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OPERATIONS OF ENGINEER TROOP UNITS

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PART ONE

CONTROL OF ENGINEER OPERATIONS

CHAPTER 1

INTRODUCTION

1. Contents

This manual contains the basic doctrine for the operations of engineer troop units in a theater of operations. Both the combat and the communications zone are discussed, with emphasis on the units of a field army.

2. Part One

Part One covers the *control* of engineer operations by commanders, together with activities which are not an end in themselves but an essential to operations; that is, staff planning and supervision, intelligence and reconnaissance, estimates, plans, orders, supply, maintenance, and signal communications.

3. Part Two

Part Two covers the *conduct* of engineer operations. Doctrine rather than technique is emphasized. The sequence of treatment is by function.

4. Teamplay

Engineer units are part of the United States Army team. While many of their tasks are specialized, they are related to analogous activities of the Army as a whole. Throughout the text, it is sought to bring out this interrelationship, and the means of attaining mutual understanding and cooperation.

5. References

FM 5–5, and engineer T/O & E's, list and describe the personnel and equipment of engineer troops. Various field manuals of the "5" series describe in detail the operations of individual engineer units. Other texts deal with engineer techniques and field data. Army field manuals of other series cover staff management, combat doctrine, training, administration, personnel management, and the like. The present text is tied in to this body of literature. Since its coverage must be extensive, details are kept to a minimum by cross-references.

CHAPTER 2

MISSIONS, ASSIGNMENTS, AND EMPLOYMENT OF ENGINEER TROOPS

6. Missions

The missions of the Corps of Engineers and of engineer troop units in a theater of operations include those listed below.

a. Participation in all forms of combat, including advance, attack, pursuit, defense, retrograde movements, denial operations, airborne, and amphibious operations. In these operations they perform various specialized tasks, alone or in cooperation with other units, such as the destruction, breaching, or passage of obstacles; the construction of obstacles and of certain complex defense installations; and river crossings in the presence of the enemy. In an emergency they fight as infantry.

b. Numerous technical operations, including—

(1) All types of general construction, such as cantonments, depots, warehouses, and hospitals, with their utilities.

(2) The construction or reconstruction of roads, railroads, bridges, airfields, pipelines, and port facilities.

(3) Maintenance and repair of the foregoing in most cases.

(4) Recommendations for traffic regulation, in cooperation with other agencies.

(5) Water supply.

(6) Topographic services including mapping of all types; surveying both land and geodetic; geodesy and photogrammetry for target location; reproduction; and map supply.
(7) Demolitions.
(8) Camouflage.

c. Engineer supply and maintenance of engineer equipment, both for themselves and (excepting organizational maintenance) for other troop units in the theater.

d. Technical assistance to other arms and services.

7. Categories

There are seven general categories of engineer troop units—

a. Divisional units (organic to divisions).

b. Combat support units (operating in contact and cooperation with tactical units of all arms engaged in combat).

c. Constructions units.

d. Topographic units.

e. Maintenance and supply units.

f. Units with the Air Force. These belong to the SCARWAF category ("Special Category Army Units With Air Force") (see ch. 21).

g. Teams of the engineer service organization (T/O & E 5–500A).

8. Assignments

a. Engineer troop units may be assigned to division, corps, army, communications zone, or an independent task force. SCARWAF engineer units are components of the theater air force; other engineer units, especially of the maintenance and supply category, may be temporarily assigned or attached to a theater air force or subordinate agencies thereof.

b. A unit assigned as above is frequently further assigned or attached. For example, a unit assigned to the communications zone may be further assigned to a section thereof; a unit assigned to an army may be further assigned or attached to an engineer group functioning under army.

9. Engineer Units in Theater

a. Table VII lists all fully organized engineer troop units found in a theater, with their T/O & E numbers, normal assignments, and normal or frequently used attachments and reassignments. If separate T/O & E's exist for the unit as a whole and for subordinate units, all are listed. Table VIII lists teams of the engineer service organization, with their normal assignments or attachments.

b. Units normally assigned to a certain type of command may be assigned or attached to a lesser command performing the same mission.

c. The missions, assignments, capabilities, internal organization, equipment, communications, and methods of employment of the individual troop units listed above are set forth in FM 5–5, and in more detail in various field and technical manuals dealing with individual units or techniques.

10. Engineer Support in Theater

The units listed in appendix II are organized to handle various specialized tasks. Collectively they constitute the engineer support given the theater. There are certain recognized groupings of engineer units needed to support the major component parts of a theater. No precise lists can be given, since no two theaters, and no two areas of a theater, have the same engineer problems or needs. The data given below are representative for average conditions. It is assumed that the theater army command comprises one or more type field armies and a fully organized communications zone. The supporting engineer units assigned to any command are themselves dependent for support upon engineer units in rearward areas.

a. Engineer Support for Division. The divisional battalion.

b. Engineer Support for Type Corps (additional to *a* above).

(1) Two engineer combat groups, each having three engineer combat battalions (army), a light equipment company, a panel bridge company, and a float bridge company. To one of these groups there is also assigned a dump truck company.
(2) One field maintenance company.
(3) One topographic company (corps).
(4) One team IG, intelligence (collection).
(5) One team EC, special equipment maintenance.

c. Engineer Support for Type Field Army (additional to *a* and *b* above).

(1) Two or three combat groups, each having three engineer combat battalions (army), a light equipment company, a dump truck company, a panel bridge company, a float bridge company, and two ponton bridge companies.
(2) Two construction groups, each having three construction battalions and a dump truck

company. To one of these groups there is also assigned a heavy equipment company.

(3) One maintenance and supply group, having three supply point companies, a depot company, a parts depot company, three field maintenance companies, a water supply company, a dump truck company, and such firefighting and maintenance and supply teams as are needed.

(4) One camouflage company.

(5) One topographic battalion (army).

(6) One engineer aerial photo reproduction company.

(7) One team IH, intelligence (research).

(8) Three combat battalions (army), one light equipment company, two ponton bridge companies, one float bridge company, and one panel bridge company are available for attachment to groups as required.

(9) Utility and other teams as needed.

d. Engineer Support in Communications Zone. This cannot be as closely estimated as in the case of a type field army. It depends on the nature, climate, and topography of a theater, and also on the duration of the campaign. In a new theater of operations there will be a great initial demand for construction and reconstruction which may be reduced as the theater is developed. At the same time there will be an increasing load in such fields as maintenance. The following are representative:

(1) Construction groups in the communications zone are organized in a manner similar to those of a field army, but may include spe-

cial units such as port construction companies.

(2) Maintenance and supply groups may differ from those of a field army by having units assigned for depot maintenance and the operation of base depots, and for special operations. Usually supply point companies are not assigned.

(3) Base topographic battalions, pipeline companies, and camouflage battalions are usually found in the communications zone.

(4) Two or more construction groups and a maintenance and supply group may be combined into an engineer brigade. One or more such brigades, plus camouflage and topographic troops, would be appropriate engineer support in an advance section supporting one or more field armies. In intermediate and base sections, brigades, groups, base topographic units and smaller units would be assigned as needed.

11. Relation to Other Arms

a. The basic mission of all engineer units is to serve the commands with which they are associated. This may be attained by general support, direct support, or attachment.

(1) An example of *general support* is a divisional engineer battalion, under the orders of its commander, working on tasks which benefit the division as a whole.

(2) An example of *direct support* is one company of such a battalion working on tasks for the specific benefit of one infantry regi-

ment of the division, although still under the orders of the engineer battalion commander.

(3) An example of *attachment* is one company of such a battalion placed temporarily under the command of the infantry regimental commander, as in the formation of a regimental combat team on a specific separate mission where divisional control is not possible.

b. Attachment may be qualified, as by stating that one unit is attached to another "for supply" or "for rations." Unless so qualified, the attachment is for all purposes except for such personnel matters as transfer and promotion.

c. In the relations between a supporting and a supported unit, the latter has no control over the former and no responsibilities toward it, although the requests and wishes of the supported commander are complied with as far as practicable. Attachment places the attached unit under the direct orders of the commander of the unit to which it is attached, and he thereby becomes responsible for it.

d. The capacity of an engineer command for useful output is greater than the sum of the capacities of its component parts operating independently, since the element of team work is all-important in engineer operations. Therefore, the attachment of elements of an engineer unit to another command should in principle be exceptional, and should be terminated as soon as possible in favor of a supporting role, general or direct. The criterion for attachment should be: Engineer units are attached to units of other arms only when distance, or the nature of the operation, prevent the senior engineer commander from exercising adequate control over his subordinate units.

e. Men work together more effectively after they have come to know each other and to understand each other's capacities and limitations. This applies in the relations between an engineer unit and the command it serves. For example, in an infantry division where engineer companies often operate in direct support of infantry regiments, the same company should consistently be placed in support of the same regiment. This is called normal association.

12. Supplementation

The capabilities of an engineer unit may be increased by—

a. The attachment of another engineer unit or element thereof.

b. The assignment or attachment of organized groups of civilians or prisoners of war.

c. The attachment of troop units or details from other arms or services.

13. Employment

a. Engineer troops should be employed primarily on work requiring technical skill and special equipment. They should be assigned tasks in accordance with approved priorities based on their importance to the command as a whole and its mission. They must not be regarded as pools of laborers and mechanics to be allotted individually to various operations.

b. Engineer units should be committed as infantry only in extreme emergencies. The decision to commit should be considered carefully, the advantage of such employment being weighed against the consequences of probable loss of trained troops to perform engineer functions in the future.

CHAPTER 3

COMMAND AND STAFF SUPERVISION

Section I. PRINCIPLES OF STAFF WORK

14. General

a. The Corps of Engineers has a dual status as an arm and a technical service (AR 10–260). It is charged with construction, supply, maintenance, and other specialized duties affecting all arms, and has representatives on the staffs of all major commands in a theater. It also has a wide variety of troop units, some of them combat units. Therefore, every engineer officer must know how to exercise command, how to organize and operate a staff (which is a major element in exercising command), and how to be a staff officer himself and to operate a section of a higher staff.

b. The Army is based on the "line-and-staff" system of organization. This is a working compromise between the purely "line" organization (which has no machinery for specialization and coordination at higher levels, and is suited only for small units), and the purely "functional" organization (which undermines the principle of unity of command, and is in general unsuited for military use).

c. Two types of staff are found in the Army: the "departmental" type, used (for example) in the Office, Chief of Engineers; and the "general staff" type. This text deals only with the general staff type, including the simplified forms of it found below brigade level.

Note. A third type, the "director" type, was used during World War II by the National Military Establishment. It was characterized, among other things, by the fact that certain members exercised command.

15. Purpose of a Staff

a. The staff of any unit consists of the officers who assist the commander, at his level, in his task of exercising command over subordinate units. The staff and the commander should be considered as a single entity. The existence of the staff in no way relieves the commander of his sole ultimate responsibility for what his unit does or fails to do.

b. More specifically, the major functions of a staff are to—

(1) Provide information.

(2) Make a continuing study of the situation.

(3) Based on such information and study, and on the commander's will, prepare coordinated plans and recommendations for the commander's consideration and decision.

(4) Prepare and distribute orders expressing the commanders decision.

(5) Supervise their execution.

16. Categories of Staff Officers

a. The staff of a division or higher command normally contains four categories of officers: general staff officers, special staff officers, personal staff officers, and liaison officers.

b. The general and special staff officers at a headquarters, as groups, are called respectively "the general staff" and "the special staff" of the command.

c. The personal staff includes the officers such as aides whom the commander elects to coordinate and administer direct instead of through his chief of staff. Liaison officers perform liaison duties for the commander and his staff.

17. Staff Authority

a. Staff officers cannot exercise command. Neither the staff as a whole, nor any staff officer, can exercise command. The power and the responsibility inherent in that function rest with the commander, and cannot be delegated. The exception to this rule is in the case of dual capacity.

b. The commander may authorize his staff to issue orders in his name. To carry out the task of translating a commander's decisions into detailed concrete action, a great number of orders must be issued from his headquarters, formal and informal, written and verbal. The commander cannot and should not attempt to see and personally approve more than a small fraction of them. Therefore he delegates to his staff, not only the authority to draft such orders, but the authority to issue them without personally consulting him, *provided that*—

(1) They are issued in his name.

(2) They are issued through command channels.

(3) They are clearly within the framework of his policies and decisions, and are intended to implement them.

(4) They are issued, in every case, by an appropriate staff officer, and within the limits of the authority specifically delegated to him.

c. Final authority rests only with the commander. The distinction between the power of command and the power exercised by a staff officer is by no means the mere form of words that some officers tend to consider it. A staff officer undoubtedly wields very real power. But that power is always subject to check by the commander, and is always subject to appeal through command channels.

d. Certain officers are both staff officers and commanders. An example is the division engineer, who is a special staff officer of the division commander and also commanding officer of the divisional engineer battalion. Corps and army engineers also have this dual capacity (SR 310–30–15). The two activities are distinct, and in exercising the latter the officer has full powers of command.

18. General and Special Staffs

a. General Staff. The general staff is a group of planning, coordinating, and supervisory officers. The division of duties among them is functional, but the functions are of a character affecting directly all units of the command. Members of the general staff of a headquarters are—The chief of staff, who directs and coordinates the entire staff, the deputy chief of staff, the secretary of the general staff, and four assistant chiefs of staff—the personnel officer (G1), the intelligence officer (G2), the operations and training officer (G3), and the logistics officer (G4), together with their assistants.

b. Special Staff. The special staff includes all staff personnel at headquarters not part of the general or personal staffs. Special staffs vary at different levels, and in particular cases two or more sections may be consolidated, or an existing section divided. The special staff of an infantry division normally includes the following sections: adjutant general, artillery, chemical, engineer, light aviation, medical, ordnance, quartermaster, signal, chaplain, finance, public information, inspector general, judge advocate general, dental, provost marshal, and special services. Other staffs may include sections for military government, psychological warfare, and historical records, and a chief of information (normally at army or higher headquarters, where he replaces the public information officer of division and corps staffs). If there is an attached unit of an arm or service having no special staff representative, its commanding officer acts as advisers to the commander and staff in his special field, and may have a liaison officer at headquarters.

c. Individual Duties. The individual duties of general and special staff officers, except the engineer, will not be dealt with further. For details see FM 101–5.

19. Relationship of General and Special Staffs

The four assistant chiefs of staff supervise and coordinate, each within his own sphere, all activities of special staff officers falling within that sphere.

20. Staff Supervision

a. This is one of the most important duties of a staff, and is peculiarly the one which brings staff officers and troops into contact. There are several methods, and several points to be observed.

b. Personal inspection by the staff officer and his assistants is the best single method of supervision, and should *always* be utilized as far as practicable. There is no complete substitute for face-to-face contact. However, in a large command this of itself is not adequate.

c. Personal inspection must be supplemented by reports, statistical and other. Statistical reports are needed at all levels to give accurate current information and are an essential basis of most planning. Nonstatistical reports are also highly valuable. There are two dangers, however, which a staff must guard against in this field: the danger of asking for *too many* reports, which arouses extreme irritation in hard-pressed troop units; and the danger of *trusting them to the exclusion* of personal inspection and contact. A report can be statistically accurate and written in good faith, and yet can give a misleading picture and form an unsound basis for plans and decisions. The true and complete picture of a situation is hard to put into words, and can never be put into graphs and statistics, essential though these are.

21. Dealings With Other Agencies

a. *Subordinate Agencies.* A vital part of a staff officer's training is in how to deal with the commanders and staff officers of units subordinate to his own commander. His first duty is to convince them that he is there to assist them. If he is conveying instructions, and especially if he is conveying or making criticisms, it must be done clearly but with courtesy and tact. If he is inspecting a unit or any element of it, he must always report to the commander, or to his headquarters, at the beginning and end of the inspection. He must never take advantage of his position to dodge responsibility. Above all, when he finds the unit in real need of something to assist it in accomplishing its mission, he should make every effort to obtain it. If a staff officer's inspection is followed by the prompt dispatch of a vital item of equipment, the assignment of badly needed personnel, or the correction of some inequity—or even by a telephone call to the unit, stating that the staff officer has reported the difficulty and that action is being taken—he will thereafter be a welcome visitor, and his own task will be made far easier for him.

b. Senior Staffs. Direct contact between opposite numbers—both general and special staff officers—in junior and senior staffs always exists. Information can be transmitted and business transacted quickly and easily in this manner. How much business is thus handled, rather than through more formal channels, depends on the policies of the commander and chief of staff of the senior headquarters. (See also par. 26.)

22. Staffs of Small Units

At regimental (group) and battalion level, the places of the chief of staff and the four G's are taken by the executive officer and four officers known as S1, S2, S3, and S4, whose duties generally resemble those of the G's on a smaller scale.

Section II. ENGINEER SECTIONS OF HIGHER STAFFS

23. General

Engineer sections of the staffs of higher units exist at theater level (including the theater air force commander) and on the staffs of army groups, armies, corps, divisions, the communications zone and its sections, and any other Army agencies in the theater having general and special staffs. The present text confines itself to Army and lower staffs.

24. Duties of Staff Engineer

a. The duties of a staff engineer in a theater may include the following (see FM 101–5):

(1) Command of all engineer units not assigned or attached to subordinate commands.

(2) Advice to the commander and staff on engineer matters.

(3) Determination of requirements for, and the procurement, storage, distribution, issue, and documentation of engineer supplies.

(4) Recommendations for the procurement and employment of engineer troops and their allotment to subordinate units.

(5) Preparation and supervision of training programs for engineer units (if any) under his own command, and technical supervision of engineer training throughout the command.

(6) Planning and supervision of engineer operations, including—

(*a*) Construction, maintenance, and repair of roads, trails, and inland waterways, as well as new construction and major repair of railroads.

(*b*) Construction, maintenance, and operation of military pipeline systems.

(*c*) Construction, maintenance, rehabilitation, and repair of camps, cantonments, warehouses, hospitals, and other structures of every character (including incidental installations except signal communications), airfields, harbors, permanent fortifications, and all means of river crossing.

(*d*) Construction of certain defensive works, minefields, roadblocks, and other obstacles, and the clearance of passages through such barriers; however, this responsibility is not exclusive (see ch. 12).

(*e*) Construction, maintenance, repair, and operation of utilities, including water supply systems, fixed bathing installations, and portable and fixed electric power plants.

(*f*) Fire protection at camps, depots, ports, hospitals, and airfields.

(*g*) Procurement, administration, and disposition of real estate.

(*h*) Procurement, reproduction, and distribution of maps and map substitutes, and the reproduction of air photos for the use of Army units.

(*i*) Camouflage measures, preparation of instructions on camouflage materials.

(*j*) Engineer reconnaissance, field surveys, mapping projects, and the preparation of terrain studies.

(*k*) Demolitions.

(*l*) Generation of certain gases.

(*m*) Recommendations for traffic regulations on roads and bridges as indicated by their physical condition; preparation of all signs for making routes; posting of all signs, except those for temporary routes and traffic control; issue of signs and/or sign materials to the Military Police Corps for preparation and posting on routes of a temporary nature incidental to traffic control.

(*n*) Insect and rodent control and the fumigation of buildings.

(*o*) Operation of engineer maintenance and repair facilities.

(*p*) Examination and processing of captured engineer supplies.

(*q*) Collection, evaluation, and dissemination, in coordination with G2, of information concerning enemy engineer activities.

b. The above list is comprehensive, and it is unlikely that a staff engineer at any one level below theater would have all these responsibilities. Some are normally confined to staffs in the combat zone and others to those in the communications zone. However, a problem arising in any command in any of the above categories thereby comes within engineer purview.

25. Coordination

a. The staff engineer constantly has matters to coordinate with all four of the assistant chiefs of staff. Examples are: with G1, personnel matters affecting the engineer troops of the command; with G2, policies on communications security, engineer intelligence, mapping, and the issue of maps; with G3, planning of troop movements, training of all troops on engineer items, barrier planning, combat operations, allocation of scarce equipment and supplies, and special lists of equipment; with G4, all logistic items. Many of these questions concern more than one G and need joint coordination.

b. Since a large part of the engineer effort in any command is devoted to routes of communication and to construction, maintenance, and supply, some staff engineers have more frequent dealings with G4 than with any other assistant chief of staff. The engineer's relations with G4, as with all general staff officers, should be close and cordial. However, he is not a command subordinate of G4 (or of any other assistant chief of staff) and his relationship to that officer by no means precludes him from dealing direct with other G's and with the chief of staff. The Army doctrine on this point is clear, and a staff engineer may expect that the commander will require adherence to it by all members of his staff.

c. The staff engineer should also seek to gain the confidence of the commanding general, so that he has access to that officer at need, and so that his presence is desired and his advice sought in any conference or discussion which may affect or bring about engineer activities. (It may be added that almost any decision made by a commander, involving action by all or any considerable part of his command, will result in some sort of engineer activity.) In his contacts with the commander, the engineer must be careful not to bypass or ignore the general staff personnel.

d. In addition to the foregoing, the engineer has many dealings with other special staff officers and sections. He deals with ordnance, signal, and other technical service representatives, as regards the supply and the field and depot maintenance of equipment issued by those services to engineer troops; with the provost marshal as regards traffic control; with the surgeon as regards medical service for engineer personnel, and hospital construction being undertaken by engineer units; and, in more general terms, with the representative of any agency which has an interest, and has or should have a say, in any engineer activity. An important part of the staff engineer's duties is to know just what agencies *are* thus concerned; to adapt his plans to their wishes if he can, or to convince them that this is impracticable; and to obtain their concurrence. This is largely done by informal discussions and conferences. When a staff engineer presents to the general staff a plan of engineer action which is in accord with the commander's wishes and policies, is sound and workable, and has the concurrence of all interested agencies, he has done a good staff job.

26. Technical Channels

a. A staff engineer at any level is concerned with the activities of commands at other levels or under other control. A corps engineer's activities affect, and are affected by, the unit engineers of the divisions under corps control, and the engineer maintenance and supply units in corps and army service areas, all of which support the corps and its divisions. There must be direct contact—in person, by telephone, and by correspondence—between the engineers and engineer sections at these various levels, to work out details, convey technical information and policies, remove misunderstandings, and expedite supply and maintenance.

b. It is a primary duty of officers who make use of these technical channels to see that their dealings are in meticulous accord with their respective commanders' desires and policies. The engineer of subordinate headquarters must never be placed in the position of having to reconcile a conflict between the aims of his own commander and those of the engineer of a higher headquarters. Any violation of the letter or spirit of this rule by engineer agencies will arouse justified resentment in the commander concerned and in his general staff, and may result in a restriction of technical contacts which will seriously hamper the engineer effort.

27. Engineer Staff Sections, General

Engineer staff sections are organized and trained to perform the functions set forth above, so far as they pertain to the command to which a particular section belongs. Since the nature, volume, and relative importance of different functions vary with the size and nature of the command, the organization of engineer sections varies correspondingly.

28. Army Engineer

a. The army engineer performs, for the army, the duties set forth in paragraph 24 above so far as they pertain to that command. Included in these is command of army engineer troop units.

b. The engineer troops in a type field army (see ch. 2) may include two or three combat groups, two construction groups, a maintenance and supply group, and other units. The combat groups are trained and equipped particularly for work in contact with tactical units; the maintenance and supply group devotes much of its effort to serving divisional and corps troops; and the construction groups, though their normal field is the army service area, are available for work farther forward. A vital element of the army engineer's activities is therefore to see that the corps and divisions of his army receive the fullest measure of support from army engineer troops, and that if a corps is faced with an exceptional engineer workload, which it cannot handle with its own resources, army troops are at once made available to assist it, commonly by taking over a part of the load.

c. The army engineer and his assistants should be personally familiar with the division engineers as individuals, and with their problems and needs. They must of course take care not to bypass the corps engineers. Corps should be notified of any inspection at divisional level by the army engineer or his representatives, unless it is a routine inspection in accord with some SOP approved by the corps engineer.

29. Army Engineer Section

a. This section of the army special staff is organized under T/ O & E 51–1. It includes (besides the army engineer) his deputy, an administration subsection, an intelligence subsection, an operations subsection, a construction subsection, and a supply subsection.

b. The deputy army engineer acts as executive officer of the section and acts for the army engineer in his absence.

c. The administration subsection includes an administration officer, a real estate officer, a chief clerk with assistant, and a clerical stenographic and typing force. It handles personnel matters pertaining to engineer troops, real estate questions, and miscellaneous administrative matters; maintains the files for the engineer section; and operates the army engineer message center. It works closely with G1 and the adjutant general. It provides a stenographic and typing pool for the engineer section.

d. The intelligence subsection includes a mapping and intelligence officer, an engineer intelligence assistant, a topographic officer and assistant, a terrain intelligence officer, a photomapping specialist (warrant officer), and specialist assistants. It collects, evaluates, and disseminates engineer intelligence, exercises technical supervision over engineer intelligence and topographic activities throughout the army, and coordinates the activities of engineer intelligence teams assigned to the army and its corps. It handles all matters pertaining to the preparation, revision, reproduction, and distribution of maps and map substitutes, so far as they pertain to the army engineer's sphere of responsibility, and within the framework of army policy as enunciated by G2. It works closely with G2.

e. The operations subsection includes an operations officer and assistant, a field engineer and three assistants, a water supply supervisor, and enlisted personnel for field supervision and drafting.

Note. In some army staffs the construction and operations subsections are combined.

Working with the other subsections, the operations subsection is primarily responsible for assembling and drafting army engineer plans and the engineer paragraph and annexes of army operations orders. It handles all staff matters pertaining to the organization and operation of engineer units in the army, excepting construction, maintenance, supply, topographic, and intelligence activities; prepares engineer operations orders; prepares training directives and supervises training; and maintains records pertaining to engineer operations, including unit combat efficiency records. It works closely with G3 and G4.

f. The construction subsection includes a construction officer with two commissioned and one warrant assistants, a utilities officer, an enlisted bridge inspector, and enlisted specialists in construction and construction drafting.

Note. As indicated above, in some army staffs the construction and operations subsections are combined.

The construction subsection supervises all engineer construction activities in the army, including the installation, maintenance, and operation of utilities and the maintenance of structures; designs and prepares plans for structures, to the extent that this cannot be handled by corps or division engineers or the staffs of construction units; and assists the operations subsection in the preparation of orders, annexes, and training directives, insofar as concerns construction matters. It works closely with G3 and G4, and with engineer construction units under army control.

g. The supply subsection includes a supply officer and two assistants, an equipment maintenance officer, two warrant officer supply assistants, a chief clerk with assistant, and supply and supply records specialists. It determines and promulgates policies, and accomplishes staff supervision, with respect to engineer maintenance and supply activities, including the activities of the engineer maintenance and supply group in the fields of determining requirements for engineer supplies, establishing and controlling supply levels, and controlling the issue of critical supplies. It works closely with G4. (See also ch. 6.)

h. The foregoing is subject to variation if the situation warrants, in the interests of flexibility and on a commonsense basis.

30. Technical Channels at Army Level

These run in three directions: downward to corps and divisions, upward to army group (if any) and theater, and rearward to the communications zone. Their smooth functioning, with the knowledge and under the policies of the commanders concerned, is vital. Army engineer units work closely, not only with corps and division units but with communications zone units.

31. Corps Engineer Section

This is organized under T/O & E 52–1A. It resembles the army engineer section, but is much smaller, since the corps is a smaller unit, has a smaller and less elaborately organized service area, and is primarily a tactical command not in the chain of supply. The corps engineer performs the usual staff functions, and commands the corps engineer troops. His deputy is his executive officer who acts in his absence. The remainder of the section includes—

a. The administration subsection, with an administration officer, an enlisted chief clerk, and clerical assistants.

b. The intelligence subsection, with an intelligence officer and enlisted assistant. It works closely wtih the corps intelligence team and the corps topographic company.

c. The operations subsection, with an operations officer and two enlisted assistants, one of them a specialist in combat construction.

d. The maintenance and supply subsection, with a maintenance and supply officer, an engineer supply warrant officer, and three enlisted assistants. One of them is an equipment maintenance specialist, the other two are supply specialists. (See also ch. 6.)

e. As in the case of the army engineer section, this may be varied as the situation indicates.

32. Division Engineer

a. The staff engineer of a division is also the commander of the divisional engineer battalion. The two tasks, though related, are distinct.

b. As staff officer, he is a member of the special staff of the division; furnishes engineer advice, information, and assistance to the division commander and staff; assists in preparing divisional plans and orders; handles engineer supply and maintenance matters for the division; maintains close liaison with other divisional units to determine their needs for engineer support; makes recommendations for engineer support from corps; and, within the framework of divisional and corps policies, maintains close liaison through technical channels with the corps engineer.

c. His command duties are discussed in paragraphs 34 through 39.

d. The engineer section of the division staff, relative to the corresponding corps and army sections, is very small, consisting of the assistant division engineer and three enlisted specialists. This is because much of the staff work of the division engineer also pertains to his command functions and is done by his battalion staff.

Note. Strictly speaking, these are not divisional staff personnel, but members of the division engineer section of engineer battalion headquarters. However, they are located at division headquarters and work closely at all times with the divisional staff.

33. Dual Role Problems

The position of division engineer presents a typical example of the problems facing an officer with both staff and command responsibilities, to either of which he could easily devote all his time. The following general rules govern:

a. The division engineer should consider his two activities as of equal importance.

b. He should so organize them that both will run smoothly in his absence. For this purpose he has at division headquarters the assistant division engineer and at battalion headquarters the executive officer (second in command) and the rest of the battalion staff. The assistant division engineer must be carefully selected and must have the confidence of the division staff.

c. He should spend some time at each headquarters, but more time in field inspections, reconnaissance, and personal contacts. His personal headquarters is normally with the battalion.

d. He should locate battalion headquarters as near to division headquarters as is consistent with proper control of the battalion; should insure good communications between the two; and should assure himself that there is continuous exchange of information.

e. See also FM 5–132.

Section III. ENGINEER COMMANDERS AND THEIR STAFFS

34. General

The basic principles governing the commander of an engineer troop unit are the same as in any other arm or service. Their application is affected by the technical and specialized character of most engineer tasks, and also—especially in combat engineer units—by their wide variety. In the accomplishment of these tasks and of the engineer mission generally, the commander is responsible that each particular task is analyzed in terms of required time, manpower, equipment, and materials; that the task or its major components are allocated to one or more subordinate units; and that its execution is adequately supervised. These duties he performs partly in person and partly by delegation.

35. Delegation

a. Some things cannot be delegated. An engineer (or any other) commander cannot delegate the responsibility for final decision, nor leave to a subordinate the tasks of leadership and the maintenance of morale. He must personally maintain adequate contact with his superior officer, with the principal members of that officer's staff, and with the commanders of troop units to which he furnishes engineer support. There is no substitute for his personal inspection of the units and activities of his own command, often enough and in enough detail so that he knows what is going on, knows his subordinates, and impresses his personality upon them.

b. Allowing for this, there remains a mass of work devolving on the unit commander's headquarters which he can and should delegate to his staff. Failure to do so will cause him to lose himself in a maze of detail. After he has delegated everything which he can on sound principles, he will still need all his time to do his job properly.

c. Parenthetically, it may be noted that the term "delegation" is sometimes used in military texts to mean either the delegation of duties by a commander to his staff or the delegation of duties to subordinate units. These two forms of "delegation" are of a different nature. The former is the division of a commander's duties into the more and the less important, and the assignment of the latter to his staff. The latter (which is more properly termed "allocation") is the division of a task into several component tasks and the assignment of each, in its entirety, to an operating unit.

36. Allocation of Tasks

a. The tasks of an engineer unit may be allocated to it, and by it to subordinate units, on either an area basis, a task basis, or a combination.

b. An area allocation gives to a unit the responsibility for all engineer work within a definite area. Area assignments should not be changed more often than necessary.

c. A task allocation gives to a unit the responsibility for one or more specific duties.

d. A combination of these two methods is often used in allocating engineer missions. A particular task may be emphasized even when an area allocation is made; for example, a combat company may be ordered to do all engineer work in the zone of action of an infantry regiment, but with particular attention to assisting the advance of the supporting artillery. Again, a combat or construction group may be ordered to execute all general engineer work in a specified area, and also to maintain a corps supply road outside that area.

37. Organization for Work

a. An engineer organization is made up of working units, each of which can do a definite kind and volume of work and can be combined with other units into larger groups for ease of control. In combat engineers, the basic unit for most tasks is the squad.

In other engineer organizations it is normally the platoon. Platoon, company, battalion, and other engineer headquarters are designed to control these working units, to take care of their supply and administration, and to reinforce them with men and equipment for tasks beyond their capacity.

b. Troop units should be given tasks under their own leaders. When one engineer unit is attached to another, the former should work under the direct control of its own commander.

c. If two or more similar engineer units are assigned to the execution of a detached mission or are attached to some other unit, a higher engineer headquarters should be furnished to command both elements. Thus, instead of designating two platoons for a mission, it is preferable to designate a company less one platoon. This is especially important when engineers are attached to other arms.

d. The size of a work party should be determined with great care. Too few men will not get the work done on time; excess manpower is wasteful of means needed at other places. Even when the work must be expedited to the utmost, limitations of space, tools, or materials usually place a limit on the number of men who can be employed effectively. In such a case the working party should be divided into shifts, and the shift not working allowed to rest. The latter may also be designated as a reserve to assist the security detachment.

e. If possible, a unit should be kept on an assigned task until it is completed.

f. See also chapter 18 for a discussion of job management.

38. Staffs of Engineer Commanders

a. The staffs of engineer commanders at battalion or higher levels generally resemble those in other arms.

b. At levels below the battalion, staff organization is elementary. In a divisional combat company, the company commander's staff reduces to an executive officer, a first sergeant, and certain enlisted administrative and supply personnel. Variants of this are found in more specialized engineer units.

39. Staff of Engineer Combat Battalion, Divisional

This may be taken as typical of the staffs of engineer commanders at battalion level, and does not differ fundamentally from those at group level. Its components are the executive officer; the assistant division engineer; the administrative, intelligence, operations, and supply sections; the communications and maintenance sections; and the medical detachment. It may be noted that, at this level, the distinction between "staff" and "operating" agencies often becomes blurred. Thus, the battalion maintenance officer performs certain specialized staff functions for his commander, but the section which he commands is also an operating unit.

a. The executive officer is second in command of the battalion, and also corresponds to the chief of staff on a general staff. He usually remains at battalion headquarters when the commander is not there.

b. The assistant division engineer represents the division engineer on the division staff, and in the division engineer's absence should be empowered to make minor decisions in his name. He should be familiar with all the activities and plans of the engineer battalion. He should develop the confidence of the division staff in his ability to keep them advised on these activities, and to give engineer advice and information. By this means he can relieve the division engineer of much routine responsibility. He should also be familiar with divisional activities and plans affecting the engineers, and should keep the division engineer and his staff informed of them.

c. The administrative, intelligence, operations, and supply sections are headed respectively by S1 (battalion adjutant), S2, S3, and S4. In general terms, the duties of these officers and their sections correspond to those of G1, G2, G3, and G4 on a general staff. S4 is also the division engineer supply officer.

d. The communications section is headed by a communications officer. He advises the battalion commander and staff, including S4, on signal communications techniques and supply and maintenance problems; establishes and supervises the battalion radio and wire nets and communications center; supervises communications training; and makes recommendations for locations of the battalion CP, for replacing specialist personnel, and related matters. (See also ch. 8.)

e. The maintenance section is headed by the battalion motor officer. As a staff officer he advises the battalion commander, his staff, and subordinate commanders on technical aspects of automotive and equipment operation and maintenance; supervises the training of drivers, mechanics, and operators; prepares reports; and keeps records on equipment and supplies. (See also ch. 7.)

f. The medical detachment is commanded by a medical officer. He supervises the medical service of the battalion; advises the battalion commander, his staff, and subordinate commanders on health and sanitation problems; instructs battalion personnel in hygiene and first aid; supervises medical supply; makes medical and sanitary inspections; prepares and keeps up to date the battalion medical plan; establishes and operates the battalion first aid station; supervises the collection and evacuation of the wounded; and prepares reports pertaining to his duties, including casualty lists.

g. For further details, see FM 5–132.

CHAPTER 4

ENGINEER ESTIMATES, PLANS, AND ORDERS

Section I. GENERAL

40. General

a. Basis of Action.

(1) Any commander, facing a situation which requires action, will take certain steps in logical order, as follows:

(*a*) Collection of essential information.

(*b*) Preparation of an estimate of the situation to arrive at a decision or general course of action.

(*c*) Development of the selected course of action into a detailed plan.

(*d*) Conversion of the plan into orders, and their issue and dissemination.

(*e*) Supervision to insure that the orders are carried out.

(2) Of the foregoing, step (*a*) is dealt with in chapter 5 and step (*e*) in chapter 3. Steps (*b*), (*c*), and (*d*) are considered below.

b. Definitions. An *estimate of the situation* is a canvass of all the elements, material and psychological, which lead up to a decision and enter into the formulation of a plan. A *plan* is a statement in detail of the action to be taken to carry out the decision. An *order* is the means of conveying the decision and plan to others. The chief difference between a plan and an order arises from the fact that the order will be transmitted, directly or indirectly, to a large number of people and will guide their action. Therefore it must be worded with great care and precision, and where practicable should follow certain forms which are generally understood.

c. Forms.

(1) At one extreme, estimates, plans, and orders may be written documents, prepared successively in great detail according to prescribed frameworks. At the other extreme, the estimate form may be merely a mental process to insure consideration of all factors; the plan may be a similar hasty mental formulation; and the implementing orders may be oral or fragmentary. The usual case lies somewhere between these extremes.

(2) In this chapter, estimates, plans, and orders are described on the assumption that they are written documents. How far they actually will be, in a given situation, the commander must decide on a basis of common sense. (In most engineer commands a written estimate will be exceptional.) Regardless of form, the principles herein set forth apply.

d. Flexibility. Except as regards certain administrative SOP's and an occasional fast-moving "set piece," no estimate, plan, or order can be prepared, once and for all, to cover completely an operation of any length and magnitude. It is the nature of field operations that conditions change, and a commander must adapt his action to them. Generally speaking, this is the more true as one moves toward the front. Estimates, plans, and orders at a high level—for example, those culminating in a theater directive which prescribes the basic strategy of a campaign—may remain unchanged for months, whereas the estimates, plans, and orders of a commander in battle may be altered in hours or minutes. The latter commander may in fact be conscious only of issuing a succession of hasty orders. Nevertheless, though he may not realize it, he is continuously reformulating his estimate of the situation and revising his plans as needed, and his orders are the result of this mental process.

41. Estimates of Situation

An estimate of the situation is based on a statement of the mission; a description of the situation; a statement, analysis, and comparison of various possible courses of action, both the enemy's and our own; and a decision. The content of the different parts of the estimate will vary with the mission. Certain questions arise in the mind of any commander who faces a certain situation and has been given a mission. His planning is based on these, and is concerned with formulating the answers. The questions are—

a. What am I ordered to do (that is, my mission)?

b. What resources does the enemy possess to interfere with my doing it; what alternative plans might he adopt for using them; and which of these plans is it most likely that he will adopt?

c. What resources have I to carry out my mission; what alternative plans might I adopt; and which one should I adopt? The answer to the last question becomes my *decision*.

42. Plans

a. Development. The decision made in the estimate is developed into a finished plan by working out the most feasible answers to the more detailed questions, such as:

(1) How will I balance the total task's requirements of men, material, equipment, and time to meet my resources? (In many tasks two or more of these factors are interrelated; some materials require less labor or time, but possibly more equipment; time, equipment, and manpower.)

(2) How will I divide the work among subordinate units? (Closely related to (1) above.)

(3) What problems of administration, transportation, and supply will arise and how can they be solved?

(4) What problems of control and signal communications will arise and how can they be solved?

b. Continuity of Planning. For simplicity it is assumed here that planning starts with the assignment of a specific mission, and culminates in a plan for accomplishing it. In fact, however, planning must be thought of as a continuing process. Current plans, in the course of implementation, will need periodic revision as the situation changes or new information comes to hand. Moreover, in spite of the stress and pressure of current operations, the commander and his staff must give thought to the future, and must have ready, at least in outline form, one or more plans for the next major operational phase, based on reasonable assumptions as to how the present phase will develop. Failure to do this may result in hasty and ill-advised action when the next phase does in fact arrive. There must be no waiting for a specific order or directive from higher authority to undertake such advance planning.

43. Orders

a. Types. Orders issued in a theater of operations may be combat orders or routine orders. Combat orders include operations orders and administrative orders. Routine orders include general, special, and court-martial orders, as well as bulletins, circulars, memoranda, and others; they are not considered in this chapter.

b. Operations Orders. These set forth the situation, the issuing commander's decision, and such details of execution as will insure coordinated action by the command. They are classified as required by AR 380–5. They may be written or oral, complete or fragmentary. They are issued at all levels of command, each being based on some corresponding order from higher headquarters.

c. Administrative Orders. Administrative orders are orders, supplementary to operations orders, setting forth the commander's plan for providing administrative support for operations. An operations order is not necessarily accompanied by an administrative order.

44. Reference

For further discussion of the basic principles of Army plans, estimates, and orders, see FM 101–5.

Section II. ENGINEER ESTIMATES OF THE SITUATION AND PLANS

45. General

An estimate of the situation, and a plan, made by an engineer commander are arrived at by the same mental processes as in the case of any other commander. Differences result from the special nature of engineer units and engineer work.

46. Engineer Estimates of Situation

a. General. A formal engineer estimate follows the standard five-paragraph Army form.

b. Mission (par. 1). This is usually stated in terms of an overall task to be undertaken by the engineer unit in support of the tactical or administrative mission of a higher command.

c. Situation and courses of action (par. 2).

(1) For a purely tactical mission in which the obstacles to be overcome arise primarily out of enemy action, this may be broken down as follows:

(*a*) Considerations affecting the possible courses of action, including physical and other characteristics of the area of operations, and the relative combat power of ourselves and the enemy, having regard to strength, composition, disposition, status of supply, reinforcements, morale, and training.

(*b*) Enemy capabilities (alternative courses of action and their effect.)

(*c*) Our possible courses of action.

(2) In a situation where the obstacles are primarily physical and enemy action is of sec-

ondary importance, the following breakdown is more appropriate:

(*a*) Obstacles to be overcome: time limitations; difficulties inherent in the location; difficulties anticipated in getting men, materials, and equipment to site; probable enemy interference and its effect.

(*b*) Means available: men, materials, equipment including transportation, and assistance if any from other sources, with details as to location, time when available, and other pertinent aspects.

(*c*) Possible alternative courses of action.

d. Analysis of Opposing Courses of Action (par. 3). In a purely tactical situation, this paragraph analyzes the effect of the enemy capabilities on each of our own possible courses of action. In the alternative situation it analyzes the merits and demerits of each of our possible courses. If the mission or task is multiple, paragraph 3 has a separate subparagraph for each of the major elements.

e. Comparison of Our Own Courses of Action (par. 4). This involves the determination of which one promises to be most successful in accomplishing the stated mission. Here also, if the mission or task is multiple, there is a separate subparagraph for each major element.

f. Decision (par. 5). Here the selected course of action is concisely stated, in terms of what is to be done, with as much of the elements of *who*, *when*, *where*, *how*, and *why* as may be appropriate.

g. Special Characteristics of Engineer Estimates. Among these may be mentioned—

(1) The sometimes minor part played by enemy action.
(2) The fact that, especially in rear areas, minor changes in our own tactical situation often do not affect the estimate.
(3) The large part played by engineer techniques, especially in the construction and allied fields.
(4) The emphasis on engineer support of other troops.

47. Engineer Plans, General

The decision arrived at, by means of the estimate, is the framework on which the engineer plan is built. Such a plan, when approved by higher authority, is the basis for orders issued to engineer troops.

48. Form for Engineer Plan

a. The plan may be written or unwritten, complete or fragmentary, depending on the nature and size of the unit, the scope of the operation, and the time available for making the plan. Plans for extensive work by an engineer battalion or higher unit are normally written.

b. A formal written engineer plan follows the same sequence of paragraphs as a formal engineer operations order, and contains in large part the same material. It may have other material not in the order; for example, one or more alternate plans of action for possible changes in the situation, and capable of being translated promptly into orders if need arises.

49. Elements of Engineer Plan

An engineer plan must deal with, or take into account, the following features, among others:

a. Basic information needed to develop the plan and translate it into orders. This is obtained largely by reconnaissance, which is a prerequisite to adequate planning.

b. Time limitations and priorities.

c. The assignment of men and equipment.

d. Problems of transportation, supply, and maintenance, including the maximum use of local resources.

e. Problems of security.

50. Construction Plans

a. An engineer plan for a mission involving construction or related activities must also take into account certain special features, including—

(1) Primary considerations involving theater construction, especially the elements of speed, economy, and flexibility, and the principle of scheduling work to meet immediate needs.

(2) Basic standards and policies of theater construction, including standardization, simplicity, and the omission of needless features; limitations on types of construction and factors of safety; allowances for possible future expansion; and the maximum use of existing facilities.

(3) The principles of organization for work and of job management, including the analysis of the task into component parts, the conversion of these into quantitative

estimates, an assignment of men, equipment, and materials to the component tasks, and the preparation of work schedules.

b. The foregoing are discussed in chapter 18, and will not be further dealt with here. It must be borne in mind that they often form the most important part both of an engineer plan and of the implementing orders.

51. Approval of Plans

The engineer plan for a major operation is normally submitted to the next higher commander, and on approval is published as the engineer annex to that commander's operations or administrative order.

Section III. ENGINEER ORDERS

52. Engineer Operations Orders

A *formal* engineer operations order follows the standard Army form, consisting of a heading, five paragraphs, and an ending. Within this frame it is so worded as to adapt it to the nature of engineer operations.

a. Heading. This includes a statement of the issuing headquarters, the place, date, and time of issue, the message reference number, the type and serial number of the operations order, references to maps, charts, and other relevant documents, the time zone used throughout the order (if necessary), and the task organization (if not covered in par. 3).

b. Paragraph 1, "General Situation." This has either two or three subparagraphs—

(1) Subparagraph 1*a* gives relevant information about the enemy. Information on the

likelihood and nature of air attacks and guerrilla activities is appropriate here.

(2) Subparagraph 1*b* gives relevant information about friendly forces other than those covered by the operations order, which may directly affect the operations of subordinate commanders. This is also an appropriate place for data affecting the operations of the command.

(3) Subparagraph 1*c* lists units attached to or detached from the issuing unit (or formation) by the order, with the times when effective, unless this information has already been given under "Task Organization," in which case the subparagraph is omitted.

c. Paragraph 2, "Mission." This gives a clear, concise statement of the task of the commander and its purposes. The latter is often expressed, in engineer orders, as the support of specified tactical or administrative activities of a higher command.

d. Paragraph 3, "Execution." This contains in the first subparagraph a summary of the overall course of action intended. Subsequent subparagraphs assign specific tasks to each element of the command charged by the order with the execution of duties, and give any necessary details of coordination and of the task organization grouping not already included under "Task Organization." If desired, instructions applicable to two or more elements of the command may be placed in a final subparagraph headed "Coordinating Instructions."

e. Paragraph 4, "Administration and Logistics." This contains a statement of administrative and logistical arrangements applicable to the operation.

If lengthy, or if not ready for inclusion in the operations order, these may be issued separately and referenced here.

f. Paragraph 5, "Command and Signal." This contains any necessary signal, recognition, and identification instructions and data on headquarters locations and movements, code words, code names, and liaison.

g. Ending. This includes the signature of the commander, a list of annexes, a statement of distribution, and the authentication.

h. Security Classification. This appears on the face of the order.

53. Other Operations Orders

a. Oral orders are given by an engineer commander when time or other considerations do not permit written orders. The recipient normally makes notes, and may record the order verbatim. It is usual to confirm an oral order in writing, but exceptions are often made to this in a fast-moving situation where the order will have been completely executed before it could be confirmed. The text of an oral order should normally be recorded by the officer issuing it or his staff.

b. Fragmentary orders are often used in a fast-moving situation. They are sent to one or more subordinate elements, telling each one what part it is to play in an operation or any phase of it. Their content follows the general sequence of a formal written order, but they omit any superfluous material and may be in a single paragraph.

c. Warning orders contain advance information to permit the recipients to prepare for an operation which later operations orders will initiate.

54. Engineer Material in Higher Operations Orders

a. When a tactical unit has an engineer component, the unit's operations order deals with the engineers in the appropriate place or places. Thus, in the case of a division having a tactical mission, the tactical mission of the divisional engineer battalion is stated in one of the subparagraphs of paragraph 3 of the division operations order, and becomes the substance of paragraph 2 of the battalion operations order. Also if paragraph 4 of the division order gives administrative details, engineer material is included.

b. Quite commonly, for brevity, paragraph 4 of the operations order of a division, corps, or army is confined to a reference to an administrative order or to annexes, which contain engineer and other material of an administrative nature.

55. Engineer Material in Higher Administrative Orders

a. An administrative order is normally in six paragraphs, of which engineer material is commonly found in paragraphs 1 and 4, and possibly in paragraph 6. These paragraphs are—

(1) Supply. Indicates supply installations (engineer and other), location, time of opening and closing, the operating and supported units, stocks, levels, credits, and the like. May be classified by classes of supplies (see ch. 6) including maps and water; by technical branches; or by installations such as depots. The first system is most common for divisions and corps.

(2) Evacuation and hospitalization.

(3) Transportation.

(4) Service. One subparagraph deals with service, other than supply, rendered by engineer components (such as construction, maintenance, engineer procurement, topographic work other than map supply, utilities, and real estate).

(5) Personnel.

(6) Miscellaneous.

b. It is to be noted that material which is "administrative" at one level often becomes "operational" at another. Thus, if an army engineer unit is ordered to build and maintain a road, this is covered in the army's administrative orders, paragraph 4; but for the engineer unit it becomes a mission and the subject of an engineer operations order.

56. Engineer Annexes

An engineer annex to an operations order of a higher command normally follows the standard five-paragraph form of the order itself, and may be the operations order of the engineer component of the command.

57. Responsibility for Preparation

The staff engineer of a command is responsible for preparing engineer paragraphs of the command's operations and administrative orders and engineer annexes thereto, for coordination and approval by the appropriate general staff officers; and for coordinating these with the operations orders of the engineer component or components of the command.

58. Maps, Overlays, and Sketches

These are often used to simplify and clarify engineer orders and expedite their issue. An operation overlay may be issued as an order or as an annex to an order; the written part of the order may be in the margin of the overlay or attached to it. (See also FM 101–5.)

59. Standing Operating Procedures

a. Definition. A standing operating procedure (SOP) is a set of instructions, for a particular unit, covering such tactical and administrative features of the unit's activities as the commander desires to make routine. It permits operations orders to be much more brief, insures against overlooking any features of an operation, promotes teamwork, and facilitates training.

b. Form. The standing operating procedure of a command may be combined into a single document or issued in a series of documents. In either case, the SOP may be organized on either one of two bases, given below, depending on the nature of the unit and the wishes of the commander. The first method follows the standard general staff division of duties. The second method is more common in small organizations.

(1) In the first method the separate SOP's (or sections or paragraphs of the consolidated SOP) deal with—

(*a*) Personnel.

(*b*) Intelligence.

(*c*) Operations.

(*d*) Training.

(*e*) Logistics.

(*f*) Command.

(2) In the second method the separate SOP's

(or sections or para. of the consolidated SOP) deal with—

(*a*) Command, staff, and liaison.
(*b*) Administration.
(*c*) Movement.
(*d*) Security.
(*e*) Communications.
(*f*) Intelligence and reconnaissance.
(*g*) Supply and maintenance.
(*h*) Reorganization for combat.
(*i*) Any special operational activities of the unit which it is desired to standardize.

(3) The foregoing are subject to common sense modifications at the commander's discretion.

(4) In the case of a consolidated SOP, an initial "General" section or paragraph may be added.

c. Content. An SOP must conform to the SOP's and policies of higher headquarters. It may include extracts therefrom. It should contain instructions on activities which occur often enough, are important enough, and affect enough people to warrant inclusion, and which the commander wishes to standardize. However, SOP's do not normally include copies of material from official publications, though reference thereto may be made. *Care must be taken* that an undue desire to standardize does not lead to including matter which usurps the command and staff prerogatives of subordinates, or undermines their initiative and sense of responsibility.

d. Revisions. Any SOP must be revised from time to time, due to changes in the doctrines, policies, and SOP's of higher authority; changes in the commander's own policies, and changes in the activities, mission, and state of training of the issuing command. The use of loose-leaf SOP's makes for convenience in revision.

e. Example. Appendix III gives an outline for a typical engineer SOP.

CHAPTER 5

ENGINEER INTELLIGENCE AND RECONNAISSANCE

Section I. GENERAL

60. General

a. Engineer Information. The conduct of engineer operations requires a great deal of specialized data on the topography, resources, and works of man in the theater of operations, and on enemy installations and activities. Such data, in the form in which they are initially obtained, are known collectively as *engineer information.*

b. Engineer Intelligence.

(1) Intelligence is defined as information which has been evaluated to determine its accuracy and the reliability of its source, and interpreted to determine its significance in the light of what is already known. The production of intelligence may be divided into four phases—

(*a*) Collection of information.

(*b*) Processing of the collected information to produce intelligence.

(*c*) Use of the resulting intelligence.

(*d*) Direction of the collection effort.

(2) These four phases may be concurrent (see FM 30–5); the use of previously processed intelligence will be proceeding while later information is being collected and processed

and a new collection plan is being prepared for a later operation.

c. Engineer Reconnaissance. This is the operation of searching for engineer information in the field. It is the most important single means of collection.

d. Continuity. The collection and processing of engineer information is a continuing and never-ending process. Failure to keep up with daily or even hourly changes in a situation may result in faulty intelligence, which is dangerous intelligence.

61. Classes of Intelligence

Engineer intelligence is produced at both combat and strategic levels, and is classified as terrain intelligence, engineer technical intelligence, and counterintelligence.

62. Terrain Intelligence

a. Terrain intelligence is intelligence on the militarily significant physical and economic characteristics of an actual or potential area of operations. It is produced by terrain analysis, which is the process of interpreting a geographical area to determine the effect of natural and manmade features on military operations.

b. The objectives of terrain intelligence are to provide intelligence for the commander's plans and dispositions, and for engineer and other staff sections and troops for planning and operations.

c. The elements of terrain intelligence are—

(1) Natural features, including weather and climate, land forms and relief, drainage features, surface materials (including condition

of ground), vegetation (including crops), coasts and landing beaches.

(2) Manmade features, including routes of communication, urban areas, defenses, and fortifications.

(3) Economic features, including labor and mineral resources, industrial facilities, and utilities.

(4) Military interpretation, including observation, fields of fire, obstacles, cover, concealment, key terrain features, conditions affecting cross-country movement and established routes of communication, construction sites and materials, and water supply.

63. Engineer Technical Intelligence

a. Technical intelligence is intelligence pertaining to the design and operation, nomenclature, physical characteristics, performance, operational capabilities and limitations of foreign materiel and facilities used by or for the support of military forces. It may also embrace the manufacture, storage, installation, and maintenance of such materiel.

b. Technical intelligence has the following objectives: prompt development of countermeasures to foreign tactics and weapons; prompt exploitation of new ideas derived from foreign sources; accurate deductions as to the military capabilities of foreign nations; and the most effective use of captured enemy materiel.

64. Counterintelligence

a. Counterintelligence is that aspect of intelligence relating to all security control measures, both active and passive, designed to protect information, equipment, personnel, and installations against espionage, sabotage, or subversive activities.

b. The objectives of counterintelligence are to conceal from the enemy our intentions and activities, and to neutrailze or destroy the effectiveness of enemy intelligence activities.

65. Intelligence Responsibilities

a. Engineer Intelligence. The engineer has a dual intelligence responsibility. First, he produces engineer intelligence for his commander's planning and operational needs. Second, he produces both engineer intelligence, and the combat intelligence common to all branches, for use in connection with the planning and operational needs of engineer commanders, staffs, and troops. Both types are produced from similar sources and by similar means; they differ in emphasis and amount of detail. The production of combat intelligence is covered in FM 30–5, and is not dealt with in this manual.

b. Terrain Intelligence. With respect to terrain intelligence, after G2 has stated his terrain requirements, the engineer collects and processes the necessary intelligence to meet both those requirements and his own. He prepares a systematic presentation of this terrain intelligence, known as a *terrain study*, which is transmitted to G2 for processing into a "terrain estimate." The engineer is also responsible for developing techniques for terrain analysis and training specialized personnel in them.

c. Commanders. Intelligence is a command responsibility, devolving on every unit commander. Training in this field must be emphasized, to place it on a par with operation and supply. This includes indoctrinating individual soldiers and subordinate commanders with an understanding of the nature and importance of engineer information, the techniques of collecting it, and their own responsibilities with respect thereto. Every officer and enlisted man must realize that he is a link in the intelligence chain. One of the marks of well-trained engineer personnel is their ability to collect and turn in routine and other information while engaged in normal work assignments.

d. Staffs. Detailed responsibility for intelligence is delegated by the commander to his intelligence officer. In a large command having both general and special staffs, the intelligence officer is G2; the engineer section of the special staff likewise has an intelligence subsection (see ch. 3) which works closely with G2. At lower command levels the intelligence officer is S2.

e. Specialized Personnel. Certain engineer units have specialized intelligence personnel. For example, in the headquarters of the engineer combat battalion, divisional, the intelligence section is responsible for divisional engineer intelligence.

f. Specialized Units. For engineer intelligence teams, see paragraph 80. For engineer topographic units, see chapter 23.

66. Sources of Engineer Information

These include the following, which are discussed in paragraphs 67 through 86:

a. Engineer reconnaissance, both ground and air.

b. Maps and photographs.

c. Liaison with other agencies of the armed services, including—

(1) Other troop units, such as advanced combat elements.

(2) Intelligence staff sections and unit engineers of higher units.

(3) Allied armies.

d. Civilians and prisoners of war.

e. Other sources.

Section II. ENGINEER RECONNAISSANCE

67. General

a. Purpose. The purpose of engineer reconnaissance is to obtain, in the field, detailed information for the use of—

(1) The engineer commander and staff, for planning purposes.

(2) The engineer officer in direct charge of any field activity, to enable him to estimate the personnel, materials, equipment, and time needed for his task.

(3) Intelligence and other agencies at higher headquarters.

b. Types. Engineer reconnaissance may be *general* (to secure engineer information of a general character in a given area) or *special* (to secure detailed information bearing on a specific task or situation). The latter normally follows the former. Officers assigning reconnaissance missions, even general ones, should be as specific as possible about what information is wanted.

c. Timing. Reconnaissance normally precedes engineer operations, but should not delay them. All reconnaissance personnel must realize the importance of the time factor. *Timely information, even though incomplete, is valuable; complete information received too late is worthless.*

d. Echelons. The principal echelons of engineer reconnaissance, from front to rear, are—

(1) Engineer air reconnaissance and observation.

(2) Advanced ground reconnaissance, by engineer personnel with advance or covering forces.

(3) Division area reconnaissance, by elements of the divisional engineer battalion.

(4) Rear area reconnaissance, under the direction of corps, army, and communications zone engineers. In the case of large scale projects in rear areas, such as port facilities, major utilities installations, and the like, the "reconnaissance" involved may approximate peacetime engineer investigations and studies.

e. Combat. Engineer reconnaissance is often conducted close to the enemy. A reconnaissance party is expected to defend itself if attacked, but otherwise not to fight unless it must do so to accomplish its mission. The chief of party is responsible that the party is not needlessly exposed to enemy fire and observation. He must remember that the mere knowledge that our troops are reconnoitering a certain area may be valuable to the enemy. These rules are general. Other and more special precautions must be taken if the mission requires that the party be not observed by the enemy.

68. Reconnaissance Responsibilities

a. Unit Engineer. The unit engineer of an infantry division or similar command is responsible, directly or through his intelligence officer, for coordinating reconnaissance in his command so that the field is fully covered without lost motion or overlapping. He initiates the search for information needed at his level, either by reconnaissance or from other sources. He must be prepared to make recommendations to the tactical commander on the engineer phases of any proposed operation, and he must therefore obtain in advance the information needed for this purpose. He often carries out important reconnaissances in person. Similar responsibilities devolve on all engineer commanders within their spheres of action.

b. Engineer Intelligence Officer. He is responsible for all details of the foregoing which his commander delegates to him. He must work closely with the operations officer and try to anticipate the needs of the latter. He may ask the operations officer for additional reconnaissance personnel.

c. Engineer Operations Officer. He may himself initiate reconnaissance missions, as by sending out patrols.

d. Engineer Reconnaissance Officer. He conducts or arranges for reconnaissances as directed by the engineer intelligence officer.

e. Command Responsibility. When a reconnaissance mission has been assigned to an engineer unit, the commander thereof is personally responsible for the organization and conduct of the mission and the adequacy and timeliness of the report.

69. Sequence of Activities

The following steps are involved in reconnaissance:

a. Planning. This includes—

(1) Determination of mission.
(2) Route and time schedules.
(3) Personnel and equipment.

b. Observing and recording.

c. Reporting.

70. Mission

Orders for a reconnaissance must specify—

a. What its scope and purpose are, what is to be especially noted, in what detail, and with what priorities.

b. Where the area to be reconnoitered is, including boundaries and features of special interest.

c. When, *where*, and *to whom* the report is to be submitted.

d. Any other information or instructions needed to make the mission clear to the chief of party.

71. Scheduling

a. Route. The general route of the reconnaissance party should be chosen in advance so as to cover the area adequately in the shortest time. Give consideration to enemy observation and interference.

b. Timing. A time schedule is nearly always needed to guard against either: going so slowly, and recording in such detail, that there is no time to finish the task; or going so fast that important items are missed. One way of scheduling is to set "control points" along the route, each of which the party must reach at a specified time. Points and timing are selected to provide for uniform and systematic coverage of the area, allowing for running or marching time, time to observe and record (when not moving), possible delays, and total time available.

72. Personnel and Equipment

a. Select trained and qualified personnel. If any technical problems are involved, such as bridge construction, quarry operations, or demolitions, one or more qualified experts should accompany the party. The chief of party must be carefully briefed.

b. Equipment depends somewhat on data desired. The following may be used as a checklist for general engineer reconnaissance purposes, the quantities to be as conditions indicate—

(1) Field glasses.
(2) Pace tally.
(3) Clinometer.
(4) Compass.
(5) Steel tape.
(6) Camera.
(7) Paper and pencils.
(8) Forms as needed.
(9) Maps.
(10) Bridge card.
(11) Rations.
(12) Weapons.

73. Observing, General

Constant alertness and attention to detail are necessary. Quantities, sizes, capacities, and other data expressible in numbers must be measured or counted if time permits; otherwise they must be estimated as closely as possible. The character and type of such items as equipment or structures must be clearly specified.

74. Checklists for Observers

a. References for reconnaissance in connection with—

(1) Offensive operations. (See chs. 10, 13, and 14.)
(2) Defensive operations. (See ch. 11.)
(3) Minefield breaching. (See ch. 12.)
(4) Selection of sites for camps and bivouacs. (See ch. 16.)
(5) Construction in general. (See ch. 18.)
(6) Road and railroad work. (See ch. 19.)
(7) Bridges and bridge sites. (See ch. 20.)
(8) Airfields and pipelines. (See ch. 21.)
(9) Water supply (field sources). (See ch. 22.)
(10) Demolition projects. (See ch. 24.)

b. Reconnaissance of City or Town. Much of the detailed technical data listed here under water supply, sewerage system, and utilities would not be obtained by the initial hasty reconnaissance of combat engineer units, but by specialist troop units or teams. Much of this data as well as other valuable information, can be obtained by questioning local officials and later making spot checks.

(1) Name.
(2) Location.
(3) Population.
(4) Water supply: source(s), seasonal variation, dams if any, raw-water aqueducts or conduits, purification system (settling basins, filters, chemical processing, chlorination) and its adequacy, reservoirs and tanks, pumps and pumping stations, mains, and pressures.

(5) Sewerage systems: portion of town served, location and adequacy of mains, nature of treatment if any, capacity of treatment plant, ultimate disposition, extent of separation of domestic (or industrial) sewage and storm runoff.

(6) Electric power supply: motive power (water, coal, oil), generating stations, prime movers, generators, auxiliaries, distribution system, transformer stations.

(7) Utilities in general: with respect to water, sewerage, electric power, and similar utilities systems, give in each case—

(*a*) Full information on capacities, types, and technical data in general.

(*b*) Condition of equipment and installations, and repairs or reconstruction needed.

(*c*) Practicability of expansion.

(*d*) Repair shops, and stocks of spare parts, pertaining to utilities systems.

(*e*) Vulnerable points, nature of danger, and means of guarding against it (includes poisoning of water supply).

(8) Local facilities, industries, and engineer stores: for example, quarries, sand and grave pits, sawmills, brick and cement plants, steel mills, machine shops, factories of all sorts, stocks of solid and liquid fuel and explosives, other supplies and materials of military interest; with locations, designations, quantitative data, and technical details.

(9) Facilities for quartering troops, for offices, storage, repair installations, and other military needs.

(10) Through routes.

75. Recording and Reporting, General

Observed information must be recorded at once, rather than entrusted to memory. Recording may be by written notes, sketches, the use of prepared forms and maps. Standard military symbols are used. Photographs are a valuable supplement to a reconnaissance; personnel must be trained to get good photographs under adverse conditions.

76. Report Forms

The form of a report depends on the type of reconnaissance. Because of the variety of situations encountered in the field, no form can cover every contingency, nor can it be a substitute for practical reconnaissance training and for specific instructions given for any particular mission. However, forms are very useful to guard against omissions and to expedite and systematize the preparing of the report. A model form for a general engineer reconnaissance is shown in figures 1 and 2.

77. Fragmentary Reports

Both specific reconnaissance instructions and generalized SOP's may require that certain types of information be reported immediately. If practicable and permissible, this is done by radio in a prearranged code. In any case, there should be some means of sending in fragmentary reports without seriously delaying the conduct of the reconnaissance.

FRONT

ENGINEER RECONNAISSANCE REPORT

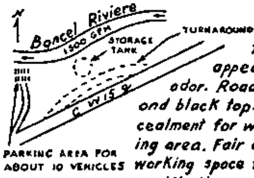
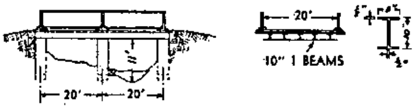
File No. 256 Page 1 of 1

Report No. 3 Party leader O'Neil (Name) 1st Lt (Grade) Co A (Organization)

H 840-295 (Place) 071700 May 54 (Hour and date)

Maps AMS M 861, Sheets XXX 3,4,5 and 6 (1:25,000)

Deliver to 1st Engr C Bn Hq (Organization) H 917-274 (Place) 072200 May 54 (Hour and date)

Key	Coordinates	Object	Time Observed	Work Estimate?	Additional Remarks and Sketch
1	H 950-274	Engr. Equip.	1845	No	2 Bulldozers, D-8 1 Carryall scraper, 12yd 1 Grader, Galion 4 Trucks, dump, 2½T Friendly equipment, idle; all in good running condition; not the property of 1st Eng Com Bn
2	H 965-298	(W) dp	1858	Yes	Water is slightly turbid, has oily appearance and fishy odor. Roads generally gravel and black top. Excellent concealment for water point and parking area. Fair drainage. Ample working space for one portable purification set, out of light artillery range. No artillery or aircraft targets in area. Soil well-drained sandy loam, trafficability good.
3	H 968-302	Bridge	1910	Yes	Stream data-10 ft Wide, 1 ft deep, moderate current firm gravel bed, bank-3ft high, 4 to 1 slope, firm gravelly soil. Abutments, ordinary concrete; height above ground 4' and 5', thickness at top 1½', length 26', refused. Pier, ordinary concrete; height above stream bed 8', length 26'. All concrete good condition. Stringers-Five per span, steel. 10in. I-beams. Flooring-Plank. 3in X 12in with decking, Plank 3in X 12in. Approaches: Water-bound macadam on sand-gravel soil. Demolition-⊠ Location of charge.

O'Neil
(Signature)

1st Lt., Co A
(Rank) (Organization)

(ENGINEER WORK ESTIMATE ON OTHER SIDE)

Figure 1. Typical form report of an engineer reconnaissance (face of form).

BACK

ENGINEER WORK ESTIMATE

Location Key	Description of Task	Unit Req'd	Hours	Equipment: Type	Equipment: No	Equipment: Hours	Materials: Type	Materials: Unit	Materials: Quantity
2	Construct access road and turnaround and clear parking area of undergrowth.	2 squads	2	Angledozer, D-6 Dump truck, tr Squad pioneer set	1 2 2	2 2 2	Bank gravel	cuyd	12
3	Hasty demolition of bridge Demolish center support	1 squad	1	Squad demolition set	1	1	T. N. T.	½ lb blocks	24

(RECONNAISSANCE REPORT ON OTHER SIDE)

Figure 2. Typical form report of an engineer reconnaissance (reverse of form).

78. Work Estimates

Reconnaissance reports should include estimates of materials, time, and labor required for probable engineer operations. These are especially important for roads, bridges, and stream crossings. A form for an estimate should be provided on the rear of the report form.

79. Air Reconnaissance

a. General. This is especially valuable for covering large areas or scattered or remote activities in a short time, and for observing areas inaccessible from the ground, such as areas close to or behind the enemy lines. Its conduct is not slowed down by road obstacles or difficult terrain. Its limitations are bad weather and the impossibility of observing or identifying certain objects and details from the air. For the use of air photography, see chapter 23.

b. *Facilities.*

(1) The engineer combat battalions, divisional and army, and the armored engineer battalion each have a helicopter and operating and maintenance personnel. Hq & Hq Co, engineer combat group, has two 2-place fixed wing aircraft.

(2) In addition to this aviation under engineer control, reconnaissance is frequently made in planes provided by higher Army authority or the Air Force.

(3) Every engineer unit having occasion to practice or profit by air reconnaissance should train selected and qualified personnel as air observers.

c. *Types of Photography.* Photography obtained by tactical air reconnaissance is grouped into three types—

(1) *Basic cover.* Used with a field army to study terrain, trafficability, and other subjects of tactical interest to a depth of about one hundred miles into enemy territory. It is flown seasonally so that the background of vegetation, snow, or drainage features indicates the true nature of the area. It need not be current, but should be recent enough for intelligent tactical planning.

(2) *Frontline cover.* Used to determine current enemy dispositions, locations, troop concentrations, mobile and semimobile installations; to detect troop movements; and for repetitive cover studies or as map supplements. It is flown daily or as required, to

a depth which includes the bulk of enemy artillery positions.

(3) *Special cover.* Cover not included in either basic or frontline cover. It may represent requirements for identification or confirmation of specific civilian or military activities, or details of some objective. It is often requested on specific installations deep in enemy territory.

80. Collection of Technical Intelligence

Much of the work involved in collecting technical intelligence is carried on at strategic levels. Certain aspects, however, are handled at division, corps, and army level.

a. Divisional Engineer Troops. These troops are often the first to come in contact with new enemy techniques and material. Information thereon is in any case reported, as technical intelligence, through engineer channels. If of interest as combat information, it is also reported through command channels.

b. Corps. With respect to technical engineer intelligence, the corps engineer's primary function is to direct its collection. For this purpose he is assigned a technical intelligence team IG (Collection) of the engineer service organization. The team is qualified to find, collect, identify, photograph, and report on elements of engineer technical intelligence. Actual collection, however, is partly by divisional and corps engineer units. Reports are sent to divisions, to other corps of the army, and to army, normally through technical channels.

c. Army. The army engineer has somewhat wider duties. He is assisted by a technical intelligence team IH (Research). This is larger than the corps team IG and is qualified to evaluate as well as collect information, and to assist in the interrogation of engineer prisoners of war and civilians with technical information. It coordinates the collecting and reporting activities of the corps teams.

Section III. OTHER SOURCES OF ENGINEER INFORMATION

81. Maps and Photographs

These are a vital source of information. Maps include those obtained from civilian sources, directly or through the Department of Defense; those made by our forces in the theater; and captured enemy maps. The first category especially must be checked to insure that they are up to date. Air photographs, and controlled and uncontrolled mosaics made therefrom, are used in that form, and also constitute the basis for most maps which are made in the theater. For further information on maps and photographs, see chapter 23.

82. Units of Our Armed Forces

Such units often acquire information of value to engineers. Since this is usually incidental to their main mission, it is the normal responsibility of engineer agencies to obtain such information from them. This may be done by liaison officers who are in touch with the units, or by engineer staff sections of higher headquarters, working under G2 coordination. The sources to be considered include—

a. Advanced Infantry and Armored Elements. These often have information on enemy obstacles, fortifications, roads and bridges, streams, and engineer equipment and supplies, including construction materials. Engineer detachments may accompany armored and other reconnaissance parties.

b. Air Force. In addition to air reconnaissance undertaken by engineer units or for their benefit, visual and photographic information useful to engineers is often obtained by air observers operating primarily for other Army agencies or for the Air Force. Such information normally comes to G2 for dissemination.

c. Navy. This is a useful source of information on ports, navigable channels, coastal areas, and islands.

d. Other Sources. Artillery observers keep close check on possible enemy targets such as fortifications, obstacles, and roads serving the front line. The artillery is also interested in information of this sort which engineers obtain. Mutual liaison is beneficial. Information about water supply can often be obtained from medical sources. The military police are a valuable source of information on the condition of roads.

83. Intelligence and Engineer Staffs

Full use should be made of engineer channels, both command and technical, to obtain information possessed by other headquarters, whether superior, subordinate, or laterally situated in the chain of command. There must be free exchange of information among engineer units, the engineer staff section of a headquarters, and G2. Through continual dissemination, timely intelligence flows up, down, and laterally to those who need it.

84. Allied Armies

Much useful engineer information is obtainable from allied forces, but the process calls for care, skill, and experience. Extensive liaison is needed. Also, because of the different shades of meaning of similar words, the lack of common technical terms, and the language barrier, information requests from one nation to another are seldom completely satisfied. A liaison agent who is expert in the languages, technical vocabularies, and habits of thought of both nations is invaluable. Informal liaison can generally be counted on for the exchange of combat information between an American and an adjacent allied unit. For obtaining strategic information from the war office of a major allied power, a formal liaison office with clerical and technical staff may be required. Information obtainable includes data on research and new development, the results of espionage, and previously secured and filed data on a wide variety of subjects.

85. Civilians and Prisoners of War

a. A great deal of information, including engineer information, is obtainable from prisoners of war; from American and allied agents; from members of underground organizations opposed to the enemy; from members of our own or allied armies, formerly prisoners of war, who have escaped or have been recaptured; and from the civilian population of the theater.

b. Prisoners of war are interrogated at each level for only such information as is required by the headquarters conducting the examination, except when a higher headquarters directs a specific line of interrogation.

c. Engineer units do not normally question any prisoners of war except those whom they capture; these may be examined for engineer information of immediate concern to the capturing unit. G2 sections automatically forward to engineer channels any engineer information brought out by their own interrogations. In addition, however, if an engineer unit needs some particular information which prisoners of war are likely to possess, it should ask G2 to obtain it. In a division, such a request goes to the engineer battalion S2, who contacts the division G2, who transmits the request to the interrogation teams at regimental and divisional collecting points. When an engineer company supports the same infantry or armored regiment for each operation, the company commander should arrange for liaison with the regimental S2. For corps engineer troops, the channels to be followed are engineer command and operational channels to the corps engineer, engineer intelligence officer to corps G2, corps G2 to corps collection point and to division G2, and division G2 to division collection point. Corps engineer troops supporting a division can save time by contacting S2 of the divisional engineer battalion, through their liaison officer. For army and communications zone troops, similar procedures apply.

86. Other Sources

These include books, magazines, pamphlets, reports, and miscellaneous material obtainable from libraries or elsewhere, captured enemy documents, and captured material and installations. For the latter, see FM 30–15.

87. General

As stated above, engineer information collected by reconnaissance or otherwise is converted into engineer intelligence by the successive steps of recording, evaluation, and interpretation, and is then disseminated. This work is accomplished by all intelligence agencies of the command, under G2 coordination.

88. Engineer Records

The principal intelligence records kept in engineer units and sections are the journal, the work sheet, and the situation map. They correspond, on a smaller and specialized scale, to the similar records kept by G2 of a general staff.

a. Journal. This is a permanent chronological record containing briefs of important information received and notations of orders, records of conferences, etc., pertaining to intelligence matters. In corps and higher engineers staff sections it is kept by the intelligence subsection. In groups and battalions it may be kept by S2, or there may be a combined staff journal.

b. Work Sheet. This is based on the journal, but with the items grouped by subject instead of chronologically. It is used for convenient reference, and also to assist in preparing periodic intelligence reports. It is not a permanent record.

c. Situation Map. This is used to record graphically all pertinent information about the enemy and the enemy-held area, including roads, bridges, fords, crossing sites, road blocks, water supply points, and the like. It normally shows more technical and less tactical information than does a G2 situation map. It also shows a limited amount of information about our troops. Standard conventional signs are used. Separate situation maps are often made for specialized data, such as road and bridge information.

d. Other Records. These include reconnaissance and observers' reports and objective folders. Data on engineer supplies and materials reported to S2 are transmitted to S4.

e. Files. Reports, messages, and other original intelligence material are filed and cross-indexed for future reference. The scope and volume of intelligence files in an engineer headquarters or section varies with the size and nature of the command.

89. Evaluation

Evaluation is the appraisal of an item of information to determine its pertinence and accuracy and the reliability of the source or agency. For the evaluation procedure and rating code used in evaluating engineer information, see FM 30–5.

90. Interpretation

Interpretation involves analyzing information to determine its significance with respect to information or intelligence already at hand. It converts the raw information into intelligence. For procedure, see FM 30–5.

91. Dissemination

a. The object of dissemination is to insure that staffs and troops will have all available facts concernings the enemy and the terrain which are pertinent to their needs, and that the intelligence pictures at various echelons are consistent. To insure this, every intelligence officer must disseminate the intelligence he produces to higher, lower, and adjacent engineer echelons.

b. The following rules govern the dissemination of intelligence:

(1) It must be timely. Intelligence must reach the user in time to be used in his planning.

(2) It must include all users who have need for the intelligence.

(3) It should carry an evaluation as to accuracy and completeness.

92. Methods of Dissemination

a. The engineer intelligence officer disseminates intelligence by personal contacts, conferences and briefings, messages, reports, studies, displays, maps, and map substitutes. Reports include periodic engineer intelligence reports, special intelligence reports, engineer intelligence summaries, and terrain studies.

b. Within his own headquarters the engineer intelligence officer disseminates intelligence by formal or informal conferences and briefings, using the engineer intelligence situation map as an aid. Technical information is disseminated in written or graphic form.

c. Dissemination of intelligence by personal contact gets the intelligence to the user expeditiously and creates a closer bond between the engineer intelligence officer and the user. The intelligence officer establishes personal contact by visits, by the use of liaison officers, and by telephone and radio communication. Intelligence thus transmitted is recorded in brief notes in the intelligence journal.

d. Messages transmitted by special courier, radio, or wire are used to disseminate urgent intelligence. Important items may be transmitted by more than one means.

CHAPTER 6

ENGINEER SUPPLY

Section I. GENERAL

93. Aspects of Supply

a. There are three aspects of supply which may concern an engineer officer in a theater:

(1) Supply of nonengineer items (for example, rations and ammunition) to engineer troop units.

(2) Supply of engineer items to nonengineer units.

(3) Supply of engineer items to engineer units.

b. Of the foregoing, (1) is an aspect of routine unit administration, and is not dealt with in this chapter, which confines itself to (2) and (3).

c. For *water supply*, see chapter 22. For *map supply*, see chapter 23. For *repair parts supply*, see chapter 7.

94. Classes of Supplies

All supplies issued to the Army fall into one or another of five classes, as follows:

a. Class I. Items which are consumed by personnel or animals at approximately uniform rates regardless of tactical or other factors; for example, rations and forage.

b. Class II. Items for which allowances are established by the Department of the Army: for example, clothing, weapons, spare parts, and mechanic's tools.

c. *Class III.* Solid and liquid fuels and lubricants, other than those for use in weapons such as flamethrowers. Aviation fuels and lubricants are class III (A).

d. *Class IV.* Supplies and equipment for which allowances are not prescribed, and which are not otherwise classified: for example, construction and camouflage materials, and construction or utilities equipment not covered by T/O & E or equivalent. Aircraft, and the equipment, parts, and supplies pertaining to them (other than fuels, lubricants, and ammunition), are class IV (A).

e. *Class V.* Ammunition, explosives, and chemical agents.

95. Characteristics

a. *Expendability.* Items of classes I ,III, and V are expendable. Items of classes II and IV may not be expendable. Most nonexpendable items of Army supply are in class II.

b. *Basis of Issue.*

(1) Class I. Per man or animal, per unit of time.

(2) Class II. Per man, per unit, or per machine.

(3) Class III. Per vehicle per unit of distances, or on some other reasonable basis.

(4) Class IV. Per project, per mission, or on some other reasonable basis.

(5) Class V. Per weapon, per unit or user, per area or mission, or on some other reasonable basis.

c. *Consumption.* Items of classes I, III, and V are normally consumed soon after issue to using troops; reissue is frequent and follows promptly on consumption. Nonexpendable items of classes II and IV normally have rather long useful lives, and reissue is intermittent. Expendable items of classes II and IV (for example, repair parts, road material) are in most cases consumed soon after issue, but reissue depends on circumstances.

96. Supply Services

a. (1) Items of Army supply may also be classified according to the technical services which procure, store, and issue them. There are seven such services—

(*a*) Army Medical Service.
(*b*) Chemical Corps.
(*c*) Corps of Engineers.
(*d*) Ordnance Corps.
(*e*) Quartermaster Corps.
(*f*) Signal Corps.
(*g*) Transportation Corps.

