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Major-General Lewis A. Pick, C.B., Chief of Engineers, U.S. Army meeting Major-General A. D. Campbell, C.B., C.B.E., D.S.O., M.C., Engineer-in-Chief. The photograph was taken in the E.-in-C's office and shows two of the four Boards with names of King's Chief Engineers and subsequent titles from 1078 onwards.

Visit Of Major-General Lewis A. Pick

EDITORIAL NOTES

VISIT OF MAJOR-GENERAL LEWIS A. PICK
(Chief of Engineers, United States Army)

DURING 9th–24th July, 1950, Major-General Pick visited R.E. units and formations in the United Kingdom at the personal invitation of the C.I.G.S.

His visit included discussions with members of the Army Council and other senior officers in the War Office, followed by visits to 32nd Assault Regiment, R.E., V.I.S.T.R.E., M.E.X.E., Transportation Centre and S.M.E.

Whilst at Chatham he attended the R.E. Ball.

During the latter part of his visit he and E.-in-C., with their wives and members of their staff, were the guests of the Port of London Authority who arranged a tour of the Port on S.Y. *Katherine*, which was personally conducted by Admiral Sir Alan Hotham (Retd.), one of the Directors, and Mr. Leslie E. Ford, General Manager of the P.L.A.

He also attended the Sovereign's Parade at Sandhurst, as the guest of the Commandant.

General Pick was invested with the C.B. by the C.I.G.S. and the following citation was read by the Military Secretary (Lieut.-General K. G. McLean):

"In addition to his more obvious task of building and maintaining the Ledo—Burma Road, one of General Pick's tasks was to supply the 36th Division. Prior to being under command of N.C.A.C., this division had no knowledge of air supply, and were in some doubts as to its possibilities. These, however, were soon dispelled and the supplies were dropped as demanded.

"At no time was there any need to slow down the advance for lack of food or ammunition, and it was possible to carry out the tasks allotted with the minimum of delay. Owing to the comparatively small amount of transport available initially, the division was doubtful whether they could move at the speed required to keep the enemy in retreat and, at the same time, keep themselves closed up as much as possible. However, General Pick persuaded them that no reserves should be carried and that they should rely entirely on daily maintenance. This was done successfully.

"In spite of the adverse monsoon conditions, and the distances from the air base at Moran, on one day only did some of the supplies fail to arrive. The whole division very soon had complete confidence in air supply, but had it not been for General Pick's determination to succeed, the advance might well have been slowed up. General Pick also helped considerably with the reconstruction of the railway which enabled more rapid advance. He agreed to take over the repairs to the bigger bridges and always completed his tasks up to schedule.

"The liaison between General Pick's staff at Ledo and B.A.B. was always excellent and a great spirit of friendly co-operation existed between S.O.S., B.A.B., and 36th Division."

It is of interest to note that this is the first time that the Chief of Engineers, U.S. Army, has ever visited a foreign army.

A copy of the presentation programme handed to General Pick can be seen in the R.E. Museum at Chatham.

THE CHESNEY GOLD MEDAL

THE Chesney Gold Medal is presented by the Royal United Service Institution in recognition of outstanding contributions to Service Literature. General G. T. Chesney, K.C.B., C.S.I., C.I.E., was a Royal Engineer officer.

On the 4th July, 1950, the Medal was presented to the Rt. Hon. Winston S. Churchill, O.M., C.H., M.P.

In accepting the Medal Mr. Churchill made special reference to two previous recipients of the Medal, who were officers of the Corps of Royal Engineers.

The following extracts from his speech are reproduced from the Report in the R.U.S.I. *Journal* for August, 1950, by courtesy of the Council of the Institution.

"I am delighted to see in the list (of recipients) General Sir James Edmonds—'Archimedes' as he was called in the little group of high military officers at the War Office, among whom Sir John French and Sir Henry Wilson were prominent and who thought intently about the conditions under which Great Britain could send an army—an idea which had been discarded for half a century—to fight at the side of France upon the European continent. They all had nick-names, and I well remember 'Archimedes.' He has been occupied ever since that war—the first World War, which certainly seems to most of us a long time ago, in writing the official history of it in one fine volume after another, all packed with facts and devoid of prejudice of any kind. I understand that he has now finished his labours.

"Then there is General Swinton—I must tell you a story about him. I am so glad that he is the holder of this medal ; no one could deserve it more. This was at the beginning of the 1914–18 War, about six weeks after the armies were engaged. In those days the Press were not given any look in at all. They were told 'No, it is war ; you get out of the way.' This position was not maintained indefinitely, and the war correspondent reappeared and has now built himself up a position in all military operations which, from what one can read in the newspapers, seems to have been in no way diminished or inroaded upon in the latest examples which are before us. But to return to my anecdote. We had a Cabinet close by here, and the question was raised in September '14 of proper representation of the Press, giving the public more information. A very strong discussion took place, and Lord Kitchener, on whose left I sat, was very much for holding the firm position which had been taken and for leaving the public to learn from the published despatches of the Generals, which would reach them in due course and in proper time, what was actually happening at the front (*Laughter*). I did not think that this attitude could be effectively maintained even in those far-off happy days, and I said to Lord Kitchener, 'Why don't you have an official correspondent, a friend of the General, living in his entourage, who will give a continuous stream of information to the public, who are naturally rather interested in what is going on (*Laughter*), and at the same time will neither commit indiscretions nor associate the Supreme Command with every word that is written ?' His Lordship looked round and turned to me and said, 'It is easy to make such suggestions, but whom would you propose ? Give me an example.' I said, 'Why not Major Swinton ?' 'Major Swinton ? Who is he ? What has he ever written ?' So I said, 'Have you read *The Defence of Duffer's Drift* ?' 'What !' said Lord Kitchener, 'did he write that ?' The subject dropped, but that afternoon Swinton went out to Sir John French's headquarters as an official correspondent (*Applause*)."

ORGANIZATION, TRAINING AND EQUIPMENT REQUIRED BY THE ROYAL ENGINEERS

By MAJOR M. L. CROSTHWAIT, M.B.E., R.E.

(Winning Essay for the Cooper's Hill War Memorial Prize—1950)

SUBJECT

The scope of engineering in the field extends with every war and as a result engineer units which exist in peace cannot produce effective work without a very large dilution of labour and plant. Discuss the organization, training and equipment required in peace in order that the engineer units going to war may be able to handle engineering of the size and scope likely to be required.

INTRODUCTION

1. The object of this paper is to discuss the peace-time structure of the Royal Engineers. The importance of ensuring that this structure is correct needs no stressing. It is perhaps comparatively easy at times to scheme and plan as to what will be required in war. There are, however, so many difficulties, frustrations, restrictions and imponderables under conditions as we know them to-day, that, despite the fact that what is required in war may be known, it seems extremely difficult to get those requirements properly reflected in peace.

2. When war breaks out Service requirements become top priority, and as long as time is available to readjust to war conditions, peace-time errors and shortcomings can be retrieved. This time for readjustment has been always apparent in the past—inasmuch as no disaster has fallen on us so quickly that we have been unable to regain our balance. A possible future war, we are assured, will allow of no such breathing space. Despite many excellent reasons for being unprepared (there are always excellent reasons to-day for not doing things) we will stand or fall by the armed forces produced once the first mobilization plans have gone into action. It is indeed important that the units produced by putting the peace-time organization of the Royal Engineers on a war footing, should be equal to their tasks.

3. In discussing this peace-time organization two points are fundamental. These are :—

(*a*) An exact idea must be obtained of what units will be required in war.

(*b*) In peace, although the ideal laid down in (*a*) must be approached as closely as possible, it must be approached realistically. Difficulties and restrictions do exist. To disregard them or to try to brush them aside will get nowhere. Therefore to plan for what is actually possible to carry out efficiently, is better than to plan for something, good on paper, but quite impracticable to implement. The art of peace-time planning is to know what difficulties must be accepted and which surmounted.

It should be understood that these two points are behind the proposals laid down in this paper.

4. The method of discussing the Engineer peace-time organization will be as follows :—

(*a*) To discuss briefly the tasks that will face the engineers in the opening stages of a future war, and their implications.

(*b*) To discuss the capabilities of the various types of units, as at present organized, to carry out these tasks.

(*c*) To discuss the peace-time structure of the National Army—Active, T.A. and S.R.

(*d*) To discuss the equipment to be provided.

(*e*) To discuss the training of the National Army.

(*f*) To discuss the bearing which allied co-operation might have on the above.

5. Throughout it is not proposed to open the discussion on any particular subject *ab initio*. It is assumed that the reader is already familiar with the way the Royal Engineers are at present organized for peace, and in general why they are so organized.

The Next War

6. The last war is so lately ended that it is only natural that when planning for the next, inspiration is drawn from it. To what extent is it dangerous to do so? To what extent can the latter stages of the last war be safely drawn on to build a picture of the *first stages* of the next?

7. To take the latter stages, which are most fresh in people's minds, is dangerous. The Allies were then certain of victory. Materially they were in a strong position. However, it is perhaps reasonable to take the last war as a whole as a suitable starting point, but with the following differences :—

(*a*) The initiative will lie wholely with the enemy. The war in all its fury must be expected from zero hour.

(*b*) The destructive and killing power of weapons will have increased tremendously. This of course includes atomic weapons. It will mean greater dispersion. But it is reasonable to assume, that although the scientist will have introduced far more efficient weapons, their tactical handling—the conduct of the actual battle—will follow a comparatively familiar pattern.

(*c*) There will be constant and sustained attacks from the air. The R.A.F. can only be expected to provide very local air superiority.

(*d*) For the first time, we must expect a very real threat from fifth columnists. This, coupled with an aggressive use of paratroops, will demand a high standard of alertness and security.

(*e*) From the engineer point of view heavier loads, incessant air attacks, improved methods of destruction and acts of sabotage will mean that the task of keeping communications open will be extremely difficult.

(*f*) The enemy will be vastly superior in numbers and will accept very heavy casualties. Attacks will be sustained for long periods in the face of heavy opposition. The endurance of the defenders will be tested to the uttermost.

(*g*) Gas and bacteriological warfare—or the threat of it—will be a great test of morale. There must be complete trust in the ability of our own scientists to combat it.

(*h*) There may be many technical developments in engineering equipment. These may be heavier bridges, non-detectable mines, mechanical mine-laying devices, etc., and a host of minor improvements. It will be noted that the word " may " has been used. As the opening stages of the war only are being considered many new developments, although fully designed, may not be fully in production.

(*i*) Airfield construction may assume a great importance from the word go. The opening stages of a war may well include a race to build airfields in the most unexpected parts of the world. With the great range of modern bombers, the scope for doing this is tremendous. A quick operation, which is likely to be unopposed, to capture the base, followed by the quick construction of a fighter airfield will be the essence of these moves. Unless the fighter airfield is built rapidly, the enemy is likely to make the base untenable.

(*j*) Mass destruction in the U.K. may entail the Army giving considerable help in first aid and rehabilitation to the Civil Authorities.

(*k*) In the opening stages equipment of all sorts, especially transport, will be lacking.

(*l*) The supply of kerosene, diesel oil and petrol will be of great importance in every theatre. There will be heavy demands on the engineers for P.O.L. installations of every description.

(*m*) Invasion or offensive operations are only likely to be undertaken on a small scale. The demand for Assault and Airborne Troops will therefore be small.

(*n*) Communist propaganda will be a real threat to the morale of our own troops.

8. In the previous section the main differences from the last war have been stressed. In addition the following tasks will have to be carried out in much the same manner as before :—

(*a*) Transportation. Units will start moving overseas almost immediately. Port and railway operating troops will be required both at home and abroad.

(*b*) Construction, including stores supply. This is likely to be especially heavy in the U.K. Repair of railways and ports or the construction of new ones may be very important.

(*c*) Bomb disposal.

(*d*) Survey.

(*e*) The setting up, or reinforcement of, base installations such as workshops and depots.

9. The above is a brief summary of the background—as it affects the Engineers—against which the opening stages will be fought. It is now intended to examine the implications of this background. Any changes in the familiar organization of engineer units will be necessary because of these implications.

Implications

10. What main conclusions can be drawn from the preceding paragraphs ? The most important are considered to be the following :—

(*a*) The great importance of a high morale and complete trust of the Army in its leaders. High morale will be the worst enemy of propaganda.

(*b*) Heavy damage, heavy loads and even routine tasks will demand a large output of man-hours. The only sure basis on which the Engineers can plan to produce these, is by more efficient use of engineer man-power (and not by increasing it), by greater use of mechanical aids, and by insisting on priority in obtaining the use of unskilled labour, e.g., pioneers.

(*c*) Transportation tasks, both constructional and operating, and airfield construction will be of great importance. They must not be neglected in any peace-time organization.

(*d*) Ordinary building construction—both to produce new installations and to repair damage—will also make heavy demands. The Works Services and other units capable of construction must be prepared from the word go.

(*e*) Tasks in general will be strenuous and varied, and will demand both soldierly and engineering qualities. A well-trained field engineer is always likely to pay good dividends.

(*f*) Units must be kept mobile on the very minimum of transport. There will be little use in providing for generous scales on equipment tables, as the transport will not be available.

(*g*) Liaison between Engineer Commanders and local Civilian Authorities must be fostered in peace-time. Commanders may change, but the need for the education of local authorities in the capabilities of the military engineer will remain.

(*h*) From the civilian morale point of view a Bomb Disposal organization (either Civil or Military) must be available on the outbreak of war. The Army must be prepared to play a part in B.D.

(*j*) Due attention must be given in peace, and having available on mobilization, Survey, E. & M., and the normal Base engineer units.

(*k*) High priority in terms of equipment and man-power should not be given to assault and airborne units as such.

ENGINEER UNITS REQUIRED

11. It is intended that the knowledge on the part of the reader, which has been assumed (see para. 5), together with the foregoing, has provided a sufficient background by which to judge whether the type of units being built up now will be adequate for the tasks envisaged. Further discussion will consider the following :—

(*a*) The degree to which specialization is desirable.

(*b*) The effect, if any, which the need for air-transportability should have.

(*c*) The changes which are considered desirable in units as they are planned at the moment.

Specialist or all purpose

12. The first question to be answered when designing an organization to carry out various tasks, is to what extent a unit should be capable of carrying out all or at least some of the tasks, and to what extent it will pay to have specialists. Six factors are relevant :—

(*a*) In the next war the opening stages will be all important. It is for these stages that the peace-time Army should be raised and trained and units should be designed accordingly. Such modifications as become necessary later can be made as the war progresses.

(*b*) Inasmuch as the early stages only are being considered, some tasks are likely to be definitely foreseen. It may even be possible to allot units to these tasks in advance.

(*c*) Peace-time training possibilities are severely limited. Good general all round training is difficult.

(*d*) Specialist units, if correctly employed, are more efficient for the rôle in question than all purpose units.

(*e*) Many other countries rely on specialist troops; cf. U.S.A. and Water Supply Companies ; Portugal with Wet Bridging Troops.

(*f*) Specialist units are less economical in man-power.

13. As far as the British Army is concerned, the following principles are suggested on which to base planning :—

(*a*) As far as possible basic organizations should assume that units will undertake as many tasks as possible. There must clearly be many exceptions such as E. & M. Squadrons, B.D. Squadrons, Workshop & Park Squadrons, etc.

(*b*) Inasmuch as definite tasks can be foreseen certain all purpose units should be practised in these tasks exclusively. This applies, for instance, to Construction Squadrons earmarked for Port and Railway Construction.

(*c*) Notwithstanding (*a*) or (*b*) each unit must be considered on its merits. For instance a Construction Squadron earmarked for Transportation Construction may well find itself only employed on such tasks. In which case it may pay in the end to modify its establishment, and accept that it will in practice always be used in a specialist rôle. The main point here is that whether a unit is specialized or otherwise, it should be controlled by one Chief Engineer and not allowed to become part of a " private Army."

(*d*) In order to make an all-purpose unit, in fact, live up to its name, this may entail including, in its establishment, tradesmen who will only be used in very special circumstances. This means that these tradesmen may never, or rarely, be properly used. In these cases the unit should be empowered to ask for other types of tradesmen—very possibly field engineers—unless employed or likely to be employed on the specialized task in question. To keep a proper balance will be very difficult, but this point must be carefully watched.

For instance, each Construction Squadron has at present fifteen platelayers on its establishment. Rigidly to implement these vacancies in all Construction Squadrons when it becomes clear what the railway construction commitment is, and which units will be required to carry it out, is wasteful.

Air Transportability

14. One of the lessons of the late war was the importance of the transport of both men and material by air. It is important therefore to decide in peace how much weight is to be put on this requirement, as obviously whether a unit is to be readily air transportable will have a very great bearing on its organization, and in particular on its equipment.

15. This question is of great importance to the Royal Engineers, on account of their heavier equipment. As it is the early stages of a war which must govern our peace-time organizations, it is considered that the air portability factor should have no direct influence on organizations. The possibility of air portability should be covered by :—

(*a*) When designing equipment, the fact that it should be air portable must be given due weight ; but efficiency should only be sacrificed to this requirement to a small extent.

(*b*) How best a normal unit can be made air portable in an emergency should be made the subject of staff studies during peace.

Present Units

16. With the foregoing as a background, in the following sections it is proposed to discuss individual units as listed in the present order of battle.

The most important units will be taken in turn.

Field Engineer Regiment (Inf./Armd. Div.)

17. (*a*)(i) In general it is considered that there are too many tradesmen in the Royal Engineers. A great effort is expended in training them and too often individuals are found who have only seldom been properly used at their trade. When they have been used, as often as not the class of work required could adequately have been carried out by a well-trained handyman under skilled supervision. In other cases tradesmen become Regimental N.C.Os. and again seldom, if ever, use their trade skill.

(ii) In war especially, the tasks required of a Divisional Engineer Regiment do not call for large numbers of skilled tradesmen.

(iii) An examination of the previous paragraphs in this paper will show three significant points. First the necessity for using more plant of all types. Secondly that heavier bridging equipment and mechanical aids (minelaying, demolitions, compressors, etc.) will entail the employment of a well-trained field engineer (operator rather than a tradesman). Thirdly that transport is likely to be severely limited. It will not be possible, therefore, to carry around quantities of tools. All these reasons suggest that it is field engineers and not tradesmen that are mainly required.

(iv) If the regiment is employed on constructional tasks, these are likely to be adequately performed by a small number of good tradesmen, aided by well-trained field engineers or handymen.

It is, therefore, considered that tradesmen in the Field Units should be very drastically reduced and that field engineers should be substituted. Only a nucleus of tradesmen should be retained and these should be held in Squadron H.Q.

(*b*) The transport now allotted for war, i.e., on higher establishments, should be reduced. This will mean cutting down equipment (including tradesmen's kits). The armoured vehicles should also be reduced—the latter to be on an average scale of two vehicles per troop. It may be possible to increase the transport as production improves, but planning should be based on starting a war with much reduced scales. In addition more use should be made of trailers.

(*c*) Although plant will be required on a large scale it is not considered that it would be economical to increase the basic allotment. The supply position will preclude this even if it were desirable. Field Engineer Regiments should, however, be given some priority when demanding on the Plant Squadron for extra plant.

(*d*) A section should not be split when allotting to tasks. As it may be assumed that a section will need less men when working with plant, it will be possible to reduce the size of each section. This should be done by dividing a troop into four sections instead of three, retaining approximately the same number of men in a troop.

(*e*)(i) The retention of the Bridge Troop is debatable. As a rough guide if 60 ft. of Class 80 bridge can be carried in fifteen lorries then this troop should be retained. If the heavier bridges demand more transport than this, let alone the mechanical aids to erect them, it will be uneconomical to decentralize. All bridging should then be carried in R.A.S.C. Bridge Companies.

(ii) With shortage of transport at the start of a war it may not in any event be possible to provide regiments with their Bridging Troops. To do so may be at the expense of finding men and vehicles for R.A.S.C. Bridge Companies, and the latter should be given priority.

(iii) If this troop is abolished there must clearly be some alternative method of providing bridging equipment for unforeseen gaps. To sub-allot a Bridge Company platoon—or portion thereof—on a semi-permanent basis is obviously no solution. More use of plant to provide diversions and " first aid " is one answer ; more use of mechanically laid bridges is another. This is discussed further under " Assault Engineers " in paragraph 22.

Command and Control of the Field Engineer Regiment (Division)

18. (*a*) Although on the same subject as para. 17 this point is being treated separately. It is for discussion whether the increased load on the engineers will necessitate changes at H.Q., R.E., or whether that headquarters is capable of carrying out the advisory and executive duties required of it. The only change that is worth considering is whether the C.R.E. should be a Colonel, with an advisory rôle only, and the regiment should be commanded by a Lieut.-Colonel, with no advisory duties.

(*b*) Factors are as follows :—

(i) The C.R.E. undoubtedly has a heavy responsibility to carry. He has however a Major to help him carry it.

(ii) If a Colonel is introduced he in turn will require a small staff of (say) an Intelligence Officer/Adjutant and a Reconnaissance Officer. Each division will therefore require an addition in its officer strength and in particular will require three high-grade engineer officers—a Colonel, Lieut.-Colonel and the Major Second-in-Command.

(iii) The realities of man-power, especially at the start of a war, will make this difficult.

(iv) The Divisional Commander will expect an efficient service, both in advice and execution from his engineers. In this connexion the advice is often more sound if it is given by the same man as is responsible for carrying out any plan based on it.

(v) The Brigade Group system is now well established. This means that the field squadrons are more often than not in support of brigades. This does not absolve the C.R.E. from his duty of being continually appreciating whether centralized control would not be more desirable, but it also means that he does in fact have more time to be planning and advising.

(vi) In static conditions, when the C.R.E's. command is centralized, there will be less time taken up in frequent deployments and changes of plan, and more time available for him to command his units and to plan ahead.

