter the molecular structure of hydrocarbon compounds through the application of heat and pressure, or heat, pressure, and a chemical catalyst.

c. Natural Gas Processing. Natural gas, as it comes from the ground, contains a small amount of heavy molecules which, when separated and condensed, form liquids in the gasoline range (natural gasoline).

8-23. Transportation

The transportation of petroleum and refined products is discussed in chapter 5, Transportation.

8-24. Sources of Information

The sources of information on petroleum and natural gas are similar to those listed for pipelines in chapter 5. These sources are publications, personal contacts, direct observation, and photography. The most important of these is publications. The principal publications, in order of importance as sources of information, are:

a. Technical Publications. These deal with location, size, and capacity of oil fields or processing and transportation installations, and describe methods and equipment for production, handling, and distribution.

b. Company Publications and Annual Reports. These provide statistical data on production and performance, and discuss operations and plans for expansion.

c. Trade Journals and Economic Periodicals. These analyze the effects of changes of fuel supply

upon the country's economy and provide technical and engineering data.

d. Governmental Publications. These deal with the administration, technology, regulation, production, and expansion of fuel supplies.

e. Equipment Manuals. These give specific details on capacity, operation, and maintenance of individual pieces of equipment.

8-25. Collection Checklist—Petroleum and Natural Gas

FIELDS:

1. *Identification.* Local name and military designation.
2. *Location.*
 - a. Map reference*—Include series and sheet number(s) of both tactical and air-ground series.
 - b. Political unit, area, nearest town, UTM coordinates, and geographic coordinates.*
3. *Ownership.* Government or private.
4. *Type.* Wet or dry.
5. *Areal extent.*
6. *Status.* Exploited or unexploited.
7. *Production.* Barrels, tons, cu. ft., per time unit.
8. *Number of producing wells.*
9. *Percentage of national production.*
10. *Product.* Type and characteristics (specify).
11. *Reserves.* Proven and Unproven (barrels).
12. *Planned expansion.* Expected increase, date and method.
13. *Transportation.*
 - a. Method* (pipeline, railroad, road, water).
 - b. Identification and destination.*

PROCESSING PLANTS:

1. *Identification.* (Same as 1 above.)
2. *Location.* (Same as 2 above.)
3. *Type of plant.* Complete, skimming, cracking, distilling, synthetic, etc (oil or gas).
4. *Ownership.* Government or private.
5. *Percentage of national refining/cracking capacity.*
6. *Year completed.*
7. *General condition.*
8. *Rated production capacity.* Barrels, tons, cubic feet, per time unit.
9. *Equipment.*
 - a. Number and type.*
 - b. Rated capacity and condition.*
10. *Output.* Product, quantity, and quality.

11. *Power source.*
12. *Water source.*
13. *Transportation.*
 - a. Raw materials in (identification, method, and origin).
 - b. Finished products out (identification, method, and destination).
14. *Planned expansion.*
15. *Buildings.* Type, number, and characteristics.

STORAGE FACILITIES:

1. *Identification.* (Same as 1 above.)
2. *Location.* (Same as 2 above.)
3. *Type.* Gas or petroleum.
4. *Ownership.* Government or private.
5. *Total storage capacity.* Barrels, tons, or cubic meters.

6. *Percentage of national total.*
7. *General condition.*
8. *Storage tanks.*
 - a. Displacement (aboveground or underground).
 - b. Shape (cylindrical, spherical, spheroid, etc).
 - c. Top (flat-roofed, peaked, floating top, dry gasometer, wet gasometer).
9. *Storage drums.*
 - a. Manufacturing (location and capacity).
 - b. Cleaning and reclamation (location and capacity).
 - c. Filling facilities (location, equipment, and capacity).
10. *Transportation.*
 - a. In (method and origin).
 - b. Out (method and destination).
11. *Buildings.* Number, type, and characteristics.

Section IV. CONSTRUCTION RESOURCES

8-26. Construction Intelligence

Construction intelligence is the data from which estimates can be made concerning a nation's capabilities for the type of construction work comparable to that carried out by the US Army Corps of Engineers. It is also concerned with the problems involved in the construction necessary to support US military operations in a foreign area. It deals with civil works, as well as with construction that is wholly military in nature or that which may influence military construction. Construction intelligence is used in determining the capability of a nation to execute the construction necessary to support its own armed forces in any of its operations, and in the planning and conduct of operations by United States forces in foreign areas. It is also used to make comparisons between US Army research and development, policies, and practices, and those of a foreign country.

8-27. Military Construction

Military construction consists of both the construction executed by the armed forces of a nation, and that required to support its armed forces. Intelligence on military construction covers armed forces construction doctrine; division of construction responsibility among various arms and services; types and amounts of construction required by military forces; standards, techniques, procedures and new methods; and research and development which deal with military construction. It also includes the ability of the

construction industry to support the armed forces of a nation in a war.

8-28. Civilian Construction

Civilian construction covers all types of construction carried out in war and peace, both for civil works and for military support. Intelligence on civilian construction covers standards and codes; division of responsibility among government agencies and commercial organizations; general needs of the country for various types of construction; state of development of the industry; quality and quantity of materials; prevalent practices; and construction planning and problems.

8-29. General Construction Problems

Problems which arise in both military and civilian construction may be of an environmental nature, or they may be related to other factors. Those which are environmental include climate (rain, snow, temperature, fog, haze, winds), terrain (surface configuration, soils, rocks, vegetation, drainage, permafrost) or special physical phenomena (earthquakes, volcanic activity). Other factors entering into general construction problems are the availability and quality of construction materials, availability of workers, and the level of manual and technical skills of construction workers.

8-30. Military and Civilian Relationship

Construction of any facility requires basic tasks

that may be done by either a military or civilian organization. For example, roadbuilding requires aligning and locating the road, clearing and grubbing, building drainage structures, earthmoving and grading, and surfacing. Since the same tasks are involved in both military and civilian construction, the nation often adopts civilian standards and methods to military use. A country with a highly developed construction technology will incorporate much of its civilian technology in military construction.

8-31. Organizations

To evaluate a nation's construction capabilities, it is necessary to know the general organization of the construction industry and the structure and capability of its major firms or organizations. The size, capital assets, organization, leadership, amount of equipment, skill of personnel, experience, and degree of specialization will influence the capability of any construction firm. The availability and quality of the labor force at all levels (professional engineers, architects, skilled technicians, mechanics, and unskilled labor) have a direct relationship to the construction capability of a nation. The top administrators of governmental and civilian construction organizations and the leading design, construction, and research engineers may greatly influence construction. Information relative to the professional capability of such men is extremely useful.

8-32. Specifications, Standards, and Policies

a. Specifications. Specifications are a detailed enumeration of requirements for carrying out a construction project. They are of two basic types: those that describe in detail the quality of materials and the mode of construction, and those that prescribe the result desired, leaving the choice of details to the contractor responsible for the finished construction. Detailed information on specifications is needed to assess the quality of construction in a nation.

b. Standards and Policies. Construction is controlled by national and state standards and policies which are developed to achieve uniformity in planning and to assure adequate construction. These may be issued either by governmental agencies or by various professional groups or associations. Standards are more general than specifications. They usually give minimum standards for a type of construction and are not detailed instruc-

tions for an individual job. Standards often specify the procedures and methods to be used in designing structures.

c. Standard or Typical Plans. Uniformity of planning and construction is obtained with the use of standard or typical plans for structures. Standard plans may be drawn for structures of various sizes which can be adapted to any site. When used, standard plans allow prefabrication and stockpiling of elements.

8-33. Engineering Properties of Materials

The selection of a material for a given use depends on two factors: durability and economy. Durability, in general, denotes the presence of qualities in a material which enable it to function properly and resist deterioration over a long period of time. Depending on the use and environment, the durability of a material may involve any of the following factors: resistance to changes in dimensions; weight of the material; resistance to failure under load; resistance to weathering; resistance to freezing and thawing; resistance to erosion; resistance to rotting; resistance to abrasion; and resistance to change in properties. Some of these factors can be expressed only in relative terms.

8-34. Construction Materials

Detailed information on the engineering properties of construction materials used in a nation is needed to assess the quality of construction. Intelligence on the availability and general quality of construction materials is of great value in planning military operations in a foreign country.

a. Wood. Lumber is sawed wood used for construction. The term timber refers in general to standing trees; however, in construction work, timber often means large pieces of lumber. Wood is classified as hard wood or soft wood: hard woods being those of deciduous trees; soft woods those of coniferous trees. This classification is apt to be misleading, since, in a mechanical sense, some of the hard woods are softer than soft woods. In the United States soft woods are classified as yard lumber (material less than 12cm thick used for general building purposes), structural timber (joists, planks, beams, stringers, posts, and timbers), and factory or shop lumber (doors, window casings, etc.). All of these types come in various grades, depending on the quality.

(1) Lumber is available in certain standard sizes and special shapes. It is cut to nominal sizes

such as 5cm by 10cm (2 inches by 4 inches) when green. Because of waste in cutting and shrinkage in drying, the dimensions of rough dry timber will be less than the nominal dimensions. If the material is finished or dressed by planing, the size again will be decreased. For example, the standard dressed "two by four" measures 4cm by 9cm (1 $\frac{5}{8}$ inches by 3 $\frac{1}{2}$ inches).

(2) Plywood is a term applied to panels composed of two or more thin sheets of wood glued together with the grain of one or more of the sheets at right angles to the grains of the others. Laminated or built-up structural units are prepared by gluing together links of small clear stock to form beams, columns, arches, etc. Since wood in small sections is easily bent, it is possible to produce long span arches and other curved sections by this method.

b. Steel. Steel is a commercial form of iron containing between 0.12 and 1.7 percent of carbon as an essential alloying constituent. The properties of steel may be varied greatly either by changing the carbon content or by alloying with other metals. Most structural steels are low carbon steels with 0.15 to 0.30 percent carbon, although some higher carbon steels are used. Steel is available in a number of different standard shapes, all of which are rolled to rather strict tolerances. Among the standard shapes are wide flange sections, I beams, angles, channels, tees, zees, plates and bars. In general, the properties of interest are shape, nominal size of section member, weight per foot, area of section, depths of section, web thickness, flange width and thickness, moment of inertia, section modulus, and radius of gyration about the principal axes.

c. Nonferrous Metals. While steel is by far the most widely used structural metal it is subject to corrosion and has a high weight-to-strength ratio. Various nonferrous metals and their alloys are superior to steel in these respects and may be more desirable than steel for some structures. While the use of light metals in construction is limited, information on any application of these metals in construction would be of great value, due to the possible advantages of their use.

d. Cement. Portland cement is by far the most commonly used cement and, unless reference is made to the type, it may be assumed to be Portland cement. In recent years, the use of Portland-pozzolan cement has come into prominence and is rapidly increasing. Natural cements have only about half the strength of Portland cement. Be-

cause of the wide variety of raw materials used in its manufacture, there is considerable variation in the properties of natural cements made in different localities.

e. Concrete. Concrete is a mixture of sand and rock or similar inert material (aggregate) held together by cementing material, usually Portland cement. The most common aggregates are sand, gravel, and crushed rock, although cinders, blast furnace slag, crushed brick, or other materials can be used. The materials should be relatively free from organic impurities and fine materials such as dust, silt, coal, mica, clay. Water should not contain any chemicals which interfere with the hydration of the cement. Generally, water suitable for drinking purposes is satisfactory for use in concrete.

f. Masonry. Masonry is defined as anything constructed by masons of such material as stone, brick, or tile. It may be divided, according to the material used, into stone masonry, brick masonry, hollow tile masonry, and block masonry.

(1) *Stone masonry.* The simplest form of masonry, riprap, consists of uncut stones piled together without any adhesive mortar. Riprap has very little structural strength and is used primarily for the protective embankments of streams and for low stone walls. Rubble masonry is made up of uncut stones piled and cemented together with mortar. Squared stone masonry is built of stone dressed to regular shapes. The common building stones include granite, limestone (including marble), sandstone, and slate.

(2) *Clay products.* Clay products include brick, terra cotta, hollow blocks, tile, and conduit (sewer pipe and drain tile). Building bricks are made from clay or shale. The quality of the brick is dependent on the materials used and the degree of burning in the kilns. Red or well-burned brick form the standard output of kilns. Paving bricks are usually made from shale and, in the process of manufacture, a higher temperature is used than for building bricks. Refractory or fire bricks are used for lining chimneys and furnaces.

(3) *Other burnt clay products.* The term "terra cotta" is applied to specially molded shapes used for architectural purposes. The raw material is fire clay or a mixture of fire clay and shale. Terra cotta lumber and blocks are used for unexposed structural work. Hollow building blocks are used for walls, ceilings, floor arches, etc. They are made from terra cotta clay. Tiles are made in a variety of sizes and shapes; they have different

properties depending on whether they are to be used for roofing, walls, or floors. Drain tiles are made from a clay similar to that used in making terra cotta products and are well burned. Sewer pipes are molded from a good grade of clay or shale and are glazed by the addition of salt to the kiln so they will be nonabsorptive.

(4) *Concrete and cinder blocks.* These are neither stone nor clay products but both are used in masonry construction.

g. Bitumens. Asphalt and tar products are the principal bituminous materials used for road and airfield construction. Asphalt is derived from petroleum or from natural sources. Tar is derived from the distillation of coal or the production of water gas. Both asphalt and tar consist principally of hydrocarbons, called bitumens, and both materials are often designated by that name.

h. Soils. All structures except floating structures and those built on solid rock have their foundations on soil and are affected by the properties of the soil. In some forms of construction, such as embankments, earth dams, and dry weather roads, soil is a principal construction material. Soil is a natural material and extremely variable in its qualities.

i. Crushed Stone. The properties of crushed stone and other aggregates depend upon the parent material and the size distribution and shape of the particles. The properties of usual interest are particle shape, strength, size, distribution, resistance to abrasion, soundness, and freedom from organic impurities.

j. Hardware and Other Materials. All types of construction materials are of interest. Hardware such as nails, screws, nuts, bolts, etc., is manufactured in standard shapes and sizes and shipped or sold in standard quantities. Other materials such as wallboard, glass, and roofing are items which will be standardized in a country.

8-35. Sources of Information

The best sources of comprehensive technical data on construction are publications, organizations engaged in construction or related activities, personal observations, interrogations, and graphic material. In certain areas of the world, security restrictions limit access to publications; however, photographs, sketches, and skillful interrogations may provide important leads concerning new developments or improvements in military and civilian construction.

a. Publications. Publications are among the most valuable sources of construction data. Sources of publications include foreign government agencies, international conferences, fairs and exhibitions, libraries, research foundations, universities, professional societies, book stores, photography shops and private collectors.

(1) Administrative publications are valuable sources of information. Official or semiofficial publications are prepared by both military and civilian components of government and by the construction industry.

(2) Among the various technical publications are text books, technical papers, and reports. Typical publications are concerned with architecture, engineering, construction materials, highway construction, railroads, bridges, water supply, sewage disposal, airfields and many other facilities.

(3) Newspaper and magazine articles contain descriptions of work in progress and of completed projects. Material from such sources lacks detail, and may have a low reliability, since it often expresses a particular editorial viewpoint; however, many articles are useful in confirming information obtained from other sources, and in furnishing leads to source material. Photographs and graphic materials from these sources are often of value.

b. Organizations. Many organizations engaged in construction are also potential sources of information. In addition to government agencies, they include construction firms, material suppliers, manufacturers, professional societies, trade associations, and many others. Most of these organizations will answer requests for information or supply data received from their membership. They also issue publications, reports, publicity releases, and other valuable data.

c. Personal Observations. Direct personal observations are concerned principally with details on specific construction projects. In general, they should be undertaken only after full documentary exploitation, thereby limiting reconnaissance to specific gaps in information.

d. Graphic Material. Graphic material can often supply data more clearly, concisely, and comprehensively than words alone. All submitted material of this nature should be marked clearly to show exactly what they represent, from what position they were taken, and the date the photographs or sketches were made. Whenever possible, actual negatives or positive prints should be submitted in preference to halftone reproductions obtained from printed matter.

8-36. Collection Checklist—Construction Resources

1. *Timber (unexploited)*.
 - a. Location and extent of forest.
 - b. Tree height and diameter.
 - c. Nature of wood (deciduous or needleleaf).
 - d. Development aspects (nearby sawmills, etc).
2. *Stone (unexploited)*.
 - a. Location and extent of deposit.
 - b. Depth or height of exposed rock.
 - c. Type (igneous, sedimentary, metamorphic).
 - d. Potential use (aggregate, binder, ballast, masonry, etc).
 - e. Development aspects.
3. *Gravel and sand (unexploited)*.
 - a. Location and extent of sources.
 - b. Type of material (sand or gravel).
 - c. Size (fine, coarse, medium).
 - d. Shape (angular, flat, rounded).
 - e. Grade (well graded, poorly graded).
 - f. Type of gravel (alluvial, hill or bank).
 - g. Potential use (concrete, bitumen, surfacing, subgrade, etc).
 - h. Development aspects.
4. *Quarries*.
 - a. Location.
 - b. Method of operation (single, multiple trench).
 - c. Nature of stone (soft, hard).
 - d. Daily capacity (uncrushed stone, crushed stone by sizes).
 - e. Machinery and equipment (rock crushers, drilling equipment, loaders, etc).
 - f. Hauling requirements.
 - g. Relation to road net.
 - h. Turnarounds.
 - i. Crushed stone on hand (quantity, quality, and size).
5. *Sand, gravel and borrow pits*.
 - a. Location and nature of raw material.
 - b. Quantity and quality.
 - c. Overburden (amount, depth, and type).
 - d. Condition of drainage.
 - e. Ground-water level.
 - f. Standing water.
 - g. Utilities available.
 - h. Equipment available.
 - i. Method of extraction (hand labor, machinery, dredging).
 - j. Method of cleaning and sorting.
 - k. Daily production capacity.
 - l. Access roads and turnarounds.
6. *Sawmills*.
 - a. Location and relation to road net.
 - b. Nature of timber used (hard, soft, and size limitations).
 - c. Daily production capacity.
 - d. Availability of indigenous labor.
 - e. Equipment used.
 - f. Hauling requirements.
 - g. Finished lumber on hand (quantity and sizes).
 - h. Timber on hand.
7. *Stockpiled material*.
 - a. Location.
 - b. Type of material (crushed stone, sand, lumber, cinder, cement, asphalt, glass, pipe, bricks, concrete blocks, hardware, tile, plywood, explosives, structural steel, etc).
 - c. Characteristics of material (dimensions, grade).
 - d. Quantity stockpiled.
 - e. Loading equipment.
8. *Production facilities*.
 - a. Identification and location.
 - b. Major items produced.
 - c. Plant description.
 - d. Production data (capacity, labor, rates, items, inventory, etc).
9. *Potential installation construction areas*.
 - a. Area identification and location.
 - b. Extent.
 - c. Construction materials available (aggregate, cement, timber, structural steel, etc).
 - d. Water sources (location, drainage, and yield).
 - e. Labor potential (number, skills, housing).
 - f. Electric power (substations, transmission lines).
 - g. Transportation. Cross reference to appropriate collection file.

CHAPTER 9

RECOGNITION OF INDUSTRIAL FACILITIES

Section I. INTRODUCTION

9-1. Purpose

This chapter is designed to aid the collector in identifying industrial facilities by recognition of architecture and other external features which might be seen by a traveler or a casual observer. Each subject is covered from four points of view:

- a. *Location.*
- b. *Buildings and equipment.*
- c. *Input materials.*
- d. *Products.*

9-2. Plant Layouts

Typical plant layout sketches are included where possible to assist the user in developing an awareness of various recognizable portions of a plant and their relationship. For example, an integrated iron and steel plant contains blast furnaces for making pig iron, open-hearth furnaces and bessemer furnaces for making steel, and rolling mills for making plates, bars, rails, etc. In addition, it has coke ovens to produce the necessary coke for the blast furnaces. Prior to this, the coke gas is first passed through a coke byproducts plant where a variety of chemicals and hydrocarbon derivatives, such as ammonia, naphtha, and benzol are produced. Since such a plant needs a tremendous amount of power, an electric powerplant may also be on the premises. At times when the capacity exceeds the plant's needs, some energy may be fed into the local power network. Thus, we have an iron and steel plant which produces pig iron and steel ingots and also coke, chemicals, semifinished steel products, finished steel products, electricity, and, at times, household gas.

9-3. Use of Illustrations

Illustrations of facilities in this chapter should be used with caution; for many industries there are no truly *typical* plants or buildings. The buildings housing an old chemical plant may, in an illustra-

tion or a photograph, look like those of an engineering plant. An observer should realize that he will see many things which are not illustrated, or which look somewhat different from the illustrations. For example, a factory in one country will look superficially very different from a corresponding factory in another country although the detailed recognition features may be present in both cases.

9-4. Disassociated Recognition Features

An observer may see many apparently disassociated objects at or near a plant site. For example, coke and limestone may be seen in dumps out-of-doors at one place, old scrap iron and steel somewhere else, and metal waste associated with metal manufacturing at a third place. What the observer sees are indications of what is being produced, even though the end items are hidden by buildings. If he is familiar with the pattern of industrial facilities, he may be able to deduce relationships within a given site that will enable him to accurately assess the facility in question.

9-5. Potential Recognition Indicators

For the most part, industrial activity takes place inside buildings. Only in few cases will the buildings be unique to the industry. It is, therefore, necessary to seek other points of recognition. These may include such potential recognition indicators as noise, odors, dust, discoloration on buildings, input or output material, smokes, scrap and rejected material, and similar indicators of the kind of activity. The type of clothing worn by workers may also help in identifying the activity at an installation. A variety of indicators must be observed in order to properly identify an industry.

9-6. Judgment in Reporting

Unless the observer is absolutely certain as to what is manufactured at a particular facility, and

can support his claims of recognition by citing products, plant name, etc., it is preferable that he catalog and describe what he sees as accurately and completely as possible, and leave recognition to the intelligence analyst. The four main recognition categories should be used as a broad outline in compiling information to be reported. Photographs or sketches of the buildings and plant area

are most helpful in the identification process. When photography is taken, information should be provided as to the location of the camera and the direction in which it was pointed for each shot. The focal length of the camera, an estimate of the target's distance from the camera, and the time of day the photographs were taken also are useful information.

Section II. GUIDED MISSILE INDUSTRY

9-7. Airframe/Assembly Plants

a. Location. Generally located near large urban areas for labor force purposes, plants require nearby access to rail, and highway transportation. Airfields may also be associated with this type of manufacture.

b. Buildings and Equipment. Buildings which house missile fabrication and assembly operations are not standardized in size, shape, or number. Almost any industrial structure with sufficient floor area (including some high-bay area) will serve. The aircraft industry will produce aerodynamic missiles and drones, while ballistic missiles are usually produced in automotive, ordnance, or aircraft plants. Although significant distinguishing characteristics may vary greatly from one missile to another and from one plant to another, they fall into the following categories:

(1) Distinctive test facilities. These include areas for static firing of missile system; moderate height structure, 15 to 18 meters (50 to 60 feet) for hydrostatic testing of tankage; and, although not a necessity, some plants may include a vertical test facility 30 to 46 meters (100 to 150 feet) high to house the entire missile for systems checks. The latter two would be found only at or near a plant producing ballistic missiles.

(2) Distinctive products and handling equipment. A missile, or part of a missile, may be the only external indication of the plant's function. Handling gear includes transporters, erectors, and large cranes.

(3) Specialized transport facilities. Delivery methods may be indicated by very long, flat-bed trailers in the plant area, modified rail cars on sidings, and large transport aircraft near the plant.

(4) Security. Security measures will be unusually stringent.

(5) Electric power. Most liquid-propellant missile production plants contain electric power

substations and high-voltage power transfer lines. Electric power is usually used for the welding of tankage.

c. Input Materials. Raw materials entering the plant include large quantities of sheet, bar, and tube stock, probably of aluminum, stainless steel, or titanium composition. There will also be a considerable quantity of components consisting primarily of guidance equipment and engines. Engines may be distinguishable by the size and type of shipping container.

d. Products. When missiles are in series production, many are likely to be stored outside for shipment. The number and description of the missiles are important to determine the type of missile and production data. When a well-organized effort is made to conceal plant activities, the missiles in production may not appear outside; however, there are likely to be training mockups or discarded airframes of obsolete models somewhere within the plant area.

9-8. Rocket Engine Plants

a. Location. Plants can be near population centers where technically skilled personnel are available, or in the heart of an industrial area. A test area may be located near the plant or it may be miles distant. Highway and railway facilities are needed.

b. Buildings and Equipment. The manufacture of liquid-propellant rocket engines and jet missile engines is essentially a machine-shop operation. Such installations as aircraft and aircraft engine plants and other metalworking facilities can be used. The distinguishing feature is a test area near or associated with the plant. The test area for liquid-rocket engines is separately fenced, has a large apron and blast deflector, flushing and drainage facilities, and propellant storage drums or tanks. Test facilities for ramjet engines require

a considerable amount of piping and tanks of various diameter to provide the necessary high-speed air flow. The sound of engine testing and the light from such tests frequently can be observed. Solid-rocket engines are essentially like shell casing, but with a throat and nozzle at the firing end. Both are made in generally the same way, and the assembly of the complete engine is primarily a munitions manufacturing and loading type operation. Test facilities represent the major clue to recognition of a solid-rocket plant. The actual test cells are isolated and well-separated by blast walls or heavy revetments from the rest of the plant.

They have aprons and instrumentation centers, and there is some provision for flushing and draining away residues.

c. Input Materials. Generally, raw material in ingot form and subassemblies and accessories may be seen. Propellants or their components, or both, may be received by truck and railway tank cars.

d. Products. Engines normally are transported in shipping containers by rail or by truck. Empty containers are often stored outside the plant. Completed engines may also be outside, particularly in the testing area.

Section III. AIRCRAFT INDUSTRY

9-9. Airframe Plants

a. Location. Generally in or near large urban area, plants have direct rail connections and good all-weather highways. The key to identification lies in the necessity to use airfields or seaplane stations in flight testing the finished aircraft. The majority of plants are adjacent to airfields or seaplane stations; if not, there must be taxiways for moving the aircraft to the airfield.

b. Buildings and Equipment. The main assembly building is the largest and tallest of all buildings in the plant, especially in older plants. It has very large, clear spans in the interior as compared with buildings of similar size in other industries. The size of these spans is important. The building will have clear access to the airfield and large, hangar-type doors opening to the access strips. Aircraft are rolled out of this building and are often parked relatively near it. Among other buildings are forge and foundry shops; in newer plants these shops may be connected to the main assembly building.

c. Input Materials. Raw materials include large quantities of sheet, bar, and tube stock, and extruded forms of great variety, as well as ingots. The metals will probably be aluminum, steel, magnesium, titanium, or others of high strength-weight ratio. A considerable quantity of subassemblies and components, including engines, are received. These parts usually are crated and may be recognizable as parts of aircraft. In warm, dry climates, extensive use may be made of outdoor parts storage.

d. Products. Aircraft on a factory airfield are likely to be numerous, quite shiny and new, and all of the same type or of very few different types.

Information on the number and description of aircraft is important to determine the type of aircraft and production data.

9-10. Aircraft Engine Plants

a. Location. Plants are in or near large urban areas with good rail and highway transportation. Ordinarily, they are not located at an airfield.

b. Buildings and Equipment. A plant is likely to resemble any other metal fabricating shop except for the sound of engine testing, and buildings (test cells) in which the engines are tested. The sound of reciprocating, turboprop, turbojet, ramjet, pulsejet, or rocket engines, coupled with the presence of test cells, is an almost certain indicator of an engine plant or a major repair and overhaul depot. The type and intensity of sound are important information. Test cells are usually one of three basic types: the "thru"-type, the L-type, or the U-type. Test cells vary in size, but for large engines they are at least 30 meters long, 15 meters wide, and 15 meters high (100 feet X 50 feet X 50 feet). Distinguishing characteristics are their shape, the provisions for passing large volumes of air through them, and provisions for sound baffling. They are usually found in groups, since production rates and the length of performance test runs make more than one cell necessary for each plant. Test cells may be located in the plant proper or several miles from the plant area. The plant engages primarily in foundry, forging, machining, and assembly operations. Frequently, these shops are under one roof. Sand piles may indicate the presence of a foundry; rhythmic pounding may come from a forge shop or stamping machines; and scrap piles could point to a fabrication shop and the type of fabrication. Nu-

merous short vent stacks may indicate heat-treating areas.

c. Input Materials. Incoming raw materials will be in ingot form. Subassemblies and accessories may be shipped into the plant. Aluminum and magnesium ingots, and sand for molds may be observed in open storage near the plant.

d. Products. Aircraft engines may never be seen as a completed item, but the size and shape of shipping boxes should be noted as they are seen entering or leaving the test cells.