(2) In addition, certain administrative agencies have supply missions. Thus, The Adjutant general is responsible for the supply of blank forms and official publications.

b. In most cases the technical service which procures an item also stores and issues it. There are exceptions: thus, the Quartermaster Corps procures certain special class III lubricants and turns them over to the using service for storage and issue.

c. In general, class I and class III items are the responsibility of the Quartermaster Corps, except that solid fuels are a Corps of Engineers responsibility, and class V items of the Ordnance Corps or the Chemical Corps. All technical services participate in class II supply.

97. Engineer Supply, General

In an active theater some 8,000 individual items and 200,000 repair parts are listed as elements of engineer supply. Engineer supplies delivered to an active theater represent approximately one-seventh of the total supply tonnage. This includes only items that may be brought into the theater and does not include large tonnages of supplies obtained locally.

98. Principles of Supply

The following basic principles underlie military supply:

a. Impetus of supply is from rear to front. It is a function of each element in the supply chain to push supplies forward to more advanced elements. However, supply is ultimately a command responsibility, and every commander is responsible for preparing advance estimates of his supply needs, making these known to higher authority, and arranging to draw and distribute supplies allocated to him.

b. Simplicity and economy are vital.

c. Local sources of supply, and expedient substitutes for standard items which are not available, must be utilized to the utmost.

d. Since the flow of supplies is always subject to interruption, safety levels as operating levels must be maintained throughout a theater.

Section II. CONTROLLING AND OPERATING AGENCIES

99. Responsibilities, General

In the chain of control of engineer supply, higher echelons do the planning and develop the broad policies. Subordinate staff echelons implement these policies, control critical items, control the flow and distribution of stock items, and supervise the system of engineer depots. Supply responsibilities rest on the theater, communications zone, army, corps, and division engineers, and on all commanders of engineer units. Engineer troop units operate deposits, and may be assisted by other units or by local or PW labor.

100. Theater and Communications Zone

a. The chief engineer of the theater, subject to G4 supervision and coordination, is responsible for—

(1) Determining overall engineer supply requirements.

(2) Supervising the engineer supply system in the theater, including procurement, storage, distribution, and documentation; the establishment and operation of supply facilities; and insuring compliance with theater policies.

(3) Controlling the issue of critical items where necessary.

(4) Advising the theater commander and G4.

(5) Cooperating with the chief engineers of allied forces to secure coordination and interchange of engineer supplies.

b. The engineer, communications zone, subject to G4 supervision and coordination, commands all engineer supply activities in that zone. He is directly responsible for the flow of supplies through the zone and into the combat zone, for the efficient operation of engineer depots, for the maintenance of stock levels and of stock control, and for the control of critical items as necessary. He prescribes, supervises, and coordinates stock levels, distribution of supplies, and procurement within announced policies. He allots supply personnel, including troop units, civilian labor, and PW's that have been allocated for engineer use within the communications zone. He is responsible for consolidation of requisitions for transmission to the zone of interior. He insures compliance with the supply policies of the communications zone commander and his G4 and advises those officers on engineer supply matters.

101. Army

Engineer supply in the combat zone, with respect to an individual field army, is the responsibility and under the command of the army engineer. He recommends the stock levels to be established in army depots and supply points; assigns engineer supply troop units within the army service area; supervises the operation of supply agencies; supervises local procurement of engineer supplies in the army area; acts on requisitions; allocates items in short supply as directed; and assures himself that army, corps, and divisional troops are receiving adequate supplies and that supply discipline is being maintained.

102. Corps

A corps is a tactical unit, not in the chain of supply. Corps troops, including engineer units, and also the attached divisions, obtain their engineer supplies from depots or supply points designated by the army engineer. However, it is the duty of the corps engineer—

a. To be familiar with the engineer supply situation in the corps, and to give corps and divisional engineer units all possible help in solving their supply problems.

b. To coordinate requirements.

c. To see that needs for engineer supplies arising out of future operations of the corps are anticipated and met.

d. To allocate items in short supply, within the framework of corps and army policies.

103. Division

The division engineer has important supply functions, which are discussed in paragraphs 122 through 129.

104. Engineer Supply Units, General

a. Certain engineer troop units are specially organized and trained to execute supply missions, either operating or supervisory. They include—

(1) The engineer supply point company.
(2) The engineer depot company.
(3) The engineer parts depot company.
(4) The engineer water supply company.
(5) The engineer forestry company.
(6) The engineer depot battalion.
(7) The engineer maintenance and supply group.
(8) Certain teams of the engineer service organization.

b. Of the foregoing, the parts depot and water supply companies are discussed in chapters 7 and 22. The others are dealt with briefly below.

105. Operating Units

a. Engineer Supply Point Company. This unit operates engineer supply points in corps and army areas. It is normally assigned either to a depot battalion or to a maintenance and supply group. It can handle the reception, storage, and issue of engineer supplies for a corps or an equivalent population of army troops. It consists of a company headquarters and two identical supply point platoons. Each platoon can operate an independent supply point. Stock control is handled by the company headquarters.

b. Engineer Depot Company. This unit operates a depot for engineer general supplies and equipment, in the army service area or the communications zone. It is normally assigned, either to a depot battalion or to a maintenance and supply group. It consists of a company headquarters, a depot headquarters section, a stock control section, and three identical supply platoons. The latter handle the physical operations of the depot.

c. Engineer Forestry Company. This unit logs and saws rough lumber, timbers, and piling, and operates a lumber yard. It is normally assigned to an engineer maintenance and supply group in the communications zone. It consists of company headquarters and three identical engineer forestry platoons. Each platoon has a milling and yard section and a logging and hauling section. Platoons can operate independently, or the logging, milling, and yard operations of the company can be carried out on a consolidated basis. The company can produce from 30,000 to 45,000 board-feet per day, enough to meet the normal demands of about 20,000 construction troops. Types of lumber produced depend on the demand. Lumber which has been milled and placed in the yard becomes an item of depot stock, and the yard itself may be made, administratively, a detached element of some engineer depot or supply point.

d. Teams. The following teams of the engineer service organization, T/O&E 5–500A, have supply functions:

(1) Team BA, General Supply, normally used to augment an engineer depot company or to operate with a separate task force.

(2) Team BB, Depot Operating, generally similar but larger.

(3) Team BC, Equipment Supply, specializing in this form of engineer supply; normally used to augment an engineer depot or battalion, or to operate with a special task force.

(4) Team GD, Forestry, about equivalent to one platoon of an engineer forestry company; may augment such a company or operate independently.

(5) Team GI, Gas Generating, and GJ, Carbon Dioxide Generating, which can generate, store limited quantities, and transport acetylene oxygen, and nitrogen gases, and carbon dioxide respectively. They are normally assigned to an engineer maintenance and supply group.

c. Installations. The installations which these agencies operate are discussed in paragraphs 109 through 121.

106. Supervisory Units

a. Engineer Depot Battalion. This is normally assigned to an engineer maintenance and supply group in the army service area or communications zone. It has a headquarters and headquarters detachment. To this are assigned an engineer depot company and two or more engineer supply point companies (if in an army area), or two or more engineer depot companies (if in the communications zone), together with any labor companies or equivalent that may be designated.

b. Engineer Maintenance and Supply Group. This is also a supervisory unit, assigned to either army or communications zone, or on occasion to a theater air force. It may be made part of an engineer brigade. It represents the lowest level at which engineer maintenance activities and supply activities, other than organizational, are brought together under coordinated control. It has a headquarters and headquarters company. To this are assigned a varying number of units, which may include any of the engineer troop units of either a maintenance or a supply category. What particular units are thus assigned depends on the location and duties of the group.

Section III. REQUIREMENTS: PROCUREMENT

107. General

a. Determination of engineer and other supply requirements for the current and future operations of any unit or installation in a theater is the responsibility of the commander and his staff.

b. For the theater as a whole, responsibility for determining requirements falls on the theater and communications zone headquarters. Initial equipment requirements are primarily the responsibility of the zone of the interior. Requirements for replacement of equipment and for current consumption are computed on the basis of actual or expected troops in the theater, tables of allowances, experience tables, and a consideration of tactical and strategic plans. Reserves are computed on the basis of minimum level of supply. Project requirements represent items of supply which are not included in T/O & E, T/A, or other formally prescribed allowances, but are needed for specific tasks. In the field of engineer supply and at higher levels, their determination with any degree of accuracy is complex and laborious. They are principally Class IV items used in the construction, repair, and maintenance of field fortifications, roads, railroads, bridges, port and waterfront facilities, housing and structures of all types used in the theater, water supply and electric power, and so on. How much will be needed, when and where, is affected by such factors as the facilities and resources of the theater at the outbreak of war; the extent to which the enemy may have destroyed them; whether the campaign will develop offensively or defensively; and the extent to which we can keep command of the air and minimize enemy bombing.

c. Procurement from the zone of interior is also a task handled primarily by theater and communications zone headquarters and the Department of the

Army. Initially, troop units are sent to a theater fully equipped. For a certain period following initial occupation, supply from the zone of interior is largely automatic, at a rate prescribed by the Department of the Army. At a later stage the basis of procurement changes from automatic shipment to requisition. Theater requisitions for engineer and other supplies are based primarily on prescribed minimum and operating levels, but must take careful account of project requirements for special large-scale operations.

108. Local Procurement

a. The task of providing engineer supplies for a modern army from the zone of interior, especially in an oversea theater, is so large, so complex, and so costly in manpower, materials, and money, that every effort must be made to simplify it by local procurement. The four recognized methods for this are by purchase, by requisition, by confiscation, or by requiring money contributions. The last three are used only in hostile territory.

b. Class IV engineer supplies include many categories of items suitable for local procurement. Among these are—

(1) Items such as lumber, cement, structural steel, and railroad rails and ties, local procurement of which will save a great deal of shipping space on account of their bulk and tonnage.

(2) Other manufactured items such as plumbing and electrical supplies, hardware, paints, and camouflage materials obtainable from civilian sources. The local procure-

ment of these items will reduce and simplify the support of the theater by the zone of interior.

(3) Repair parts for nonstandard items such as local power plants, water supply systems, and machine shops which engineer units must operate and maintain.

c. Engineer commanders and staff officers at all levels must always be alert to ascertain and utilize such local resources. Policies are set by theater headquarters on recommendation of the theater engineer, and are supervised and enforced by engineer staff sections and commanders at lower levels.

d. Local procurement by engineers often involves using the output of industrial plants in the theater, and may involve taking over such plants and supervising their operation and maintenance.

e. Probably the most common form of local procurement is the use of sand and gravel resources and the quarrying of rock. Another form is the exploitation of forests by engineer forestry companies.

Section IV. STORAGE AND DISTRIBUTION

109. Depots, General

A depot is an installation which handles the receipt, processing, storage, and issue of supplies. The term includes the operating personnel, the structures and fixed installations, and the stocks of supplies. Supply points and dumps are elementary forms of depots.

110. Location of Depots

a. An engineer depot may be in the base, intermediate, or advance section of the communications zone, or in an army service area. Depending on such location, it is known as a "base," "intermediate," "advance," or "army depot." Supply points operated by engineer supply point companies may be located in army or corps service areas; divisional supply points, in division areas. Dumps of engineer supplies are established in the combat and communications zones as conditions warrant.

b. The precise location and layout of an engineer depot are determined by many factors, including: the general topography of the theater; its division into zones and sections; location of the base ports (if the theater is overseas), of principal rail and highway communications, and of navigable inland waterways if these have any importance, suitable terrain, with space for dispersion; location of principal demands for engineer supplies; and availability of labor.

111. Organization of Depots

a. An engineer depot, with respect to organization, may be an independent entity, in which case it is called a branch depot. Alternatively it may be one element of a "general depot" which also includes depot installations of other technical services.

b. The branch depot is the more common type. The general depot type of organization is used when the branch depots of several services are closely adjacent, so that there must be coordination of their common resources. They then become branch sections of the general depot. The commanders of those sections, including the engineer section, are under the orders of the general depot commander with respect to such matters as transportation and labor pools, housing, utilities, traffic control, security, and the like. However, the general depot headquarters is not an element in the chain of supply; with respect to supply matters, the engineer and other sections function in the same way as if they were branch depots.

c. Depots may be designated as class I depots, class II depots, etc., depending on the classes of supplies that they stock. Engineer supplies, except solid fuels (class III) are only of classes II and IV, and most engineer depots, or engineer sections of general depots are organized to handle both classes.

d. Issue to users in the combat zone is normally from supply points rather than depots. If a depot issues direct to users, it organizes a separate section for that purpose known as a distribution section. Preferably this should be physically separate from the rest of the depot.

e. Solid fuels, because of their bulk, tonnage, and handling facilities, are not generally handled in depots. They are generally shipped direct from the port or port area stockpiles under engineer control to the user or local distribution stockpiles.

112. Categories and Missions

With respect to supply mission, three categories of depots are recognized: distribution, key, and reserve depots. A depot may also perform other types of mission, such as assembly, maintenance, or training. (See SR 780–10–1.)

113. Distribution, General

a. Distribution of supplies includes the following: establishment of policies governing the movement of supplies, assigning responsibility for storage and issue, and setting forth the missions of supply agencies; establishment of supply levels; establishment and supervision of procedures for stock control, and for the requisitioning, issue, loan, sale, transfer, return, or other disposal of supplies; maintenance of stock records; and necessary inspections.

b. Distribution also includes the physical operation of depots and supply points and the transportation of supplies. Operation of depots may include the technical processes of reception and unpacking, identification and marking, processing, reclassifying, storing, maintenance while in storage, packing and loading for transport, delivery, repair, and salvage, including coordination with maintenance and repair agencies. Not all depots and supply points engage in all these activities.

114. Levels of Supply

a. Supplies will not flow into the theater, and through it to using troops, continuously and uniformly. The total in the theater, or in any element of it, will always be fluctuating. It must be held high enough to avoid disastrous shortages and low enough to avoid congestion. For this purpose, levels of supply are established.

b. For the theater as a whole—

(1) *The operating level of supply* is the quantity of supplies needed to sustain operations between successive replenishment shipments, assuming that these proceed on schedule and have been properly estimated.

(2) *The safety level of supply* is the reserve needed to sustain operations if such replenishment is delayed or is otherwise inade-

quate, that is, if the operating level is drawn down to zero.

(3) The sum of these is the *stockage objective* authorized to be in the theater at any time.

(4) All three levels are normally expressed in "days of supply" and are set by the Department of the Army.

c. For subdivisions of the theater, levels of supply are set by lower level agencies, subject only to the requirement that the theater totals be not exceeded. Levels for the combat zone and the communications zone are set by theater army headquarters; for base, intermediate, and advance sections, by communications zone headquarters. Levels are also set for individual depots and other installations. Staff engineers, and commanders of engineer depots or engineer sections of general depots, recommend appropriate levels and changes therein.

115. Principles of Stockage

a. When items of engineer supply are placed in a forward depot, the area within which they can be used is restricted, since the movement of supplies should be forward, or in special cases may have to be lateral, but not backward. Therefore, in the interest of flexibility, the bulk of engineer supplies in a theater should be held well to the rear.

b. However, items needed for day-to-day operations must be immediately available to users, with a reasonable reserve to allow for interruption in supply movements, destruction of stocks by hostile action, or unforeseen demands caused by an emergency.

c. Congestion at base ports, or other points of entry into a theater, must be avoided at all costs.

d. Engineer supplies, especially class IV, are needed everywhere in a theater, and for some categories, such as construction materials, the demand is often greater in rear areas than in the combat zone. In this respect they differ from such supplies as ammunition, most of which is used at or near the front.

116. Stockage and Flow of Engineer Supplies

a. Engineer supplies entering the theater normally move first to base depots (fig. 3). Certain special processes occur here, including identification, conditioning, or other processing if necessary, and picking up the items on stock records.

b. Normally, the next movement is to depots in the intermediate section, where large stocks are kept. However, items may go direct from port to intermediate depots under certain conditions.

c. For items used in the combat zone, the next normal movements are to advance depots near the rear boundary of the army service area, and to army depots in that area. At army depots the policy is to maintain balanced stocks of limited size, consisting mostly of items in common use. Army depots may be depots of issue to units in the army service area. They also deliver to supply points for issue to corps and divisional troops. There should be at least one engineer supply point per corps, located well forward.

d. For items of engineer supplies used in rear areas, depots of issue are established in the communications zone convenient to users. These are often physically a part of base or intermediate depots, a special section being organized by the depot for retail issue.

e. Items in short supply are in general held in rear-area depots, but there must be means for prompt delivery to users if the need arises.

f. A depot which supplies either another depot or a supply point is normally responsible for initiating transportation requests for shipment, and for loading out the shipments of supplies.

117. Delivery to Using Units

The two usual means are supply point distribution and unit distribution.

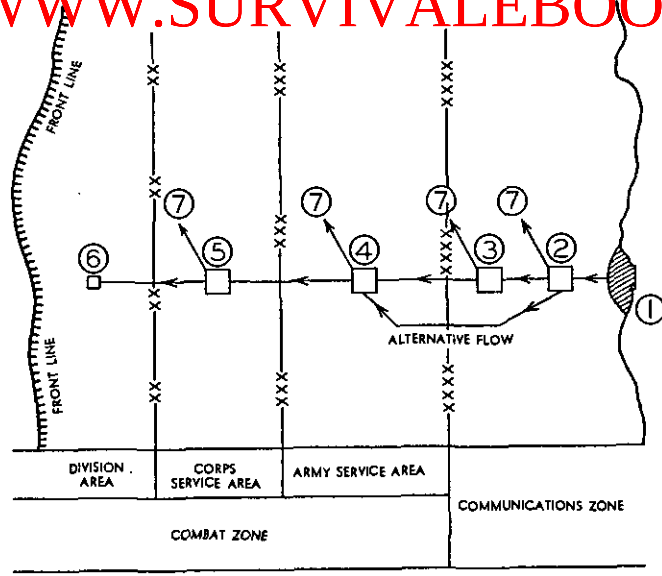
a. In supply point distribution the using unit sends its transportation to the depot of issue, supply point, railhead, truckhead, or pipehead, picks up the supplies, and delivers them to the unit bivouac, dump, or distributing point. This system is commonly used by armies and divisions in making supplies available to their subordinate units.

b. In unit distribution, delivery is made to the using unit at its bivouac, dump, or distributing point, in transportation furnished by a higher echelon. This system is commonly used by the communications zone in delivering supplies to an army, and by a regiment in delivering supplies to its companies.

c. See also paragraphs 122 through 129.

118. Locally Procured Supplies

Stockage and movement of these obey the same principles as in the case of supplies from the zone of interior. However, since they may "enter the theater" (that is, be procured) in any zone or section, the points of storage, processing, and issue are determined on a commonsense basis.



1 PORT

2 : COM Z ENGR BASE DEPOT, CL. II & IV

3 COM Z ENGR INTERMEDIATE OR ADVANCE DEPOT, CL. II & IV

4 ARMY ENGR DEPOT, CL. II & IV

5 ARMY ENGR SUP PT

6 BN SUP OFF, DIV ENGR BN

7 REPRESENTS ISSUE TO LOCAL USERS, SOMETIMES FROM DEPOTS OF ISSUE PHYSICALLY OR ADMINISTRATIVELY SEPARATE FROM OTHER DEPOTS

Figure 3. Flow of engineer supplies.

119. Stock Control

a. Stock control requires keeping up to date a mass of statistical data on all items of supply. The data include total stocks on hand, receipts and issues, authorized levels, requisitioning objectives, quantities in transit, items unserviceable but repairable, items suspended and impounded, and other pertinent information. Such data, for the theater as a whole, are maintained at a central point of record by the technical service concerned. They are the basis for theater procurement, requisitioning, distribution and redistribution, declaration of excess, disposal of surpluses and of obsolete items, supervision of repair operations, and the determination and revision of replacement and maintenance factors.

b. Similar data, differing in detail, are kept by subordinate agencies in the supply chain. Consolidation of these is the basis for the theater data.

c. Supply control, of which stock control is a part, involves the computation, enforcement, maintenance, and periodic revision of stock levels for each area of the theater and each supply installation. "Stock levels" are, in effect, supply levels translated from *days of supply* into *quantities*. The ideal which the theater supply system seeks is to maintain stock levels throughout the theater, at all times, at the correct values, which lie between minima and maxima corresponding to minimum and maximum supply levels. More specifically, the system seeks to insure that—

(1) Every using unit, and every depot or equivalent, has on hand enough and not too much.

(2) Adequate reserves are maintained.

(3) Requisitions are filled with a minimum of delay and of back orders.

(4) Excess stocks are promptly located and put back into circulation.
(5) Shortages at supply installations are discovered and corrected before the using units are affected.

120. Credits and Requisitions

a. A *credit* issued by an authorized headquarters to a command subordinate to it or dependent on it for supplies, entitles that command to draw, from the theater supply system, specified kinds and amounts of supplies without further authority from the issuing headquarters. A credit is normally established in one or more designated depots and for a limited period. With respect to combat troops, credits are established for a field army, but not ordinarily for subordinate units of the army.

b. A *requisition* is a request for supplies, made by a user in some prescribed form and through prescribed channels. Depending on circumstances, it may be a formal written document, an informal message, an oral request, a call against a credit, a status or expenditure report, or other form. (Not all these are applicable to the issue of engineer supplies.) A formal requisition for engineer supplies should not include items of any other category of supplies. Regulated items should be requisitioned separately from other items.

121. Issue of Engineer Supplies

a. General. Since engineer supplies, with the exception of solid fuels (class III), are either class II or class IV, certain procedures used for other classes of supply do not apply to them.

b. Requisitions. Divisional units, including engineer battalions, submit requisitions for engineer supplies to division headquarters. They are edited in the division engineer supply office, consolidated, and sent to supply points or depots for filling. Corps and army units, and units in the communications zone, requisition on supply points or depots of issue.

c. Points of Issue. What supply points or depots of issue will supply what units with what items, is prescribed: in the combat zone, by army headquarters; in the communications zone, ordinarily by section headquarters. A typical arrangement would be as follows:

(1) Divisions in line, and corps troops, obtain general engineer supplies from engineer supply points in the corps or army service area; engineer spare parts from engineer field maintenance companies similarly located; engineer equipment from engineer depots of issue, located either in the army service area or close behind its rear boundary.

(2) Troops in the army service area or communications zone obtain engineer repair parts from engineer field maintenance companies, but obtain both engineer equipment and general supplies from engineer depots of issue conveniently located.

Section V. DIVISIONAL SUPPLY

122. General

a. The division engineer is responsible for the engineer supply of the division, and also has command responsibility for the supply of the divisional engineer battalion. His activities include the establishment and operation of engineer divisional supply installations. He normally delegates details of these tasks to S4 of the divisional engineer battalion.

b. S4 is assisted in supply operations by the supply section of battalion headquarters, which includes a battalion supply sergeant, storekeepers, clerks, and others. He may obtain more personnel from the headquarters and service company. Lettered companies assist in battalion supply as required; for example by doing road work at supply points or furnishing details to load, unload, and handle bulky supplies.

123. Division Engineer Supply Points

a. *Number*. At least one engineer supply point is always operated for a division. Normally, one is enough, but in defense, in a rapid advance, when the division is operating on a wide front, or when the road net is poor or congested, secondary supply points with limited stocks may be needed.

b. *Location of Principal Supply Point*. It should be beyond range of enemy medium artillery. It must be easily accessible from the main supply route (MSR), and preferably near it. A central location is desirable. When the division is in bivouac, the point is normally located near the bivouac of the headquarters and service company. It should be concealed from air observation. Advantage should be taken of natural obstacles against raids by armored vehicles. Stocks should be camouflaged and dispersed. When the division is on the march, the point may move in two echelons, so as to open at a new location before closing at the old one. If it displaces in one echelon, the "supply point" during the march consists of the vehicles transporting the supplies.

c. Operations of Principal Supply Point. It is normally operated by at least one noncommissioned officer and several privates. If frequent issues of heavy materials are required, more men are assigned. The supply point is stocked initially with the equipment and supplies carried by headquarters and service company for battalion and division use. Additional stocks are obtained from army depots and local sources as the division engineer may direct, using the transportation which is released when the normal loads are thus dumped. Stocks of engineer supplies found in the area, such as lumber and road materials, may be used to increase the stock of the principal supply point, or may be distributed from a secondary supply point set up on the spot. Using units send their own transportation to the supply point, unless the engineer supply officer can spare enough transportation to make deliveries. Normally they do their own loading at the supply point.

d. Secondary Supply Points. These may be established anywhere in the division area. Cover, concealment, and easy access are desirable characteristics. They may consist of dumps of road metal, bridge timbers, or the like, spotted for the immediate repair of roads or bridges expected to be damaged by the enemy; or of local stocks of material issued where obtained or found; or of installation like the principal supply point but smaller. The minimum operating personnel for such a point, for 24 hours, is one noncommissioned officer and two men.

124. Issue at Supply Points

Expendable supplies are usually made to troops upon a statement from the commander who draws them that they are necessary. Nonexpendable supplies are issued in accordance with approved requisitions or established credits. A running account of stock is kept, and is studied to determine what items are being expended most rapidly. An orderly arrangement of stocks is maintained to promote efficient operation.

125. Other Divisional Supply Installations

A distribution point for camouflage supplies may be established by a camouflage company. Forestry companies may operate distributing points for lumber. Dumps of certain engineer materials for divisional use may be placed by corps or army agencies in the corps service area if conditions justify it. For water and map supply to divisions, see chapters 22 and 23.

126. Supply in Offensive

a. In the offensive, the principal items of engineer supply are materials for the repair and maintenance of routes of communication. Road metal is required in large quantities. It is procured locally if possible and placed along the MSR. Road plank for bypassing craters is concentrated in dumps. Bridge timbers and steel I-beams are located near bridges which may be destroyed by enemy fire or need to be strengthened for heavy loads.

b. As the attack progresses, dumps are advanced. Captured supplies, and local resources such as rock quarries and standing timber, are exploited to the utmost. This calls for active and persistent engineer reconnaissance of captured ground. As the divisions advance, the army engineer, operating through the army maintenance and supply group, takes over operation of engineer dumps which the divisions relinquish. The army engineer assists the supply operations of corps and division engineers by advancing materials to forward dumps operated by army engineer personnel.

127. Supply in Pursuit or Rapid Movement

The location of rapidly moving columns must be determined in advance if supply is to be maintained. Engineers accompanying the columns carry carefully selected engineer supplies and equipment for which a definite need can be foreseen, such as tactical bridging. Local materials and abandoned enemy supplies are exploited to the utmost.

128. Supply in Defensive

a. A wide variety and heavy tonnage of engineer class IV supplies are needed for organizing a defensive position. Among the items are barbed wire and accessories; sandbags; chicken wire and other revetting materials; lumber, nails, and bolts; cement, reinforcing steel and aggregate, if concrete is used; materials for camouflage; and items needed for such general engineer work as roads, and bridges. If elaborate shelters are involved, calling for lighting and ventilating systems and other refinements, the demand is further increased.

b. Generally speaking, these items are handled through normal engineer supply channels. Materials needed should be delivered as far forward as possible without exposing the distributing points to enemy fire. The vicinity of the regimental reserve line is often a good place, but items which will be used at once may be delivered even further forward. Distributing points are normally one per frontline battalion, close to roads, with defilade from ground observation. They may also be placed farther to the rear to serve flank positions or blocking positions in rear areas. Sometimes a distributing point is not manned, the supplies being dumped and the local commander immediately informed of the location and items.

129. Supply in Retrograde Movement

a. In this situation the division is moving toward its base of supplies. The engineer items chiefly needed during the movement are for the temporary repair of the roads and bridges used by the marching columns, and for any temporary defensive positions which may be organized. Issue is largely from vehicles. If the retrograde movement has been anticipated long enough in advance, supplies may be kept loaded in advance.

b. The most difficult engineer supply problem in this situation is likely to be that concerned with excess stocks of supplies. Once the decision to withdraw has been reached, the forward movement of supplies is kept to a minimum and every effort is made to use up existing stocks. Those which cannot be used up should be evacuated if practicable, or destroyed. However, care must be used in destroying them, since widespread fires or explosions are an indication to the enemy that a retrograde movement is contemplated. Decision to destroy or abandon supplies is made by the division commander or higher authority; the division engineer should request such a decision if he foresees the need for it. Evacuation of supplies to the rear must not interfere with the movement and supply of divisional troops. See also the discussion of denial operations in chapter 11.

c. If it is foreseen that the division will occupy and organize a defensive position at the end of the retrograde movement, the supply problems connected with this become those associated with the defensive. Such a position may be more or less completely organized in advance by corps or army agencies. (See also ch. 11.)

Section VI. SUPPLY PUBLICATIONS

130. General

Numerous publications control the policies and practices of army supply. They may be directive or informative. They may be general or specific, either in scope or in application. They may be reasonably permanent, or may deal with an immediate and transitory situation.

131. Directive Publications

The fundamental publications of a *directive* character are Army Regulations (AR's) and Special Regulations (SR's). AR's prescribe basic policies in rather general terms. SR's cover the detailed steps for putting these policies into effect. AR's and SR's on related subjects have a parallel system of numbering: thus, AR 735–150 sets forth the principles of accounting for lost, destroyed, or damaged property, and SR 735–150–1 fixes procedures and responsibilities in connection therewith. Both types of regulations are comparatively permanent.

132. Issue Authorities

The fundamental *issue authorities* (publications which authorize the issue of specific items of supply to specific users) are Tables of Organization and Equipment (T/O & E's), and Tables of Allowances (T/A's).

Note. T/O & E's also prescribe the personnel of troop units, and contain other basic information about such units.

T/O & E's list the individual and organizational equipment, of a nonexpendable character, which troop units need to perform their basic mission—the "tools of their trade." Examples are weapons, vehicles, technical machinery and apparatus, hand or power tools of various crafts, and housekeeping equipment such as cooking utensils. T/A's list clothing, items needed for administrative activities and training, and allowances of expendable supplies.

133. Supply Manuals, General

The fundamental publications giving detailed information about Army supply items are the Department of the Army supply manuals. Their purpose is to simplify and standardize the cataloging of supplies and to identify items in all phases of supply operations from procurement to disposal. A group of such manuals exists for each technical service having supply functions. The cataloging scheme is similar for all the services, but each service has its own letter prefix used in the designations of its manuals, as follows:

a. Army Medical Service—MED.
b. Chemical Corps—CmlC.
c. Corps of Engineers—ENG.
d. Ordnance Corps—ORD.

e. Quartermaster Corps—QM.

f. Signal Corps—SC.

g. Transportation Corps—TC.

134. Engineer Supply Manuals

a. ENG 1 is the introduction to all engineer supply manuals, and explains their purpose, scope, systems of classification and numbering, and other characteristics.

b. ENG 3 lists current issue items, and is published as a series of manuals covering each federal class of general engineer items of supply, numbered ENG 3–00, ENG 3–03, etc. An appendix includes weights and cube data. These manuals are to be used for requisitioning general engineer items.

c. ENG 5 series of manuals is a series of manuals numbered ENG 5–00, ENG 5–03, etc., listing all general engineer items of supply. These manuals are for use as a reference by depots, supply organizations, and procurement agencies.

(1) ENG 5–1 is a series of manuals numbered ENG 5–1–1 through 5–1–29, listing all stocked engineer repair parts, pricing, weight, and cube data. These manuals are for use as a reference by depots, supply organizations, and procurement agencies.

(2) ENG 5–2 is a series of manuals numbered ENG 5–2–100, ENG 5–2–103, etc., listing pricing information for all general engineer supply items. These manuals are for use as a reference by depots, supply organizations, and procurement agencies.

(3) ENG 5–3 is a series of manuals numbered ENG 5–3–A, ENG 5–3–B, etc., listing cross-reference information pertaining to engi-

neer repair parts. These manuals are primarily for use as a reference by depots, supply organizations, and procurement agencies.

d. ENG 6 is a series of supply manuals dealing with sets of engineer equipment. Each manual contains the stock numbers of the component items and unit quantities which comprise the set.

e. ENG 7, ENG 8, ENG 9, or combinations thereof, cover organizational allowances and stock guides for field and depot maintenance agencies with respect to repair parts, tools, and publications applicable to specific end item(s). These manuals are guides to be used in requisitioning repair parts.

f. ENG 9 series lists component assemblies, parts, and accessories of a specific end item.

Note.—If such information is contained in any D/A technical publication (s) (TM, TB, ENG 7, 8), it is not repeated in an ENG 9.

135. Other Supply Publications

The above are all of general and widespread application. There are also many other supply publications such as circulars, memoranda, and letters. They are issued from time to time by the Department of the Army and other agencies, including, in a theater of operations, theater headquarters, and subordinate headquarters having supply missions. They may be either directive or informative. They are in general more limited than AR's or SR's in application and duration, and are in greater detail.

CHAPTER 7

ENGINEER MAINTENANCE

Section I. CATEGORIES AND AGENCIES

136. General

a. In this chapter the term "maintenance" means maintenance of engineer equipment in the hands of troop units in a theater. The term is also used, in a different sense, to refer to the maintenance, by engineer agencies, of installations which they have built. That topic is not covered here.

b. Every troop unit, including engineer units, has equipment which was procured and issued by various technical services. In general—

(1) A using unit is responsible for the *preventive* and *organizational maintenance* of all its equipment, regardless of source. The issuing services advise and assist by liaison and periodic inspections.

(2) For *field and depot maintenance* of any item of equipment, and for *parts supply*, a using unit looks to the technical service which issued the item.

(3) There are exceptions to the foregoing. Certain engineer troop units are authorized to perform limited field maintenance of their equipment, and others are authorized to perform complete depot maintenance. In addition, the theater commander may at his discretion assign the field maintenance of equipment to other than the using service.

c. Therefore, there are four aspects of maintenance (as defined in *a* above) which may concern an engineer officer in a theater—

(1) Organizational maintenance of engineer equipment, by engineer or other troop units.

(2) Organizational maintenance, by engineer units, of nonengineer equipment (not dealt with in this chapter).

(3) Field and depot maintenance of engineer equipment, and parts service, by engineer maintenance troop units.

(4) Same, for nonengineer equipment issued to engineer units, by maintenance agencies of the issuing services (referred to briefly in this chapter).

137. Definitions

a. Preventive Maintenance. Such activities as lubricating, refueling, checking coolant and lubrication oil levels, adjusting, cleaning, and checking condition of equipment.

b. Salvage. The collection of condemned, discarded, or abandoned property, with a view to restoring it to service or otherwise disposing of it.

c. Reclamation. The renovation or repair of items of equipment or components thereof, for return to supply channels.

d. Cannibalization. The stripping of usable assemblies, subassemblies, or parts from a disabled item of equipment to repair another item of the same sort.

e. Scrapping. The recovery of raw materials from unrepairable equipment.

f. Categories and Echelons of Maintenance. Engineer maintenance falls into five successively more complex *echelons*, numbered from first to fifth. These are grouped into a total of three *categories*, respectively organizational, field, and depot maintenance.

138. Organizational Engineer Maintenance

This is performed, either by the operator or by specialists within the using organization. It includes—

a. Minor adjustments of the type which are needed periodically and can be made with first- and second-echelon tools.

b. Replacement of minor assemblies and subassemblies.

c. Replacement of such parts as have a high wear factor and are easily replaced, without need for special tools or complex adjustments.

d. Minor reconditioning of parts, assemblies, and subassemblies.

139. Field Maintenance

a. This is normally performed by engineer field maintenance companies in direct support of using units. It embraces third- and fourth-echelon maintenance, and includes—

(1) Major adjustments of a type needed periodically.

(2) Replacement of major assemblies, subassemblies, and parts.

(3) Repair of assemblies, subassemblies, and parts which have a high-wear factor, and can be repaired by field maintenance equipment.

b. Using organizations may under special circumstances, be authorized by supporting field maintenance units to perform a limited amount of field maintenance.

140. Depot Maintenance

a. This is normally performed by engineer depot maintenance companies. It embraces fifth-echelon maintenance, and includes—

(1) Replacement of major parts, components, assemblies, and subassemblies.

(2) Overhaul and rebuilding of all types of engineer equipment, and of recoverable major parts, components, assemblies, and subassemblies.

(3) Disassembly of uneconomically unrepairable equipment, and the return to parts supply channels of serviceable assemblies, subassemblies, and parts, after necessary repairs.

(4) Limited manufacture of critically needed parts.

b. Units responsible for depot maintenance necessarily do a certain amount of 1st through 4th echelon work as well.

141. Agencies and Facilities

These include—

a. Maintenance personnel in using organizations.

b. The following engineer troop units: engineer field maintenance company, engineer depot maintenance company, engineer parts depot company, engineer maintenance and supply group, and certain teams of the engineer service organization.

c. Maintenance troop units of other technical services.

142. Using Organizations

a. Any individual operating a piece of engineer equipment must understand its preventive maintenance. If need be, he is issued simple tools for that purpose and trained in their use.

b. In general, engineer units at company or battalion level have specialist personnel trained and equipped for second-echelon maintenance. In the engineer combat battalion, divisional—

(1) Each combat company has an equipment and maintenance section, which includes (besides operators) a motor sergeant, automotive and heavy equipment mechanics, a mechanic's helper, and an electrician, with suitable tools.

(2) Battalion headquarters has a battalion maintenance section, under the direct supervision of the battalion motor officer and a warrant officer assistant. It operates a battalion shop for second-echelon maintenance which companies cannot handle. It also inspects, supervises, and assists with organizational maintenance done at company level and coordinates higher echelon maintenance problems with those concerned.

143. Engineer Maintenance Units

a. Engineer Field Maintenance Company. This unit can perform field maintenance for an equipment population of about 1,500 major items of engineer equipment, including maintenance inspections of, and the issue of parts to, the units it supports. It consists of headquarters, a service, supply, and special equipment platoon, and three identical maintenance platoons. Most of its work is done in the company shops, but it can handle a certain amount of "job-site repair" by sending out mobile parties. It is semimobile, and so organized that it can open a shop at a new location before closing down at the old one. It may be assigned either to corps, army, or communications zone. For a type army of three type corps, normal assignment is one company per corps in the corps service areas, and three companies serving army troops in the army service area; for the communications zone, as the equipment population warrants. Companies in army or communications zone areas are normally assigned to a maintenance and supply group.

b. Engineer Depot Maintenance Company. This unit can perform depot maintenance and allied activities for up to 9,000 major items of engineer equipment. It consists of headquarters, a shop service and supply platoon, a construction equipment rebuild platoon, and a special equipment rebuild platoon. It is assigned to communications zone, where it operates in support of from 4 to 6 engineer field maintenance companies or an equivalent load.

c. Engineer Parts Depot Company. This unit operates a depot for receiving, storing, issuing, and shipping repair parts. It consists of headquarters, a storage and issue platoon, and a stock control platoon. It can furnish parts support for about 9,000 major items of engineer equipment. It is normally assigned, either to army, supporting from 4 to 6 engineer field maintenance companies, or to communications zone, supporting 4 to 5 such companies plus an engineer depot maintenance company.

d. Teams. The following teams of the engineer service organization perform maintenance work:

(1) Team EA and Team EB, Field Maintenance, can provide field maintenance for about one-tenth and one-fourth, respectively, as large an equipment population as can a field maintenance company. They are normally assigned, either to such a company or to a task force.

(2) Team EC, Special Equipment Maintenance, is trained and equipped to perform this type of maintenance, and is normally used to augment the special equipment repair section of a field maintenance company.

(3) Team ED, Parts, can operate a small parts depot. It may be assigned to a task force, or (in combination with team EB) may be used to augment a parts depot company or to cooperate with a depot maintenance company.

144. *Maintenance Activities of Other Services*

The most important, from the engineer viewpoint, are the following:

a. The Ordnance Corps, which has a number of agencies in the combat and communications zone for maintaining the automotive vehicles which that Corps issues, and for the issue of such items as repair parts, tires, tubes, and cleaning materials. A different group of ordnance units maintains weapons and other articles of ordnance issue.

b. The Quartermaster Corps, which maintains quartermaster equipment, and is responsible for the disposal of scrap generated by engineer maintenance activities.

c. The Signal Corps and other services, which maintain equipment issued by them (ch. 8).

145. Staff Engineers

Staff engineers must be fully informed as to the status of engineer equipment in their commands, and must provide technical advice and assistance in its maintenance. In a division, as a minimum, this should include—

a. Advising and assisting unit commanders throughout the division in the maintenance of engineer equipment.

b. Making technical inspections of such equipment and of its maintenance.

c. Keeping the division commander and staff advised of the status of such maintenance, and furnishing them with information, recommendations, and plans in this field.

d. Making available, to all concerned, data on engineer equipment, repair parts, and maintenance.

146. Using Organizations

a. Maintenance Discipline. The first requisite of a successful solution of the maintenance problem is good maintenance discipline in using organizations. This involves not only well-conducted organizational maintenance, but also correct operation.

b. Responsibilities.

(1) It is a command responsibility of the unit commander to see that high standards prevail in these fields. He should know enough about his equipment to be able to tell whether it is being properly operated and serviced, what tasks are involved in its organizational maintenance, and whether they are being efficiently carried out. He should

inspect equipment frequently to assure compliance with maintenance directives.

(2) Higher headquarters are responsible for promulgating and enforcing sound principles of maintenance discipline. Commanders are advised and assisted in this task by their staff engineers.

(3) Technical inspections of a using unit are a responsibility of the unit which gives them field maintenance support. Normally such an inspection is made by a team organized from one of the maintenance platoons of the field maintenance company. Its purpose is to check on the adequacy of organizational maintenance in the using unit, give advice, and establish adequate liaison between the supported agency and the maintenance agency. Unit commanders should extend every facility to technical inspectors, invite constructive criticisms, and give their personal attention thereto.

147. Maintenance Discipline

a. The following are important criteria of good maintenance discipline in a using unit:

(1) Avoidance of the practice of cannibalization, which is normally performed only at depot maintenance level.

(2) Proper procedure with respect to repair parts. The authorized stock levels of the using unit should be maintained, readily available and identifiable, and in good condition. Hoarding of parts is a violation of maintenance discipline, and if permitted will produce an artificial shortage. Requisi-

tioning of needed parts should be planned well in advance and carried out in time to avoid critical shortages.

(3) Adherence to adequate standards of organizational and preventive maintenance. Crises may occur when such maintenance must, for a brief period, be sacrificed to immediate emergency work demands. But it must never become standard practice to do this, or to deem the ordinary work load an "emergency" in that sense. Time taken out for preventive and organizational maintenance, and a systematic withdrawal of equipment from use for checks and adjustments, will pay off in the long run. Failure to do so will result in so much equipment being deadlined that the unit's effectiveness is lost.

(4) Prompt and systematic calls by the using unit for field maintenance support. This must be especially emphasized in the case of "cross-service" support.

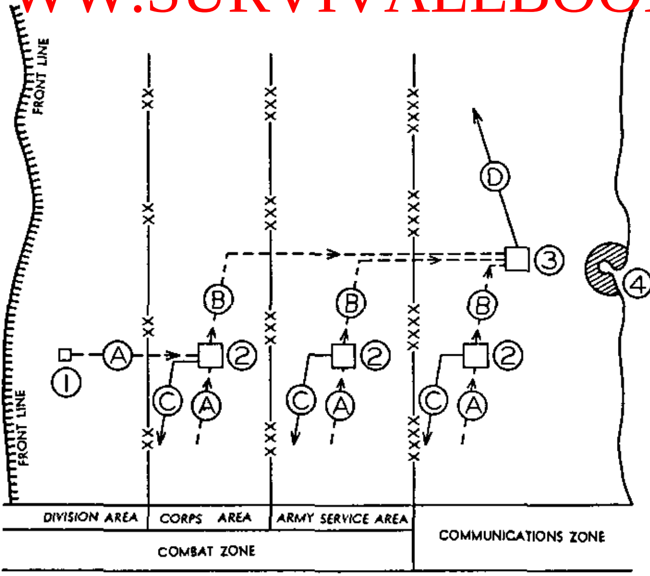
b. Inspectors who deal with using units should emphasize the above criteria. In doing so, they should cultivate the habit of looking at maintenance problems from the unit commander's viewpoint as well as from that of abstractly sound maintenance practices. If a unit has suffered from an inability to obtain needed parts or adequate field maintenance support, the temptation to hoard parts or to carry on maintenance work of a higher category than authorized is very great. The *first* step, in such cases, is not to rebuke or check the unit commander but to see that he receives better maintenance support. It is for this reason, among others, that technical inspections by maintenance specialists should be supplemented and tempered by high-level command inspections.

148. Flow of Disabled Engineer Equipment

a. A using unit, having an item of equipment beyond its maintenance capabilities, notifies the supporting field maintenance company, preparing the necessary forms (see fig. 4). The company decides whether to make repairs on the site or to evacuate the item to its shop. If the latter, the using unit normally transports the item to the shop.

b. If the field maintenance company finds that it cannot handle the repair work, it notifies the using unit. The using unit then arranges with a troop supply unit for a replacement and evacuation of the unserviceable item. If it is clear from the outset that the entire item requires depot maintenance or is unrepairable, the equipment may be evacuated direct from using unit to the depot maintenance unit through the supporting troop supply unit. The supporting field maintenance company is notified of the evacuated item.

c. If practicable, the field maintenance company repairs and returns to the using unit the same item which was turned over to it. If this involves excessive delay, or if the item must be evacuated to a depot maintenance shop, the item does not go back to the using organization, but is either turned in to supply depot stock, after repair, for reissue, or is scrapped. The using unit in this case requests a replacement.



(1) BN EQUIP OFF (BN MAINT SEC) DIV ENGR BN

(2) ENGR FLD MAINT CO

(3) ENGR DEP MAINT CO

(4) PORT

(A) DISABLED EQUIPMENT FROM USING AGENCY FOR FIELD MAINTENANCE

(B) DISABLED EQUIPMENT FOR DEPOT MAINTENANCE

(C) REPAIRED EQUIPMENT FROM FIELD MAINTENANCE TO USING AGENCY OR DEPOT

(D) REBUILT EQUIPMENT FROM DEPOT MAINTENANCE TO DEPOT. (REBUILT PARTS OR ASSEMBLIES TO PARTS DEPOT.)

NOTE: ORGANIZATIONAL MAINTENANCE (1st and 2d echelons) occurs throughout the theater; FIELD MAINTENANCE (3d and 4th echelons) at field maintenance companies, and to a limited extent in certain operating units; DEPOT MAINTENANCE (5th echelon) at depot maintenance companies.

Figure 4. Flow of disabled engineer equipment.

147. Other Aspects

a. Liaison. It is important that close liaison exist among the agencies which are concerned with maintenance and parts supply. Engineer maintenance units are responsible for establishing such liaison. Supervising headquarters at all levels are responsible for seeing that it exists.

b. Special Equipment. A relatively new field of engineer maintenance, which is of increasing importance, is the maintenance of highly specialized equipment such as sniperscopes, mine detectors, infrared devices generally, precision instruments, and the like. These items present special problems to engineer maintenance. Sniperscopes, for example, are widely used by nonengineer troops. Precision surveying instruments, on the other hand, are used almost exclusively by engineer units. There are sections in both the field and the depot maintenance company which are specially trained and equipped for this work, as is Team EC of the engineer service organization.

c. Captured Enemy Equipment. If this is useful enough to our forces to justify the effort involved, it may be put into service. Decision to do so on a large scale is normally made at a high level. In the case of complex equipment performing the same functions as standard American equipment, the decision must take into account the problems of maintenance, spare parts, and the training of operators.

d. Utility Equipment. Utility equipment, such as engine generators, requires prompt and effective support, since other equipment and utility services are dependent upon it.

150. General

a. The mechanization of warfare has made the supply of repair parts an immensely complex problem. The Engineer Supply Manuals (par. 134) list about 200,000 items of engineer repair parts needed in a developed theater of operations. The equipment of a single combat engineer company has thousands of parts. Lack of any one may put out of action a vital piece of equipment at a critical moment; yet it is impossible for the company to stock more than a very few of them. There is no perfect solution and a reasonably satisfactory solution calls for a high degree of maintenance discipline and issue experience. Failure to carry out aggressive advance planning to cope with the volume and complexity of parts supply invariably results in quantities of deadlined equipment. Due to lack of sufficient qualified personnel and inadequate supply installations, depots become congested, records inaccurate, and parts which are available and could be used are in dead stock. These dangers must be recognized and avoided by programming sufficient troop units, providing suitable installations, and maintaining an accurate population inventory of equipment supported. TM 5–505 should be consulted for details on repair parts supply.

b. This section deals only with engineer repair parts. The principles governing other technical services, which maintain items issued to engineer units, are in general the same.

c. The term "parts" is here used to include all essential elements, materials, components, assemblies or subassemblies.

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151. Fundamental Aspects

In any large theater of operations it is probable that—

a. Repair parts, as a whole, will be critical supplies.

b. Experienced parts personnel will be scarce.

c. There will be increasing emphasis upon maintenance by the replacement of assemblies and subassemblies, especially in the lower echelons of maintenance. This will expedite the return of equipment to service, but will increase the bulk of repair parts stocks.

d. Hoarding will need to be eliminated.

e. No agency, even a base depot, will ever have a complete stock of all the parts of all engineer equipment in a theater. In forward areas, stockage will become progressively more limited and selective.

152. Stockage of Parts

a. Parts Depots. A parts depot normally carries a 60-day supply for the maintenance of the organic engineer equipment of units served by the field maintenance companies which the depot supports. A base parts depot, supporting advanced and army depots, may be authorized up to a 360-day supply. It carries certain parts, including bulky and slow moving ones, not carried in more advanced parts depots.

b. Depot Maintenance Company. This company is normally located near a parts depot company and draws parts therefrom as needed. It will ordinarily carry a small stock of fast moving parts and common supplies.

c. Field Maintenance Company. This company carries stocks of parts for two purposes:

(1) For its own operations. (The company will not normally have quick access to a parts depot, as does a depot maintenance company.)

(2) For issue. A reasonable level is a 30-day supply of selected parts, for supported units.

d. Using Unit, Normal Case. The using unit is normally issued organizational repair parts consisting of an initial issue of a 30-day supply of certain fast-moving parts in frequent and periodic demand for second echelon maintenance of organic equipment. In oversea theaters this is subject to change, depending on conditions.

e. Special Units. Engineer units equipped to perform a limited amount of field maintenance are authorized additional parts.

f. Theater Restrictions. The above stockage figures are representative only. Actual figures will depend on conditions in the theater.

153. Flow of Parts

a. A base parts depot serves advance and army parts depots, and may also issue to maintenance agencies in the base section (see fig. 5).

b. Advance section parts depots issue to depot maintenance and field maintenance companies. Army parts depots issue to depot maintenance companies.

c. Field maintenance companies, whether in communications zone, army, or corps, issue to the troop units to which they furnish maintenance support.

d. Parts which depot maintenance companies have salvaged from unrepairable equipment and (if neces-

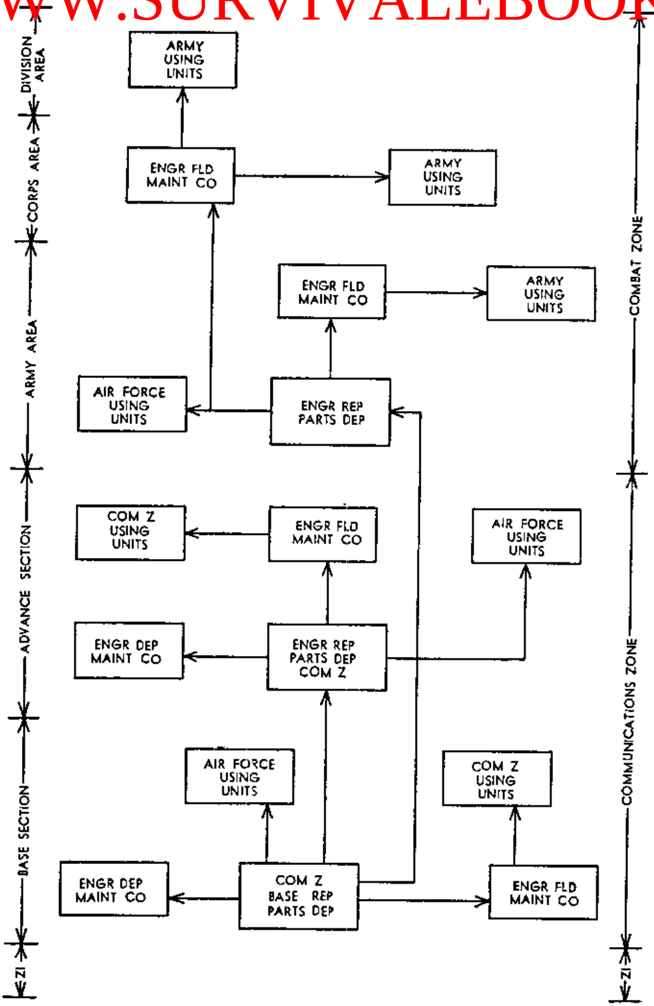


Figure 5. Flow of repair parts.

sary) have repaired or reconditioned are turned over to the nearest parts depot and placed in stock.

154. Standardization

a. The parts problem is multiplied if parts must be provided for two or more makes of machine having the same functions. This is a common situation in the case of commercial equipment which has been adopted for military use.

b. A theoretical solution would be to have only one type of equipment for any specific use. The practical difficulties which would arise at high levels, including the great expense involved, will probably make this solution unworkable in the case of such items as trucks and construction equipment.

c. However, where several makes or styles of engineer equipment of the same character and capacity are available in a theater, it is very helpful if a single make and style can be made standard in a particular *area.* Similarly, if a *unit* is initially equipped with machines of a certain make and style, every effort should be made to keep it so equipped. Establishing and enforcing such policies rests with staff engineers at the higher levels.

CHAPTER 8

SIGNAL COMMUNICATIONS IN ENGINEER UNITS

Section I. GENERAL

155. General

No military activity can be carried on unless the officer in charge can convey his orders to his subordinates and receive information from them. Except for mail and personal interview, the means of doing this come under the head of signal communications.

156. Responsibilities

a. The establishment of communications is a command responsibility. Since the most common forms involve complex mechanisms, the details of installation and supervision are delegated to trained com-
munications to a headquarters or command

b. Each commander is responsible for the signal communications within his unit.

(1) Within the resources at the disposal of the commander, a unit is responsible for the establishment and maintenance of signal communications to the command post of an immediately subordinate unit.

(2) Lateral signal communications between adjacent units are established as directed by higher authority.

(3) In the absence of specific instructions, a unit is responsible for establishing com-

munications to a headquarters or command post on the right. This rule may be disregarded in the event of tactical necessity.

(4) The general principle of communications between supporting and supported units of the same level is that supporting units provide communications to units being supported.

c. The communications officer of an engineer unit, if one is provided by T/O & E, supervises the installation, operation, and maintenance of communications equipment, and the maintenance of signal security throughout the unit; advises the commander and staff in communications matters, including the supply of equipment; submits recommendations for establishing a system of communications within the unit, for effecting the best coordination of communications with other units, and for replacing communications personnel; assists S3 to prepare training directives; drafts or secures SOI and SSI; and performs other appropriate duties. In a company, these tasks normally devolve on the executive officer.

157. Means, General

a. There are six means of communication:

(1) Radio.
(2) Wire.
(3) Messenger.
(4) Visual.
(5) Sound.
(6) Pigeons (or trained animals).

b. Radio and wire are discussed in paragraphs 163 through 171.

c. Since no means of communication is proof against breakdown, it is a commander's responsibility to see that alternative means are available.

158. Messengers

a. This means of communication is almost universally used, regardless of what others are available. It is, in one sense, the most flexible of all means, and aften provides the most expeditious handling of bulky materials such as documents and photos. Its disadvantages are that it may be relatively slow, especially if the messenger must go on foot; that the messenger may lose himself or be disabled or captured; and that some terrain is impassable to foot or motor messengers, either by its nature or by reason of enemy action.

b. Messengers should have courage, self-reliance, loyalty, discretion, and physical stamina. They should possess, or should be trained to acquire, a sense of direction and the ability to find their way through difficult country and in the dark. The training of messengers is an important duty of every unit commander.

c. If a message is important, or if there is danger involved in carrying it, it may be written in duplicate (or given verbally) and carried by two men. They may go by different routes, or may go together, keeping in sight of each other but far enough apart so that both would not be disabled by a single shell burst or an ambush.

159. Visual Communications

This includes all messages received by eye. Visual communications have the advantage of being instantaneous and simple. Their drawbacks are limited range, liability to interruption, the fact that they may be read by the enemy, and the fact that some types can send only very simple messages, and others need a good deal of time to spell out a message. The principal types are—

a. Flag or Arm Signals.—These are often used in combat, the control of vehicular movement, etc.

b. Lamps and flashlights. These are very useful in some tactical situations, such as ship-to-shore signals in an amphibious operation.

c. Panels (for Ground-to-Plane Signaling, Pyrotechnics, and Smoke Signals). These are normally used to send some simple and predetermined message, as that a unit is in position or that it needs fire support. They call for special equipment.

d. Infrared Signaling Devices. These are valuable at night, provided that their use has been prearranged so that the sender and receiver are properly located and are equipped with viewing devices. The possibility must be allowed for that enemy observers also have viewing devices.

160. Sound Communications

This classification includes communication by gong, siren, whistle, or similar devices, but not telephone. Sound signals are normally used for some simple and predetermined message, especially one which it is desired to convey to an entire command simultaneously, such as a gas or air-raid warning.

161. Message Center

a. A message center at a headquarters has the following duties:

(1) Handling all messages to and from the headquarters except those transmitted direct by

the originator or handled by military or civil post, and keeping records thereon.

(2) Selecting the means of transmitting messages, checking on their flow, and reporting to the originator any undue delay in transmission.

(3) Coordinating the means of communications and checking on their effectiveness.

(4) Observing security regulations.

(5) Keeping up-to-date information on where unit CP's are located and how to reach them.

(6) Keeping the official time of headquarters.

b. In large headquarters a message center may be part of a communications center, which also contains a cryptographic section.

162. Axis of Signal Communications

This is the route along which the command post is to be moved, or its probable successive locations, when its displacement is planned. It is prescribed either by higher authority or by the unit commander.

Section II. RADIO AND WIRE

163. General

a. Advantages and Disadvantages. Radio and wire are the two chief means of communication of engineer units. Both have the advantage of instantaneous transmission. Comparing the two, wire communication is less subject to mechanical failure and less affected by terrain and by most kinds of weather. It takes more time and effort, and a greater bulk of material, to install than does radio. It is more subject to interruption by enemy fire, enemy sympatilizers, or the carelessness of friendly troops. It cannot be used if either the sender or the receiver is in motion. For relative security risks, see paragraph 172 through 180.

b. Operating and Maintenance Personnel. The T/O & E's of units provide certain personnel for radio and wire equipment. With respect to these, however, it is the duty of the unit commander—

(1) To assure himself that they are properly trained.

(2) To train other men as assistants or replacements. The T/O & E allowance of operators is not always enough to operate all units at once, and does not allow for continued 24-hour operation or heavy casualties. Training is also desirable to provide for interchangeability among communications personnel.

164. Radio Equipment, Types in Use

The following sets are issued to engineer troop units:

a. SCR–188. For ground installations, ground-to-ground or ground-to-air communication. Range up to 100 miles on continuous wave (CW) or 30 miles on voice.

b. SCR–193. For installation in vehicles. High power, range up to 60 miles, provides CW, tone (MCW), and voice communication.

c. SCR–506. For installation in vehicles. Medium power, range up to 75 miles on CW or 20 miles on voice.

d. AN/GRC–9. For installation in vehicles or use as a portable set; range up to 20 miles; CW, MCW, or voice.

e. AN/PRC–10. Portable "walkie-talkie," weight 20 pounds, range 5 miles with 10-foot antenna; may be mounted on a vehicle.

f. AN/PRC–6. Light portable "handie-talkie," weight 6½ pounds, range up to 1 mile.

g. AN/GRC–8, –7, –6, –4, and –3. For installation in vehicles. All these slightly different sets are designed for short-range radiotelephone communications.

h. AN/VRC–10 and –8. Similar in many ways to the AN/GRC–8 and –6 sets; range up to 15 miles.

i. AN/PRR. Portable set, receiver only.

165. Netting

Radio sets are operated in "nets" of two or more stations, all operating on the same frequency. Radio sets which can work together because of similar frequency setting, similar type of signal ("CW," "MCW," or "voice"), and similar type of modulation (FM or AM), are said to be capable of "netting" with each other. With respect to the above-listed sets—

a. AN/PRC–6 and –10, AN/GRC–8, –7, –6, –4, and –3, and AN/VRC–10 all net with each other. In addition, AN/GRC–4 and –3 net with AN/VRC–8.

b. SCR–188, SCR–193, SCR–506, and AN/GRC–9 net with each other.

166. Radio Nets

a. A net is formed when two or more stations operate on the same frequency and can intercommunicate. Each station has a call sign, which is periodically changed. In forming a net, definite procedures are required to adjust equipment, control transmission, and clear messages. There is a net control station (NCS), the duties of which are to open and close the net and maintain discipline within it. Sometimes an alternate control station (NCS 2) is designated.

b. In an infantry division there are normally three types of divisional nets:

(1) The division command net or nets, including headquarters, the three infantry regiments, and the liaison officers with adjacent divisions.

(2) The division administrative net or nets, entered by the infantry regiments, tank battalion, divisional artillery, and engineer battalion.

(3) The division reconnaissance net or nets.

c. Armored and airborne divisions have somewhat different nets.

d. The nets within an engineer command vary widely, depending both on the unit and on its mission. Figures 6 and 7 show typical nets in an engineer combat battalion, divisional, and in an armored engineer battalion.

167. Factors Affecting Radio Transmission

The range and clarity of radio communications are affected by many factors, some of which can be controlled by the operator, communications officer, or unit commander. They include—

a. Factors in the sending apparatus, especially frequency, power, and properly designed and installed antennas.

b. Factors in the receiving apparatus, especially its sensitivity, its selectivity, and the antennas.

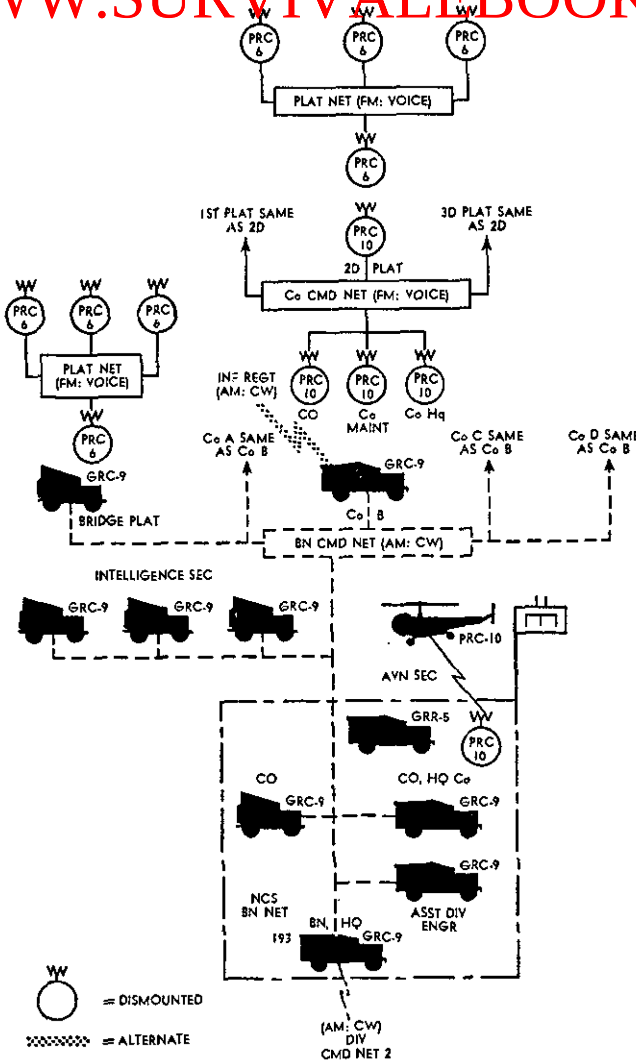


Figure 6. Typical radio nets, engineer combat battalion, divisional.

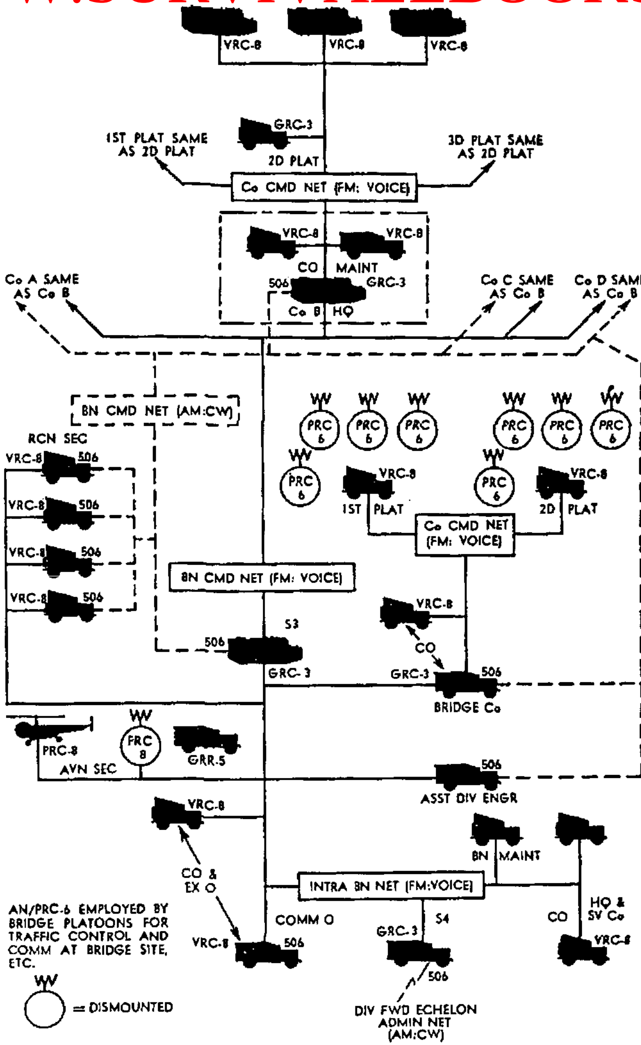


Figure 7. Typical radio nets, armored engineer battalion.

c. Static, both natural as from thunderstorms and manmade (as from electrical ignition devices or electric motors near the receiver).

d. Interference from other transmitters of adjacent frequencies, or deliberate jamming by enemy equipment.

e. Terrain factors. Flat, open country, or open water, between transmitter and receiver gives better transmission than rugged and broken country. The effect of the latter is increased by high mountains. Moist ground gives better conductivity than dry.

f. Skip distance.

g. Motion. A radio set on a vehicle normally has a longer range when the vehicle is stopped than while it is moving.

h. The skill and training of the operator.

168. Location of Radio Stations

A number of considerations enter into this. Sometimes they are in conflict and there must be a compromise.

a. Technical Requirements. As far as possible, avoid intervening hills or rough country; avoid the base of a cliff, or a deep valley; seek a "line of sight" location; seek moist ground; avoid buildings, tunnels, underpasses, heavily traveled roads, pole wire lines (especially powerlines), and any machinery which generates static; keep antennas clear of foliage.

b. Tactical Requirements. Locate the station for convenient contact with the message center and command post. Do not, however, locate it so close that, if the enemy identifies it by direction finders and shells it, the command post will be endangered. Avoid crest positions where the station would be silhouetted against the skyline. In certain cases, apparatus (except antennas) can be installed below the surface of the ground.

169. Wire Equipment, Types in Use

The principal elements of wire equipment issued to engineer troop units are the switchboard, field wire, and telephones.

a. Switchboard. Three types are in use: SB–22/PT, SB–18/GT, and BD–71.

b. Field Wire. Several types are issued, together with reels and other equipment for laying.

c. Telephones. Types issued include the sound-powered handset, TS–10 for short range use (3 to 5 miles), and the field telephones EE–8–(A) and TP–9.

d. Issue to Units. All engineer troop units have some wire communications facilities. Combat battalions, some combat support units, and supervisory headquarters such as groups are equipped to set up good-sized switchboards and establish rather extensive radio and wire communications systems between headquarters and subordinate agencies. Other units may have only a few telephones, or even a single one which must be tied to a switchboard by higher authority. (See also FM 5–5.)

170. Laying Wire

a. How Placed. Wire may be laid on the ground, hung on supports above ground, or buried. An aerial line usually gives longer range and better physical protection for the circuit, but takes more time to install. If a line is laid on the ground, its reliability varies widely, depending on how much care is used to place it so that the danger of injury is minimized.

b. Routing. The following considerations apply; sometimes there must be a compromise between conflicting considerations:

(1) Select a reasonably direct route.

(2) Avoid rugged country and dense undergrowth.

(3) In principle, a cross-country route is better than one along a road. Especially, avoid road-building activities; if this is impossible, maintain close contact with the construction unit.

(4) Avoid areas where there is reason to believe that there will be heavy shelling or large movements of tracked vehicles.

(5) Avoid built-up areas, which make maintenance difficult and sabotage easy.

c. Sequence of Work. Establishment of wire service is often of the highest urgency. Therefore a fundamental principle is: *first get the wire in, and establish communications; then improve the installation progressively.*

d. Records. A *traffic diagram* is a schematic chart showing the number of wire circuits available to the switchboard operator. A *line route map* is a map or overlay indicating to the commander, and to higher headquarters, the location of the wire as laid. Both are prepared by the agency which installs the system.

e. Recovery. Whenever possible, field wire is recovered for use. However, authority must be obtained from the next higher headquarters before doing so.

171. Signal Supply and Maintenance

a. General. Communications supply and maintenance, other than organizational maintenance, is a Signal Corps function. The principles governing it are in general similar to those of engineer supply and maintenance (chs. 6 and 7).

b. Supply. Requisitions for signal equipment and supplies needed by engineer units are prepared at company level and forwarded to battalion or group headquarters. Here they are consolidated, checked, and transmitted to the appropriate signal agency. (A separate engineer company not under battalion or group control requisitions direct on the appropriate signal officer.) In the combat zone this signal agency is normally the division, corps, or army signal officer, depending on the assignment of the engineer unit; in the communications zone, as designated. The communications officer of an engineer unit assists the commanding officer in preparing, checking, and following up on requisitions.

c. Maintenance and Inspections. First-echelon maintenance is the responsibility of the operator; second-echelon maintenance, of the repair personnel in the using organization. Field maintenance is handled by the appropriate signal agency (in a division, the division signal company), to which the using organization turns over unserviceable equipment. The appropriate staff signal officer (in a division, the division signal officer), using specialist personnel available to him, is responsible for technical inspections of communications equipment in the using unit, and for advising and assisting the unit commander with respect to training, operation, organizational maintenance, and communications discipline.

172. Security: Importance and Categories

a. Success in war requires the greatest possible concealment from the enemy of our future plans, and of the present nature and location of our troops and installations. A major potential source of information to the enemy is our communications system and the messages sent over it. It is a command responsibility to insure that all personnel who use or operate the communications system receive careful security training and abide by established procedures.

b. There are three categories of communications security: physical, cryptographic, and transmission.

173. Physical Security

This covers the protection of classified documents, materials, and equipment from compromise through capture or theft, or through their inspection, reproduction, or injury by unauthorized persons. The techniques are in general the same as those used to guard and protect any other valuable property. However, items such as codes and ciphers have the peculiarity that the harm done by their disclosure to the enemy is far greater if we are not aware of the disclosure.

174. Cryptographic Security

a. In general, all messages should be encrypted if their interception by the enemy would be of value to him. This is especialy important with electrical transmission, but applies equally to other means, such as messenger services, if the danger of interception exists.

b. The use of a crypto system may involve some delay at both the sending and the receiving end. In a fast-moving situation, this may handicap our operations. The criterion then is, whether—if a message is sent in the clear and intercepted—the enemy can act on the information in time to disarrange our plans.

c. Most codes and ciphers can be broken by experts, given enough data, and simple ones can often be broken quickly. Commanders should therefore require that only approved codes, ciphers, or crypto material prescribed in SOI and SSI be used.

d. For further details see, AR 380–5 and SR 105–25–2.

175. Transmission Security

Transmission security is that component of communications security which results from all measures designed to protect transmissions from interception and traffic analysis. It is especially important with messages transmitted by radio or wire.

176. Communications Discipline

a. It must be assumed that the enemy may intercept every radio message transmitted. To reduce the amount of intelligence which the enemy may gather from this source, certain operating procedures have been prescribed. Adherence to these also insures a rapid and standardized method of transmitting and receiving messages.

b. The only absolute security in this field is *radio silence.* But this defeats the purpose of radio communication. The question of whether and when to break radio silence is a command decision, often made at a high level, based on the situation, and for which no rigid rules can be given.

c. Short of radio silence, security can be enhanced by imposing listening silence, training operators in the use of proper operating procedures, monitoring messages, and taking immediate action against breaches of discipline.

d. A peculiarly important field is that of the radio-telephone. An individual talking into an ordinary hand set may forget that he is not using a wire system, and that his message, some of which may be in the clear, will be instantly picked up by an enemy who can also determine exactly where he is located. The danger is obvious, and can be minimized only by rigid security discipline, careful selection of words, and a constant realization that the message is being intercepted.

e. Messages transmitted by wire, while not as easily intercepted as radio messages, can be intercepted either by tapping or by the induction method. A tap can often be detected and located, but may not be found until great damage has been done. An induction device, located within a few feet of wire, is undetectable if carefully concealed, and can intercept messages even if the device is buried, or is otherwise separated from the wire by a solid barrier. Accordingly, the only safe course is to assume that any wire message may be intercepted, and to take all practicable precautions.

f. The risk of visual and sound communications is that they may be seen or heard by the enemy. The risk of messenger or pigeon transmission is the capture of the carrier. Precautions should be taken accordingly.

177. Voice Procedure

A certain procedure, called "voice procedure," has been standardized as an aid to security in radio-telephone transmission, and also to save time and lessen the chance of errors. It is chiefly used in lower echelons when secrecy is relatively unimportant because of the time factor or for other reasons, though it may be used as high as division level. It involves—

a. The use of a phonetic alphabet (ABLE, BAKER, etc.) and of certain rules of pronunciation.

b. The use of standard words and phrases (called "prowords") such as ROGER, OVER, WILCO.

c. Special techniques for such purposes as establishing contact, identifying sender and receiver, phrasing and transmitting a message, closing a net, and authentication.

178. Classification of Documents

Any military document which should not be open to public inspection is classified according to one of the three standard categories: "Top secret," "Secret," and "Confidential." The rules as to what type of material pertains to each category, who can classify and declassify, and how classified material should be prepared, transmitted, guarded, filed, and accounted for, must be known to all concerned and strictly enforced. (See AR 380–5.)

179. Field Messages

a. Drafting. A message must be *clear, complete, concise, and incapable of being misunderstood.* These requirements, especially the last, are easier to state than to meet. After writing a message, read it over and ask yourself whether there is any word, phrase, or implication in it which anyone could *possibly* misunderstand, or any idea in your mind which the recipient should know and which you have not *clearly* conveyed. If a message *can* be misunderstood, assume that it *will* be, and revise it accordingly.

b. Form. At division level and lower, field messages are normally written on forms in Message Book 210B.' All concerned should be trained in its use, including the rules for classification, authority to send in the clear, addressing, dating, and signature.

c. Precedence. The precedence of a message is determined by the originator or releasing officer. There are six standard precedences, in orders as follow: Flash (OC), Emergency (O), Operational Immediate (OP), Priority (P), Routine (R), and Deferred (NM). The common tendency to *assign too high a precedence* to a message must be carefully guarded against. A message of any given precedence is processed, transmitted, and delivered ahead of all messages of lower precedence. In the case of an OC, O, OP, or P message, the transmission of any message of lower precedence is interrupted for the purpose, except that an R message is not interrupted for a P message unless the former is exceptionally long. For details see FM 24–5.

180. Instructional Documents

The communications procedures of an engineer unit are controlled by three types of documents: Signal Operation Instructions (SOI), Standing Signal Instructions (SSI), and Standing Operating Procedures (SOP).

a. SOI and SSI. These are signal publications, issued normally at divisional or higher level, for the technical control and coordination of the signal agencies of the issuing command. SSI are confined to data which are not frequently changed, and to instructions for the use of SOI. Copies of both documents are issued to engineer units.

b. SOP. The regular SOP of an engineer unit (ch. 4) contains signal operating procedures applicable to it, covering such items as radio nets, wire channels, and alternative or emergency means of communication.

PART TWO

CONDUCT OF ENGINEER OPERATIONS

CHAPTER 9

ENGINEERS IN COMBAT

Section I. GENERAL

181. General

Engineer troops in a theater participate actively in combat in their support role. Engineer units either organic or attached, have important roles in every type of offensive or defensive operation undertaken by a large ground force of combined arms, both in rear areas and in the combat zone. The combat losses sustained by engineers may often be expected to equal those of the infantry or any other components of the armed force.

182. Tactical and Technical Missions

No precise line can be drawn between the tactical (combat) or technical missions. With a few exceptions, such as fighting as infantry in an emergency, all activities of engineers in a theater are in a sense "technical," since they involve specialized techniques, equipment, and supplies. But such tasks as the construction and repair of roads and bridges or the preparation and execution of demolitions, although technical in themselves, are often carried on in the heat of battle and under fire.

183. Offensive and Defensive Missions

The nature of an engineer unit's combat activities varies according as the force of which it forms a part has an offensive or a defensive mission.

a. In an offensive situation, engineers support the advance, the attack, and the pursuit. They have important specialized duties with respect to the passage of obstacles, the assault of fortified positions, and river crossings in the presence of the enemy.

b. In a defensive situation, engineers participate in the organization of a position for defense, in the establishment of obstacles and road blocks and the laying of minefields, and in retrograde movements of all sorts.

c. In either situation, engineers must of necessity provide their own security.

184. Types of Combat Engineers

a. For normal combat engineer activities, both offensive and defensive, the prototype is the *engineer combat battalion, divisional*, operating as an organic part of the infantry division. The other two types of divisional engineer troops—the armored battalion and the airborne battalion—operate on generally similar patterns, modified by the nature and activities of the divisions to which they belong.

b. Engineer combat support units have the mission of giving direct support or assistance to combat elements. This may involve work either in contact with divisions and divisional engineer battalions, or in corps or army service areas. One very specialized operation in which combat support units normally have important roles is a large-scale river crossing in the presence of the enemy. Another is an amphibious landing, participated in by the engineer shore battalion as an organic element of the amphibious support regiment and by any other engineer units which may be attached to the regiment.

c. Engineer service support units normally operate out of contact with the enemy, but in an emergency may have to engage in combat.

d. All engineer units in a theater, regardless of their category, mission, or location, have security problems and problems arising out of movement from one locality or base of operations to another.

Section II. ENGINEER COMBAT BATTALION, DIVISIONAL

185. Mission and Capabilities

This unit is an organic element of the infantry division. It is trained and equipped to increase the division's combat effectiveness by general engineer work; and specifically to—

a. Plan and supervise engineer operations in the division, including the operations of attached troops.

b. Conduct technical reconnaissances.

c. Build, repair, maintain, and mark roads, trails, fords, bridges, and culverts, including the installation of standard bridging equipment, organic and other.

d. Construct landing strips.

e. Undertake simple types of construction.

f. Execute demolitions.

g. Establish and operate divisional water supply points.

h. Furnish engineer supply service to the division.

i. Provide technical assistance and service to other troops in various phases of defensive combat and retrograde movements, including the construction or supervision of specialized defensive installations, the installation of obstacles and roadblocks and if necessary their defense, the laying of minefields under certain conditions, and denial activities.

j. Provide technical assistance and service to other troops in various phases of offensive combat, including the advance, attack, and pursuit, the passage or destruction of obstacles, the breaching and clearing of minefields under certain conditions, and the assault of fortified position.

k. Fight as infantry in an emergency.

186. Organization

The battalion consists of—

a. Battalion headquarters, including S1, S2, S3, and S4 sections, a division engineer section; a communications section, a maintenance section, and an aviation section.

b. Headquarters and service company, including a company headquarters section, a bridge platoon, an equipment platoon, and the enlisted personnel of battalion headquarters.

c. Four identical engineer combat companies, each including a headquarters and three identical engineer combat platoons. A platoon includes a headquarters and three identical engineer combat squads.

d. A medical detachment.

187. Equipment

In general terms, the battalion and its components are organized and equipped to do a wide variety of engineer work of somewhat limited volume, on a decentralized basis, with emphasis on speed, flexibility, and improvisation. More specifically—

a. Sets of pioneer and carpenter tools, and of demolition equipment, are in the hands of operating platoons and squads. Headquarters and service company has suplementary special purpose tools, construction supplies, and explosives.

b. The battalion has mine detectors and minefield marking equipment.

c. With respect to construction and material-hauling equipment, each lettered company has an air compressor and crawler-type tractor equipment. Headquarters and service company can augment these with additional compressors and crane-shovels, graders, tractors with angledozers and bucket loader, and welding equipment. The battalion has a considerable number of dump trucks and pole-type trailers, and a few semitrailers.

d. Stream-crossing equipment includes assault boats, infantry support rafts, and steel treadway bridging. The latter is also used for crossing gullies and in the passage of obstacles.

e. The battalion has sufficient water purification equipment to furnish water to an infantry division.

f. The battalion has organic equipment to install radio and telephone nets for internal communications and to enter the divisional administrative radio net.