(vii) In the future the division is more likely to require reinforcement—either with a Corps or Army Engineer Regiment. The C.R.E. may therefore have a Regimental Commander or even an Engineer Group Commander under his command.

(*c*) The following solution is suggested :—

(i) The C.R.E. should be a Colonel. His responsibilities are such as to merit this, apart from possible complications of having a more senior officer put under his command.

(ii) With a Second-in-Command, the C.R.E. should be capable of both commanding the regiment and advising the Divisional Commander.

(iii) Experience in war, and a less urgent need to economize in experienced officers, may mean that a Regimental Commander, in addition to a C.R.E. (Colonel) with a separate staff, can and should be implemented at a later date.

Field Engineer Regiment (*Corps*)

19. (*a*) As suggested for the Divisional Regiment, tradesmen should be reduced and replaced by field engineers.

(*b*) Similarly there should be a reduction in transport and re-organization of the troop on a four-section basis.

(*c*) As ever, every possible opportunity must be taken to save man-power while at the same time preserving efficiency. The provision of the Field Park Squadron, one for each regiment, although desirable as the ultimate aim, could be modified, as long as the quick supply of stores (especially if a regiment is detached in support of a division) is not prejudiced. It is suggested that the H.Q. of each regiment should include a small stores element, similar to that found in the H.Q. of a Construction Regiment or C.R.E. (Works). Otherwise the Workshop and Plant Troops, again with a stores element, should be centralized under the Engineer Group H.Q. Thus a saving of one Squadron H.Q., one Plant Troop and one Workshop Troop is achieved.

20. The following two units, although not part of the Corps Engineers, should be available to work very closely with them.

(*a*) *Dog Troops*

Planning should be based on these units being available in the Corps area. Although the allotment may be, due to shortage of trained dogs and handlers, on a basis of one Dog Squadron per Army, it is considered that each Corps should have a direct call on at least one Dog Troop. It will only be possible to dispense with these units when other methods of mine detection have been perfected.

(*b*) *Pioneer Units*

Road maintenance, one of the tasks most frequently likely to fall to the Corps Engineers, will require both plant and labour. In the first instance such labour should whenever possible be civilian and not military pioneers. But, from whatever source the labour must be obtained, close liaison with Pioneer units will be necessary.

Both the above units should be available and trained in peace-time.

Army Engineer Regiment

21. (*a*) The establishment of this unit is the most difficult of all on which to decide. Designed as it is to carry out work ranging from the assault crossing of a water obstacle to the construction of heavy bridges and airfields on the L. of C., it is difficult to say how it should be constituted.

(*b*) There is, under these circumstances, a danger of trying to provide tradesmen of every description, so no matter what tasks come along there will be a nucleus of skilled men available to tackle them. This will undoubtedly lead to waste—certainly so in peace, probably so in war. Many tradesmen may find themselves never used, and will merely become " handymen " in those trades in more general demand. Railway and Port Construction Draughtsmen and

Refrigeration Mechanics are possible examples. The only tradesmen with guaranteed and continued use are those of the more common building trades and field engineers.

(*c*) To a more limited extent the arguments for cutting down tradesmen and increasing field engineers, apply to Army Engineer Regiments as to Field Engineer Regiments. It is considered, therefore, that the present Army Engineer Regiment establishments should also receive a cut in tradesmen. Those tradesmen that remain, however, should not be centralized into Squadron H.Q., but should remain with their troops.

(*d*) The trades structure of the Regular Regiments on lower establishments should be greatly modified to cater mainly for field engineers. Such tradesmen as there are must be really well trained—an easier task if there are fewer to train—but the regiment's main effort should go into turning N.S. men into good field engineers.

(*e*) Inasmuch as tasks can be foreseen, Army Engineer Regiments especially should be earmarked for given tasks and told to study them. Airfield construction, construction of permanent defences, heavy improvised bridging are examples. This naturally applies mostly to the T.A. Study will be chiefly by paper schemes for Officers and N.C.Os.

(*f*) A knowledge of the organization of civilian labour may also be an important requirement for Army Engineer Regiments and should be studied. The importance of knowing the correct and economical use of plant goes without saying. Scales of plant carried by the regiment should not be increased. If more plant is required it should be made available from Plant Squadrons.

Assault Engineer Regiments

22. (*a*) It has already been stated that it is not considered that there will be a high priority for this type of unit in the early stages of a possible war. The technique of assault engineering must, however, be kept very much alive and up to date. This needs enthusiasm and imagination rather than a large expenditure of man-power and equipment.

(*b*) The organization of the regiment depends to a great extent on the type and capabilities of its equipment. The equipment (of the type normally associated with Assault Engineers) which is likely to be of the most use in the early stages of a war is (in order of priority) :—

(i) Gap crossing devices. As has already been discussed the provision of quickly constructed bridges in the divisional area will be a difficult problem. Equipment, other than Bridge Company equipment, which can be made available for this task will be developments of :—

(*a*) Bridge-layers (as at present carried and launched by the Churchill)

(*b*) Gap "fillers," such as fascines

(*c*) "ARKS."

(ii) Flails. These are at present an R.A.C. responsibility, but are considered under this heading—chiefly for the reason that it is considered that they should be taken over by the Royal Engineers.

(iii) A.V.R.E.

(*c*) (i) It is considered that by far the most important of these are the bridge-layers. (It must be remembered that these arguments are based on there being no Divisional Bridge Troop.) If they can be so developed as to span, say 60 ft. gaps, and be usable equally conveniently by both wheels and tracks, a most important step forward will have been achieved. So important in fact that priority, above other Assault Engineer equipment, for research and development should be given to it.

(ii) It is further considered that these bridge-layers should be decentralized to Divisional Field Engineer Regiments, on a basis of three per regiment, and to Corps Field Park Squadrons, on a basis of two per squadron. In addition to this they should still be held by H.Q. of Armoured Brigades, on a scale of four per brigade. The latter to be operated by the R.A.C. If the need for these bridges is also found in the Army area, then they can also be held by Army Engineer Regiments.

(iii) It is stressed again that the opening stages only of a war are being considered. To mobilize and equip an Assault Engineer Regiment as we know it at the moment may be an impossibility, even if desirable. Tank production will be much more vital. There is no reason to put these bridge-layers necessarily into an Assault Regiment organization when they can be decentralized as efficiently.

(*d*) For certain gaps with which a division is likely to be faced, especially narrow wet ones, the "fascine" principle will still be most useful. At the moment fascines have always been operated from A.Vs.R.E. and it is admitted that these are the best machines for doing so. But divisional engineers should develop some method, on an improvised basis, possibly by dragging the fascine on a sledge behind an armoured dozer, the dozer then to unhitch and push it into the gap, so that the principle can still be used even if no A.Vs. R.E. are available. There is no point in planning or using A.Vs. R.E. for this particular rôle, only to find that A.Vs.R.E. cannot be provided when the war starts.

(*e*) There is still likely to be a use for "ARKS." Unlike A.Vs.R.E., "ARKS" should always be available, as they will be adapted from obsolete tanks. They must be able to take both wheels and tracks. They should be held in "store" and drawn out when required.

Drivers must be provided by user regiments. This will admittedly provide a difficult training commitment. "ARKS" will not, however, entail a man-power or supply problem.

(*f*) The provision of flails will entail the formation of a special squadron or squadrons. These squadrons should be Army troops. They should be based initially on the supply and maintenance organization of the most conveniently placed armoured brigade.

(*g*) No mention has been made of the projected developments of mechanical minelaying devices and rapid demolition devices. If these are available (and again priority of production should come well below that of tanks) they should be decentralized to divisions, forming a small heavy-tracked element in the Field Park Squadron together with the bridge-layers.

(*h*) The above has taken, perhaps, a pessimistic view of the possibilities of forming up an Assault Engineer Regiment at the start of a war. If this view is not justified, then the regiment should be formed up to include all the equipments here mentioned, including bridge-layers and flails, as early as possible, but giving A.Vs.R.E. low priority.

23. Finally an Assault Engineer Regiment should be considered as an *assault* regiment, with no secondary rôle of "helping out" as engineers in a dismounted rôle. Thus in general, tradesmen, other than field engineer/operators, will not be required, and training should be concentrated only on the assault rôle.

24. To summarize :

(*a*) There will be a general demand for some of the equipments associated with Assault Engineer Regiments. These equipments are those which will either be used by, or in close conjunction with, Field Engineer Regiments, especially gap crossing devices. It will be more economical to decentralize to Field Engineer Regiments than to form up separate Assault Regiments.

(*b*) Independent Flail Squadrons should be available as Army troops, but should be incorporated into Assault Engineer Regiments as and when these are formed up.

(*c*) In any event as the supply position improves, Assault Engineer Regiments should be formed to take over all these equipments. The A.V.R.E. will be the main weapon in these regiments, but these vehicles will be of low priority in the first stage of war.

Airborne Engineer Regiment

25. (*a*) The same remarks as regards the establishment of tradesmen apply to these units as to the Divisional Field Engineer Regiment. Apart from a high standard of training, the regiment's

efficiency will rest largely on the excellence of its technique and equipment. Its priority for man-power and calls upon production (save those required to develop equipment and technique) should only be above that of the Assault Engineer Regiment.

(*b*) A possible rôle on the outbreak of war is the capture of airfield sites and construction of fighter air-strips (see also para. 7(*i*)). Equipment and technique for this rôle should be studied.

Bomb Disposal Squadrons

26. (*a*) This commitment will assume its largest proportion in the U.K., especially if the Army is asked to provide after-raid help to the Civil Authorities. It is a commitment which the civilians should be encouraged to carry out for themselves, as it may well become an embarrassingly large one. However much the civilians plan to do, the Army would be unwise to disclaim all responsibility. If the first stages of war show that the U.X.B. problem is considerable, public opinion and political pressure is likely to force the Army to take action whether units are trained or not.

(*b*) B.D. units should therefore be trained in peace and be available on mobilization. They should be designed for B.D. only, and only tradesmen required for this rôle should be included in their establishments.

(*c*) In theatres abroad any engineer unit must be prepared to deal with U.X.B. Reliance must be placed on ordinary field engineer training.

Construction Regiments

27. (*a*) These units will only be able to carry out their rôle if they hold a large proportion of tradesmen. The tendency, however, to provide the more specialized tradesmen on the establishment of all squadrons, must somehow be avoided.

(*b*) As far as possible, as with Army Engineer Regiments, it is very desirable that individual squadrons should be warned for particular rôles, e.g., the construction of airfields or railways, and should train for that rôle *only*. Transportation construction, in particular, should be specialized as much as possible to avoid unnecessary dispersal of specialized tradesmen. The ideal is that, although all Construction Squadrons should be basically the same, some should carry out all transportation construction tasks (once these can be assessed in terms of units required), while being still available, if necessary, for other types of constructional work. Only these latter units would include plate-layers, for instance, on their establishment. Plate-layers in all other Construction Squadrons would be replaced by field engineers or by some other commonly used tradesmen.

(*c*) It is on the provision of well-qualified officers and well-trained tradesmen that the capability of Construction Regiments to carry out all the tasks required of them will rest. Organization in peace-time must provide for this, despite the difficulties of training and recruiting tradesmen for the Reserve Army (but see also para. 43 below).

Works Services

28. The reputation of the Royal Engineers will, as ever, and despite the performance of the Field units, very largely depend on the ability of the Works Services. Added to its normal difficulties, the tendency for more "man and plant" hours to be required nearer the battle line will mean that the difficulties of the Works organization in competing for labour and plant will be enhanced.

29. (*a*) On the outbreak of war destructive bombing attacks and demand for accommodation for mobilizing units will throw a very heavy load on the U.K. Works organization, while arrangements for an expeditionary force will also require trained Works officers and men.

(*b*) Under these circumstances, less dislocation will be caused in the U.K. if the Works organization is civilianized to as great an extent as possible. Clearly its personnel must be "reserved"—anyway for the early stages of the war. A very close liaison should be built up with the Ministry of Works and R.A.F. Works branch. This will be especially necessary if all the resources of the country have to come to the rescue of atom-bombed towns.

(*c*) This damage in the U.K. may mean that theatres abroad are starved of construction units, e.g., Construction Regiments. This will mean that civilian labour abroad will have to be exploited to the maximum, and will be reflected by an extra load being thrown on Cs.R.E. (Works) and their staffs.

Stores Units

30. Heavier engineering tasks require more stores, besides more plant, transport and labour. Therefore the efficiency of the Stores organization will assume an increased importance. As no engineering work can start until the stores have arrived, there must be a comprehensive organization in peace-time ready for immediate action on war. Most Stores units must be in the active Army, otherwise war reserves, ready for immediate issue on war, cannot be built up. Neither can the all-important development of technique in stores handling (in which the Army has yet much to learn) be carried out. The Stores units for an expeditionary force will have to be found by the Reserve Army. They should exist in peace.

Plant Units

31. (*a*) Enough has been said in the foregoing to show that these units will be amongst the most important in the order of battle.

(*b*) There is no doubt that in the early stages plant will be desperately short. This means that care must be taken that the machines available are economically used and well maintained.

(*c*) It is comparatively easy to run an efficient maintenance system if all machines belong to one unit and are working centrally under that unit. Plant, on the other hand, will seldom be worked except when decentralized to a lesser or greater extent. If the load is very heavy, machines from the Plant Park Squadron may be worked by casual operators, who will have no personal interest in the machine itself. Maintenance will, therefore, be extremely difficult.

In general, maintenance under these conditions can only be efficiently carried out if based on a sound administrative system, whereby documents and inspection records are kept up to date, and well-equipped maintenance teams are provided. These teams must obviously be mobile, so that they can visit the sites of the work and will be responsible for inspection and first-aid repair. Establishments of Plant Squadrons and Plant Parks must provide for these elements. Not to do so will be false economy of the highest order. If spare parts, etc., are short, as they will be, the " ability of the Royal Engineers to carry out speedily and efficiently the tasks required of them " may depend in large measure on their work.

Pioneer Companies

32. (*a*) As during the last war, these units will be invaluable whenever large-scale engineering work is being undertaken. The efficiency of pioneers depends not so much on organization and equipment—or even training—but on a high standard of man management, a will to work and high morale.

(*b*) As far as Engineer Commanders are concerned they should see that the welfare of any Pioneers allotted to them has as much attention paid to it as for their own troops.

(*c*) It may not be possible in peace to earmark Pioneers for permanent allotment to the Royal Engineers, but it is highly desirable that the same Pioneer units should always work with the Engineers. The more an Engineer-Pioneer spirit is built up in peace the better. Pioneer units should be available on mobilization. They should exist (in the Reserve Army) in peace.

Electrical and Mechanical Squadrons

33. These units will have as one of their chief responsibilities the installation of pipe lines. This work, in particular for the supply of

fuel to the R.A.F., will be of the highest importance and it is essential that some of these units should be trained in peace so as to be immediately available in war.

Other Units

34. It is not intended to discuss the remaining units shown in the order of battle. With few exceptions they will all be required in the early stages of a future war. In general they must be organized in peace, but no detailed remarks are considered necessary on the existing plans for providing them or on their organization.

Summary

35. (*a*) The object so far has not been to decide how the Royal Engineers should be organized to fight the next war in general. It has been to discuss how Engineer units should be organized for the *first* stages of the next war. It is for the first stages, with the inevitable confusion bred of unpreparedness, shortages of equipment and materials and lack of as thorough training as could be wished, due to financial restrictions in peace-time, on which planning must be concentrated.

(*b*) The characteristics of the first stage of the war have been discussed, and individual units have been measured against this background. Individual units only have been taken as it is these individual units which must be raised and trained in peace. Exactly how these units should be grouped and handled in war is outside the scope of this paper.

It is now intended to discuss what the structure of the peace-time Engineers should be in order to provide these units.

PEACE-TIME ORGANIZATION

Basic Planning

36. Before determining what peace-time organization is the most suitable to produce the units required in war, certain basic factors must be taken into account. These are :—

(*a*) As far as possible all units required on mobilization, i.e., in the first few months of war, should exist in peace.

(*b*) The National Army—Regular, T.A. and S.R.—must be thought of as a whole. The possibilities and best use of each need very full investigation.

(*c*) A realistic view must be taken of the man-power potential—especially as to the number of volunteers that can be expected—and the amount of equipment which will be available.

(*d*) The possibilities for training must be carefully studied. There is little use in planning, recruiting and organizing a unit and then finding that no proper training, through lack of training facilities and instructors, can be given it. If this happens the unit will get frustrated and low spirited. It will start at a disadvantage when and if war comes.

37. Based on the foregoing, the following method of planning is suggested :—

(*a*) Consider the units which political and operational reasons demand that the Regular Army should have available at all times.

(*b*) Taking the mobilization order of battle and the units listed under (*a*) into account, decide which units should be found by the Reserve Army. A very careful assessment must be made as to which units should be in the T.A. and which in the S.R. (or which should be a combination of both—see para. 43 below).

(*c*) Decide how the balance of the man-power available in the Regular Army (it is fair to assume that it will not all be required for (*a*)) can best be organized so that it is of maximum assistance to the Reserve Army. This assistance will be either by giving direct help or—and more likely—sending to the Reserve Army the type of men that it most wants.

38. The more popular conception of the rôle of the Regular Army is for it to produce as many active divisions as possible, thereby having mobile, field trained troops always available. No painful improvisations then have to take place if a sudden commitment appears, e.g., Malaya or Hong Kong. Also such units have a visible effect, which all can understand, especially on a would-be aggressor. This is quite logical at first sight, but it is also quite essential that the S.R., T.A. and Regular Army should be viewed as a whole. If the best way to produce, on mobilization, a more efficient whole is by having more active divisions, then this should be done. But, on the other hand, as it is the Regular Army which must produce instructors and most of the administrative units—which are impossible to train in the S.R. and T.A.—and which will also be the major source of recruits for the Reserve Army, a Regular Army with an apparent lack of divisional troops may well be the soundest.

39. It is apparent that, in the past, some of these considerations have not been taken into account. The number of volunteers, financial restrictions, geographical distribution—and hence what units can reasonably be expected of the T.A.—have all received insufficient attention. It is to be hoped that the reorganization now being undertaken in the Reserve Army has struck a better balance.

The Engineer Organization

40. This paper is concerned with the Royal Engineers. Are the Royal Engineers now so organized that they may best be able to produce results in war? Has the balance between Engineer units in the Regular, T.A. and S.R. been correctly preserved? Is the Reserve Army receiving the type of trained Sapper which it most wants? These questions will be discussed in the following paragraphs. The Reserve Army will be considered first, as it is the needs of the Reserve Army that the Regular Army must do its level best to supply.

The Territorial Army

41. The Territorial Army is the major partner in the Reserve Army. On it rests, in great measure, the responsibility for producing the bulk of the units required on mobilization. But the chief point to be remembered about the T.A. is that it can, in general, do only two things :—

(*a*) Produce units which have a fine unit spirit and are indeed *units* and not just a collection of men.

(*b*) Impart, in fairly good measure, field engineer training and some purely military training. It cannot undertake technical or trades training. Lack of instructors, workshops, training facilities all mitigate against doing this.

42. The T.A. can, then, only be considered as a breeding ground of good field engineering units. As such, therefore, as many Field Engineer Regiments as possible should be required from it. The more good field engineers that are sent to it from the Regular Army, the more chance there is that these men will be kept up to scratch and will stay useful soldiers. In fact, once again, the more that the Royal Engineers produce a well-trained field engineer/handyman the better. A man who is a member of a good unit, in which he is contented and in which his morale is high, and in which he feels he is getting useful training, will be very much more useful than a man who has joined an allegedly technical unit, which attempts, but fails, to carry out technical training, and in which an atmosphere of frustration and defeatism prevails.

43. There is no doubt, however, that tradesmen must be forthcoming from somewhere. It is to be hoped that men discharged from their regular engagements, with perhaps some handyman grounding in a trade, will improve as they gain more experience in their civil occupations. But more active steps than this must be made to ensure that the basic structure of first-class field engineer trained units in the T.A. can produce the technical work required of them. The following methods are suggested :—

(*a*) Although the Regular Army must supply a stream of well-trained field engineers to the T.A. it must also supply some *good* tradesmen as well.

(*b*) T.A. technical units should specialize in their training as much as possible—anyway in Summer Camp. This point has already been raised, and Construction units earmarked for transportation construction work have been quoted as an example. All camps, and not just a few, should be devoted to the specialist rôle.

(*c*) (i) There should not be a hard and fast dividing line between the T.A. and S.R. It should be possible for, say, a Construction Squadron to have two troops T.A.—mainly field engineers and the backbone of the unit "spirit"—and one troop S.R. This troop would be made up exclusively of tradesmen, who could of course be recruited on a county-wide (if not a country-wide) basis. The three troops would join up for Summer Camp when the two elements—T.A. and S.R.—would be treated, without distinction, as one unit. All officers would be, as a rule, T.A.

(ii) By so doing on mobilization a well-found unit would be got together—and not just a collection of men as an S.R. unit may tend to become.

(iii) This method might also encourage volunteers for the S.R. Many men, especially possibly tradesmen, would like to belong to the local T.A. unit, but find they cannot spare the time in the evenings or week-ends. Or they may have been put off by the fact that the unit does no technical, but only field engineer, training. Some men might, however, be willing to come to Camp in the Summer, as long as they had no other training commitment, and would join the S.R. to do this.

(iv) It is realized that the obligations of the T.A. and S.R. are different and that in certain circumstances the T.A. can be embodied but not the S.R. If this happens then the mixed units will be in an unfortunate position. But it is a risk worth taking, and should not obscure the main issue—that the National Army on general mobilization should be as efficient as possible.

