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PREFACE

I.—Training Manuals

A list of the manuals common to all arms and of the principal manuals of each individual arm is contained in the Preface to Field Service Regulations, Volume II, 1935.

The manuals peculiar to engineers are :—

Serial No. (1)	Manual (2)	Nature of contents (3)
1	Engineer Training	The organization, drill and training of engineer units and their distribution and employment in war.
2	Manual of Field Engineering, Vol. II (R.E.).*	
3	R.E. Pocket Book	
4	Manual of Engineer Services (War).	
5	*Military Engineering* :—	Reserved for " Searchlights ".
6	Vol. I	Defences—Principles and construction of permanent and semi-permanent land defences.
	Vol. II	
7	Vol. III, *Bridging* :— Part I	General principles and methods of construction of bridges other than standard equipment.
8	Part II	Standard equipment—A series of pamphlets giving details of drills and methods of construction.
9	Vol. IV	Mining and demolitions.
10	Vol. V	Roads.
11	Vol. VI	Water supply.
12	Vol. VII	Accommodation and installations.
13	Vol. VIII	Railways.
	Anti-Aircraft Units (Additional)	
	Manual of Anti-Aircraft Defence (Army Units) :—	
14	Vol. I, Part II	Searchlights, tactical.
15	Anti-Aircraft Searchlight Drills.	Drill instructions.
	Fortress Units (Additional)	
16	Instructions for the manning of C.D.E.L. Stations.	Organization, duties and training.
	Technical Handbooks, Manuals, etc.	
17	Theory of Searchlights	Technical instruction.
18	Text Book of— Mechanical Engineering	Technical instruction.
19	Electrical Engineering	Technical instruction.

* Manual of Field Engineering, Vol. I (All Arms), is common to all arms.

II.—General Instructions

1. This manual deals with :—

i. The drill of engineer units.

ii. The training of engineer units and their duties in war.

The instructions which it contains and the principles which it lays down are based on those for the organization, training and leadership of the Army, as set forth in Field Service Regulations, which should be studied by every officer.

2. Engineer training may be defined as the practical and theoretical education by which officers and other ranks of the Royal Engineers are instructed in the duties which will be required of them in war, and by which they are shown how their special professional qualifications can best be applied in the unit and formation to which they belong for the purpose of the Army as a whole.

3. The enunciation by officers responsible for the training of engineers of principles contrary to those contained in this manual and the practice of methods not based on those principles are forbidden.

III.—Definitions

Bound.—A movement from one tactical position to another, or the tactical position reached at the end of a movement.

Column.—Bodies of troops on parallel and successive alignments whose front ranks are distant from the front ranks of preceding units by a number of paces equivalent to their respective frontages.

Close column.—A column with distances reduced to suit requirements.

Open column.—A column with distances increased to suit requirements.

Column of route.—A column of fours (or threes) with not more than four (or three) men abreast in any part of the column, including officers and supernumeraries. The normal formation for troops marching on a road.

Communications.—Roads, railways, waterways and air routes.

Connecting file.—A single man or men in pairs specially detailed to assist a detached body in keeping touch with its main body.

Covering fire.—Fire by units and arms to engage the

enemy's attention and force him to seek cover, in order that other units or arms may advance or retire.

Deploy.—To extend a formation or unit into a more open formation, *e.g.* a brigade deploys from column of route or from mass into formations more suitable for manœuvre or battle : a company column deploys into four section columns at wider intervals and distances, etc.

Echelon.—A step-like formation of successive and parallel units facing in the same direction, each on a flank and to the rear of the unit in front of it.

Double echelon.—A form of echelon in which a central body is in advance, with the others on its left and right rear.

Enfilade fire.—Fire which sweeps the position or body of troops from a flank.

Field of fire.—The area of ground exposed to the effective fire of a given number of men or group of guns.

Fire unit.—Any number of men firing by the executive command of one. The section is the normal infantry fire unit.

Forward slope.—The side of a hill or mound which is towards the enemy. Hence the *reverse slope* is that away from the enemy.

Ground scouts.—Men employed to ascertain whether the ground in the immediate vicinity is passable and to discover the most favourable route for movement in any direction.

Half-column.—A form of echelon in which the several bodies composing it are so placed that a half wheel to one flank brings them into line with the proper intervals (if any), whilst a half wheel to the other flank brings them into column.

Horse-length.—A term of measurement (8 feet).

Intercommunication.—The means of transmission of all orders and information, by which the close co-operation of all forces in the field is ensured. This means includes the service provided by the Royal Corps of Signals, by regimental signallers and orderlies, by liaison officers and by the army postal service.

Liaison.—The close touch kept between units or formations by the visits or attachment of officers or others to interchange information.

Oblique fire.—Fire which is directed diagonally, roughly half-way between front and flank.

Order (mounted).—The usual distance between front and rear rank.

Open order.—An increased distance between ranks to suit requirements (three horse-lengths on ceremonial parades for inspection purposes).

Close order.—A reduced distance to suit requirements.

Orderly.—A man detailed to carry messages.

Patrol (cavalry and infantry).—A small moving body of men used for reconnoitring, protection, visiting sentries or connecting with other portions of our own troops.

Patrol, fighting.—A patrol used for reconnoitring, to obtain identification or to harass the enemy. It will usually have to fight and its strength must therefore be sufficient for the task which it has to perform.

Patrol, standing.—A small party of men under a N.C.O. posted a considerable distance in advance of other troops to watch either the enemy, a route by which he might advance or a locality in which he might attempt to concentrate unseen.

Piquet (tactical).—A self-contained party detached for a definite period from a force for the purpose of carrying out protective duties in the case of warfare against savage or semi-civilized enemies.

Point (with reference to an advanced guard or patrol).—The man or men moving immediately in advance of a van-guard or patrol.

Reconnaissance.—Examining, exploring and searching the country in order to discover and locate the enemy or to find out the lie of the land.

Reverse fire.—Fire directed against the rear of a position.

Sanitation.—The practical application of certain well-established laws with regard to the preservation of health and the prevention of disease.

Scouts.—Men detached to reconnoitre; or individual members of a patrol.

Sections.—One of the divisions of a field company. When used with reference to mounted drill, it denotes four front-rank men with their coverers, if any.

Half-section.—Numbers 1 and 2, or 3 and 4, of any section with their coverers, if any.

Shouldering.—Wheeling on a moving pivot with an indefinite radius.

Troop guides.—N.C.Os. or men in the centre and the men on the flanks of the front ranks of each troop, who are responsible for maintaining accuracy of direction or movement.

PART I—TRAINING

CHAPTER I

INTRODUCTORY

1. Nature and scope of military engineering

1. The role of the military engineer in war is to apply engineering knowledge and resources to the furtherance of the commander's plans. The following paragraphs deal with the distinctions between engineering practice in civil life and that in a theatre of war, and with the qualifications necessary in a military engineer.

2. Engineering in civil life is becoming increasingly specialized, both in personnel and in tools and plant. The broad classifications of civil, electrical and mechanical engineering now cover many sub-divisions, to any one of which an engineer may devote his whole life. This degree of specialization is unsuited to military requirements, as it would lead to a vast multiplication of engineer personnel and equipment, much of which would at any one time be unemployable.

On the other hand, all major developments of engineering knowledge and practice in civil life are ultimately adopted in, or adapted to, military engineering. Some of these are sufficiently important to call for specialization. The development of motor transport, aviation and telegraphy have provided salient examples. In other cases, such as railways, a more limited or temporary specialization within the main organization of military engineers has sufficed. The extent of specialization in military engineering organization must, however, always be less than in civil life.

3. In a major expedition, the engineers of the force will be drawn from the Regular Army and its reserves. The permanent cadre of officers must therefore be able to deal with a wide variety of engineering problems incidental to the campaign. Furthermore, it must contain a quota of specialists, qualified to fill key positions such as will be required in the directorates of railways, docks and so on.

In a national war, the permanent cadre will be re-inforced by an influx from all branches of the engineering profession in civil life. To direct the activities of this re-inforcement,

the officers of the permanent cadre must be not only trained soldiers, but also engineers of wide experience ; and the filling of the key positions will demand officers whose technical qualifications are such as to command the confidence of their subordinates drawn from civil life.

4. Engineering practice in civil life is characterized by the deliberate perfection of specialized organization, resulting eventually in rapid and efficient execution. Cost and durability are usually important factors, compared with weight and speed of execution.

In war, the necessity of speed, often combined with lightness and portability, overrides technical perfection, and (within limits) cost. Moreover, highly specialized plant and labour will seldom be available in the forward areas.

5. The distinctive features of the organization and technique of military engineering are therefore the comparative absence of specialization and the wide range of general engineering which it embraces ; the necessity for speed ; and the capacity for improvisation from the slenderest resources.

The necessity for exploiting to military purposes the wide resources of engineering science, for effecting technical surprise where possible, and for guarding against its employment by the enemy, render it essential that military engineering should be in close touch with the latest developments in civil practice. This contact should be maintained continuously in peace, if it is to produce its effects in war.

2. The engineer officer

1. In war, the engineer officer assists the commander in two ways : firstly, with advice on the bearing of technical factors on plans contemplated ; and secondly, by the execution of work required in furtherance of plans.

In peace, the first responsibility of the engineer officer is to fit himself for his role in war ; the second is the discharge of various technical duties connected with peace administration.

2. The technical requirements of engineer officers follow from the considerations outlined in Sec. **1.** They require initially a broad engineering education, followed by practical experience in its application. A limited number must be afforded openings for prolonged specialization, but for the majority this is to be avoided.

3. All engineer officers should be thoroughly trained and up-to-date in military duties, so that they may be quick to appreciate the mutual relationship between military and

technical factors. Without this knowledge they will fail to retain the confidence of commanders, and plans will be inadequately considered and indifferently executed.

As engineer officers will often be required to assume tactical command in war, they must be competent to handle mixed forces in the field.

4. The training of the engineer officer should thus aim at a high standard as an engineer and as a soldier, and at the maintenance of a balance between these two requirements. The officer who aspires to become an efficient engineer commander must follow up his initial technical and military training with unremitting effort in subsequent years to profit by every opportunity of acquiring further experience. And the self-evident importance of the military side of his knowledge should not be allowed to obscure the fact that, without a high standard of engineering knowledge, he will be unable to fill the role for which the military engineer exists.

3. The engineer soldier

1. The training of the engineer soldier, like that of the officer, falls under two headings, the technical and the military. Under the former are included skill at an engineer trade and proficiency at field engineering : under the latter, drill, weapon training and the other normal duties of a soldier.

2. Although engineers are not normally called upon to fight as infantry except in emergency, experience has repeatedly shown that such emergencies occur, and that they demand the highest standards of military instinct and discipline.

Moreover, the liability of engineer work, even in the rearward areas, to disturbance by attacks from the air, with gas, or by armoured fighting vehicles, calls for a high standard of training, if the work is to proceed with the minimum of delay and loss.

It is important, therefore, that the military training of the rank and file should receive careful attention, and in particular, that specially employed men, away from the supervision of regimental life, should not be allowed to develop any tendency to slackness or unsoldierly methods.

3. Technical efficiency, especially in trade skill, can only be achieved and maintained by constant practice. Any shortcomings in this direction will lead to inferior engineer work in war.

It should be the constant aim of engineer officers in peace,

therefore, to maintain a proper balance between the conflicting claims of technical and military training on the time available for the training of their men. The ideal is the sapper who is equally at home in the workshop, at field engineering, on the rifle range or on parade.

4. In the training of N.C.Os., special attention should be given to the development of self-reliance and powers of leadership, based on a sound professional knowledge combined with practical experience in the organization and execution of engineer tasks, both technical and military. No N.C.O. can be considered to have attained an adequate peace-time standard until he has fitted himself for promotion to a higher rank in war.

4. Technical establishments

1. The maintenance of adequate technical standards depends largely on certain establishments engaged in training, experiment and research. The activities of these establishments are interdependent; and progress depends on their co-operation, both mutually and with engineer units.

Training Establishments

2. *The School of Military Engineering* (S.M.E.).—The S.M.E., closely associated with the R.E. Depot, is the technical headquarters of the Royal Engineers. The Commandant is *ex officio* Inspector of the Royal Engineers.

The organization and functions of the S.M.E. are laid down in King's Regulations.

Its functions include the instruction of engineer officers and selected soldiers in their normal technical and military duties, and for any special duties for which the necessity may arise. It conducts courses for personnel of other arms and services as required.

The S.M.E. also undertakes other duties allotted to it from time to time, such as research, experiment, design, etc.

Individual officers and soldiers will be encouraged to submit proposals for improving engineer equipment and plant or technical methods; in this connection attention is drawn to King's Regulations, as affecting inventions.

It is important that close contact should be maintained between engineer commanders and the S.M.E.

3. *The School of Electric Lighting* (S.E.L.).—The scope of the S.E.L. is laid down in King's Regulations.

4. *The School of Anti-Aircraft Defence* (S.A.A.D.) (*Engineer Wing*).—The scope of the S.A.A.D. is laid down in King's Regulations.

5. *The Railway Training Centre* (Ry. T.C.).—The Ry. T.C. is responsible for the training of engineer officers in the survey, construction, operation, maintenance, demolition and hasty repair of railways and their equipment; and in their duties as officers of the transportation directorate in war: for the training of various categories of railway tradesmen: and for the training of transportation units of the Supplementary Reserve in the application of civil practice to military needs.

In addition to an instructional depot company, the centre includes a railway construction and operating unit, of which one section forms a nucleus for the formation of a railway survey company.

The principle underlying all training is that the units concerned should be able at the outset of a campaign to undertake that work which is not part of the ordinary work of the civil railwayman.

6. *The Ordnance Survey.*—The Ordnance Survey is a civil department, largely staffed by engineer officers and other ranks, who are organized for convenience of administration as a battalion. The technical routine of the engineer personnel consists of surveys and revisions for, and reproductions of, the maps of Great Britain. This routine, alternating with periods of military duty, provides a proportion of personnel qualified for the survey requirements of war. From time to time, personnel are selected for duty on colonial surveys and boundary commissions, thus gaining further experience under conditions similar to those of survey work in a theatre of operations.

Close contact is maintained between the Ordnance Survey and the Geographical Section of the General Staff at the War Office; the latter being responsible for advice on general questions of survey policy, for the preparation, reproduction and distribution of maps for training and war, and for survey and geographical intelligence.

Experimental and Research Establishments

7. *The Royal Engineer and Signals Board.*—The R.E.S. Board and its main committees are composed of technical military members, with whom are associated representatives of the Staff, of various technical interests of the three defence services, and of leading civil institutions concerned with scientific research and education.

Its functions include :—

i. Research, experiment and investigation connected with engineering material.

ii. Contact with the productive engineering resources of the United Kingdom.

iii. Contact with scientific and engineering developments at home and abroad.

iv. Design of samples of new equipment on which subsequent production shall be based.

The normal work of the board is conducted by its committees. Its experimental work is carried out by various agencies, including the Experimental Bridging Establishment and the Air Defence Experimental Establishment.

Half-yearly reports are published by the board and circulated to Chief Engineers (C.Es.) ; Commanders, Royal Engineers (C.R.Es.) ; educational establishments and others.

CHAPTER II

INITIAL TRAINING

Officers

5. Officers (Regular Army)

1. The objects of the initial training given to the young engineer officer, on appointment to a regular commission, are :—firstly, to fit him for the normal responsibilities of a junior subaltern ; and secondly, to provide him with a broad military and engineering education on which to build, throughout his service, by study and experience.

Officers commissioned from a cadet college undergo a course of nearly three years' duration, of which two academic years (less the intervening long vacation) are spent at Cambridge University, and the remainder at the S.M.E., Chatham. The university course deals mainly with the theoretical principles of engineering ; and instruction in the military application of these principles is carried out at the S.M.E., where also the military education of the officer continues from the start made at the cadet college.

At the end of his second academic year at Cambridge the young engineer officer is required to gain honours in the Mechanical Science Tripos.

University graduates selected for appointment to regular commissions undergo the S.M.E. portion of the above course.

2. The Young Officers' Course at the S.M.E. and at Cambridge includes :—

i. *General military training.*—

Drill, weapon training, anti-gas training, physical training.

Discipline, organization, administration, interior economy, hygiene and sanitation.

Corps history.

The tactics and organization of the other arms and services.

The employment of engineers in war.

Whilst under instruction at the S.M.E., officers are attached to companies of the R.E. Depot to learn the interior economy of a unit and to obtain experience in dealing with men.

Whenever possible, officers are attached for a short period to units of another arm during collective training.

ii. *Special training.*—

Field engineering, including field defences, mining and demolitions, the use of spars and tackles, bridging, river-crossing expedients, communications, semi-permanent fortifications, the principles of coast defence, anti-gas protection, water supply, engineer reconnaissance and engineer tactics.

Civil and general engineering, including applied mechanics (structural), nature and strength of materials, building trades, building construction and barrack design, camp services, semi-permanent camps and hutting, masonry structures, concrete and reinforced concrete, structural steelwork (including bridges), road engineering, hydraulics and water supply, drainage and sewage disposal, heating and ventilation of buildings, estimating, engineer services, works economics and works management and administration.

Electrical engineering, including the general principles of electricity and magnetism; the theory, design, erection, and testing, of electrical machinery and plant; power installations, power transmission and distribution; indoor wiring, illumination, searchlight installations, telephones and the electrical firing of charges.

Mechanical engineering, including workshops practice; the lay-out of workshops and erection of machinery; boilers and steam engines, internal combustion engines, pumps, refrigerators, compressors, and the use of pneumatic tools; and the driving, maintenance and organization of mechanical transport.

Survey, including field sketching, levelling, chain survey, railway and road reconnaissance and survey, the use of the theodolite, trigonometrical and topographical survey, the application of air photography to survey, and the compilation, reproduction and printing of maps.

3. At the conclusion of the course at the S.M.E. and at Cambridge, all officers undergo a five-weeks' course in mounted duties at the R.E. Mounted Depot at Aldershot, and a five-weeks' course in anti-aircraft and coast defence searchlights and their employment at the S.E.L., Gosport.

This completes the initial training of the regular officer, who will then normally be posted to a unit at home or abroad. It

is of the first importance that officers, at the outset of their career, should gain experience of the command of men, before being allowed to take up employment away from troops.

4. After the completion of five or more years' service, a limited number of officers are selected to undergo advanced "post-graduate" instruction, combined with a period of executive experience, with a view to their acquiring specialized knowledge of certain subjects.

These subjects may include :—

i. *Civil, general, electrical and mechanical engineering.*—In addition to receiving advanced instruction at the S.M.E., the officers selected may be attached to civilian firms and employed subsequently on the executive staff of major engineering enterprises at home and abroad.

ii. *Railway engineering.*—Courses are held at the Ry. T.C., Longmoor.

Practical experience is obtained at Longmoor and also on Colonial railways as opportunities arise. In addition, a number of officers are employed on the Indian railways.

iii. *Survey.*—In addition to correspondence courses, which are open to all officers, special courses are held at the S.M.E., Chatham. Practical experience is gained in the Ordnance Survey at home, in the Survey of India and on various boundary commissions and colonial surveys. In addition, openings occur from time to time for survey work in connection with expeditions organized for exploration or scientific research, and in other pioneering enterprises.

6. Officers (Supplementary Reserve and Territorial Army)

1. The training obligations accepted by officers appointed to commissions in the Supplementary Reserve and Territorial Army, are laid down in Supplementary Reserve Regulations and Territorial Army Regulations respectively. Officers must appreciate, however, that these obligations represent a minimum, to be added to by voluntary training, if they are to reach the standards of efficiency necessary for the military engineer. Moreover, much of this voluntary training should be undertaken early in their military careers in order to fit them for their duties as trainers and leaders.

2. All officers commissioned into the R.E., Supplementary Reserve, except those exempted under Supplementary Reserve Regulations, will be required to undergo a preliminary training of 14 days with a regular unit. The objects of this training are to give them an insight into military duties and administration, and to instruct them in the adaptation of engineering practice in civil life to the problems of the military engineer.

Officers appointed to army troops companies, electrical and mechanical companies, and workshops and park companies, and all works officers, will undergo their preliminary training at the S.M.E. The training will include military duties and organization, and the elements of field engineering.

Officers appointed to transportation units will undergo their preliminary training at the Ry. T.C., the course being on lines similar to the above, but modified to meet transportation requirements.

Officers of army postal units have no compulsory training obligations.

In addition, officers of the Supplementary Reserve should take the earliest opportunities of undergoing such voluntary training as is provided for in Supplementary Reserve Regulations, with a view to making themselves efficient in the military and engineering duties appropriate to their various roles in war. Such training may take the form of attachments to regular units or of attendance at courses of instruction at army schools, and, in the case of officers of army postal units, voluntary attendance with those units during army manœuvres.

3. All officers commissioned into the R.E., T.A., except those exempted under Territorial Army Regulations, will be required to undergo a full T.A. recruits' course (*see* Sec. 8, 2) as part of the preliminary training laid down in Territorial Army Regulations. This training is the special duty of the permanent staffs of units ; and at its conclusion officers will be passed out at an examination to be held under the orders of the commanding officer.

Officers should take the earliest opportunity of qualifying for promotion to lieutenant by attendance at a junior officers' course at the School of Military Engineering.

In addition, officers should take the earliest opportunities of completing their initial training by voluntary attendance at courses of instruction as under :—

i. Within four years of being appointed to commissions, but after completion of the full T.A. recruits' courses, officers of divisional engineers and army troops companies should also

undergo the Preliminary Fieldworks Course for officers of the T.A. at the S.M.E. This course is organized in three successive periods of a fortnight each, dealing with different subjects, any one of which can be taken separately, if desired. They may also take a S.M.E. correspondence course in air survey, with a view to familiarizing themselves with the use of air photographs.

ii. Officers of fortress engineers and engineer officers of anti-aircraft units should attend specialist courses of instruction at the schools appropriate to their various roles, *e.g.*, at the S.E.L., S.A.A.D. Before attendance, officers must have reached the standard of efficiency laid down for the particular course.

SOLDIERS

7. The recruit sapper (Regular Army)

1. The object of the initial training given to the recruit sapper on enlistment is to produce a man sufficiently well grounded in his duties as an engineer soldier to take his place in the ranks of a unit.

2. The R.E. Depot, at Chatham, is responsible for the training of all regular recruit sappers.

With the exception of trade-testing on arrival, no trade training is carried out during the recruits' course. The course, exclusive of fixed leave periods, occupies 36 weeks, and includes the following :—

i. *Formation of party* (two to five weeks, depending on the rate of intake).

Trade tests, medical examination, vaccination, administrative routine.

Elementary drill, physical training, educational training.

ii. *Military training* (ten weeks, including one week's refresher course before leaving).

Drill, bayonet fighting, preliminary weapon training, anti-gas training.

Route marching, tactical training in field operations, map-reading.

Educational training, physical training, swimming, recreational training.

Discipline, cleanliness, smartness and administrative duties.

iii. *Weapon training* (four weeks).

Preliminary weapon training, rifle and light machine gun courses on the range, small arms anti-aircraft training.

Visual training.

Smoke, flares and signal lights.

iv. *Field engineering* (17 weeks).

Knotting, lashing and use of spars.

Field fortification, including the siting and construction of trenches and their concealment from ground observation; clearance of field of fire; preparation of obstacles against infantry and armoured fighting vehicles.

Sapping and mining. Gas proofing of dug-outs.

Watermanship, wet and dry bridging with the mobile bridging equipments and with improvised methods. Use of semi-mobile stock-span bridges and heavy expedients.

Water supply, including the use of service equipment and laying of pipe lines.

Demolitions and camouflet method of road cratering.

Use of power tools.

The educational and physical training of the recruit sapper should receive continuous attention throughout the course, if he is ultimately to reach the standards required. No trained sapper can be considered efficient until he has obtained a second class certificate of education and developed a good physique. Without these qualifications he will lack the mental alertness to discharge his technical duties and the physical ability to perform ordinary engineer tasks in the field. No recruit sapper should normally be accepted, therefore, whose classification, on the preliminary educational test, is below "C"; and no recruit will be considered fit for posting to the ranks of a unit who has not obtained at least a third class certificate of education.

3. On completion of the recruits' course, sappers will be posted to units. For certain units a further course of specialized instruction is necessary in order to fit the recruit for his duties.

Sappers selected for posting to the field squadron as mounted sappers undergo a ten weeks' course in mounted duties at the R.E., Mounted Depot, Aldershot.

All sappers selected for fortress and anti-aircraft units undergo an elementary course in searchlight duties at the S.E.L., Gosport. Those selected for anti-aircraft units undergo collective training in anti-aircraft duties with an anti-aircraft battalion.

Similarly, sappers selected for duty with the Ordnance Survey, and with railway companies, receive further specialized

instruction at Southampton, and at the Ry. T.C., Longmoor, respectively.

8. The recruit sapper (Supplementary Reserve and Territorial Army)

1. Recruit sappers enlisted into Category B of the Supplementary Reserve (which includes army troops companies, electrical and mechanical companies, workshop and park companies, and sappers not organized in units) incur certain extra training liabilities during their first year, as laid down in Supplementary Reserve Regulations. These consist mainly of additional drills, and the firing of a recruits' course of weapon training instead of the trained soldiers' course. Commanding officers will organize these additional drills as a recruits' syllabus, adapted to the needs of the unit, and will arrange for the training to be carried out under the supervision of the permanent staff. The syllabus will include drill and military duties, preliminary weapon training and individual training in field engineering appropriate to the role of the unit. At the conclusion of the course, recruits will be passed out at an examination to be held under the orders of the commanding officer.

Recruit sappers enlisted into Category A of the Supplementary Reserve, *i.e.*, into transportation units, incur no extra training liabilities during their first year. The Commandant, Ry. T.C., will therefore arrange that first-year recruits receive special training, especially in drill and military duties, during the annual camp training.

Personnel of Category C of the Supplementary Reserve have no training liabilities.

Personnel of army postal units can attend voluntarily when these units are called out for training during army manœuvres.

2. Recruit sappers enlisted into the Territorial Army will be required to undergo a special recruits' course, as part of the preliminary training laid down in Territorial Army Regulations. The detailed organization and supervision of this training will be the duty of the permanent staff, but in principle the training of recruits should be the duty of their own officers and N.C.Os. The course will include :—

i. General military training.
ii. Weapon training.
iii. Special military training.

The general military training will include squad drill and rifle exercises, preliminary weapon training, individual anti-gas training, discipline, smartness and army routine.

The weapon training course is laid down in Small Arms Training.

The special military training may include field engineering or training for the special role of the unit, or both of these. The syllabus will be framed so as to lead up to the collective training syllabus laid down in Chapter III of this manual.

At the conclusion of the course, all recruits will be passed out at an examination to be held under the orders of the commanding officer.

9. The recruit driver

1. The object and scope of the initial training given to the recruit driver are analogous to those of the training of the recruit sapper, allowance being made for his role in the unit.

2. The R.E. Depot, Chatham, is responsible for the training of all regular recruit drivers (I.C.).

The training is the same as that laid down for the recruit sapper in Sec. 7, 2, except that the field engineering portion of the course is omitted, and in its place the recruit driver undergoes an eight-weeks' course in driving and maintenance of mechanical vehicles, which is carried out at the S.M.E.

3. The R.E. Mounted Depot, Aldershot, is responsible for the training of all regular recruit drivers (H.T.).

The course, exclusive of fixed leave periods, occupies 36 weeks and includes the following :—

i. *General military training and weapon training* (18 weeks).

Foot drill with and without arms, preliminary weapon training, anti-gas training.

Range courses and visual training.

Educational training, map reading, physical training, swimming, recreational training.

Discipline, cleanliness, smartness and administrative duties.

Stable routine, work on the dummy horse.

ii. *Riding* (15 weeks).

Horsemanship, horsemastership.

Riding drill.

Care of one horse and one set of saddlery.

March discipline, camp duties.

iii. *Driving* (five weeks).

Ride and drive, long rein driving.

Driving drill.

Care of a pair of horses and a double set of harness.

Pack transport duties.

Horsemanship in barracks and in the field.

The educational and physical training of the recruit driver must receive continuous attention throughout the course if he is ultimately to reach the standards required. Under war conditions, he will frequently be required to assume the unaided charge of his vehicle for considerable periods and over long distances. A recruit driver cannot, therefore, be considered fit for posting to a unit unless he has a good physique and has obtained at least a third class certificate of education.

4. Recruit drivers (I.C.) enlisted into non-regular units will sometimes have a knowledge of driving and maintenance duties as a result of their training and experience in civil life. The initial training of such driver will therefore be mainly devoted to :—

i. General military training.

ii. Training in the type of vehicle with which the unit will be equipped.

iii. Map reading, march discipline.

Many drivers will, however, lack civil training, and will need complete training after enlistment.

The object of the recruit driver's course will be to produce a man trained on lines similar to the regular driver. Commanding officers will organize the training in accordance with local conditions.

CHAPTER III

ANNUAL TRAINING

10. General instructions

1. Training Regulations contain general instructions on the system to be employed in the organization and conduct of training. These instructions are amplified in Army Training Memoranda, in S.M.E. technical circulars and in instructions issued under the authority of G.Os.C.-in-C. C.Es., C.R.Es., of divisions and areas and all engineer officers holding lieutenant-colonels' commands and appointments will ensure that the above instructions are brought to the notice of officers for whose training they are responsible.

2. The range of knowledge required of the military engineer is so wide that it is only by continuous study that engineer officers and N.C.Os. can keep abreast of requirements. This should include a preliminary study of the appropriate portions of the various Manuals, concurrently with all training in which they may be engaged throughout the year.

Theoretical study, to be of practical value, must be followed by the application of theory to definite problems. For the training of officers and N.C.Os. serving with units such problems can be studied with troops, equipment and other resources. But for the training of officers not serving with units, and for the study of wider problems for which the requisite resources in personnel and material cannot easily be made available, exercises without troops (*see* Sec. **26**) will be essential.

3. The wide diversity of engineer roles in war, and the consequent organization of engineers into units and categories of distinct and partially specialized types, result inevitably in a tendency for the peace training of individual officers and men to become concentrated on specialized lines. Unless this tendency is resisted, the lack of adaptability of officers and men will prejudice the ability of the engineer organization, as a whole, to expand in any particular direction required by the circumstances of a campaign, or to make good any abnormal wastage occurring in particular categories.

While the training of certain units must be largely influenced by their primary roles in war, it is therefore important that training should be kept on as broad a basis as possible. Since

N.C.Os. and sappers of all regular units, on completing their colour service, form (with few exceptions) a general pool of reservists, all should receive a training in general military duties and in field engineering, which will fit them to take their places in field units on mobilization.

4. Further, since readiness for war is the aim of all training, there can only be one standard of training as the objective of all engineer units, both regular and non-regular, namely the ability of the unit to fulfil its role on mobilization.

In regular units the standard reached by the end of the collective training should be such that cadres can be thrown off on mobilization, and reservists absorbed, without affecting the ability of the unit to carry out its role in war. To this end, special attention must be paid to the training of junior officers, and of junior and potential N.C.Os., so that there may always be young men coming on, fit for promotion on mobilization.

In non-regular units the limited time available for peace-time training necessitates consideration of the circumstances of the various categories; so that, according to the liabilities of each unit under the mobilization arrangements in force, the time may be spent to the best advantage on those branches of training which will be essential to the discharge of its role in war. Here also the training of junior leaders will be of the utmost importance, but the general scope of the training will necessarily be somewhat narrower than in regular units.

5. Regular officers and N.C.Os. will frequently be required to assist in the training of non-regular units and personnel. Only those officers and N.C.Os. should be selected for this duty who possess the ability, enthusiasm, tact and sympathetic outlook necessary to produce the best results, as time wasted cannot be made good.

The principles underlying the training of non-regular troops differ in no respect from those applicable to regular troops. Praise, when merited, should be freely given; but if short-comings are apparent, helpful criticism will be more appreciated than empty praise. As far as possible, the regular instructor should confine himself to explanation and demonstration, and should insist on executive orders being given by the officers and N.C.Os. of the unit. As a general rule, the regular instructor should first instruct a cadre class of officers and N.C.Os., and the latter should then pass on the instruction directly to their men.

6. In the engineers of the Supplementary Reserve, the officers, as a result of their training and experience in civil

life, are usually trained civil engineers, and the men have the requisite trade training. The personnel are, as far as possible, recruited into the branches for which their civil qualifications best fit them. The completion of their training as military engineers falls, therefore, under two main headings: firstly, military training, consisting of drill, weapon training, individual protection against gas, discipline and knowledge of army routine; and secondly, engineer training. The latter heading covers a wide range, but the training of a particular category must be mainly directed to those subjects which its war role primarily requires. In general, this training should aim at utilizing their trade skill in the collective execution of work, and at the execution of engineer tasks under active service conditions with the types of equipment, tools and plant likely to be available in the field. Further guidance as to training subjects for specific types of units is given in Secs. **17** to **19** and **23.**

In certain units it may be advisable to organize the camp training on a two-year or four-year cycle, so that effort may be concentrated on different branches of training in successive years. In view of the diversity of conditions obtaining in different localities (*e.g.* camp sites, camp dates, availability of equipment from command pools, etc.), no uniform system can be laid down. But it is the duty of C.Es. and other engineer commanders concerned to advise the higher command with a view to instituting a continuous policy for the training of the engineers of the Supplementary Reserve for whom they are responsible, so as to cover the ground in the manner best suited to local conditions. With such a policy settled, it will then be the duty of unit commanders so to frame their out-of-camp training arrangements as to lead up to the camp training.

7. In the engineers of the Territorial Army the majority of the officers are engineers in civil life, but the proportion of tradesmen on the peace strength of a unit seldom bears a close relation to that authorized for its war establishment. All officers commissioned into the Territorial Army without previous experience as military engineers should, if possible, undergo the prescribed course of instruction, at the S.M.E. or other appropriate establishment, within four years of being commissioned; otherwise such officers will lack the military engineering knowledge required for the discharge of their duties in peace and war. Any discrepancies between the trade qualifications on the peace strength of a unit and those required for its war establishment, must be corrected by regulating the in-take of recruits on mobilization, when it may be assumed that the requisite trades will be forthcoming. It

is not possible to devote any time under peace conditions to that branch of training which should be adequately covered by the experience of civil life.

The training policy for engineer units of the Territorial Army is affected by the liabilities of the various categories under the mobilization arrangements in force. Certain units assume war-time liabilities immediately on embodiment, whereas others are reasonably assured of a period of post-embodiment training in which to bring the general state of training to the standard required for war. In units of the former category effort must be concentrated on those branches of training which are essential to meet their war-time commitments, even if this involves a falling below the standards normally to be expected in other desirable but less important branches. The shortcomings which result will have to be rectified during such periods as can be spared after embodiment, and a well-trained body of instructors will therefore be necessary to cope with the necessary post-embodiment training of the trained men, as well as with the intensive instruction of post-embodiment recruits, whose training will have to proceed concurrently with the performance of the unit's war role. In the units of the latter category the objects will be—firstly, to train a body of instructors capable of conducting intensive post-embodiment training to the required standard, and secondly, to ensure that the general level of training of the rank and file shall rest on a sound foundation, rather than that it should aim at a higher standard than can be properly secured.

In Territorial Army units the out-of-camp training should mainly be devoted to individual instruction, designed to fit officers and men to take their parts in collective training; special classes should be formed, when conditions permit, to give more advanced instruction to instructors and potential instructors. In addition, week-end camps may afford opportunities of collective training for all ranks, and of enabling recruits to settle down to military routine.

While the camp training period should, in principle, be devoted to collective training as a unit, such circumstances as lack of time, the absence of facilities at drill stations or a recent influx of recruits will often necessitate some portion of the period being spent on individual training. This can best be done during the first week while officers and N.C.Os. are working out details of the collective exercises to be carried out later by units and sub-units.

While training standards and broad principles can be laid down for the guidance of engineer commanders of the

Territorial Army, the varying circumstances of different units render it dangerous to generalize on the details of methods to be employed. C.Es. have therefore a special responsibility for studying the individual requirements of units, and for advising G.Os.C.-in.C., so that these requirements can be met from the resources which can be made available.

11. Training responsibilities of engineer commanders

1. The C.E. of a command is responsible for carrying out the following duties :—

i. Advice to his G.O.C.-in-C. on the training and efficiency of the engineers in the command. For this purpose he will carry out such inspections as he finds necessary to judge their efficiency, both collectively and individually in their technical duties, and, in respect of units under sub-para. iv, below, in their military duties.

ii. Advice as to the co-ordination of the training of all engineers in the command, so that the fullest use may be made of the technical equipment, transport, training areas and other facilities which can be made available.

iii. Advice as to the inclusion of engineer problems in exercises carried out under the orders of the command. (*See also* Secs. **14,** 4, and **26,** 4.)

iv. Responsibility for the military efficiency and, except in regard to the specialist training of survey and transportation units, for the technical efficiency of engineer units in the command not forming part of formations.

v. The setting and direction of command engineer exercises without troops, as laid down in Sec. **26,** 4.

2. The C.R.E. of a division (or O.C. field squadron) is responsible to his formation commander for the training and efficiency of the engineers under his command. He will advise as to the inclusion of engineer problems in exercises carried out under formation headquarters, and will bring to notice engineer factors affecting other tactical or administrative problems under consideration.

The C.R.E. of an area is responsible to his C.E. for the military and technical training of all Regular Army, Supplementary Reserve and Territorial Army units and personnel in the area (*see* para 1, i and iv, above) not forming part of formations, except survey and transportation units, and unless otherwise ordered by the G.O.C.-in-C. of the command.

C.R.Es. will draw up annual training programmes and forward them to divisional headquarters, with copies to the

C.E., in the case of divisional engineers ; or direct to C.Es. in the case of other units, not forming part of formations.

All C.R.Es. have a special responsibility for the military and technical training of the officers under them, and for developing their powers of training and leadership. As a means to this end, engineer commanders will insist on junior officers being given definite commands and spheres of responsibility, so that they may have ample opportunities for directly instructing their men by means of lectures, exercises, etc. Unless the junior officer is forced to overcome the diffidence frequently experienced at the outset, he may fail to develop the self-confidence required in a successful trainer and leader.

The training programmes of regular C.R.Es. will provide for the training of all officers employed on works services by means of T.E.W.Ts., E.E.W.Ts. and attachments to units, and by any other means available.

3. The instructions contained in paragraph 2, above, apply both to regular and non-regular engineer units. The commander of a non-regular unit who finds difficulty (owing to a shortage of qualified instructors, or for any other similar cause) in carrying out the training of his officers will first apply for assistance direct to his affiliated regular unit. If the latter is unable to give the requisite help, the commander of the non-regular unit will apply for instructions through the usual channels.

4. Engineer commanders, when carrying out training inspections, or when accompanying higher commanders on such inspections, must bear in mind that training results should not be judged solely on the merits of the work produced. By employing only the best N.C.Os. and men, it is a simple matter to produce a work of a high order. But such methods mean that training is being concentrated on those who least need it. Under a sound system the least efficient should receive the most practice, and N.C.Os. and men of proved efficiency can be exercised in responsibilities of a higher order.

12. Individual training

1. Individual training consists of :—

i. General military training.
ii. Weapon training.
iii. Anti-gas training.
iv. Field engineering.
v. Constructional and trade training.
vi. Special role training (where applicable).
vii. Physical training.
viii. Mental and educational training.

The above items are amplified, and the requisite standards of efficiency are indicated, in the succeeding paragraphs of this section.

2. *General military training.*—The foundation of the training of all ranks of the engineers of the Regular Army is a firm grounding in the military side of their duties, including the acquisition of habits of self-reliance and resolution, combined with smartness, discipline and *esprit-de-corps*.

Officers, on the completion of their Young Officers' Courses (*see* Sec. 5), will therefore normally be posted to a unit for a period of not less than one complete training year. During this period it is essential that they should be given a definite command and sphere of responsibility, in order that they may acquire at the outset of their service habits of self-reliance and the power of command. Commanding officers will further ensure that such officers obtain a complete knowledge of the details of administration, and of the pay, allowances, rations, feeding, clothing, recreation and general welfare of their subordinates. They should be given every opportunity of instructing in all branches of training, in order to acquire a correct and effective method of teaching. It should be the ambition of officers to return to the command of troops at intervals in each stage of their service.

It is particularly important that officers of field rank should qualify themselves for the appointments of C.R.E. of a division or of corps troops in time of war. For this reason all majors, before promotion to lieutenant-colonel, should attend the Senior Majors' Course held annually at the S.M.E. in the spring.

The general military training of N.C.Os. should be maintained throughout their service, and it is the duty of all commanding officers to ensure that no N.C.O. (except those in special employment, *e.g.* clerical or engineer services) remains too long in sedentary appointments, and to ensure that only those who are fully qualified to command are recommended for promotion.

General military training includes :—

i. *Drill and duties.*—All ranks should appreciate that smartness at drill is a standard by which the efficiency of a unit is commonly judged, and that experience has shown it to be a reliable indication of efficiency in war. Training in drill and duties will be based on the Manual of Elementary Drill (All Arms) and the Manual of Ceremonial, and Chapter V of this manual. By constant insistence on smartness of movement on daily working parades, and on good drill in marching to and

from work, it is possible to maintain a high standard of drill and turn-out without devoting excessive time to drill parades. The tedious repetition of movements which have been well executed, and the unnecessary keeping of men at attention or at ease when they should be standing easy, are errors to be avoided. The standard reached will depend largely on the powers of command of the junior N.C.Os. Drill and duties courses for such N.C.Os., whether for selected N.C.Os. with the Training Battalion or for others under locally centralized arrangements, are therefore a valuable means of raising the standard.

ii. *Map reading and reconnaissance.*—Attention will be given to practical map reading on unfamiliar ground, so that all ranks may be able to find their way across country from a map. The ability of dispatch riders and of drivers to select and follow a route to a rendezvous by day or night will be important. Under home conditions advantage may be taken of the early sunset period to practise route finding in darkness. N.C.Os. and men will be practised in reconnoitring and reporting on routes, having regard to facilities for movement, concealment, etc.

iii. *Tactics.*—The tactical training of officers aims, for the reasons given in Sec. **2, 3**, at the standard required for the command of a mixed force. The methods to be employed are explained in Training Regulations, and the scope follows from the promotion examination syllabus for each rank given in King's Regulations and in other regulations.

The tactical training of warrant officers and N.C.Os. covers the tactical duties likely to be required of an engineer unit in the field. It will therefore be based on the normal war organization (squadron or company) of the engineer unit concerned. Attack, defence and protection, on the move and at rest, will be studied, each with a simple tactical background arising from an engineer situation. Instruction will conform in principle to Infantry Section Leading. Leaders should be instructed in formations and the use of ground, as affecting the movement of engineers and equipment vehicles seeking concealment from ground or air observation, and in the measures to be adopted on coming under artillery fire or air attack. The greater part of this training will necessarily be carried out by means of exercises without troops (*see* Sec. **26**).

iv. *Equitation and horsemastership.*—All mounted ranks will be trained to a standard of horsemanship and horsemastership which will enable them to cover long distances across country without undue fatigue, and without injury, to man or horse. In partially mechanized mounted units all

sapper ranks will be fully trained in equitation and horse-mastership.

v. *Driving and maintenance of mechanical transport and dispatch riding.*—N.C.Os. and others who may be required in war to drive cars or combinations, or to ride motor cycles, will be trained in this duty during the individual training season. The training and practice of dispatch riders, both in their special duties and in the management of their machines, must not be overlooked.

M.T. drivers will be trained to a standard which will enable them to drive any type of M.T. vehicle in the unit accurately and without damage, by day or night, across any type of country that the vehicle is designed to traverse. In addition, they should be competent to carry out running repairs and maintenance.

vi. *Packing and loading of transport.*—All ranks must be trained to pack the equipment and to load up the classes of transport with which their unit is equipped.

vii. *Hygiene and sanitation.*—In accordance with King's Regulations, engineer commanders will arrange for a medical officer to conduct a course of lectures and demonstrations for the instruction of all ranks in hygiene, sanitation and the use of the first field dressing.

In addition to the above, King's Regulations require that the authorized scales of personnel (as laid down in the war establishments of field units and peace establishments of depot units) shall be trained at the Army School of Hygiene in sanitation and water duties.

viii. *First aid.*—In all field squadrons and companies of divisional engineers, two N.C.Os. and sappers will be trained in stretcher bearer and first aid duties, under the supervision of a medical officer, in accordance with King's Regulations. Whenever possible, these numbers should be increased to a scale of one N.C.O. for each squadron or company and one sapper for each troop or section. In all engineer units, and if possible in sub-units, there should be N.C.Os. and men trained in simple first-aid in case of accidents, and in the application of artificial respiration to the apparently drowned.

3. *Weapon training.*—This includes :—

i. Rifle, bayonet, pistol and light machine gun.
ii. Visual training and judging distance.
iii. Indication and recognition of targets.
iv. Fire direction and control.

The training syllabus and standards to be attained are laid down in Small Arms Training and in Infantry Section Leading.

Although this branch of training is largely, but not entirely, individual training, considerations of weather and convenience will often necessitate the annual course of range practices and the preliminary training taking place during the collective training season. Nevertheless, the best results will be obtained in the annual course if short periods can be made available from time to time throughout the year for refreshing the men in the tests of elementary training prescribed in Small Arms Training; and much of the work required under items ii, iii and iv, above, can be undertaken during the individual training season.

The summarized results of weapon training are published annually in Army Training Memoranda; and, by comparing these with their own weapon training results, engineer commanders can see whether their units are above or below the average.

In each divisional engineers, battalion or similar unit one officer should have qualified recently at the Small Arms School in the use of the rifle, pistol and light machine gun. In each squadron or company at least two N.C.Os. should be similarly qualified.

4. *Anti-gas training.*—Training will be based on the instructions contained in Defence Against Gas and in the Manual of Field Engineering, Vols. I and II. The position of the engineers, as the basic arm, to advise, to co-ordinate and to carry out the more technical tasks, in measures for defence against gas, calls for a thorough individual grounding in this subject.

Officers should maintain a thorough and up-to-date knowledge of the various methods of gas attack open to an enemy, of the tactical, administrative, topographical and climatic considerations which influence the choice of the methods to be employed and of the general effects of these methods on the dispositions and movements of our troops. Without this knowledge they will be unable to foresee the possibilities of a situation, to tender adequate advice to staffs or to anticipate engineer requirements. They should understand the importance of maintaining at all times a system of gas intelligence, and must be able to organize a decontamination service, including the construction of the necessary decontamination stations.