CHAPTER 10

ENGINEER COMBAT BATTALION IN OFFENSIVE

Section I. ADVANCE AND ATTACK

188. The Offensive, General

a. Phases. A divisional attack normally has three phases: the advance, the development, and the attack proper. If the enemy is defeated there may be a fourth phase, the pursuit.

b. Divisional Combat Teams. A regimental combat team (RCT) within an infantry division is reinforced infantry operating as a balanced unit of essential arms. A typical RCT includes an infantry regiment, a battalion of light artillery, a battery of AA artillery and a company of engineers. Other groupings may be ordered, as the situation demands.

c. Division in the Advance. When an infantry division advances in the combat zone on an offensive mission, out of contact with the enemy but expecting contact, control is normally decentralized into several march serials. A typical distribution would be three RCT's, as described above, and fourth and fifth serials composed of other division troops and division trains, with the necessary covering force and close-in security detachments.

d. Divisional Development. When an advancing division comes under enemy fire, or when the division commander's judgment indicates, the divisional units are regrouped. This process begins with the division in marching formation as described above. It ends when the division has occupied assembly positions and is prepared to deploy for the attack, or earlier if the enemy is sooner engaged.

e. Division in the Attack. An infantry division may attack initially with either one, two, or all three of its infantry regiments. The most common formation is: one regiment executing the main attack, one executing the secondary attack, and one in divisional reserve.

f. Variations. The foregoing merely describes typical formations and dispositions, and is subject to a great number of variations.

189. Engineers in Advance

a. Disposition.

(1) Each marching column should have engineer support, and there should also be a reserve under the immediate control of the engineer battalion commander. When a division moves in two parallel columns, each headed by an RCT, an engineer company is commonly attached to each of the leading RCT's. Another company, or lesser unit, may be attached to the covering force.

(2) In a column to which an engineer company is thus attached, a typical disposition is: one platoon with the advance guard, one squad being with the advance party and the remainder of the platoon with the support or reserve; the company less this platoon, near the head of the main body. An engineer battalion reconnaissance party may accompany the leading element. Engineer companies, platoons, and squads thus disposed must have with them whatever tools,

equipment, and supplies they may need for emergency work.

(3) An engineer unit with an advance guard may leave temporarily one or more work parties at critical points where it is foreseen that engineer aid to the advancing column will be needed. If this results in excessive depletion of the advance-guard unit, the next higher engineer commander may relieve it with another similar unit.

(4) The engineer battalion, less detachments, is so placed in one of the advancing columns that it can reinforce any engineer detachment needing assistance, or can perform any special tasks ordered by division headquarters.

b. Duties. The duties of engineers in the advance are—

(1) Reconnaissance.

(2) Improvement of routes.

(3) Other.

c. Reconnaissance.

(1) Initial engineer reconnaissance should be carried out prior to the advance, normally by reconnaissance teams from battalion headquarters, supplemented as necessary by air reconnaissance and study of maps, photographs, and other data. Reconnaissance parties examine carefully the proposed routes of advance for the condition of roads; the condition, adequacy, limiting loads, and clearances of bridges; alternative routes; defiles; enemy mines; local contstruction materials and resources; potential water

points; and other pertinent items. Plans and work estimates are prepared for improvement and maintenance of routes. Traffic circulation plans are developed in cooperation with other agencies.

(2) While reconnaissance for the advance should be completed before the movement starts, engineer units with the advancing columns take every opportunity to collect and report useful engineer information.

d. Routes. Improvement of roads and bridges to the point that they are adequate for the division's advance should be completed before the movement starts. However, additional work during the advance will often be needed on account of accidents, enemy bombing, unexpected weakness of structures, and heavy rains or floods. It is a prime duty of the engineers with the advancing columns to keep the roads open and the troops moving.

e. Other. For supply in general, see chapter 6. Water supply may be handled by battalion headquarters, or detachments from its water supply subsection may be attached to the engineer companies with the various columns. Maps are distributed before the advance begins. Construction of advanced landing strips, and the removal of minefields and other obstacles, may be necessary during the advance.

190. Engineers in Attack

a. General. The duties of engineers in the development period and in the attack proper are quite similar, and will be considered together. When the RCT formation terminates, engineer components of RCT's revert automatically to battalion command.

b. Disposition.

(1) Assistance to the attacking troops, especially infantry, is the central feature of the engineer combat battalion's offensive mission, on which all else turns. This requires—

(*a*) That the engineers should be in such close contact with attacking troops as to learn or anticipate their needs, and

(*b*) That the maximum engineer support should be promptly available for meeting those needs.

(2) Normally these ends are best attained by placing an engineer company in direct support of each *attacking* infantry regiment, the rest of the battalion remaining in general support. The regiment can then count on this minimum of engineer support at all times, and the engineer battalion can give effective assistance to the supporting company in an emergency. The supporting company commander is responsible for maintaining liaison with regimental headquarters, making contacts himself. He should sit in on the planning phases of the attack.

(3) The same engineer company should always be placed in support of the same infantry regiment.

(4) Engineers also assist other divisional units in direct support or general support.

c. Duties. In part these resemble the duties of engineers in an advance. However, the attack develops new demands for engineer assistance.

(1) Reconnaissance is required both before and during the attack, especially of the main

supply route (MSR) and other routes of advance, and of enemy obstacles.

(2) Routes of advance (including bridges) for combat troops, and for the forward movement of essential supplies, must be established and maintained.

(3) Advanced landing strips may be required.

(4) Water service must be maintained.

(5) Specialized assistance from engineers may be needed for the passage, breaching, or removal of obstacles, the assault of fortified positions, or the establishment of flank protection and the organization of captured ground against counterattacks. (See ch. 11.)

d. Control.

(1) The commander of an engineer unit operating in direct support retains full control of his unit, but must adapt its actions to the needs of the supported unit.

(2) The engineer battalion commander has full command responsibility for his command at all times save as regards detached units, and in any case remains responsible for technical supervision. He maintains liaison with advance elements. He maintains staff and command supervision over the engineer phases by frequent visits to regimental headquarters and to the supporting engineer units.

e. Liaison. Liaison between supporting and supported units is the responsibility of the former. Between adjacent units in line, responsibility is with the left-hand unit unless otherwise specified. Liaison between the engineer battalion and division headquarters is normally the responsibility of the assistant division engineer.

191. Assistance to Divisional Engineers

In a major attack, the engineer battalion will normally need and receive assistance from a corps engineer combat group. This may take several forms, including the following:

a. The group, at the outset of the attack, may take over certain of the divisional battalion's responsibilities in the divisional rear areas.

b. As the attack progresses, the group will progressively extend its boundary forward to relieve the divisional battalion.

c. In the case of a division making a major effort, the group may designate one or more of its combat battalions as "direct support battalions," operating with the division and often in the same areas as elements of the divisional battalion. Other units, such as bridge companies, may be similarly designated. Such units remain under group control. The division of tasks between them and the divisional battalion may be arranged by agreement between the division engineer and the group or unit commanders.

d. Attachment of corps engineer units to the division or the divisional battalion will be the exception.

e. Due to the limited number of engineer troops in a division, infantry and other troops in an attack must do a part of their own pioneer work. Infantry may clear passages through wire, and provide bridges over narrow and shallow streams by expedient means. The infantry pioneer and ammunition platoon has much the same training and equipment as the combat engineer squad with respect to basic pioneer, carpenter, demolition, and mine warfare techniques. Infantry and other troops have equipment and responsibilities with respect to removing enemy mines (see ch. 12).

192. Engineers in Pursuit

a. The purpose of pursuing a defeated enemy is his capture or destruction. The pursuing force must maintain the continuity of the attack, exert constant pressure, and seek to place troops across the enemy's line of retreat. It must be highly mobile.

b. The engineer element of the pursuing force is often attached to it in order to insure adequate coordination if the force becomes separated from the remainder of the division. Its composition depends on needs, and also on what engineers are immediately available. It should be well forward in the pursuing column, with the primary mission of opening routes of movement, providing for stream crossings, and clearing any obstacles to the advance of our troops.

c. Engineer operations in the pursuit are fundamentally the same as in the attack. They are characterized by speed, boldness, improvisation, and the subordinating of everything else to the requirement of maintaining contact with, and intercepting, the enemy.

d. Engineer assistance from corps is in the same general form as in the attack. The pursuing force may need the help of certain engineer combat group agencies, such as bridge companies.

193. General

a. In an attack, enemy obstacles which cannot be bypassed are dealt with by breaching or by surmounting. The type of obstacles and the time and equipment available will indicate the method to be employed. Breaching is generally accomplished either by removal or by destruction of the obstacles. Surmounting may be accomplished by bridging or by ramps. The width, or number, of passages provided will be dictated by the capabilities of the attacking force to prepare the passages. The location of the passages will be determined by consideration of terrain, enemy dispositions, and the nature and extent of the obstacles.

b. An important duty of engineers in an attack is to render specialized assistance in the passage of obstacles which are elements of the enemy's defensive position. The nature of the obstacles which may be encountered is described below. They will vary greatly, according as the enemy's defenses are hasty or deliberate field fortifications or permanent fortifications.

c. For details regarding passage of obstacles, see FM 5–32 and TM 5–220.

194. Types of Obstacles

The principal types to be considered, besides minefields, are—

a. Wire entanglements.

b. Wooden, steel, or concrete structures, such as roadblocks, abatis, walls, belts of antitank obstacles, and beach and underwater obstacles.

c. Antitank ditches.

d. Inundations, including flooded ditches and moats.

195. Means of Passing

Two general means are to be considered: breaching or destruction by explosives; and surmounting. For passage of minefields, see chapter 12.

196. Explosives, General

a. Explosive charges for destroying obstacles may be placed by hand, and by mechanical means. (Air bombardment and artillery fire are not considered in this section.)

b. For a brief discussion of the techniques of explosive demolition, including the destruction or breaching of solid obstacles, see chapter 24. For further details, see TM 5–220 and FM 5–25.

197. Hand-Placed Charges

a. Demolition by hand-placed charges is the most common method of destroying or breaching obstacles in an assault. Each individual job should be planned so that the explosives are placed and fired quickly. Work at the site of the obstacle should consist of placing the packaged charge, attaching it if necessary, completing the connections of the firing system, and firing.

b. Under assault conditions there will usually be little or no opportunity to bury the charge in or under the object to be destroyed, or even, in many cases, to tamp it adequately. Liberal amounts of explosive should be used. Plastic charges are most effective. More than one man will often be needed to carry, place, and connect up without delay the amount of explosive needed for an individual demolition.

Men should practice in advance to perform their team task with no waste time or lost motion.

c. The explosive selected should be a type that does not normally detonate when struck by a bullet or shell fragment.

d. To avoid casualties to nearby friendly troops, the unit or detachment which fires the charge should give warning by some prearranged signal or by firing at a prearranged time.

e. Hand-placed charges are effective against antitank concrete obstacles such as cubes, cylinders, tetrahedrons, and "dragon's teeth"; steel or steel and concrete obstacles of the type used both against tanks and on beaches; concrete walls, both backed and unbacked, including the walls of defensive structures and the lining of concrete ditches; and wooden posts, walls, and revetments.

f. A shaped charge (see ch. 24) may be used to make a borehole for placing an internal charge, if the loss of time in placing and firing the shaped charge is outweighed by the greater effectiveness of the internal demolition charge.

198. Bangalore Torpedo

This is composed of a series of 5-foot watertight tubes, which can be filled with explosive and connected together to form a torpedo of any desired length. The sections are light and readily portable. The torpedo is commonly used to breach wire entanglements. In an assault, the breaching party moves up to the friendly edge of the entanglement. The torpedo is assembled section by section, and as it is assembled is pushed forward into the belt of wire and detonated. A torpedo will clear a lane 10 to

15 feet wide, and will also detonate antipersonnel mines and some antitank mines.

199. Demolition Snake

This adapts the principle of the bangalore torpedo to a much longer and heavier device, mechanically placed. In its completed form it consists of two parallel linear explosive charges encased between corrugated aluminum plates, bolted together to form an assembly 400 feet long, or of such lesser length as is desired. A 400-foot snake contains 4,500 pounds of explosive. It is assembled under cover, towed and pushed by an armored vehicle into place, and detonated. Its most important use is in breaching mine-fields, but it may also be used to breach bands of log, steel, or small concrete antitank obstacles, or unrevetted antitank ditches. It is completely effective against wire entanglements, although it would not normally be used for this purpose alone.

200. Surmounting Barbed Wire

In the absence of equipment for breaching or ripping out wire entanglements, they can be surmounted by placing on top of them anything on which men can walk. For narrow belts, prepared wooden ramps or similar light structures may be used. Another means is to use some flexible material like chicken wire, canvas, hardware cloth, cyclone fence, or galvanized mesh. This may be wound around a flat frame 5 feet long, and placed by a man who flops it over from end to end on top of the wire, walking forward on it as it unfolds; or it may be rolled around a pole and similarly used. Sectional landing mat may be used by wiring several sections together end-to-end and unfolding them across the wire. It is heavier and harder to place than flexible material, but troops can cross it faster.

201. Surmounting Ditches

The two general means are to fill the ditch with a bulldozer; and to bridge it. Steel treadways can be used to cross vehicles over ditches.

202. Surmounting Walls

a. Vehicles. Vehicles can be passed over a wall by building an earth ramp with a bulldozer or tank-dozer, or if the wall is not too high, using treadways or equivalent propped against the wall. Needless to say, if the wall is an isolated structure, means must be provided for getting the vehicle down the other side, which the enemy may have under fire.

b. Personnel. Common methods are as follows:

(1) Standard scaling techniques by which men hoist, boost, and pull each other up and over.

(2) The use of wooden stiles, if a wall has a vertical face and is not too high.

(3) Scaling ladders.

(4) Wooden ramps, placed slanting against the wall; they are heavier than ladders but easier to mount.

203. Water Obstacles

A narrow ditch or moat filled with water may be dealt with in the same manner as a dry ditch. If it is too wide for such treatment, as in the case of an unfordable river or inundated area, the problem becomes a special one, to be dealt with as described in chapter 14.

204. Final Disposition of Obstacles

The final clearing of enemy obstacles in a zone or area which has been passed through by our advancing troops is normally undertaken by engineer units of corps, army, or communications zone, often assisted by civilian labor. Since it is not done under enemy fire, it can be carefully planned, and conducted with special attention to safety and economy of effort.

Section III. ASSAULT OF FORTIFIED POSITIONS

205. General

a. A fortified position is defined and described in chapter 11.

b. Infantry tactics in the assault of a fortified position, including employment of supporting troops and weapons, are discussed in FM 31–50 and FM 100–5. The basic assault unit for such an attack is the infantry platoon. Supporting units may include artillery, airborne, antiaircraft, armored, chemical, and engineer troops, as well as combat aviation. The duties of engineers in such assaults are fundamentally an application of the techniques of passing obstacles to the operations of a combined team under heavy fire.

206. Phases of Assault

a. The assault of a fortified position can be divided into four phases. In action they often overlap, especially on weaker parts of the front. These phases are—

(1) Reducing the hostile outpost system and developing the attack.

(2) Breaking through at the most favorable point.

(3) Extending the gap by isolating and reducing hostile emplacements on its flanks.

(4) Moving mobile reserves through the gap, to complete the encirclement and isolation of the remaining fortifications, while continuing to attack from the front.

b. Immediate exploitation of success is imperative in each phase. If the position is organized in depth, the attack must proceed to the second line of fortifications as soon as possible after breaking through the first. The same techniques are used in reducing a second line as in the case of the first line.

207. Engineer Missions

a. During the attack the principal mission of the engineers is breaching the outer and larger obstacles which protect the main fortified positions. Reduction of weapons emplacements, bunkers, and pillboxes, and the clearing of close-in and minor obstacles, are the mission of specially organized and equipped infantry squads which lead the attack. This means that the effective gapping of a strong enemy fortification system requires close coordination between the engineers, who gap the line of obstacles, and the infantry, who reduce the fortifications.

b. After the fortified line has been breached, the primary engineer task is creating and maintaining routes to and through the gap. Engineers also render captured forts or pillboxes unsuitable for reoccupation.

c. Engineer casualties will be heavy in operations of this sort, and trained replacements must be immediately available.

208. Reconnaissance

a. Preliminary Study. Before the assault begins, a preliminary engineer study is made of the terrain, bridges, routes of communication, and artificial obstacles such as minefields, tank traps, and emplacements. The technique of attack, and the requirements for engineer breaching personnel, supplies, and subsequent reconstruction, are planned from this study. Information for the study may come from various sources, of which ground reconnaissance is the most satisfactory. For areas beyond the reach of ground reconnaissance parties, information must come from air photographs and other sources.

b. Ground Reconnaissance. Ground reconnaissance before the attack should if possible cover obstacles in front and on the flanks of the enemy main battle position. Minefields are reconnoitered to determine their boundaries; the type of mines; the presence of gaps in the field, and whether and how they are marked; possible detour and approaches; and the location of defending weapons and gassed areas. The reconnaissance parties seek to determine the portions of the obstacles which are best adapted for clearing operations, either because of their weakness or because they are not well covered by fire.

c. Organization of Reconnaissance Parties. Reconnaissance of enemy obstacles requires careful organization and skilled execution. Normally it is done by the troops who are to breach the obstacles. Parties are given definite routes and areas, and are carefully instructed in their duties and, if necessary, rehearsed. Personnel are briefed on all information which has already been obtained. Parties are made as small as possible, since secrecy is of primary importance, both to conceal the intentions of our force and for the safety of the parties themselves.

209. Engineer Clearing Parties, General

The strength, organization, equipment, and means of transportation for each clearing party are carefully planned, on the basis of its mission and the nature of the obstacles. Parties may be organized to clear obstacles in front of the enemy position at the beginning of the attack; to clear obstacles encountered within the enemy position as the attack progresses; or to dispose of obstacles already passed by the leading elements. Parties must have the same mobility as the units they accompany. Parties which accompany infantry are moved as far forward as practicable in their own transportation. Supplies carried are carefully planned to provide all essentials and eliminate nonessentials.

210. Duties of Engineer Clearing Parties

Clearing parties normally are organized into task groups. When the obstacle to be breached is formidable and complete information about it is available, the task groups may be highly specialized, each one being instructed in detail and rehearsed in the performance of its precise duties. However, a flexible organization is needed to deal with obstacles encountered after the attack begins and on which there is little or no advance information. A typical party of this sort might contain small groups as follows:

a. A group to precede the breaching personnel and clear antipersonnel mines.

b. A group to breach or otherwise neutralize the obstacle.

c. A group to mark the boundaries of the gap and the routes between successive gaps.

d. A group to provide local security.

e. A group to lay smoke screens to cover the operations of the party.

f. A contingent to furnish replacements or reinforcements to the other groups.

211. Training for Assault

Training for the assualt is divided into two parts: technical training and rehearsals for all troops to be used in the assualt.

a. Technical Training. Technical training is training in the special techniques, weapons, and equipment to be used. Engineers construct mockups, and help train the infantry assault units to use demolitions to pass obstacles.

b. Rehearsals. The technical training and coordination of all troops concerned are continued during rehearsals. Whenever possible, troops rehearse until perfection is obtained, on ground similar to that over which the attack is to be made, including simulated enemy works. Care must be taken that these training aids, if photographed from enemy planes, will not give a clue to our tactical plans.

212. Breaching Techniques

See paragraphs 193 through 204. For minefields, see chapter 12.

213. Rear-Area Obstacles

Engineers accompanying troops which have broken through or enveloped an enemy position may also be used to overcome rear-area obstacles.

214. General

a. To accomplish their mission, engineer units must often engage in, or be prepared for, small-scale combat; for example, to provide close-in security on the march, in bivouac, or at work. In addition, combat and other engineer units may on occasion be relieved of most of their normal functions by higher authority, and be assigned specific infantry combat missions. Typical situations in which a divisional engineer battalion might be thus used are—

(1) An overextended divisional defensive front.
(2) A sudden enemy penetration or turning movement.
(3) An enemy airdrop, or an outbreak of organized guerrilla activity, in the divisional rear area.
(4) Need for a divisional reserve to relieve infantry for some decisive combat role.

b. A commander of a combined arms team, before giving his engineers an infantry mission, will weigh carefully the effect of the resultant reduction of engineer support available to the rest of his command. Certain normal engineer missions, such as water supply, must in any case be carried on except in the most critical emergencies.

215. Combat Capabilities

a. As compared with an infantry battalion, the divisional engineer battalion is inferior for combat purposes in three major respects:

(1) It lacks the vital supporting weapons of the infantry battalion.
(2) It normally has less combat training.

(3) Its internal organization is not designed primarily for infantry combat missions.

b. To compensate for these deficiencies, when the engineer battalion fights as infantry—

(1) It is normally attached to an infantry regiment, which is then responsible for providing supporting fires.

(2) It is by preference placed in reserve or given a defensive mission. However, engineer battalions have been used for the most aggressive types of infantry mission, and must be prepared to undertake them at need.

(3) As a preliminary to undertaking an infantry mission, it is reorganized.

216. Reorganization for Combat

a. Prompt and effective reorganization is a vital element in training and preparing an engineer battalion for combat as infantry, and should be incorporated into the battalion SOP.

b. When any engineer unit is about to enter combat, it is divided into a forward and a rear echelon.

(1) The forward echelon consists of the elements which actually engage in combat, plus necessary command, communications, and supply elements. Normally the light vehicles are included, for purposes of security, communication, ammunition supply, and the displacement of crew-served weapons.

(2) The rear echelon consists of the personnel and equipment not needed for combat. Its composition varies with the situation and the size of the unit. The equipment normally includes kitchen trucks, trucks carrying supplies and equipment not needed with

the forward echelon, and special vehicles such as air compressors, tractors, graders, and cranes. The personnel are the minimum needed to protect and render mobile the rear echelon and to carry on essential administration. The echelon is commanded by the senior officer present.

(3) In the case of small isolated units, the rear echelon may stay close to the forward echelon. With an engineer battalion in defense, the rear echelon will be well to the rear.

c. The extent of reorganization varies with size of unit, mission, and time available. In the case of the battalion as a whole, there is generally enough time to commit it to combat with some deliberation and therefore to make necessary adjustments *before* meeting the enemy. On the other hand, an isolated platoon (for example) which is suddenly involved in combat is reorganized rapidly by fragmentary orders issued *after* contact.

217. Supporting Fires

In order that the engineer battalion may fight effectively as infantry, it must have supporting fires. If it is committed deliberately as an infantry unit, it is normally attached to an infantry regiment, whose commander provides heavy weapons fire support. A common means is to assign one or more platoons of the heavy mortar company in direct support of the battalion. The forward observers join the engineer combat companies employed on the frontline. The supporting field artillery battalion also supplies forward observers and an artillery liaison officer for the engineer battalion.

218. Antitank Protection

The engineer battalion has 3.5-inch rocket launchers. In addition, the infantry regimental commander may attach elements of his tank company to the battalion; or, the tank company may be held in reserve, prepared to counterattack any penetration in the engineer or other sectors.

219. Communications

When reorganized for combat, the engineer battalion will need to improve and supplement its communications system. How this is done depends somewhat on the situation.

a. If lateral radio communications are needed, radios can be taken from the battalion net and netted with the units on the right and left.

b. A radio set of the battalion communication section enters the regimental net.

c. The infantry regiment lays a wire from its switchboard to the engineer battalion switchboard. The field artillery also lays a wire to the battalion switchboard, and continues its wire lines down to each frontline engineer company.

d. The engineer battalion communications system lays wires to each engineer company, lays a lateral line to the battalion on the right, and receives a lateral line from the battalion on the left.

e. See also FM's 7–10, 7–20, 7–24, and 7–25.

220. Battalion Operating Independently

If the reorganized engineer battalion is not attached to an infantry regiment, but enters combat as an independent battalion, it must normally do without the fire support and other assistance which the regiment would otherwise extend, and its effective-ness as a combat force is correspondingly less.

221. Tactics

The combat tactics of the reorganized battalion are similar to infantry tactics. See FM's 7–10 and 7–20.

CHAPTER 11

ENGINEER COMBAT BATTALION IN DEFENSIVE

Section I. DEFENSIVE POSITIONS

222. Defensive Positions, General

a. Object. The general object of defensive combat is to gain time pending the development of more favorable conditions for undertaking the offensive, or to economize forces on one front for the purpose of concentrating superior forces for a decisive action elsewhere.

b. Doctrine. Army defensive doctrine is based on a battle position to be held at all costs, supplemented by covering forces to delay, disorganize, and deceive the enemy before he reaches the battle position, and by reserves to counterattack and eject him if he does reach and penetrate it.

c. Principles. The selection and organization of a defensive position are based on certain general principles, including the following:

(1) Adaptation of the defense to terrain features. The character of the terrain, including natural obstacles, natural cover, commanding ground, and natural routes of approach from front and rear, has a decisive influence on the selection and improvement of defensive positions.

(2) Mutual support of defensive elements, involving, among other things, coordinated plans for fire, antitank defense, and barrier planning.

(3) All-around defense.
(4) Defense in depth.
(5) Flexibility.

d. Layout. A fully organized defensive position normally includes the following elements:

(1) An air security echelon which may include both tactical (Air Force) planes and planes organic to the ground forces.
(2) A covering force.
(3) The outpost position, divided into a general outpost line, and, to the rear of this, a line of combat outposts.
(4) An organized battle position, based on the main line of resistance and including the regimental reserve area.
(5) Divisional and higher reserves, and installations in the service area.

223. The Division in the Defense

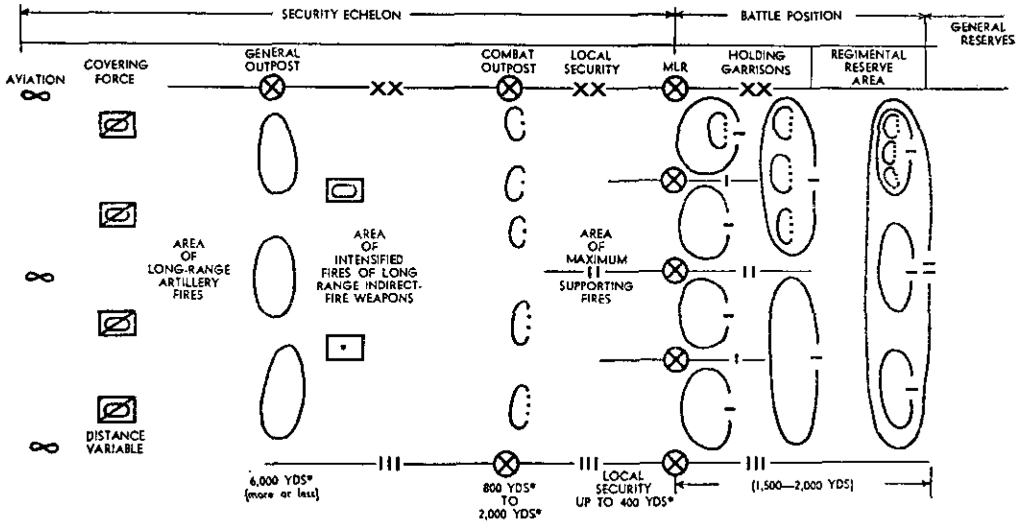
In a typical defensive situation (see fig. 8)—

a. One or more corps are in line, each corps having two or more of its divisions in line.

b. The covering force is normally furnished by corps and coordinated by army.

c. Each division in line furnishes its components of the general outpost (normally from units not assigned sectors in the battle position) and of the combat outpost (normally from battalions of frontline regiments).

d. A common initial distribution of divisional troops is: two infantry regiments holding the battle position and furnishing local reserves; the third on general outpost, less a battalion in divisional reserve; combat outposts manned by regiments on the MLR, normally from frontline battalions; tanks in



* FIGURES DENOTE DISTANCES FROM MLR

Figure 8. Schematic layout of a defensive position.

divisional reserve; other elements in support as required.

224. Defensive Installations, General

a. Classification. The most general classification of fortifications is into "permanent" and "field." The latter, in turn, are classified into "deliberate" and "hasty." The distinctions are largely a matter of degree, although each category has certain special features. This manual deals mostly with field fortifications.

b. Organization of Ground. This is the process of strengthening a defensive position by field fortifications and accessory installations. It begins as soon as the position is occupied, and is a progressive process. (A defensive position may of course be organized behind the lines, for later occupation by combat elements following a retrograde movement.)

c. Installations. The principal installations typical of a defensive position are entrenchments, emplacements, shelters, and obstacles including minefields.

d. Priorities. Precise priorities cannot be set for every situation. The following principles apply in the average case:

(1) Top priority is given to clearing fields of fire; installing obstacles (especially wire and antitank mines) at critical avenues of approach; preparing elementary protection for men and weapons; and installing the element of observation and communications systems.

(2) High priority is given to preparing key demolitions, improving routes of supply and

evacuation, and installing vital service facilities.

(3) Thereafter comes the progressive and systematic improvement, extension, and coordination of all features of the position, by which it is converted from the hasty to the deliberate type of field fortification.

e. Concealment and Camouflage. These are important considerations. Camouflage discipline must be enforced, and camouflage techniques employed from the beginning of the development of the position, or the enemy will find evidences of the position in air photographs.

225. Shelters and Emplacements, General

a. As the terms are here used, a *shelter* is designed primarily to protect personnel from enemy fire; an *emplacement* primarily to give such protection to a weapon while allowing it to fire from the emplacement, and also to protect the crew and accessories of the weapon. A shelter may vary from crude partial protection improvised by a man under fire, to an elaborate installation in which men may live comfortably and be protected from the heaviest bombs and shells. Progressive improvement of shelters and emplacements should be possible when a defensive position is to be occupied for some time.

b. On the basis of strength, shelters are classified as bombproof, and blast- and splinter-proof. On the basis of general construction they are classified as surface, cave, and cut and cover.

c. The surface shelter is built wholly above ground. It is hard to conceal and to make strong, but easy to build, drain, and ventilate. It is mainly used when light protection only is needed, and/or in wet or rocky ground.

d. The cave shelter is built wholly underground, by driving a tunnel, sinking a shaft, and driving galleries therefrom. It is easy to conceal and make strong; but hard to build, drain, and ventilate.

Note. The cave shelter can be given any desired strength by going deep enough. However, about 75 feet of overhead earth cover are needed to guarantee protection against a 2,000-pound bomb.

e. The cut-and-cover shelter, with sufficient cover, and wholly underground has the characteristics of a cave shelter but is easier to construct because open excavation rather than mining techniques are employed. Modified cut-and-cover shelters, partially above ground, have characteristics which are compromises between the advantages and disadvantages of the surface and cave types.

226. Types of Shelter

These include the following, among others:

a. Shell craters, hastily improved with entrenching tools.

b. The skirmisher's trench.

c. The prone shelter.

d. The foxhole. A number of types are recognized, including the 1-man, 2-man, and 3-man (V-type or Y-type). Overhead camouflage or cover, caches for ammunition, and various other refinements may be added.

e. The cave hole.

f. More deliberate structures, utilizing heavy timbers, steel, concrete, heavy earth cover, deep excavation, or a combination of these.

g. Trenches.

h. Command posts and observation posts, which may vary from simple and improvised structures to very elaborate ones.

227. Types of Emplacement

There are a great variety of these. The principal categories of weapons or accessories for which emplacements may be built in a defensive position are the following:

a. Infantry weapons.

b. Field artillery.

c. Antiaircraft artillery, and such accessories as powerplants, directors, and radar.

d. Searchlights and accessories.

228. Principles of Design

Details of the design of shelters and emplacements are given in FM 5–15. Certain requirements must be met in all types except the most temporary; others become important if occupancy is prolonged. Among them are—

a. Ventilation.

b. Drainage and the control of seepage.

c. Revetments (or retaining walls if needed) for earth cuts or parapets. Among the common materials used for revetments are brush and pickets, sandbags, chicken wire and burlap, and such expedients as empty boxes filled with earth, salvaged armor plating, galvanized iron, and doors or other structural portions of wrecked buildings.

d. Overhead cover may be built in a fully bombproof structure in as many as four layers: a camouflage layer, a burster layer, a cushioning layer, and a distributing layer. Various materials may be used, including some of the improvised materials listed in the preceding subparagraph.

e. Storage space for weapons, ammunition, water, and food.

f. Toilet, cooking, and sleeping facilities.

g. Communications facilities.

h. Lighting and sometimes heat and *power* facilities.

i. Gasproofing.

j. Fireproofing or fire-preventive measures.

229. Engineers in Defense, Disposition

a. The covering force of a defensive position normally operates some distance in front, under conditions calling for quick decisions and close coordination. If it includes an engineer component, as it usually does, the component is attached, because control through normal channels would be inadequate.

b. On the outpost line of resistance, engineer troops are employed as dictated by the situation. Generally, supporting engineer units are attached to the infantry units to achieve a local unity of command.

c. In the battle position, normal RCT association of supporting engineers is maintained, on a supporting basis, insofar as work priority permits.

d. Any engineer support needed for the combat outpost line should be furnished from the engineer element supporting the troops which man the line.

e. The rest of the divisional battalion operates in general support.

f. The foregoing are subject to variation as conditions indicate; for example, if flank protection becomes exceptionally important.

230. Engineers in Defense, Duties

The principal duties of the divisional engineer battalion in the defense are the following:

a. Reconnaissance.

b. The provisional and maintenance of routes of communication.

c. Cooperative preparation of traffic control plans.

d. Engineer supply, primarily fortification and camouflage materials.

e. Water supply.

f. Map supply.

g. Installation and operation of general engineer service facilities.

h. Combat as infantry in an emergency.

231. Engineer Reconnaissance

a. Engineer reconnaissance in the defense is conducted according to the principles set forth in chapter 5. However, certain features are stressed, including terrain studies, routes of communication, sites for obstacles (including minefields), sites for the preparation of demolitions, and natural cover.

b. Various tasks connected with the organization of the ground in a defensive position are the responsibility not only of divisional engineers but also of other troops. Reconnaissance of such features should be coordinated.

c. Often a divisional defensive position is one to which our troops have withdrawn after previously passing through it, or even occupying it, during an advance. In such case a good deal of information on the area is available in corps, army, or elsewhere in the theater. The division engineer should be alert to collect and use such information, taking the initiative through technical channels.

d. Once the decision to occupy the position is made, engineer reconnaissance is initiated without delay.

232. Roads and Traffic

a. If our troops have previously occupied or passed through the position now being defended, it will probably have some sort of road net, including bridges, capable of carrying divisional loads. However, the roads may not be numerous enough, or located properly, to serve the position as laid out. Axial roads to deliver ammunition and reinforcements promptly to hard-pressed sectors and to evacuate wounded, and lateral roads to permit shifting of reserves, are vital to a successful defense.

b. Bridges, and other critical localities on the roads serving the position, will be targets for concentrated enemy fire and bombing. The division engineer must have plans prepared, and materials assembled or earmarked, for the prompt repair of such damage or for the opening of alternative routes. Alternative routes are likewise important in case a road, though itself undamaged, is temporarily blocked by wreckage resulting from enemy bombing.

c. It is sometimes necessary to relocate a section of critical road, otherwise satisfactory, so as to conceal it from enemy observation.

233. Organization of Ground

a. Combat troops are, in general, responsible for organization of the ground and construction of defensive works in their assigned areas and sectors.

b. The responsibilities of divisional engineers are advice and assistance, engineer work, and engineer supply. Engineers furnish plans, supervision, supplies and assistance as needed for CP's, emplacements, camouflage and special problems encountered in drainage, clearing, excavation, and construction. Engineer troops accomplish specialized construction. The precise division of responsibilities is dependent upon troops, time, equipment, and materials available.

c. With respect to local control of work, when occupying troops are working on the organization of the ground their commander should be responsible. Engineer technical assistance for the task as a whole should be handled by assigning an officer or skilled noncommissioned officer, and other personnel as needed, to maintain liaison with the commander of troops, furnish advice and plans, and see that he receives needed engineer supplies. Installations to be built by engineer troops are an engineer responsibility, not under the control of the local area commander.

234. Other Engineer Responsibilities

a. Water points should be located conveniently to occupying troops, far enough to the rear so as not to be caught in an enemy penetration, defiladed from observation, and well camouflaged.

b. Map supply is normal, except that there may be a special demand for maps of large scale, or blown up to large scale, for planning and recording detailed defense installations. For further details, see chapter 23.

c. For camouflage, see chapter 25. For supply in the defensive, see paragraph 120.

235. Assistance to Divisional Engineers

a. When a division organizes its own defensive position, the engineer battalion will normally need and receive assistance from corps. This may be extended in the same form as in the case of an attack. Included in the tasks which the corps engineer combat group may take over are road work and water supply in the rear areas; emergency installation of standard equipment bridges, to replace bridges in the divisional area destroyed by enemy fire or bombing; earthmoving, using light equipment and dump-truck companies; specialized camouflage tasks, using engineer camouflage troops if available; and the preparation of obstacles for flank or blocking positions.

b. Engineers of higher headquarters may assist division engineers by the loan of technical specialists not available to the latter.

c. When the need can be foreseen and conditions permit, a defensive position may be prepared more or less completely before the arrival of the occupying troops. Such work is normally a corps or army responsibility. It is important that civilian labor be used to the maximum extent practicable. When the occupying division takes over such a position, the division engineer must immediately contact the engineer responsible for the advance work and familiarize himself with what has and has not been done, the condition of roads and bridges, the location of engineer supplies, and other vital points. If possible, he or his representative should do this in advance of occupation.

Section II. OBSTACLES AND BARRIERS

236. General

a. An obstacle is any obstruction (natural terrain feature, condition of soil or climate, or manmade object or work) that stops, delays, or diverts movement.

b. A barrier is an interlocking series of natural and artificial obstacles designed and employed to channel, direct, restrict, delay, or stop movement of an opposing force. Normally a barrier is covered by fire.

c. Mine warfare is dealt with separately in chapter 12, and will not be further referred to in this section. It must however be remembered—

(1) That mines are commonly laid in connection with most types of obstacles described below.

(2) That minefields are commonly associated with barrier systems in a defensive installation.

237. Responsibilities

a. As explained above, troops which garrison a position are in general responsible for the defensive installations, including obstacles. Divisional engineers normally assist in barrier operations. Besides their supply, reconnaissance, and supervisory missions, they may be called on for barrier planning and the construction of obstacles that need special skills. In large-scale defensive positions prepared in advance, especially in rear areas, the engineers of corps or army may be responsible for all obstacles, with such help from other troops or civilian labor as higher authority may approve. Divisional and other engineers must be fully trained in the design and installation of all forms of obstacles.

b. Combat engineers are trained and equipped to defend as well as to construct obstacles and barriers, and on occasion must do so, especially in defense of their own activities and work sites. However, in divisional and larger scale operations, other troops normally take over the defense of any such installations built by engineers, to free the latter for engineering work.

238. Classification of Obstacles

a. Obstacles may be classified as natural or artificial. Examples of the former are steep slopes, gullies, streams, lakes, swamps, dense vegetation, and deep snow. Examples of artificial obstacles are minefields, barbed-wire entanglements, roadblocks, antitank ditches and structures, abatis, demolished bridges, and craters. Structures built for peacetime purposes are often very effective obstacles. In general, best results are obtained by *selecting a natural obstacle and improving it by artificial adjuncts.*

b. Based on the primary end they are meant to serve, obstacles may be classified as antimechanized (antitank) obstacles, antipersonnel obstacles (of which wire is the most important), obstacles to the landing of planes, and beach and underwater obstacles. The classifications are not rigid; thus, a roadblock designed primarily to stop tanks will also stop other types of vehicles and delay a marching column.

239. Antimechanized Obstacles

These are designed to stop tracked and wheeled vehicles. The principal types are—

a. Antitank Ditches. They may be built either with a triangular or a trapezoid cross section; the latter is harder to construct and maintain, but more effective. Of themselves, ditches will not stop a determined tank attack properly supported, but they can delay and channel the attack. They should be used in conjunction with mines and other defensive elements, and concealed as far as possible from enemy ground observation. If they can be flooded their effectiveness is increased, although maintenance difficulties may also be increased. Antitank ditches occupied by the enemy become readymade fire trenches for him; therefore, they are most commonly used behind our main line of resistance to guard against sudden armor penetration, echeloned in depth.

b. Log, Steel, and Concrete Obstacles. They may take many forms, and may be used either to block roads and narrow defiles or to provide a cross-country defensive belt. Common types include—

(1) Rows of obstacles made by driving heavy logs or wooden posts deep into the ground; by sinking steel I-beams or H-beams into concrete foundations so that they project vertically or are slanted toward the enemy; or by more elaborate steel or concrete obstacles, firmly anchored. (A common form is the so-called dragon's tooth, which is a truncated four-sided pyramid.) They must be high enough, strong enough, close enough together, and installed sufficiently in depth so that tanks cannot pass over or between them or push them over, and so that they cannot readily be bridged or blown up by enemy assault troops operating under fire. Barbed wire is often installed within the obstacle belt to make it effective against personnel as well as armor.

(2) Solid log cribs, spiked or wired together, and filled or backed with earth, make effec-

tive blocks on roads or in narrow defiles. A simple variant of the crib is the hurdle, consisting of a large log (18 inches or more in diameter) or of smaller logs lashed together, laid horizontally and fixed in place by stakes. On steep slopes which armor has difficulty in negotiating, the added effect of the hurdle will stop a tank.

(3) In heavily timbered country, trees properly felled can be made into formidable obstacles, either as roadblocks or against the cross-country movement of tracked vehicles. The standard obstacle for the latter purpose is the abatis, constructed by felling trees criss-cross. A belt of such felled trees will stop mechanized vehicles if the trees are 3 feet or more in diameter; smaller trees will block wheeled vehicles. If the abatis is wired, it becomes an effective antipersonnel obstacle.

c. Demolitions. A crater in a road will block the movement of wheeled vehicles, and also of tracked vehicles if the crater is large enough and cannot be bypassed. A demolished bridge over a nonfordable stream will effectively stop all vehicular movement until the bridge is repaired or replaced, or until rafts and ferries are put into service. For further details on demolitions, see chapter 24.

240. Barbed Wire, General

Barbed wire is in many ways the simplest, most effective, and most flexible form of antipersonnel obstacle. It may also be used to hinder the movement of wheeled and tracked vehicles.

241. Classification of Entanglements

a. By mission, entanglements are classified as tactical, protective, and supplementary. *Tactical* wire is placed in front of a position to break up the enemy's attack formations and hold him in, or channel him into, areas of intense defensive fire. *Protective* wire is placed to guard against close-in surprise assaults; it should be near enough for day and night observation, but beyond normal grenade range. *Supplementary* wire may be added to conceal the exact line of the tactical wire, and to provide additional protection. Figure 9 shows examples of all three types in a battalion defense area.

b. By depth, entanglements are classified as—*belt* (a single line of entanglements) ; *band* (two or more belts in depth, no interval) ; and *zone* (two or more bands in depth, with intervals). To be effective, entanglements should be arranged in depth. Zones should be used when practicable, especially for tactical wire.

c. Wire obstacles may be either fixed or portable.

242. Siting and Layout of Entanglements

a. Entanglements should be—

(1) Under friendly observation, covered by fire, and preferably protected by mines.

(2) Concealed from enemy observation as far as practicable, by terrain features (including reverse slopes, hedges, and fence lines) and natural cover.

(3) Placed on an irregular and nongeometrical trace.

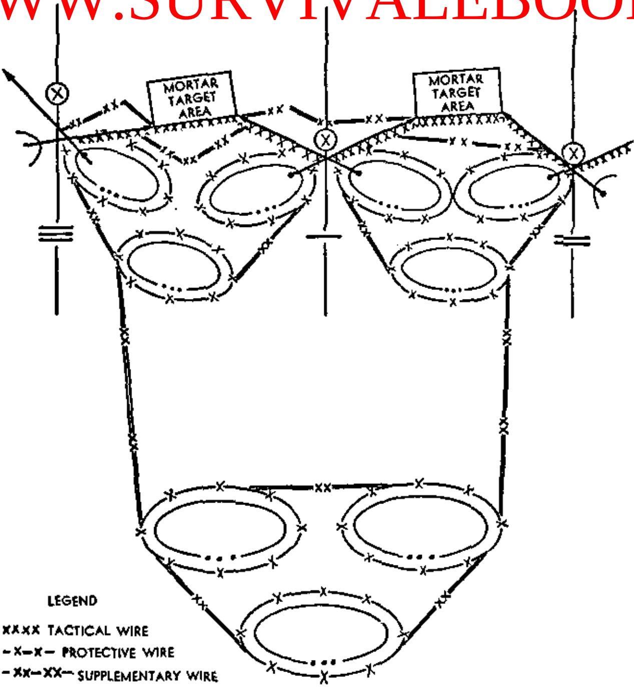


Figure 9. Types of wire entanglements, battalion defense area.

(4) Coordinated with other elements of the defense.

b. Gaps are left in wire to provide passage for patrols and other expected troop movements, including counterattacks. When not in use they are blocked by portable obstacles. Gaps for a general advance or counteroffensive, following defensive operations, are cut just before the advance starts.

243. Design and Construction of Entanglements

a. Structurally, the principal types of entanglement are—

(1) The double-apron fence and its variants, including the low-wire entanglement, the high-wire entanglement, the four-strand fence, the trestle apron fence, and the Lapland fence.

(2) The various types of concertina entanglement.

(3) Portable wire obstacles.

(4) Combinations.

b. Portable wire obstacles are used to close gaps or provide hasty protection.

c. Standard types of entanglement are often combined, strengthening the obstacle and making it harder for an attacking force to breach.

d. For details see FM 5–15.

244. Obstacles to Airplanes

A level area on which it is feared that enemy planes may land can be protected by placing obstacles which will wreck any plane making the attempt. They must be so placed, and of such size and weight, that some part of the plane is certain to hit one or more of them while it is going fast enough to insure wrecking it. If the area to be protected is an airstrip in use by our troops, the obstacles must of course be portable, and capable of being placed promptly upon receipt of the warning of an attack.

245. Beach and Underwater Obstacles

a. These are designed to hamper enemy landings (fig. 10). On a tidal beach, the most important obstacles are installed to extend from the high water

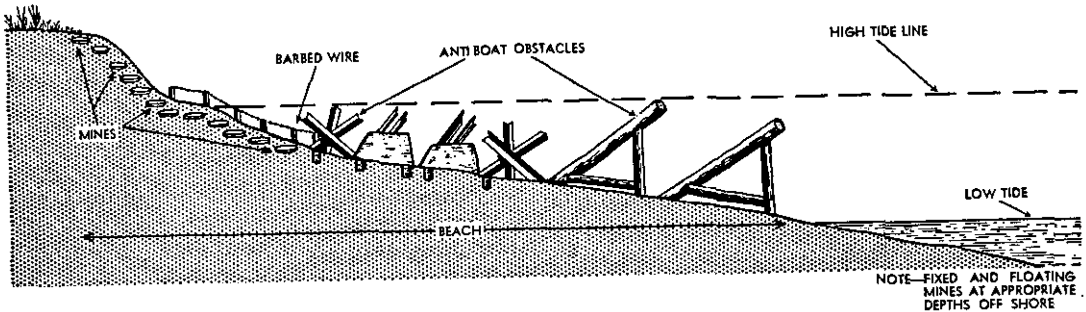


Figure 10. Beach and underwater obstacles.

mark for several hundred yards seaward, the distance depending on slope of beach and range of tide. Their height should be such that they are just under water at high tide. They are covered by heavy fire. If landing craft approach at high tide they are wrecked by the obstacles; if at low tide, the men are forced to cross the belt of obstacles, which are designed both to stop or wreck hostile craft and to delay personnel.

b. Common antiboat obstacles include—

(1) "Element C," a sectional prefabricated steel fence.

(2) The horned scully, a block of concrete with projecting steel members which will rip the hull of a boat.

(3) The hedgehog, made of steel channels or angles bolted together.

(4) Log cribs, posts or barricades, rock mounds, and heavy precast concrete shapes such as dragon's teeth.

c. The most effective antipersonnel obstacles is wire strung between the antiboat obstacles. Land mines should be used if practicable, but in a sand beach subject to surf action there may be difficulty in burying them satisfactorily.

d. Above the high-tide level, beach obstacles are installed on the same principles as in the case of any other open and level ground. Since a successful amphibious operation requires the prompt organization by the attacking force of a large area of beach, the defense should install numerous mines and booby-traps to delay and disorganize the enemy if he makes good his initial landing.

e. The above principles also apply on the shores of a nontidal waterway.

246. Other Obstacles

a. In Arctic or cold winter conditions, deep loose snow and icy roads and slopes are effective antimechanized obstacles.

b. In tropical jungles, antipersonnel traps can be made by fixing sharpened bamboo stakes upright in covered and camouflaged pits; anyone falling on them is impaled. Boobytraps ("bamboo whips") can be made by bending bamboo so that, if it is released by tripping a trigger, it will kill the man it strikes or impale him on a spike.

c. Artificial inundations are effective obstacles. They may be produced by damning a water course, or (temporarily) by blowing a dam and releasing the retained water.

d. Illumination of a defensive front by searchlights or flares is useful against surprise night attacks.

247. Barriers, General

a. Classification. By location, barriers are classified as—

(1) Covering barriers, in front of the battle position.

(2) Rear area barriers, blocking routes in rear of the battle position.

(3) Flank barriers.

b. General Character. A barrier system is an integrated system of barriers and natural and artificial obstacles in an area. *To be effective, it must be covered by fire, must be organized in depth, and must have its flanks protected.* Barrier tactics are tactics based on the use of barriers defended by artillery, antitank weapons, and machinegun or small-arms fire to prevent or delay enemy advance in the protected area.

248. Employment of Barriers

a. In defensive or retrograde movements, barriers are used to—

(1) Delay initial enemy advances on our front or flanks.

(2) Restrict the maneuvers and channelize the movement of an enemy force which may approach or penetrate our position.

(3) Hamper enemy pursuit.

(4) Allow our forces to be withdrawn or weakened on one front to permit a concentration of force elsewhere.

b. On the offensive, barriers are used to—

(1) Provide flank security.

(2) Protect sections of our front which are not strongly held, and on which we do not expect to undertake or continue the offensive immediately.

(3) Guard against surprise frontal attacks or counterattacks against elements of our forces which have halted to await reinforcements or consolidate a captured position.

249. Barrier Planning

The decision to install a large-scale defensive barrier system, and the general overall plan, are made at army or higher level and supplemented by more detailed plans by corps. At division level the commander's orders cover the following: the plan of obstacles and barriers, and the purpose each is to serve; demolition orders; routes to be kept open through the barrier system; assignment of troops and equipment for installing and protecting the system; limitations on the use of chemical agents; the need for secrecy; and timetables of construction, including priorities.

250. Engineers in Barrier Planning and Operations

a. At all levels, the staff engineer has primary staff responsibility for barrier planning. He plans and supervises the technical aspects of barrier employment, and assists G3 in the barrier annex of the operation plan or order. Engineers may be made responsible for the physical location and construction of elements of a barrier system which require special skills or equipment. Barrier instructions include the allocation of engineer support, labor, material, and transportation.

b. At division level, based on the division commander's plans and orders, and on map and photographic studies and careful reconnaissance, the division engineer prepares a detailed barrier plan, including the evaluation of all natural obstacles to be incorporated into it and the artificial obstacles which are to supplement it, together with time, labor, and material estimates. This is coordinated by the division staff, which determines what work is to be undertaken or supervised by the engineers and what supplies or other assistance they are to furnish. The detailed plans and orders for such engineer activity are prepared, issued, and implemented by the division engineer.

c. The heavy demand for labor for barrier construction calls for the maximum utilization of native labor to supplement troop effort.

251. Defense of Roadblocks

a. Engineers must sometimes defend roadblocks and other local obstacles which have been attacked before the engineer force constructing them was relieved, or which the engineers install to protect their own activities. A common example is an obstacle covering a prepared demolition.

b. A roadblock may be defended by a squad or fraction thereof, or by a larger unit, depending on whether it is for local security or is part of a larger plan.

c. The essential elements in the defense of a roadblock, besides the siting and structure of the block itself, are—

(1) The selection and occupation of concealed positions for machineguns and antitank weapons to cover the obstacle, the approaches thereto, and the neighboring area.

(2) Positions for riflemen to protect the heavier weapons against attack by enemy infantry.

(3) Adequate observation.

(4) Covered routes to the rear for supplies, reinforcements, and withdrawal.

d. Several obstacles may be prepared on a section of road or other avenue of approach, and defended by withdrawals to successive positions.

252. Permanent Fortifications

a. General. These are most commonly built in peacetime to protect a nation's vulnerable frontiers or territorially isolated possessions, but they may be built in wartime in a theater of operations. On occasion they may evolve progressively from field fortifications.

b. Classification. A *fortified area* is one containing numerous defensive works of an elaborate character and fully integrated. If the works are grouped about a single location of rather limited area, this is a *fortified locality.* A series of mutually supporting fortified localities, disposed both linearly and in depth, is a *fortified position.* Other terms used in this connection are *fortified belt* (a linear grouping of fortified works), and *fortified zone* (fortified works grouped linearly and also in depth).

c. Elements. The elements of a fortified area are of the same general character as those of field fortifications. The distinction is chiefly one of degree. The area as a whole, and sometimes its major elements, is organized to permit all-round defense, to resist heavy shells and bombs, and to be self-contained for a long period if isolated. Extensive use is made of concrete forts, emplacements, and pillboxes. The garrison is housed in bombproof installations usually deep underground and with heavy concrete cover. These are ventilated, gas-proofed, and in general self-contained. Hospital, communications, storage, water supply, and electric power facilities are similarly protected. Provisions are made for disposing of human wastes and garbage. Elements of the fortified area are interconnected by underground passages. The central core of the area is surrounded by an elaborate outpost zone, protected by deep minefields and zones of barbed wire, concrete walls and ditches, tank traps, and other obstacles such as inundations and electrical cables.

d. Semipermanent Fortifications. A defensive position which is not a "fortified area" in the full sense may yet have certain of the more easily built features of permanent fortifications, such as concrete pillboxes.

253. Fixing of Responsibility

In a theater of operations, responsibility for rear-area defenses, including permanent and semi-permanent fortifications, must be clearly fixed and understood.

Section III. RETROGRADE MOVEMENTS

254. General

a. Definitions. A retrograde movement is any movement of a command to the rear or away from the enemy. Retrograde movements are classified as withdrawals from action; retirements; or delaying actions.

(1) Withdrawal from action is an operation in which all or part of a deployed force disengages itself from the enemy in order to position itself to initiate some other action.

(2) Retirement is an operation in which a force withdraws without enemy pressure, refusing combat under the existing circumstances.

(3) A delaying action is an action in which space is traded for time and maximum punishment is inflicted on the enemy without becoming decisively involved in combat.

(4) Within a large command which is in contact with the enemy, a combination of these types usually is necessary, either simultaneously by adjacent units or by one type developing into the other. A retirement may be preceded by a withdrawal from action, and may be covered by a force executing a delaying action.

b. Purpose. A retrograde movement may be undertaken to disengage from combat; to avoid combat under undesirable conditions; to draw the enemy into an unfavorable situation; to gain time without fighting a decisive engagement; to place forces involved in a more favorable position in relation to friendly troops; and to permit the use of a portion of the force elsewhere. Each of these operations is primarily a defensive action; each involves movement to the rear; each seeks to gain time or more favorable conditions for combat; and each involves a sacrifice of terrain.

255. Engineers in Retrograde Movements, Disposition

There is a parallel between the disposition of divisional engineers in a retrograde movement and in the advance. Each major withdrawing or retiring element or column should have engineer support, as should the covering force, and there should be a reserve under the immediate control of the engineer battalion commander. In a typical situation with the division moving into columns protected by a covering force, a reasonable distribution might be an engineer company in support of each column and a company attached to the covering force. Water supply parties may also be attached. Decentralization of tasks within companies is largely practiced. The precise distribution of such units, and also the location of the engineer battalion less detachments, will depend on terrain, weather, enemy situation, mission of friendly forces, and the composition of the force withdrawing. Engineers will be needed with covering forces or rear guards, to repair damage inflicted by enemy artillery or aircraft on designated routes of withdrawal.

256. Engineers in Retrograde Movements, Duties

In general terms, the essential duties of the divisional engineers are to assist the division's movement and to impede the enemy. More specifically they include—

a. Maintenance of routes of withdrawal.

b. Providing engineer support for delaying and security operations.

c. Denial operations.

d. Reconnaissance necessary to the above missions.

e. Routine engineer duties such as water supply and map supply.

f. Combat as infantry if required.

257. Routes of Withdrawal

A division in a retrograde movement normally moves over the roads which have heretofore been used to supply it or to serve the corps and army troops behind it, and which, therefore, should initially be in good condition. However, if the enemy has effective airpower, he will seek during the retrograde movement to destroy bridges and to block roads by attacking and wrecking motorized columns. Divisional engineers with the advance guards must be on the alert to repair such damage and prevent any serious delays.

258. Engineer Support to Delaying and Security Operations

a. These include demolitions, installations of minefields and other obstacles, and assistance to other units in the organization of the ground and in flank security. They are conducted on the same general principles as apply in the defense. Emphasis is especially on—

(1) Preparation of demolitions to be executed by the rear guards or last elements of the covering force.

(2) Obstacles which can be hastily installed to cover temporary positions occupied by elements of a covering force such as light bands of wire and abatis. Antipersonnel and antitank mines are extensively used.

(3) Boobytraps and delayed action mines which will disorganize the enemy's advancing columns after our covering force has withdrawn.

b. For the planning and execution of demolition projects in retrograde movements, see chapter 24. For the use of mines, see chapter 12.

259. Denial Operations

a. "Denial" is action taken to deny to the enemy, or hamper him in the use of, any material objects, areas of terrain, or personnel. Within the framework of theater and other high-level policies, it is a responsibility of all commands. For a commander with area jurisdiction, denial responsibility extends to everything in his area. For any other commander it extends to the equipment and supplies of his unit plus any items or fields of action specifically assigned to him.

b. A retrograde movement always involves denial to the enemy of certain objects and facilities which should be of immediate military value to him. How far denial operations will go beyond this minimum, up to the ultimate limit of a "scorched earth" policy involving complete devastation of an area and the evacuation of its inhabitants, is a matter for major command decision. Such a decision, if soundly made, will take careful account not only of the present tactical situation but also of future plans, the contemplated strategy of the campaign, and considerations of national policy. Useless and wanton destruction may have serious effects both on the conduct of a war and on the postwar situation. See also chapter 24.

c. Denial may take the form of removing material objects from the reach of the enemy; damaging them to limit or delay his use of them; destroying them or rendering them permanently useless; and denying areas of ground by mines, flooding, chemical agents, or atomic weapons used for destruction and/or area contamination. Physical agents of damage and destruction include explosives; the fire of weapons; fire, using flammable liquids or incendiaries; hand and power tools; water, acids, or contaminating agents; and the dumping of equipment and supplies into water or over cliffs.

d. In a retrograde movement the division commander, acting under orders and policies of higher authority, is responsible for preparing and executing a plan for denial operations in his area. All troops may participate in certain aspects, including the destruction (if ordered) of organic equipment and supplies, procedures for which are normally a part of unit SOP's. The divisional engineer battalion is well suited and equipped to supervise and execute denial operations.

260. Reconnaissance

Reconnaissance by divisional engineers in a retrograde movement is characterized by the collection of advance information on roads and bridges, terrain features, installations, and resources of the territory through which the movement will take place. This territory having been in friendly hands will be known, and detailed reports will be available through engineer channels.

CHAPTER 12

ENGINEERS IN MINE WARFARE

261. General

The term "mine warfare" includes the employment of mines against an enemy and the countermeasures employed against the enemy's use of mines. Primarily it deals with the use of minefields as obstacles. As thus defined, mine warfare has both defensive and offensive aspects, since the breaching or clearing of enemy minefields is a necessary feature of an advance and attack.

262. Engineer Interests and Responsibilities

All members and units of the Armed Forces receive certain training in the nature and use of mines, and the tactics and techniques of their employment, and in a theater of operations may be called on to apply their knowledge. All commanders and staffs must be familiar with the doctrines, and the techniques of employment, of mine warfare. Engineers have certain special interests and responsibilities.

a. Training in certain aspects of mine warfare, including breaching, is confined to the engineers and other combat arms. Either engineers or infantry specialists will be required to perform or closely direct the performance of boobytrapping, laying of the more complex types of mines, and other related and highly specialized activities. All combat engineer units may expect to be called on frequently to lay or supervise the laying of minefields and the execution of difficult nuisance mining.

b. The staff engineer is the chief technical adviser of the command on the techniques of land-mine warfare. When a decision has been made to employ mines for a specific purpose, the engineer is best qualified to recommend how they can most effectively be employed to achieve that purpose. He must be prepared to furnish data on the materiel requirements, the time required for laying minefields after the materiel is available, and the capabilities of the engineer troops of the command for minefield laying in view of other engineer requirements. Staff reference manuals give general planning data, which the engineer must adapt to conditions in his command.

c. The staff engineer is charged with preparation of terrain studies for the intelligence officer. These studies are usually prepared in advance for the next anticipated area of operations. While it may not be possible for them to contain an analysis of the terrain for a specific military operation, the engineer should be familiar with salient features of the terrain and prepared to recommend tentative minefield locations based upon the announced scheme of maneuver.

d. When the tentative plans have been coordinated and approved, the engineer prepares detailed plans for those minefields which are the responsibility of the division or higher unit. These include a recommendation on who is to lay the minefields, the trace, the pattern or other laying instructions, types of mines and fuzes, gaps, use of phony minefields, and supply points to be established.

e. The staff engineer is responsible for maintaining detailed records of minefields, and assists in disseminating information thereon.

f. Technicians from engineer units of the command may be temporarily attached to inexperienced non-engineer units to assist in mine warfare activities. The staff engineer must insure that such attachments are temporary. When new items of material are introduced, engineer detachments may be used as instructional teams to orient other troop units.

g. As part of the duties of engineer technical intelligence teams (ch. 5) they deal with information and intelligence on the mine warfare materiel used by the enemy, how he employs it, whether it is suitable for reuse by our forces, and countermeasures.

h. For engineers in barrier planning and execution in general, see chapter 11.

263. Basic Doctrine

The following principles are the basic current doctrine on mines and minefields:

a. Purpose. Minefields are active obstacles, designed to improve the security of our forces by restricting enemy movement. They may be located in front, flank, or rear. While primarily defensive in character, they are often used as adjuncts to the offensive. They are an essential element of a barrier plan.

b. Method of Employment. This is governed by the overall scheme of maneuver, enemy capacities, effort involved, fire-support plan, overall barrier plan, and political and economic implications if any.

c. Use in Depth. For minefields to be fully effective on a large scale against an aggressive enemy, they must be in depth, successive fields being located one behind another, and interconnected both within themselves and to natural and artificial obstacles.

d. Authorization and Reports. Minefields are laid only by the authority of the commanders indicated below. Reports before, during, and after installation must be submitted by the officer or agency installing the field.

e. Enemy Minefields. These, as soon as discovered, must be reported and marked.

f. Limitations. A minefield will not give complete security of itself. It must be covered by fire, unless (as with nuisance and phony minefields) it is not meant to stop an enemy but merely to delay, disorganize, or deceive him.

264. Mines, Types and Characteristics

a. The most common classification of mines is into the types listed below:

(1) Antitank (A/T) mines, used against wheeled or tracked vehicles. They operate on the pressure principle, and require a greater pressure than the weight of an average man to detonate. All troops must be capable of laying them.

(2) Antipersonnel (A/P) mines which operate by pressure, by trip wire, or by a combination; the latter is the basis of our current design. However, even if a mine is designed to be actuated in either way, it may be laid without trip wires, so that it is actuated by pressure only.

(3) Antiamphibious mines.

(4) Antiairborne mines.

(5) Mines may also be improvised by trained troops, using shells or bombs, standard explosive, or other means.

b. A boobytrapped mine is one which, in addition to the main fuze, has a firing device which will detonate the mine if subjected to a particular initiating action; for example, if the mine is moved after being placed. Laying or removing boobytrapped mines is a task for highly trained troops.

c. Mines may be either metallic or nonmetallic.

265. Minefields, Classes

a. Minefields are normally classified as follows:

(1) *Protective minefield:* Laid to assist a unit in its local close-in protection.

(2) *Defensive minefield:* Laid to strengthen the positions of units of less than divisional size, by delaying, disorganizing, or canalizing enemy attacks or counterattacks, or halting penetrations.

(3) *Barrier minefield:* Laid to cover intervals between defended localities, or to cover the flanks of a large unit, or extending axially forward to canalize an approaching enemy. The same term is applied to an extensive minefield along the front of an army or larger unit.

(4) *Nuisance minefield:* Laid to delay and disorganize the enemy and hinder his use of a certain area or route, which may or may not be covered by fire.

(5) *Phony minefield:* An area faked to make the enemy thing that it is a minefield.

b. The more important characteristics of these five types are discussed below.

c. Minefields may also be classified as A/T, A/P, or mixed minefields.

266. Protective Minefield

This is appropriate to the defense of a small unit in its battle position, or in a rear area where enemy penetration or large-scale guerrilla activity is feared, or on an independent or isolated mission. It may use both A/T and A/P mines. It is laid initially on short notice for a limited period, to be readily removable; this prohibits nonmetallic- or special-type mines. It may either continue in the status of a protective minefield or be later absorbed into a more comprehensive minefield system. It is placed far enough out to be beyond hand-grenade range. Battalion and higher commanders have authority to employ such fields unless higher headquarters states otherwise, and may delegate this authority not lower than company commanders. The authorizing officer must take into account the possible effect of the field on other security measures, on the normal activities of his unit, and on future plans, and is responsible for liaison and coordination with adjacent units.

267. Defensive Minefield

This is an element of the overall defense plan, and must be carefully coordinated with that plan. It may also be employed when an offensive has been halted, to guard against counterattack. It may be placed on the front, the flanks, or even the rear of a position. Any type of mine may be used, but in the use of nonmetallic or other special mines their present advantages must be weighed against future disadvantages. A defensive minefield is usually placed out of range of enemy fire and observation, and before security elements are withdrawn; if not, it is laid at night or in low visibility and under cover of defensive fires. Regimental and higher commanders may authorize defensive minefields, and may delegate this authority not lower than battalion commanders.

268. Barrier Minefield

This is a major element in the organized defense of a large unit. It may have not only tactical but strategic significance: for example, as part of the plan for defending a vulnerable frontier, in which case it may be laid in peacetime. It must offer the maximum resistance to breaching. It is normally anchored to other major natural or artificial obstacles. Its plans must be carefully integrated with other minefield, barrier, obstacles, and demolition plans, and with the plans for possible future offensives, counterattacks, or withdrawals. Highly mobile reserves should be available to protect the field if need arises, and the field must be kept under constant surveillance. Any type of mine may be used. Division and higher commanders may authorize barrier minefields.

269. Nuisance Minefield

This is used to harass advancing enemy troops. It must be laid with imagination to produce the maximum delay, disorganization, imposition of caution, and lowering of morale. It is especially appropriate to retrograde movements, denial operations, and position defense. It must be coordinated with the overall plans of higher authority or of the authorizing agency, and its characteristics will largely depend on whether the area is or is not to be reoccupied in the near future by our forces. It is an effective means of mining in depth when used along routes of movement, and in connection with demolitions and bottlenecks. All types of mines and boobytraps may be used. Army and higher commanders may authorize nuisance minefields; authority may be delegated to not lower than division commander. (See also par. 278.)

270. Phony Minefield

This may be used when conditions do not permit placing any other type or to economize on mines. Normally it is installed in conjunction with a live minefield; for example, to disguise the lanes through the latter, or to camouflage its actual extent. To be effective, a phony minefield must resemble an actual minefield. Live mines are not normally used, but a few may be placed to increase the deception. The field may be employed by any commander who has authority to employ the type of live minefield which it simulates.

271. Siting of Minefields

a. General. The siting of a minefield is determined by the commander's mission and future plans, the terrain, the enemy's tactics and equipment, the type of field, its precise purpose, the quantity and kind of mines available, and the availability of troops trained to lay them.

b. Fire. For maximum effect *it is vital that a minefield be covered with fire.* An exception may be made for nuisance minefields. In the case of barrier minefields, plans should be made for fire coverage by maneuver elements when passage of the field is attempted by the enemy.

c. Terrain. For maximum effectiveness, a minefield should be anchored to natural obstacles and so placed that the enemy cannot see it or can see it only with difficulty. Scattered mines may be utilized to increase the obstacle value of areas of low trafficability.

d. Coordination of Planning. As explained above, *a minefield plan must be carefully coordinated with other operational plans.* Consideration must be given to the safe withdrawal of the troops laying the field. There must be strict coordination between the unit which lays the field and the unit which will protect it.

e. Reconnaissance. Ground reconnaissance, preceded by a study of maps, photographs, and air reconnaissance, is usually necessary for determining the location, boundaries, and other details of a proposed major minefield.

272. Installation of Minefields, General

The site of a minefield having been determined, it is necessary to decide whether a pattern is to be employed; to place, arm, and camouflage the mines; and to mark the field and any lanes through it. Careful records are kept during installation and the required reports and records are rendered.

273. Patterns

Mines in a field may be laid either in some definite pattern or scattered. Pattern laying can be done faster and more efficiently; insures thorough coverage and uniform density; facilitates recording and later removal; and exposes a minimum of personnel. Scattered mining makes it harder for the enemy to breach and clear the field, and is more adaptable to varying terrains. Figure 11 defines and illustrates the standard cluster used in pattern laying, figure 12 illustrates the arrangement of clusters in strips in pattern laying, and figure 13 illustrates a minimum

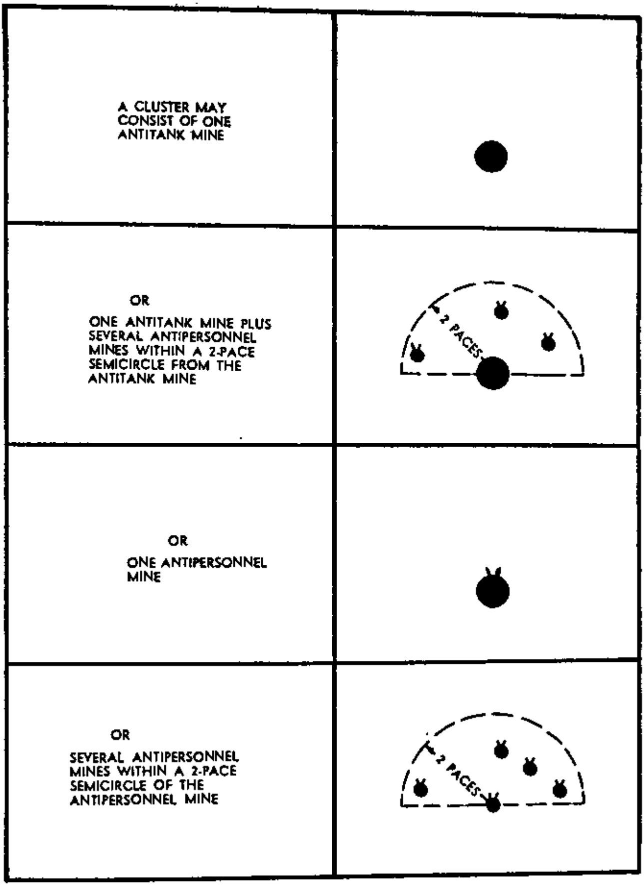


Figure 11. The cluster.

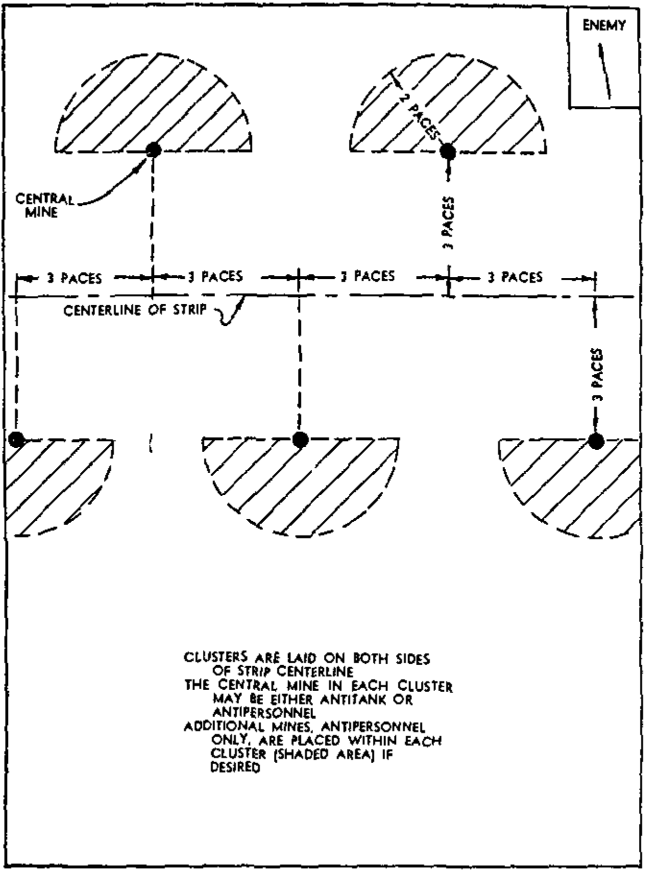


Figure 12. Clusters laid on both sides of a strip centerline.

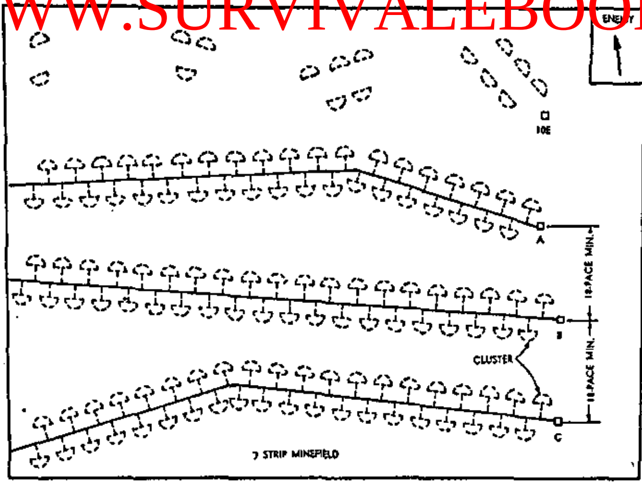


Figure 13. Three-strip minefield.

effective minefield of three strips and an irregular outer edge (10E).

274. Fencing and Marking of Minefields

a. Friendly minefields are normally fenced at the time they are laid, and marked with marking signs. In general, fencing does not follow the boundaries of the field, but is so placed as to conceal from the enemy the exact location.

b. Protective minefields need not be fenced if they are so guarded as to preclude casualties to friendly troops and civilians.

c. Defensive minefields are always fenced on the friendly side. Whether the flanks and enemy side are marked depends on circumstances. A fence well in advance of the enemy side and under observation and fire may delay an enemy attack and be useful in orienting patrols.

d. Barrier minefields are in general fenced and marked in the same way as defensive minefields. Occasionally all markings may be removed to provide secrecy. On the other hand, conspicuous marking on the enemy side is sometimes useful to deflect an enemy attack toward a chosen killing ground.

e. Nuisance minefields are not fenced or marked unless they will endanger friendly troops before an enemy advance reaches them.

f. Phony minefields are fenced and marked in the same way as the fields they represent.

g. Rear-area minefields are fenced and marked all around, and may require more elaborate marking than those in forward positions. If an enemy advance reaches or approaches over a field, all or part of the fencing and markers may be removed as conditions indicate.

h. Enemy minefields are given standard fencing and marking when discovered, if the tactical situation permits.

275. Lanes

When lanes are left through a forward minefield, their location must be carefully concealed from the enemy, but so marked or recorded that friendly troops can find them. Means of marking include carefully placed wire, phosphorescent tape, and luminous buttons. If the sensitivity of the mines precludes entry into all parts of the field for remining, access may be provided by lanes, either kept clear or having readily detectible and removable mines. In a static situation, patrol lanes in forward area minefields should be frequently changed.

276. Recording and Reporting

a. In general, three informal reports are made to the next higher headquarters on the laying of a minefield:

(1) A report of intention to lay the field, with essential data.

(2) A report, by the commander in charge of laying the field, when he is ready to proceed.

(3) A report of the fact of completion, with essential data.

b. Simultaneously with the laying of the mines, a minefield record form is prepared and forwarded up the chain of command. Copies are made at various headquarters in accordance with announced policies. The standard minefield record form is used if available. It has space for more than the minimum information required; whether the additional information is to be included is decided by the commander directing the laying.

c. In the case of protective minefields, very detailed records are kept. Such details, in excess of those required as per *a* and *b* above, are not normally forwarded. If a unit which laid a protective minefield is relieved, the relieved unit removes the field unless the relieving unit commander specifically requests that it be left in place. In the latter case, records are transferred to the relieving commander and a report of transfer signed by both commanders is forwarded to the next higher headquarters which commands both units.

d. Changes in minefields are recorded and reported as appropriate.

e. Prompt reports and records are made of enemy minefields or mining operations, or of enemy reconnaissance or other activity in friendly minefields.

277. Nuisance Mining

a. Nuisance minefields have been discussed. Some applications of the same principle, however, are more accurately described as *nuisance mining*, since no concept of a limited area or field is involved.

b. Common characteristics of nuisance mining are the use of special mines, fuzes, and boobytraps; the absence of an overall standard pattern; the use of highly trained troops; no marking, unless as a temporary measure to protect our troops; recording limited to the location and extent of the mining.

278. Categories of Nuisance Mining

Categories of nuisance mining include the following:

a. Route Mining. This may be resorted to as a protective measure by a small unit, or may be an element of a deliberately planned defensive barrier, or nuisance minefield. It is much used in retrograde movements. Mines are laid largely on roads, but also in areas likely to be used by advancing troops.

b. Facility Denial. As an alternative to complete destruction, in limited denial operations, facilities of military significance may be covered with boobytraps and delayed fuzed mines. Public buildings, warehouse areas, airfields, abandoned military supplies, and important railway installations are among the facilities appropriate for such treatment.

c. Harassment. Friendly guerrilla forces, raiding forces, or aerial mining may be used for nuisance mining behind the enemy line.

279. Clearing of Minefields, General

a. Definitions. To *breach* a minefield is to make a safe lane for passage of personnel and equipment through the field by removing or destroying all mines in the lane. To *clear* a minefield is to remove or destroy all mines in the field. *Sweeping* is the process of searching for mines by the use of detectors.

b. Responsibility.

(1) Each branch must expect to conduct certain mine-clearing operations. Infantry must be able to advance through mined areas without engineer assistance, although engineers normally furnish mine reconnaissance parties to accompany advance infantry elements. Tank crews and artillery personnel are trained to clear mines by manual removal. Service units are responsible for mine clearing in their bivouac and work areas. All troops must maintain mine discipline in mined areas.

(2) Engineers are trained in all techniques of clearing and breaching, including neutralization and removal of special type mines and fuzes and assault breaching. Normally they are protected by other troops during such operations. In amphibious landings they support and cooperate with Navy underwater demolition teams, and are responsible for clearing mines inshore from the high water mark. When practicable, engineers supervise the training of other troops in land mine warfare.

280. Locating Mines

Three common means are visual inspection, the use of detectors, and probing.

a. Visual inspection is often effective in locating both minefields and individual mines. Evidences of mining operations include discarded safety pins, tracing and friction tape, trip wire, empty containers, unusual roadside markers, and any evidences of disturbance or discoloration of the earth. Likely places to look for enemy mines are those which we ourselves would use in the enemy's place: for example, chuck holes in roads, shoulders of roads, craters, obstacles, defiles, areas likely to be used for traffic or parking, and approaches to important installations.

b. Detectors are of two main types: the *small-metals* detector, which detects metallic mines or small metal parts of nonmetallic mines; and the *nonmetallic detector*, which detects something in the ground differing from the rest of the ground over which the detector is being moved.

c. Probing is an effective way of locating mines in soft ground, and mines with nonmetallic cases. Stiff wire, a bayonet, or the issue hand probe may be used.

281. Disposal of Mines

a. Mines occurring individually or in a field can be disposed of in three ways. In order of preference, these are—

(1) By detonating in place.

(2) By pulling out the mine with a length of rope or cable.

(3) By neutralization and hand removal. (Some mines cannot be dealt with in this way.)

b. Detonation in place may be acomplished—

(1) By mechanical means, including rollers,

plows, flails, or similar devices pushed by an armored vehicle; and the procedure of causing a vehicle to run through the field under its own power without driver. All have their limitations.

(2) By explosive means, such as hand-placed charges on individual mines, bangalore torpedoes, and demolition snakes. (See chs. 10 and 24.)

c. Personnel engaged in mine removal must strictly observe certain safety precautions, including the following:

(1) Handle mines and fuzes with extreme care. In a mine-infested area, move slowly and check the ground in front of you. Before starting to work on a mine, examine the area around it. Be on the lookout for boobytraps and firing devices.

(2) Before moving or lifting a mine, cut all *slack* tripwires and disarm all fuzes and boobytrapping devices. (If they cannot be neutralized, do not attempt to move the mine.) Any mine or boobytrap not neutralized must be plainly marked and reported at once.

(3) Never use force when neutralizing or moving a mine or boobytrap.

(4) In neutralizing an A/P mine, reinsert all safety pins before moving the mine.

(5) When cutting wires leading to an electric detonator, cut them one at a time to avoid a short circuit.

(6) *Never cut a taut wire. Never pull a slack wire.*

(7) When probing, push the probe gently and stop when it touches an object.

(8) When pulling a mine by a rope, remain at least 50 yards away. After pulling, stay under cover for 30 seconds, in case of a delayed-action fuze.

282. Breaching a Minefield

a. Breaching is the operation of opening a lane through an enemy minefield. The lane may be opened to pass a patrol, an infantry attack, armor, or artillery and supporting troops, or for several of these purposes. It is often developed from an initial footpath to a two-way vehicle lane.

b. In an attack, the number of breaches, the width of each lane, and the method of breaching depend on the tactical situation, available equipment, and climatic conditions. If conditions permit, mechanical or explosive techniques are preferred. The time element is highly important.

c. A usual procedure will be to clear a minimum of one lane on the front of each infantry assault company, which is used to pass the infantry in single file. The assault elements establish the equivalent of a bridgehead beyond the minefield. The footpaths are widened as soon as possible to permit two-way vehicle traffic (16 yards). On occasion, a vehicle lane may be required from the start. Prompt provision is made for marking the lanes.