9-11. Aircraft Component Plants

a. Location. Plants may be in large urban areas or near small towns. The labor force may be smaller than in airframe or engine plants.

b. Buildings and Equipment. With the exception of propeller manufacturing plants and airframe subassembly plants, it is almost impossible to identify plants manufacturing aircraft components. The propeller plants, especially those manufacturing large propellers, will have one or two propeller test cells. These cells are similar to engine test cells, but because of the need for greater and smoother air flow, they are generally larger than engine test cells, and the "thru"-type is more prevalent. The size of the cells is important. Airframe subassembly plants bear a resemblance to airframe plants.

c. Input Materials. Input items include ingots or bars, as in engine plants. Semifinished forgings or extrusions may be in view. In the case of sub-

assembly plants, input material is sheets, bar and tube stock, and extruded forms; however, the variety is not as great as that found at an airframe plant. Rough forgings may also be observed.

d. Products. Three-bladed propellers are sometimes shipped in a distinctive triangular box, which also indicates the size of the propeller. Airframe subassembly plants may be identified by the finished subassemblies awaiting shipment.

9-12. Repair and Modification Plant

a. Location. Plants will, of necessity, be located at airfields.

b. Building and Equipment. Repair plants are similar to manufacturing plants except that the foundry and forge shops are smaller in proportion to total plant size. It is difficult to distinguish between large repair bases and small production plants except for the lack of new aircraft, and the presence of sizable scrap dumps around the repair plant. Modification facilities will have only rudimentary forge and foundry shops, and there will not be many discarded parts lying around the plant.

c. Input Materials. The distinguishing points between the modification plant and the repair plant lie in the raw materials received. Much basic ingot material comes into a modification plant but very little goes to a repair plant. A repair plant receives a number of engines in need of maintenance and modification.

Section IV. ATOMIC ENERGY

9-13. General

The preliminary steps of an atomic energy industry—i.e., mining and concentration of uranium ore, and extraction of uranium from the ore—are performed in industrial facilities which cannot be distinguished readily from other facilities performing basic mining and metallurgical operations. The key portions of the industry are the plants which produce fissionable materials either by irradiating uranium in a nuclear reactor to produce plutonium and then chemically separating the plutonium from the uranium, or by separating the U-235 isotope from natural uranium by physical separation methods (usually by gaseous diffusion).

9-14. Installations

a. Location. Fissionable material production plants are usually located in isolated areas for reasons of security and safety, but may have associated residential communities nearby. Plants have very reliable power supplies, furnished by a combination of powerplants and connections to local power grids. In addition to good highway transportation, most production sites are rail-served.

b. Buildings and Equipment. Reactors capable of producing significant quantities of plutonium include power reactors, large research reactors, and reactors designed specifically for this purpose. Their physical appearances may vary

widely. Adjacent to the reactor building, a reactor stack normally emits no visible vapor or smoke. Most reactors designed specifically for plutonium production are cooled by water, heavy water, or a gas (CO₂), and substantial pumping or blowing equipment is necessary. Cooling towers and water purification equipment may also be seen. The building designed for the chemical separation of plutonium from the irradiated fuel elements is known as the *canyon building*. It is of heavy construction with a large amount of equipment below ground level. A large stack, 60 meters or more (200 feet or more), will be adjacent to the canyon building. Facilities for the disposal of radioactive wastes, such as buried tanks or secluded basins, are located nearby. A network of piping and chemical storage tanks is in evidence. Irradiated fuel elements, in heavy well-shielded casks, are removed from the reactor site to the canyon building, usually by rail. The gaseous-diffusion process for the enrichment of U-235 is carried on in extremely large buildings with several million square feet of floor space. Water cooling towers may be present along with a dependable supply of water. Huge electric power requirements are met by power substations and possibly local power-plants.

c. Input Materials. The only feed material suit-

able for the large-scale separation of uranium isotopes by the gaseous-diffusion process is uranium hexafluoride (UF₆). This material, although a gas at the temperature and pressure of the diffusion process, is a dense (300 lb. per cu. ft.) solid at ordinary temperatures. It is toxic and corrosive; it reacts readily with atmospheric moisture and vaporizes at atmospheric pressure without first melting. It is usually transported in low-pressure tanks of not more than a few cubic feet in capacity. Uranium hexafluoride may be produced at the site of the gaseous-diffusion plant, in which case the input material may be uranium compounds in the form of powders. Tremendous amounts of electric power are used in U-235 production by the gaseous-diffusion process. Lines entering the plant area are of high voltage and usually carry at least 8 insulator sheds. Feed material for plutonium producing piles is uranium metal, usually in the form of rods, bars, or sheets. The quantity of electric power required for this operation is much less than that required for U-235 production.

d. Products. The output of a plant producing either plutonium or U-235 will be shipped to a weapons production plant. The product will not be observed as it will be shipped under guard and well concealed.

Section V. CHEMICAL PLANTS

9-15. General

Chemical plants are often characterized by extensive tankage and visible piping. The plants may contain a few large buildings and a number of smaller buildings of light construction. Water supply and facilities for disposal of large amounts of waste liquid are essential to most chemical plants. This will dictate location on rivers, lakes, and seashores, or the use of cooling towers and waste disposal basins. The requirement for large amounts of process steam at most plants will make a steam plant necessary.

9-16. Chlorine Plants

a. Location. Primary considerations governing location are the proximity of consuming markets, availability of abundant and cheap electric power, and a nearby source of salt, the principal raw material. Plants generally are located on or near a body of water which serves as a source for steam and for cooling purposes.

b. Buildings and Equipment (Fig. 9-1). The

principal building, and the only one absolutely essential to the manufacturing process, is the electrolytic cell building. The cell structure is usually a long, low building flanked at one end or one side by a much higher structure which houses the power rectifiers. Good ventilation is essential; the building will have numerous windows or ventilators. Other items of equipment are the cooling and drying towers located in the cell building or in an adjacent or nearby building. If the towers are located outside the cell building, a maze of pipelines may be seen connecting the buildings. A strong smell of chlorine will permeate the plant area. Caustic soda (sodium hydroxide), also produced in a chlorine plant, is fused in a building recognizable by its row of stacks.

c. Input Materials. Salt is the principal input material; however, as salt is extremely soluble, it will be stored under cover, transported in closed conveyances, and may not be visible. Also, salt is an input item for numerous other chemicals, and its presence alone is not proof of the existence of a chlorine plant.

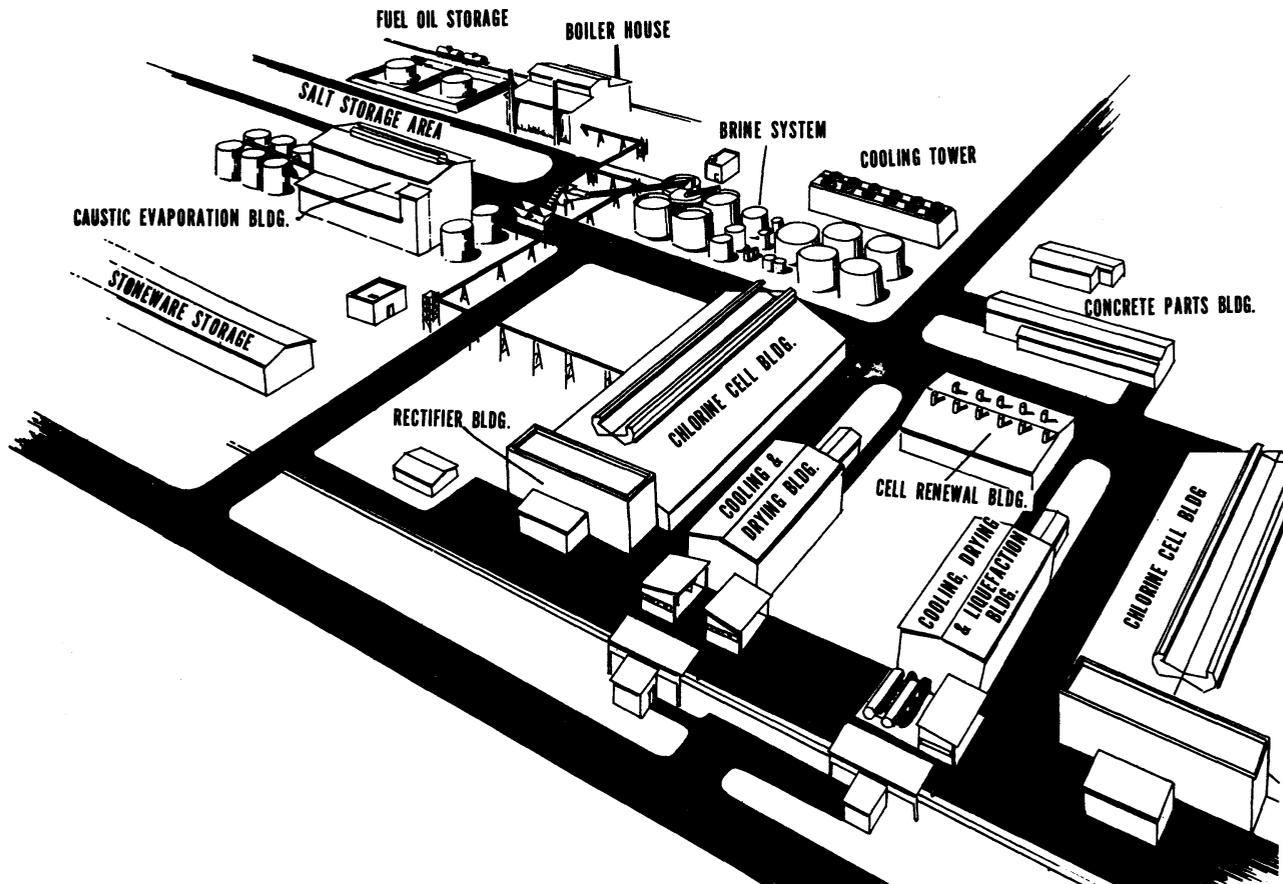


Figure 9-1. Sketch of chlorine plant.

d. Products. Chlorine, as initially produced, is a greenish-yellow gas with a noxious odor and an irritating effect on the membranes of the eyes, nose, and throat. Chlorine may be converted readily to a yellowish liquid that can be transported in cylinders, drums, or tank cars. Caustic soda may be in clear liquid form or in white powder, flakes or pellets. Because of its corrosive nature, caustic soda must be packed in wooden or metal containers.

9-17. Oxygen Plants

a. Location. Plants are found in many industrial areas, such as welding, metalworking, steel production, chemical manufacturing, etc. Although most oxygen used in such industrial enterprises is in gaseous form at the time of use, it is frequently produced as a liquid and gasified prior to use to facilitate shipping and storage. In many cases a plant is an integral part of a large manufacturing complex, such as a steel mill, and it supplies a portion of its produce directly to the adjacent users in gaseous form.

b. Buildings and Equipment (Fig. 9-2). Most oxygen plants built by the same company are fairly similar in overall configuration and vary only in size and physical layout of the structures. The manufacture of liquid oxygen by air separation is a straightforward process with no unusual techniques that are, within themselves, characteristic of its production; however, there are a number of characteristics which together, are indicative of a liquid oxygen plant. These are:

(1) *Power requirements.* One of the most obvious characteristics of a liquid oxygen plant is the large amount of electric power required. This requirement is greater in relation to the actual size of the plant than for most other manufacturing facilities. Thus, a number of high tension wires and possibly an electrical substation will be one indicator.

(2) *Water requirements.* Large quantities of water are required. In the absence of an abundant water supply, large cooling towers will be necessary. Storage tanks are often necessary to insure an adequate and continuing supply of water.

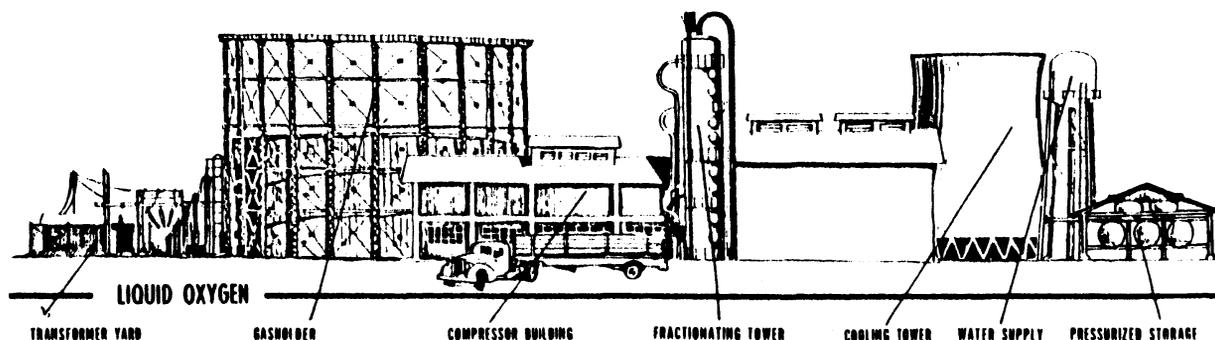


Figure 9-2. Sketch of liquid oxygen plant.

(3) *Storage facilities.* Liquid oxygen plants will have sizable storage facilities. Most of them produce equal or greater quantities of liquid nitrogen which must also be stored. Storage facilities vary in size and configuration; tanks may be located in the open, in separate buildings, or inside the production building. A prime indicator of a cryogenic produce storage facility (not necessarily liquid oxygen) is the evidence of frost on transfer lines at uninsulated points, such as joints and valves. Assuming the use of adequate insulation, no vapors will be visible from storage tanks except during the time when tanks are being filled; however, the dense white vapors associated with liquid oxygen evaporation may be observed under the same conditions with any cryogenic liquid. The white vapors are nothing more than water vapor frozen by the extremely cold escaping gases.

(4) *Transportation equipment.* Transportation equipment may include cylinders for gaseous oxygen, small trailers, trucks, or railroad cars.

(5) *Physical configuration of the plant.* Important features to be noted are storage tanks, distillation columns, water storage tanks, water cooling tower, loading facilities, electric power lines, ventilation louvers, gas holder, air intakes, and allowances for overhead traveling cranes inside the building.

c. Input Materials. There are no major recognizable raw materials; air is the major input.

d. Products. Gaseous oxygen may be shipped as a compressed gas in metal bottle-shaped cylinders similar to the conventional cylinder used in welding or it may be shipped in much larger cylinders, horizontally mounted on rail cars. It may also be piped to nearby consumers. Liquid oxygen and nitrogen may be shipped in double-walled spherical or cylindrical containers. Relatively small

quantities of rare gases, such as argon and neon, may be produced and shipped, although these generally would not be detected.

9-18. Sulfuric Acid Plants

a. Location. Located near a river or lake for necessary water supply, the plant will normally be part of or adjacent to a plant which uses sulfuric acid in the production of other chemicals. Acid plants using smelter gases as raw material will be found adjacent to copper, lead, or zinc plants.

b. Buildings and Equipment (Fig. 9-3). Equipment may be located either in the open or in lightly-constructed buildings, depending on the climate. The equipment will vary, depending on whether the plant uses the contact process, the chamber process, or the tower process—a variation of the chamber process. Common to all plants, except those using smelter gases, are large sulfur or pyrite roasting kilns. All plants have acid storage tanks. If the plant uses the contact process, its most notable feature is a series of absorption towers about 5.5 meters high and 5.2 meters in diameter (about 28 feet high and 17 feet in diameter). A conventional chamber process plant will contain a series of large rectangular lead chambers and Glover and Gay-Lussac towers (square, brick towers, 9 to 12 meters high). The tower process equipment resembles chamber process equipment except for the substitution of packed towers for the lead chambers. The smell of sulfur and sulfur oxide fumes is detectable. Strict safety precautions are taken to avoid contact with the acid.

c. Input Materials. Except for those acid plants which use raw material smelter gases piped from adjacent nonferrous metals plants, there will be large supplies of either sulfur (yellow crystalline powder), sulfide ores (yellow in color), or, to a

lesser extent, gypsum (a white powder). These are the basic raw materials to be fed into the roasting kilns. They normally arrive at the plant by rail.

d. Products. Sulfuric acid is a heavy, viscous liquid, practically colorless, smelling of sulfur oxide. It is normally shipped either in tank cars or in glass carboys (bottles). Stringent safety precautions are taken in the loading of the product.

9-19. Synthetic Ammonia Plants

a. Location. Most plants are located on the outskirts of a city or town.

b. Buildings and Equipment. A plant will have several tall gasholders for the storage of raw gas, hydrogen, nitrogen, and synthetic ammonia. Another identifying feature may be a battery of coke ovens or a gas generator. A converter building and compressor building are essential. These buildings are often combined into one unit, in which case the converter portion is the taller. Hydrogen and nitrogen, the basic raw materials, are compressed in the compressor buildings and forced into the converters where they are combined under pressure to form synthetic ammonia. Other facilities collocated with a synthetic ammonia plant may include a fertilizer plant and storage building, and a nitric acid plant, identified by a nitric acid absorption tower, which produces a reddish-brown smoke.

c. Input Materials. The major input material is hydrogen which may be obtained from petroleum refineries, coke oven gas, water gas, or the electrolysis of water or brine. Coke oven gas is transported to the plant through a large pipe which could be as much as 5 feet in diameter. Plants of more modern design obtain hydrogen from natural gas or hydrocarbons of petroleum sources.

d. Products. Synthetic ammonia is shipped in metal cylinders, carboys, and in pressurized or insulated tank cars. Shipping containers and tank cars usually carry special designations or color codes identifying the contents.

9-20. Synthetic Rubber Plants

a. Location. Normally, plants are located near petroleum refineries, ethyl alcohol plants, or calcium carbide plants, depending on the raw material the plant is designed to use. If it produces chloroprene rubber, there will normally be an adjacent chlorine plant. In all cases, synthetic rubber plants are located near a large supply of water which is needed for the production process. Plants may be found near rubber fabrication plants to reduce transportation costs.

b. Buildings and Equipment (Fig. 9-4). The plant will contain a series of multistoried buildings of medium construction; however, much of the equipment is in the open. A maze of piping and tall towers will be visible. Equipment will vary with the raw material used and the type of synthetic rubber to be produced. General-purpose plants contain numerous storage tanks for butadiene and other intermediate products. Highly flammable materials are involved in the production of synthetic rubber of any type and, as a result, extensive firefighting equipment will be found. In addition, butadiene storage tanks may be placed under water as an added precaution. If ethyl alcohol or petroleum fractions (either butylene or isobutylene) are used as the raw material, an extensive tank storage farm will be visible. The smell of rubber will be evident.

c. Input Materials. If ethyl alcohol is used as the basic raw material, the plant will be served by tank cars delivering the product to the alcohol storage farm. If petroleum fractions are used, the

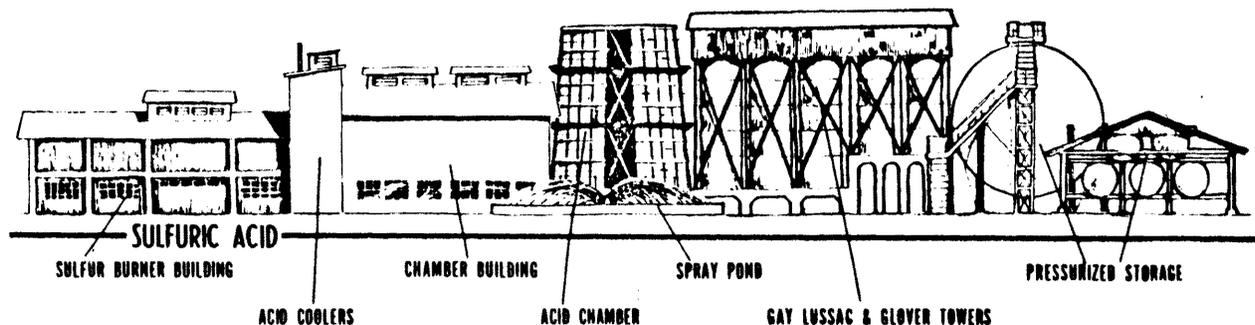


Figure 9-3. Sketch of sulfuric acid plant.

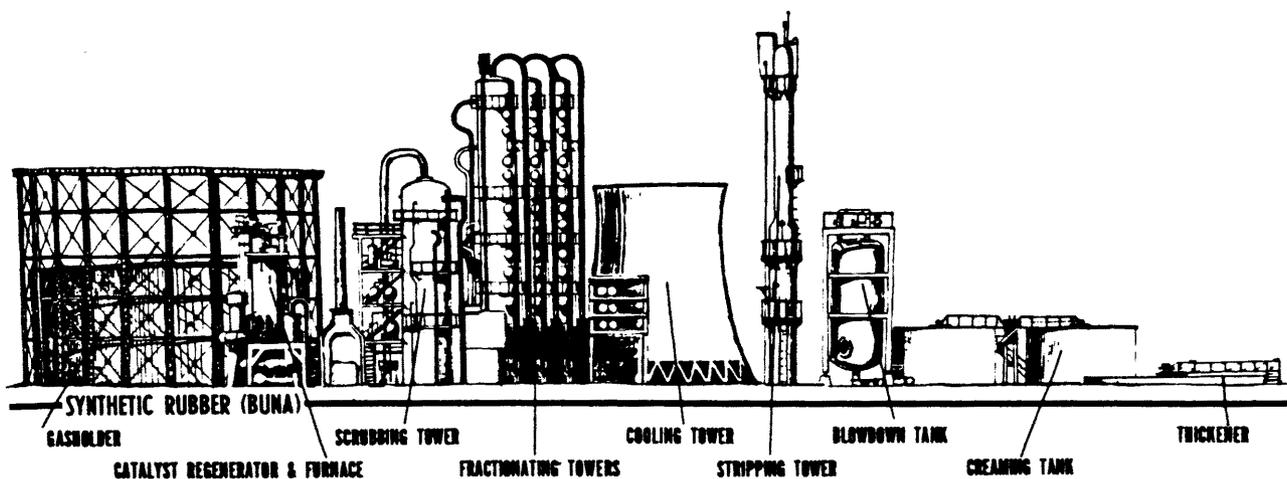


Figure 9-4. Sketch of synthetic rubber plant.

raw material may arrive by tank car or may be piped from a neighboring refinery. If calcium carbide is used as the basic raw material, it will be stored in airtight metal drums.

d. Products. Synthetic rubber is normally shipped out in bales; however, in the form of latex, it may be shipped to fabricating plants in tank cars.

Section VI. COKE, IRON, AND STEEL MILLS

9-21. General

The manufacturing processes of coke, iron, and steel are so completely interdependent and closely associated they are treated as an integrated plant in this manual. The interdependence stems from the need for coke and coke oven gas as fuel in the production of the metals, while a large percentage of blast furnace gas is used in production of coke. It is possible for units of this interdependence to operate independently, and occasionally they will. Therefore, it must not be assumed that because a blast furnace is seen, coke ovens, rolling mills, or open-hearth furnaces also exist in the complex.

9-22. Installations

a. Location. Integrated steel plants are usually found in or near coal producing areas where abundant water supply and cheap transportation are also available. Iron ore is transported to the plant, sometimes from great distances. Most plants are situated close to urban areas where an adequate labor force is available.

b. Buildings and Equipment (Fig. 9-5).

(1) Units of an integrated steel plant include a byproduct coke plant consisting of a long row or rows of coke ovens, surmounted by tall coal bunkers or towers from which coal is fed to a hopper

car to be deposited into the individual coke ovens through holes in the top. One coal tower usually serves two batteries of coke ovens. Each battery is served by a tall stack. The white-hot coke is pushed out of the oven by a pusher or ram on one side of the battery into an open railroad car on the other side which quickly rolls under a quenching tower (sometimes a part of the coal bunker) where the coke is cooled with a spray of water. This quenching operation creates a dense cloud of steam which can be seen for some distance. The coke is then ready for use in the blast furnace.

(2) During the carbonization of the coal in the ovens, gas and tar are produced as by-products.

(3) The blast furnace, where pig iron is produced, is a cylindrical steel shell lined with fire brick. It is served by an inclined track or elevator (skip hoist) by which the raw materials are carried to the top of the furnace and dumped in. On its way to the furnace, an air blast is heated in hot stoves which are cylinders nearly as tall as the blast furnace and about 6 meters (20 feet) in diameter. Care should be taken not to confuse these hot stoves with the blast furnaces. There are at least three and usually four hot stoves for each blast furnace.

(4) There are four methods of making steel from pig iron: open-hearth furnace, Bessemer

converter, basic oxygen converter, and electric furnace. The open-hearth process is the most widely used and accounts for 80 to 90 percent of all steel produced. Furnaces are usually arranged in groups of three or more in a long steel-framed building about 45 to 60 meters (150 to 200 feet) wide, and varying in length according to the number of furnaces. These buildings are the largest of all the surrounding structures and are distinguished on the outside by a row of tall smokestacks, one for each furnace. The preferred type of roof is unsymmetrical gable with the smokestack side (charging side of the furnace) wider and terminating closer to the ground. The Bessemer converter is a tilting, pear-shaped vessel, with a capacity of from 5 to 45 tons per charge. After it is filled with molten iron, air is blown up through

the molten mass from holes in the bottom. The "blow" or burning off of impurities which lasts from 15 to 30 minutes, lights up the area with a bright flame that occasions their popular name of "blast furnaces." During the day, a large cloud of yellow smoke may be seen whenever a blast furnace is working. The roof over the Bessemer converters is usually open to allow the hot gases and smoke to escape. They may be housed in a section of the open-hearth building to take advantage of the handling equipment, or they may be in a separate smaller building. The basic oxygen converter (fig. 9-6) is manufactured in the 35 to 50-ton capacity range, and can be much larger. This type of converter may be found associated with the open-hearth furnace shops. Electric furnaces may be very small (1 ton or less) or they may have a

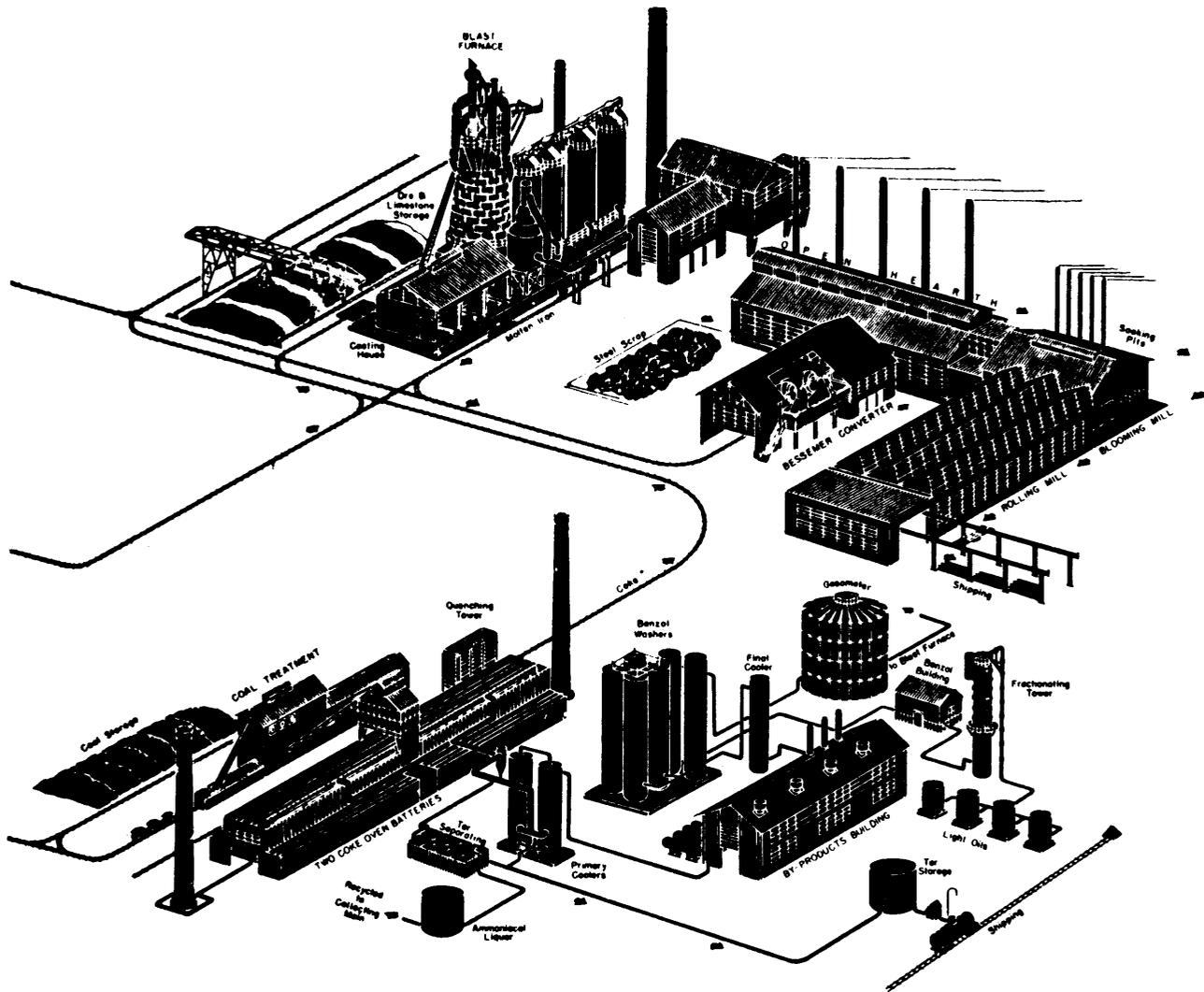
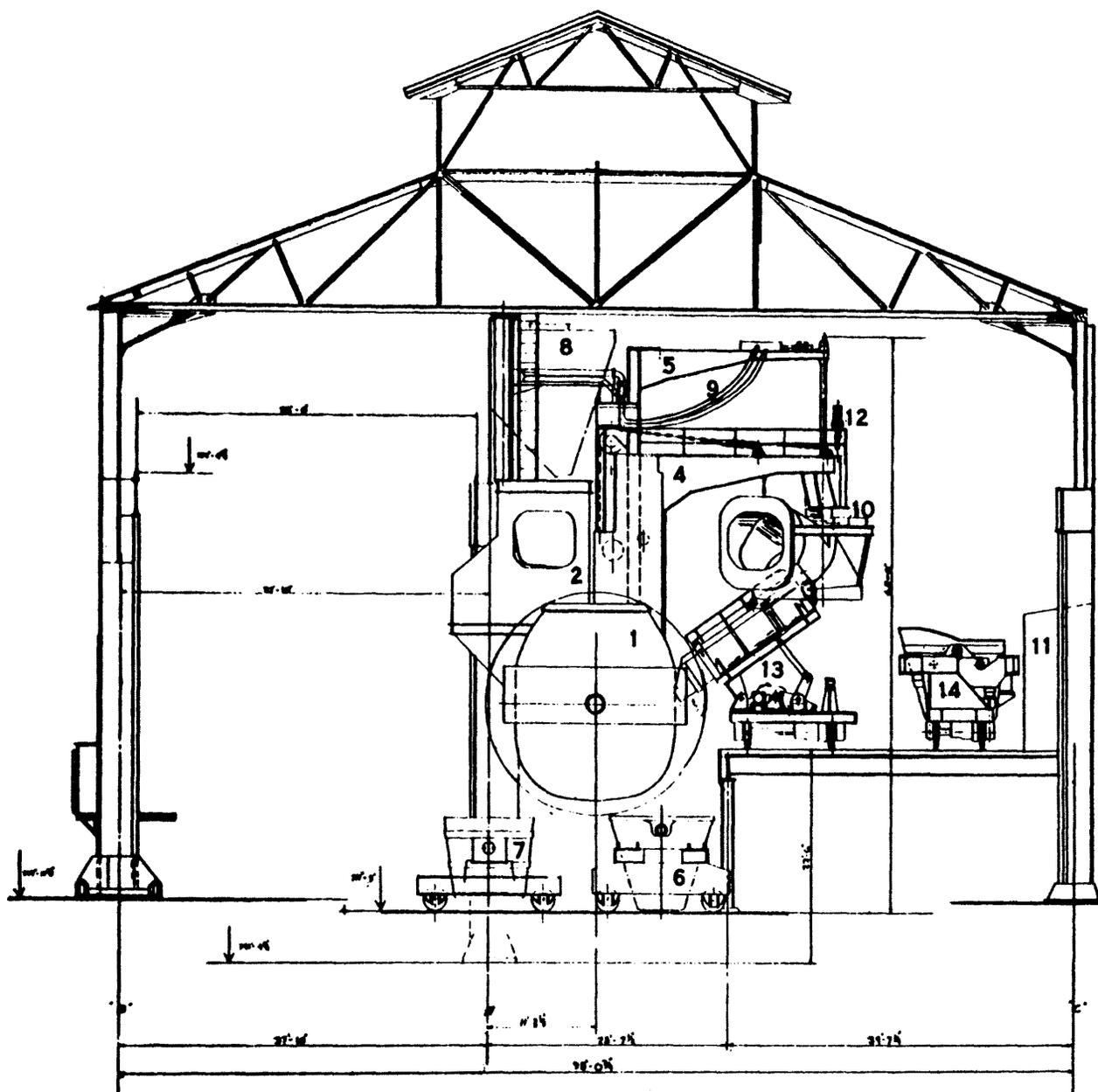


Figure 9-5. Generalized sketch showing typical features of an integrated iron and steel plant.