N.C.Os. should be familiar with the measures appropriate to the various situations in which they may be confronted with gas, *e.g.*, on coming under gas attack or on reaching a contaminated area. They should be competent to undertake the gas-proofing of buildings, hutted structures dug-outs, etc.;

and to decontaminate areas, structures, etc. They should be conversant with the inspection, fitting and maintenance of the respirator, and with the care of such other protective equipment as may be issued.

The individual anti-gas training of all ranks will include :—

i. A knowledge of the characteristics and effects of the four main groups of gases, and the ability to recognize them as far as possible from their description, or from the smell of such authorized training samples as may be available.

ii. A general knowledge of the methods of gas attack open to the enemy.

iii. A knowledge of the construction of the service respirator, and of its care and maintenance. The use of such other personal equipment (*see* Defence Against Gas, 1935, Sec. 6) as may be issued in peace. The use of such unit protective equipment as may be issued in peace.

iv. The use of the decontaminating materials and measures likely to be available in the field ; the immediate decontamination of the person ; the measures suitable for decontaminating such materials as concrete road surfaces, metal surfaces, wooden surfaces, etc. ; and the method of decontaminating vehicles and equipment belonging to the unit.

v. The various types of sound alarms, detectors and warning signs, as laid down in Defence Against Gas. The methods of reconnoitring and marking a contaminated area.

The standards to be attained are laid down in Defence Against Gas.

The wearing of the respirator results in excessive loss of individual efficiency unless personnel have accustomed themselves to it by regular practice. Engineer commanders of all grades will ensure that a proportion of every type of training and work is carried out as though in the presence of gas. All engineer personnel of whatever rank in all forms of employment without exception will be periodically exercised in wearing the respirator, and will each year wear the respirator on at least one occasion for a continuous period of two hours. When protective clothing is available, all ranks of divisional engineers will be practised in wearing it during short spells of work.

All engineer officers will pass the prescribed courses of anti-gas training at the S.M.E. All adjutants of non-regular units and at least one officer in each regular company or equivalent unit should have recently undergone such a course. In divisional engineers two N.C.Os. in each squadron or company, and in other units one N.C.O. in each company, should have recently undergone a course in the Anti-Gas Wing of the Small Arms School. Permanent staff instructors of non-regular units

will be required to pass such a course before or soon after posting.

5. *Field engineering.*—The individual training of officers in field engineering requires a familiarity with all the subjects included in the various volumes of Military Engineering, with the exception of the specialized parts of railway work in Volume VIII. Such knowledge can only be gained by frequent practice in solving concrete problems such as may arise in the field. These will be presented both in the form of technical projects on the lines of the examination in subject (*f*) for promotion to captain, and by means of engineer exercises without troops (E.E.W.Ts.). They will not be confined to work such as may fall to units with forward formations, but must frequently deal with the organization of work in rear areas and especially with work in connection with the preparation of bases and advanced bases. The theoretical knowledge so acquired will be confirmed by officers being required during the collective training season to design, organize and execute field engineering tasks under active service conditions. The training of officers and N.C.Os. by means of engineer exercises is dealt with in Secs. **25** to **27.**

Officers will be encouraged to attend the heavy bridging courses for regular and Territorial Army officers held annually at the S.M.E.

For N.C.Os. the standard of individual training will be based on the rule that every N.C.O. must be fully qualified to exercise command in the rank next above his own. Serjeants should therefore be qualified to carry out the normal duties of a section officer, and lance-serjeants should reach this standard before promotion to serjeant. Corporals and lance-corporals should be fully qualified to instruct parties in all the subjects required for the standard tests of elementary field engineering (*see* Manual of Field Engineering, Vol. II) ; to take charge of parties engaged on bridging, over both wet and dry gaps ; to mark out work in field defences ; to calculate tasks, tools and working parties ; to distribute parties on the work ; and to control working parties, both of engineers and of other arms. They should further be able to execute simple engineer reconnaissances, including simple dimensioned sketches and working drawings, to calculate charges and prepare and execute simple demolitions of all types, and to prepare demands for all classes of field engineering stores and materials, using the correct nomenclature and units of measurement.

The instruction of N.C.Os. in the above subjects during the individual training period will require the formation of classes, generally under centralized control (*e.g.*, divisional engineers),

as well as instruction in units by means of E.E.W.Ts. and engineer reconnaissances. Selected N.C.Os. will be detailed to attend the advanced military engineering and heavy bridging courses held at the S.M.E. In each squadron or company there should be a senior N.C.O. who has recently passed in each of these courses.

The individual instruction of N.C.Os. will continue throughout the collective training season, and it is the duty of engineer commanders to ensure that they receive opportunities of exercising command and responsibility in the execution of field engineering work.

The individual field engineering training of the sapper involves essentially the passing of the standard tests of elementary field engineering laid down in the Manual of Field Engineering, Vol. II. Those tests should be applied annually, and no sapper will be allowed to pass two training seasons without being tested. The requirements of trades training must take precedence during the individual training season, but opportunities must be made available for field engineering training. The sand table and models may be used with profit for such training, both with N.C.Os. and with sappers.

For the training of N.C.Os. and sappers of the Supplementary Reserve and Territorial Army, whose instruction must generally be individual and carried out in the evenings in drill halls, the use of sand tables and models, and the application of standard tests, their passing in which can be recorded, are of particular value.

The higher the standard of training reached during the individual training season, the greater will be the time available for collective and practical training during the collective training season.

6. *Constructional and trade training.*—

i. The training of the officer in those branches of building construction (including the provision of water, light and power, the disposal of sewage and the construction of roads, etc.) which may fall to his lot in war, and which form a large part of the duties of the engineers in peace, will be obtained mainly during tours of duty on works services. A period of such employment is desirable in every rank up to and including that of lieutenant-colonel. During such employment officers should strive to obtain practice in design and to acquire a detailed knowledge of methods of construction, of specifications, of the framing and conclusion of contracts, etc. They will not then be dependent on an expert engineer staff and experienced contractors, who may not be available in the circumstances of war.

Subject to the primary importance of the training of officers serving with units in their military duties, in field engineering, and in the special role of the unit, it is the duty of engineer commanders to ensure that officers serving with units receive opportunities during the individual training season of extending their knowledge of constructional engineering. This may be done by placing them in charge of the design, organization and execution of works to be carried out by their own units (*see* Sec. **13**) ; or by allotting to them projects connected with the local engineer services, such as the design and estimate for minor buildings, the survey and calculation for the construction of roads, improvement of areas, extension of water supply, electricity and sewage disposal systems for new areas of construction, or the recalculation of existing systems which have become more heavily loaded with the evolution of the barrack area.

Considerable value may be obtained by visits of parties of officers and senior N.C.Os. to engineering works and to engineering projects under execution. Such visits should be carefully planned and organized ; and those under instruction should be required to submit reports on specific items, *e.g.* on methods and processes which appear to have a military application. Without some such check there is a risk of a visit degenerating into mere sight-seeing.

The N.C.O. should not only be a competent tradesman, able to instruct and to oversee work in his own trade, but should also have a sufficient general knowledge of other trades and of constructional practice to be able to take charge of parties on building work, reinforced concrete construction, water supply, road work, etc. The execution of engineer services, as described in Sec. **13,** provides opportunities for the acquisition of this knowledge.

The maintenance of a high standard of constructional and trade skill in the sapper ranks of regular engineer units calls for the provision of adequate facilities for peace time training. Without these facilities the engineers will be unable to meet the demands on their technical skill in war, and will fail to attract the right stamp of recruit in peace. The greater part of the time that can be made available during the individual training season will, therefore, be devoted to maintaining and improving the individual trade skill of the sapper ranks. In those units which have a special role, such as fortress engineers, engineers of anti-aircraft formations, and transportation and survey units, individual training for that special role (*see* paragraph 7, below) should claim particular attention, but such training itself usually involves a considerable measure of trade training. In field squadrons and field companies

trade training should be carried out continuously throughout the individual training season, except during the leave period, the periods allotted to other branches of training (Sec. **12,** 10) and occasional days required for some other purpose. In field park companies the necessity of a high standard of trade skill will normally require the allotment of eight months of the year to trade training, the extra time being obtained at the expense of the collective training periods (*see* Sec. **16,** 2).

ii. Efficient trade training depends on the adequate provision of :—

Workshops, with the necessary equipment, instructional tools and plant.

Workshop control organization and a staff of trades instructors.

Expendable stores and materials.

The authorized scales of workshop accommodation for the trade training of engineer units are normally laid down, either in the Barrack Synopsis or in tables specially approved by the higher command. Where the existing provision is inadequate, it is the duty of engineer commanders to initiate action to make good the deficiencies. Where a number of engineer units are grouped together in one station, the C.E. will advise the higher command as to the extent to which their workshop requirements can be combined, so as to minimize expense and to reduce the overhead organization for their control. A divisional engineers quartered in one station will normally be provided with combined workshops.

Tools for trade training, whether carried out in workshops or on outside works, will be supplied on loan for the individual training season by the officer in charge of R.E. stores from Class A stores. They will be supplemented by tools on unit peace equipment charge, except in stations where centralized workshops are in use. The principle to be followed is that every man under training should be supplied with his individual set of tools, which he can be required to maintain in good order and for which he can be held responsible.

Plant for trade training other than plant on unit peace equipment charge will be held as Class B stores.

The control organization and instructional staff of the workshops of engineer units will be drawn from the authorized establishments of the dependent units. An officer in charge of workshops will normally be appointed ; and he should not be changed, if it can be avoided, for a year. When a field park company is present in a station, it should be vested with the organization and control of the workshops, including the

maintenance and store accounting of equipment, tools and expendable stores, the supervision of all work carried out in the shops and the maintenance of attendance rolls, job cards and such other records as may be ordered by the engineer commander. For these purposes the field park company may require to be reinforced during the individual training season by personnel lent by other dependent units.

Stores and materials appearing in the V.A.O.S., required for trade training of trade classes under instruction in unit workshops, will be drawn as required from the R.A.O.C. (Equipment Regulations, Part I, 1923, para. 399A). Non-vocabulary stores required for the purpose, and all stores to be expended on engineer services, will be supplied under arrangements to be made by the C.R.E. of the area in which the unit or work is located, and their cost will be debitable to Vote 10c.

iii. In organizing trade training in units, engineer commanders should bear in mind the two-fold effect of the maintenance and improvement of trade skill in the individual. In addition to maintaining or increasing his value as a tradesman during his colour service, it enhances his prospects of obtaining civil employment at his trade, and thus of maintaining his skill during his service in the reserve. Every effort should therefore be made to enable qualified tradesmen seeking such employment to work continuously at their trades during the last four months of their colour service, if necessary at the expense of other branches of training in which they are already proficient.

Pioneers, R.E., on completion of their recruits' training, are normally retained at the R.E. Depot, Chatham, for a course of trade instruction to enable them to obtain a trade rating. Pioneers who have failed to reach this standard before joining their units should be formed into special trade classes during the individual training season. Pioneers * will also be given the opportunity, during the last six months of their colour service, to acquire a standard of skill sufficient at least to qualify them to act as mates to skilled tradesmen on return to civil life. With these two exceptions, the claims of pioneers to trade training must necessarily be subordinated to those of skilled tradesmen, especially as regards the requirements of fatigues and of unit employment. These employments should be kept under constant scrutiny and reduced to a minimum; and every opportunity should be taken to give trade training

* The army vocational training centres are closed to R.E. personnel except drivers H.T. and I.C. (driver-mechanics, Class I, in Group "C" of the Pay Warrant, 1932, Appendix IV, are excluded).

to pioneers who approach the standards required of skilled tradesmen.

Personnel of field park companies employed on works or trade training should, as far as possible, be exempted from garrison and regimental duties on working days. During the trade training periods allotted to these and to all regular engineer units the aim should be to work at least to a 30-hour week at trade instruction.

iv. The initial training of a man for a trade rate, or for a higher rate, is best carried out in a properly supervised class in a workshop. A progressive syllabus will be essential, and progress should be checked at intervals by means of regulating tests designed to show whether the learner has mastered each stage.

When the learner has acquired the requisite knowledge and skill, he should (in appropriate trades) be given practical experience by employment on outside jobs, so that he may acquire confidence to apply his craftsmanship under the conditions which he will find both on active service and as a reservist in civil life. Such experience may often be combined with the execution of productive work, including works services under the C.R.E.'s staff (*see* Sec. **13**), but the paramount consideration must be the enhancement of the trade skill of the individual.

Full advantage should be taken of the trade improvement classes held at the S.M.E.

7. *Special role training.*—The special roles of certain engineer units require a high standard of individual technical training in the use of the equipment, tools and plant with which those units are equipped. Details are contained in the appropriate technical manuals.

The training, particularly of officers, in the special role should not, however, be allowed to obscure the necessity of the wider training already mentioned. Conversely, all officers should have some knowledge of the work of that large proportion of the corps which operates searchlights, whether in coast defence or in anti-aircraft work.

Some knowledge of transportation work is also desirable and, where facilities exist, lectures by expert officers should be arranged, and demonstrations organized, for the instruction of officers and N.C.Os. of non-specialist units.

8. *Physical training.*—The maintenance of physical fitness is largely a matter of individual initiative, which engineer officers must do all in their power to encourage and facilitate. Engineer officers themselves, in addition to taking part in games, should be encouraged to follow such pursuits as

flying, hunting, polo, big game shooting, yachting and ski-ing. The inclusion of engineer officers in expeditions organized for purposes of exploration or scientific research is particularly valuable.

In each squadron or company at least one N.C.O., not above the rank of serjeant, should have qualified at the Army School of Physical Training.

All trained soldiers will be exercised as laid down in Physical Training, 1937, Sec. 22. No engineer soldier can be considered physically efficient until he has passed the swimming test (normally carried out during the recruits' training course). This consists of swimming a distance of 60 yards (100 yards in salt water), wearing a suit of canvas. Men who have not passed this test will be placed under instruction until successful.

9. *Mental and educational training.*—The regulations for the conduct of education in the army are contained in Educational Training. Formal education is, however, only a preliminary step towards the mental efficiency of the individual. The maintenance of mental alertness is dependent on individual initiative, and is an essential qualification for all engineer officers and other ranks who aspire to professional advancement. Every encouragement should therefore be given to officers and N.C.Os. for the private study of subjects for which they have a natural bent. These subjects include military subjects, general subjects (such as languages and the various optional subjects included in the Staff College entrance examination) and a wide range of technical subjects dealing with the engineering sciences.

No N.C.O. can be considered to have reached an adequate standard until he has gained the first class certificate of education; and no sapper or driver will be properly equipped for his duties until he has gained the second class certificate. These are minimum standards; the educational training of the soldier will therefore continue until he reaches these standards.

10. *Training in administrative duties.*—It is the duty of every engineer commander to ensure that he has an adequate and fully trained administrative staff, that his pay and quarter-master's staff are fully conversant with their duties, and that the clerical staff is efficient and is given opportunity and encouragement to improve its efficiency in drafting routine correspondence, its knowledge of the regulations and its proficiency in typing and shorthand. On the efficiency of the administrative staff depends largely the liberty of the commander to give full time to his duties of training the fighting portion of his unit.

The training of the administrative staff in its individual and collective duties in war must not be overlooked.

11. *The organization of the individual training period and unit programmes.*—The individual training season normally covers a period of five to six months, including a leave period of four weeks. The courses of trade training should therefore be not less than sixteen weeks, exclusive of periods of preparation and closing down.

In organizing individual training in regular units, it will be necessary so to arrange leave and furlough that units or sub-units may be as complete as possible for continuous periods of at least a month at a time. The programme should be drawn up on a flexible basis, so as to allow for holidays, inspections and other unforeseen commitments which will inevitably encroach on it. To this end, it may be desirable to regard each month as consisting of four weeks, each of four and a half working days (two afternoons for recreational training) ; so that Saturday mornings can be reserved for military or other training, or for administrative routine ; and so that there may be some spare days in hand.

Of the main items of training, as classified in para. 1, above, portions of items i, ii, iii, iv, vi and vii, can suitably be included in the syllabus of cadre classes for the training of unit instructors. In divisional engineers, and in units of similar organization, these classes should be held under centralized arrangements, so that the fullest use may be made of the pooled resources in officers and N.C.Os. who have undergone courses at army schools of instruction, or who have special knowledge of certain subjects.

In framing the individual training programme, the demands of items v and vi (para. 1, above) on the time of the sapper ranks will generally confine instruction and practice in items i, ii, iii, iv and vii to one half-day in each week (*e.g.* to Saturday mornings), reserved for that purpose as indicated above, and to such other short periods as can be made available (*e.g.* to an opening half-hour on four days a week).

Appendix I shows, in illustration of the above considerations, a typical individual training programme for a divisional engineers located in one station.

12. *Employment records.*—In order to allow commanders to see that personnel are not wrongly employed, and to permit of the correct preparation of the statistics required by A.F. B 2094 and A.F. B 2094A, all engineer squadrons and companies (Regular Army), except depot units, will maintain in convenient form an employment book showing the employ-

ment of each man on each working day throughout the year. The following abbreviated headings are given as an example :—

T—Trade training.
M—Military training.
F—Field engineering training.
R—Special role training.
S—Sick list.
L—Leave.
D—Guards and duties.
A—Employment in an administrative appointment.
E—Fatigues and other employment.

This book will be shown at all technical inspections.

13. *Individual training in non-regular units.*—In organizing individual training in non-regular units, the limited time available in the out-of-camp training period will call for planning in considerable detail, but the special circumstances of the Supplementary Reserve and the Territorial Army will render flexibility of even greater importance. Separate classes should be formed for men suitable for advancement, for trained soldiers and for recruits ; and every effort should be made to synchronize the attendances of the members of the classes, so as to minimize repetition or omission of items on account of the absence of individual members in a class.

During the early part of the out-of-camp training period, or as soon as practicable after the conclusion of the annual camp training, cadre classes should be held with a view to providing a plentiful supply of officer and N.C.O. instructors for the ensuing individual training. The success of these classes will depend largely on the extent to which it has been possible to send officers and N.C.Os. to undergo courses at the S.M.E. or other establishments appropriate to the role of the unit.

For each class a syllabus should be drawn up, showing the ground which it is intended to cover at each attendance, with references to the training manuals concerned. The existence of a clear syllabus, combined with a record of the attendances of each member of the class, will help to preserve continuity, and to avoid overlaps and omissions, due to unavoidable changes in the instructor or to irregular attendances of those under instruction.

As indicated at the end of para. 5, above, the application of standard tests and the maintenance of a record of results obtained for each soldier will help to direct effort towards definite objectives. Moreover, under such a system, the spirit of rivalry between detachments, sections and units

will stimulate both instructors and men under instruction to cover the requisite ground. (*See* Appendix VIII.)

The success of the individual training season will, however, depend ultimately on the amount of voluntary effort which all ranks are prepared to make, over and above the minimum obligations which they have accepted. The example set by the officers and N.C.Os. of a unit, and the extent to which they can lend interest and conviction to their training, will usually be the measure of the response made by their men.

13. Employment of engineer units on works services

1. The employment of engineer units on the execution of works services for the works staff of the C.R.E. of the area may afford valuable training. Its possibility will depend on factors such as the strengths of units in officers and other ranks, the standard of trades skill in units and the nature of the services awaiting execution. Thus in favourable circumstances a unit may be able to take over a service from the outset, and to complete it within the time available, at least to a definite stage. On the other hand it may only be possible to employ a limited number of skilled tradesmen (*see* Sec. **12,** 6, iv) for work under the direct supervision of the C.R.E.'s staff.

Such employment, in addition to providing a productive means of improving trade skill, may afford useful opportunities for officers and N.C.Os. of units to practise themselves in the preparatory measures incidental to the execution of every engineering work, and in its organization and direction. It must be clearly understood, however, that the primary requirements of officers and N.C.Os. serving in units are to carry out their duties in the unit and to profit by the experience which such service alone can afford ; and these requirements must not be subordinated to an over-ambitious programme of employment on works services. This applies particularly to junior subalterns in their first year of service with units.

2. When a unit takes over the execution of a complete service, it is desirable that one officer should be in continuous charge from start to finish, and that the work should be carried out as far as possible by his own unit tradesmen. His responsibilities may then include :—

i. Design of small works, or, if a standard plan is to be used, its adaptation to the site.
ii. Estimates of stores, and demands for them as required during execution.
iii. Working drawings of details.
iv. Levelling and lay-out.

v. Organization and supervision of work.

vi. Estimates of the cost of stores and of the labour costs of all work not to be carried out by unit labour, the two making up the total estimated cost of the work as executed. The C.R.E.'s work staff will estimate the cost of the work by contract; and the two estimates will be compared before the work is authorized.

The preparation of detailed drawings should, as a rule, be carried out by the draughtsmen of the unit rather than by the C.R.E.'s staff.

The demands on the officer's time by his other duties in the unit may preclude his discharging all the responsibilities enumerated above, and his duties must therefore be clearly defined beforehand.

Interest will be stimulated by the maintenance of a time and progress schedule, by means of which the rate of progress of the work can be compared with a standard based on the constants of labour given in Military Engineering, Vol. VII.

3. As a rule, the most suitable services for execution by a unit will be Part II services, or services forming part of a Part I general item, involving the employment of a variety of trades in proportion to the strength of trades in the unit. The C.R.E. will submit recommendations to the C.E. a year in advance, and the latter will obtain the authority of the command staff for a selected service to be ear-marked for execution by an engineer unit.

Failing suitable larger works, a variety of smaller works may be selected for their training value both to tradesmen and to junior N.C.Os., who can be made responsible for their execution.

The work or works selected should be within the compass of the engineer unit or group of units (*e.g.* divisional engineers) which is to be responsible, without any risk of encroachment on other training activities planned.

In order to avoid waste of time on uninstructive work, arrangements should be made for the execution under normal works staff routine of such preparatory work as demolition, clearing of the site, levelling and in special cases, foundations, stacking stores on site, drainage, etc. It may also be desirable to provide some civilian labour for use as mates, but this must be carefully organized so that such labourers may be fully employed during hours when the troops are not on the work. In no circumstances will unit tradesmen, of trades not wanted on the work, be employed as labourers to building trades on the unit task.

14. Collective training—General

1. The collective training season of regular engineer units, subject to certain exceptions specified in the succeeding sections, consists of three periods :—

i. General military training.
ii. Special military training.
iii. Combined training in co-operation with other arms.

The time to be allotted to each period depends on the type of unit and on local and other factors. The periods will not necessarily be continuous ; and allowance will be required for seasonal leave.

2. The period allotted to general military training necessarily includes a short time for the recapitulation of certain military training items of the individual training periods. Engineer commanders must appreciate, however, that such recapitulation should be reduced to the minimum necessary to ensure a sound basis for the collective training to be undertaken. Any tendency to shelve such items during the individual training season, with a view to carrying them out during the early part of the collective training season, must be suppressed. Furthermore, if the fullest use has been made of the time available during the individual training season, it should be possible to economize in the time to be allotted to such subjects as elementary drill, and to allot adequate time to those subjects which, for climatic and other reasons, can only be studied during the collective training season.

During the general military training period the following will be among the subjects requiring attention :—

i. Drill and manœuvre of units, sub-units and transport.
ii. Tactical training.
iii. Weapon training, including the annual range practices.
iv. Collective anti-gas training.

At the conclusion of this period, the unit should be able to move efficiently, embussed or otherwise, by road or across country ; to adopt suitable formations, or to take other appropriate action, in such situations as it may encounter in war in respect of ground, enemy fire, enemy air action and gas ; to make full use of concealment and cover ; to undertake its own protection against all forms of attack ; and to fight as infantry (or dismounted cavalry), if required.

3. The special military training period is sub-divided into two parts : field engineering, carried out by the majority of engineer units ; and special role training, carried out by those engineer units (*e.g.*, anti-aircraft units and railway companies) which have a special role.

The period of training in field engineering (or, in specialist units, the period of training in the special role), as being the main period during which the unit is practised as a whole in the execution of its engineer role in war, is of primary importance. It is therefore essential that every man of the unit should take part in it and that the minimum periods laid down in the following sections should in no case be reduced. Administrative and other employed men should be relieved of their duties as far as possible, so that they may undergo at least a proportion of the training. No soldier will be granted total exemption from it, save in exceptional circumstances and with the sanction of divisional or higher headquarters.

(For personnel of the Railway Training Centre the sanction of the C.E., Aldershot Command, will be required for exemption from either military or field engineering training.)

All collective field engineering training should be given a tactical background and should be carried out against time and under war conditions. At least twice in each collective training season each unit should execute a considerable work, such as bridging, mining, etc., extending over 48 hours and involving work in continuous reliefs and by night. For this purpose it may be necessary to group two or more units together to form a unit at war strength.

Wherever, throughout the field engineering training period, a definite job, limited by the conditions of the tactical situation, cannot be given, it is important to stimulate interest and energy by organizing training in the form of task work, or by introducing the element of competition between units or sub-units. Just as engineer tasks in war call for speed in execution, so also in peace the idea should be eradicated that all work necessarily starts and stops at fixed hours; and all ranks should understand that smart and zealous work, resulting in early completion of the job in hand, will earn them increased leisure.

When a senior inspecting or visiting officer approaches an engineer unit or party at work, the officer or N.C.O. in charge of the party will, if conditions of safety permit, fall out and report the designation of the party and the nature of the work in hand. He will not call the party to attention and interrupt the work.

Training in field engineering and in special roles will be based on the details contained in the Manual of Field Engineering, Vols. I and II, in the volumes of the military engineering series and in the special technical manuals.

4. Training in co-operation with other arms is the culmina-

tion of the annual training of all engineer units, other than those, such as transportation units, having an administrative role.

In units which have a special role, such as fortress companies, anti-aircraft units and survey companies, the type of co-operation required is usually of a definite nature. In order that the requisite units of the other arms, or of the Royal Navy and Royal Air Force, may be made available to participate in this training, the higher engineer staffs must plan well ahead. Exercises should be drawn up by or with the approval of the commander concerned, in order to ensure that the schemes on which the training is to be based are practical and likely to afford the desired instruction, and that the troops required to co-operate shall be made available.

In units which have a more general role, such as divisional engineers, the difficulties of the execution of engineer work under peace time conditions are apt to detract from the realism of the co-operation which it is desired to practise ; and it is only by the active liaison of C.Es. and C.R.Es. with the staff, in the preparation of the tactical exercises to be carried out, that the best results can be achieved. For further details, *see* Sec. **28,** 6.

5. Throughout the collective training period engineer commanders will ensure that an adequate proportion of training in night work is carried out in their units. Regular units will practise by night every type of operation, both military and technical, that they may have to carry out by night in war.

Training under gas conditions will be carried out both by day and by night. All ranks will be exercised at least once in wearing respirators for a period of two consecutive hours, this being the essential minimum necessary to accustom them to carry out their normal duties in the presence of gas. (*See* Defence Against Gas.) All ranks will be practised in working in protective clothing.

6. Appendix II shows a type of collective training programme suitable for a field company. As in the specimen individual training programme, to provide flexibility, the month is treated as consisting of four weeks, each of five working days.

All regular engineer units will keep a record of the collective training carried out, on A.F. B 2094, in accordance with the instructions given on that form.

7. The collective training of non-regular engineer units, although based on the same principles as that of regular units, is necessarily carried out on a different system. The main

difficulties to be overcome are the shortage of time available for training, the frequent shortage of training facilities (instructors, ground and equipment), and the uneven standard of training among recent recruits and trained men of varying length of service. The remedies applicable will vary with the circumstances of each unit, but some or all of the following points will always require attention :—

i. Every item of training must be prepared beforehand in detail, so that, according to the resources known to be available and to the standard of knowledge of the unit or sub-unit, a scheme or programme can be drawn up which will convey the required lessons in the shortest time. Without such preparation time is invariably wasted.

ii. Whenever possible, annual camp training should start and finish on a Sunday. The parades held on the middle Sunday of a fifteen-day camp may afford incidental practice in close order drill and turnout, thus saving time for other training on week-days.

iii. Week-end camps during long holiday week-ends, such as Easter, may afford opportunities of eliminating or reducing the time which would otherwise have to be found for items of training at the annual camp. The growing resources of command pools of mobile bridging equipment and of power plant increase these possibilities.

iv. The relative importance of the three sub-divisions of collective training (para. 1, above) must be carefully weighed according to the role of the unit in war and to the availability, or otherwise, of a final period of post-embodiment training ; and time must be allotted accordingly.

v. Full use will be made of the assistance which can be given by affiliated regular units, and any difficulties should be reported to the C.E. of the command for instructions (through the C.R.E. of the area, if applicable).

15. Collective training of a field squadron

1. In a field squadron (Regular Army) the training of the horsed sections (if any) and of the mechanized sections, both military and technical, will of necessity differ. It is essential that there shall be a regular turn-over of N.C.Os. and men between the two, which should be complete every two years.

2. The military training period will normally last six weeks. The training of the horsed sections will conform in principle to that of a horsed cavalry section, with the omission of the portions relating to shock tactics. An important part of the training will aim at making the sections capable of independent

movement in the neighbourhood of the enemy. Swimming of horses will be carried out during the field engineering training period.

The training of the dismounted sections will cover the subjects in Sec. **14**, 2.

3. The field engineering training period will last twelve weeks, and will include :—

For the horsed sections.—

i. Reconnaissance for and the making of reports, both verbal and written, on the subjects detailed in items ii to vi, below, and also on engineer stores and water supply. N.C.Os. will be trained to make quick and accurate sketches.

ii. Wet and dry bridging with the mobile equipments and by improvised means.

iii. Demolitions.

iv. Hasty field fortifications.

v. The organization and control of working parties.

vi. Communications.

For the mechanized sections.—

vii. Wet and dry bridging with the mobile bridging equipments, and expedients for swimming horses and rafting vehicles across rivers. For this purpose the field squadron will attend a bridging camp annually for not less than two weeks.

viii. Demolitions and road cratering, and hasty methods of wrecking power stations and other installations.

ix. Communications, including roads and tracks, and the decontamination or safe passage of routes contaminated with persistent blister gas.

x. Hasty field fortifications in mobile warfare, including the siting, design, construction and concealment of field defences (including gas-proof structures), and the clearance of fields of fire, road blocks and other obstacles against infantry and armoured fighting vehicles.

xi. Water supply.

xii. Camp services.

And, if time permits.—

xiii. Bridging with the heavier natures of stock span bridges, and with R.S.Js., heavy timber and improvised piers.

4. The period of training in co-operation with other arms will depend on the programme of higher training, but every effort should be made by C.Es. and field squadron commanders to ensure that field troops, at least, are employed in the brigade training exercises, even if no higher formation training is to take place. This is essential for the training of troop leaders in the control of their troops.

5. In field squadrons of the Territorial Army the annual camp training will follow the general lines described in the preceding paragraphs. The wide range of training to be covered will necessitate the training being organized on a four-year cycle, in a similar manner to that described in Sec. **16,** 4, for divisional engineers of the Territorial Army.

16. Collective training of divisional engineers

1. In a regular field company, provided that the necessary opportunities for drill, weapon training, etc., are made during the individual training season, it should be possible to reduce the general military training period of the collective training to four weeks. It may, however, be extended with advantage to six weeks, so long as the full field engineering course is not reduced thereby. Opportunities for tactical training, which should not be neglected, will occur during later periods of the collective training season.

The general military training period will cover the subjects specified in Sec. **14,** 2.

A period of not less than twelve weeks will be allotted to field engineering, and will on no account be curtailed. The subjects for training will include :—

i. Field fortification in mobile warfare, including : the siting, design, construction, repair, concealment and camouflage of all forms of field defences (including gas-proof structures) ; the clearance of fields of fire ; and the preparation of obstacles against infantry and armoured fighting vehicles.

ii. The elaboration of field fortifications in position warfare, and the deliberate preparation of a defensive system, including reinforced concrete works.

iii. Wet and dry bridging with the mobile bridging equipments, and improvised methods of crossing rivers and gaps.

iv. Bridging with the heavier natures of stock span bridges, and with R.S.Js., heavy timber and improvised piers.

v. Communications, including roads and tracks, and the use of road making machinery.

vi. Decontamination of areas and structures, and the safe passage of routes contaminated with persistent blister gas.

vii. Demolitions and road cratering, and the hasty wrecking or dislocation of power stations and other installations.

viii. Mine warfare.

ix. Water supply.

x. Camp services, including the erection of standard war hutting and shedding.

Of the above items, ii, iv, viii ix and x may, at the dis-

cretion of the C.R.Es. be covered in a two-year cycle, but i, iii, v, vi and vii will be practised annually.

Of the field engineering period not less than three weeks should be spent in bridging camp for the practice of pontoon and folding boat equipment bridging. One working week should suffice for the more elementary drill with the equipment, rowing, etc., the remainder of the time being devoted to larger exercises involving the complete passage or bridging of a stream under active service conditions. Each unit will carry out at least two such exercises by night. For these larger schemes it may be necessary to combine units to form units at war strength, any surplus officers and N.C.Os. being employed on watermanship, reconnaissance and T.E.W.Ts. or E.E.W.Ts. involving preparation for the passage of a river.

The period of training in co-operation with other arms will depend on the programme of higher training, but every effort will be made by C.Es. and C.R.Es. to ensure that field companies are employed in the brigade training exercises, even if no higher formation training is to take place.

2. The collective training season for a field park company will normally be four months, including the general military training period of four weeks (as laid down for a field company in para. 1, above), but excluding the period during which the unit may be employed in the construction of camps, which may be regarded as part of the trade training period.

The exact allotment of the time available will depend to some extent on the programme of higher formation training for the year; but, in making this allotment engineer commanders must bear in mind the primary functions of a field park company (*see* Sec. **54,** 2), which are essentially technical, involving a high standard of skill with tradesmen's tools. A typical allotment of the four months available might work out as follows :—

General military training	...	four weeks.
Field engineering	...	ten weeks.
Co-operation with other arms	...	two weeks.

The field engineering period will be devoted to the items laid down in para. 1, above, for a field company, omitting item viii. Items ix and x will often be covered adequately by the period spent on camp construction, supplemented by practice in hasty methods of water supply in the field. Of the remaining items, i, iv, vi and vii, will be practised annually and ii, iii and v at least biennially. The field park company should attend bridging camp for three weeks, at least in alternate years.

The field park company will join in combined training with

other arms only in divisional and higher formation exercises. On such occasions a M.T. pool for the carriage of a field company should be formed.

Although the collective training of the personnel of a field park company will be carried out on uniform lines, the functions of the various sub-units will be practised. Thus the mobile workshop may be employed for turning out stores required by the field companies and for camp construction. Opportunities should be found to use the bridging and stores groups during the field engineering course and during the combined training of all arms. The electric light detachment, which should be duplicated, will be used in camp and during higher formation training.

3. C.R.Es. of divisions should endeavour once in each collective training season to carry out a combined engineer exercise for all units of their command, under their own direction or that of their divisional headquarters, in which movement is combined with field engineering or with the preparations for the execution of work carried out under war conditions.

4. In divisions of the Territorial Army the annual camp training will follow the general lines described in para. 1, above. The wide range to be covered in the field engineering and other collective training renders it essential, however, that the training should be planned generally on a four-year cycle, so that each man who attends camp may cover the whole syllabus during the term of his normal engagement. Details of the cycle may vary with local conditions, but a suitable cycle might run as follows :—

i. Field defences, obstacles and demolitions.

ii. Wet bridging, preferably at a major bridging camp.

iii. Dry bridging, with resources provided under command arrangements.

iv. Drill, manœuvre and mobility, combined with engineer reconnaissance, and such items as water supply and hasty communications.

At least one annual camp in a four-year cycle should be arranged in conjunction with units of other arms ; but combined exercises should be held sparingly, and only when it is clear that they will afford definite training for the engineers.

5. The camp training programme should be framed on progressive lines, and should include exercises involving movement both on a section basis and on a company basis, for which purpose the pooling of transport is essential. The

responsibility of company commanders for directing the training of their own units should be curtailed as little as possible. The number of officers employed on the supervision of elementary field engineering should be reduced to a minimum, and every opportunity should be taken to develop the technical leadership of officers and N.C.Os. by means of exercises on the ground. At annual camps all officers should make the most of the opportunities of commanding their men on parade.

Appendix III gives an outline programme for the organization of the camp training period, for the general guidance of C.R.Es. This should be adapted to local requirements rather than rigidly followed.

The framing of the detailed programme should be put in hand well in advance of the camp period, so that there may be ample time available for reconnaissance for the work to be undertaken, and so that the stores and transport required for each item can be worked out and allotted to the best advantage. By thoroughness and foresight it is possible to eliminate delays due to officers and N.C.Os. being inadequately informed of their roles in the work of the day, or to the late arrival of transport, or to a shortage of essential stores. Such delays cause waste of time and deaden interest in training.

17. Collective training of army troops companies (Supplementary Reserve and Territorial Army)

1. The collective training of an army troops company will aim at fitting it for any of the roles that it may have to fill in war. For, although individual companies may be allotted initially to the forward area and to the L. of C. area respectively, it is probable that they will be transferred later, as the engineer situation requires.

In the forward area, as corps engineers, they will be required to undertake a wide variety of constructional work and they will also be required to supplement and to re-inforce the engineers of forward divisions in such work as field defences, bridging and other communications, and demolitions. (*See* Secs. **69,** 2; **92,** 4; **93,** 5; **95,** 7; **101,** 3; **106,** 5; and **110,** 30.) In this role their military training and their training in field engineering will have to be comparable to that of the field companies; but, as they will seldom be employed in such close proximity to the forward troops, a less rigorous standard will suffice. It will be essential, however, that they shall be trained to the effective use of their weapons, and in the measures necessary for defence against gas and attack by armoured fighting vehicles, and all forms of air attack.

In the L. of C. area they will be mainly employed on con-

structional work, but they may also be required to play an active part in L. of C. defence (*see* Sec. **119**). Thus, although the standard of military training required may be somewhat less than that demanded in the forward area, they will still require a sound knowledge of the use of their weapons, and of defence against gas, attack by armoured fighting vehicles and all forms of air attack.

2. While the training standards required thus cover a wide scope, the short time available to the Supplementary Reserve and the Territorial Army for collective training necessitates the elimination of those branches which are adequately covered by the civil occupations of the officers and men. For example, general constructional work, camp water supply and other camp services, as required in corps areas or on the L. of C., do not call for any qualifications that differ materially from the normal peace experience of the men especially in Supplementary Reserve units, so long as the officers have a knowledge of the general nature of the work required.

On the other hand, training will be required in purely military duties, in branches of field engineering which have no exact counterpart in civil practice and in the use of engineer tools, plant and equipment which are employed in the field.

3. The collective training of an army troops company should therefore include :—

i. Drill, weapon training, fire direction and control, elementary tactical work, and anti-gas discipline and procedure.

ii. Elementary field defences, the use of obstacles of all kinds, and the gas-proofing of structures.

iii. Demolitions.

iv. Rough communications and tracks in the field, and the decontamination of gassed routes.

v. Bridging with the medium and heavy mobile bridging equipments.

vi. Heavy bridging with stock spans and other means.

vii. The use of technical vehicles and power tools of the types forming part of its war equipment.

viii. Water supply in the field.

Of the above items, i must be carried out annually, and the remainder should be covered in a four-year cycle.

4. In addition to the above, every opportunity should be taken during the annual camp to broaden the scope of the training of officers and N.C.Os. by means of reconnaissances and of engineer and tactical exercises without troops.

It will be of value if officers can be attached to regular field companies during the field engineering courses carried out by the latter, or during the period when camps, water-points, etc., are being prepared for manœuvres.

18. Collective training of electrical and mechanical companies (Supplementary Reserve)

1. In the collective training of electrical and mechanical companies the technical training and experience of the personnel in their civil occupations will enable attention to be devoted chiefly to the purely military aspect, and to the adaptation of their skill to war conditions.

2. The collective training of an electrical and mechanical company should therefore include :—

i. Drill, weapon training, fire direction and control, elementary tactical work in the defence, and anti-gas discipline and procedure.

ii. Elementary field defences, including measures of defence against air attack with H.E., incendiary or gas bombs, and against air spray ; and the construction of revetted traverses and shell slits.

iii. Methods of gas-proofing various structures, their decontamination, and the decontamination of gas-sprayed machinery.

iv. Demolitions, with special reference to methods of wrecking large installations for the supply of power, light, water, etc. (*See* Sec. **97,** 2, last sentence.)

v. Extemporized arrangements for the supply of power or water from ill-assorted units of equipment and plant, under active service conditions.

vi. The use of technical vehicles and power tools of the types forming part of the war equipment.

Of the above items, i must be carried out annually, and the remainder should be covered in a two-year cycle.

The execution during the annual camp of engineering work outside the scope laid down above may sometimes be desirable, provided that it exercises officers and N.C.Os. in the technical control of their sub-units and stimulates the collective efficiency of the whole company.

3. As in army troops companies (Sec. **17,** 4), the scope of the training of officers and N.C.Os. can be broadened considerably by the conduct of exercises to study details of method and organization for the execution of which facilities may be lacking.

Collective training will be facilitated if the annual camp can be held, once in every two or three years, in the vicinity of a big military centre, where the cooperation of engineer units and establishments of the Regular Army can be ensured.

19. Collective training of a workshop and park company (Supplementary Reserve)

1. The collective training of a workshop and park company will be generally similar to that of an electrical and mechanical company, as given in the preceding section, except that items v and vi are inapplicable. In addition, army methods of workshop organization (*see* Textbook of Mechanical Engineering, and Military Engineering, Vol. VII), and of the classification of and accounting for engineer stores should receive attention.

2. In framing exercises for the training of officers and N.C.Os., schemes for the adaptation and utilization of local resources in workshops and stores may usefully be included.

20. Collective training of fortress engineers

1. In fortress units (Regular Army), the general military training period will normally last six weeks, and will cover the subjects specified in Sec. **14,** 2.

The special military training consists of field engineering and special role training, the latter being mainly concerned with the defence of the fortress against attack by ships or by aircraft, according to the special role of the unit or sub-unit.

The field engineering course should last at least eight weeks, and will cover the same subjects as those laid down for a field company (Sec. **16,** 1), subject to modifications based on local requirements and on local facilities. Thus the period allotted to field fortifications (item i of the field company syllabus) may suitably include beach defence works, under-water obstacles against landing craft, electrified wire obstacles and the operation of remote-control devices against a landing. Similarly, the bridging work (items iii and iv of the field company syllabus) may be partially replaced by pier construction work as on a landing beach ; and the work on communications should include light railways and beach roadways. The importance of this course lies not only in its direct training value to the fortress engineers, but also in its being an essential condition for the flexibility of the engineer organization as a whole, for the reasons given in Sec. **10,** 3. On the other hand the primary war role of fortress engineers necessitates a definite priority of importance being given to their special role training.

For this reason it will not usually be possible to cover the whole syllabus of the field engineering course in a single year, and it should therefore be organized on a two-year cycle.

The special role training of an electric light company consists of the manning of the engineer defence installations or equipment of the fortress to which it is allotted, firstly by sections, and then as a company, to fit it for the combined training with other arms later. This training may be spread throughout the year to suit local conditions, *e.g.*, at home stations, the early darkness of the winter evenings is often the most convenient period.

The special role training of an anti-aircraft company consists of the manning of the anti-aircraft searchlight stations of the fortress to which it is allotted. Training cannot be carried out without the co-operation of aircraft, and will take place at such times of the year as weather conditions will be least liable to prevent night flying. Individual training may be carried out by sections; but for night co-operation as many stations as possible should be manned by the company, since it is not possible to get good training when only a few lights are employed.

The special role training of both electric light and anti-aircraft units, carried out under the supervision of the O.C. Fortress R.E., will include night runs (at least 20 for a coast defence unit and 40 for an anti-aircraft unit), distributed as convenient throughout the year. The opportunity will be taken to practise electric light personnel in manning anti-aircraft lights, and *vice versa*, so that the units may be capable of reinforcing each other mutually in case of necessity.

The combined training in co-operation with other arms is carried out under the orders of the commander of the defences in conjunction with the manning of the fortress by the garrison, or with that of the air defences by the troops and aircraft allotted to them.

The O.C. Fortress R.E. is responsible under the C.E. or C.R.E. (as applicable) for the technical training of the personnel, and for ensuring that the lights, machinery and telephonic communications are in good order; while the commander of the defences is responsible that the unit is trained to work in tactical cooperation with the other arms.

2. In the Territorial Army the collective training of fortress engineers will follow the general lines laid down above, but the shortness of time available will necessitate certain modifications.

In electric light companies, and in electric light and works companies, the military training and the special role training

will be of predominant importance, but field engineering must also receive attention. With this end in view, a modified course of field engineering, on the lines laid down for regular fortress engineers, should, if possible, be carried out on a four-year cycle. This can usually best be carried out during the daylight hours of the camp training period. Although the functions of the works sections of electric light and works companies are the execution of minor repairs and the construction of fieldworks required for the fortress, these sections will be trained on the same lines as the companies to which they belong.

In anti-aircraft companies of the Territorial Army the shortage of time precludes peace time training in field engineering, but any opportunities should be taken after embodiment of rectifying this omission. At annual camps, therefore, attention will be given to military training and to training in the special role of anti-aircraft defence.

21. Collective training of an anti-aircraft battalion

1. In a regular anti-aircraft battalion the military training period will last six weeks, and will cover the subjects specified in Sec. **14**, 2.

The technical training period will include eight weeks' field engineering and sixteen weeks' anti-aircraft work, the latter including training in co-operation with the artillery and with the air force.

During the anti-aircraft course every effort will be made to carry out an average of ten night runs a month, or 40 in all.

Training in field engineering is of importance for the reasons given in Sec. **10**, 3, and also in view of the fact that anti-aircraft units, the only engineers of anti-aircraft formations, may be required to execute much of the engineer work required by their formations. The course will include items i, iii, iv, v, vi, vii, ix and x of those laid down for a field company, of which i, v, vi, vii and ix will be practised annually, and iii, iv and x on a two-year cycle.

2. In anti-aircraft units of the Territorial Army the collective training will be conducted on similar lines, except that the field engineering course will be omitted from peace time training and the annual camp will be devoted to military training and to training in the special role of anti-aircraft work in the field.

In order to achieve an adequate standard in this special role, the night runs which can be arranged during the annual camp will have to be supplemented by runs during week-end

camps and on such occasions as can be arranged during the out-of-camp training.