283. Area Clearing

This is the process of completely clearing a minefield, undertaken after the tactical units which breached the field have moved on. It is not normally conducted under fire, nor under the pressure of extreme urgency. It follows a successful offensive or advance, and may be continued in a theater after hostilities have ended. Standard techniques are used, but safety is a prime consideration and speed of secondary importance.

CHAPTER 13

OTHER ENGINEER UNITS IN COMBAT

Section I. ARMORED ENGINEER BATTALION

284. Armored Division

a. General. The armored division, as compared with the infantry division, is a somewhat specialized unit, offensive in character, having great mobility, flexibility, and firepower, and subject to certain limitations inherent in these qualities.

b. Organization. The principal elements of the division are three 90-mm. tank battalions, one 120-mm. tank battalion, four armored infantry battalions, a reconnaissance battalion, the armored division artillery, the armored engineer battalion, and service elements.

c. Combat Commands. For combat, the division is normally organized into combat commands. The divisional T/O & E provides, in addition to division headquarters, three combat command headquarters, each capable of commanding and controlling whatever elements of the division are assigned to it for a particular operation. A combat command normally includes tank, infantry, and engineer elements, but its precise makeup depends on the situation.

d. Offensive Employment. The division's offensive tactics are characterized by careful planning followed by swift and intensive attack. It relies on mobility, shock effect, and firepower. Attack orders to combat commands or other elements of the division are normally of the "mission" type, leaving wide discretion to the commanders as to how to employ their troops to attain the specified end. An armored attack, once launched, is not normally checked until it has run its course, since success depends largely on retaining momentum and leaving the enemy no opportunity to rally. Specific offensive tasks for which the armored division is well suited are to exploit a breakthrough, to execute a wide envelopment or turning movement, to attack an objective deep in the enemy's rear, and to pursue a broken and retreating enemy.

e. Defensive Employment. As a part of a larger defensive force, the armored division is especially useful as a reserve of a corps or army, to execute counterattacks against enemy penetration and to give armored support to a general counterattack. Its own defensive tactics are characterized by mobility and by a distribution of its elements in depth.

f. Limitations. The principal limitations and weaknesses of the armored division are inherent in its qualities.

(1) It is sensitive to terrain. Deep water or swamps, deep dry gullies with steep banks, steep rocky slopes, dense and heavy timber, and antitank ditches and obstacles will stop armor.

(2) It requires large amounts of liquid fuel and lubricants, and is immobilized at once if their supply is cut off.

(3) Its vehicles need constant and intensive maintenance.

(4) Once the division is immobilized—whether by natural or artificial obstacles, lack of fuel, inadequate maintenance, or for any

other cause—it becomes quite vulnerable to artillery and air attacks, although it may still have a relatively high combat potential.

285. Armored Engineer Battalion, General

The battalion's mission is to facilitate movement of the armored division and increase its effectiveness by general engineer work. Its organization, equipment, and training reflect the peculiarities of the division. For full details, see FM 5–134.

286. Organization

a. The elements of the battalion are headquarters, headquarters and service company, four armored engineer companies, a bridge company, and a medical detachment.

b. Battalion headquarters in general resembles that of the engineer combat battalion, divisional, having administrative, intelligence, operations, supply, communications, maintenance, and division engineer sections.

c. Headquarters and service company has a company headquarters, an aviation section and an equipment and maintenance platoon. It lacks a bridge platoon, whose functions are performed by the bridge company.

d. Armored companies are organized as are engineer combat companies, divisional, into a headquarters and three identical platoons, each having a headquarters and three identical squads. They are larger than engineer combat companies. The difference is principally in the armored company headquarters, which has more drivers, mechanics, radio operators, and mess personnel.

c. The bridge company includes headquarters and two identical bridge platoons, each having a headquarters, a float section, and two identical fixed sections.

287. Equipment

With respect to equipment, the principal differences between the divisional combat battalion and the armored battalion are the following:

a. The armored battalion has a little more heavy construction equipment and considerably less material hauling transportation.

b. The armored battalion is partially equipped with tracked vehicles, used for carrying squads with their tools into close proximity with the enemy.

c. The armored battalion is equipped with two sets of widened steel treadway bridging.

288. Employment, General

a. Typical missions of the armored engineer battalion include—

(1) Performing engineer and tactical reconnaissance.

(2) Building, repairing, and maintaining roads, fords, ferries, floating and fixed bridges, landing strips, obstacles, and specialized defensive installations.

(3) Assisting the movement of armor over difficult terrain and through obstacles.

(4) Executing demolitions.

(5) Laying, breaching, and clearing minefields, either alone or in cooperation with other units.

(6) Assisting in tactical river crossings and the assault of fortifications.

(7) Providing engineer supply service for the division.

b. Elements of the armored engineer battalion are frequently attached to combat commands, the remainder of the battalion being held under battalion control in support of the division. A typical attachment to a combat command would be an armored engineer company, a platoon of the bridge company, an engineer reconnaissance team, and water supply personnel. Effort is made, in these attachments, to follow the rule of habitual association.

c. In an attack, the principal task of the attached engineers is to keep their combat command moving. They must be kept well forward in the moving columns, and must be trained to the utmost efficiency and speed in installing and operating bridging and ferries, clearing obstacles, and similar tasks.

d. A combat command staff engineer is often designated by the battalion commander to accompany a combat command, in addition to the company officers of the attached engineer elements; especially if more than one engineer company is attached to the command. He functions as a staff engineer for the combat command and also as commander of the attached engineer troops, permitting company officers to concentrate on their own operations.

e. While attachment of engineer units at combat command level is frequent, they should not be broken up by numerous fragmentary subattachments, which greatly reduce their effectiveness.

289. Planning

a. Armored action involves long road spaces, close timing, and elaborate measures for the supply of fuel, lubricants, and ammunition and for the maintenance and repair of tracked vehicles. It also requires careful communications plans, based on radio. Planning at all levels in the division, before a major operation, must be careful, deliberate, and detailed. This applies especially to the armored engineer battalion. On the other hand, once the operation has begun, engineer operations are characterized by speed, flexibility, and improvisation.

b. Reconnaissance is a vital element of armored operations. Engineer reconnaissance is a function of the intelligence section of battalion headquarters.

290. Bridging

a. The mobility of armor, its ability to penetrate deep into enemy territory, and the habitual use of combat commands, all require that there be ample bridging in the division. Elements of the bridge company are normally attached to each combat command, and must be kept well forward in an advancing column ready for instant service. Delay in getting armor across rivers or similar obstacles must be avoided at all costs, on account of its vulnerability when halted.

b. Bridging which has been installed and has served its purpose may be dismantled by the bridge company and returned to stock, provided the bridge site remains in the division's area of operations. If the bridge is to be left behind, the company replenishes its stock by drawing replacement equipage from an engineer depot. Dismantling of the bridge then becomes a corps responsibility, normally handled by an engineer battalion of the corps engineer combat group.

c. In terrain where little or no bridging is needed, the bridge company may be used to haul liquid fuel, ammunition, water, or other needed supplies.

291. Battalion in Defensive

When the armored division adopts a defensive role, the armored engineer battalion has the usual responsibilities with respect to such matters as supply, obstacles, and organization of the ground. However, principal emphasis is likely to be on reconnoitering and preparing routes for counterattacks to be launched by the reserve armored elements stationed in rear of the defensive system.

292. Future Theaters

American experience with armored engineers in battle has been principally in western Europe, which has an excellent road net, and at a time when we had air superiority. These conditions may not obtain initially in a future theater, in which case the responsibilities of the armored engineer will be increased accordingly.

Section II. AIRBORNE ENGINEER BATTALION

293. General

The airborne engineer battalion is organic to the airborne division, which is the basic large unit of the combined arms organized, equipped, and trained for the conduct of airborne operations. See FM 57–30 and FM 57–20.

294. Mission

The mission of the airborne engineer battalion is to increase the combat effectiveness of the airborne division by general engineer work. See FM 5-132 for details.

295. Organization

a. The elements of the battalion are headquarters, headquarters and service company, three airborne engineer companies, and a medical detachment.

b. Battalion headquarters, and headquarters and service company, in general resemble those of the engineer combat battalion, divisional, but in the airborne unit are somewhat larger.

c. Airborne companies, like divisional combat combat companies, are organized into company headquarters and three identical platoons, each consisting of a headquarters and three identical squads.

296. Equipment

With respect to equipment, the principal differences between the divisional combat battalion and the airborne battalion are the following:

a. The construction equipment of the airborne battalion is in some cases lighter.

b. The airborne battalion has considerably less materials-hauling transportation.

c. The bridge platoon of the airborne battalion is equipped with aluminum deck balk bridge, which is used to erect fixed bridging on the steel trestles provided with the set or some other intermediate support, or an abutments only. It is air transportable. The platoon also has assault boats.

297. Employment, General

a. Typical missions of the airborne engineer battalion include—

(1) Performing staff planning of engineer operations within the division, including that

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required for the operations of attached engineer troops.

(2) Conducting engineer reconnaissance.

(3) Constructing, repairing, and maintaining roads, fords, culverts, bridges, obstacles (including minefields), landing strips, command posts, shelters, and defensive installations.

(4) Executing demolitions; placing and removing obstacles, including minefields.

(5) Providing engineer supply service for the division, including the establishment and operation of water points.

(6) Landing by parachute and aircraft, less certain mission items of heavy equipment.

b. In an airborne operation of division scale, an airborne company normally is attached to each regimental combat team for the initial assault. As soon as centralized control is established by a division, normally the airborne engineer companies revert to battalion control, providing direct support to each airborne infantry regiment. Headquarters and headquarters and service company normally land with division troops.

c. The functions of the engineer units, especially in the initial occupation of the airhead, are conditioned by certain factors peculiar to airborne operations:

(1) Equipment and transportation initially available at the airhead are limited.

(2) Losses, dispersal, and confusion may accompany the landing.

(3) The engineers may have to meet concurrent and pressing demands for engineer work

of an offensive and of a defensive character; and either or both may be interrupted by the need to fight as infantry.

298. Planning

The battalion commander's planning includes—

a. Reconnaissance and terrain studies.

b. Preparation of his own operational SOP and detailed loading and landing plans, including loading plans for engineer equipment.

c. Training of his command for the operation, including designation and training of the parachute elements.

d. Liaison with the combat teams to which elements of his command will be attached.

e. Liaison with troop carrier personnel.

f. Advice to the division commander in engineer matters, and preparation of engineer annexes and paragraphs of divisional orders.

299. Engineer Reconnaissance and Terrain Studies

a. Ground reconnaissance being impossible for an airborne operation, the engineer staff must rely on large-scale maps, air photographs, mosaics, G2 reports, agents in enemy territory, and visual inspection by air in advance of the operation. Except for the last item, such information must be furnished from a higher level, and the battalion has no direct preoperational reconnaissance responsibilities. It has the vital responsibility of studying carefully all information made available to it.

b. Thorough knowledge of the landing area is essential. A landing area study, which normally becomes a part of an intelligence annex, is developed. The landing area study contains details concerning—

(1) Drop zones.
(2) Landing zones.
(3) Existing airfields and airstrips.
(4) Potential airfield and airstrip sites.

300. Augmentation

If it is expected that an airborne operation will result in sustained and intensive fighting over a considerable period, or if for any other reason an exceptionally heavy engineer workload is likely, the airborne engineer battalion may be augmented by attaching additional airborne troops.

301. Echelonment of Engineer Battalion

For an airborne operation, the battalion is normally organized into three echelons:

a. Assault Echelon. This includes the bulk of the battalion, as follows: an airborne company (including parachute elements) less detachments, with each of the three combat teams, and battalion headquarters and headquarters and service company less detachments.

b. Followup Echelon. This includes heavy equipment and other items which are needed in the airhead, but not immediately, and which can therefore wait until they can be flown in, or otherwise transported, without interfering with more urgent demands on transportation.

c. Rear Echelon. This consists of administrative personnel, who are normally incorporated into a divisional administrative pool, and either held until the division returns or moved into the airhead after the situation has stabilized.

302. Engineer Supplies and Equipment

a. General. Because of weight limitations, the engineer supplies and equipment to be flown in are carefully scheduled. Only those required for the assault phase accompany the airborne elements in the combat and followup echelons of the operation. The battalion S4 must have immediately available all supplies required under the various sets of plans and alternate plans. The battalions S3 and S4 work together in planning for an operation.

b. Squad and Platoon Tools. Some of the squad and platoon tools may be dropped with the parachute element. The rest are brought in by plane.

c. Dozers. The dozers and some one-quarter-ton trucks have first heavy equipment priority. They are brought in on the first wave, fully fueled and ready to operate upon landing.

d. Trucks. Trucks are brought in immediately behind the dozers and the one-quarter-ton trucks. Trucks and their trailers should be loaded with mines, lumber, explosives, tools, and similar items, the precise loads depending upon the anticipated tactical need. They should be fueled and should carry a reserve of gasoline.

e. Replacements. Replacement supplies and equipment may come in by parachute, by aircraft, or over land or sea. Replacement by parachute is least efficient because of the dispersion of the parachutes, the greater breakage, the limited quantity per parachute, and the difficulty of recovering the scattered bundles.

f. Water-Supply Equipment. This is brought in during the first day, and put to use as soon as an acceptable water-supply source is acquired. Soon after landing, medical companies and detachments will require water, since they will bring with them only about a day's supply.

303. Engineer Missions After Landing, Parachute Elements

Parachute engineers are the first element of the battalion to land. Their potentialities, until vehicles and equipment begin to arrive, are somewhat limited, and their assigned missions should take this into account. Appropriate initial tasks include—

a. Removing obstacles on existing landing strips to be used by our aircraft.

b. Limited demolitions.

c. Hasty obstacle construction, including small minefields.

d. Neutralization, on a limited scale, of enemy minefields and prepared but unexecuted demolitions.

e. River crossings, using pneumatic or captured boats.

f. Expedient bridge construction and minor bridge repairs.

304. Engineer Missions After Landing, Other Elements

a. In the average case, the sequence of activities of the airborne engineer battalion, after the principal elements of the first echelon have landed, is likely to be about as follows:

(1) Assemble and collect transportation and equipment, and reorganize.

(2) Neutralize enemy-prepared demolitions, destroy enemy communications system, install essential antimechanized obstacles, and lay minefields, insofar as parachute elements have not done these things.

(3) Establish a water point, and open up any immediately vital routes of communication, including bridge repairs.

(4) Execute other engineering tasks, including additional work of the above mentioned categories.

b. However, due both to the possible confusion attendant on an airdrop and to the unpredictable nature of the enemy reaction, the precise sequence of engineer tasks cannot be anticipated in advance. The battalion commander's plans must be flexible, and he must be prepared to meet emergencies as they arise, if necessary by interrupting one task so as to undertake another which has become more urgent.

305. Construction of Airfields in Airheads

a. Unless an airfield already exists in an airhead and has not been seriously damaged, independent airhead operations will require that one be built. However, except for the initial preparation of landing areas for assault aircraft, the organic engineer battalion of the airborne division will be fully occupied in furnishing engineer support to that division. Therefore airfield construction in an airhead will be by nondivisional engineer troops, normally furnished by army. Construction equipment which is airdroppable is a requisite.

b. The Air Force will take over the responsibility for such airfields on the decision of the joint airborne task force commander.

306. Later Phases

As the situation stabilizes, the missions and tasks of the airborne division and of its engineer battalion approximate more and more closely those of an infantry division and its divisional combat engineers in normal ground operations. After the airhead has been firmly established, airborne units are either relieved to permit preparation for subsequent airborne assault or are directed to prepare for sustained ground operations.

Section III. ENGINEER SHORE BATTALION

307. General

a. The engineer shore battalion is a unit organized, equipped, and trained to perform engineer shore party functions in connection with a joint amphibious operation by our forces. It is organic to the amphibious support regiment, which in turn is organic to the amphibious support brigade. Three regiments are in a brigade. The brigade, together with certain attached Army and Navy units, forms the shore party for an amphibious landing involving a force of one type corps reinforced, under average conditions. Its basic missions are to unload supplies and equipment; to provide for receiving, segregating, and safeguarding them when ashore; to maintain the security of the beach support area; and to evacuate casualties, prisoners of war, and other personnel as directed.

b. For full details of the battalion and its operations, see FM 5–156.

308. Amphibious Operations, General

a. Amphibious operations may be classified as *shore to shore* or *ship to shore.* In the former, all or most of the landing force is carried from the point or points of embarkation to the point of landing in landing ships, craft, and/or vehicles, without transsphipment. Range is limited by the ranges of the vessels used. In a ship-to-shore operation, the landing force is carried most of the way in seagoing ships and then transhipped to landing vessels. The tactical crossing of an unfordable stream (see ch. 14) is a form of shore-to-shore operation.

b. Amphibious operations may also be classified as *seizures*, *raids*, or *invasions*. A *seizure* is a limited-objective operation to capture and hold a small area—for example, an island or port—as an end in itself. If successful, it is completed in a short time, normally using only the force with the initial expedition. In the case of an *invasion*, on the other hand, the securing of the beachhead which is the initial objective is merely a prelude to a major campaign in a large area inland from the beachhead. Such an operation is lengthy, and involves much larger forces than those in the initial expedition. A *raid* is an operation, usually small scale, involving the temporary seizure of a limited objective. It ends with a planned withdrawal upon completion of the assigned mission.

c. The planning and conduct of an amphibious operation differ radically according to whether or not enemy resistance is expected. This manual deals only with the case where opposition is expected.

d. The main phases of an amphibious operation, from the viewpoint of the amphibious support brigade and its component engineers, are—

(1) Preparation of plans, and the assembly and training of the force.

(2) Near-shore engineer activities.

(3) Loading and embarkation.

(4) Initial debarkation.

(5) Organization and development of the beach support area.

(6) Transition to base operations.

309. Engineer Shore Battalion, Organization and Equipment

a. The battalion consists of a headquarters, headquarters and service company, and three identical engineer shore companies. It has no organic medical detachment, but looks to the amphibious support regiment for medical service.

b. Battalion headquarters, and headquarters and service company, are much smaller and less elaborately organized than those of an engineer combat battalion, divisional. There is a combined administrative and supply section, an operations section which also performs any required intelligence functions, a communications section, an equipment section, and a maintenance section. All these are smaller than their prototypes in the divisional battalion, except the communications section, which is larger.

c. A shore company is organized quite differently from a combat company of the divisional engineer battalion. It includes company headquarters, a good-sized communications section, a strong equipment repair platoon which includes drivers and operators, and two identical shore platoons each consisting of a headquarters and three identical shore sections. It is about 40 percent larger than the divisional combat company.

d. With respect to equipment, the principal differences between the shore battalion and the divisional combat battalion are as follows:

(1) The shore battalion has fewer dump trucks, but has tractor trucks and amphibious trucks.

(2) The shore battalion has no bridge equipage.

310. Employment, General

Typical missions of the engineer shore battalion include the following:

a. Preparing and executing embarkation plans as an element of an amphibious force.

b. Performing, when suitably reinforced, shore-party work during a joint amphibious operation, in support of one reinforced infantry division operating either alone or as an initial element of a corps landing operation.

c. Performing shore-party work in support of one regimental combat team in a shore-to-shore operation. Suitable augmentation from other elements of the amphibious support brigade is required.

d. Performing general engineer work in developing, improving, and expanding an organized beach support area.

e. Fighting as infantry in defense of the beach support area.

311. Intelligence

Precise and detailed data are needed for the engineer and other planning involved in an amphibious operation. They are obtained from air photographs, charts, meteorological and other scientific records, intelligence agents, scouts secretly landed at debarkation points, and other sources. Most of this material comes to the shore battalion from a higher level, except as its personnel may inspect the landing area from the air. Specific points to be covered include the following:

a. Beach conditions, including gradients, offshore bars, firmness of sand, and terrain immediately inshore from high-water mark.

b. The terrain and road net behind the beach.

c. Hydrographic data, including depths offshore, tides, currents, surf, natural obstructions, and anchorage areas.

d. Weather forecasts for the period of operations, and weather records in the past.

e. Enemy defenses, with special reference to antiboat obstacles, minefields, and organized defenses on and close behind the beach.

f. Enemy capabilities.

g. Engineer materials and civilian labor locally available in the debarkation area.

h. Similar data for such other areas, adjacent to the approved landing area, as are to be studied on the assumption that the point of landing may have to be changed at the last moment, due to enemy disposition, stress of weather, navigational errors, or similar causes.

312. Planning

a. General. Battalion planning starts with a careful analysis of what must be done after landing—the "far-shore mission." Based on this the commander and his staff develop, in reverse sequence, the training, loading, and landing plans to meet the far shore requirements.

b. Landing Plans. These include plans for—

(1) Removing or breaching obstacles which interfere with landing and efficient unloading.

(2) Construction of unloading facilities and an elementary road net.

(3) Cargo handling.

c. Beach Organization Plans. These include plans for—

(1) Installing and maintaining adequate communications, including radio, wire, and messenger.

(2) Establishing and operating engineer supply points and dumps, including water points.

(3) Traffic control.

(4) Security measures, to include beach support area defense.

(5) Progressive development of the beach support area.

d. Alternate Plans. These must be prepared to take account of such possibilities as heavy losses of key men and equipment, change in landing area, and unexpectedly strong enemy reaction.

e. Loading Plans. Loading plans are prepared with great care and in the utmost detail, using standard forms. Those prepared by unit commanders include unit personnel and tonnage tables, vehicle summaries and priority tasks, cargo and loading analyses, and cargo manifests. Those prepared by loading officers, and issued as annexes to embarkation orders, include consolidations of these unit tables, and also stowage diagrams and profile loading diagrams.

f. Rehearsals. An amphibious operation is normally preceded by careful rehearsals, participated in by the battalion as one of the elements of the expedition.

313. Augmentation

Depending on the nature of the landing area, enemy capabilities, and other peculiarities of the operation being planned, the amphibious support regiment may need to be augmented in both equipment and personnel.

a. Additional equipment to be considered may include "Navy cube" pontoons (ch. 21), bridging, prefabricated road material, bulldozers, cranes, roller conveyors, sandbags, and communications equipment.

b. Additional personnel to be considered may include elements of an engineer light equipment company, of an engineer combat battalion, of a Navy beach group, of quartermaster service companies, or of Transportation Corps elements of the amphibious support brigade.

314. Security

Rigid security measures are enforced in the planning period. In the average case, the enemy is likely to know that an amphibious operation is being prepared. However, there are three vital items of information which it is especially important to conceal. In order of importance, these are the exact landing area; the date of landing; and the size and composition of the expedition.

315. Near-Shore Activities

If embarkation is not from an organized port, the engineer shore battalion may be called on for considerable amounts of preembarkation work, including such items as—

a. Construction of roads causeways and ramps, hardstands for vehicles and for supplies in open storage, and of elementary covered storage.

b. Layout and preparation of assembly areas and "slots." A slot is a stretch of beach earmarked for the beaching of a particular landing vessel, or of the lighters designated to load a particular seagoing ship. Behind each slot is the assembly area for vehicles and personnel earmarked for that vessel or ship. The terms are also used in the case of lighters and vessels loading at berths of regularly equipped ocean terminals.

c. In coordination with the Navy beach party, assistance in marking embarkation beaches, and in selecting points for the loading of landing craft and of lighters used in load seagoing ships.

d. Supervision and assistance in ship and craft loading.

e. Establishment of regulating points, and the provision of adequate communications, to insure the orderly flow of supplies, equipment, and personnel.

f. Provision of craft control and communications, via the beachmaster.

g. Assist in loading convoys and cargo according to a reverse unloading priority.

316. Loading

a. The shore battalion, like other units of the expedition, is reorganized before embarkation. Certain personnel and items of equipment are left behind. The rest are distributed among the vessels assigned to the battalion, or other vessels of the landing force, with due regard to the landing priorities of the various elements. Care must be taken that the loss of any single vessel will not deprive the battalion of all the personnel or equipment needed for any essential activity.

b. An officer is assigned to each vessel as embarkation team loading officer. He prepares a detailed loading plan for vehicles and personnel, subject to Navy approval. The vehicles and personnel should be at the designated assembly area, arranged in prescribed loading priority, when the vessel or lighter arrives in the slot. Careful scheduling is needed to avoid either delays in loading or the needless holding of troops in assembly areas. A good communications net is essential.

c. In spite of the most careful planning, some last-minute adjustments will probably be needed.

317. Initial Debarkation

a. A typical priority of landing of engineers and cooperating personnel is about as follows:

(1) Shore platoon, obstacle clearance, reconnaissance, communications, and command elements.

(2) Naval beach party personnel for reconnaissance and other initial missions.

(3) Bulldozers and pioneer construction elements.

(4) Shore company reconnaissance personnel.

(5) Medical reconnaissance personnel.

(6) Additional operating personnel and equipment of shore companies and naval beach parties.

b. It is desirable that the headquarters of each shore party land at the same time as the headquarters of the troops which it initially supports.

c. Clearing or breaching of obstacles is a joint Army-Navy responsibility. Specially trained Navy underwater demolition units may be charged with clearing underwater obstacles up to high-tide level (ch. 11), or this may be handled by a Navy-engineer team. Elements of engineer combat companies normally clear lanes through the beach barrier system above high water mark for the passage of tactical vehicles and assaulting troops, and thereafter clear the beach of all mines and obstacles.

318. Missions of Shore Party After Debarkation

These include the following, not necessarily in the precise sequence given:

a. Reconnaisance to determine any changes in the previously planned layout of the beach support area.

b. Installation of beach markers and location of landing slots.

c. Establishment of an adequate radio net and other elements of a communications system.

d. Location and initial improvement of beach exit roads axial to the beach support area, and of a lateral road.

e. Location of initial installations, including CP, water points, dewaterproofing and emergency maintenance stations, dumps, hospital and PW areas, bivouac areas, and vehicle parks.

f. Organization of an efficient system of unloading, lighterage, stevedoring, and beach defense, and the disposition on shore of stocks of supplies.

g. Establishment and enforcement of a traffic-control system.

h. The progressive and systematic development of the beach support area and its routes of communication.

319. Development of Beach Support Area

Figure 14 shows, schematically, a typical beach support area shortly after the initial debarkation of the amphibious expedition, and the same area some days later, after it has been organized and developed and a perimeter defense has been installed.

320. Transition to Base Operations

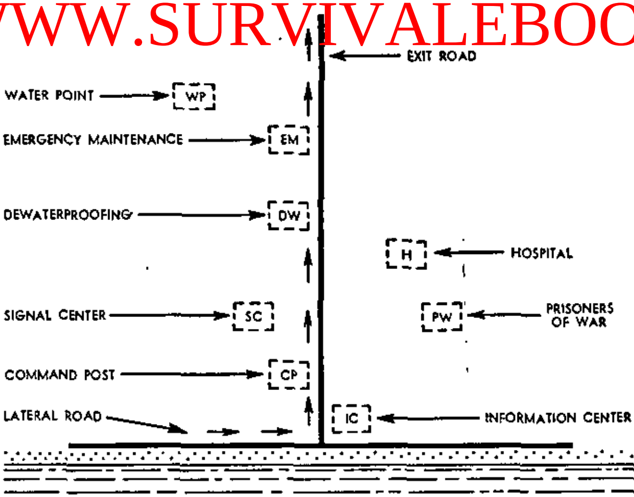
a. In an amphibious landing preliminary to an invasion, the assault phase terminates when our troops have established themselves in an area large enough for the orderly deployment of the invading forces. At about this time, the regular logistical organization which is to support the invading force normally takes over control of the beach support area. That area may be developed into a full-fledged base port, or alternatively the invading forces may capture and base themselves on one or more existing ports, and the original landing area may be abandoned.

b. At some stage in this process, the amphibious support brigade is likely to be withdrawn, and the expansion and operation of port facilities taken over by other agencies.

Section IV. ENGINEER COMBAT BATTALION, ARMY

321. General

The engineer combat battalion, army, is in many respects quite similar to the engineer combat battalion, divisional. The principal differences in organization, equipment, capabilities, and utilization are given briefly below.



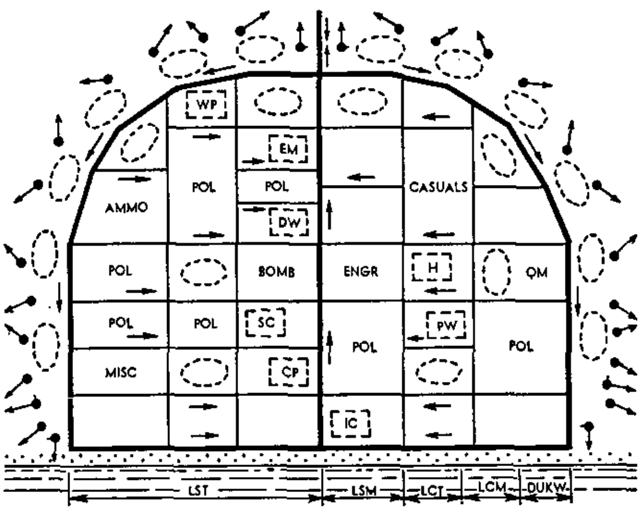


Figure 14. Progressive development of division beach support area (schematic). (Top is the initial phase, bottom is the final phase.)

322. Organization

a. General. The battalion is organized into a headquarters, headquarters and service company, medical detachment, and three combat companies, in place of the four combat companies of the divisional battalion.

b. Headquarters and Headquarters and Service Company. The army battalion lacks the division engineer section and the bridge platoon found in the divisional battalion.

c. Combat Companies. The combat companies of the army battalion have the same organization as the divisional combat companies, being formed into a headquarters and three identical combat platoons each having a headquarters and three identical combat squads.

323. Equipment

With respect to equipment, the principal differences between the two units are that the army battalion has no organic bridging, considerably less construction equipment than the divisional battalion, and only about two-thirds as much materials-hauling transportation.

324. Employment, General

a. The battalion is normally an element of an engineer combat group. The group may include several such battalions, bridge companies, a dump-truck company, and a light equipment company. Thus, while the army battalion of itself is considerably less powerful than the divisional battalion, the group of which it ordinarily forms a part can handle a much greater number and variety of engineer tasks.

b. The battalion is of the "combat support" category. It may be employed, either on general engineer work in the corps or army service area, or in combat operations with divisional troops. In the latter case it normally remains under group command, in general or direct support of a division.

c. On the average, an army battalion spends more of its time on road and bridge work than does a divisional battalion, and less on pioneer work (organization of the ground, tactical demolitions, obstacles, and the like) and on the laying and removal of minefields.

325. Combat Support Activities

For the battalion on combat support duty in general offensive and defensive operations and in tactical river crossings, see chapters 10, 11, and 14.

326. Combat as Infantry

During World War II, in Europe, army battalions engaged in combat as frequently as divisional battalions. The army battalion has the same types of weapons as does the divisional battalion, although somewhat fewer, and is fully trained in their use. The procedure of reorganizing it for combat is in general the same as with the divisional battalion.

CHAPTER 14

TACTICAL RIVER CROSSINGS

Section I. GENERAL

327. General

a. A tactical river crossing is the crossing, by a ground force, of an unfordable river which is without usable bridges and whose far bank is held by the enemy. Usually the mission is to seize and hold a bridgehead as the preliminary to a general advance. It is a specialized form of offensive combat, differing in various respects from other types of ground attack. The chief differences are—

(1) A greater requirement exists for special equipment and specially trained personnel.

(2) Command and control of units must be very detailed, owing to space, traffic, and communications restrictions.

(3) Tactical courses of action are severely limited.

(4) Once our forces and equipment are committed to action, withdrawal or deviation from the initial plan of action is difficult or impossible.

b. For details not covered in this text, see FM's 31–60, 7–10, and 7–40.

328. Types of River Crossings

Tactical river crossings are commonly classified as "deliberate" and "hasty." The precise distinction is not always understood.

a. If an alert and efficient enemy holds the far bank of a river strongly, with a force which can place artillery and small-arms fire on all practicable crossing areas and can organize a counterattack against any troops which do cross, the operation must be a *deliberate tactical* crossing.

b. If no enemy is present, the crossing is not *tactical* as the term is here used, but reduces to such technical problems as installing ferries and bridges and controlling traffic during the crossing.

c. A situation between these two extremes is appropriate for a *hasty tactical* crossing. It may arise, for example—

(1) If the opposition is merely a "nuisance force" which can be brushed aside by crossing a small infantry unit in boats or ferries.

(2) If the enemy has no artillery or heavy weapons, and can be kept down by fire until a fair-sized infantry or armored contingent can be crossed to deal with him.

(3) If the enemy, although present in force, is disorganized, ill-prepared, and not on the alert, as in a retreat, and if a crossing can be forced prior to his reorganization.

d. It follows that, while fairly clear-cut principles of general application can be laid down for a deliberate crossing, this is not true of a hasty crossing. It may be said that the latter operates on the principles of the former, *minus* those aspects which the situation and the judgment of the commander indicate to be needless.

e. This chapter deals chiefly with deliberate crossings. It is, however, to be emphasized that a hasty crossing is always the more desirable type, and the one to be sought if conditions permit.

329. Elements of the Operation

a. The elements of a tactical crossing are—

(1) Planning, including reconnaissance, special training, and rehearsals.

(2) The advance to the river.

(3) The assembly and preparation for crossing.

(4) The assault.

(5) Advance on the far bank.

b. Normally, three successive objectives are to be attained on the far bank, although two or all three may coincide. They are—

(1) *First objective.* A position which will eliminate the enemy's direct fire on the crossing front.

(2) *Second objective.* A position which will eliminate the enemy's observed fires on the selected crossing sites.

(3) *Third objective.* A position which will eliminate the enemy's effective sustained fires of ground weapons on the selected crossing sites and will provide enough space on the far bank for maneuver of the command.

330. Time of Crossing

The crossing may be either secret, usually under cover of darkness, or preceded by an artillery and/or air bombardment, usually in the daytime. Each has its advantages and disadvantages, and the choice depends on various factors, including need for concealment, state of training of our troops, nature of the terrain, characteristics of the river, enemy dispositions and capabilities, and the need for speed. A dawn or daylight crossing is generally better with inexperienced troops. In either case, the planning and initial movements must be conducted with the utmost secrecy.

331. Forces and Equipment Involved

a. A crossing may be an army, corps, division, or task-force operation. Quite commonly the crossing mission is assigned to a corps, with such air and ground support as are required.

b. The assault force may be considered as consisting of five basic echelons, respectively the *assault*, *fire-support*, *engineer*, *followup*, and *rear* echelons. This functional grouping is merely for planning purposes and convenience of description, and the terms do not correspond to any command or operational control.

332. Engineer Forces

The engineer forces involved in a corps crossing, in which one infantry division makes the initial assault, normally include the divisional engineers and one corps engineer combat group in support. If more than one division is involved in the initial assault, a group is needed in support of each. A representative organization, for a group assigned such a mission, includes group headquarters, three or more engineer combat battalions, army, a panel bridge company, a float bridge company, a ponton bridge company, a dump-truck company, and a light equipment company. More bridging units may be added if the width of the river requires them. Additional engineer support from army may be needed because of special characteristics of the crossing area or nature of enemy resistance; if so, such elements are attached to the corps engineer combat group. The foregoing correspond, for the most part, to the "engineer echelon" as the term is used in paragraph 331, but certain engineer elements are commonly spoken of as parts of the assault and followup echelons.

333. Engineer Equipment

The physical means of crossing the river include standard equipage assault boats, rafts, footbridges, floating bridges, and fixed bridges. Storm boats are sometimes used instead of assault boats. Such equipment is in general included in the organic equipment of the engineer units supporting the operation. If this is insufficient, it may be supplemented from army depots.

Section II. PLANNING

334. General

Plans for a deliberate river crossing must be developed in great detail. In view of the interrelation of the various phases of the operation, and the close cooperation among different arms required at all levels, planning must be characterized by close liaison, and each headquarters must be constantly informed of the plans and activities of higher, lower, and adjacent headquarters. *Secrecy in planning is vitally important.*

335. Engineer Missions

The general mission of the engineers is to furnish engineer support to the assaulting troops before, during, and immediately after the crossing. This may include—

a. Construction, maintenance, and repair of road nets and routes of communications.

b. Removal of mines and other obstacles.

c. Construction of near-bank ferry and bridge approaches.

d. Operation of assault boats, or on occasion storm boats.

e. Construction of footbridges.

f. Construction and operation of ferries.

g. Installation of vehicular bridges, floating and fixed.

h. Construction of far-bank exits.

i. Construction of bridge protective devices.

j. Construction of dummy bridges.

k. General engineer work, including water and map supply, miscellaneous engineer supply, camouflage, and demolitions.

336. Employment of Engineers

The employment of the engineers is determined by the mission of the assaulting force, the availability of engineer troops and equipment, and the characteristics of the water obstacle. The division engineer is responsible for the technical plans for crossing his division. He determines the engineer assistance required, and works closely with supporting engineer unit commanders in coordinating engineer support for his division crossing. Engineer commanders responsible for specific tasks control the necessary engineers. Plans include arrangements for advance engineer parties to do the following: make early reconnaissances, complete the detailed reconnaissance of the crossing site, and start preparatory work, all within the limitations imposed by secrecy.

337. Allocation of Engineers

a. Integrity of units and the preservation of habitual association are especially desirable with this type of operation. With respect to an assaulting division, and especially to the elements thereof which make the initial crossings and conduct the initial operations on the far bank, it is in principle desirable for the company of the divisional engineer battalion which is normally associated with an assaulting infantry regiment to support that regiment in the assault boat and footbridge phases, and thereafter give it far-bank support. As far as practicable, this is done.

b. However, there may not be enough divisional engineers for all these direct support tasks, especially if the divisional crossing involves the simultaneous use of several assault infantry battalions. Assistance from corps engineer units will then be required in this field. The decision on what tasks to assign to them, from among those normally the missions of the organic divisional engineers, will depend on conditions and require careful thought. In making the decision, it must be remembered that engineer losses in the initial assault operations may be heavy, necessitating the possible initial retention by the division engineer of a considerable reserve. This in turn may further reduce the number of organic engineers initially available for direct support.

c. In principle and with the above qualifications, nonorganic engineers should be allocated such tasks as the installation or erection of fixed and floating bridges, road work, and the taking over of rear-area tasks from the divisional engineers, initially on the near bank, and progressively on the far bank as the attack advances. A reserve under the corps engineer is also important.

338. Control of Engineers

a. The division engineer retains his role in a river-crossing operation. His knowledge of the procedures and capabilities of the divisional units and the division method of operation make him the engineer who can best recommend the location, employment, and strength of the engineer support.

b. Divisional engineer troops accompanying the assaulting infantry may be either in direct support or attached, attachment terminating at some time after all or most of the division has crossed. Corps engineer troops (if any) engaged in crossing the assaulting infantry are normally in direct support, remaining under the orders of the engineer group commander. Corps engineer units on rear-area work, bridge work, and the like remain under group command in general support.

c. The corps engineer is normally present in person at the operation, and supervises all engineer activities connected with the crossing.

339. Crossing Sites

a. The general location of the crossing is determined by higher authority, based on such considerations as the location, strength, and dispositions of the enemy, the road net, and the adaptability of the terrain on the near side of the river to advancing and assembling our forces under cover. Engineer needs and reconnaissance play an important part in the selection. In general, a stretch of river suitable for a crossing should have the following features:

(1) Undefended crossing points if possible.
(2) Good avenues of approach to the crossing points on the near shore, and of advance to the chosen objectives on the far shore.
(3) Dominating ground on the near shore for support of the attack by overhead fire and artillery observation.
(4) A salient toward the attacker.

b. Within the limits thus set, and having regard to location of assembly areas, location and direction of the main effort, and similar factors, precise sites must be selected for crossing by assault boats, foot-bridges, rafts, and bridges.

c. Common characteristics for any such crossing site include a gentle current near each bank (more usually found in a straight reach of the river than in a sharp bend); banks not so high or steep as to need excessive grading; approaches firm and not too densely overgrown; stream free from snags, sand-bars, or rocks; absence of a divided channel with intervening islands.

d. An assault-boat site, in addition to the items listed above, should have routes from the assembly areas practicable for foot troops and for carrying the boats; cover near the bank; and a usable stretch of river long enough to launch and load the required number of boats simultaneously, without confusion or interference.

e. A raft crossing site, in addition to the items listed above, should have a site for a short and easily constructed access road, cover, and concealment on both shores, a covered route of approach to the far bank assembly area, and water at both banks deep enough to float the loaded rafts.

f. A footbridge site, in addition to the items listed above, should have covered routes of approach on both sides, natural anchorages for cables, and an area on the near bank for unloading and assembling the equipage.

g. A floating bridge site, in addition to the items listed above, should permit the installation of short and easily built access roads which will support the heaviest vehicles and will tie to the road nets on both banks; existing or easily prepared areas suitable for assembling crews and equipment; a river current parallel to the banks; and a stream bottom in which anchors will hold but not foul.

340. Detailed Plans for Initial Crossings

a. In the crossings by assault boat and raft, the infantry units must be broken down into contingents small enough for a single boat or raft, and each must be accompanied by a detachment of engineers. The final sorting out of infantry and engineer detachments must be accomplished in the attack positions, often in the dark, and with a minimum of delay, noise, or confusion. This calls for careful planning and preparation at all levels down to squads. Assignments of parties, by individuals, are made in advance; the individuals concerned are made acquainted with each other; and careful plans are made for the times and places of meeting in the attack areas. The infantry soldiers in the assault boat waves are trained in carrying, launching, loading, and unloading the boats, and in helping to maneuver them. Detailed loading plans and priorities must be worked out for the assault boat and raft crossings.

b. Since confusion, delays, or unexpected casualties at the last moment may always prevent the formation of parties in the attack areas precisely as planned, infantry and engineer officers must be ready to improvise alternative plans.

341. Deception

Deception is one means by which the attacker achieves surprise. Every effort is made to conceal the exact time and location of the crossing from the enemy. Surprise is achieved by speed; concealment; use of feints, demonstrations, and dummy smoke-screens; careful timing; and communications security. These remarks apply to all participating troops. Specifically, engineer measures may include camouflage supervision, and the construction of dummy bridges as an element of a feint.

342. Engineer Supply

a. A reserve of engineer equipment is necessary to insure that the vital river crossing means are kept in operation. Although the engineer combat groups supporting the divisions should have more bridging material in their organic equipment than is required for the construction of the bridges which are planned, adequate material should be placed near the bridge sites to maintain them after they have been constructed, and to replace material sunk or damaged by enemy fire during construction. This will prevent the organic equipment of the engineer groups being dissipated in maintenance operations. Corps G4, after conferring with the corps engineer, should arrange with army G4 for the establishment of such engineer bridge dumps.

b. In a hasty river crossing especially, full advantage should be taken of locally available material to supplement organic crossing means. Captured river boats and barges can be used to assist in ferrying operations. Partially demolished bridges can be made usable by short spans of organic bridging, or by timber and other construction materials found nearby.

343. Engineer Regulating Point

This is a point at which a responsible engineer headquarters exerts technical control to insure proper use of the river crossing means. The headquarters normally exercises such control by informing the traffic control headquarters of the correct classification for each crossing means. Traffic control headquarters, in turn, issues instructions to the traffic control posts. Technical control includes—

a. Examining vehicles to detect improper loading with respect to technique, weight, or dimensions.

b. Recommending the rerouting or halting of certain traffic when technical difficulties make one or more of the crossing means inoperable or reduce their capacity.

c. Assisting the traffic control headquarters to maintain maximum traffic density.

344. Engineer Reconnaissance and Intelligence

The general principles of chapter 5 apply. Information is especially sought on the following:

a. General. Roads, trails, and natural routes of approach; minefields and other natural and artificial obstacles; terrain features and cover; concealed locations for engineer equipment parks, supply points, and dumps, and for engineer troop units;

structures and artificial installations of all sorts; and engineer construction materials, including any boats or other equipment which might be used to supplement standard crossing equipage.

b. River. Width, depth, and current velocities; cross currents and undertow; shoals, snags, rocks, islands, and sandbars; character of bottom; height, slope, and character of banks; soil and drainage conditions near the banks; present and probable river states, liability to flooding, frequency and height of floods; liability to floating ice and driftwood; fordability by troops and vehicles, and by animals if any; crossing means such as bridges and ferries; demolished bridges; mines and underwater obstacles; wrecks in the river; enemy capabilities of producing floods or inundations by release of water from upstream dams or reservoirs, or by blocking the flow downstream; and suitable assault boat, raft, footbridge, floating bridge, and fixed bridge sites.

c. Combined Reconnaissance. After the divisional plan is completed and zones of action are assigned to infantry regiments and battalions, a coordinated reconnaissance is made by officers of the infantry and of supporting engineer units, during which such details as those mentioned in paragraph 340 are worked out. Officers of other arms may also participate.

345. Rehearsals

Rehearsals of the detailed procedures of moving to assembly areas, the division of the assault force into crossing parties, the carrying and launching of boats, loading, and unloading, are normally undertaken in rear areas. Training open to enemy observation should be so located and conducted as to give no precise indication of what operation is being planned, or where.

Section III. CROSSING

346. Advance to River

During this advance, troops are deployed in readiness for the crossing. The approach is on a broad front. Enemy strong points which must initially be bypassed are neutralized, and minefields and other obstacles are breached. Speed is highly important. If a retreating enemy is caught astride the river, or if bridges can be seized intact or quickly repaired by the engineers, it may be possible to convert the operation to a hasty crossing which can be promptly exploited. Engineers should check any such bridges for prepared but unexploded demolitions and neutralize them at once.

347. Assembly and Preparation for Crossing

a. Normally all troops and their accompanying vehicles assemble in the dispersed staging areas, and advance, when ordered, through the assembly areas to the river. All units should be moved into the dispersed staging areas in accordance with their mission in the crossing operation, regardless of their previous functions during the advance to the river.

b. Bridging and assault boat equipment is assembled in engineer equipment parks so that it can be checked, essential hasty repairs made, and if necessary the loads broken down and reloaded. Engineer troops who are to erect or man the equipment assemble concurrently.

c. Figure 15 is a typical layout of near-bank areas and routes involved in the foregoing.

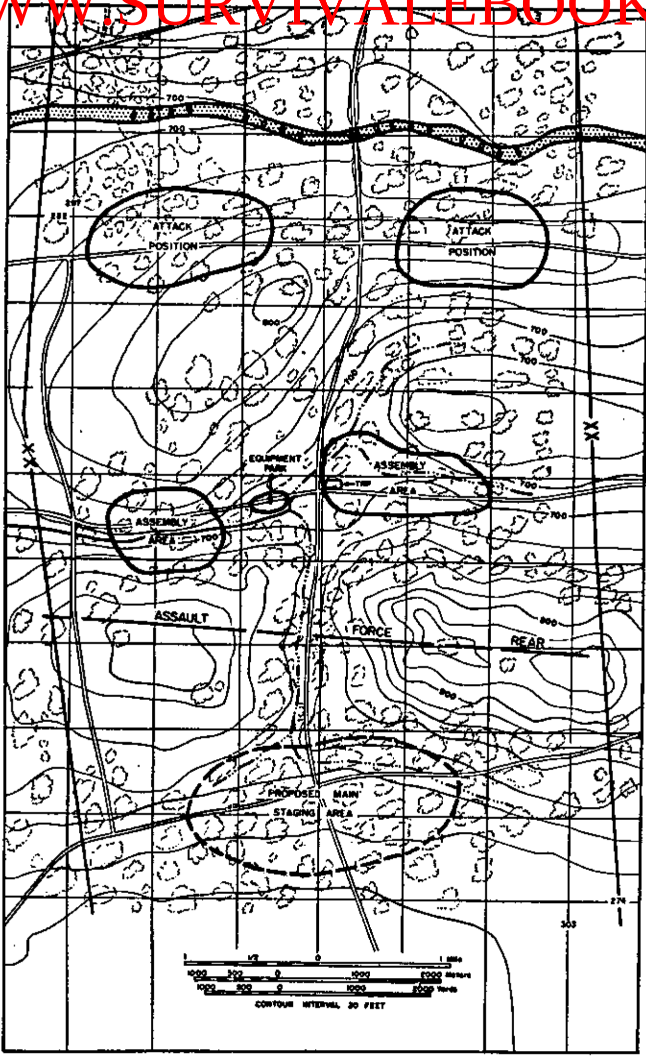


Figure 15. Preparation for a tactical river crossing: initial assembly areas, attack positions, etc.

348. Infantry-Engineer Cooperation

a. Engineers are assigned to specific boat groups before the infantry boat groups arrive at attack positions. The infantry must complete plans for the attack before leaving the assembly areas. Engineer guides meet the infantry boat groups at the attack position and lead them over a previously reconnoitered and marked route to the embarkation point.

b. Close cooperation is essential between infantry and engineers in the assault. In the assembly areas, engineer and infantry commanders confer to insure that routes, order of march, and entrances into the attack position are clearly understood. Engineer guides lead the infantry boat teams, with a minimum of delay and previously selected routes, to the correct locations. The senior infantryman in each boat team is responsible for the tactical employment of the team. The engineer boat commander is responsible for all aspects of the loading, crossing, and unloading of his boat; the senior infantryman is responsible for assisting him in these operations.

349. Initial Crossings

a. Boats are unloaded from transportation by the engineer crews and located either in the attack position or at an intermediate boat area between the attack position and the river. Engineer guides from the engineer assault boat teams meet infantry units as they enter the attack positions and guide them to their respective boats. Assault boats are hand carried by the infantry-engineer teams to the river. The boat carry should be as short as possible consistent with cover, concealment, security, and surprise. At the designated time, the first assault wave moves forward to cross the line of departure at H-hour.

b. As soon as each boat of the first wave is loaded, it is paddled across the river. No attempt is made to maintain alinement between boat groups. On arrival at the far shore, silence is maintained unless the enemy has discovered the movement and opened fire. After a boat is unloaded, the troops proceed to their predetermined assembly area, and the engineer crew paddles it back across the river and upstream to the crossing point.

c. Assault boats return to the near bank as soon as each trip is completed, to pick up subsequent waves. If an engineer boat group has sustained heavy losses in men or boats, it may need reorganization.

d. An infantry-support raft-ferry service is established at several sites along the crossing front.

e. Heavy rafts are constructed as soon as possible. They are used to ferry heavier vehicles, including armor, until vehicular bridges can be built. The tactical use of rafts continues at least until enough bridges are installed; they may also remain in use thereafter to supplement bridge traffic, evacuate wounded and prisoners of war, and move civilians.

350. Crossing by Footbridges

Footbridges are often a valuable supplement to other means of crossing in the early stages of the operation after hostile small-arms fire can no longer reach the river. They are best suited to relatively narrow and sluggish streams. They present poor targets to artillery or bombing planes, and allow units to cross more nearly intact than do rafts or assault boats. Their construction can be started concurrently with the assemblage of rafts.

351. Use of Storm Boats

These may be used instead of assault boats if speed of crossing is more important than secrecy. Storm boats hold fewer men than assault boats and are noisy, but they are fast. For use in a crossing, they are either towed in secretly by night and moored to the bank at the crossing point, under cover, or if this is impossible are carried close to the bank and concealed, ready to be launched at the moment of crossing. It is highly important that the motors be tuned up in advance, and that each operator know the peculiarities of his particular motor, so that there will be no delay in starting them. When the first wave is assembled at the river bank, the boats are launched (if necessary), loaded, and placed in position to start. At the direction of the crossing control officer, motors are started simultaneously, the boats cross to the other shore, are unloaded, and return for the next wave.

352. Clearing Mines and Obstacles

Mines and obstacles on the near bank, under water, and on the far bank are removed by clearing or demolition. Where deception is paramount, the underwater obstacles and far-bank mines and obstacles may have to be removed by special teams accompanying assault troops. As engineer resources are greatly strained during early phases of the operation, infantry teams may be assigned to the breaching of minor obstacles on both banks.

353. Installation of Floating Bridges

Construction of these, at as early a moment as possible, is of high importance for the rapid crossing of armor, artillery, and foot and motorized troops. Decision on when to start is normally made by the corps commander, based on the sometimes conflicting considerations of—

a. Possible failure of the attack if strong supporting elements do not cross soon enough.

b. Possible destruction of the bridge if it is started while the enemy can still place effective artillery fire on the construction site.

354. Fixed Bridges

The crossing operation of a large force is not usually considered as complete until one or more fixed bridges have been installed capable of carrying the heaviest military loads. Construction cannot ordinarily start until the assaulting force has attained and held the third objective. It should be started as soon as practicable thereafter, sometimes on the same day as the assault crossing. This requires that all plans be worked out in detail in advance, and that materials and transportation be assembled and troops designated for the task. Decision on when to start rests with the corps commander.

Section IV. SPECIAL ASPECTS

355. Airborne Movements

a. Regularly organized airborne units, including engineers, may be used in a deliberate crossing. Among their possible missions are: advance seizure of a bridge; establishment of an initial far-bank bridgehead; interception of enemy mobile reserves; capture of defended areas in the enemy's defense system; and seizure of important terrain features. For the operations of airborne engineers, see chapter 13.

b. It may be possible to use Army aircraft, especially helicopters, to transport infantrymen to the far bank and to evacuate casualties. Assault troops and equipment may be crossed by cargo helicopter units in a hasty crossing involving a lightly held river line. The possibility also exists of parachute drops of heavy equipment, including engineer equipment, into a bridgehead in advance of bridge construction and as a supplement to rafting.

356. Winter Conditions

The presence of floating ice complicates stream crossings. Assault boats are vulnerable to it and may be damaged or sunk if forced through it. Rafts may become unmanageable and footbridges unusable. The use of floating bridges requires special precautions. On the other hand, crossing on the ice is a possibility in the case of a solidly frozen river. See also chapter 26.

357. Swampy Areas

a. In some terrains, broad swampy areas exist on one or both sides of a river. Also, a swamp with deep water or bogs is itself a natural obstacle which may be used defensively by the enemy in the same manner as a river, and its tactical crossing becomes a variant of a standard river crossing.

b. Land movement through a swamp is normally limited to main routes of communications, which are often causeways. Standard or improvised engineer bridging is used to close gaps. Advance seizure of a causeway, before the enemy can destroy it, may be an appropriate mission for airborne troops or mobile ground troops with engineer support. Engineer floating equipment may be needed to supplement other means of traversing a swampy area, or to bypass a gap in a causeway.

c. The possibility of bypassing a difficult swampy area, rather than crossing it, should always be carefully canvassed.

358. Future Trends in Tactical River-Crossing Operations

a. The trend toward air transport may reduce the necessity for assaulting river lines on the ground.

b. The increasing range and mobility of artillery and other weapons will affect the selection of objectives.

c. The development of new types of multipurpose amphibious vehicles may decrease the requirements for standard river-crossing means.

d. The crossing of personnel, supplies, and vehicles by aerial ferry will aid materially in reinforcing the initial assault units.

e. Radioactive materials may be used to deny the use of desirable crossing sites, assembly areas, and approach routes.

f. Vehicles with improved cross-country mobility and low ground-bearing pressures may reduce our present dependence on a good road net.

g. Developments in the tactical employment of atomic weapons may bring about considerable changes in river-crossing doctrine and techniques.

CHAPTER 15

SECURITY

359. General

a. Security embraces all measures taken by a command to protect itself against enemy interference, surprise, and observation. Each commander is responsible for the local security of his command, regardless of measures taken by higher commands. Security measures are appropriate to the threat, and increase as the danger becomes greater.

b. Security may be active or passive. The former involves firepower and the use of troops; the latter, such measures as observation, cover, dispersion, and the use of obstacles. Normally a combination of active and passive measures is used.

c. The mission of security detachments is to protect against surprise attack and observation by hostile ground and air forces, and to maintain freedom of action for the command by gaining the time and space required to make proper dispositions to meet a threat. The detachments are kept to the minimum strength needed to accomplish these missions. They should retain tactical unity, and should be at least as mobile as the enemy forces with which they may have to deal.

d. Adequate and timely information is the basis of all security measures. It is vital to have an efficient warning service, including observers and means of communication, to give prompt notice of any threat from organized enemy ground or air forces or guerrillas.

e. For further details, see FM 100–5.

360. Engineers With Other Troops

Engineer support of security measures taken by a force of mixed arms is covered elsewhere in this text, as indicated below, and will not be further dealt with here.

a. For engineers with an advance guard, see chapter 10.

b. For engineers as an element of an outpost of covering force, see chapter 11.

c. For engineers with a rear guard and in a retrograde movement, see chapter 11.

d. For engineer activities in the laying of minefields and in nuisance mining, see chapter 12.

e. For obstacles, see chapter 11.

f. For demolitions as a security measure, see chapters 11 and 24.

g. For camouflage, see chapters 11 and 25.

361. Security of Engineer Units, General

a. The measures taken by an engineer unit for its own security will depend on—

(1) Size and type of unit.

(2) Its location.

(3) Nature of its activities.

(4) The nature of the possible enemy threat—whether small-arms or artillery fire, bombing, minor or major ground attacks, airborne attacks, guerrilla action, or sabotage.

b. No part of an active theater of operations is immune against sudden enemy attack of some type. The need for security must always be present in any engineer commander's mind. It is an excellent form of mental training for an engineer officer, in charge of any theater activity, to imagine that the enemy has just taken some *specific* surprise action, which has done such-and-such *specific* damage to his personnel and to the work he is doing; and then to ask himself: what he could reasonably have done in advance to ward off the danger; and what he would now do to make good the damage and get on with the work.

c. On the other hand, the engineer officer who allows himself to become unduly preoccupied with the safety of his command, and to devote an undue amount of effort to security measures, is cultivating a negative and defensive habit of thought, and is thereby losing sight of his primary mission. It is far better to run some security risks than to fail in the essential task of the Corps of Engineers—namely, to support and serve the major combat arms.

362. Engineer March Security, General

An engineer unit moving on an independent mission provides its own security. This may be required for the front (advance guard), the flanks (flank guards or patrols), the rear (rear guards), during halts (march outposts), and against attacks from the air. Engineers usually move by motor, in which case their security detachments are also motorized.

363. Engineer Advance Guards

Security in front is provided by an advance guard. Its strength varies with the situation and location. Normally, in forward areas where contact with the enemy is possible, it should not exceed: for an engineer battalion, one company; for a company, one platoon; for a platoon, one or two patrols. In rear areas, unless there is reason to fear guerrilla activity, the strength is less.

364. Engineer Rear Guards

A rear guard, when one is required, is weaker than an advance guard unless there is danger of being overtaken by an enemy force. Under normal conditions of engineer employment, it will have only limited and local threats to guard against. When a retreating engineer unit is in contact with a strong enemy force, it is likely to be operating as part of the rear guard or covering force of a larger command. A possible exception is in a more or less disorganized retrograde movement in which an engineer unit is separated from its command and must look after itself. In such a case its operations resemble those of a comparable infantry unit (FM 7–40).

365. Outposts, General

a. A unit in camp or bivouac or occupying a defensive position, which must provide its own security against enemy ground action, does so by organizing a covering detachment known as an outpost. Its duty is to secure the main body against close observation and surprise by the enemy. It is so organized and disposed that it can deal with a minor enemy threat without disturbing the main body or forcing it to take action; and that, in case of a major threat, it can at least hold off the enemy until the main body can make orderly preparations for action.

b. The fully organized outpost of a large command is divided from front to rear into outguards, supports, and a reserve. For details of their composition, missions, and operations, see FM 100–5.

366. Engineer Outposts

a. General. Engineer units are rarely justified in establishing outposts as elaborate as those required for a large combat force, but the same basic principles apply.

b. Battalion Outpost. An engineer battalion in bivouac in a forward area, and required to furnish its own security, may need an outpost of the strength of a company. Ordinarily one company is so assigned, in the interest of tactical unity. (An exception to this might occur in the case of a battalion having to furnish unusually strong all-round security; in such a case, each of its companies might be assigned a sector, and required to designate a platoon or other detachment for outpost duty therein.) The outpost company will place outguards, will normally establish one or more supports, and may hold out a reserve.

c. Company and Platoon Outposts. An engineer company operating alone normally uses not more than one platoon on outpost duty. This platoon may establish a support and a line of outguards, or if it has to cover a wide sector may establish outguards only. An engineer platoon operating alone seldom uses more than one squad for bivouac security. If an outpost consists only of outguards, the main body functions as their support.

d. Aspects of Outpost Organization.

(1) The distances of outpost elements from the main body depend on terrain and the strength of the forces involved. The main body needs protection from effective small-arms fire, and time to assume a posture of defense if an attack occurs.

(2) Machineguns and antitank weapons are especially valuable in outposts. Close-in protection must be provided for all crew-served weapons; routes of withdrawal must be preplanned and reconnoitered by crews.

(3) Mines and minefields, wire entanglements, and road blocks are valuable elements of an outpost position from the defensive viewpoint, and are often so used. However, it must be remembered that they involve a good deal of time and effort to install, and that they may later involve additional time and effort to remove.

(4) To insure timely warning of enemy action, security elements must have means of rapid communication. Full use is made of radio, motor messengers, and visual signals.

367. Security of Engineer Work Sites

See chapter 18.

368. Partisans and Guerrillas, General

a. Partisans are individuals in the theater of operations, not members of the enemy's organized armed forces or regular espionage service, who are devoted to the enemy's cause and are prepared to work for it. Their organized activities fall into two general categories—

(1) Underground or clandestine activities such as passive resistance, sabotage, espionage, subversion, and propaganda. These are more commonly carried on in cities or industrial areas. (Partisan activities, for example, by so-called subversive groups, may also occur in our zone of interior and in a

period of technical peace. They are not considered here.)

(2) Aggressive action by armed and organized bands called guerrillas. These often separate in the open country where cover and concealment exist. Their operations are characterized by raids, ambushes, and attacks on our routes of communication and isolated units and installations. In an area where a well-organized partisan movement exists, "underground" activities and "guerrilla" activities may be coordinated by a central organization, which in turn is in contact with the enemy's armed forces and adapts its action to their needs.

b. Decisive action against organized guerrillas must be offensive. It calls for specially trained troops, intimate knowledge of the country, continuous pressure, unconventional tactics, emphasis on surprise, and a determination to capture or destroy the guerrilla bands. Engineers do not normally conduct such operations, though an engineer unit is likely to be an element of a mixed force having an antiguerrilla mission.

c. Pending such decisive action, isolated engineer units or detachments in a territory infested by guerrillas must take special precautions.

369. Nature of Guerrillas

a. Guerrilla bands know the territory and its inhabitants, and are expert in concealing themselves in the open and in hand-to-hand combat. They often have sympathizers among an apparently peaceful local population. They may be counted on to have agents who are ostensibly laborers, merchants, or other persons in friendly contact with our troops, and who gather information about our activities, installations, defensive dispositions, and habits of life.

b. Guerrilla attacks are characterized by surprise, stealthy approaches, sudden rushes, and an attempt to produce panic by loud cries and other frightening noises. They may also be characterized by atrocities against individuals and by other violations of the codes of civilized warfare and common morality. Night attacks, and attacks during periods of relaxation such as meals, are common.

c. Guerrillas are expert in sabotaging isolated installations. They are also expert in ambushes. They may combine the two, as by damaging a bridge and then preparing an ambush or booby traps for a detachment sent to repair it.

370. Security Measures Against Guerrillas

The precautions and countermeasures to be used by an isolated engineer command against guerrillas correspond to the nature of the threat.

a. Camps and Bivouacs. Guards must be posted at all times, including periods of rest and recreation. All-round protection is essential. At night, special precautions are needed. Guards must learn to keep themselves concealed, and patrols to move without noise. Barbed wire, readily removable A/P mines, and improvised alarm devices are valuable. Groups of local inhabitants of any considerable size must not be allowed near the bivouac except for an obviously legitimate reason or unless they are known to be friendly.

b. Installations. In the case of engineer installations where men are habitually working and valuable property is located, such as supply points and maintenance shops, similar precautions are observed. Local civilians working in such areas are subjected to rigid security checks. The entry of unauthorized persons is prohibited. Undue dispersion, either within an installation or as regards associated installations under common control, increases the danger of effective guerrilla action, although there may have to be a compromise between this aspect and the demand for dispersion against air attacks.

c. Working parties. The precautions discussed in chapter 18 must be strictly observed by engineer work parties, while working, while resting or eating, and while en route to and from the job. Men must have their arms always at hand. The officer or NCO in charge must have in his mind a plan of what to do in case of a sudden guerrilla attack. When a party leaves a task to return to camp, it should take with it all tools, transportation, and readily removable equipment. A party returning to an incompleted task should be alert for ambushes or boobytraps. In principle, it is desirable that unfinished construction jobs be guarded after work hours. However, in a guerrilla-infested country a small guard at an isolated locality may be in extreme danger, and a commander cannot afford to disperse his unit unduly by leaving strong guards at numerous points. In this field, as elsewhere, security measures must be kept in balance with the basic mission.

d. Individuals. All men must be trained to habits of alertness and suspicion. They must learn to have their arms always with them or readily available. Contact with local civilians, other than in line of duty, must be avoided if the situation indicates that any danger is involved. Men must not talk to local inhabitants, or in their hearing, about security measures or the plans and activities of the command.

e. Information. The commander should gather and disseminate all appropriate information about guerrillas and their customary weapons, habits, modes of fighting, and strong and weak points.

f. Training. Individuals, and the command as a whole, must be taught what to do, and how to avoid panic and disorganization, in case of a guerrilla attack.

g. General. The total strength of guerrilla bands operating effectively in a particular territory is often quite small. They rely on their local knowledge, on ingenuity and ruthlessness, and on the psychological effects of surprise and terror. If this is fully realized, and if all concerned are trained in how to deal with them, the guerrilla problem may be reduced from the proportions of a menace to those of a minor nuisance.

CHAPTER 16

TROOP MOVEMENTS AND SHELTER AREAS

Section I. ENGINEER TROOP MOVEMENTS

371. General

a. Means. A troop unit may move by foot, truck, rail, water, air, or a combination of these methods. Foot and truck movements are normal in forward areas, and are common anywhere in a theater. In general, engineer units are moved by truck instead of on foot when practicable, to conserve time and energy.

b. Definitions. The following are certain terms used in connection with troop movements:

(1) Entrucking point (EP): the point where the head of a truck column halts for loading.

(2) Detrucking point (DP): same, for unloading.

(3) Initial point (IP): the point to which elements of a truck column are directed to report, preliminary to their being assembled into a single column and moved out.

(4) Release point (RP): the point to which a truck column is directed to report, preliminary to its being broken up into groups to be separately moved to EP's, DP's, bivouac areas, or other destinations.

(5) Entraining (detraining) point: the railroad station, yard, siding, etc., at which troops are entrained or detrained.

(6) Serial: one or more units placed under a single commander for march purposes. (The elements of any one serial should preferably have the same march characteristics.)

c. Reconnaissance. Any troop movement should be preceded by adequate reconnaissance (see ch. 5).

d. Security. For march security, see chapter 15.

372. Authority

An engineer unit may move as part of a larger command or separately. In either case the movement is normally directed by a higher commander. If it is initiated by an engineer commander, he requests authority for it. Orders authorizing an engineer troop movement cover such items as means of movement; destination; times of departure and of arrival (or duration of move); route of movement; location of IP or EP, and routes to be used in going there; missions (if any) en route; mission, or action to be taken, on arrival; secrecy and security precautions; instructions for detachments which may precede the main movement or remain behind; instructions on supply and evacuation; and any other details which must be coordinated by higher authority.

373. Preparatory Action

a. In preparing for a movement, arrangements must be made for disposition of surplus equipment. Engineer units may have equipment or supplies issued for special work and not needed at their new location. Such items are turned over to other troops or returned to depot. Detachments from engineer depot companies may assist.

b. Administrative preparations should insure that—

(1) Men, equipment, and motor vehicles are in good condition.
(2) Units are properly equipped.
(3) Vehicles are properly loaded and serviced.
(4) Replenishment of supplies is provided for.
(5) Traffic-control arrangements are complete.
(6) Provision is made for the care and evacuation of sick and wounded.
(7) The new bivouac area has been reconnoitered, authority obtained and plans made for its occupancy, and any necessary advance work done.

374. Foot Movements, Plans and Orders

Orders for a march normally follow the form of the standard five-paragraph field order (see ch. 4). A typical march order for an engineer foot movement covers the following:

a. (Paragraph 1.) Information of the enemy and our own troops.

b. (Paragraph 2.) Object of the march; time of departure; route(s); destination.

c. (Paragraph 3.) Detailed instructions for—

(1) Each march serial, to include such points as the location of, route to, and time of clearing the initial point (IP); route of march; march formation; rate of march; position of the serial in the march column; intervals to be maintained; supplies and equipment to be carried; missions en route; liaison.
(2) Subordinate units to be attached to other commands, to include such points as liaison to be established prior to attachment; time and place to report for attachement; sup-

plies and equipment to be carried; missions while attached; duration of attachment.

(3) Precautions as to secrecy, security, and march discipline applicable to the command as a whole.

d. (Paragraph 4.) Detailed instructions for supply and evacuation, including arrangements for supply of engineer materials needed to accomplish missions en route, and for the evacuation of casualties during the march.

e. (Paragraph 5.) Detailed instructions for the maintenance of signal communications, including the location of the commander (or the place where messages to him are to be sent in the march column), and the location, and time of opening of any temporary command post to be established during the march.

375. Foot Movements, Conduct

a. Unit commanders are responsible for assembling their units and moving out from the assembly areas at such time as to pass the initial point on schedule.

b. On the march, rest halts are usually made for 15 minutes at the end of the first hour and 10 minutes per hour thereafter. Men should sit or lie down, loosen their packs, and rest.

c. Men should drink all the water they need before starting, and drink sparingly during the march. All drinking water must be from approved sources.

d. The head of each march unit maintains a steady, even pace.

e. The engineer commander and his staff ordinarily move at the head of his main body.

f. Stragglers are either picked up by an ambulance (on authority of the unit medical authorities) or taken in charge by a small guard marching at the tail of the unit column.

g. Troops are never kept in column, or standing, or under arms, any longer than necessary.

h. Normally the organic transportation of a unit is moved at the same time as the personnel. The march order must provide for the movement of the bulk of the transportation so as not to interfere with the rest of the unit. It may precede the foot troops, follow them after an interval, or go by a different route. It may move by bounds if periodic contact with the marching men is desirable. Space in vehicles which is not otherwise needed is utilized to carry whatever personal equipment of the marching men the tactical situation and other conditions permit.

376. Truck Movements

a. In general, the orders for a truck movement follow the same general sequence as those for a foot movement. Initial points (IP), entrucking points (EP), detrucking points (DP), and regulating points (RP) are specified and accurately described, and all movements are timetabled. For details see FM 25–10.

b. Some engineer units are completely mobile, in the sense that all personnel and organic equipment can be moved simultaneously in organic transportation. Other types of unit can accomplish such a move by shuttling. Still others have no organic transportation capable of moving the bulk of their personnel and equipment. For details of mobility, see the T/O & E's of various engineer units, and also FM 5–5. If an engineer unit is ordered to move, higher authority must supplement the organic transportation if and as necessary. Common sources are transportation truck units, engineer dump truck companies, and organic transportation borrowed from nearby units.

c. If a truck movement involves shuttling, it must be remembered that each separate trip requires specific planning and timetabling.

377. Movement by Rail

a. Rail movements of troop units in a theater of operations are on standard trains. These are of several types, depending upon the type of unit to be moved.

b. Engineer troop units moving by train usually have their organic equipment on the same trains. Sometimes, however, organic transportation is moved by highway.

c. Plans for a rail movement include entraining points, number of trains available, times of departure, all details of train movements, destination, detraining points, and other pertinent data. Not all of these details are conveyed to the unit commander. His primary concern is with the orderly entrainment and detrainment of his unit as scheduled, the comfort and safety of his troops, security measures at entraining and detraining points and en route, and special supply and administrative arrangements required, and with the advance reconnaissance and planning which these involve. He has no control over the details of train movements and schedules. A Transportation Corps officer, or a representative of the railway, accompanies each train, and the commander of troops deals with him on all railway questions.

d. For details on such points as formal orders, entraining tables, and the loading and securing of equipment, see FM 25–10 and FM 101–5.

378. Movement by Water

a. In general, troop movements by water involve large bodies of troops and are covered in detail by orders from higher headquarters. The functions of unit commanders in such movements are primarily administrative.

b. Ships are loaded in accordance with an embarkation order and schedule issued by the port commander. The unit commander's order for loading is based on these. Troops are marched or transported to the pier at the designated hour, and checked on board by name. They load their personal baggage. Organization equipment is normally loaded in advance by civilian labor or specially trained troops, in accordance with a detailed plan.

c. For each vessel a commanding officer is designated, who commands all military personnel except casual senior officers, and who issues all orders needed to provide for administration, security, and health and sanitary measures. Troop accommodations are inspected daily, men are exercised and required to bathe if possible, and bedding is aired. Boat and fire drills are held as directed.

d. Debarkation is controlled by the commander of the port of debarkation. Before debarking, troop details police the ship and arrange for removal of the baggage. Troops leave the ship by unit. Each unit places a guide on the pier before debarking, as directed by the debarkation officer, and forms on this unit guide.

379. Movement by Air

The movement of engineer troops by air is usually limited to airborne divisions and to troops attached to, or working for, Air Force units. Equipment and supplies are kept to the minimum consistent with the mission. For the operations of airborne engineers, see chapter 13, and also FM 5–132.

Section II. ENGINEER ASSISTANCE TO OTHER ARMS

380. General

One of the duties of engineers in a theater is to assist other arms in connection with troop movements and shelter areas.

a. Nature of Assistance. It normally includes—

(1) Work at points of entraining and detraining, embarkation, and debarkation.

(2) Road work on the line of march.

(3) Work in shelter areas.

b. By Whom Rendered.

(1) For divisions or elements thereof, such work is normally done by their organic engineer battalions. However, if a division is moving in a rear area, engineer support may be provided in part by other units.

(2) Nondivisional troops normally receive such engineer support from engineer combat groups (in corps or army areas), engineer construction groups (in army area or the communications zone), or elements of such groups.

(3) Specialized engineer units with limited facilities for pioneer work may receive similar assistance from other types of engineer troops.

c. Disposition of Troops. To accomplish such missions, some engineer troops may be kept at the starting point until the force being assisted has left, and others may be sent to the destination before the force has arrived. It may also be necessary to have engineer troops accompany elements of the force during a truck or rail movement.

d. Limitations. In general, engineer assistance is limited to work which benefits the command as a whole and for which engineers are specially trained and equipped. Other arms provide their own facilities as far as they can.

381. Entraining and Detraining Points

a. Nature of Work. Engineer work may include—

(1) Building or strengthening ramps and loading platforms.

(2) Building or improving approach roads for vehicles.

(3) Building or improving railway spurs and sidings.

(4) Assisting troops of other arms in loading, by the use of engineer equipment.

b. Entraining Points. Entraining points are chosen so as to require a minimum of new construction or improvement. The work most frequently needed is the construction of ramps and platforms for side or end loading.

c. Side Loading. A platform with a ramp at one end is built parallel to the loading track to accommodate loading on the side of a flat car or through the side door of a boxcar. Prior to construction of such a platform the clearance diagram which is maintained by the Transportation Corps should be checked for proper side clearance to accommodate the rolling stock in use.

d. End Loading. A ramp is built at the end of a siding or spur, or on the loading track, so that a vehicle can drive directly onto a flat car backed up to the ramp, or can have its contents unloaded into the car. If a string of flat cars is to be thus loaded, gaps between the cars are bridged by wood or metal spanning platforms; vehicles drive up the ramp and close up on the most forward flat car until all are loaded. If the ramp is built across a track, the section of track at the foot of the ramp is protected by docking. If an extra heavy vehicle, such as a tank, is to be end loaded on a flat car, the car is supported on blocks or cribbing so that the weight and impact of the vehicle will not damage either the car or the track.

e. Treadways. Steel treadways make good ramps and spanning platforms.

382. Embarkation and Debarkation Points

These are usually at ports whose facilities are generally adequate. When engineer work is required, it is likely to consist of minor repairs and the improvement of routes of approach. The construction, reconstruction, or major repair of port facilities is the function of engineer port construction companies and other associated units. (See ch. 21.)

383. Road Work on the Line of March

For the improvement and maintenance of roads and associated structures by engineers in connection with a troop movement, including preliminary reconnaissance and planning, see chapter 19. Engineer elements may accompany the marching column, and may also be stationed at bridges, defiles and other key localities, to take prompt action if the route is blocked by enemy action, accidents, or the failure of structures. For traffic control, see chapter 17. For engineer units in a tactical advance or retrograde movement, see chapters 10 and 11.

384. Camps and Bivouacs

Engineer work at camps and bivouacs intended for or occupied by troops of other arms normally includes the items listed below. If time permits, such work, or as much of it as possible, is done before the occupying troops arrive. Full use must always be made of existing facilities.

a. Water supply, including development of source, purification, storage, the organization of water points, and water distribution insofar as that may be directed by higher authority.

b. Roads, walkways, hardstandings, and traffic signs.

c. Utilities (electric, etc.) so far as they are to be provided.

d. General construction as directed; the erection of tentage other than individual shelter tents, provision of tent floors if authorized.

e. The erection or supervision of any installations which need special skills or special equipment.

f. Maintenance and repair of items, and operations of utilities, for which engineers are responsible, during the period of occupation of the camp or bivouac.

g. Figure 16 shows schematically a typical bivouac for an engineer combat battalion in a combat zone. Figure 17 shows schematically a camp layout in an area where enemy attack or interference is not anticipated.

385. Cantonments

Engineer responsibilities for advance construction, and for continuing maintenance and utility operation, are in principle the same for cantonments as for camps and bivouacs, but may be on a much larger scale. The provision of an elaborate rear area cantonment, housing tens of thousands of men, is a major construction job, which may be allocated to an engineer construction group or brigade supplemented by civilian labor, prisoners of war, and specialist teams of the engineer service organization. The maintenance of such a cantonment, and the operation of its utilities, are also tasks of some magnitude needing specialist personnel.

386. Engineer Units in Rest Areas

When a mixed force which includes organic or attached engineers is sent to a bivouac, camp, or cantonment in a rest area, the engineers are as much in need of rest and training, and as much entitled to it, as the remainder of the force. Other engineer troops, designated in advance by the local or area commander, should take care of any advance preparations in the rest area, and also of maintenance and utility services as far as practicable. The organic engineers should be relieved of such tasks, and should not be required to devote their time to specialized services for other troops who themselves are resting or train-

Note 2: Small security detachments are posted at key approaches outside the area to warn and defend against surprise ground attack by guerrillas or hostile troops if in area.

Note 1: Vehicles, tents, etc., are dispersed and under cover if subject to hostile air activity.

(Schematic—not to scale)

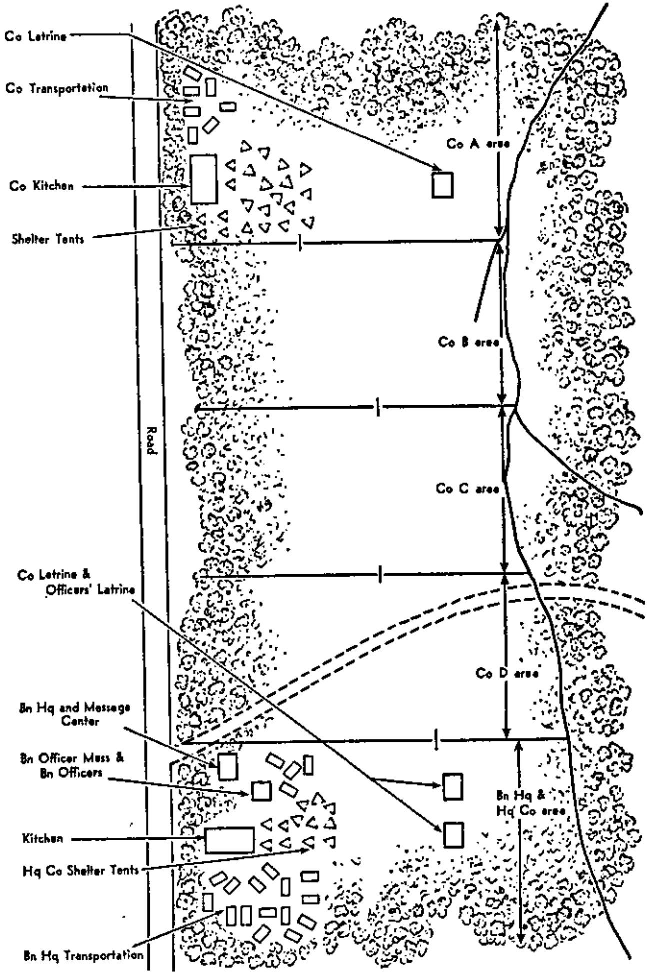


Figure 16. Layout of engineer battalion bivouac, combat zone.