(*d*) (i) Special commissions should be given in the T.A. to technical officers, who may be unable to join a T.A. unit as such, due to geographical or other factors, and yet would be willing to do so if offered favourable terms, and whose technical knowledge, e.g., in a Plant Park Regiment, Workshop Regiment or as a D.C.R.E. (Works) would be invaluable. Such officers would not be on the permanent strength of any unit, but would be required to carry out, say, four weeks' training every other year, or two weeks' training yearly, and would also be liable to be called upon for other training commitments when so required. During their training they would be sent on courses or attached to units, or be required to do an attachment to a C.R.E. (Works) Staff, etc., as is convenient at the time.

(ii) Such commissions would not be the same as S.R. ones, as the individual would be required as an individual (as opposed to being part of a unit) who has some especial knowledge or skill of use to the Army, and who would also have T.A. and not S.R. liabilities. This scheme is already in operation to a limited extent as far as Geologists are concerned, eight of whom have been given T.A. commissions, but are not members of any particular unit.

Officers skilled in bulk oil installations, pipe line construction, harbour works or with general " Works Service " background would be of the type required.

44. It is not intended to discuss individual units as this has already been done in a preceding section, except to stress the importance of plant units in the T.A. Inasmuch as equipment can be found for them on the outbreak of war, all such units as are considered necessary must be organized in peace, so as to be immediately ready for war. Technical training for these units does not offer the same difficulties as with other technical units. Instructors, plant and land are the pre-requisites. As long as high enough priority is given, none of these obstacles are insuperable.

45. To summarize: Training difficulties in the T.A. are such that the T.A. should aim at producing units of high morale and well trained in field engineering. Methods of providing the tradesmen and technical elements include the giving of special commissions to technical officers and the incorporation of tradesmen S.R. sub-units in T.A. units. The difficulties of technical training should not be accepted in the case of plant units and these should be formed in the T.A. The Regular Army can best help (apart from providing instructors and helping in training generally) by sending to the T.A. well-trained field engineers and some good tradesmen.

The Supplementary Reserve

46. The S.R. has three main rôles :—

(*a*) By not restricting recruiting to a small geographical area, to provide those units which have on their establishments a high proportion of tradesmen. These tradesmen can then be recruited from widely dispersed districts.

(*b*) By forming up units from peace-time organizations (such as the railways). The units are then required to do a similar task in war as that required from the organization in peace.

(*c*) To enable the N.S. man who has finished his active service, but who is badly placed geographically as regards the nearest engineer T.A. unit, to continue to serve in the Royal Engineers.

47. As there has been no opportunity yet to study the latest proposals for the S.R. it is not possible to comment on the existing system in any detail. Clearly the rôle in para. (*b*) above has great potentialities as far as the Royal Engineers are concerned, and should be encouraged to the full.

48. The C.O. of an S.R. unit has two main problems :—

(*a*) To turn his command from being a collection of men into a well-knit unit.

(*b*) To give his unit the training required for its specialized rôle.

Both these tasks are difficult and will be discussed more fully in the section on training. The advantages of combining T.A. and S.R. units, inasmuch as (*a*) above is thereby much easier, are obvious. In S.R. units proper, (*a*) will also be much easier if recruiting for a particular unit is confined to as small a geographical area as possible.

The problem of how to administer and train S.R. units is discussed in paragraph 80 *et seq.* below.

The Regular Army

49 (*a*) It is not proposed to discuss the present organization in detail, but only to state where changes in the present organization are considered desirable. Basic changes in units themselves have already been discussed. No further mention will be made of administrative units—Stores Depots, Workshops etc. That these units must be efficient goes without saying. If they are efficient it will not matter to what extent changes in engineering methods will need different types of stores or will raise different workshop problems. The efficiency of these organizations will depend on the type of officer posted to them. Perhaps more ruthlessness in posting some types of officers in, and other types of officers out, would pay dividends.

(*b*) Training regiments will be discussed in the next section.

Regular Regiments

50. The only units whose rôles are sufficiently flexible to allow of great variation in their peace-time organization and training, are the various types of Engineer Regiments. Suggestions as to changes in organization of these units have already been discussed in paras. 17 *et seq.* The following are stressed :—

(*a*) The importance of giving really good field engineer training. Too much attention must not be deflected from giving this training by having also to spend considerable time in trades training. The arguments for cutting down in tradesmen have already been set forth. A Field Engineer Class II standard for *all* field engineers must be the aim.

(*b*) Although the main effort should go into field engineer training, both from the point of view of the active and reserve armies, some tradesmen will naturally be required. In the aggregate their numbers will be quite considerable. They should be found from regular soldiers and N.S. men, who should be trained accordingly. However the numbers of tradesmen should be sufficiently reduced, compared to present conditions, to allow of two things :—

(i) To allow of a greater measure of selection. It should never be neccessary to train a man as a tradesman for the sake of so doing (as is the present policy with regular soldiers). As a result a higher standard of trades training should be achieved.

(ii) To allow of more effort in terms of time and stores for field engineer training, as less will be required for trades training.

Army Engineer Regiments

51. It is for consideration whether these units are required at all in the Regular Army—or anyway whether such a high proportion as three are necessary. Training in them is apt to fall between two stools—neither good field engineers, many of whom are filling trade vacancies on the establishment and therefore have to spend time on trades training, or tradesmen are produced. It is considered that the two Army Engineer Regiments (those in the U.K.) should be converted to Field Engineer Regiments (Corps) by exchanging with two of this type of unit in the T.A. Or, alternatively, they should be considered merely as N.S. continuation training regiments with the main object of producing field engineers. A further possibility for another use for Army Engineer Regiments is discussed in para. 66, when Training Regiments are being considered.

Assault Engineer Regiment

52. This unit has already been discussed in detail. As far as its existence in peace-time goes, it should not absorb many men, and its rôle should be the development of technique and creating a reserve of men capable of driving tracked vehicles. If bridge-layers are developed, as discussed in para. 22, the training of drivers will be a major responsibility.

Airborne Engineer Regiment

53. This unit has been reduced, quite rightly, to the strength of a squadron. Its rôle will be the development of technique and the keeping alive of the traditions of a *corps élite*.

Tradesmen

54. It has already been stated that Regular units must not be

burdened to excess with the training of tradesmen. The rôle of the Regular Army must be to produce first-class trades instructors, and to fill the reduced tradesmen ceiling with good tradesmen. It should only be necessary to train men who already have trades experience or marked aptitude. The main training effort must come from industry. If such men are not forthcoming, it is suggested that a recent scheme of the R.A.F. should be examined, whereby tradesmen are enlisted from certain firms for a period of three years. The Army would then guarantee to train and *employ* (most important as far as the R.E. are concerned) the man in his trade. At the end of three years the man would return to his firm.

The merit in any such schemes is to relieve the Regular Army of as much *ab initio* trades training as possible, so that with less effort a higher standard of tradesmen can be achieved and units can concentrate more on field engineer training. The scheme for recruiting men from industry could usefully be applied to plant operators.

Plant Units

55. (*a*) The Regular Army must have a well-trained nucleus of these all-important units. At the same time a continual stream of trained operators should be passed to the Reserve Army. On mobilization not only are there the plant units themselves to be provided with operators, but many other units have some plant operators on their establishments.

(*b*) Whatever other trades training responsibilities are removed from regiments, that for training their plant operators should remain.

(*c*) It must be remembered that on mobilization the supply of machines will be restricted. The aim in peace should, therefore, be to train no more (but including some reserve) than are required to fill all the vacancies in the mobilization order of battle. These operators must, however, be well trained. Opportunities in the T.A. may be restricted, therefore operators must arrive in the T.A. having already reached a reasonable standard.

(*d*) In war the need for a large-scale plant operator training organization will soon become apparent, and mobilization plans should provide for this.

Works Services and Stores Units

56. As already pointed out, careful attention must be given to the Works organization, so that it can start off on the " right foot " on mobilization. The following is suggested :—

(*a*) After having assessed the minimum number of Regular Officers and O.Rs. who should be getting experience in Works Services in the U.K. the remainder should be civilianized.

(*b*) To provide for the expansion in war, the special scheme for T.A. commissions (as applied to Geologists, see para. 43) should be implemented. Both senior officers and junior officers should be encouraged to join. Training should be devoted to Works procedure and organization. Thus regular officers can be replaced early on mobilization with the minimum dislocation.

(*c*) Where Construction Regiments T.A. demand the inclusion of Works Sections, these can be found on a normal T.A. basis or as a S.R. sub-unit (see para. 43). If on a T.A. basis, the technical training can best be carried out by correspondence courses on Works procedure, and attachment to Cs.R.E. (Works) for Summer Camp. In addition ordinary " unit " training can be carried out in drill halls in the normal manner.

(*d*) As far as the Regular Army itself is concerned a continual stream of officers of all ages should be given tours in Works Services. A two year tour should in most cases be sufficient. Such tours should be approached in the regimental spirit—that is to say that the same standard of smartness and man management are required as in a unit. Such an attitude will enhance the status of the Works Services in the eyes of the rest of the Army, and it is considered that, even in such points as this, the ability of the Royal Engineers to provide the work required of them is improved.

(*e*) Similar remarks as in the above sub-paras apply to Stores units.

57. To summarize: As far as the Regular Army is concerned much of its structure is determined by its day to day tasks, operational or administrative. Administrative units can make themselves most efficient for war by making themselves as efficient as possible in peace, as they will be required to do similar work in war. The right selection of officers for such units is the secret of success. The rôle of the Engineer Regiments should be the production of good field engineers. The establishment of tradesmen should be cut, and a higher over-all standard for the remaining tradesmen must be achieved. Means of training plant operators must be found, but the numbers turned out must bear a realistic relationship to the numbers of machines likely to be available on mobilization. The Works Services and Stores units must receive their full share of attention when planning for mobilization.

Equipment

58. So far, no specific mention has been made of how units should be equipped in peace. Heavier engineering will demand heavier equipment cranes, larger dozers, road-making plant etc. These

must be available in war and no doubt to a certain extent will be, even in the early stages. These equipments are a matter of design and production and are beyond the scope of this paper, which is concerned with the equipment that should be available here and now in peace. Further, under peace conditions heavy road-making machinery, for instance, probably could not be used even if it were issued.

59. What in fact are we mostly concerned with in peace? Two items are of paramount interest to any unit :—

(*a*) Its G.1098 (or G.1198) entitlement.

(*b*) The stores it can get for training in addition to the G.1098 scale.

In what way can these be improved so that units will not be too handicapped when faced with their war tasks? The first point will be discussed now. Training stores belong more properly to a following section.

60. A unit's G.1098 or 1198 equipment, on which the scope of its day to day capabilities for work mainly depends, is largely a matter of the efficient discharge of staff duties. It is the duty of the staff to see :—

(*a*) That the types of stores, most of them "small" ones, such as tool kits, compressor tools etc., with which a unit is basically equipped, are in fact the best of their kind, and the most efficient that industry produces.

(*b*) That the equipment tables are so made out that, after taking into account financial restriction, they do really give a unit all those items which it wants—no more, no less—and these items are the most efficient that are available for the task.

61. These may be very simple rules, but it is by no means apparent that they are followed. It is probably no exaggeration to say that many a G.1098 has been made out, none too carefully, by merely embellishing an old one. A new type of unit often has to make do with an existing G.1098 roughly altered to suit the new requirements.

In short, a thorough overhaul of G.1098 scales is required.

62. In case it is thought that design and development has been brusquely brushed aside, it should be stressed very clearly that research organizations must be provided with the very best officers and men available for that type of work, and the means with which to develop their ideas. One point which should receive considerable attention, and the results of such investigations incorporated in unit

equipment scales as soon as possible, is to ensure that as much use as possible is being made of power tools. For heavier tasks, such tools in the hands of trained field engineers, supervised by good tradesmen, will be invaluable. Under this heading come mechanical saws, automatic drills and augers, and other power-driven hand-tools. Electrical-driven as well as compressor-driven tools should be investigated. The scale of compressors and/or electric generators for this task will certainly need revision.

63. *Transport*

(*a*) It has already been said that those units which expect to receive their full scale of transport on mobilization, may receive a rude shock. These scales should be overhauled as soon as possible, so that units can base their peace-time schemes on a realistic entitlement. An Enginer unit has to balance carefully the factors that a Sapper without tools or stores (which presupposes transport) is useless, and the fact that transport will be short. It must also be remembered that transport in particular is a fine target for an enemy fighter. The less transport a unit has, the less can it be disorganized by transport losses.

(*b*) It must be recognized that as a commodity becomes scarcer, so it must be rationed on a centralized basis. The Engineers must, therefore, plan on being very dependent on the R.A.S.C.—in particular on Tipper Companies. It is very much a Royal Engineer concern that the R.A.S.C. peace-time organizations should be designed so as to provide for our likely transport demands in the early stages of a war.

64. Although the results of the labours of research and development organizations may often not be in the hands of troops for train ing purposes much before a war starts, there is no reason why unit C.Os. should not be kept very fully in the picture as to what is going on. This particularly applies to bridging and demolition developments. An excellent scheme to promote this, and which has occasionally been done in the past, is to show a group of officers the prototype, or working drawings, of an equipment and then to set a tactical scheme to study its use in the field. This naturally can only be done at the development centre itself. It results in great benefit to both " users " and " designers."

Training

65. The basic principles for Royal Engineer training are well known and will not be elaborated here. Only those points considered to require special comment will be discussed.

Training Regiments

66. (*a*) The stress in all basic training is, wisely enough, on the production of field engineers. The declared aim is to turn a man into a Field Engineer Class III before he leaves his Training Regiment. It is, however, quite clear that fourteen weeks' basic training does not give sufficient time for this to be done. Unfortunately only a proportion of N.S. men leaving a Training Regiment are likely to attain a higher standard of field engineering than that which they have when they leave, as many of them are needed in units where systematic field engineer training is not possible. This state of affairs is unfortunate, both from the point of view of the Active and Reserve Army.

(*b*) To combat this the following is suggested :—

(i) It should be an accepted fact that basic training has failed unless it produces Class III Field Engineers.

(ii) The problem as to how long a man can stay at a Training Regiment resolves itself into one of man-power and accommodation. It is assumed that the latter difficulties can be solved.

(iii) It is considered that the rôle of a Training Regiment is more useful than that of an Army Engineer Regiment. These units as they stand have already been discussed in para. 51. It is suggested that one of the Army Engineer Regiments in the U.K. should be sacrificed to provide the extra man-power and equipment required for Training Regiments to give recruits extra training.

(iv) Recruits earmarked for trades training should not complete the basic field engineer course, but would be withdrawn after a suitable period—possibly the present fourteen weeks. As tradesmen will be carefully picked and are guaranteed to be good tradesmen, their trade training will be of greater importance than their field engineer training. The reason for withdrawing them is so that less training man-power and accommodation will be used up. All regular soldiers should, however, complete the basic field engineer course.

(v) The Royal Engineers should study the Infantry training system whereby an active battalion—which is periodically changed—is made responsible for a basic training centre. On mobilization it may, therefore, be possible, if the Infantry system is adapted to our needs, to withdraw the Training Regiment staff, or a proportion of it, to form an Engineer Regiment. Such a system would not be desirable in itself for Engineers, but might be a possibility in an emergency.

N.C.O. Training

67. (*a*) Perhaps the most important role of all for the Active Army is to produce good Regimental N.C.Os. Unless these are available

the R.E. will not be able to produce the required results in war, quite apart from the purely engineering difficulties. Here again, it is field engineer training which is most likely to produce good N.C.Os.

(*b*) There is no reason to suppose that the Apprentice Schools (such as the old Chepstow) will not continue to produce the finest N.C.O. material of all. Every encouragement should be given to boys to join the Royal Engineers via one of these schools.

(c) If N.C.Os. are to be recruited from those possessing a trade background (which automatically suggests a higher intelligence) the promotion rules for N.C.Os. must be revised. If a Sergeant must become Class I in his trade he will be most reluctant to be so far removed from it that he cannot preserve his skill. In any event an N.C.O. has no business to be thinking more of his trade rather than of his N.C.O. duties. This means that a tradesman may not join the Army, or if he does he may not enter as whole-heartedly into Regimental N.C.O. training as he should.

It is no solution to say that he should become a Field Engineer Class I. Good N.C.Os. are required in units which never do, or have little opportunity to do field engineering, especially of Class I calibre.

(*d*) Although there must be a promotion test, to continue with the trade test is unwise.

Officer Training

68. If engineering in the field is to become harder the basic training of the officer needs very careful consideration. Two points stand out :—

(*a*) It must be based on good sound principles

(*b*) It must have a good practical bias.

How does the present officer training appear when examined from this point of view?

69. Principles in engineering are the same whether the engineer is military or civilian. Therefore, clearly it is very desirable that the military and civilian engineer should have in common the same basic qualifications. Under present circumstances this is normally taken to be a good engineering degree.

70. There is thereafter one great difference between the military and the civilian engineer. The latter will be putting his theory into practice for the rest of his life. The former may never directly practise more than the elements of his learning until a considerable number of years have elapsed—even if he ever has to practise it at all.

Therefore, to teach the military engineer theory beyond a certain point is a waste of time. Once an engineering background has been obtained details in that background will be forgotten and the time spent in learning them might have been spent to better advantage.

71. Two points emerge from this. Firstly, two years is the maximum that should be spent on theory. Secondly, an Engineer Officer should be given more opportunity to gain practical experience. This practical experience must be civil (or mechanical etc.) engineering rather than field engineering. It should be so spaced in his career that it will be near enough to his theoretical training so that he will not find the exercise of theory unduly difficult. Being of a practical nature it will not be easily forgotten and will stand him in good stead for the remainder of his service.

72. Some officers do in fact have the opportunity of doing this by taking a long engineering course. But these courses last two years, which is longer than the average officer, who may be aspiring to the Staff College also, can afford. The following plan is suggested :—

(*a*) Theoretical training should be limited to two years. It should result in gaining at least the equivalent of Sections A and B of the Institution of Civil Engineers Membership Examination. Cambridge is ideal for this (apart from the other advantages besides engineering training which Cambridge has to offer).

(*b*) The Military College of Science degree course, if it is longer than two years (it is understood that it will shortly be of three years) will not be suitable. To do an extra year's theory is likely to have had a completely negative influence on the average officer by the time he is 30, beside unduly protracting the training stage of his career.

(*c*) Those who cannot obtain a vacancy at a university should be brought up to Section A and B standard at the S.M.E.

(*d*) Each officer, as and when he can most conveniently be spared, should be attached to a civil firm, seconded to the Colonial Office etc., for one year, when he will be given the opportunity of gaining Section C of the A.M.I.C.E. This can be varied as necessary if an officer's interests are other than *Civil* Engineering.

It is suggested that the above plan will make the best of all opportunities. In all, an officer's training will take three years, apart from periods spent at the S.M.E. doing field engineering, but that is no more than the Military College of Science projected degree course. By the time an officer is 35 to 40 there will be little doubt as to which three years will have been best spent.

At all events if an officer is to be practised in heavier engineering it is probable that he will only get this practice, by an attachment to a civil firm engaged in carrying out suitable tasks. Every effort must therefore be made to evolve a plan by which this can be done.

Unit Training

73. Most units in the Active Army have a daily fixed task required of them—Stores, Works Services etc.—and it is only the Engineer Regiments, with their primary task of training N.C.Os. and Field Engineers, that can vary their training so as to take into account the heavier engineering tasks that may confront them in war. In general the existing practice, whereby a considerable effort is put into field engineer and, to a lesser extent, trades training, while Officers and N.C.Os. by means of lectures and paper schemes also study their possible rôles in war, is all that is practicable.

74. There remains, however, the principle that units of both the Active and Reserve Armies should be allowed, under certain circumstances, to carry out tasks for civil bodies. At the moment, however good training such " useful work " might be, such activities are forbidden. As a typical instance, it is known to the writer that an offer of useful training by a West Country landowner, who wished to have a road made down the face of an escarpment so as to allow growing timber to be cut and fetched from the higher slopes down to the foreshore, has had to be refused. Such work would have been excellent training in both road-making and the use of timber, especially as a suitable camp site with some " camp structures " was also to be made available. The landowner made it clear that if the Army could not do this work, he had insufficient capital to have it done by other methods. It is considered that urgent and definite steps should be taken to enable such offers to be examined on their merits. Many units may be so busy with basic training that they have no time for such tasks, but if and when the opportunity offers, there should be some conditions under which it can be accepted.

75. Reasons why such authority is refused are based on :—

(*a*) Alleged opposition from local contractors.

(*b*) Alleged opposition from trade unions, who do not like having craft work carried out by men not under their control.

(*c*) The possibility of abuse—especially with T.A. units, e.g., the men might get paid extra, or a unit commander might get work done for his private benefit.

76. These reasons may be very excellent, but they are not insuperable. Indeed it is well known that T.A. units have built bridges for local shows etc., without local opposition. On the contrary, it would appear that if the question was taken up on a *sufficiently high level* results would be achieved. There is the precedent of the Festival of Britain bridge to prove that.

Admittedly the Army may, under certain circumstances, be employed if full civilian rates are paid. But this is tantamount to forbidding such tasks as no civilian body will pay full civilian rates for semi-skilled and unpractised labour. That some repayment should be made for services rendered is reasonable. But to rule out one of the most fruitful sources of giving Engineer units some opportunity of doing practical tasks is short-sighted. It is hoped that sufficient interest will be taken at the correct levels to ensure progress in solving this question in the near future.

Trades Training

77. The recommended reduction in the numbers of tradesmen will mean that the available instructional effort can be used to a greater extent to "reinforce success" and turn out tradesmen of a higher standard. The present policy whereby the basic training organization is responsible for Class I and Class III tradesmen, while units must do their best to train up to Class II is basically sound, but can only be efficiently implemented when the supply to units of trades training resources has been put on a proper footing, which is not the case at the moment. Priority in unit trades training should, however, go to turning selected field engineers into handymen. Those units most badly placed for trades training should receive assistance from the basic training organization in training their Class II tradesmen.