22. Collective training of a field survey company

1. The training of a field survey company is carried out by the Director General, Ordnance Survey (D.G.O.S.), under instructions issued by the War Office.

2. The military training includes drill, a triennial course of weapon training and training in anti-gas protection, including the decontamination of instruments and equipment and the gas-proofing of structures.

3. The technical training, in addition to the survey work afforded by the normal occupation of the personnel, should include :—

i. Exercises for officers in trigonometrical reconnaissance.

ii. Exercises for officers, in co-operation with artillery commanders and staffs, in the study of survey problems without troops.

iii. Exercises for N.C.Os. and men in :—
Triangulation and computing.
Height control for mapping from air photos.
Air photo plotting.
Medium scale plane tabling.

iv. Exercises in co-operation with the artillery survey company.

23. Collective training of a railway company

1. In a regular railway company the general military training period will last four weeks, and will cover the subjects laid down in Sec. **14**, 2.

2. A fortnight's course of field engineering will be held, based on the following items from the syllabus for a field company (Sec. **16**, 1) :—i, iii, v, vi, vii, ix and x. Owing to the short time available, these subjects will be dealt with at the discretion of the Commandant, Ry.T.C., on a two-year cycle, and in co-ordination with other field engineering subjects which form part of the special role training of railway units.

The remainder of the training season will be devoted to the special role of railway work under instructions from the War Office.

3. The commanding officer of the railway troops will be responsible for the general military and field engineering

training to the C.E. of the command, and for the training in railway work to the Assistant Director of Transportation at the War Office.

4. Personnel of transportation units of the Supplementary Reserve undergo collective training at the Railway Training Centre. This includes military training on the lines of para. 1, above, and training in transportation, the latter being primarily designed to train the personnel in the application of their knowledge of civil practice to military requirements.

CHAPTER IV

TRAINING IN FIELD OPERATIONS

24. General considerations

1. The training of an engineer unit for field operations should be based on a study of the sequence of events which take place in the execution of the tasks which may be allotted to it in war. Thus in the forward area, such a sequence might include reconnaissance, planning, the movement of the unit under tactical conditions and the execution of the work.

More often than not, in war, there will be difficulties in assembling the necessary engineer resources in men and material at the site of the work. These difficulties must be overcome, as delay may prejudice the success of the operations for which the engineer work is needed. It follows, therefore, that the individual and collective efficiency of the personnel at their work will be inadequate to ensure success unless the officers and N.C.Os. are trained to a high pitch in the solution of the technical, tactical and administrative problems on which the effective direction of engineer operations depends.

2. In peace training relatively few works of construction and destruction can be executed outside the restricted training ground allotted for the purpose, owing to the expense and inconvenience which would result. On grounds of expediency, therefore, the training of engineer leaders in their professional duties must be to a large extent carried out without troops and without the execution of works. Fortunately, much of the training required by officers and N.C.Os. lends itself readily to study without troops and without the execution of works. In such circumstances there is practically no limit to the choice of a suitable terrain; and any tactical or administrative situation that will serve to bring out the lessons of the training can be assumed, so long as it is true to the possibilities of war.

Furthermore, the study of problems without troops has the advantage that sound principles can be instilled in the minds of leaders, and their mistakes explained, without the risk of units and sub-units forming wrong impressions through being incorrectly handled. Consequently, even in those branches of training which can be readily undertaken with troops and with the execution of work, the preliminary training of leaders in exercises without troops is often desirable.

3. The succeeding sections deal in greater detail with the considerations outlined above.

25. Training in engineer reconnaissance

1. Field Service Regulations, Vol. II, deals with reconnaissance in general; and Sec. 90 of this manual with its use in engineer operations. This section deals with the training of officers and N.C.Os. in reconnaissance duties.

2. The execution of an engineer reconnaissance depends partly on the technical knowledge of the individual, and partly on his training in the technique of reconnaissance. Although no two reconnaissances are exactly alike, there is a method of procedure common to nearly all reconnaissances, a grasp of which is essential to success.

When an officer or N.C.O. is ordered to carry out a reconnaissance, his first duty, after he is satisfied that he clearly understands the questions which he is required to answer, will be to plan the reconnaissance. This involves an appreciation of the situation, however brief, on the lines laid down in Training Regulations.

Firstly, he should define, for his own guidance, the *object*, which will usually be a list of the points on which he must obtain information, so as to be able to answer the questions put to him by the officer ordering the reconnaissance. If this list is committed to writing, it will lessen the chance of any important detail being overlooked.

Secondly, he should consider the factors bearing on the accomplishment of that object. These may include :—

i. A study of the map, and of other information available, which may narrow the scope of the reconnaissance.

ii. Points on the ground which must be visited, or from which a good field of view is obtainable.

iii. The time by which the reconnaissance is to be completed, so as to admit of a report, verbal or written, being submitted by the time ordered.

Thirdly, he will formulate a plan for the execution of the reconnaissance. This will always include an itinerary and approximate timings of the route which he intends to follow. In addition, if the reconnaissance is to be followed by the execution of an engineer work, the plan may include preliminary movements of units, equipment and stores to convenient rendezvous, and other anticipatory measures.

3. On completion of a reconnaissance, a written report will often be required. In drafting this report, the individual who has carried out the reconnaissance must discriminate between the broad questions to which the commander requires

a brief reply and the often considerable detail involved in producing that reply. The latter may be of value to the commander to study at leisure later, or it may only concern the unit which is to act on the reconnaissance results. The report should therefore be submitted under two headings, such as " Summary " and " Detail." The former, although placed first, may sometimes have to be compiled last.

Sketches, adequately dimensioned and described, are a good method of showing engineer information, and may serve to reduce the length of reports.

Further details on engineer reconnaissance will be found in the Manual of Field Engineering, Vol. II.

4. Although an engineer reconnaissance is primarily technical, the tactical aspect must not be overlooked. For, although technical considerations may sometimes rule out what is tactically desirable, the reverse is equally true. Moreover, both the design and the method of execution of engineer works may be largely affected by tactical factors.

5. In training personnel in engineer reconnaissance the first and most important consideration will be to teach the general principles of the methods outlined above. With this object the exercises set in the early stages should involve only the simplest technical problems, well within the powers of the students.

When these principles have been mastered, the scope of the exercises can be extended to include more advanced technical questions ; and the experience of the students can be widened by introducing such problems as are mentioned in Sec. 90, 2.

26. Exercises without troops

1. Exercises without troops are a convenient method of training leaders of all grades, from the higher engineer commander to the junior N.C.O., in the duties which they may have to carry out in war. Almost any situation can be depicted, and it is thus possible to bring out a variety of lessons on the handling of engineer problems in the field.

Training Regulations contain detailed information on various types of exercises without troops.

The aim of this form of training, whether applied to tactical or to technical work, should be that company commanders should eventually be practised in dealing with the problems which confront a C.R.E., and junior officers with those of a company commander. Similarly, warrant officers and senior N.C.Os. should be practised in the command of a detached

section, and junior N.C.Os. in such problems as might face a section serjeant.

2. The tactical training of engineer officers, and especially of those not serving with units, will be carried out largely by means of T.E.W.Ts., framed and conducted on the principles laid down in Training Regulations. As the setting and conduct of a successful T.E.W.T. demand experience, the fullest use should be made of the services of officers who have been through the Staff College or the Senior Officers' School, for the preparation of such exercises. All engineer officers should be encouraged to practise the setting of T.E.W.Ts., which is itself highly instructive ; but they will be well advised to obtain competent advice on their early attempts, until they have acquired experience.

In most stations, where engineers are quartered with or near units of other arms, it will be possible for engineer officers to take part in T.E.W.Ts. arranged by formations and units, thus affording them the opportunity of taking part in the discussions, and in addition of giving engineer advice on the problems which arise.

If a C.R.E. anticipates any difficulties in the tactical training of his officers, he will arrange through his C.E. for a system of affiliation to be incorporated in the command training instructions. Under this system each geographical group of officers will be affiliated to a formation or unit for tactical training ; and the formation or unit will then be responsible for notifying the dates of all T.E.W.Ts., so that the officers may be enabled to attend them. This applies particularly to officers in the works service ; but any engineer officers, whatever their employment, may be included.

When engineer officers are to take part in a T.E.W.T. organized by another arm, additional value will be obtained if the C.R.E. can arrange for one or more problems to be set which will bring out engineer factors as affecting the other arms. The engineer factors should be clear and convincing, and free from technical detail. Furthermore, C.R.Es. should represent to commanders that it is essential to practise the giving of engineer advice in situations where it would be necessary in war.

3. The tactical training of engineer warrant officers and N.C.Os. by means of T.E.W.Ts. is a duty which all engineer officers must be competent to undertake. Exercises will be based on engineer war organization and will introduce such action by the other arms as might be expected in war, *e.g.* supporting machine gun or mortar fire, or timed artillery concentrations on suspected enemy localities.

The essence of success will be simplicity and the intention to bring out one or two clear lessons. Relevant discussion should be encouraged as a proof of interest and a stimulus to attention; but the directing officer must sum up the main points and dispel any erroneous ideas.

Tactical schemes for warrant officers and N.C.Os. will be based on engineer situations and can often be combined with simple exercises in field engineering such as might be the work of an engineer section in war, *e.g.* the demolition of a bridge, combined with protective dispositions to cover the working party and action when attacked.

4. E.E.W.Ts. afford valuable opportunities, at a minimum expense, whereby engineer leaders can study the engineer problems which they will be required to solve in war. They range in scope from a command engineer exercise, in which senior engineer officers are assembled at the selected centre for several days, to minor exercises of a few hours' duration, such as should be conducted by a junior officer for the training of his N.C.Os.

In the framing of exercises to be held under the orders of G.Os.C.-in-C. and formation commanders, C.Es. and C.R.Es. advise on problems affecting the handling of the engineers. The repercussions of plans and decisions in the forward area, not only on the engineers directly affected but also on engineer services and units on the L. of C. and at the base, must be taken into account: and questions of the availability of stores and the provision of transport to move them should be considered. Although exercises of this nature deal only with the broader aspects of engineer problems, and are of themselves unsuitable for their more detailed study, they form an admirable setting for the framing of E.E.W.Ts. in which the engineer issues raised can be thoroughly investigated. C.Es. and C.R.Es. will therefore study the exercises held by the higher command with a view to the formulation of engineer exercises based on the situations depicted. In addition, the campaign set for winter study, or a battlefield tour held by a formation commander, will often provide a framework on which both tactical and engineer exercises can be based, the situation being transferred to the local terrain. From time to time, also, specific military problems arise and call for study by the army and its engineers. In the absence of any such external stimulus, the subjects suitable for study in engineer exercises for the instruction of officers may include the following:—

i. The formation of a base or advanced base.

ii. The provision of aerodromes and subsidiary air force accommodation.

iii. The preparation of a defensive system, both deliberately and against time.

iv. The execution of a large demolition scheme, both deliberately and against time.

v. The organization of a decontamination service, and the execution of air raid and gas attack precautions.

vi. An opposed river crossing.

vii. An opposed landing on a coast.

It is of the first importance that the study of engineer problems likely to arise in the L. of C. area should receive adequate attention in peace ; and that, as in problems occurring in the forward area, full weight should be given to such factors as air attack, armoured fighting vehicle attack and gas. Furthermore, if the problems are to be probed in adequate detail, officers with a practical knowledge of transportation survey, anti-aircraft defence, etc., may have to be borrowed from outside sources, and included either in the directing staff or in students' syndicates. Full consideration should also be given to problems involving the delivery of engineer stores in the forward area against time.

C.Es. should hold at least one three-day engineer exercise every year. C.R.Es. (or equivalent commanders) should hold engineer exercises aggregating not less than eight days in the individual training season, of which no officer should attend less than six days. Although non-regular officers may be unable to carry out these requirements, they should be given every facility for attending the exercises conducted by C.Es. and regular C.R.Es. ; and C.Es. will ensure that Supplementary Reserve and Territorial Army engineer units are kept informed of the dates and rendezvous of all suitable exercises and that vacancies are offered to them.

5. E.E.W.Ts. for the instruction of N.C.Os. should be similar in principle but of shorter duration and of more limited scope. Where applicable, the correct sequence of events of the various engineer operations should be studied, step by step, *e.g.* reconnaissance, preliminary movements, design, estimates of time and stores, organization of work, movement to the site of the work and tactical security.

The following will be among the subjects suitable for study :—

i. The improvement of a route.

ii. The defence of buildings and other localities.

iii. Demolitions.

iv. Road-blocks.

v. River crossings.
vi. The passage of obstacles, including contaminated areas.
vii. The construction of water-points.
viii. Reconnaissance of local resources.
ix. The lay-out and organization of a divisional store dump.
x. The gas-proofing of buildings, and their adaptation to form a decontaminating station.

6. The details which should receive attention in all E.E.W.Ts. will be found by reference to the appropriate sections in Chapters X and XI. The most important points are usually connected with early information, engineer advice to commanders and the assembly of labour and stores at the desired points; but purely technical details of engineer calculations and design should also receive attention.

It is important to train all engineer leaders in the tendering of engineer advice, clearly, concisely and without irrelevant detail, so that the commander may make his decision with an adequate grasp of the engineer factors which affect it.

27. Exercises with troops

1. The training of an engineer unit by means of exercises with troops is a necessary preliminary to its training in co-operation with other arms. Some of the time allotted to collective training will therefore be given to training the unit in its duties in the field under the following main headings :—

i. Movements and quartering.
ii. Tactical training.
iii. Engineer training.

While these headings offer a convenient classification, there is no rigid line between them. Under modern conditions of air development and of highly mobile armoured fighting vehicles, tactical considerations will seldom be absent.

2. Field Service Regulations, Vols. I and II contain instructions regarding quartering and movements, respectively.

Movements should be practised by route march and by mechanical transport, both by road and across country. During such training concealment from observation both from ground and air must be practised, and special attention must be given to protective measures against all forms of attack, both from ground and air.

The ability of a unit to pitch and strike camp or bivouac, rapidly in the dark, is an appreciable factor in reducing the fatigue inevitable under war conditions. Advanced parties

of units, possessed of full information as to requirements, and with plans of alternative lay-outs to suit differently shaped bivouac areas, should therefore be practised in laying-out camps and in guiding units into them. Units should be trained to adapt standard lay-outs to the ground available, and to move into the area without delay. Consideration must be given to the active means of defence against aircraft, and to such passive measures against air bombing, air spray and persistent blister gas as local conditions render possible, including the organization of a decontamination service.

While some of the above activities may be covered by the normal peace routine of regular units, they will be of considerable importance in non-regular units, and they should receive attention during the course of the annual camp training cycle.

3. In the tactical training of engineer units by means of exercises with troops the earlier exercises should, as a rule, be rehearsed over the same ground by means of exercises without troops, so that officers and other leaders may have a clear conception of the objects of the exercise and the lessons to be brought out, and of the means to be adopted to these ends. As the unit gains in experience, the rehearsals may be dispensed with.

In view of the short time available for tactical training, the key-notes of such training must be simplicity and attention to essential principles. Thus attacks should be against a single objective, covered by a simple fire plan ; the defence of a locality may include an immediate counter-attack to restore that defence ; protection, to which particular importance will be attached, should be based on the protection of the unit at work, at rest or when moving alone ; the defence of a mine-field or road-block should be practised ; and the withdrawal may be confined to successive dispositions to cover the movements of vehicles.

The manœuvre period of the higher formation training will sometimes afford opportunities of utilizing engineer units as the " enemy," when conditions are unsuitable for the employment of the engineers in their normal role, but this use of the engineers must not be overdone.

4. An engineer exercise with troops is generally applicable to the execution of any of the normal tasks of a unit, whether its role be of a general nature (*e.g.* a field company) or of a specialized nature (*e.g.* an anti-aircraft unit). A normal sequence of events might be as follows :—

i. The preliminary issue, the day before, of the general situation from which the exercise starts.

ii. The issue on the day of the exercise of a "situation," requiring executive action by the commander of the unit.

iii. The organization of reconnaissances; and the issue of orders for the preliminary movement of sub-units and stores to the rendezvous, and of sub-unit commanders to the same or more forward rendezvous.

iv. The execution of the reconnaissances, co-ordination, and issue of orders for work to sub-units.

v. The movement of sub-units to their tasks.

vi. The execution of tasks.

If, as frequently happens, the execution of the work is impossible, the necessary stores and equipment should nevertheless be taken to the site and unpacked as for use, and the working parties should be told off to their tasks, the details of the tasks being fully explained to the men.

5. In exercises with troops it is essential to give a tactical background to the exercise. By this means some semblance of realism can be introduced, and the exercise will have a meaning for all taking part.

A final conference of leaders should be held, at which the director should sum up, criticize faults and emphasize the main lessons. If the conference is likely to be short and circumstances are favourable, this can be done while the unit is moving back to its quarters. Otherwise it may be preferable to hold the conference later.

28. Engineers in co-operation with other arms

1. All ranks of the engineers must understand that they exist solely to assist the other arms and services in war. Training in co-operation with other arms is therefore the final stage in the sequence of training for war. The restrictions which are imposed on engineer work by the conditions of peace time training tend to obscure the presentation to the other arms and services of a clear picture of the many ways in which the engineers can help them, and of the many administrative and other details which are an essential preliminary to the prompt execution of engineer work. These difficulties can only be overcome by a thorough knowledge, on the part of the engineers, of the requirements of the other arms, and of the most effective methods of meeting them, and by an understanding, on the part of the other arms, of what their requirements involve. All engineer officers must therefore gain the confidence of the commander, staffs and units with whom they are associated. Given this confidence, it will be their

duty as far as possible to anticipate how the engineers can best help; and it will be a point of honour to ensure that the help given is the most effective that high traditions and engineer skill can contrive. These principles apply equally in the L. of C. and in the forward areas; and the requirements of the services must not be overlooked.

2. The general policy of training in co-operation is initiated by the higher command. C.R.Es. will give advice as to the compilation of training exercises affording scope for such co-operation. They will also advise as to the provision of vacancies for the attachment of individual engineer officers to formations and units of the other arms during the collective training season.

3. Engineer officers serving in units, and those who have had recent experience of such work, may with advantage be attached to formations and units of other arms in order to broaden their experience. As a general guide, the more junior officer will derive most benefit from attachments to infantry units during the battalion training period, and senior officers can suitably be attached to the higher headquarters at a later stage, or to other arms.

Engineer officers without recent experience in units should preferably be attached to engineer units.

The details are, however, a matter for the decision of C.R.Es. of divisions and areas, according to the vacancies available and to the interests and capabilities of the officers concerned.

4. The period allotted to battalion (or equivalent) training will not as a rule afford much scope for the cooperation of engineer units. So far as the exigencies of the field engineering training period permit, engineer commanders should, however, provide any detachments that may be required for such purposes as bridging, the preparation of a defensive position, etc., and the attachment of officers and N.C.Os. will be of value, to look for and point out occasions where engineers could usefully assist.

5. The brigade training period will usually include a proportion of schemes in which there will be scope for the co-operation of a part of the divisional engineers. A suitable engineer unit or sub-unit (*e.g.* a field company or field troop) should therefore be made available for this purpose, if possible. It will greatly facilitate liaison and co-operation in war if the same engineer unit can always train with a particular brigade (*see also* Sec. **91**, 4).

During brigade training the engineer unit allotted for co-operation will only take part in those exercises in which there is scope for useful engineer co-operation. On other days the unit should be employed on exercises of the nature referred to in Sec. **27**, or on some other useful work ; and only a few officers and N.C.Os. should accompany the brigade for engineer liaison and reconnaissance duties.

6. Divisional and higher formation training should afford opportunities for the co-operation of engineers with other arms. This co-operation may take the form of the actual execution of engineer work on the ground, or of make-believe representation of such work, or usually of a combination of both.

The actual execution of work, when possible, is the more effective since all the troops see for themselves what the engineers do in war, and since such factors as time, transport and administrative measures are clearly brought out. It is chiefly applicable to the laying of minefields, to bridging and to water supply ; and to some extent, especially in stations abroad, to the improvement of communications and to hasty defence works.

The make-believe execution of works of construction and destruction (in connection with the umpiring devices described in Training Regulations, 1934, Sec. 76) is of value in that engineer work is represented and directly influences the course of operations. It applies to such work as demolitions, road-blocks, anti-tank minefields, road-craters, defended buildings, enemy gas contaminations, the decontamination of gassed routes and the re-construction or repair of make-believe damage to communications.

The make-believe execution of engineer work depends essentially on good umpiring, with the inclusion of an adequate number of engineer officers in the umpire staff, and on the cooperation of the engineers and other troops engaged. An engineer officer who claims to have carried out a work under this system will submit to the umpire staff full details in support of its practical possibility. Technical details, including calculations, will be required ; and all necessary movements of personnel, equipment and stores will be carried out, tools will be unpacked at the site of the work and working parties detailed. If stores have necessarily to be imaginary (*e.g.* from a timber yard), or if personnel and transport are represented in skeleton only, it must be clearly shown that they would have been available in war, and that adequate time has been allowed for the assembly of all requirements at the site of the work. On these data the umpire staff will

assess the extent of the work carried out and the time at which it was completed.

When a bridge demolition is to be claimed, and if local conditions permit, a full-scale plan or elevation of the bridge will be taped out in an adjoining field, full charges of dummy explosive will be placed on it and connected up for firing with live detonators, and the demolition will be fired in the presence of an umpire. Firing will not take place until the expiry of the time which would have been required for the preparation of the demolition in war, as agreed by the umpire. The umpire will assess the damage caused on the technical and administrative soundness of the demolition plan, coupled with the results of the actual firing of the detonators.

When the planning of higher formation training is first taken in hand, higher engineer commanders must find out the nature of the operations which it is intended to practise, and familiarize themselves with the general topography of the training area. They will consider the extent to which actual or make-believe engineer work can be undertaken, and advise the commander accordingly, so that the exercises may be framed or controlled in such a way as to create openings for engineer operations in suitable areas.

In view of the shortage of men in engineer units in peace, engineer commanders will have to advise or to decide on the extent to which units should be amalgamated to form composite units, or should operate on a skeleton basis as cadres. The former system may be necessary for the actual execution of work, but the latter, besides offering better facilities for the training of junior leaders, will present a truer picture of the engineer influence on the course of operations. All make-believe work should be based on war establishments. A divisional engineers may thus be organized to form one strong company and three cadre companies, or a company may be formed as one strong section and three cadre sections, or, if preferred, the normal organization can be left undisturbed with each unit and sub-unit in cadre form. In the latter event, with each man representing, say, eight men, it must be understood that the movement of personnel by mechanical transport will require the full scale of lorries or their cadre equivalent; otherwise false situations will develop.

7. During the course of higher formation training higher engineer commanders must bear in mind their duty of offering assistance not only in the handling of engineer units but also in the field engineering activities of the other arms. As the engineer advisers to commanders they can do much to disseminate a knowledge of principles of engineer work.

It is also the duty of engineer commanders to exercise, under the orders of formation commanders, a general supervision of the anti-gas precautions taken in the formation, and to draw attention to any points calling for attention.

29. Night operations

1. There are few forms of engineer work which will not require to be undertaken under cover of darkness at some stage of a campaign. Without a high standard of training in night work, engineer units will suffer unnecessary casualties and fatigue, and the course of operations may be prejudiced by slow or inefficient work. In principle, therefore, engineer units must be trained to carry out at night any operation that they may have to carry out by night in war.

2. All ranks, and especially leaders, intercommunication personnel and drivers, must be trained to find their way about at night with the aid of a map. In addition officers and senior N.C.Os. must be trained to a high standard of leading units or sub-units by road or across country, with the aid of a map and a prismatic compass.

Training of this kind can be easily carried out, after the elementary groundwork of map reading has been mastered, by giving individuals a sequence of bearings and distances on which to move, destined to bring them to a rendezvous. On arrival at the rendezvous, each individual is allowed to dismiss and to return to barracks.

3. Suitable subjects for practice by night will include :—

i. Movements across country with transport, including the marking of tracks.

ii. Measures preliminary to the execution of an engineer work, *e.g.* movement of the men to a rendezvous, drawing tools and stores and deployment to their tasks on the work.

iii. Field engineering, *e.g.* defences, bridging or any special role allotted to the unit.

iv. Simple tactical work.

The effect of even a few short parades of an hour's duration in developing the night-sense of all ranks is of great value ; but during the later stages units should be practised in the execution of full tasks by night, including the practice of reliefs.

4. If opportunity offers, engineers may usefully be practised, in co-operation with other arms, in such duties as marking

the starting point of a night march with shaded lights, in taping or spit-locking the starting line for a night attack, and in taping routes (*e.g.* for an opposed river crossing by night).

Night reconnaissance, under the conditions of close contact with the enemy, may also be practised with advantage.

CHAPTER V

DRILL

30. Introductory

1. The object of drill is to enable a unit to carry out at any place or time by day or by night, whether by itself or as part of a larger unit or formation, any movement that its commander may direct, whether laid down in this manual or improvised to meet the exigencies of the situation.

In addition, drill is a preliminary step towards manœuvre, by which it must be supplemented under the varying conditions of ground, fire, and other tactical considerations, encountered in the field.

2. Engineer units comprise :—

i. Dismounted units without transport;
ii. Dismounted units (partially mechanized and partially horsed) with mechanized transport;
iii. Mounted units with mechanized transport.

The standard organization of an engineer unit is taken to be the company of four sections, each of four sub-sections, with mechanized transport.

Units the organization of which differs from the standard will modify the drills set out in this manual to suit their own organization.

3. This chapter, together with Infantry Section Leading,* the Manual of Elementary Drill (All Arms) and the Manual of Ceremonial, furnishes the details required for the training in drill and manœuvre of sappers (mounted or dismounted). The Manual of Horsemastership, Equitation and Animal Transport deals with the training of drivers of horsed transport and the Manual of Driving and Maintenance of Mechanical Vehicles (Wheeled) deals with the training of drivers of mechanized vehicles.

4. The drills set out in this manual are therefore :—

i. Section drill;
ii. Company drill;
iii. Field formations;

* Cavalry Section Leading applies to horsed sappers.

iv. Drill for mechanized vehicles and for units with mechanized vehicles.

v. Drill for a field squadron.

5. Rules of general application, such as those relating to dressing, changing ranks and movements to be completed at the halt, are given in the Manual of Elementary Drill (All Arms), and are not repeated in this manual.

Section Drill

31. General rules

1. The section may be formed as follows :—

i. In line (*see* Plate II).

ii. In column of route (*see* Plate III).

2. The section commander and the section serjeant, when the section is acting alone, or at a distance from other sections, will place themselves where they can best exercise supervision. The normal positions of commanders and supernumeraries in line and in column of route are shown in Plates II and III.

3. In column of route the left will always direct, with the following exceptions, when the right will direct :—

i. In countries where the " off side " rule of the road obtains ;

ii. When the right is the pivot flank.

4. The following will act as guides :—

i. When a section is in line, the sub-section commander of the directing flank. He will be responsible for the maintenance of direction.

ii. In column of route, the leading sub-section commander.

5. Before a movement in close order is made, arms will be sloped.

6. When a supernumerary requires to pass through the ranks, the two files immediately opposite him will make way on the command *Make—Way*. If he is coming from the front, they will take a pace to the rear and a side pace outwards ; if from the rear, a pace forward and a side pace outwards. They will resume their positions as soon as the supernumerary has passed through.

32. Forming up, inspecting, telling off and proving a section

The section will fall in for inspection by its commander, in line. The inspection should usually be carried out at the *order* as follows :—

i.	**Section—Attention. Fix—Bayonets.** **Open order—March.**	Given by the section serjeant.
ii.	**Unfix—Bayonets.** **For inspection port—Arms.** **Examine—Arms.** (If required.) The section commander will inspect arms.	Given by the section commander.
iii.	**Section—Attention. Close order—March.** **By subsections—Number. Form—Fours. Form—Two deep. About—Turn. Form—Fours.** **Form—Two deep. About—Turn.**	

To avoid unnecessary loss of road space in column of route when sub-sections are numerically weak, the section or two sub-sections may be numbered off and proved together for the purpose of forming fours. This numbering must not preclude sub-sections from being separated under their own leaders for any individual action required.

33. Drill movements for the section

Sections will be exercised in the movements detailed in the Manual of Elementary Drill (All Arms), 1935, Chapter III, Part II, the word " section " being substituted for " squad." They will also be trained to adopt rapidly and without confusion the open formations described in Sec. **38,** and will frequently be practised in re-assembling when dispersed.

Company Drill

34. General rules

1. The company may be formed as follows :—
   i. In close column (*see* Plate IV).
   ii. In column of route (*see* Plate V).

2. The positions of all commanders and supernumeraries in these formations are shown in the plates. During drill and manœuvre the company commander and second-in-command will place themselves where they can best exercise supervision.

The positions of the C.S.M. and C.Q.M.S., as shown in Plate IV, remain the same whether the company is by the right or by the left.

3. i. In close column, the four sub-section commanders on the directing flank will act as guides.

ii. In column of route, the left will direct, except as laid down in Sec. **31,** 3.

4. In action or in high wind it will often be impossible for words of command to be heard. The company commander should therefore frequently practise his command in working by signal.

5. The general rules for section drill in Sec. 33 refer also to company drill, where applicable.

6. Unless otherwise ordered, a company will fall in in close column and will be inspected and proved as in Sec. **34.**

7. When cautions or commands are given for formations to or from one flank only, the same rule applies when forming to or from the other flank.

8. When it is desired to *Advance* (or *Retire*) *in column of route,* this caution should precede all other commands.

9. In the detail of company drill the title of the movement is shown in *italics,* and is followed by the company commander's commands in **thick type.** The detail of the movement then follows, in which orders to be given by section commanders are printed in *italics.* The company commander's cautions or words of command, when referred to in the detail, are printed in SMALL CAPITALS.

35. Drill movements for a company

1. *A company falling in in close column.*

The C.S.M. will give the command " *Markers* ", on which a marker from each section marches out and falls in in line, facing a flank and stands at ease. No. 1 Section marker will place himself opposite the C.S.M., with the other markers in the order of their sections, *i.e.* No. 1, 2, 3 and 4.

The C.S.M. then gives the commands " *Markers—Attention* ". " *No.* 1 *to the right, remainder to the left* (or *vice versa*) *Outwards—Turn* ". " *To close column distance—Quick—March* ", on which Nos. 2, 3 and 4 markers step off. When No. 2 marker takes his seventh pace, he will halt, touch No. 3 marker on the shoulder and turn about. Nos. 3 and 4 markers will act in a similar manner to No. 2.

The C.S.M., having covered off the markers, will give the command " *Markers—Stand at ease* ". On this command, not only the markers but all ranks waiting to come on parade will stand properly at ease.

The C.S.M. will then give the command " *Fall in* ", or the

bugler will sound "*Fall in*", on which the men will fall in, pick up their dressing and stand at ease. If the men are under arms, they will fall in at the *slope*, and, on arrival at their positions, will order arms and stand at ease.

The C.S.M. will then give the command "*Company—Attention—Call the roll*", on which the section serjeants will call the roll, inspect their sections and stand them at ease. The C.S.M. will then call the company to attention, slope arms (if the parade is under arms), collect reports from the section serjeants and report to the senior officer on parade. The latter will then detail the officers to join and inspect their sections.

2. *A company, when halted, changing ranks.*

About—Turn.

The whole will turn about, except officers and supernumeraries, who will regain their positions by passing round the flanks or through the ranks of the company, sub-section commanders making way for them on the command "*Make way*", by placing themselves between the files on their right or left, and afterwards aligning themselves with the front rank.

i. If ranks are changed on the march, sub-section commanders will make way by checking the pace slightly and inclining outwards.

ii. If it is desired to turn about without changing ranks, the command ABOUT—TURN will be preceded by the caution THE COMPANY WILL RETIRE and, in order to resume the original direction, THE COMPANY WILL ADVANCE.

3. *A close column, when halted, forming column of route.*

i. **Advance** (*or* **Retire**) **in column of route from the right. Form—Fours. Right.**

The commander of the leading (*or* rear) section will give "*No. . . . Section, Left* (or *Right*)*—Wheel. Quick—March*", and each section commander will act similarly in time to gain his place in column of route.

ii. **Move to the right in column of route. Form—Fours. Right.**

The commander of the leading (*or* rear) section will give "*No. . . . Section, Quick—March*", and each remaining section commander will give "*No. . . . Section, Left* (or *Right*)*—Wheel. Quick—March*" in time to gain his place in column of route.

(*a*) Unless otherwise ordered, a company will move off from the right of the leading section, or from the left of the rear section.

(*b*) A company can be marched off from any section as follows: ADVANCE (*or* RETIRE), ETC., IN COLUMN OF ROUTE IN THE FOLLOWING ORDER, NO. 1, NO. 2, NO. 3, NO. 4 SECTION.

4. *A column of route forming close column forward at the halt.*

At the halt. On the left. Form close column.

The commander of the leading section will at once give "*No. . . . Section. At the halt. On the left. Form—Section*". The commanders of the remaining sections, on arriving at close column distance, will act in a similar manner.

5. *A column of route forming close column at the halt, facing a flank.*

At the halt. Facing left. Form close column.

The commander of the leading section will halt his unit and turn it to the left by giving, "*No. . . . Section. Halt. Left—Turn*". The remainder will be led by their guides by the shortest route to their position in column (or close column), where they will receive the command "*No. . . . Section. Halt. Left—Turn*". On the word HALT, the right guides will at once turn to their left and take up their covering and distance from the right guide of the section in front.

6. *Dismissing.*

The company will be dismissed in accordance with the instructions laid down in the Manual of Elementary Drill (All Arms), 1935, Secs. **27**; **42**, 6 and **72**, 7.

FIELD FORMATIONS

36. General remarks

1. When a unit or sub-unit is liable to come under artillery or other fire, or to be subject to air attack, it may be necessary to adopt an open formation. Quickness in adopting such a formation is of vital importance; and deployment must be practised constantly during training, so that all ranks may become thoroughly flexible in their movements. It is easier to carry out movements which are thoroughly ingrained in the minds of the troops than to improvise them on the spur of the moment.

2. The company commander is responsible in the first instance for ordering the deployment of the company from close formation to open formation.

Once the company has deployed, each section commander is responsible for the formation to be adopted by his section, and for leading his section.

Finally, when the section has deployed, each sub-section

commander is responsible for the formation of his sub-section, and for leading it.

3. The training of an engineer unit thus involves a thorough knowledge of :—

i. Extended order movements (*see* Sec. **37**).
ii. Sub-section formations (*see* Sec. **38**).
iii. Section and company formations (*see* Sec. **39**).

These must be practised, firstly as a drill, to impart a thorough knowledge of the procedure ; and secondly as a manœuvre in the field, so as to ensure that the formations can be taken up without rigidity and adapted to the tactical situation and ground conditions.

4. The varying numbers of engineer vehicles which may be grouped together in the field make it impossible to lay down any completely standardized manœuvre formations for M.T. vehicles. Moreover, such vehicles are more sensitive to ground conditions than are the sapper personnel of units and sub-units, and they therefore require even greater flexibility in manœuvre.

The principles underlying the manœuvre of the sapper personnel are, however, generally applicable to M.T. ; and a high standard of training will be required in all M.T. N.C.Os. and drivers. The following will serve as a guide :—

i. The M.T. wing commander's responsibilities for the movement and deployment of his command are analogous to those of a company commander ; the M.T. section commander corresponds to the section commander ; and the individual M.T. driver is in the position of a sub-section commander.

ii. M.T. forming part of or accompanying a unit will conform in principle to deployments ordered for the unit, subject to restrictions of ground and to local differences in the tactical situation (*e.g.* exposure to fire).

iii. M.T. moving independently will deploy on the same principles as those laid down for units and sub-units.

37. Extended order movements

1. *General instructions.*—Drill in extended order movements should be practised. The rifle will normally be carried at the TRAIL when moving in extended order in line, and at the SLOPE when in fours or file. Correct dressing and keeping step are not required, but an approximate line should be kept ; otherwise, when extended, men may mask one another's fire. Commanders should place themselves where they can best

supervise their commands. It should be explained that, as extensions are usually made in order to develop fire or avoid loss, they are normally carried out at the double. An extended line is closed only when under cover or when not under fire; closing is therefore carried out in quick time unless it is desired to close on the move. Unless otherwise ordered, men extend and close from or to the centre file, which should be named.

In some circumstances it may be advisable that the extension should be made between pairs and not between single men. In this case the rear rank man forms on the left of and remains with his front rank man, the latter being responsible for gaining and keeping the extension ordered.

2. The cautions before drill is begun are as follows:—

No. . . . Centre file and file of direction. The objective is . . .

The front rank man of the given file will prove by raising the disengaged arm. If it is required to march by a flank, the front rank man of the file on that flank will prove.

3. *A unit in line extending from the halt to the halt.*

To . . . paces, Extend.

The front rank man of the centre file will stand fast. The remainder will turn outwards and extend, or increase their extensions, moving in double time. The rear rank men will form on the left of their front rank men. Each man is responsible that the given number of paces separate him from the man who is next to him and nearer to the centre.

i. If it is required to extend to a flank, or from a named file, the above command will be preceded by the caution TO THE RIGHT (*or* LEFT), *or* FROM NO. . . .

ii. When extending on the move, the front rank man of the file from which the extension is being made will continue to advance in quick time, the remainder acting as above.

iii. During a more advanced stage of instruction, rough-and-ready expedients for extending will be practised, in order to form a firing line quickly in any direction from any formation.

4. *A unit marching in fours extending to a flank.*

To the right (*or* left), to . . . paces, Extend.

The whole will form two deep.

i. If the extension is to the right, the left man of the leading file will continue to advance, the other man of the file forming up on his right at the number of paces ordered. The remainder will make a partial turn in the required direction and will

double into their positions. The left man of each file will form on the left of the other man of the same file. As each man reaches his position, he will break into quick time and continue to advance in the original direction.

ii. If the extension is to the left, the right man of the leading file will continue to advance and the right man of each file will form on the right of the other man of the same file as above.

iii. Should it be required to form in a direction oblique to the line of advance, the words HALT (QUARTER *or* THREE-QUARTER) RIGHT (*or* LEFT) will precede the commands given before.

5. *An extended line closing.*

Close ; *or* To . . . paces, Close.

The men will close on the centre, taking up their original positions in two ranks, or will decrease their extensions to the given number of paces. The front rank man of the centre file will stand fast, the remainder moving in quick time.

i. If it is desired to close or decrease extensions towards a flank or on a named file, the above command will be preceded by the caution ON THE RIGHT (*or* LEFT, *or* ON NO. . . .

ii. If the command is preceded by the caution AT THE HALT, the centre (right or left-hand) man will halt, the remainder acting as above and halting as they reach their places.

iii. If it is desired to close on the move, the front rank man of the centre file will continue to advance in quick time, the remainder doubling to their places and resuming quick time on arrival.

38. Subsection formations

1. The open formations of an engineer subsection are the same as those of an infantry section. These formations and the circumstances for which they are suitable are explained in Infantry Section Leading, 1934, Sec. 36.

2. The methods of adopting these formations from file and single file are shown in Plate VII.

39. Section and company formations

1. The normal method of deploying a company into open formation is shown in Fig. 1 of Plate VI. In the absence of other orders this method will always be adopted.

The signal for moving the company into open formation is the " *Deploy* ". On this, the leading section will move out half-right until it is about 200 yards ahead of the third,

while the second section moves out half-left until it is roughly on the same alignment and at about 200 yards interval from the leading section. Meanwhile the third and fourth sections move straight out at right angles, to the right and left respectively, until they are at about 200 yards interval.

If it is desired to deploy to a flank, the company commander will point to the required flank after giving the "*Deploy*" signal. If the deployment is to the left, the third section will halt until the leading section has gained about 200 yards distance, while the second and fourth will move out to their positions on the left. If the deployment is to the right, the fourth section will halt until the second section has gained about 200 yards distance, while the leading and third sections will move out to their positions on the right.

2. The normal method of deploying a section into open formation is the same as that described above, except that the intervals and distances between sub-sections should be about 100 yards.

3. It must be clearly understood that all open formations should be taken up loosely, with the fullest adaptation to the ground and to tactical considerations, and without any geometrical rigidity. Distances and intervals are given as a general guide only.

4. The company commander will move in the position from which he can best exercise control. Subordinate commanders are allowed similar latitude, but must place themselves so that they can see the signals given by their superior commander.

5. On the "*Close*" signal from the company or section commander, sub-units will resume the formation in which they were before receiving the order to deploy. If the commander wishes to close his unit otherwise than on his headquarters, he will point to the sub-unit on which he wishes the remainder to close.

6. The formations suitable for engineer companies and sections, when tactically employed as infantry, are the same as those described in Infantry Training, for a rifle company and rifle platoon. Plate VI of this manual illustrates four formations commonly employed in the attack.

40. Field signals

1. *General remarks.*

i. The control of troops, when deployed, can usually be exercised better and more quickly by signals than by verbal orders.

ii. In controlling troops by signals, a " short blast " of the whistle (*i.e.* the " cautionary blast ") will be blown before the signal is made, in order to attract the attention of the troops. When he is satisfied that his signal is understood, the commander will drop his hand to his side, on which the units under him will act as ordered. Signals should be made with whichever arm will show most clearly what is meant.

2. *Signals with the hand.*

The following control signals are used :—

i. **Deploy.**—The arm extended to full extent over the head and waved slowly from side to side, the hand to be open and to come down as low as the hips on both sides of the body.

If it is required to deploy to a flank, the commander will finish the signal by pointing towards that flank.

ii. **Advance.**—The arm swung from rear to front below the shoulder.

iii. **Halt.**—The arm raised to the full extent above the head.

iv. **Retire.**—The arm circled above the head.

v. **Change direction right** (*or* **left**).—The arm is first extended horizontally to the side in line with the shoulder. A circular movement is then made, on completion of which the arm and body should face in the required direction.

When troops are halted, the above signal means " *Change position right* (or *left*) ".

When troops are in field formation, in column of route, in file or in single file, the above signal means " *Right* (or *left*) *wheel* ".

vi. **Right** (*or* **left**) **incline** (*or* **turn**).—The body or horse is turned in the required direction, and the arm extended in front of the shoulder, pointing in the required direction.

vii. **Close.**—The hand placed on top of the head, the elbow to square to the right or left according to the hand used.

The above signal denotes " *Close on the centre* ". If it is required to close on a flank, the leader will point to the required flank before dropping his hand.

If, when on the march, it is required to halt as well as close, the leader will give the halt signal before dropping his hand.

viii. **Quick time.**—The open hand raised alongside the shoulder with the palm to the front ; the elbow bent and close to the side.

ix. **Double.**—The clenched hand moved up and down between the thigh and shoulder.

x. **Follow me.**—The arm swung from rear to front above the shoulder.

xi. **Lie down.**—Two or three slight movements of the open hand towards the ground.

xii. **As you were.**—The arm extended downwards with the hand open, and waved across the body, parallel with the ground.

3. *Signals with the rifle.*

The following " communicating signals " are made with the rifle :—

i. **Enemy in sight in small numbers.**—The rifle held above the head at the full extent of the arm and parallel with the ground, muzzle pointing to the front.

ii. **Enemy in sight in large numbers.**—The rifle held as in previous signal, but raised and lowered frequently.

iii. **No enemy in sight.**—The rifle held up at full extent of the arm, muzzle uppermost.

These signals may be used by scouts, etc., sent on ahead by their sections. Care should be taken that the signal cannot be seen by the enemy.

4. *Control by whistle blasts.*

The following whistle blasts are used :—

i. **The cautionary blast (a short blast).**—To draw attention to a signal or order about to be given.

ii. **The rally blast (a succession of short blasts).**—To denote " close on the leader " in wood, bush, fog or darkness, when the signal cannot be seen.

On the above blast being given, the men will double towards the sound of the whistle, and will rally on the leader, facing in the same direction.

iii. **The alarm blast (a succession of alternate long and short blasts).**—To turn out troops from camp or bivouac to fall in, or to occupy previously arranged positions.

iv. **Enemy aircraft in sight (a succession of long blasts).**—Since this signal will often be inaudible, a visual signal will also be used to attract attention, viz :—both arms held above the head and the hands waved. On this signal, troops either get ready to fire, open out or take cover, according to the orders in force.

v. **Enemy aircraft attack ended (two long blasts repeated at intervals of five seconds).**—On receipt of this signal, all troops resume previous formations. Troops which have been firing will recharge their magazines before moving off.

Drill of M.T. Vehicles

41. General remarks

1. The object of drill for M.T. is to ensure that the actions necessary for movement are carried out in an orderly and

systematic manner, and in the most rapid and efficient way. Attention is drawn to Field Service Regulations, Vol. II, 1936, Sec. 25; the Manual of Elementary Drill) All Arms), 1935, Secs. 88 and 91, and the Manual of Driving and Maintenance of Mechanical Vehicles (Wheeled).

2. For purposes of administration, the whole of the M.T. of an engineer company is grouped together in the M.T. wing, under the command of the officer i/c transport, who will normally be the second-in-command of the company. He is assisted by a M.T. serjeant.

Unless the tactical or engineer situation requires section vehicles to move independently in rear of their own sections, it is desirable that the M.T. wing should march grouped in rear of the company.

3. i. In so far as the organization of the unit permits, the M.T. wing should be sub-divided into sections, each of four or five M.T. vehicles with their drivers and spare men, and commanded by a N.C.O. The actual number of vehicles in a section will vary according to the organization of the unit, but will not exceed five.

ii. The maintenance of a steady pace and correct distances on the move is essential. An error in distance should be rectified gradually. The pace will be regulated by the leading vehicle of a command, and must be such that the slowest vehicle can keep in position.

For drill movements the normal pace will be 10 m.p.h.

iii. No man may enter or leave a vehicle while it is in motion. M.T. section commanders will ensure that all men are mounted before reporting a section as being ready to move off.

iv. Drill of a large number of vehicles by one commander will be avoided. Sections will move independently in accordance with orders given by the commander.

42. Intervals and distances

1. *Intervals* are measured from right to left, from the front near wheel of one vehicle to the front off wheel of the next vehicle.

The normal intervals at the halt are :—

Between vehicles two yards.
Between sections ten yards.

2. *Distances* are measured from the tail of one vehicle to the head of the next.