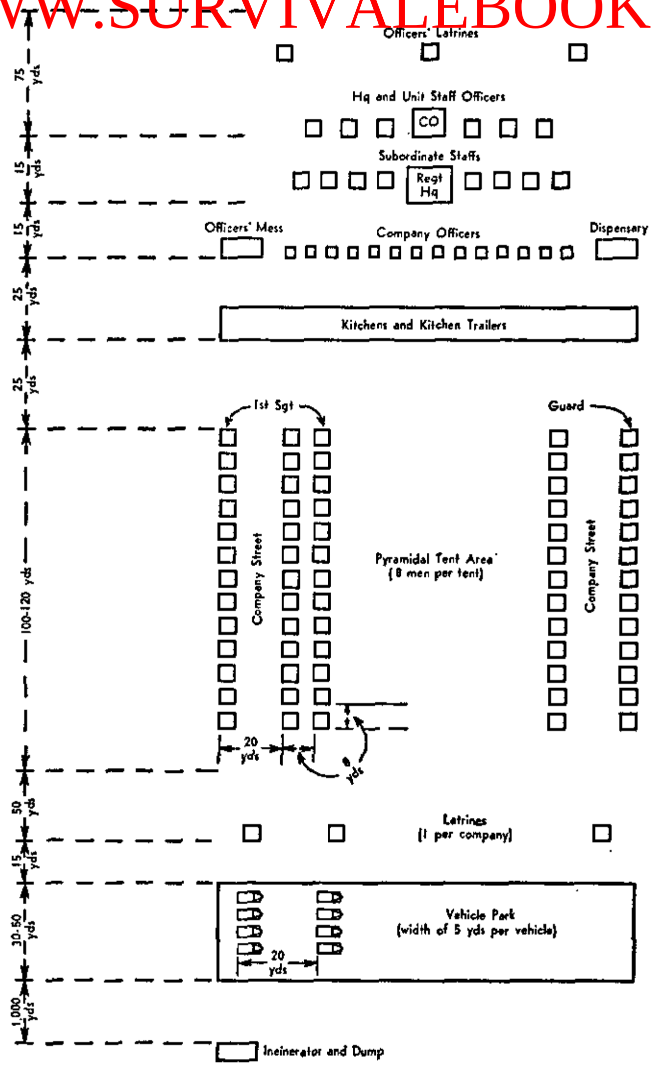


Figure 17. Diagrammatic layout for a semipermanent tent camp in area safe from enemy attack.

ing. Decision in such matters will of course lie with the commander of the force in question; but it is the duty of the unit engineer, or of the senior engineer officer present, to make any necessary representations to him and to his staff.

CHAPTER 17

HIGHWAY TRAFFIC

Section I. GENERAL

387. General

a. The control of traffic on roads in a theater of operations has always been a difficult military problem. In modern war it has been complicated by the following factors:

(1) Greater *volume* of traffic due to the mass movement of motorized and mechanized troop units.

(2) Greater *speed and weight* of individual vehicles, affecting the design, construction, and maintenance of roads and bridges.

(3) Interference with traffic by enemy air action.

b. Ability to control traffic, and to insure the reasonably fast and safe movement of troops, delivery of supplies, and evacuation of wounded, is vital to the success of a campaign. It is a complex task involving the close cooperation of a number of agencies, and the formulation and enforcement of plans which must be both detailed and elastic.

388. Definitions

a. Traffic regulation is the planning, routing, scheduling, and directing of the use of necessary routes by vehicles, animal, and foot traffic. It includes the preparation of the traffic circulation plan; the designation of main supply routes (MSR's) and supplementary routes; direction of the flow, speed, and priorities of traffic; and restrictions on the use of roads and bridges. It is essentially a *planning and supervisory* function.

b. Traffic control is the enforcement of rules of the road, traffic regulations, and road discipline, including control at key points. It is essentially an *operational* function.

c. A *traffic plan* is the basic plan for traffic regulation and control in a given area.

d. A *traffic regulation plan* is that element of a traffic plan which includes routes, direction of movements, and reservations or restrictions placed on any specific roads and bridges.

e. Traffic flow is the number of vehicles that pass a given point in an hour or other specified period.

f. Traffic capacity is the maximum traffic flow obtainable on a given stretch of road, assuming all lanes fully used, no extraneous interference or accidents, and efficient operation by all concerned.

389. Classification of Routes

On the basis of the degree of traffic control necessary, routes may be classified as—

a. Open routes—traffic requires only organizational control.

b. Supervise routes—traffic control is on an area basis.

c. Dispatch routes—higher degree of control is required, involving priority of use and the scheduling of traffic movements.

d. Reserved routes—roads reserved for some particular unit, type of traffic, or purpose (normally for a limited and specified period). They require intensive control to bar unauthorized traffic.

390. Responsibilities, General

The following agencies have responsibilities with respect to traffic regulation and control in the area occupied by our troops under the jurisdiction of any headquarters—

a. The commander.
b. G4 and G3.
c. Traffic headquarters.
d. The unit engineer.
e. The provost marshal.
f. The signal officer.
g. Commanders of all troop units using roads.
h. Commanders of installations served by the roads.

391. Commander

Traffic regulation and control are command responsibilities vested in the senior officer in the area in question. He exercises this function chiefly by delegation.

392. General Staff Officers

G4 is responsible for staff coordination and supervision of traffic regulation plans. He works closely with G3.

393. Traffic Headquarters

The traffic headquarters of a unit may be either an element of the transportation section of the special staff if such a section exists, or an element of G4. Under G4 supervision it is responsible for formulating traffic plans. It receives, correlates, and distributes traffic information, submits traffic reports, and supervises the activities of other agencies which have traffic responsibilities.

394. Engineer

The engineer is responsible for making recommendations for traffic regulations on roads and bridges as indicated by their physical condition; the preparation or procurement, and distribution, of road maps and approved traffic circulation maps; the supply and posting of signs, route marking materials, and route markers, except those for temporary routes and emergency traffic control; and the conduct of traffic control under certain conditions. He and the provost marshal work in close cooperation in traffic matters.

395. Provost Marshal

The provost marshal is responsible for traffic-control reconnaissance and planning; the execution of traffic control, including emergency control measures such as rerouting of traffic; the posting of route markings and traffic-control signs for temporary routes or emergency use; the furnishing of traffic information and directions to persons or units moving on roads; and the submission of reports on traffic obstructions, accidents and damage.

396. Signal Officer

The signal officer is responsible for providing any communications needed for traffic control.

397. Unit Commanders

The commander of any troop unit which moves by highway or operates highway transport is responsible for organizational control of the movement. This includes adherence to traffic regulations and to schedules; enforcement of march discipline; handling any emergency situation; and (insofar as is not prescribed by higher authority), fixing the speed and spacing of vehicles, protecting the column, providing traffic control personnel at points of doubt or congestion, and supplying guides.

398. Installation Commanders

The commander of an installation containing a road net is responsible for any action, supplementary to that of regular traffic control agencies, needed to control traffic entering, leaving, or within his installation.

Section II. TRAFFIC PLANS

399. Data Needed

For the formulation and enforcement of sound traffic plans, full information must be collected by reconnaissance and other means on a number of subjects, including the following:

a. The number, nature, and disposition of troops to be served.

b. The tactical situation, and the plans of the commander and of higher authority.

c. The supply and evacuation plan of the command, including the location of supply, maintenance, and other service installations in the area or serving it.

d. The road net—

(1) Layout.

(2) Length, width, limiting grades, surfacing, drainage, and condition of all roads.

(3) Nature, structure, capacity, limiting dimensions, and other features of bridges and other highway structures.

(4) Obstructions and bottlenecks.

(5) Facilities available in personnel, equipment, and supplies for the upkeep and repair of roads.

e. Full information on any operating railroads or water terminals in the area.

f. Existing civilian traffic: volume, direction, and time of flow, nature (with reference especially to means of movement, whether foot, animal drawn or carried, bicycle or motor), and extent to which it could be curtailed without unduly disrupting the local economy.

g. Any restrictions on movement on any road imposed by higher authority or by enemy action or threat.

h. Anticipated military traffic *demand* on the various roads; a function of *a*, *b*, and *c*, above. It should be analyzed by number, weight, speed, and other pertinent characteristics of moving elements, including foot troops. (See also ch. 19.)

i. Anticipated military traffic *capacity* of the various roads; a function of *d*, *e*, and *g* above. (See also ch. 19.)

j. If anticipated demand exceeds anticipated capacity to a greater extent than can be met by a practicable curtailment of civilian traffic, the capacity must be increased by improving the road net. This, however, is not a part of the traffic plans as such.

400. Traffic Plans, General

Based on such data and on the recommendations of interested agencies, traffic plans are formulated. The principal features of a good traffic plan are discussed briefly in succeeding paragraphs.

401. Simplicity

Traffic plans should be simple and easily executed. Regulation and control should be kept to a minimum.

402. Flexibility

Movement of highway traffic in an active theater, especially in forward areas, is liable to unpredictable interference or disorganization. Traffic plans and traffic control must be flexible enough to meet such situations. In part, this calls for specific advance preparations such as the provision of alternate routes, the spotting of key equipment such as wrecking trucks or bulldozers at critical points, and the preparation of alternative traffic circulation plans based on various possible tactical developments. In part it calls for careful training and indoctrination of MP's, regarding their duties in any such emergency, and of every officer, regarding his duty to take emergency action with respect to a traffic block developing on a road on which his command is moving.

403. Priorities

a. When priorities are necessary for different categories of traffic on a road, their establishment is a command decision, which may be delegated by the commander to G3 and G4 for coordination within prescribed policies. A reasonable system of priorities in an average situation is—

(1) Engineer and ordnance equipment proceeding to a traffic block.
(2) Tactical troop movements.
(3) Wire patrols and construction crews.
(4) Ambulances.
(5) Staff and messenger vehicles.
(6) Supply vehicles:

(a) Class V.
(b) Class III.
(c) Class I.
(d) Other.

b. However, the actual priorities will depend on conditions. Situations may arise in which highest priority is assigned to the movement of ammunition, or to the evacuation of wounded, or to retrograde movements of key equipment.

c. It is the duty of unit engineers, if necessary, to represent strongly to higher authority the vital importance of giving priority to the movement of engineer troops, supplies, and heavy equipment for emergency needs such as the repair of roads or bridges.

404. Routes and Directions of Traffic

a. Roads are classified, with respect to degree of control of traffic, as explained in paragraph 389. Restrictions imposed by higher headquarters are incorporated.

b. If the total mileage of the roads in a certain area, which are designated for miiltary use and incorporated into the traffic circulation plan, exceeds the maintenance capability of the available engineers, movement of traffic will suffer. In such a case the unit engineer should recommend either that the mileage be reduced or that his troops be reinforced.

c. Heavy vehicles or fast traffic are barred from roads or bridges which will not take them.

d. The number of traffic lanes on a road is prescribed if necessary.

e. Multiple-lane roads most commonly take two-way traffic. However, one-way flow may be prescribed on them to give full traffic capacity in one (the critical) direction, or for safety under blackout conditions, or to regulate movements at complex intersections. A desirable condition precedent to establishing one-way traffic is the existence of a loop around which traffic may flow. One-way roads need very careful marking. It is to be noted that standard bridging equipment in general provides only single-lane bridges.

f. Single-lane roads are normally one-way. A road with the equivalent of two narrow lanes may be classified for intermittent two-way day traffic and one-way night traffic, although such an arrangement to some extent violates the principle of simplicity.

g. Intersecting streams of traffic, and left turns, are avoided when practicable.

405. Area Jurisdiction

If a road which is essential to a particular command for supply purposes passes through the area of another command of coordinate rank, or along an area boundary, traffic regulations affecting it call for approval by higher authority. Traffic control is by agreement between the commands affected.

406. Speeds

a. The plan prescribes limiting speeds as necessary.

b. The average speed of traffic at bottlenecks must be carefully estimated in computing the traffic capacity of a road. A grade intersection may reduce the flow past the intersection by 50 percent or more; and a hill where trucks must shift to low gear may reduce it by as much as 75 percent. If there is a steady and heavy flow of traffic, such a delay may be reflected back for miles from the bottleneck. This not only interferes with supply and troop movements but may result in disastrous losses by air attacks on congested traffic. Therefore, if such bottlenecks cannot be eliminated on a particular road, the traffic on that road should be as limited and local as possible.

407. Segregation of Traffic

The use of the same road by types of traffic having different march characteristics—especially different speeds—makes for confusion and delay. This may be avoided by reserving particular roads for particular types of traffic. Such reservation may be permanent or temporary.

408. Civilian Traffic

Civilian traffic may have to be severely curtailed to prevent interference with military traffic. Pedestrians and animal-drawn vehicles may be required to keep off the regular traffic lanes. Access to or the crossing of MSR's may be forbidden or restricted. Signs must be posted informing civilians of any such restrictions. Action in this field is coordinated with local authorities.

409. Communications

For effective traffic control, especially in sudden emergencies, there must be two-way communications, interconnected traffic regulation headquarters, traffic regulation points, and MP traffic control posts and patrols. Radio is in general the best means. Wire may be used if the problems of installations and maintenance can be met, or if a wire system is there already. Messengers are too slow for immediate emergency action, but should be available as an alternate means.

410. March Security

See chapter 15.

411. Traffic Circulation Map

This is a map or overlay showing the road net of the area in question, with all necessary road data, the prescribed circulation of traffic on roads, etc. A typical circulation overlay is shown in figure 18.

412. Publication of Traffic Plan

Having been prepared and checked, the traffic plan is published in an operations or administrative order or annex thereto. The traffic circulation map is normally an annex to the plan.

Section III. TRAFFIC CONTROL

413. General

Traffic control is normally by the military police, but is sometimes an engineer responsibility. Engineer officers must be familiar with its basic principles, which are discussed briefly here. For further details, see FM 19–25.

414. Systems

There are two general systems of traffic control: organizational and area. Which one to use depends upon the road net, traffic conditions, and tactical considerations.

a. Organizational Control. Under this system the commander of an organization on the march exercises traffic control, usually by an escort. The escort regulates traffic only along the route traveled by the column, and only to the extent needed to insure that the column moves in accordance with its priority and

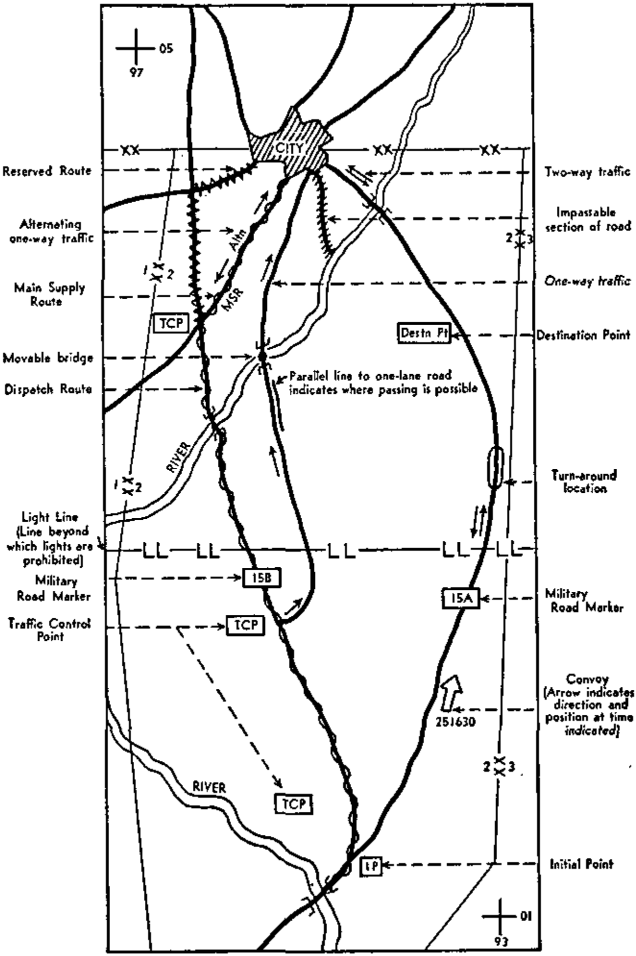


Figure 18. Traffic circulation overlay.

schedule (if any), and with minimum interruption by other traffic of lower priority. Organizational control is used chiefly in movements of individual units when conflict with civilian or less important military traffic is the most serious difficulty to be anticipated.

b. Area Control. Under area control, the traffic control headquarters assigns personnel to regulate all traffic in accordance with the traffic circulation plan and other pertinent orders. Area control is used chiefly when traffic is heavy and unified control is necessary.

415. Techniques

There are three techniques of traffic control: point control, patrols, and escorts.

a. The point-control technique uses traffic control posts at road intersections and other bottlenecks such as bridges, roadblocks, and defiles. Each post enforces compliance with general traffic regulations and with any special traffic orders in effect at that point, and helps units to maintain march discipline. If security considerations permit, it is well to supply each post with the following: the area circulation map, general and special traffic control orders, priority lists, march tables or march graphs covering the movements of large units, and red and white lanterns for use where lights are allowed.

b. Regulation by escort is effected by a motorized traffic control group which precedes each column or serial. The escort notifies any control posts to block off all traffic until the column has passed. At key locations such as intersections and supply points, if there is no traffic control post, the escort itself performs this function. As soon as the head of the column reaches a post thus established, the escort proceeds to the next unposted point, clearing the road as it goes. This system is most appropriate when the moving column has first priority on the road.

c. Regulation by patrol consists of using motorcyclists who singly or in groups of two or more constantly patrol the road between traffic control posts. They are charged with the same general duties as traffic control posts, and should be furnished the same types of information.

d. A combination of point control and patrols is normally required in area control. The escort method is often used in organizational control. Each technique must be used to best advantage, and all must be coordinated into a good control plan.

e. For the classification of military bridges and vehicles, and the conditions under which a particular vehicle is permitted to cross a particular bridge, see chapter 20.

416. Traffic Control for Engineer Troop Movements

a. When an engineer unit moves as part of a column of mixed troops, the engineer commander has no responsibility for traffic control other than that of enforcing compliance with traffic regulations and march discipline within his unit.

b. When an engineer unit moves independently as a march serial, escorts may be provided by the unit commander to supplement the established area control.

417. Traffic Control by Engineers, General

As stated previously, engineers may be given traffic-control responsibility at points where engineer work or engineer interests are of major importance, especially if traffic control at those points is associated with engineer assistance to moving columns. The principal cases are fixed and floating bridges, defiles, points of potential traffic breakdown, and engineer supply points.

418. Fixed Bridges

a. Engineers are charged with control measures when necessary to prevent damage to an important bridge by vehicles too heavy for it, or otherwise unsuited for it, or moving too fast.

b. Where traffic is light, and turnarounds are available near the ends of the bridge, a single guard for a short bridge, or a guard at each end of a long bridge, may be adequate. Guards examine all vehicles attempting to use the bridge, turn back those which might damage it, and enforce speed regulations. They are furnished lists of the classes of vehicles which may and may not use the bridge, and with circulation maps showing detours available for those which may not. They may also have materials and tools for minor maintenance.

c. Where traffic is heavy, more elaborate arrangements may be required for examining and screening vehicles. Screening posts may be some distance from the ends of the bridge, at points where turnarounds exist. A good location is a road intersection not too far from one end of the bridge. Other guards may be placed on all main roads approaching the bridge. Speed on the bridge is then controlled by other guards posted on the structure itself. If the screening of vehicular traffic, and the incidental halting and sorting out of vehicles, are on such a scale as to raise complex traffic control problems, MP posts should also be provided, the MP and engineer personnel working together.

d. Measures like the above are not usual at small and unimportant bridges, where it is normally sufficient to post signs showing weight limits, clearances, and permissible speeds.

419. Floating Bridges

A floating bridge requires careful traffic control to insure proper spacing and speed of vehicles using the bridge. If possible it should be part of a one-way route. In that case, traffic control primarily involves controlling the speeds and driving techniques of vehicles on the bridge. If two-way traffic must be accommodated, traffic-control posts are established some distance from each end of the bridge to screen and reroute vehicles, and to control the alternate movement of traffic. Telephone or radio communication is provided to assist in traffic control.

420. One-way Defiles

The control of traffic at the site of engineer work frequently involves moving two-way traffic through a one-way defile. Common causes are repairs to bridges or roads damaged by enemy bombardment, and such work as filling chuck holes, placing road oil, and reconstructing culverts.

a. Traffic movement through a short defile of this sort, on a road carrying light traffic, can be handled informally by visual signals from a guard placed at the center of the defile.

b. (1) Long defiles require more extensive provisions for the control of two-way traffic.

Generally, the minimum requirement is that one guard be placed at each end of the defile to halt traffic, and release it to go through the defile when notified by the guard at the other end that the route is clear. The simplest means is the use of a baton or other signal handed to the driver of the last vehicle of a group entering the defile, who delivers it to the guard at the exit. (This is the same system often used on roads under civilian repair in the United States.) Supplementary means of communication, such as telephone, may be provided, and patrols may be employed to regulate traffic within the defile. For a long stretch of road, a number of short one-way regulated sections separated by stretches of two-way roads provide greater traffic capacity than a single long defile, although the former calls for more traffic control personnel.

(2) When traffic through a one-way defile is heavy, special measures may be required to provide security against enemy aviation. These include the routing of as much traffic as possible by other roads; the provision of areas at each end of the defile where vehicles can be moved off the road, and either parked under cover or dispersed, while waiting their turn; the provision of traffic-control posts at some distance from the entrances of the defile, to warn traffic against closing up before coming to a halt; and the provision of traffic patrols to enforce such measures.

421. Points of Potential Breakdown

Engineers may regulate traffic at places where they must assist vehicles negotiating difficult stretches of road. The main objective of the regulating agency is to prevent vehicles from jamming so that they interfere with the assistance being rendered or create favorable targets for enemy aircraft. Typical situations are the approaches to a ferry or bridge in muddy or sandy areas, a deep ford, and a steep slope covered by mud, snow, or ice.

422. Supply Points

At engineer supply points, including water-supply points, special measures may be necessary to control traffic entering, leaving, or within the area. Preferably, regulation of traffic at the intersection of the access road and the main road is provided by military police, but engineers may handle it if necessary. One man at the intersection is generally enough. Within the supply-point area, traffic-control posts may be established to give instructions to drivers, and patrols may be employed to enforce these instructions.

CHAPTER 18

CONSTRUCTION AND JOB MANAGEMENT

423. Responsibilities

a. The Corps of Engineers is responsible for all military construction in a theater, except: signal communications construction; and such construction, incident to organization of the ground in a defensive position, as may be undertaken by the garrisoning troops (ch. 11). Engineer responsibilities include all types of general construction, cantonments, depots, hospitals, roads, railroads, bridges, airfields, ports, pipelines, and the utilities required in connection therewith. They also include, in most cases, the maintenance, repair, and rehabilitation of the foregoing, and the operation of utilities.

b. Past experience indicates that 60 percent of the engineer effort is devoted to work on roads, bridges, and general construction, and 40 percent to pioneer and demolition work, mine warfare, combat as infantry, training, and miscellaneous tasks.

424. Engineer Construction Units, General

a. Engineer support in a type theater includes construction units of both operating and supervisory types, as follows:

(1) Engineer construction battalion.
(2) Engineer heavy equipment company.
(3) Engineer dump truck company.
(4) Engineer pipeline company.

(5) Engineer port construction company.
(6) Engineer dredge crews (five types).
(7) Engineer construction group.
(8) Engineer brigade.
(9) Certain teams of the engineer service organization.

b. For the pipeline and port construction companies, and the dredge crews, see chapter 21. The others listed are described briefly below. For further details see FM 5–5 and the appropriate unit manuals.

c. In addition to the foregoing—

(1) Engineer divisional, armored, airborne, shore, and army combat battalions are trained and equipped for a wide variety of construction tasks.
(2) Engineer aviation battalions have as their primary mission the construction and rehabilitation of airfields and accessories (ch. 21).
(3) Engineer bridge units have, as one of their missions, supervising the construction of bridges from their organic equipage, and can themselves construct them at need (ch. 20).

425. Operating Units

a. Engineer Construction Battalion. This unit has the mission of building, rehabilitating, and maintaining military routes of communication and facilities except routine maintenance of railroads and of communication other than signal facilities; it performs related engineering work in either the communications zone or rear areas of the combat zone. It is normally assigned to an engineer construction group. It can handle all types of general construction, roads, bridges, and deliberate field fortifications, and can also build port facilities and airfields, if provided with proper equipment and operators to perform this work. It consists of a headquarters and headquarters and service company and three identical construction companies. Lettered companies have a headquarters and three identical platoons, each having a headquarters, a structures section, and a utilities section. It has a greater quantity and variety of heavy construction equipment than engineer battalions.

b. Engineer Heavy Equipment Company. This unit has the mission of maintaining and operating a pool of heavy construction equipment in support of other engineer construction units, especially construction battalions. It is normally assigned to an engineer construction group in the communications or combat zone, with special reference to earthmoving and surfacing work. It functions by direct support, by attaching men and equipment to another unit, or on occasion as a unit assigned a specific mission. It consists of a headquarters, an excavating platoon, a surfacing platoon, a transportation platoon, and a repair platoon.

c. Engineer Dump Truck Company. This unit has the mission of operating dump trucks in support of other engineer units. It is normally assigned, either to an engineer combat group in the combat zone, or to an engineer construction group in the combat or communications zone. As in the case of the heavy equipment company, it can function either by direct support, by attachment of certain of its elements, or on the basis of a company mission. It consists of a headquarters, a service section, and two identical dump-truck platoons.

d. Teams. For engineer teams having construction or equipment operating missions, see appendix I.

426. Supervisory Units

a. Engineer Construction Group. This unit has the mission of performing, for army or the communications zone, large-scale coordinated engineer construction work and allied activities. In the communications zone it may be assigned to an engineer brigade. It is a flexible unit with an organized headquarters and headquarters company, to which are assigned such engineer construction units as the situation indicates. These normally include engineer construction battalions and engineer dump truck and heavy equipment companies, and may include other units such as engineer port construction companies. Civilian and prisoner-of-war labor may also be placed under group control.

b. Engineer Brigade. This is a flexible organization similar to an engineer construction group, but at the next higher level, with an organized headquarters and headquarters company to which troop units and civilian and PW labor are assigned as the situation indicates. Its principal components are engineer construction groups. It operates only in the communications zone.

427. Theater Construction, Primary Considerations

These are as follows:

a. Speed of Construction. Construction programs must be capable of fast completion under difficult working conditions.

b. Flexibility. Plans for construction must be made in advance and with great care. However, they are necessarily based on assumptions which may not work out as expected, and they are subject to change at any time due to enemy action or unforeseen developments. Therefore, all plans and programs must be flexible and subject to change on short notice.

c. Satisfaction of Immediate Needs. In building any structure or installation, work should be so scheduled that some portion or element is ready for use promptly, and that the effective capacity increases steadily as work progresses.

d. Economy. The need for economy is an ever-present one. An officer in a theater must think of it, not only in money terms—though these are important in themselves—but also and primarily in terms of available manpower, materials, transportation, and equipment. All these must be conserved to the utmost in the field of construction. Extravagance in the use of manpower will result in the delay or failure to accomplish esential projects. Waste of equipment and materials means that sea and land shipping space must be used to bring replacements, instead of being used for other useful purposes. Local procurement, and the proper operation and maintenance of mechanical equipment, are valuable aids to economy.

428. Theater Construction, Policies and Standards

In the light of these primary considerations, certain basic policies and standards have been established for theater construction, with respect to standardization, simplicity, elimination of nonessential features, types of construction, factors of safety, sequence of construction, allowance for expansion, and the use of existing facilities.

429. Standardization

a. As far as possible, theater construction follows standard designs. Such designs are prepared and published in peacetime by the Department of the Army and kept up to date.

b. The advantages of standard designs are obvious. First, being prepared and studied at leisure by experts, they can be better than designs made hastily under the pressure of war. Second, they permit fairly accurate computations of the amounts of construction materials needed for the logistical support of a force of any given size. Third, they permit construction units to develop standard techniques.

c. Standard Department of the Army designs are always subject to modification in a theater, to take account of local weather conditions, available materials, and the skills and limitations of local labor. Theater headquarters may, and often will, prepare and issue standard designs of its own.

d. The existence of standard designs must never deter an engineer officer from improvising and using expedients, in the common situation where items of a standard bill of materials are not obtainable or are not of the precise types, sizes, or shapes called for by the design. Standard plans must be drawn to permit this use of substitute materials.

e. For the adopted standards for airfields in a theater, see chapter 21.

430. Simplicity

One of the most important ends to be attained in the standardizing of designs is simplicity, with respect both to general layout and to individual structures. Complications in wood framing, in concrete shapes and forms, in assemblies of steel members, in plumbing and electrical installations, must be avoided, as must any design whose execution would demand specially skilled men or some special and perhaps unobtainable structural shape or other item. It must always be assumed that available labor will not be highly trained and will be working under pressure.

431. Restriction to Bare Necessities

The minimum demands for military construction in a theater are so large, and impose such a drain on manpower, transportation, and national resources, that everything nonessential must be omitted. No structure or installation should be built unless it can be shown that it will be a material aid in accomplishing some military mission. Granted that this can be shown, the design must still be reviewed in detail to see whether any needless refinements can be eliminated. Many features which are taken for granted in peacetime construction in the United States, such as sanitary sewerage, running hot and cold water, and interior finish, are absent from theater construction or employed on a restricted scale.

432. Temporary Construction

Allied to simplicity and the elimination of nonessential items is the practice of making all construction of a temporary nature. The mission of construction agencies is to build the maximum number of facilities needed by combat troops in the shortest possible time, not to erect high quality structures. The use of wood instead of steel, and of green lumber, untreated piles, and concrete of low cement content, are common examples. Factors of safety are much lower than in peacetime practice.

433. Stage Construction

a. The consideration of satisfying immediate needs, mentioned above, gives rise in a theater to the practice of stage construction, defined as "the completion of a structure or installation by construction units or by levels of improvement."

b. Building the ordinary theater of operations type of structure calls for a number of different processes. Thus, barracks construction normally involves the pouring of concrete footings, several kinds of carpentry work, placing the roofing, installing electrical connections, and so on. If a work team is trained to perform each of these operations repeatedly for each of a number of identical buildings, and to do nothing else, the work teams will become highly skilled, and the project will be built very efficiently; the work teams working their way successively through all the units of the project, and one work team following another on each unit. However, nothing will be ready for use until the last work team has finished the first unit (although, from then on, the units will be finished rapidly). Therefore, if carried to an extreme, this "assemblyline" method clashes with the principle of stage construction, which may require that a working group perform all the different processes on one unit of construction before going to the next unit. Thus, maximum efficiency may have to be sacrificed to the demand for immediate partial usage.

c. However, by careful planning, the officer in charge of a construction project can usually combine the two techniques, and provide early usage of some units of the project, while largely retaining the advantage of specialized working groups.

d. If using troops have occupied the completed part of a project while construction troops are working on an adjacent part, they are likely to get in each other's way. Close cooperation between the commanders concerned, and a mutual understanding of each other's problems, will avoid friction and lowered efficiency.

434. Allowance for Expansion

It is quite common to underestimate the ultimate required capacity of a theater of operations logistical installation. A very serious mistake is made by an officer laying out and designing any such installation, if he fails to allow for possible expansion, even though the directive from higher authority may contain nothing specific on the subject. This is true, not only for the project as a whole, but for each of its major components, since any one of them may prove to have been out of balance with the others. Having made a rough tentative layout of a project, the designer should check it item by item, and ask himself what would happen if, at a later date, there arose a demand for additional housing, or mess facilities, or open or covered storage, or maintenance facilities, or hardstands and parking areas, or bed space for a hospital, or runway capacity at an airfield, or water and electric power. The project plans should contain a brief but clear indication of how such possible future expansion might best be handled. This may influence the choice of site, an otherwise favorable one being sacrificed to another which is somewhat inferior but provides room for growth.

435. Use of Existing Facilities

a. It is a general rule in a theater not to build any new structure or installation if an existing one can be made to do. This is one of the most effective ways of economizing on time, manpower and materials. Past experience in World War II indicates, as a rough average, that rehabilitation and conversion to military needs of existing installations involved only about 20 percent as much general construction effort as the building of new equivalent ones. The principle applies regardless of enemy demolitions. A wrecked and abandoned port or airfield may present a picture of hopeless chaos, but when the wreckage is cleared away and the situation studied, it will usually be found that a great deal remains which can be adapted to our needs. An abandoned depot may have had all its structures and supplies burned to ashes and its utilities wrecked. Nevertheless the area is cleared and drained; it is, or can readily be, connected to the adjacent road and rail net; it has its own road net and hardstands, intelligently laid out and largely intact; it has at least a potential water supply; and foundations of structures may be usable. Each of these items represents a large saving in time, men, and materials, when rehabilitation is compared with new construction.

b. These remarks apply to existing civilian as well as military installations. Most housing, office buildings, warehouses, and commercial premises are readily convertible to military use.

436. Sequence of Work

a. In any construction project there is a logical sequence of work determined by military needs, working conditions, and the available men, equipment, and materials. The normal sequence is as follows:

(1) Issue of a directive for the work.
(2) Reconnaissance and site selection.
(3) Layout.
(4) Estimate of the situation.
(5) Preparation of plans and schedules, and their embodiment in an order.
(6) Conduct and supervision of the work, including assembly of supplies.

b. The last three steps are often referred to collectively as "job management."

437. Directive for Work

All construction projects are initiated by directives. If the project is a small one, forming a minor element of some larger task which has been assigned in its entirety to an engineer or commander, that commander may himself issue the directive, in the form of brief oral instructions to a subordinate to undertake the project. In the case of a large project the directive is usually written. It includes a statement of the nature and scope of the project, its location, the troops, materials, and equipment available, and the date when completion is desired. This places on the unit commander to whom it is addressed the full responsibility for doing the job, and authorizes him to use his available means to that end.

438. Reconnaissance and Site Selection

Within the limits prescribed by the directive, the officer in charge of construction must select the precise site for the project. This may involve a study of maps, reports, and air photographs, and always involves ground reconnaissance. (An initial reconnaissance is often made by the authorizing headquarters before it issues the directive, the officer who is to be assigned the work participating in it.) A construction reconnaissance may cover the following points, some of which are of interest only in a large and complex project:

a. Site: location, description, boundaries, and nature of proposed construction.

b. Accessibility: transportation facilities.

c. Regional factors: population density, nearby towns, billeting accommodations, nature of surrounding region, and attitude of inhabitants.

d. Adequacy of area for present needs and possible expansion.

e. Usable existing structures.

f. Flood, tidal, and weather data, including prevalent high winds and heavy snows.

g. Terrain, elevation, soil, drainage, ground water, and subsurface conditions if known.

h. Necessary clearing.

i. Natural cover (concealment qualities).

j. Presence or absence conspicuous adjacent landmarks.

k. Existing or available water supply, electric power, and sewerage, or the practicability of installing new facilities or connecting to existing facilities.

l. Availability of construction materials.

439. Layout

After the site has been chosen, a tentative layout is made, showing all structures, utilities, roads, and other facilities. Depending upon the complexity of the project, the layout may be made by the constructing agency or by a higher headquarters. Thus, if the base section of the communications zone decides to enlarge a depot and assigns the work to an engineer construction group, which in turn assigns it to one of its component construction battalions, the layout might be made: by the section engineer, or at group headquarters, or at battalion headquarters, or section headquarters might make a preliminary layout and authorize the constructing agency to adjust it after discussion with the depot commander.

440. Job Management, General

a. Job management, or construction management, is defined as the application of men, materials, and equipment to a job in such a way as to do it in the quickest, most efficient, and most economical manner. It is a command responsibility, resting directly on the officer in charge of the job and on each subordinate who has charge of any element of it. It is applicable to any task from the smallest to the largest. In civilian life and in peacetime, the measure of successful job management is usually money profits. In a theater in wartime, the measure is speed of completion of the job as a whole, and of each of its prescribed phases, with the utmost economy of materials and human effort.

b. As stated above, the elements of job management are an estimate of the situation by the responsible officer, the preparation of a plan, the issue of orders to implement it, and the direction and supervision of the work up to completion.

Note. The "estimate of the situation" must not, of course, be confused with the quantitative estimates of materials, and man-hours which are part of the planning phase explained in paragraph 444.

441. Estimate of the Situation

The preparation of an engineer estimate of the situation is covered in chapter 3, both for purely tactical missions and for those in which the obstacles to be overcome are primarily of a physical nature, enemy action being incidental. The latter is the more common situation as regards construction projects.

442. Planning, General

Construction planning involves an analysis of a job into its component parts, the conversion of these into quantitative estimates, and assignment of men, equipment, and materials to the component tasks, and the preparation of work schedules. Throughout the process of planning, as well as during construction, the responsible officer must be alert to anticipate special situations, unusual conditions, unexpected obstacles, and changes of plan.

443. Analysis Into Components

a. The first purpose of the analysis into components is to permit the preparation of quantitative estimates. The second purpose is to permit assignment of the components to various subordinate construction agencies.

b. Liberal allowances must be made for the often extensive and laborious tasks which are auxiliary to construction work in the strict sense. Examples are: adequate work roads and turnarounds; bivouac facilities for construction units which remain at the job site; materials yards; hardstands and servicing facilities for construction equipment and transportation; *adequate drainage at the site;* the opening and operation of gravel pits and quarries; water for construction; and security measures, including camouflage during construction if required by higher authority.

444. Quantitative Estimates

These are of the following categories:

a. Estimates of construction materials needed. If standard designs are used, the accompanying detailed bills of material permit highly accurate estimates, provided that items are available of the same kind, size, and shape, as in the designs. If substitutes or nonstandard designs must be used, more effort is involved. Certain items must, by their nature, be specially computed even in standardized construction. For example, material for fills for a road or railroad (amounts dependent on topography), and bearing piles (length and number dependent on the bearing power of the soil).

b. Estimates of materials which may or may not enter into the finished structure or installation, but must be dealt with by the constructing agency. The most common case is earth and rock excavation.

c. Estimates of man-hours and equipment-hours needed to do the job. Analysis into components and quantities is the necessary preliminary. Given these data, the estimates may be based either on the experience of the responsible officer and his staff, or on experience tables. The former method is the better if the individuals in question do in fact have the experience needed. If they have not yet acquired it, experience tables based on average conditions are a valuable aid. FM 5–35 and TM 5–252 have numerous tables of man-hour and equipment-hour output.

d. Estimates of men and equipment needed to do the job and its various components. These are directly derivable from the estimated man-hours and equipment-hours needed to do the work, and the number of hours which the directive allows to the officer in charge (or which he allows to himself) to finish the project.

445. Assignment of Tasks

The responsible officer is now in a position to divide up the work among the subordinate construction units or detachments which are at his disposal. The following considerations are to be borne in mind:

a. Assignments may be on a task basis, an area basis, or a combination. The former is more common for small working units.

b. The sometimes conflicting considerations of stage construction and specialized gangs and assembly-line production methods must be carefully weighed to reach a sound solution.

c. A task must be within the capability of the working group. If more is demanded of men than they can accomplish, they become discouraged and lose all enthusiasm for the task. On the other hand, if not enough is demanded, men become slack and acquire bad working habits.

d. Tasks must be equitably divided up so that no one element of the force has a materially harder or easier working schedule than any other.

e. Wherever possible, the integrity of units should be preserved, and the men should work under their own leaders. This principle may have to be departed from, especially in small units, if it is necessary to pool special skills such as carpentry or electrical work. Pooling of skills is of course implied in the policy of specialized work gangs and assembly-line production.

f. Frequent changes in assignment should be avoided. Time is lost while a group is starting a new job, orienting itself, learning what has been done, and getting organized. Moreover, there is more incentive to good work when a group of men can start a job and see it through to completion. This, incidentally, is a drawback inherent in assembly-line production methods. The average man takes more interest and more pride in one structure which he and his group have built in its entirety, than in half a dozen structures to each of which he and his group have made a limited contribution. If assembly-line methods are to be used, the officer in charge must allow for this attitude and find other incentives which will offset it.

446. Operation by Shifts

If enough men are available and if the task is urgent, much time can be saved by organizing some or all of the working gangs into shifts. This is often done. However, the following points should be noted:

a. Work by shifts calls for careful organization, and places an additional load on administrative and mess personnel. If men have to be transported to and from the work site, operation by shifts puts an additional load on the transportation agency as well.

b. Two shifts, working in daylight only, are usually the most efficient form of shift organization. This method is appropriate to long daylight periods (summer in the Northern hemisphere). Night-work commonly results in a marked falling off of efficiency, and may not be permissible for security reasons, especially in the combat zone.

c. Shift organization has a certain tendency to create a feeling of irresponsibility. For example, if a piece of equipment being operated on two shifts breaks down due to misuse, each operator can blame the other, and often does.

d. Three-shift, round-the-clock work greatly multiplies administrative and other complications. Round-the-clock operation *of mechanical equipment* should be restorted to *only* in an acute emergency and for short periods. It leaves no time for systematic servicing and organizational maintenance, and if continued will result in deadlining large amounts of equipment, thereby crippling the construction unit.

e. In general, two shifts do not produce twice as much as one, and three shifts by no means produce three times as much as one. However, time is often more important than theoretical efficiency. Shift organization must always be considered, and frequently should be adopted.

447. Construction Schedules

a. A construction schedule is a detailed time plan which coordinates all construction operations for a project. It shows the planned starting and finishing dates for each subtask or work item, and also the times when labor, equipment, and materials for each are to be made available. It is the basis for work orders issued to subordinate units, for plans made by them, and for the operations of the agencies responsible for providing and delivering supplies and equipment and transporting men.

b. The schedule is developed from the above studies. Once it is known, for each subtask, what quantities of work are involved, what these mean when translated into man-hours and equipment-hours, what troop unit is doing the subtask, and what is that unit's productive capacity, all the elements of the schedule are given except the time when each subtask is to be started. This is decided by a consideration of the job as a whole, each subtask being fitted in so as to give a logical sequence of work.

c. For very small and simple jobs, scheduling may reduce to a few mental or written notes on the sequence of work items, the organization of working groups, and the assignment of equipment and materials. For jobs of any size or complexity, written schedules are prepared. The ordinary form shows a column for the various subtasks or elements of the work, a column for quantities, and columns for the personnel and equipment handling the subtask; following this are bar graphs showing the beginning, duration, and end of each subtask. Often there are two bar graphs for each subtask, one (the schedule proper) showing the planned duration, the other serving as a progress report and filled in as the work proceeds.

d. The requirements of stage construction must be carefully considered in making the schedule.

448. Initiation of Work

Plans and schedules having been completed, the responsible officer issues orders to do the work. For forms of engineer orders, see chapter 4.

449. Supervision, Progress Reports

a. Supervision of a construction project, by commanders senior to the one in immediate charge of each subtask, is conducted by personal inspections and by oral and written reports. The most important of the latter are progress reports.

b. Progress reports are the best statistical means of keeping track of a construction project. Common forms include the following:

(1) Bar graphs showing, for each element of the job, what percentage has been completed up to the date of the last report from the field. This type is simple and compact, but does not show the varying rates of progress to date, and is somewhat abstract in character.

(2) Coordinate graphs on which, for each element of the job, percentage of completion is plotted against time, giving a sloping line. Commonly one line is drawn to show scheduled progress and another to show actual progress. This type does show varying rates of work, and thereby makes it easier to forecast the time of completion. It has the drawback that not many concurrent subtasks can be shown on the same sheet.

(3) Layout reports. In this type the actual layout of the project is used, and the stage of construction of each of the elements is shown by colored crayons, crosshatching, or other means. A variant, often used in road projects, shows the road as a straight line or bar with mileages indicated, and uses colors to show what stretches have been

cleared, graded, and surfaced. A layout report is concrete, and is well adapted to show progress in terms of specific phases of work instead of percentages of completion; though it may be used for either purpose.

c. The chief difficulty in preparing a progress report on a percentage basis is to determine what the percentage of completion, at any given moment, actually is.

(1) So far as a project can be broken down into a number of operations or subtasks, each of a single type and measurable in a single unit, the progress to date *of each one individually* can be shown either by comparing man-hours of work already done with man-hours estimated to complete, or by comparing quantity of work of a certain type already done with total quantity. The latter is more accurate, but takes more time and needs more elaborate recordkeeping.

(2) However, the percentage of completion of the operation *as a whole* is not directly deducible, as an exact figure, from the percentages of completion of its components. In fact, unless the overall job can be expressed in some common unit, "percentage of completion" is incapable of precise measurement, and an element of judgment must enter. Higher headquarters often demand reports on this basis, and the demand is legitimate, but allowance must be made for this margin of uncertainty.

d. Progress reports are used—

(1) To forecast the time of completion of the job.

(2) To determine whether the original planning assumptions were accurate, and if not, how they should be revised.

(3) To determine whether men and equipment are so assigned as to give a balanced working force, and whether there are any bottlenecks to be corrected.

e. A common error in interpreting a progress report is to confuse percentage of completion with time to complete. A job nearly always goes slowly at the beginning and at the end. The fact that it is 98 percent complete at the end of a month's work does not necessarily mean that it will be finished in 1 more day. The final 2 percent may represent some slow and complex task on which only a small force can work or the installation of some item whose delivery has been delayed.

450. Security at Work Sites

a. The possibility of enemy attack must always be borne in mind by the officer in charge of a construction project, and he is responsible for taking reasonable and proper security measures. However, he must not become so "security conscious" as to lose sight of his mission and disorganize his work schedule.

b. In forward areas of the combat zone the principal types of enemy action to be considered are dismounted patrols, motor or mechanized raids, and air attacks. Farther to the rear, enemy ground action is less likely except as regards guerrillas (see ch. 15). Air attacks may occur anywhere in a theater. However, rear area construction activities are likely to be immune from low-flying enemy attack aviation, which can be a serious danger to working parties in the combat zone. Enemy bombers which penetrate far. behind our lines are normally seeking major targets, and are unlikely to concern themselves with small construction projects. Major projects such as ports, depots, and cantonments are in constant danger of bombing, regardless of their location in the theater, until we have command of the air.

c. Normally, enemy ground action can be guarded against by careful observation and by small security detachments covering probable avenues of approach. These may be supplemented by readily removable road blocks, portable wire obstacles, and mines. The number of men withdrawn from useful work for security purposes should be kept to a minimum. However, each chief of a working party should always be prepared for possible enemy ground raids or harassing attacks. The arms of troops at work should be close at hand, under guard, and working parties must be trained to assemble at once under cover with their weapons, on warning given.

d. Security of working parties in danger of air attack is afforded by warning, concealment, dispersion, and fire. Men should be trained to identify friendly and enemy aircraft. Guards are posted at points of vantage. Vehicles and equipment not in use are dispersed and concealed. When an air alarm is given, men suspend work and take cover unless the work is urgent. If the size of the party and the job justify it, machineguns may be emplaced so that they can be promptly manned and used against low-flying aircraft.

e. For protection against air attack of a major rear-area project—for example, a base depot being built by an engineer construction group—elaborate plans may be made including liaison with friendly combat aviation units and the air-raid warning net and the assignment of AA artillery and firefighting equipment.

f. When work at a site is suspended at night, precautions should be taken against pilferage or sabotage.

451. Camouflage

There are two aspects of camouflage activity at a work site: concealment of the work party and concealment of the thing being built.

a. For the protection of its personnel and equipment, if for *no* other reason, a work party should keep its bivouac, water point, parked equipment, and stocks of materials concealed as effectively as practicable, and should practice camouflage discipline (ch. 25).

b. Whether and to what extent an attempt should be made to conceal the thing being built depends on circumstances. It is impossible to conceal a bridge project on a wide river or a road project in open country. On the other hand, small but important structures or installations can often be concealed during construction, and should be. If dispersed parking to be provided at an airfield is in the woods, the natural cover over each parking place should be disturbed as little as possible, drapes may be placed before clearing and surfacing is started, and the construction crew should observe camouflage discipline in such matters as going to and from the site so as to avoid leaving wheel tracks visible from the air. Similar precautions may be taken in organizing a defensive position, key work being concealed by a combination of natural cover, camouflage materials, and careful discipline.

c. It must be remembered that, once the enemy has made an air photograph of an unconcealed object under construction, subsequent concealment of the object is largely ineffective. If concealment is intended, it must be practiced from the moment that construction starts.

CHAPTER 19

MILITARY ROADS AND RAILROADS

Section I. MILITARY ROADS, GENERAL

452. General

Adequate roads are essential to large-scale military operations. Their provision and upkeep are one of the heaviest and most continuing responsibilities of engineer agencies. No troop units are organized and trained solely for road work, but a large proportion of the engineer units in a theater will devote part of their time to it.

453. Definitions

a. Axial road: Generally perpendicular to the front.

b. Lateral (or belt) road: Generally parallel to the front.

c. Main supply route (MSR): One which has been designated as the principal traffic artery of a division or higher unit. Normally it is an axial road.

454. Road Net, Combat Zone

Under normal conditions the following are representative needs for a type field army:

a. MSR's. At least two from railhead into the army service area; at least one into each corps service area; at least one to each divisional sector. This assumes railhead reasonably close to the front (not over 75 miles or so).

b. Feeders. In a divisional area, to the artillery positions and to each regiment in line. In corps and army service areas, as the situation dictates.

c. Main Laterals. One in each corps service area, and one in the army service area, near the respective rear boundaries of those areas.

455. Tonnage Demands, Combat Zone

a. An infantry division in attack may use up to about 600 tons of all classes of supplies per day; an armored division, up to about 700 tons. For a corps of four divisions, and an army of three corps, in active combat, the daily tonnages are about 2,100 and 8,600, respectively. For divisions in reserve, or for a corps or army on an inactive front, the figures are much less. For details see FM 101–10.

b. These figures are a partial measure of the traffic on MSR's, but do not tell the whole story. Those roads, during active operations, will have heavy troop movements, both motorized and foot and both to and from the front, as well as rearward movements of wounded and prisoners of war. Such movements of personnel may make much heavier demands on an MSR and its feeders than do supply movements.

c. Traffic on corps and army lateral roads will largely pertain to lateral troop movements, and no representative figures can be given.

456. Traffic Capacities, Combat Zone Roads

a. Experience has shown the following with respect to daylight motor vehicle movements on a road with easy curves and grades and in good condition, assuming no interruption of traffic and good march discipline:

(1) Capacity in vehicles per hour increases rapidly with speed up to about 25 miles per hour. Above that, further increases in speed, though they may have other advantages, have little effect on capacity.

(2) A 2-lane highway 20 feet wide (10 feet per lane), with fairly balanced 2-way traffic, will carry about 1,000 vehicles per hour (total for both lanes). Increasing it to the width of 22 feet will increase the figure to about 1,500. If the road is made one-way and both lanes are used, the above figures will be increased about 25 percent.

(3) A truck column moving at 25 miles per hour should have average intervehicular leads of 40 to 50 yards.

Note. Intervehicular lead—the clear distance between two successive vehicles plus the length of a vehicle.

A similar column of truck trailers will have only slightly larger leads, but will carry more cargo per unit. Therefore truck trailers increase the *tonnage* capacity of the road.

b. These figures may be drastically reduced by various forms of interference, chiefly the following:

(1) *Traffic interference.* This may be cross-interference (intersecting roads); merging interference; marginal interference, due to objects or marching men too close to the road; internal interference (trucks bunching up and then stringing out, often a sign of bad march discipline); or medial interference, between vehicles moving in oppo-

site directions, especially common on narrow roads.

(2) Enemy interference by fire and bombing. Its effects may include—

(*a*) Stopping traffic temporarily by damage to a bridge or the roadbed, or by wrecking vehicles which block the road.

(*b*) Forcing vehicles to keep long distances apart.

(*c*) Restricting traffic to hours of darkness.

(3) Deterioration or blocking of the road due to poor maintenance, floods, or other causes.

(4) Bad weather.

c. The extent to which daylight capacity is reduced at night depends chiefly on whether undimmed headlights can be used.

457. Communications Zone

Traffic in the communications zone is very heavy on occasion; for example, on the roads leading to base ports and cantonments and on the MSR's from base to intermediate and advanced depots. Critical sections of such roads may have to be built with 12-foot lanes, with 3 or 4 lanes, and with surfacing and tolerances approximating zone of the interior standards.

458. Roadwork in a Theater

A large and fully organized theater involves all types of road construction and maintenance, including highly improved rear area highways. These latter, however, are likely to be long-range projects. Characteristically, military roadwork is rough and hasty and is done with an eye to immediate short-term needs.

459. Use of Existing Roads

a. Maximum use is made of existing roads. Sometimes they can be used "as is." More commonly the road net needs to be supplemented by widening, strengthening of structures, turnouts, reinforcement of surface or subgrade, and by building stretches of new road. Considerable lengths of new road should not be built until the responsible officer has convinced himself that the need cannot be met by improving an existing road. The latter will at least possess a cleared right-of-way, some sort of drainage, and some sort of subgrade, all of which take time and labor to provide in a new road.

b. This and the next two sections deal largely with building new roads. It is to be understood that the principles set forth apply equally to adapting and improving existing roads.

460. Simplicity and Economy

a. The layout, design, construction, improvement, and maintenance of military roads are all characterized by simplicity, speed, and the greatest economy of labor, materials, and transportation. Maximum use must be made of local materials.

b. While speed is essential, the builder should never make the mistake of starting large-scale work without adequate planning and organizing. Careful reconnaissance, an intelligent selection of routes, and the development of a systematic plan for construction, preferably by stages, give quicker and better results in the long run, and prevent the committing of needed resources to a project which may have to be radically revised.

461. Route Reconnaissance

a. This term is applied to the engineer reconnaissance preliminary to building a military road or to adapting an existing road to military use. In the former case it is called a *location reconnaissance;* in the latter, a *road reconnaissance.* The term "road reconnaissance" is also applied to the periodic routine checks on the condition of a road in use.

b. These two types of reconnaissance are not wholly distinct. A road reconnaissance may show that the existing road needs extensive work, and perhaps partial relocation, to adapt it to military needs. In that case there will be needed some or all of the data appropriate to a location reconnaissance.

c. Location reconnaissance on the ground is usually preceded by a study of maps and air photographs to narrow down the field of investigation. How much time and care is devoted to this depends on the situation.

462. Initial Road Reconnaissance

a. The initial reconnaissance of an existing road must obtain both tactical data concerning the suitability of the road for immediate military use, and technical data bearing on its future improvement. In a fast-moving situation the initial reconnaissance may be tactical only, followed by hasty work to make the road immediately usable, followed in turn by a more deliberate technical reconnaissance.

b. Data to be obtained by a tactical reconnaissance include items given below. Some of these can best be presented on a map or overlay, the rest in a brief written report.

(1) Location of road (or of each section which is reported on separately).
(2) Length and usable width.
(3) General condition.
(4) Mines, if any.
(5) Overhead clearances.
(6) Bridges and fords: locations, conditions, limiting loads, possible alternative sites.
(7) Critical defiles and bottlenecks of all sorts, including fords and bridges and possible bypasses.
(8) Visibility to the enemy.
(9) Estimated traffic and load capacities, including running time.

c. Data to be obtained by a technical reconnaissance include the following:

(1) Grades, including the lengths and slopes of steep grades.
(2) The radius of abnormally sharp curves.
(3) Pavement: structure, materials, thickness.
(4) Structural data on bridges and culverts; approximate drainage areas of streams, and areas draining into culverts; adequacy of structures against anticipated or computed high water.
(5) Drainage of road: crown, ditches, groundwater and high-water levels.
(6) Nature and characteristics of soil.
(7) Data needed to make time, labor, and materials estimates of contemplated improvement and maintenance.

d. Route reconnaissance of a road in the forward area, or of any road which may fall into the hands of the enemy, should include demolition data for key structures and defiles, and roadblock data, with work estimates.

e. For a condensed method of presenting road data obtained by reconnaissance, see TC 7, 1954, Route and Road Classification System.

463. Periodic Road Reconnaissance

Any agency responsible for the maintenance or progressive improvement of a road must have up-to-date knowledge, obtained by periodic reconnaissance and plotted on a situation map, of the current condition of the roadbed, structures, and drainage installations, present and anticipated maintenance needs and work estimates thereon, effects of past work, and lessons to be drawn from it. Such reconnaissance must be frequent, especially in bad weather or periods of heavy traffic. A military road can go to pieces in a surprisingly short time and needs constant watching.

464. Location Criteria

If a new road must be built, there are certain criteria to be met, including the following:

a. Tactical and Logistic Criteria. Among these are the following:

(1) The road must be finished on time.

(2) It must carry the expected traffic.

(3) It must be well located with respect to its function. Thus, a divisional MSR should be generally along the axis of the area in which the bulk of supplies will be used and the major axial troop movements will occur.

(4) Where practicable it should be concealed from the enemy by defilade, overhead cover, and camouflage when justified.

(5) It should be located with an eye to suitable sites for vicouacs, supply points, and similar installations; to a possible expansion of the road net; and to practicable bypasses at critical defiles.

b. *Technical Criteria.* Among these are—

(1) Good natural drainage, supplemented by all necessary drainage structures. The need for these should be kept to a minimum by intelligent siting. A sunny location is helpful in rainy or snowy climates.

(2) Stable soil, with high bearing power, easily drained.

(3) Road surface safely above water table.

(4) Easy grades.

(5) Good alinement. Avoid sharp and sudden curves, especially near the top or bottom of a grade.

(6) A minimum of earthwork, especially rock excavation. Balanced cuts and fills.

(7) Ease of construction. Factors making for this include accessibility of site, availability of materials, few and simple structures, and the ability to work concurrently at various points along the route.

(8) Ease of maintenance.

(9) Practicability of further improvement at a later date.

465. Location Reconnaissance

This involves a preliminary study, by map and on the ground, of possible alternative routes; a selection of one or two, perhaps more, for more careful check; and the collection of all data bearing on the location and design criteria, which are tabulated or entered on a map.

466. Design Criteria

See TM 5–250.

Section III. MILITARY ROADS, CONSTRUCTION AND MAINTENANCE

467. Sequence of Construction

a. This section deals primarily with building new roads. For an existing road the same principles apply, but some steps can be omitted.

b. The structural elements of a completed road (see fig. 19) are—

(1) The subgrade, which is the material underlying the base course.

(2) The base course, which is the layer of material placed on the subgrade.

(3) The surface course.

(4) The shoulders.

(5) Drainage structures and facilities, including ditches, culverts and bridges.

c. Which of these features need to be provided depends on circumstances. The subgrade may or may not need special preparation, and the base course is often omitted. Drainage must always be provided.

d. The successive steps of construction are: clearing, drainage, earthwork and grading, preparing the subgrade; and surfacing. Work on drainage and drainage structures, while it begins early in the construction schedule, continues concurrently with later phases.

Typical Cross Section—2 Lane Road

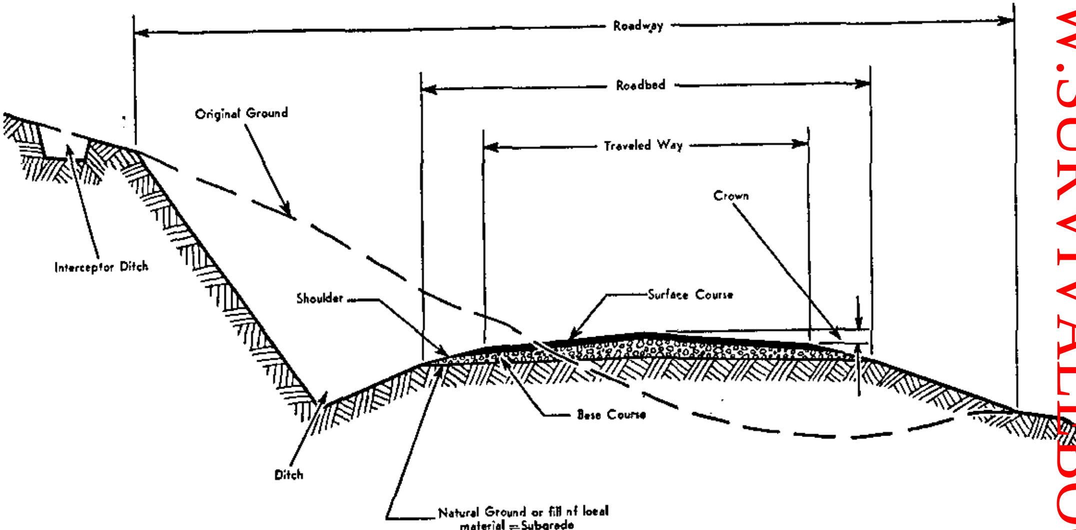


Figure 19. Elements of a road.

d. In an emergency, such as a fast-moving attack or pursuit, elements of sound road construction may have to be sacrificed to the immediate need of getting supplies and transport forward. In such a case, if the road is to remain in use, the responsible officer must make good any vital defects or omissions as soon as possible.

468. Clearing

The right-of-way is first cleared of trees, brush, large boulders, debris, decaying vegetation, and humus. If the latter is very deep, a fill of good material may be needed.

469. Drainage, General

a. The three principal types of drainage are cross, longitudinal, and surface. *Cross* drainage permits water to cross the line of the road below the level of the roadbed, by means of culverts or bridges. *Longitudinal* drainage collects water from the roadbed and adjacent land, and carries it parallel to the road until it can be disposed of. *Surface* drainage is accomplished by crowning and waterproofing; on steep grades, this may be supplemented by open-top culverts.

b. Adequate drainage is attained not only by drainage structures but by locating the road properly, and by raising it above the surrounding level on a fill or causeway if necessary.

470. Cross Drainage, Bridges

See chapter 20.

471. Cross Drainage, Culverts

a. Location. A culvert is needed where water must be passed under the road to prevent it from over-flowing or saturating the roadbed, but where a bridge is not appropriate. The culvert is normally perpendicular to the road, but may be angled to conform to direction of flow. Grade should be steep enough to prevent silting, but not so steep as to cause undue scour; 2 percent is a good average figure. The top of the culvert must be deep enough below the road surface not to be crushed by traffic.

b. Design. The cross section can be computed by formulas or based on local information. The length should be enough so that the road will not be scoured and undercut by backwash. Strength depends on expected wheel loads and on depth of fill above culvert. Headwalls are desirable to prevent water from seeping downstream through the fill, outside the culvert, and causing a failure.

c. Structural Types. In a military road the most common types are box culverts of lumber or round timber, and metal pipes, especially the corrugated type. Concrete culverts are used in more permanent work. Expedient types include oil drums, their ends burnt off and welded together, and sandbags (sometimes filled with concrete) used as sidewalls, with wooden or steel planks for top and bottom. Two or more culverts are often placed side by side, to avoid an unduly high opening.

d. Supplemental Ditching. There may need to be ditching, downstream from the culvert, to get the water well away from the road.

472. Longitudinal Drainage

a. Side Ditches. These must be provided at an early stage of road construction. Their purpose is to collect water from the roadbed and adjacent land and carry it to point of discharge, while never allowing it to rise high enough to flood or saturate the road. Ditches on the uphill side are relieved by emptying into culverts or streams. Downhill ditches may require laterals to drain their water away from the road. If practicable, ditches are cut by grader, giving a triangular section; otherwise, hand work may be needed. They should be kept at a safe distance from the road and shoulders. If the road is on a fill, it is best for the ditch to be in the original material, at a little distance from the toe of the fill.

b. Interceptor Ditches. Drainage is sometimes aided by supplementary ditches back from the road and generally parallel to it. A common case is the protection of a sidehill cut by a ditch just behind its upper edge, which catches water flowing down the hillside and prevents it from eroding the face of the cut.

c. Erosion of Side Ditches. If this is anticipated, due to slope and nature of soil, check dams should be used; or if the grade exceeds about 5 percent, the ditch should be paved. Check dams are so spaced, and of such height, as to reduce the slope of the ditch between dams to around 2 percent. They may be built of timbers, sandbags, or stone. Sometimes they are sodded. They should have paved aprons and a notched crest.

473. Surface Drainage

In military roads, surface drainage is for the most part attained by side ditches and by elevating the road if necessary. Subsurface drains are unusual. If they are needed to drain the subgrade, one means is to cut ditches at intervals, perpendicular to the axis of the road, from the subgrade through the shoulder to the side ditches, and then backfill them with gravel.

474. Earthwork

a. In flat or very slightly rolling country a road may follow the natural surface. No earthmoving is then involved except for ditching and grading. In irregular terrain, however, both cuts and fills are necessary. Efficiency and economy of effort dictate a balancing of cut and fill as nearly as possible. The first step is to plot the grade of the centerline and the cross sections of the right-of-way, usually at 100-foot intervals, and compute the cut and fill. The ideal to be sought is that, for every stretch requiring a cut, there should be a closely adjacent stretch requiring an equal volume of fill; and that, on a sidehill site, the cut should balance the fill in each cross section. If the road grade as first located does not approximate to these conditions, it is adjusted on the profile and restaked. However, in flat terrain and a rainy climate, long stretches of road may have to be on fill.

b. The road is then brought to rough grade by cutting and filling, using standard earthmoving machinery and handwork where necessary. If cut and fill cannot be made to balance, fill is brought in from borrowpits or excess earth wasted.

c. In an earth cut, given good drainage, the natural soil is often (not always) a satisfactory foundation for the road. An earth fill, however, requires treatment. For best results it should be placed in layers and rolled with sheepsfoot or rubber-tired rollers or both, moistening the soil as necessary. In very deep fills there may be only time to roll the upper layers. Some settlement of deep fills is to be expected, especially if they have not been carefully rolled, and may need later correction.

475. Subgrade

a. The subgrade must be capable of taking the traffic load without settlement or failure. The natural surface of the ground after clearing, the exposed surface of a cut, or a properly compacted fill may be a satisfactory subgrade. If not, it will need treatment. In the case of organic material, silt or clay, it may be covered by a fill, or a surface layer may be removed and replaced by better material. In the case of loose sand, a clay binder may be added. Good drainage is vital.

b. In swampy or mucky ground the foundation can be stabilized by corduroy or a mattress covered by a gravel or boulder fill. (See also par. 484.)

476. Surfacing, General

a. Under favorable conditions, the natural earth may be used as a road surface (*earth roads*, sometimes called *unsurfaced roads.*) More commonly, military roads are surfaced. The surface may be built in a single course, or there may be a base course and a surface or wearing course. A base course is likely to be used only for heavy roads.

b. In rear areas and in stabilized situations, bituminous construction or even concrete may be used.

477. Earth Roads

These require a good quality of soil, good weather, good drainage, constant maintenance by drags and graders, and oiling or other treatment to reduce dust. They are most suitable for light traffic running at moderate speeds. For important roads carrying heavy traffic, or for any roads if weather or other factors are unfavorable, they should be considered a temporary expedient, calling for surfacing if they are to be used for any length of time.

478. Surfacing, Thickness of Pavement

This depends on expected load, expressed as wheel load in pounds; strength of subgrade; and strength of surfacing materials. The two last are commonly expressed in terms of "bearing ratio" (the observed bearing strength of the material, as compared with that of a standard sample). It can be determined by a simple test. Given these data, the thickness of pavement can be determined from empirical graphs. For good results a pavement should seldom be less than 5 or 6 inches thick.

479. Surface Course

As stated above, the surface course is often the only course. The nature of the surfacing depends largely on available materials. Common materials are—

a. Crushed rock, placed in layers, graded, and rolled. It makes a good road, but supply may be restricted by available quarrying and crushing equipment. If solidly cemented by adding screenings and rolling while wet, it is called *waterbound macadam.*

b. Coral, similarly placed.

c. Gravel, properly moistened and with an adequate binder admixed.

d. A *sand-clay* mix, which makes a good surface for medium traffic if the materials are rightly proportioned and thoroughly mixed. With a clay subgrade, the natural clay may be scarified and sand and water added; and vice versa.

480. Base Course

If one is built, it may or may not be of the same material as the surface course. Materials having considerable strength but relatively low resistance to direct wear are often used for base courses; for example, sand-clay, water-bound macadam, and telford macadam (made of larger stones or rock fragments than is ordinary macadam).

481. Bituminous Pavements and Surfacing

a. These are not commonly built in forward areas or in fast-moving situations, but may be used in the rear areas of a well-developed theater. The engineer heavy equipment company and the engineer construction battalion have a certain amount of equipment for the purpose, and the latter may be augmented for large-scale work.

Note. This is also true of the engineer aviation battalion, which uses such equipment primarily for runways and taxiways.

Four techniques of bituminous surfacing are in common use:

(1) Plant mix: the bituminous material and the aggregate are mixed in a central plant, hauled to the site and spread. This gives excellent results but calls for rather elaborate equipment.

(2) Road mix: the aggregate is placed loosely on the road site, the bituminous material is added, the two are thoroughly mixed by harrowing and windrowing, and the mixture is spread.

(3) Penetration: the aggregate is placed and graded, and the bituminous material is applied under pressure to penetrate the aggregate and fill the voids. It is more suitable for a base course than a surface course.

(4) Surface treatment, the bituminous materials being merely spread over the surface. It is fast, economical, and less effective than the other methods.

b. Many theaters will have existing bituminous roads which will be used as miiltary roads and must be maintained. Roadwork involving bituminous materials may therefore develop as a maintenance problem, regardless of whether new roads are thus built.

482. Expedients, General

In military roadwork, expedients are often necessary. There are two classes: hasty expedients and heavy expedients.

483. Hasty Expedients

These are used in situations where a passable temporary road is needed so quickly that there is no time for systematic construction as described above. Hasty expedients must be light, compact, and easy to place under difficult conditions, including darkness. They are temporary, require careful maintenance, and must be replaced or periodically rebuilt if the road remains in use. Examples are—

a. Wire mesh, which will give a passable temporary surface on sand or similar soil if laid in one or several layers and properly staked. Types include chicken wire; chain link fencing; Sommerfield track, made of wire mesh on steel bearing rods, which comes in rolls; and square mesh track, resembling Sommerfield but heavier. On very soft or wet sand, a "sandwich" may be made by enclosing flexible duckboards between two layers of Sommerfield mesh or equivalent.

b. Expedient constructions of light wood. Among them are chespaling (made of the trunks of small saplings laid side by side and wired together) and woven bamboo mats.

c. Suitable types of prefabricated landing mat, such as steel and aluminum plank.

d. Monkton pack, which is Sommerfield track prepared in 7½-foot lengths and folded into a pack of this length to be placed by unfolding.

484. Heavy Expedients

These are used when the critical element is not time so much as difficult conditions of construction, such as muddy or swampy ground. Some of them take about as much time to install as does standard surfacing. Examples of heavy expedients are—

a. Corduroy, consisting of round or split logs laid side by side perpendicular to the axis of the road. They may be placed directly on the ground; or on round-timber stringers running lengthwise; or the stringers may in turn be placed on cross-members (sleepers).

b. Fascines, which consist of brush or saplings bound into cylindrical bundles. They are used as a substitute for corduroy if the timber is not available.

c. Log tread roads, in which split logs, laid lengthwise on sleepers, are used to pave the tracks or treads of the road (a crude application of the "treadway" principle).

d. Plank roads, which may be built like corduroy (crosswise planks bolted to stringers) or like log tread roads (lengthways planks forming the tracks or treads, bolted to sleepers).

e. Wooden causeways, in which a plank road is supported on short piles, clear of the ground; usable in very soft or marshy stretches.

f. Metal planks may also be used to make a heavy-expedient road if a double layer is used and the subgrade carefully prepared and drained. (See also ch. 21.)

485. Maintenance, General

Military roads, especially in the combat zone, are seldom up to peacetime standards, they carry heavy traffic, and they are subject to damage by the enemy. Maintenance must therefore be more or less continuous. It is usually done by crews assigned to the roads in a certain area, or to sections of an important road. Roads must be constantly patrolled, repair materials must be conveniently stockpiled, and damage must be made good as soon as it occurs and with minimum interruption to traffic. Liaison between maintenance and traffic control agencies is important.

486. Types of Maintenance

There are four general types: surface, drainage, winter, and combat damage maintenance.

a. *Surface Maintenance.* This has to do with damage caused by ordinary wear. The two principal methods are grading and dragging; and repair of deep puddle holes or chuck holes by cleaning and refilling with good compacted material. In most cases, surface maintenance can and should be carried on without closing the road to traffic; this requires careful training of crews.

b. Drainage Maintenance. Side ditches must be cleared of deposits, and erosion must be checked or made good. Check dams need periodic repair. Side slopes of both cuts and fills must be kept planted or revetted as far as possible, and gullying or slides must be prevented or made good. Culverts must be checked, especially after heavy rains, for silting, outfall erosion, and structural damage.

c. Winter Maintenance. This involves: removal of light snow by graders, and of heavy snow by bulldozers, V-plows and (if necessary) rotary snowplows; removal of heavy ice deposits; sanding or other treatment of icy surfaces; and the timely removal of snow from drainage channels to permit flow of water. Snow fences may be installed at critical points to keep the road from being blocked by drifts. (See also ch. 26.)

d. Combat-Damage Maintenance. This may take a number of forms, including the repair of demolished or damaged structures and the filling of craters. Combat damage may be the result of enemy shells or bombs, or of enemy demolitions executed during a withdrawal. In either case it is important to reopen the road promptly and keep it open, often before the damage has been fully made good. Bypasses around badly damaged areas, built by some hasty expedient means, are an important element in this type of maintenance.

487. General

a. In general, railroads are the best means for the bulk movement of troops and supplies by land over long distances. In a theater having a peacetime rail net they are likely to be a vital factor in transportation, especially in rear areas.

b. Standards for military railroads are lower than those used in peacetime. Nevertheless, railroad construction in a theater is a slower and more elaborate process than ordinary military road construction, calling for special skills and considerable tonnages of critical materials. In most cases new construction is limited to such areas as base ports or major supply centers, and takes the form of extensions to existing lines, expansion of yards and terminals, and the like. The bulk of railroad work, other than operation and maintenance, is major repairs and reconstruction. However, if the enemy has executed demolitions before our arrival in the theater, or has efficient air bombardment forces, railroad repair and reconstruction will often approximate to new work, especially if temporary relocation of a line is involved.

c. Most of this section deals with new construction. The principles apply to reconstruction and extraordinary repairs.

488. Responsibilities

Basic decisions as to the construction, location, and capacity of new railroads, the rehabilitation and use of existing ones, the location of termini, regulating stations and railheads, and the like, are a command responsibility in the G4 zone of primary interest.

Operation and maintenance of railroads and their rolling stock and facilities are the responsibility of the Transportation Corps. Construction, reconstruction, and extraordinary repairs are the responsibility of the Corps of Engineers, except as regards signal communications. When special structures must be built and equipped, such as shops for servicing or repairing rolling stock or warehouses for spare parts, the Corps of Engineers must look to the Transportation Corps for specifications.

489. Elements of Functioning Railroad

The essential elements are—

a. Stable and well-drained roadbed; trackage with adequate rails, grades, curvatures, and ballast; bridges adequate for expected loads; sufficient clearance in tunnels, bridges, and underpasses.

b. Adequate passing sidings.

c. Adequate yards, terminals, regulating stations, and railheads, including storage, loading, and handling facilities.

d. Water and fuel stations.

e. Signal communications adequate for control of traffic.

490. Gage

a. The standard gage (distance between rails, measured from the gage lines) is 4 feet 8½ inches in the United States and many other nations. Some nations have a different standard gage. In a theater where this is true, adaptation of the railroads to military use will involve relaying rails if American rolling stock is to be used.

b. Narrow-gage railroads are those having a much narrower gage than the standard, and correspondingly lighter rails and rolling stock and lesser capacity. They have been built in many countries, usually as supplements to standard-gage railways, and have been used in war to provide rail transportation in forward areas. The increasing efficiency and flexibility of wheeled and tracked motor vehicles will militate against their general use in the ordinary theater.

491. Surveys and Planning

The surveys, studies, and plans involved in building a railroad are more elaborate than in the case of a military road. The principal steps are as follows:

a. Map studies are made, using the best available topographic maps, to narrow down the choice of routes to be reconnoitered.

b. Ground reconnaissance is made of favorable routes. Items to be noted include odometer and barometer observations of distances and elevations, general character of the terrain, controlling curvatures, soil and drainage conditions, bridge and tunnel sites, the size and character of bridges needed, intersections with railways or important roads, availability of ballast and other construction material, and points at which construction parties would have access to the railway route. For American rolling stock and motive power used in the theater of operations, the limiting grade should not exceed 1.5 percent whenever possible, and the desired maximum curvature should not exceed 8°.

c. This is followed by a preliminary survey, which covers a strip of ground from 300 to 1,000 feet wide and fixes the general line of the railway. Trial locations are plotted therefrom and adjusted to give the best balance of grades, alinement, and cuts and fills.

d. The precise line is then located by field survey parties and staked. This calls for much more precision than the location survey of a new road, since the curves of a railway must be laid out according to certain mathematical principles and superelevations must be accurately computed.

492. Construction, Materials

a. The principal items are as follows:

(1) Ballast, which may be crushed rock or slag, gravel, shells, cinders, or similar material.

(2) Material suitable for foundation and embankments. Given good ballast and drainage, any fairly good soil will do.

(3) Rails, spikes, ties, tie plates, angle bars, track bolts, frogs, switches, and other special items.

(4) Materials needed for bridges, culverts, fuel installations, water tanks, and similar auxiliary structures.

(5) Tools and construction machinery, including certain specialized tools.

b. The weight of such construction material is considerable. A mile of track built with 80-pound rails requires 375 tons of rails, ties, and minor metal parts, and (on the average) about 100 tons of bridge and culvert materials. This takes no account of ballast, or of auxiliary structures, yards and sidings.

Note. Rails are classified by their weight in pounds per yard of length. An 80-pound rail is the adopted standard for military use. This is much lighter than that used on the main lines of modern commercial railroads.

498. Construction Procedure

a. The successive steps are as follows:

(1) Clear, excavate, and make embankments (fills).

(2) Install drainage structures, including culverts and ditches. The same general principles apply as with roads.

(3) Prepare the subgrade.

(4) Deliver the track materials, except ballast, along the right of way, as close as possible to the point of use.

(5) Place the ties, alined at one end.

(6) Place one set of rails ("line rail") near the alined ends of the ties, in approximate position, with allowance for expansion.

(7) Install the joint bar material, and spike the line rails to the ties.

(8) Place the other set of rails ("gage rail") at gage distance from the line rail; join and spike.

(9) Aline the track horizontally with precision.

(10) Unload the ballast.

(11) Jack up the track and place the ballast.

(12) Aline the track vertically with precision ("final surfacing") using jacks.

(13) Dress the top of the ballast to proper level.

b. Great care must be taken, in final alinement and surfacing, to provide the correct computed superelevations at curves.

c. Sidings are installed in the same general way. There are special problems in the placing of frogs and switches.

d. Initial delivery of materials may be made along the graded right of way, or from an adjacent or intersecting road. Ballast is usually delivered over the unballasted line by bottom dump cars. Sometimes a railroad is built from one end by a work train carrying materials, tools, and the construction crew.

494. Yards

A yard is an area containing a system of interconnected tracks, generally parallel to each other and accessible from the main line, used for making up trains, storing cars, and other purposes. Yards are essential adjuncts to a railroad at terminals, regulating stations, and other key points. A yard may include the following categories of trackage:

a. Receiving tracks, on to which arriving trains of cars are moved.

b. Classifying tracks, on which the cars from the receiving tracks are regrouped.

c. Departure tracks, on which the regrouped cars are placed and made into trains, and from which they leave the yard.

d. Repair tracks.

e. Storage tracks.

495. Railheads

a. A railhead is the point at which supplies destined for a particular unit, installation, or area are transferred from rail for delivery by some other carrier (usually trucks). A railhead may be either somewhere along the line or at the terminus of the line. The installations at a railhead vary with its use. A division railhead normally needs two sidings, one for the daily train and one for fuel and ammunition; approach roads, parking areas, and loading facilities; and limited storage. More important railheads need additional tracks or a yard.

d. A railhead site should meet the following criteria, among others:

(1) Be located conveniently for the units to be served, with an adequate road net and turnaround, short road haul, concealed loading and truck parking areas if practicable, and no undue interference with other traffic.

(2) Utilize existing facilities if any, and be adequate for present needs and anticipated expansion.

(3) Be out of range of enemy artillery.

(4) Provide for concealment or dispersion of supplies at railhead, especially fuel and ammunition.

496. Regulating Stations

A regulating station is an installation on a military railway line, intermediate between the base port or terminal and a group of railheads, at which the flow of supplies and other items, including personnel, between the former and the latter is directed and controlled. It is an important link in the chain of supply and evacuation. Its facilities include a yard, a varying amount of open and covered storage, and possibly temporary housing and messing facilities for transient personnel.

CHAPTER 20

MILITARY BRIDGES AND PASSAGE OF STREAMS

Section I. TYPES AND CLASSIFICATIONS OF BRIDGES

497. General

a. The construction, repair, and maintenance of highway and railroad bridges in a theater of operations is one of the most important and complex responsibilities of the Corps of Engineers. For details, see TM 5–260, TM 5–370, Department of the Army Training Circular 24, 1953, and the various manuals dealing with standard bridge equipage.

b. The design and construction of military highway bridges, and the selection of appropriate standard bridging equipage when this is used, are intimately connected with the standard classifications of bridges and vehicles, which are discussed in this section.

498. Types of Military Bridges

Bridges may be classified in the following ways:

a. As railway bridges, highway (vehicular) bridges, or footbridges.

b. According to whether they are or are not built of standard Army bridging equipage.

c. As fixed or floating. Floating bridges are normally built of standard equipage.

d. In the case of fixed bridges, according to types of substructure and of superstructure. There are many varieties of both, which may be found in existing bridges in a theater. As regards fixed bridges built by our forces in the theater, other than of standard equipage, by far the most common type will be stringer-type bridges on piers or bents.

e. As single-lane, two-lane, or multilane.

f. By capacity or strength.

499. Types of Load

a. Dead Load. This is the weight of the bridge itself.

b. Live Load. This is the weight of anything that moves on the bridge.

c. Impact Load. The impact of moving traffic adds to the stresses in bridge members. This is allowed for, in military bridge design, by increasing the live load.

d. Concentrated Load. This is one applied at a single point of the flooring of a bridge. Wheeled vehicles transmit their weight by concentrated axle loads, each consisting of two or more concentrated loads transmitted by the wheels.

e. Uniformly Distributed Load. This is one spread more or less uniformly over an appreciable length of bridge. The dead load of the bridge, the weight of a tracked vehicle, and the weight of a column of marching men are examples.

f. Reference. See TM 5–260 for the approximate dead load, per foot of span, for stringer-type bridges of various spans and strengths.

500. Factors Affecting Bridge Capacity

The capacity of a bridge span to carry loads varies according to the type of load (single concentrated load, two or more axle loads, uniformly distributed load); the length of the span; the number, size, and shape of the stringers; the size, shape, and arrangements of other elements of the bridge; and the strength of the materials. The condition of the structure and the extent of damage or deterioration must also be considered. For a bridge with stringers, capacity is usually limited by the strength of the stringers to resist bending.