Command Pools of Training Stores

78. The most important source of training aids, with all that that implies, are Command Pools. With the accent on the production of field engineer/handymen, and the ability of field engineers to operate "plant" (compressors, concrete mixers, pile drivers, tar boilers, etc.), this means that Command Pools will need drastic revision, both as to items available and to scales. This problem is an urgent one and must be approached with imagination and drive. It applies not only to the U.K., for the establishment of pools on a sound basis applies equally overseas.

T.A. Training

79. (*a*) T.A. Training has had many difficulties to contend with, and much is due to the enthusiasm of Engineer H.Qs. that so much progress has been made. Within the nature of things T.A. units can only attempt to train field engineers, whatever the type of unit. Technical training must be provided by the man's normal occupation, although some units may be better placed than others in practising him in the military application of his trade.

(*b*) As the object of T.A. training is to produce a good unit as such, opportunities for carrying out a task as a unit are essential.

Useful tasks offered by civilian authorities are, therefore, of great importance. This has already been discussed.

(*c*) Some attempt must also be made to study the unit's task in war and to train accordingly. This can generally only be done by officers carrying out paper schemes or by "training visits." Units should be given some guidance as to the lines along which they should be thinking as to their possible rôles.

(*d*) Where it is possible to earmark a unit for a special task, that unit should train for that task, and that task only, during the Summer Camp. This has already been discussed as far as Construction units are concerned.

S.R. Training

80. This is more complicated than T.A. training, as there is no organization "on the ground" to start from. It is only the Summer Camp period that is involved. It has already been suggested that S.R. units should be of two types :—

(*a*) Those units which are part of a T.A. Regiment. These units must obviously be looked after and train with their parent units.

(*b*) Independent S.R. units.

81. The following points are considered important :—

(*a*) T.A. training must have priority. That is to say that to attempt to integrate T.A. and S.R. training at Summer Camp (unless the S.R. unit comes under para. 80(*a*) above) may mean getting neither unit well trained. T.A. units must have first call on the efforts of Group H.Q. and on the available training stores.

(*b*) This will mean that S.R. training must be centralized. Overheads must be found from somewhere and these can only come from the Regular Army—again without prejudice to T.A. training. It may be that S.R. units will be able to follow on after T.A. units at Bridge Camps, under the direction of a nominated Group H.Q. This smacks of expediency rather than desirability. Bridge Camps are in general fully booked up—and an Engineer Group H.Q. should already have its hands full with its own T.A. training.

(*c*) It is considered that all S.R. training—other than that which is a fair charge on T.A. units—should be carried out at three centres. Longmoor, Long Marston and the R.E. Depot, Barton Stacey. A permanent staff element should be set up at each to plan, administer and organize the training. This has already been done at Longmoor and is believed to be in process at Long Marston, where the training of specialist Transportation and Stores units respectively will be undertaken.

(*d*) The heaviest load is, however, likely to fall on Barton Stacey. It will warrant the appointment of a permanent H.Q.—on the lines of an Engineer Group. S.R. units will be accommodated in tented camps and must, of course, carry out as many of their own administrative duties as possible. Such remaining help that is required being given by men being held at the Depot, or even by successive outputs from Training Regiments. A temporary delay in the supply of reinforcements must be accepted.

(*e*) Lack of engineer training facilities at the Depot need not matter. By definition S.R. units should be made up of technicians, and the object of the annual training should be to weld together a unit. Hence military training and such field engineer training as is possible at Barton Stacey would be sufficient. Officers and N.C.Os. can also carry out indoor schemes on the unit's rôle in war.

(*f*) The T.A. may have to play its part in the provision of a proportion of the instructors. After a particular unit's annual camp is finished, then the S.R. should be empowered to borrow P.S.Is.—on a short-term basis.

82. No apology is made for discussing this training in some detail. The suggestions given may not be entirely practicable, but the main point is that the Royal Engineers must be fit for war on mobilization. The S.R. will—or should, if proper use is made of it—provide many valuable units. If these units are not well trained, which they won't be unless the training is properly and thoroughly organized, we will only have ourselves to blame.

Pioneer Training

83. The same organization as discussed in para. 81 should be able to cater for some Pioneer units. The Royal Engineers will be a large user of Pioneer labour and it will be in our interests to help in their training as much as possible. The object of such training will again be to turn out well-knit units, and units which will hold the Royal Engineers in some affection. If it is possible for a proportion of Pioneers to work with T.A. units at bridging camps, so that some experience is gained of the "labour" side of bridging so much the better. Such attachments are also more likely to be beneficial rather than harmful to the T.A. training.

Training Aids and Methods

84. There have been many developments in these since the end of the war, and Method of Instruction teams have done much valuable work. It is not intended to discuss the activities of these teams here—beyond drawing attention to their importance and to the fact that their influence has yet to find itself in every Army class-room. There is no doubt that the more efficient the methods of instruction and associated training aids are, the better and more lasting the

results of basic training will be, and the more a man will remember when he leaves the Active Army for the Reserve.

85. As far as training for the heavier engineer tasks is concerned, two methods—the use of films and film strips—have more possibilities than any other. The scope for treating various subjects is tremendous —in general the only restrictions are financial. Compared to many other arms the Engineers are not well provided with training films—although the last one to be made —*Pile Driving*—was a very good step in the right direction, but, as a Corps, we should try and allot more of our resources—suitable officers, trained troops, etc.—to the making of films and strips. At the moment, even if finance has been available, the full possibilities have not been exploited because of lack of "man-power." Man-power is a question of priorities, the laying down of which rests in our own hands. The making of films and film strips deserves careful consideration.

Training Areas

86. Under present circumstances each Command has its own bridging camp where bridging and some field works can be carried out in a non-tactical setting. These camps are very necessary and should still be the centre of annual training for both Active and Reserve Army units. Ideally, however, a large Engineer Training Area is necessary, where all types of engineer training, including tactical bridging, "damaging" training (plant and demolitions) and large road and bridging projects can be carried out. This area would also provide a centre for S.R. training. Some permanent buildings and camp structures would be necessary.

87. This ideal is unobtainable at the moment. Restrictions on buying land, on providing Works services, conflicting claims of T.A. week-end centres, all mitigate against it. But the plan should be prepared and put into action directly more favourable conditions arise. Really efficient comprehensive practical training, which is the goal of all unit commanders, will not be possible until this area is in being.

Some Points for Training

88. It has already been said that it is not intended to list all the points which should receive attention in peace-time training. The following are, however, considered sufficiently important to merit special attention when carrying out both practical and paper schemes.

(*a*) The use of plant in general is now fairly well known—but the *correct* and economical use of it will always need study.

(*b*) Night work in general, and in particular the use of plant at night, must be practised. Enemy air superiority may mean that in certain areas, only night work—however undesirable from the engineering point of view—may be possible.

(*c*) The quick repair of roads and airfields will ever be a problem which will need considerable attention.

(*d*) The strengthening of bridges—including culverts—will be very important indeed. To find routes—or to prepare them—capable of taking heavy tanks on their transporters may be exceedingly difficult, but possibly vital to the conduct of the battle.

(*e*) The best methods, both orthodox and improvised, of providing tank obstacles.

Morale

89. A most important aspect of all training will be to prepare a unit morally for the impact of war. Reference to para. 7 will show that it is considered that the next war in its opening stages will not give time for a period of adjustment. Complete lack of air support, heavy bombing attacks, gas, lack of transport, lack of welfare facilities, anxiety as to how families are faring—all these things will be a severe test of morale.

90. Training schemes must not always assume that equipment in quantity will be at hand, or that the full entitlement of a unit's transport will be available for it to move as it will. Any unit which has not been properly orientated in peace, may find itself unable to produce the work required of it in war. The difficulties likely to arise in the all-important first stages of a war must be anticipated. Units must find themselves on mobilization with a fine sense of unit spirit and a confidence in themselves.

91. These are platitudes. What can be done about it ?—and be it noted all units in the National Army are involved, Active, T.A. and S.R. Some points to be considered are these. Enthusiasm and efficiency can be engendered by careful selection and encouragement of officers. Schemes must be set with realism and imagination. Proper man-management of the N.S. man while in the Regular Army, so that a man always has a sense of usefulness. And perhaps above all, on frequent visits of senior Engineer Officers, who must take every opportunity of talking to units and telling them what will be and is required of them. The writer of this paper can well remember an informal talk by a senior Engineer Officer to all officers of a unit being inspected, on what the Corps expects of its officers. That talk of about twenty minutes was probably worth a year of miscellaneous exhortation. Such talks as these would be particularly valuable for T.A. and S.R. units carrying out their annual training.

Allied Co-operation

92. To-day, no paper on a subject such as this would be complete without some mention of allied co-operation. The whole basis of the Atlantic and Western powers is full and complete trust and aid one to the other. That there may be many practical difficulties is admitted, but the foundations of co-operation must be laid in peace if they are to bear fruit quickly enough in war.

93. Much has already been done on the first and most profitable line of approach—the standardization of procedure, technique and equipment. As far as the Engineers are concerned standardization of plant is most important. There may be greater scope for the exchange of technical officers. But obviously the engineering efficiency of all armies will very largely depend on the ability of the Allies as a whole to produce, transport and use equipment which is the best suited to the tasks in hand.

94. As far as organization and training are concerned, little more can be done than to study and derive benefit from the experience and technique of others. This is best done by the exchange of officers rather than the study of reports. It is not considered that a time will come, or that it is desirable that it should come, when the engineer resources of the Allies will be completely integrated, each country only raising and training those units which it can most efficiently produce. Each army must always be capable of carrying out the engineer work required by it, with its own resources.

95. Finally it should be noted that a particularly fruitful way of exchanging " techniques " is in the making of training films. Where basic methods have much in common, e.g., construction of improvised timber bridges, each country might well agree to make the type of film which it is best placed to produce, for its own benefit and the benefit of others.

Conclusion

96. To-day, for those whose nature it is to achieve very little, there are always very many good reasons why, despite great efforts, very little has in fact been done. Finance, materials in short supply, political considerations, trade union opposition—all these reasons and many more—they all play their part in explaining procrastination and delay. But, on the other hand, many of them are in fact very excellent reasons and it is unrealistic to pretend that they do not exist. The underlying theme of this paper is that there is little to be gained in embarking on too ambitious and unrealistic schemes for training Royal Engineers to carry out heavy engineering tasks in war. It is hoped that this attitude has not been unduly unenter-

prising, but that a correct balance has been obtained between what is possible and what is not.

97. The important points are considered to be :—

(*a*) The National Army—Regular, T.A. and S.R.—must be treated as a whole and the needs of the one must be carefully studied in relation to the others.

(*b*) When planning for war only the first stages should be considered. To think further ahead may mean that the first stages are not successfully surmounted.

(*c*) Certain changes in the organization of individual units are desirable, either on the grounds of efficiency or of making a better use of man-power.

(*d*) The trades structure of the Corps needs close examination. More stress should be laid on the training of really good field engineer /handymen, while industry must be depended on to train technicians. The inclusion of the more specialized tradesmen in the establishment of "all purpose" units may lead to wasted skill.

(*e*) Every effort should be made to obtain more practical engineer training—both for individuals and units. In particular more interest on a high level should be shown in making it possible for units to undertake work for civilian bodies.

(*f*) The problem of S.R. training needs careful consideration.

(*g*) The rules for the promotion of N.C.Os. must be reconsidered, otherwise many useful men may be lost to the Corps.

(*h*) A better balance must be obtained between the theoretical and practical training of officers.

(*i*) Research and development organization must have the services of the best officers available.

(*j*) Units must be realistically trained so that their morale may be unimpaired by the unpleasant realism, which the opening stages of a possible war are likely to bring. A high morale will only be obtained if units have complete confidence in themselves and their leaders.

98. Finally this paper has only set out to state what is considered possible now. The ideal target for when conditions become easier—the building of comprehensive training areas, the employment of more instructors, plant and man-power ; the dispatch, possibly to B.A.O.R., of complete regiments to gain experience in certain aspects of engineer training, the building of a new School of Military Engineering containing every modern facility for the study and and practice of military engineering—these are some of the things which must also be studied and planned. Although the present atmosphere of expediency is to be condemned as a state of permanent being, the time for these other things is not just yet.

ON THE RÔLE OF THE TECHNICAL STAFF OFFICER

By MAJOR K. STEWART, Ph.D., D.I.C., B.Sc., R.E.

MORALE is one of the all important imponderables of war, which Foch described[1] as those principles which senior officers seem always to understand and juniors never. However, since his time the subject has been extensively studied by psychologists[2] in all its aspects and is no longer the mystery it once appeared to be. An individual may be said to be of high morale when his standard of action remains on a high level under adverse conditions and this state of mind is attained by the knowledge that the organization of which he is a member is doing everything in its power for him. The response to rise to even greater heights can be obtained even when success of the operation is far from clear.

Before examining what influence on the maintenance and development of morale the technical staff officer can have, we must attempt to define him. A very narrow and far from true definition would be an officer who has completed a specified type of course. However, this definition is clearly unsatisfactory. In general, he is the officer who possesses a sound scientific and technical background and a thorough knowledge of the rôle of the army in a war involving the whole nation. It follows that if he is to be sound and experienced in his technical and scientific knowledge then he must continually apply himself to its study. He will not be therefore, and cannot be expected to be, as experienced in regimental duty as the officer who devotes his service to this, although he may be equally sound in the knowledge and application of the principles of man management and of war. As all staff officers, he must understand the structure of the army and be a willing and efficient instrument in the fulfilment of his commander's plans.

It can safely be said that armies from earliest history have included technicians of one kind and another. It should be noted also that the great captains of history were not only masters of the art, but also the science, of war. For example, one reason why the Mongol cavalry of Genghiz Khan and his successors was so much more successful than that of the earlier nomadic horsemen was their use of stirrups.[3] At a later period we find Marlborough preferred the sabre to the inaccurate horse pistol for the cavalry weapon.[4]

[1] Principles of War.
[2] E.g. see *The Structure of Morale* by J. T. MacCurdy and *Morale in Battle: Analysis* by Field-Marshal Montgomery.
[3] *Genghiz Khan* by C. C. Chapman.
[4] *Marlborough—His Life and Times* by W. S. Churchill.

The two world wars have seen the rise in importance of science, so that in the near future it will assume paramountcy. It seems clear that the next world war will be between the democracies of the West and the U.S.S.R. For although both would avoid it, the inexorable doctrine of communism allows no escape, unless we forsake our principles. In such a conflict the West possesses an advantage in science, technology and industry, but this advantage is not great enough to overcome the mass of the Russian and satellite peoples unless employed to greatest advantage. The very knowledge that the officer corps of the army is being thoroughly grounded in science, technology and the potentialities and limitations of industry will heighten the morale of the civilian soldier to be. That we shall have the chance to defend successfully our freedom by forethought and application of scientific discovery, not at the time of the onslaught, but now, is a sobering thought indeed.

From the two definitions given above it is clear that, as science and technology have wrought such immense changes in the battlefield, which for example is now three dimensional, the technical staff officer has become essential and must play his part in the maintenance and development of morale. In discussing the rôle of the technical staff officer *vis-à-vis* morale in detail I shall assume that he possesses sound knowledge and experience of one, or more, of the sciences, with its technical application, and of the army; is not a pure research scientist nor primarily a troop officer, but one who understands the problems of both. First let us consider conventional armaments and equipment currently in service use. He will understand their limitations and the extent to which they can be employed for special tasks outside their prime rôle. From this knowledge, and by working with the troops using such weapons and equipment, he will be able to visualize those changes which are necessary and practicable to increase the over-all usefulness of the item and satisfy the commander's tactical development, and be able to pass this information to the scientists so that they can understand the soldier's needs better and for their own part explain such limitations as science imposes. The realization of this progress will be by the technical staff officer's ability to think, speak and write in both the language of the soldier and of the scientist. Ultimately the soldier using the weapon or piece of equipment will know he is armed with the finest material his country can produce. This knowledge will produce confidence and high morale. In order to achieve this it is clear that the technical staff officer must divide his time between the research and development organization and the field of battle—the latter is not identical with regimental soldiering. Much useful information will come from the private and N.C.O. and these will be accessible normally to the technical staff officer, provided the unit commander appreciates his rôle and virtue. It is clear too that the technical staff officer while being a diplomat will also have to be something of a psychologist so that he can really understand individuals at all levels. Thus the unit commander's viewpoint on a certain weapon or item of equipment will be his own, modified to a greater or lesser extent by the opinions of his subordinates and as a first approximation should provide a reasonable solution. However, it is common knowledge that unit commanders' reports and opinions on weapons and equipment are frequently at variance to an extraordinary extent, showing the existence of faults, such as prejudice and lack of understanding of real purpose. The technical staff officer must be able to weigh and assess these various reports and together with his own considerations formulate the changes which are really needed.

From his first rôle of progressing already accepted as standard items along the road to perfection or oblivion, we pass to that of studying the weapons and equipment of other nations. In time of war enemy material will require particular study ; in peace-time that of potential enemies. This study will go clearly beyond the straightforward intelligence task of description and salient features to ways and means of nullifying or reducing the value of such weapons and equipment to the enemy. Good features can be adopted, modified as necessary, by ourselves : the technical staff officer being well qualified to point out the merits, as the soldier sees them, to the scientist.

Arising logically out of these two current and continuous tasks will be the design and development of new weapons. In this function the scientifically and technically trained officer will clearly have to be well versed in, if not a master of, tactics and possibly, strategy. He will certainly have to possess rank, personality and the ability so to understand the soldiers and technicians that he can overcome the inertia natural in men amongst well-established tools. In this field particularly it must be realized that in general a man will only be able to be productive in one science (remembering, of course, that the boundaries between the sciences are becoming less distinct) with the associated engineering. I pointed out earlier that the technical staff officer must be familiar with the field of battle and with the reactions and outlook of troops. In order that they shall be able to contribute effectively to the development of new material and tactics, it is suggested that those who demonstrate the possession of originality of thought and constructive ability should serve their periods of regimental duty in a particular way. The way would be for them to serve for suitable periods (say six months), with units of the different arms, studying the application of particular scientific or technical fields to the operations these units would perform. The adoption of a plan of this kind and its publication throughout the service would, in fact, of itself strengthen the morale of all ranks a great deal, for it would be widely realized that weapon and equipment development was really being carried out within units as well as in special establishments.

So far I have considered only conventional armaments using the United Nations nomenclature. The problems of the weapons of mass destruction and morale demand a very intensive study and for this purpose a group of specially trained scientist-soldiers are required. They may have to operate in territory which has been subjected to attack by atomic weapons or to suffer attack themselves. One example will serve to show the immense bearing on morale these particular weapons will possess. The command decision as to whether or not rescue troops shall be sent into an area contaminated with radiological material, and for how long, will require competent staff advice, if it is not indeed a case where the decision should be made by the scientist-soldier only.

Discussing the rôle of the technical staff officer in the maintenance and development of the morale of the soldier it has become clear that he must be a rather special type of individual. His appreciation of war on the battlefield must be sound, he must be well grounded in science, technology and engineering, with specialization in one subject, and he must be able to think, speak and write in both the language of the soldier and of the scientist and technician. Without specialization, involving possibly research or development experience, his knowledge will enable him to understand, but not to produce. I would prefer to name this species the scientist-soldier and from their number the supreme commanders, logisticians and planners of future wars will come. They should therefore be given select instruction in the art of command, and albeit tested thoroughly, but pardoned the tedium of extensive regimental soldiering, particularly in peace time. Remembering that the armies which fight wars are national armies of civilians rapidly trained, with a hard core of regulars, it is clear that the morale of these forces will be the greater if they know that their commanders are masters in the design of weapons and equipment and have been responsible for much of the progress made during the years between. Indeed it appears to me that, although the scientist-soldiers certainly must not be a race apart, they should form a corps d'élite and, in the greater plan, come from all three Services to form a special group or division under the Minister of Defence. I have suggested this scheme because the alternative of distributing the technically trained staff officer throughout the army, in the same way as the conventional staff officer, will result in individuals being able to contribute so very little to the development of new weapons and equipment because of full-time occupation with the usual chores of the unit officer. There is no danger in a sound scientist-soldier losing contact with troops and becoming a race apart, because by definition he is employing science to forge the sword of victory ; which victory is gained through the common soldier.

Having dreamed dreams, so to speak, of the possible future for the scientist-soldier it is essential as well to write briefly on his own morale under cold reality. His morale will fall if at any time it appears he is less likely to gain command or promotion than the normal staff officer or regimental officer. In order that he may perform his rôle to best advantage, command and rank are essential. Unless an officer can be sure he is being employed to the best advantage in accordance with his training he will feel his time is wasted.

In conclusion it may be said that the scientist-soldier can bring about the critical increase in the power of the army, enabling it to wage war successfully, which knowledge properly disseminated will raise the morale not only of the regular soldier but of the nation. However, in order that he may fulfil this rôle successfully his own morale must be high and this can only be realized by a proper acknowledgement of his value by his position within the structure of the army command.

CIVIL AND MILITARY ENGINEERS

By " Anonymous "

On the " Long Civil Engineering " course Sapper officers are now being given the opportunity to work on civil engineering projects alongside their civilian contemporaries, both on the site with contracting firms and on the design in consultants' offices. It is an exceptional opportunity for helping the civilian and military engineer to understand each other's problems and idiosyncrasies, besides giving the soldier the chance to add to his knowledge and experience in the considerably wider and more experienced civil field.

This article attempts to make some comparison between civil and military engineering, both in their practices and their own problems. As regards military engineering, the emphasis has been made on war-time work where the degree of control, both financial and technical, is, due to circumstances, considerably more haphazard than in peace. Peace-time military engineering follows fairly closely civilian practice, apart from the added stifling effects to be found in any large bureaucratic organization.