The normal distances are :—

i. When halted in column of route :—
Between vehicles two yards.
Between sections 20 yards.

ii. When halted in close column :—
Between sections ten yards.

iii. When on the move in column of route :—
Between vehicles 20 yards.
Between sections 40 yards.

43. Signals

1. Verbal orders should be given when they can be easily heard, but, whenever engines are running and always in column of route, all orders will be given by signal preceded by the cautionary blast on the whistle. Visual signals will be repeated by section commanders, who will be responsible that they are conveyed to the drivers. Many of these signals may be given at night by means of a torch.

2. The signals to be employed are given in the Manual of Driving and Maintenance of Mechanical Vehicles (Wheeled) and are common to all branches of the service. In addition the following signals will be used :—

Movement order	*Signals*
i. Form close column ...	The hand raised perpendicularly above the head and lowered and raised several times.
ii. Form line	The arm waved horizontally from right to left and back again as though cutting with a sword, finishing with delivery of a point to the front.
iii. Right (*or* Left) take ground.	The hand brought to shoulder with fist clenched, and the arm extended sharply in the required direction two or three times. Of use to get M.T. vehicles off the road, when practicable, to avoid enemy aircraft attacks.

44. Drill movements of M.T. vehicles

1. *The posts of officers, etc.*, for the M.T. wing of a company are given in Plates VIII, IX and X.

On the move in column of route, posts will be as follows :—

Movement order	*Signals*
i. O.C. M.T. wing ...	30 yards in front of the leading vehicle of the leading section.
ii. Second - in - command, M.T. wing.	15 yards behind the last vehicle.

(N.B.—The above distances are those to be adopted when the unit of M.T. wing is moving independently.)

iii. N.C.O. i/c section ...	On the leading vehicle of his section.
iv. N.C.O. i/c M.T. wing ...	On the last vehicle.
v. Motor cyclists	One immediately behind the car of the O.C. M.T. wing. Remainder as ordered.

2. The parade formations for M.T. vehicles will be as follows :—

i. In line (Plate VIII).
ii. In close column (Plate IX).
iii. In column of route (Plate X).

3. The normal positions of all ranks are shown in the plates. During drill and manœuvre the parade commander will place himself where he can best exercise control and where his signals can be seen by all concerned.

4. Details of " turning out ", drill before moving off, drill on the line of march and dismissal are contained in the Manual of Driving and Maintenance of Mechanical Vehicles (Wheeled).

45. Drill and manœuvre of an engineer unit with M.T.

1. *General.*—The normal parade formation will be close column. The dismounted personnel will be as shown in Plate IV and the M.T. as in Plate IX.

The leading section of the M.T. will be 15 yards in rear of the dismounted personnel.

2. *Forming column of route from close column.*

i. **Advance** (*or* **Retire**) **in column of route from the right.**

Movement order	*Signals*
Dismounted personnel ...	As in Sec. **35**, 3, i.
M.T.	Will conform under the orders of the M.T. commander, the leading vehicle being 15 yards in rear of the dismounted personnel.

ii. **Move to the Right in column of route.**

Dismounted personnel ...	As Sec. **35**, 3, ii.
M.T.	Will conform as above under the orders of the M.T. commander.

3. *Forming close column from column of route.*

i. **At the halt. On the Left. Form Close Column.**

Dismounted personnel ...	As in Sec. **35**, 4.
M.T.	Will conform under the orders of the M.T. commander.

ii. **At the halt. Facing Left** (*or* **Right**). **Form Close Column.**

Dismounted personnel ...	As in Sec. **35**, 5.
M.T.	Will conform under the orders of the M.T. commander.

46. Movement of an engineer unit by M.T.

1. The administrative procedure for the conduct of movements by M.T. is laid down in Field Service Regulations, Vol. I. The tactical considerations affecting such movements are outlined in Field Service Regulations, Vol. II.

2. In order to minimize delay and fatigue in the movement of an engineer unit to the points where its services are required, and to ensure its adequate protection from ground and air attack throughout such a movement, it is essential that all ranks should be thoroughly familiar with the tactical and administrative factors involved and with their respective roles.

All movements by M.T. carried out in a theatre of war or for training purposes will therefore be conducted in accordance with the administrative procedure laid down; and, in the absence of orders to the contrary, tactical precautions will be taken.

Field Squadron Drill

47. General remarks

1. A field squadron consists of a headquarters, a headquarters troop and two or more field troops.

There are two alternative organizations :—

i. One section in each field troop mounted and provided with pack horses ; the remainder of the personnel together with the engineer equipment in M.T. ; or

ii. All the personnel on a mechanized basis.

In addition to the M.T. required for the conveyance of the dismounted personnel and engineer equipment, the squadron transport includes the M.T. required for the bridging group.

2. This manual therefore provides for the drill of two categories of personnel, of M.T. and of the squadron as a whole.

48. Drill of horsed personnel

1. The drill and manœuvre of a mounted section of a field troop are identical with those of a mounted section of cavalry, as laid down in Cavalry Training and Cavalry Section Leading.

For purposes of close order drill, pack horses and leaders will parade and move as a supernumerary rank covering off the section or half-section as applicable.

For purposes of manœuvre in the field, pack horses and their leaders will move in accordance with tactical and engineer requirements, as ordered by the section leader.

2. As the mounted sections of the field troops normally operate independently, the necessity for the drill of a completely mounted detachment or troop of more than one section can only arise exceptionally. In such circumstances, the drill of a mounted sabre troop of cavalry will apply, as laid down in Cavalry Training.

49. Drill of the dismounted personnel

The drill of the mechanized personnel of a field squadron will be carried out as laid down for a company in Secs. **34** and **35**, the words " squadron ", " troop " and " section " being substituted for " company ", " section " and " subsection ", respectively.

50. Drill of the M.T. of a field squadron

The drill of the M.T. of a field squadron, including that of the personnel-carrying lorries, will be as laid down in Sec. **44**.

51. Drill of the field squadron as a whole

1. Tactical and engineer considerations, and administrative convenience, will normally preclude the necessity of horsed personnel parading and moving in immediate association with the mechanized part of a field squadron. Under peace conditions and for short movements, however, such necessity may arise.

2. The drill formations of a field squadron are :—

i. Close column.

ii. Column of route.

Column of route is adopted by the movement in succession from the right of each troop into that formation. Dispatch riders and the headquarter troop serjeant follow in rear of their respective troops, and the second-in-command follows in rear of the squadron.

The horsed sections of the field squadron (if any) will always be on the directing flank or at the head of their troops, outside or in front of the troop leaders' cars.

3. The horsed sections (if any) conform generally to the movements of the squadron, carried out as laid down in Sec. **44.**

PART II—WAR

CHAPTER VI

WAR ORGANIZATION OF ENGINEERS

52. General principles

1. Engineer activities in a theatre of operations cover a wide range. The resulting organization falls broadly into two categories :—

i. Engineer staffs and units allotted to formations, to areas and to fortresses.

ii. Engineer staffs and units allotted to the services (*see* Field Service Regulations, Vol. I).

Personnel, and to some extent units, are liable to transfer between these categories ; and the line of demarcation between their functions is not rigid.

2. Engineer units are allotted to divisions and to anti-aircraft groups on a permanent scale. The allotment made to other formations, and to the services, is necessarily on a more flexible scale, depending on the engineering requirements of the campaign.

3. Some services, notably the transportation services (*see* Sec. **63**), are organized on a basis of geographical regions; others have an organization which conforms to the areas of armies, corps and divisions, and to the L. of C. area. In all cases close liaison between the engineers of services and formations is essential, particularly at points where the responsibility of a service ends and that of a formation begins.

53. Roles of engineer units

1. *Divisional engineers* (*including the field squadron of a mobile division*).—To execute the field engineering required to enable the division to fulfil its role as a fighting force. This does not include highly specialized work, for which special units exist, *e.g.* survey, anti-aircraft defence, and transportation. (*See also* Sec. **54**, 1 and 2.)

2. *Army troops companies.*—To execute both field engineering work and constructional work in army or corps areas, usually in rear of forward divisions ; to reinforce the divisional engineers for particular operations ; to carry out engineering work, mainly constructional, in the L. of C. area.

3. *Electrical and mechanical companies.*—To execute all types of electrical and mechanical engineering work required in army or corps areas, and in the L. of C. area, including second-line repairs to engineer plant; to carry out demolitions of electrical and mechanical installations in a withdrawal.

4. *Workshop and park companies.*—To hold, distribute and account for engineer stores in the L. of C. area, and in advanced store dumps, if formed; to manufacture special engineer stores required for experiment, or in emergency, or ordered to be produced locally.

5. *Engineer base workshops.*—To execute repairs to engineer plant and stores which are beyond the capacity of the mobile workshops of the E. and M. companies; to manufacture special engineer stores required for experiment, or in emergency, or authorized to be produced in the theatre of operations.

6. *Engineer store base depot.*—To hold, distribute and account for engineer stores at the base.

7. *Well-boring sections.*—To carry out well-boring operations as required, but exclusive of the installation and operation of pumping plant connected therewith.

8. *Fortress engineers.*—To operate the searchlights and other engineer equipment and plant required for the defence of a fortress against sea-borne and air attack; to carry out other engineer work required in connection with the defence of the fortress.

9. *Anti-aircraft battalions.*—To operate the searchlights and other engineer equipment of their formations; to execute any other field engineering required by such formations.

10. *Field survey companies.*—To carry out the executive work of the survey service according to their particular allotments. (G.H.Q., corps, etc.)

11. *Transportation units.*—To survey, construct, maintain and operate railways; to maintain and operate docks and inland waterways and to carry out demolitions of railways, waterways, docks and installations connected therewith, during a withdrawal, in so far as these are under the control of the transportation services.

12. In addition to the above, the engineer requirements of a campaign may necessitate the provision of units for special roles, such as road construction, quarrying, tunnelling and other purposes. (*See also* Sec. 72.)

54. Allotment of engineers to formations

1. *Mobile divisional engineers.*—A field squadron is permanently allotted to a mobile division. It consists of a headquarters, headquarter troop, three field troops and a bridging section. The headquarter troop is responsible for the custody and running of the electric light plant for divisional headquarters, in addition to other engineer duties. A field troop can be temporarily detached to a mobile brigade operating independently.

2. *Divisional engineers.*—An engineer headquarters, a field park company and three field companies are permanently allotted to a division. The field park company has the following special duties :—

i. Operation of the divisional engineer workshops, and running of the electric light plant for divisional headquarters.

ii. Custody of the divisional mobile bridging equipment.

iii. Operation of the divisional engineer stores dump.

iv. Custody of such power tools and plant as are held centrally and not by field companies.

v. Custody of the divisional engineers M.T. pool.

vi. Execution of field engineering work, including anti-gas measures, the operation of minor installations, and other administrative tasks, in the rear portion of the divisional area.

3. *Corps engineers.*—A chief engineer and staff are permanently included in the organization of a corps headquarters. In addition, the number and type of engineer units allotted to a particular corps depend on its engineer requirements. These units are commanded by a C.R.E., corps troops.

The work of the corps engineers will usually include heavy constructions and technical installations, requiring highly-skilled labour and power-driven plant. In addition, the work of the divisional engineers will have to be supplemented by work requiring more time and continuity in execution, such as heavy bridging, road construction and permanent water supply. For these purposes the corps engineers will normally include army troops companies, electrical and mechanical companies and possibly boring sections.

If mine warfare is to be undertaken, the corps engineers may also include tunnelling companies, but the need for continuity of policy will more frequently require that these units should be retained under army control.

The field survey company allotted to a corps is part of the survey service and does not come under the command of the C.R.E., corps troops. (*See* Sec. **61.**)

4. *Army engineers.*—A chief engineer and staff are permanently included in the organization of an army headquarters. In addition, an army is allotted a variable number of engineer units, depending on the engineer requirements of the particular army. These units are commanded by a C.R.E., army troops.

The work of the army engineers is analogous to the heavier and more technical natures of engineering work required in the rear of the corps areas. For this purpose the army engineers will normally include army troops companies, electrical and mechanical companies and boring sections. If mine warfare on a large scale is to be undertaken, tunnelling companies will be included and special circumstances may necessitate the allotment of highly specialized units for such purposes as road construction, water supply, power-drawn tramways and so on.

5. *Anti-aircraft groups.*—An anti-aircraft battalion consisting of a headquarters and a variable number of companies (normally four) is permanently allotted to an anti-aircraft group.

6. *Fortresses.*—The defence of coastal fortresses involves the allotment of fortress engineers, on a scale framed to meet the special needs of the particular fortress, for anti-aircraft defence and for defence against sea-borne attack. These units are responsible for meeting all engineer requirements in fortress defence, including beach defence and defence against attack by land. In addition, personnel of the works service are provided for the execution of works services.

7. *The L. of C. area.*—Administrative requirements on the lines of communication are provided for by the organization of the services, outlined in Secs. **57** and **58.** Tactical requirements will be met, either by the allotment of units by G.H.Q. or by arrangements to be made by engineer officers of the works service under the orders of the commander, L. of C. area. (*See also* Chapter XII.)

8. *G.H.Q. engineers.*—The engineer units at the direct disposal of G.H.Q. may include all types of units mentioned in this chapter. In practice, the majority of these units will be allotted by G.H.Q. to armies and corps, and to the various services, in accordance with the anticipated requirements of engineer work.

Should it be found desirable to retain engineer units under the direct control of G.H.Q., either as a reserve or for special engineer work, a C.R.E., G.H.Q. troops, will be appointed to the executive command of the group of engineer units so retained.

55. The survey service

1. The field survey organization includes :—

Survey directorate.
Army field survey companies.
A field survey depot.
Corps field survey companies.

2. The organization of a field survey company depends on the theatre of war and on the allotment of the company (whether to G.H.Q., army, or corps). A company consists of a headquarters and a number of self-contained technical sections, each of which is a serjeant's command and each of which is designed to carry out some particular survey or cartographic process.

56. The army postal service

The personnel of the army postal service is drawn from the Royal Engineers, Supplementary Reserve.

The organization consists of a base post office, auxiliary postal companies on the L. of C. and postal units at G.H.Q. and at the headquarters of armies, corps and divisions.

57. The transportation services

1. The organization of the engineer staffs and units allotted to the transportation services is shown in Appendix IV.

The appointments of railway construction engineer, district operating superintendent, mechanical engineer, railway storekeeper and docks superintendent are all analogous to that of C.R.E. of a formation in that the holder commands, and executes his work with, a number of engineer companies.

2. The transportation services are organized by districts. A district conforms to the geographical lay-out of the carrying agency concerned, and not necessarily to a formation or administrative area.

3. Under favourable conditions the transportation services may consist of a skeleton organization assisting and controlling a friendly civilian administration.

4. Further details will be found in Chapter XII and in the Manual of Movement (War) and Military Engineering, Vol. VIII.

58. The works and engineer stores services

1. The organization and duties of the works service are laid down in Field Service Regulations, Vol. I, and in the Manual

of Engineer Services (War). The service is organized to conform to the sub-areas constituting the L. of C. area, and is responsible for all engineer work on the L. of C. other than that specifically the responsibility of other services.

Engineer units will be allotted to the works service by G.H.Q. as required. These units will normally include army troops companies, electrical and mechanical companies, and, possibly, field companies sent out in advance of their divisions. In addition, boring sections and other specialized units may be required. The engineer units will further need to be supplemented by semi-skilled and unskilled labour.

2. The organization and duties of the engineer stores service are laid down in Chapter VIII, and in Field Service Regulations, Vol. I, and the Manual of Engineer Services (War).

The units which form an essential part of the engineer stores service include :—

Workshop and park company.
Engineer base workshop.
Engineer store base depot.

The necessity of exploiting local resources may also require the inclusion of special units such as quarrying and forestry units.

CHAPTER VII

ENGINEER DIRECTION AND COMMAND

59. General principles

1. The chain of engineer direction and command is shown in Appendix V.

2. Formation commanders are responsible for directing the activities of all engineer units allotted to their formations, and issue orders for this purpose to engineer commanders through the general staff. In order to assist commanders in deciding on the most effective employment of engineer resources, senior engineer officers are appointed to headquarters of formations as engineer advisers.

The functions of these engineer advisers are, in the main, purely advisory; but they are authorized to issue technical instructions direct to the engineer commanders of their own and subordinate formations. They are not concerned with the direction and technical working of the services, but should maintain contact with the local representatives so as to facilitate co-ordination of the whole field of engineer activities. In special circumstances, where a large engineer work has to be undertaken (such as an elaborate defensive system or a large-scale area destruction), a formation commander may place his chief engineer in executive command of all engineer and other units to be employed on the work.

The executive command of the engineer units allotted to a formation is normally vested in a C.R.E., who receives his orders from the general staff, except that in armies and corps the C.R.E., army or corps troops, will receive his technical instructions from the C.E.

In divisions (*see* Sec. **70**), the C.R.E. combines the duties of engineer adviser and engineer commander.

3. Directors of services, acting under the orders of the appropriate branch of the staff at G.H.Q., are responsible for the working and technical details of their services. Local representatives and units of services are thus under G.H.Q. for general administration and under area or formation commanders for local administration (*see* Field Service Regulations, Vol. I, 1930, Secs. 10 and 11). The latter will include such matters as supplies, discipline and medical attention, and in addition measures of tactical security.

60. General headquarters

1. *General staff branch.*—The establishment of the general staff at G.H.Q. provides for an engineer officer specially appointed for advice on engineer questions. This officer will keep in touch with the Director General of Engineer Services (D.G.E.S.) (*see* para. 4, below), as senior engineer adviser at G.H.Q., on all major engineer questions on the general staff side.

The duties of the general staff which most closely affect the engineers include :—

i. The organization of engineer units, and the distribution of engineer units to formations.
ii. The continuous study of the engineering aspects of the military situation, forecasts of engineer work, and provision for future contingencies.
iii. The collection, collation, study and dissemination of engineer intelligence.
iv. Control over the engineering policy of the forces in the field, the preparation of engineer plans requiring G.H.Q. co-ordination, and the issue of orders thereon.
v. Engineer training.
vi. The allotment of engineer stores to formations and areas in consultation with the Q.M.G.'s branch (*see* Sec. **76,** 1 and 2).
vii. The control of the survey service.

2. *Adjutant-General's branch.*—The A.G.'s branch includes an A.A.G. for engineer personnel questions, including appointments of engineer officers. He will keep in touch with the D.G.E.S. on all major engineer questions affecting the branch.

3. *Quarter-Master-General's branch.*—The duties of the Q.M.G.'s branch include :—

i. The control of the army postal service.
ii. The control of the transportation services.
iii. The control, through the D.G.E.S., of the works and engineer stores services.
iv. The allotment of tonnage for the transportation of explosives and other ordnance stores, of transportation stores and of engineer stores, required by formations and by engineer units and services in accordance with the policy of the general staff.

4. *Director General of Engineer Services.*—The duties of the D.G.E.S. in relation to the works and engineer stores services are dealt with in Sec. **64,** 1.

In his capacity as senior engineer adviser at G.H.Q., his duties include :—

i. Advice on the matters specified in Sec. 60, 1, 2, and 3.

ii. General supervision of the technical methods employed by all engineer units and services.

iii. Inspection of all engineer units and services with a view to ensuring the co-ordination of all engineer resources and the correct execution of the G.H.Q. engineering policy and, if necessary, to recommending the modification of that policy.

The D.G.E.S. is not responsible for the working of the services, other than the works and engineer stores services, and does not issue orders to them.

61. The survey service

1. The survey service in the field is controlled by the intelligence section of the general staff.

2. The head of the survey service is designated the Director of Survey and is at G.H.Q. He is represented by an Assistant Director of Survey at each army and at each corps headquarters.

3. The survey directorate advises the various survey units on the execution of their work and is responsible for its co-ordination and technical direction.

4. In addition to the technical control of mapping, the survey directorate is responsible for the co-ordination of all other surveys and for giving technical advice to other arms and the general staff.

5. Survey duties in general include :—

i. The preparation and printing of maps.

ii. The maintenance of a trigonometrical framework on which maps and all field and artillery surveys can be based.

iii. The examination and disposal of captured maps and plans.

6. The officer commanding an engineer field survey company is in executive charge of all R.E. survey work in accordance with the instructions of the survey directorate.

62. The army postal service

The duties of the Director of Army Postal Services are laid down in Field Service Regulations, Vol. I, and the Manual of Army Postal Services.

63. The transportation services

1. The Director-General of Transportation, acting under orders issued by the D.Q.M.G., controls the technical working of the transportation services through their respective directors. Subordinate representatives of the various directorates are located at points selected for convenience of technical working, which do not necessarily coincide with the headquarters of formations or areas.

2. When, however, a transportation system is placed at the exclusive disposal of a formation (*e.g.* a light railway system in an army area), a representative of the directorate will be located at or near formation headquarters, and will receive orders for traffic from the Q.M.G.'s branch of the formation staff.

3. Details of the methods of control are given in Field Service Regulations, Vol. I, and in the Manual of Movement (War).

64. The works and engineer stores services

1. The D.G.E.S. carries out the following duties (in addition to those specified in Sec. **60, 4**) in relation to the works and engineer store services :—

i. Executive control, through their respective directors, of these two services.

ii. Approval of designs of engineer stores for local production, standardizing where desirable.

iii. Collaboration with the War Office (Director of Fortifications and Works) in the design of stores for production in the home country.

iv. Periodic forecasts of requirements of engineer stores for supply from the home country.

2. Details of the system of control in these services are given in Field Service Regulations, Vol. I, and Manual of Engineer Services (War).

65. Duties of a C.R.E., base or L. of C. sub-area

The duties of a C.R.E., base or L. of C. sub-area, include :—

i. The execution of all works services in accordance with the authority delegated to him by the Director of Works (*see* Manual of Engineer Services (War)), and advice to the sub-area commander in respect of such services.

ii. The execution of all field engineering works required by the sub-area commander for, or in connection with, L. of C. defence.

iii. Advice regarding and control of anti-gas measures.

66. Duties of an anti-aircraft unit commander.

The duties of the officer commanding an anti-aircraft unit include :—

i. Advice to his formation commander on searchlight co-operation.

ii. The disposition and operation of the lights so as best to fulfil the formation commander's intentions.

67. Duties of a C.E. or C.R.E. of a fortress

1. The duties of a C.E. or C.R.E. of a defended port or fortress include :—

i. Command of all engineer units allotted to the defence, whether for defence against air attack or sea-borne attack or for any other role, and advice to the fortress commander on engineer questions. (During operations and combined training, however, the lights are under the command of the fire commander or the air defence commander, and these two officers are the advisers to the fortress commander on technical distribution and handling.)

ii. Responsibility for the efficiency, from the engineer aspect, of all defences, whether fixed or mobile, including the defence of beaches, and defence against attack by land.

iii. The execution of works services, and arrangements for the provision of all engineer stores.

2. In a large defended port the scope of the engineer work required may necessitate a special works organization to carry out engineer services, the responsibility for engineer duties in the defence resting with the engineer fortress companies. Under such conditions the C.E. (or C.R.E.) of the fortress will have as his two principal subordinates a C.R.E. (or O.C.) fortress companies and a C.R.E. (or D.C.R.E.) works ; and he will usually exercise executive command over the engineer troops, in addition to acting as technical adviser to the fortress commander.

68. Duties of a C.E. of an army, and of a C.R.E., army troops

1. The C.E. of an army normally has no functions of executive command and fills an advisory role. In this capacity his duties include :—

i. Advice on the bearing of engineer factors on operations contemplated or likely to develop, with recommendations for the best utilization or redistribution of engineer resources.

ii. Advice as to co-ordination of engineer tasks allotted to corps, to ensure that the main engineer effort is in furtherance of the army commander's plans, and to eliminate waste of effort resulting from non-continuity of policy.

iii. Continuous study from the engineer aspect of all available information relating to the resources and physical features of ground over which operations are likely to develop, and advice to the general staff as to additional information required.

iv. Inspections of engineer work in progress, so as to ensure that the work conforms to the policy of the army commander, or alternatively to find out if the policy requires modification.

v. Co-ordination of demands for engineer stores submitted by corps, and advice as to the demands which should be made to G.H.Q.

vi. Advice as to the distribution of engineer stores allotted by G.H.Q.

vii. Arrangements with the engineer stores service for the forwarding of engineer stores to destinations, as fixed by the general staff.

viii. The issue of technical instructions to the C.Es. and C.R.Es. of formations in the army.

2. Exceptionally, the C.E. may be given executive command of concentrations of engineer and other units for the execution of engineering works on a large scale (*see* Sec. **59,** 2).

3. The duties of a C.R.E. army troops include :—

i. Executive command of engineer units allotted to army troops, and responsibility for the execution of engineer work allotted to the army troops engineers.

ii. The execution of engineer work required by army troops, subject to the approval of the general staff and to the technical instructions of the C.E.

iii. The control of army dumps of engineer stores under the direction of the C.E.

69. Duties of a C.E. of a corps, and of a C.R.E., corps troops

1. The duties of a C.E. of a corps, and of a C.R.E., corps troops, are analogous to those of the corresponding engineer officers in an army.

2. The C.E. of a corps can, subject to the necessary approval of the commander, give material help to the engineers of forward divisions by extending the limits of corps engineer responsibility as far forward as possible.

70. Duties of a C.R.E. of a division

1. The C.R.E. of a division, in addition to commanding the engineer units allotted to the division, is the divisional commander's technical adviser on all engineering matters, as affecting operations contemplated or in progress, including anti-gas measures.

2. He is responsible for the general direction and control of all work carried out by the divisional engineers or by engineer units attached to the division. He is authorized to inspect and advise on all engineering work carried out by units of the division other than engineer units. Orders for such work will be issued by the divisional staff to brigades or other formations concerned, after consultation with the C.R.E.

3. He is responsible to the divisional commander :—

i. For the efficiency of the divisional engineers and for their employment to the best advantage in furtherance of the commander's plans.

ii. For the technical soundness of his designs and for the economical employment of the engineer resources at his disposal.

4. He will study the information supplied by the general staff, and will initiate technical reconnaissances, as necessary.

5. He will advise the divisional commander regarding the organization of anti-gas intelligence and the execution of protective measures.

6. He will submit forecasts of engineer stores likely to be required for his division, and proposals for the utilization of local engineer resources. He will indent for engineer stores on area parks or dumps up to the quantities allotted for his division.

7. An O.C. field squadron carries out similar duties for a mobile division.

71. Duties of an O.C. bridge company, R.A.S.C., and of the senior engineer officer of the unit

1. The duties of the R.A.S.C. officer commanding a bridge company include :—

i. The command, administration, discipline and interior economy of the unit as a whole.

ii. The operation, maintenance and repair of vehicles in accordance with the system laid down in Royal Army Service Corps Training.

iii. The delivery of bridging equipment at the required place and time.

iv. The accounting for the engineer technical equipment held by the unit.

He will be guided by the advice of the senior engineer officer on the points mentioned in paragraph 2, iii, below.

2. The duties of the senior engineer officer on the establishment of a bridge company include :—

i. Command of the engineer detachment and responsibility to the O.C. bridge company for its discipline and efficiency.

ii. Responsibility to the O.C. bridge company for the maintenance of the bridging equipment, for reporting damage and deficiencies, for suggesting programmes of overhaul and for initiating demands for replacements, etc.

iii. Advice to O.C. bridge company as to the interpretation and execution of orders dealing with the technical employment of the bridge company, *e.g.* bridging units to be despatched, their order of march, distribution of engineer personnel, requests for engineer escorts to be supplied by receiving formations (*see* Sec. **95,** 6).

In the event of a break-down during the approach march he will advise as to the reorganization of the equipment and the material, if any, to be dumped. He will normally be the channel of technical liaison between the O.C. bridge company and the engineer H.Q. of corps and lower formations.

3. Should the incidence of casualties result in an engineer officer becoming the senior officer present with the unit, he will assume command for the time being. He will, however, be guided in all technical and administrative matters which are normally in the sphere of the R.A.S.C. by the advice of the senior R.A.S.C. officer.

72. Engineer work for the air force

1. The engineers are responsible for the execution of all engineer work required by the air force component with an army in the field, except only special items for which the air force is itself equipped, *e.g.* squadron lighting in the forward area.

2. An engineer officer is appointed as C.E. to headquarters, R.A.F., to carry out the following duties :—

i. To submit technical advice to the air officer commanding on engineer questions.

ii. To deal direct on matters of technical detail with

engineer commanders charged with the execution of work for the air force.

Two or more engineer officers, selected from the works directorate of the R.A.F., are included in the C.E.'s staff.

3. In the forward area the engineer requirements of the air force will, with the exception of landing grounds, be similar to those of army formations, *e.g.* billets, water supply, roads, etc. In principle, any army formation to which an air force formation has been allotted will be responsible for meeting its engineer requirements. The engineer responsibility for advising staffs as to these requirements, and as to the measures necessary for meeting them, will thus devolve mainly on C.Es. of armies and corps.

Landing grounds will be selected by the air force with engineer advice. It is essential that an engineer officer should take part in the reconnaissance, to give technical advice and to ascertain the engineer work required.

4. In the L. of C. area the engineer requirements of the air force will be of a more technical nature, and the responsibility for provision will rest with the Director of Works. In order that the requisite technical experience of the special requirements of the air force may be available, the works directorate includes a number of engineer officers, specially selected from the works directorate of the R.A.F. Of these officers one or more of the seniors will act as staff officers to the Director of Works for air force work; and the remainder, if any, will perform the ordinary executive duties of engineer officers of the works directorate, but will normally be employed in those sub-areas where air force work is most required.

The procedure for the initiation and execution of engineer work required by the air force differs in no respect from that in force for other engineer work in the L. of C. area, and is laid down in the Manual of Engineer Services (War).

CHAPTER VIII

SUPPLY OF ENGINEERING EQUIPMENT AND STORES

73. General

1. Field Service Regulations, Vol. I, defines the headings under which equipment and stores are classified, and outlines the processes involved in the design, provision and holding of stores, and in their despatch to delivery points.

2. The responsibility for the supply of the engineering equipment and stores required by engineer units and organizations in a theatre of operations rests as follows :—

i. Engineer stores, with the engineer stores service.

ii. Unit equipment, and explosives other than unit equipment, with the ordnance service.

iii. Transportation stores, with the transportation service concerned.

The definitions referred to in para. 1, above, must be borne in mind, and it should be noted that the engineer stores service is itself a user service partially dependent on the ordnance service.

74. The engineer stores service

1. The engineer stores service is responsible for the provision, local production (if advantageous) and holding of engineer stores, and for their despatch to destinations within the L. of C. area. For arrangements forward of railheads, *see* Sec. **75.**

2. At the outset of a campaign, a workshop and park company, consisting of headquarters, advanced park sections and workshop sections, will establish an engineer store depot and engineer workshops at the base. As the campaign develops, it will normally be necessary to detach an advanced park section to railhead ; and if an advanced base is formed, a workshop section will probably be required there.

If the campaign is of minor scope, an expansion of the workshop and park company by the formation of additional sections may be adequate to meet requirements. Otherwise it may be necessary to allot an engineer store (base) depot and an engineer (base) workshops for duty at the base ; and the

workshop and park company will be required at railheads and in army or corps areas.

The details of the organization to be adopted will depend on the magnitude of the campaign and on local conditions, but it must provide for an adequate store-holding organization and productive workshops, both at the base and at such points on the L. of C. as will render possible a reasonable flow of engineer stores to all areas.

3. The administrative regulations for the working of the engineer stores service are contained in the Manual of Engineer Services (War).

75. Engineer stores organization in front of railhead

1. The successive organizations through which engineer stores will pass after off-loading at railhead will include some or all of the following :—

i. An engineer dump at or near railhead.

ii. An engineer dump under divisional control, which will normally be organized by the field park company.

iii. Minor distributing centres organized by the field companies, either for their own tasks or for issues to infantry brigades.

The railhead dump, which will usually be essential, will be operated by an advanced park section detached from the workshop and park company. In a temporary emergency it may have to be organized from the resources of a corps engineer unit ; but the denuding of a field unit for this purpose should be avoided.

The field park company normally handles all engineer stores in transit to the forward troops, the field companies acting as subsidiary distributors, if convenient. The location of the workshops and field stores groups of a field park company needs careful consideration. To develop their full capacity as a store with productive workshops, they require a site with good road approaches, with a flat well-drained storage space and with cover for machinery. Supplies of water, light and power will be of great assistance.

If the delivery points are known in advance and the distances are not too great, double handling may be saved by eliminating one or more links ; *e.g.* by delivery direct from railhead dump to a brigade area or to the site of a work.

2. Transport and labour are the most important factors affecting the delivery of engineer stores throughout the channel of supply. The transport allowed for engineer stores in the war establishments of a field park company and of the

formation supply column R.A.S.C. is sufficient only for the minimum needs of a division in highly mobile operations. When any considerable flow of engineer stores is required, special allotments of transport will be necessary from railhead to the forward troops. These demands will often be urgent, and it is incumbent on engineer officers to look ahead and to give warning of probable transport needs. Similarly, the provision of labour for the off-loading and loading of engineer stores will often be an essential factor, calling for forethought by the engineers and staffs concerned.

76. Demands for and issue of engineer stores

1. Demands for engineer stores in the forward areas will be made through the normal channels of command, either on the C.R.E. of the formation, or, if there is an engineer unit "under command" or "in support", on that unit. Co-ordination of demands is effected by the general staff at division and successive higher formation headquarters, in consultation with the engineer representative.

Demands for engineer stores in the L. of C. area will be made as prescribed in the Manual of Engineer Services (War).

As an exception to the above, a C.R.E. will indent direct on the engineer store base depot (or on the advanced base park section of the workshop and park company, if established) for spares for the maintenance of engineer plant, other than unit equipment. Indents will be certified as replacements of parts worn out or lost through the exigencies of the campaign.

2. Demands for engineer stores will be co-ordinated finally at G.H.Q. (or at army headquarters, if so authorised), and issues decided according to stocks available and to the relative importance of demands. Allotments will be notified to subordinate formations; and the Q.M.G.'s branch will issue orders for executive action to the directorate of engineer stores, which will be responsible for despatch by rail to destinations. These destinations will normally be area parks or dumps, serving the L. of C. area or the areas of corps and divisions.

On notification of the G.H.Q. allotment to formations, C.Es. will notify to the engineer store base depot the destinations required and the quantities for each.

3. When stores are due at railheads, C.Es. of corps will initiate action through the Q.M.G.'s branch, for the off-loading of stores from rail and for their onward despatch by the formation supply column, R.A.S.C., or by such specially allotted transport as may be required.

Army headquarters are responsible for delivery to corps dumps, and corps headquarters are responsible for delivery to divisions. C.Es., by working in close touch with their formations, can materially assist both staffs and lower formations by the exercise of forethought and initiative.

4. Within divisions, issues of engineer stores will be made by the C.R.E. in accordance with the scales or policy laid down by the commander. Subject to the restrictions imposed by their engineer commanders, engineer officers have discretionary powers in meeting minor demands from dumps in their charge. Demands for stores must be in writing, and receipts must be given by the persons authorized to draw them.

5. The C.E. of an army may reserve certain stores in a corps park or dump for issue on his own authority only. The C.E. of a corps may impose similar reservations on divisional parks or dumps.

77. Principles underlying engineer stores practice

1. The rate of supply of stores is governed by some or all of the following factors :—

i. Timely forecasts of demands.

ii. Factory or workshop productive capacity.

iii. Transportation facilities (including shipping) from the source of production, in the home country or in the theatre of operations, to delivery points.

2. Considerable delay is to be expected in obtaining a substantial flow from home sources of any new pattern of store. A change of pattern of store will usually check its output for a time. The decision to make an important change must, therefore, be accompanied by provision for interim measures pending the development of the new output.

3. When there is an appreciable demand for made-up stores of a similar type, time and labour will be saved if the pattern can be standardized and its production undertaken in workshops under the engineer headquarters of the formation or area concerned. The extent to which this is possible may vary from the production by a field park company of a store to meet a temporary demand in its own division to the standardization of a store for the whole force and its production in the home country or at the base.

It is not, however, the function of divisional and corps units to undertake the production of stores which have been

standardized for the force, except for trial and experiment or to tide over a delay in the main supply (para. 2, above).

The standardization of a store can only be fully effective if current designs of engineer works make full use of the pattern standardized.

4. Apart from the accounting duties imposed on certain L. of C. units in respect of stores held by them, the ability to report stocks in hand is essential for efficient maintenance. In all parks, and when possible in dumps, simple accounts will be kept in tally card form showing receipts, issues and balance in hand, so that stocks are always known with reasonable accuracy.

5. The accumulation of large reserves of stores by formations without authority is forbidden, as this leads to the locking up of stores needed elsewhere. Unavoidable accumulations will be reported to the higher command for disposal orders.

78. Unit equipment

1. The replacement of unit equipment, as authorized in War Equipment Tables (Army Form G 1098), is effected by the ordnance service on indents submitted to the D.A.D.O.S. of the formation. As an exception to this, the replacement of normal wastage of equipment explosives is immediately effected from the reserves carried in the formation ammunition company R.A.S.C., by notification from the C.R.E. to the Q.M.G.'s branch of the formation staff. (*See also* Sec. **79.**)

2. Certain engineering tools and expendable stores are common both to War Equipment Tables (ordnance service supply) and to normal engineer stores (engineer stores service supply). It is desirable that requirements under each category should be demanded from the correct source, as the articles of ordnance supply conform more accurately to equipment specifications, including weight, which are important for packing and mobility. When active operations are imminent, however, there is no objection to engineer units making good equipment deficiencies from engineer store dumps, if this is the only means whereby such replacements can be effected in time.

3. The responsibility of divisional engineers and army troops companies for the maintenance of engineer equipment and plant on their charge is limited to first-line repairs. (*See* Field Service Regulations, Vol. I.)

Articles requiring second-line repairs will be sent to the ordnance service if unit equipment, and through the usual

channels to an electrical and mechanical company if engineer plant.

Articles beyond the capacity of second-line repair organizations will be returned for L. of C. repair.

As a rough guide, a second-line repair may be taken as one that can be effected within four days. But the exact line of demarcation between different classes of repair will depend on local circumstances.

79. Explosives

1. When any abnormal expenditure of explosives is anticipated in the forward area, the C.R.E. or C.E. will arrange for its supply with the Q.M.G.'s branch of the staff.

2. A strategic reserve of explosives will be maintained in the field so as to ensure that an adequate supply shall be available for strategical demolitions on a large scale. The size and location of this reserve, and its provision, are the responsibility of G.H.Q.

3. Explosives are delivered by the ordnance service at ammunition railheads and conveyed forward to units in ammunition echelons R.A.S.C.

4. The normal channel of replacement of equipment explosives of field companies is through the field park company of the division.

80. Local resources

Engineer officers will take every opportunity to ascertain by reconnaissance the local resources of engineer stores in their vicinity. The general principles governing their acquisition are laid down in Field Service Regulations, Vol. I, and further details are given in the Manual of Engineer Services (War).

During a pursuit, the enemy engineer dumps may provide a valuable source of supply. Engineer commanders of leading formations should therefore report their locations and contents to higher authority.

81. Economy and salvage

Engineer officers are responsible that stores and plant are economically used. Their replacement constitutes a burden on the resources of the force and of the nation. The salvage of stores and plant is an appreciable contribution to this end.

CHAPTER IX

CONTROL OF WORK IN THE FIELD

82. Principles of control

1. In order that the engineer resources of a force may be utilized to the greatest effect, the following principles should be observed :—

i. Conformity of work to the requirements of the strategical, tactical and administrative situation.
ii. Economy of engineer resources, coupled with their concentration at the decisive time and place.
iii. Avoidance of divided control.
iv. Continuity in the execution of work.

2. It is the duty of the general staff to co-ordinate and to control the general scheme of engineering work in furtherance of the commander's plan, and to ensure by frequent inspection that the directions of the higher command are being followed. (*See also* Sec. **59.**)

3. By careful forethought, based on reconnaissance and on other sources of engineer information, the allotment of engineer resources in personnel and material can be economically planned. By foresight and anticipation, their concentration can often be pre-arranged at the times and places where their employment will be most effective.

4. The evils of divided control can only be obviated by a system under which responsibility is clearly allocated for the initiation of a work, for its design, execution and inspection, and for the supply of the labour, tools, material and transport required for its execution.

5. Continuity of execution is based on a clear initial scheme for the engineer contribution towards the commander's plan ; and is maintained by the higher command ensuring that no deviation occurs therefrom under the influence of irrelevant factors such as the reliefs of formations and units employed in its execution.

83. Classification of engineer work

Engineer work in a theatre of operations falls under two main headings :—

i. Field engineering.
ii. Services.

Field engineering is intimately connected with tactical operations, and is mainly confined to the areas of forward formations. Tactical requirements such as L. of C. defence may, however, call for field engineering work in the L. of C. area.

Services, which are further sub-divided into transportation services and works services, are mainly concerned with work in the L. of C. area. Such work includes engineering works of a more general and deliberate nature, largely for administrative purposes, and is under the centralized control of directorates at G.H.Q. For details, *see* Field Service Regulations, Vol. I, the Manual of Engineer Services (War) and the Manual of Movement (War).

The division of engineer work under these two headings depends rather on the agency by which they are carried out than on the nature of the work: and it is essential that work in the forward area, as for example, on communications, should be co-ordinated with the requirements of the L. of C. into which they will later be absorbed. Nor can a hard and fast line be drawn between the sphere of the engineers of the forward formations and that of the L. of C. services: it may in certain circumstances be convenient for the latter to take over certain types of work within the area of forward formations. Unity of engineer policy is therefore of great importance.

84. Authority for the execution of work

1. Field engineering is carried out under the orders of the commander concerned or in conformity with the intentions and policy laid down by him.

2. When time permits, the order for the execution of a field engineering work is given or confirmed in writing. All orders for work will normally be received through the correct channels of command. Officers outside those channels are forbidden, except in emergency, to issue orders for changes in or deviations from the work authorized.

3. The authority for ordering the execution of a *service* is delegated in accordance with the administrative regulations of the directorate concerned, in accordance with the policy for which the Q.M.G.'s branch is responsible.

85. Technical approval of design

Under active service conditions it is often impossible, before starting a work, to carry out the full preparation of drawings and examination of engineering details which are possible in

peace. Time will frequently be the ruling factor. Junior officers must therefore be prepared to assume full responsibility for the design of works required at short notice, and to produce rough working drawings adequate for their execution; and senior officers must decentralize their responsibility accordingly.

86. Execution of a work

1. The execution of any but the smallest engineering work calls for attention to the following measures :—

i. The clear definition of the object of the work, consideration of all relevant factors and an appreciation culminating in a plan.

ii. The design of the work, with estimates of the time, labour, stores and transport necessary for its execution.

iii. The allocation of responsibility to formations and units for its execution.

iv. Arrangements for the security of all troops to be employed on the work.

v. Administrative arrangements for the assembly of the resources, estimated in sub-para. ii, above, at the desired times and places.

vi. Explanation to all ranks of the nature, extent and probable duration of the tasks allotted, and of the method of distributing the party on the work.

vii. The provision of technical advice and help as necessary.

viii. Inspection of the work in progress.

ix. The submission of regular progress reports, and of a completion report.

2. The security of troops employed on a work may be provided for either by the existing dispositions of other troops or by detailing a special protective detachment to cover the working party. The senior officer present is at all times responsible for the security of the working party. If he considers the protective arrangements inadequate, he will apply for the necessary troops to be detailed; and, pending their arrival, he will detail protective troops from the working party.

When there is any possibility of a working party being required to use its weapons, its commander will ensure that the weapons are immediately accessible.

The liability of working parties to air attack may necessitate special protective arrangements for unarmed labour in the back areas.

3. Demands for working parties will be estimated by

engineer officers: orders are issued in terms of numbers of actual workers required. Units detail parties ordered by complete sub-units calculated to produce the numbers ordered.

Engineer officers, in submitting working party demands, will state the rendezvous and arrange for the provision of guides. They will also state the name and unit of the engineer officer in charge of the work, the nature of the work, and its probable duration or the hour of return to the rendezvous. They will stipulate what tools are to be brought by working parties, what additional tools and stores will be provided, where the additional tools and stores are to be drawn and where tools are to be returned. If the working party is a large one, the demand will show the number and sizes of the parties into which it is to be sub-divided, and the hour at which each is to be at the rendezvous.

The duties of engineer officers as regards the provision of engineer stores necessitate their organizing the supply so that dumps may be available in convenient positions for issue to working and carrying parties, with the tools and stores laid out so as to facilitate rapid issue and easy carriage.

Transport will be required for the carriage of stores, and possibly of personnel, and may include carrying parties for stores when in close proximity to the enemy. It will usually be the duty of engineer officers to provide the necessary data for the issue of orders on these points. Demands for carrying parties will conform to the rules given above.

4. The best method of allotting work is to allot tasks to sub-units whenever practicable. The tasks will be allotted on estimates of the time required for their completion. These estimates should be generously framed, so that the troops may realize that hard work will be rewarded by early release from a sometimes arduous duty. Whenever possible, as on large road construction work, tasks should be allotted by the week, so that the more energetic units may by their zeal earn a clear day's rest.

Trained sappers are capable of eight hours' work a day, provided that the march to and from work does not exceed one hour each way. Night work is more exhausting, and six hours is as much as can be expected without loss of efficiency. Infantry working parties do not as a rule produce the best results on heavy manual labour, such as digging, for longer than four hours at a stretch. If there are more than two reliefs of infantry working parties, the engineer reliefs should be arranged not to coincide with the infantry reliefs, in order that continuity may be facilitated.

Experience has shown that output of work is not increased by working more than six days a week. Attempts to exceed this as a normal routine use up the reserves of energy which enable the troops to make a special effort in emergency. Furthermore, troops which are called upon to carry out exacting work over a long period must have good food and rest under reasonable conditions of comfort and security.

It is important, especially for night work, that troops should be saved all unnecessary fatigue. By careful organization to avoid delays when going to and from work, and by arrangements for the provision of hot meals, the troops will be enabled to produce the best results in difficult circumstances.

87. Responsibility for the execution of work

1. Field engineering work includes :—

i. *Work for which the engineers are responsible.*—This may be carried out solely by engineer units, or by engineer units assisted by working parties of other units, or by military or civilian working parties working under engineer direction.

ii. *Work for which the other arms are responsible.*—This will be carried out with material supplied by the engineers, but generally without engineer supervision or help other than technical advice or minor assistance in technical details.