(1) Furnace, (2) Dust Collector—Spark Box, (3) Water-cooled Hood, (4) Hood Post Crane, (5) Lance Retracting, (6) Slag Pot Car, (7) Steel Transfer Car, (8) Additive Bins, (9) Flexible Hose, (10) Lance Gate and Clamp, (11) Converter Pulpit, (12) Auxiliary Hoist, (13) Scrap Charging Car, (14) Hot Metal Charging Car.

Figure 9-6. A typical basic oxygen converter installation.

capacity of 25 tons or more. The building housing electric furnaces has no distinguishing characteristics but will have a set of electric power transformers nearby.

(5) The rolling process involves running the hot steel ingots between a series of heavy rollers which press the steel into various elongated shapes. Ingots must first be heated to a uniform high temperature in soaking pits. The soaking pit

building can be identified by a row of smokestacks. Open-hearth smokestacks are much heavier and taller than those for soaking pits. Rolling mill buildings, usually long and monitor-roofed, have no particular identifying features, but are always adjacent or attached to the soaking pit building and the process is extremely noisy. They usually have a craneway extending into the open from one side or end.

c. Input Materials. Major visible input materials are iron ores (ranging in color from dark grey to a dull reddish-orange), coal, and limestone. When coke ovens are not present, coke becomes an input material. Coke will appear to be dark grey, porous, and uniform in size. Should the plant have only open-hearth furnaces, pig iron will be a major input material. The industry requires a large amount of electric power and water. Many plants have their own generating facilities; others depend on outside sources. When a plant is not

located on a river or large body of water, it will have cooling towers or spray ponds.

d. Products. Coke and coke chemicals are produced in the coke ovens; pig iron and slag (which may create large slag dumps) are products of the blast furnace. Steel ingots are the product of steel-making furnaces, and rolled steel shapes are produced in rolling mills. Rolling mills may produce only billets, usually round bars; slabs, elongated pieces with a rectangular cross section; or, semifinished or finished sheets, rails, or shapes, such as I-beams or channels.

Section VII. ELECTRIC POWER INDUSTRY

9-23. General

Almost all outdoor components associated with the electric power industry can be readily identified by nontechnical observers. Principal components are the powerhouse, transformer substation, transmission lines, and water storage reservoirs. Almost every generating plant has a transformer station within its own area, located near the generator hall. There are, in addition, many transformer substations situated separately and connected to generating plants only by way of long-distance, high-voltage transmission lines. In general, the smaller the power installation, the more obscure are the recognition features.

9-24. Hydroelectric Power Plants

a. Location. Plants are on or near a river or other body of water. Water flow is controlled by one or more dams. In flat terrain, the plant is frequently constructed at a relatively narrow point on the river and at a location where the land facilitates construction. In mountainous terrain, natural gorge-type sites are utilized; dam and powerhouse are constructed on the downstream extent of the gorge, with the gorge serving to contain the reservoirs. Dam and powerhouse are separated, often by considerable distances.

b. Buildings and Equipment. Components are dam, powerhouse, transformer station, and high-voltage transmission towers. There are, however, three principal types of facilities which differ in appearance in many essential aspects:

(1) *Foot-of-dam.* This type consists of one or more parts, including an earth dam, a concrete powerhouse section, a spillway, and locks to permit passage of boats between the reservoir and river. In some instances, the powerhouse may not

be discernible in that it is combined within the spillway. In others, the spillway is an integral part of the main dam and is difficult to recognize. On the downstream side of the powerhouse, turbine water discharge outlets may be visible; the number of outlets are important in determining the number of turbines.

(2) *Separated dam and powerhouse.* This type is built in mountainous areas to provide the necessary water pressure by using a difference in height between the water source and the powerhouse site. Prominent features are systems of open canals, tunnels, and penstocks (large downhill pipes leading to the powerhouse) which carry water from the dam to the powerhouse, frequently over a distance of many miles. The size, length, and number of penstocks is important in estimating the number of turbines and the capacity of the plant.

(3) *Run-of-river.* This type is operated by using the direct flow of the river, and does not have an associated reservoir. The generator hall may appear to dam or bridge over a canal or narrow river.

c. Input Materials. The input material is water under pressure. It flows from a higher to a lower elevation and imparts its energy to the turbines. The vertical distance through which the water drops (known as the water head) is significant. A drop of 30 meters (100 feet) or less is classed as low head; 30 meters to 305 meters (100 feet to 1,000 feet), high head.

d. Products. The only product is electrical energy fed from the turbogenerators via transformers and switch-gear to transmission lines for ultimate delivery to customers, usually many miles distant.

9-25. Thermal Power Plants

a. Location. Plants are frequently located near the points of major power consumption, although some may be located near the fuel source, as in a coal mining region. Space is required for receiving and storing fuel, and in most cases cooling water must be available. Plants located in regions of inadequate water supply must have cooling towers or spray ponds.

b. Buildings and Equipment. Plants consist of a compact group of buildings and prominent smokestacks, often quite tall. The number of smokestacks is a significant aid in determining the number of boilers and turbines and evidence of plant expansion. The boiler house and the turbogenerator hall are frequently incorporated into one rectangular, multistory, masonry or concrete building with an attached electrical control house. The highest section is the boiler house; metal smokestacks rise from its high roof, or masonry stacks rise in a line along the outside of one wall. The adjacent medium height section is the generator hall. The lowest section is the electrical control house. The largest transformers may be outdoors. Additional facilities may include railroad sidings, inclined conveyors, car dumpers, oil tanks, coal storage yard, switchgear, high-voltage transmission towers, cooling towers, spray ponds, and pump houses. The construction of complete plants with no walls and very little roof is a recent development. Large industrial plants, such as steel mills and petroleum refineries, may include thermal powerplants to furnish heat and steam in addition to electric power. The powerplant structures are usually grouped together rather than scattered through the larger industrial premises and can be readily recognized.

c. Input Materials. Fuel, the basic input material, is received, handled, and stored in large quantities. Coal, peat, and oil are the common fuels; natural and manufactured gas are also used to some extent. In most cases large quantities of water in steady flow are needed to cool the steam condensers.

d. Products. Usually there is only one product, electrical energy. Some plants may, in addition, provide heat and industrial steam to nearby industrial or urban sites.

9-26. Internal Combustion and Mobile Power Plants

a. Location. The plant is generally located very

close to its power consumers. It is relatively small in size and may be mounted on truck, trailers, skid, or railroad car. Truck-mounted plants are not readily identifiable. Rail-mounted plants may be either steam- or diesel-driven. Steam-driven types, when in stationary operation, may be identified by condensers on the car roofs and at least one stack on the boiler car roof. Diesel types could merely resemble diesel locomotives. It is probable that most train-mounted missile launching systems would utilize train-mounted diesel power.

b. Buildings and Equipment. Stationary plants of significance usually have diesel engine-driven generators. The generator hall is small and of medium height, with a row of short, small-diameter stacks protruding from the roof. In some cases cylindrical exhaust silencers are located just outside the wall, each with a short stack extending above the roof line. Oil storage tanks and small water cooling towers may also be observed.

c. Input Materials. Fuel is used for diesel engines. Cooling water may be required, but in quantities so small as to elude observation.

d. Products. Electrical energy is the only product.

9-27. Nuclear

Few nuclear power plants are in existence, and each is unique in most aspects. Their design is still experimental, and standard visual recognition features are difficult to establish. The reactor building may appear as a steel structure, spherical or at least dome-shaped. Nuclear fuel is handled either within the reactor building or in adjacent buildings; there is no requirement for handling and storing conventional fuels. An exhaust stack will probably be visible, but, in contrast to a conventional plant, it will not issue smoke. Special containers for handling spent fuel may be on the premises. The turbogenerator hall, electrical control house, and transformer station are features common to both nuclear and thermal powerplants.

9-28. Transformer Substations

a. Location. Transformer facilities situated apart from a generating plant are called substations. They are located relatively close to industrial or populated sites where any sizable amount of power is received for use on dense power networks, or on long distance lines at convenient sites for economical power switching and not necessarily near power consumers. Substa-

tions receive power and modify it (usually only its voltage and current) in preparation for more economical distribution and for utilization by various power consumers.

b. Buildings and Equipment. In outdoor substations most of the equipment can be identified. Significant features include transformers, associated switchgear (some of which may be within a building), switches, circuit breakers, lightning arresters, and other related equipment. Indoor substations are identified principally by the numerous powerlines leading into and out of a small building. Transformers are frequently located outdoors.

c. Input Materials. The input is electrical energy, received over long distances via at least one high-voltage transmission line from one or more generating plants.

d. Products. The only output is electrical energy, distributed at acceptable lower voltages via numerous distribution lines, to several power consuming points within relatively short distances.

9-29. Power Transmission Lines

a. Location. Ideally, power transmission lines may follow perfectly straight routes between generating plants and transformer substations. In reality, deviations are necessary to avoid wide river-crossing, to minimize changes in elevation in mountainous regions, and to minimize right-of-way acquisition and clearance costs. Frequently, the most expedient route is one that parallels an existing transportation medium. An actual transmission line consists of a series of straight line

segments, with angular deviations at turning points usually less than 10° and only occasionally greater than 30° . The smaller turns may not be noticed by the casual observer.

b. Buildings and Equipment. High-voltage transmission lines consist of a series of steel, wood or concrete tower-like frameworks with crossarms. The towers support chains of porcelain insulators which in turn support the bare metallic conductor cables. The number of insulators is significant. A large number of insulators indicates a higher voltage; however, the number may be increased in swampy areas and when powerlines are in proximity to other lines. Insulators which are bundled (usually two rows of parallel insulators per conductor) do not increase the carrying capacity of the line above that of a single row of insulators. The usual transmission line supports either three or six widely spaced conductor cables; in some rare cases nine cables may be carried on a tower. In addition to the conductor cables, there may be, at the highest level of the towers, one or two uninsulated ground wires to reduce vulnerability to lightning. High-voltage towers vary in height from 45 to 150 feet and are spaced at intervals of 500 to 1,300 feet. The higher the towers the greater the spacing between towers and, consequently, the higher the voltage of the powerline.

c. Input Materials. The input material is electrical energy received from a generating plant, in some cases by way of a transformer substation.

d. Products. The only output is electrical energy delivered to a transformer substation.

Section VIII. ELECTRONICS INDUSTRY

9-30. General

The electronics industry includes tube and lamp plants, communications equipment plants (radio, TV, telephone and telegraph), electronic parts plants (resistor, capacitors, etc.), and special equipment plants (radar, sonar, etc). These plants are generally found separately, but it is not unusual to find one plant engaged in two or more fields of activity. Most modern plants incorporate an integrated electronics components manufacturing facility with equipment assembly and research.

9-31. Installations

a. Location. The prime factor governing location is a labor force. Large plants are located in urban areas; smaller plants can be located in small towns. Rail connections are not essential except for plants producing large items, such as ground radar. Most products and raw materials are moved by truck.

b. Buildings and Equipment. Plants have few characteristic features which permit recognition by external observation. They are housed in light industrial buildings of various sizes and shapes.

From the outside, there is no discernible relationship between the appearance of an electronics plant and the flow of production materials within. Features most useful in recognition are labor force, antennas, and finished equipment under test. The labor force, observable during shift changes, is composed largely of women. Antennas for test, calibration, and research and development purposes often appear on roofs, although newer plants may use a tower for service ease or security reasons. Also, antennas may be located in areas adjacent to the plant. Large items of finished equipment under test can sometimes be seen at or near plants. Gas storage facilities are peculiar to tube and lamp plants, which require large amounts of gas, both natural and processed.

c. Input Materials. End-assembly plants receive shipments of most input components (tubes, capacitors, resistors, transformers, etc.), as well as raw and semifinished materials such as copper, copper wire, chemicals, steel wire, and insulating materials. Electronic tube plants may fabricate their own tube envelopes in attached glass plants or receive finished glass input from a vendor.

d. Products. Practically all products are packed, with the exception of large radar units. These may be installed on truck chassis at the plant or parts may be shipped to ultimate users or final assemblers. Research and development facilities will produce only prototypes or very limited production runs. The amount of material leaving such plants will be negligible.

Section IX. MACHINERY AND EQUIPMENT INDUSTRY

9-32. General

The plants in this group have no general distinguishing features; however, they do have common characteristics in their versatility. Equipped with a variety of basic tools, they can, by making certain adjustments, readily convert to the production of a variety of items. Similarly, output capacity cannot be predicted on the basis of previously observed production. General identifying characteristics include size and conformation of buildings, heavy handling equipment, and outdoor storage.

9-33. Abrasives Plants

a. Location. Crude abrasives plants are governed in their location by a need for cheap and plentiful electric power. Bonded abrasives plants are located according to economic factors.

b. Buildings and Equipment. Units of a crude abrasives plant consist of a furnace building (with heavy electric powerlines), storage silos, dust collectors, and conveyor lines. Abrasives bonding plants may be identified by piles of crude abrasive stones which vary in color from pink to dark brown; the peculiar round stacks above rotary kilns; and the gray dust and the dust collectors associated with crushing, screening, and truing operations.

c. Input Materials. If the crude abrasive is aluminum oxide, the major input material is bauxite (often red in color). If it is silicon carbide, the raw materials are coke, sawdust, and silica sand.

Abrasive stone (light pink to dark brown in color) is the raw material for bonding plants.

d. Products. Either crude abrasive or grinding wheels are produced.

9-34. Agricultural Machinery Plants

a. Location. Plants are generally located near customers in farming areas. Rail service is found at plants producing the larger types of farm machinery.

b. Buildings and Equipment. Buildings vary with the types of machinery produced. Plants producing large combines and similar equipment will be of high, clear span construction permitting use of cranes. Other plants are generally single-story, assembly- or shed-type buildings. Finished products are often stored in the open in yards adjacent to the plant.

c. Input Materials. Steel sheets and bars, lumber, and cast iron parts comprise the variety of input materials.

d. Products. Products include the entire range of agricultural machinery from large combines to small gardening equipment.

9-35. Antifriction Bearing Plants

a. Location. Plants are located in the larger urban areas near customers.

b. Buildings and Equipment. Buildings conform to no definite or recognizable pattern. Facilities may be housed in multistory brick buildings or in

single-story, assembly-type buildings. There are no characteristic sounds or odors associated with the industry and no outside storage.

9-36. Storage Battery Plants

a. Location. Location is generally determined by economic needs.

b. Buildings and Equipment. Plants differ widely in construction and layout; there is no "typical" plant. Outside recognition often depends on signs or names. There are no distinctive odors, noises, or workers' clothing associated with battery plants.

c. Input Materials. Raw materials consist of rubber, zinc, and chemicals. All of these materials are probably received in covered containers, although glass carboys might be observed.

d. Products. Products are generally shipped in boxes or covered containers and will seldom be seen.

9-37. Chemical Equipment Plants

a. Location. Plants are normally situated adjacent to a rail line and have spur-track service.

b. Buildings and Equipment. Plants may be recognized by the semifabricated materials, such as pipes and sheet steel, or finished products, such as tanks, towers, vats, and stills stored in the yard. Structurally, these plants can seldom be distinguished from others in the heavy industry or metal fabrication field.

c. Input Materials. Pipes, steel sheets, and some steel shapes, such as channels or I beams, make up the input material. Some sheets and pipes will be of stainless steel.

d. Products. Products consist mostly of steel vessels of various sizes and shapes, partially assembled pipe groups, and partially assembled units comprising both piping and vessels.

9-38. Electric Wire and Cable Plants

a. Location. Located to meet economic needs, plants are usually rail served.

b. Buildings and Equipment. Facilities vary widely in design and size, depending on scale of operation, range of products, and age of company. The most common recognition feature is the large reels stored in open areas or leaving the plant on flat cars with finished cable. Odors of insulation

materials (natural or synthetic rubber and resin compounds) are characteristic.

c. Input Materials. The item in largest quantity will be copper or aluminum wire. Other items are resin compounds, rubber and cloth. With the exception of the wire arriving in coils, most input material is in closed containers. Although not a raw material, large numbers of empty cable spools will be received.

d. Products. Large size cable will be shipped on large wooden or metal spools. Small gauge wire will often be on spools in boxes.

9-39. Foundries

a. Location. Located near a labor pool and customers, a foundry is often an integral part of a larger installation.

b. Buildings and Equipment. Older foundries are usually untidy in appearance. The building where casting is carried on is a long gable- or monitor-roofed structure. The cupola stacks either protrude through the roof or through the lean-to addition to the main building. Stocks of coke, pig iron, and sand are found in open storage in the plant area. Molding flasks are often stored in the plant yard, and gantry cranes are usually visible in the yard vicinity. A pattern (woodworking) shop is in the plant area.

c. Input Materials. Coke, pig iron, steel, sand, and some scrap iron and scrap steel, are the major input items.

d. Products. Rough, semifinished or finished castings are shipped to customers. Castings are usually shipped from a covered dock but sometimes are left exposed on the ground.

9-40. Heavy Electrical Equipment Plants

a. Location. Location is governed by transportation and labor force needs.

b. Buildings and Equipment. The common feature is the heavy steel frame construction necessary for the support of large overhead traveling cranes. Plants usually have a foundry, a forge, assembly and production buildings, and auxiliary shops, as do all heavy equipment plants. Both materials and finished products are generally stored under cover.

c. Input Materials. In the large plants, pig iron, coke, and rough castings are received. Smaller plants may use small finished castings, wire, and copper products.

d. Products. Products include large electric motors, generators, transformers, and switchgear. Smaller units are boxed. Sometimes this type of plant assembles electric locomotives.

9-41. Heavy Equipment Plants

a. Location. Rail rolling stock, earth-moving, and mining and oil extraction machinery and equipment plants are usually rail-served and located near their customers; for example, oil extraction equipment would be manufactured in oil refining areas.

b. Buildings and Equipment. Buildings are of large, heavy steel frame with a high, clear span. Plant will include a foundry, a forge, and associated shops.

c. Input Materials. Raw materials consist of sheet, steel shapes, and subassemblies. Larger plants may receive steel billets or slabs if the plant has rolling capacity.

d. Products. Finished products are exposed at the end of the manufacturing process. Practically all products will be visible in the final assembly yard. Equipment is often disassembled for shipment.

9-42. Machine Tool Plants

a. Location. Plants are generally located near a large labor pool. Most plants are rail-served.

b. Buildings and Equipment. There is no typical building associated with these plants. The wide variety of tool sizes ranging from a small bench

lathe or grinder to a large shaper or radial drill requires different types of building for production. Characteristics, common to all buildings, will be a high, clear span with craneways and an overall orderliness to the plant area. Some plants have their own foundries.

c. Input Materials. Most smaller plants assemble tools from semifinished components such as castings, electric motors, small pumps, and semifinished steel parts. Large plants may produce many of the parts used in electrical equipment.

d. Products. Small tools are generally boxed for shipment although the very large units are disassembled and crane-loaded direct on rail cars.

9-43. Optical and Precision Instrument Plants

a. Location. The major factor governing location is the need for highly skilled labor.

b. Buildings and Equipment. Small plants could go unnoticed as they may be on upper floors of commercial buildings. In larger plants, production is normally carried on in multistoried buildings, with no external evidence of operation. Glassmaking facilities are sometimes associated with optical plants. The glassmaking buildings are usually parallel structures with a stack at one end. The glass furnace building can be confused with an open-hearth building if only the stacks are observed.

c. Input Materials and Products. There is little if any external evidence of materials and products.

Section X. NONFERROUS METAL INDUSTRY

9-44. Alumina Plants

a. Location. Plants may be located at a bauxite mine site, near an aluminum plant, or actually integrated with an aluminum plant. Usually the location, when away from the mine, is adjacent to water or rail transport facilities.

b. Buildings and Equipment (Fig. 9-7). The usual method of making alumina is by the Bayer process. In this process, the ore is crushed and roasted to remove any water. It is then ground very fine and "digested" with sodium hydroxide (caustic soda or lye) in autoclaves or large pressure cookers. The autoclaves are heated by steam; the steam boiler is usually in a separate building. The alumina in the bauxite is dissolved, while the

waste material remains solid. The solution is separated from the waste by Dorr thickeners and filters; the waste is piped to a red mud deposit, usually called a "red mud lake." The solution containing the alumina is piped to tall precipitation tanks, which may be identified by ventilators on the roof. Aluminum hydroxide precipitates to the funnel-shaped bottom of the precipitation tanks from which it is drawn off and sent through filters for removal of the liquid. The aluminum hydroxide is then sent to rotary kilns where it is calcined to produce alumina. The alumina is usually stored in tall silos.

c. Input Materials. The major input material is bauxite, which is usually very dusty, and may be

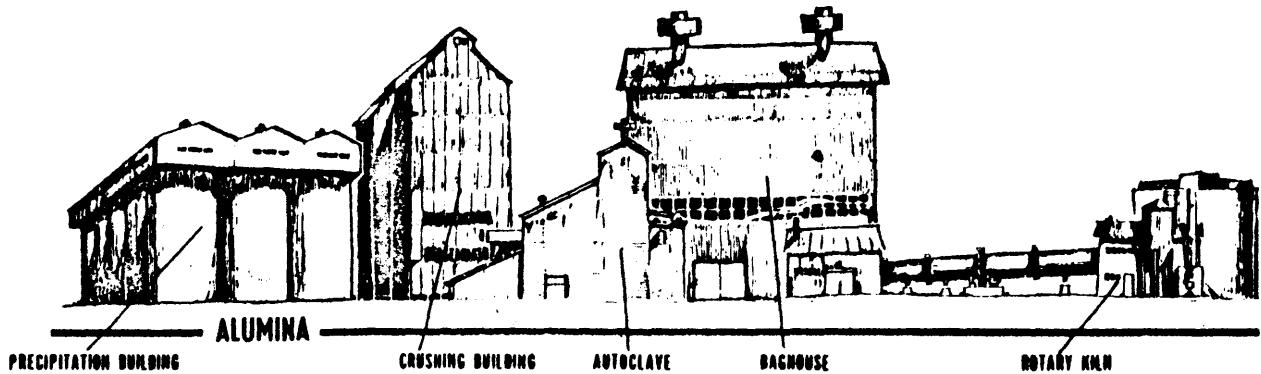


Figure 9-7. Sketch of alumina plant.

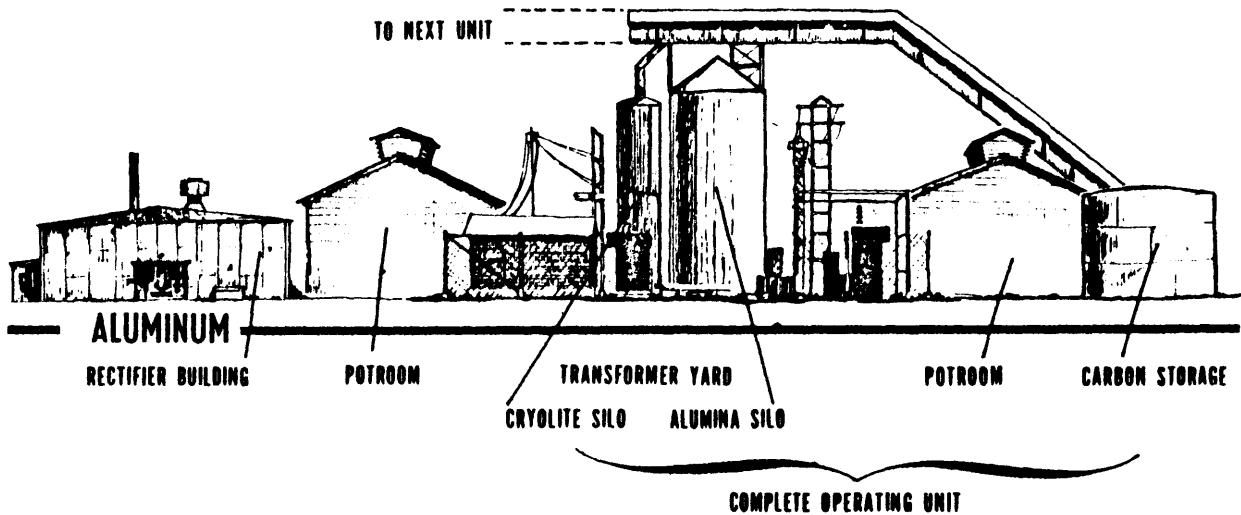


Figure 9-8. Sketch of metallic aluminum plant.

brown, yellow, reddish, light gray, or white in color.

d. *Products.* Alumina, a white powder, may be shipped in bags, boxes, or closed freight cars. The nearby "red mud lake" is quite easily recognized.

9-45. Metallic Aluminum Plants

a. *Location.* Plants are located where adequate electric power is available.

b. *Buildings and Equipment (Fig. 9-8).* In the most common Bayer process, alumina is dissolved in molten cryolite (aluminum sodium fluoride) in an electrolytic furnace called a "pot." These furnaces are housed in long single-story 137 to 183 meters (450 feet to 600 feet) buildings having monitored roofs. These buildings, called "pot rooms," are always parallel to each other in groups of two, three, or more. At one end is an alumina storage bin or silo. The pot rooms may also have a stack to carry off fumes. Extending

across the end of the pot rooms is a rectifier building and a transformer yard. There will probably be a carbon paste or an electrode plant associated with the aluminum reduction plant. This installation will probably be the only multistoried building in the plant complex. Elevated tanks will be visible and fabrication shops may be present. Casting, rolling, forging, or extruding buildings will normally be long, monitor-roofed, and of relatively light construction. Buildings housing heavy forging presses (10,000 tons or over) may be high-bay due to the size of heavy press equipment. The buildings will generally resemble light engineering plant structures, but in configuration will be more representative of a heavy engineering complex.

c. *Input Materials.* In addition to alumina, stored under cover, the most important input material is electric energy. A tremendous quantity of electricity will arrive at the plant on lines with about 7 to 10 insulator sheds.

d. Products. The aluminum is cast into pigs resembling iron pigs but light in color, and approximately two feet long. Other products will be slabs, billets, and various rolled or extruded shapes, plates, and strips.