From my own somewhat limited experience I found on many occasions in the last war difficulty in appreciating the attitude of mind of the uniformed civil engineer. There is no doubt that many of them reciprocated this misunderstanding, possibly from preconceived prejudiced notions that they were also " Real Engineers " as well as " Royal Engineers." We all, both soldiers and civilians, must now appreciate that in times of national emergency our two dissimilar spheres of work are complementary towards the whole war effort. In addition, the military sphere will have to be considerably augmented by enlisting into the Army civilian engineers, who will have to adjust their style and learn to approach engineering problems with fundamentally different ideas.

Basically the civil engineer is primarily interested in costs and permanency, whereas the military engineer is chiefly concerned with time and works that are really only semi-permanent. The airfields, the harbours, the bridges, etc., of the last war " had " to be completed by a fixed date if operations were to succeed, yet how many of these works are still now in use?

This implies that the civilian has more time in which to prepare his plans in detail, his method of executing the work and also to organize his equipment and stores, whereas the soldier more often has to produce a workable solution without the same degree of leisure and usually accompanied by a fair amount of improvisation. On the other hand the soldier, in war-time, is not continually hamstrung by costs. The design, scope and execution of military projects are almost entirely dictated by the availability of labour, plant and stores, and the soldier does not have to consider every item of his work from the costs side with the spectre of financial loss, if not bankruptcy, forever looming over him. Even in peace-time the soldier does not bear such intimate connexions with the financial gain or loss, and only his reputation, and neither his purse nor his job, is at stake.

These fundamental differences produce many anomalies which are not always appreciated by both sides. The civil engineer in particular is often inclined to disregard the peculiarities of military engineering, especially that vital element of time. He will recount tales of military incompetence and waste that he saw in the last war, forgetting the " time " factor and also what a large preponderance of war-time Sappers came from his element. Similarly the methods and attitude of the uniformed civilian has often appeared at variance to the soldier, especially his apparent lack of personal responsibility and his inability to take complete charge and to organize his work on the lines we have been taught in the Army.

Let us therefore consider how a civil engineering project is organized and executed. There are three main parties involved ; the promoter or user, who pays for the work and more often does not understand the technicalities and is only concerned with the ultimate costs and the completion date ; the consulting engineer, who designs and supervises the construction on behalf of his client, the promoter ; and lastly we have the contractor who carries out the work.

The scheme is initiated by the promoter, who will engage a consultant, usually one specialized and experienced in the type of work involved. The consultant " sells " his ideas to his client and eventually a definite plan emerges, from which detailed drawings, specification and a bill of quantities are prepared. The specification will detail the standard of work and of materials, and also any tests. The bill merely lists the different items of work with an approximate quantity for each.

Contractors are then asked to tender, quoting rates of payment for the items on the bill, and eventually a contract is signed with one of the tenderers for the execution of the work. There are of course variations in the method of both placing contracts and paying for the work, such as nominated contractors and payment on a cost-plus basis, but in general the procedure outlined above is followed and is very similar to that in our own Works Services in peace-time.

The contractor, when preparing his tender and rates, will sketch for his own benefit an outline plan as to how he intends to undertake the work in order to make up his prices for the different items of work. He will consider alternative methods of carrying out the various tasks and stages in construction, the prices of materials and the cost of plant. His yardstick is costs, as his survival in business rests entirely on his ability to show a profit.

On large schemes several separate contracts may be given out, and even more than one consultant employed by the promoter, each handling a separate portion of the scheme.

On the design side in the consultant's office, it is interesting to see the amount of thought and detailed preparation that goes into a project. The actual design, that is the calculating and drawing, occupies a small percentage of the effort, the bulk of which goes on site investigation—surveys, borings, soil analysis, etc.—and on investigating a mass of administrative problems, ranging from the availability of materials and the elucidation of the promoter's exact requirements to the negotiating of Parliamentary Bills and the settling of private disputes. Fortunately we soldiers are spared most of these problems, certainly in war-time with our large powers of requisition. The civilian designer must also pay particular attention to the permanency of the work and to the avoidance of future trouble due to flaws in the design or construction, to litigation and also excessive maintenance.

All this work occupies considerable time and effort whilst each point is thrashed out in detail and all the pros and cons carefully considered. There is almost a complete absence of urgency and there is none of the military "bash on" attitude. The scheme slowly follows a long period of indeterminate gestation, which no one seems prepared to interrupt in case it might prejudice the birth and success of the perfect solution. To watch the days spent plotting surveys, abstracting quantities and the fruitless efforts spent arguing over some triviality is all very irksome to the military trained engineer, who has been taught to regard time as such a vital factor.

On being awarded the contract, the contractor becomes responsible for producing the work according to the consultant's design and up to the standard laid down in the contract documents. He will appoint an agent to supervise the work at site, assisted by a staff of engineers, foremen and chargehands.

The consultant will similarly appoint a resident engineer, with a staff of engineers and inspectors, who will remain on site to see that the work is correctly carried out and also to liaise with the contractor's agent. The resident engineer is also responsible for measuring the work done and for passing the monthly certificates on which the contractor receives advanced payments for completed work. The consultant's fee from the promoter is usually based on a percentage of the cost of the work.

The term engineer applies to persons qualified technically in engineering, usually a degree or diploma and later on associate membership of the Institution of Civil Engineers. Their position *vis-à-vis* the Army is that of officer. In addition there will be "learner" engineers, such as students on vacations from universities and articled pupils under agreement. The foremen and inspectors are promoted tradesmen, corresponding to Warrant Officers and senior N.C.Os., and the chargehands are equivalent to junior N.C.Os.

As soon as the contract has been placed, the contractor starts his detailed planning of how he intends to carry out the work with the equipment and plant that he has available or which he can obtain. A considerable amount of this work will have already been done when the contractor was estimating his rates for his tender, since obviously the cost of the various items of work will be largely dependent on how they are carried out. The type of work that contractors can undertake and their method of execution largely depends on their resources of plant, so that at this stage the contractor may ask for modifications to the design to suit his plans. The principal point here is that before any work is attempted on the ground, the contractor is in most cases in possession of complete drawings of what is required and he has also prepared a fairly comprehensive scheme for executing the work. There are of course exceptions to this and sometimes the contractor is asked to commence work before all the drawings are ready and even before the contract has been signed, though these exceptions, like the war-time costs-plus contracts, provide loopholes for extra payments. Such exceptions of course rely on the goodwill and understanding between consultant and contractor and probably a financial risk on the part of the promoter, as it may not be possible to estimate the final costs.

In comparison the military engineer more often starts work with a somewhat vague directive of the final requirement and invariably with little time and poor facilities to prepare a comprehensive plan. Site investigation by civilian standards will be undoubtedly sketchy. His work must therefore be more of an improvisation carried out with inadequate resources and often by a non-specialist and more often comparatively inexperienced staff. Planning and construction so often run concurrently and under the same head, whereas in civil life they are invariably separate responsibilities.

In the past the two spheres of engineering, consulting and contracting, were somewhat antagonistically disposed towards one another, the former regarding themselves as a *corps-élite* and their opposites as a gang of roughnecks, more interested in making money than in engineering or even producing good work. To a certain extent this was true in the last century when contractors were generally men of lesser education and refinement, but times have changed and the Institution of Civil Engineers now acknowledges and accepts contractors as " engineers." The present day trend for very detailed specification of work no doubt dates back to the days of sharp practices amongst the older type of contractors during the time of the rapid industrial expansion in the last century, when large works, notably the railways, had to be undertaken under inadequate supervision.

The actual constructional work on the site is almost entirely carried out under the contractor's foremen, one to each type of work—carpenters, fitters, steel erectors, etc. A general foreman coordinates the work of these foremen and he in turn comes directly under the agent, or on large works under a sub-agent. It is here that we encounter a big divergence from military practice. In the Army, the organization is forced by circumstances to be decentralized down a well defined chain of command, whereas in civil life the organization is centralized in the interests of efficiency and economy. In other words an O.C. puts his officers in sole charge of different sections of the work and they in turn subdivide the work to their subordinates, giving to each the necessary men by trades together with plant and stores. In civilian practice the different trades work independently under their own foremen and the engineers are employed mostly on setting-out, site design and measurement of completed work, with little executive authority over the men. For example, a section of work such as a concrete foundation would in the Army be the personal responsibility of one Officer or N.C.O. but in civil life the work would be set out by an engineer, then the carpenters, the steel-fixers and the concrete gang would all work in turn each under their own foremen, who at the same time would be supervising other parties scattered all over the site.

There is therefore no well-defined chain of command as we know it in the Army, nor are the engineers so completely responsible for work to the same extent as their officer counterpart. In fact there exist two parallel organizations, one technical through the engineers and the other executive through the foremen.

The foremen and the higher skilled tradesmen are, in general, contractor's men who have worked for many years with the same firm. They are therefore of proved worthiness, proficient and well experienced in their type of work to a degree to which the military tradesmen never has the opportunity to aspire. They are best left alone on the work instead of being bossed by young and inexperienced engineers.

The less skilled men and the unskilled will most probably be locally engaged and their standard varies enormously. Some are good, some indifferent and some just disinterested, regarding their job as a means of "winning" their pay with as little effort as possible. But the soldier, though he may lack the same skill and experience, can at least be compelled to work under discipline to an extent not possible with the civilian, who can, and nowadays all too frequently, demand his "cards" over the slightest pretext. The result is that the civil engineer can impose more reliance on his skilled men, but cannot be too firm with the more recalcitrant staff. In other words he cannot always take charge in the true military sense.

He tends too to treat the men as another piece of equipment, there just to be applied to work, and provided they work, all is well. Man management as applied in the Army tends to be neglected and often is almost non-existent. There is not much attempt to foster morale or interest in the work, or to develop a man's enthusiasm or sense of responsibility. Men are shifted from one job to another at a moment's notice without completing the first, warned for overtime or late work at the last moment and too often they work to a variety of hazy orders from foremen, engineers and others. On the other hand, considering the independence of spirit of the labourer, whose attendance at work sometimes resembles a voluntary fatigue parade, it is difficult to see how the military system could be made to function successfully. But the soldier must appreciate, when making these comparisons, the very powerful advantages he has with his backing of discipline and powers of compulsion.

On the other hand, the civil engineer is not involved to the same extent over problems of welfare and administration. True, that in many cases, such as hydro-electric projects in the Highlands of Scotland, he has to build and run camps for his labour, but rarely does the problem assume the same magnitude as in the Army, where men are forced to live in uncomfortable, monotonous and probably dangerous conditions for an indefinite period without relief and without the privilege of departing when they so feel. In the one case the object of administration is to attract men to the work and to humour them into staying, whereas in the other it is a problem of improvising an organization to keep men physically and mentally in good condition. The result is that the civil engineer does a minimum of administration, usually employing a specialist, but the military engineer officer becomes involved in a mass of administration to the detriment of his engineering.

I feel that in the past both sides have tended at times to underrate the worth of the other, yet failing to understand each other's problems. We as military engineers are perforced by our lack of opportunity during peace-time to be less skilled and less experienced than our civilian contemporaries. It is up to us, therefore, to impress our point of view on engineers outside the Army in order to be ready, should the time come again, for the military mobilization of the country's engineering resources, for the more rapid and more peaceful integration of civilian and military engineering, both within the uniformed ranks of the Army and outside. We soldiers will have to dictate our requirements and be able to exercise a general supervision of the engineering work of our civilian counterpart both in uniform and in mufti. To achieve this successfully, and with the least friction, both sides must appreciate each other's points of view and "speak the same language."

Footnote by D. F. W. :—"This article refers almost entirely to the work of engineers in war. It should not be forgotten that in peace-time the Corps runs a large building programme in permanent construction, perhaps larger than that of any other single corporate organization. The work involved in the planning and execution of this programme bears a close resemblance to the work of the Civil Engineer."

THE UNIVERSITIES AND THE ARMY

By Colonel D. Portway, T.D., D.L., J.P., A.M.I.C.E.

Chairman Cambridge University Board of Military Studies

IT is a commonplace that the ever-growing complication of modern warfare, embracing almost every branch of science ranging from psychology to nuclear energy, makes the closest co-operation between the Universities and the Armed Forces a matter of considerable importance. It is therefore a very unhappy fact that, in some respects at least, such contacts between the Universities of Great Britain and the Army have rarely been less. Certain Senior Staff Officers at the War Office have shown much concern at this and, while it is not easy to attribute blame, the realization of a fault is surely the first step towards its eradication.

The writer of this article can only claim close and detailed knowledge of the circumstances of one University—that of Cambridge—but he has reason to think that the circumstances in other Universities are very comparable.

The most direct contact between the Universities and the Army has always existed through the agency of the Varsity Training Corps, although in the past the inclusion of Military Studies in some Universities, as part of the Ordinary Degree Course, has not been without importance.

The University Training Corps in their modern form owe their inception to Lord Haldane ; they began in 1907 and flourished in a somewhat crude and loose organization until the 1914–18 War proved their worth in the thousands of already partly trained officers they gave to the Army. During that war they were of limited importance, but as soon as the war was over the contingents were reconstituted in very much their pre-war form, being officered by young dons who had had considerable active service experience. Right through the 'twenties and 'thirties these units, although militarily not very impressive and hopelessly starved of equipment, continued their useful work, their morale being of the highest. Graduate officers were numerous and they were naturally in close contact with undergraduates who were encouraged in scores of cases to take Regular commissions.

Yet another useful purpose was served by a considerable degree of "back-room boy" activity. At Cambridge, for example, an Inglis Bridge (made entirely at private expense) was in use almost unknown to the Army some years before 1914, and in between the two wars a hand-made "walkie-talkie" was in use in the Signal Company long before it was developed in the Regular Army. Many of the graduate officers of this one University alone were men who had made a considerable reputation in science, in scholarship or in administration. Amongst their number have been two Professors of Engineering, the present Head of the Canadian Atomic Energy project, a scientist whose name has been given to a layer of the stratosphere, a Deputy Scientific Adviser to the War Office, several pioneers in Radar and a well-known Vice-Chancellor of a large modern University. Surely such men have been of the utmost value to the Army, and other Universities can no doubt produce similar lists. The fact that practically all Regular R.E. officers and many Royal Signals officers graduated at Cambridge between the two wars, and many are doing so now, provides another reason for the closest of contacts between University and Army.

During the 1939–45 War the University Training Corps was taken very seriously by the War Office. In the larger Universities the contingents were often commanded by Regular officers, and the number of cadets was very great. When the war ended they came back on to a voluntary basis and numbers became very small. Neither for the ex-serviceman, who had had quite enough of soldiering, nor for the deferred man, who had, in any case, to do his full National Service training, was there much appeal. The War Office continued to provide enough Officers and N.C.Os. to run these cadres and the years have gone by without the graduate officer being in any way interested. At Cambridge for the last few years there has been no "don" in the contingent, and the old tradition of military service by University lecturers and College Fellows has completely disappeared.

How this tradition of service in the permanent staff of the University is to be restored is one of the many problems. A small percentage of men is usually to be found in any large organization who find a genuine fascination in amateur soldiering, and the writer of this article has cashed in on this in getting from the University two or three of his best officers in the Army Cadet Force, in which he serves as County Commandant. The best hope is probably that some National Service officers will be appointed to Fellowships and Lectureships and will restore the old tradition. To the Regular Staff of officers the urgency of this need may not be so obvious because the Training Corps in its reduced numbers is "ticking over" at present, but no activity in any University is likely to flourish under the guidance of a small band of migrant outsiders.

Some years after the end of the war the University avenue to Regular Army commissions was renewed. The Army was a good deal behind the R.A.F. in this move, and conditions, as at first enunciated, were far from satisfactory from the University standpoint. Changes since made have put the Varsity candidate roughly on a level with the Sandhurst graduate, though the latter now gets his pre-commission education paid for by the State, which may or may not be the case with the University man. It is a regrettable fact that applicants of a suitable type have been far from numerous ; it is likely that the type of man who, in the old days, became " bitten with the military bug " at the Varsity now tends to get this very desirable infection during the time of his National Service and therefore does not come to the University at all. Moreover, the graduate officer in the U.T.C. is now no longer an ambassador for the Army.

The technical arms, which are the very branches that would benefit so much from the admission of the better type of honours man, now get virtually no one from the University. Graduates in Engineering in particular, are very much wanted in civil life and the supply is less than the demand, while the virtual removal of technical pay in the Army has killed any financial inducement. It seems very unlikely that R.E., Royal Signals or R.E.M.E. will attract undergraduates under present circumstances, but conditions of pay and prospects in the R.A.E.C. are so much better than those in secondary schools that this Corps should provide considerable inducements for the budding schoolmaster.

The future of the Training Corps at all British Universities is much tied up with the alternative possibilities of the student undergoing National Service training before or after his University course. The Scottish and the modern English Universities receive their intakes, in general, at an earlier age than Oxford and Cambridge, and most of their undergraduates come into residence before joining the Army. At present these men have very little inducement to join the U.T.C. as they get no sort of allowance for doing this, although certain privileges are available for the successful Certificate "A" candidate and the boy who has not gained this at school has then the opportunity of doing so at the University. It is not too much to say that the whole success of the U.T.C. depends on some allowance being made for U.T.C. training by the deferred National Service man. At Oxford and Cambridge, the trend is now in the same direction, although the undergraduate who comes straight from school is still in the minority.

It is quite impossible to lay down the law as to the better of these two alternatives. The boy who joins the Army from school and passes his W.O.S.B. and O.C.T.U. leaves the Army a much improved person, but all too many regard military service as a necessary evil. Such lads tend to waste two years of the most formative period of their lives as Orderly Room clerks or as junior N.C.Os. in the R.A.E.C. This type steadily deteriorates, and they come to the Varsity definitely the worse for their period of service.

It is of the utmost importance, both to the Army and to the boy himself, that the very best advice should be provided as regards deferment and with respect to choice of Arm some time before he joins up. Even in the best call-up conditions, it is almost inevitable that a necessarily hasty decision by a Personnel Selection Officer will often result in much waste of potential officer material.

The writer of this article is impressed with the degree of care and attention that is given to these matters by the various personnel Directorates, but, until there is a much closer liaison than exists at present between the Universities and the Services, the number of cases of mishandling is likely to be all too large. This waste of officer material is one that the country cannot afford, and any steps that can be taken to improve conditions in this respect are well worth trying.

DIVISIONAL ENGINEERS WILL SUPPORT THE ADVANCE.

By COLONEL R. N. FOSTER, D.S.O., O.B.E.

ONE frequently reads accounts of engineer operations, which are depicted as growing in the rough out of an intention and a plan, being polished by recce, preparation and provision of the necessary labour, equipment, tools, stores and transport, and finally exhibited in execution as little individual gems, complete and detached in themselves for the critics of the future to analyse.

At the time, however, they followed previous actions and were immediately succeeded by further plans, of which some became little gems and were added to the necklace, others showed faults and were discarded.

The following reminiscences of the C.R.E. of 49 (W.R.) Infantry Division seem to be linked up as one necklace, and aim at giving an idea of the typical day to day employment of Divisional Engineers when supporting a division in the pursuit rôle.

The sequence of events described occurred after the capture of Le Havre in September, 1944, in which 49 Infantry Division took a major part, and follows the rapid advance of the division acting as right flank guard of the Canadian Corps in its sweep up the coast from Antwerp to the mouth of the Rhine, which was reached in the first week in November.

It divides itself naturally into five phases :—

1. The advance from the Escaut Canal to capture the Turnhout-Antwerp Canal.
2. A period of consolidation and improvement of the position gained, and planning for the future operations.
3. The advance to Rosendaal.
4. The capture of Rosendaal.
5. The advance over the River Mark to the south bank of the Hollandsche Diep, culminating in the capture of Willemstadt.

Phase 1.—The Escaut to the Turnhout Canal

On 22nd September, the 49 Division was arriving by brigades south of the Escaut Canal to take over from 7 Armoured Division after a long march up from Le Havre battle. On 23rd September, 147 Infantry Brigade were taking over from 131 Infantry Brigade when our programme was rudely accelerated by the enemy who slipped away. Recces were rushed to the canal, the Commander ordered an immediate advance—our bridging equipment was miles back, coming up with the Field Park Company. Military Police in red and yellow chequered jackets (signal for priority on the road), were sent roaring off on motor-cycles to bring up the bridging.

147 Brigade on the right advanced into Herenthals (see Map 1) and O.C. 756 Field Company who had been told he would get no equipment, improvised a Class 9 bridge by night, over a lock, using R.S.Js., which had been buried for years by the Belgians in their back gardens. He dealt with a crater in the main route in Herenthals by using a private entrance and drive on to the railway, pulling up some rails and getting 200 Infantry on to shovelling ballast into gaps between sleepers. This diversion enabled all the brigade transport to get through, until 240 Field Company (placed under our command from 1 Corps Troops) later built two Class 40 bridges on the arrival of the equipment.

On the left, 294 Field Company prepared the gap between the abutments at Massenhoven by nightfall. Since the Boche aircraft were busy at Arnhem, we rigged up electric-light stanchions and augmented the light with headlights of two jeeps and two 3-ton lorries. Some time after midnight the bridging arrived, after a gallop from Brussels, and a 110-ft. T/S Bailey was open by 0815 hrs. (see Photo. 1). The circus-like illumination was justified by the situation.

On 24th September we were up to the Turnhout Canal where the Divisional Commander intended to cross on the Ryckevorsel road (see Map 2). Recce disclosed a narrow gap at the lock, a mile to the east, so the plan was altered and the Lincolns put in a night attack, establishing a bridgehead by 0415 hrs. 757 Field Company had leap-frogged through 294 Company, and Lieutenant MacWatt had a busy night, on his stomach, clearing mustard pot mines from the cobbled approaches on the lock, while keeping his seat below the line of fire of our own Brens. We slipped over a 30-ft. S/S Bailey by 0615 hrs. and the bridgehead was secured. It rained a good deal at this time.