501. Classification and Marking of Highway Bridges

a. The class number of a military highway bridge is the number representing the safe load-carrying capacity of the bridge under "normal crossing" conditions (par. 503*a*). Class numbers range from 4 to 150. Bridge class numbers may be single-lane, multilane, or dual. A single-lane class number is the largest bridge class number, either for a single-lane bridge or for a 15-foot lane of a multilane bridge which will permit the crossing of either wheeled or tracked vehicles either of whose vehicle class numbers may be equal to the single-lane class number. A multilane class number is the largest bridge class number which will permit the crossing in all lanes simultaneously of either wheeled or tracked vehicles either of whose vehicle class number may be equal to the multilane class number. On multilane bridges, the single-lane class number is always to the right of the multilane class number. A dual class number is a dual number which indicates one single-lane or multilane class number for wheeled vehicles and another single-lane or multilane class number for tracked vehicles. Dual class numbers may be used only when the span length is less than 100 feet and when the bridge is capable of passing tracked vehicles whose vehicle class numbers are 50 or larger.

The wheeled vehicle class number is always shown above the tracked vehicle number. Ferries and their approach ramps are similarly classified.

b. The class numbers of standard equipment bridges and ferries are determined by the Chief of Engineers. Nonstandard bridges and ferries installed in a theater of operations are classified by the engineer unit making the design. Bridges found in place in a theater, and used for military purposes either in their original condition or after repair or alteration, are classified by the appropriate engineer agency.

c. Highway bridges and ferries in a theater are conspicuously marked in a prescribed manner, to show their class number. Two numbers on the marker are used in case of a multilane classification. Adequate bridge marking may also include signs and "telltales" showing limiting overhead clearance, signs showing limiting width (for abnormally narrow bridges), and signs along the approach road to warn traffic and permit the diversion of vehicles which cannot use the bridge.

d. For details see Department of the Army Training Circular 24, 1953.

502. Classification and Marking of Vehicles

a. A military vehicle is any item of equipment, including mobile construction equipment, which habitually moves on land and is mounted on wheels, tracks, or a combination. For classification purposes, military vehicles are referred to as *single* or *combination.*

(1) A single vehicle is one which has only one frame or chassis, such as a prime mover, tank, halftrack, full trailer, or gun carriage.

(2) A combination vehicle is one consisting of two or more single vehicles, spaced less than 30 yards apart, which move as one unit. Examples are: a prime mover towing a full trailer, a tongue or pole trailer, or a gun carriage; a prime mover pulling a semitrailer supported on the "fifth wheel" of the prime mover; and any single vehicle towing any other single vehicle at a distance of less than 30 yards.

b. Except for certain very light vehicles, all vehicles in military use are classified. The class number is the whole number representing the effect which the vehicle has on a bridge, ferry, or ferry approach when crossing it, and thus corresponds to the bridge classification numbers discussed above. It depends on gross weight and on the weight distribution to the axles or tracks. Standard Army vehicles are classified by the Chief of Engineers. Nonstandard vehicles in a theater including captured enemy vehicles, are classified by the staff engineer of the nearest division or higher headquarters. In an emergency a temporary classification may be given by the using unit.

c. Classified vehicles are conspicuously marked, in a prescribed manner, with their class numbers. Special markings are used for combination vehicles. Temporary marking may be used in certain cases for unloaded vehicles, or for vehicles operating only on highways and for which an overload has been authorized.

d. Responsibility for initial placement of vehicle signs and markings rests with ordnance agencies, but their maintenance is a command responsibility.

c. For further details, see Department of the Army Training Circular 24, 1953.

503. Crossings

The crossing of a military vehicle or group of vehicles over a military bridge is determined on the basis of the relative classifications of bridge and vehicle.

a. Normal Crossing. This is one in which the vehicle class number is equal to or less than the bridge classification number. In such a case, vehicles maintain 30-yard convoy spacing. On a floating bridge, the speed of a normal crossing is restricted to 25 miles per hour, and sudden stopping or acceleration is forbidden.

b. Special Crossings. Under exceptional conditions the theater commander, or local civil authorities in areas under their control, *may authorize* vehicles to cross bridges having a lesser class number than the vehicles. Special crossings, when authorized, are limited to the following types:

(1) *Controlled crossing.* A crossing on a multilane bridge, in which the vehicle class number is not more than 50 percent greater than the multilane class number, and the vehicle is centered over two or more lanes. One-way traffic is enforced at this time and there is a limitation of one vehicle on each span of the bridge.

(2) *Caution crossing.* A crossing in which the vehicle class number is no more than 25 percent greater than the bridge single-lane class number. For standard prefabricated bridges, the vehicle class number will not

exceed the published caution class. Certain special precautions are taken.

(3) *Risk crossing.* This is one made only on a standard prefabricated fixed or floating bridge, when the vehicle class number does not exceed the published risk class number of the bridge. Risk crossings are made only in the gravest emergencies, and certain special precautions are taken.

(4) *Reference.* For further details, see Department of the Army Training Circular 24, 1953.

Section II. DESIGN, CONSTRUCTION, AND REPAIR OF BRIDGES

504. Design, General

a. Standard designs for various types and sizes of military bridges, utilizing other than standard bridge equipage, are prepared and published in peacetime by the Department of the Army. A theater headquarters may prepare and issue designs intended to utilize local materials and skills, simplify construction, or meet special load requirements. Officers responsible for the design and construction of bridges in a theater should adhere as closely as practicable to standard designs unless there is good reason to depart from them. However, this policy should never operate as a barrier to making any changes which will expedite work or economize labor or materials.

b. So far as a standard design cannot be used as given, the responsible engineer headquarters must do its own designing. For the techniques involved in designing a bridge, or (what comes to the same thing) in computing accurately the strength and capacity of an existing bridge, see TM 5–260.

505. Widths and Lanes

a. A *single-lane* bridge is one whose roadway is not wide enough for more than one column of vehicular traffic of the type indicated by the bridge classification number. Minimum widths for a single-lane bridge are: for bridge classes 4 to 30, 11 feet; classes 31 to 60, 13½ feet; classes 61 to 100, 15 feet.

b. A *two-lane* bridge is one whose roadway is wide enough for two columns of vehicular traffic of the type indicated by the bridge classification number. Minimum widths are: for bridge classes 4 to 30, 18 feet; classes 31 to 60, 24 feet; classes 61 to 100, 27 feet.

c. A *multilane* bridge is one whose roadway is wide enough to accommodate two or more columns of vehicular traffic; the term thus includes two-lane bridges. In computing the number of lanes on a bridge, the following minimum lane widths will be used: for bridge classes 4 to 30, 9 feet; classes 31 to 60, 12 feet; over class 60, 13½ feet.

506. Materials

a. Most military bridges, other than standard equipment bridges, are made of wood. Milled lumber, if available, is used for stringers, bents, flooring, curbs, and handrails. When milled lumber is not available, round timber is used.

b. Steel, if available, may be used for stringers. The structural shapes best adapted to the purpose are I-beams and wide-flange beams. The use of railroad rails, steel trusses, and steel members of various types salvaged from other bridges is common.

507. Elements of a Fixed Bridge, Stringer Type

a. A fixed bridge has two main parts, the substructure and the superstructure. In a stringer-type bridge (fig. 20) the principal elements of the substructure are the end supports or abutments, and the intermediate supports (if any) of various types, including trestle bents, pile bents, and piers. The principal elements of the superstructure and stringers, flooring, curbs, and handrails. Trusses and floor beams are also found in a truss bridge.

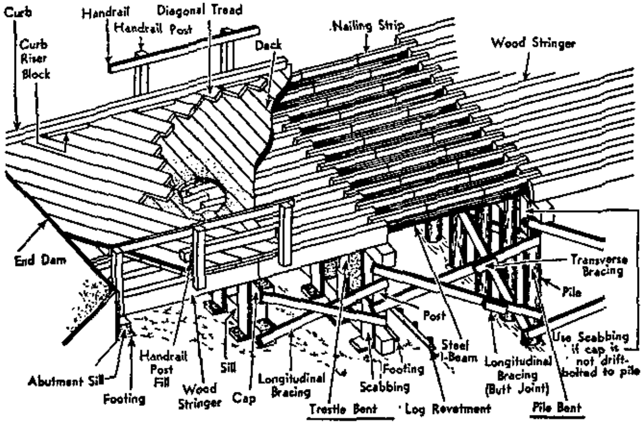


Figure 20. Elements of a timber trestle bridge.

b. An *abutment* is the ground support at the end of the bridge.

c. A *trestle bent* consists of a horizontal *sill* or *mudsill* resting on the ground or on a prepared foundation; two or more vertical or battered members called *posts*, resting on the sill; a horizontal *cap* or *capsill* resting on the posts; and diagonal and other *bracing*.

d. A *pile bent* is similar except that it has piles, driven into the ground, in place of a mudsill and posts.

e. A *pier* is a stronger form of intermediate support. It may be rock or concrete masonry, cribbing, or several bents built as an integral unit.

f. Stringers are horizontal members running axially with the bridge. If there are no *trusses*, the stringers carry the load to the abutments and intermediate supports, on which they rest. If there are trusses, these carry the load and are connected crosswise by members called floor beams which support the stringers.

g. The *flooring* rests on the stringers. It commonly consists of two layers of wooden planking, a lower or *deck* layer and an upper or *tread* layer; the latter may be placed diagonally.

508. Capacity Estimates, Stringer-Type Bridge

The determination of stringer capacity is only one element of bridge design. However, as explained above, it will often be the limiting factor in the capacity of a bridge. It is therefore desirable to have some rough and hasty method of relating a known load to a known type and size of stringer. Means of doing this, based on stringer capacity and the gross weight and characteristics of the load, are explained in TM 5–260.

509. Bridge Sites, General

a. Building a military bridge of any size involves a considerable expenditure of effort and materials. It should not be done if it can be avoided by some such alternative as using an existing bridge, building a culvert and fill (for a small waterway), using a ford, or using a detour of reasonable length. Once the need for a new bridge has been determined, the site is selected by reconnaissance, preceded if necessary by a study of maps, photographs, special intelligence reports, and other pertinent data.

b. Criteria for selecting a bridge site are both tactical and technical.

510. Tactical Criteria for Bridge Site

The bridge must be located with reference to the tactical plan of the troops that are to use it. Activities in the area to be reconnoitered should be held to a minimum to gain surprise both as to the location of the selected site and the time of construction. The prime requisite is speed. Covered areas, accessible by existing roads, should be sought in the immediate vicinity of a site. The reconnaissance should also take into consideration all the measures required for the security of the troops constructing the bridge and the traffic that will lead to or pass the site. For site criteria in a tactical river crossing, see chapter 14.

511. Technical Criteria for Bridge Site

These include the following:

a. Satisfactory river conditions. Fast currents, great depths, and excessive width should be avoided if possible, although these criteria are not always compatible with each other. A moderate current parallel to the bank is desirable. The river characteristics will affect bridge design. For example, a shallow stream with uniform gravel bed lends itself to trestle bents, and a deep stream with soft bottom to piles.

b. Site readily accessible from the road it is to link up.

c. Firm, well-drained approaches, above flood level if possible. If all the bottom land adjacent to the river is liable to flooding within the period when the bridge will be needed, the plan should include elevated approaches (earth fill, trestle, or the like). Approach fills may require large culverts or supplementary bridging to take care of overbank flood flow.

d. Banks firm and stable. The reconnaissance party should look for evidences of widespread instability, shown by stretches of bank near the site which are caving or have caved in some recent high water. A fast-flowing river in a broad alluvial plain may shift its banks hundreds of feet in a single flood period, completely flanking a bridge site. In bridging such a river, it is well to seek a straight stretch or "reach" rather than a deep bend. Bank revetment may be needed.

e. Adequate, well-drained working areas close to the site, including a bivouac for the working party, space for construction materials, and turnarounds and parking places for vehicles and heavy mobile equipment. Bivouac and parking areas should be under cover.

f. Areas or stretches close to the site, near or alongside the approach roads, where, in case of traffic congestion, vehicles using the completed bridge can park off the road and under cover while waiting their turn to cross.

512. Reconnaissance of Bridge Sites

a. A bridge reconnaissance party should include an officer familiar with bridge design, and also, if possible, the commander of the unit which will build the bridge.

b. The following checklist may be used as a guide for bridge reconnaissance, either for new construction or for existing structures. It must be used with judgment, disregarding needless or inappropriate items. Time will rarely permit securing in full detail all the information listed.

(1) Type, number of lanes and width of each, number of spans, length of each, length of panels, arrangement of spans.

(2) Height above riverbed, overhead clearance for vehicles, class.

(3) General conditions.

(4) Stream data: width, depth, velocity of current, direction of flow; type of bottom, estimated bearing capacity of bottom; height, slope, and nature of banks.

(5) Road data on access roads and approaches, including a work estimate on approaches and access road between existing road net and bridge.

(6) Sites for equipment near bridge (turnarounds, access, and concealment).

(7) Abutments: type, dimensions, condition.

(8) Intermediate supports: type, dimensions, condition, relative position.

(9) Stringers: number each span, type, size, spacing, condition.

(10) Flooring: type, dimensions, condition.

(11) Truss, arch girder, suspension system: type, dimensions of principal members, condition (particularly connections).

(12) Number and types of local boats, barges, and other floating plant.

(13) Location of locks and dams in vicinity.

(14) Work estimate to construct (include method).
(15) Work estimate to restore to original capacity (include method).
(16) Work estimate to strengthen to amount specified (include method).
(17) Demolition data (method, sketch showing location and placement of charges, work estimate).
(18) Estimate of effectiveness of demolition (possible detours or expedient crossings, time and labor to cross).
(19) Large-scale sketch of site showing concealment afforded, turnarounds, parking areas, detours, and expedient crossings.

c. For forms for bridge reconnaissance reports and work estimates, see TM 5–260.

513. Reconnaissance of Existing Bridges

a. This is undertaken as an item of the initial route reconnaissance when our forces move into a new area, to determine the characteristics, condition, and capacities of bridges and the repairs or improvements needed. It is also undertaken periodically as an item of routine road reconnaissance.

b. Items to be noted:

(1) Check the abutments, piers, and other members for mines, boobytraps, or evidences of sabotage. Look for built-in demolition chambers.
(2) Check all members for misalinement or undue settlement. See that each stringer and supporting member is carrying its share of the load.

(3) Examine wooden members for rot, splitting, warping, crushing, decay, termites, marine borers (in members immersed in salt water), and other physical damage. Check flooring for smoothness; rough flooring increases the impact load and stresses in all bridge members.

(4) Examine steel members for corrosion, distortion, and other damage.

(5) Examine stone or concrete masonry for cracks, settlement, bulging, sliding, crumbling or any sort of distortion. Check reinforced concrete for exposed reinforcement.

(6) Check for loose, damaged, or missing nails, bolts, rivets, bracing, and other fastenings.

(7) Check the riverbanks at and above the site for signs of recent erosion.

(8) On a periodic inspection, check for any *change* in conditions since the last inspection, especially changes with respect to masonry, since a visible change in a short period may point to an impending collapse.

514. Report on an Existing Bridge

a. The initial report on a serviceable bridge should in any case include a summary of its structural characteristics, a statement of its critical dimensions (length, usable width, overhead clearance if limited), an estimate of its capacity, and a statement of its condition in whatever detail is needed.

b. If the bridge is damaged or wrecked, the report will also include—

(1) Structural details of the bridge in its original form.

(2) Nature and extent of damage; position of debris; details regarding any salvageable members or materials.

(3) What loads, if any, can still cross the bridge.

c. If the bridge is damaged or wrecked, or if, although undamaged, it is inadequate to military needs, the report will also contain information on alternative sites, which will permit determination of whether to abandon it and build a new bridge elsewhere. If the decision is against this, the report will contain data bearing on the repair, reconstruction, or reinforcement of the bridge.

d. The checklist of paragraph 512, omitting irrelevant items, will serve for an existing bridge.

515. Preparations for Bridge Construction

a. In the case of a large and elaborate bridge project not involving standard equipage, the preliminary work may include all of the following steps:

(1) Careful surveys of the site, including soundings, profiles of the riverbed and approaches, and subsurface exploration of foundation conditions.

(2) Development of a suitable design, and the preparation of working drawings, specifications, and bills of material.

(3) Breakdown of the task into component items.

(4) Based on the foregoing, an estimate of the labor and equipment needed. This turns on the scale and nature of the project, the time which can be allowed for completion, and the productivity of the working crews. Experience tables giving the man-hours needed to perform various types of work

are valuable in this connection, but must be used with caution and judgment, and with allowance for weather and other natural conditions and for the experience and skills of the force which will do the work. Enemy interruption must always be taken into account.

(5) Preparation of work schedules.

(6) Installation of access roads and preparation of the working area, including ample space for the orderly storage of materials and equipment and the housing of such units as are to remain at the site during construction. Adequate drainage is vital. Consideration must be given to possible flooding. In laying out the working area, there must often be a compromise between the criterion of maximum theoretical efficiency and the need for some dispersion and concealment.

(7) A construction survey.

(8) Assembly of men, equipment, and materials.

b. In the ordinary military bridge project, especially in the case of a highway bridge in a forward area, there is neither need nor time for elaborate preparatory work. Site surveys and investigations are cut to the minimum. Standard bridge equipage is used if it is available and adaptable to the site; if not, standard designs are used, with the minimum of change to meet local conditions. The use of a standard design greatly expedites the preparation of a bill of materials. Since an engineer troop unit is normally the erecting agency, an experienced commanding officer can make a rapid and fairly accurate forecast of its productive capacity, the probable time needed for the work, and whether and how the organic construction equipment must be supplemented.

c. The principles of job management, discussed in chapter 18, are of course applicable to bridge erection.

516. Bridge Construction

For a discussion of the techniques of erecting military bridges, see TM 5–260 and the various manuals on standard bridge equipage.

517. Repair and Reconstruction of Bridges

a. Extensive work of this sort follows the same general principles and sequence as does new construction, except that the first step is usually to clear the debris and salvage useful structural members. Demolished abutments may be replaced by backfilled retaining walls or cribs. A partly wrecked masonry pier can often be leveled off and used as a base on which cribbing or trestle work is built up to the proper level. If a span has been dropped by explosives but is not badly damaged or twisted, it may be jacked up into place. Standard fixed bridging equipment may be used in place of a demolished span. Work of this sort puts a premium on ingenuity and improvisation.

b. It is often necessary to rebuild wrecked bridges having long spans or of special design. The best method is usually to build enough intermediate supports (if any are needed) in each wrecked span so that the gaps can be safely spanned by standard equipage or by using salvaged material or expedient means, rather than to attempt to reproduce the original design.

An existing bridge, although undamaged, may need strengthening to carry military loads. Often there is no time for accurate computations, and rule-of-thumb methods must be used. The first requisite is of course to determine by inspection what feature or features of the bridge need reinforcement.

a. Flooring. Wooden flooring of a military bridge should be from 3 to 4 inches thick, and for heavy loads should be 5 inches or more. If a bridge has too light a flooring system, a layer of diagonal planking may be laid on it. If the old floor is to be used, worn or damaged planks should be replaced.

b. Stringers. If a rough check shows that the stringer system is too weak, more stringers are sometimes added. However, this requires removing the flooring, and also there may not be room for the additional stringers needed. Other methods (see below) are more commonly used.

c. Adding Supports. Often the quickest and easiest way to reinforce a bridge is to build one or more intermediate supports. The following methods do not apply to reinforced concrete structures and may actually reduce their capacities. Common types are—

(1) Trestle bents, the easiest to place if working conditions permit. After a bent has been erected, wedges are driven between the cap of the bent and the existing stringers; or the cap may be jacked up tight against the stringers, and the posts cut to fit under it.

(2) Pile bents, similarly wedged.

(3) Wooden cribbing, filled with rock. It may extend all the way from streambed to

stringers, or may be built up to high water only and a trestle bent or other supporting structure added.

(4) Diagonal or knee braces to existing supports.

(5) Commercial shores.

(6) A-frames or king-post trusses.

519. Traffic Control at Bridges

See chapter 17.

Section III. STREAM CROSSING EQUIPAGE

520. General

a. A wide variety of standard equipage for crossing streams or bridging gaps is issued by the Department of the Army and will be available in an active theater of operations. Some are organic to engineer troop units; other types are stocked in theater depots until needed. Categories of standard equipage include—

(1) Small boats.

(2) Footbridge equipage.

(3) Floating highway bridge equipage.

(4) Fixed highway bridge equipage.

(5) Railway bridge equipage.

(6) Rafts and ferries.

(7) Cableways and trainways.

b. For full details of equipment, capacities, and construction techniques, see TM 5–260 and the various manuals on standard equipage.

521. Small Boats

These include pneumatic reconnaissance boats, assault boats, storm boats, and bridge erection boats.

a. Pneumatic reconnaissance boats come in three sizes. The 2-man and 5-man sizes are used for such purposes as reconnaissance on inland waterways and utility work during the bridge construction. The 10-man size is used chiefly for reconnoitering hostile beaches. They are inflated for use, and are propelled by paddles.

b. The assault boat, M2, is a square-ended plywood boat, commonly used for the initial assaulting waves in a tactical stream-crossing operation (see ch. 14).

c. The storm boat is a plywood boat with outboard motor, used for tactical crossings of wide streams when speed is more important than secrecy. It can also be used as a utility boat.

d. Bridge erection boats, powered by inboard motors, are used during bridge construction to move pontons, propel rafts, and carry and place anchors and cables. They come in 19-foot and 27-foot sizes, the latter being much more powerful. They have towing bits, and the 27-foot boat has a pushing knee in the bow.

e. Table I gives certain characteristics of these boats.

Table I. Characteristics of standard equipage small boats

Boat	Capacity	Propulsion	Speed	Weight	How transported
Pneumatic reconnaissance boats:					
2-man, canvas	2 to 3 men depending on current	Paddles	Depends on current.	25 lbs.	1 man can carry when rolled and packed.
5-man, canvas	5 to 7 men	do	do	110 lbs.	2 men can carry when rolled and packed.
10-man, rubber	10 to 12 men	do	do	417 lbs.	6 men can carry when rolled and packed.
Assault boat, M2	15 men, including 3-man engineer crew.	do	do	410 lbs.	Nested on truck or trailers; 10 to 12 men can carry for launching.
Storm boat	9 men, including 2-man engineer crew.	Outboard motor 50 to 55 hp.	20–23 m. p. h. fully loaded; up to 32 m. p. h.	440 lbs; motor, 200 lbs.	Nested on trailer; motors carried in truck which tows trailer.
Bridge erection boat:					
19-foot	4,000 lbs. of cargo and a 2-man crew; can propel light rafts in currents up to 5 f. p. s.; for faster currents used 2 boats.	57-hp. inboard gasoline engine.	Depends on current and what the boat is carrying or moving.	1,800 lbs.	2-wheel trailer.
27-foot	4,500 lbs. of cargo and a 2-man crew; can propel heavy rafts in currents up to 8 f. p. s.; for faster currents use 2 boats.	Two 85-hp. inboard gasoline engines (twin screw).	do	6,250 lbs.	Do.

Table I. Characteristics of standard equipage small boats—Continued

Boat	Capacity	Propulsion	Speed	Weight	How transported
Assault boat, ponton	24 men, including 2-man engineer crew in current of 5 f. p. s. or less; or 17 men, including 2-man engineer crew in current of 7–9 f. p. s.	25-hp. outboard	10–17 m. p. h	820 lbs.	Same as assault boat M2.

522. Footbridges

a. M1938 Footbridge. This is a floating footbridge consisting of a series of bays, each of which is made up of two floats, a duckboard, and handrail posts. The bays are joined end to end. The bridge is held in place by anchor cable and bridle lines or by guy lines, and has a float cable to guard against submerging or overturning. Capacity, 75 men per minute in daylight or 40 at night in currents not over 3 f. p. s. (feet per second); less in faster currents. The bridge can be reinforced to carry men at double the above rate, and to carry horses at long intervals and man-towed antitank guns. The equipage is being replaced by the aluminum footbridge.

b. Aluminum Footbridge. This consists of a treadway carried on aluminum pontons. Capacity, 100 to 150 men per minute; a maximum load of 2,500 pounds; will carry motocycles with sidecars; with float cables will carry horses at long intervals.

523. Floating Highway Bridges

a. M2 Assault Boat Bridge. This consists of plywood treadways clamped to and supported by assault boat pontons (M2 assault boats joined stern to stern). Either 2 or 3 treadways may be used, and the pontons may be installed at either normal or reduced intervals. The bridge is held in place by anchor cables. It is suitable for moderate loads.

b. Widened Steel Treadway Bridge. The roadway is made of two tracks of rigidly connected steel treadways and an intermediate track of plywood treadway. The treadways are supported by pneumatic pontons, which consist of a saddle carried on a float. A set includes trestles, other accessories, and assembly equipment. The bridge is suitable for medium tanks and other heavy vehicles.

c. M4 Bridge. The roadway is a continuous deck of hollow aluminum alloy deck-balk, which acts as both stringers and flooring. It is supported by aluminum pontons, which come as half pontons and are assembled stern to stern. Pneumatic floats are provided to carry the roadway in shallow water or over soft ground. A set also includes trestles and various parts and accessories. The bridge is suitable for military vehicles in general, especially those too heavy or large for lighter bridges. It can be reinforced to increase largely its normal capacity.

d. Airborne Division Floating Bridge. Consists of a roadway of aluminum-alloy deck-balk supported on pneumatic floats. Suitable for tactical use with an airborne division.

e. Class 60 Floating Bridge. Consists of a steel superstructure with full-width flush deck supported on pneumatic floats. The superstructure bay is of two-deck tread panels and one-deck filler panel. There is a saddle assembly, with saddle panels and saddle beams. The floats come as half-floats and are assembled stern to stern. A set includes trestles and other accessories. The bridge is suitable for heavy military loads.

f. Assembly Times. The time to assemble a floating bridge may be affected by any of the following variables: approach road work, site preparation; abutment preparation; installation of trestles; installation of anchorage system; number, training, and physical condition of troops; enemy interference; weather conditions; mechanical and/or operational difficulties; blackout conditions; and current velocity.

Time must be allowed for initial preparation of access roads, abutments, and assembly sites; this may vary from less than an hour to 12 hours or more, although it does not usually exceed 4 hours. The following are representative figures for assembly time for the different types of floating highway bridge, but must be used with caution and with the foregoing qualifications in mind:

(1) *M2 assault boat bridge.* Under favorable conditions an engineer platoon can assemble 192 feet in 40 minutes, exclusive of unloading time.

(2) *Widened steel treadway bridge.* A float bridge company and a company of combat engineers can assemble 150 feet in 2½ daylight hours, 250 feet in 4 hours, and 500 feet in 7 hours, exclusive of approach work and preliminary site clearing.

(3) *M4 bridge.* Given prepared abutments, a ponton bridge company and one or two engineer combat companies can build 150 feet in 3 hours, 250 feet in 5 hours, 500 feet in 8 hours, and 1,000 feet in 14 hours.

(4) *Class 60 floating bridge.* Under favorable conditions an experienced crew can assemble 90 feet in the first hour and 120 feet per hour thereafter.

g. Capacities. Table II gives the classes of floating highway bridges for the different types of crossing and for various current velocities.

Table II. Capacities (by class) of floating bridges

Type of bridge		Stream velocities in feet per second for specified crossings														
		Normal					Caution					Risk				
		3	5	7	9	11	3	5	7	9	11	3	5	7	9	11
M2 assault-boat bridge	Normal	8	6	5	--	--	8	6	5	--	--	9	7	6	---	--
	Reinforced	13	9	7	--	--	13	11	8	--	--	14	12	9	---	--
Widened steel treadway		50	50	40	30	15	50	50	45	35	20	55	55	50	45	30
M4 bridge	Normal	60	60	50	35	20	60	60	60	50	40	65	65	65	55	45
	Reinforced	95	95	95	70	40	100	100	100	85	55	105	105	105	100	70
Airborne division bridge		[1] 45	[1] 35	30	10	--	50	[1] 40	35	15	--	55	50	45	25	--
Class 60 floating bridge		65	65	55	45	25	70	70	60	50	35	80	80	70	60	50

[1] These classes do not govern the crossing of the M4A3, M26, M45, and M46 tanks. These tanks may make a normal crossing in currents up to 5 feet per second, even though they have a vehicle class number greater than 35, because they have a greater out-to-out tread width than the hypothetical vehicles of their class. This out-to-out tread width forces them to nearly straddle the center line of the airborne division bridge, approximating a caution crossing (whereas the out-to-out tread widths of the hypothetical vehicles permit an eccentric loading which was taken into consideration in establishing the classes given). These exceptions do not apply to other bridges or to other vehicles.

a. Panel Bridge, Bailey Type M2. A through steel truss bridge supported by two main trusses. The trusses are assembled from 10-foot sections called panels. Transoms are laid between the main trusses and carry steel stringers, which in turn carry a flooring of wooden chess. Trusses may be 1, 2, or 3 panels wide and up to 3 panels high, and are designated by two-letter combinations of the letters "S" (single), "D" (double), and "T" (triple). The first letter shows how many trusses (on each side of the bridge) are placed side by side; the second, how many stories there are. Thus, SS (single-single) means one truss; DT (double-triple) means two trusses side by side in three stories. In practice, SD or ST bridges are not built, which leaves seven combinations. Trusses can be placed below or above floor level, or part below and part above. Triple-story bridges with all three stories above floor level require overhead bracing. Table III gives the capacities, expressed by class, of different types of Bailey bridge for normal, caution, and risk crossings.

b. Modification of Bailey-Type Bridge. Bailey-type panel trusses can be used for highway or railway-deck-type bridges. Panel bridge parts can be combined with special parts to form panel crib piers. A two-lane Bailey-type bridge can be built, the center truss being a common support for the two lanes. A floating-panel bridge can be built on barges or other floating supports.

c. Bridge, Fixed Panel, Single Lane Aluminum. This is generally similar to the Bailey-type panel bridge. Trusses are formed from 15-foot truss panels and can be installed double or triple. The

Table III. *Capacities (by classes) of M2 panel type Bailey bridges*

Span in feet	Class by type of construction and type of crossing																				
	SS			DS			TS			DD			TD			DT			TT		
	N[1]	C[1]	R[1]	N	C	R	N	C	R	N	C	R	N	C	R	N	C	R	N	C	R
30	30	40	45																		
40	26	35	40																		
50	23	30	35	65	70	95															
60	22	30	35	60	70	85															
70	21	28	30	55	65	80															
80	17	22	26	50	60	75	75	95	100												
90	11	17	19	40	45	55	60	65	80												
100	10	12	16	28	35	45	45	50	60	75	85	100									
110				21	29	35	35	40	50	60	70	80	90	100	100						
120				16	22	29	26	35	40	50	55	65	65	80	100						
130				12	18	22	20	28	35	35	45	55	55	65	80	80	90	100			
140				10	13	18	16	22	28	29	35	50	45	50	65	65	75	95			
150							11	17	22	23	30	35	35	45	55	60	65	80			
160							9	12	17	18	24	30	27	35	45	50	60	75	75	85	100
170										13	18	25	20	28	35	45	55	65	65	75	95
180										9	13	19	15	21	30	35	45	55	55	65	90

190	--	--	--	--	--	--	--	--	--	--	--	--	--	10	15	22	30	35	50	45	55	70
200	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	22	30	40	35	45	55
210	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	22	30	27	35	45

[1] N—Normal, [2] C—Caution, [3] R—Risk.

main components of the bridge are made of high-strength aluminum alloy. The bridge will carry any divisional load. It can safely carry class 60 loads on single-truss spans up to 135 feet, and on double-truss spans up to 195 feet.

d. Assembly Times.

(1) *Bailey-type panel bridge, M2.* Two engineer platoons can normally construct an 80-foot DS bridge in 3 daylight hours; four platoons, a 140-foot DD bridge in 8 daylight hours.

(2) *Aluminum fixed-panel bridge.* Under favorable conditions and with a prepared site, a crew of 1 officer, 24 men, and equipment operators can build a 75-foot single-truss bridge in 90 minutes, working with crane. Using manpower alone, a crew of an officer and 55 men can do the same job in 75 minutes.

525. Expedient Fixed Highway Bridges, Standard Equipage

a. Items from the widened steel treadway floating bridge set can be used to build a fixed bridge across a narrow or shallow gap. A clear span bridge can be built with two to five 12-foot lengths of steel treadway. For greater lengths, 25-ton or 50-ton trestles may be used. Using equipment furnished by a panel bridge company, an engineer platoon can build a 75-foot bridge in 90 minutes under favorable conditions. A single span over a short gap can be installed by an engineer squad. Capacities for normal crossing vary from class 90 for a clear span of 20 feet to class 16 for a clear span of 58 feet.

b. Items from the M4 or the airborne division floating bridge set can be used for fixed bridging, using deck balk for the flooring. The balk may be laid as a single span, or as a multiple span using intermediate trestles or expedient piers. An engineer platoon can normally install a 75-foot bridge in 90 minutes.

c. Standard metal trestles of two types of standard steel trestle are issued, the 25-ton and the 50-ton. They may be used to support deck balk or other type of decking.

526. Railroad Bridges, Standard Equipage

a. I-Beam Standard Bridge. This type is assembled from wide-flange steel I-beams and other standard parts. The I-beams, which are used as girders, come in standard lengths of from 17 to 35 feet, and either 18 or 24 inches deep. Either 4 or 6 I-beams may be used to a span. The railroad ties rest on and are fastened to the top flanges of the beams. Bridges of this type will carry loadings up to Cooper's E–45.

b. Unit Construction Railroad Bridge. This is a truss-type steel bridge made of standard unit parts and easy to erect. It may be assembled as a deck bridge, using either 2 or 3 trussed girders, the ties bearing on and fastened to the top chords; or as a through bridge, using either 2 or 4 girders and a conventional stringer and floor system. It will carry loadings up to Cooper's E–45. It will accommodate nonstandard railway gages. With decking, the through bridge will serve as a highway bridge.

c. Through-Truss Railroad Bridge. This is a through-trust bridge made of standard unit parts, having a conventional floor system with ties fastened directly to the stringers. It is heavier than the unit construction railroad bridge, and is used where wide gaps must be bridged without intermediate piers. It will carry loadings up to Cooper's E–45.

527. Rafts, Standard Equipage

a. Infantry Support Raft. This consists of plywood treadways clamped to assault-boat pontons, with curbs inside the treadways. Either 3, 5, or 7 pontons may be used for a raft. These rafts are used to ferry light vehicles in the early stages of a tactical river crossing. They can be combined to form an M2 assault boat bridge.

b. Widened Steel Treadway Raft. This consists of steel and plywood treadways on pneumatic floats. Either 4 or 5 floats may be used to a raft. Suitable for ferrying medium weight equipment and vehicles.

c. M4 Raft. This is assembled from the components of the M4 floating bridge, using either 4, 6, or 7 pontons. Suitable for ferrying heavy loads.

d. Airborne Division Raft. This is assembled from the components of the airborne division floating bridge, using either 4 or 6 floats. Suitable for ferrying vehicles and equipage of an airborne division.

e. Class 60 Raft. This is assembled from the components of the class 60 floating bridge, using either 4, 5, or 6 floats. Suitable for ferrying heavy loads.

f. Assembly Times. Subject to qualifications of the same sort as indicated in paragraph 523, the following are representative figures for trained troops:

(1) *Infantry support raft.* In daylight a platoon can assemble a 3-ponton raft in 10 minutes, a 5-ponton raft in 15 minutes, and a 7-ponton raft in 20 minutes.

(2) *Widened steel treadway raft.* A platoon can assemble a 4-float raft in 30 minutes and a 5-float raft in 45 minutes.

(3) *M4 raft.* A platoon can assemble a raft in about 60 minutes.

(4) *Airborne division raft.* A platoon can assemble a 4-float raft in 60 minutes and a 6-float raft in 90 minutes.

g. Capacities. Class 60 rafts of six floats can carry loads up to class 60 in currents up to 11 feet per second. Capacities of other types of standard equipage raft, for normal and risk crossings and for various current velocities, are given in table IV.

Table IV. Capacities (by Class) of Standard Equipage Rafts

[Classes are based on loading with center of gravity 6 ft. downstream of center line of raft. Floats must be properly inflated]

Type of raft	Number of pontons or floats	Stream velocities in feet per second for specific crossings							
		Normal				Risk			
		3	5	7	9	3	5	7	9
Infantry support raft	3	8	8	4	------	10	9	5	2
	5	13	10	5	------	15	13	8	3
	[1] 7	[2] 13/21	13/21	8/13	—/—	16/23	15/23	10/16	5/8
Widened steel treadway	4	35	35	35	20	45	45	40	25
	5	45	45	45	25	50	50	50	30
M4	4	55	55	55	55	60	60	60	60
	6	75	75	75	70	80	80	80	80

Airborne division	7	90	90	90	85	95	95	95	95
	4	35	35	30	20	45	45	40	25
	6	55	50	45	------	65	60	50	15

[1] Single-vehicle class.
[2] Two-vehicle class (vehicles approximately the same weight).

528. Operation of Rafts and Ferries

a. Power. Infantry support rafts are normally propelled by outboard motors, other types by the 27-foot bridge erection boats. All standard rafts can be operated as trail ferries.

b. Crews. A representative average figure for a raft crew is an NCO and 12 men, though the figure will vary according to type of raft, loads carried, and other factors. Additional men may be needed to operate landing stages. Experience and teamwork are vital to the safe and efficient operation of rafts and of ferry service, and crews must be carefully trained in handling various types of loads under various operating conditions.

c. Loading and Unloading Points. These must be carefully prepared. If practicable they should be opposite each other, but in fast currents the unloading point may have to be downstream from the loading point. If a staream is wide enough, two or more rafts may be operated between a single pair of points. If approach roads can be easily built, rafts may operate from multiple loading and unloading points. Adjacent points on the same shore should be at least 100 feet apart.

d. Precautions. Special precautions must be taken in loading and unloading rafts, and in their operation, especially in swift currents, in darkness, in conditions of high wind and wave action, or on a river carrying floating ice or debris (see TM 5–260).

529. Cableways and Tramways

Three types of equipage of this sort have been designed primarily for mountain operations.

a. Medium Cableway. This is used in place of a bridge across a deep gap. It consists of a $\frac{7}{8}$-inch track cable suspended between two steel towers. A traveling carriage, suspended from the track cable, can be moved back and forth across the gap, carrying a maximum load of 3,000 pounds. Power is furnished by gasoline engines. Capacity is 17 tons per hour over a 1,000-foot gap.

b. Light Aerial Tramway M2. This is used to supply troops and evacuate casualties in terrain inaccessible to pack animals. It consists of two track cables, suspended from a series of towers, on which carriers are operated by a gasoline engine. It can be used on step slopes. Maximum load is 350 pounds. A 3,000-foot tramway can carry 1 ton an hour one-way, or 2 tons an hour with carriers loaded for the return trip.

c. Light Pioneer Aerial Tramway and Cableway, M1. This may be used as either a cableway or a tramway. The set provides track and haul cables, carriages, a power unit, and accessories, but towers must be improvised from round timber or other materials. Operating characteristics—

	As a cableway	*As a tramway*
Maximum installed length	1,500 ft	2,000 ft.
Maximum load	2,000 lbs	310 lbs.

The set may also be used, in snow or on smooth ground, as a toboggan hauling unit.

530. Stream-Crossing Expedients

a. Among the items which can be used in making expedient floats or rafts are canvas paulins and truck covers, shelter halves, large inner tubes, empty gasoline tins or other containers, lumber, round timber, saplings, and brush.

b. Canvas floats can be made by filling the canvas loosely with brush and tying it at the corners; or the canvas can be laid on the ground, the load stacked on it, and the edges of the canvas turned up around the load high enough for flotation and held in place by a frame or rim. Two truck bows tied securely end to end make a good rim. The canvas cover of a 1½-ton truck will float the equipment of a caliber .30 machinegun squad with 27 boxes of ammunition. Two shelter halves will float the individual equipment of two riflemen. A ¼-ton truck can be floated by driving it on to a 2½-ton truck cover, the edges of which are turned up around the truck and secured. These are merely illustrative examples. A launching surface must be provided on which to slide the raft into the water without tearing the canvas. Planks smeared with mud are one means.

c. Floats can be made from inner tubes, empty gasoline tins, or drums, to support a footbridge or to ferry vehicles and equipment.

d. Rafts of many types can be made out of round timber of milled lumber. Flotation is limited in the case of heavy and dense woods or green lumber, and can often be profitably augmented by expedient floats built into the raft.

Section IV. ENGINEER BRIDGING UNITS

531. General

Three types of troop units are organized primarily as bridging units: the engineer panel bridge company, the engineer ponton bridge company, and the engineer float bridge company. They have certain features in common:

a. They are "combat support" units. They are normally assigned to army, or (as regards the panel bridge and ponton bridge companies) to corps, and in either case are subassigned to an engineer combat group.

b. All three have the primary mission of maintaining, loading, transporting, and supervising the erection or installation of their bridging equipment. They can also erect or install it themselves. However, they do not have the manpower to do this as fast as the tactical situation often demands, and it is normally done by divisional or army engineer combat battalions.

c. If more bridging than their organic equipment is needed, they transport it to site from depot or dump.

d. They may be required to furnish bridge guards and to maintain bridges after erection.

e. The float bridge and ponton bridge companies normally disassemble the bridges after the need for them is past, the equipage returning to the status of organic equipment. The panel bridge company normally obtains a new set of equipage, the bridge being left in place until replaced by a more permanent type of structure.

532. Engineer Panel Bridge Company

This unit consists of a company headquarters and two identical bridge platoons. It is equipped with one set of panel bridge equipage. It also has blacksmith, carpenter, and welding sets for maintaining and repairing the bridge equipage, and a truck-mounted crane shovel and tractor with bulldozer for erection and for a limited amount of site preparation. It is fully mobile, using organic transportation.

533. Engineer Ponton Bridge Company

This unit consists of a headquarters and two identical bridge platoons. It is equipped with M4 floating bridge equipage. It also has blacksmith, carpenter, and welding sets, a motorized general-purpose shop for maintaining and repairing the bridge equipage, and truck-mounted crane-shovels, air compressors, and tractors with bulldozer. It is fully mobile, using organic transportation.

534. Engineer Float Bridge Company

This unit consists of a headquarters, three identical float bridge platoons, a support platoon, and an equipment and maintenance platoon. Its standard bridge equipage is the class 60 floating bridge with steel superstructure. It also has assault boats, aluminum footbridge, and equipment for infantry support rafts, including outboard motors. Other equipment includes pioneer, carpenter, and welding sets for maintaining and repairing the bridge equipage, and crane-shovels, air compressors, and tractors with bulldozers. It is fully mobile, using organic transportation.

535. Other Organic Bridging Equipage

The three types of divisional engineer battalion all have certain organic equipage for crossing streams or gaps. The engineer shore battalion has certain amphibious vehicles. For details, see FM 5–5 and the T/O & E's of the units. Engineer units operating in terrain calling for the use of standard tramways or cableways would be issued such equipage, with transportation.

536. Erection of Bridges

a. All engineer officers must understand the erection of all types of standard bridging equipage, and the design and construction of ordinary nonstandard military bridging. All engineer enlisted personnel, as part of their basic training, receive instruction in the use of standard bridging equipage.

b. Divisional engineer battalions of all three types are trained in the erection of their organic bridging, as are the bridging units listed above. They, the engineer combat battalion, army, and the engineer construction battalion, are also instructed in the erection of all types of military bridging.

c. All engineer units operating in the field in a theater must be able to do minor and routine jobs of bridge erection and repair, using local materials and expedients, which are needed for accomplishing their missions.

d. Special and complex jobs of bridge design are handled in the engineer sections of theater or other high-level headquarters.

CHAPTER 21

AIRFIELDS, PORTS, AND PIPELINES

Section I. AIRFIELDS

537. Responsibilities

a. Emergency landing strips in the combat zone, for the primary use of the organic aviation equipment of divisions and other Army units, are commonly provided by divisional, corps, or army engineer troops. However, with the increasing use of organic aircraft by ground combat units, and the corresponding demands for airstrips, using units may on occasion have to provide and maintain their own strips, perhaps with engineer advice and assistance. (See TB 5–250–1.)

b. With respect to airfields pertaining to a theater air force, the basic decisions as to number, location, type, and capacity are made by the air force commander and his staff, within the framework of the theater commander's policies. Detailed planning, construction, and major repair or rehabilitation are the responsibility of aviation engineers.

c. Engineer service agencies have certain responsibilities toward aviation engineers; see FM 5–5. For the supply of liquid fuel by pipeline, see paragraphs 563 through 574.

d. All engineer officers should understand military airfield planning and construction.

536. Aviation Engineers

a. Category. These are so-called SCARWAF troop units ("special category Army units with the Air Force"). They are under Air Force operational control. For their precise status with respect to the Air Force and the Army, see FM 5–5.

b. Engineer Aviation Battalion. This is the basic aviation engineer unit. Its mission is to construct and rehabilitate airfields, roads, utilities, buildings, structures, and other ground theater of operations type facilities required exclusively to support the operations of the Air Force and to defend the construction sites. It does not handle routine maintenance.

(1) *Organization.* The battalion consists of a headquarters, headquarters and service company, three identical engineer aviation companies, and a medical detachment. Battalion headquarters includes administrative, communications, operations, and supply sections. The headquarters and service company includes company headquarters, maintenance and heavy equipment platoons, and the enlisted personnel of battalion headquarters. Each line company includes, besides headquarters, a general construction platoon with three identical general construction squads, a transportation platoon with three identical dump truck squads, and an earth-moving platoon with an earth-moving squad, a compaction squad, and a grading squad.

(2) *Equipment.* The battalion is essentially a construction organization, and is so

equipped. Its organic construction equipment greatly exceeds that of other types of engineer battalions, and includes earthmoving, grading, surfacing, concrete, and quarry equipment. Augmentation may be authorized for special workloads. Radio and telephone communications are provided.

c. Other SCARWAF Engineer Units. The engineer aviation group is at the next higher command level. Its principal components are engineer aviation battalions. There is no approved engineer aviation brigade or force; the Air Force is using TD units.

d. ARWAF Units. This term ("Army units with Air Force") is applied to engineer or other troop units of a standard type of organization which are temporarily assigned or attached to a theater air force or element thereof.

539. Categories of Airfield

a. Airbase. An airfield of permanent construction with operational facilities, shelter for personnel, and facilities for supply and repair of aircraft; not a typical theater of operations installation.

b. Air Depot (tactical air depot). A theater of operations airfield with base facilities and facilities for the wholesale receipt, storage, and distribution of Air Force supplies, and for salvage, exchange, and the administering of fourth echelon maintenance to aircraft.

c. Airfield. An area prepared for the accommodation, landing, and takeoff of aircraft. The term has been generally adopted to designate theater of operations landing grounds other than airbases and air depots. Specifically, it includes the following:

(1) *Emergency landing strip* (*ELS*). A marked rectangular area naturally suited, or readily made suitable, for the emergency landing of aircraft; not suitable for their operation.

(2) *Refueling and rearming strip* (*R & R*). A "frontline" runway with enough level, compacted surface for landing and taking off, and having warmup aprons; suitable for refueling and rearming during the critical phase of an offensive. May be developed from an ELS. Not recommended for overnight accommodation of aircraft.

(3) *Advanced landing ground* (*ALG*). An airfield having the same facilities as an R & R strip, together with dispersal areas.

(4) *Fighter field.* An airfield built to accommodate normally one or more operational groups of fighter type aircraft.

(5) *Bomber field.* An airfield built to accommodate normally one or more operational groups of bomber-type aircraft.

(6) *Photo reconnaissance field.* An airfield built to accommodate normally one or more operational groups of photoreconnaissance-type aircraft.

(7) *Troop carrier field.* An airfield built to accommodate normally one or more operational groups of troop-carrier-type aircraft.

(8) *Supply and evacuation field.* An airfield built to accommodate the outloading of casualties and the unloading of freight. Parking facilities are not normally provided.

(9) *Headquarters field.* An airfield built to accommodate a limited number of administrative aircraft; usually located at a wing, command, or air force headquarters.

(10) *Occupational field.* An airfield of semipermanent construction built to accommodate one or more fighter or bomber groups; usually located at a rehabilitated enemy air base.

(11) *Airstrip or strip.* A clear area of land, normally of limited length, used for the landing and takeoff of light, liaison-type aircraft.

540. Elements of an Airfield

A fully developed tactical airfield in a theater of operations has the following major elements:

a. One or more flightways. The elements of a developed flightway (fig. 21) are the runway proper; the shoulders; a cleared area on each side of the shoulders; a clear zone at each end of the runway; and an approach zone at each end. The horizontal angle which each side boundary of the approach zone makes with the axis of the runway is called the "flare angle." Within each approach zone no obstacle may extend above an inclined plane whose vertical angle with the surface of the runway is called the glide angle. This angle will normally lie between 1 on 30 and 1 on 50, depending on the type of aircraft using the field.

b. A system of hardstands and taxiways. A hardstand is the prepared parking place for a plane. In a field liable to enemy air attack the hardstands should be widely and irregularly dispersed and camouflaged. They must be large enough, and with strong enough paving, to allow aircraft to taxi in and out and turn around under their own power. A taxiway connects a group of hardstands with the runway and warmup apron. If no enemy attack need be considered, planes may be parked on a strip parallel and adjacent to the runway, which also serves as a taxiway.

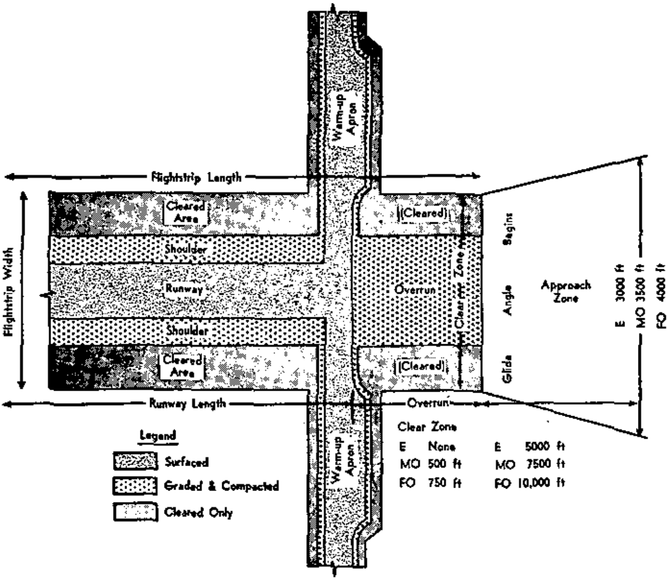


Figure 21. Elements of a flightway.

c. One or more warmup aprons close to one or both ends of each runway.

d. Operational facilities, including the control tower, operations and briefing rooms, windsocks, and other items.

e. Storage facilities for liquid fuel, which may range from stockpiles of drums to an elaborate system including tankage, pipes, pumps, and fueling points. Great care must be taken to disperse, conceal, and protect these facilities.

f. Ammunition storage, also dispersed and concealed.

g. Storage of other types.

h. Repair and maintenance facilities for aircraft, accessories, and automotive vehicles.

i. Housing, community, and office facilities, including elementary shelter for small groups of men who must sleep, or remain on duty, near parked planes.

j. Roads, walkways, utilities, communications, firefighting facilities, and the like, serving the above.

k. Security and safety installations.

541. Standards of Construction

a. There are three accepted standards in a theater for *operational* facilities at an airfield:

(1) *Emergency* (the lowest) provides a basic minimum of facilities to allow aircraft to fly under favorable operating conditions. Safety factors are at or near minimum. The runway may merely be graded, drained, and compacted, though some surfacing is usually needed. Hardstands, taxiways, fuel ammunition storage, and other essential facilities are provided for the initial occupying force.

(2) *Full operational* (the highest) meets established standards for safe and efficient use of the airfield under both normal and adverse conditions.

(3) *Minimum operational* lies between the foregoing.

b. There are also three accepted standards for *housing* and *administrative* facilities—

(1) *Field standard* (the lowest) is based on tentage without framing, flooring, or screening; other facilities to correspond; utilities at a minimum.

(2) *Temporary* (the highest) is based on cantonment-type structures, electricity, running water, possibly sanitary sewerage, and other facilities to correspond.

(3) *Intermediate* lies between the foregoing. It usually involves tentage provided with frames, screens, floors, heating if needed, and electric light and other facilities to correspond.

542. Site Selection and Reconnaissance

The general location, operational type, capacity, and other basic characteristics of a proposed airfield having been decided by the Air Force authorities, the appropriate engineer aviation agency must determine the precise site and layout, subject to Air Force approval. This is done by studies of maps and other data, air and ground reconnaissance. If the site is in enemy hands, and the intention is to develop it when captured, preliminary plans are based on air reconnaissance, subject to revision. The following are the principal items of information to be developed:

a. The size of the area. It must be large enough for the specified need, *and with room for expansion;* with liberal allowance for dispersion of planes and stocks of fuel and ammunition.

b. Accessibility by road. Large airbases and other installations in rear areas may also need railroad connections.

c. Suitability from the camouflage aspect.

d. Topography suitable for the flightway(s). This involves, for each proposed flightway—

(1) A gently sloped and well-drained or drainable area for the runway(s) and overruns.

(2) Satisfactory approach zones. There should be no irremovable obstructions inside the area defined by the flare angles and projecting above the inclined plane defined by the glide angle. The approach zone should not be used for such installations as fuel or ammunition storage, supply and maintenance facilities, or living quarters.

e. Topography suitable for other elements of the airfield, especially hardstands and taxiways.

f. Soil conditions, especially at the sites of the flight strip, apron, hardstands, and taxiways.

g. Existing ground cover, with special reference to—

(1) The amount of clearing and grubbing involved.

(2) The extent and nature of cover which can be retained and used for dispersed and concealed installations.

h. Information on the weather, with special reference to—

(1) The direction, intensity, and seasonal variation of prevailing winds.

(2) Any significant local variations in weather. For example, in some parts of the world large variations in average rainfall, fog, and visibility may occur within a range of a few miles, and may determine the exact choice of an airfield site.

i. Hydrology, including—

(1) General drainage conditions.
(2) Data on flowing and perennial streams, including liability to floods.
(3) Sources of water supply.

j. Construction materials available near the site.

k. Any existing airfield facilities which might be used. However, if the site is in enemy hands, it should be assumed that before he withdraws he will wreck or remove everything which would be immediately useful to us.

l. Data bearing on defensibility (suitable outpost positions, fields of fire, and routes of approach).

543. Layout of Runways and Accessories

a. Number of runways. More than one runway will be needed—

(1) If the expected load exceeds the capacity of one runway.
(2) If wind conditions make a single runway inadequate.

b. Relative Location of Runways. Under condition *a*(2) above, the two runways must of course make an angle with each other, and should preferably be located as an open **V** or **T** rather than an **X**. Under condition *a*(1) above only, this may also be done, or alternatively the runways may be parallel.

c. Orientation of Runways. In determining the runway orientation, special consideration must be given to wind of various ranges of intensity and direction. Air Force specifications require that a beam wind component of 13 miles per hour or less exist 90 percent of the time. Air Force field commanders have the authority to waive this requirement under mitigating circumstances.

d. Layout of Hardstands and Taxiways. This is determined by the location of the runway(s), the number of aircraft to be parked, the terrain, natural cover, and the degree of dispersion required.

544. Design and Construction of Runways and Accessories

This bears many resemblances to road design and construction. In each case there arise the problems of bearing power of soil, drainage, cut and fill, limiting grades, determination of strength of pavement based on expected loads, and the design of the foundation, subgrade, base, and surface courses. Construction materials involved are in general the same: sand, gravel, crushed rock, coral if available, bituminous materials, and concrete. The principal differences are—

a. A runway for modern planes must be designed for greater static loads and impact stresses than the ordinary military road. It should also be noted that the stresses on taxiways and hardstands are even greater than those on runways.

b. Aircraft movement on a runway cannot be slowed down or detoured, and the surface must be correspondingly dependable.

c. Runway construction is concentrated, and therefore lends itself better than ordinary road construction to organization for fast, efficient quantity production using large amounts of mechanized equipment. Engineer aviation battalions are equipped for the purpose. On the other hand and for the same reason, an airfield construction job can fall into extremes of confusion and inefficiency if *not* properly organized. Inadequate drainage is a common cause of this.

545. Portable Airfield Surfacing

This has been used extensively, and will continue. A number of types have been developed, of which some are considered obsolete and others are currently in use.

a. Desirable Characteristics. An ideal portable surface would be cheap and easy to produce in quantity; light and readily transportable; easy and simple to install, take out, replace, and maintain; having no loose parts; strong enough to take the stresses imposed on it; durable; capable of repeated reuse; resistant to heat, cold, moisture, and the effects of spilled gasoline. No ideal type exists, but several approximate it.

b. Standard Types. Standard types at present are M6, M8, and M9. M6 and M8 are pierced steel planks, rolled to shape, and pierced for lightness. They are laid side by side and end to end and locked together to form a continuous surface. M6 requires a separate locking member (end connection); M8 does not. They can be placed on sod or on a prepared surface. The surface should be well drained and preferably compacted. If it is bare earth, crushed coral, or the like, a serious dust nuisance will exist, which can be mitigated by a layer of straw under the plank (*not usable with jets*). The plank is fairly quick and simple to install, and can generally be reused. It is slippery when went. M9 is of the same general design and characteristics as M6 and M8, but is made of aluminum and is lighter and less durable.

c. PSP and PAP. PSP (pierced steel plank) and PAP (pierced aluminum plank) which are earlier models of the foregoing, are at present limited standard. They have certain drawbacks, including a tendency to curl up, which later models have obviated.

d. Other Uses. Pierced plank may be used to surface parking areas for motor vehicles. If it is to be in use for long, the subgrade should be prepared as in the case of a runway.

546. Camouflage of Airfields

This is of the utmost importance if the enemy is strong in the air. It is next to impossible, under that condition, to prevent the enemy from knowing that an operating airfield exists in a certain general locality, but certain steps can be taken to prevent or minimize damage from enemy bombing.

a. Responsibility. The engineer aviation unit which builds or reconditions an airfield is responsible for camouflage during construction. If so ordered, it will effect camouflage of the completed installations and build flattops and dummies. If the camouflage is extensive, an engineer camouflage unit may be temporarily attached. Occupying troops are responsible for placing coverings directly on aircraft, and for all camouflage maintenance and discipline.

b. Site. An airfield should not be placed close to any conspicuous landmark. For example, if an airfield lies within a clearly defined loop of a river, enemy bombers need only aim for the area within the loop, and by staging a saturation raid will be sure of doing great damage.

c. Construction Period. For camouflage discipline during construction, see chapter 18.

d. Runways, Aprons, and Taxiways. These can be toned down with texturing materials (see ch. 25). *Texturing must not be placed on a runway used by jet aircraft.*

e. Dispersion. Dispersion of parked aircraft and of fuel and ammunition storage is highly important. It is also important that aviation engineers make clear to higher authority *the price which must be paid for excessive dispersion*, both in the materials and man-hours needed for longer roads and utility lines, and in the operational inconvenience involved in widely scattered personnel and aircraft. Unreasonable demands along this line may unduly lower the overall productivity of an engineer aviation force, in terms of the total number of installations it can provide in a given time.

f. Camouflage Installations. Flattops or drapes should be placed over exposed stocks of bombs, gasoline drums, and the like. Dazzle painting and toning may be used on structures.

g. Dummy Fields. The installation of a dummy airfield may be worthwhile to divert an enemy bombing attack directed against an adjacent real airfield. The dummy field should resemble the real one as regards terrain and layout; should be on the side from which the raiders would most probably approach; and should be close enough to the real one for plausibility, but far enough away for safety. From 2 to 5 miles is a reasonable distance. The usual measures (ch. 25) should be adopted to deceive the enemy, including dummy aircraft, vehicular traffic, and similar signs of activity. A 24-hour guard with flare guns should be on duty to prevent friendly aircraft from landing. About a dozen men are needed to operate and maintain a dummy airfield.

547. General

a. Adequate ports are essential in any protracted oversea campaign. One of the first objectives of the campaign will be to secure them. If possible, this is done by seizing (or in the territory of a friendly nation, negotiating for the use of) existing ports. Construction of an entirely new port is undesirable; first, because the port facilities themselves take time and a great deal of manpower and materials to build; second, because there should be an urban community at or near the port.

b. It is probable that no existing port will have the precise facilities needed for our use; and that if a port is in enemy territory, it will have been badly damaged by the time we occupy it. Therefore, construction work at ports in a theater will consist partly of repairing or rebuilding old facilities, and partly of enlarging them or adding new ones. If the enemy is strong in the air, periodic major repairs will also be needed.

548. Responsibilities

a. Basic decisions as to the location of ports, capacity, utilization, wharfage and storage facilities, and the like, are made at theater or communications zone headquarters level.

b. The Transportation Corps is responsible for operating ports and port facilities and for maintaining liaison with the Navy, the Air Force, the Coast Guard, interested agencies of Allied armed forces, and local civilian authorities. It recommends what port work should be undertaken. The overall functioning of the port, as a component of the theater logistical system, is under the base section commander, subject to policies and directives from higher authority.

c. The Corps of Engineers is responsible for building, repairing, enlarging, and maintaining ports and port facilities, including minor salvage work and channel improvement. Transportation Corps and engineer agencies cooperate closely in developing layouts, designs, schedules, and priorities. Detailed planning and construction, and channel work, are performed by specialized engineer units.

d. The Navy is responsible for large-scale salvage of sunken ships.

549. Engineer Port Construction Company

a. This unit has the mission of performing engineering work involved in the provision of waterfront facilities of a port, except that subaqueous excavation beyond the capacity of the company's dragline equipment must be done by dredge units. It does not handle minor repairs or routine maintenance.

b. It is normally assigned to communications zone, and subassigned to an engineer construction group operating in that section in which the port is located. It may operate independently.

c. It consists of company headquarters, including a headquarters section, operations and engineer section, supply section, and diver section; a construction platoon, including headquarters, a construction section, and an equipment section; and a service platoon, including headquarters, an equipment and transportation section, and a shop section.

d. Equipment includes compressors, crane-shovels with dragline and piledriving attachments and accessories, power hoists, bulldozers, centrifugal pumps, shallow and deep draft diving equipment, and a wide variety of equipment for jetting piles, pipefitting, blacksmith and tinsmith work, welding, and underwater cutting (oxyacetylene). It has Navy-type pontoon barges and gasoline lighter tanks.

e. For further details, see FM 5–5.

550. Teams

a. Team HA, headquarters port organization, of the engineer service organization, includes a port and dock engineer, a port mechanical engineer, a coast surveyor, and a designing draftsman. It is normally attached to an engineer construction group having port construction responsibilities, to augment its design and planning staff with specialists.

b. Team HB, diving, includes an officer and nine enlisted diving specialists, and has certain diving equipment. It is normally attached to a port construction company, to augment its diving facilities.

551. Dredge Crews

a. The Engineer Service Organization T/O & E includes the following dredge crews:

(1) Team JA, 20-inch cutter pipeline dredge.
(2) Team JB, 24-inch cutter pipeline dredge.
(3) Team JC, diesel-electric seagoing hopper dredge, 700 cubic yards.
(4) Team JD, diesel-electric seagoing hopper dredge, 1,400 cubic yards.
(5) Team JE, diesel, seagoing hopper dredge, 2,700 cubic yards.

b. As the titles indicate, the first two crews operate hydraulic suction dredges, suitable for sheltered water; the last three operate seagoing (self-propelled) hopper dredges, suitable for ocean bars and other unsheltered sites. A crew designated for dredging duty would normally be assigned to the engineer construction group in charge of the port project.

c. See also FM 5–5.

552. Other Construction Units

a. In a large port expansion or rehabilitation program, engineers have a wide variety of duties besides the provision of waterfront structures and the dredging of channels and slips. Among them are the provision of warehouses, depots, quarters for transients and port personnel, tank farms, roads, railroads, and utilities. Such a port project is normally under an engineer construction group, which, besides the port construction and dredging units, would include construction battalions, dump truck and heavy equipment companies, and other units as needed.

Note. Tank farms, pipelines, and accessories are installed by engineer pipeline troops normally reporting direct to theater headquarters; see paragraphs 563 through 574.

b. For further details of the troop units referred to above, see FM 5–5. For port design and construction, see FM 5–10, FM 101–10, and TM 5–360.

553. Definitions

a. *Wharf*. A waterfront installation where freight and passengers are transferred from vessel to shore, or vice versa. It may be open or have structures on it. It may carry railroad tracks. It is generally designed to carry trucks and mobile cargo-handling equipment. Wharves are classified as *piers* or *quays*, although a pier is not necessarily a wharf. Also, wharves may be fixed or floating.

(1) A pier is a structure built out from, and more or less perpendicular to, the shore line,

into deep water. It may be designed for use as a wharf either by having one or more vessels berth alongside it on one or both sides (usually both), or by building a section for that purpose at the outer end and generally parallel to shore (T-*head wharf*). A pier may also be used in other ways. For example, to carry a pipeline out to deep water, where it may be attached by flexible connections to a moored tanker.

(2) A quay is a wharf lying along shore. Its water edge is the *quay wall*, which must be vertical and in water deep enough for vessels to berth against it.

(3) Wharves are normally fixed structures. Floating wharves may be used as expedients. A standard type developed by the Navy has, as a basic unit, a steel ponton or "Navy cube" 5 feet by 5 feet by 7 feet; these can be assembled into a floating structure of any reasonable desired size. They may also be used as lighters.

b. Apron. The strip of wharf adjacent to the edge where vessels berth. It may have railroad trackage for direct transfer of cargo between vessel and rail.

c. Gantry Crane or Gantry. A crane traveling on tracks along the apron of a wharf.

d. Classification Shed. A covered structure in which incoming freight is sorted and classified preparatory to moving it to warehouses or depots. In peacetime port construction, such structures (often called *transit sheds*) are commonly on the wharf, and all freight, not transferred direct to truck or rail on the apron passes through them. In military port construction it is better to have a minimum of covered structures on wharves, and to sort in the open as far as practicable, sheds being provided near the open storage area for such sorting as must be done under cover.

e. Berth. The water area occupied by a vessel while loading or unloading at a wharf.

f. Slip. The water area between two adjacent piers, generally used for berthing vessels.

g. Dolphin. A pile cluster in the water, used to moore a vessel or to keep it from striking and injuring a wharf.

h. Lighter. A small vessel used to transfer cargo or passengers from a larger vessel to shore, or vice versa.

554. Layout of Port Facilities

A port is a highly complex integrated mechanism. The layout and design of a new port, or the expansion and adaptation of an existing one, are specialized tasks. A few basic principles for military ports may be mentioned; not all of them can always be adhered to in practice.

a. Provide enough wharfage to unload the tonnage which the port must handle. Allowances for delays, departures from shipping schedules, and the like, should be more liberal than in peacetime.

b. Keep ship terminals separate from lighterage terminals. Keep ammunition and liquid fuel terminals separate from general cargo and passenger terminals.

c. Provide *ample* open storage areas for bulky equipment and supplies; these should be well drained, hard surfaced, serviced by road and railroad, and fairly close to the terminals. This is one of the most vital features of a military port.

d. Locate receiving, classification, and departure railroad yards near the wharf zone, but not closer than the open storage areas.

e. Provide *ample* covered storage (warehouses and sheds), outside the wharf area and well dispersed, with adequate rail and highway connections to the wharf area, to prevent waterfront congestion and the use of transit sheds for storage. Isolate tank farms and ammunition storage.

f. Establish transient camps 10 miles or more from the wharf area.

g. Make all possible provisions for speeding up the flow of supplies, such as mechanical unloading equipment at wharves; mechanical handling equipment in open and covered storage areas; apron tracks for direct ship-to-rail transfer; ample railroad yards; ample space for the movement, parking, and turnaround of trucks; and circulatory road and track systems serving wharves.

h. See that facilities are balanced; otherwise, bottlenecks will develop and the port will become congested.

i. Make all possible provisions against sabotage and enemy action.

j. Allow room for the expansion of all facilities.

555. Port Capacity

This is defined as the estimated tonnage that can be discharged daily at the port, assuming that facilities exist to clear it from the port after discharge. It depends on wharf facilities, discharge rates, anchorage areas, and other factors.

556. Wharf Facilities

a. The total length of wharfage usable for berthing cargo ships must be enough to provide berths for the maximum number of ships which will be unloading simultaneously. The depth of a berth at low tide should be somewhat greater than the maximum loaded drafts of the ships to be served. The width of a slip which has a berth on one side only should be considerably greater than the maximum beam of the ships to be served, to give room for tugs and other harbor craft. If the slip has a berth on each side, double the width.

b. Table V shows ship dimensions which may be used in planning lengths of wharves, depths of berths, and widths of slips.

Table V. Ship dimensions

Category of vessel	Length	Beam	Loaded draft
	Feet	*Feet*	*Feet*
Cargo ships, 10,000-ton deadweight capacity.	450	60	28.
Cargo ships, 12,000-ton deadweight capacity.	500	70	29.
Troop transports	600	80	35.
Largest transports	About 1,000	100 or more	38 or more.

c. The minimum width of a wharf apron should be 40 feet. The minimum width of a pier, with berths on one side only, should be from 60 to 90 feet; if there are berths on both sides, considerably more than this.

d. The deck of a wharf should be at least 5 feet above extreme high tide.

e. For lighterage wharves, allow 100 feet of length per berth; minimum pier width of 32 feet (one side used) or 42 feet (both sides used); depth depending on lighter.

f. Covered classification storage may be computed as follows: Assume that all berths are occupied; estimate what percentage of the total cargo being unloaded in these berths must be classified under cover.

Note. A rough average is 50 percent of all cargo arriving at a theater port.

Compute the area needed for it, assuming a reasonable tiering height (7 feet is often used) and adding 25 percent for aisle space. Between 35,000 and 40,000 square feet for a 10,000-ton vessel carrying general cargo is a representative figure. This of course assumes that the clearing of freight throught the sheds keeps pace with the unloading of ships.

g. Enough cargo-handling devices, including truck and track capacity, must be provided so that, allowing for the additional capacity given by ship's tackle, vessels can be unloaded at the prescribed rates, *and the wharf kept cleared*, when all berths are in use.

557. Discharge Rates

a. From ship to wharf, for general cargo, allow 500 long tons per 20-hour day.

b. From ship at anchor to lighters, using as many lighters as can be placed alongside and served by ship's tackle, and assuming reasonably calm water, allow 300 long tons per 20-hour day. From one lighter to a wharf, allow 100 long tons per 20-hour day.

c. These figures are representative only. They will vary widely with type of ship and cargo, training of port personnel, weather conditions, and other factors.

558. Anchorage Areas

a. There must be one or more sheltered areas where vessels can anchor while waiting to unload. Minimum depth should be computed on the same basis as channel depths (see below). Maximum depth should not exceed about 200 feet. For moderate depths, a single vessel should be allowed a circular area of 800-foot radius for deep water, more is needed. If there is no danger of air attack, anchorage areas can be laid out in a regular pattern, square or staggered, to economize space. Otherwise anchored vessels should be irregularly dispersed.

b. If there are no tidal currents or strong winds, and space is very limited, vessels waiting to be unloaded may be moored bow and stern to dolphins or equivalent.

559. Channels

a. Depth. The design depth of a port channel should equal the loaded draft of the deepest draft vessel it will serve, plus allowances for "squat" (the additional draft of a moving vessel, aft) and for "send" (the up-and-down motion of a vessel caused by waves). Also, in dredging a channel, overdepth is desirable to avoid constant maintenance. A rough average rule is to allow 3 feet more at low tide than the maximum draft to be accommodated, and then dredge 2 or 3 additional feet overdepth. If this much dredging is impracticable, extra-deep vessels can "work the tides" to make their way to deep draft berths.

b. Width. The bottom width of a main port channel should seldom if ever be under 200 feet, preferably a good deal more.

560. Other Factors Affecting Capacity

Estimates of a port's capacity must make reasonable allowances for high winds, swells, heavy rains, ice conditions, extremely high or low tides, and enemy action.

561. Design and Construction of Waterfront Structures

See TM 5–360.

562. Port Reconstruction Phases

a. The reconstruction of a captured port normally has three phases:

(1) Reconnaissance, clearing of debris, essential salvage, clearing of channels, and the provision of minimum unloading facilities by using DUKW's and lighters.

(2) Expedient construction to provide berths for the direct unloading of ships.

(3) Progressive development of the facilities needed for a smoother functioning port.

b. If the enemy is strong in the air, periodic damage to ports may be expected. Troops, equipment, and materials must be available, and plans must be made in advance, to repair such damage promptly, and meanwhile to provide for unloading by expedient means.

563. General

This section deals briefly with military pipelines used for liquid fuel, the storage and other accessories thereto, and the agencies which install and operate them. Some of the principles set forth apply also to water pipelines.

564. Demands for Liquid Fuel

Modern land and air warfare makes heavy demands for liquid fuels, especially gasoline. A typical "field army slice" in an active theater may require up to 2 million gallons (6,000 tons) of liquid fuels per day. This amount can be handled by four standard 6-inch pipelines. Considering the amount of rail or truck transport that would be needed to handle the same tonnage, the importance of pipelines to theater logistics is obvious.

565. Responsibilities

a. The Quartermaster Corps, as the technical service having dominant interest, prepares broad plans for the supply and distribution of petroleum products. These plans state the phased requirements for petroleum products, the points at which these petroleum products are to be stored and/or delivered to the user, and the means of delivery to those points (for example: pipelines, railroad, highway, inland waterway, or air). For pipeline operation, the Quartermaster Corps is responsible for determining what petroleum products are to be transmitted through pipelines and the destinations to which the products are to be pumped. It operates dispensing facilities for filling standard type petroleum containers assigned to the Quartermaster Corps, and operates bulk petroleum-dispensing storage facilities, including organizational maintenance.

b. The Transportation Corps arranges for the movement, except by pipeline, of bulk and package petroleum products including the scheduling of shipments where necessary with the Navy (MSTS), the Air Force (MATS), and commercial agencies. It also provides military railroad, highway, and inland waterway operating services, including necessary equipment to implement approved plans for the supply and distribution of petroleum products.

c. The Corps of Engineers designs, builds, and maintains pipeline systems, off-vessel submarine lines and manifolds, bulk storage facilities, and dispensing facilities (except first and second echelon maintenance). It operates pipeline systems, pipeline terminal and regulating storage facilities, and off-vessel submarine lines and dock manifolds not an integral part of a quartermaster installation. The engineer troop units available for this purpose are engineer pipeline companies and pipeline operating teams. Civilian or prisoner-of-war labor is often used.

d. The Signal Corps is responsible for communications required for building and operating pipeline systems, other than those communications organic to the troop units themselves.

566. Engineer Pipeline Company

a. This unit has the missions of building and rehabilitating petroleum unloading and storage facilities and pipeline systems, and of operating and maintaining the pipeline systems.

b. It is normally assigned to theater headquarters for the performance of intersectional service, operating under the engineer responsible for such service, and attached for administrative purposes only to an appropriate area command. However, if its duties are wholly within one area command, it may be assigned to that command for all purposes.

c. It consists of—

(1) Company headquarters, including an administrative and supply section, an operations and construction section, and a maintenance and equipment section.

(2) Four identical pipeline platoons, each consisting of a headquarters and four identical pipeline sections.

d. Equipment includes carpenter, pioneer, pipefitting, rigging, blacksmith, tinsmith, and welding sets for pipeline construction and maintenance; special truck-body sets for handling pipeline supplies and construction materials; floodlighting equipment; survey equipment; air compressors, bulldozers, and a crane-shovel. *Communications* are provided by higher headquarters, except that the company has limited telephone equipment.

e. The company can construct on a 1-shift or limited 2-shift basis, and can operate and maintain pipelines on a 24-hour basis.

f. See also FM 5–5 and TM 5–350.

567. Pipeline Operating Team

Team GC, pipeline operating, of the engineer service organization can operate and maintain a pipeline system not exceeding 50 miles of line and 3 pumping stations. It may be attached to an engineer pipeline company, or may function independently. The team cannot handle construction or major repair jobs.

568. Special Construction Materials

a. Pipeline. Standard pipeline is made of 6-inch steel pipe; 4-inch pipe may be used for branch lines and 8- or 12-inch pipe may be used for ship unloading or trunk pipelines. Accessories include couplings, block and check valves, sandtraps, pressure reducers, and other items.

b. Pumping Stations. On ordinarily level ground, stations are 16 miles apart. The standard station has four 4-stage centrifugal pumps powered by gasoline engines. Other types of pumps may be used in tank farms, at water terminals, and in 8-inch and 12-inch pipelines.

c. Storage Facilities.

(1) Standard steel tanks, assembled by bolting sections together, are made in six sizes: 100, 250, 500, 1,000, 3,000, and 10,000 barrels. Net weights vary from about 1 ton to about 39 tons.

(2) A synthetic fabric tank, holding up to 10,000 gallons, has been developed for use at forward supply points or beachheads. It is quickly and easily installed.

(3) Existing civilian tanks are used if available.

d. Sets. There are standard sets of pipeline equipment and accessories. They include sets for a "unit" of pipeline, for ship unloading, tank-car loading and unloading, dispensing, and tank farm manifolds.

369. Planning of Pipeline System

a. Overall Plan. This is normally prepared at theater headquarters. It includes tentative locations of base and forward terminals and of all proposed installations such as tanker and barge unloading points, storage points, dispensing points, routes of pipelines, and pumping stations; also the number and capacity of pipelines and other basic data. Locations are subject to change after reconnaissance.

b. Water Terminals for Pipelines. Elements of such a terminal are: a wharf or dolphins for mooring tankers; a pipeline to shore, which may be on the wharf or submerged, but must have a flexible connection to the unloading tanker; suitable storage; and all required accessories, such as pipelines, pumping stations, security and firefighting installations, and quarters and shops for operating personnel. As to storage, about two-thirds of a theater's reserve supply is usually carried in base section tankage near the terminal.

c. Regulating Storage. Storage forward of the base section is important. A desirable minimum is a total of 15 days' supply in all forward-area tankage. Along the pipelines a storage capacity of 12 hours' pipeline capacity per type of fuel being pumped should be provided at every alternate pumping station, to prevent the line being at once shut down by a break in a rear area. At airfields, the troops which install pipelines install concurrently 2 days' storage, which should later be increased to 15 to 30 days' storage. Separate tanks are of course needed for each type of fuel.

d. Dispensing Facilities. Engineers plan and install dispensing pipelines; tank-car loading and unloading facilities; filling stands for tank trucks, planes, drums and cans; and tankage needed for the foregoing. Using services operate these facilities.

e. Reference. For further details see TM 5–350.

570. Selection of Route

a. Final selection of the route of a pipeline involves a map study followed by reconnaissance. Strip air photographs are useful. Points to be borne in mind include: direction of route, and departure from a straight line; accessibility of route for construction and maintenance; topography and hydraulic grade line; soils and drainage; and suitable sites for storage and pumping stations.

b. For convenience of installation and maintenance, the line should be readily accessible from a road but not directly alongside the road. Populated areas, and military installations having a high element of fire risk (for example, ammunition dumps), should be avoided.

c. Marshy or flooded areas should be avoided. If the line is to be buried, rocky areas should be avoided.

d. Changes of direction, both vertical and horizontal, should be gradual.

e. Hydraulic characteristics of the system must be carefully checked.

571. Construction of Pipeline System

a. The first step is clearing the right-of-way and leveling any irregularities. If the line is to be buried, the ditch is then dug while pipe and other materials are being assembled. Maximum use is made of local and prisoner-of-war labor for such work as hand clearing, grading and ditching, and loading and unloading pipe. Personnel of a pipeline company must be trained to organize and supervise such labor.

b. For installation of a pipeline, the operating unit within the pipeline company is the platoon. Normally, one section of the platoon hauls and strings the pipe; a second section installs tanks, pumping stations, road, and river crossings; the other two are organized into 4-man coupling crews.

c. For stream crossings a fixed bridge is used if available, the pipe being placed on brackets projecting out from the downstream side of the bridge, or otherwise attached so as to be readily accessible and not to interfere with traffic. If no bridge is available, one may be built, or a submerged line may be installed, resting on the bottom of the river. In the latter case the line is assembled on the near bank and then pulled across the river with winch lines. For a navigable river the line must be submerged unless there is a fixed bridge with enough vertical clearance to permit navigation. A ponton bridge may be used temporarily, but an alternative crossing must be prepared as soon as possible.

d. For road crossings a box culvert may be constructed in advance and the pipe slid through it. Existing culverts may be used if there is no danger of drainage complications.

e. Great care must be used to clean each joint and the interior of the pipe before coupling. Failure to remove earth, pebbles, fragments of wood, and other foreign matter will cause clogging of pipes, sand-traps, and valves, interrupting the service and necessitating dangerous and time-consuming repairs.

f. In a major offensive the pipelines must follow the advancing troops. Intervals between tactical advances must be employed in bringing up pipeline materials, reconnoitering forward of the pipehead, and making all advance preparations for immediate installation of the next section of line when it is ordered. Such intervals may also be used to build tankage needed for forward area storage.

572. Testing

When first installed, a pipeline may have leaks, especially if the construction crews lack experience. A leak in an operating line wastes valuable fuel and is dangerous to repair. Therefore, except under conditions of utmost urgency, a new line should be tested for leaks and obstructions before liquid fuel is pumped into it. Water or air may be used for testing; the former is better.

573. Security Measures

A pipeline is difficult to conceal from air observation, and ordinarily no attempt is made to do so, since it is a poor target for bombing. Pumping stations, however, should be under cover or camouflaged. Large tanks and tank farms cannot be placed under cover, but should be toned down or otherwise treated to reduce their visibility. Pipelines must be patrolled as soon as operation commences, to protect against pilferage and sabotage. Pumping stations and tank farms must be protected by armed guards and by wire and other obstacles.