9-46. Magnesia Plants

a. Location. Two sources are used to produce magnesia: dolomite and magnesite ores, and salt water or brine. Plants using magnesite and/or dolomite will be located near mines producing these ores. Plants using sea water or brine will be located on the shores of salt water or in areas of salt or brine deposits.

b. Buildings and Equipment. Magnesite or dolomite ore is simply crushed, powdered, or concentrated by flotation, and heated in rotary kilns to yield magnesia. Recognizable units are the silos and large roaster and filter buildings. A kiln is always located near the filter building. In the salt water or brine process, the salt water (or brine) is mixed with slaked lime (calcium hydroxide) or calcined dolomite, concentrated in thickener tanks, filtered, and finally heated in rotary kilns to yield magnesia. The plant is recognizable by the sea water pipeline, large flocculator tanks, and magnesium hydroxide rotary kilns. A small pump-house is usually located near the shore to pump the sea water to the hydrotreater tanks.

c. Input Materials. Ores are shipped in by rail and stockpiled near the primary crusher building. The ores are light in color and cause some discoloration in shipping and handling area. In the salt water or brine process, large pipes convey the water from the nearby ocean or salt lake, or the brine will be pumped through wells from subterranean deposits. A quantity of calcined dolomite

is shipped in. Seashells, a source of lime in one process of magnesia production, may be seen in large piles.

d. Products. Magnesia is shipped in covered containers from the storage silos. An additional output of the plant will be semiliquid tailing which will originate from the Dorr tanks.

9-47. Metallic Magnesium Plants

a. Location. Plants are located in areas of abundant electric power.

b. Buildings and Equipment (Fig. 9-9). Most magnesium is produced electrolytically. Units consist of kilns, chlorinators, and electrolytic cells. Large plants will be in a linear arrangement, but small plants with only an electrolytic section and associated units will not follow the pattern. The chlorinator building is a tall structure. The electrolytic building is characterized by rows of short, usually circular, ventilators.

c. Input Materials. Magnesium oxide is mixed with various salts and coal or peat, and fed into the kilns; if an electrolytic process is used, they are fed into a chlorinator. The salts and the magnesium oxide will be stored under cover. Electric energy is used in very large quantities. Lines with 8 to 10 insulator sheds will feed into the plant, and a large transformer station may be visible.

d. Products. Metallic magnesium is similar to aluminum in color; pigs are sharply defined, and will be easily confused with aluminum pigs. Ingots will also appear the same. Chlorinators produce an unrefined metal called "cheeses." These may be stored in the open awaiting refining in the electrolytic cells.

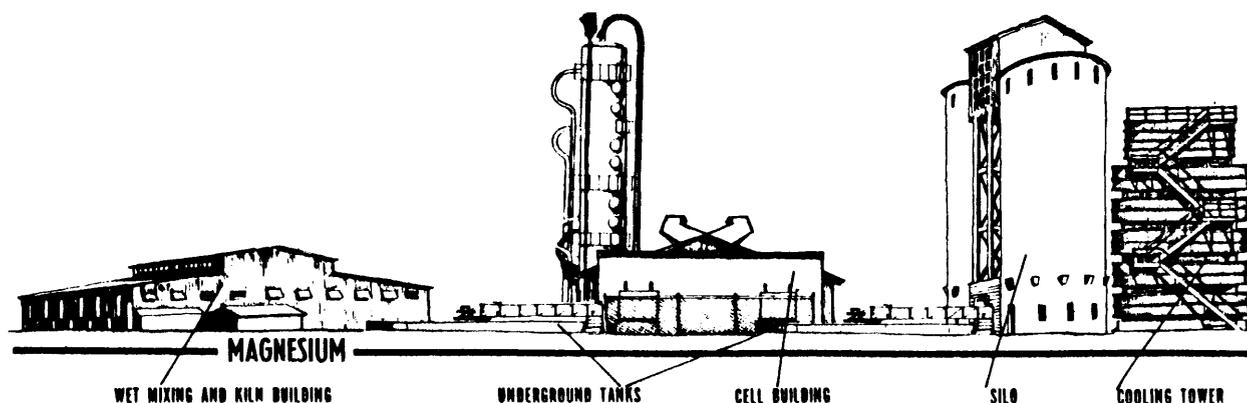


Figure 9-9. Sketch of metallic magnesium plant.

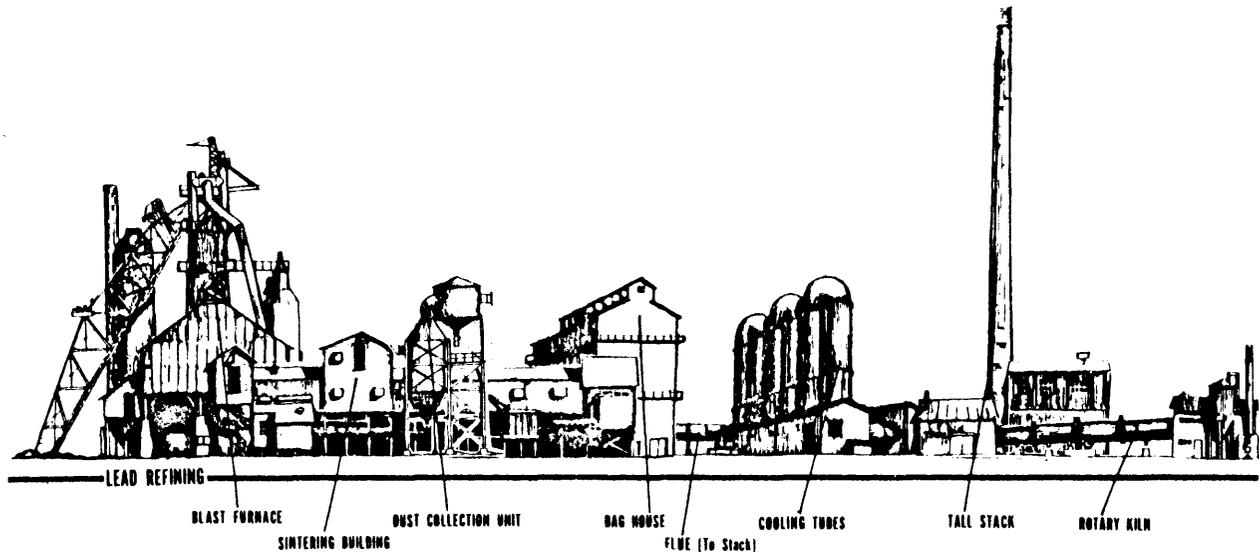


Figure 9-10. Sketch of lead refining plant.

9-48. Primary Lead Plants

a. Location. Because of the acrid and even deadly fumes given off, plants are generally located away from population centers. They are rail or water served and require an area where slag may be dumped.

b. Buildings and Equipment (Fig. 9-10). Plants are characterized by tall stacks, black slag piles, large flues connecting main production buildings with stacks and dust recovery system, and aerial and ground conveyors. Lead ore or concentrate is crushed and ground in the primary processing buildings which are medium-sized structures connected by conveyors. The crushed ore is then sintered and/or roasted to drive off sulfur and other impurities. The sintering building usually has a gable roof and is one of the larger buildings. Large flues carry gases and dust from these buildings to the dust recovery buildings. The sintered ore passes to the blast furnace building for smelting. The blast furnace building is normally the largest structure; the number of short stacks on this building determines the number of furnaces. The lead bullion produced by the blast furnaces is usually refined at the plant. The refinery is a large two-story building with a number of small stacks. Other installations surrounding the refinery include a casting building and solution tanks.

c. Input Materials. Ores or concentrates arrive in large quantities; additional materials are coal or coke, and fluxing materials. Lead ore is very dark in color, even black.

d. Products. Finished lead is cast into ingots having rather well defined shapes. They are usually rectangular with a heavy lip at each end. Freshly cast ingots have a silvery luster, but rapidly turn to dull grey. A very large amount of black slag is produced and dumped nearby. Some byproducts are produced, notably sulfur compounds.

9-49. Primary Zinc Plants

a. Location. Location depends on the existence of a sulfuric acid plant as a unit of the zinc smelter. Gases can be processed in the sulfuric acid plant, thus eliminating much of the adverse effects that would result in the surrounding area because of acid fumes. Plants are usually rail- or water-served.

b. Buildings and Equipment (Fig. 9-11). Zinc is produced principally by the horizontal retort method or by the electrolysis method. Both types of plants may include stacks, roasting buildings, ore preparation buildings, and cadmium and sulfuric acid plants. Ore or concentrate is brushed, ground, and roasted for the elimination of sulfur. The roaster building is usually very high with a gable roof. Flues may lead to a single large stack or to a sulfuric acid plant. The roaster building may have a stack for each furnace. In the horizontal retort process, the roasted ore is frequently sintered and mixed with coke or coal in preparation for smelting in the retort furnaces. The retort furnace buildings are usually four or more in

number, all identical, and with thick white smoke issuing from the several stacks attached to each building. Normally, a pottery plant for production of retorts is included in a horizontal retort plant. Frequently also, a zinc oxide plant is in the area. In the electrolytic process, the roasted ore is bleached and purified in a single building of moderate height, with several small stacks, and large pipes extending to the electrolytic cell building. The electrolysis building is the largest in the plant, with numerous pipes entering it, and several large tanks adjacent to the building. Other buildings include a casting building, a dust precipitator, and a sulfuric acid plant.

c. Input Materials. The two major input materials are zinc ore and coal or coke. The ore, light to dark brown in color, will be stored in the open or in hoppers.

d. Products. The main product is metallic zinc, usually in slabs about 2 feet by 4 inches. Color is a dull blue-gray. Electrolytic zinc is also found in sheets 3 feet by 2 inches. Zinc oxide, a white powder, is shipped in closed containers. Sulfuric acid

is shipped in carboys or tank cars of special design. Black slag will cover a large area.

9-50. Copper Smelters

a. Location. Production of commercial copper involves smelting of the ore to produce blister copper or anodes, and refining to produce marketable copper. Smelters are usually located near ore supplies in somewhat isolated areas. The noxious, brimstone-like fumes make a smelter a poor neighbor. Rail or water service from the mine and to the refinery is essential.

b. Buildings and Equipment (Fig. 9-12). Smelters are characterized by very high stacks, up to 150 meters (500 feet) issuing dense white smoke; sprawling black slag dumps; and wide flues connecting the principal production buildings. Copper smelters resemble lead plants but are generally much larger. The stack may be removed from the plant and located on high ground with a long flue extending to the plant (fig. 9-13). Ore or concentrate is crushed and ground in the crushing building, a tall structure with an irregular roof. It is

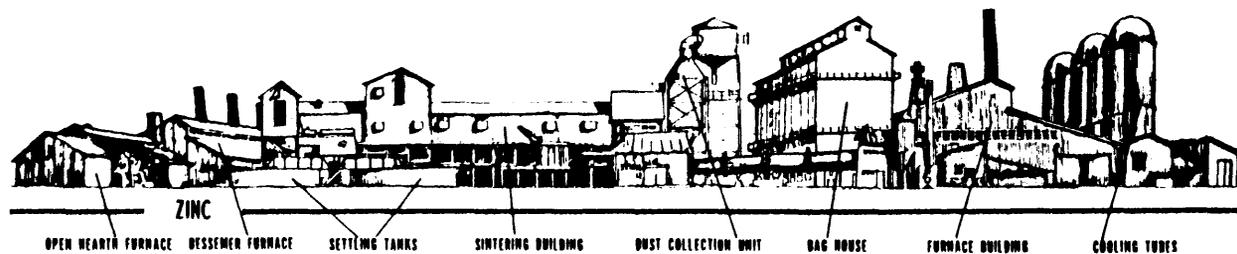


Figure 9-11. Sketch of zinc plant.

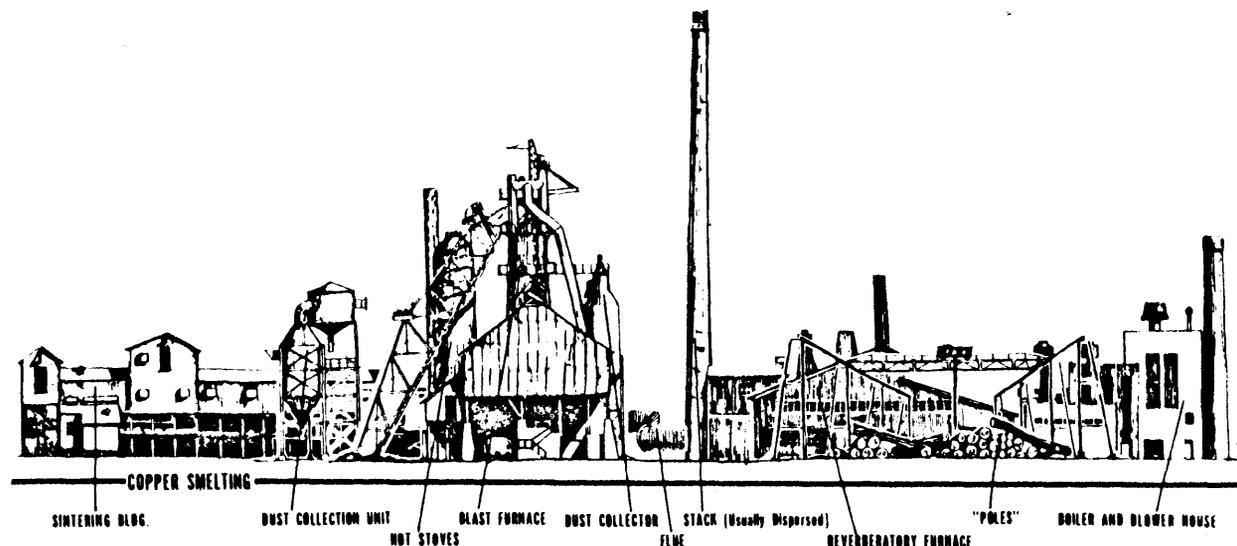


Figure 9-12. Sketch of copper smelting plant.

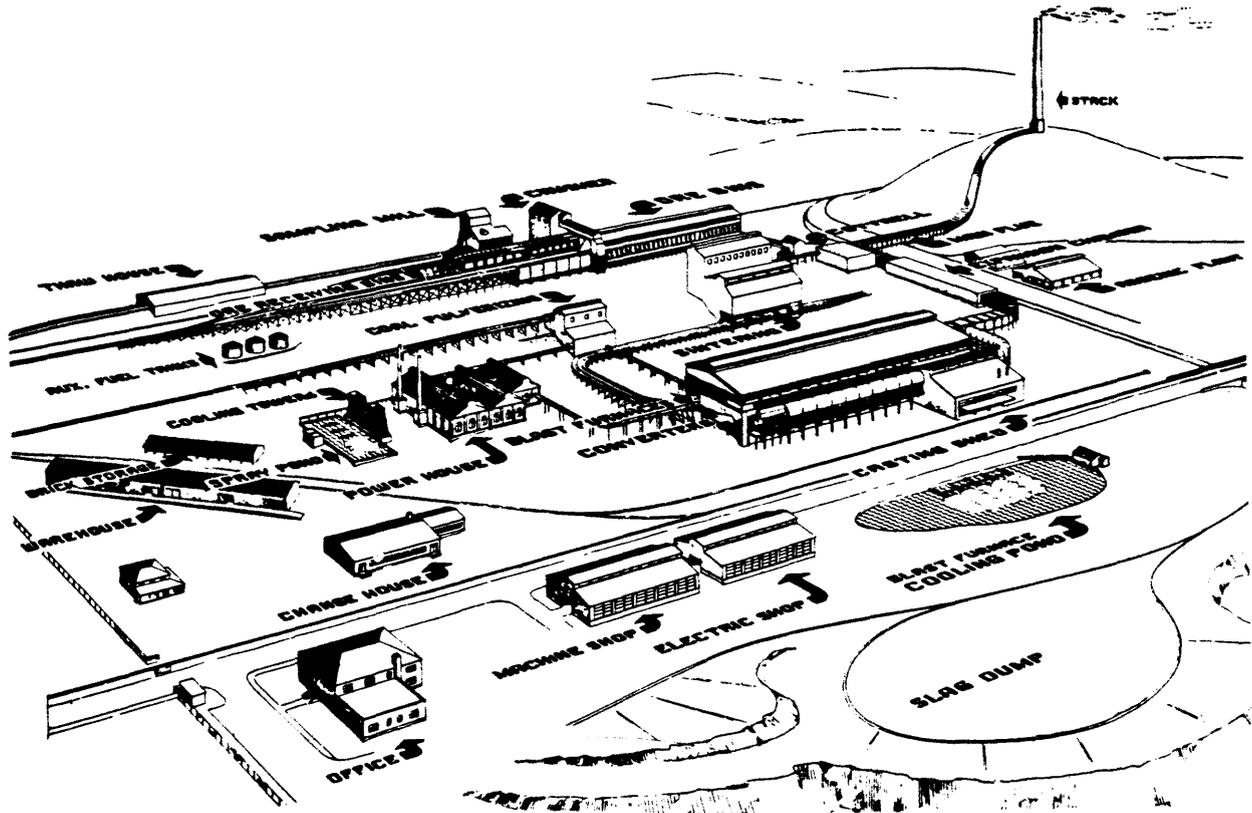


Figure 9-13. Layout sketch of typical copper smelter.

then roasted in a high roaster building which is usually one of the larger buildings in the plant. The number of furnaces may be indicated by flues or stacks. The roasted ore is then processed in the reverberatory and converter building. Other buildings may include a casting building for copper anodes, a Cottrell treater for metallic residues, and a powerhouse. Cooling towers or a spray pond are near the roaster building.

c. Input Materials. Materials consist of ore in large quantities—ranging from light to dark red in color—with lesser quantities of limestone. Electric power and a large amount of cooling water are needed.

d. Products. The main product is called an anode or blister. The anode is a copper slab about 0.6m by 0.9m by 10cm (2 feet by 3 feet by 4 inches). Blister copper is about the same size, but does not have the well-defined surfaces of the anode. Color will often be black.

9-51. Copper Refineries

a. Location. Refineries may be located in an urban area or in open country adjacent to mining

operations. Adequate transportation must be available.

b. Buildings and Equipment (Fig. 9-14). Refineries are difficult to distinguish from other types of industrial plants. Copper scrap and basic shapes may be seen in the plant yard. The large tank house and the casting building with its several stacks aid in identification. Blister or smelted copper arriving at the plant is charged into anode furnaces and cast into anodes. This is done in the furnace or casting building, one of the two largest structures in the area. This building has several stacks, indicating the number of furnaces. Anodes are then refined electrolytically in the tank house which is the largest building in the plant area. This structure is multibayed with powerlines leading into it. Usually, there is a byproducts building which is no particular size or shape, but is well-ventilated and has scattered short stacks, some emitting steam.

c. Input Materials. Materials consist of smelted anode and blister copper. A very large amount of electric energy is required.

d. Products. Refined copper may be in the shape

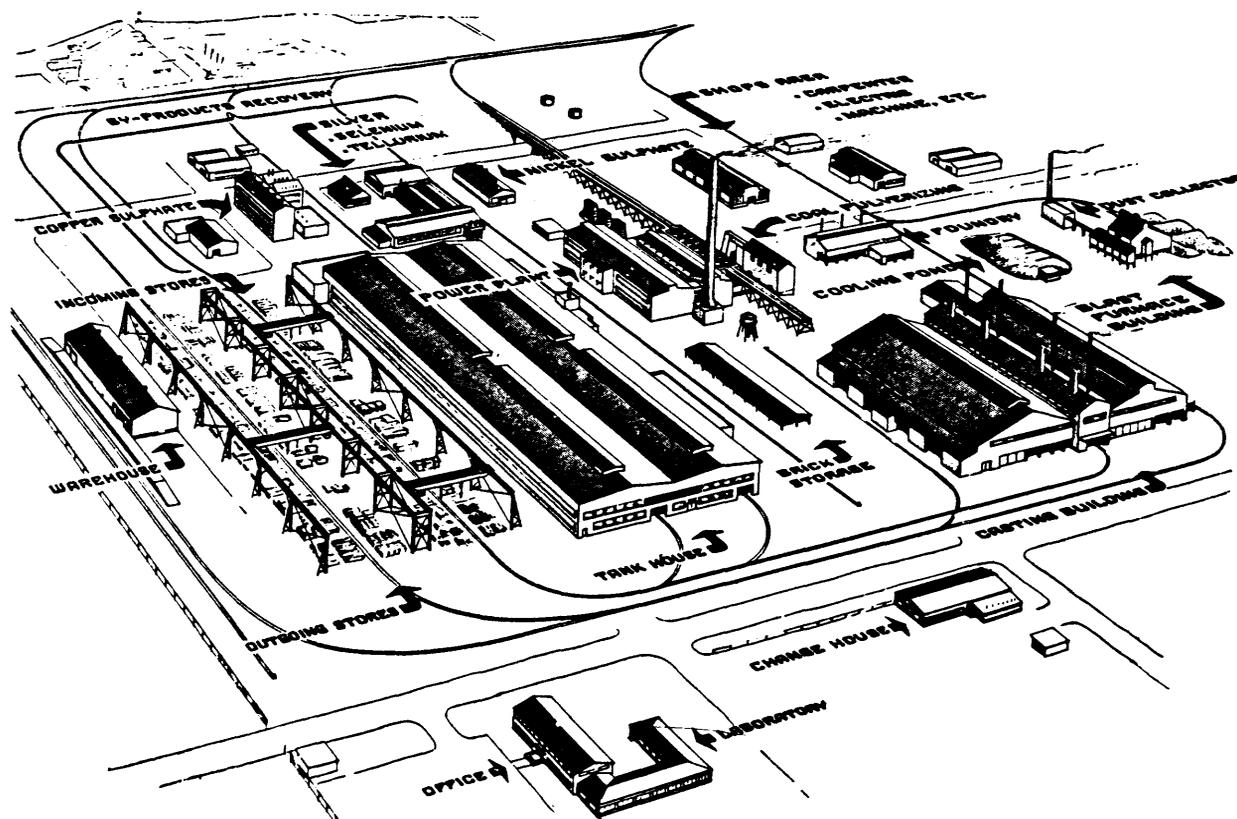


Figure 9-14. Layout sketch of typical copper refinery.

of ingots, billets, cathodes and cakes. The most distinguishing feature will be the typical copper color.

9-52. Nickel Refineries

a. Location. Refinery is located in or near urban area where adequate transportation facilities are available. Often it is integrated with a nickel smelter at a nickel ore extraction site.

b. Buildings and Equipment. Refineries are quite similar to other nonferrous metal processing plants. They resemble copper refineries perhaps more than others, especially where electrolytic refining processes are involved. The principal units in a refinery are: an electrolytic tank house, generally the largest and most noticeable feature of the plant; a rectangular multibayed structure, approximately 30 feet high, sometimes with overhead wires leading to the electric power station;

the casting building, usually the second largest structure, is distinguished by a row of furnace stacks along one side; a smelter building (which is not always present) for smelting reverts, such as anode furnace slag; and a storage yard which is serviced by overhead cranes. The tank house and the casting building will be associated with a large electric power plant or substation.

c. Input Materials. Input material consists of either smelted nickel anodes or copper-nickel matte. A very large amount of electric power is required.

d. Products. Nickel cathodes, cut to convenient size, constitute the form in which most nickel is used by industry. Sludge from the electrolytic tanks contains metals, such as cobalt, platinum, gold, silver, selenium, and tellurium, all of which can be recovered.

Section XI. PETROLEUM INDUSTRY

9-53. Crude Oil Refineries

a. Location. To reduce the transportation burden, refineries may be situated in or near produc-

ing fields, at transportation centers, or near consuming centers. A principal requirement is transportation for bringing in crude oil and shipping

out products in large quantities. Transport usually includes rail or waterway facilities and long-distance pipelines. A plentiful source of water for cooling and boiler feed is essential, as is electric power for pumps, lighting, and automated equipment. Other site requirements are those typical of industrial plants with extremely heavy equipment.

b. Buildings and Equipment (Fig. 9-15 through 9-23). Buildings house offices, powerplants, control equipment, laboratories, boilers, packaging facilities, package storage, workshops, firefighting equipment, and some specialized processing, such as filtration. Salient recognition features are large processing units, mainly in the open and visible for some distance, and groups of storage tanks for crude oil and refined products. The basic distillation equipment consists of large furnaces for vaporizing petroleum; fractionating columns (tall vertical cylindrical steel structures) from which different types of products are drawn off at different levels; and heat exchangers (coolers) for extracting heat from the products. Large units are also used to break up hydrocarbon molecules (cracking) or to combine molecules (polymerization) in order to form more desirable products from charge stock derived from initial distillation. Both cracking and polymerization involve the use of heat, catalysts, and, in some instances, pressure, or steam. Equipment appears in many varied forms and sizes, but vertical steel cylindrical structures predominate. The recognition of processing units by specific function is not within

the capability of a casual observer who lacks extensive training or experience in the industry. The collector lacking detailed knowledge can best satisfy requirements by simply identifying a refinery as such and by obtaining good photography, plans, and layout diagrams wherever possible.

c. Input Materials. Crude oil arrives in large quantities by pipeline, barge, ship, or, at times, by rail.

d. Products. Output consists of fuels, lube oils, greases, waxes, and tars. Distribution is accomplished mostly by tank cars, barges, and pipelines.

9-54. Natural Gasoline Plants

a. Location. Plants are located at oil fields or natural gas fields where quantities of "wet" gas (natural gas which contains a variable quantity of natural gasoline) are sufficient to warrant processing for recovery of gasoline and products such as propane and butane.

b. Buildings and Equipment. The principal units are towers, a compressor building, storage tanks, gasometers, and possibly a cooling tower. It may have a stabilizing unit in which raw recovered gasoline is redistilled to control its boiling range and vapor pressure. These plants resemble small refineries but may generally be distinguished by the predominance of horizontal cylindrical storage tanks, and the absence of furnace buildings with tall metal smokestacks. The fractionating columns will be cleaner in appearance and possibly more closely spaced.

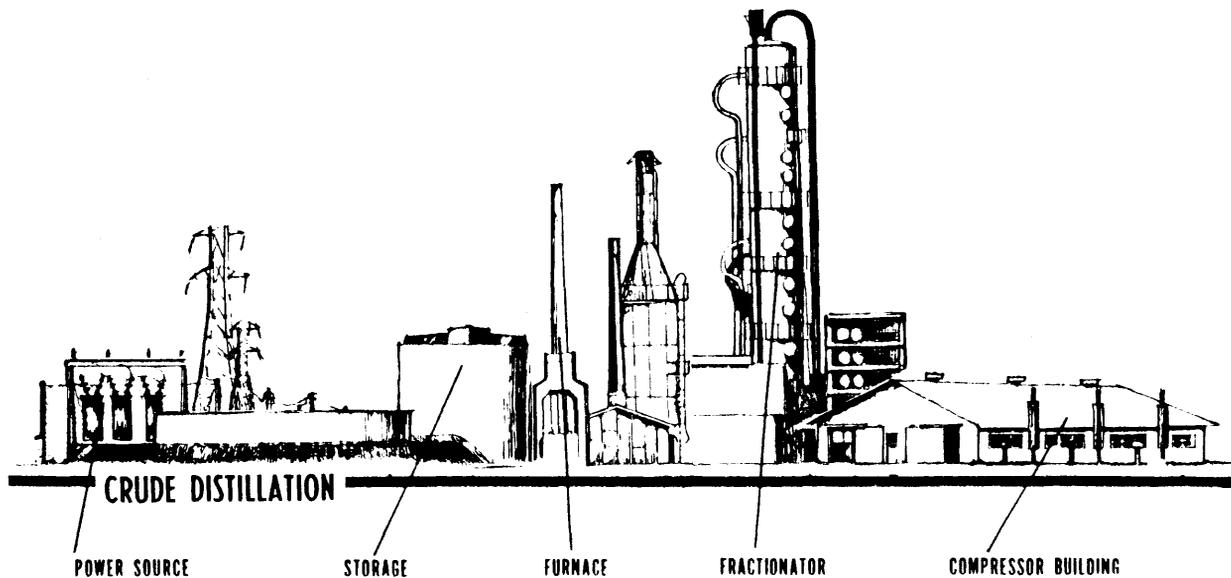


Figure 9-15. Sketch of crude distillation process.