I believe the first Britisher to enter the cement factory over the canal was my covetous Field Park Company Commander, whom I met returning from placarding it with his unit signs. For the next two days we scrapped to evict the enemy, who had returned into the factory, but they left the signs in position when finally driven out and our enthusiastic Major got his desired site.

On 25th September the Royal Scots Fusiliers forced a crossing north of Turnhout, but were driven back.

On 26th September the original bridgehead was very firm and we put another bridge over the lock site to give two-way traffic, after an unfortunate moment when some enemy 88 mm. shells wounded the Chief Engineer (slightly), Major Brown, Lieutenant Pratt, a Sergeant and five Sappers, and killed three Sappers, while we were all looking at the bridge clearance job, which 757 Field Company were doing.

On 27th September the Gloucesters attacked south-west from Ryckevorsel, enabling a recce of the site on the Ryckevorsel road. That night 294 Field Company put up an 80-ft. D/S Bailey, after a ticklish job of clearing the wreckage of the old bridge by Wade charges and the use of winches and two R.E.M.E. recovery vehicles. Each bang of ours caused enemy shelling, but fortunately their registration was out by 50 yds.

The Polish Armoured Division now crossed into the bridgehead, which was duly expanded.

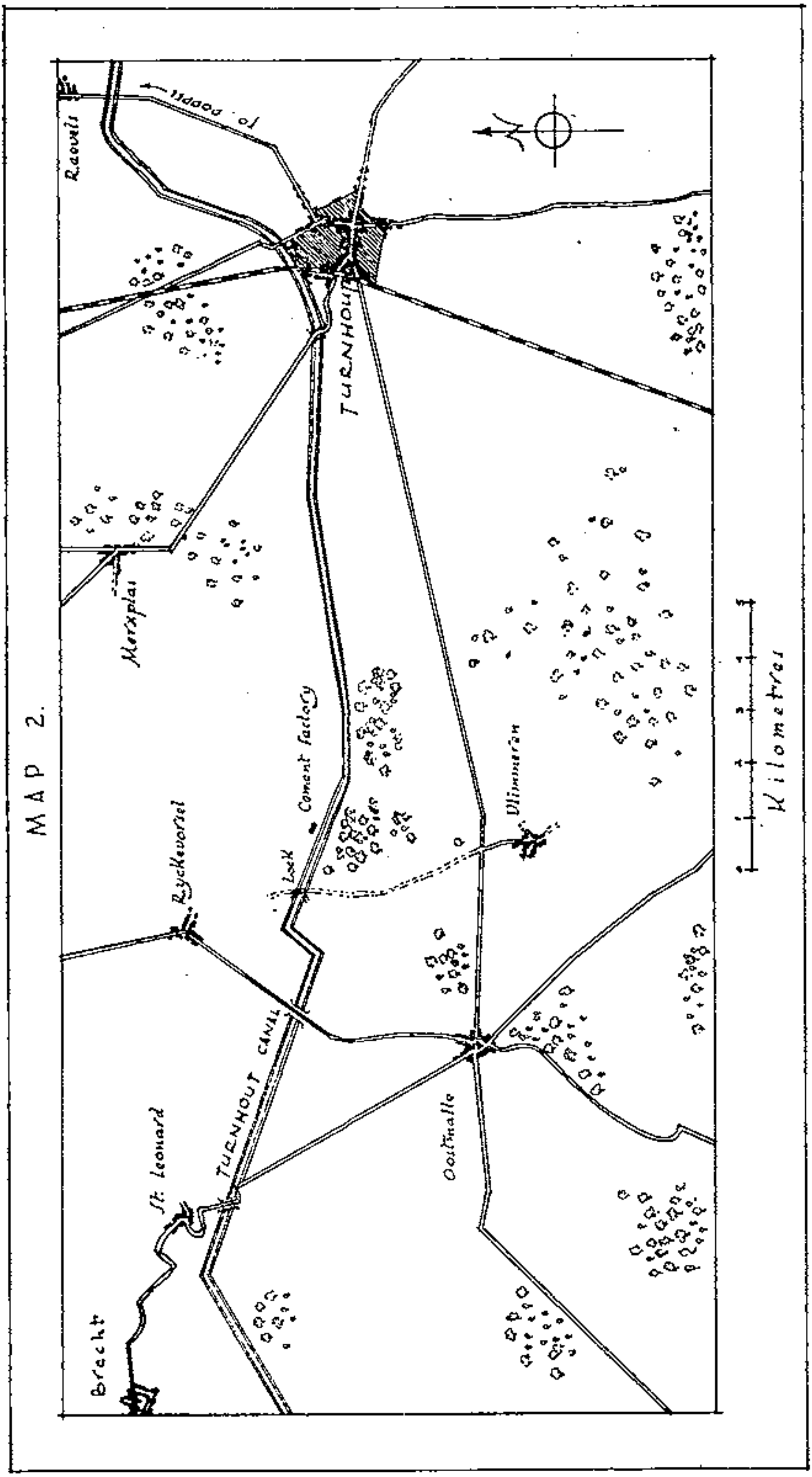
On 1st October, 756 Field Company built an 80-ft. D/S Bailey 2 miles west of Turnhout in six hours by night. 240 Field Company, of 1 Corps Troops, built a Class 9 F.B.E. bridge and 19 Field Company an 80-ft. D/S Bailey, north of Turnhout.

Thus finished all opposed crossings.

PHASE 2.—CONSOLIDATION

Now followed a period of road maintenance and mine clearance.

294 Field Company built a continuous 210-ft. T/S Bailey, supported on Bailey cribs, north of Turnhout, got the Belgians to relay their steam tramways over it and provided a road deck as well. This enabled us to run the "Polar Bear" Express, Poppel to Turnhout, on which troops from the forward area could get into Turnhout for an evening's relaxation.


To Poppel
TURNHOUT
Merxplas
Cement factory
Lock
Ryckevorsel
Vlimmeren
Kilometres
TURNHOUT CANAL
St. Leonard
Oostmalle
Brecht

MAP 2.

There was an incident when a booby trap party of 756 Company, in two half-tracks, missed our forward troops in the dark and bumped a German patrol on the road in no-man's-land. Their own fire caused impartial but concentrated mortar fire from both sides, who were a bit touchy at the time. All took to the road-side ditches. Two sappers found a German between them in their ditch and informed him that he was surrounded and a prisoner. He was nothing loath, and in good English stated that he intended to desert anyway and would be pleased to guide his captors back to their lines since they had obviously lost their way.

757 and 19 Field Companies were used as Infantry in a force centred on St. Leonard, since the divisional front was very extended. The sappers had one very successful ambush of the enemy in this area.

756 Field Company made an improvised mobile Bailey on transporter axles for use in a planned attack on Tilburg. Plans, however, changed and the division concentrated by 19th October round St. Leonard for " Operation Rebound."

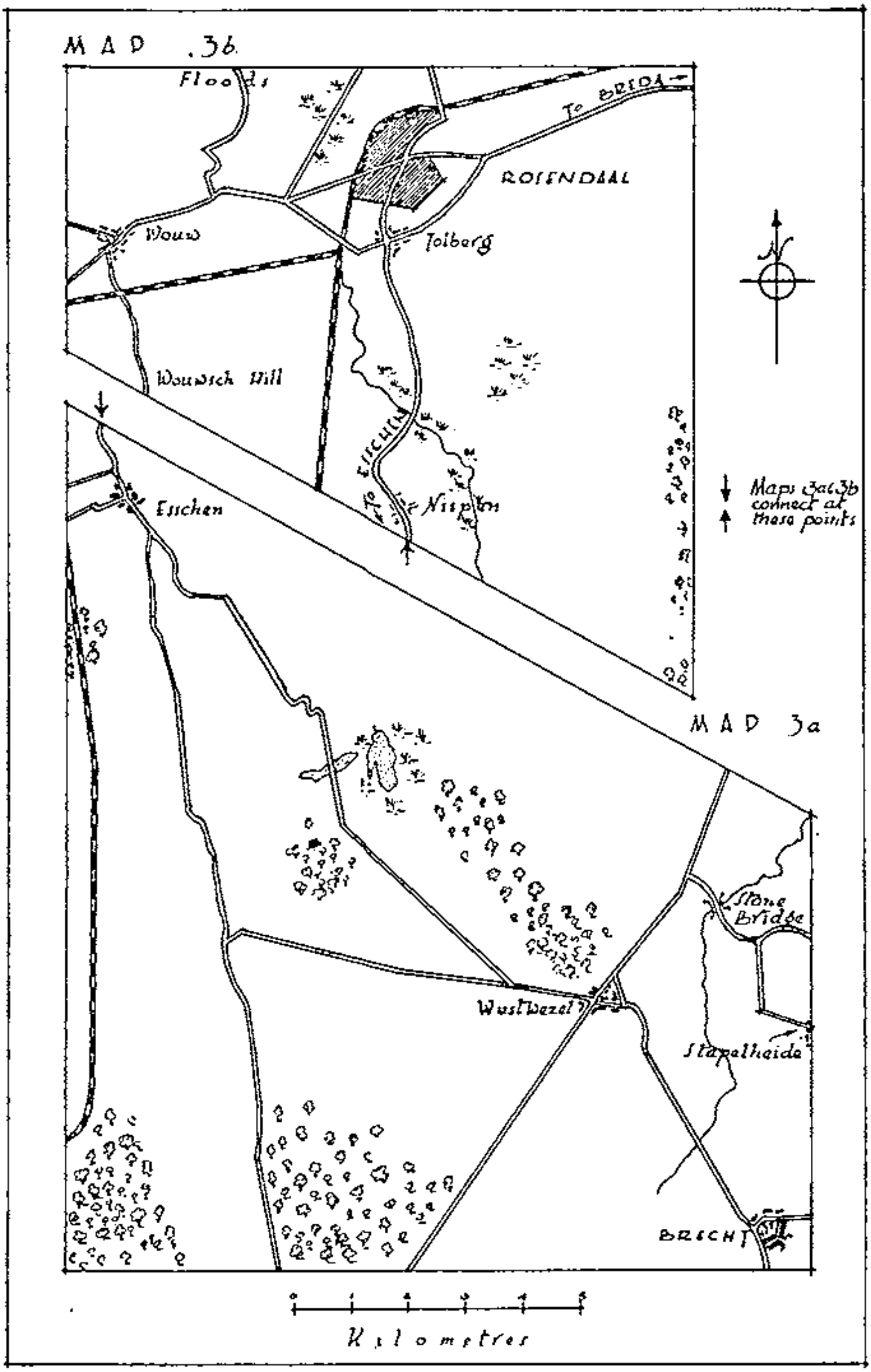
Phase 3.—Advance Towards Rosendaal " Operation Rebound "

The advance commenced on 20th October. 49 Division with 34 Tank Brigade under command, were flanking the Canadians' advance on our left and the 104 U.S. Infantry Division were put in on our right. The latter were held up more than we, so that we frequently had a long and exposed right flank.

The enemy were pushed back fast, but made good use of some thirty self-propelled guns, and a few infantry.

On 20th October, after 56 Brigade had captured Stapelheide (see Map 3a), " Clarkeforce," consisting of the 34 Tank Brigade, less one regiment and including the Divisional Recce Regiment, took Stone Bridge by 1630 hrs., swung left and took Wustwezel. Stone Bridge was partly blown and a platoon of 294 Field Company made it passable for one-way wheeled traffic and " deloused " it of thirty-one 50-kg. bombs.

756 Field Company in support of " Clarkeforce " provided a classic example of the correct use of the "Jumbo" bridge-layers. These were laid over gaps in the main road, offset so as to allow replacement by Bailey, while supported by tanks. The tanks then crossed, and Bailey or another bridge-layer was rushed to the next gap, depending on the enemy resistance. Meanwhile, Bailey was used to bridge the initial gap and the "Jumbo" recovered for future use.


MAP 3b
Floods
To BREDA
ROSENDAAL
Wouw
Tolberg
Wouwsch Hill
To ESSCHEN
Esschen
Nispen
Maps 3a & 3b connect at these points
MAP 3a
Stone Bridge
Wustwezel
Stapelheide
BRECHT
0 1 2 3 4 5
Kilometres

756 Field Company's tasks on the advance from Brecht to Esschen were as follows :—

20th October

A 40-ft. D/S Bailey, without endposts, was launched as S/S, with only one bay as nose and then doubled up in position.

21st October

(*a*) "Jumbo" laid to one side of the road for tanks. When a bridgehead was made, a 50-ft. D/S Bailey was constructed without endposts and the "Jumbo" recovered.

(*b*) Second "Jumbo" used. 40-ft. D/S Bailey, without end-posts, replaced it and "Jumbo" recovered.

22nd October

(*a*) A 40-ft. D/S Bailey was built within 1,000 yds. of the enemy in full view. In fact the Sappers were watched by one individual down the road, who later turned out to be a Boche with a Spandau. Luckily, like Ferdinand the Bull, "he did not want to fight."

(*b*) A 50-ft. D/S Bailey was built in even closer proximity to the enemy. Meanwhile Headquarters R.E. at Wustwezel had been shot up by an enemy S.P. gun at 300 yds. range supported by Infantry. The Command vehicle was smashed, Intelligence Officer wounded and his clerk killed. We shook out into a cabbage field to repel the Infantry, informed Divisional H.Q. of the menace and were much relieved to find a company of Hallams were just coming up to this position, when the S.P. gun withdrew.

23rd–27th October

294 Field Company built a double carriage-way Bailey to open the lateral road south-west of Wustwezel, and all companies then were employed in culverting small ditches to give access to the divisional positions centred on Esschen. Having little Chespale we started a Firpale factory, using 6 ft. by 3 in. diameter fir poles wired together, in anticipation of fascine work for the anti-tank ditches round Rosendaal.

Phase 4.—Attack on Rosendaal "Operation Thruster"

27th October.—To enable 34 Tank Brigade to deliver a left hook on Rosendaal, via Wouwsch Hill and Wouw (see map 3b), the anti-tank ditch near the former had to be crossed. This was dealt with by one armoured D.7 Bulldozer, operated by a stout-hearted Canadian, supported by tanks. Though exposed every time his machine tipped forward down the near bank and with bullets rattling round inside his cab, and wounded in one leg, he filled the ditch in daylight. He later limped back driving a posse of prisoners.

On this date also the recce officer from 757 Field Company, Lieutenant Johnston, an officer of the Royal Canadian Engineers, had an adventurous experience with "Clarkeforce." He set off early in the morning in his Humber recce car to act as engineer adviser to Brigadier Clark. When he returned in the evening and was talking to his Company Commander about what had happened, some difficulty was experienced in finding out exactly where he had been on the map. Johnston seemed to be fairly certain that he had got as far as Wouw, but his Company Commander claimed that this was quite impossible as the town was, as far as was known, still in enemy hands at that time.

However, events proved that this was quite true, as in fact the tanks of the leading regiment of "Clarkeforce" had occupied Wouw in face of very stiff opposition from German Infantry and anti-tank guns. Johnston in his Humber recce car had taken part with tanks of this regiment in a first-class battle.

29th October.—294 Field Company culverted the stream north of Nispen with armco, bulldozed spoil and put down a surface of Firpale. They then built a 60-ft. D/S Bailey on the road alignment.

147 Brigade was now engaged in bitter fighting for a bridgehead over the anti-tank ditch south of Rosendaal. After twenty-four hours of see-saw battle the Leicesters secured a bridgehead of 500 yds., north of Tolberg on 29th October. No. 1 Platoon 756 Field Company, under Lieutenant Higton, who was later awarded the M.C., worked under continuous mortar fire with an armoured D.7 dozer and pushed a house into the anti-tank ditch south-west of the town during the night. This enabled 147 Brigade to enter Rosendaal at the same time as our attack came in from the west. The enemy evacuated the town during the night.

We then divided the town into company sectors for clearance of formidable reinforced concrete road blocks, clearance of mines and improvement of communications generally. The country north of Rosendaal was inundated up to the River Mark, but since the cause of the trouble was damaged sluices, still in enemy hands to the west, we could only mark roads with poles in the verges where necessary.

Phase 5.—The Advance to the Hollandsche Diep "Operation Humid"

On 2nd November, the enemy were still just south of the River Mark (see Map 4).

The plan was for 104 U.S. Division to cross at Standaarbuiten. Here, in their first Class 40 bridging operation by night, they were shelled every time their engineers tried to bridge. In the morning they discovered three Boches, hidden in the abutments of the old bridge on the south bank, acting as F.O.O. with a wireless set—a hard lesson in mopping up!

49 Division were to cross opposite Barlaque and to take Steam Pump bridge intact if possible, also to take Stampersgat and bridge the River Mark there.

Most of the ground north of Oudgastel was inundated and the Sappers made several short improvised culverts and bridges to assist the approach to the river, using F.B.E. superstructure, kapok floats, bridges track 12 ft., poles and sleepers.

The Essex made a silent crossing in assault boats and secured Barlaque by midnight. A Recce officer of 294 Field Company nearly captured Steam Pump bridge by himself, as he lost his Infantry party in the dark and arrived first to find the Boche garrison in occupation. In a few minutes the Infantry turned up and captured the bridge intact.

The Gloucesters took the road junction half a mile east of Stampersgat, but could not get on much further.

On 3rd November the Gloucesters attacked Stampersgat, enabling 757 Field Company to do some quick bridging between 0315 and 0410 hrs., during which time a 70-ft. S/S Bailey and a 30-ft. S/S were erected. Flood poles were put up on the road running north from Oudgastel.

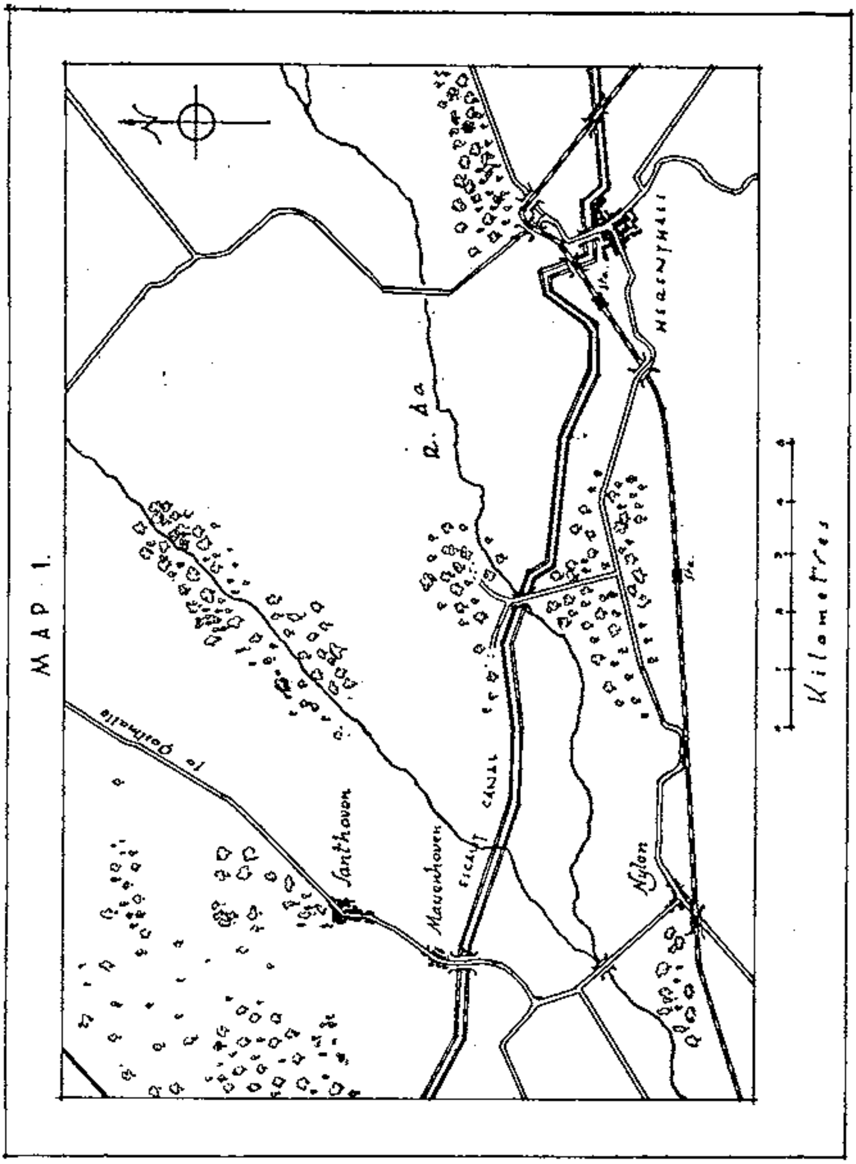
The South Wales Borderers had crossed the River Mark by assault boats and rafts, and by midnight 146 Brigade got up to Fijnaart.

On 24th November, 146 Brigade took Fijnaart and Klundert, while a platoon of 294 Field Company built a 40-ft. S/S Bailey. On the left, the Gloucesters crossed the Mark at Stampersgat and 756 Field Company built a 200-ft. Continuous Class 18 Bailey, cunningly supported on the remains of the skewed pier by use of timber and cribs. This bridge was completed at 0435 hrs., 5th November (see Photo. 2). Meanwhile, a platoon of 294 Company, under command of 756 Field Company, put up a 30-ft. S/S Bailey in one hour.