2. The formation commander, after consultation with his engineer adviser, decides what work is to be done by the engineers or under engineer control, and what work by other formations and units. He allots definite tasks and responsibilities to each.

3. When working parties of other arms are employed on work for which the engineers are responsible, the division of responsibility is as follows :—

i. The engineer officer in charge of the work will be responsible for the following :—

(*a*) Preliminary reconnaissance.
(*b*) The correctness of the design.
(*c*) Marking out of work.
(*d*) Demanding the working party.
(*e*) Demanding a covering party, if necessary.
(*f*) The supply of stores, additional tools, measuring rods, templets, etc.
(*g*) The supply of guides for the working party.
(*h*) Explaining the task and the time required for it.

(*j*) Notifying to the commander of the troops in the sector the nature and timings of the work which is to be carried out, and the consequent movements, so that all subordinate commanders in the vicinity, including artillery and other supporting units, may be duly warned.

(*k*) The submission of progress reports.

(*l*) Ensuring that the completed work is in accordance with the design.

ii. The officer in charge of the working party is responsible for the following :—

(*a*) Explaining the work to his subordinates.

(*b*) Ensuring that his men have the necessary tools and materials.

(*c*) The allotment of tasks to, and disposal of, his men on the work.

(*d*) The diligence of his men.

(*e*) The discipline of the party and the observance of orders regarding lights, smoking and silence.

(*f*) The execution of the work in accordance with the instructions received.

While the engineer officer in charge of the work must give the officer in charge of the working party every assistance, it is essential for the maintenance of discipline that the latter should be responsible for sub-alloting the task, and, if the engineer officer so directs, for checking the work on completion and withdrawing his party when he is satisfied that the work has been completed. To enable the officer in charge of the working party to discharge this responsibility, he must be supplied with the necessary designs, measuring rods and templets.

As an exception to the above rule, when parties of the other arms are detailed to assist engineers on technical tasks, and the labour is organized in mixed parties of engineers and other arms, the officer in charge of the working party will be responsible only for the discipline and diligence of his men, but will, as far as possible, be the channel through which instructions are conveyed to them.

4. In the event of serious casualties being incurred by a working party, the *senior officer on the spot* will be responsible for deciding whether the working party should be withdrawn temporarily or whether an attempt should be made to carry out the task at all costs.

If heavy casualties are anticipated, the commander who

orders the work will give definite instructions as to its urgency.

88. Records

1. When the construction or maintenance of an engineering work covers a long period of time, it will often be advisable for the engineer officer in charge to maintain a record file or log book containing the following :—

i. All orders received about the work from the staff, and any technical instructions issued by higher engineer authority.

ii. Standing orders issued by the engineer officer in charge.

iii. Technical plans and explanatory notes, with special reference to any unusual features and to the necessities of maintenance routine.

iv. A diary of important items of work done.

2. Such a record may be of great importance in such work as the maintenance of a prepared demolition or of a bridge over a difficult river. Moreover, the handing-over of charge, owing to reliefs or casualties, will be simplified, and discontinuity of technical policy avoided.

CHAPTER X

ENGINEER DUTIES IN THE FIELD

89. Principles of employment

1. Time is usually a predominant factor in war. As engineer work takes time, not only in execution, but also in the preliminaries of design, lay-out and the assembly of personnel and stores. Every effort must therefore be made to save time by forethought.

The following principles should be observed :—

i. Close touch is essential between commanders and their engineer advisers, so that the latter may have early information of the commander's plans and ultimate objects, and so that there may be no delay in such measures as the provision of stores and transport required for engineer work.

ii. Engineer officers should tender the earliest advice to commanders on the bearing of engineer factors on plans and contingencies, with recommendations for the effective employment of engineer resources. They should exercise forethought in providing for future tasks, and should be prepared to recommend dispositions of engineer resources in anticipation of their being required.

iii. The earliest possible engineer reconnaissance should be arranged, and full use made of all sources of information obtainable.

2. The heavy and often urgent demands for engineer work necessitate the observance of the following principles, in order to achieve economy :—

i. Centralized control (*see* para. 3, below), with the engineers working as units under engineer commanders, should normally be adopted.

ii. The section is the smallest engineer sub-unit which can be economically employed, and it should rarely be split up. A section should be given a task or group of tasks in a restricted area. The attaching of a few engineer personnel to other arms can seldom be justified.

iii. Clearly defined tasks or responsibilities should be given to engineer units.

iv. When the demand for engineer work exceeds the resources available, the staff will lay down an order of priority.

v. In order to derive full advantage from his technical resources, a commander should not usually employ engineers on work (such as trench work and wiring) which the other arms are in a position to do for themselves. But, when tactically necessary, engineers may be so employed pending a more normal distribution of work.

vi. An engineer reserve should be kept in hand to meet unforeseen demands. If necessary, this reserve may be employed on work which can be left at short notice. But engineers, like other troops, need regular periods of rest: and tired units cannot be regarded as effective reserves.

3. The control of the engineers of a division may be organized in any of the three following ways:—

i. Normally and whenever circumstances permit, the engineer units will work under the direct control of the C.R.E. Under this system engineer units of a division may be attached for convenience of administration (*e.g.* supplies and medical purposes) to the infantry brigades in whose areas they are located; but they will not be at the disposal of infantry brigades for work. Demands by the other arms for engineer work is made to divisional headquarters.

ii. Engineer units may be placed "*in support*" of infantry brigades, to carry out tasks the execution of which closely affects those brigades. Under this system engineer unit commanders will meet demands for engineer assistance made by their brigades, so long as this can be done without prejudice to the tasks ordered by divisional headquarters.

iii. Engineer units may be placed "*under command*" of infantry brigades. This system will often be adopted when a brigade is detached for a specific task, such as advanced guard. Under other conditions, where divisional control has to be temporarily decentralized, such as in the early stages of the hasty organization of a defensive position, this system may also be employed.

If a system of decentralized control of engineers is adopted, however, it is a principle that centralized engineer control should be resumed as soon as a unit has completed the particular duty for which it was detached and the C.R.E. is in a position to exercise such control effectively.

90. Information and reconnaissance

1. The senior engineer adviser with a formation will need timely and accurate information on which to base both the advice which he tenders to the commander and his own

technical plans, and must be prepared to initiate action to obtain it. Such information may be forthcoming from intelligence reports, air photographs (preferably stereoscopic pairs), maps and record plans and guide-books, or from the archives of municipal offices and commercial concerns. But any information so gained must be supplemented and verified, whenever possible, by reconnaissance.

It is the duty of engineer advisers of formations to bring to the notice of commanders the need for completing and verifying the required information, and to obtain their co-operation, where necessary. This may take the form of (for instance) application to higher headquarters for assistance, special air reconnaissance, special interrogation of prisoners, orders to subordinate formations, etc.

2. Among the objects of engineer reconnaissance are :—

i. To ascertain where engineer work is or is likely to be required.

ii. To obtain early and definite information of the nature of the work, and of the resources required for its execution, so that the latter may be assembled in time.

iii. To ascertain the resources of an area in tools, materials, water supplies, accommodation, concealment, etc.

iv. To ascertain the capacity of, and improvements or repairs required for roads, bridges, etc.

v. To obtain the information required to prepare a demolition plan.

3. While engineer units should always take every opportunity of examining and reporting anything of engineer interest within their zone of action, extended reconnaissances unconnected with their immediate tasks, which may absorb personnel and transport required for other duties, should not be undertaken without higher authority.

If the execution of extended reconnaissances of this nature involves the co-operation of other arms or of subordinate formations, the commander concerned will issue the necessary orders ; but if the engineers of the formation are alone concerned, the engineer commander will issue the orders, after discussion, if necessary, with the commander concerned.

4. The engineer officer ordering a reconnaissance must have a clear idea in his own mind of the points on which he requires information. He should express these in the form of questions requiring definite answers, arranged in order of priority ; and he must state the time by which the report is to be handed in, to whom and where.

If time does not permit of written orders, it will usually be advisable for him to dictate the essential points.

If he divides the reconnaissance among two or more individuals, he must allot definite tasks to each, or he may define areas of responsibility.

5. Detailed instructions for the execution of an engineer reconnaissance are given in the Manual of Field Engineering, Vol. II.

6. Full use should be made of the facilities afforded by advanced troops, important patrols and independent mobile forces, by attaching engineer reconnaissance parties to them.

7. It is essential that reconnaissance reports should reach the destinations ordered in time to be of use. For this reason it will often be necessary to make special provision for the rapid transmission of such reports by allotting M.T. or motor cyclists to the reconnaissance parties.

Detachment commanders, such as an advanced guard commander, should be kept informed on any points likely to affect them, preferably by a separate message. The despatch of the report must not be delayed on this account.

8. The C.R.E. of a division is responsible for co-ordinating the engineer reconnaissances of his command with those carried out by his engineer detachments (*e.g.* the engineers allotted to an advanced guard). He will further arrange for the timely transmission to higher formation, or to formations cooperating, of any engineer information likely to be of value. Information, other than of purely technical interest, will be transmitted through the general staff.

9. The above paragraphs deal mainly with the reconnaissances required in connection with the immediate task of the formation or of its engineers. In addition, there is a mass of technical information concerning the theatre of operations which should be collected in readiness for future reference. Such technical information may include :—

i. Data regarding main communications by rail, road, waterway and air route.

ii. Data of important waterways and other physical features, and of their main crossing places, regarded as potential obstacles to our own or to enemy movement.

iii. Details of enemy bridging equipment, including stock-span bridges.

iv. Capacity and other details of installations for power, lighting, water supply and engineering works. Water supply maps, with geological information.

v. Local resources of engineer stores of all kinds, and potential sources of supply in adjacent territories.

Such information may be obtainable through the intelligence section of the general staff in the home country or in the field, from local records or by reconnaissance.

10. The collation, record and distribution of technical information are duties of the engineers, but the general staff is responsible for the distribution of all intelligence, including engineer intelligence. The extent to which these duties can be carried out by the engineer staffs of formations is limited by the degree of mobility of operations; and their performance will therefore largely be centralized at G.H.Q. under the direction of the engineer staff, who will prepare the necessary instructions for technical reconnaissances and distribute technical information as required.

11. Engineers may be required to obtain information of the character of the country in regard to tank obstacles, such as rivers, railway cuttings and embankments, woods, sunken roads, etc. Officers of the Royal Tank Corps should, however, usually be associated in such reconnaissances, and their record on special tank obstacle maps is the duty of the general staff.

12. The organization of a system of anti-gas intelligence is a special duty of the engineers. To assist in this, chemical advisers should be attached to the headquarters of certain formations. For details, *see* Sec. **98.**

91. Engineer liaison with other arms

1. Close and effective liaison between the engineers and the other arms is essential. When an engineer unit is placed under command of, or in support of, a formation, this liaison should be automatic, the commander of the unit performing for the formation duties similar to those of C.R.E. of a division. In other circumstances it may be necessary to detail an engineer liaison officer for duty at the headquarters of a formation.

2. The duties of an engineer liaison officer detailed to the headquarters of a formation are :—

i. To advise as to the situations in which engineer assistance should be asked for, and as to the nature of that assistance.

ii. To inform his own engineer commander of any engineer assistance required, or likely to be required, with details of the personnel and stores needed for its execution.

iii. To carry out any preliminary measures possible, pending

the arrival of engineer assistance, *e.g.* detailed reconnaissance and organization of infantry working parties.

iv. To advise as to the technical details of work required which, though the responsibility of the formation to execute, may be such as to render technical advice desirable.

3. The establishment of engineer officers with formations precludes the detailing of liaison officers unless exceptional circumstances render this essential.

An engineer liaison officer will usually require the assistance of a small party of engineer personnel. If the inter-communication arrangements between the formation headquarters and the higher command are liable to severance, the liaison party of engineers should include a runner or despatch rider.

4. Liaison in battle is most effective when it is a continuation of a liaison which has been established under more peaceful conditions while resting or in reserve, or in the administrative routine of peace. It is therefore desirable normally to employ a particular engineer unit to train with, and to work for, the same infantry brigade; but this does not mean that the infantry brigade has the right always to have the service of this, or indeed of any, engineer unit.

92. Forward communications

1. Troops in contact with the enemy require communications adequate for freedom of movement and security of maintenance. During the earlier phases of an operation conditions will often limit the provision which can be made to the use of the existing road system, supplemented by such rough tracks as can be improvised by the forward troops.

In such circumstances the work to be done by the engineers may include:—

i. Making a passage through hedges, fences and other obstacles.

ii. Clearing and improving tracks, filling in craters, marking routes in featureless country and signposting.

iii. Making a passage round or through woods, cross-roads and other areas which have been contaminated with persistent blister gas (*see* Sec. **98**). The protective equipment carried may have to be kept well forward.

iv. The passage of rivers and other gaps (*see* Secs. **95** and **110**).

Where concentrations of transport are expected, *e.g.* at ammunition, delivery and refilling points, the engineers may

be required to provide traffic circuits. This will be of special importance where air concealment necessitates vehicles parking under cover of woods.

2. Engineer effort may be economized when it is possible to co-ordinate the work to be done by lower formations with the subsequent policy intended by higher formations. During active operations, however, coordination may have to be subordinated to the necessity of meeting the immediate needs of the forward troops as quickly as possible.

3. It is the duty of engineer commanders, in conjunction with formation staffs, to consider, before operations begin, where engineer work on communications will be most needed. If decisions reached are notified (*e.g.* in operation orders) in the form of definite tasks or responsibilities for the engineers, it will not only facilitate the rapid execution of the work, but will also ensure its immediate value to the other arms. Nevertheless, the many unforeseen needs of the forward troops can only be fully and promptly set by continuous liaison between engineer officers and the units engaged, and by the retention of engineer reserves.

4. In the later stages of most operations the development of the tactical situation will enable a more definite plan to be framed for the organization of the communication system. Engineer units will be concentrated on the arteries required, special transport will be necessary for bringing up engineer stores, and the makeshift provision referred to in para. 1, above, will be improved and developed.

During lulls in the operations, particularly if a further advance is intended, properly organized communications will be pushed as far forward as tactical conditions permit; and forward engineer store dumps will be formed. Following behind the divisional engineers, the engineers of corps will be engaged in road construction of a more permanent type, up to, and within, the rear of divisional areas. The work of the corps engineers on the more permanent roads will be appreciably lessened if it has been found possible for some of the earlier tracks to follow alignments suitable for these roads.

In order to co-ordinate the initial development of the forward communications during an advance with the road system ultimately intended, the fullest use should be made of the corps field survey companies. By means of stereoscopic mapping processes, location plans for roads behind the enemy front can be produced within four to six days of the provision of the necessary air photographs. While it may not always be possible to site forward tracks on pre-selected alignments,

any success that can be achieved in so doing may materially reduce the time required for the execution of the subsequent road construction programme.

5. While the conditions of mobile warfare practically limit the forward communications to the systems of roads and tracks described above, position warfare introduces further variations. Thus, in the immediate vicinity of the foremost defences, communications will perforce be by means of trenches, as described in the Manual of Field Engineering, Vol. I (All Arms). Furthermore, the difficulties of transporting the numerous stores required under position warfare conditions may necessitate the provision of tramways both in trenches and on the surface. While hand-drawn or animal-drawn systems may be installed and operated by the engineers of forward divisions, power-driven tramways can best be operated with a more centralized control; and it is therefore possible that any extensive system of power tramways will be included in a Directorate of Light Railways. In any event co-ordination by the higher command will be necessary to obviate the non-continuity of policy which may result from the reliefs of forward divisions.

93. Roads

1. The road requirements of a force depend on the types of transport with which the fighting troops are equipped and on which the maintenance system is based. In a major war in a civilized theatre of operations the normal situation will be as follows:—

i. Units of the fighting arms will have first-line transport of considerable cross-country capacity. In the area forward of ammunition and delivery points good roads are therefore a convenience to be sought rather than a necessity. Essential requirements can be met by the hasty expedients summarized in Sec. **92.**

ii. Second-line transport will be M.T. with a limited cross-country capacity. Between refilling points and delivery points good tracks, or roads of a low type of construction, will therefore be a necessity for ordinary running, especially if distances are great.

iii. Third-line transport will be M.T. with little or no cross-country capacity for ordinary running under load. Between railhead and refilling points roads will therefore be essential; and these must be of a high type of construction if required for more than a few weeks.

iv. Transportation on the L. of C. will be by rail or river,

but roads will be required for local traffic at the base and at other important centres, and possibly for short subsidiary branches from the main L. of C.

2. Between railhead and refilling points the volume of traffic will be greater, and individual vehicles generally heavier, than in the areas of forward divisions. Traffic will tend to be concentrated into a few main arteries. Although the ideal for each division will be one up and one down artery, it will often be impossible to provide more than one good two-way road for each corps, except in well-developed countries. Moreover, only roads of first-class construction will stand up to military traffic for any length of time; and reliance on inferior roads will entail serious risk of an administrative breakdown.

3. If important changes in the battle front are unlikely to develop, the lay-out of the road system in the areas of forward divisions will be planned so as to serve the tactical and administrative needs of the troops, as far as technical resources permit. If an advance is contemplated, however, it will be essential to plan this lay-out so that some of its arteries may eventually fit in with the forward extension of the run of the third line transport, when railheads and refilling points move forward.

Considerations of continuity, economy of effort and possibly secrecy may thus necessitate a measure of control over road policy by the higher command. In addition, the necessity for relating the demands for engineer stores for road construction to the supplies which can be made available will call for such control.

4. In planning the lay-out and construction of roads forward of railheads, the following factors may need consideration :—

i. Concealment from ground observation, artificial screening, and the avoidance or bye-passing of villages and depots within range of the enemy's artillery.

ii. The alternatives of providing durable roads at the cost of time, or of temporary reliance on inferior roads.

iii. The adaptation and improvement of existing roads.

iv. The technical possibility of rapid (*e.g.* mix-in-place) methods of making temporary roads, or of temporarily surfacing more permanent roads under construction.

The time and labour saved by road-making machinery may justify the adoption of new alignments suited to its use, rather than the improvement of inferior roads on alignments not so suited.

5. The road work to be done forward of railheads will be

carried out under corps control, the corps engineers being reinforced, as necessary, by army engineer units, by field companies temporarily withdrawn from divisions and by labour units.

If the problem is abnormally acute, it may be necessary to create a special organization, with road engineers attached to formation headquarters and specially-raised road construction units.

The importance of continuity, as well as the superior resources in plant and labour available behind the leading formations may justify the extension of the responsibility of the works service for road construction forward of railheads, and of corps responsibility into the areas of forward divisions.

6. Economy of time and labour may sometimes be effected by the installation of light railways in the forward area, especially when the ground is suitable for rapid railway construction and when the stores supply favours such a course. For military reasons, also, it may be feasible to substitute a light railway for one or more links in the road transport system, thus liberating road transport units for use in active operations elsewhere.

Any form of railway is, however, more susceptible to serious interruption by enemy artillery fire and air attack than is a road system.

7. Within the L. of C. area the design and lay-out of all roads will be planned to the highest engineering standards. By this means the wear and tear of vehicles will be minimized and road maintenance work kept down. The construction and maintenance of such roads are the responsibility of the works service.

8. Technical details of road engineering will be found in Military Engineering, Vol. V (Roads).

94. Transportation

1. The engineers allotted to the transportation services are responsible for the survey, construction, maintenance and operation of all railways, docks and inland water-ways serving a field force.

The methods of the internal working of these services will vary in accordance with local conditions, but will generally follow the principles laid down in Military Engineering, Vol. VIII, which will be supplemented by working instructions issued under the orders of the Director General of Transportation.

2. In the absence of adequate communications by rail or river it may be necessary to organize an intensive system of road transportation by M.T. under the direction of the movement control staff. The provision, operation and maintenance of the M.T. is the responsibility of the R.A.S.C.; and engineer responsibility will be limited to the provision of adequate roads and ancillary accommodation.

3. Tramways are not normally a transportation service, but are the responsibility of the engineers of formations or of the works service, according to their location.

4. Further details will be found in the Manual of Movement (War).

95. General arrangements for bridging

1. Engineers will be required to assist in the passage of troops across rivers and other gaps over which inadequate means of passage exist. Their work will range from hasty expedients, such as the marking of fords or the operation of ferries, to the construction of permanent bridges of great strength.

The increased weights of the vehicles which form part of a modern army have limited the results obtainable by extemporization, and have rendered more difficult the technical problems of crossing a river, both in the face of opposition and otherwise. Forethought in estimating and assembling the resources necessary for such a contingency is therefore essential, so that the success of the operations may not be prejudiced by delay.

On the other hand the facilities offered by an efficient engineer intelligence organization, supplemented by a full use of air reconnaissance, should afford commanders and their engineer advisers timely warning of any important water obstacles likely to be met: and it will usually be possible to anticipate the main requirements for the crossing of such obstacles. It is the duty of the engineer advisers at G.H.Q. and at the headquarters of lower formations to study the information available, to press for the acquisition of any further information that they require (both from intelligence sources and by means of engineer reconnaissances and air photograph interpretation) and to advise commanders as to the preliminary measures desirable. The distribution of engineer personnel and equipment must receive early consideration.

2. The classification of military bridges, according to the loads which they are designed to carry, and the nature of the various equipments and stock-span bridges normally available are given in Appendix VI.

The responsibility that the normal loads of vehicles are not exceeded rests with unit commanders. C.Es. and C.R.Es.

will arrange with the Q.M.G.'s branch for a check to be kept on all impressed or locally requisitioned vehicles, and on new or abnormal types of military vehicles, with a view to their immediate classification for load purposes.

3. The utilization of existing bridges and the construction of new ones call for close co-operation between engineers and the commander whom they are advising.

The duties of the engineers will usually include :—

i. The inspection, estimating of capacity for loads and traffic-streams, and sign-boarding, of existing bridges ; their improvement and maintenance (possibly through local civilian authorities).

ii. Reconnaissance for projected crossing places.

iii. Advice as to the bearing of technical factors in the selection of sites, in deciding on the load-class of bridges required and (if likely to affect operations) in settling the general type of construction to be adopted.

iv. The design of bridges to meet the requirements of the command, with estimates of labour, stores, transport and time required for construction and maintenance.

v. Advice as to preliminary measures and distribution of resources required.

vi. The construction, sign-boarding and maintenance of new bridges.

vii. Notification of restrictions for technical reasons on weight, speed of traffic and distances to be kept.

viii. The technical security of bridges against mines and other floating objects.

4. The engineers should seek information or give advice on any or all of the following points :—

i. Early intimation of river crossings likely to be needed, and the initiation of engineer and other reconnaissances.

ii. Decision as to crossing sites, load-classes and (if likely to affect operations) the general type of construction to be adopted.

iii. Preliminary movements of resources required, often in anticipation of an actual decision to construct bridges.

iv. Tactical security from ground and air attack.

v. The ordering of restrictions, as in para. 3, vii, above ; and traffic control.

vi. Time-tables for road and river traffic, both military and civilian.

5. When the possible need for any important bridging operation becomes apparent, it will be the duty of the staff at G.H.Q., in consultation with their engineer advisers, to

ensure that the necessary resources in labour, stores and transport are made available, and to order such preliminary movements as will obviate delays when a decision is reached.

Responsibility for the conduct of the operation will usually be delegated to the formation or area concerned; and the work will be carried out under the orders of the C.R.E. by the engineers (or other labour resources) of the formation or area, reinforced as necessary.

Close liaison will be required throughout the engineer channels of technical control, to ensure accurate coordination of the executive action proposed with the resources to be made available.

As a partial exception to the above, railway bridge construction is technically the exclusive concern of the transportation services. Nevertheless, situations will occur in which economy of effort will result from cooperation between the engineers of the transportation services and the engineers of formations; and it is the duty of the staff at G.H.Q. to ensure such coordination.

6. The movement of the echelons of mobile bridging equipment into the areas of forward divisions calls for thorough reconnaissance and careful organization, in order that confusion and dangerous delays may be avoided. The vehicles and their trailers are unwieldy, difficult to turn and liable to cause a complete block in case of accident in a narrow road. The risks of mishap are further enhanced by the frequent necessity of restricting their movements to the hours of darkness, when a considerable amount of other urgent traffic may be on the roads. The traffic routes, circuits and timetables drawn up are based on detailed personal reconnaissances by engineer officers. The passage of the bridging vehicles will be always policed.

In addition, the staff will fix rendezvous and times at which engineer officers of forward formations will meet the mobile bridging equipment. Each officer will check the allotment made to his formation and will guide it to the destination ordered. Where a delay in the arrival of the equipment will have serious results, it will be desirable to detail a party of engineers to accompany each detachment of the bridge company, sufficient to remove obstacles and to unload and re-pack the pontoon and other units in case of accident.

7. It is important, especially during mobile operations, that divisional engineers employed in bridge construction should be relieved as early as possible, to enable them to resume their roles with their own divisions. Once the bridging requirements of divisions have been met, therefore, arrange-

ments should be made for the engineer units engaged to hand over their responsibilities to corps engineer units; the latter carrying out such further improvements and maintenance duties as may be required. Alternatively, it may sometimes be possible temporarily to reinforce the divisional engineers with a unit of corps engineers, subsequently to be left behind for maintenance.

When the construction of a bridge is complete and all improvements have been effected up to the standard desired, the engineers in charge will be reduced to the minimum detachment necessary for maintenance. Where conditions permit, maintenance parties should ultimately be replaced by civilian labour.

8. It is a principle that all mobile bridging equipment used in bridging operations must be replaced at the earliest opportunity by more permanent structures, so that it may be set free for its primary role of meeting urgent bridging requirements, usually with forward formations.

As the equipment cannot fulfil this role without the transport specifically allotted for its carriage, the use of this transport for other purposes is forbidden, except under the authority of the general staff of the formation to which it is permanently allotted.

9. All bridges will be provided with sign-boards showing the name of the bridge, its load-class and any special restrictions to be observed by troops crossing it. Sign-boards will be erected at both ends and, where applicable, at the point where the approach road to the bridge takes off from the route to an alternative crossing.

10. Technical details of reconnaissance and selection of sites for, and the construction and maintenance of, bridges are given in Military Engineering, Vol. III, together with details of the service equipments likely to be available.

96. Obstacles

1. Obstacles, both natural and artificial, may be used for the following defensive purposes :—

i. To hold attacking troops under the close fire of the defence, so that they may be destroyed by that fire.

ii. To restrict the freedom of manœuvre of an attack, and to herd it into pockets where it can be effectively dealt with by the fire of the defence.

Obstacles of the first category, such as a wire entanglement directly covering the front of a defensive work, are known as *protective obstacles*.

Obstacles of the second category, such as a wire entangle-

ment or a dyke running obliquely across the enemy's line of attack, are known as *tactical obstacles.*

Some obstacles, by virtue of their deterrent effect against attack, are both protective and tactical.

2. Where important natural obstacles exist, the plan of defence may have to be adapted to make use of them.

3. Generally speaking, obstacles should be sited under the effective fire of the defence ; and the following factors should be considered :—

i. Unless an obstacle is under the effective fire of the defence, its delaying power is limited to the time required for its unopposed passage. While the effects of a wire obstacle against infantry will in such circumstances be small, the effects of a strong natural obstacle against armoured fighting vehicles and transport may be appreciable in limiting the probable lines of attack.

ii. Obstacles, and especially road-blocks, produce their maximum effect when they are encountered unexpectedly by the enemy at places where a deviation round them is difficult.

iii. The delaying power of an obstacle is considerably enhanced if facilities for its reconnaissance can be denied to, or disputed with, the enemy.

iv. The siting of obstacles must not afford obvious clues to the position of the works which they protect, or of the weapons which enfilade them.

v. The system of obstacles must allow for the counter-attack requirements of the defence, for the passage of patrols and for the withdrawal of covering troops.

4. The responsibility for the siting of obstacles rests with commanders. When this responsibility is delegated to engineer officers, the staff will define any restrictions to be observed in the lay-out. This is of particular importance in the siting of tank obstacles. Nevertheless, engineer officers will often have to assume the responsibility for the lay-out of obstacles required at short notice.

The construction of obstacles in accordance with the instructions issued is the duty partly of the engineers and partly of the infantry, as explained in the succeeding paragraphs.

Infantry Obstacles

5. The construction of ordinary obstacles for defence against infantry attack (*e.g.* wire entanglements) is a duty of all arms in organizing their defences. Engineers will not normally be employed on this work, their responsibility being limited to the provision of the stores required.

When a commander considers that the urgency of a situation necessitates the employment of engineers on such work, engineers may be so employed until other arrangements can be made.

6. The construction of obstacles requiring technical skill and the use of special tools or explosives is a duty of the engineers.

7. Inundations of limited and local scope may be undertaken by the engineers. Inundations of any magnitude should not, however, be carried out without the authority of the higher command owing to the effects which they may have on water supply, irrigation and inland navigation, at a considerable distance from the site of the inundation.

Armoured Fighting Vehicle Obstacles

8. Against armoured car attack the obstacle most frequently required will be some form of road block.

Engineers may suitably be employed on the construction of road blocks, but in their absence troops of other arms should be able to devise suitable expedients. The considerations outlined in para. 3, i and ii, above, will be of special importance. The use of tank mines is dealt with in para. 11, below.

9. Against tank attack the best form of obstacle will usually consist of natural barriers to their movement. The reconnaissance of areas for natural tank obstacles is a duty which will frequently be required of engineer officers.

10. The construction of artificial tank obstacles requires much time, technical labour and materials ; and it will rarely be undertaken, except under the conditions of a deliberate and premeditated defence, where considerable engineer resources are available, or where the gap to be closed is a narrow one.

11. Apart from the *passive* means of defence against tanks (Field Service Regulations, Vol. II, 1935, Sec. 39), the *active* obstacle most commonly employed will be the mine-field of anti-tank mines. The small number of portable contact mines likely to be available during mobile operations necessitates their careful siting in accordance with the principles laid down in Field Service Regulations, Vol. II. The construction of imitation mine-fields may sometimes serve as a deterrent against tank attack, especially if the enemy has already become aware of the existence of real mine-fields on other lines of approach.

Anti-tank mines will be laid, maintained and lifted by the engineers. The general staff are responsible for deciding on

the position and degree of efficiency of the mine-fields to be laid, and the moment when the mine-field is to be rendered active, and for defining the formation or unit responsible for protecting or covering the mine-field with fire.

On the completion of a mine-field, it is the essential duty of all engineer commanders to report, both to the local commander and to the staff of their formation, the position and limits (with map references) of the mine-field or mine-fields. They will similarly report when the mine-fields are rendered active, and again when a mine-field is removed.

A record map of mine-fields will be maintained by all engineer headquarters and units concerned. The maintenance of general staff record maps at the headquarters of formations is a general staff responsibility.

12. In order that the engineers may be able to create the necessary obstacles on the main lines of approach open to enemy armoured fighting vehicle attack without delay, full use should be made of the mobility conferred by M.T. Moreover, when it is desired to remove mine-fields no longer required, special transport must be provided to retrieve the mines.

13. Further details of the uses and methods of construction of obstacles are given in the Manual of Field Engineering, Vols. I and II.

97. Demolitions and destructions

1. The principles governing the use of demolitions are given in Field Service Regulations, Vols. II and III, and technical details in Military Engineering, Vol. IV. All engineer officers must have a clear conception of the general purposes which demolitions serve, and of the significance of individual demolitions, so that they may be able adequately to advise commanders on their use, and effectively to undertake those ordered.

2. Individual demolitions vary greatly in importance. The destruction of a large bridge, tunnel or canal, for example, may have a prolonged and far-reaching effect on future operations owing to its bearing on the maintenance system of a force. Such major demolitions will seldom be executed without the express authority of G.H.Q.

On the other hand the execution of minor demolitions can generally be left to the discretion of the commanders of lower formations, as their repair, clearing or circumvention is a matter of hours, or a few days, as opposed to weeks or months in the case of major demolitions.

G.H.Q., and higher formations generally, will clearly define any restrictions that they wish to impose on lower

formations. But it should always be remembered that forbearance from a demolition during a withdrawal, with a view to a subsequent advance, confers on the enemy an advantage which he may not reciprocate when he in turn retires.

The preparation and execution of demolitions in a road system will be carried out by the engineers of formations or by engineer units acting directly under G.H.Q.; but the responsibility for the design, preparation and execution of the demolition of railways, waterways, telegraphs, etc., and of depots of stores and installations of all kinds, will normally rest with the services or directorates responsible for their operation.

3. Demolitions are mainly used for protective purposes, either strategical or tactical, but may also be used offensively.

The strategical use of demolitions aims at a prolonged effect upon operations over a wide area, and usually involves extensive demolitions throughout a belt or belts of country with a view to delaying the enemy in moving his railheads forward as he advances, and generally to crippling his maintenance system. The object may be to deny certain courses of action to the enemy or to confine him to certain lines of approach. Frequently it will be to diminish pressure during a withdrawal, to gain time for the elaboration of a defensive system and to delay the enemy's preparations for attack when he reaches that system.

The tactical use of demolitions may aim at assisting disengagement by delaying the movement of the enemy's forward fighting troops, at affording flank protection or checking the enemy on a front selected for defence. Such demolitions therefore include both minor obstructions (such as the hurried destruction of culverts and small road bridges, the blocking of roads by craters, felling trees or other means) which are intended to gain temporary and local relief from pressure and are often of special value against armoured fighting vehicles; and also co-ordinated schemes designed to impose a serious delay on all arms over a wide front. The commonest and most effective form of such demolitions is the destruction of all bridges over a waterline. Tactical demolitions may be undertaken in conjunction with, or independently of, a strategical demolition plan.

Offensive demolitions may be undertaken with the object of striking at the enemy's maintenance system by an attack or in conjunction with a wide turning movement or raid behind his forward defences.

4. The technical object of a bridge demolition should be at least to create an effective gap wider than the corresponding span of the enemy's mobile bridging equipment. If, in

addition, the piers, abutments, approaches, launching space facilities and deviations can be so damaged as to compel the enemy to undertake reconstruction on a new alignment, the best results will be obtained.

The strategical or tactical value of a bridge demolition is measured by the amount of delay which it imposes on the enemy. The mere creation of a physical obstacle may produce sufficient delay for the object in view; but this delay will be considerably increased if the enemy's arrangements for the reconnaissance and passage of the obstacle can be hampered by fire or by action from the air.

Unco-ordinated and isolated demolitions of a road system, however, have usually only a local value, while the partial execution of a co-ordinated scheme may result in an illusory and dangerous sense of security. It is of the first importance, therefore, that demolitions should be carried out on a definite plan, and so as to ensure the creation, with the time and resources available, of a really effective obstacle.

5. In planning large-scale schemes of strategical demolitions the respective functions of road communications and of railway or waterway communications should be borne in mind. Although organization can be adapted to make these functions to some extent interchangeable, they are normally separate and mutually complementary.

Railway and canal demolitions should generally be placed as far forward as possible, as their full effect on the enemy's maintenance system (*e.g.* on the position of his railheads) will only be felt some time after his forward divisions have passed the points in question.

On the other hand a system of road demolitions has its maximum effect soon after the enemy's leading troops pass it. The demolition plan may therefore have to include special attention to road communications in what will eventually become the enemy's divisional and corps areas.

6. Since time and resources will generally be limited, the development of any extensive demolition scheme, whether strategical or tactical, that may be subject to enemy interference will begin with the preparation, without delay, of a minimum *primary belt* of demolitions, sufficient to form an effective linear obstacle. For this purpose a waterway will normally be selected, and every route across it severed with breaches of approximately equal delaying value, the less effective breaches being supplemented with additional obstacles (*e.g.* cratering of bridge approaches). The *primary belt* should be so sited as to ensure that its preparation can be completed free from enemy interruption.

Where no natural obstacle exists, an arbitrary line or belt must be selected and prepared for blocking with demolitions such as road craters. In this case particular care will be necessary in a well-roaded country to prevent the enemy from re-establishing routes through the area by the use of lateral roads or by diverting road traffic over railway bridges.

Under conditions of urgency all available resources may have to be concentrated, in the first instance, on the preparation of the essential *primary belt* and of such major railway and canal demolitions on the enemy side of that belt as are mentioned in para. 2, above. To guard against partial failure, the resources allocated to the preparation of the *primary belt* should be on a liberal scale.

As time and resources permit, the *primary belt* will be extended laterally and in depth by *subsidiary* belts or zones of demolitions. If these *subsidiary* belts or zones can be formed successively nearer to the enemy, their delaying power will have earlier effect: but the necessity of carrying out the work free from interference by enemy action may render this impossible.

Strategical demolition schemes may include the devastation of all means of passage, accommodation and supply, the wrecking of vital services and the use of delay action methods, contact mines and traps.

7. The carrying out of a demolition scheme involves the following stages:—

i. *Reconnaissance*, including technical designs, and estimates of personnel, stores, transport and time required for each stage.

ii. The *assembly* of personnel, stores and transport at convenient centres, normally the report centre of each group of demolitions, ready for distribution.

iii. *Preparation* of the demolitions, including the fixing of charges.*

iv. *Execution*, including the posting of demolition parties, final connecting up and firing.

These stages may be carried out as one continuous operation, or at considerable intervals of time under separate sets of orders. (*See also* para. 9, below.)

8. In respect of their execution, demolitions are classified as:—

i. *Preliminary demolitions*, which can be executed at once in advance of the main scheme.

* In some European countries important bridges are provided with charge chambers as part of their structure, the necessary explosives, tools and stores being stored within easy reach.

ii. *Deferred demolitions*, which are to be executed as late as safety permits, usually in accordance with a pre-arranged time-table.

iii. *Final demolitions*, which must be left for execution by rear guards in contact with the enemy, the timing depending on the movement of those rear guards.

9. If time permits, the first step will be the formulation of an outline scheme at G.H.Q. (or at the headquarters of the formation responsible), and the issue to formations and services of instructions for detailed reconnaissances and the drawing up of plans. These instructions will define the purpose of the scheme, the nature of the delay required, the primary and subsidiary belts and the responsibility for the reconnaissances. A forecast of the time and resources likely to be available should be included.

As a result of these reconnaissances the staff will issue instructions for the assembly of the necessary resources and for the preparation of the demolitions. (*See* para. 7, above.) These instructions will define :—

i. The primary and subsidiary demolitions, their nature and order of priority and the dates on which they are to be ready for execution.

ii. The responsibility for the preparation and execution of the demolitions, including coordination between formations and the representatives of services allotted tasks within formation areas.

iii. The allocation of resources in technical troops, explosives, stores and transport.

iv. The classification of the *preliminary* and *deferred* demolitions, and the time-table for their execution.

If time precludes the possibility of carrying out the procedure described above, it will be necessary to set the machinery in motion so that work may start at the earliest possible moment. In such an event a scheme will be formulated from the map and from engineer intelligence records ; resources will be distributed at once on some arbitrary basis of estimating ; reconnaissances will be de-centralized from the start ; and adjustments will be made later. In such a case time may be saved by starting the preparation of the primary demolitions while the reconnaissance of the subsidiary demolitions is in progress. No demolition scheme framed without detailed engineer reconnaissance on the ground can, however, be regarded as reliable.

10. The execution and even the preparation of demolitions are liable to detection from the air, and may thus disclose an intention or plan of retirement. Moreover, their effect on the

morale of our own troops may be adverse. In principle, therefore, while preparation may be made unobtrusively before there is any intention to retire, execution should be deferred to the latest safe moment.

On the other hand the avoidance of unnecessary risks requires that *final* demolitions should be as few as possible. Their selection will be governed largely by tactical considerations; but engineer officers should always represent that it is undesirable to select as final demolitions those which cannot be completely prepared without closing the roadway, which will require more than one series of blows or which are open to surprise interference by the enemy. When in the case of a bridge such a selection is inevitable, it will sometimes be possible to provide a light and easily destructible bridge to meet tactical needs, and to demolish the main structure at leisure.

11. Subject to the restrictions on major demolitions mentioned in para. 2, above, the responsibility for ordering the execution of both *deferred* and *final* demolitions will be delegated to the formation in the area of which they are located. Adequate warning must be given, to ensure that the demolitions are ready for firing at short notice when ordered. In view of the risk of a failure of the intercommunication arrangements, an engineer officer who is out of touch with the headquarters responsible for ordering the execution of his group of demolitions will ensure that his demolitions are in such a state of readiness for firing as the tactical situation demands.

The orders for firing *deferred* demolitions will normally be issued by the general staff of the formation responsible, through the engineer channel, to the engineer officers in charge of groups of demolitions.

The responsibility for ordering the firing of *final* demolitions will usually be delegated to rear guard commanders, and the procedure will be as follows :—

i. The firing order will be communicated to the commander of the demolition party, either by rear guard headquarters or by a specified officer. The latter may be the commander of the rear party which is to cross the bridge, the engineer officer in charge or some other officer. In any event the title of the officer to whom has been entrusted the duty of ordering the firing will be communicated in writing to the demolition party, together with any other special instructions regarding the demolition.

ii. Should the intended procedure miscarry (through the officer detailed to order the firing becoming a casualty, or for any other reason) and it become evident to the commander

of the demolition party that further delay will, on account of the closeness of the enemy, prevent the demolition being carried out, he will on his own responsibility order the charges to be fired, unless he has written instructions specifically forbidding such action.

iii. The commander of the demolition party will ensure that all ranks understand the arrangements made, so that there may be no mistake if he becomes a casualty. In no circumstances must a bridge ordered and prepared for demolition be allowed to fall undestroyed into the hands of the enemy.

iv. The engineer officer in charge of a group of demolitions must keep his demolition parties informed of the tactical situation. The demolition parties must also make direct touch with units near them.

v. On completion of a demolition, the commander of a demolition party will report to his unit commander the time of demolition, the amount of explosive used and the damage effected. This information will be sent without delay to the C.R.E. and to the rear guard commander.

vi. The above procedure applies also to the railway and other administrative services responsible for demolitions in their own spheres. Engineer commanders of formations must ensure that the demolition parties of the services have received the necessary instructions, and that there is no hiatus in the organization for the execution of *all* demolitions within the sectors of their formations.

12. In addition to normal tactical protection, the following security measures may be needed for demolition work :—

i. Guards to prevent the approach of undesirable persons during the preparation of demolitions.

ii. Guards over all charged demolitions ; these are essential.

iii. Traffic control police on mined routes.

Personnel required under (i) and (iii) will be demanded by the engineer commander concerned.

13. The importance of starting preparations well to the rear of a retiring force will usually entail the employment of engineer units centralized under engineer commanders (*e.g.* chief engineers) specially appointed by the higher command for the conduct of the scheme. It is, however, desirable that the engineer commanders and units who will be responsible for the execution of demolitions should also carry out their reconnaissance and preparation. The demolition belts and areas should therefore be divided, for reconnaissance, preparation and execution, into sectors corresponding to the sectors of subordinate formations.

The demolitions within these sectors should further be divided into groups and sub-groups allotted to units and sub-units. The engineer officer in charge of a group, normally the unit commander, will establish a report centre in rear of his command, to which reports, explosives and stores will be sent.

If the responsibility for a sector or group is transferred, the out-going unit will leave behind liaison parties to hand over to the relieving unit.

Engineer Responsibilities

14. Engineer advisers of all formations should keep constantly in mind the possible bearing of demolitions on operations in progress or likely to develop. They must be prepared to offer early advice to the general staff as to the desirability of preparing schemes, and to submit proposals as to the location of belts or areas, the nature and extent of demolitions possible in the time available, the resources required in troops, explosives, stores and transport, and their allocation, and the organization to be adopted for preparation and execution.

They will initiate proposals for the organization of the detailed reconnaissances necessary to give effect to the outline schemes approved by the general staff, and for any preliminary moves of engineer units and stores that may be possible at this stage.

15. It is the duty of the engineer staff at G.H.Q. to initiate such action as will ensure the accumulation and record of complete engineer intelligence regarding bridges, waterways and local conditions likely to affect the formulation of demolition schemes. In addition, engineer advisers of formations should accumulate similar information within their own areas. In conditions of urgency the effectiveness of demolition schemes may depend largely on the foresight displayed.

In order to ensure that the information gained is readily available where required, and to avoid duplication of reconnaissance, close liaison will be necessary throughout the engineer channel of control.

16. Engineer advisers of formations are responsible for initiating action necessary to secure liaison between the formation engineers and the demolition parties of the administrative services working in their areas (*see* Sec. **97,** 2). They must further ensure that the division of responsibility is clearly defined, and that there is co-ordination where interests conflict, *e.g.* where the premature destruction of a railway bridge would

block an important road, or where failure to destroy it would offer to the enemy an easy diversion for road traffic.

17. When a co-ordinated demolition scheme is initiated by G.H.Q. or by a lower formation, the engineer adviser at that headquarters will prepare a schedule of the demolitions approved. This schedule will show in tabular form by sectors or belts all demolitions required, and against each demolition a serial number, a map reference, a description, the breach to be made, the charge, the time required (for preparation and execution), the strength of the working and demolition party, the headquarters authorized to order preparation and execution, the category (preliminary, deferred or final), the state of readiness and, eventually, the result. A suitable form for a demolition schedule is given in Appendix VII.

Copies of this schedule, together with a general report on the sector or belt, illustrative maps and explanatory details of important items, will be filed by the engineer staff of the headquarters concerned; and will be made available for the use of staffs, units and services charged with the preparation and execution of the scheme, when it is to be put into effect.

Reports required to maintain schedules up to date will be made through both the staff and engineer channels.

98. Protection against gas

1. The general precautions to be observed in operations against an enemy who may use gas are laid down in Field Service Regulations, Vol. II. The special precautions and measures to be taken by individuals and units of all arms and services to counter the effects of gas are laid down in Defence against Gas.

The duties of the engineers in securing protection against gas will include :—

i. Technical advice and the initiation of executive action on major questions of gas defence policy, particularly at the headquarters of formations.

ii. The provision of gas-proof accommodation, including the proofing of buildings and shelters against all types of gas.

iii. Arrangements for the passage of areas contaminated with blister gas.

iv. The organization of decontamination services, including the erection of decontamination stations or the adaptation of existing buildings for that purpose; and the decontamination of structures, routes and areas the use of which is a military necessity.

v. Technical advice on, and, as necessary, executive action for, the organization of an anti-gas intelligence and security service. Such a service must be initiated at the outset of the campaign.

In principle, all arms and units are responsible for their own protection and for such reconnaissance of gassed areas, and their marking and decontamination, as is within their power. The engineers (as is the case of other field engineering work) will be employed on such skilled or extensive work only as the other arms cannot carry out for themselves: in this the engineers may require the assistance of working parties of the other arms. The division of responsibilities laid down in Sec. **87** is equally applicable to this type of field engineering.