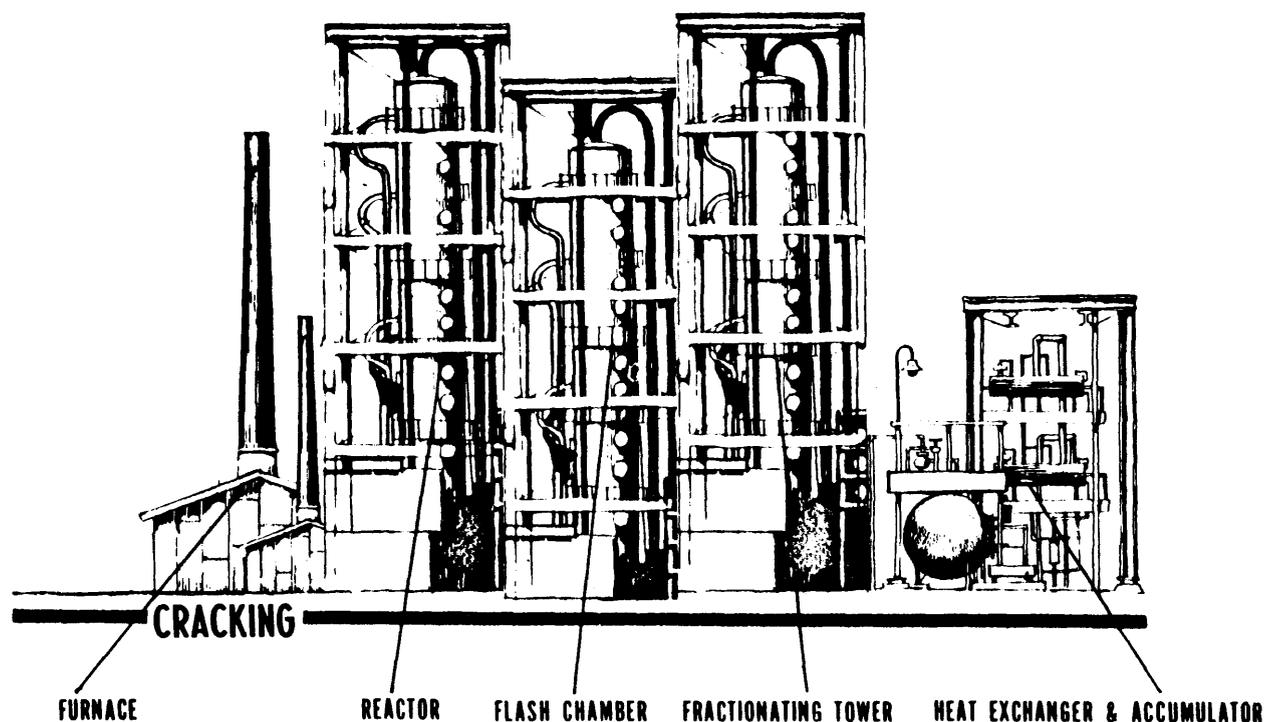


Figure 9-16. Sketch of petroleum cracking process.

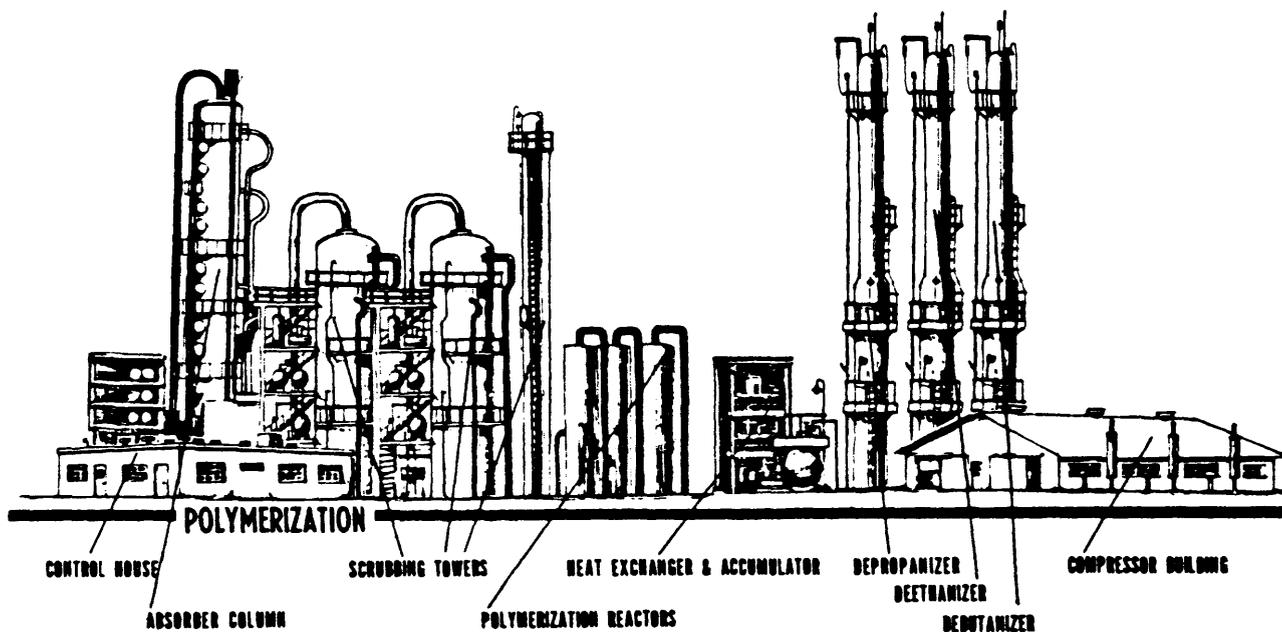


Figure 9-17. Sketch of petroleum polymerization process.

c. Input Materials. Wet gas, a raw material, can serve for the synthesis of lubricants and high octane gasolines.

d. Products. These gases usually contain material amounts of propane, butane, pentane, hexane, and higher members of the series.

9-55. Synthetic Fuels Plants

a. Location. Plants are located near natural deposits of coal. A substantial quantity of cooling water and reasonably good transport facilities are needed.

b. Buildings and Equipment. Plants are distin-

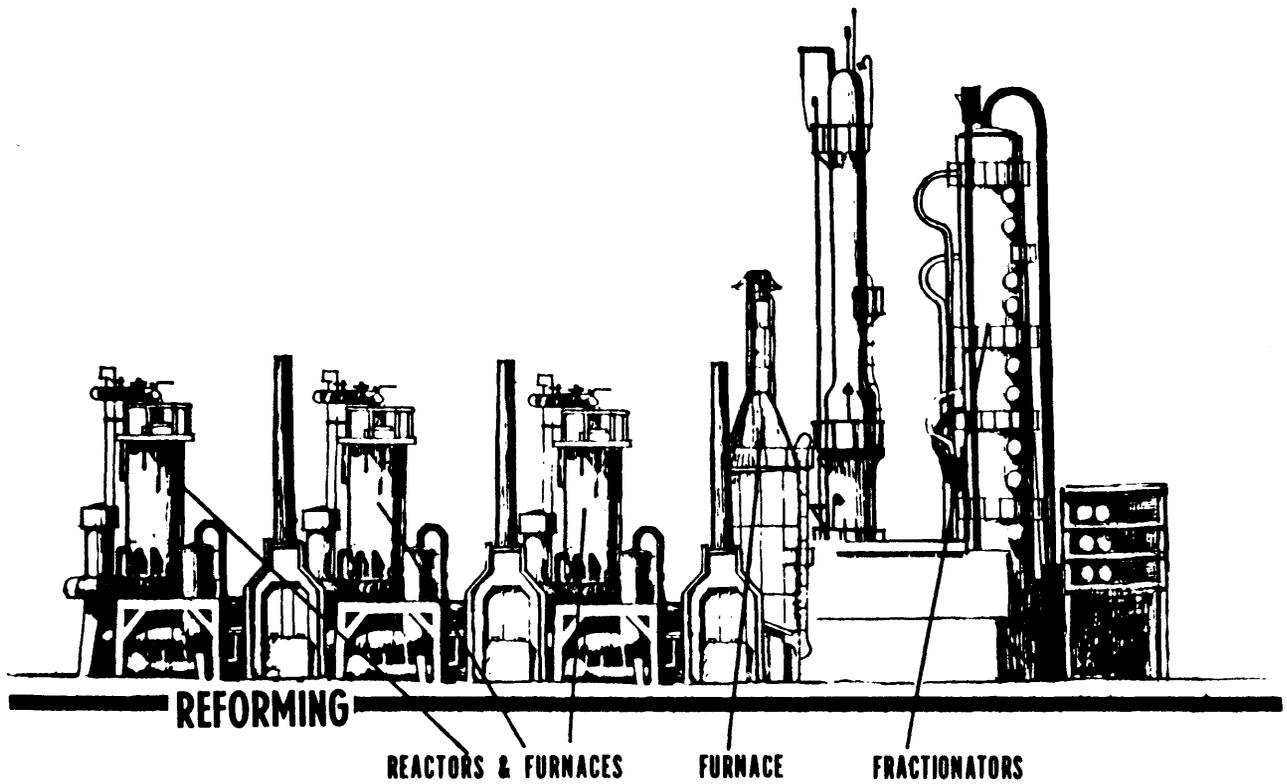


Figure 9-18. Sketch of petroleum reforming process.

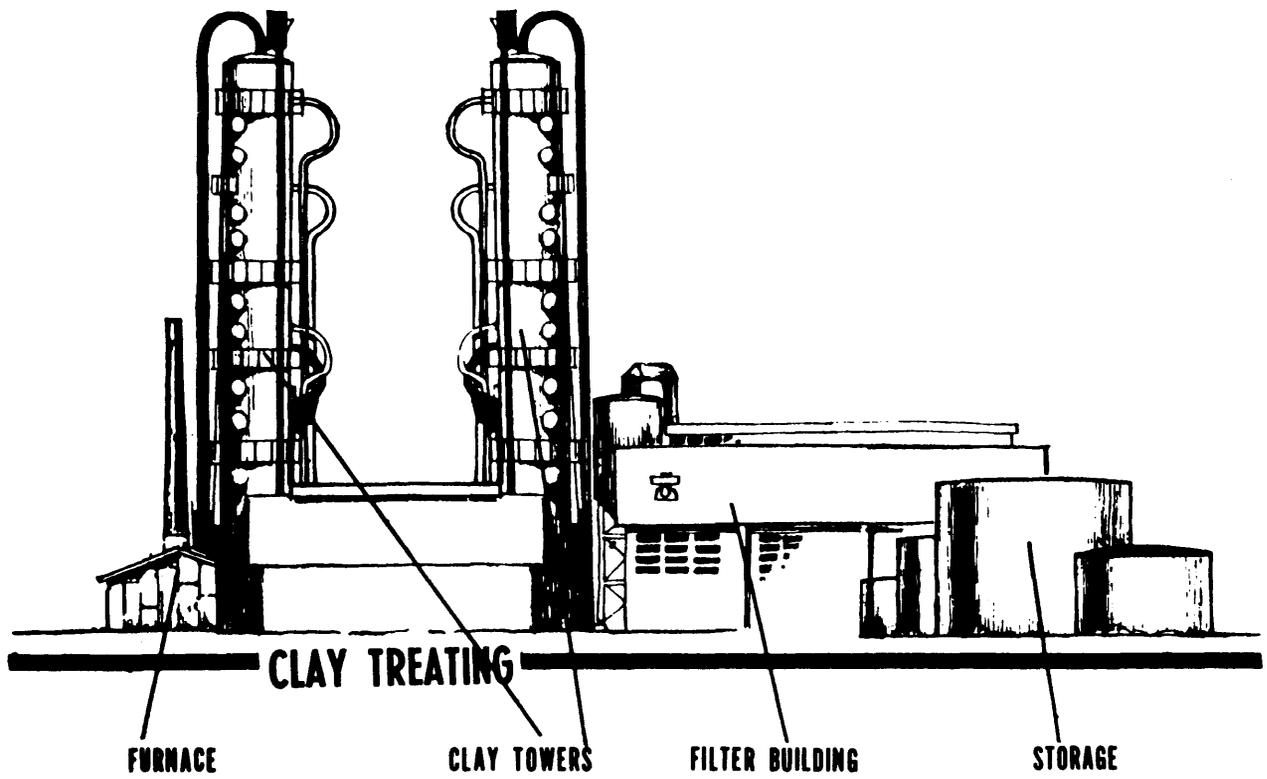


Figure 9-19. Sketch of clay treating process.

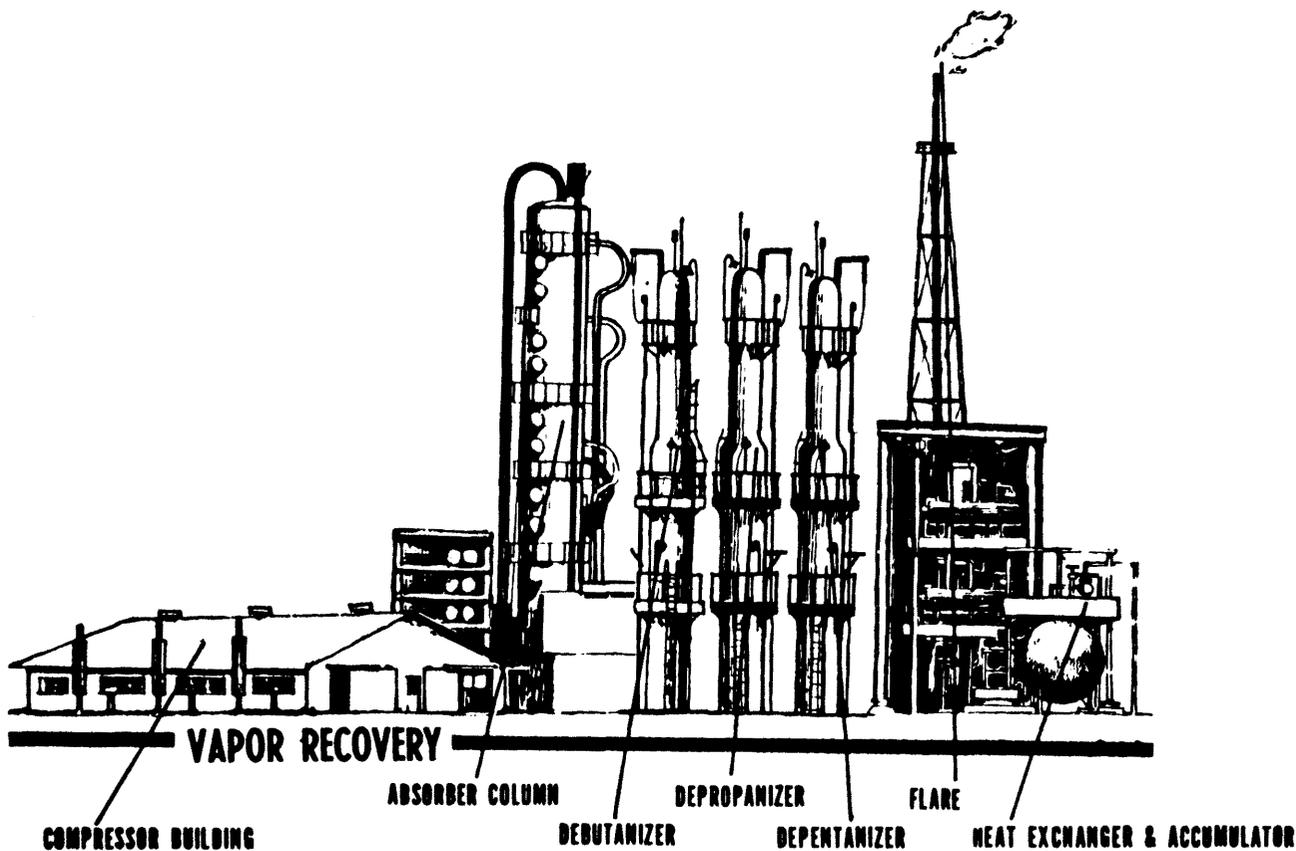


Figure 9-20. Sketch of petroleum vapor recovery process.

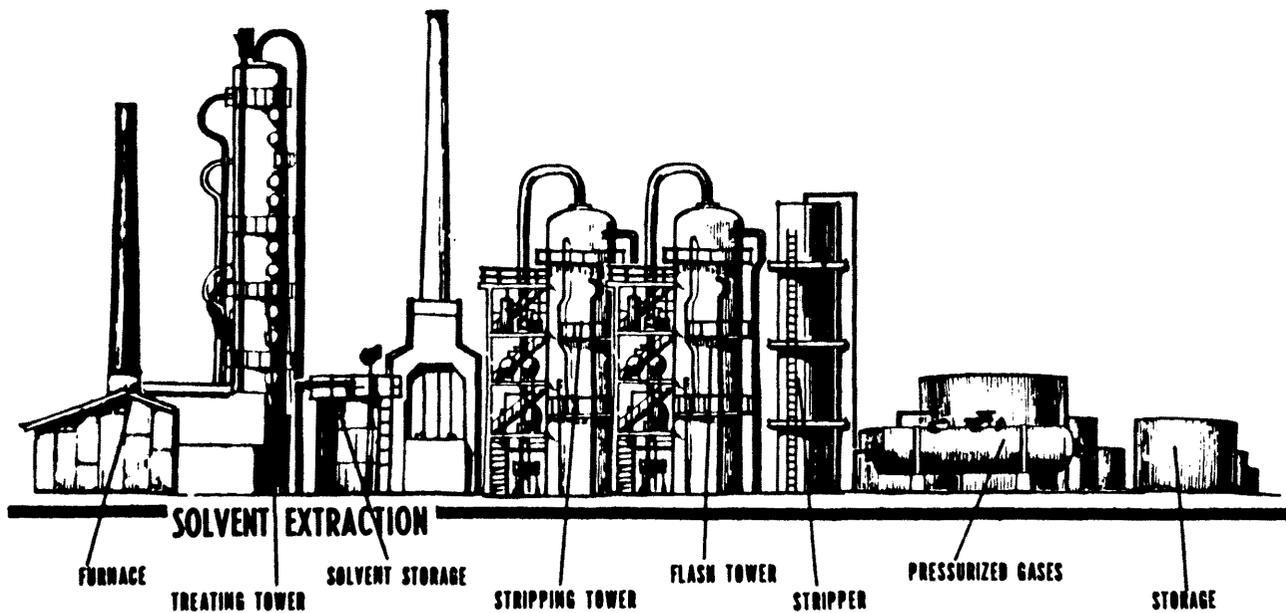


Figure 9-21. Sketch of petroleum solvent extraction process.

guishable by the refining equipment, such as fractionating columns and storage tanks. The two basic processing techniques have distinctive features which enable the observer to identify the

process used. The Fischer-Tropsch process utilizes a synthesis gas derived from coal. This process produces a synthetic crude oil, which is distilled, cracked, and otherwise treated in the same way as

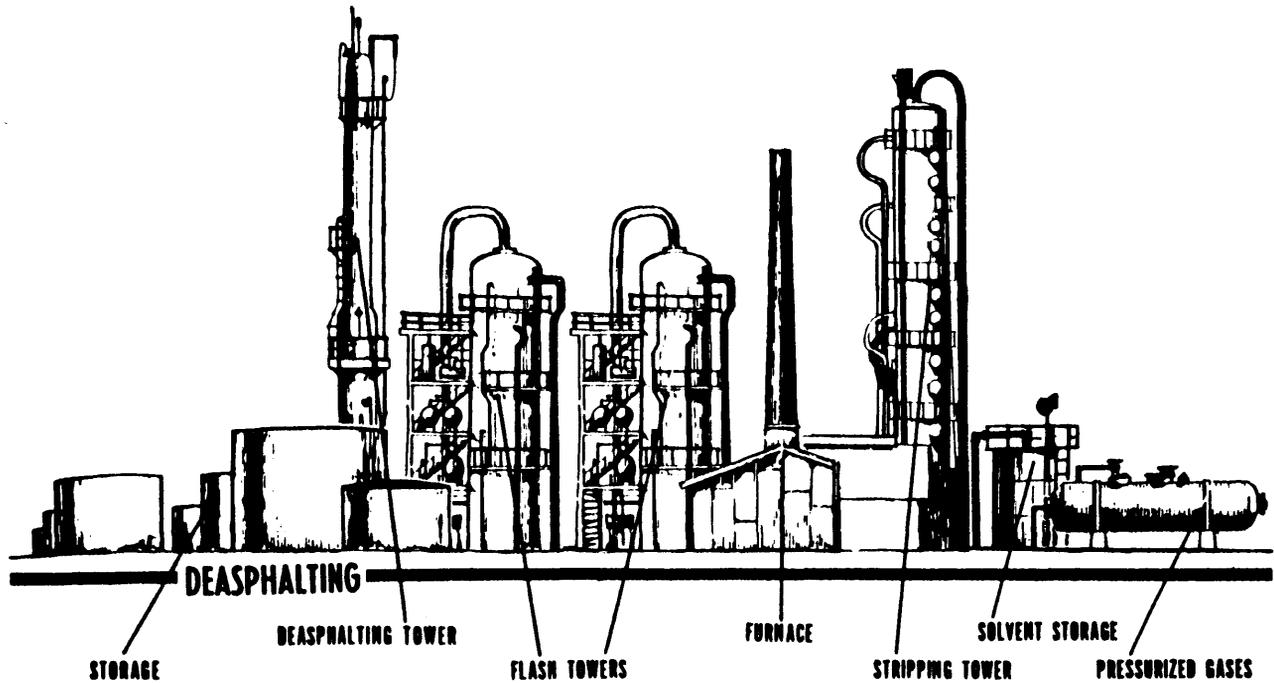


Figure 9-22. Sketch of petroleum deasphalting process.

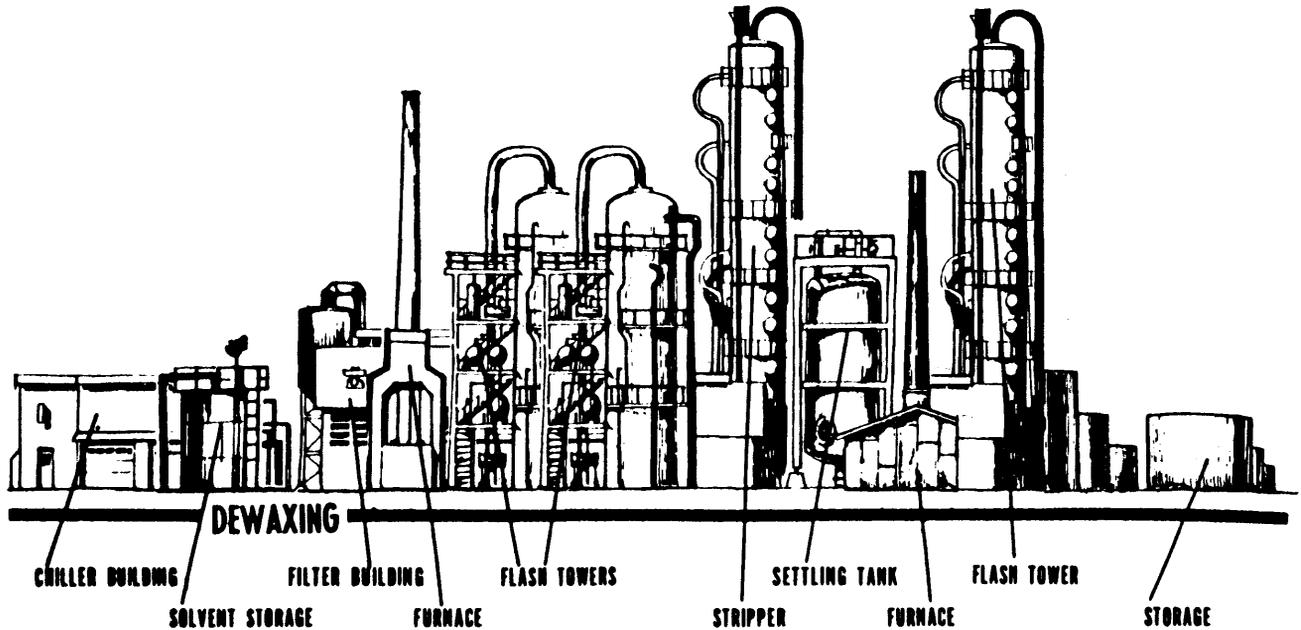


Figure 9-23. Sketch of petroleum dewaxing process.

natural crude petroleum. These plants may be identified by large quantities of coal on the premises and by gas generators which stand out by reason of their cupolalike construction. Should gas from underground gasification of coal be used, the generators would not be present. Plants using the Bergius hydrogenation process will have hy-

drogenation columns in "stalls," usually in line, and serviced by a large crane. In this process, hydrogen reacts catalytically with coal, coal tar, or petroleum to form liquid products for further refining. Synthetic fuels plants may closely resemble certain types of chemical plants, but can generally be distinguished by the heavy reinforced

concrete stalls which frequently surround three sides of the hydrogenation columns to minimize dangers following explosions.

c. Input Materials. Coal and coal derivatives provide the raw materials; however, the form of the input will vary, depending on the process being used.

d. Products. Products are stored in tanks. The liquid hydrocarbons resulting from the Fischer-Tropsch process are the equivalent of a very paraffinic crude oil and can be worked into standard refinery products. The Bergius hydrogenation method yields materials suitable for processing

into motor gasolines, aviation gasolines, and jet fuels.

9-56. Shale Oil Plants

a. Location. Plants are always located near deposits of oil-bearing shales.

b. Buildings and Equipment. Key facilities are the rotary or stationary "retorts." In these units, a continuous charge of crushed shale is subjected to treatment by steam and air. The resulting overhead, consisting chiefly of crude petroleum and steam, is condensed. After separation, the petroleum layer is recovered and worked in the same manner as crude oil.

Section XII. PHARMACEUTICAL AND DRUG INDUSTRY

9-57. Antibiotic Plants

a. Location. No specific factors govern location.

b. Buildings and Equipment. The general method for production of antibiotics by the biological process involves: fermentation in tanks of 10,000- to 80,000-gallon capacity, allowing the micro-organisms to grow while the culture is held to the proper growth temperature; purification and concentration by use of centrifuges, absorption columns, vacuum drying, and other means; and the preparation of the desired end product, involving blending with other ingredients. Each of the various steps may be performed in a separate building or in a single large structure. Most antibiotics, such as penicillin, streptomycin, terramycin, etc., are produced from byproducts of a fermentation process. Other antibiotics, such as chloromycetin, are produced synthetically by chemical methods. The fermentation process requires plant structures several stories in height to accommodate large fermentation tanks. The chemical process does not require the use of such large equipment, and may be housed in structures of any size. Antibiotics, such as penicillin, streptomycin, etc., may be stored at the plants where they are produced. Some antibiotics require refrigeration. Most do not require low temperatures, but are best maintained at slightly below ordinary room temperature.

c. Input Materials. Raw materials that might be observed are cornsteep syrup, soybean meal, grain, sugar, salt, test tubes, flasks, petri dishes, filter pads, and chemical reagents. Materials arrive in bags, cartons, barrels, drums, carboys, and tank cars.

d. Products. Preparations leave the plant in dry, liquid, or ointment form. They are normally placed in containers ranging in size from small 1 cc ampoules to 1-pound jars. Containers might be packaged and shipped in cartons holding six or more units. Cartons are usually labelled to indicate their contents.

9-58. Vaccine and Serum Plants

a. Location. Plants may be found in conjunction with pharmaceutical plants or as individual units.

b. Buildings and Equipment. For production of bacterial vaccines, bacteria are grown in large glass carboys or in tanks of varying sizes. For production of virus vaccines, the virus is usually cultivated in egg embryos. Thus facilities for handling large numbers of eggs are necessary. All operations are characterized by means for maintaining sterile conditions. For production of serums, facilities will be available for handling large animals, such as horses, sheep, and goats. Equipment for concentration and purification of the products are centrifuges, freeze-drying equipment, cold storage rooms, and ampoule-filling equipment.

c. Input Materials. Culture media, eggs, laboratory glassware, and large quantities of ampoules are the input materials.

d. Products. Products are most commonly dispensed in ampoules containing a dry powder or small amounts of liquid.

9-59. Biological Warfare and Chemical Warfare Plants

a. Location. Established chemical or pharmaceutical plants may be engaged in the production of chemical warfare (CW) or biological warfare (BW) agents, or plants may be specifically designed for such purposes. Buildings are fenced and guarded.

b. Buildings and Equipment. There are few distinctive building types associated with these activities. CW agent production buildings resemble ordinary chemical plants with conveyors, high-stacks, and ventilators. BW agent production may be carried out in any type building that has temperature control to protect the living organisms. A large-scale BW plant requires refrigeration units for extending the useful life of agents in storage. Protective clothing is required for work-

ers in either type plant. Storage may be in underground bunkers, buildings, or sheds. They are isolated from other buildings and have walls or double fences and guard towers.

c. Input Materials. Chemicals constitute the major input material at CW plants. BW production requires nutrient materials (cornsteep syrup, glucose, sugar). Materials arrive in various containers, such as barrels and carboys.

d. Products. Products are not recognizable unless the plant fills CW munitions, in which case, the products would resemble any other munitions. They would be shipped in closed, steel containers and marked with a color code or other identification symbol. Special types of tank cars may be used for rail transportation of liquid materials. BW agents may be shipped under refrigeration.