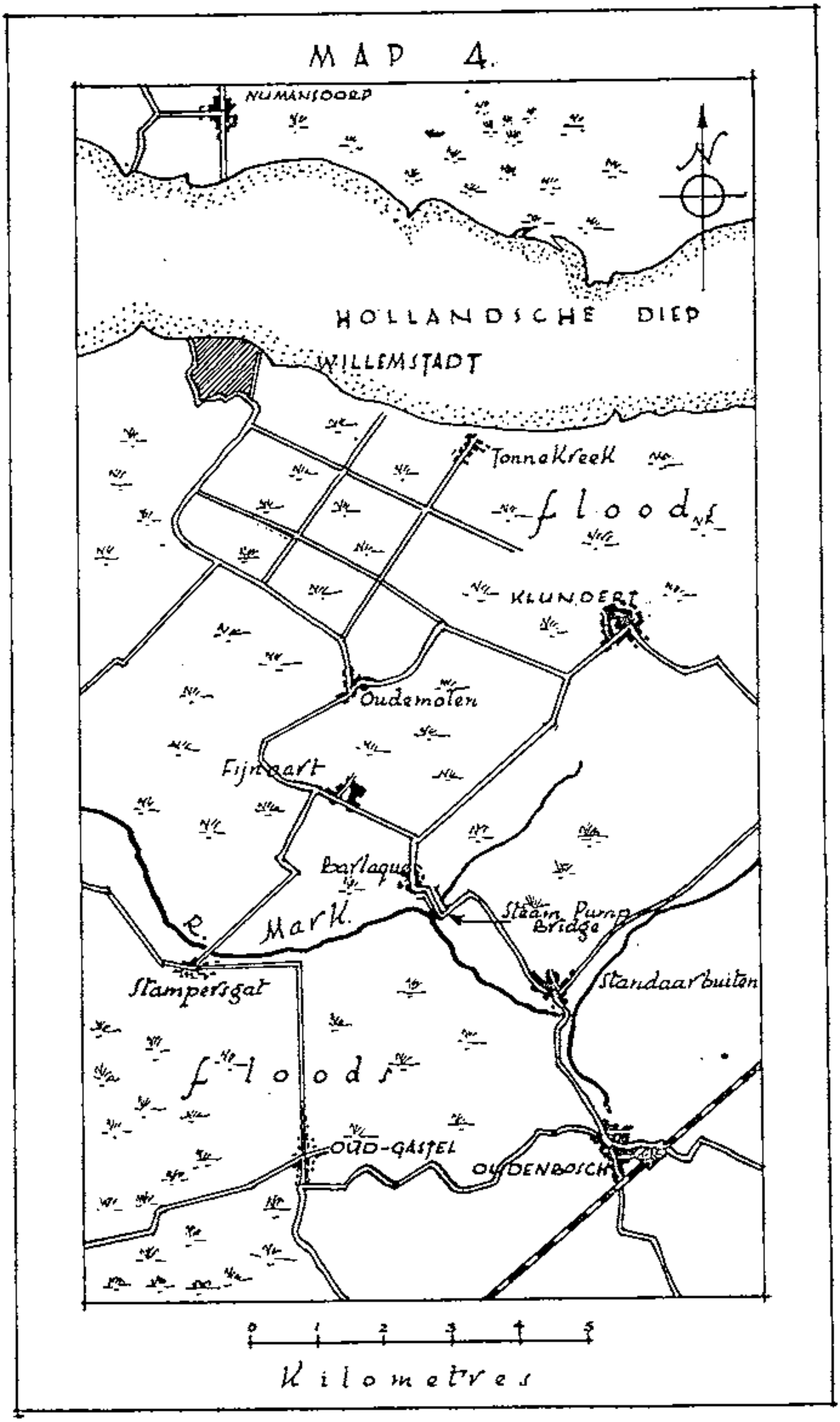
Operations north of the River Mark were very difficult, since the going was so bad that only the embanked roads could be used.

On 5th and 6th November, 146 Brigade was strongly counter-attacked at Oudemolen, but the enemy withdrew and the Lincolns went through to occupy Tonnekreek and on the night 5th/6th November reached the outskirts of Willemstadt. 294 Field Company, in support, had completed a causeway over a crater and were clearing mines round Klundert.

Willemstadt was a regular moated fort surrounded with a wide deep ditch, filled with water.



MAP 1.


MAP 4.
NUMANSOORD
HOLLANDSCHE DIEP
WILLEMSTADT
TonneKreek
flood
KLUNDERT
Oudemolen
Fijnaart
Barlaque
R. Mark
Steam Pump
Bridge
Standaarbuiten
Stampersgat
floods
OUD-GASTEL
OUDENBOSCH
0 1 2 3 4 5
Kilometres

Preparations had been made for Kapok bridge crossings under fire and a full scale attack, but when this went in at 0200 hrs. 7th November, the Boche had made a well organized escape. The platoon of 294 Company had a task of clearing prepared demolition charges from the church tower and the jetties to the north. They searched for booby traps, made a 7-ft. route for Jeep entry from the west and filled a huge crater to make a permanent entry route from the east.

Away to the north-east the great Moerdijk bridges were blown and we were faced with an expanse of water.

After a short period of work on communications and attempts to reduce the floods, the division was called away to join 12 Corps near Weert and so ended our gallop with the Canadians.

Conclusion

I have omitted much in this story. Even the bridge construction has been reduced to accounts of only those bridges we needed for the forwarding of our own troops.

There is no moral and the lessons to be drawn are not new. Whether the fighting troops are active or at rest the Sappers are always busy. Yet we found that in this period there was never a day when a minimum reserve of two platoons who had had a night's rest could not be produced.

Intelligent anticipation and the spirit of getting on with the job by all ranks makes the running of Divisional Engineers a happy job.

I remember when we were entering Rosendaal, after a battle in which all arms had been stretched, my reserve Company Commander asked if he might get on that night with a bridge to restore the important lateral route through the town.

At the Divisional " O " Group the next morning the Commander was complimentary to most of those assembled.

Then, thinking of our next tasks he said, " Oh, C.R.E., I think you'd better see if you can bridge the canal on the Breda–Bergen road. We'll want it as a lateral."

C.R.E., looking at his watch, " It should be open for traffic in ten minutes' time, Sir."

Commander, " Hmph—Well done the Sappers."

Photo 1.—Bridge built by 294 Field Company at Massenhoven at the start of the advance.

Photo 2.—"Iris" bridge at Stampersgat built by 756 Field Company. Originally constructed as 120 ft. double-single and 70 ft. single-single. The support on a skewed pier involved some cunning crib work. Photo shows the bridge after being raised by 1 Corps Troops to make the the canal navigable for barge traffic.

Divisional Engineers Will Support The Attack 1,2

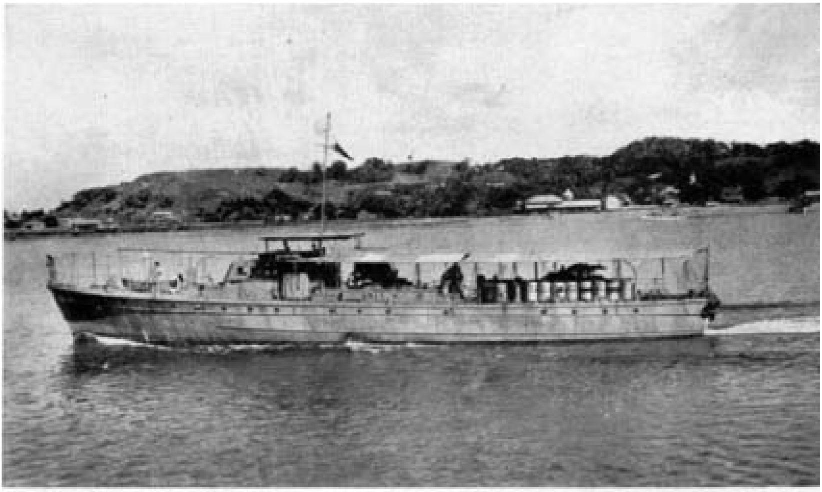


Photo 1.—*Fairmile* (AV2769) leaving Thursday Island for Darwin.

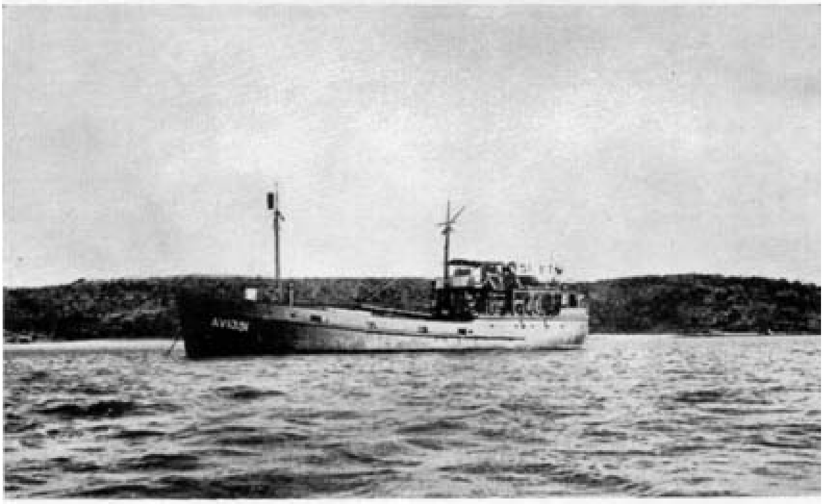


Photo 2.—*Vasse* (AV1351) at anchorage at Bird Island.

Northabout Passage 1,2

NORTHABOUT PASSAGE

By LIEUT.-COLONEL J. B. HIGHAM, R.E.

ONE of the legacies of demobilization is the problem of re-deployment. Whereas the early days of peace found most of our remaining watercraft on the east coast, the framework of the peace-time army included a Transportation Squadron (No. 3) in Western Australia. It was accordingly decided to allot, among other small craft, a small cargo ship and a target towing vessel to the West Australian Unit, located in Fremantle. The former was a 125-ft. wooden ship, of cargo carrying capacity 300 tons deadweight, built in Fremantle during the war. She was named *Vasse*. The latter was a 112-ft. craft of "Fairmile" design, with a laminated wood hull, bearing the number AV2769 and christened *Maureen*, but in the convoy usually referred to as the *Fairmile*. *Vasse* was indiscriminately known either by her name or by her number AV1351.

The immediate problem was—how to get the ships from the east to the west coast. They were too large to be "shipped" on the deck of a merchantman, yet rather on the small side for making the passage under power in peace-time conditions, when neither finance nor public opinion will sanction the taking of risks with men's lives and public property—risks which are taken daily during war, without a second thought. The *Fairmile* carried a reserve of fuel on deck in drums, with strict instructions that refuelling from the deck reserve would only be carried out in port, or at anchor with *Vasse* standing by with fire-fighting equipment and ship's boats in the water. Both ships were equipped with radio for ship-to-ship and for ship-to-shore working.

Meanwhile, the preparation, equipping and victualling of the vessels were going forward. Crews were chosen and assembled, and arrangements for fuelling, rationing and watering during the voyage were completed. The masters of the two vessels were experienced and qualified officers, Captain A. Mellor, R.A.E., who had served in the Royal Navy during the 1914–18 war, was in command of *Vasse* and also of the convoy as a whole, and Captain R. Tanner, R.A.E., who had been a Merchant Navy Officer with an ocean-going master's ticket, in command of the *Fairmile*. The author of this article, as Director of Transportation at A.H.Q., was to accompany the convoy as far as Darwin.

The deck and engine-room sections of the crew were all R.A.E. personnel, the only non-R.A.E. members being two cooks of the A.A.C.C., one signaller of the R. Australian Signals and the author.

Plans were made for a third vessel, an ex-Army landing barge (A.L.C. 120) now belonging to the Australian Whaling Commission, to sail in the convoy; just a week before departure, however, an unexplained fire in her engine-room put her completely out of the running. It is understood that she later made the voyage to the west by the Southabout passage, and her story should be an interesting one.

Both craft were put into the hands of the shipwrights to prepare for their voyage, while a preliminary survey of weather conditions was made. It was eventually decided, not without a few dissentient voices, to attempt a "Northabout passage" from Brisbane to Fremantle via Darwin. A tentative starting date of 1st November was selected, so as to enjoy the favourable weather on the Queensland coast, whilst arriving in Western Australia before the bad weather which can be expected from the end of December onwards.

One important factor bearing on the choice of season was the anticipated length of voyage. *Vasse* was powered by Ruston-Hornsby diesels, which gave her a maximum cruising speed of 7½ knots. The *Fairmile*, designed originally as a combat craft for use in the English Channel, was driven by two Hall-Scott petrol motors which gave her a reasonably economical cruising speed of 12–14 knots. Now aviation spirit as used in the Hall-Scotts is a chancy fluid, and besides the obvious fire risk there was the anticipated difficulty of finding stocks of spirit in the isolated ports of the north-west coast. Behind this lurked the financial and political aspect of using a fuel which was severely rationed to the general public on account of the dollar content. Reinforcing the argument in favour of towing the *Fairmile* behind *Vasse* was the obvious impossibility of a 7½-knot ship and a 12-knot ship travelling in strict convoy.

The factor which decided against the towing project was speed—and its inevitable reaction on safety. The speed of *Vasse* and her tow would be 3–3½ knots, and the 4,000 odd miles would take about seven weeks' sailing time alone; allowing for time in port for refuelling and revictualling, and also for certain unavoidable night anchorages, the voyage might extend to three months. Increase of the convoy speed to 7½ knots, the speed of *Vasse* without the tow, would reduce the timing to a month and a half.

It was accordingly decided to sail the two vessels under their own power but under centralized command. On each "leg" of the course the *Fairmile* was sent on ahead to await, in port, the arrival of *Vasse*. By this means, if anything should happen to either ship, the other would never be more than a day's sailing away. As an additional precaution full equipment was carried for towing if necessary.

Various delays in obtaining spare parts set back the date from 1st November, and the sailing was finally scheduled for 1600 hrs. on Thursday, 10th November. Vessels and crews were concentrated in Brisbane, total complements being *Vasse* twenty and the *Fairmile* ten. These numbers allowed for three watches in each ship. By the morning of the sailing day both vessels were lying at New Farm Wharf and ready for sea, with last minute loading of Commonwealth stores for Darwin going on aboard *Vasse*. During the forenoon fresh rations had been delivered to the ship's side. The loading of fuel and fresh water had been completed late on 9th November. Precisely at 1559 hrs. the officer in charge of the convoy reported "Convoy ready to move" to the Director of Transportation, and a minute later both ships were under way.

FIRST STAGE

(*See map on Folding Plate facing page* 432).

	miles
Brisbane — Mackay	530
Mackay — Cairns	345
Cairns — Thursday Island	490
Total	1,365

The *Fairmile* moved off into mid-stream and, under instructions, followed 100 yds. astern of *Vasse* down the Brisbane River on the 14-mile run to the "Pile" light in Moreton Bay. This well-known lighthouse had been almost completely carried away by an incoming tanker a week or so previously, and the wrecked piles and superstructure carried a temporary light. The crew, who had been at "harbour stations" when moving off from the berth, were now busy making fast all loose gear and tidying up. The run down the winding Brisbane River was completed by 1800 hrs. and the *Fairmile* was instructed to proceed independently to Mackay. As she slipped off at 12 knots there was perhaps something sinister about her lines, bearing a resemblance to a miniature warship, while *Vasse* looked rather staunch and matronly.

After a further five hours pilotage in the gathering dusk through the channels of Moreton Bay, via the Cowan Light and Caloundra Head, the vessels were fairly set on the first leg of their course to Breaksea Spit Lightship. Rounding this at 2000 hrs. on 11th November, the feeling aboard *Vasse* was that we were round

"Windy Corner" and well on our way up the coast. A course was set inside the Great Barrier Reef and during the next two days *Vasse* met with good weather, calm seas and clear visibility. At daybreak on 13th November, the light on High Peak Island was rounded, and soon after sunrise the ship passed through the Percy Islands and the Northumberland group of islands.

Vasse reached Mackay harbour at 1530 hrs. on Sunday, 13th November, where the *Fairmile* had preceded her, arriving at 1300 hrs. on Saturday, 12th November. The *Fairmile* took on fuel, and both vessels were rationed and watered. Crews stretched their legs ashore, and sampled the delights of local society. The harbour is almost entirely artificial, having been constructed with solid piers of the local stone. It owes its existence to the trade in raw sugar which is produced in the surrounding area.

Both vessels put to sea at 0500 hrs. on 15th November, the *Fairmile* proceeding independently to Cairns. A strong north-easterly with moderate seas livened things up for the *Fairmile*, and she struck the first swell out of the harbour with a noticeable impact. Within a few hours the weather moderated, and a very pleasant course was followed through the Cumberland Islands, and the famous Whitsunday Passage. This is the centre of the Queensland coast tourist traffic, which extends to such well-known resorts as Daydream, Hayman, South Molle and Lindeman Islands. Passing through Whitsunday Passage, *Vasse* dropped anchor for two hours off South Molle, and the crew, with the exception of the duty watch, visited the settlement for a swim. On reaching Townsville a course was set through the Palm Islands, possibly the prettiest group on the Queensland coast. Cairns was reached by the *Fairmile* on Wednesday, 16th November, at 0900 hrs. and by *Vasse* on Thursday, 17th November, at 1100 hrs.

Both vessels were at first accommodated alongside the main quays, as the oil berth was occupied by a R.A.N. Boom Defence vessel; later, both had to move to berths at Smith's creek to make way for commercial vessels waiting to discharge and load cargo. Fuel was taken on here, since the oil berth was later required for the passenger liner *Changte.* The convoy was delayed in Cairns to carry out a top overhaul on the starboard main engine of *Vasse*, which had become urgent; the engineers of both vessels worked in shifts to complete the job.

Vasse departed Cairns at 2300 hrs. on 18th November for Thursday Island. On this occasion the *Fairmile* was instructed to delay her departure until 0600 hrs. on 19th November. The narrow Cairns Harbour entrance, a three-mile pilotage, was traversed in darkness by *Vasse*; the *Fairmile*, following on, had caught up her consort by 1400 hrs. on 19th November. A spare member of the crew was transferred at sea from *Vasse* to help out the *Fairmile*, making use of the dinghy from the *Fairmile*, after which the vessels proceeded independently.

The run from Cairns to Thursday Island is perhaps the most hazardous of the whole voyage from the point of view of coastal navigation. Lighthouses are widely spaced and dangers such as reefs and shallow patches abound, close to the recommended course, all the way north from Cooktown. The crow's nest specially fitted for the voyage, and also the platform fitted at the ship's side for the use of the seaman taking soundings, were both of the greatest use at this stage of the voyage. A special covered-in chart table with internal lighting had been fitted on the bridge and was appreciated throughout the voyage. The recently issued polarized eye shades were used continually by the crow's nest look-out and by the officer of the watch for spotting shallows by the change in colour of the water.

On this stretch, navigation at night was too hazardous so anchorages were used each night. These were selected at a distance of twelve-hours daylight sailing apart, calculated at 80 miles for *Vasse* and 125 miles for the *Fairmile*. *Vasse* anchored at Lizard Island, Stanley Island, Night Island, Bird Island and Lacey Island.

The course passed close to Resolution Island, made famous by Captain Bligh of the *Bounty*, who succoured and refreshed his crew of a small ship's boat there on his way to Timor after the mutiny. At Bird Island members of the crew landed and "bagged" over two dozen Torres Island pigeons. The island is a mile long by ¼ mile across, and is a natural pigeon-loft; thousands of these birds breed here, and in the evening great flocks of them return to roost. They make excellent eating, and the island also abounds in large oysters. Quite a number of fish of all shapes and sizes were caught by the crews of both vessels, some from the dinghies and some on lines trailed behind the ship. As usual, it was always the largest fish that got away—including what was agreed by all must have been a monster "groper."

Thursday Island was reached by the *Fairmile* on Tuesday, 22nd November at 1700 hrs. and by *Vasse* on Thursday (appropriately) 24th November at 1030 hrs. The climate had been growing gradually more tropical, but the change did not become obvious until the vessels were stationary in port. The islands round Thursday Island are of general interest and contain certain old coastal defence installations dating from the end of the last century. There is also an interesting church containing relics of the wreck of the steamer *Quetta*, which sank after striking an uncharted rock in 1890 with large loss of life.

SECOND STAGE

		Miles
Thursday Island	— Cape Wessel	330
Cape Wessel	— Darwin	435
	Total	765

It was arranged that *Vasse* should take the *Fairmile* in tow on leaving Thursday Island as a trial run until the evening. For towing purposes *Vasse* had been fitted with a pendant of 1¼-in. diameter S.W.R. Suitable chafing protection pads were provided, and a large 15-in. heart-shaped thimble was located aft, fitted with a large "D" shaped shackle. The *Fairmile* had a 7-in. white sisal towing pendant secured right round her hull, well spliced and chafe-protected at the stern and also fitted with a large 15-in. heart-shaped thimble at the bows provided with a large "D" shaped shackle. The tow was 670 ft. of 9-in. coir with a thimble spliced into each end.

At 0800 hrs. on Friday, 25th November both vessels left Thursday Island for Cape Wessel. They proceeded independently to the outer buoy, where the process of taking in tow was completed in fifteen minutes. The trial was satisfactory in every way. Weather conditions in the Gulf of Carpentaria were perfect, not a ripple appearing on the water; you could see your face reflected from the glassy surface. The taking in tow and casting off were both uneventful, as both masters had had much experience in towing. The whole procedure was watched with interest by a school of porpoises, the leader of which took station six inches in front of the bows of the *Fairmile* and maintained his exact position for long periods, plainly visible in the clear water. During the nine hours' tow the steering of both craft was satisfactory, helped by the clean lines of the *Fairmile.* The over-all speed while towing, assisted by a slight current, was 4.5 knots.