It must be clearly understood that engineer responsibilities for anti-gas measures rest with all engineer advisers and commanders throughout the theatre of war; and, for their execution, with all types of engineer units both in the forward and L. of C. areas. They are not the exclusive concern of any special personnel or units. To assist engineer commanders and advisers, expert chemical advisers should, however, be allotted to certain headquarters of formations and areas.

2. The use of gas by an enemy, in violation of international agreements, may necessitate the development of a special engineer organization to counter the menace.

3. The initial detection of gas contamination in an area is the duty of the troops in it, or of the first troops to enter it. If the contamination is of blister gas, it will be for the commander on the spot to decide whether access to the area is tactically or administratively essential. If so, it will be the duty of the engineer commander to advise the staff on the method of de-contamination or passage most suitable, on the organization of the work and on the most effective employment of the engineers and other arms. In mobile operations the considerable delay entailed by the sealing or destruction of blister gas will often demand other measures to enable movement to continue, and reconnaissances will be carried out to ascertain routes for circumventing the gassed area. While it is the duty of the forward troops, as far as time permits, to mark the gas-contaminated areas which they encounter, it will be the duty of the engineers to complete and perfect the system of marking, and to sign-board the route to the diversions discovered or prepared.

When no deviation round a gassed area is possible, a commander may be faced with the necessity of traversing an area contaminated with blister gas, so as to gain tactical objectives of immediate urgency, and of suffering gas casualties

as a result. The resultant casualties can be considerably reduced if contact can be eliminated between the troops and the contaminated ground. It will be the duty of the engineers to provide such means as it may be possible to improvise to prevent the troops touching the contaminated ground. These means may take the form of light bridges, causeways or surfacing (brushwood, fascines, planking, etc.), pending thorough decontamination of the route.

When an enemy displays marked activity in putting down blister gas contaminations at road junctions and at other points to be traversed by the troops, it may be necessary to organize some system of mobile engineer detachments, carried in M.T., to deal with the areas affected, so as to minimize delay to the movement of the troops. This may be even more important in a retirement than in an advance.

4. Gas-proof buildings and shelters may be required for important headquarters and medical establishments. Under stabilized conditions it will be possible to provide gas-proof accommodation on a wider scale. Details are given in Defence against Gas and in the Manual of Field Engineering, Vols. I and II.

5. When troops are liable to contamination with blister gas, the institution of a simple and effective organization for the decontamination of personnel will be an important factor in minimizing gas casualties. In the L. of C. area, and on portions of the front where the situation is stable, the provision of decontamination stations readily accessible to the troops will be essential. Under more mobile conditions a study of the possible intentions of the enemy in different areas (whether to advance, to withdraw or to hold his ground), and of the technical suitability of local conditions for the use of gas by the enemy, will often disclose the localities in which he is likely to use blister gas, thus enabling the decontamination service to be strengthened at the appropriate points.

Details of decontamination stations are described in Defence against Gas.

6. The efficacy of the gas defence policy to be adopted depends essentially on close co-operation between engineer advisers and those formations and units with which they are working, and on the maintenance of an efficient gas intelligence system.

The latter cannot be organized entirely with engineer personnel. The assistance of all units and areas should be enlisted to report any unusual occurrence that may indicate the use of, or intention to use, gas by the enemy, to forward at once to higher headquarters all enemy anti-gas or gas

apparatus found or captured, etc. The investigation of such reports will be carried out by engineer headquarters, while equipment will, after examination by the chemical adviser, be forwarded immediately for test by the central chemical laboratory under G.H.Q.

99. Smoke

1. The tactical employment of smoke is the province of the general staff, but engineer advisers must be prepared to offer advice in connection with its employment.

2. The employment of smoke by the engineers is limited to the installation and operation of such projector and generator apparatus as may be placed at their disposal and is part of the normal duties of divisional engineers.

100. Survey

1. At the outset of a campaign the engineer officer appointed as Director of Survey to the force receives from the War Office all available data for his service. He will advise the commander as to what survey work can best be done on the ground, where air survey photographs will be required and which areas should be photographed first. The War Office decides what maps should be produced in the theatre of operations, what can best be done in the home country, the type of grid system to be used, the grid unit, the projection, style, contour interval, and other details of the maps to be drawn. As a result of these decisions the policy of map production is settled.

2. The functions of the echelons of the survey organization are as follows :—

The survey depot is an L. of C. unit responsible for the storage and issue of maps printed at home or at G.H.Q.

The army field survey companies are responsible for the control (*i.e.* main triangulation) covering the theatre of operations, and for all new mapping required.

The corps field survey companies are responsible for :—

i. Breaking down the control produced by the army field survey company or existing in the country.

ii. Supplying to the artillery survey company at the earliest possible moment descriptions and co-ordinates of a series of trigonometrical points referring to the grid on which the maps of the

theatre of operations are based. The density of this series of trigonometrical points will vary with circumstances, but one point to six square miles represents a fair average.

iii. Printing available large scale maps of the area covered by the corps during mobile operations.

iv. Revising large scale maps of the area occupied by the corps during a period of temporary stabilization for a major engagement.

3. As regards new mapping, considerations of speed and of inaccessibility of areas to be surveyed will usually necessitate the extensive use of air survey methods. Air photographs for such survey are taken by the Royal Air Force. Their provision depends on the tactical and air situation and the necessary aircraft, instruments and specially trained personnel being available.

4. Even in well-mapped countries the necessity of accurately recording developments on both sides of the front of operations (such as gun positions, tracks, dumps, etc.) will usually demand continuous survey activity.

5. When offensive operations are to be undertaken, particularly in ill-mapped countries, it will be important to fix points behind the enemy's front so as to form an accurate basis for the compilation of maps of the country to be traversed. The time required for the compilation and reproduction of these maps, even by the rapid methods now possible in the field when air photographs are available, calls for close previous liaison between the general staff and the survey directorate so that unnecessary delay may be eliminated.

6. On some occasions engineer trigonometrical control may possibly be absent and artillery surveys are then perforce based on a temporary origin and orientation, thus fixing gun, O.P. and target on a " temporary grid." It should be the endeavour of the survey directorate to arrange control in such a way that this improvisation is avoided.

7. Survey work, not necessarily carried out by the survey service, may be required in planning large engineering schemes such as :—

i. Water supply.
ii. Inundations.
iii. Road and railway locations.

The use of air photographs, if they are available, may considerably assist engineer officers in planning engineer work, particularly on inaccessible ground.

8. The availability of personnel of the survey service does not relieve engineer units of other branches of the duty of carrying out elementary survey work, as a technical detail of general engineering, nor does it relieve the director of railways from the responsibility for initiating and executing railway surveys. Similarly, field survey companies will not be called upon to produce sketches and diagrams to illustrate reports or operation orders; such work is the responsibility of draughtsmen provided for the purpose in the war establishments of the headquarter staffs.

101. Water supply

1. The responsibility for the provision of water in the field is as follows :—

i. The engineers are responsible for ascertaining the sources of supply, and for advice as to their utilization; for the collection and storage of water, and for its delivery at selected points in accordance with instructions received; and for the provision, erection, operation and maintenance of any engineer plant required for purification purposes.

ii. The medical service is responsible for advice as to the suitability of water for human consumption, and as to the methods of purification to be adopted.

iii. Military or regimental police are responsible that sources of supply are not fouled, either by troops or by inhabitants, and for traffic control and discipline at water points, in accordance with orders issued by the staff (in emergency by the engineer officer on the spot).

iv. Units are responsible for all duties in connection with water which they have taken over, for the provision of labour required for operating hand pumps at the water points and for the erection of water containers which form part of their own equipment.

2. The standard of provision will depend on the time and resources available, and on the extent to which local supplies of water have been already developed. Thus in billets in a civilized country little work may be needed to achieve the highest standards; and in semi-permanent camps a high standard may be attainable. But in undeveloped regions in mobile warfare, when halts may be of short duration, it may

only be possible to give troops access to streams from which water carts can be filled and animals watered. In the interests of the troops, however, the arrangements should be the best possible in the circumstances. To achieve this, engineer reconnaissances for water must be initiated early and mobile engineer detachments sent ahead to develop the resources at intended halting places.

3. Where large concentrations of troops are concerned, water supply may present a problem of the first importance. A special water supply organization may be required, with technical engineer advisers at the headquarters of higher formations, and specially formed water supply units. For effective coordination more centralized technical and administrative control will probably have to be exercised by the higher headquarters.

In such circumstances the assumption of the offensive may present problems of peculiar difficulty, for which normal field engineering methods afford an inadequate solution. The essential preliminaries will be : accurate engineer intelligence of the country to be traversed ; a sound technical and administrative plan ; and the provision of the resources in personnel and stores for its execution. As a general principle the engineers of leading formations will be required to exploit local water supplies as the advance progresses, and the engineers of higher formations will push forward with the more permanent arrangements in rear. During periods of rapid movement the provision of water convoys may be essential to success.

4. When the facilities for access to water are limited in proportion to the size of the force, the engineers will furnish details of the maximum numbers that can draw water at one time, to enable time tables to be prepared.

5. Improvised water points in the field will be flagged as follows :—

White for drinking water.
Blue for animals' water.
Red for washing water.

6. Details of water supply work are given in Military Engineering, Vol. VI (Water Supply).

102. Accommodation

1. Troops in the forward area require the best possible accommodation, both when operations are mobile and during

periods of stability; the latter situation may develop from military factors giving rise to position warfare, or from climatic factors rendering mobile operations impossible.

During mobile operations the accommodation which can be provided for the leading troops will depend on local conditions; and the possibilities of improving it will be limited. In rear areas, however, more can be done.

2. Moving troops will be accommodated either in bivouacs, with or without improvised shelter from fire and weather, or in billets. Unless halts extend beyond a single night, engineer work will be mainly confined to the provision of water supply, with possibly the provision of gas-proof accommodation for medical units and for important headquarters. Improvised decontamination stations may also be required.

3. During position warfare one of the first considerations of a commander will be so to dispose his troops as to expose the minimum number to the discomfort and strain entailed by contact with the enemy in the forward positions; and to withdraw the remainder to better accommodation in reserve, where their morale and fighting qualities may be more easily maintained.

The engineers will assist the forward troops to develop shelters against enemy action and climatic severity, and to carry out other measures necessary for their well-being, by the provision of engineer stores and by the execution of the more technical works.

4. When troops are in billets, engineer work will be directed to water supply and to measures affecting the health and well-being of the troops. It may also be necessary to develop a system of protection against gas and against artillery and aerial bombardment.

In the absence of adequate billets the necessity of forming temporary camps will arise. In the first instance such camps will be largely tented, but, as time goes on, hutted structures may gradually replace the tents. Ultimately it should be possible to provide considerable facilities for training and recreation.

5. In deciding on the general policy for the accommodation of troops during a period of stability the limiting factors will be time, labour, materials and transport.

Any large demand for temporary hutting accommodation will strain available resources to the utmost, and the engineers will require the fullest assistance from the unskilled labour of the troops themselves. Accommodation of this nature involves the provision of portable huts of simple construction

and standard design, suitable for mass production. The arrangement for the provision of such huts, adapted to local conditions, is a duty of the engineer staff at G.H.Q.

6. Details of this subject are given in Military Engineering, Vol. VII and in the Manual of Engineer Services (War).

103. Application of modern developments to engineer duties in the field

1. It is of the utmost importance that engineer officers should keep in touch with modern developments, in war as in peace, both with a view to their application to all forms of engineer work and in order to guard against the possibility of the enemy engineers effecting a technical surprise. Experience has shown that scientific inventions and processes which appear under peace conditions to be at an immature experimental stage, or to be devoid of practical significance, are often rapidly perfected under the stimulus of war.

2. The influence of air photography on survey, and on engineer reconnaissance for the planning of work in areas not yet accessible, is discussed elsewhere in this manual.

The performance of aircraft has now reached a stage at which it is possible to land engineer parties behind a hostile front for the carrying out of demolitions or for other purposes. The possibility of such action by the enemy must influence engineer commanders in advising the commander as to the relative importance of engineer structures and installations which are open to attack by this means, with a view to provision being made for their security.

3. In any future national war it can be foretold with certainty that new and unexpected methods will play a large part, and that the engineers will usually be closely concerned. This applies not only to engineer operations in the forward area, but also to the heavier engineering work on the lines of communication, where the influence of commercial, industrial and economic developments will also be felt.

CHAPTER XI

ENGINEER TACTICS

104. Marches

1. A proportion of engineers is normally placed well forward in the order of march to deal at once with any work needed. The proportion allotted to the advanced guards will depend on the work likely to be required to ensure the unimpeded advance of the columns.

Engineer reconnaissance parties move as far forward as possible; otherwise only such engineers as may be required for immediate work (*e.g.* the removal of blocks) march with the vanguards. The bulk of the advanced guard engineers normally march with the main guards; any vehicles not required with them move with the next engineer unit in the column or with the "B" echelon transport.

To enable the corps field survey company to supply control points to the artillery at the earliest possible moment (*see* Sec. **100**), the topographical section of the corps field survey company works in the area of, or immediately behind, the advanced guards. The observers work in pairs, leapfrogging, and move by M.T.; an escort will be demanded if required.

2. Engineer work on the march may include :—

i. The passage of obstacles, the detection and rendering harmless of mines and traps and the marking of gassed areas.

ii. Improving communications generally, marking and improving bridges and fords, improving roads, making road deviations and sign-boarding routes.

iii. Bridging waterways and ravines.

iv. Making obstacles against armoured fighting vehicle attack, especially on the flanks of the route followed.

v. The carrying forward of the survey triangulation controlling predicted fire by the artillery.

vi. The provision of temporary water supply.

3. Engineer units or sub-units which have begun a work should, if possible, stay behind to finish it, their place in the order of march being taken by other units or sub-units brought up from the rear.

The amount of work which can be undertaken will be governed by the necessity of the engineers not falling too far

behind the other fighting troops of their formation; but a C.R.E. is responsible for carrying out all work required to ensure the movement of the transport of his formation on the line of march. Subject to this provision, works of a substantial or semi-permanent nature should be left for execution by the engineers of higher formations.

The C.R.E. should inform the commander of his formation of engineer work left to be done by formations following in rear, and at the same time furnish technical details direct to the C.E. of the higher formation.

4. Engineers cannot perform their role unless accompanied by their equipment vehicles. For a special enterprise, where the role of the engineers is definitely known, and where mobility and road space are of exceptional importance, transport can be reduced by packing selected equipment only. This should, however, generally be avoided, as it involves time and labour, disturbs normal organization and reduces the efficiency of the unit. On the other hand it is sometimes necessary to attach transport from rear echelons (*e.g.* field park company or bridge company, R.A.S.C.) to forward engineer units for a special purpose.

5. When possible, parties of engineers should be sent on ahead of the marching column to improve the water supply and communications at the place where the force is to be quartered for the night, or to improve the road for the next day's march.

105. Engineers in the attack

1. The work of the engineers will depend on the nature of the attack and the amount of time available for preparations. Their tasks will vary in accordance with the degree of organization of the enemy defences, from hasty work on communications and field defences to elaborate projects involving tunnelled approaches and heavy constructions.

In open warfare these tasks may include :—

i. The improvement of communications to facilitate the assembly, deployment and advance of troops, guns and tanks, including the screening of exposed points.

ii. The passage of obstacles, including the location and removal of anti-tank and delay action mines, and the repair and construction of bridges.

iii. Field defences, such as the preparation for defence of important localities won during the attack and provision against counter-attack by armoured fighting vehicles.

iv. The provision of engineer stores for consolidation, *e.g.* barbed wire and pickets.

v. The demolition of enemy defences.

vi. Gas defence duties.

vii. The carrying forward of the survey triangulation controlling predicted fire by the artillery; and the supply of 1/25,000 maps of the target area as soon as it is apparent that a major operation is impending.

viii. Water supply in the captured area.

2. It is unsound to send engineers forward with attacking troops, except for a specific task such as the passage of a known obstacle. Close touch with the progress of the attack must be maintained by means of reconnaissance parties and, if necessary, liaison officers at infantry brigade headquarters. Engineer units should, however, be held in reserve in the early stages and be sent forward only when the situation permits of their starting work on specific tasks, which they should then be left to complete.

3. In proportion as the strength of the enemy position increases with the passage of time, and as the preparations for attack become more deliberate, so will the work of the engineers develop and conditions approximate to those of position warfare.

106. Engineers in the attack in position warfare

1. The amount and scope of the engineer work will depend on the strength of the enemy, the extent to which his positions are prepared and the amount of artillery at his disposal. The attack on a strong enemy in a well-prepared position necessitates thorough preparation and a large amount of engineer work.

2. For the preparatory period detailed schemes, in the compilation of which the engineers will assist, are drawn up showing :—

i. The items of work in order of priority.

ii. The commanders responsible for each item.

iii. The labour, tools and stores required.

iv. The dates on which each item may be started and must be completed.

v. The measures to be taken for concealment.

Allowance is made for interference by enemy action, and a reserve of engineers should be kept in hand for unexpected emergencies.

During this phase the control of engineer units should be centralized as far as possible under C.R.Es.

3. During the preparatory period engineer work in the forward area may include: the removal of obstacles, the marking and construction of tracks, bridging, and clearances; the construction of battle headquarters, observation posts and intelligence posts; special machine gun and mortar emplacements; advanced dressing stations and shelters, proof against bombardment and gas; water points; preparations for the extension of trench tramways; and possibly tunnelled approaches and mine warfare.

In countries possessing a large scale map the corps field survey companies will meanwhile have been engaged in their revision and in overprinting them to show the latest developments in the enemy defences and the disposition of enemy troops so far as located. In unmapped countries all that can be done in the absence of air photographs will be to provide a close trigonometrical control for artillery and other surveys. Should air photographs have been provided, the army field survey companies will rapidly produce large scale (1/25,000) maps covering the whole enemy positions.

Farther to the rear engineer work will include the maintenance and improvement of the main communications, including bridging; water supply; accommodation for troops, including gas-proof structures; prisoners-of-war cages; tank obstacles for the protection of headquarters; and so on.

In all areas arrangements will be required for the lavish provision of sign-boards and direction posts, for special camouflage work and for the formation of engineer store dumps.

The liability of engineer work to disclose both the intention to attack and the progress of preparations calls for special measures for its concealment during this phase.

4. The launching of the attack may necessitate some decentralization of control of the engineers, and the placing of specific units under command or in support of forward infantry brigades.

It may be advisable to send engineer reconnaissance parties forward in close proximity to the assaulting troops, but engineer working parties should seldom go forward until reports show that they can start work on their tasks. Such parties should be held in reserve under cover near the headquarters of the infantry brigade in whose sector their tasks lie. Engineer liaison officers will often be required at the head-

quarters of forward infantry brigades for the purposes described in Sec. **91.**

An engineer reserve will be required at the disposal of the C.R.E. to provide reliefs and to meet unexpected demands.

5. During the progress of the attack the engineer work of the forward divisions will include the development of communications to admit of the forward movement of guns, tanks, ammunition and supplies; preparing captured localities for defence against counter-attack; the construction of tank obstacles; water supply; the construction of new headquarters; the extension of trench tramways; anti-gas measures; the detection and rendering harmless of mines and traps left by the enemy; and the formation of engineer store dumps in the captured area.

The engineers of corps and higher formations will develop communications to take all military loads, and will be responsible for the more elaborate technical constructions required to place on a sound footing such items as water supply, tramways and other installations.

In order to prevent the dispersion of the divisional engineers in excessive depth, the engineers of corps may have to take over work begun by the former.

6. The heavy demands which will be made for additional transport, carrying parties and labour, to meet engineer requirements during the progress of an attack, will often be the limiting factor in the amount of work that can be undertaken. Hence early consideration and a carefully planned programme of work are essential.

107. Engineers in the defence

1. The principles of the control of engineer work in the defence are in some respects the reverse of those in the attack. In the attack the tendency is for control to be centralized at the outset, with some degree of decentralization later. In the defence, on the other hand, the earlier stages will call for decentralization to avoid loss of time, but centralized control will be re-established as soon as conditions permit.

2. In the rapid organization of a defensive position under the conditions which will frequently obtain in mobile warfare it is essential to save time and rapidly to dispose the troops in their positions so that all units, including engineer units, may start work without undue delay. The preliminary reconnaissance of the force commander may thus be of a cursory nature, possibly little more than a verification on the ground of broad

conclusions reached from a study of the map. As a result a tactical plan will be formed in outline, frontages and boundaries of subordinate formations will be provisionally decided and executive action decentralized without delay. A similar process will continue throughout the chain of command down to lower formations, units and sub-units. The basic principle, when time is short, will be: rapid reconnaissance and decentralization, followed by minor adjustment and coordination as time permits of more thorough reconnaissance. Steps must be taken in ample time, moreover, to ensure that the infantry brigade and divisional reserves of tools are available for distribution without delay.

During this stage it is essential that formation commanders in every grade should be accompanied on their reconnaissances by their engineer advisers, so that they may have prompt advice as to the most effective employment of their engineer resources in the time available. Within divisions C.R.Es. will detail engineer liaison officers to advise brigadiers of forward infantry brigades (and other commanders as necessary), unless such brigades have already been allotted an engineer unit under command or in support of them.

Engineer reconnaissance parties should be early on the ground, in readiness to take up the duties required of them. The reconnaissance of the ground in front of and within the defensive system, with a view to locating areas impassable to enemy tanks or suitable for the creation of anti-tank obstacles, is a duty which may well fall to the engineers.

3. In the early stages of the hasty occupation of a defensive position it will often be impossible to draw up a definite programme of work for the engineers. Some of the divisional engineers may then be placed under command of infantry brigades, to afford them all possible help in strengthening the defence; some will be required for divisional tasks under the direct command of the C.R.E.; and an adequate reserve should be maintained to meet the demands for technical work requiring early execution. Engineers placed under command or in support of other arms should always be employed on specific tasks, suited to their training and equipment; they should not be dispersed as assistants among units of the other arms.

The collection of engineer material available locally, such as barbed wire and pickets, is an important duty at this stage, and will fall particularly to the working sections of field park companies.

If the intention to adopt a defensive attitude can be foreseen in time for engineer advisers to arrange for a supply of engineer

stores, additional anti-tank mines, etc., to be at railhead or on wheels in the corps area from the outset, the effective consolidation of the defensive zone will be very greatly expedited.

4. As the plan of defence develops in greater detail and the requirements in engineer work become more definitely known, the work of the divisional engineers will be more and more co-ordinated by the C.R.E. Centralized control by the C.R.E. will be resumed, and engineer work will follow a co-ordinated programme approved by the divisional commander. This programme will show all important items or headings of work, with an order of priority, and will be governed by the tactical situation and the time and resources available.

5. The most probable engineer tasks during the early stages of defensive operations are given below. The list should be considered in conjunction with the duties which may be expected under position warfare conditions, and it must be remembered that considerations of speed and concealment will often necessitate much of the work being done by night.

i. Clearances and obstacles requiring the use of explosives or engineer tools, including anti-tank obstacles and demolitions.

ii. The preparation of buildings for defence.

iii. The construction of observation posts and machine gun and mortar emplacements requiring technical skill.

iv. Shelters and dug-outs for important headquarters, including gas-proofing arrangements.

v. The improvement, maintenance and sign-boarding of communications, including bridging.

vi. Camouflage work requiring special skill, and the provision of camouflage material.

vii. Water supply.

viii. The provision of engineer stores and extra tools.

6. In the hasty occupation of a defensive system the task of the survey service is somewhat easier than in the attack, since the ground later to be occupied by the enemy is accessible. Failure to obtain survey air photographs will not preclude map-making as it would in the attack nor is the task of obtaining the air photographs so difficult. The corps field survey companies will be engaged in providing control points for artillery surveys and, provided that there is a main triangulation, points of the requisite closeness should be available within eight hours after the ground is reached. Army field survey companies will be occupied in the production of large scale maps for the whole defensive area, using air photographs when available.

108. Engineers in the defence in position warfare

1. The circumstances in which a period of position warfare may develop and the method of organization of the defence during such a period are described in Field Service Regulations, Vol. II. The technical details of work required in the deliberate preparation of a defensive position are dealt with in the Manual of Field Engineering, Vols. I and II, and of the more permanent works in Military Engineering, Vol. II.

2. As the defence becomes more highly organized and approximates to position warfare, the development of works in the outpost system will be the duty of forward formations, with such engineer help as may be necessary in works requiring technical skill. The bulk of the divisional engineers will normally be employed under the C.R.E. in the main system on works requiring technical skill, or of such magnitude or urgency as to necessitate special organization.

3. During the initial stage of position warfare the engineer tasks may include :—

i. Special drainage work.
ii. Special trench revetments.
iii. Camouflage and screening.
iv. The laying of tramways.
v. Local inundations of a minor nature.
vi. The issue of revised large scale maps.

4. At a later stage, the necessity for more permanent defensive works will arise, possibly including :—

i. Reinforced concrete emplacements for machine guns and headquarters.
ii. Snipers' posts, observation posts, etc.
iii. Tunnelled dug-outs for personnel, proof against gas and all forms of bombardment.
iv. The electric lighting of underground works.
v. The inception of offensive and defensive mining.

The demands on the engineers for technical work will be enhanced by the need for healthier and more comfortable conditions for troops in and behind the line, for the construction and maintenance of light railway and road communications, and for measures in preparation for the resumption of the offensive.

The efficient and timely execution of the work will depend on the issue of programmes of work by the general staff and their periodical revision, and on the careful organization of the available resources in labour, stores and transport. While

all arms should carry out for themselves all works that involve little or no technical skill, it will often be necessary to allot to the engineers permanent working and carrying parties of the other arms.

The survey service will be in a position to supply 1/25,000 maps extending back to the rear of corps, and even of army areas, if required. In addition, they will be able to supply larger scale maps showing details of the enemy trench systems and works.

5. The higher command exercises sufficient control over the design and development of defence schemes to prevent waste of effort due to non-continuity of policy when forward formations are relieved. It will assist in maintaining continuity if engineer field companies are not relieved simultaneously with the infantry brigades in whose sectors they work.

109. Engineers in a retirement

1. The principles governing the conduct of a retirement are contained in Field Service Regulations, Vols. II and III.

2. Whether the operation is a planned withdrawal carried out at leisure in accordance with a pre-arranged programme or a forced withdrawal in the face of a pursuing enemy, the primary task of the engineers will be to delay the advance of the enemy by the creation of obstacles, and especially by the use of demolitions. In a planned withdrawal the character of these demolitions will be largely strategical, and in a forced withdrawal tactical.

In either event the demolition scheme will be framed and executed in accordance with the principles contained in Sec. **97.**

3. As shown in Sec. **97,** the time required to complete a system of demolitions will usually necessitate its being started so far in rear of forward divisions as to require its preparation by engineer units, drawn if necessary from such divisions, working under the direct control of engineer commanders specially appointed by corps or other higher formations. The same applies to the construction of deliberate defensive systems in rear, on lines where it is intended to bring the retirement to an end.

In a planned withdrawal the proportion of engineers which should be left with forward divisions for their immediate requirements will be small; the bulk of the engineers should be made available for centralized employment in rear.

In a forced withdrawal, where the rear guards are fighting to delay the enemy advance and to cover the retirement of the main bodies, the need for last minute work will be greater, and a larger proportion of engineers will be required with forward divisions. Even so, since all engineer work demands time for its completion, the bulk of the engineers left with a forward division can be more effectively employed, under the direct orders of the C.R.E., on tasks well in rear of their division; and the proportion allotted to the rear guard itself should be small. Further the commander of the engineer detachment allotted to the rear guard may require considerable latitude, and thus not be required to conform closely to the movements of the rear guard, if he is to ensure the timely completion of his tasks.

Engineer parties left in position to fire final demolitions and create final obstructions after the passage of the rear guards should be instructed, after reporting results to rear guard commanders, to rejoin their units as soon as possible.

4. Although the preparation of co-ordinated demolition systems will usually be carried out under the higher command, the responsibility for the execution of many of the demolitions will ultimately devolve on forward divisions as they retire. It will not then be sufficient to assume that the organization of the system is complete. The C.R.E. must ascertain the location of the engineers in charge of groups of demolitions, and the nature and state of readiness of each demolition; he must correct any oversights or errors in the arrangements for their execution, arranging for the adjustment of the time-table of firing of deferred demolitions as necessary; he must advise as to the issue of orders to the demolition parties regarding the firing of final demolitions; and he must establish close liaison with the representatives of the administrative services engaged on demolition work in the divisional sector. Finally demolition parties must be instructed as to their action on completion of their demolitions.

5. The survey service will require early information from the general staff as to the withdrawal plan. Arrangements can then be made for the necessary trigonometrical control to be provided by the corps field survey companies for the use of artillery survey companies during the withdrawal.

Unless the withdrawal is being undertaken over country previously mapped, *e.g.* after a long period of position warfare, there will usually be little opportunity of producing new large scale maps.

Army field survey companies should be used to map the

area of the rear defensive system on which the commander intends to stop the enemy.

6. When a retiring division has to occupy a rear defensive system which has been prepared under the orders of a higher formation, the C.R.E. will ascertain the plan of defence and undertake any engineer work required to add to its effectiveness.

7. In addition to the duties mentioned above and to normal administrative tasks such as water supply, the engineer work required for a forward division in retirement may include :—

i. The improvement of communications of all kinds, including arrangements for the passage of gassed defiles, to facilitate the uninterrupted withdrawal of transport, guns and troops.

ii. The creation of such additional obstacles, demolitions and destructions as may be possible and desirable in the time available. In particular, the blocking of lateral approaches by which enemy armoured fighting vehicles might threaten the security of the main lines of retirement may be required.

iii. The hasty preparation of rear positions for delaying action, including the supervision of military and local labour, the preparation of villages for defence, the creation of tank obstacles and the provision of engineer stores locally obtainable.

8. While the reconnaissance and organization of positions for delaying action (para. 7, iii, above) are the responsibility of the commander concerned, shortage of time will necessitate the settling of many details of the engineer work by the engineers themselves. In such positions facilities for withdrawal will be important.

9. During a withdrawal, especially if it is under pressure, it is to be anticipated that there will be rapid changes in the situation, coupled with urgent and varying demands on the engineers and frequent changes of orders. To avoid the confusion which may so easily occur under such conditions, engineer commanders must make every effort to keep in touch with the situation, with the action of neighbouring units and with their own units and detachments. They must work in close touch with commanders and staffs, while being fully prepared to assume responsibility and to act on their own initiative. Engineer commanders in all grades must be ready to respond to calls for assistance from the other arms, if they are satisfied that the call is warranted and can be met without prejudicing more important tasks. Close touch must be kept with rear guards.

iv. Routes for the forward movement of troops and bridging equipment from the rear by stages to the river bank (for details *see* para. 5, below).

v. Requirements in time, labour and stores for work on or incidental to the items given above.

In order to make the fullest use of the often limited time available for reconnaissance, engineer officers must work in the closest touch with officers of the other arms, so that their energies may all be directed to the same ends.

5. To minimize the risk of a hitch in the progress of the operation, special care must be given to the selection of the following points and of the routes forward from them :—

i. The *rendezvous* (*see* Sec. **95,** 6) at which the mobile bridging equipment of the bridge company, R.A.S.C., will be taken over by the engineers of forward divisions, or at which that carried by the field park companies will be taken over by the field companies. Parking space for the re-marshalling of columns will usually be required at the rendezvous, and the forward routes may need sign-posting.

When bridging with the bridge company, R.A.S.C., equipment is to be undertaken, it may also be necessary to select a *parking area* under cover and with easy access to the bridge sites, where the bridging vehicles may be formed up to wait until each is required at the off-loading point, and where vehicles can be marshalled after off-loading.

ii. The *off-loading points*, at which the bridging equipment will be finally off-loaded from its transport for onward carriage by hand. To save hand carriage, these points should be near the sites at which the equipment is to be made up into bridge or rafts ; but the noise of the vehicles will usually impose a minimum of some five hundred yards from the river, except for such equipment (*e.g.* medium and heavy bridge) as will not be required in the assault phase, which may be able to drive up to the actual bridge sites when required. Traffic circuit facilities will be important.

iii. *Assembly positions*, at which the assaulting units and forward engineers assemble, well before zero hour, and are organized into bridging parties, boat parties and raft parties, as required for their various roles.

iv. *Forming up places*, at which boats are opened and carrying, rowing and assaulting parties formed into their final order for the assault, etc. They must be sufficiently far from the enemy to ensure that the noise of opening boats, positioning the personnel, etc., is not heard. (Where Kapok

bridging equipment is used, such points are termed *bridge forming points*, at which the bridging equipment is joined together into the bridge.)

6. As a result of the detailed reconnaissance, full information should be available to enable the formation commanders, with engineer advice, to reach decisions on the following points :—

i. Sites for the crossings of the forward sub-units of the assaulting infantry.

ii. Sites for the light bridges or ferries for the " A " echelon transport and other supporting weapons.

iii. Sites for the medium and heavy bridges.

iv. Requirements in material, working and carrying parties, and time, at the various sites and on their approaches.

v. The sub-allotment of the available resources.

The outline plans used as a basis for the reconnaissances will now be confirmed or modified, and amplified in details. Although technical considerations, including the quantities of bridging material available, will often impose limitations, there will usually be some latitude of choice within which tactical factors will predominate.

7. At corps headquarters, the C.E. will be required to advise as to the number and types of bridges which can be constructed with the equipment available ; the possible sites for the heavy and medium bridges with their technical advantages and disadvantages ; whether their construction should be undertaken by the corps engineers or delegated to forward divisions ; whether the engineers of forward divisions will need reinforcement from or subsequent relief by the corps engineers ; and the allotment of the mobile bridging equipment.

Within the division the C.R.E. will usually retain direct control over any heavy or medium bridge construction delegated to the division. On the other hand, as the tactical control of the crossings by the forward infantry and by their more closely supporting weapons will normally be exercised by commanders of infantry brigades, engineer field companies (or detachments) should be placed under the command of forward brigades for the execution of the engineer work in those crossings.

Within forward infantry brigades the engineer commander, acting under brigade headquarters, will usually retain direct control over light bridge and light ferry construction. It may be necessary to place small engineer detachments under the

command of forward battalions for specific engineer tasks in the assault crossings; but undue de-centralization of the engineers is undesirable.

The C.R.E. of a division will advise as to the best distribution of bridging equipment, and will distribute it as ordered. The engineer commander with a forward infantry brigade will carry out similar duties for his brigade. An adequate proportion of spares must be allotted, to allow for damage, errors in estimating and unforeseen difficulties.

8. The initial assault crossings should be planned to take place at a number of points simultaneously, possibly in conjunction with feints designed to draw the enemy's reserves.

The successful launching of the assault crossings will be followed at the earliest opportunity by the construction of light bridges and ferries to provide for the passage of light vehicles in immediate support. As the opportunities will occur at different times along the front of attack, the decision to act will usually be delegated to commanders of forward infantry brigades. Similarly the times at which it will be possible to start medium and heavy bridge construction cannot be foreseen, and will be decided by the divisional staff as operations develop. In order to be in a position to advise on this point, engineer commanders must keep in close touch with the situation and must, if necessary, organize their own system of liaison and reporting.

9. An opposed river crossing may be expected to meet with varying degrees of success on different parts of the front. The plan must therefore be sufficiently elastic to provide for the exploitation of success, and for the diversion of resources away from crossings which offer less prospect of rapid success. While it will generally be desirable to allot the whole of the Kapok and folding boat equipment to assaulting divisions from the outset, a proportion of the pontoon equipment, sufficient at least to construct one bridge, should usually be retained in reserve, in order that the corps headquarters may be in a position to vary the allotment of bridges in accordance with the success of the initial crossing. In any case the actual ordering forward of the pontoon equipment should generally remain the responsibility of corps, and it may even be necessary for a yet higher headquarters to retain a measure of control.

The engineer plans should, if possible, provide for alternative sites for bridges; so that, where communications permit, some diversion of resources not already committed may be practicable. The maintenance of a reserve of engineer labour will also be an important factor if the

development of the operations calls for a modification of the original plans.

Preparations

10. The time available for preparations may range from a few hours to some days, or even weeks when the passage of a serious obstacle against a well-organized defence is to be undertaken.

Under average conditions, engineer responsibilities will include :—

i. Arrangements for the forward movement and dumping of bridging equipment and other engineer stores, including its handing-over to the engineer or other units to which it has been allotted.

ii. The improvement, marking and screening of communications at and between *rendezvous*, *off-loading points*, *assembly positions* and *forming-up places*, assisted by working parties of other arms. The possibility of the blocking of approaches by enemy harassing fire or counter-preparation should be foreseen and provided against.

iii. The inspection of crossing sites by junior engineer leaders and the instruction of all ranks in their duties.

iv. Measures of camouflage, concealment and deception generally.

v. The preparation of any improvised bridging expedients required to supplement the standard equipments, and of notice-boards and other accessories necessary for the bridges and their approaches.

11. When more than one night is available for preparations, the early initiation of preparatory measures involves the risk of detection of the plan by the enemy, or of damage to material by his harassing fire. Engineer officers must therefore advise staffs as to the engineer aspect of postponing some or all of these measures to the last night. Where, for example, cover exists for dumps, it will often be preferable to risk the loss of a proportion of the dumped material rather than to risk a failure in delivery at the last moment.

12. Troops must at all times be prepared to carry out a crossing with such equipment or expedients as can be made available. But, if circumstances permit, every opportunity should be taken thoroughly to rehearse the troops, both engineers and infantry, in the intended operation and in the use of the type of bridge or ferry to be employed.

The Initial Assault Crossings

13. The means of carrying out the initial assault crossings may include :—

i. Existing crossings, such as undemolished bridges, fords, locks and ferries.
ii. Local boats.
iii. Folding boat equipment.
iv. The Kapok assault bridge.
v. Improvised rafts and similar expedients.

These means are dealt with below.

14. If an enemy has had time in which to organize the defence of a river line, all crossings which he has been unable to demolish are likely to be covered by effective fire. The use of such crossings is mainly a tactical problem but the engineers should be able to facilitate the task of the assaulting troops by work before and after they cross.

During a rapid advance the leading troops may be able to seize lightly-held crossings ; and it is their paramount duty to exploit their opportunities with such resources as they may find on the spot. It is, however, equally the duty of the forward engineer units to be in close touch with the situation, and to give the earliest help without waiting for formal demands.

15. The tactical control of a boat crossing is the responsibility of the commander concerned, but the operation, handling and navigation of any form of boat is in principle an engineer responsibility.

The engineers will inform the staff of the carrying capacity of each boat ; and parties, normally complete sub-units, will be detailed to them. When a boat leaves the near bank, the executive command is vested in the engineer officer or soldier in charge during the round trip.

If the demand for rowers is heavy, it may be necessary to supplement the engineer personnel with men selected from the other arms. These men will require previous training in watermanship.

When possible, the earliest opportunity should be taken to pass a rope or cable across the stream, so that rowers may be economized.

16. *Folding boat equipment.*—This equipment may be used in the initial assault crossings as single boat ferries, with or without outboard motors. It is a means of crossing rivers which are too wide or too swift for the Kapok equipment or similar expedients.

Its transport (except in the bridge company, R.A.S.C.) and

operation are engineer responsibilities. For its forward carriage from off-loading points infantry parties may be required ; but in proximity to the river bank it may be preferable to employ engineers accustomed to handling it.

17. *Kapok assault bridge.*—This equipment is suitable for the assault bridging of rivers of moderate speed up to 100 feet or 150 feet in width with low banks. Engineer advice should always be obtained as to its suitability for the task proposed. Under favourable conditions it is the most rapidly made bridge, and can effect the continuous and speedy passage of the assaulting troops across a river.

A crossing by Kapok assault bridge is an infantry operation, for the detail and control of which the engineers are not responsible. The engineers are, however, responsible for technical advice on the use of this equipment, and for its issue to the infantry in accordance with the allotments ordered. They are also responsible for assistance in launching the bridge, especially if technical difficulties arise, and for the maintenance of bridges in position. The infantry are responsible for organizing the operation, for the forward carriage of the equipment from off-loading points, and for forming and launching the bridge, as laid down in Infantry Training and the Manual of Field Engineering, Vol. I (All Arms).

Kapok equipment can, under the most favourable conditions, be allotted in bays (6 ft. 6 in.) ; but practical considerations, under the conditions of speed and darkness, will usually render it inadvisable to break up load-units of transport (27 bays in a lorry and trailer).

18. Rafting expedients are in principle an engineer responsibility. On the other hand simple assault bridging expedients, similar in design to the Kapok equipment, may be treated as an infantry bridge if there has been ample opportunity for the infantry to be trained in its use.

The Passage of the Supporting Arms

19. As soon as the assaulting troops have gained a footing on the far bank, the earliest opportunity must be sought to effect the passage of the supporting weapons, so that the impetus of the attack may be maintained and adequate support given for its development in depth.

The normal method of effecting the passage of the lighter natures of supporting weapons is by the use of the folding boat equipment, either as a ferry (tracked raft or decked raft) or as a continuous bridge. The latter will generally be found to be the quickest method, whenever circumstances are favourable to its use.

When, owing to shortage of material, it is necessary to use, as single boat ferries in the assault crossings, the folding boat equipment required subsequently for incorporation in light bridge or raft ferries, the following points will need consideration :—

i. There should be no great distance or intervening obstruction which would prevent the boats being rapidly towed to the light bridge site.

ii. Clear instructions must be issued by the infantry brigade headquarters (or by divisional headquarters if two brigades are concerned) to indicate when the boats are to be withdrawn from the ferrying for incorporation in the light bridge.

20. Similar considerations will apply to any form of assault crossing equipment that it is intended to incorporate in the light bridge or ferries.

The ferrying by single boat and raft should continue uninterruptedly with the remaining equipment until the light bridge is established.

21. In the absence of folding boat equipment recourse may be had to light bridges or rafts improvised from the material, or the type of materials, used for the assault crossings ; or heavier forms of equipment may have to be utilized. The main objection to most of such expedients is the comparative slowness of construction inherent in improvised or heavy forms of material.

22. Except to the extent indicated in paras. 16 to 18, above the engineers are responsible for the transport and operation of equipment required for light bridging operations, and for its distribution as ordered. Allotments of folding boat equipment should be made in sets or by load-units, as suitable.

23. The decision to start the construction of light raft ferries will rest with the battalion or brigade in accordance with their allotment. On the other hand, the decision to start the construction of the necessary light bridges is normally a responsibility, with engineer advice, of forward infantry brigades ; but the responsibility for notifying that the situation permits of light bridging may, if necessary, be delegated to forward battalions. Although bridge construction under the aimed small arms fire of the defence is generally impossible, engineer officers must be prepared to accept considerable risks in advising when bridging can suitably be attempted. Apart from their direct tactical value, the mere starting of the bridges encourages the forward troops who have already crossed.

It is therefore essential that close touch should be main-

tained between the engineer officer in charge of each crossing and a representative of infantry brigade headquarters, so that immediate decisions may be given on questions liable to arise. Such questions may include the advisability of starting, suspending or abandoning bridging operations, the order of priority of traffic, etc. In addition, the engineer officer must be kept informed of the brigade commander's intentions and of the course of operations, so that he may in emergency give his own decisions on these points.

Construction of the Medium and Heavy Bridges, and the Passage of the Remainder of the Force

24. The passage of the remainder of the force will usually necessitate the construction of both medium and heavy bridges as soon as the situation permits. The possibility should be considered, however, of dispensing with some or all of the medium bridges, and of proceeding directly to the construction of heavy bridges.

In general, the vulnerability of the equipment on the march, and the delays in construction caused by heavy shell fire, render it undesirable to start work on the medium and heavy bridges until the approaches and sites are reasonably secure: but, when the early provision of such a bridge is essential (*e.g.*, for the passage of tanks), risks may have to be accepted.

On the other hand it may be desirable to establish heavy ferries at an early stage of the action, and to allot the necessary equipment to forward divisions for this purpose. Such equipment should not be relied on as available for subsequent use in bridge.

If a bridge is likely to be greatly exposed to shell fire, the provision of a ferry at an adjacent site may also be desirable, or a heavy ferry may be utilized to supplement a medium bridge.

25. In calculating the equipment for each bridge, allowance must be made for errors in estimating the gap, for the possible unsuitability of the site for the use of trestles, for accidents and losses during the forward move and for damage at the site caused by artillery and air action. The allowance must be assessed according to circumstances, but 33 per cent. may not prove excessive against an enterprising and well-equipped enemy.

26. Except at sites allotted solely for tracked vehicles, the preparation of the bridge approaches will often be the ruling factor in estimating the time required for the completion of the work. It may sometimes save time to open the bridge for

traffic at a temporary site as early as possible, and to move it to an adjacent site later, when the approaches are ready.

The incidence of shell fire and air bombing may also necessitate the preparation of alternative sites to which bridges can be shifted in case of need.

The large requirements of personnel and stores needed for work on the approaches must therefore be appreciated and provided for in the bridging plan.

27. For each bridge, or group of adjoining bridges, an O.C. bridge should be appointed in orders. This officer will command the engineer troops allotted for the construction of the bridges and their approaches and will be responsible within the limits of his instructions for the assembly of the labour and materials at the sites, and for the execution of the work. He will establish a headquarters in proximity to the site. It is important that signal communication should be provided from the headquarters (division or corps) under which the O.C. bridge is working to his headquarters.

The O.C. bridge should receive definite orders whether construction is to proceed at all costs, or whether, in the event of severe bombardment, personnel and material are to be safeguarded by concealment or dispersion until conditions improve.

He should in addition receive instructions as to the point at which bridging equipment will come under his orders, whether at the *rendezvous* or at the *parking area* (*see* para. 5, i, above), and as to the disposal of the bridge company, R.A.S.C., vehicles after unloading. Normally these should be returned to a rendezvous for handing over to the O.C. bridge company : but, as an exception, certain vehicles may have to remain under the O.C. maintenance parties, as mentioned in para. 30, below.

Vehicles, with the exception of conversion and cut bay units, should be fully unloaded at the bridge sites and not returned partially loaded.

28. Early steps should be taken to provide for the semi-permanent and permanent bridges which will be needed to set free the mobile bridging equipment for its primary role (Sec. **95,** 8). The requirements of such replacements will be taken into account in the location of temporary bridges, so that traffic may continue during the construction or re-construction of the more permanent crossings.