Section XIII. OTHER SIGNIFICANT INDUSTRIES

9-60. Explosive Plants

a. Location. Plants and storage are normally located away from built-up areas. If located near a built-up area, they will be surrounded by a cleared belt of land.

b. Buildings and Equipment. Areas are always well-guarded. Storage facilities usually are of prestressed concrete or cinderblock construction (sometimes partially underground) and are well-dispersed. Boundaries are defined by fences, walls, and guard towers. Smokeless powder plants require extensive area because of the large number of buildings needed. Distance between buildings is necessary to prevent spreading of an explosion or fire. When sufficient area is not available, individual buildings are protected by mounds or barricades. The majority of buildings are of light construction and most are surrounded or partially shielded by blast walls. In the case of a smokeless powder blending tower, safety chutes serve as an important recognition feature. Usually nitric acid is manufactured or concentrated in the powder plants. The most important military high explosive is TNT. Important indicators are reddish brown smoke from the nitric acid production building; the nitric acid concentration building; and the three nitration buildings in the TNT area. Safety chutes permit rapid evacuation of buildings in case of emergency. The waste from TNT processing is a yellow, dirty liquid, smelling strongly of caustic.

c. Input Materials. Materials consist mostly of chemicals. These are received in tank cars, in drums or other closed containers, or in closed rail cars.

d. Products. Products will not be visible in most cases. They are shipped by truck or rail and the carrier will be labeled as containing explosives. Rail shipments consist of only a few cars at a time.

9-61. Motor Vehicle Production Plants

a. Location. Plants are rail-served and most of the older facilities are located in large urban areas. Newer plants are located in rural areas.

b. Buildings and Equipment. Very large plants may be fully integrated, including open-hearth steel. Others may be concerned primarily with the final assembly of vehicles or with the production of one or more major components, such as engines, bodies, and transmissions. Generally, a plant is similar in construction to a metal product or machinery manufacturing installation. Buildings can be either single- or multi-storied. In addition, there may be one or more of the following features:

- (1) Test rack for motor vehicles.
- (2) Parking lot for vehicles awaiting shipment.
- (3) Constant sound of engine testing.

(4) Foundry. The roof is generally a monitor-type and has several short stacks.

(5) Forge. Roof is possibly a monitor-type with at least one short stack.

(6) Large assembly building of brick or sheet metal construction, with high clear span and possibly a sawtooth roof.

(7) Machine shops of brick or steel metal construction, a heating or power plant, and service buildings.

c. Input Materials. Major input items are steel billets, sheet steel, glass, rubber tires, petroleum products, and upholstery materials. Depending on the degree of integration, the plant may receive engines, bodies, or other components in large quantities.

d. Products. The output consists of finished automobiles, trucks, buses, tractors, trailers, military personnel carriers, prime movers, and specialized vehicles, such as firefighting and ambulance. If the plant is concerned with the production of components, it may produce engines, chassis, drive shafts, radiators, electrical components, etc.

9-62. Ammunition and Armament Plants

a. Location. Plants are rail-served, and located near a large labor pool.

b. Buildings and Equipment. There are no characteristic features which, from a distance, enable an observer to distinguish an ammunition and armament plant from an ordinary heavy machinery or engineering plant. The principal buildings, mostly two and three stories, are constructed of brick and reinforced concrete with structural steel roof supports utilizing flat, arch, or gable-type skylights. One or several large smokestacks can be seen from a distance; however, this would not be a means of identification without other evidence. Revetments and blast walls may surround a production and storage facility for heavy caliber ammunition. The plants normally consist of an integrated complex of weapons forging and foundry facilities, heat treatment and machine shops, and final assembly and finishing shops. A major caliber gun plant would have an extremely tall tower or building section where large gun barrels are lifted from a treating pit. This building section could be 150 feet tall.

c. Input Materials. Materials consist of ingot steel, forged steel rods, and perhaps steel gun

blanks. Carriages and mounts for artillery pieces may be shipped in.

d. Products. Completely assembled weapons may leave by rail or truck; field artillery pieces may be towed. Small arms and ammunition are shipped in boxes of various sizes.

9-63. Shipbuilding and Repair Yards

a. Location. Maritime shipyards are located on protected harbors or estuaries of sufficient depth to accommodate the ships launched or repaired. Inland shipyards usually produce and repair smaller craft for use on rivers or lakes, but may also construct submarines. Boat yards producing smaller craft, both maritime and inland, can be located on any protected waterfront. Some of these yards build small, high speed, naval craft which carry and launch short-range missiles.

b. Buildings and Equipment. The essential operations in shipbuilding are: design and layout fabrication, assembly, erection, launching, fitting-out, and engineering. *Design and layout* (drawing of detailed lines of the entire ship's hull and preparation of full-size templates of all structural parts of the ship) are done in a large well-lighted area usually referred to as a mold loft, close to or built as a second story to the fabrication shop. *Fabrication* (cutting, drilling, punching, and forming steel plates to the size and shape of templates) is done in a large factory-type building which is close to, or may include, the plate shop. *Launching* is accomplished by sliding the hull of a ship from the building way into the water by means of a ramp known as a launching way. Yards designed for repair only have no mold lofts or building ways, but usually have marine railways for hauling small craft out of the water and/or graving dock or floating dry docks. A great deal of shipyard work is done in the open, and outdoor cranes of various types are conspicuous.

c. Input Materials. Quantities of steel plates are conspicuous. Pipes, steel shapes, large castings, lumber, and various types of ship equipment will be seen. The large labor force includes many skilled workers as well as manual laborers.

d. Products. Major products are completed or repaired ships. It is important to note sizes and types of ships under construction, types of repair being made, and the size of a ship in dry dock. Products other than ships may include dredges, cranes, floating dry docks, prefabricated houses, and a variety of small metal articles. Less fre-

quently, rolling mills, hydraulic pumps, tractors, tanks, locomotives, and other heavy machinery are manufactured.

9-64. Tank and Self-Propelled Gun Plants

a. Location. Plants are rail-served, and generally are located near urban areas. Large quantities of water are necessary.

b. Buildings and Equipment. Buildings may be indistinguishable from those of a railroad car manufacturing plant, except that a tank plant may well have security measures in force. The complex may even have its own open-hearth furnaces to take care of the large steel consumption.

The tank assembly building is a large, high, clear span structure with rail lines entering the building. A crane-serviced storage area may be adjacent to the building. A test track will be within the plant area, or in the vicinity. Large forges and extensive casting facilities are common as well as heating and power plants, and maintenance and tooling shops.

c. Input Materials. Input may consist of pig iron (if the plant has open-hearth furnaces), ingot steel, steel castings, and components such as track links, engines, turrets, and gun barrels.

d. Products. Tanks or self-propelled guns will be shipped by rail or driven to a local depot.

CHAPTER 10

TERRAIN STUDIES

Section I. DESCRIPTION

10-1. Purpose and Scope

a. A terrain study is an intelligence product which presents an analysis and interpretation of the natural and manmade characteristics of an area and their effects on military operations. It contains only the information that has a direct bearing on a specific requirement. It is prepared at all echelons and is used by the intelligence officer in preparing the analysis of area of operations that forms part of his overall intelligence estimate. At army level, terrain studies are prepared primarily to assist the commander and his staff in planning operations. At lower levels, they are intended chiefly for tactical use and include more details of the terrain and its effect on tactical operations.

b. Special studies devoted exclusively to specific terrain features or effects may be prepared to meet the requirements of a particular plan or operation. Produced by technical personnel or terrain teams, they may include, but are not limited to, construction problems, movement, water resources, lines of communication, site selection, coast and landing beaches, barriers, defenses, airborne landing areas, soils, rock types, drainage, surface configuration, inland waterways, or other areas which require special consideration.

10-2. Format

The terrain study covers only those items applicable to the operation being planned. The primary requirement at army, corps, or division level is that it must present the intelligence in a form that can be easily utilized by field units. Written description should be kept to a minimum, and intelligence should be presented graphically whenever possible. The format suggested consists of three parts: a text, a terrain study map or series of terrain components maps, and a regional description section. A fourth major part, "Analysis of Area of Operations," is prepared by the intelligence officer as described in FM 30-5.

a. Text. The text follows the sequence of the terrain study outline and sample studies shown in the following sections. Tables and charts are used to simplify, amplify, and clarify the presentation. The text should be as concise as possible.

b. Map. Wherever possible, terrain intelligence should be presented on a terrain study map, based on a topographic map of appropriate scale. A map scale of 1:50,000 is usually utilized for brigades and divisions. Corps and army headquarters usually do not require a scale larger than 1:250,000. The terrain intelligence is overprinted on the topographic map or is an overlay to the map. Appropriate symbols are used to present items of terrain intelligence. Conditions for movement are portrayed by designated movement colors.

c. Regions. For the purposes of terrain analysis, a military geographic region is an area in which the combinations of environmental conditions would have a relatively uniform effect on military operations. Terrain features exist in certain patterns or combinations which create distinctive terrain regions. Usually the area of study encompasses several regions. The regional description gives the user an understanding of the terrain by explaining the combined effect of terrain features in the regions. Brief descriptions summarizing the terrain intelligence for each region may be printed on the back of the terrain study map.

10-3. Reproduction

Reproduction of terrain studies should be done by the fastest, cheapest, and easiest method, and only in the number of copies necessary for primary users. The engineer topographic battalion assigned to army has the capability for map reproduction, and it can also perform other printing and drafting necessary for the reproduction of terrain studies. The engineer topographic company assigned to corps has basically the same cap-

abilities as the topographic battalion but is limited in volume and equipment. A division has no organic topographic units.

10-4. Dissemination

The Engineer, or Engineer Terrain Detachment, or the G2 Staff Engineer, disseminates the completed terrain study to the G2 and other interested staff elements. The G2 utilizes the study

according to the tactical situation and presents the resulting terrain estimate to the commander. If necessary, the study is disseminated to subordinate and adjacent units. It is also disseminated through engineer channels, and copies are sent to lower echelons to assist them in planning and preparing their own terrain studies. A copy is sent to higher engineer headquarters, and another is sent through engineer channels to the Office of the Chief of Engineers.

Section II. TERRAIN STUDY OUTLINE

10-5. Purpose and Limiting Considerations

State the purpose and limiting considerations under which the study is being prepared. This statement should include the scope of the study in area, time and subject matter, and any information on the tactical situation, mission, or method of operation that is pertinent to the study.

10-6. General Description of the Terrain

a. Synopsis. State briefly the impact of the terrain on military operations.

b. Climatic Conditions. Describe predicted meteorological conditions for the period, based on climatic data. Present data graphically whenever possible.

(1) *Temperature.* Frequency of occurrence of temperatures during period.

(2) *Precipitation.* Frequency of occurrence of precipitation by type and amount.

(3) *Winds.* Frequency of occurrence of winds of certain velocities and direction.

(4) *Visibility.* Graphic data on time of sunrise, sunset, twilight, moonrise, and moonset; effect of fogs, mist, haze, and other influences on visibility; expected visibility by distance when applicable.

(5) *Cloudiness.* Frequency and time of occurrence of various cloud conditions, when applicable.

(6) *Humidity.* Describe only when significant.

(7) *Electrical disturbances.* Describe only when significant.

c. Topography. If pertinent, describe the following characteristics by written or graphic means. The use of a topographic map overprint to emphasize particular characteristics is recommended.

(1) *Relief and drainage systems.* Use ridge

and streamlining, contour, emphasis, hilltopping, or relief shading to outline the ridge and valley systems. Use numbers, words, or standard symbols to indicate critical relief or drainage conditions.

(2) *Vegetation.* Location, type and size of trees; density of stands; undergrowth; location, type, and density of other significant vegetation.

(3) *Surface materials.* Type and distribution of soils, subsoils, and bare rock in the area; trafficability under various weather conditions.

(4) *Manmade features.* Significant manmade features such as roads, railroads, bridges, tunnels, towns, important buildings, fortifications or airfields.

(5) *Special features.* Significant special features such as earthquake zones or active volcanoes.

d. Coastal Hydrography. Describe when applicable. Use graphic means whenever possible.

(1) *Sea approaches.* Nature of approaches, bottom conditions, obstacles, gradients, and coastal structures.

(2) *Beaches.* Dimensions, trafficability, and exits.

(3) *Tides and currents.* Expected time of occurrence and stage of tides. Currents by direction, velocity and duration.

(4) *Sea and surf.* Height of sea, type of surf, width of surf band, height of surf, and expected duration.

10-7. Military Aspects of the Terrain

From an analysis of data on natural and man-made obstacles, soils trafficability, climate, topography, coastal hydrography, and other terrain factors, determine the following military aspects and describe them by written or graphic means. Use of an overlay to the basic topographic map is recommended.

a. Observation. The effect of terrain factors on observation from the ground, from the air, and by means of electric or sonic devices.

b. Fields of Fire. The effect of terrain factors on the ability of flat- and high-trajectory weapons to deliver projectiles to a target. Consider nuclear weapons when applicable.

c. Concealment. The capability of the terrain to provide concealment for men, equipment, and installations. Consider the effect of terrain on concealment by artificial means.

d. Cover. The capability of the terrain to provide cover for men, equipment, and installations. Consider the problem of cover from flat-trajectory, high-trajectory, and nuclear weapons when applicable.

e. Obstacles. The capability of the terrain to delay the advance of military forces or impede military operations. Consider both natural and manmade obstacles.

f. Movement. The ability of troops and equipment to move through the area. Use standard color code to describe movement conditions. Use specific terms of movement whenever possible; i.e.—vehicular, cross country, and foot.

g. Key Terrain Features. Terrain features which appear to be critical, such as a dominant height, a highway, a communication center, or an airfield.

h. Avenues of Approach. The avenues of approach to the objective. Consider existing routes of movement, possibilities of cross-country movement, and amphibious or airborne or airmobile operations when applicable.

10-8. Engineering Aspects of the Terrain

Determination of the following military aspects is essential to planning the engineer phase of operations.

a. Construction Sites. Areas suitable for construction of roads, airfields, buildings, underground installations, surface defensive installations, or others.

b. Construction Materials. Probable location of rock, gravel, sand, and other natural construction material.

c. Water Supply. Probable location of potable water and water suitable for construction use.

10-9. Maps and Charts

Maximum use is made of maps and charts. Among these are topographic, trafficability, landing (where applicable), and special maps, such as geological, soils, hydrographic charts, town plans, roadmaps, and Joint Operations Graphic (JOG). The preferred map scale for most terrain studies is 1:100,000. However, these are not always available covering certain parts of the world, and the 1:250,000 scale maps are usually used instead.

Section III. SAMPLE TERRAIN STUDY

10-10. General

a. This section contains sample topical and evaluative subjects that are components of a terrain analysis. It describes how they are prepared and presented in usable form for field use. The subject outlined must, necessarily, have flexibility due to changing terrain conditions and mission requirements. In other words, if certain topical subjects are not needed to fulfill the mission requirements, they should be deleted and replaced by subjects not covered here but of importance to the requirement. Also, certain topical subjects can be combined or altered and presented to fulfill mission requirements.

b. Topical subjects discussed are: Landforms and Surface Configuration; Suitability of Soils for Military Uses; Rock Types; Drainage; Water Resources; Vegetation; and Culture Features of

Military Significance. Topical components consist of detailed analyses of significant terrain elements.

c. Evaluative subjects discussed are: Cross-Country Movement and Airborne Operations; Suitability for Irregular Force Operations; Nuclear and CBR Employment; Suitability for Road and Airfield Construction; and Suitability for Underground Installations. Evaluative subjects consist of detailed evaluations of the terrain elements for various aspects of military operations.

10-11. Landforms and Surface Configuration

The landforms and surface configuration component shows the distribution and describes the salient features of major landforms in the study area.

a. The map (fig. 10-1) will show the areal ex-

tent of the major landforms by appropriate symbols. The major landform types shown will be plains, hills, and mountains; if necessary, types may be further subdivided into flat plains, dissected plains, etc. The landforms will be grouped into regions and subregions, which will be delineated by regional and subregional lines. Important minor features such as passes, escarpments, and so on, will be shown by special symbols. If the map has a coast, potentially usable beach areas will be delineated.

b. The table (table 10-1) will be organized by landform regions and subregions corresponding to those shown on the map. The table will include landform types and distribution; surface characteristics; local relief; slope; elevations; passes; coasts and beaches; and suitability of surface configuration for cover, concealment, and observation sites.

10-12. Suitability of Soils for Military Uses

The soils component shows the distribution of soils and describes the physical characteristics of

each soil type and its suitability for military purposes.

a. The map (fig. 10-2) will show the distribution of soils, delineated on the basis of their military significance in accordance with the Unified Soil Classification System.

b. The table (table 10-2) will be organized by categories of soils corresponding to those shown on the map. The table will include, for each category: landform type and location; soil profiles; engineering classification and description of each soil layer; suitability for surface course, base course, fill material, natural foundations, and shallow excavations; traction capacity for vehicles when soil is wet and when dry; and special construction problems.

10-13. Rock Types

This component portrays the distribution and describes the major rock types within the study area.

a. The map (fig. 10-3) will indicate the major

Table 10-1. Landforms and Surface Configuration

DESCRIPTION	A short paragraph at top of each map sheet should briefly summarize terrain types of area covered.
LANDFORM REGIONS	A landform region is an area in which landforms are more or less similar throughout.
SUBREGIONS (if applicable)	If, within a landform region there are district differences in the major landform types, the region may be divided into subregions.
LANDFORM TYPES AND DISTRIBUTION	Plains, hills or mountains; areal extent and location; orientation of valleys, escarpments, troughs, ridges.
SURFACE CHARACTERISTICS	Rocky, gravelly, rough, smooth, rolling; vegetation; alluvial fans, swamp, marshes, glacial features, lakes, lava flows, sand dunes; landslides or earthquakes; volcanic activity to include period of occurrence.
LOCAL RELIEF	The need for determining local relief (differences in elevation between summits and adjacent valley bottoms) will depend on area covered by study.
SLOPE	Indicate by following categories: 0-2%, 2-10%, 10-30%, 30-45%, over 45%. Also indicate position in respect to crest, middle or base, and whether straight, concave, convex or uniform.
ELEVATIONS (in meters)	Average and maximum elevations within region. Distances below sea level, if applicable.
PASSES	Name, location and relationship to adjacent landform units; elevation of pass and bordering heights; likelihood and period of occurrence of rock slides, mud slides, snow avalanches; degree of difficulty to bypass.
COASTS AND BEACHES	General coastal configuration to include physical nature of varying sections. Describe potentially usable beaches and terrain inland from beach for maximum of 5 miles or to first major topographic feature, such as hill or mountain range. Plot 5- and 10-fathom depth curves.
COVER, CONCEALMENT AND OBSERVATION	Indicate terrain elements that afford best cover from fire and from ground and air observation. Also indicate eminences that would provide vantage points for observing surrounding terrain.

Table 10-2. Suitability of Soils for Military Uses

LANDFORM AND LOCATION	Describe to include type of terrain and general location.
SOIL PROFILES	Soil layers, depth from surface, overall depth to bedrock. Soil profiles may be shown graphically or described in writing.
SUITABILITY FOR: SURFACE COURSE BASE COURSE FILL MATERIAL NATURAL FOUNDATIONS (including subgrade) SHALLOW EXCAVATION	Descriptive adjectives will be used to denote general suitability for each subcategory. Suggested adjectives for suitability columns are good, fair, poor, or unsuited, or ranges of these terms.
ENGINEERING CLASSIFICATION AND DESCRIPTION OF EACH SOIL LAYER	If graphic presentation is used the symbols of the Unified Soil Classification will be used. Description will include physical gradation or composition.
TRACTION CAPACITY FOR VEHICLES: WET DRY	Descriptive adjectives to be used are: high, medium, and low.
REMARKS	Include statements on drainage, availability of aggregate material, and special construction precautions, if applicable.

categories of rocks—hard, mixed hard and soft, and soft—and if necessary, subcategories of these types. Unconsolidated material also will be shown. Existing quarries with data on rock type and ease of excavation will be portrayed by appropriate symbols.

b. The table (table 10-3) will be organized by categories and subcategories of rock types corresponding to those shown on the map. The table will include physical description of rock type; quarrying and ease of excavation; engineering properties; and suitability for construction.

10-14. Drainage

The drainage component presents data on all of the surface water features that are significant to any aspect of military operations.

a. The map (fig. 10-4) will show by appropriate symbols the width and depth of streams and canals and the velocity and discharge of streams; areas subject to flooding; permanently wet areas; densely ditched or canalized areas; dams; and any other drainage feature that may have military significance. Drainage regions (areas with similar drainage characteristics) will be delineated.

Table 10-3. Rock Types

MATERIALS	The breakdown will be in 3 major categories of general rock types: hard, hard and soft, and soft. A further unit will be devoted to unconsolidated materials more than 6 meters thick overlying bedrock. Within the 3 major categories, the following 16 types are of primary interest: quartzite, granite, gabbro, rhyolite, basalt, gneiss, conglomerate, sandstone, serpentine, marble, limestone, slate, tuff, shale, schist and gypsum. Unconsolidated materials will consist primarily of one or more of: gravel, sand, silt, clay, marl, or volcanic ash. Order of listing may be determined either by relative hardness or by areal extent.
PHYSICAL DESCRIPTION	Items to be considered include type of rock, surface characteristics and relation to landforms, degree of consolidation, texture, structure, mode of occurrence (attitude), thickness, and permeability.
QUARRYING AND EASE OF EXCAVATION	Items to be considered include quarry siting, overburden, method of excavation (hand-tools, power tools, drilling and blasting) and stability of excavations.
ENGINEERING PROPERTIES	Engineering properties include strength, durability, resistance to abrasion, absorption, mineral reaction in concrete, susceptibility to asphalt film stripping, compaction, and bearing strength.
SUITABILITY FOR CONSTRUCTION	Construction uses include building stone, riprap, roofing slate, crushed rock (for base course, surface, aggregate or ballast) fill, and natural foundations.

b. The table (table 10-4) will be organized by drainage regions corresponding to those shown on the map and will present information in more detail than appears on the map. Data will include general characteristics of the region; regimen; bank and bottom conditions; widths; depths; velocities; discharge; and ice condition, if applicable.

10-15. Vegetation

The vegetation component will delineate and describe all vegetation of military significance.

a. The map (fig. 10-5) will show the various types of vegetation by standard symbols.

b. The table (table 10-5) will be organized by the vegetation types shown on the map, and will provide details on categories; description; distribution; potential uses; and any special considerations, such as susceptibility to fire and the effect on cross-country movement of vehicles and foot troops.

10-16. Water Resources

This component presents detailed data on both surface and ground water resources within the study area with regard to all probable military uses of water.

a. The map (fig. 10-6) will show both surface water resources and ground water resources.

Available quantities of surface water will be indicated by color overprints on the surface water features and available quantities of ground water will be shown by the use of layer tints. Existing supply sources, such as wells and springs, will be plotted on the map using standard symbols.

b. The table (table 10-6) will be in two parts, printed on one sheet. The part on surface water will be organized by the surface water sources indicated on the map and will give details on quantity, quality, and development problems. The part on ground water will be organized by the quantity categories shown on the map and will present data on drilled wells; dug or driven wells; springs and existing wells; and the quality of the water available.

10-17. Culture Features of Military Significance

This component delineates and describes concentrations of militarily significant culture features.

a. The map (fig. 10-7) will show the dispositions of culture features depicting the various density categories—high, moderate, and low. Individual culture features will be shown by standard symbols.

b. The table (table 10-7) will be organized by the density categories shown on the map and will include details on settlements; routes of communi-

Table 10-4. Drainage

DRAINAGE REGION	Regions may be based on regime, similarity of features, direction of flow, seasonal flow, relationship between landforms and streams, density of drainage features, or a combination of these.
GENERAL CHARACTERISTICS	Types of streams (perennial or intermittent), quality of drainage, drainage pattern, lakes, canals, obstructions, names and general length of major streams, wet areas, and areas subject to flooding.
REGIME	Periods of low and high water, to include extent, effect, and periods of flooding if applicable.
BANKS	Composition, slope, height, stability (including artificial control or improvement).
BOTTOMS	Composition, stability.
WIDTHS (in meters)	General statement followed by precise figures for various stages of major streams. Widths should be given as bank-to-bank and actual water gap.
DEPTHS (in meters)	General statement followed by precise figures for various sectors of major streams. Depths should be given for mean low water and mean high water.
VELOCITY	General statement followed by representative velocities of principal streams at various stages and locations; mean low water and mean high water.
DISCHARGE	Minimum and maximum discharge by season or month.
ICE CONDITIONS (if applicable)	Earliest, latest, and mean breakup dates; extent of frozen surface; depth of freeze; bearing capacity.

Table 10-5. Vegetation

CATEGORY	Categories will be portrayed by standard US Army map symbols. Major breakdown and subdivisions are— Trees dominant: needleleaf evergreen, broad evergreen, broadleaf deciduous, combinations. Shrubs dominant: scrub, tundra. Grassland dominant: savana, scrub, grassland. Cultivated vegetation dominant: crops, wetland rice, vineyards, orchards, plantations. Vegetation scarce or lacking: alpine vegetation or barren. Swamps, marshes, and bogs.
DESCRIPTION	Type, species, average height, diameter at breast height, spacing, and type of canopy. Growing season of crops, dates of harvest. Type, density, and height of undergrowth. Period of defoliation or period when trees are in leaf.
DISTRIBUTION	Types of terrain and elevation at which growth commonly occurs.
POTENTIAL USES	Suitability for construction, camouflage, fuel cover and concealment.
SPECIAL CONSIDERATION	Obstacles to movement Susceptibility to fire

Table 10-6. Water Resources

SURFACE WATER	
QUANTITY	High water period: indicate amounts available and months of occurrence. Low water period: same (quantitative terms are—large, more than 1,500,000 g.p.d. (gallons per day); moderate, 150,000 to 1,500,000 gpd; small, 15,000 to 150,000 gpd; meager, less than 15,000 gpd.)
QUALITY	Amount and kind of contamination (if any), turbidity, taste and odor, chemical content, organic matter, and dissolved mineral matter to include hardness.
DEVELOPMENT PROBLEMS	Indicate accessibility for intake points; height, steepness, and stability of banks; depth of water and bottom materials; availability of natural filtration materials; effects of variations in water level; shifting channels; and freezing conditions. Further indicate general distribution of sources.
GROUND WATER	
DRILLED WELLS (more than 6 meters deep)	Quantity of fresh water: generally plentiful, locally plentiful, scarce, or lacking. Siting: distribution of sources and ease of siting. Source and probable depth: type of underlying strata and depth to source. Drilling and casing: type of material between surface and source, and need for casing or special protective equipment.
DUG OR DRIVEN WELLS (less than 6 meters deep)	Quantity: same as for drilled wells. Source: indicate depth to water table.
SPRINGS AND EXISTING WELLS	Quantity: same as for drilled wells. Distribution: general location, spacing, types of terrain, and accessibility.
QUALITY	Amount and kind of contamination or pollution (if any), taste and odor, chemical content, and dissolved mineral to include hardness.

cation; cultivated areas; dams, quarries and mines; industrial concentrations; and operational aspects.

10-18. Cross-Country Movement and Airborne Operations

This component is an evaluation of the suitability of the terrain for cross-country movement of ve-

hicles and foot troops and for airborne operations—paradrops and landings of fixed-wing assault aircraft and assault helicopters.

a. The map (fig. 10-8) will show the distribution of areas that differ in suitability. Areas suitable for cross-country movement will be depicted by map units signifying good, fair, poor, and unsuited. Suitability for airborne operations will be

treated under the same map units, but with slightly different terms, namely: suited, restricted, and unsuited. Existing airfields will be symbolized in terms of suitability for different types of aircraft. Seasonal suitability will be noted.

b. The table (table 10-8) will be organized by units corresponding to those shown on the map. Cross-country movement will be described in terms of general terrain conditions and the suitability for movement of tracked vehicles, wheeled vehicles, special vehicles, and foot troops. Airborne operations will be described in terms of suitability for airdrops, landings of fixed-wing assault-type aircraft and assault helicopters; gen-

eral effects of terrain; and effects of climate on operations.

10-19. Suitability for Irregular Force Operations

This component evaluates the significant terrain elements of the study area for operations of irregular forces.

a. The map (fig. 10-9) will show the physical and culture features of significance to operations. These will include populated places, transportation lines, vegetation, surface drainage, caves and quarries, and significant boundary fortifications.

Table 10-7. Culture Features of Military Significance

SETTLEMENTS	Urban and rural. Building spacing, physical size, and construction type.
ROUTES OF COMMUNICATION	Roads, railroads, waterways, airfields, ports, and telecommunications to include density of lines, height of lines, and general location.
CULTIVATED AREAS	Embankments, field terraces, walls, hedges, flooded fields, drainage ditches, irrigation projects, vineyards, estates, plantations.
DAMS, QUARRIES AND MINES	Describe installations and associated features.
INDUSTRIAL CONCENTRATIONS	Type, areal extent, characteristics, military significance.
OPERATIONAL ASPECTS	Discussion of features according to their aid or hindrance to military operations, including movement, paradrops, cover, concealment, fields of fire, construction, billeting, storage, supply.