574. Operation of Pipeline System

The following are basic principles:

a. Economy. Gasoline is always at a premium in a theater, and all personnel engaged in handling or dispensing it must be impressed with the need for rigid economy and the avoidance of wastage.

b. *Fire Hazard.* A consciousness of this must always be present in the minds of pipeline personnel. Especially, every precaution must be taken to guard against leaks, and to deal with them at once if they occur.

c. *Integrated Operation.* Tanks, pumps, and pipelines form a single closed system, usually containing several million gallons of gasoline in the process of transfer from one tank to another through pumps and pipe. Operation of this system must be handled as a unit. When a tank is full or empty it is cut off from the system by closing a valve, and another tank is added to the system by opening the proper valve to continue the transfer of gasoline from one tank to another. In operation, one man, the pipeline dispatcher, controls this transfer through tank gagers and pump operators by telephone or teletype communication.

d. *Hourly Accounting.* For the successful operation of any pipeline system, the entire fluid content of the system must be accounted for hourly. This is done through hourly telephone and teletype gage reports of the fluid content of each tank in the system.

e. *Pipeline Dispatch Control.* Each pipeline system, military or civil, must be operated by a dispatcher, usually located at the base terminal or battalion headquarters, who receives hourly reports from the entire pipeline and keeps a running record.

f. *Continuous Communications.* The pipeline system cannot function successfully without a continuous and exclusive means of communications, which should be a telephone system for short lines and a teletype system for lines of 100 miles or longer.

CHAPTER 22

WATER SUPPLY

Section I. GENERAL

575. Nature and Importance of Problem

a. A suitable supply of water is one of the most fundamental needs of an army. Without water, no unit or individual can function effectively for more than a day or so. Without reasonably pure water, a unit's effectiveness may be reduced or nullified by disease in a short time. Defective and impure supplies of water have determined the outcome of many campaigns in the history of war. Modern techniques of water purification and distribution will permit troops to maintain their health, and to carry on operations, in areas and under conditions that would have made this impossible a century ago.

b. Water supply is commonly spoken of as a "supply problem," and water supply troop units are considered to be in the "maintenance and supply" category. However, it differs considerably from the ordinary supply problem, since the commodity it deals with is not handled through normal supply channels. It might be better to think of the activity as "water service."

576. Scale of Problem

Table VI gives approximate figures of minimum and average demand for water, by troops in a theater under various conditions. The figures are subject to considerable variation on account of climate, terrain, physical condition of the troops, water discipline, and other factors.

Table VI. Per capita water consumption in a theater

Situation	Gallons	Remarks
Troops in combat	½	Absolute minimum, drinking only, not over 3 days.
	1	A small additional allowance for cooking.
March or bivouac	2	Minimum for drinking, cooking, washing mess utensils, hands, and face.
	5	Allows in addition some bathing and laundry.
Temporary camp	5	Minimum; see preceding.
	15	Includes bathing and waterborne sewage on an economy basis.
Semipermanent camp	30–60	
Cantonment (theater)	60–100	
Hospital	[1] 10	Minimum.
	[1] 50	Allows for waterborne sewage.

[1] Per bed.

577. Responsibilities

a. Technical Services. The Corps of Engineers is responsible for water supply, including reconnaissance and development of sources, the production, treatment, and, to a limited extent, transportation of water, and the supply, installation, operation, and maintenance of equipment. The Army Medical Service is responsible for determining whether water is safe. It is equipped to perform bacteriological tests, and its representatives work closely with the engineers. The Chemical Corps has responsibilities with respect to areas or facilities, including water-supply systems, which have been contaminated by toxic agents.

b. Staffs. Engineer staff officers at all levels are responsible for planning, supervising, and inspecting the water supply activities in their commands.

c. Operating Agencies. The water-supply mission is normally assigned coincident with the work-area assignments of battalion or higher units. Units assigned water responsibility for populations with a greater demand than can be furnished with organic equipment will have attached water-supply teams as necessary.

d. Troop Commanders of All Arms. While troop commanders look to the engineers for their water, they have their own responsibilities in this field, including water discipline, the prevention of wastage, and sanitary precautions to insure the continued purity of stocks of water within their units. Troop commanders are also responsible for insuring the prompt and proper use of individual methods of water purification during periods in which their units are isolated from water-supply points.

578. Engineer Water-Supply Agencies

a. The engineer combat battalion, divisional, has a water-supply subsection with four sets of purification equipment and operators. Each set can produce 2,100 g. p. h. (gallons per hour) of pure water, and can store 9,000 gallons in fabric tanks. The subsection is responsible for producing, purifying, and storing at water point the water for the division, but not for delivery.

b. The armored engineer battalion and airborne battalion have similar equipment, and similar responsibilities to their respective divisions. The engineer combat battalion, army, has similar equipment, and is a source of water for engineer and other troop units operating near it which it is designated to supply. The engineer shore battalion and the engineer construction battalion have two similar sets. The engineer aviation battalion has one.

c. The engineer water-supply company has no other function than water supply. It can produce up to 27,000 g. p. h., and can also transport water in tank trucks or semitrailers with a total capacity of 18,000 gallons. It operates in the army service area or communications zone, serving units as directed. See also FM 5–5.

d. Four teams of the engineer service organization have water-supply missions. Team GF, water purification, has field equipment which can produce 3,000 g. p. h. and store 12,000 gallons. It may function with a water-supply company or independently. Team GG, water purification, provides supervisory personnel for operating a municipal system or equivalent. With augmentations, it can operate large-scale purification units, or can operate a system for up to 200,000 users. It is normally assigned to an engineer brigade in the communications zone. Team GH, water transport, has a hauling capacity of 4,500 gallons, and may be used to augment a water supply company. Team GE, well drilling, has a well-drilling rig and operators. It is attached to any engineer construction unit needing its services; the unit must assist the team with additional men and equipment.

579. Engineer Water Supply Equipment

a. Such equipment, organic to troop units, includes the following major items: a centrifugal pump, a suction hose with intake nozzle, a discharge hose, apparatus for filtering and purifying the raw water, fabric tanks for storing it, and the required auxiliary valves, fittings, tools, and chemicals. Several types of purifying apparatus are in use; for details see TM 5-295.

b. For distilling salt or brackish water, the army has several units using gasoline or diesel fuel. Their production varies from 60 to 300 g. p. h. They require from 2 to 6 gallons of raw water per gallon of distilled water produced, depending on the type of unit.

580. Aspects of Water Supply

a. If water must be provided from a natural source—as is often the case in a theater, especially in the forward areas—the steps involved in water supply are—

(1) Location and evaluation of a suitable source and water point.

(2) Installation of the water point; treatment, storage, and distribution of the water; and associated problems such as traffic control, camouflage, and security.

b. If a developed source—for example, a municipal water supply system—is available, the same problem exists, but their scale, relation, and solutions differ.

Section II. LOCATING AND EVALUATING WATER SOURCE

581. Sources, General

The principal natural sources of water are—

a. Streams, lakes, and ponds (surface water).

b. Springs.

c. Wells.

d. Sea water.

e. Rain.

f. Snow and ice.

582. Locating Source

This involves field reconnaissance, usually preceded by a study of existing data. If a high-level study is involved—for example, by a theater or army engineer with respect to a large area—it may include intelligence reports and hydrological, geological, and climatic data. At lower levels and in a fast moving situation it may involve only a brief study of a map. Ground reconnaissance is always essential.

583. Water Points, General

a. A locality where purified water is stored, or otherwise made available for delivery to the water trucks or other transportation, is called a *water point*. In the field it is usually close to the source of the water. Alternatively the water may be hauled to a distribution point remote from the source.

b. In a divisional area there are usually three water points, so located that the various units of the division can be served from them without congestion or interference with normal traffic circulation. As the divisional battalion has 4 purifying units, it can operate 3 water points and keep 1 unit in reserve. Four water points may be operated if desired.

c. In corps and army service areas and the communications zone the number and location of water points depend on the number, location, and character of using troop units and installations.

d. It is not usually necessary to designate water points to be used by units. Ordinarily water is supplied to any unit or individual appearing at the water point. If a water point becomes overcrowded, its capacity should be increased or a new point established. When water is extremely scarce, as in some desert areas, a rationing system may be necessary.

584. Data Needed, General

The study and reconnaissance must furnish information on—

a. Quantity of water.
b. Quality of water.
c. Communications.
d. Site conditions.

585. Quantity of Water

a. Flowing Water. The flow of a stream, or of the outlet of a spring can be computed by any one of several methods, varying in complexity and accuracy.

b. Wells. If a well already exists and time permits, a drawdown test can be made by pumping water from the well at a known rate. Otherwise the engineer must rely on local information.

c. Standing Surface Water. If a lake or pond is so small, compared to demand, that its productive capacity must be known and allowed for, it can be approximated by measuring the outflow. More refined results are given by considering rainfall, evaporation, and possible seepage.

586. Quality of Water

a. This should always be checked, on a common-sense basis, by observing the following: color of water, turbidity, odor, taste, and possible sources of pollution. With respect to the latter, and especially as regards surface water, the drainage area should be reconnoitered as thoroughly as time permits, to check on pollution by human wastes, industrial wastes, carrion, or poisoning by enemy action. Dead or mottled vegetation close to surface water may have been caused by toxic agents.

b. Supplementing the above, the standard water quality control kit permits residual chlorine tests (a measure of the chlorine dosage needed for disinfection); pH determination (a measure of the acidity or alkalinity); coagulation tests (to determine the optimum pH and the proper alum and soda-ash dosages); and tests for salinity and turbidity. There is a special Army kit for testing for chemical warfare poisons. If radioactive contamination is suspected, a Geiger counter or similar device will give a check.

c. Use of the standard testing kit will tell the operators how much chlorine is needed to neutralize the micro-organisms in the water. However, it will not tell them what the organisms are, or whether they are pathogenic. To determine this, other tests are needed, using apparatus issued to medical personnel. In a fast-moving situation such tests must often be omitted or postponed.

587. Access

A water point should have—

a. A road system connecting it with the users. It should be as close to a main supply route as is practicable without interfering with the movement of through traffic. Isolated locations should be avoided, as they will seldom be used and are hard to defend.

b. An all-weather access road leading to the point of storage, with a turnaround or a separate exit (one-way traffic).

c. An all-weather off-road parking area for trucks waiting to be filled.

d. Directional signs marking all routes from the using unit areas to the water point. Signs must be visible day or night, and should be standardized for easy identification. In addition, the unit engineer rapidly disseminates the location of a new water point.

588. Site Conditions

Reconnaissance should cover the following:

a. Cover and concealment.

b. Possible nearby targets which may attract enemy artillery fire or bombing.

c. Drainage.

d. Condition of the bed and banks of the source of water (if a surface source) and the means required to develop the source.

e. Road connections, parking, and turnarounds if needed.

f. A bivouac area for the operating party.

589. Other Aspects

a. If a source is to be used for some time, thought must be given to seasonal variations which may reduce the flow of water below the amount needed. In the case of a running stream there is also the possibility of high water flooding the water point. Information on this may be obtained from local residents, supplemented by a study of the banks, their vegetation, driftwood besides the stream bed, etc.

b. The fact that one good source has been found should not preclude continued reconnaissance for alternative sources which may be better, or which may be needed if the first source dries up, is flooded, or is made untenable by enemy action.

c. In a moving situation, reconnaissance should be more or less continuous, to locate sources which may be needed later if the troops being served move to new positions.

d. The fact that water from a source is not of the best quality does not preclude its use. Water from any natural source is likely to contain some impurities and pathogenic organisms which call for treatment. Exceptional contamination calls for exceptional measures.

Section III. DEVELOPING AND OPERATING WATER POINT

590. General

A suitable source having been found and a water point selected, the following steps are involved in putting it into operation:

a. Decision on the location and nature of the intake. This will vary with different terrains, soils, and types of source.

b. Installation of apparatus.

c. Provision of traffic, drainage, and security facilities, and of bivouacs for the operators; operation of the water point, including record keeping.

If the water near the bank is deep and clear, with a hard bottom, the intake strainer may be placed on a rock elevated above the bottom and at least 6 inches below the surface, or hung from a stake. In a deep stream with variable level it may be hung from an anchored float. If this is not satisfactory, the following are alternatives:

a. A dam across the stream, to deepen it and permit a satisfactory intake.

b. A pit dug in the streambed. To prevent silting, this may be surrounded by a crib of timber, rock, or sandbags, leaving enough of the stream bed open to allow free flow. A variant, useful with a muddy stream, is to fill the pit with gravel in which the intake is inserted; this acts as a filter.

c. If the soil and topography are suitable, a shallow well may be dug in the bank near the stream, which seepage will fill.

d. A gallery or trench may be dug in the ground near the stream, to a depth well below the water table, and filled with gravel in which the intake is sunk.

592. Flowing Subsurface Water

In semiarid country, or following a severe drought, there will often be a flow of subsurface water under an apparently dry streambed. This may yield considerable amounts of excellent water. An exploratory pit will give an idea of the nature and amount. The intake may be placed in such an open pit, or in a pit dug and filled with coarse gravel. Such a source is sometimes improved by a subsurface dam, just below the intake, made of sheet piles or equivalent driven across the bed well below the surface.

This may raise the water table enough to permit longer continuous pumping.

593. Springs

a. If a spring is used as a source, the spring itself and the adjacent area should be carefully cleaned, loose rocks and vegetation removed, and the area fenced.

b. If the intake is to be placed at the spring, the latter should be inclosed. The inclosing structure may be anything from a wooden box to a small concrete reservoir. It should be covered. A screened overflow must be provided. Alternatively the spring water may be led by a trench or pipe to a lower collecting point where the intake is placed.

c. Springwater is by no means immune from contamination. The usual precautions must be taken with it, including reconnaissance for sources of contamination. In populated territory a common source is outdoor privies.

594. Wells

a. A well is more trouble to install and operate than a surface source, but must often be resorted to. Existing wells may be used, though they should be checked for contamination and will often need to be cleaned before using. There are several ways to increase the yield of an existing well. Sometimes, however, it is more trouble to do this than to dig a new well.

a. Wells are classified as shallow or deep. A "shallow well" is generally considered to be one not over about 25 feet deep. A shallow well may be dug by hand and lined, or, like a deep well, may be drilled and a casing and well point used.

d. Digging or drilling a well should be preceded by as careful a study as time and data permit of the likelihood of finding water and its probable amount, depth, quality, and seasonal fluctuation. The best source of this information is a study of nearby wells, if any, including drawdown tests.

595. Sea Water

Sea water may have to be used, either raw for bathing, or after distillation for drinking and cooking, if there is little or no fresh water. In developing an intake for sea water the engineer should first look for a tidal creek or a sheltered cove with minimum wave action and tidal fluctuation. The intake can then be installed as with a fresh-water surface source. If this is impossible, a well may be dug close enough to a sandy beach to provide an ample flow by seepage, but above the level of storm waves.

596. Layout of Water Point

Figure 22 is a typical layout for a water point in the combat zone, showing intake, coagulating tank, treatment unit, filter unit, distribution tank, and a standpipe, with necessary pumps and lines. The intake is shown as being in a flowing stream, but the layout would be generally applicable to any of the sources and intake locations discussed above. If the source is a stream, the bivouac area should be downstream from the intake. For further details of layout, see TM 5–295.

597. Delivery

Water from a distribution tank can be pumped into tank trucks. This requires continuous operation of a pump while the trucks are being filled. A better

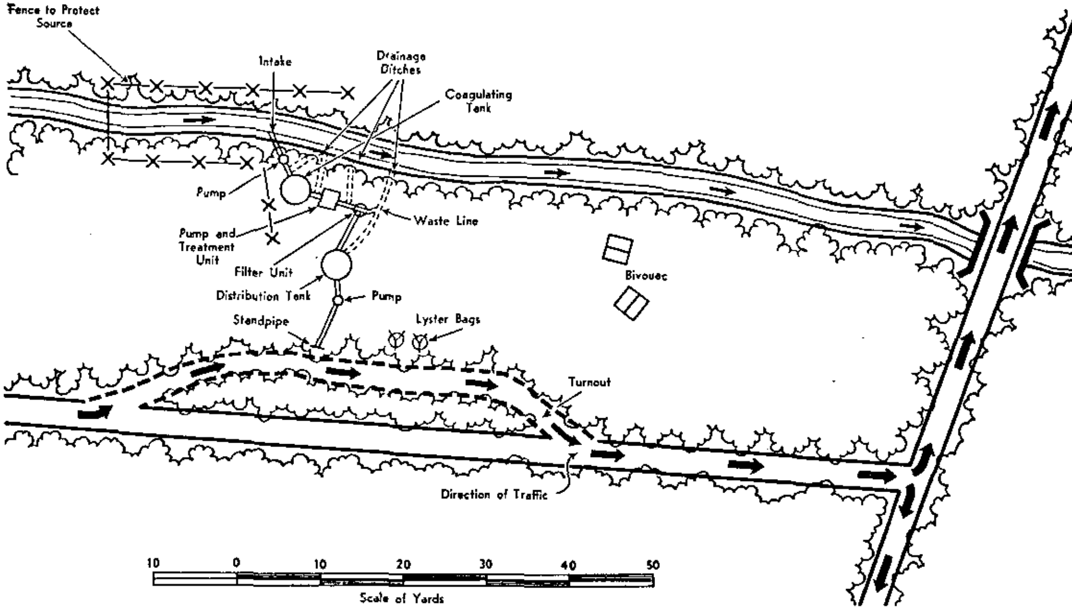


Figure 22. Typical water point, combat zone.

arrangement is an elevated distribution tank connected to one or more standpipes containing water under pressure, each with a flexible hose having a nozzle and valve. The tank truck parks beside the standpipe and is filled through the hose. If demand is heavy, or if for security reasons the trucks should not be kept waiting at the water point, two or more standpipes can be placed side by side so that trucks can load in parallel.

598. Drainage

The area of the water point, including roads, should be carefully ditched. It is desirable to place all apparatus on platforms elevated clear of the ground. Roads and parking places should be hard surfaced. Gravel walkways are desirable. If the source is a stream or lake, it may be well to revet the bank near the intake.

599. Roads

Approach roads must be laid out so as to avoid congestion and, if possible, eliminate the need for passing or overtaking. One-way circulation is desirable. If the water point is close to a highway, the latter may be widened to provide a turnout. Signs are placed on the highway with arrows pointing to the water-point turnout.

600. Security

Necessary provisions must be made for physical security. As an element of this, if the water point is not sheltered from observation by trees, it may be desirable to camouflage the apparatus and the point of delivery, and to hold waiting trucks at a distance from the latter until their turn comes to be filled.

601. Use of Existing Water-Supply Systems

a. Use will be made of previously existing water-supply systems in a theater whenever practicable.

b. When an army is advancing in territory containing cities and towns with municipal water-supply systems, engineer water-supply units may use these as sources. In forward areas a water point can be established with the regular field apparatus, as previously described, using a fountain or watering trough as an intake, or drawing water through a hose from a main, faucet, or fireplug. Initially such water should always be treated.

c. As the situation stabilizes, municipal systems can be used for direct supply, delivery to tank trucks being from connections to the city mains, and water being piped to camps, cantonments, and hospitals. Before this is done, the system should be carefully checked by the engineers and medical authorities, and may need to have purification units installed. The possibility of contamination of a city water supply by enemy agents, especially in hostile territory, must always be kept in mind.

d. In rear areas where there are large concentrations of troops, local water-supply systems may be taken over and operated by the communications zone authorities. Operation is normally under a section engineer or an engineer brigade, with American supervisors and specialists. Local operating personnel are used as far as it is safe to do so.

e. Finally, conditions may require expanding the municipal water supply systems in the rear areas of a theater, or even constructing completely new systems of a corresponding size and complexity. This becomes a major engineering task, for which special personnel may need to be brought from the zone of interior.

CHAPTER 23

MAPPING AND MAP SUPPLY

Section I. MAPS AND MAP SUBSTITUTES

602. General

A wide variety and large quantity of maps of the theater of operations are essential in modern war. A certain amount of maps and topographic data will be furnished the theater commander by the Department of Defense. They must always be supplemented by extensive mapping operations after the campaign starts. For details of such operations, and of the storage and distribution of maps in a theater, see TM 5-231.

603. Principles of Classification

Military maps are classified as follows:

a. General Classification.

(1) Planimetric map.
(2) Topographic map.
(3) Relief map.
(4) Photomap.
(5) Photomosaic.
(6) Special map.

b. Classification by Scale.

(1) Small scale—1:600,000 and smaller.
(2) Medium scale—Larger than 1:600,000 but smaller than 1:75,000.
(3) Large scale—1:75,000 and larger.

c. Military Classification.

(1) General map.
(2) Strategic map.
(3) Strategic—tactical map.
(4) Road map.
(5) Tactical map.
(6) Artillery.
(7) Photomap.
(8) Town plans.

d. Other considerations. The following must also be considered:

(1) Mosaics.
(2) Special-purpose maps.
(3) Aeronautical charts.
(4) Nautical charts.
(5) Overprints.
(6) Overlays.

604. General Classification

a. Planimetric map—a map representing only the horizontal position of features.

b. Topographic map—a map which presents relief of the vertical position of features in measurable form as well as their horizontal position.

c. Relief map—

(1) A map on which differences in elevations are depicted by shading, tints, colors, etc.
(2) A three-dimensional map produced by molding plaster, rubber, or other materials.
(3) Plastic relief map, a three-dimensional map usually topographic, molded in plastic.
(4) Terrain model, a three-dimensional representation of an area, usually at very large scale showing cultural and terrain features realistically instead of by topographic symbols.

d. Photomap—A reproduction of a photograph or photomosaic upon which grid lines, marginal data and place names are added. Photomaps are normally of the planimetric type; however, they may be of the topographic or relief types by depicting the relief contour lines or by molding respectively.

e. *Photomosaic*—Assembly of aerial photographs to form a composite picture.

f. *Special map*—Maps for a special purpose such as traffiickability maps, transportation maps, boundary maps, etc.

605. Military Classification

a. General maps have scales smaller than 1:1,000,000. They are used for general planning.

b. Strategic maps are of scale 1:1,000,000 and are used for strategic planning, including troop movements, concentrations, and supply.

c. *Strategic*—tactical maps on a scale of 1:250,000 (alternate for 1:500,000) may be used for both purposes when other scales are not available.

d. Road maps are normally scale 1:250,000 or smaller. They are used for tactical and administrative troop movements and as guides for individual drivers. They may also be used as strategic—tactical maps.

e. Tactical maps normally scale 1:50,000 (alternate 1:100,000 or 1:25,000) are used for general tactical and administrative purposes.

f. Artillery maps normally on a scale of 1:25,000 are used for directing artillery fire.

606. Mosaics

A mosaic, or photomosaic, is a montage of aerial photographs. It may be—

a. Uncontrolled: consisting of contact prints which are oriented and fitted by matching details along the lines of overlap, without ground control. It is pictorially valuable, but may be very inaccurate.

b. Semicontrolled: also made with contact prints, but laid to ground control augmented by radial-line or slotted-templet positions.

c. Controlled: in which, before the photographs are thus laid to ground control, they are corrected in projection to bring them to the same scale and restore them to the vertical view (offsetting the effects of tip and tilt). If carefully made, a controlled mosaic approximates a map in accuracy, although certain inherent distortions can never be wholly eliminated.

607. Special-Purpose Maps

Among these are—

a. Trafficability maps, intended to show to what extent a section of terrain will support cross-country traffic. Data shown include the wet and dry bearing capacities of soils, load capacities of roads and bridges, areas or obstacles impassable to such traffic, recommended routes, and traffic control by key areas. The scale depends on the situation.

b. Communications maps, which emphasize alternative means of communication. The usual scale is 1:250,000.

c. Various other special-purpose maps, such as *assault maps* and *amphibious-assault maps*. They are normally large scale, with special data overprinted.

608. Other Categories

a. Aeronautical charts are used for air navigation and the planning and conduct of air operations. They include planning charts, long-range and standard air-navigation charts, approach charts, target charts, and others.

b. Nautical charts include naval-approach charts, naval-bombardment charts, naval-air-support charts, and naval-landing charts.

c. The Corps of Engineers is not concerned with the preparation and distribution of the foregoing, except as regards engineer hydrographic charts made in connection with the improvement of harbors and inland waterways in a theater.

609. Overprints

Overprinting is the superposition, on a previously prepared map, of data needed for some special purpose.

610. Overlays

Overlays consist of such special data printed on transparent material; they can be placed over a map, the features of which can be read through the overlay sheet.

Section II. AGENCIES AND RESPONSIBILITIES

611. Basic Responsibilities

a. Mapping is a command responsibility, the execution of which is supervised and carried out by technical agencies.

b. The Corps of Engineers, under G2 supervision, prepares specifications and priorities for military liaison with joint and Allied mapping agencies; and is responsible for the production, revision, reproduction, storage, and issue of maps, map substitutes, and topographic data of all sorts.

c. The Air Force is a cooperating agent in aerial photographic mapping and in the procurement of general purpose aerial photography. The engineers are responsible for specifications, for initiating requests for aerial photography, and for final evaluation. The Air Force flies the photographic missions.

d. The Navy is a cooperating agency in mapping. The Marine Corps conducts extensive beach survey operations and the Navy Hydrographic Office furnishes hydrographic data to the Army for mapping purposes. The Navy is also the primary source of aerial photography, under the same arrangements in *c* above, in areas of primary naval responsibility such as island commands.

612. Control of Theater Mapping

a. The theater commander is responsible for any mapping and charting directed by higher authority, and for the preparation and execution of a coordinated mapping and charting program for the theater.

b. The theater G2, in coordination with G3, acts for the commander in directing and coordinating the theater program. The theater engineer performs the assigned engineer functions at theater level.

c. Staff engineers at various levels, down to corps engineers inclusive, have corresponding responsibilities, within their fields, with respect both to any part of the coordinated theater program that may be assigned to them and to work not included therein but needed by their own commands.

d. For duties with respect to map supply, see paragraphs 627 through 635.

613. Engineer Topographic Troop Units, General

These include the corps topographic company, the army topographic battalion, the base topographic battalion and the four types of topographic companies that normally comprise it, and certain teams of the engineers service organization. Among them they perform the various engineer mapping functions, either within the same unit or on a more specialized basis.

614. Engineer Topographic Company, Corps

This unit is normally assigned one per corps, and provides maps and survey information for the corps and its divisions. It consists of headquarters (which includes map distribution personnel), a survey platoon, a photomapping platoon, and a reproduction platoon. Among its duties are making and reproducing sketches, drawings, maps, overlays and map substitutes; revising maps; making mosaics, photomaps, and provisional maps from air photographs; distributing maps to corps units according to G2 policies; establishing ground survey control for topography; establishing and extending the survey control net for the artillery; tieing in to the control nets of adjacent corps, and to control brought forward by army topographic troops; establishing geodetic control for radar sites; and producing and binding special intelligence publications. Since it is designed to do almost all kinds of military topographic work, and since it must be mobile, its capacity in any particular line is limited. If need arises, it may request assistance from an army topographic battalion.

615. Engineer Topographic Battalion, Army

This is an army unit, and is normally assigned on the basis of one per field army. It consists of headquarters, headquarters and service company with a survey platoon, an engineer map reproduction and distribution company, army, and an engineer photomapping company, army. Its duties include making and reproducing maps, photomaps, sketches, drawings, overlays, and related material; storing them; distributing them to army troops and to corps in accordance with G2 policies; undertaking surveys, including topographic surveys; and preparing engineer intelligence reports. It can lay controlled mosaics, but is better adapted to making photomaps from individual photographs or uncontrolled mosaics. It can establish horizontal and vertical survey control in the army area, tie it to control brought to the army rear boundary by base topographic units, and extend it forward for pickup by corps. It may reinforce overloaded corps topographic troops, either by attaching personnel to them or, more commonly, by taking over some portions of their missions.

616. Engineer Aerial Photo Reproduction Company

This unit is normally assigned to army, and functions with units of the joint air photo center. It consists of a headquarters and four identical reproduction platoons. Among its duties are editing for reproduction developed film covering missions requested by the ground forces; producing from negatives air photographs for army units, and packaging them for delivery. It has a large capacity for reproduction and packaging.

617. Engineer Base Topographic Battalion

a. This is a flexible unit consisting of a headquarters and headquarters company, to which are assigned base topographic companies as the situation may demand. There are four such types of company: the engineer base survey company, the engineer base photomapping company, the engineer base map reproduction company, and the engineer base map depot company. These companies can operate independently, but are commonly assigned to battalions. When all four are thus assigned, the battalion can perform a diversity of topographic functions with a high degree of specialization by its component units.

b. Normally the battalion is assigned to theater headquarters and operates in the communications zone. It may be further assigned to an engineer brigade. Among the tasks which may be delegated to it, depending on the component units, are—

(1) Surveys, including the establishment or recovery of horizontal and vertical control, the carrying forward of such control to army rear boundaries, the location and identification of control for photomapping, and ground reconnaissance to identify features on air photographs.

(2) Making maps by photogrammetric methods.

(3) Reproducing maps and photomaps.

(4) Operating base and advanced theater map depots.

(5) Photogrammetric location of targets designated by the Air Force and guided-missile units.

The engineer service organization has ten types of teams for topographic work, as follows:

a. Team IA, Survey: provides one survey party. Normal assignment, one per engineer brigade.

b. Team IB, Survey Platoon: provides three survey parties, and can prepare map manuscript on a limited scale. Normal assignment to a base survey company.

c. Team IC, Photomapping: can make maps from air photographs by multiplex methods. Normal assignment to a base photomapping company.

d. Team ID, Map Reproduction Platoon: can reproduce maps from original manuscripts, and make limited amounts of photostats. Normal assignment to a base survey company.

e. Team IE, Map Depot Platoon: can operate a depot to receive, store, issue, and distribute maps. Normal assignment, three per army topographic battalion.

f. Team IF, Relief Map Making: can make and reproduce terrain models. Normal assignment, one per base topographic battalion.

g. Team IG, Technical Intelligence (Collection): can find, collect, identify, photograph, and report on elements of engineer technical intelligence. Normal assignment, one per corps.

h. Team IH, Technical Intelligence (Research): can collect, receive, evaluate, photograph, and report on elements of engineer technical intelligence. Normal assignment, one per field army.

i. Team IJ, Geodetic Survey: can make high-order geodetic surveys and computations, for gnided missiles or other purposes. Normal assignment, one per field army.

j. Team IK, Terrain: can collect, evaluate, and disseminate terrain data and make terrain studies. Normal assignment, one per field army.

Section III. MAPPING PROCEDURES

619. General

a. The production of maps includes—

(1) Establishing horizontal and vertical ground control.

(2) Collecting source materials.

(3) Compiling the maps.

(4) Reproducing them in quantity.

b. Of the foregoing, (1) may follow (2) or precede it, or the two may be carried on more or less concurrently.

620. Control

Establishment of control involves the conventional ground survey procedures. Surveys may be mapping surveys, artillery surveys, or special purpose surveys. "Classification surveys" are sometimes listed as an additional type, but in fact should rather be considered as a means of collecting source material.

a. Under peacetime conditions these are based on a system of first-order triangulation. In a theater, however, basic triangulation, if it must be done, is normally third order, and is tied to existing basic control of a higher order. Exceptions may be made by theater headquarters if special conditions demand higher accuracy. Within the triangulation net, traverses and leveling of various degrees of accuracy are used to give the density of control needed for mapping. As stated above, control is brought forward by base topographic units to the rear boundary of the army area, and by army topographic units thence to the rear boundary of the corps service areas, where corps topographic units pick it up.

Note. The pickup point may be at any reasonable location near the boundary.

b. Artillery surveys are needed to support fire-direction control. A corps topographic company carries the control forward to a point (determined either by higher headquarters or by informal agreement) where the artillery surveyors pick it up and extend it as needed.

c. Special surveys by topographic troops may be made for a variety of purposes such as port development or precise control for radar and guided-missile launching sites.

621. Source Materials, General

These may be collected by air photography, ground parties, or a combination.

622. Air Photography

This is the most common way of collecting source materials for theater mapping. Its advantages are that it can cover a large area in a short time, that it can be extended to and behind the enemy lines, and that the photographs themselves, or uncontrolled mosaics which can be quickly and easily made from them, give pictorial representations which are very useful for some purposes. Its drawbacks are that it is limited by weather; that ground control, and a series of complex processes, are needed to make the photographs into a reasonably accurate map; that a certain element of inaccuracy is inherent in the process; and that the photographs cannot show certain things which should be included in some types of map. Since ground control cannot be extended up to or behind the enemy line (unless, of course, our troops have withdrawn from an area in which we had previously established control points identifiable in air photographs), the control for photographs of that area must be extrapolated. This can be done, but the results are increasingly inaccurate as the control is progressively advanced.

623. Ground Collection of Source Materials

a. Military maps of various sorts should include certain types of information which can be collected only by ground parties. Examples are details regarding buildings or installations used for certain special purposes, such as factories and warehouses; the names or designations of local features such as towns, waterways, and roads, and facts about objects which can only be determined from the ground even though the objects are visible in photographs (such as soil conditions, the condition and precise structure of a bridge, or what a building contains).

b. Ground collection of data may involve a survey to locate an object and tie it to the control net. This is the case if the object is not identifiable on a photograph (for example, a ford without noticeable approaches, or something in a wood). On the other hand, if the object, though not its nature, is identifiable on a photograph, no ground surveying is needed. Thus, the photograph may show an unmistakably large building at a certain point, and inspection may show it to be a warehouse. Similarly with information of a nonmaterial nature such as place names.

d. If an area is accessible but cannot be covered by air photography on account of weather conditions, all source material can of course be collected by ground parties, as was always the case until air-mapping techniques were developed. Planetable work is largely used.

624. Compilation, Photomapping

a. The basic data in this case are: overlapping sets of air photographs covering the area to be mapped; any other source materials; and control points, identifiable on photographs, whose positions and elevations have been established by ground surveys or other procedures. The use of photogrammetric methods and instruments, and the application of various corrections, produce from such data a "map manuscript," which includes vertical relief shown by contours. The principal stereoscopic plotting instruments used are the multiplex projector and the stereocomparagraph.

b. The manuscript is converted into a map by drafting, which gives it a presentable and standard appearance and adds title, scale, orientation, positioning, and marginal data.

c. If a fully prepared map is not needed, or there is not time to make one, the photographs may be made into an uncontrolled, semicontrolled, or controlled mosaic, or a photomap.

625. Compilation, Other Means

If the source material does not include air photographs, the manuscript is compiled by plotting the control and superposing on it the source material collected by ground methods.

626. Reproduction

a. Photolithography. This is the most common method of reproducing military maps. It involves three steps: photography, platemaking, and printing. The drafted map, or the portion of it that is to go on a single sheet, is photographed in a process camera. The image is then transferred to a prepared plate. For a colored map, one plate must be made for each color. After the image has been fixed on the plate, the latter is placed in a press and the paper run through it to produce the final sheets. A separate run must be made for each color. The number of sheets made is determined by higher authority.

b. Other Means. There are various other means of reproduction, including direct photography of the drafted map (highly accurate if done with care, but slow, and limited as to color); the gelatin duplicator (fast, cheap, simple, and crude); blueprints, vandykes, and brownprints.

Section IV. MAP SUPPLY

627. General

The storage and distribution of maps have very special features, and cannot be handled as a routine supply matter.

a. The security problem is always present. Even if the maps contain no classified information, the fact of their issue in large quantities points to tactical activity at an early date, and may give some indication of where it will be.

b. Maps, especially those pertaining to some specific operation, cannot be issued far in advance of their use—

(1) Because of the security problem.

(2) Because of their bulk.

(3) Because the precise missions of units must be decided before it can be known just what maps they will need.

c. It follows from *b* above that the phasing of map issues is very important.

d. Many types of maps become obsolete because of changes in the situation, or because they must be revised to include fresh data.

628. Responsibilities

a. At theater, army, corps, and division level, G2 is responsible for establishing policies with respect to supply, including allowances, within the framework of policies set by higher authority.

b. The staff engineer is responsible for map supply in accordance with those policies. To carry out this duty *he must be kept constantly informed of existing and proposed troop distributions and operational plans*. He must assure himself that the sources of supply available to him can furnish the maps his command needs, and if not, must recommend corrective action. He must compute and tabulate the needs of his command, and accomplish delivery to the appointed location, which may be a base depot, advance depot, army depot, corps depot, or division map distribution point.

c. Unit commanders of regiments, separate battalions, and separate companies are responsible for obtaining the maps from such point of delivery and issuing them to users.

629. Distribution Plan

The following are involved in making an engineer plan for map supply and distribution in a theater, and will be carried out at successive levels:

a. Locate and establish map depots, to include: a base depot (near a base port in an oversea theater); branch depots to serve theater headquarters and base section units; advance depots to serve advanced communications zone units and army depots; army and corps depots; and divisional distribution points.

b. Obtain, from G2, policies on initial and replenishment allowances and security measures.

c. Obtain, through G2, the strategic and tactical plans of the commander, and the units involved, in enough detail to compute map needs. This information must be up to date at all times.

d. Determine coverage, and compute the nature, volume, and timing of initial and replacement issues, and the needed reserve stocks.

e. Establish, through engineer channels, standards and procedures for packaging, coding, and guarding the maps, and an orderly arrangement of breakdown points, bulk and package deliveries, and their phasing.

630. Channels of Supply

a. The flow of requisitions is through engineer technical channels, as follows: division engineer to corps engineer; corps engineer to corps map depot or army engineer; army engineer to an army map depot or an advance map depot in the communications zone. If there is an army group, an army engineer's requisition on a communications zone depot goes through the group engineer.

b. The flow of maps is as follows:

(1) The base map depot receives maps from the zone of the interior, from base topographic reproduction units, from allied troops if any, and from any available civilian sources in the theater. It also interchanges topographic data with naval and air force chart depots.

(2) From base depot the flow is successively to advance communications zone depots, army depots, advance army depots, corps depots, and divisional map distribution points. Issues to theater, communications zone, army and corps headquarters, and to troops pertaining thereto, are accomplished from branches or sections established by appropriate depots.

c. Figure 23 illustrates the foregoing.

631. Depot Operations

a. These include receiving incoming maps, checking them against requisitions and shipping tickets, counting them and entering them on stock records; storing them according to some system that will permit prompt location; shipping them, which involves counting (by hand, weight, or other means), packaging, marking, addressing, and arranging for transportation; inventorying, and the keeping of records. An efficient map depot should have mechanical handling devices and ample space for processing and systematic storage.

b. Security is a vital element of map depot operations. The depot itself, and vehicles delivering maps, should be under armed guard. Personnel should be carefully screened before assignment.

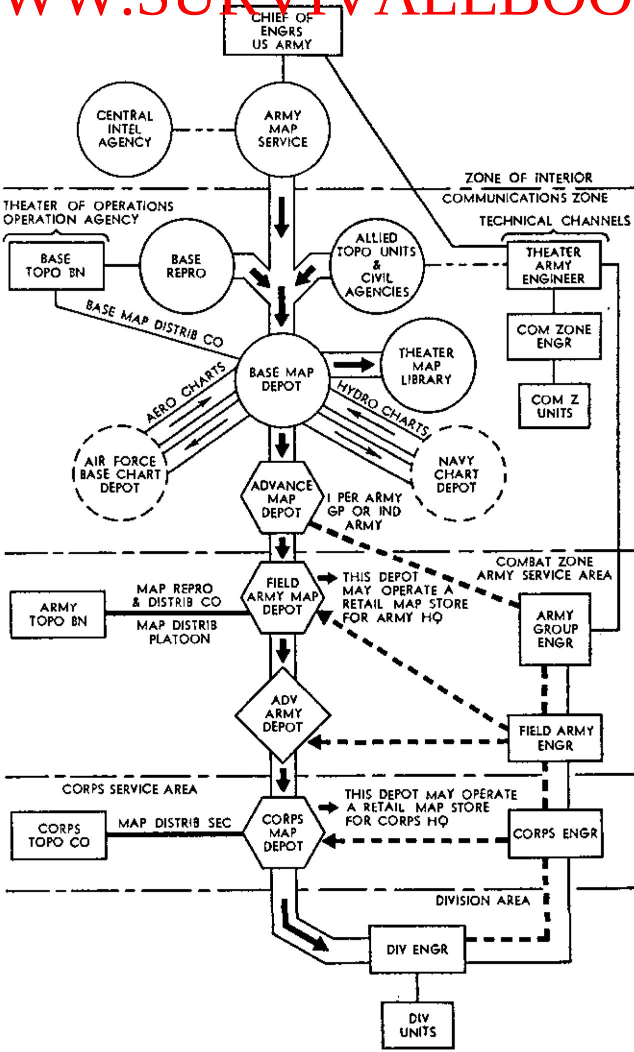


Figure 23. Channels of supply for maps in a theater.

Entrance to distribution areas should be by special pass. Counting and coding maps, and destroying unneeded maps, should involve double checking. At critical periods it may be necessary to quarantine working groups.

632. Coverage for a Field Army

a. To determine this the army engineer should show on his map indexes the following:

(1) Army, corps, and divisional boundaries.

(2) A forward map-limit line and an intermediate map-limit line. Their locations will depend on the situation and overall plan. For an army offensive, representative figures are 100 miles and 30 miles forward of the army objective, respectively.

(3) Lateral map-limit lines, well outside the exterior corps boundaries.

b. On the same indexes should be shown the coverage and nomenclature of the map sheets of various categories.

c. Issue might then be based on the following policies, subject of course to G2 approval:

(1) To each division in line; all sheets covering its zone of advance and those of its adjacent divisions (for a flank division, coverage to the lateral map-limit line). Coverage forward: for large-scale maps, to the intermediate limit line; for others, to the forward limit line.

(2) To each division in corps reserve, and to corps troops: all sheets covering the zone of advance of that corps and of the two adjacent corps (for a flank corps, to the lateral limit line).

(3) To each division in army reserve all sheets covering the army zone of action, extended to the forward limit line and both lateral limit lines.

(4) To army troops: same except that forward coverage is to the intermediate limit line only.

(5) Reserve stocks in corps and army map depots would have the same coverage as for corps and army units respectively.

633. Allowances

Coverage having been determined, the initial and replacement issues are computed by using a table of allowances. Quantitative data are given in FM 101–10 and TM 5–231. In a theater, final determination is by G2.

634. Scheduling of Deliveries

Careful thought must be given to this. A map delivery made too late may result in the failure of an operation. Maps delivered too soon are a grave security risk. Combat units cannot carry with them enough maps for a lengthy compaign. Moreover, with respect especially to smaller units, it is impossible to foresee for any length of time just what maps they will need, since this is affected by day-to-day changes in the situation. If maps are issued to a unit and it then develops that the unit does not need them, it is very difficult to withdraw and reissue them. It is evident that devising, and (especially) carrying out, a properly phased distribution plan needs the best efforts of all concerned. There must be close and constant liaison between engineer map supply agencies at all levels.

635. Turning in and Destruction of Maps

a. The replacement of obsolete issues of maps by new editions is controlled at army or corps level. Mixed issues of old and new editions, for a given engagement, are undesirable, and replacement is not normally undertaken during an engagement.

b. Individuals are instructed to turn in or destroy obsolete maps as new issues are made. Instructions governing the disposition of obsolete issues should insure that security precautions are observed.

c. Complete destruction of large stocks of maps is difficult, takes time, and if not properly done may result in the widespread scattering of undestroyed fragments. To minimize the need for destruction in advanced areas, stocks of maps in those areas should not be allowed to become too large.

CHAPTER 24

EXPLOSIVES AND DEMOLITIONS

Section I. GENERAL

636. Purposes of Demolitions

Military demolitions have three principal purposes:

a. To destroy, render unusable, or reduce the utility of material objects of value to the enemy, which it is feared might fall into his hands.

b. To destroy or make gaps through enemy obstacles.

c. To destroy materials in our possession, the retention of which would interfere with the accomplishment of any military mission.

637. Responsibilities

a. The planning and execution of demolitions, other than those carried out by artillery fire or bombing, or by units of other arms with respect to their unit equipment, is the responsibility of the Corps of Engineers. The decision whether and when to execute a demolition project is a command responsibility.

b. No engineer troop unit is organized solely to execute demolitions. In the three types of divisional combat battalion and in the army combat battalion, operating squads and platoons have sets of demolition equipment, and headquarters and service company has supplementary equipment and explosives. In these units, also, there is a demolition specialist in the S3 section who aids S3 in making demolition plans, instructs in demolition and mine warfare courses, inspects battalion demolition projects, and assists subordinate units in their demolition problems. All engineer officers and enlisted men are trained in the use of explosives and in demolition techniques.

638. Methods

a. The principal methods used in executing demolitions are—

(1) Hand-placed explosives.
(2) Artillery fire or aerial bombing.
(3) Fire.
(4) Mechanical smashing.
(5) Water.

b. Of the foregoing, explosives are usually the most rapid, dependable, and effective means. They are also the most complex with respect to technique of use.

c. Demolitions are also classified as *hasty* and *deliberate.* The former are employed when time is limited and are characterized by haste and improvisation, and usually by a liberal use of explosives. Deliberate demolitions can be prepared in a more systematic and leisurely way, and are likely to be more thorough and more economical in explosives. They are appropriate only if an enemy breakthrough or a retrograde movement by our forces is foreseen well in advance, or for the destruction of useless supplies or equipment in rear areas.

639. Scope of Discussion

This chapter deals with military explosives and accessories, with the elements of demolition procedures, and with the planning and execution of demolition projects by the use of various agents, especially explosives. For the use of explosives in wrecking or breaching enemy obstacles, see chapter 10. For mines, see chapter 12. It is also to be noted that explosives are used for other purposes than demolition, for example, quarrying, ditching, and digging postholes.

Section II. MILITARY EXPLOSIVES AND ACCESSORIES

640. Nature of Explosives

a. Every military explosive except those of the "atomic" category is a chemical compound or mixture which, under suitable excitation, undergoes a rapid chemical reaction whereby it is converted into hot gas with great expansive power. For ordinary explosives the exciting agent is either heat, impact, or friction. The reaction spreads through the explosive at a speed called the velocity of detonation. In gunpowder and the various propellant powders the spread of the reaction is by rapid burning or deflagration. In high explosives it spreads much faster, by a detonating wave with a velocity of several miles per second.

b. If the explosion has a low rate of spread, the effect exerted by the expanding gas is essentially to *push or lift* whatever material is in contact with it; if a high rate of spread, the effect is to *shatter*. This, at one extreme, the nitrocellulose powders are used as propellants in artillery and small arms. At the other extreme are explosives with a very high velocity of detonation, most effective for such cases as cutting steel. Intermediate are certain high explosives with a moderate velocity, most effective for such uses as cratering or quarrying where a combination of lifting and shattering power is needed.

c. This chapter does not deal with propellants as such.

641. Explosives

a. Military explosives should have the following major characteristics: relative insensitivity to shock, friction, or heat (*Note.*—They will, however, *burn* when heated, and some will also detonate if the heat is intense enough); positive detonation by easily made primers; chemical stability in any climate; suitability for underwater use; a detonating velocity varying with their intended use, but in general high. It is also desirable that they have high power per unit of volume. They are packaged in forms convenient for immediate use.

b. The principal military explosives are—

(1) TNT, a good all-purpose explosive, especially adapted to forward areas.

(2) Composition C-4, a plastic explosive more powerful than TNT.

(3) Ammonium nitrate which has lower velocity of detonation than TNT and is especially suitable for cratering.

(4) Military dynamite.

c. Land mines, aerial bombs, and artillery shells, including captured enemy stocks, may on occasion be used as hand-placed demolition charges, though normally this is not good practice. In general they are most effective for cratering. Special techniques are needed for detonating them. Duds should never be used.

d. American commercial explosives (ordinary and ammonium dynamite and blasting gelatin) may also be used in a theater, preferably in rear areas or for certain types of training. They require more careful handling than military explosives. Foreign-made explosives may on occasion be used under similar conditions.

642. Shaped Charges

A shaped charge is a charge of explosive shaped into a cylinder with a recess at one end. When it is detonated, a large part of the force of the explosion is concentrated in a line along the axis of the charge. Shaped charges are used to cut holes in steel or concrete or into the solid ground, the charge being first fixed to the surface so that the blast will be directed against it.

643. Accessories

These include—

a. Caps, containing a very sensitive explosive which detonates the main charge. Electric caps are detonated by connecting them into an electric circuit and passing a current through them; nonelectric caps, by a fuze.

b. Time fuze, which burns slowly.

c. Special fuzes, including delay fuzes which detonate after a certain interval, and fuzes designed for mines and booby traps.

d. Detonating cord (primacord), which, when detonated by a cap, explodes at the rate of travel of the detonating wave (about 20,000 feet a second).

e. Accessories for making and detonating charges, including cap crimpers, sealing compounds, fuze lighters, blasting machines, and firing wire.

f. Devices for boring or digging holes for the placement of explosives, including earth augurs, drills, and the blast-driven earth rod.

644. Storage and Transportation of Explosives

Special precautions must be taken. Magazines should be remote from other installations, and if practicable from each other, or if not, should have baffle walls built around them. They should be dry, well drained, and protected against artillery or bombs. Certain elementary precautions are:

a. Never permit matches, fire, lamps, metal tools, or anything which might cause sparks (including shoes with exposed metal) in a magazine.

b. Store and stack boxes of explosives so that they are well ventilated and are protected from moisture, contact with the ground, and rodents.

c. Do not store or transport caps with other explosives.

d. Do not keep primed charges in a magazine.

e. Rotate stocks.

f. Keep the area surrounding the magazine clear of flammables, and fence it.

g. Vehicles carrying explosives must be specially marked and carefully driven.

645. Preparation of Charges

For the detailed techniques of priming and packaging charges, placing and testing circuits and firing systems, detonating, and dealing with misfires, and for the safety precautions observed in these operations, see FM 5–25.

646. Placing of Charges

a. An explosive is most effective if it is in close contact with the object to be destroyed, and is confined on all sides. For such demolitions as cratering, both of these ends can be attained by burying and tamping the charge. If the charge must be placed outside the object to be destroyed, a part of the explosive power is dissipated. This can be partly prevented by tamping the charge after placement, using packed clay or sandbags. If a charge is not tamped, more explosive must be used.

b. Most military demolitions by explosives involve one or more of the following: cutting steel or wooden members; breaching or shattering concrete or masonry; and cratering.

647. Cutting Charges

a. Steel. To cut steel girders, I-beams, H-beams, columns, or rails, the charge is placed in close contact with the steel, tied firmly, and tamped if time permits. With I-beams and H-beams, which are the most common structural shapes, the charge should be against the web. Normally it is placed on one side only; if on both sides, the charges are placed so as not to be opposite to each other. With such members as cables, chains, and complex joints, close contact which cannot be affected using ordinary explosives, and larger charges are needed. Plastic explosives are very effective for such cases, and for steel cutting in general. They can be molded to the metal and have great shattering power.

b. Wood. For external charges, the same principles apply as with steel. The charge is placed against the wider side of a wooden structural member, or, if a tree is to be felled, on the side toward which the tree is to fall. If time permits, however, it is more economical of explosives to bore a hole in the wooden object, insert the charge, and tamp.

648. Breaching Charges

If a large enough charge is placed against a concrete or masonry wall, the explosion will breach the wall. The amount of explosive needed increases rapidly with the thickness of the wall. Tamping is important. If the explosive can be set into the aperture in the wall, it is more effective. Normally it should be placed at or near the base. If the purpose is not simply to breach the wall but to collapse it, the explosive must be distributed along an adequate length of wall, having regard to the material, its ability to develop arch action, and what the wall supports.

649. Pressure Charges

A pressure charge is one placed on top of a structural member such as a concrete beam, to break it by the downward force of the blast. The action of the explosive is aided by gravity.

650. Cratering Charges

a. Cratering is an effective means of blocking traffic on a road, provided the crater is too wide to be spanned by tracked vehicles and too steep for vehicles to pass through it, and the terrain is such that the crater cannot be easily bypassed. Defiles, steep sidehill cuts, and high embankments are good locations.

b. The standard procedure for cratering a road is to bore holes on a line across the road, about 5 feet apart and 5 to 7 feet deep, load, tamp, and detonate simultaneously. If the pavement is hard surface, it may be breached by small well-tamped charges of explosive, by blast-driven earth rods, or by shaped charges, to expedite boring the holes.

c. A crater at a culvert serves the double purpose of blocking the road and wrecking a drainage structure. If the fill over the culvert exceeds about 5 feet, the explosive may be placed as described above. If the fill is shallower, the charge may be placed in the culvert, well tamped with sandbags.

d. Ditches, for antitank or other purposes, may be dug rapidly by cratering techniques.

651. Size of Charges

See FM 5–25.

Section III. DEMOLITION PROJECTS

652. General

a. Demolitions are planned in relation to a specific strategic and tactical situation. This should govern the decisions on *what* is to be destroyed, *when*, and *how extensively*. Frequently demolitions are associated with a retrograde movement of our forces and an expected enemy advance. Their purpose is partly to delay the enemy, and partly to deny him the use of certain installations or supplies. These are valuable ends to attain. Against them, however, must be weighed the future effect of the demolitions if our forces reoccupy the area. Military history has many examples of demolitions on an excessive scale. This is, in the first place, a waste of valuable materials and manpower. What is even more serious, it may later impose on our forces a heavy burden of rebuilding needlessly demolished structures, or of caring for civilian populations whose housing and means of livelihood have been uselessly destroyed.

b. As stated above, the decision to prepare and execute demolitions is a command decision, often made at a high level. However, insofar as engineers in staff or command positions have any voice in the matter, they should urge adherence to a rational policy in this field. The burden and onus of making good any needless damage will in any case fall on them later.

c. Two fundamental points in preparing a demolition project are—

(1) It should be preceded by as careful a reconnaissance as time permits, on the basis of which the plan for the project is prepared.

(2) The responsible engineer must have clear-cut instructions on what is to be demolished, in what degree, and when or under what conditions the demolition is to be executed.

653. Reconnaissance

The precise data needed to make a demolition plan will vary widely and must be determined in detail on a common sense basis. The following are representative of what a normal reconnaissance report should show—

a. Map location of the object to be demolished, normally shown on a sketchmap or overlay with coordinates.

b. Necessary dimensioned sketches of the object and its critical elements, in enough detail to permit a decision on how to execute the demolition and an estimate of time, labor, equipment, and materials.

(1) Information should include such items as—

(*a*) Dimensions and cross sections of steel or wooden members to be cut.

(*b*) Thickness, length, and height of walls to be breached or collapsed, and type of construction.

(c) Dimensions of concrete beams, arches, or other members to be broken.

(d) Widths and nature of pavements and roads to be cratered, and the practicability of bypassing.

(2) In the case of a steel or wooden bridge, truss, or similar structure, the sketch should show the overall dimensions of critical structural members.

c. Any special features of the object or site affecting the technique of demolition.

d. A priority program. In a fast-moving situation, the demolition crew may be forced to evacuate the site before completing their mission. If this is anticipated, the work should if possible be phased so that at least a partial demolition can be executed.

e. A sketch of the firing circuits to be used.

f. A bill of materials, including explosives, accessories, tools, and special equipment.

g. Estimates of time, personnel, and transportation.

h. Security details.

654. Highway Bridge Demolitions

a. *Procedures.*

(1) *Steel truss.* Cut key members so that the truss either falls on its side or, if it falls straight, it is too badly damaged to be jacked up and restored to use.

(2) *Plate girder.* Cut one or both girders with offset charges placed against the web.

(3) *Concrete superstructure.* Break the beams with pressure charges, or, if the bridge must stay open till the last moment, and if time

and labor permit, place breaching charges against the beams under the bridge.

(4) *Pier.* Throw it with breaching charges placed against one side, low down.

(5) *Abutments.* Place the charge against the land face (underground) of the abutment. Compute it as a breaching charge. It may be supplemented by an external breaching charge on the river side of the abutment, for more complete destruction.

(6) *Suspension bridge.* Cut the cables.

(7) *Concrete or masonry arch.* Blow the abutments if time permits, or use breaching charges at the haunches or crown (the latter are most effective with a flat arch).

(8) *Timber bridge.* Blow the abutments if time permits; cut key members with explosives or with hand or power tools. Burning is usually unreliable.

(9) *Floating bridge equipment.* Sink steel pontons by blowing holes in their bottoms with small charges; sink pneumatic pontons by machinegun fire.

b. Extent of Destruction. The following principles apply—

(1) Do not carry destruction beyond the point where it is easier for the enemy to build a new (temporary) bridge than to repair the old one.

(2) Cutting and dropping a span is quick and easy, but the enemy can quickly repair the damage by substituting prefabricated panel bridging, unless the span is too long for his equipment. To meet this difficulty, destroy one or more piers.

(3) Destruction of abutments is very effective, but takes time and effort.

655. Highway Demolitions

In addition to bridge demolitions, highways can be blocked by cratering, as explained above.

656. Railway Demolitions

a. Switch points, frogs, crossings, and switch mechanisms can be broken with small explosive charges, as can individual rails. A length of track can be overturned by men with levers, or peeled off by cabling one end to a locomotive. However, if the roadbed is undamaged, the track is easily restored unless the rails are rendered useless by explosives or otherwise. Ties can be burned. Fills can be blown. In a period of high water, blocking of culverts may produce washouts.

b. Stocks of rails and auxiliary supplies and equipment, which the enemy might use to repair the railroad, should always be removed or destroyed. The extent to which fixed installations and machinery should be destroyed will depend on our future plans.

c. Tunnel demolition is highly effective, repairs being slow and difficult. The quickest way to destroy the portals is by breaching charges placed from above. Given more time, the lining or interior surface can also be blown, by charges placed in bore holes. This is especially effective in rock such as shale, as it may result in a widespread collapse of overlaying strata. If there is no time to prepare demolitions, the tunnel may be blocked by derailing cars, or by arranging a head-on collision of two trains or locomotives. After derailment, all axles should if possible be broken.

d. The same principles apply to railway bridges as with highway bridges, except that allowance should be made for the fact that a railway bridge takes more time and effort to repair or replace.

e. Rolling stock can usually be evacuated.

657. Communications Demolitions

a. Telegraph and telephone lines: cut or ground the wires; if time permits, fell and burn the poles. Radio and telephone control equipment can usually be evacuated; if not, destroy by explosives or hand tools.

b. Destruction of a railway's communications system is an important factor in putting the railway out of commission.

658. Demolition of Structures

a. Wooden Buildings.—Burn or wreck by explosives. An adequate charge on the ground floor will wreck an ordinary building.

b. Masonry or Concrete Buildings.—Place breaching charges along the inside base of one or more exterior walls.

c. Steel-Frame Buildings.—Expose and cut the supporting members.

d. General. Short of complete destruction, buildings can be made temporarily useless or of limited utility in a number of ways, such as cutting roof trusses and wrecking interior utilities with small explosive charges.

659. Timing of Execution

It is of the highest importance that the authority ordering a demolition *specify clearly the time when, or the conditions under which, it is to be executed.* The officer responsible for actual execution must assure himself that he has unambiguous instructions on this point. They will normally be in one or another of the following forms:

a. Execute only on orders (usually written orders) from (such and such headquarters).

b. Execute when it is apparent to you that the enemy will (cross the bridge, pass the defile, capture the depot, etc.).

c. Execute either on orders from (such and such headquarters), or when it is apparent to you that the enemy will (etc.), (*combination of* (*a*) *and* (*b*)).

d. Execute at (such a date and hour).

e. Execute as soon as completed.

660. Demolition of Equipment and Supplies

a. Every unit or installation in a theater should prepare and keep up to date, as an element of its SOP, a plan for the demolition of all items of its equipment and supplies. The plan should be flexible enough to work in any situation. It should include methods of destruction, priorities, supplies, and equipment needed, and individual responsibilities. Alternative methods may be prescribed, one of which should be demolition wholly by hand tools. All personnel should be trained and given periodic practice in simulated demolitions.

b. Demolitions of this character are accomplished only on orders from divisional or equivalent level, or from a higher level.

c. Principal agents used in equipment demolitions are hand or power tools, especially sledges, axes, picks, saws, and knives; explosives; the fire of weapons and the use of grenades; fire, using combustible liquids or incendiaries; damage by water, acids, or contaminating agents; and the dumping of equipment into water, especially salt water. Napalm dropped by planes is a quick way of producing widespread fire. Which agent or combination is used depends on what is to be demolished, how thoroughly, and under what circumstances, and on how much time is available. Ingenuity is needed both in preparing such a demolition SOP and in carrying it out.

d. Delicate apparatus, such as radio or topographic equipment, can be reduced to small fragments by hand tools if it is deemed worthwhile. In the case of large and massive items of equipment, however, it is very difficult to "demolish" them in the literal sense. A demolition plan for such items should be designed—

(1) In any case, to render them unusable by the enemy *as he finds them.* This can be simply and quickly done by destroying one or more essential parts, such as the carburetor, distributor, or fuel pump of an internal combustion engine. (If a number of similar pieces of equipment are thus treated, *destroy the same item or items in each.*)

(2) In addition, if time permits, to render them irreparable by the enemy, and useless to him as a source of critical repair parts. This requires more time and effort than (1) above.

e. For detailed demolition techniques to be used with various types of equipment and supplies, see FM 5–25.

f. A comprehensive demolition program may involve such nonstandard items as water supply systems, electric power plants, factories with their equipment, or locking machinery in canals. The same principles apply as with standard mechanical equipment. Spare parts or spare units for plant and equipment of this sort are often difficult or impossible to come by under war conditions. They should be denied to the enemy. If possible this should be done by removal, so that we may put the equipment back into operation if we reoccupy the area.

CHAPTER 25

CAMOUFLAGE

Section I. DUTIES AND RESPONSIBILITIES

661. General

"Camouflage" is a general term used to describe any measure intended to mislead by misrepresenting the existence or the true identity of any installation, equipment, or activity; or a series of related concealment and deception measures forming part of the overall plan for the protection of installations, equipment, or activities.

662. Responsibilities

Research and development, and the procurement, storage, and issue of decoys, dummies, and other physical means of deception are responsibilities of the Corps of Engineers. For the responsibilities of engineer camouflage units, see paragraph 664. However, while certain elements of camouflage are technical and specialist, other and more important elements are not. Responsibility for camouflage rests, to a varying degree, on all troop units and all members of the armed forces in a theater of operations.

a. Individuals. Every officer and enlisted man must be trained to understand the basic principles of keeping himself concealed from the enemy, and of helping to conceal the positions, installations, and activities of his unit.

b. Commanders. Every commander of a troop unit or installation is responsible for the necessary camouflage measures in his command, including (within the limitations imposed by his mission) choice of position, use of material means for concealment, and the enforcement of camouflage discipline.

c. Staffs. The operations and training officer, in coordination with other staff officers, plans and supervises the execution of combat deception plans. The intelligence officer works closely with him on this task, with particular emphasis on counterintelligence activities. The personnel officer may assist in deception planning by personnel activities calculated to mislead the enemy, and the logistics officer by deceptive logistical activities. The signal officer arranges signal support for deception plans. The engineer officer furnishes technical advice and supervision on camouflage, the construction of dummy positions, and the use of dummies. For further details, see Department of the Army Training Circular 5, 1953.

d. Displays of Dummies. See paragraph 699.

663. Engineer Troop Units, General

a. In the combat battalion, divisional, there is a camouflage inspector on the staff of the battalion S2. His duties are to assist in the camouflage instruction of divisional personnel, to demonstrate camouflage materials, and to assist S2 and the division engineer in making camouflage plans and conducting inspections. In addition, the battalion may be called on to install, or assist in installing, camouflage devices at key points such as division headquarters.

b. The armored and airborne engineer battalions have similar duties with respect to their divisions. The engineer combat battalion, army, has similar duties with respect to troops which it is assigned to support.

c. All engineer units involved in construction work in a theater are responsible for such camouflage measures at construction sites as are indicated by the situation and are consistent with the need to do the job within the assigned time limit. Plans for structures may include plans for their camouflage after erection. Layouts for depots, parks, shop areas, and the like must be planned with the basic principles of camouflage constantly in mind. See also chapter 18.

664. Engineer Camouflage Battalion

a. This is a specialized unit, normally assigned to a communications zone but may be assigned to a field army. It can plan and supervise the installation of large-scale camouflage projects; assist in the supply of camouflage materials; manufacture them on a limited scale, or supervise their manufacture on a larger scale by civilian labor, given suitable working facilities; inspect and supervise camouflage discipline and training for all troops in a designated command or area; furnish teams to give camouflage instruction; and prepare instructional material.

b. The battalion is a flexible unit consisting of a headquarters and headquarters detachment to which are assigned camouflage companies as the situation demands. Headquarters and headquarters detachment, in addition to overhead and housekeeping personnel, has a transportation section and factory section. The latter is the largest element of the detachment, consisting mostly of camoufleurs and painters. Each camouflage company consists of a company headquarters and four identical camouflage platoons, which operate as units.

c. The normal allocation is one camouflage company per field army.

d. Units of the battalion can erect small, highly specialized camouflage installations at key points, but lack the manpower for large jobs. They should be utilized primarily for planning, supervision, inspection, and instruction.

e. For further details, see FM 5–5.

Section II. BASIC PRINCIPLES

665. Observation

a. Since the purpose of camouflage is to mislead enemy observers, it must be considered what an enemy can observe, and how. Observation may be by sight or by sound, the former being by far the more important. Visual observation may be from the ground or the air. Also it may be direct (by the human eye) or indirect (by photographs). Indirect observation is usually from the air.

b. It must be assumed that the enemy will use both direct and indirect observation. The advantages and limitations of the two are as follows:

(1) Direct observation permits movement to be observed. If a suspicious or interesting object is noted, it can be studied from various angles and distances. Three-dimensional perspective exists to a varying degree; rela-

tively little for a high-altitude observer in a plane. Direct observation is limited as to area observed, is restricted by weather and light conditions, and is affected by visual inaccuracies and the ability of the observer to interpret what he sees.

(2) Indirect observation gives a permanent record, mechanically accurate except for optical distortions, which can be studied at leisure with magnifying devices. It can cover a large area. It can utilize infrared film to detect details not otherwise noticeable. It cannot detect movement unless successive photographs of the moving object are made and compared, or unless the movement has some recognizable symptom such as dust from a marching column or the wake of a boat. It is strictly two-dimensional unless overlapping photographs are observed stereoscopically. Its interpretation calls for specially trained men.

666. Factors of Visual Recognition, General

The characteristics of any object which permit it to be observed by the human eye or in a photograph are called *factors of visual recognition.* The most important are *shape*, *shadow*, *texture*, *color*, and *movement.* To these may be added *shine* and *tone.*

Note. Position, defined as "the relation of an object to its background," is sometimes listed as one of the factors of visual recognition. Strictly speaking, however, when we look at an object against a background, we do not recognize it by its position as such, but by its color, texture, movement, etc.—that is, by one or more of the *other* factors of recognition. In a somewhat different sense of the word, however, "position" is a vital element in camouflage; see paragraphs 674 through 680.

667. Shape

a. Most large items of military equipment have characteristic and unmistakable shapes. Even a slightly trained observer can recognize, from the ground or the air, an unconcealed truck, tank, field gun, plane, or tent.

b. Manmade entities tend to have regular and more or less mathematical shapes, often symmetrical, and bounded or defined largely by straight lines. This is true of individual objects; and there is a similar tendency with respect to groups of objects, if convenience and efficiency are the governing factors. For example, if a bivouac, camp, depot, airfield, or truck park is laid out with the sole ends of administrative convenience and efficient operation in mind, it will have a great deal of symmetry; structures will mostly be rectangular; and structures or other objects will often be set in straight rows, uniformly spaced.

c. Order, symmetry, and the straight line are thus characteristic of the works of man. In nature, however, there are almost no straight lines; and except for the structures of organisms, there is (in this sense of the word) almost no visual order or symmetry.

668. Shadow

The shadow of an object is revealing because of its shape, which is often recognizable, and also because it stands out strongly against a lighted surface. A neutral-colored plane parked on a neutral-colored field may be almost invisible from above on a dull day, but will be revealed at once if the sun casts its shadow obliquely. On the other hand, an object in the shadow of another object may be concealed by it.

669. Texture

a. Texture is the degree of roughness of a surface. The rougher it is, the less light it reflects per unit area to the eye of an observer or the lens of a camera. A surface like high grass or woods which, on account of its texture, reflects little light, appears dark in a photograph, as compared with a close-cropped field of grass or a smooth surface without vegetation.

b. A polished surface is the extreme limit of smooth texture. It reflects light with practically no diffusion, producing what is called *shine.* Shine occurs in nature most commonly when light is reflected from still water. It is also characteristic of many manmade things, especially metal objects.

670. Color

a. The color of an object makes it conspicuous to the extent that it is seen against a background of a contrasting color.

Note. In this chapter the term "background" includes the ground on which an installation or object is placed, since, to an airplane observer, this is its background.

Certain colors are also associated in the mind with certain kinds of objects.

b. Colors on the ground tend to fade out to gray if observed from altitudes of 10,000 feet or more.

c. In a photograph not made with color film, all colors appear as either black, white, or some shade of gray. The particular shade which an object has, in the photograph, is called its *tone.* As explained above, the rougher the texture of an object, the darker will be its tone in a photograph.

671. Movement

Movement is perhaps the most important of all factors of visual recognition. An object, especially if seen from the air, may be quite unnoticed as long as it is still, but may be detected at once when it moves. Even if the observer cannot at once identify the object, his attention is drawn to it and his interest aroused.

672. Summary

The following shows in tabular form the factors of recognition of an object and the corresponding means used to prevent recognition:

An object is brought to the attention of a visual observer (directly or photographically) by virtue of—	*Means used to prevent this:*
a. Characteristic shape; straight lines; symmetrical layout.	*a.* Conceal the object, or change its apparent shape by camouflage devices; avoid symmetry, straight lines, and straight rows of objects.
b. The shadow it casts.	*b.* Keep it out of the sun.
c. The nature of its texture: the smoother the texture, the more light the object reflects.	*c.* Conceal smooth-textured objects, or roughen their texture; seek a background of the same texture as the objects; especially, prevent "shine."
d. Its color, and the contrast with the color of its background.	*d.* Avoid vivid colors not usual in nature; use the greens, grays and browns most common in nature; seek a background colored like the object to be concealed.
e. Its movement.	*e.* Avoid visible movement.

673. Methods of Concealment

a. The above tabulation states the methods of concealment of an object in very general terms. They are elaborated below.

b. An object or installation may often be concealed or rendered less visible, without the use of any structure, installation, or device, by a careful selection of its *position*, or *siting*. Alternatively, as a supplement or substitute, *devices of concealment* may be employed. In either case, certain precautions must be taken by personnel associated with the object or installation, which are known collectively as *camouflage discipline.*

Section III. CONCEALMENT BY SITING, CAMOUFLAGE DISCIPLINE

674. General

The location to be selected for an installation, such as a defensive position, camp, depot, or road, will to a large extent be fixed by the assigned mission and the orders and policies of higher authority. *These are always the governing factors.* Within their limitations, every effort should be made to conceal the installation as a whole, and its component parts, by siting them intelligently.

675. Pattern of Ground

a. Seen from the air, the general appearance or visual pattern of an area varies according to the use that is made of it. An area more or less in a state of nature has a haphazard and irregular pattern. In an urban area the structures are mostly rectangular. In many countries, including our own, the same is true of the street layouts. In agricultural territory there is likely to be a less pronounced pattern of straight lines.

b. An installation should conform as far as possible to the ground pattern of its site. This principle has a wide variety of applications. If a group of trucks must be parked without cover, in open pastureland covered with boulders or clumps of bushes scattered haphazardly, the trucks should also be placed haphazardly, perhaps directly beside the scattered natural objects. In a town of rectangular layout, the same trucks should be parked close to buildings and parallel to the pattern line. Again, certain features of a defensive position may be determined by the location and direction of ditches or hedges, or by contour plowing.

676. Cover and Defilade

a. As far as possible, an installation and its component items should be defiladed from enemy ground observation and fire, and concealed from air observation by natural overhead cover. Trees are the most common cover, and in some respects the best. If an object is too large to be wholly concealed by a tree, it may still be much less conspicuous when placed partly under the tree. Houses, barns, and other structures give perfect concealment to any person or thing inside; but the fact that they are being used is often betrayed by tracks or smoke, and they are pinpoint targets. Cliffs and steep banks, properly oriented to the sun, may give partial concealment by the shadows they cast.

b. If it is impossible to conceal the presence of a troop unit or installation in an area, it may still be important to conceal certain elements of it. Thus, if a tank unit in bivouac hides its tanks, the enemy may know that some sort of troops are there, but he will lack the vital information that they have armor.

677. Avoidance of Landmarks

It is well to avoid a location close to any conspicuous landmark visible to the enemy. This is especially true for units or installations within range of enemy artillery.

678. Dispersion

Dispersion is a vital element of both concealment and safety. A group of objects gathered close together is in general more conspicuous than are the same objects widely dispersed. It is also more vulnerable to attack. Objects placed side by side in a long straight line are peculiarly vulnerable to bombing. Subject to considerations of terrain pattern, the elements of a cantonment, depot, or similar installation are safer to the extent that they are dispersed in irregular patterns, with winding roads.

679. Roads and Tracks

a. Wherever possible, use should be made of already existing roads, which are probably recorded on the enemy's air photographs and maps. If a new road or track must be put into use, it should be sited in advance by a responsible officer. It should not lead up to the position and stop, but should be continued past the position to a plausible apparent destination.

b. Half a dozen vehicles milling about for a few minutes in a field, during the initial occupation of a position, may leave a betraying pattern of tracks that cannot be eradicated before the enemy has observed them. Prevention of this is one of the principal elements of camouflage discipline.

680. Other Aspects

a. Excavated earth, and trash generally, is often very conspicuous from the air, and should be placed under cover.

b. Light discipline is important at night; always near the front, and also throughout the theater unless we have command of the air. Sound discipline is important at all times in areas within range of the enemy's listening devices and patrols.

c. It must again be emphasized that none of the above rules is to be adhered to rigidly at the price of failing to accomplish a mission. Often there must be compromise. An example is dispersion, which, if carried too far, hampers efficient operation. (See pars. 537 through 546.) But the plea of efficiency should not be used as an excuse for failure to observe proper concealment precautions and camouflage discipline, which often stems from mere inertia or carelessness.

d. Camouflage discipline is especially important with respect to a camouflaged position or object. If the enemy's attention is drawn to such a position or object, he may bomb or shell it without knowing what it is, on the assumption that, if it was worth camouflaging, it is worth attacking.

e. Camouflage discipline and the effectiveness of camouflage measures should be periodically checked by responsible staff officers, by direct observation and air photography. A commanding officer should seek opportunities to observe from the air the camouflage measures of his unit or installation.

681. General

a. Concealment by choice of position and site and by careful discipline, described above, is often supplemented by the use of material devices. They may have three purposes:

(1) *Hiding*, whereby an object is completely concealed.

(2) *Blending*, whereby an object, though remaining in the observer's field of view, is made inconspicuous.

(3) *Simulating or deceiving*, whereby an object is made to look like something else.

b. Hiding and blending grade into each other, and can be considered together. They may employ either natural materials such as leaves, grass, and earth or artificial materials such as nets, garnishing, and paint or a combination. Deception must be considered separately.

682. Live Vegetation

This can be used for concealment in various ways, in addition to the use of trees for overhead cover. Grass, shrubs, and ferns can be planted on areas of raw earth, such as excavations, spoil banks, and the exteriors of bunkers or dugouts made of timber and earth. Vines can be trained to grow up the sides of steep slopes or to cover concrete pillboxes. The types of vegetation to be used will vary widely in different theaters and with the seasons. Rainy tropical areas are especially adapted to this form of camouflage.

683. Cut Vegetation, Nature and Limitations

This is often an excellent *temporary* means of concealment. Its chief drawback is that it wilts, and after wilting is generally useless for concealment. The following points are to be noted—

a. Large cut branches last longer before wilting than do small ones.

b. Cut branches of coniferous trees last longer than those of deciduous trees. The former may last 1 or 2 weeks, without water, before wilting; the best of the latter, not much over a day.

c. Among deciduous trees, those with large leaves of a tough, leathery texture last best.

d. Branches which grew in sunlight last longer than those which grew in the shade.

e. Grasses and weeds wilt so fast after cutting as to be almost useless for camouflage.

684. Use of Cut Vegetation

a. It can be laid on top of an object, or leaned against it, or supported by a net or framework to form overhead cover. It must always be placed in its natural growing position. For example, if a branch is to be laid flat on a horizontal surface, it should be a branch that has grown in a horizontal position, and it should be placed with leaf surfaces uppermost.

b. As long as the natural vegetation of an area is green and fresh, cut vegetation used for camouflage must also be fresh, and must be changed before it wilts. However, if the season and climate are such that the trees have lost their leaves and the grasses and weeds have withered, dead vegetation properly arranged makes excellent camouflage, and does not need frequent replacement.

685. Other Natural Materials

a. Dirt and mud are valuable for toning down or concealing shiny or brightly colored surfaces.

b. Any form of trash or debris, or any aggregation of nonmilitary materials, that would naturally be found in a locality, is useful for concealment. The debris of structure in a town that has been shelled, a dump of discarded automobiles, a haystack, or a woodpile all offer possibilities of concealment.

686. Artificial Materials, General

Those most commonly used for camouflage, either alone or combined with natural materials, are—

a. Garnished nets or other devices, to blur the outline of an object or otherwise make it inconspicuous.

b. Paints, and texturing materials, to change the color and tone of a surface or obscure its outline.

c. Screens to hide an object.

687. Nets and Garnishing

a. The purpose of a camouflage net is to support the garnishing, which is attached to the net in such patterns, and of such colors and textures, as to make the net and anything under it inconspicuous to the observer. Proper garnishing is the first requisite for this type of camouflage.

b. Nets are made either of twine, woven in 2-inch squares, or of woven wire.

c. Twine nets are normally garnished with strips of burlap, cloth, or oznaburg, which is woven into or tied to the net in a predetermined pattern. The most common patterns are the Greek key and the U-pattern; others are the straight-line, patch, and bow-tie patterns. The pattern is important, and is varied for different uses.

d. Wire nets are issued both with and without garnishing. The former are garnished with burlap, steel wool, chicken feathers, and glass fiber. Wire nets last longer and need less upkeep than twine nets.

e. Nets may also be garnished with cut vegetation, but in the growing season the replacement problem is difficult. If dead vegetation can be safely used, this objection does not exist.

688. Use of Nets

The most common uses are as drapes and as screens.

689. Drapes

A drape is a garnished net draped over the object to be concealed, such as a truck or tank, a small building, or stacked supplies. Its purpose is to present to the observer an irregular shape and a neutral colored surface. It should be held away from direct contact with the concealed object to the extent needed to hide the shape of the latter. If possible, its folds should have a flat enough slope so that, for most elevations of the sun, the draped object casts no exterior shadow.

690. Screens

A screen is intended not simply to make an object less conspicuous or to alter its apparent color, shape, and tone, but to conceal it completely. A common example is a screen built across a road on which an enemy may advance, high enough to conceal from a ground observer what is behind it—which may be a defended roadblock, a minefield, or (perhaps) nothing whatever. An approaching enemy has the choice of halting to reconnoiter, which means delay, or crashing the screen without knowing what may be waiting for him. Overhead screens may also be erected to conceal a stretch of road, a railroad siding, or the like.

691. Paints and Texturing, General

Their principal uses in camouflage are—

a. To change the color of a surface.

b. To change its texture.

c. To disrupt its apparent shape as seen by an observer.

692. Change of Color

Since the visibility of an object depends largely on its color as compared to the background color, visibility can often be reduced by changing the color, make it accord with a particular background or the average background. This should be done by or on the advice of someone having knowledge of the properties of color and the principles of visibility. The effect of coloring an object like its background is largely nullified if the object is so sited as to cast a conspicuous shadow.

693. Change of Texture

Two surfaces may have the same color and yet present a quite different appearance to an observer, and produce a quite different tone in a photograph, on account of a difference in texture. Texture can be changed by applying various materials to a surface, using an adhesive. Among the common materials are cork, scraps of leather or rubber, bark, pine needles and gravel. Perhaps the simplest form of temporary retexturing is to smear a polished surface with mud.

694. Disruption of Form

a. This can often be accomplished by applying colors or texturing materials to the surface of an object in a particular way. The commonest means is to paint the surface in irregular, meaningless patterns. This form of deception is not proof against lengthy and careful observation, but can be quite confusing to a casual observer.

b. For such patterns, 2 or 3 contrasting colors should be used, generally resembling the background coloring. They should be darker on top and lighter below. Patterns should be fairly large; the size is of course controlled by the object being patterned. If they are meant to deceive a high altitude observer, the color contrasts should be rather bold.

c. Common examples of large-scale disruption of form are the pattern painting of ships and of large buildings, and the pattern coloration of airfields to obscure the outlines of runways.

d. Undue reliance must not be placed on pattern painting to the exclusion of defensive precautions. This is especially true of large installations like depots and cantonments.

Section V. DECEPTION BY FEINT AND DISGUISE

695. General

a. There are many facets to the military art of deception, which seeks to place the enemy at a disadvantage and our forces at an advantage. Simulation, which is perhaps better stated as deception, falls into three categories: immediate or small unit deception; tactical deception; and strategic deception. Immediate deception can be employed by the individual by simple ruses, such as throwing a stone to attract the enemy's attention and lure him into exposing his position by firing in the direction of the sound. The efficient use of decoys and dummies, to simulate military equipment or activities, presents to the enemy a fictitious situation to which he may react to our advantage. The Trojan horse is the first classic example of outwitting an enemy by deception.

b. Most tactical and all strategic deception operations are planned at army or higher headquarters, and are generally of a highly classified nature. For them to be effective, there must be thorough coordination among the services involved. Deception is only effective if it deceives the enemy, and a poorly executed deception plan may have disastrous results.

c. Deceptive simulation consists of exposing something to an enemy observer in order that he may mistake it for something else, or misinterpret its meaning. It may be a solid object, a painted pattern on the ground simulating a solid object, a sign of activity, or a large-scale installation combining all these features. Normally it pretends to be something more important than it is, and thereby seeks to focus the enemy's attention and act as a decoy. On occasion it may pretend to be something less important than it is, and thereby direct the enemy's attention from it or cause him to lose interest. For example, a commander may wish to conceal the fact that an armored unit is moving over a certain route. If possible, of course, the unit will be moved secretly. However, if this is impossible, it may be worth while to disguise the tanks (for example, as cargo trucks) so that the enemy, while observing the movement, will not attribute any special importance to it.

d. Deceptive displays, to become effective, must present a "live" situation. No matter how well the dummies are built and displayed, they do not present a convincing picture unless signs of life normal to the organization being simulated are also provided. Activities that the enemy and his agents may observe must be carried on with painstaking thoroughness if the ruse is to remain undetected.