29. When the medium and heavy bridges are open to traffic, the material used in the assault and light bridges should be dismantled as soon as it is no longer required, and re-loaded. The divisional echelons will be completed first

with serviceable material; and the remainder, including damaged material, will be returned to bridge companies.

MAINTENANCE AND IMPROVEMENT OF COMMUNICATIONS

30. Ultimately the engineers employed on the construction and improvement of the various bridges and their approaches will be relieved by, or reduced to, minimum detachments for maintenance. The strength of these detachments must be sufficient to carry out such repairs and replacements of piers as may be necessary; and the maintenance routine may include the forming of cuts or the swinging of the bridge.

If there is any likelihood of the maintenance of a bridge being rendered impossible owing to enemy artillery or air activity, the engineer plan may have to provide for the selection of an alternative site, and for the extra labour and material required for the transfer of the bridge to that site. The engineer officer in charge of the maintenance detachments will require instructions for his guidance in such an eventuality.

It may be possible to economize personnel and material required for maintenance by grouping two or more bridges under one engineer unit provided with M.T. for the movement of personnel and stores.

FURTHER CONSIDERATIONS

31. When the waterway to be crossed is of exceptional width, as in an estuary or in the lower reaches of a large river, the crossing arrangements may necessitate a high degree of organization comparable to a combined operation for an opposed landing on a hostile coast. In such a situation assault bridging will be technically impossible, and the assault crossing will be effected in boats. It may be necessary to provide for organized embarkation beaches and landing beaches; and the engineers, as the arm responsible for the transportation of the force across the water, will to this extent be in a position analogous to the Navy in a combined operation.

111. Engineers in an opposed landing

GENERAL CONSIDERATIONS

1. The conditions under which an opposed landing may be undertaken are governed by strategical, tactical and political factors, and by a variety of geographical and other physical considerations. As a basis for the study of the engineer problems involved it is therefore necessary to assume a sequence of events, some or all of which have their place in any typical operation of this nature which combined naval, military and air forces may be required to undertake.

2. The ports from which the constituent units of a field force and its stores are drawn may well be so distant from the coast where the landing is to be made as to necessitate the establishment of an *advanced base* at a harbour more accessible thereto. Such a harbour may be found in our own or in friendly territory, or it may have to be seized from the enemy by means of a preliminary operation.

3. The purpose of such an *advanced base* is to provide accommodation for personnel, stores and hospitals, either pending, or as an alternative or supplement to, their accommodation at a base to be established after the landing. In addition it affords a final opportunity for adjusting, to suit tactical needs, the embarkation of personnel and stores required in the landing.

4. The military force to be employed in the operation will be organized in two portions, the *covering force* and the *main body*, and embarked accordingly.

The *covering force* will carry out the initial landings and secure an objective, or objectives, known as the *covering position* and selected to give adequate security for the disembarkation of the main body. The covering force is normally conveyed from its ships to the shore by a series of trips in smaller craft. The troops conveyed in the first trips are known as the *first flight*. In addition to the troops ordered to land the commander of the covering force retains a *floating reserve* for employment as the situation requires.

The coast section on which a landing operation is to take place contains a number of beaches, selected on previous information as suitable for landing. Each *beach* usually contains two or more *landing places*, which are the actual sites selected for beaching craft or building piers.

As a result of the operations of the covering force, the naval and military commanders, in consultation, decide which *beach* or *beaches* are to be developed for the landing of the main body.

5. If the enemy defences include any coast defence batteries within range of the landing, or of the warships and transports co-operating, security will usually necessitate steps being taken to silence them. This may involve a military operation to capture them outright, or a raid with a view to their destruction : and, in either alternative, this task may be undertaken by the covering force or may necessitate a separate and distinct operation.

6. If the landing has been planned with a view to the seizure

of some enemy port suitable for use as a base for further operations, the operations of the landing force will be directed at an early stage to the capture of that port. If there is no such port within practicable reach, it will be necessary to develop the main landing, or some other place, as a base for the future operations projected.

7. On the basis outlined above, the engineer problems in a combined landing operation may be considered in the following stages :—

i. Planning and preparation.
ii. Preliminary operations.
iii. The action of the covering force.
iv. The landing of the main body.
v. The development of the base.

Planning and Preparation

8. The appreciation leading to the inception of a landing operation will include the following engineer considerations :—

i. The suitability of the coast for pier construction and other landing facilities.

ii. Freedom from weather liable to jeopardize maintenance by damaging piers.

iii. Water supply.

iv. Inland communications.

Engineer advice on these points will be based on information from intelligence sources, confirmed by air and other reconnaissances.

The speed of the landing and the reduction of the engineer commitments will depend very largely on the extent to which special motor landing craft can be provided and transported to the scene of operations. Every effort should therefore be made to ensure an adequate supply of motor landing craft.

9. It will be necessary at an early stage to consider the question of map supply. Air photographs should be taken if possible but, as air photography and naval survey activities may seriously prejudice the secrecy of the operations, it may be deemed advisable not to initiate new mapping, and any foreign maps existing must then be solely relied on. The provision of an accurate large scale map will, however, greatly facilitate the preparation of the preliminary engineer plans and the effective fire support of the landing.

The provision of the necessary ground control for the air survey photographs, if they can be taken, is a matter for the survey service. The co-operation of the naval survey service should be obtained.

10. The decision to undertake the operation will be followed by the early selection of the landing beaches and of the covering position. From this juncture the engineer staffs must plan in detail to ensure that the necessary engineer troops and stores shall be put ashore when and where they are needed. Provision will be required for :—

i. The disembarkation of stores, animals and vehicles ; and the reembarkation of casualties, etc.

ii. Communications from the beaches, including the passage of obstacles (other than in the sea, which is a naval responsibility), bridging and any special duties required in connection with the passage of gassed areas.

iii. Water supply.

iv. Field defences.

Provision will also be needed for engineer work to be expected during the operations subsequent to the completion of the landing ; but this does not differ in principle from that required for any campaign, and calls for no special comment.

11. Accurate data must be obtained as to depth of water, slopes and dimensions of beaches, and the nature of the country inland. This information can be obtained from intelligence sources and air photographs (taken at different states of the tide), if the taking of the photographs will not militate against surprise.

The extent to which special landing craft are to be provided will define the engineer requirements for landing the covering force and the main body. The weights of individual items of stores to be landed must be studied : and it will help materially if the maximum load to be put ashore during the landing of the covering force can be restricted to a load which can be man-handled.

For the heavier stores, and for vehicles which have to be lifted out of the holds of lighters, lifting appliances will be required on the pier-heads, unless the craft carry their own. Light railway or tramway tracks and trucks (drawn by hand, horse or power) will probably be required at the beaches selected for the landing of the main body.

From a consideration of these and other factors the engineers will design the structures and estimate the stores required. Unless standard stores (such as mobile bridging equipment or tubular scaffolding) are to be employed, all material must be prepared to the correct dimensions in readiness for assembly, so that the work of construction on the site may be reduced to a minimum. As far as possible, the component parts of structures should be packed together by bays, piers or other

convenient units, complete and clearly marked, and with a proportion of spares.

On long gently-shelving beaches, where the construction of a pier for use at all tide levels may be too great a task for completion in the early stages, a shorter pier for use at high tide levels may suffice as a temporary measure.

The provision of engineer stores for pier construction is an engineer responsibility, except that the Navy may be asked to supply craft required for floating pier-heads. As the naval authorities during a landing normally clear all troops and stores from the seaward side of " the line of demarcation between the services," there must be a clear previous understanding between the naval and engineer officers at each landing place that engineer personnel and stores required for work on piers and beach-roadways shall not be disturbed.

12. In planning for the communications forward from the beach the best possible information will be needed as to the nature of the ground to be traversed, *e.g.* wet sand, dry sand, pebbles, cliffs, marshes, dykes, etc. In the early stages, when speed is all-important, the most rapid means of crossing should be provided, utilizing such expedients as wire netting, expanded metal and corduroy track.

Maps and air photographs should be studied with a view to detecting localities suitable for gas contamination by the enemy, and to arranging counter-measures.

13. If accurate information of the local water supply resources is obtained beforehand, so that the necessary equipment for their development can be made available, no difficulty should arise. If there is an absence or a shortage of water, it will be necessary to arrange for a supply to be maintained by means of a service of special waterboats to be provided under naval arrangements. The liability of a sea-borne water supply to interruption by enemy action or storm conditions renders it desirable that a reserve of water should be stored on shore as soon as possible ; for the same reason the installation of distillation plant near the beach may be advisable.

14. The tonnage available for engineer stores for field defences will probably be limited. The engineers, acting on the general staff appreciation of the nature of enemy attacks to be expected (whether with armoured fighting vehicles, gas, etc.), will therefore advise how this tonnage can best be allotted.

15. The embarkation of troops and stores in the transports, and their subsequent transfer to smaller craft for landing, call

for meticulous care and forethought, so as to ensure that personnel and stores land in the correct order. The rule "first in, last out" applies generally to stores.

The arrangements for engineer units and equipment and for engineer stores will require attention to the following points :—

i. Although the most suitable beach for development for the landing of the main body can be pre-selected, it does not follow that the result of the operations of the covering force operations will admit of its adoption. The main engineer resources must therefore be flexible, for employment at any beach. For this reason the ships conveying the main body of engineers and their stores must be grouped together in the convoy and these ships must not carry other units or stores liable to interfere with the essential flexibility of the engineers. A possible course may be to carry the engineers in ships allotted to the covering force, so that, when the covering force disembarks, the engineers will be the sole occupants and thus completely flexible.

ii. Engineer equipment and stores should, if possible, be carried in the same ships as the engineer units to which they belong. Nevertheless, certain heavy items, such as derrick lorries, may have to be carried in M.T. ships. Each ship which carries engineer stores should also carry an engineer detachment under an officer, who will be responsible for its correct stowage and unloading in accordance with the engineer commander's plans and orders. If there is a likelihood of casualties among the ships owing to enemy action or other causes, it will be advisable so to distribute the engineer troops and stores that the loss of one ship will not completely negative the execution of the engineer plan, *e.g.* owing to the loss of all stores of a particular category.

iii. All engineer stores required for the landing itself should be sent ashore in the same craft or in the same tows as the engineers who are to use them.

iv. Economy of landing craft can be effected by floating ashore such engineer stores, *e.g.* pontoons and timber, as are suitable for towing.

Preliminary Operations

16. Detailed information on the engineer work likely to be required for the establishment of an advanced base and of an aerodrome will be found in Military Engineering, Vol. VII, and the Manual of Engineer Services (War).

The Action of the Covering Force

17. The action of the covering force usually consists of a number of separate landings, probably carried out

simultaneously, at the selected beaches. At the outset each column will be fighting its own actions at, and inland from, its beach, which may well be isolated from the other beaches. In these circumstances it will usually be necessary to place an engineer detachment under the command of each column. The size of this detachment, after allowing for casualties, should be limited to what is essential for the engineer work anticipated, which may include :—

i. Engineer reconnaissance inland in co-operation with the column commander.

ii. The hasty improvement of landing facilities to the extent necessary for the covering force only ; as the main body is not yet, and may not be, concerned.

iii. The improvement of exits from beaches, the removal of land obstacles, bridging, the passage of gassed areas, and rough communications in general.

iv. A hasty water supply.

18. As indicated in para. 5, above, the covering force commitments may include also the organization of an enterprise, including lightly-equipped demolition parties, to deal with enemy coast batteries.

19. Engineers will not land with the first flights unless there are definite engineer tasks for them to carry out. Engineer reconnaissance parties should land with the second flights, and it may be advisable to land the working parties at the same time.

It will usually be unnecessary for the covering force commander to retain an engineer reserve with the floating reserve, but it may be justifiable in special circumstances.

20. In addition to the covering force engineers, reconnaissance parties will be detailed by the C.R.E. to land at some or all of the beaches, with the later flights of the covering force. These parties will not be under the covering force. Their duties will be to plan the lay-out of piers and beach roadways in co-operation with the beach-masters and military landing officers, and to plan for other tasks ordered by the C.R.E.

The Landing of the Main Body

21. As soon as the covering force operations have made sufficient progress to enable the commander to decide which beach or beaches are to be used for the landing of the main body, the engineers of the force (less those allotted to the covering force) will normally be landed, and preparations will be put in hand for the landing of the main body.

The engineer work may include :—

i. The development of landing facilities to meet all requirements in stores, vehicles, animals, etc.

ii. Communications, including beach roadways and light railway tracks from pierheads to dumps.

iii. Sign-boarding.

iv. Water points.

v. Prisoners of war cages.

vi. Field defences, shelters, etc.

vii. Camp services.

22. It is desirable that the engineers attached to the covering force should revert to the control of the C.R.E. as soon as the landing of the main body has progressed sufficiently to enable divisional control of the operations to be established.

23. The prompt and effective application of the main engineer effort will depend largely upon adequate intercommunication between the C.R.E. and the force commander, and between the C.R.E. and his units. If the C.R.E. cannot be in the same ship as the force commander, it may be possible to accommodate him in the same ship as the commander of the covering force. The latter ship may be expected to be in reliable communication with the force commander : moreover, the ships of the main engineer contingent can often be included in the covering force convoy. But in either case the C.R.E. will require a picket boat, so that he may be free to move to any beach, independently of the commander with whom he is accommodated.

Visual signal communication between the C.R.E. and all engineer ships will be essential, so that the beach or beaches for development may be notified without delay.

The Development of the Base

24. Engineer duties in the development of a base are given in Sec. **121** ; in Military Engineering, Vol. VII, and in the Manual of Engineer Services (War).

112. Engineers in anti-aircraft defence

1. Engineer anti-aircraft units co-operate with fighter aircraft and with anti-aircraft artillery in the destruction of enemy aircraft. Their equipment includes searchlights, sound-locators and instruments for determining the height and course of aircraft, thus enabling them to carry out the following functions :—

i. The direct illumination of aircraft.

ii. "Pointing". The intersection of several beams indi-

cates to friendly aircraft the approximate position of the enemy, even when the latter is not illuminated.

iii. The provision of information about the height and course of aircraft.

2. The lay-out of the lights will depend on the performance of both the attacking aircraft and the anti-aircraft defence equipment. With the ever-improving performance of modern aircraft, it may well be necessary for the illuminated area to extend to a distance of eight miles or more outside the area to be protected.

3. The distribution of anti-aircraft units to co-operate in the defence of a particular area is made by the anti-aircraft formation commander, acting on instructions received from the general staff as to the areas to be protected and their order of priority in importance.

As a rough guide, an anti-aircraft company organized on a normal basis of four sections, each of six lights, can illuminate a circular area of about four and a half miles radius; two companies can illuminate an area of about six and a quarter miles radius; three companies about eight miles; an anti-aircraft battalion, consisting of four such companies, can cover a circular area of some nine and a quarter miles radius. It follows that little assistance in the defence of a vulnerable point can be afforded by an anti-aircraft searchlight company, and that the effective defence of an area of any magnitude will require the co-operation of a group of at least four companies. Further details are contained in the Manual of Anti-Aircraft Defence (Army Units), Vols. I and II.

113. Coast defence

1. The term " coast defence " may cover a wide variety of situations, such as the all-round defence of fortifications deliberately prepared for the protection of a naval base, with a garrison liable to beleaguerment, or the guarding of a stretch of coast on which a hostile landing is to be apprehended.

The engineer roles in such situations, or in a combination of them, will be considered under the following headings :—

i. Defence against naval attack.
ii. Defence against a hostile landing.
iii. Defence against air attack.
iv. Defence of the land front.

Defence against Naval Attack

2. The forms of naval attack to be expected may be classified as follows :—

i. Bombardment.
ii. Attack by blocking ships and boom smashers.
iii. Attack by destroyers and motor torpedo boats.

These forms of attack may be used singly or in conjunction with other forms of attack mentioned in this section.

3. Naval bombardment, usually at long ranges, may be directed at an area, such as docks, harbour works, towns, oil depots and other installations; or at defence works, in conjunction with a land attack or a landing. In addition to H.E., an enemy may employ gas and incendiary shells.

The special engineer tasks required to meet this form of attack may include :—

i. The construction (normally in peacetime) and maintenance of fixed defences, as required by the general staff.

ii. The construction of such additional defences as may be found necessary, including command posts, range-finding posts and shelters for personnel and ammunition, proof against bombardment and gas.

iii. The manning of battery engine rooms for providing power to the counter-bombardment guns.

iv. Arrangements for the localization of damage caused by bombardment, including engineer work necessary for fire-fighting and fire prevention.

v. Decontamination, assisted by the other arms and by civilian labour, of gassed areas and structures.

4. Attack by blocking ships and boom smashers, for the success of which surprise is a vital factor, will usually be delivered by night, or under cover of fog or smoke. Such attacks will be engaged by the artillery of the fixed defences, and the main engineer role will be the operation of the observation and fighting lights (*see* para. 6, below) to detect and illuminate the approaching enemy ships.

5. Attack by motor torpedo boats (M.T.Bs.) relies for success on the exceedingly high speed of the craft engaged, combined possibly with the employment of a large number of such craft. Such attacks will be met by the lighter close defence batteries of the fixed defences. The main engineer role will consist of the illumination of an area by means of the illuminated area lights (*see* para. 6, below).

While the illuminated area should, if possible, be in advance of the anti-M.T.B. boom or entrance to be defended, it must be clear of the observation and fighting lights referred to in para. 4, above; otherwise the concentrated beams of the latter, as viewed from a flank, will tend to obscure the approach by their blanketing effect.

6. Defence electric lights fulfil the following functions :—

i. *Observation*—to detect the approach of hostile craft.

ii. *Fighting*—to illuminate a hostile craft which has been selected as a target by the artillery. Under this heading are included the examination lights for illuminating vessels in an examination anchorage.

iii. *Illuminated area*—to illuminate water on which craft will come under the fire of anti-M.T.B. and other close defence batteries.

Concentrated beams are used for i and ii ; and dispersed beams for iii. Certain lights may have to combine the roles of i and ii.

Searchlights are usually provided in pairs, so that, if one light is temporarily doused, the other may take up its work. The direction of the light is effected by remote control from a directing station, which, together with the engine room and a pair of searchlights, constitute the normal tactical unit, commanded by an engineer N.C.O. An electric light officer will be placed in charge of one or more units, as necessary.

A pair of observation lights normally consists of a " sentry beam ", maintained on a fixed bearing across a channel, and a " search beam ", intended to search over an area outside or inside the sentry beam. The artillery are responsible for observing targets in a sentry beam ; but the engineers are responsible for detecting targets picked up by a search beam.

The tactical control of the lights rests with the artillery, the engineers being responsible for carrying out the tasks ordered. The fire commander exercises general coordination of lights and guns, issuing his orders for lights to an officer commanding electric lights. In addition he normally retains direct tactical control over observation and illuminated area lights. On the other hand the necessity for rapid action to repel attack usually entails decentralization. Consequently the battery commander controls the fighting lights, issuing his orders to an electric light officer.

It is a principle of defence against naval attack (other than long range bombardment) that the defence lights should be organized in such depth as geographical conditions permit. Consequently all lights work in combination and will have to be manned against any form of attack, so that enemy craft which penetrate the outer lights will next be confronted with the inner lights.

Defence against a Hostile Landing

7. If the transports conveying a hostile force are compelled to move or to anchor within the range and arcs of fire of the

artillery of the fixed defences, the defence problems during this stage will be similar in principle to those of meeting a naval attack. Subsequently, while the landing force is being conveyed in smaller craft from the transports to the landing beaches, it will be especially vulnerable to artillery and small arms fire. The further engineer problems to be considered are, however, chiefly concerned with the defence of beaches and with operations subsequent thereto.

8. The strategical and tactical circumstances of the defence of a stretch of coast may vary considerably. Thus, on the one hand there may be a relatively small force available for the defence of a long coast line, which offers numerous suitable landing beaches to the enemy ; on the other hand the possible landing beaches may be clearly limited in number owing to marine conditions (depth of water for anchorages, currents, rocks, etc.), and this number may be still further restricted by land conditions such as the difficulty of inland communications from the beaches to probable enemy objectives.

While it will always be necessary to secure the earliest warning of the direction of enemy attacks by means of naval and air patrols and by a system of coast watchers, the two extreme situations described entail correspondingly different defensive measures, both of which may apply in varying degree in an average situation. In the former considerable reliance will necessarily have to be placed on the action of highly mobile reserves, provided with good communications to the most likely avenue of attack ; in the latter it will be possible to a greater extent to commit resources to the close defence of those beaches which alone are open to attack.

9. The arrangements for the defence of a beach differ from those in a normal defensive system in land operations in two respects. In the first place the defence will be to some extent linear rather than in depth, partly because the enemy must be destroyed while he is at the greatest disadvantage immediately before and during his landing on the beach, and partly because the majority of beaches favour the development of fire from a forward linear system. In the second place it will be necessary to place the machine guns in the foremost defences so as to obtain fire effect, and to hold rifle units and sub-units in reserve for immediate counter-attack.

If the beaches open to attack are limited and well defined, additional strength may be obtained by the siting of light guns and beach lights in the forward defences. Such beach lights may be used either as concentrated beams to illuminate the tows as they approach the shore, or as dispersed beams to

illuminate the shore. The change-over is effected during the attack by means of lenses.

10. Should the enemy effect a landing at one or more beaches, considerable importance will attach to engineer measures for hampering the exploitation of his success, by the use of normal land operation methods, so as to gain time for the intervention of the reserves or for such other measures as may be planned by the commander.

11. To sum up, the engineer work required may include :—

i. Beach light work for the defence of beaches.

ii. The construction of strong (*e.g.* concrete) emplacements for guns, machine guns and searchlights, including command posts, shelters, etc.

iii. The construction of under-water obstacles on the landing beaches.

iv. The construction of special obstacles on shore, such as electrified wire entanglements on a wide front.

v. The improvement of communications for the use of forward troops and reserves.

vi. The preparation of defended localities and other expedients for delaying the exploitation of a successful landing, including the destruction of water supplies and the operation of remote control devices.

vii. Normal administrative tasks.

12. The question of the concealment of engineer preparations from enemy aircraft will require decision by the general staff. While the detection of some activities will be prejudicial to success, it is possible that the deterrent effect of other visible preparations may contribute to the success of the commander's plan.

Defence against Air Attack

13. The role of engineer anti-aircraft units is outlined in Sec. **112.** Difficulty is to be expected in securing adequate illumination on the seaward side of the area to be protected.

14. In addition to the anti-aircraft searchlights role, the engineers will be required to undertake measures for affording shelter from air bombing with H.E., gas and incendiary bombs and for localizing its effects. These measures will be of a similar nature to those referred to in para. 3, above.

Defence of the Land Front

15. The general principles of defence on land are laid down in Field Service Regulations, Vols. II and III, and the engineer

considerations are outlined in Secs. **107** and **108** of this manual. While these are generally applicable, the following factors must be borne in mind :—

i. The defence may be almost completely static, any but the most limited counter-offensive being locally out of the question.

ii. If the ground available for the system of defence is limited, as it usually will be, the loss of ground may be more serious than in normal warfare.

16. While the preparation of elaborate permanent fortifications in peace is apt to result in their lay-out becoming accurately known to potential enemies, and to their proving obsolete against new armaments, the following measures, in which the engineers are intimately concerned, should be undertaken in anticipation of likely contingencies :—

i. Defence schemes will be prepared in accordance with King's Regulations and any special instructions.

ii. A nucleus of defensive works, solidly built in concrete, may be desirable (*see* Military Engineering, Vol. II).

iii. Accurate survey maps, suitable for the predicted artillery fire of the defence, must be prepared and maintained by the survey service.

iv. Strict control must be maintained over building and planting operations in the probable area of operations.

v. The main road and railway communications should be developed.

vi. Splinter-proof protection should be provided for the main signal intercommunication arteries.

vii. The security of the water supply against beleaguerment must be ensured.

viii. Storage, with security against bombardment, may be required for the necessary reserves of stores of all descriptions, including engineer stores.

ix. Provision must be made against the possible development of mine warfare.

x. Provision must be made for the aerodromes and other accommodation required for the aircraft likely to be available for the defence.

17. On the outbreak of war, when the defence problem is more clearly defined, and when security measures against espionage can be more rigidly enforced, the defensive arrangements will be further developed, as necessary. It is important that the stores, labour and transport required for this further development should be fully appreciated in the defence scheme (para. 16, i, above).

114. Mine warfare

1. In view of the time required for the development of a mining system, mine warfare is peculiar to a war of position. It absorbs vast quantities of labour and materials, an expenditure of resources which is rarely justified by the tactical value of the results. No offensive mining must, therefore, be undertaken without the prior sanction of the higher command, and it should only be initiated with the object of attacking a definite and important objective which cannot be more expeditiously or effectively attacked by other means.

On the other hand, when a prolonged period of stabilization is anticipated, with only a narrow " no-man's land " between the two fronts, the possibility of enemy mining must be considered and effective measures must be taken to detect it. Failure to take such measures may have a depressing effect on the morale of troops occupying the forward defences. The construction of listening galleries and the preliminaries of a counter-mining system may then be necessary ; but, since mining begets mining, such precautions, if not absolutely necessary, are likely to incite the enemy to undertake counter-mining, and thus a form of warfare may develop from which little gain is to be expected.

No mining operations should be undertaken, therefore, without the sanction of army headquarters ; while important offensive mining operations require the approval of G.H.Q.

2. Once the decision to undertake mining has been made, however, success will depend on a vigorous prosecution of both offensive and defensive mining. Speed and surprise in carrying out a definite, consistent and aggressive plan of action, aiming at results of real importance, are then essential to success ; and these in turn depend on a high degree of organization and technical skill, and on a concentration of all the mining resources that can be utilized as part of a large offensive operation. The plan and control of mining must, therefore, be in the hands of a higher formation which will not be changed owing to reliefs ; and such control will in consequence normally be exercised by G.H.Q. or army headquarters in all important mining operations, and by corps headquarters in operations of only minor or local importance. The creation of a mining directorate and the employment of special tunnelling units will also become necessary (*see* Military Engineering, Vol. IV).

3. But, while the control of the plan will be with the higher headquarters, the provision of working parties and the above-ground defence of mine shafts will be the responsibility of

forward formations. As the latter will be the first to suffer from any lack of success in our mining operations, it is essential that engineer officers charged with the execution of mines should work in close and friendly liaison with the formations occupying the sectors of mining activity. By this means local commanders will be in close touch with the progress of the mining operations, and thus in a position to render active support to the engineers.

4. Details of mine warfare and of the conditions governing its inception and conduct will be found in Military Engineering, Vol. IV.

115. Engineers in night operations

1. The work of the engineers in night operations, such as marches, advances, attacks and withdrawals, will resemble that in similar operations by day. The marking of routes with whitened posts or mounds, the temporary blocking of side tracks, and the marking of assembly areas with boards, tapes or shaded lights, will need special attention.

In open country, and especially in featureless plains, the checks, delays and fatigue incidental to the march of closed columns by night can often be minimized by sending ahead strong engineer parties with suitable protective troops to prepare and mark the route to be followed.

Similarly in close or broken country, or on a route crossing numerous dry water courses, the sending ahead of engineer parties to clear and to mark a broad track will allow the main column to march at a normal rate.

2. When a force is halted in close proximity to the enemy, many demands for night work will inevitably be made on the engineers. Such work may be of a tactical nature in connection with defences, or of an administrative nature, as in drawing water from a river of which the far bank is in the hands of the enemy.

The efficient and expeditious execution of engineer work under such conditions depends on careful organization, based on thorough preliminary reconnaissance, and on a high standard of training in night work among the men. Without these essentials the working parties will sustain unnecessary casualties, and the progress of the work will suffer.

Men must be trained to work silently and swiftly in the dark, and must understand that work must continue in spite of fire unless orders are given to the contrary. Should the fire persist, the engineer officer in charge will decide, according to the orders which he has received, whether he should

temporarily withdraw his men to cover. In exposed situations arrangements will be necessary for the removal of casualties.

Night work is particularly suitable for the allotment of a collective task to each working party or sub-unit employed.

Engineer commanders whose troops are working in the forward area, and especially in front of our foremost localities, must ensure that all neighbouring troops, including supporting arms, are aware of the presence and position of the engineer working parties.

3. Although the leading of night marches and night advances is a duty of officers of all arms, it is one which engineer officers, by virtue of their special training, will often be called upon to undertake. As in all work by night, the first essential is the most thorough reconnaissance possible, both by day and by night; and no precaution which may assist in following the route should be neglected.

In short movements by routes in which there are easily recognizable landmarks one officer may suffice to lead the movement. In more difficult movements, across featureless country where a single bearing has to be followed for several miles, it will be advisable for one officer to concentrate on the direction, with an assistant to reckon the distance. On a long march it may be necessary to provide hourly reliefs for these officers.

CHAPTER XII

ENGINEER WORK ON THE LINES OF COMMUNICATION

116. General considerations

1. The dependence of a modern army on its lines of communication demands that they shall be secure from frequent or prolonged interruption, whether by enemy action or from other causes. Apart from tactical security, which is a general staff responsibility, the L. of C. services must therefore be staffed and equipped on a scale sufficient to ensure a capacity well in excess of the average rate of flow required. Any attempt to economize at the expense of the security or capacity of the L. of C. involves the risk of an administrative break-down, which may result in a military disaster of the first magnitude.

2. The engineers play the leading executive role in the establishment and operation of the L. of C. ; and the organization provided for this role consists chiefly of :—

i. The engineer services (Secs. **58** and **64**).
ii. The transportation services (Secs. **57** and **63**).
iii. Field units allotted for L. of C. defence.

The engineer effort in the L. of C. area, as measured in personnel, in engineering equipment and stores, and in output of engineer work, will thus frequently represent fully half of the engineer contribution to the entire campaign. Moreover the work required will be largely of a nature that must conform to the highest standards of modern engineering.

It is important that the magnitude and nature of the engineer commitments on the L. of C. should be fully appreciated by all engineer officers ; and that engineer staffs, in tendering advice to the higher command on the inception of a campaign or on an expansion in its scope, should ensure that this aspect receives full consideration.

3. The general system of organization and administration of the L. of C. is described in Field Service Regulations, Vol. I, and the Manual of Movement (War) ; the administrative regulations for the work of the engineer services are contained in the Manual of Engineer Services (War) ; and technical data are given in Military Engineering, Vols. VII and VIII.

117. Engineer services

1. The works service is responsible for the execution of the following engineer work in the L. of C. area :—

i. Accommodation of all kinds.

ii. Erection of workshops, including constructional work required for the installation of machinery.

iii. The erection and operation of systems of water supply, power and lighting.

iv. The erection and engineer maintenance of installations such as laundries, bath houses, disinfecting stations, mineral water factories, ice factories, cold storage, bakeries and so on.

v. Roads and bridges (other than railway bridges).

vi. Training and recreation facilities.

vii. Lands and hirings (unless a separate directorate is formed).

viii. Work for the R.A.F. (*see* Sec. **72**).

The exact line of demarcation between certain items of works services and transportation services cannot be expressly defined. The policy will be laid down by G.H.Q. at the outset, and adjusted as necessary from time to time.

2. The engineer stores service is responsible for the execution of the following engineer work in the L. of C. area :—

i. The provision of engineer stores in general.

ii. The despatch of routine detail issues, and of bulk issues ordered by the Q.M.G.'s branch, to distant destinations, as indicated in Sec. **76.**

iii. The operation of engineer workshops.

iv. The inception or taking-over of productive installations for the development of local resources, *e.g.* :—forestry, saw mills, sand and gravel pits, stone quarries, brick and tile works, lime and cement works, etc. (*See also* Chapter VIII.)

3. At garrisons and posts on the L. of C. for the defence of which no engineer unit or detachment has been specifically allotted, the senior engineer officer of the works service will also be responsible, in accordance with orders to be issued by the C.R.E. of the sub-area, for engineer advice and assistance to the commander of the troops. In this capacity, his duties may include :—

i. Engineer work in connection with defences (other than anti-aircraft searchlight work).

ii. Measures for defence against gas.

iii. Engineer work in co-operation with mobile columns operating from posts on the L. of C.

Such officers must be in the confidence of local commanders

so that they may be prepared to render prompt assistance when required. For example, mobile operations will usually involve engineer work, such as water supply or demolitions, for which personnel, equipment and transport may have to be extemporized. (*See also* Sec. **119.**)

4. Engineer units allotted for L. of C. defence, when not required for specific duties in that respect, may, with the concurrence of their formation or sub-area commander, be employed on the execution of works services under the C.R.E. of the sub-area.

118. Transportation services

1. The responsibilities of the transportation services in a theatre of war will depend on local conditions. In a friendly country, equipped with adequate and reliable means of transportation, these responsibilities may be purely advisory, executive functions being entrusted to the existing civil agencies; or it may even be feasible to leave the entire responsibility, both advisory and executive, in the hands of the existing organizations.

In a hostile or ill-developed country, on the other hand, the entire responsibility for the establishment, maintenance and operation of the necessary transportation facilities may have to be assumed by the engineers of the transportation services.

While an average situation may be expected to lie between these two extremes, a proportion of engineers will usually be required for work in the forward areas, and for the provision of additional facilities, especially at the base or advanced base.

Subject to the above factors, the responsibilities of the transportation services can now be summarized.

2. The railways service is responsible for the execution of the following engineer work :—

i. The survey of new routes, including local development and connections, *e.g.* within the base sub-area.

ii. The construction and maintenance of railways.

iii. The operation of railways.

iv. The provision and operation of gun spurs for heavy artillery on railway mountings (*see also* Manual of Movement (War)).

v. The provision and technical operation of armoured trains in guerilla warfare (*see also* Manual of Movement (War)).

The responsibilities of the light railways service do not

differ in principle from those of the railways service, except that the use of artillery on railway mountings is normally inapplicable.

3. The docks service (*see* Manual of Movement (War), 1933, Sec. 50) is responsible for :—

i. The working and maintenance of the shore portion of the port serving the force, and the checking and transit through the docks of stores and M.T. unloaded. This does not include the disembarkation or re-embarkation of personnel and animals, except routine arrangements with the sea transport staff for the convenient berthing of vessels.

ii. The development by the appropriate agency (*see* end of this para.) of facilities for berthing vessels and handling stores.

iii. Checking stores from ships discharging into lighters. When cargoes are discharged into inland water transport lighters for onward transit, the responsibility includes correct stowage.

iv. Railway operation within the docks area, the locomotives and rolling stock being supplied by the railways service.

v. The operation of and running repairs to cranes, conveyors, elevators, etc., within the docks area.

vi. Arrangements with the base commandant for local facilities such as electric light and power.

vii. Advice to the movement control in the preparation of the stores shipment programme, in respect of the capacity of the port or ports (*see* Manual of Movement (War), 1933, Sec. 71).

In the event of transportation construction units being available, the docks service will also be responsible for the erection or improvement of such facilities as wharves, cranes, conveyors, etc. Otherwise the executive responsibility for these will devolve on the works service.

4. The inland water transport service (*see* Manual of Movement (War), 1933, Sec. 51) is responsible for :—

i. The operation and maintenance of the waterways, including dredging, buoying and lighting ; the working of locks, lifts, culverts, syphons, etc. ; the control of local craft ; and other services.

ii. The operation and maintenance of the craft employed, including the installation and working of shops, dry-docks and yards, for light repairs ; and the working and maintenance of cranes and other necessary machinery.

iii. The installation of telegraph and telephone circuits for traffic control (personnel and stores being supplied by the Royal Corps of Signals).

5. In addition to the responsibilities enumerated above, the transportation services are responsible for the provision and distribution of transportation stores.

6. As stated in Sec. **117,** 1, the exact line of demarcation between the responsibilities of the transportation and works services may vary with circumstances. The similar nature of much of the work to be done by these services, and of many of the stores required for that work, calls for coordination by G.H.Q. Furthermore, delay and wasted effort can only be eliminated by spontaneous cooperation between the engineer officers concerned.

119. Field units allotted to the L. of C.

1. In a campaign against a well-equipped enemy, the anti-aircraft defence of the L. of C. area will be of great importance. The allotment and employment of engineer anti-aircraft units will follow the principles outlined in Sec. **112.**

Engineer advice and assistance in provision for anti-gas defence may be of considerable importance.

2. In the ground defence of the L. of C. against a modern army, unless the L. of C. is abnormally exposed to attack, the main threat will often be that of raids by enemy mobile columns, probably including armoured fighting vehicles, with a view to the interruption of the maintenance system by demolitions and other means. Against a tribal enemy, or one who employs guerilla methods, the defensive measures will need to be thorough, so that no vulnerable point is left unguarded.

The duties which will be required of the engineers will depend on the general staff appreciation of the situation, and will not differ in principle from those described in Chapters X and XI. Special importance may, however, attach to the provision of mobile engineer detachments for cooperation with columns sent out to meet, or to pursue and intercept, enemy raiders.

120. General engineer work on the L. of C.

1. Engineer work on the L. of C. comprises the following main categories :—

i. Essential work on the temporary base or bases.
ii. The establishment of the permanent base or bases.
iii. The establishment of the advanced base or bases.
iv. Miscellaneous work at other points on the L. of C., including work for the R.A.F.

2. The considerable period of time required for the construction or development of an overseas base necessitates the establishment of a temporary base as an interim measure, essential to maintenance. In order to avoid disorganization of, and interference with, the arrangements for the development of the permanent base, it is desirable that the site selected for the temporary base should be clear of that selected for the permanent base. In highly-developed countries, provided with several ports, such a course may well be feasible. In less-developed countries having perhaps only one suitable port, it may still be possible to form a temporary base clear of the area selected for the permanent base. Failing this, it will be necessary to form the temporary base within what will eventually become the base sub-area. In such a situation the possibility must be considered of laying out the temporary base in such a way that it can ultimately be adapted for use as part of the permanent base.

In all circumstances, however, it is essential that the work done on the temporary base should be the minimum necessary to enable it to function. All such work is necessarily a diversion of effort which delays the inauguration of the permanent base, on which the efficiency of the force depends.

3. Work on the permanent base will usually be unceasing throughout the campaign, and will absorb the major share of the engineer effort on the L. of C. The first objective will be its development to a stage at which, though incomplete, it can be taken into use as a permanent base, capable of filling its role. The work required is described more fully in Sec. **121.**

4. Work on the advanced base will follow the same lines as for temporary and permanent bases.

5. Work on other parts of the L. of C. will consist largely of accommodation for rest camps, convalescent depots, training establishments and productive installations (Sec. **117,** 2). In addition, the improvement of communications by road, rail and waterway, and the replacement of temporary bridges by permanent structures, will be a prominent feature.

121. Establishment of an overseas base

1. A base sub-area consists of two main parts :—

i. The *docks*, which is solely a transit locality.

ii. The *depots*, under which term are included camps, hospitals, personnel and store depots and other installations.

The factors affecting the lay-out of a base are given in Field Service Regulations, Vol. I ; the Manual of Movement

(War) and Military Engineering, Vols. VII and VIII, but the influence of transportation considerations is predominant, in the docks and in the lay-out of the stores depots.

2. In order to prepare for the reception of the force at the overseas base, an advance party (as laid down in Field Service Regulations, Vol. II and the Manual of Movement (War)) will precede it to the theatre of war. In addition to representatives of the staff and services, this party will include certain engineer units, of which the following will usually be essential :—

Army troops companies.
A field survey company.
Electrical and mechanical companies.
A workshop and park company.
A railway survey company and a railway construction and operating company.
Docks units.

3. Before the despatch of the advance party, the administrative staff will draw up a preliminary scheme, on the information available, consisting of two parts :—

i. The *maintenance project*, containing tentative proposals for the maintenance of the force, both under initial temporary conditions and under ultimate permanent conditions.

ii. The *1st key plan*, consisting of a large-scale map showing the proposed allotment of areas to the various depots and installations, and serving as an appendix to the maintenance project.

This scheme will be the basis of the ground reconnaissance carried out by the advance party. Exceptionally, if lack of time or information precludes the preparation of even a tentative scheme beforehand, it may have to be drawn up on the results of the first reconnaissance ; but this is abnormal.

As a result of the more reliable information gained by reconnaissance, an *amended maintenance project* and a *2nd-key plan* will be prepared, providing for both the temporary and permanent maintenance of the force, and clearly showing the areas at the base to be allotted to the various services for their installations.

It may sometimes happen that a final decision on the permanent maintenance system cannot be reached until the ground has been surveyed in some detail, with a view to ascertaining its suitability for development from either the works or the railway aspect. This may necessitate the further preparation of a *revised maintenance project* and a *3rd-key plan* to deal with permanent maintenance.

In the event of it being necessary to survey the site of the proposed base after the arrival of the advanced party overseas, this duty will be carried out by a composite survey party, formed by temporarily withdrawing surveyors, as required, from the engineer units (other than transportation units) which have arrived. The senior engineer officer will advise the officer commanding the advanced party as to the orders which should be issued for this purpose.

4. The administrative staff is responsible for the production of the key plans, acting in consultation with the technical advisers of the various services. The advice tendered by the latter falls under three headings: firstly, the extent of the provision to be made for a service, *e.g.* tonnage, storage space, etc.; secondly, the scales of accommodation required; thirdly, the technical factors to be considered in fitting the requirements of the service into the general lay-out of the base.

Under the first heading, the extent of the provision required for the services found by the engineers can be estimated from the data given in Military Engineering, Vols. VII and VIII, amplified by special War Office instructions covering requirements peculiar to the campaign projected.

Under the second heading, details of the approved scales will be found in Military Engineering, Vols. VII and VIII. Minor modifications to meet special conditions may be necessary.

Under the third heading, engineer considerations, and especially the requirements of transportation, will be of the first importance. Transportation requirements will be found in Military Engineering, Vol. VIII. In addition, the works service will tender advice on the following points:—

i. The possibility of constructing additional landing facilities.

ii. The adequacy of existing sources of water supply.

iii. The suitability of ground for drainage.

iv. The standard of communications within and round the area.

v. Existing sources of supply of electric light and power.

5. The execution of works services in the base sub-area will be entrusted to one or more C.R.Es. Each C.R.E. must be instructed as to the essential work which is to have priority, and he must have general instructions as to future developments.

The essential work required to enable the permanent base to function will include the following:—

i. The provision of landing facilities (*see* Sec. **118, 3,** ii).

ii. The provision of minimum quantities of covered store and workshop accommodation in depots and workshops.

iii. The provision of offices in depots and workshops.

iv. The provision of latrines, ablution places, cookhouses, dining halls, messes and offices, in camps.

v. The provision of similar buildings in hospitals: of a few wards for serious cases and of special technical buildings such as operating theatres.

vi. The provision of hard standings and special buildings in remount depots and veterinary hospitals.

vii. The provision of water supply, and of electric light and power throughout the area.

viii. The provision of roads and bridges.

ix. Defensive measures against air attack with H.E., incendiary and gas bombs, and air spray.

6. The final stage, the development of the base to full capacity, will be the continuation of the work begun, as in para. 5, above.

In addition, if a winter campaign is envisaged, the major problem of hutted sleeping accommodation for personnel must be taken in hand in good time. A work of this magnitude will probably form a separate service under a special C.R.E.

7. Transportation work in the base sub-area must be put in hand at the earliest moment. It will consist of the development of the means of ensuring rapid clearance of the docks, and of the construction of rail facilities in the various depots, with easy connection to the main line.

As the engineers of the transportation services will be working in the closest contact with those of the works service (the shedding being erected by the latter, and the lines serving it by the former), the closest co-operation will be required. The local representative of the Director of Works and the local representative of the Director of Railways will therefore be in frequent consultation and their offices should not be far apart.

122. Strategic withdrawal

1. The circumstances in which a strategic withdrawal may be undertaken are described in Field Service Regulations, Vol. III. The engineer aspect of such an operation, with special reference to the use of demolitions and destructions, is described in Sec. **97.**

2. As stated in Sec. **97,** 2, the responsibility for the design, preparation and execution of the demolition of railways,

waterways, telegraphs, etc., and of depots of stores and installations of all kinds, will rest with the services or directorates concerned. The transportation and engineer services have thus a role to fulfil which may well be vital to success.

3. While the orders for the initiation of a demolition scheme affecting the L. of C. services will normally be issued by G.H.Q. to the directorates concerned, the responsibility for co-ordinating the execution of all demolitions in the forward area will usually be delegated to corps commanders within their areas. In these circumstances, executive authority to co-ordinate and control the work will be given to C.Es. of corps, and in some cases to C.R.Es. of forward divisions. It will be the duty of engineer officers of the L. of C. services to gain touch with the engineer commanders concerned, and to conform to the arrangements ordered.

APPENDIX I

SPECIMEN TRAINING PROGRAMME FOR DIVISIONAL ENGINEERS

Individual Training Season

(*See* Sec. **12**, 12.)

Rank	October				November				December				January				February				March				Remarks
	1	2	3	4	1	2	3	4	1	2	3					4	1	2	3	4	1	2	3	4	
Officers.		A		E	A	D	C	D	B	D	C					D	B	D	C	D	C	F		B	i. The meaning of A, B, C, etc., is given on the next page. Each column represents one week.
			←-	-G	(1)-→			←	(G)	(2)-→						H	←-	—	-J-	—	→-				
N.C.Os.	-M→						C				C					←-	-N-	—	C	-O-	C →-		←-	P→	ii. Officers will also attend (*a*) Exercises of their affiliated brigades, as required.
	S		←-	—	—	—	-T-	—	—	—	→-					←-	—	—	-T-	—	—	→-		U	(*b*) All command lectures (*e.g.* at 1730 hrs. on 1st and 3rd Thursdays.
Sappers and pioneers	S		←-	—	—	—	-T-	—	—	—	→-					←-	—	—	-T	—	—	→-		U	
M.T. Wing	S		←-	—	—	—	-V-	—	—	—	→-					←-	—	—	-V-	—	—	→-		W	iii. By counting a month as four working weeks, this programme allows one spare week before, and one after, Christmas to meet unforeseen interruptions.
	X				Y											Z									

HOURS OF WORK.

1. *General.*

First parade ...	0730 hrs.	
Working parade	0800 hrs.	(Not on Sat.)
Break	1045 hrs.	
Resume work ...	1100 hrs.	
Dismiss	1230 hrs.	(1200 hrs. on Sat.)
Afternoon parade	1330 hrs.	(Not on Wed. and Sat.)
Dismiss	1700 hrs.	(1600 hrs. on Fri.).