Table 10-8. Cross-Country Movement and Airborne Operations

CROSS-COUNTRY MOVEMENT	
GENERAL TERRAIN CONDITIONS	Brief description of terrain to include slopes, vegetation, drainage, state of ground, soils and culture features. Seasonal variations, including snow-cover if applicable. Special phenomena such as landslides, mudslides, dust storms, shifting sand dunes, etc.
TRACKED VEHICLES	Rating for each movement element by use of defined adjectives, to include effects of terrain and seasonal implications.
WHEELED VEHICLES	
SPECIAL VEHICLES	
FOOT TROOPS	
AIRBORNE AND AIRMOBILE OPERATIONS	
SUITABILITY	Each cross-country movement (CCM) map unit should be described in defined terms of general suitability for airdrops, landing assault-type aircraft, and landing assault-type helicopters.
GENERAL EFFECTS OF TERRAIN	Descriptive evaluation of terrain factors which will affect operations. Describe also existing airfields, including requirements for special equipment or engineering effort.
CLIMATE	Climatic regions, major seasons, transitional periods. Seasonal precipitation in regions; average monthly variations. Seasonal temperatures, humidity and cloudiness. Periods and duration of fog. Surface winds (direction and velocity). Special phenomena such as hurricanes, typhoons, monsoons.

Table 10-9. Suitability for Irregular Force Operations

TERRAIN DESCRIPTION	Description of terrain with emphasis on features that affect irregular force operations; landforms, vegetation, drainage, water resources, state of ground and culture features.
POTENTIAL FOR COVER AND CONCEALMENT	Description of forests, surface irregularities, cover, buildings, embankments and other physical manmade features which may provide cover and concealment. Describe density, seasonal changes and accessibility of features.
POTENTIAL FOR MOVEMENT	Evaluation of cross-country movement, primarily for foot troops, but also on wheeled and tracked vehicles. Consider these in relation to density and conditions of roads, tracks, trails and waterways as avenues of movement.
POPULATION CHARACTER AND ATTITUDES	General statement of population density, pattern, and areas of greatest and least concentration. Discuss political, economic, religious and social attitudes of people as it may pertain to their relationship to irregular force operations.
SETTLEMENTS	General distribution, number and types of settlements; areas of greatest and least concentration; sizes of towns and villages; and average distances between settlements. Discuss physical characteristics including street pattern and building construction.
SUSTENANCE AND SHELTER	Agricultural pattern, types of crops, growing season; natural subsistence such as animal, plant and water; shelter, shelter material, fuel; air or beach resupply points; sources of recruits and supplies.
STRATEGIC AREAS	Significant features that could affect operations, such as transportation and telecommunications centers, industrial facilities, urban centers, airfields, passes.
CLIMATE	Significant aspects of climate, including seasonality. A separate table may be used to cover such factors as temperatures, precipitation, winds, humidity, snow cover, length of twilight and dawn, and number of clear nights.
REMARKS	Additional factors that may be included are natural construction materials, local diseases, dangerous animals, poisonous plants and data on boundaries.

b. The table (table 10-9) will be organized by units corresponding to those shown on the map and will include details on cover and concealment; potential for cross-country movement; population characters and attitudes; settlements; strategic areas; subsistence and shelter; climate; and other factors that influence operations.

10-20. Nuclear and CBR Employment

This component evaluates the terrain elements for their effect on the employment of nuclear detonations and chemical, biological, and radiological (CBR) agents. The preferred map scale is 1:500,000.

a. The map (fig. 10-10) will show the military geographic regions of the study areas by regional and, if appropriate, subregional lines.

b. The table (table 10-10) will be organized by military geographic regions corresponding to those shown on the map. The table will present details on nuclear employment to include the modifying effects of terrain on air and ground blasts, thermal conditions, and radiation, and the effects of climate on the employment of nuclear weapons.

Contingent effects such as induced radiation, tree blowdown, fire areas, and cratering, and the effects of climate and terrain on the employment of CBR agents will be discussed, as well as force vulnerability in terms of dispersion and mobility.

10-21. Suitability for Road and Airfield Construction

This component evaluates terrain elements for their effect on the construction of roads and airfields.

a. The map (fig. 10-11) will show the relative suitability of the terrain for construction of both roads and airfields as good, fair, poor, and unsuited. Any existing airfields and landing strips will be symbolized on the map.

b. The table (table 10-11) will be organized by units corresponding to those shown on the map, and will present detailed information on general terrain conditions; suitability for both road and airfield construction; the availability of construction materials and water; climatic conditions; and special construction problems encountered.

Table 10-10. Nuclear and CBR Employment

NUCLEAR CONSIDERATIONS	
MODIFYING EFFECTS OF TERRAIN ON—	<p>BLAST: Surface reflecting quality; surface configuration; characteristics of ground for shock effects; distribution of blast by permafrost; blast induced avalanches; shielding potential; surface geology; vegetation; mineralogical composition and moisture content of surface materials.</p> <p>THERMAL EFFECTS: Surface reflecting quality; surface configuration; forests, fuels; mineralogical composition and moisture content of surface materials; distribution and construction materials of buildings and walls.</p> <p>RADIATION: Surface configuration; mineralogical composition and moisture content of surface materials; distribution and construction materials of buildings.</p>
CLIMATE	Precipitation data; snow cover; winds, both surface and upper air, and possible effects on blast and fallout; relative air density; very low temperatures (−50°F); height and percent of cloud cover.
CONTINGENT EFFECTS	<p>INDUCED RADIATION: Soil and rock classification and condition, to include mineral composition and moisture content of surface materials, depth of rock and thickness of overburden, depth of water table.</p> <p>TREE BLOWDOWN: Forest types and conditions.</p> <p>FIRE AREAS: Susceptibility of forest floors and vegetation to conflagration.</p> <p>CRATERING: Topographic influences and characteristics, and depths of soils, rocks and water table.</p>
CBR CONSIDERATIONS	
CLIMATE	Local windspeed, direction, and periods of occurrence; cloudiness; visibility, precipitation; mean relative humidity at specified hours; mean daily maximum and minimum temperatures.
TERRAIN	Effects of landforms, vegetation, drainage and soils on employment of specific agents.
FORCE VULNERABILITY	
DISPERSION	Feasibility of troop dispersal from affected areas.
MOBILITY	Evaluation of cross-country movement conditions in each region.

Table 10-11. Suitability for Road and Airfield Construction

GENERAL TERRAIN CONDITIONS	Brief description of terrain to include slopes, vegetation, drainage, state of ground and soils.
ROAD CONSTRUCTION	Detailed evaluation of the effects of terrain on construction. General discussion of alignments, grades, natural foundations and construction problems to include seasonal effects, grading, clearing, effects of flooding and landslides.
AIRFIELD CONSTRUCTION	Detailed evaluation of terrain suitability for construction of small and large airfields. Discussion will include air approaches, runway orientation, natural foundation, construction problems, clearing, grading, seasonal effects.
CONSTRUCTION MATERIALS AND WATER	General discussion of availability, location, and accessibility of construction materials such as rock, sand, gravel and of water.
CLIMATIC CONDITIONS AND SPECIAL CONSTRUCTION PROBLEMS	Effects of extreme climatic conditions such as heavy rainfall or snowfall, extremely low temperatures and depth of frost line, frozen drainage features, etc. and periods of occurrence. Special construction problems. Special problems include seismic activity, unstable surface conditions, and permafrost.

10-22. Suitability for Underground Installations

This component evaluates the suitability of terrain for the construction of underground installations.

a. The map (fig. 10-12) will show the suitability for construction of both tunnel- and bunker-type installations in terms of differing suitability or in the types of problems involved. Existing underground installations such as mines and caves will be symbolized.

b. The table (table 10-12) will be organized by units corresponding to those shown on the map. It will include data on terrain, rock, and soil characteristics; conditions for the construction of both

tunnel-type and bunker-type installations; availability of natural construction materials; and special problems encountered.

Table 10-12. Suitability for Underground Installations

TERRAIN, ROCK, AND SOIL CHARACTERISTICS	Salient characteristics of major map units with emphasis on slope, rock and soil characteristics and drainage conditions.
CONDITIONS FOR TUNNEL INSTALLATIONS	Surface configuration, primarily slope and local relief, as it affects the number of potential sites, length of entry required, type of entry possible, ease of draining, access to potential sites, and thickness of protective cover (90 meters of hard cover desirable for best sites; 30 meters of hard rock cover desirable as minimum). Discuss thickness, ease of excavation and stability of rock. Discuss effects of ground water and vegetation, and any special maintenance problems.
CONDITIONS FOR BUNKER INSTALLATIONS	Surface configuration as it affects the number of sites, ease of draining, excavation and access to potential sites. Discuss drainage conditions, stability, soils and soft rock conditions, and vegetation. (6 meters of easily excavated dry soil or soft weathered rock above water table is desirable for best sites.)
CONSTRUCTION MATERIAL AND SPECIAL PROBLEMS	General availability of natural construction materials such as aggregate, timber, and water; effects of weather on soil workability and depth and duration of snow cover and frozen ground; special problems such as seismic and volcanic activity, landslides and permafrost.

APPENDIX A

REFERENCES

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115-10	Meteorological Support for the US Army.
115-11	Army Topography.
115-21	Hydrologic Services for Military Purposes.
310-1	Military Publications—General Policies.
310-25	Dictionary of United States Army Terms.
310-50	Authorized Abbreviations and Brevity Codes.
380-series	Security.
381-series	Military Intelligence.

A-2. Department of the Army Pamphlets (DA Pam)

108-1	Index of Army Motion Pictures and Related Audio-Visual Aids.
310	Military Publication Indexes.

A-3. Field Manuals (FM)

1-60	Army Air Traffic Operations.
3-8	Chemical Reference Handbook.
3-10	Employment of Chemical and Biological Agents.
3-12	Operational Aspects of Radiological Defense.
5-1	Engineer Troop Organizations and Operations.
5-15	Field Fortifications.
5-20	Camouflage.
5-30	Engineer Intelligence.
5-34	Engineer Field Data.
5-35	Engineer's Reference and Logistical Data.
5-36	Route Reconnaissance and Classification.
6-15	Artillery Meteorology.
19-40	Enemy Prisoner of War and Civilian Internees.
21-5	Military Training Management.
21-6	Techniques of Military Instruction.
21-26	Map Reading.
21-30	Military Symbols.
21-31	Topographic Symbols.
24-1	Tactical Communications Doctrine.
24-19	Communications-Electronics Reference Data.
30-5	Combat Intelligence.
(C)30-10A	Special Applications of Terrain Intelligence (U).
30-15	Intelligence Interrogation.
30-16	Technical Intelligence.
30-20	Aerial Surveillance-Reconnaissance, Field Army.
31-3	Weather Support for Field Army Tactical Operations.
31-25	Desert Operations.
31-35	Jungle Operations.

31-36 (Test)	Night Operations.
31-60	River Crossing Operations.
31-70	Basic Cold Weather Manual.
31-71	Northern Operations.
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(C)32-20	Electronic Warfare (Ground Based) (U).
55-8	Transportation Intelligence.
57-35	Airmobile Operations.
100-5	Operations of Army Forces in the Field.
101-5	Staff Officers' Field Manual—Staff Organization and Procedure.
101-10-1	Staff Officers' Field Manual—Organizational, Technical, and Logistical Data—Unclassified Data.

A-4. Technical Manuals (TM)

1-300	Meteorology for Army Aviation.
3-210	Fallout Prediction.
3-240	Field Behavior of Chemical, Biological, and Radiological Agents.
5-200	Camouflage Materials.
5-240	Compilation and Color Separation of Topographic Maps.
5-243	Cartographic Aerial Photography.
5-245	Offset Photolithography and Map Reproduction.
5-248	Foreign Maps.
5-249	Terrain Models and Relief Map Making.
5-270	Cableways, Tramways, and Suspension Bridges.
5-297	Well Drilling Operations.
5-312	Military Fixed Bridges.
5-330	Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations.
5-332	Pits and Quarries.
5-342	Logging and Sawmill Operation.
5-343	Military Petroleum Pipeline Systems.
5-360	Port Construction and Rehabilitation.
5-370	Railroad Construction.
5-443	Field Classification Surveys.
5-530	Material Testing.
5-545	Geology.
5-700	Field Water Supply.
11-695	Electrical Power Systems, Fixed Telecommunications Stations.
30-245	Image Interpretation Handbook.
(C)30-245A	Image Interpretation Handbook—Vol 2 (U).
30-246	Tactical Interpretation of Air Photos.
(C)30-251	Inventory of Military Imagery Interpretation; Keys and Related Material (U).
(C)30-253	PIK: Deception, Concealment, Camouflage and Decoys (U).*
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(C)30-260	PIK: Industrial Components (U).*
(C)30-263	PIK: Chemical Processing Industry (U).*
(C)30-265	PIK: The Petroleum Industry (U).*
30-268	PIK: Building Structure Analysis.*
(C)30-274	PIK: The Aluminum Industry (U).*
(C)30-280	PIK: The Explosive Industry (U).*
(S)30-285	PIK: Consolidated Subject Keys (U).*
(C)30-305	Imagery Interpretation Key: Interpretation of Infrared Imagery (U).

* Photographic Interpretation Keys (PIK).

A-5. Joint Chiefs of Staff Publications (JCS Pub)

JCS Pub 1 Dictionary of United States Military Terms for Joint Usage.

A-6. Other Publications

DOD-DIA Glossary of Mapping, Charting and Geodetic Terms.
 JANAP-169 Joint Army-Navy-Air Force Publication No. 169.

A-7. International Standardization Agreements (STANAG) NATO

2010	Bridge Classification Markings.
2012	Military Route Signing.
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2022	Intelligence Reports.
2033	Interrogation of Prisoners of War.
2201	Standard Unit of Vertical Measure Shown on Land Maps.
2251	Scope and Presentation of Military Geographic Information and Documentation (MGID).
2253	MGD—Roads and Road Structures.
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2256	MGD—Inland Hydrography.
2257	MGD—Railroads.
2259	MGD—Terrain.
2260	MGD—Electric Power.
2263	MGD—Coastal Areas and Landing Beaches.
2269	MGD—Engineer Resources.
2271	MGD—Urban Areas.
2275	Indexes to Military Geographic Information and Documentation.
3423	Glossary of Technical Terms Used in Air Photography.

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By Order of the Secretary of the Army:

W. C. WESTMORELAND,
General, United States Army,
Chief of Staff.

Official:

VERNE L. BOWERS,
Major General, United States Army,
The Adjutant General.

Distribution:

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Note from the Scanner

Attached at the end of this manual is a large sheet containing 12 letter size map samples. The sheet is folded so that the 4th map on the first row is shown. That map is named Drainage. Above the title is the phrase, "Appendix N. Topical and Evaluative Map Samples." The map samples are:

Landforms	Suitability of Soils	Rock Types	Drainage
Vegetation	Water Resources	Cultural Features of Military Significance	Cross-Country Movement and Airborne Ops
Suitability for Irregular Force Operations	Nuclear and CBR Employment	Suitability for Road and Airfield Construction	Suitability for Underground Installations

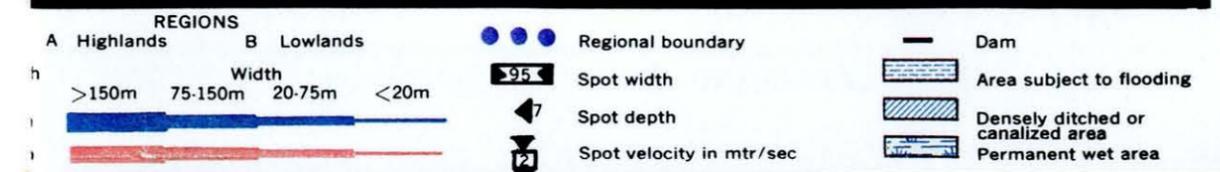
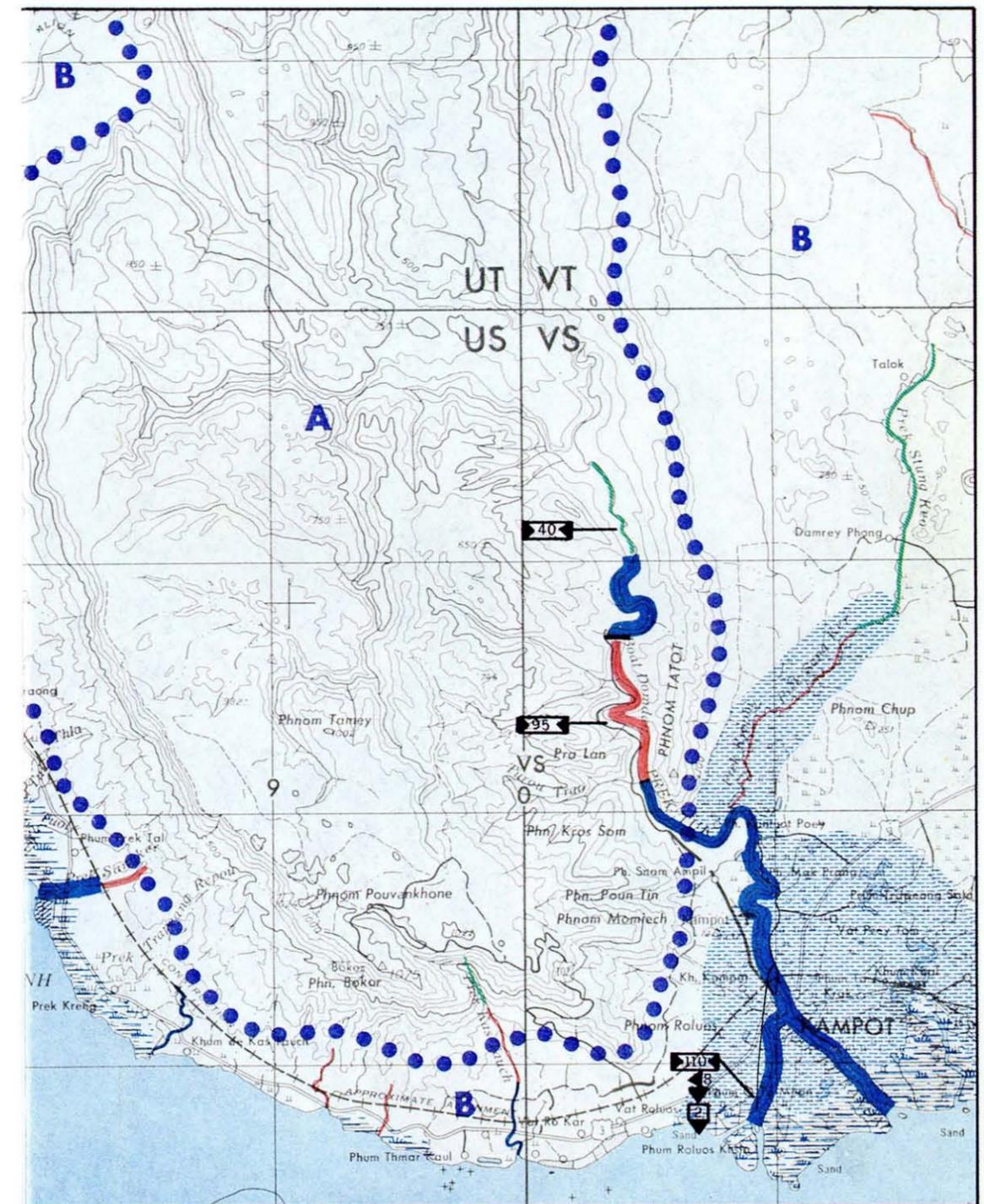
The folded map is shown on the next page.

All 12 maps follow in order after that.

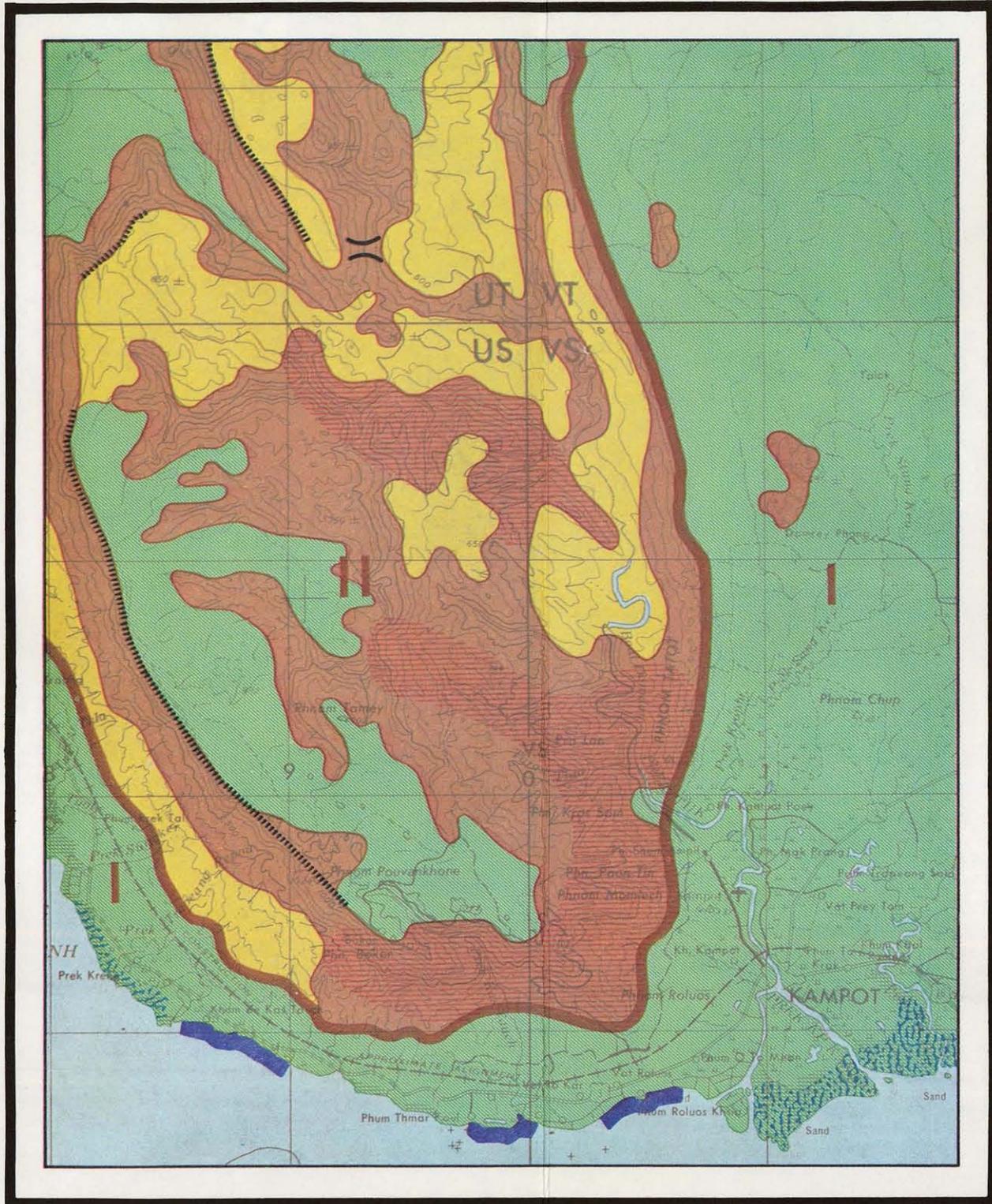
Bob Bolin

APPENDIX N. TOPICAL AND EVALUATIVE MAP SAMPLES

DRAINAGE

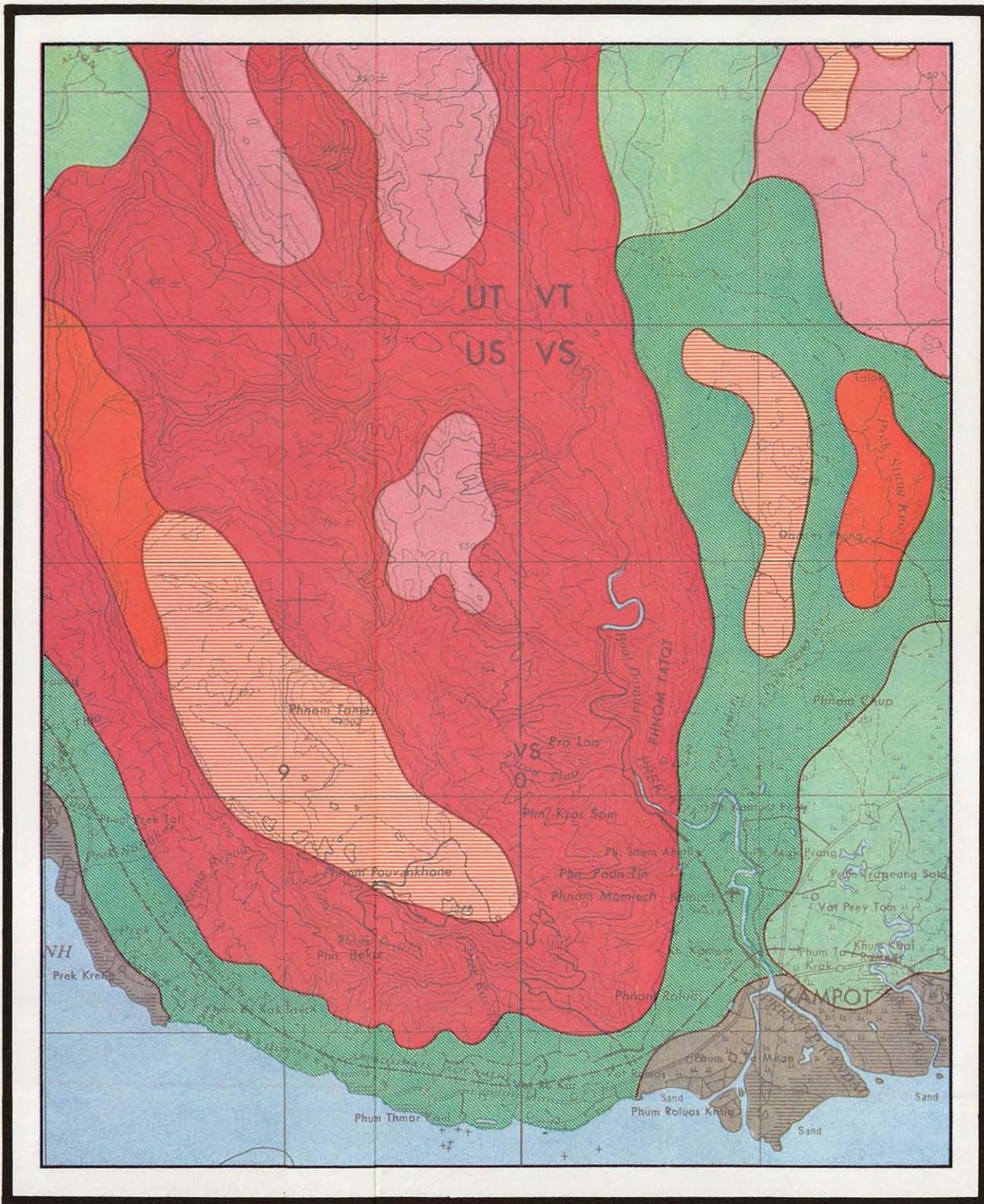


LANDFORMS AND SURFACE CONFIGURATION



- | REGIONS | LANDFORM TYPES | |
|-----------------------|----------------|---|
| I Lowlands | Plains | Escarpment |
| II Interior Highlands | Hills | Areas of critical slope too steep for movement (over 45%) |
| Landform region line | Mountains | Mangrove |
| | Pass | Beach |

SUITABILITY OF SOILS FOR MILITARY USES



COARSE-GRAINED SOILS

- Silty sand, gravelly sand, and clayey sand; moderately deep to deep*
- Poorly graded sand, silty sand, and clayey sand; very deep

FINE-GRAINED SOILS

- Clayey silt, silt, and clay of low plasticity; moderately deep to deep
- Clays of low and high plasticities; moderately deep to deep

COARSE-GRAINED AND FINE-GRAINED SOILS

- Clayey silt, gravelly sand, silty sand, and gravelly clay; shallow to deep
- Poorly graded sand, clayey sand, silt, clays of low and high plasticities; very deep

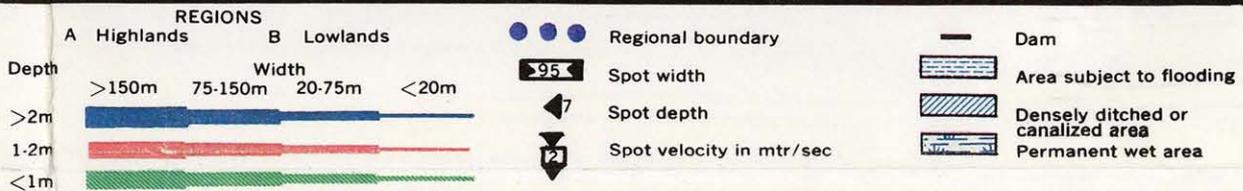
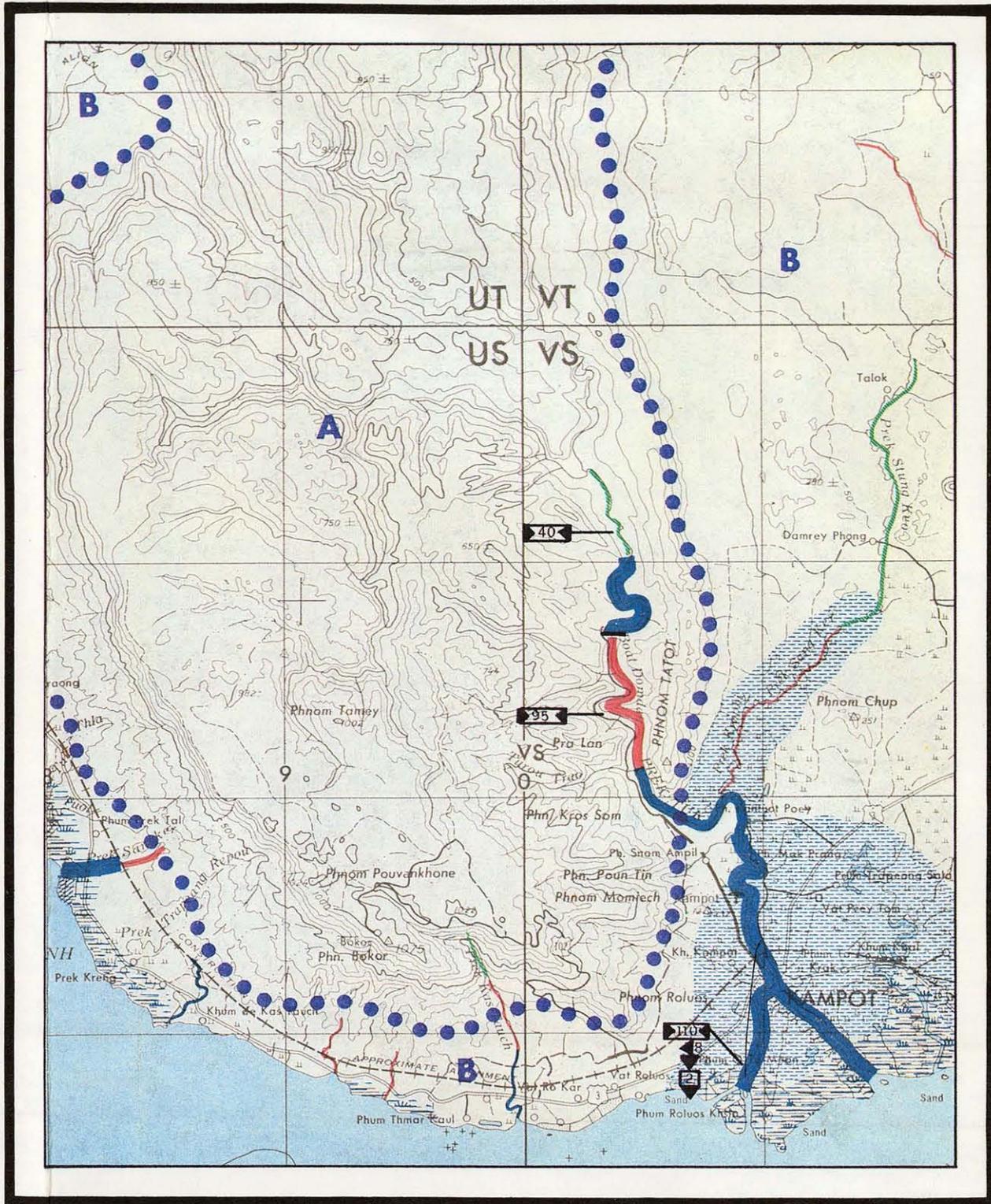
FINE-GRAINED AND HIGHLY ORGANIC SOILS.