696. Principles of Dummies

a. A dummy must look like the object it purports to be.

b. It must be visible to be effective. On the other hand, if it simulates an object that would normally be hidden, it must not be too obviously visible. Rather, it should give the appearance of having been inadequately or inefficiently camouflaged or concealed.

c. A dummy installation as stated above, must include the principal and obvious features normally associated with the thing it simulates. For example: if the installation simulates an armored unit in reserve, a real tank should be used to make a few tracks, visible to enemy planes, and from time to time should add fresh tracks. If it simulates an operating airstrip, with dummy planes, these planes should be moved from time to time, and trucks should move about the field in the presence of an observer, and should leave changing patterns of tracks. (See also ch. 21.) The officer responsible for a dummy installation must think in terms of what an intelligent enemy will expect to observe if he is to be deceived into thinking the installation a real one.

d. The purpose of a dummy is not simply to deceive the enemy, but to deceive him for a particular tactical or strategic end. On a small scale this may be merely local security, as when a company in a concealed position draws the enemy's attention to a nearby unoccupied position, hoping to divert his observation and fire. A large dummy installation is usually an element of a major plan of operations, and must be carefully tailored to that plan. The purpose may be to focus the enemy's attention in one direction, while an offensive thrust is being prepared in another; or to make him believe that a part of our force, which he knows to exist, is in a rear area when it has in fact been moved into line; or to give him an exaggerated idea of our strength in a certain area, and discourage an attack which we do not wish to meet; or to divert bombing or artillery fire from a real installation to an adjacent simulated one.

697. Examples of Simulated Objects

The possibilities of dummies and simulation are limited only by the ingenuity and resources of the responsible officer. Any large weapon or piece of machinery can be imitated by the use of cloth, wire, lumber, and paint, if prefabricated simulation devices are not readily available. Wrecked planes and trucks can be patched up to appear serviceable. Defensive positions can be simulated with shallow trenches and faked emplacements. Apparently three-dimensional objects, such as warehouses or parked planes, can be simulated by painting the shape and shadows on the ground. Whether and for how long such an object will deceive the enemy depends on how like it is to the real thing. Thus, a painted area on the ground simulating a parked plane, or a shallow trench simulating a deep trench will be detected if the enemy makes enough observations to note the absence, or the implausible shapes, of shadows cast at various times of day.

698. Simulated Signs of Activity

These should include signs of a sort which no real command or installation, of the kind being simulated, could possibly conceal, and which, therefore, the enemy will certainly expect to observe. They may also include signs of a sort which might readily show as a result of defective camouflage discipline. Examples of both sorts include roads, paths, or wheel tracks leading to a pretended position; simulated smoke from kitchens; dust, produced by dragging a log behind a truck on an unsurfaced road, to suggest a marching column; light at night; and deceptive radio messages.

699. Responsibility for Deception Measures

a. Small-unit displays are the responsibility of the unit commander, and are implemented by his troops.

b. Displays of a tactical or strategic nature, planned by higher echelons, require the assistance of various services. Information on this topic is largely classified and is beyond the scope of the present manual.

c. One phase of engineer responsibility concerning deception is planning for, erecting, and maintaining decoys and dummies. Camouflage troops familiar with deceptive displays are usually employed. If the displays are of a scope beyond the physical capabilities of these troops, additional troops are used, with supervision and technical assistance furnished by the camouflage troops.

CHAPTER 26

ENGINEER OPERATIONS IN ABNORMAL TERRAINS AND CLIMATES

Section I. GENERAL

700. "Normal" Climates and Terrains

a. This manual is written with primary reference to conditions in the temperate zones of North America and Europe, and also in limited areas of South America, southern Africa, eastern and central Asia, and Australia, and in some oceanic islands. In general, within these areas—

(1) There is a clear-cut division of the year into four seasons, with large annual variations of temperature. However, extreme heat and cold are of short duration.

(2) Precipitation lies within or close to the range of from 20 to 60 inches per year, and there are no strongly pronounced wet and dry seasons.

(3) Terrain varies from flat plains to fairly high mountains, but in general is well drained and is passable without extreme difficulty.

(4) Vegetation and ground cover, of the temperate zone variety, are almost universal.

(5) Population is moderately dense and at a high level of civilization, and the cities, routes of communication, and industrial and agricultural resources of the areas are at a corresponding level.

b. Areas having these features are thought of as "normal" by Americans and Europeans. The term is in fact relative, since such conditions by no means prevail over a majority of the earth's surface.

701. Other Climates and Terrains

a. There are at least four types of areas in which the climate and terrain are strikingly different from the foregoing. These are—

(1) Arctic areas.
(2) Deserts.
(3) Jungles.
(4) Very high mountains.

b. The first three of these cover large parts of the earth's surface. Limited areas, partaking of some of their characteristics, are also found in or adjacent to "normal" areas. With respect to very high mountains, the only large area occupied exclusively by them is that part of central Asia which includes the Himalayas and extends north and northwest from them. High mountain areas of smaller extent are found on all the continents.

c. Swamps and marshes are sometimes classified as another distinct type of terrain. However, there are few such areas of large extent, and they may better be thought of as special features associated with other types of territory.

d. Each of the geographical and climatic categories listed above has peculiarities which produce their effects on military operations, including engineer operations. The effects may include changes in layouts, designs, construction techniques, equipment, supply and maintenance practices; changes in tactical operations, including marches, bivouacs, security measures, and the engineer support of combat troops; and a changed relative emphasis on the various types of engineer operations.

e. The four succeeding sections indicate very briefly how engineer operations in these "abnormal" areas differ from those in a "normal" theater. If no difference is indicated, ordinary rules and practices apply. For further details, see FM 5–15, FM 31–25, FM 70–10, and FM 72–20.

Section II. ARCTIC AREAS

702. General

a. Arctic and subarctic areas are found in parts of Canada, Alaska, Asiatic and European Russia, and Greenland, and to some extent in Iceland and northern Scandinavia. The conditions of snow, ice, and extreme cold typical of these areas are not, in general, continuous throughout the year. However, even in summer the arctic weather and terrain differ from those of the temperate zone.

b. In the Southern Hemisphere, extreme Arctic conditions obtain in Antarctica. Military operations in that area seem unlikely.

c. Parts of this section apply to operations in high mountains (pars. 757 through 767), and in the temperate zone in very severe winter conditions.

703. Arctic and Subarctic Areas

The areas mentioned above may be divided into "Arctic" and "subarctic," the latter being a zone of transition between temperate and Arctic conditions. The true Arctic may be further divided.

a. The subarctic area has no definite southern boundary, grading imperceptibly into the temperate area. In general it is heavily timbered, and its northern boundary is ordinarily taken as the timber-line.

b. The southern part of the true Arctic belt, covering most of northern Canada and Siberia, is characterized by level or rolling treeless plains called the tundra.

c. Both these areas were covered by the icecap of the last glacial epoch. Its withdrawal has left numerous lakes, thick deposits of sand and gravel, and other evidences of recent glaciation.

d. In the extreme north are areas, such as Greenland, where the icecap of the glacial epoch still remains. Most of the land and much of the sea is permanently covered, and the limited land areas which are uncovered in summer are largely rock.

704. Climate

The principal characteristics are—

a. Long summer days and winter nights (occupying the entire 24 hours, for varying periods, north of the Arctic Circle).

b. Intense cold for much of the year. Temperatures below zero Fahrenheit are normal; below −40°, quite common; below −60°, may be expected at times. Below −40°, military operations become increasingly difficult.

c. Periodic blizzards of extreme severity and long duration, during which the difficulty of conducting military operations is greatly increased.

d. Heavy snow and thick ice.

e. High visibility except during storms, although fog, mirages, and blowing snow may occur.

f. Short and often hot summers, during which the snow and ice cover at low elevations may melt.

705. Terrain

a. Topography. This varies from quite flat tundra to the rugged mountains of northwestern Canada and Alaska and the high ice plateau of Greenland.

b. Water. There are numerous lakes and rivers. In summer, swamps and bogs are common in tundra areas. Precipitation is largely snow.

c. Permafrost. In much of the Arctic areas the soil is permanently frozen to a great depth, except for a thin surface layer (the "active zone") which thaws in summer. This condition is called "permafrost." The frozen mass may be homogeneous, or may be interrupted by lenses or layers of unfrozen soil or of ice.

d. Vegetation. The subarctic has heavy stands of timber at moderate elevations. The Arctic tundra is mostly covered by a bed of moss, lichens, and stunted vegetation, underlain by ordinary soil or mud.

e. Coasts. Mostly rugged, indented, and blocked with ice for much of the year.

706. Military Operations, General

a. They are likely to be on a limited scale on account of the difficulties of supply, transport, and weather. However, Arctic operations on even a limited scale might be important or decisive in a future war involving this country.

b. Tactically, Arctic operations are characterized by small, mobile, self-contained, highly trained combat teams; light mobile artillery and armor; free maneuver, with flanking and enveloping movements; and the extensive use of aviation. All tactics are conditioned by supply difficulties and by the behavior of weapons, machinery, ammunition, lubricants, and fuels in extreme cold.

707. Clothing and Equipment

Special clothing, skis, and snowshoes are used. Winterization of weapons, fire-control instruments, tanks, and other equipment is necessary. Special precautions and procedures are required in operating, servicing, and maintaining equipment in cold weather.

708. Health Problems

Most Arctic areas are relatively free from pathogenic organisms, and are quite healthy places for troops to live if they are well trained and well cared for.

Note. After long Arctic service a man may lose part of his natural immunity to Temperate Zone diseases.

The principal problems are—

a. The effects of extreme cold in the open. Careful indoctrination is needed, since an untrained and careless man may be seriously frostbitten, or overcome by cold and frozen to death, without noticeable pain or other symptoms.

b. Physical dangers inherent in moving about in deep snow and on the frozen surfaces of lakes and rivers.

c. Difficulty in maintaining standards of personal cleanliness and sanitation, especially in conditions where shelters, latrines, and washing facilities cannot be kept reasonably warm.

d. Snow blindness.

e. Mosquitoes, gnats, black flies, and other insects. In general they do not carry diseases as do insects of the temperate and tropic zones, but they can be a great nuisance, interfere with work, and affect morale. Nets, gloves, and insect repellents are necessities to summer operations in many Arctic areas.

f. Carbon monoxide poisoning, which can be a major health hazard when using liquid fuel.

709. Engineer Operations, General

The weather and terrain conditions of the Arctic involve certain changes in many basic engineer techniques such as construction, utilities, road building, and water supply. Maintenance difficulties are greatly increased. Extreme simplicity and economy must govern in all fields because of the supply problem.

710. Engineer Supply and Maintenance

a. The principal supply difficulties arise out of limitations on transportation; the almost total absence of local construction materials and resources, especially on the tundra or the permanent icecap; and the difficulties inherent in storing certain substances in extreme cold.

b. Engineer equipment maintenance is a difficult problem. Even shop maintenance is a slow process, since equipment must be thawed out and warmed before effective work can start. Field maintenance presents further complications. A mechanic's hands may be painfully frozen if gasoline spills on them and evaporates, or frozen and abraded by contact with cold metal. If the hands are protected, the operator is clumsy. It has been estimated that maintenance work in the open is impossible below −25° F., and that maintenance under cover requires up to five times the normal period if the temperature is

−40° F. or lower. Some form of heated shelter is practically essential for effective maintenance.

711. Field Fortifications

a. Excavation is difficult in either frozen or thawed ground. In frozen ground, hand tools are of little use. Explosives are effective when properly used, but large quantities are required. An expedient is to build a fire over a metal sheet and then dig out the ground as it thaws. Too much thawing of large areas, however, makes digging difficult unless there is adequate drainage. Gravel is easier to excavate because it does not freeze as solidly as soil, and has better drainage.

b. Extensive use is made of snow, ice blocks, and "icecrete" (a dense frozen mixture of water, sand, and sometimes gravel). Foxholes, trenches, breastworks, and emplacements may be provided by digging into the snow, or through it and into the underlying ground. They may be strengthened by compacting the snow or by building up a parapet of packed snow or icecrete. Sandbags filled with such materials are also used. Snow trenches may need revetting. In very deep snow, tunnels may be dug; they are not proof against artillery, but give perfect concealment. Long tunnels must be ventilated. All the foregoing disintegrate under heavy fire.

712. Mines

a. Mine warfare presents complications. Laying mines in quantity, and especially arming them, is slow and difficult in very cold weather. If a mine, after placing, is covered by an additional thick layer of fallen snow, it may be buried too deeply to be effective until the snow cover has partly melted. A mine may also become temporarily ineffective if water seeps into it and then freezes. Antipersonnel mines in deep snow may need bearing devices to keep them near the surface.

b. White-painted mines and trip wires, and colored tapes, are useful.

c. The *ice mine* is made by filling a bottle with explosives, inserting a fuze, and closing the bottle with a waterproof seal. A field of such mines is effective under the ice cover of a lake or stream. Holes are drilled in the ice about 3 yards apart and the mines suspended about 2 feet under the ice. Detonation of one mine by a firing device will produce a sympathetic detonation of the whole field.

713. Obstacles

a. Antitank obstacles can be made by freezing large masses of snow or icecrete into any desired shape, or by icing steep drifts.

b. A roadblock can be made by icing a section of road, preferably one which the enemy must approach on an upgrade. Its effectiveness can be increased by a wire cable, painted white, stretched diagonally across the road about 2 feet above the surface. Antitank mines should be placed beside the road.

c. A tank trap over water can be made by cutting out and removing a strip of ice about 15 feet wide, letting the water surface refreeze lightly, and then preventing further freezing by covering it with a mat. Artificial or natural snow cover on the mat conceals the trap.

d. In placing barbed wire, metal pickets are better than wooden ones. Extra long pickets are needed in deep snow. Pickets should be painted white.

Wire should be placed low to prevent tunneling; if heavy snowfall makes its ineffective, more strands can be added to build it higher. The "Lapland fence" is a portable wire obstacle suitable for frozen or rocky ground. Concertinas are very effective in deep soft snow.

714. Transportation and Troop Movements

a. On Snow. In general, most vehicles are immobilized in wet snow from 3 to 5 feet deep. However, tracked vehicles can usually move at low speeds in packed snow not over 3 feet deep. After a packed snow trail has been formed by the passage of several heavy vehicles, normal speeds may be maintained. The surface becomes compacted into a hard mass and resembles well-packed, wet sand. This type of trail is easily traversed. However, a thaw, or the passage of a great many vehicles on a relatively warm day, will melt the snow surface, which in turn will produce a coating of glare ice. The road then becomes practically impassable to tracked vehicles unless ice cleats are installed on the tracks or the road is sanded.

b. On Ice. Lakes and streams may be crossed in winter with reasonable care. The ice must first be checked for thin spots, cracks, and pressure ridges.

c. In Spring. The spring thaw is a period of difficulty and danger for movements on ice and snow, especially the former. Cross-country movement practically ceases.

d. On the Open Tundra. After the snow cover has melted from the tundra, tracked and wheeled vehicles can move freely on it as long as it remains frozen. However, as soon as the active zone has melted, the tundra ceases to support heavy concentrated loads, and ordinary vehicles bog down. Their salvage is often difficult.

e. Navigation. The tundra is almost without landmarks. Troops moving over it must be trained to find their way by compass and dead reckoning.

f. Roads. See paragraph 718.

g. Air Transport. This is highly important when land transport has difficulty in moving.

h. Effect of Cold on Machinery. Extreme cold produces effects on liquid fuel, lubricants, and metallic parts which complicate the operation of wheeled and tracked vehicles. In general—

(1) Down to −10° F. operations are not difficult; they resemble operations in the northern United States during the hardest winters.

(2) From −10° F. to −40° F. operations are progressively more difficult. At the warm end of this temperature range, lack of winterization results in only slight loss of efficiency; at the cold end, it results in many failures to operate.

(3) Below −40° F. operations become extremely difficult. At temperatures in the vicinity of −60° F. the maximum efforts of well-trained men are required to perform even a simple task with completely winterized material.

715. Bivouacs and Shelters

a. Cold-weather bivouacs should preferably be in timber. A low improvised roof or cover, to retain heat and keep out wind, is desirable. Men should sleep well off the ground and insulated from it.

b. Several types of shelter can be made from snow and ice, including the *snow hole* and *snow cave* (dug in deep firm snow); the *snow pit* (with a roof of planks or boughs covered with snow); the *snow-house* (like a snow pit but with walls built of blocks of compacted snow); and the *igloo* (a domed shelter made entirely of snow blocks). They give shelter from the weather and to some extent from enemy action.

716. General Construction, Foundation Conditions

Perhaps the most characteristic aspect of Arctic construction is the foundation problem caused by permafrost and allied phenomena.

a. Melting of Active Zone. When the active zone melts in late spring and summer, its large water content causes it to have very little bearing power.

b. Melting of Permafrost. The frozen subsoil, below the active zone, has high bearing power. However, if the ground surface is artificially warmed (for example, by installing an occupied building on or very close to the ground) and the delicate thermal balance of the subsoil is thereby upset, the upper layers of permafrost melt, with resulting failure of any foundations resting on them.

c. Icing. With the onset of winter, the active zone refreezes from the top down. At a certain stage of the process the upper part is frozen while the lower part still contains free water. If an area of ground under a structure is kept warm so that the surface cannot freeze, the unfrozen water may break out at this point, flow over the surface in successive sheets, freeze, and engulf the building in ice. This is called *icing*. It may also occur for other reasons, such as the emergence of a spring, or of ground water whose flow has been artificially interrupted, forcing it to the surface.

d. Choice of Soils. Next to bedrock, well-graded gravel makes the best foundation material, being little affected by moisture or frost action. Coarse angular sand is also good. Silts, clay, and soil containing organic matter are undesirable.

e. Choice of Sites. Well-drained sites, exposed to the sun, are desirable. Ridges are better than flat areas. Surface springs or seepings, soil flow or creep, and exposed soil showing broad cracks of polygonal pattern are all evidences of potential icing or instability.

f. Pile Foundations. Structures built on permafrost quite commonly have pile foundations, and free space under the building for the circulation of air. The driving, loading, and stabilization of piles present special problems.

g. Other Foundations. If a structure in the permafrost zone is to rest on shallow footings, or directly on the soil, it should be insulated so as to minimize its effect on the thermal balance of the soil. Among the means employed are the following:

(1) Sills placed on the ground surface, but insulated from the ground by moss; a cheap and temporary expedient.

(2) Sills or slabs placed on a sand fill or log mat.

(3) Soil excavated to permafrost level and then filled with gravel to above the original surface; sills or concrete slabs placed on this fill.

(4) Footings sunk to permafrost level and surrounded by an insulat-layer of sand or gravel.

717. General Construction, Other Aspects

Other typical construction problems in Arctic areas include the following:

a. Dispersal. Dispersal of the structures of a depot, cantonment, or similar installation is desirable, not only for tactical reasons but to reduce fire risks. However, buildings between which individuals are constantly moving—for example, a group consisting of a barracks, messhall, and latrine—should be quite close together and perhaps connected by galleries, on account of the danger of moving in the open in Arctic storms.

b. Snow and Wind Loads. In designing structures, ample provision must be made for such loads, including the pressure of high drifts around a building.

c. Temperature Variation. The great range of temperature and the intense cold in winter require careful attention to insulation and artificial heating.

d. Fire. Fire is a major risk, on account of the prevalence of artificial heating, the difficulty of fighting fires in very cold weather, and the disastrous results that might follow the destruction of an occupied cantonment in midwinter. All possible precautions must be taken.

e. Construction Season. Winter work is very difficult. Most Arctic construction is in warm weather, though certain types of foundation work are best accomplished in late winter or early spring because of soil conditions. The long summer twilights are favorable to two-shift operation.

a. As in the case of general construction, a major factor in Arctic roadwork is permafrost and the drainage and other problems to which it gives rise.

b. Every effort should be made to site a road on high, well-drained areas of gravel or sand, exposed to the sun. Silt, clay, peat, or other organic soils, low and boggy ground, and ground showing signs of earth movement and frost action should be avoided if possible. A long winding road on good soil is better than a short straight one on bad soil.

c. If a road must be built over silty or otherwise defective soil in the permafrost zone, the following precautions are desirable—

(1) Start the work in fall or early winter after the active zone has frozen.

(2) Insulate by a thick layer of gravel, which may in turn be placed on a brush or timber mat.

(3) Do not place the final wearing surface until thermal equilibrium in the subsoil has been reestablished.

d. In spite of all such precautions, settlement will probably occur in a road built on soil of this sort, and extensive maintenance may be expected for several years after construction.

e. Cuts, including sidehill cuts, should be avoided if possible.

f. Fills are often necessary. However, if a road is on a side slope, a fill may produce special drainage complications. After the fill is built, the permafrost table (that is, the lower limit of the active zone) rises within the fill. This blocks the downhill movement of ground water. In the warm months it can be handled by ditches and culverts, but in winter it may produce icing that will engulf the road. One means of dealing with this is a wide berm on the uphill side of the fill, to transfer the icing to a safe distance.

g. Icing may also occur where a small stream or spring outlet flows through a culvert, and may be similarly dealt with (by blocking the flow at some point upstream and thus transferring the icing elsewhere).

h. Winter road maintenance involves snow removal, ice removal if icing has developed, the sanding of icy surfaces, and keeping ditches and culverts open. Snow fences are often a valuable aid to maintenance. Earth and gravel surfaces, including shoulders, should be kept smooth during winter. Frost boils, slides, and flooding from blocked ditches and culverts must be carefully watched in the spring thaw. Snowmelt and the attendant movement of floating ice may destroy or damage bridges, and prompt repairs will be needed. Maintenance and repair materials which may be required during winter and early spring should be stockpiled during the previous autumn.

i. The special problems involved in the construction and maintenance of airstrips and airbases in Arctic areas are in general similar to those involved in roadwork and general construction.

719. Bridges

a. Bridges in permafrost areas present foundation problems analogous to those of other structures. Piles are preferable to sills or cribs. If some other type of foundation is used, the area on which it rests should be deeply excavated and backfilled with gravel. If soil is subject to swelling, extra bracing is needed to increase the rigidity of the bridge.

b. A bridge over a large stream must be designed to resist heavy ice movements in spring. Fender piles or cribs, and ample space for the passage of ice under the bridge, are needed.

c. If foundation and ice conditions are too difficult, it may be necessary to build a suspension bridge, although its towers often present a considerable foundation problem in themselves.

720. Water Supply

a. If a deep lake or stream is available, there will be water under the ice cover. Pumps, filtering apparatus, and supplies of stored water should be kept under cover at temperatures above freezing. Intake pipes or hoses, and pipes used to distribute water unless buried deep and carefully insulated, must be drained except when water is flowing through them.

b. A deep well is a good source of water if the water is of satisfactory quality, which is not always the case.

c. Underground collection galleries may be dug in a stratum near the surface in which ground water is flowing. The site must be carefully selected to prevent freezing of the water, or destruction of the gallery by frost action and movements of the soil.

d. If a reservoir is required, it should be quite deep and exposed to the sun and the free movement of air. The building of a dam may involve difficult construction problems.

e. In bivouacs, on maneuvers, or at locations on the permanent icecap, the only source of water may be melted ice or snow. The cost of fuel needed to melt it, measured in terms of transportation, may require rationing of water.

721. Camouflage

a. General. Due to the high visibility of almost any object and of shadows against a snow background, camouflage in Arctic operations is important. It also presents special difficulties.

b. Blending and Concealment. Imitating snow by white paint or fabrics requires special care, in part because the reflective quality of snow is hard to reproduce, and in part because snow surfaces vary considerably in color. Painting or screening which is effective with respect to an enemy ground observer can often be detected in an air photograph. Snow itself may be the best means of concealment, either spread over a screen or piled around a large object like a tank. Equipment and small installations may be concealed by brush, planks, or sheet metal covered with snow.

c. Camouflage Discipline. Paths or tracks on snow are conspicuous. Strict camouflage discipline is therefore important, especially near positions in heavy timber or near screened pinpoint targets. Tank tracks on snow may be erased by a grader.

d. Night Movements. Difficulties of concealment place a premium on night movements. During a large part of the 24 hours, in an Arctic or subarctic winter, there is no true daylight but enough diffused light to see where one is going.

e. Deception. The same qualities of a snow-covered terrain which make concealment difficult make deception easy. Dummies are therefore an important element in Arctic camouflage. Shallow trenches filled with leaves or brush look like deep defensive works. Brush laid on snow in regular patterns may be made to resemble emplaced weapons. The fact that the lengths of shadows vary comparatively little between sunrise and sunset is an aid to such deception.

Section III. DESERTS

722. General

a. A desert is an area having little or no moisture and little or no vegetation. The principal deserts in the Northern Hemisphere are the Sahara, Arabian, and Syrian Deserts, some areas in India, the Gobi, and parts of the "Great Basin" in the United States with extensions into Mexico. South of the Equator are the Kalahari Desert in Africa, the Sandy and Victoria Deserts in Australia, and the Atacama Desert in South America. Scattered desert areas are found elsewhere, for example on some Caribbean islands and coastal strips.

b. The boundary of a desert may be sharply defined by a coast or mountain chain, or may be indefinite. In sections of the United States, for example, there is a uniform gradation from normal climate and terrain to "semiarid" areas and then to true desert. Parts of this text apply to such transitional areas.

723. Climate

The principal characteristics are—

a. Little or no rainfall or humidity.

Note. An area of very little rainfall may support considerable vegetation if there is a great deal of moisture in the air. This condition obtains on some Pacific islands.

Desert conditions ordinarily mean an annual average of not over 5 inches of precipitation.

b. Relatively little annual variation in climate, although there may be a short rainy season.

c. Great daily variations in temperature, intense heat at midday being often followed by freezing temperatures at night.

d. Sandstorms and duststorms in some areas, accompanied by winds which may attain hurricane velocities.

e. Visibility limited by glare, mirage, and dust, which interfere with accurate observation for such purposes as fire control. On the other hand, since natural cover is almost nonexistent and rain or low clouds are rare, all daylight activities are open to air observation. Troop or vehicle movements are also betrayed by dust clouds.

724. Terrain

a. Topography. Desert land forms vary greatly. They include drifted sand, barren rock, mountains, level strata cut into deep gullies or worn down to flat-topped mesas, and areas of gravel and miscellaneous soil. If a desert area is surrounded by hills or mountains so that ground water cannot drain away, it may have salt lakes or marshes.

b. Water. Surface water is scanty or nonexistent, and when it exists may be undrinkable on account of dissolved chemicals, including salt. Springs, forming oases, are found in some deserts. In some, water may be obtained under dried-up streambeds or from deep wells.

c. Vegetation. In some sand and rock deserts, there is none. In other desert areas there is scanty vegetation of types needing little water, such as the mesquite and various forms of cactus in American deserts. The oases of the Sahara and Arabian Deserts support palms.

725. Military Operations, General

a. Offensive operations are characterized by maneuver and extreme mobility; defensive operations, by the need for artificial concealment and all-round protection. In general the offensive has the advantage, and a badly beaten or demoralized force may have difficulty in escaping complete destruction. All operations are conditioned by supply difficulties, the shortage of water, and the absence of cover. Armor, motorized infantry and artillery, and aviation are the basic elements of a desert force. The desert is favorable to night operations.

b. There are some parallels, in the above respects, between desert warfare and Arctic warfare. The former, however, is not subject to such lengthly seasonal interruptions as are imposed in the Arctic by extreme cold, deep snow, and the spring thaw.

c. Radio communication is vital in desert operations, including engineer operations.

726. Clothing and Equipment

a. Clothing in the desert should include light garments allowing free circulation of air but protecting against severe sunburn, together with woolen garments to protect against the night cold. Sun helmets or equivalent, goggles, and dust respirators are important.

b. No weapons or equipment should be taken into the desert which are not mobile or easily transportable. All wheeled vehicles must carry equipment to assist in extricating them from soft sand.

727. Health Problems

The principal ones are—

a. Difficulties resulting from limited water plus extreme heat. Men must be trained to restrict their consumption of water, and also to take salt tablets to balance the loss of body salt by excessive perspiration.

b. Respiratory diseases caused by dust and by extreme temperature variations.

c. Sunstroke.

d. In some areas, various infections resulting from contaminated water, or from contact with populations having low standards of health and sanitation.

e. Insects, especially stinging flies, which are major nuisances and often carry disease.

f. Severe sandstorms, which in the case of untrained men may be a danger to life. All men should be taught what to do in a sandstorm, either on the march or in bivouac.

728. Engineer Operations, General

They are characterized by special emphasis on water supply, camouflage, mines, and rapidly installed obstacles.

729. Engineer Supply and Maintenance

a. Engineer supply, like other kinds of supply, presents unusual difficulties—

(1) Because of transportation problems.

(2) Because the mobile elements of a desert tactical force tend to outrun their lines of communications in an advance attack, or pursuit.

(3) Because it is unsafe to establish large concentrations of supplies in advance depots or army service areas, on account of the dangers

from air and mechanized raids. Stocks should be kept small, and dispersed.

b. The desert has practically no natural resources of construction materials except sand, gravel, and (sometimes) rock.

c. Special problems of equipment maintenance include—

(1) Deterioration of moving parts due to sand and dust.

(2) Rapid wear of tires, and deterioration of chassis, due to abrasive soils and rough terrain.

(3) Field and shop maintenance difficulties arising from excessive heat and blowing sand, and from shortages of spare parts.

d. Maintenance difficulties are increased by the tendency to operate vehicles at excessive speeds over bad roads, which in turn arises from the rapid tempo of desert tactics.

730. Field Fortifications

a. The only forms of ordinary desert terrain which are not readily passable to trained troops, and which therefore form satisfactory anchors for the flanks of a defensive position, are exceptionally rugged mountains, salt marshes or sinks, and the seacoast. This fact, plus the mobility of desert troops, makes organized defensive *lines* unusual, and puts a premium on perimeter defense. However, full use is made of natural defensive features when they can be found.

b. In rocky deserts, field works are installed only with difficulty. In sandy deserts, trenches and emplacements are easy to dig, but must be revetted, and may be filled by blown or drifting sand.

731. Amphibious Defenses

If a desert theater includes a stretch of seacoast which is intersected by the frontlines, amphibious landings to outflank the opposing forces may be expected by either side. If there are only a few limited stretches of coast where landings are possible, amphibious defenses of the usual type may be installed as a precaution. Otherwise the defense must rely on mobile reserves and aviation.

732. Mines

a. Mines are a special feature of desert warfare. In sandy soil they are easily placed, and blowing sand quickly effaces the disturbed surface (although on occasion it may also expose the mines, or cover them so deeply that they are ineffective). If used strategically, minefields must be very wide and deep. They are also vital to the close-in defense of organized positions. The ratio of A/T to A/P mines is in general higher than in normal terrain.

b. It follows that the clearing of mines and the breaching of minefields are major aspects of any offensive against a well-prepared enemy position.

733. Obstacles

The ability of armor to move almost anywhere on most deserts does not encourage the use of antitank obstacles other than mines, except for close-in defense. Antitank ditches are hard to construct and maintain in sand. Wire is used for close-in defense of important positions, and at isolated installations subject to attack by motorized raiders or guerrillas. Roadblocks are uncommon, since in desert terrain they can generally be bypassed.

a. Foot movements of large bodies of men for any distance are unusual in desert warfare, because of the fatigue involved, the need for speed, and the dangers of air attack. When foot movements must be made, they should if practicable be at night.

b. Tracked vehicles can move freely over most desert terrain. Wheeled vehicles can move over a good deal of it, but are often stopped by deep sand. Oversize and partially deflated tires, and the use of light vehicles, partly overcome this limitation. However, as explained above, cross-country movement wears out vehicles rapidly and multiplies maintenance difficulties.

c. Truck movements, and especially armored movements, should if possible be at night. In daylight movements especially, vehicles should move in small groups widely separated. Excessive speed should be avoided, as it further increases wear and the likelihood of breakdown.

d. Every vehicle should at all times carry a supply of water and food for all persons aboard, including the driver.

e. Every driver must be trained in what to do if his vehicle bogs down in soft sand or sink holes, and in the techniques of cross-country driving on all types of desert terrain.

f. The desert, like the Arctic tundra, has very few landmarks. Personnel and commanders must learn to make their way by compass, dead reckoning, and the sun and stars.

735. Bivouacs and Shelters

a. Troops, vehicles, and large items of equipment in bivouac should be dispersed irregularly. Shelter is not normally needed against rain and cold, but is needed against sun if the bivouac is occupied during the day, and often against wind and blowing sand. Tents or paulins may be used, or men may shelter under vehicles or inside covered vehicles. Tents should be dug in and camouflaged.

b. If a troop movement is made in the daytime, movement into bivouac should preferably be postponed until dark.

c. Security measures in bivouac are important. Troops anywhere in the theater should be alert for air attacks. Slit trenches or equivalent should be available in any shelter area occupied during the day. Troops bivouacking in the combat zone should also take precautions against night or day ground attack from any direction. Light discipline is enforced at night. Vehicles are parked ready to roll.

d. The desert is very silent when there is no wind. Therefore, troops near the enemy must carefully avoid noise, and night security detachments should include listening posts with trained observers.

736. Construction

a. Volume. On the average, construction activities occupy a proportionally smaller part of the time of engineer troops in a desert theater than in normal terrain. The difficulties of transportation, the threat of air attack, the mobility of tactical units, and the instability of the front all tend to cut down the volume of general construction. Hospitals are kept to the minimum by evacuation to other areas. Depots are small and scattered. Absence of rain reduces the amount of covered storage needed. Road work is of course done, often on a considerable scale, but it is less important than in normal terrain. Bridges are largely restricted to deep gullies.

b. Techniques. In general, desert construction does not call for special techniques except as they may be imposed by shortage of construction materials and the absence of local resources.

c. Airfields. The importance of aviation in desert warfare requires a considerable number of airfields and landing strips. Portable mat is widely used, especially at the outset of a campaign.

d. Pipelines. The importance of armor and the speed of tactical movements may call for rapid installation of liquid fuel pipelines and accessories, including storage and possibly port facilities.

e. Cloudbursts and Flash Floods. These occur periodically in certain desert areas, sometimes quite unpredictably and at intervals of several years. They may do great damage to airfields, bridges over dry gullies, exposed stocks of supplies, and the like, and may endanger the lives of troops bivouacked in low-lying areas. For a short campaign, these possibilities may be ignored as a calculated risk. For a long campaign, reasonable precautions should be taken against them.

737. Water Supply

This is perhaps the most important single engineer problem in a desert theater.

a. Sources. In some areas, water may be obtained from deep wells or by digging into the dried beds of watercourses. (See ch. 22.) Distillation of sea water, or of the highly mineralized water of desert lakes, may be resorted to. Water may be piped into a desert theater under specially favorable circumstances. Failing these means, it must be transported in tank trucks. Use of such trucks is in any case common for supplying troops in the forward areas of a fast-moving front.

b. Quality. Usually poor, often contaminated.

c. Quantity. The supply is nearly always limited. Strict water discipline must be enforced by all commanders.

d. Storage. Open reservoirs are undesirable because of rapid evaporation. Tanks or underground cisterns may be installed to store large stocks of water. All troop units should have portable water containers, normally tins holding from 2 gallons to 5 gallons or more.

738. Demolitions

With respect to tactical demolitions in a retreat during a desert campaign, two are to be noted:

a. Opportunities for delaying the enemy by demolitions are limited, on account of the absence of defiles, critical bridges, and high timber, and the ease with which most obstacles can be bypassed.

b. Two items which it is vital to deny to an advancing enemy are liquid fuel and water. If stocks of water cannot be destroyed (for example, wells), they should if possible be made unusuable. However, as in the case of all military demolitions, the extent of such action should be governed by future plans (ch. 24).

739. Camouflage

Lack of natural cover gives special importance to camouflage in desert operations, as in arctic operations.

a. Most desert areas, seen from the air, show a variegated surface, caused by scattered boulders, rock ledges, scrub vegetation, and irregularities in the ground. Strong sunlight emphasizes these. Camouflage practices in desert warfare, including the siting of parked vehicles, emplacements, trenches, wire entanglements, and dumps are determined largely by the appearance and variegations of the surface in the particular area in question.

b. Garnished drapes are widely used. They should be toned to match natural desert colors, which are in general light, although the shadows are dark.

c. Parked vehicles and weapons should be dug in. Supplies, including ammunition and liquid fuel, may be buried in sand.

d. Protective painting is much used on vehicles, equipment, and structures. Shine must be especially avoided.

e. Dummies and deception devices of all sorts are important.

Section IV. JUNGLE

740. General

a. Jungle areas are those having both a tropical climate and dense vegetation. They are found in the tropics and subtropics wherever ample rainfall occurs at low or moderate altitudes. The principal jungle areas of the world are in South America centering on the Amazon Valley, in central Africa, and in a belt extending east from central India to the Pacific and including the archipelagoes south and southeast of the Asiatic mainland. Jungle conditions are also found on certain mid-Pacific and

Caribbean islands, in parts of Central America, and in other scattered areas.

b. In a typical jungle theater of operations, true jungle areas predominate, but are usually interspersed with cultivated areas and with territory where the characteristic jungle vegetation and terrain are not found.

741. Climate

a. In general the weather is hot, humid, and subject to sudden changes. Torrential rains may come suddenly and be succeeded by bright sunshine. Humidity tends to be high because the vegetation checks evaporation.

b. Many jungle areas have both a wet and a dry season. The wet season—called "Monsoon" in southwestern Asia—at its peak may have almost continuous rainfall. The dry season may be a period of relatively cool, dry winds, and little or no rainfall.

c. Visibility is restricted by rain, clouds, steamy exhalations from wet areas, and the dense groundcover.

742. Terrain

a. Topography. Some jungle areas, especially in southeast Asia, the Pacific islands, and parts of Latin America, are volcanic terrain of geologically recent origin and therefore very irregular, with rough mountains. Other areas, especially in central Africa and South America, are low lying and generally level. A combination is sometimes found, with a flat, swampy, densely forested belt near the sea, succeeded by grasslands, foothills, and high mountain ranges, and interspersed with cleared and cultivated areas.

b. Coasts. On sheltered seacoasts with limited tides, the jungle may extend down to the water and be continued beyond the waterline by mangrove swamps. Such coastal vegetation is an almost impassable barrier to a landing. Elsewhere the coastline may consist of sand beaches or volcanic cliffs. Submerged coral reefs just offshore are common; many Pacific islands or island groups are surrounded by such reefs.

c. Water. Streams are numerous, generally muddy, and subject to sudden floods. Swamps are common. In wet seasons an entire area of flat jungle may become a continuous swamp. In areas where there is a pronounced dry season, the smaller water courses and swamps may dry up.

d. Vegetation. Characteristic types, found in different areas and altitude zones, include—

(1) The rain forest, which has a dense growth of very tall trees covered with vines and creepers. Undergrowth may or may not be present.

(2) The swamp forest, with lower trees, standing water, and dense undergrowth.

(3) Grasslands. Many tropical grasses grow to heights of 10 or 12 feet, and are practically impenetrable except by cutting a trail or (if the grass is dry) by burning it.

(4) Mangrove swamps, mentioned above.

e. Wildlife. Jungle areas are characterized by a profusion of animal life, including poisonous snakes, stinging insects, and disease-carrying insects. Some areas contain dangerous large animals.

743. Military Operations, General

a. Jungle operations are conditioned by low visibility from both ground and air, restricted fields of fire, absence of landmarks, prevalence of swampy terrain, the scarcity or absence of roads, and the extreme difficulty of cross-country movement by both wheeled and tracked vehicles and even by marching men. Specially trained infantry with supporting weapons, and light artillery, are the essentials of a jungle force. Armor and heavy artillery are of limited use. Air forces are of value in close tactical support of ground forces, are important for supply and evacuation, and are essential in amphibious operations and to protect sea communications; but their utility for observation and for tactical bombing is less than in a normal theater.

b. Night operations should be attempted only with highly trained troops.

c. While large forces may be present in a jungle theater, operations in any one area are likely *to* be on a restricted scale. Isolated pockets of enemy resistance may remain in an area long after our troops have occupied most of the area.

d. The foregoing remarks must of course be qualified with respect to cultivated areas, grasslands, or other sections of the theater which are not true jungle.

744. Clothing and Equipment

Clothing should be light. Protection against rain and mosquitoes must be provided. In general, wool, leather, and felt are not satisfactory materials for either clothing or equipment if substitutes can be provided, since they are susceptible to rot and mold.

Various special types of weapons and equipment have been designed for jungle use.

745. Health Problems

The principal ones are—

a. Tropical diseases, which are numerous and some of which are not found in the Temperate Zones. They are carried by water, by air, and by insects and vermin. Included are funguses and other skin infections, and intestinal parasites. Diseases such as malaria are often endemic in local populations.

b. Difficulties of camp sanitation on account of rain, flooding, and high ground water.

c. Heat exhaustion and salt deficiency.

d. The psychological effects of the climate, due not so much to the intensity of the heat as to its continuity and the accompanying high humidity.

746. Personal Safety

Small detachments and even individuals must often be alone in the jungle in the discharge of their duties. Also, men will sometimes be lost. The average jungle area contains numerous edible roots, fruits, berries, sources of potable water, and usable fuel. It also contains noxious plants and animals and various other dangers to life and health, not all of which are apparent to the novice. Personnel in a jungle theater must be taught how to take care of themselves in this alien environment.

747. Engineer Operations, General

The central engineer problem in jungle warfare is the construction and maintenance of routes of communication, including trails, roads, and bridges. Other important features are the construction of airstrips and airfields and of structures for depots and hospitals, the provision of port facilities, and the maintenance of equipment and structures.

748. Engineer Supply and Maintenance

a. Engineer supply problems turn largely on the following factors:

(1) Lack of local resources. There is ample standing timber, but its structural utility is often limited. Some areas are deficient in rock and even in sand and gravel. Other construction materials are likely to be non-existent.

(2) Transportation difficulties due to lack of port facilities and good roads.

(3) Rapid deterioration of stocks of food and clothing, and of exposed metal and leather. Waterproof and airproof containers are widely used.

b. Maintenance of individual and organizational engineer equipment, and constant care of practically all types of supplies, are vital and constitute a major problem. Machinery and all exposed metal must be kept lubricated and protected from rusting and corrosion. Leather and fabrics must be kept free from mold. Stored supplies and equipment must be protected from rain, flooding, intense sunlight, and termites. Maintenance of equipment is a responsibility of every individual, and the enforcement of high maintenance standards, by frequent personal checks and inspections, is an important function of every commander.

749. Field Fortifications and Accessories

These are conditioned by the limitations on visibility, fields of fire, and armor. Defensive positions are organized primarily for close-in defense against infantry forces having mobile weapons such as mortars, recoilless rifles, and flamethrowers. Liberal use is made of wire entanglements, A/P mines, boobytraps, and individual shelters and weapon emplacements, camouflaged against close ground observation. Detachments in advance posts, concealed and armed with grenades and automatic weapons, are a feature of the defense. Occupying troops must at all times be alert against surprise. Vigorous daylight patrolling is a better protection against this than passive measures. Tripwires connected to boobytraps, flares, or noise-making devices are often used.

750. Transportation and Troop Movements

a. At the outset of a jungle campaign, roads may be few or nonexistent. Those which are available or which can be promptly built are best suited to light trucks and light tracked vehicles. Motorized transport may need to be supplemented by pack animals, especially in mountainous areas, and by carrying parties, especially if the local population is friendly and can furnish porters.

b. Delivery of supplies by air is a common practice, to provide food and ammunition for frontline positions, isolated advanced posts, and advancing columns. Evacuation of wounded by air, primarily by helicopter, is also common.

c. If navigable waterways are available, they may be useful adjuncts to the transportation net for moving bulky supplies and equipment.

d. Troop movements by marching are on the average more common than in a normal theater, in spite of the fatigue caused by heat and bad roads.

e. Cross-country movement in the jungle is slow and difficult. It may be necessary to cut one's way through a continuous stand of a thick undergrowth or high grass, or to make lengthy detours to avoid impassable swamps. Such movements should be avoided if the destination can be safely reached by a road or trail, even a circuitous one.

f. A unit moving by a route not previously reconnoitered, whether by jungle trail or across country, runs the risk of being lost. As a precaution against this, it is common practice to check the movement by dead reckoning, based on the known straight-line distance and compass bearing of the destination from the starting point.

751. Bivouacs and Shelters

A site for a camp or bivouac should be near water, high, well drained, and suitable for defense. Native villages should be avoided. If the ground is wet or rain is expected, men should sleep under cover and above the ground surface. Elevated individual "rain shelters" can be readily built from materials available in most jungle areas. Camp sanitation must be carefully watched, especially in wet weather or at any site occupied for a considerable time.

752. Security

While marching columns and men in bivouac or camp must take reasonable precautions against air attack, this danger is relatively less than in a normal theater, due to the prevalence of ground cover. On the other hand, jungle conditions are peculiarly favorable for ambushes or raids by an enterprising and well-trained enemy or by guerrillas. Troops must at all times be on the alert against this. On the march, advance guards must perform their functions with great care, and must also observe and patrol to the flanks where possible. Bivouacs should be sited for all-round defense.

753. Roads and Bridges

a. As stated above, routes of communication are the largest single engineer task in a jungle theater. To begin with, roads will be few or nonexistent, most movement being by meandering trails. To establish and maintain a road net of even minimum standards calls for a greater engineer effort than in normal terrain. Divisional engineer troops must often do work normally pertaining to corps combat groups, the latter being fully occupied in the improvement, maintenance, and reconstruction of roads and bridges built by divisional troops. Initial work in forward areas may be simply the opening of trails passable by marching men, infantry support weapons, and perhaps jeeps and very light vehicles. A long interval may elapse before true roads can be built.

b. Drainage of roads is even more important in the jungle than in a normal theater. It may often be desirable to clear a right-of-way for a road well in advance of construction, so that the sun can dry out the ground. Roads in low-lying and swampy terrain, especially if they must carry heavy traffic, may need to be on high fills supported on mat foundations.

c. Lack of road metal is an additional complication in many jungle areas. Near the seacoast, coral may be available. Much use is also made of "heavy expedient" construction, using timber and brush. (See ch. 19.)

d. Factors which complicate bridgework are the frequency and intensity of flash floods, the tendency of some jungle streams to shift their courses, and the rapid decay of wooden structural members. The designer should use large factors of safety and make liberal allowances for flood flow. It must be anticipated that bridges will be periodically carried away, and engineers must be prepared to repair or replace them on short notice.

754. Other Construction

a. Problems of general construction do not differ radically from those in a normal theater. Heating is not needed. Drainage is very important. All occupied structures must be screened, and must be protected against insects which attack wood and other substances. Expedient construction of a type used by local populations, including thatched roofs, is often resorted to, both to economize transportation and as a camouflage measure. Untreated wood, especially if in contact with a moist surface or immersed in salt water, deteriorates rapidly.

b. In the construction of landing fields, major problems are drainage—especially during construction—and the frequent shortage of surfacing materials. Coral is used where available. Much use is also made of portable mats.

c. All construction work in a jungle theater is likely to be hampered by a chronic shortage of heavy equipment and repair parts.

755. Water Supply

Water is usually available in quantity and capable of treatment by the usual means. Sources must be periodically checked by medical personnel for pathogenic organisms. A source infested by the liver fluke is dangerous to bathers and to water-supply personnel who come in contact with raw water.

756. Camouflage

a. Camouflage of infantry positions, outposts, observation posts, weapon emplacements, and the like against closeup observation from the ground is highly important. This includes the camouflage of individuals occupying advance positions or doing scout and patrol duty. Extensive use is made of hiding, of blending with backgrounds and shadow patterns, and of screening with local vegetation.

b. Camouflage against air observation is of relatively less importance than in a normal theater. However, overhead cover should be preserved when practicable, especially over defensive installations, shelter areas, and dumps and parking areas, since any break in the generally uniform tree cover of a jungle area will attract the attention of enemy aircraft.

c. With respect to installations which must be in the open, such as ports and landing fields, and with respect to operations in grasslands, the ordinary camouflage practices apply.

Section V. HIGH MOUNTAINS

757. General

a. A typical high mountain area has the following features:

(1) Altitudes high enough to have a perceptible effect on an active man, due to oxygen de-

ficiency in the air, and to limit the growth of vegetation, whereby, above a certain level, there is little or no ground cover. The former effect becomes noticeable at 8,000 to 10,000 feet more or less; the latter, at heights varying primarily with latitude.

(2) At the highest levels, steep rocky peaks, permanent snow, and glaciers.

(3) At intermediate levels, steep ridges, deep canyons, and torrential streams.

b. These features do not always coexist. In the tropics, vegetation and ground cover may extend to very high altitudes. In the Arctic and subarctic, on the other hand, rocky peaks and glaciers are found at low altitudes. Desert mountains may have bold rock formations but neither vegetation, snow, nor mountain streams.

c. The largest continuous area of high mountains is in central Asia. Lesser areas are found in eastern and western Asia, the Caucasus, central Europe (the Alps), Scandinavia, central Africa, the cordillera of the western Americas from Alaska to Cape Horn, southeastern Australia, and certain Pacific islands.

758. Climate

As compared with adjacent low-lying terrain, the temperatures in a high mountain area are colder at all seasons, the weather is more variable and less predictable, winds are higher and storms more violent. There is likely to be more precipitation than in the nearby lowlands. If there are prevailing winds from a particular direction carrying moisture-laden air, which are intercepted by a high mountain range, the range may mark the boundary between a well-watered area and a semiarid or desert area.

Clouds are frequent; they sometimes cover the high peaks while the foothills and lowlands are clear, and conversely the peaks sometimes project above a low-lying cloud blanket. Visibility is high except for clouds.

759. Vegetation

As one proceeds upward there are successive belts of vegetation of different types, beginning with the same species as are found in adjacent lowlands, and ending with the stunted shrubs, grasses, and lichens that grow between the timberline and the level of permanent snow or bare rocks. Mountain valleys and meadows are usually well watered, and may have lush vegetation, good pasturage, and good crops during the short growing season.

760. Military Operations, General

a. They are characterized by—

(1) The use of relatively small and self-contained forces; emphasis on independent action rather than close mutual support.

(2) The use of specially trained infantry with supporting weapons and light artillery. Armor and heavy artillery are of limited use.

(3) Recognition of the outstanding importance of commanding heights, which permit observation by the occupying troops, deny it to the enemy, and may be held by small forces against resolute attacks because of the steep slopes.

b. It is unlikely that, in any future war, a major theater of operations of American troops will consist wholly of high mountains. More probably such operations will be secondary in nature, for example to defend a mountainous flank or sector of a broad front.

761. Mountaineering

To a greater degree than in other types of theater, successful operations in a mountainous terrain are dependent on the training of infantry in cross-country movement. This includes two different but related techniques: rock climbing, including movement up and down cliffs, on precipitous paths, and on talus slopes; and movement on snow, ice, and the surfaces of glaciers. Both techniques involve the use of ropes and of various special items of equipment. A unit which has ben properly trained in mountaineering can advance safely and systematically, carrying individual equipment and additional loads, across mountain terrain in which an untrained man would be literally unable to move in any direction without being killed; and can engage in effective combat in such terrain.

762. Health Problems

For trained men, conditioned to mountain operations and properly led, high mountains are a healthy environment. Health problems include those arising from extreme cold, oxygen deficiency, snow blindness, and the physical dangers inherent in the terrain. Untrained troops and men in poor condition may suffer from "mountain sickness," attendant on going suddenly from a low to a high altitude, and "valley disease," attendant on the reverse movement.

763. Engineer Operations, General

a. Principal emphasis is on routes of communication. Camouflage, mine warfare, and defensive measures generally are also important.

b. Engineer supply and maintenance do not present special problems other than those caused by transportation difficulties.

764. Field Fortifications and Accessories

a. Commanding positions in mountain terrain are often rocky ridges or eminences with little or no soil. Organizing such a position for defense presents difficulties. If the importance of the position justifies the time and effort involved, trenches, emplacements, and galleries can be cut into the solid rock. Parapets and breastworks or cobbles and boulders are effective against small arms but vulnerable to artillery fire. Log breastworks and protective shelters may be built if stands of timber are conveniently located.

b. Mines and obstacles find their most important use in obstructing movement on roads and trails and through defiles. Roadblocks are very effective, on account of the difficulty of bypassing them.

765. Transportation

a. Truck movements are drastically restricted by the steep grades and inferior surfaces of the average mountain roads. In general, only light vehicles are used. Daylight movement is often dangerous because of the high visibility and bold relief characteristic of mountain terrain, and night movements require great care to avoid accidents. Pack animals are often used. Overhead tramways (ch. 20) are valuable for supplying small detachments which cannot be readily reached by motor vehicle or pack train.

d. Helicopters will be increasingly used in future mountain operations, to deliver supplies, evacuate personnel, and make command inspections.

766. Roads and Bridges

a. Road construction and repair is a major engineer task. Initially, as in a jungle theater, the effort may be concentrated on the maintenance of existing trails and such roads as there may be, followed by their progressive improvement to accommodate light trucks and eventually heavier vehicles.

b. A road on the crest of a ridge is undesirable on account of visibility. A road at the bottom of a gorge may be impracticable on account of the torrential streams and masses of boulders often found at such a location. Therefore sidehill roads are common. Steep slopes and the presence of surface rock often make such roads slow and expensive to build, vulnerable to slides and avalanches, and readily blocked by snow. On a steep cliff a road may have to be built out on supports driven into the cliff, or tunneling may be necessary. A hillside composed of talus is productive of slides, especially when there is alternate freezing and thawing of underground water. Wooden cribs are widely used to support sidehill fills and to prevent slides from sidehill cuts.

c. Special attention must be given to ample culverts and to strong bridges over small streams and gullies, which often carry large volumes of water following snowmelt or mountain storms. The presence of deep gorges, and the difficulty of building intermediate supports for bridges, lead to the extensive use of suspension bridges, especially for light loads.

767. Other Engineer Operations

In general, such operations in mountain terrain do not differ fundamentally from those in a normal theater with respect to basic principles and techniques. They are affected by transportation difficulties and by the generally limited scale of mountain operations. Installations such as depots, hospitals, and cantonments tend to be small, because reasonably level sites for them are of limited size. Aircraft which support mountain operations are normally based on airfields in adjacent low-lying terrain. Heavy equipment often cannot be moved into a high mountain area, which fact slows down construction operations and emphasizes hand work.

CHAPTER 27

ATOMIC WEAPONS AND ENGINEER OPERATIONS

Section I. EFFECTS ON PERSONNEL AND MATERIAL OBJECTS

768. Effects, General

Atomic weapons produce damage by blast, thermal radiation, and nuclear radiation. Casualties within the area of destruction may result from one or a combination of these effects. The term "target damage" is applied to all types of damage occurring within the area of destruction. For a comprehensive treatment of the phenomena, effects, and damage criteria of an atomic detonation, and of protective measures against it, see FM 21–41, TM 23–200, and Department of the Army Pamphlet 20–112.

769. Effects on Structures, General

Effects on structures result primarily from the combined action of heat and the shock wave, supplemented on occasion by induced surface winds.

770. Wooden Construction

Light wooden structures are very vulnerable to an atomic explosion. This includes the standard types of building used in a theater of operations for such purposes as cantonments, depots, shops, and hospitals. Over a wide area from ground zero, any such buildings will be knocked down by the high pressure blast wave or "exploded" by the low-pressure wave behind it. Thermal radiation precedes the blast wave, causing wooden structures to burst into flame. Normally the blast wave blows out these fires, but at considerable distances from ground zero some of them may remain. Massive wooden structures made of heavy timbers are less vulnerable. The degree of damage is affected by the type and shape of the structure and its orientation to ground zero.

771. Light Metal Construction

Structures of this type—for example, shops, hangars, or warehouses made of sheet metal supported on light trusses—are vulnerable to the shock wave, which tends to collapse them and to distort the sheathing and members. Close to ground zero, surface layers of metal exposed to the radiant heat may be fused or evaporated.

772. Bearing Walls

Masonry-bearing walls are not normally used in theater construction, but are widely used for civilian structures in European and American cities. They are very vulnerable to the shock wave.

773. Concrete and Steel Frame Construction

a. Structures composed wholly of reinforced concrete, especially if of earthquakeproof design, are quite resistant to the explosion. This is especially true if they have numerous windows, which are blown out quickly by the shock wave, tending to equalize pressures inside and outside.

b. Structures built of heavy steel or concrete framing, with curtain walls, may retain their structural integrity if they are outside the high overpressure region, but the curtain walls are likely to be collapsed.

774. Slabs

Exposed slabs of concrete or other cohesive material, such as runways, roads, and paved parking areas, suffer relatively little damage from an air-burst atomic explosion.

775. Underground Structures

A well-built dugout with heavy overhead cover, at a reasonable distance from ground zero (half a mile or so for a nominal bomb), is less vulnerable to an atomic air burst than to a direct hit by a heavy delayed-action bomb or shell.

776. Closed and Open Structures

Other things being equal, an open structure is less vulnerable to an atomic explosion than a closed structure without apertures. This is because the stresses developed by the shock wave vary with the amount of obstruction which is offered to the wave's free passage.

777. Bridges

In general, fixed military bridges tend to be fairly resistant to an atomic explosion not directly overhead, as they are quite massive and open structures. However, a shock wave striking a steel or wooden bridge broadside may distort the superstructure or shift it bodily sideways on the supports. Steel trusses are more resistant than plate girders. Wooden bridges are affected primarily by blast, but may be set afire by secondary fires in their vicinity. Reinforced concrete bridges have about the same resistance to the shock wave as steel bridges, but are harder to repair if they do sustain damage by cracking or distortion. Floating bridges are quite resistant to the shock wave, but pneumatic floats may be vulnerable to the radiant heat. The same remarks apply to rafts.

778. Machinery, Equipment, and Supplies

a. Supplies stored in open storage such as artillery, tanks, trucks, construction equipment, and solidly piled stocks of supplies, are fairly resistant to the shock wave but may be charred or scorched by thermal radiation. Items such as canvas or rubber products are susceptible to burning when directly exposed to an atomic explosion.

b. In the case of machinery or equipment stored or installed under cover, the greatest dangers are likely to be from collapsed structural members and from fires following the explosion. If these dangers can be guarded against, such items have a good chance of survival.

779. Induced Fires

The instantaneous radiant heat accompanying an atomic burst will in many cases not set fire to exposed wooden objects, but merely char them. However, scattered fires may be expected at once over the area of the burst, partly from wood and vegetation and partly from more flammable materials like gasoline and lubricants spilled on the ground, and painted surfaces. Fires may be started inside buildings by the thermal radiation entering through windows and open doors. These fires may not be extinguished by the blast wave which follows. If the structures are not destroyed by blast they may be destroyed by the fires started within the buildings. The induced surface winds assist in the spread of such fires.

780. Effects on Personnel

a. The principal *direct* dangers to personnel are exposure to radiant heat and gamma rays at the moment of burst. The principal *indirect* dangers are from collapse of structures and involvement in fires. Radioactive contamination of air, food, water, equipment, and clothing, is always a possibility.

b. Direct exposure to the heat of a bomb at the moment of burst will produce fatal or serious burns for a considerable distance from ground zero. However, the effect is much reduced by even a slight screen between the burst and the human body, such as light clothing, and is practically nullified by the amount of screening offered by any opaque substance. The duration of dangerous heat radiation, following the explosion, is less than a minute.

c. Direct radiation of dangerous intensity is also of short duration, but unlike heat it requires fairly thick cover for protection. The effectiveness of the cover depends on the weight of material used.

Section II. EFFECTS ON ENGINEER OPERATIONS

781. General

a. The principal effect of atomic warfare on engineer operations in a theater will be to increase the workload. As a result there must be careful attention to priorities, and a greater emphasis on the principle of self-help by other arms and services with respect to pioneer tasks, the engineers furnishing advice and technical guidance. Engineering techniques will require relatively little change.

b. The general fields in which engineer activities are chiefly affected are *dispersion*, *camouflage*, *direct* *protection*, and *area damage control*. These are discussed briefly below, together with special problems associated with certain specific techniques and activities.

782. Dispersion

a. Dispersion of installations is the most effective means of minimizing damage from atomic weapons. Such dispersion should be adequate for protection from damage by a single burst. Duplication of vital installations must be considered. Within an individual installation ordinary rules of dispersion continue to apply.

b. Dispersion must always be subordinate to mission. Also, it must take into account the nature of the installations in question, since many are not important enough for the enemy to waste an atomic bomb on them. The protective advantage from dispersion must be balanced by the commander against the disadvantages of lowered operating efficiency and increased costs.

783. Camouflage

a. Passive protection against atomic attack emphasizes the need for large area camouflage. Smoke of the haze type, covering a large area (materially larger than the effective area of a single bomb burst) may be useful as a temporary measure, for example to conceal a major troop concentration. It has the further advantage of reducing the thermal effect of an atomic bomb.

b. If the demand for camouflage and camouflage materials increases greatly in a future theater, it is likely that emphasis will be mostly on rear area installations, and also on increased basic training of all arms in the principles of camouflage. The latter will reduce the amount of supervision and assistance extended by engineers in the camouflage field during active operations, especially in the combat zone.

784. Area Damage Control

a. Coordinated area damage control plans are prepared in army service areas and the communications zone to minimize loss and damage from atomic weapons. Their execution is under an area damage control center (ADCC) and area damage sector control posts (ADSCP). All rescue and firefighting activities in an area are coordinated by the ADSCP, which dispatches an incident officer to each disaster area.

b. Engineer units will have an important part in area damage control operations because of their firefighting equipment and other equipment needed for light and heavy rescue work. Rescue squads will be organized and equipped to remove casualties, render first aid, and salvage damaged materials. Labor and equipment squads will be organized and equipped to clear debris, search for casualties, assist in decontamination, and evacuate materials. Such engineer operations in a particular disaster area will be under the control of the incident officer.

c. The removal of victims from the wreckage of collapsed buildings will often require structural knowledge and engineering judgment. Rescue squads will need transportation for evacuating rescued casualties; first aid equipment; and such items as handtools, jacks, power winches, cutting torches, smoke masks, ropes, lanterns, and ladders.

d. See also TC 7, 1953.

Treatment of any residual radioactive contamination is a responsibility of the Chemical Corps. However, engineers may on occasion have to work in contaminated areas or deal with contaminated equipment. The following points are to be noted:

a. No troops should enter such an area until the extent and nature of contamination have been checked by qualified personnel.

b. Extreme care must be taken not to permit the entry of radioactive material into the human body by eating, drinking, or breathing, or through open cuts or sores. Personnel should wear masks or respirators.

c. If equipment is contaminated only by a layer of dust on its outer or inner surfaces, which dust is not dangerously radioactive, the equipment can probably be rendered safe by washing down with water or a soapy mixture. (The latter will itself become contaminated, and may need to be specially disposed of.)

Note. Certain elements contained within a metallic or other solid object as alloys or impurities may become radioactive if the object is exposed to intense radiation. Such an object is internally contaminated. Nothing can be done except to bury or otherwise safely dispose of it. Whether such dangerous and incurable contamination exists can only be determined by trained personnel. A rough working rule is that, if a piece of equipment is in working order after exposure to an atomic burst, it is not likely to be dangerously contaminated.

Earth surfaces, the decks of bridges, metal roofing, and the like, which are found to be contaminated, may be removed and buried or otherwise disposed of. If burial is resorted to, the area must be marked and regularly monitored. Similar means of disposition may be used with clothing, tentage, and miscellaneous supplies. It must be remembered that burning a radioactive object merely releases the radioactive atoms into the air as gas or smoke particles.

786. Field Fortifications and Personnel Shelters

a. Atomic warfare is not likely to affect this field radically, as regards techniques. Installations close to ground zero will probably be knocked out anyhow; and those at a reasonable distance from ground zero, if designed to resist conventional bombing or shelling, are likely to resist any fission bomb. However, there will probably be a greater number of protective and defensive installations built than heretofore, with a correspondingly greater demand for equipment, tools, and materials, and for engineer advice and supervision.

b. The principal problem with respect to personnel is protection from the heat and gamma radiation at the moment of burst, and the simplest effective protection is a deep earth trench of ordinary design. Official releases regarding recent tests indicate that troops can remain safely in ordinary field entrenchments quite close to an atomic burst, and can assume the offensive shortly after the burst.

c. Training and discipline are vital to the protection of personnel. All troops must be indoctrinated in the nature, effects, and limitations of atomic weapons. Deep, narrow trenches of zigzag trace must be available near all bivouacs. Men must learn to get into them as soon as a warning is sounded, and to keep their bodies defiladed from probable air bursts by an adequate thickness of earth. Stocks of fuel and ammunition, including ammunition stored at weapon emplacements, must be kept at all time under some fire-resistant covering that will not be displaced by the shock wave. Trained observers should be available to report promptly to higher headquarters the best information available as to the height and location of an atomic burst.

787. Mine and Obstacles

Techniques of mine warfare, including the design and use of obstacles, may be greatly affected by future developments in atomic weapons.

788. Troop Concentrations, General

A large number of troops concentrated within an area of a few square miles without protection or cover, or moving in column along a road or through a defile, might be annihilated by a single atomic bomb. Warfare involving these weapons will be characterized by the avoidance of such concentrations wherever possible, and by increased secrecy and rapidity of troop movements. Engineer operations incidental thereto will be accelerated.

789. Tactical River Crossings

a. The principles of this type of operation will not be affected by a situation in which the enemy has atomic weapons, but the planning and conduct of the operations will undergo some changes. Secrecy with respect to time and place of crossing will be even more important than heretofore. Large troop concentrations will be avoided. Engineer river-crossing equipage must be dispersed, and not more must be stored in advance close to the river than is needed for the initial crossings. Crossings must be planned at numerous sites. Crossing sites should not involve routes of approach through built-up areas or heavy woods, since the destruction of the latter by atomic bombing might block the roads. Speed and dispersion in the actual crossing will be emphasized.

b. It is evident that the increased dispersion, speed, and secrecy involved in the foregoing will add largely to the engineer workload in a *deliberate* river crossing.

c. On the other hand, use of atomic bombs by the attacker may disorganize the defender for a long enough time to permit a *hasty* crossing and deep penetration.

d. It is to be noted—

(1) That much of this paragraph applies, not only to a tactical river crossing but to any large-scale offensive against an organized position.

(2) That much of it applies, with little change, to operations against an enemy who has no atomic weapons, but does have a strong air force capable of staging saturation raids with high-explosive and incendiary bombs.

790. Amphibious Operations

a. These will be profoundly affected by atomic weapons, on account of the vulnerability of a flotilla of landing craft and of an occupied beachhead. If an amphibious landing is attempted against an enemy possessing atomic bombs, it is likely to be characterized by extrème secrecy, dispersion of landing forces into numerous small contingents over a broad front, and the immediate advance inland of such forces to link up the attackers and establish a deep beachhead zone. The missions of engineers will be little changed, but dispersion and increased tempo will add to the workload.

b. An atomic bomb exploded under water offshore by the defending force, given favorable winds, might saturate a stretch of beach with radioactive material and deny it to a landing force. However, the area would be equally denied to the defenders, and the extent to which contamination would extend inland could not be closely controlled.

c. Conceivably the existence of an atomic defense might make an amphibious landing so difficult that the initial assault would be wholly by air. From the engineer viewpoint, this would resemble an ordinary airborne operation (ch. 13). However, if the landing were preliminary to a large scale invasion, support by surface vessels would eventually be essential, and it would be an early duty of engineers to provide landing beaches and auxiliary facilities.

791. Structures and Installations, General

With respect to the various types of construction and repair work undertaken by engineers in a theater, the effect of atomic weapons possessed by the enemy is in general deducible from the principles set forth above. The following points are to be noted, with respect to work in any area where an atomic attack is a reasonable possibility:

a. Basic layouts will be governed by the principles of dispersion set forth in paragraph 782.

b. Structural designs will not be greatly affected. There may be increased emphasis on the bombproofing of small key installations. Depending on knowledge of atomic weapons available to the enemy, availability of materials, and importance of the installation, bombproofs will be designed to the extent practicable to withstand the maximum capability of the enemy.

c. There will be an increased tendency to place stocks of ammunition, bombs, gasoline drums, and the like under some nonflammable cover—for example, a layer of earth bulldozed and spread over them—rather than to leave them in the open, under trees, or under camouflage.

d. Pipes and conduits will normally be buried. This is especially desirable with respect to pipes carrying liquid fuel, and to water mains whose rupture would interfere with firefighting.

e. What use to make of natural cover at an installation may become a difficult problem, calling for a command decision. The importance of concealment in atomic warfare points to the use of such cover.

f. In the case of valuable machinery installed under cover, such as shop equipment, radio and telephone equipment, water-supply equipment, electric generators and motors, every effort must be made to minimize the risk from fire or the effects of the shock wave. Flammables necessary to the operation of the equipment should be stored as far away as practicable. The structure sheltering the equipment, or that part of it close to and over the equipment, should preferably be of metal.

g. Camouflage and camouflage discipline during construction will be strongly emphasized.

h. Stocks of inflammable or breakable construction materials at work sites will if practicable be limited to a few days' supply, other stocks being kept at a safe distance. Similarly, the bivouacs of working parties may be at a distance. Both procedures, however, place an extra load on available transportation. The effect of this on the work program must be weighed against the additional safety.

i. Safety precautions for working crews, both at work site and at bivouac, will include the provision of deep slit trenches with numerous traverses, which men can enter promptly if there is an air raid warning. Men must also be taught what to do if they are caught in the open by a burst.

j. If the area of a construction project is under exclusive engineer control, the engineer officer in charge is responsible for preparing the damage control plan. In the case of a large construction project such as a port or cantonment, this may involve obtaining help from higher authority. For example, by the provision of firefighting crews and equipment, and by special measures for prompt air-raid warnings.

k. An elementary precaution in any theater is the accumulation, by the responsible engineer authorities, of stocks of construction materials adjacent to all important installations so that damage by enemy action can be promptly made good. The only new feature introduced by atomic warfare is that any such stock should be far enough from the installation so that both cannot be destroyed by the same burst.

792. Water Supply

This problem is not affected by atomic warfare unless the source becomes contaminated by radioactive materials. With respect to that possibility—

a. If atomic weapons are being used in an area, water sources must be periodically checked by the medical authorities for contamination.

b. If contamination is found to exist, but not on an excessive scale, it may be dealt with by the use of the diatomaceous earth filter (standard in Department of the Army water supply set No. 4) which removes most contamination resulting from suspended particles; or by distillation. Water must be checked after treatment and before using.

c. If these means are inadequate or inapplicable, the source must be abandoned and posted.

793. Demolitions by Atomic Weapons

Engineer troops will be responsible for the emplacement and firing of any prepositioned atomic weapons which are to be used for demolition purposes.

APPENDIX I

REFERENCES

Note. This list is confined to the more fundamental reference texts. For a complete list of the FM's, TM's, TB's, and other publications covering all phases of engineer activity in a theater of operations, see SR 310–20–3.

1. Field Manuals (FM)

FM 5–5	Engineer Troop Units.
FM 5–15	Field Fortifications.
FM 5–20	Camouflage, Basic Principles.
FM 5–25	Explosives and Demolitions.
FM 5–34	Engineer Field Data.
FM 5–132	The Engineer Combat Battalion, Divisional.
FM 5–134	The Armored Engineer Battalion.
FM5–156	Engineer Shore Battalion.
FM 7–10	Rifle Company, Infantry Regiment.
FM 7–20	Infantry Battalion.
FM 7–24	Communications in Infantry and Airborne Divisions.
FM 7–25	Headquarters Company, Infantry Regiment.
FM 7–40	Infantry Regiment.
FM 19–25	Military Police Traffic Control.
FM 21–41	Soldier's Manual for Defense Against CBR Attacks.
FM 24–5	Signal Communications.
FM 25–10	Motor Transportation, Operations.
FM 30–5	(Title classified.)

FM 30–15	Examination of Personnel and Documents.
FM 31–25	Desert Operations.
FM 31–50	Combat in Fortified Areas and Towns.
FM 31–60	River Crossing Operations.
FM 31–70	Basic Arctic Manual.
FM 57–20	Airborne Techniques for Divisional Units.
FM 57–30	Airborne Operations.
FM 70–10	Mountain Operations.
FM 72–20	Jungle Operations.
FM 100–5	Operations.
FM 100–10	Administration.
FM 100–31	(Title classified.)
FM 101–5	Staff Organization and Procedure.
FM 101–10	Organization, Technical, and Logistical Data.

2. Technical Manuals (TM)

TM 5–220	Passage of Obstacles Other Than Minefields.
TM 5–231	Mapping Functions of the Corps of Engineers.
TM 5–252	Use of Road and Airdrome Construction Equipment.
TM 5–260	Principles of Bridging.
TM 5–280	Construction in the Theater of Operations.
TM 5–295	Military Water Supply and Purification.
TM 5–310	Military Protective Construction.
TM 5–360	Port Construction and Rehabilitation.

TM 5–370 Railway Construction.
TM 5–505 Maintenance of Engineer Equipment.
TM 23–200 (Title classified.)

3. Technical Bulletins (TB)

TB 5–250–1 Design Criteria of Army Airfields and Heliports.

4. Training Circulars (TC)

DA TC 8, 1953 (Title classified.)
DA TC 24, 1953 Vehicle and Bridge Classification System.
DA TC 7, 1954 Route and Road Classification System.

5. Miscellaneous

DA Pamphlet 20–112 Individual Training in Atomic Warfare.
DA Supply Manuals (ENG series)

APPENDIX II

ENGINEER ORGANIZATIONS IN THEATER OF OPERATIONS

Table VII. Engineer Troop Units

Unit	Normal assignment(s): T/O & E	Division	Corps	Army	Com. Z.	Attachments and reassignments	Remarks
Divisional engineer units:							
Engineer combat battalion, divisional.	5–15 5–16 5–17	X					With infantry division.
Armored engineer battalion	5–215 5–216 5–217 5–218	X					With armored division.
Airborne engineer battalion	5–225 5–226 5–227	X					With airborne division.

Engineer combat support units:							
Engineer combat battalion, army.	5–35 5–36 5–37			X		Engineer combat group	See note 1.
Engineer light equipment company.	5–367			X		Hq & hq co, engineer combat group.	Do.
Engineer panel bridge company.	5–137			X		do	Do.
Engineer float bridge company.	5–138			X		do	Do.
Engineer ponton bridge company.	5–139			X		do	Do.
Engineer combat group	5–192			X			See note 2.
Hq & hq det, engineer camouflage battalion.	5–96 5–97			X			
Engineer shore battalion	5–525 5–526 5–527						Organic part of an amphibious support regiment.
Engineer construction units:							
Engineer construction battalion.	5–315 5–316 5–317			X	X	Hq & hq co, engineer construction group.	
Engineer heavy equipment company.	5–328			X	X	do	

Table VII. Engineer Troop Units—Continued

Unit	Normal assignment(s)					Attachments and reassignments	Remarks
	T/O & E	Division	Corps	Army	Com. Z.		
Engineer construction units:							
Engineer dump truck company.	5–324			X	X	Hq & hq co, engineer construction group.	May also be assigned to an engineer combat group or maintenance and supply group.
Engineer port construction company.	5–329				X	do	
Engineer construction group	5–312			X	X	Engineer brigade	See note 2.
Engineer brigade	5–301				X		Do.
Engineer pipeline company	5–327						Normally under direct theater operational control.
Engineer topographic units:							
Engineer topographic company, corps.	5–167		X				

Engineer topographic battalion, army.	5–55 5–56 5–57 5–59			X			
Engineer aerial photo reproduction company.	5–54			X			
Engineer base topographic battalion.	5–346				X		See note 2.
Engineer base survey company.	5–348				X	Engineer base topographic battalion.	Normally under direct theater operational control.
Engineer base photomapping company.	5–349				X	do	
Engineer base reproduction company.	5–347				X	do	
Engineer base map depot	5–344				X		
Engineer maintenance and supply units:							
Engineer field maintenance company.	5–157			X	X	Engineer maintenance and supply.	
Engineer depot maintenance company.	5–278				X	do	
Engineer supply point company.	5–48			X		Administratively attached to M & S gp.	

Table VII. *Engineer Troop Units*—Continued

Unit	Normal assignment(s)					Attachments and reassignments	Remarks
	T/O & E	Division	Corps	Army	Com. Z.		
Engineer depot company	5–267	--	--	X	X	Engineer depot battalion.	
Engineer maintenance and supply units:							
Engineer parts depot company.	5–279	--	--	X	X	Engineer maintenance and supply group.	See note 2.
Engineer depot battalion	5–266	--	--	X	X	Hq & hq co, engineer	
Engineer water supply company.	5–67	--	--	X	X	Engineer brigade if normal assignment is to Com. Z.	
Engineer forestry company	5–387	--	--	--	X	do	Do.
Engineer maintenance and supply group.	5–262	--	--	X	X	do	

Engineer units with the Air Force:							
Engineer aviation battalion	5–415						
	5–416					Engineer aviation group.	See note 3.
	5–417						
Engineer aviation group	5–412					Engineer aviation brigade.	See notes 2 and 3.
Engineer aviation brigade						Aviation engineer force	Do.
Aviation engineer force							Do.

Note 1. These are considered army units, but may operate with a corps if the combat group to which they are attached is itself attached to the corps.

Note 2. The T/O & E listed is for a headquarters organization, to which operating units are assigned or attached as the situation requires. Where T/O & E number is not given, T/O & E has not been published.

Note 3. These are SCARWAF units. In a theater they are components of the theater air force.

Table VIII. Teams of the Engineer Service Organization

Team	Normal assignment
Administrative and headquarters teams:	
AA: Platoon headquarters	To the command of service teams, platoons of companies of various sizes.
AB: Platoon headquarters	
AC: Company headquarters.	
AD: Battalion headquarters	
Supply teams:	
BA: General supply	Engineer depot company, or task force; sometimes with team BB.
BB: Depot operating	Engineer depot company or task force.
BC: Equipment supply	Engineer depot company or battalion, or task force. May augment team BB.
Maintenance and parts teams:	
EA: Field maintenance	Task force.
EB: Field maintenance	Engineer field maintenance company or task force.
EC: Special equipment maintenance.	Engineer field maintenance company.
ED: Parts	Engineer parts depot company or depot maintenance company, or task force; may be combined with team EB.
Firefighting teams:	
FA: Headquarters	To other firefighting teams, for control and supervision.
FB: Fire truck	Post, base, camp, station, or warehouse area.
FC: Fire trailer	Do.
FD: Water tank	To augment other firefighting teams.

Table VIII. Teams of the Engineer Service Organization—Continued

Team	Normal assignment
Equipment operating teams:	
GA: Dump truck	Engineer dump truck company or other construction unit, or maintenance and supply group.
GB: Rock crusher	Engineer construction unit.
GC: Pipeline operating	Engineer pipeline company, or independent.
GD: Forestry	Engineer forestry company, or independent.
GE: Well drilling	Engineer construction unit.
GF: Water purification	Engineer water supply company, or independent.
GG: Water purification	Engineer brigade.
GH: Water transport	Engineer water supply com-company.
GI: Gas generating	Engineer maintenance and supply group.
GJ: Carbon dioxide generating.	
Construction, utilities and electrical power teams:	
HA: Headquarters port construction.	Engineer construction group.
HB: Diving	Do.
HC: Welding	Engineer construction group or maintenance and supply group.
HD: Utilities	Camp, base, depot, or installation.
HE: Utilities	
HF: Utilities	Communications zone.
HG: Utilities	Field army and communications zone.
HH: Powerline	Electric powerplant.
HI: Powerplant maintenance.	
HJ: Powerplant operating	Engineer brigade.
HK: Foundry	Engineer depot maintenance company.

Table VIII. Teams of the Engineer Service Organization—Continued

Team	Normal assignment
Topographic and intelligence teams:	
IA: Survey	Engineer brigade.
IB: Survey platoon	Engineer base survey company.
IC: Photomapping platoon	Engineer base photmapping company.
ID: Map reproduction platoon.	Engineer base reproduction company.
IE: Map depot platoon	Engineer topographic battalion, army.
IF: Relief-map making	Engineer base topographic battalion.
IG: Technical intelligence (collection).	Corps.
IH: Technical intelligence (research).	Army.
IJ: Geodetic survey	Do.
IK: Terrain	Do.
Dredge crews:	
JA: 20-inch cutter pipeline dredge.	Engineer Construction Group.
JB: 24-inch cutter pipeline dredge diesel-electric seagoing hopper dredge.	Do.
JC: 700 cubic yard	Do.
JD: 1,400 cubic yard	Do.
JE: 2,700 cubic yard	Do.

APPENDIX III

OUTLINE FOR FUNCTIONAL SOP

HEADQUARTERS
__THE ENGINEER COMBAT (GROUP)
(BATTALION) (COMPANY)
APO ______, US ARMY
STANDING OPERATING PROCEDURE

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BY ORDER OF COL WHITE
/s/ Harry C. Green
/t/ HARRY C. GREEN
Captain, CE
Adjutant

OFFICIAL:
/s/ Harry C. Green
/t/ HARRY C. GREEN
Captain, CE
Adjutant

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*6. WATER POINT OPERATION
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*8. STAFF SECTION SOP's
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*To be used where applicable.

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[AG 322 (7 May 54)]

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