2. *Education.*

Mon. to Thurs. / Fri. — 1730 hrs. to 1930 hrs.

3. *Military training.*

Daily (except Sats.)

P.T. ... ...0730–0750 hrs.

Saturday mornings.

Drill.
Weapon training.
Tactical training.
Anti-gas training.
Field engineering.
Kit inspections.
Marching (after Christmas).

Arranged in 40-min. periods, with breaks, 0730–1200 hrs.

4. *Recreational training*
Wed. and Sat.

NOTE.—Allowing 5 mins. each for morning inspection and for calling over names, and (say) 10 mins. each way for marching from parade to works, the above type programme gives 30 hrs.' trades work a week (net time), for the trades training periods.

EXPLANATIONS

A. Officer's tactical training course :—

Progressive course of six T.E.W.Ts. (assisted by officers of arms concerned) :—

First week
- No. 1. Infantry—Company and platoon attack (verbal orders).
- No. 2. ,, —Battalion and company attack (verbal orders).
- No. 3. ,, Battalion in defence, company, platoon, M.G. A.T.

Second week
- No. 4. Cavalry.
- No. 5. Artillery.
- No. 6. Infantry brigade in attack (Infantry, tanks and artillery support)

B. One T.E.W.T. (*e.g.* on Tuesday)
- Advanced guard.
- Rear guard.
- River crossings, etc., etc.

C. One E.E.W.T. (*e.g.* on Tuesday).

D. Miscellaneous military training (one afternoon or evening).
Lecture or discussion on R.E. organization and problems—period of military history, etc.
(NOTE.—Special instruction will be arranged for Staff College and promotion examination candidates.)

E. C.E.'s tour—to—October.

F. C.E.'s battlefield tour—to—March.

G. (1) and (2) Fieldworks projects in own time.

H. (*f*) Examinations.

J. " Works " project in own time.

K.

L.

M. Cadre class—Junior N.C.Os.—Drill and duties.

N. Cadre class—Senior N.C.Os'. technical course.

O. Cadre class—Junior N.C.Os'. technical course.

P. Cadre class—Weapon training and anti-gas.

S. Preliminary period—Fatigues, cleaning up, filling in trenches, opening workshops, drawing tools and stores and preparing sites for building work.

T. Trades training and testing.
U. Closed period—Closing shops, testing fieldworks stores preliminary fieldworks, standard tests.
V. Individual training in driving, care and maintenance, running repairs, map reading.
W. Collective driving instruction and drill.
X. Divisional commanders' inspection—October.
Y. Divisional " other arms " fieldworks course.
Z. Command military law lectures—February.

APPENDIX II

SPECIMEN TRAINING PROGRAMME FOR A FIELD COMPANY

Collective Training Season

Month	1st Period	2nd Period	3rd Period	4th Period
April.	Physical training—Drill—Weapon training Anti-gas training (individual) March discipline Preliminary fieldworks and standard tests. Sub-Section tactical training.	Section tactical training.	Company tactical training.	Weapon training. Range practices. Anti-gas training (collective).
May.	Weapon training. Anti-gas training. Range practices and rifle meeting.	Field defences, including No. 1 continuous operation (*see* Sec. **14**, 3), and including the use of smoke.		Spar work. S.B. girder. Improvised bridging.
June.	Improvised bridging. Preliminary pontooning and F.B.E.	———	——Bridging Camp——	———
July.	Bridging camp.	Roads and tracks. Collective anti-gas and decontamination training. Cooperation in battalion training.	Demolitions.	Heavy bridging or mining or ..... No. 2 continuous operation.

AUGUST.	——————LEAVE——————	Camping arrangements and water supply.	Divisional R.E. Training under C.R.E. (*See* Sec. 16).
SEPTEMBER.	Cooperation in brigade and inter-brigade training.	Cooperation in divisional training.	Returning stores. Q.I. Examinations.

NOTES.—1. By counting a month as four weeks the above programme allows two spare weeks to meet unforeseen interruptions.

2. *M.T. Section*—April, 1st Period { Drill. Training across country and in convoy.
2nd Period { Tactical training. Weapon training. Anti-gas training.
3rd Period { Weapon and anti-gas training. Collective tactical training with company.
4th Period. Range practices.

Remainder of collective period— { Regimental and company transport duties. Collective driving training. Regimental and company employment.

APPENDIX III

SPECIMEN PROGRAMME

ANNUAL TRAINING, DIVISIONAL ENGINEERS (T.A.)
(*See* Sec. **16**, 5.)

1st day (Sunday)	Assemble.
2nd day	Military training, including ceremonial, C.R.E. and adjutant completing preparations for scheme for company commanders.
3rd day	Company commanders and second-in-command, working scheme directed by C.R.E. Remainder, including junior officers, individual technical training under instructors.
4th day	Officers and selected N.C.Os., working schemes directed by company commanders. Remainder, individual training under instructors.
5th day	As for 4th day.
6th day	One section in each company, section training with transport. Remainder, individual training under instructors.
7th day	Competitions.
8th day	Church parade (ceremonial).
9th day, 10th day, 11th day	As for 6th day.
12th day	One company, company scheme with transport, directed by C.R.E. Remainder, section training without transport under company officers.
13th day, 14th day	As for 12th day.
15th day	Disperse.

NOTE.—Individual training in camp should be limited to those subjects which, for lack of space and other facilities, cannot be practised out of camp. Subjects, and the maximum

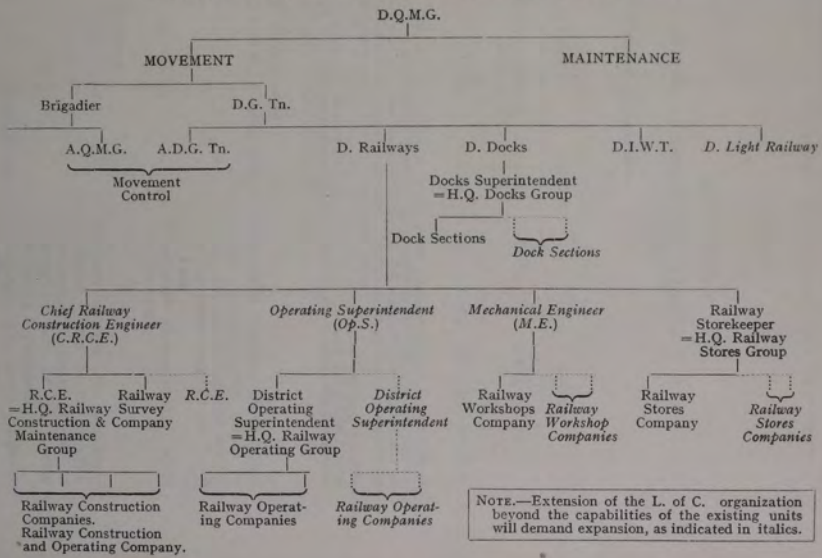
time that should be spent by individuals on each during this period, are :—

Digging	16 hours.
Revetting	8 hours.
Wiring	8 hours.
Use of spars	16 hours.
Fixing of charges	8 hours.

No individual, however, can spend the maximum time on each subject, and the subjects selected in a given year will be co-ordinated with the requirements of the training cycle for that year.

See Appendix VIII for standards of training to be aimed at by all ranks and also tests.

ORGANIZATION OF THE TRANSPORTATION SERVICES

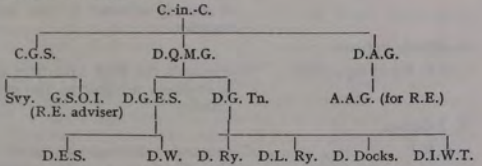


NOTE.—Extension of the L. of C. organization beyond the capabilities of the existing units will demand expansion, as indicated in italics.

APPENDIX V

CHAIN OF ENGINEER DIRECTION AND COMMAND

1. *General headquarters.*



NOTES.—The D.G.E.S. is the senior engineer adviser to the staff at G.H.Q. and has the right of direct access to the principal staff officers. He works in close liaison with the G.S.O.I. appointed to the general staff for advice on engineer questions. He is also in executive charge of the directorates of works and of engineer stores.

The D.G.E.S., D.G. Tn. and D. Svy. are respectively authorized to communicate direct with the D.F.W., A.D. Tn. and G.S.G.S.(M.I. 4) at the War Office on technical subjects affecting the work of their directorates and subject to the policy of C.-in-C.

2. *L. of C. area.*

C.R.E., L. of C. area	Commands engineer units (other than transportation units) in the area, and is engineer adviser to the commander of the L. of C. area.
A.D.G. Tn.	Commands transportation units in the area.

3. *Army.*

C.E.	Engineer adviser to the commander. May be called upon to assume excutive control of some or all of the army engineers, if required.
C.R.E., army troops ...	Commands all army engineer units.

4. *Corps.*

C.E.	Engineer adviser to the commander. May be called upon to assume executive control of some or all of the corps engineers, if required.
C.R.E., corps troops ...	Commands all corps engineer units, other than survey units.
A.D. Survey	Commands the survey unit or units allotted to the corps, and is survey adviser to the commander.

5. *Mobile division.*

O.C. Field Squadron ...	Commands the field squadron and is engineer adviser to the commander.

6. *Division.*

C.R.E.	Commands all engineer units in the division, and is engineer adviser to the commander.

NOTE.—The senior engineer officer of a formation may issue technical instructions to the corresponding officer at the next lower formation, but all orders will be issued by the general staff (*see* Sec. **59,** 2).

APPENDIX VI

CLASSIFICATION OF MILITARY BRIDGES AND OTHER DATA

1. *Classification of loads.*—In order to simplify bridging problems, military loads are divided into the following groups :—

i. *Assault.*—Infantry in single file.

ii. *Pack.*—Infantry in file ; cavalry in single file ; pack transport (including mountain artillery).

iii. *Light.*—Infantry in fours ; cavalry in half-sections ; vehicles and weapons with forward units. Includes horsed transport ; horse and field artillery (horse or tractor drawn) ; motor cars ; vans ; ambulances ; 30-cwt. lorries ; all ordinary M.T. vehicles and armoured cars up to a maximum axle load of three tons for 4-wheelers and 1·75 tons or 3·5-ton rear bogies for 6-wheelers ; light dragons, tractors and other tracked vehicles with sprung tracks and not exceeding 4½ tons * total weight.

iv. *Medium.*—All loads normally with a division. Includes all ordinary 4-wheeled M.T. vehicles up to an axle load of 5·7 tons ; all ordinary 6-wheeled M.T. vehicles up to an axle load of 3·6 tons or a rear bogie of 7·2 tons ; all tracked vehicles with sprung tracks and not exceeding nine tons total weight.

Note.—Medium artillery and anti-aircraft guns on 4-wheeled trailer platforms are excluded on account of the weight of the tractor used to draw them.

v. *Heavy.*—All loads normally with an army in the field. Includes all 4-wheeled M.T. vehicles ; 6-wheeled M.T. up to an axle load of 8·25 tons or a bogie load of 16·5 tons ; tracked vehicles with sprung tracks and up to 19·25 tons in weight provided that the track bearing length is not less than 13 feet.

vi. *Super-heavy.*—Vehicles whose weights exceed the limits of the heavy load class.

Vehicles of unusual design, such as those with an exceptionally short wheel base or short track length, are not covered and must be considered individually for classification.

It is essential that normal loads of vehicles as laid down from time to time are not exceeded. This is primarily the responsibility of unit commanders, but attention should be drawn to this point in orders and instructions whenever a bridging operation is contemplated.

Tracked vehicles should normally cross mobile equipment bridges at a crawl, and certain vehicles of wide wheel track

may require guiding to obviate the risk of the bridge ribands being seriously damaged.

2. *Classification of bridges.*—Military bridges are classified in accordance with their capacity to deal with the above load groups. They comprise the following :—

i. *Mobile bridging equipment, i.e.* equipment designed to meet tactical requirements and provided with its own transport.

Load classification	Type of equipment	Purpose
(*a*)	(*b*)	(*c*)
Assault.	Kapok. Folding boat.	For slow running streams not exceeding some 150 ft. in width. As single boat ferries carrying 25 armed men and crew of five.
Pack.	No special equipment is provided ; as a rule the light bridge will suffice.	—
Light.*	Folding boat.	As tracked rafts for the passage of infantry first line transport vehicles, provided that these do not exceed three tons in weight : tracked rafts will not take horses, so that horsed vehicles must be man-handled on to the rafts and the horses put across by swimming or other means. As decked rafts working between piers : as a bridge.
Medium.	Small box girder. Pontoon and trestle.	For spans of 32, 48 and 64 ft. As rafts or in bridge.
Heavy.	Pontoon and trestle.	As rafts or in bridge.

ii. *Temporary bridging equipment, i.e.* equipment for rapid erection in forward areas with a view to the replacement of mobile bridging equipment when the latter has to be replaced and the crossing has to remain in operation. This equipment is not permanently provided with transport but is easily transportable in normal types of army vehicles.

iii. *Semi-permanent bridging equipment, i.e.* standardized equipment for building up on the site. Primarily for use in rear areas and transportable in the vehicles which can be employed there.

* With the latest type of light bridge (1936) tracked vehicles not exceeding five tons total weight can be carried.

3. *Provision of bridging equipment.*—

i. *Mobile bridging equipment* is carried in the field as follows :—

	Kapok	Folding boat	Small box girder	Pontoon and trestle
(*a*)	(*b*)	(*c*)	(*d*)	(*e*)
Field Squadron R.E.	—	1 cav. set.	—	—
Field Park Coy. R.E.	—	2 inf. sets.	2 bridges.	—
Bridge Company, R.A.S.C.	108 bays per div.	1 inf. set per div.	1 bridge per div.	38 medium bays or alternatively 25 heavy bays of which, in each case, 12 are trestle bays and the remainder are pontoon bays.

ii. *Temporary and semi-permanent bridging* will be held in engineer parks and base depots.

4. *Details, transport and uses of mobile bridging equipment.*—

i. *Kapok.*—The bay is 6 ft. 6 in.; the transport unit is 27 bays carried in one 30-cwt. lorry with one 15-cwt. trailer.

ii. *Folding boat.*—

Composition of sets and units	Transport
(*a*)	(*b*)
Cav. Set.—4 boat units and 2 trestle units. Inf. Set.—2 raft units, 1 boat unit and 1 trestle unit. Raft Unit.—3 boats with superstructure for 1 tracked raft and 1 floating (or half-floating) bay. Boat Unit.—3 boats with superstructure for 2 floating (or half-floating) bays. Trestle Unit.—2 trestles, 2 bays of trestle superstructure and 2 shore bays.	The raft and boat units are each carried in one 3-ton 6-wheeled lorry with 4-wheeled trailer and the trestle unit in one 3-ton 6-wheeled lorry *Demands on the Pontoon Bridge Park should be in terms of transport units and not by sets.*

NOTES.—1 Each "cavalry" set of folding boat equipment will make 172 ft. of bridge, plus 34 ft. of trestle bridge. The cavalry set is capable of division into two equal parts, each making 112 ft. of bridge.

2. Each "infantry" set of folding boat equipment will make 112 ft. of bridge, plus 1 tracked raft, plus 1 spare boat. Two infantry sets combined will make 192 ft. of bridge, plus 2 tracked rafts, plus 34 ft. of trestle bridge.

iii. *Small box girder.*—The complete bridge (64 ft.) is carried in three 3-ton 6-wheeled lorries.

iv. *Pontoon and trestle.*—The bay is 21 ft. The equipment comprises 25 pontoon units, 12 trestle units, 6 odd bay units, 3 conversion units with 2 cut bay units : each unit is carried in one 3-ton 6-wheeled lorry, pontoon units having in addition a 4-wheeled trailer.

(*a*)	Composition of units (*b*)
Pontoon unit.	1 medium pier of 2 pontoons and 1 bay of medium superstructure.
Trestle unit.	1 trestle and 1 bay of heavy superstructure.
Odd bay unit.	1 bay of medium superstructure and 2 heavy shore bays.
Conversion unit.	Compound joists for 4 heavy piers.
Cut bay unit.	Roadbearers and ribands for 2 cut bays (heavy bridge).

Use of Pontoon Equipment

The equipment with a bridge company, R.A.S.C., is sufficient for :—

(*a*) Medium bridge—a combined pontoon and trestle bridge of 798 ft.

(*b*) Heavy bridge—a combined pontoon and trestle bridge of 525 ft.

Notes.—(1) Combination of trestles and pontoons is dependent on depth of water, etc. ; local conditions will, as a rule, impose some limitations on the use of one or the other.

(2) Rafts, medium and heavy, can be made with the pontoon equipment.

5. *Fords.*—The following depths are fordable :—

	ft.	in.
Cavalry	4	0
Infantry	3	0
Tanks, medium	3	0
,, light	2	6
Armoured cars	1	6
Tractors and horsed vehicles	2	6
Lorries and heavy ambulances	2	0
Motor cars	1	6
,, cycles	1	0

FOLIO............................

........Map sheet.

....

10	11
Date of execution and result	Classification and remarks
21.4.35 Clear gap 65′	Major. Final.
21.4.35 Clear gap 70′	Major. Final.

iii. *Small box girder.*—The complete bridge (64 ft.) is carried in three 3-ton 6-wheeled lorries.

iv. *Pontoon and trestle.*—The bay is 21 ft. The equipment comprises 25 pontoon units, 12 trestle units, 6 odd bay units, 3 conversion units with 2 cut bay units : each unit is carried in one 3-ton 6-wheeled lorry, pontoon units having in addition a 4-wheeled trailer.

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Tractors and horsed vehicles	2	6
Lorries and heavy ambulances	2	0
Motor cars	1	6
,, cycles	1	0

APPENDIX VII

(*See* Sec. **97**, 17.)

ABSTRACT OF DEMOLITION (OR BRIDGE) RE

DULE OF DEMOLITIONS PROPOSED OR APPROVED. .....Fo

(Delete whichever is inapplicable.)

GNATION AND/OR GENERAL LOCATION. (*E.g.* BELT OR AREA.)

OR :—..... FROM (INCL.).....

	2	3	4	5	6	7
al	Description of bridge or object to be demolished or blocked. Map reference	Load class (bridge)	Nature of main demolition and of any subsidiaries required	Preparation deta		
				Personnel	Time required	Date ordere
	Railway over road, 4 lines. Lattice girder—" through " type. Single span, 45′ brick abutments. Decking—steel troughing. Map Reference.....	R.	(*a*) Cut both girders and decking.	10 R.E.	8 hrs.	12.4.3
			(*b*) Blow west abutment by breaking through face.	20 R.E. 12 Inf.	24 hrs.	
	Road over railway. 4 lines traffic. Two 40′ span brick arches. Embanked approaches. Map Reference.....	Super heavy.	(*a*) Blow centre pier by boreholes.	10 R.E.	12 hrs.	12.4.3
			(*b*) Crater west approach by earth auger holes.	30 R.E. 25 Inf.	24 hrs.	

TE.—Details under Serial Nos. 1 and 2 are examples of the use of the form and do
ap pear on the form itself.)

		Sandbags
		Timber × Foot run
		Timber × Foot run
		Timber × Foot run
		Mining sets ×
		Mining sets ×
		Pit props
		Pit props
		C.G.I. sheets ×
		C.G.I. sheets
		Wire, S.W.G., lb.
		Wire, S.W.G., lb.

		.C. mers
		Detonators, electric
		Detonators, No. 8
		Fuze, safety, ft.
		F.I.D., ft.
		Cable, electric, yds.

Explanation of Schedule for Recording Demolition (or Bridge) Reconnaissances or Demolitions Approved

(*See* Sec. **97,** 17.)

1. This form is for use by a lower headquarters when submitting the result of reconnaissances; or by higher headquarters for scheduling the information available regarding the possible points of demolition in an area or belt, and for recording the action taken to prepare and execute a coordinated scheme of demolitions.

2. The schedule should be accompanied by a map showing the location of the points mentioned, position of the belt, etc., in accordance with the conventional signs shown below.

3. The form, as filled in to schedule the results of reconnaissances will show, in the heading, the line or area reconnoitred, and will be completed as to columns (1), (2), (3) when used to abstract information regarding bridges, and as to (4), (5) and (6) when used as a schedule of demolitions reconnoitred or approved.

4. Columns (9) and (11) will be completed by the higher headquarters in accordance with the plan of demolitions approved. In the examples shown, the execution of the major demolitions is first reserved for G.H.Q. orders, but, as the force withdraws, the responsibility for ordering execution is delegated to lower formations.

5. Columns (7) and (8) show stages in the " preparation " of the demolitions, column (8) being the record of completion reports of " preparation ".

6. Column (10) is the record of reports of demolitions executed (*see* Sec. **97,** 11, v).

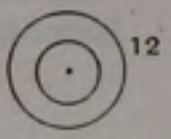
7. Included in the form is a schedule for summarizing in such detail as may be required by higher headquarters, the explosives, etc., required for the demolitions recorded on the face of the form. This schedule can be used also for summarizing the totals of all the numbered folios forming a record of one belt or area.

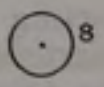
Conventional Signs for Demolition Maps

8. The following conventional signs will be used on maps illustrating demolition reconnaissances, and on maps accom-

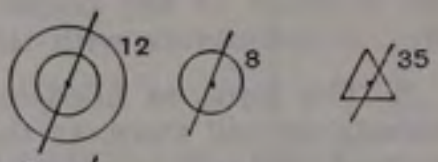
panying schedules of demolitions approved by a higher formation :—

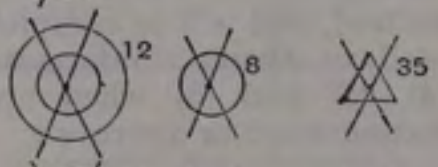
i. *Demolitions (with serial numbers).*

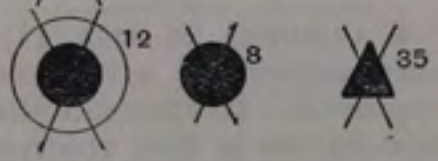
(*a*) Major demolition (reserved for G.H.Q. orders (*see* Sec. **97**, 2) ... ... 

(*b*) Other main demolitions, excluding road craters and equivalent road blocks ... 

(*c*) Cratered areas, or road blocks of equivalent delaying value ... ... 

ii. *Demolitions ordered to be prepared.* 

iii. *Demolitions—preparation completed.* 

iv. *Demolitions executed.* 

9. The centre of the circle or triangle is the pin-point of the demolition in maps prepared to illustrate coordinated demolition schemes.

10. On maps illustrating approved schemes of demolitions, all conventional signs for demolitions included in a " primary " belt or series will be in *red*. All others will be in *black*.

11. On maps illustrating original reconnaissance reports, all signs will be in *red*, and only signs shown in para. 8, i, (*b*) and (*c*), above, will be used.

APPENDIX VIII

STANDARDS OF TRAINING AND TESTS FOR ALL RANKS, R.E., T.A.

I. Standards of Training to be Aimed at

1. Anti-gas training (applicable to all ranks) :—

A knowledge of how the respirator works ; how it is looked after, put on and taken off.

Frequent practice in wearing the respirator will be combined with other forms of training.

2. Officers :—

i. *Up to the completion of two years' service.*

By the time he completes two years' service, an officer should :—

(*a*) Be capable of organizing and supervising the drill, weapon training (where applicable) and special role training of his sub-unit.

(*b*) Be able to lead his sub-unit as a component part of the company and carry out its tactical training.

(*c*) Have a good knowledge of map reading and message writing, and be able to issue simple verbal orders.

(*d*) Be able to make a reconnaissance report, including simple sketch plans.

(*e*) Have a practical knowledge of the administration, discipline and interior economy of a company at the drill station and in the field.

(*f*) Have a practical knowledge of the care, maintenance and use of the engineer equipment and M.T. vehicles or power plant with which his unit is equipped.

(*g*) Know the organization of the formation with which his unit is concerned, *i.e.* in a field unit of the division, in an anti-aircraft unit of the anti-aircraft division, and in a fortress unit of the fortress defences and of the organization of its war station.

(*h*) Have a knowledge of corps and (if applicable) divisional history.

ii. *After two years' service.*

An officer should be acquiring a thorough knowledge of both the military and the special role duties, and the

leadership and training of his unit. He should be able to instruct in these, and to set simple schemes.

After two years in the rank of lieutenant or in each higher rank, he should be efficient in the duties of the next higher rank.

3. Warrant officers and N.C.Os. :—

i. *Corporals* (including lance-corporals before promotion).

A corporal should :—

(*a*) Be able to instruct his sub-unit in drill and (where applicable) weapon training.

(*b*) Have a good knowledge of the administration and interior economy of his unit at the drill station and in the field, including guards, N.C.O's. regimental duties and discipline.

(*c*) Have a thorough knowledge of his engineer equipment.

(*d*) Have a good knowledge of map reading and engineer reconnaissance.

(*e*) Have a knowledge of the care and maintenance of the power plant (M.T. vehicles in the case of a N.C.O. driver I.C.) with which his unit is equipped.

(*f*) Special role training :—

(1) *Field units.*

Have a knowledge of the syllabus laid down in Sec. II of this appendix and be able to instruct therein.

(3) *Anti-aircraft units.*

Have a knowledge of the employment of searchlights and of the work in detail of the searchlight detachment, and be able to instruct therein.

(3) *Electric-light units.*

Have a knowledge of the employment of D.E.Ls. and of the work in detail of the D.E.L. detachment and be able to instruct therein.

ii. *Serjeants.*

A serjeant should reach in regard to his sub-unit a standard as laid down above, and in addition should be capable of commanding a section in the absence of the section officer.

iii. *Warrant officers.*

A warrant officer should be up to the standard at least of an officer of two years' service and be capable of instructing classes of N.C.Os. in their military and technical duties.

4. Sappers :—

i. *Recruits.*

Before qualifying as a trained sapper a recruit should :—

(*a*) *Drill.*

Be able to perform all movements laid down in the following chapters of the Manual of Elementary Drill (All Arms), 1935: Chapters II, III, Part II, IV (excluding sections 59–60, 65, 69–72), V, VI.

(*b*) *Weapon training* (where applicable) :—

(1) Understand the care of arms and ammunition.

(2) Have a good knowledge of firing positions and aiming.

(3) Have fired his annual practice as laid down in S.A.T., for R.E. recruits.

(*c*) *Special role training :—*

(1) *Field units.*

Be able to pass the tests of elementary field engineering laid down in Sec. III of this appendix.

(2) *Anti-aircraft and searchlight units.*

Have an elementary knowledge of the duties of his number in the detachment.

(*d*) *General.*

Be well trained in discipline and military deportment.

ii. *Lance-corporals and trained sappers.*

A lance-corporal or trained sapper should :—

(*a*) *Drill.*

Reach the standard of a recruit and in addition be able to perform the movements in the Manual of Elementary Drill (All Arms), 1935, Chapter V, Secs. 59–60, 65, and Chapter VIII.

(*b*) *Weapon training* (where applicable).

Reach the standard of a recruit, but have fired the annual practice as laid down in S.A.T. for R.E. trained soldiers, and for the anti-aircraft light machine gunner in anti-aircraft units.

(*c*) *Special role training :—*

(1) *Field units.*

Reach the standard of a recruit, with the addition of such standard tests laid down in M.F.E., Vol. II, 1936 (Royal Engineers), Appendix VIII, as relate to the work to be undertaken in the particular year of the four year cycle.

(2) *Anti-aircraft and searchlight.*

Have a thorough knowledge of his own duties in the detachment and of the collective work of the detachment.

A lance-corporal, with two years' service as such, should be capable of taking command of a detachment in the absence of the detachment commander.

(*d*) *General* :—

(1) Be well trained in discipline and military deportment.

(2) Have a knowledge of corps and (if applicable) divisional history.

(3) Know the organization of other arms with which the unit deals.

5. Drivers I.C. :—

i. *N.C.Os.* (including lance-corporals before promotion).

A N.C.O. driver I.C. should :—

(*a*) Be able to carry out the duties detailed in para. 3, i (*a*), (*b*), (*d*) and (*e*), above.

(*b*) Be an experienced driver with a knowledge of cross-country and night driving.

(*c*) Have a knowledge of mounted drill (M.T.) as laid down in the Manual of Driving and Maintenance for Mechanical Vehicles (Wheeled).

(*d*) Have a thorough knowledge of the care and maintenance of the M.T. vehicles with which his unit is equipped.

(*e*) Be able to control the vehicles of his unit on the march.

(*f*) Be able to produce a simple road reconnaissance report.

ii. *Recruit drivers I.C.*

Before qualifying as a trained I.C., the recruit driver I.C. should :—

(*a*) *Drill and (where applicable) weapon training.*

Reach the standard of a recruit sapper—*see* para. 4, i (*a*) and (*b*), above.

(*b*) *Specialist training.*

Be able to pass the standard driving tests, and to maintain his vehicle.

(*c*) *General.*

Reach the standard of a recruit sapper—*see* para. 4, i (*d*), above.

iii. *Lance-corporals and trained drivers I.C.*

A lance-corporal or trained driver I.C. should :—

(*a*) *Drill and* (*where applicable*) *weapon training.*

Reach the standard of a trained sapper—*see* para. 4, ii (*a*) and (*b*), above.

(*b*) *Specialist training.*

Reach the standard of a recruit driver I.C., and in addition have experience of cross-country driving and driving in convoy and of the use of winch gear (except anti-aircraft units).

(*c*) *General.*

Reach the standard of a trained sapper—*see* para. 4, ii (*d*), above.

II. Syllabus suggested for an Annual Test in Field Works to be carried out by all N.C.Os. of Field Units.

(When a practical test is impossible, verbal tests should be substituted.)

1. *Field geometry* and the use of the field level.

2. *Demolitions.*

Safety precautions when using explosives.
Testing fuzes (safety and F.I.D.).
Jointing fuzes (safety and F.I.D.).
Connecting up various methods of firing.
Testing for continuity.
Making up and fixing charges.

3. *Earthworks.*

Design of trenches, M.G. and observation posts.
Revetting.
Camouflage.
Gas-proofing.

4. *Obstacles.*

Types of obstacles, road blocks, wiring drill.

5. *Bridging and use of spars.*

Knotting and lashing.
Calculation and reeving of tackles.
Calculations for sizes of cordage and spars.
Section of a gap.
Uses of types of bridging equipment in the division and loads.

6. *Camping arrangements and water supply.*
   Erection and working of L. & F. pump, 600-gallon trough and 2,300-gallon canvas tank.
   Lay-out and discipline of a small water-point.
7. *Miscellaneous.*
   Duties of N.C.Os. in charge of work and working parties, including the organization of working and carrying parties, and extending working parties on tasks.
   Preparation of estimates (time, men, tools and stores), of working party tables, simple sketch plans of sites, and dimensioned plans and elevations of simple objects.
   Nomenclature of engineer tools and materials.

III. Standard Tests in Field Engineering for Recruits of Field Units

1. Coil a rope.
2. Throw a breastline.
3. Make the knots and hitches detailed in M.F.E., Vol. II, 1936 (Royal Engineers), Sec. 53, with the exception of a running bowline, bowline on a bight, man harness hitch, catspaw, draw hitch, stopper hitch, magnus hitch and rolling hitch.
4. Make a square and a diagonal lashing.
5. Reeve a block and tackle.
6. Measure 3 in., 6 in. and 9 in. with the hand, and up to 7 ft. with the hand, foot and pickhelve.
7. Drive two pegs in level, using a field level.
8. Know the dimensions and names of the parts of the normal fire and communication trenches.
9. Put in screw and angle iron or wood pickets for a double apron fence.
10. Make the fastenings for a double apron fence on screw and angle iron or wood pickets.
11. Fill and lay sandbags for wall revetment.
12. Drill and march correctly with pick and shovel.
13. Use correctly the pick and shovel.
14. March on a task with tools and equipment, and begin work.
15. Drive a 5-ft. picket with maul to the correct slope.
16. Know the safety precautions to be taken when using explosives.

17. Prepare and light a safety fuze with a match and match-box.
18. Prepare a primer, detonator and safety fuze for firing.
19. Connect a safety fuze to a fuze, instantaneous, detonating.
20. Make an insulated joint in electric leads.
21. Connect up and operate a lift and force pump.
22. Know the names of tools, power plant and components.
23. Know the names and uses of common engineer materials.

PLATE I.

KEY TO PLATES


SQUADRON OR COMPANY COMMANDER.


SQUADRON OR COMPANY SECOND IN COMMAND.


TROOP LEADER OR SECTION COMMANDER.


OTHER OFFICERS.


SQUADRON OR COMPANY SERJEANT MAJOR.


SQUADRON OR COMPANY QR. MR. SERJEANT.


TROOP OR SECTION SERJT.


OTHER N.C.O^S.


SUB SECTION COMMANDER.


VEHICLE DRIVER


FRONT RANK.
REAR RANK.


INDIVIDUAL MAN.


PACK HORSE (FR. SQUAD) WITH SAPPER.


MOTOR CAR.


LORRY.


MOTOR CYCLE & DRIVER.

SPARE MEN (IN M.T. PLATES)

PLATE II.

SECTION IN LINE

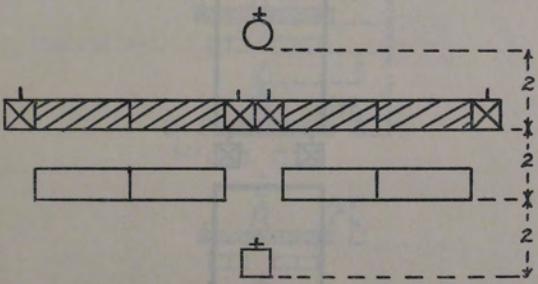


PLATE III.

SECTION IN COLUMN OF ROUTE

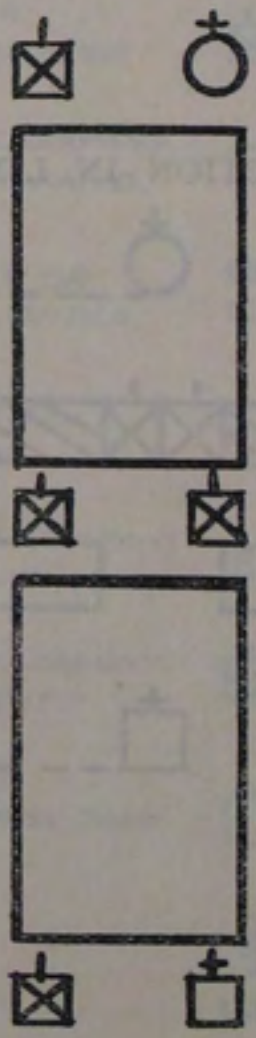


PLATE IV.

COMPANY IN CLOSE COLUMN OF SECTIONS

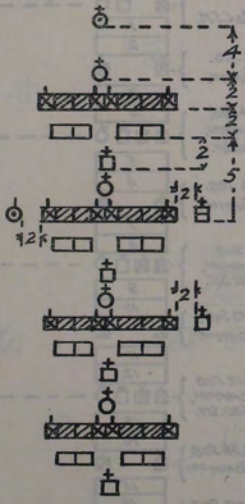


PLATE V.

A COMPANY IN COLUMN OF ROUTE

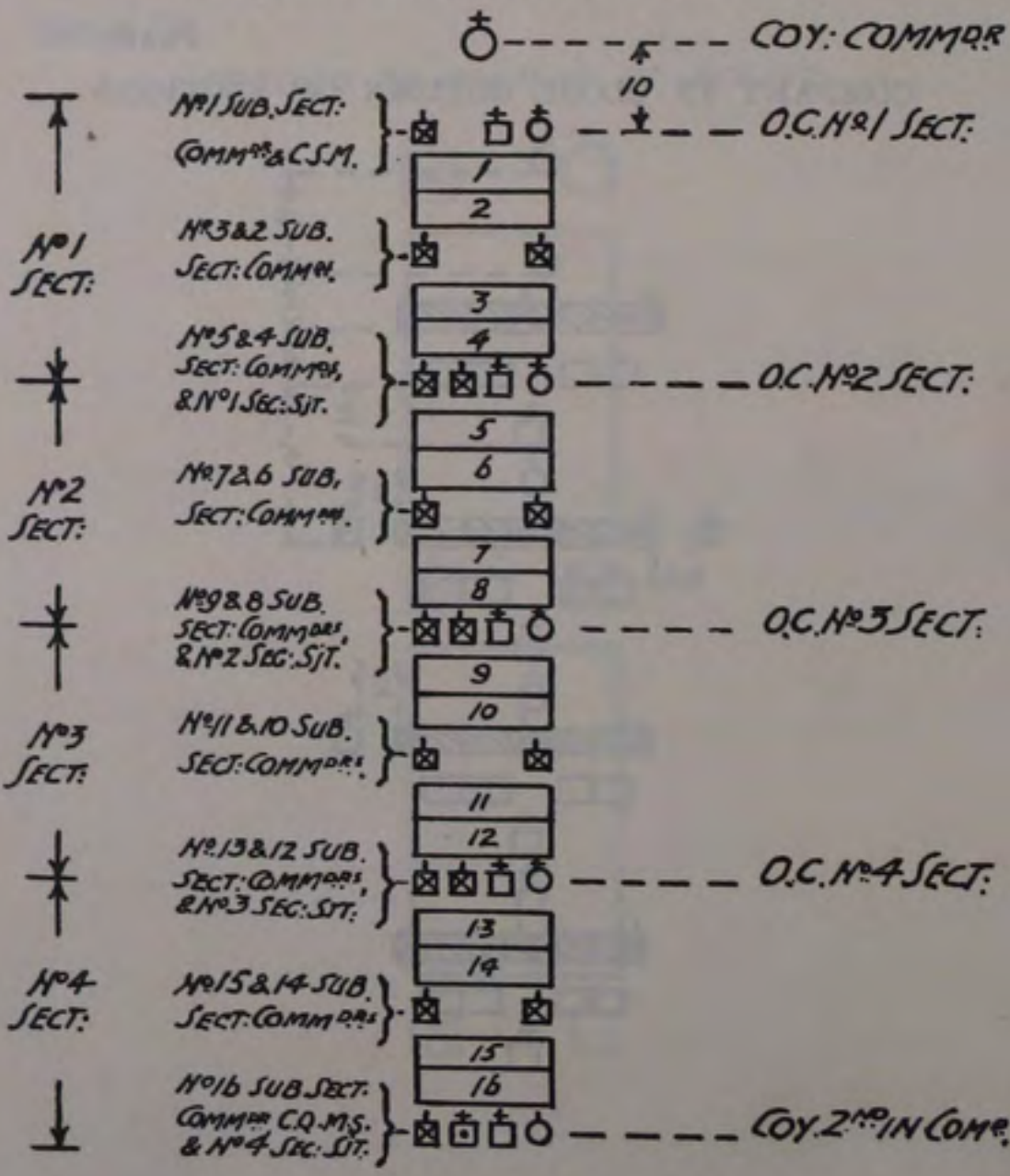


PLATE VI.

METHODS OF DEPLOYING A COMPANY

FIG. 1
DEPLOYMENT INTO "SQUARE"

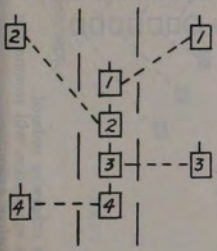


FIG. 2
"DIAMOND"

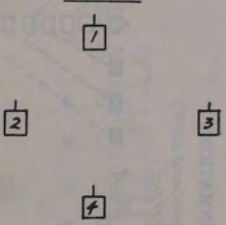


FIG. 3
"Y" FORMATION

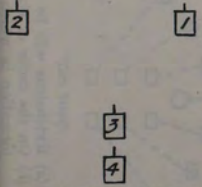
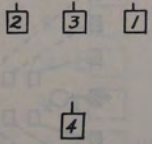


FIG. 4
"T" FORMATION



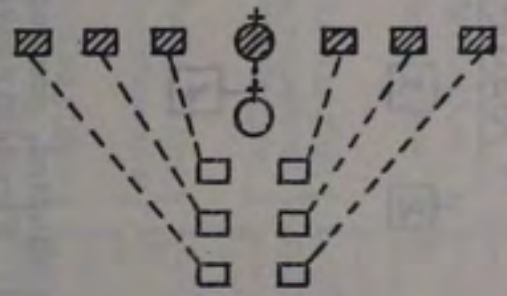
NOTE :—Whichever formation is adopted, geometrical rigidity must be avoided. Flexibility must be the primary consideration and unit or sub-unit positions must be suited to the ground.

SUB-SECTION BATTLE FORMATIONS

EXTENDED LINE

(ORDER "ON MY RIGHT AND LEFT")
(SIGNAL, "EXTEND.")

FIG. 1.



FROM FILE

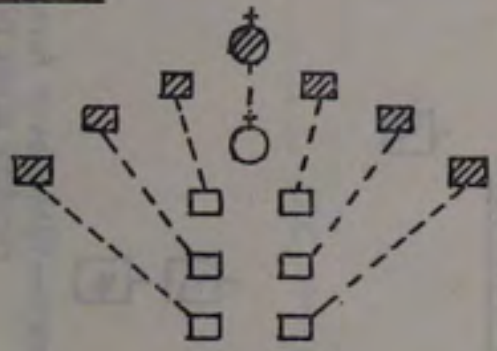
FIG. 2.

FROM SINGLE FILE

ARROW HEAD

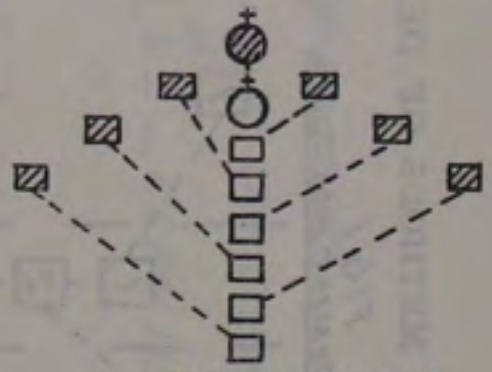
(ORDER "ARROW HEAD")

FIG: 3.



FROM FILE

FIG: 4.



FROM SINGLE FILE

NOTE:—(*a*) Extensions will be two paces unless otherwise ordered.
(*b*) On the order or signal "close," the sub-section will resume the formation in which it was moving before extension.

M.T. WING IN LINE

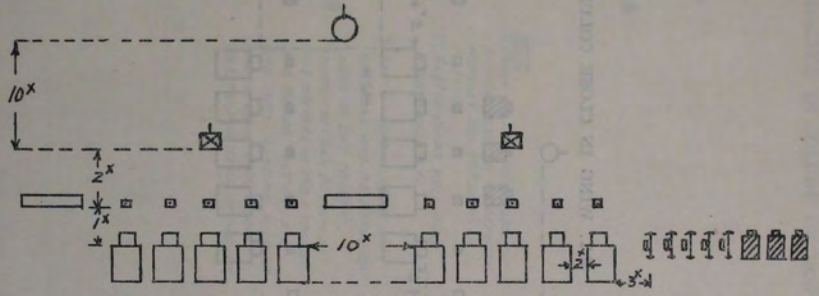


PLATE IX.

M.T. WING IN CLOSE COLUMN

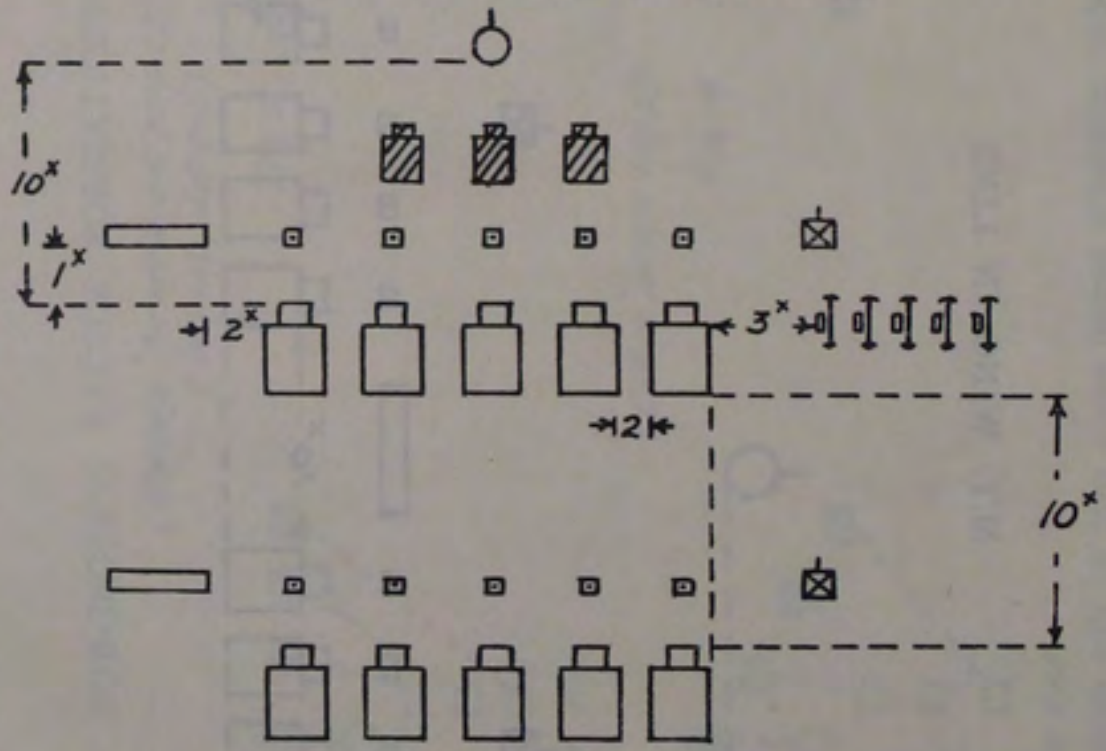
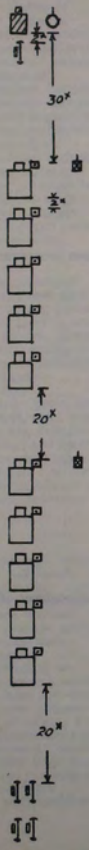


PLATE X.

M.T. WING HALTED IN COLUMN OF ROUTE



Note:

1. When on the move distance is increased to 20ˣ between vehicles and 40ˣ between sections.
2. Austin cars will move independently.
3. Section Commanders on the road will be stationed clear of the traffic, where they can be seen by the drivers of their section and where they can see the Sec: Comdrs: in front and in rear, to facilitate the transmission of orders.

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