- Peat, organic silt, organic clay, clays of low and high plasticities, and muck; very deep

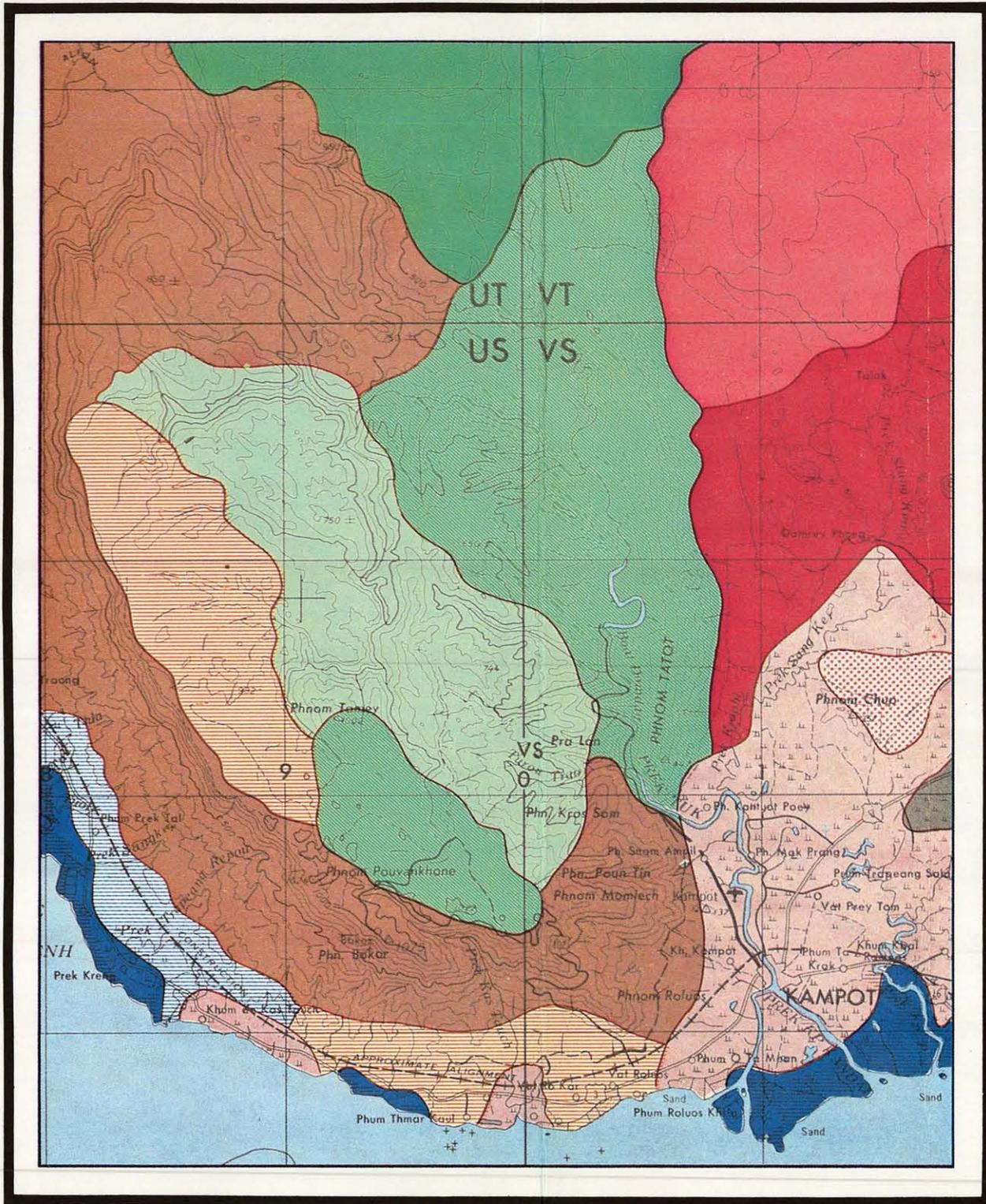
*Rating terms for depth of soil
 shallow—less than 0.5 meters moderately deep—0.5 to 2 meters
 deep—2 to 6 meters very deep—more than 6 meters

APPENDIX N. TOPICAL AND EVALUATIVE MAP SAMPLES

DRAINAGE



VEGETATION

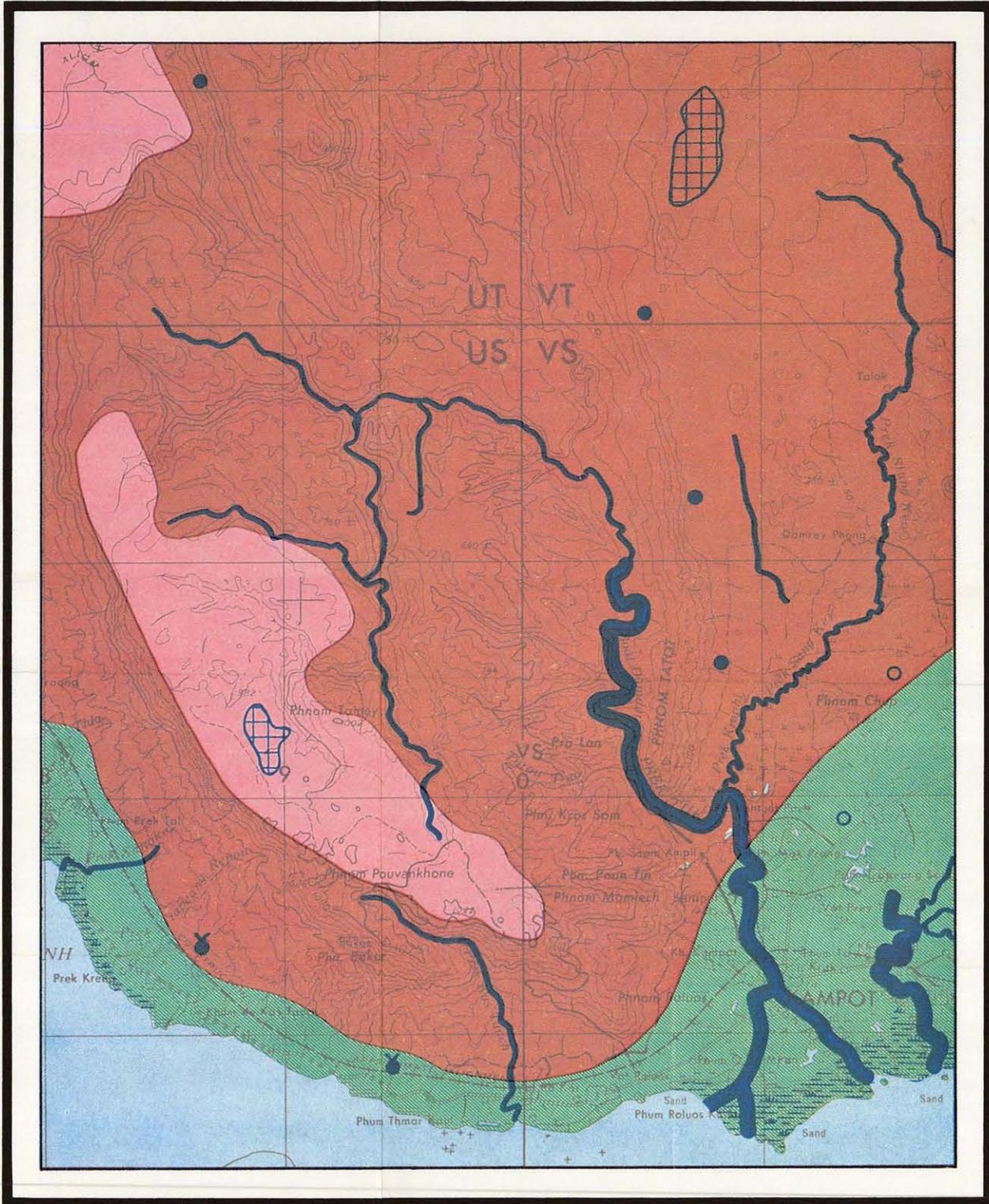


- TREES DOMINANT**
- Needleleaf evergreen
 - Broadleaf evergreen
 - Broadleaf deciduous
- SHRUBS DOMINANT**

- GRASSLAND DOMINANT
- CULTIVATED VEGETATION**
- Crops
 - Wetland rice
 - Orchards
 - Plantations

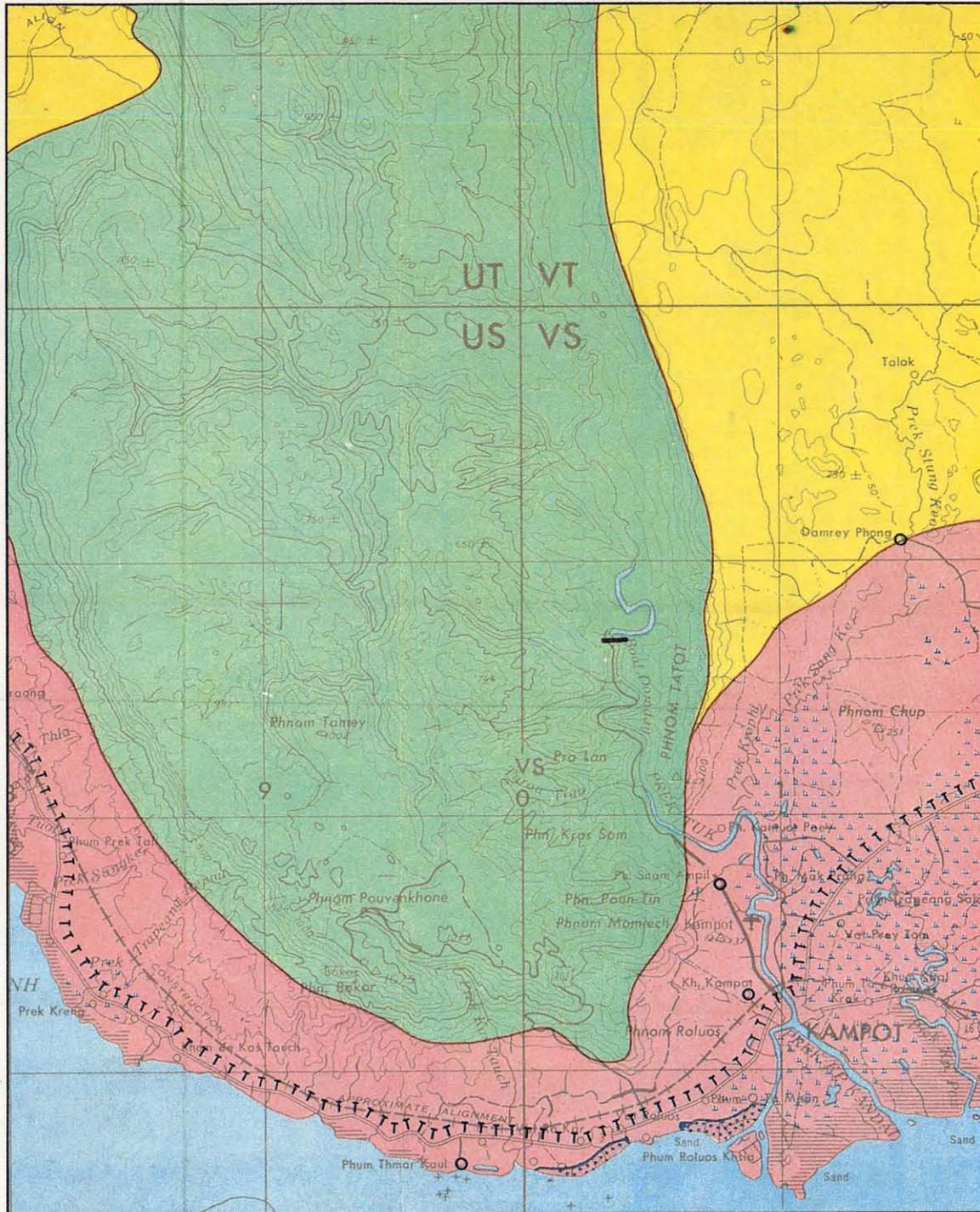
- WET VEGETATION**
- Marshes
 - Swamps
 - VEGETATION SCARCE OR LACKING

WATER RESOURCES



<p>SURFACE WATER</p> <p> Major stream source (amount and seasonality indicated in table)</p> <p> Minor stream source (amount and seasonality indicated in table)</p> <p> Major lake source</p> <p> Marshes, swamps</p>	<p>GROUND WATER</p> <p> Fresh-water generally plentiful; large* quantities</p> <p> Fresh-water locally plentiful; moderate to large quantities</p> <p> Fresh-water scarce or lacking; small to meager quantities</p>	<p> Spring</p> <p> Well</p> <p> Artesian well</p>
<p>* large—more than 1,500,000 g.p.d. (gallons per day) moderate—150,000 to 1,500,000 g.p.d. small—15,000 to 150,000 g.p.d. meager—less than 15,000 g.p.d.</p>		

CULTURE FEATURES OF MILITARY SIGNIFICANCE

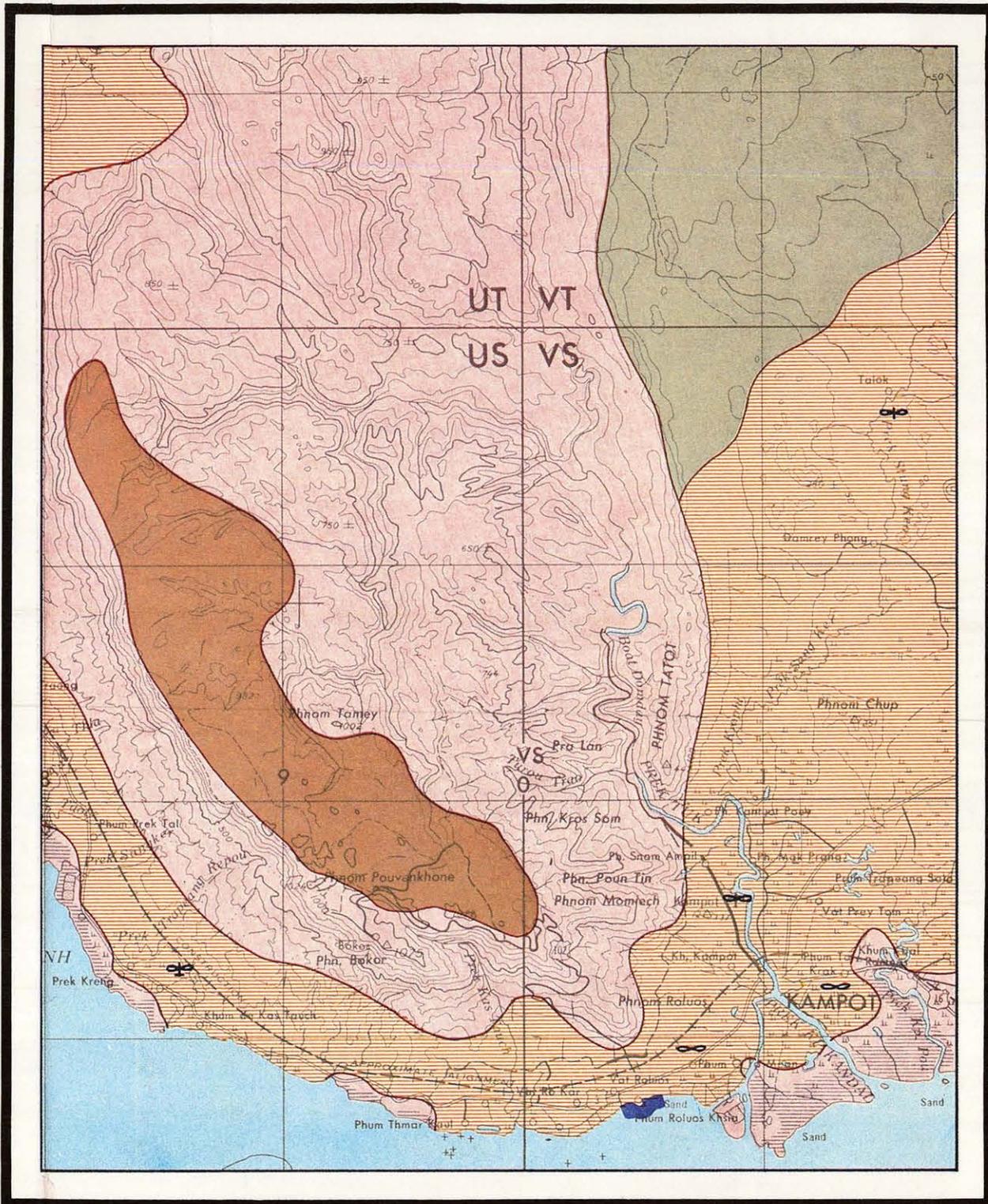


- High density
- Moderate density
- Low density

- Wet rice fields
- Town, village
- Dam

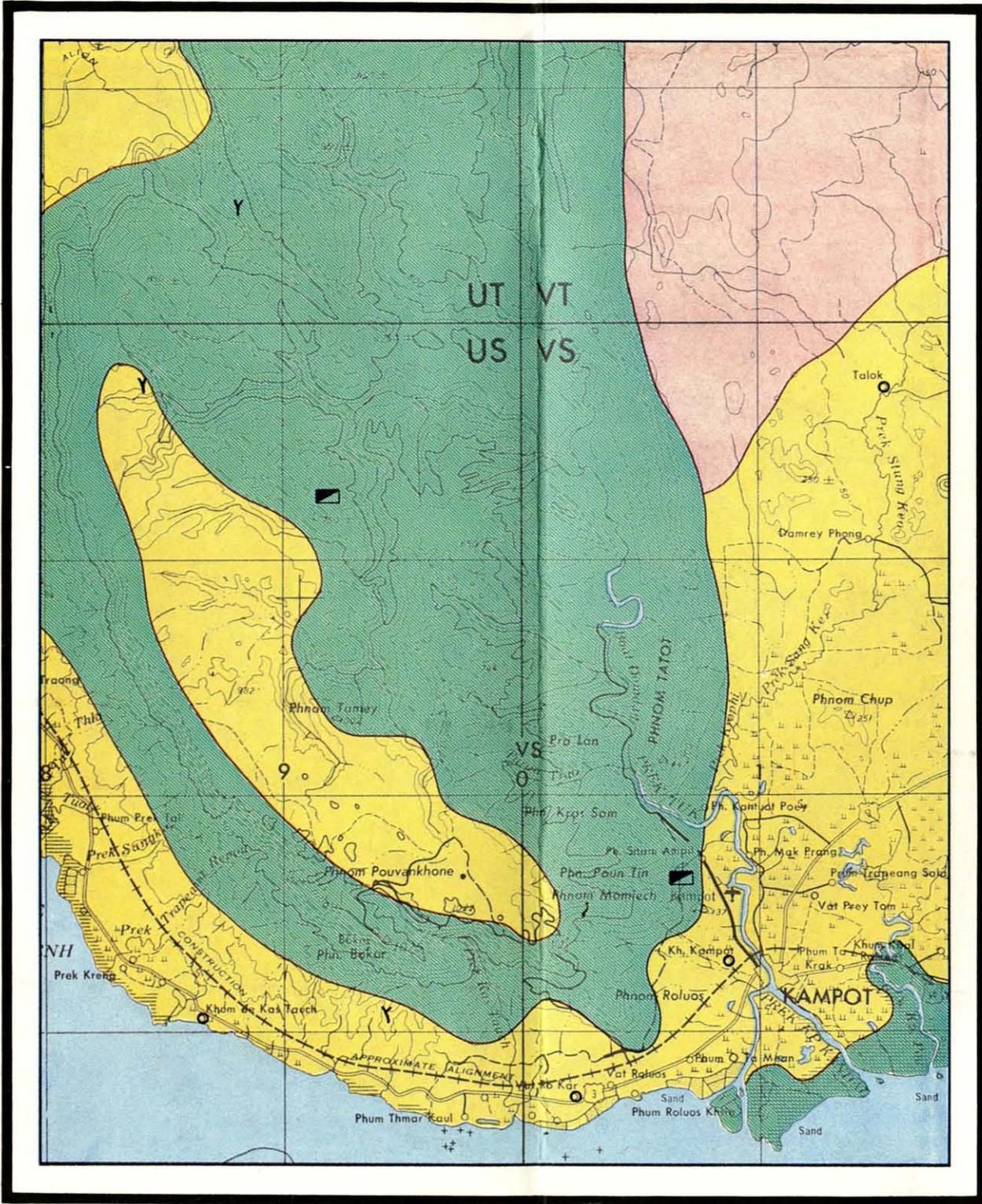
- Salt pans
- Transmission lines

CROSS-COUNTRY MOVEMENT AND AIRBORNE OPERATIONS



CROSS-COUNTRY MOVEMENT			AIRBORNE OPERATIONS				
Tracked Vehicles	Wheeled Vehicles	Foot Troops	Air Drops	Assault Aircraft	Assault Helicopter		
	Good	Good	Suited	Suited	Suited		
	Fair	Good	Suited	Suited	Suited		
	Poor	Fair	Restricted	Restricted	Suited		
	Unsuited	Poor	Unsuited	Unsuited	Restricted		
	Airfield (existing)		Landing strip for light aircraft (existing)		Helicopter landing area		Selected landing beach

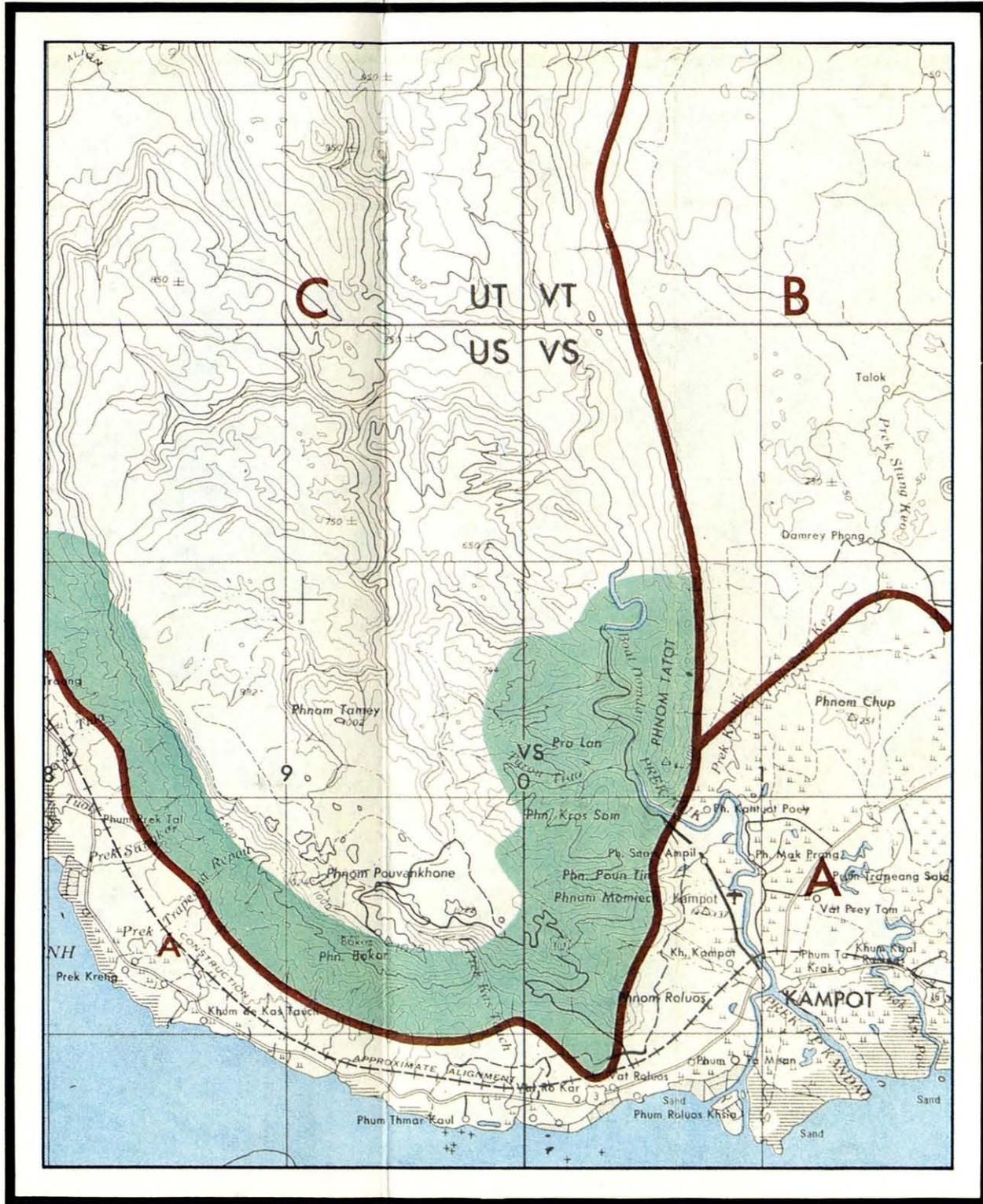
SUITABILITY FOR IRREGULAR FORCE OPERATIONS



- | | | |
|--|--|---|
|  Favorable for operations |  Unfavorable for operations |  Cave |
|  Marginal for operations |  Mine |  Town, village |

Significant data such as population density and concentrations, surface drainage, vegetation patterns, and transportation lines may also be shown, as appropriate. These should agree with appropriate topical maps.

NUCLEAR AND CBR EMPLOYMENT



REGIONS

- A** Coastal lowland
- B** Interior lowland
- C** Interior upland

Dense forest

Significant data such as soils, rock types, drainage, and depth of water table may also be shown, as appropriate. These should agree with appropriate topical maps.

SUITABILITY FOR ROAD AND AIRFIELD CONSTRUCTION



SUITABILITY	ROAD CONSTRUCTION	AIRFIELD CONSTRUCTION
GOOD: few or no construction problems	Alignments unrestricted; long tangents, long radius curves; grades less than 2%	Many sites for large airfields
FAIR: minor construction problems	Alignments moderately restricted; low grades possible, except in dissected or hilly areas	Many sites for small airfields; few sites for large airfields
POOR TO UNSUITED: severe grading, drainage, foundation, flooding or clearing problems	Alignments restricted; numerous short tangents, short radius curves, and steep grades necessary	A few sites for small airfields only
	Airfield (existing)	Landing strip for light aircraft (existing)