The tow was cast off at 1800 hrs. on 25th November, and vessels proceeded independently to a rendezvous off Cape Wessel. *Vasse* arrived at the rendezvous position at dawn on 27th November and as day broke the *Fairmile* could be seen at anchor in the lee of Cape Wessel Island. *Vasse* also cast anchor at about two cables distance, and placed a ship's boat in the water. The *Fairmile* made preparations to fuel from her deck reserve, and fuelling started at 0700 hrs. By 0900 hrs., the process was safely finished and both vessels were again under way. *Vasse* passed Cape Croker at 2100 hrs. on 28th November; Cape Don was abeam at 0600 hrs. on 29th November and the run in to Darwin was begun under pilotage of the Master. Darwin was reached at 2030 hrs. on that day. *Vasse* anchored for the night off New Wharf. Ten minutes after anchoring a severe local storm hit the ship, followed by torrential rain. These storms are known locally as "Cock-eyed Bobs" or "Willy-willys." After paying out an extra shackle of cable and posting an anchor watch, we rode out the blow, which was all over within half an hour. This was our first rain since starting our seventeen days' run from Brisbane.

Early next morning *Vasse* berthed ahead of the *Fairmile* at the New Wharf. Every assistance was given us by the local Military Headquarters. The local Navy were so enthusiastic that they had appeared to meet the *Fairmile* while still half a day's sail from the port with the intention of "piloting her in," a very kind thought, but one which brought a smile from the Master of the *Fairmile*, who was himself fully qualified to take over the Master's duties in the *Queen Mary* if necessary.

The day following our arrival the Army and Commonwealth cargo was discharged from *Vasse*. Both craft took on fresh rations which were plentiful and also refuelled. *Vasse* also loaded a full cargo of petrol for the *Fairmile*, stowing it on deck in view of the fire risk. There was now sufficient fuel in the convoy to take both ships to Fremantle.

THIRD STAGE

		miles
Darwin	— Cape Londonderry	255
Cape Londonderry	— Broome	425
	Total	680

Both vessels cleared Darwin Harbour for Broome in company at 0800 hrs. on 3rd December, and the *Fairmile* then set off independently. After thirty hours' run *Vasse* picked up Cape Londonderry ahead. As the waters off the cape were turgid and muddy to a distance of from three to five miles, and the charts omitted any mention of suitable anchorages for ships drawing 12 ft., it was decided to make certain of a safe anchorage before nightfall. A position in the lee of Lesueur Island was chosen, since the whole of the coastal area from Cape Londonderry, practically as far as Broome, is unlighted, studded with hundreds of islands and dangers and must be made in daylight running.

Cape Londonderry was rounded at 0700 hrs. on 5th December and, standing well off the reefs, *Vasse* passed through the Napier Broome Bay area and made a night anchorage at Parry Harbour.

Early next morning the vessel was under way again, later passing through the Admiralty Gulf and the Voltaire Passage. At this point the Master made a change of plan, and to save at least three night anchorages *en route* to Broome he decided to take the outer deep-water course from Voltaire Passage via Ingram Reef, Browse Island Light, Adele Island, Baleine Bank and so into Broome. This action picked up at least two days on the original schedule, and *Vasse* arrived in Broome during the forenoon of 8th December, only a few hours after the *Fairmile.*

Both craft anchored in the stream about one mile off the jetty, which neither craft was able to use owing to a 28-ft. rise and fall of tide. No fresh water was available in Broome, but arrangements were made, through the Customs Officer, for M.S. *Koolinda,* due in on 9th December, to supply 500 gallons. As the *Fairmile* had been short of fresh water, she was allowed to take the complete supply from *Koolinda*, and the Master of *Vasse* decided to proceed to Onslow to fill up there with fresh bore water.

The *Fairmile* topped up with fuel, and took on the remainder of the deck cargo of fuel from *Vasse* to her own decks. After a conference regarding weather, fuel consumption and fresh water supplies, O.C. convoy authorized the *Fairmile* to proceed independently to Fremantle, and to refuel at Carnarvon *en route.*

FOURTH STAGE

		miles
Broome	— Onslow	495
Onslow	— Carnarvon	215
Carnarvon	— Geraldton	280
Geraldton	— Freemantle	210
	Total	1,200

Both vessels left Broome at 1400 hrs. on 9th December for Onslow. By 1600 hrs. they had cleared the harbour limits and shaped their courses towards North-West Cape. A change in the weather on leaving Broome brought slight to moderate seas with cool north-west strong winds. The *Fairmile* passed out of sight of *Vasse* about 1700 hrs., dipping well into the sea. On the next day the weather eased off, and smooth seas prevailed. During the night run of 10th/11th December, *Vasse* failed to pick up Bendout Island Light. The vessel was on course, and it was later discovered that the light was not burning.

Onslow was reached at 1530 hrs. on 12th December. *Vasse* fuelled with 2,000 gallons from the reserve in her hold, and also took on 500 gallons of fresh water. She left Onslow for Carnarvon at 0800 hrs. on 13th December. North-West Cape was rounded at 1800 hrs. and a change in the weather was met, bringing slight seas, a long southerly swell and cool weather. About midnight on the 13th/14th the weather worsened, and increased from moderate to rough. A strong southerly wind increased to gale force at times with some vicious squalls. The ship rode the rough seas well. All hands had, prior to the change in weather, lashed down all moving gear, and prepared for any kind of weather.

Carnarvon was reached at 0600 hrs. on 15th December. With moderate to rough seas in the open exposed water of Shark's Bay, it was decided to drop anchor there in hopes of the weather moderating, before coming in to berth at the Town Jetty. It was intended to remain alongside only long enough to obtain fresh rations, water and mail, and then to push on direct to Fremantle. On landing, however, the Master was informed by the manager of Dalgetys, representing the Vacuum Oil Company, that they had ninety 44-gallon drums of specially blended petrol left on their hands, that had originally been sent from Fremantle to Carnarvon by sea for the *Fairmile*. When the *Fairmile* reached Carnarvon, however, she found that the coastal vessel carrying her petrol was not due until the following day. In view of the threatening weather the Master of the *Fairmile* decided not to wait, and refuelling from the town supply he set out at once, by this means reaching Fremantle without hazarding his ship in the bad weather.

Instructions obtained from Western Command were that *Vasse* should carry the fuel back to Fremantle as deck cargo. Dalgetys accordingly arranged wharf labour and train haulage from town to wharf the next day.

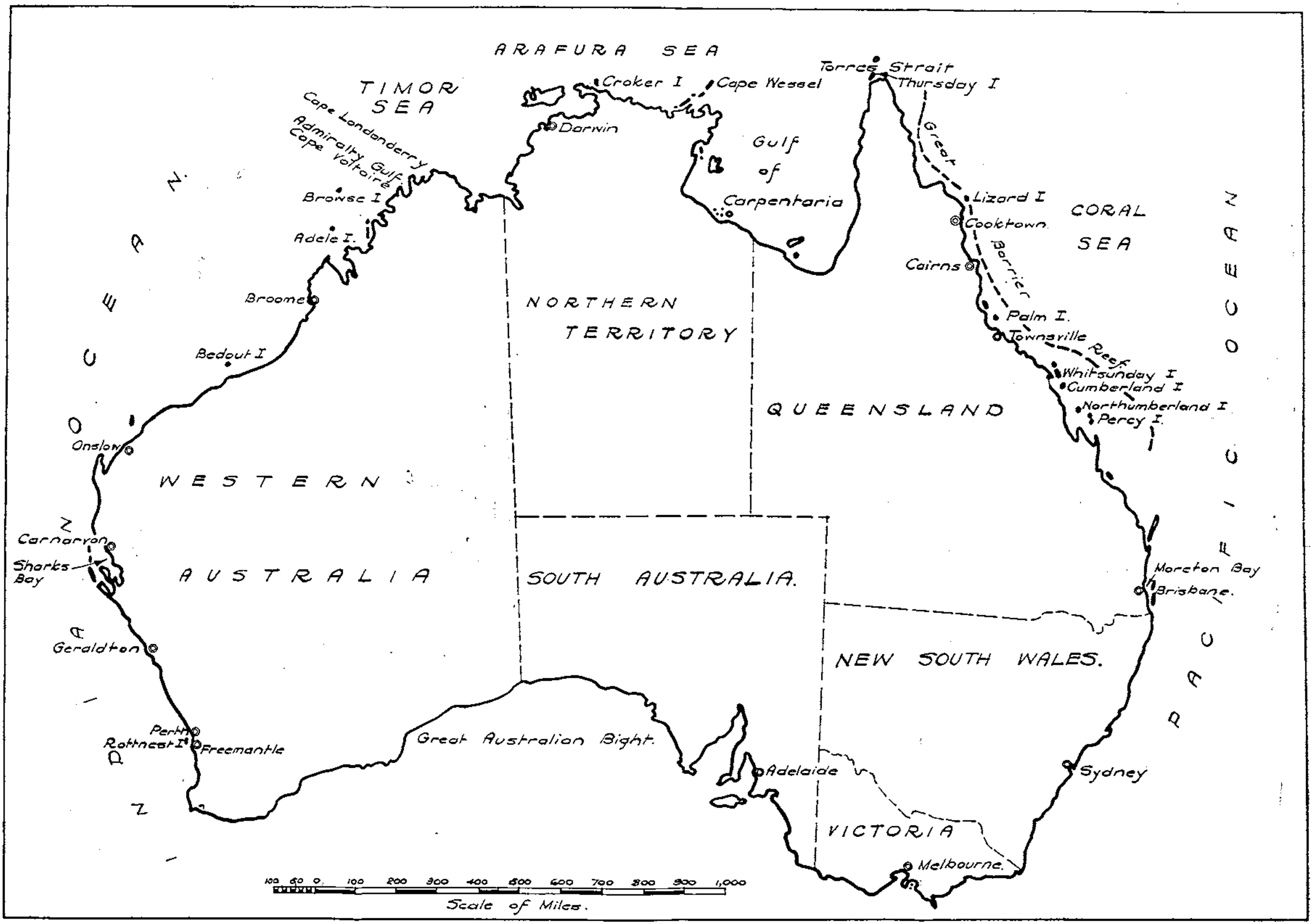
Next morning during the loading of the ninety drums, the vessel was difficult to hold alongside; one of the bitts on the forecastle head bollards snapped off, and 12 ft. of iron band on the port side sponson were torn away. As soon as the loading of the petrol was completed the vessel moved out into Shark's Bay, and remained at anchor until next day.

After a rough night at anchorage, *Vasse* departed for Geraldton at 0615 hrs. on 17th December, with the intention of sheltering at Turtle Bay if the weather outside Shark's Bay worsened. It was felt that, as the blow might easily last a week, it would be better to keep on and endeavour to make Fremantle before 25th December. On rounding Cape Inscription a course was set for Fremantle, but the ship immediately ran into some foul weather. The blow from the south increased from moderate to rough, with some bad seas which made moving forward over the decks hazardous for the crew, as at times when the ship pitched heavily she would shake herself as she rose. To prevent losing anybody overboard while making the short but dangerous journey from the poop deck to the forecastle, a short life-line was rigged over the row of oil drums on the starboard well deck. Planking was also lashed on top of the drums as a foot-hold. During the late afternoon it was necessary to alter course so as to bring the seas on to the starboard bow; this made the ship ride the weather better.

At about 1730 hrs. a succession of heavy seas shook the ship, and the 16-ft. power launch swung at starboard davits broke away. The ship was immediately hove to, and the Bosun and four deck-hands made an excellent job of securing the launch under difficulties. For fully five minutes, it looked as if the launch would either be lost overboard, stove in and damaged beyond repair, or chopped away if one set of boat's falls carried away and it were left hanging on the other set. This was the crew's first emergency job, requiring smart action and quick-thinking seamanship; the Bosun and his experienced deck-hands rose to the occasion and did a good job.

Towards daylight on 19th December, the weather eased to moderate seas, and it was decided to put into Geraldton to clean and tidy up the ship before arriving at Freemantle. The whole of Tuesday, 20th December was spent in re-stowing gear, cleaning and scrubbing paintwork and hosing down the after superstructure which had developed brine stains all over during the previous two days' rough going. At the end of the day the crew regaled themselves on the famous Dongarra crayfish, ably prepared by "Mick," the cook.

Vasse left Geraldton at 0700 hrs. on 21st December for Fremantle. Weather conditions were excellent for the last lap. Clearing harbour and setting a course for Rottnest Island, a message was sent to Western Command giving an estimated time of arrival 1400 hrs. on 22nd December. The run down the coast in fine weather at 7½ knots, however, brought the ship to the Gage Roads anchorage two hours ahead of schedule, so she anchored outside, intending to move into harbour and berth on time. At 1230 hrs. a workboat came out and gave the Master instructions as to where he was required to berth. The ship moved into harbour at 1330 hrs., and berthed at exactly 1400 hrs. at the Small Craft Slip Wharf. When "finished with engines" was rung down for the last time on the voyage, at 1401 hrs. on 22nd December, 4,010 miles had been covered in the forty-two days, at an average of a fraction under 4 knots for the whole passage.


ARAFURA SEA
TIMOR SEA
Croker I
Cape Wessel
Torres Strait
Thursday I
Cape Londonderry
Admiralty Gulf
Cape Voltaire
Darwin
Gulf of Carpentaria
Great Barrier Reef
Lizard I
Cooktown
CORAL SEA
Browse I
Adele I.
Cairns
Broome
NORTHERN TERRITORY
Palm I.
Townsville
Bedout I
Whitsunday I
Cumberland I
Northumberland I
Percy I.
QUEENSLAND
Onslow
WESTERN AUSTRALIA
Carnarvon
Sharks Bay
SOUTH AUSTRALIA.
Moreton Bay
Brisbane.
Geraldton
NEW SOUTH WALES.
Perth
Rottnest Id
Freemantle
Great Australian Bight.
Adelaide
Sydney
VICTORIA
Melbourne.
INDIAN OCEAN
PACIFIC OCEAN
100 50 0 100 200 300 400 500 600 700 800 900 1,000
Scale of Miles.

SAPPERS IN THE MALAYAN CAMPAIGN: 8th DECEMBER, 1941–15th FEBRUARY, 1942

By MAJOR (TEMP. LIEUT.-COLONEL) R. B. MUIR, R.E.

INTRODUCTION

WHEN on 15th February, 1942, Singapore was lost to the Japanese, public opinion throughout the British Commonwealth sustained a severe shock. The blow was not lessened by the realization that this disaster had befallen only ten weeks after the Japanese had invaded Malaya. It was not until six years later that the true facts of the campaign were made public in the Official Despatch submitted to the Secretary of State for War by Lieut.-General A. E. Percival, C.B., D.S.O., O.B.E., M.C., the General Officer Commanding Malaya at that time.* As far as the writer is aware, little authentic information has been published on the employment of Engineers during this campaign, although to quote the Despatch "a great deal of literature has appeared" on the campaign generally, and "often these statements and opinions have been based on false or incomplete information."

The study of the closing stages of a war is of vital importance in the formulation of post-war doctrine. Yet, for a democracy particularly, an equally critical analysis of the incipient stages can provide valuable lessons. Because our constitutional convictions deny us taking the initiative even when war appears inevitable, we must constantly strive for the most effective use of what limited military resources we possess when an aggressor strikes. Experience of past disasters can constitute a valuable insurance for the future. The object of this article is therefore to point some lessons which will be of use in training sappers for employment at the beginning of a war under circumstances such as obtained in Malaya. A number of valuable documents were destroyed at the time of the capitulation of Singapore, and others were lost during evacuation. The fact that many of the examples of sapper employment cited here were limited to the writer's personal experience is the inevitable result of the paucity of official records, which precludes any other treatment of the subject. It is believed, however, that within these limitations a reasonably comprehensive picture of sapper activity is described.

* Second Supplement to the *London Gazette* No. 38215 of 20th February, 1948.

This article will be developed as follows :—

PART I—BACKGROUND ORIENTATION

(*a*) Terrain.
(*b*) Pre-invasion period.
(*c*) Engineer Order of Battle—Malaya, 8th December, 1941.

PART II—OUTLINE OF ENGINEER EMPLOYMENT DURING HOSTILITIES

Phase I—Battle for Northern Malaya (8th–24th December, 1941).
Phase II—Battle for Central Malaya (25th December, 1941–13th January, 1942).
Phase III—Battle for Southern Malaya (14th–31st January, 1942).
Phase IV—Battle for Singapore Island (1st–15th February, 1942).

PART III—CONCLUSIONS

PART I—BACKGROUND ORIENTATION

(*a*) *Terrain*

The traveller arriving in Malaya for the first time is impressed by the universal permanent greenness of that country ; this is particularly striking if he has journeyed by way of India and the Middle East.

He will be surprised also that, although practically on the equator, headgear need not be worn for protection from the sun, whereas in lands further north, the topee is a sartorial essential if health is to be maintained. The reason, of course, lies in the high humidity, resulting from heavy rainfall, which is distributed fairly evenly throughout the year. The enervating effect of the humidity places a premium on the physical fitness of the individual. There are no seasons and little change of temperature.

An extensive mountain range runs practically the entire length of the peninsula, making overland communication between east and west coasts extremely difficult. The main north and south road from Singapore to the Thailand border, a distance of approximately 600 miles, lies west of the mountains and is flanked by a metre gauge railway. This railway, bifurcating at Gemas in Northern Johore State, crosses the mountain range into Kelantan State, so constituting the only communication between North-East Malaya and the remainder of the country. From Kelantan the railway continues into Thailand along the east coast, and joins the west coast line at Haad-Yai, about 20 miles south of Singora, thereafter connecting with Bangkok. The main west coast road, and the road from

Mersing in South-East Malaya to Singapore, have an average width of approximately 20 ft., a good tar macadam surface, and are characterized by the numerous bridges over water gaps, mostly of reinforced concrete construction. An indifferent road through jungle, connecting Kuantan on the east coast with Jerantut on the East Coast Railway, is the only other line of communication from the east coast. A fine weather coastal track runs from Kelantan down the east coast as far as Endau in North Johore, but going is made difficult by long stretches of this track being routed along the beaches, where no roadwork has been executed.

Sandy beaches extend practically the whole length of the eastern Malayan seaboard. Conditions of gradient, going, and surf are favourable to amphibious landings almost anywhere for most of the year. The west coast has a few long stretches of good sandy beaches, but generally consists of extensive areas of mangrove swamp, which preclude an amphibious landing in any force. The immediate hinterland on either coast is normally low-lying and featureless, the main obstacle to movement by tracks and wheeled vehicles being the numerous rivers and streams, mainly running east and west, which drain the extensive high central watershed. The low run-off and high water table is conducive to malaria, which is rife in Malaya except within the protected areas of the cities and large townships.

Vegetation in Malaya is prolific. The mountains are heavily timbered, and virgin jungle extends to the coast in many places. Secondary jungle and rubber plantations predominate in the plains, where coconut, oil palm, and pineapple are also extensively grown. Rice is cultivated principally in Kedah and Malacca States, but not nearly in sufficient quantities to meet the country's demand for this staple commodity. Very rich deposits of tin occur in the vicinity of Ipoh, where workings are both by dredge and gravel pump method. The only coal mines are at Batu Arang in Central Malaya.

With the exception of the open areas of rice cultivation and tin workings, natural cover from the air is excellent, and ground observation is generally restricted to less than 100 yds. Cultivated areas, including rubber and palm plantation, are easily traversed by wheeled vehicles, but even virgin jungle is not impenetrable to determined troops on foot.

(*b*) *Pre-invasion Period*

When in September, 1940, the Vichy Government allowed Japan to occupy the northern portion of French Indo-China, the vulnerability of Malaya to Japanese attack was radically altered. Before this event, the major threat to the security of Malaya had been a potential amphibious landing, following a long sea voyage from

Formosa or Japan, and supported by carrier-based aircraft only. Given time to consolidate in Indo-China, in particular by developing airfields and massing military personnel and stores, the Japanese would subsequently be capable of launching amphibious attacks over a comparatively short sea gap, supported by land-based bombers and airborne landings. Consequently, from this time, the token garrison in Malaya of considerably less than one division was strengthened, and progressively reinforced as the general political situation deteriorated. Owing to the low priority of this theatre in the world wide strategic picture, an adequate build-up of either naval, army or air forces to meet the threat was never achieved. The change in the number of Engineer field units in Malaya exemplifies the expansion which took place. At the beginning of World War II, there was only one Field Company (Sappers and Miners) in the country. At the outbreak of hostilities, there were eight Field Companies, supported by Divisional Field Park and Army units.

All Engineer units were fully committed on extensive works programmes up to the time the Japanese attacked. Productive capacity was increased by large scale employment of local coolie labour. The urgent demands of essential defence projects seriously limited the availability of personnel for training in war rôles. This situation was made worse by the high proportion in units of partially trained officers and men, the result of dilution demands to meet expansion programmes in Britain and India.

There were four principal anti-invasion defence projects on which sappers were heavily committed, and these consisted of putting into a state of defence :—

(*a*) Probable landing beaches astride Khota Bahru in North-East Malaya ;

(*b*) the beaches in the vicinity of Mersing, the " back door " to Singapore in North-East Johore State ;

(*c*) beaches on Singapore and adjoining islands ;

(*d*) the Jitra defence line, an intended " stop " position in North Kedah, some 10 miles from the Thailand border.

The work involved included the erection of R.C. pill-boxes, the laying of anti-tank and anti-personnel minefields, and the opening up of communications. Execution was generally the concern of Sapper and Miner field units, but the Fortress Companies R.E. contributed their share, and did particularly good work in the erection of anti-boat obstacles on the Singapore beaches. Extensive demolition schemes were reconnoitred and planned in support of defence positions. It soon became apparent that the scale of demolitions contemplated would far exceed the capacity of available Engineers to execute within the estimated time limits.

Various means were devised of substantially reducing the time and effort required to complete them in the event of an emergency, including the construction of demolition chambers in piers and abutments. One particularly valuable contribution to this preparatory work was the evolution locally of the now well-known method of blowing craters by a combination of canister and *in situ* piping. Twelve-inch diameter R.C. pipes, spun in the country, were sunk in roadways at approaches to bridges, in high embankments and deep cuttings, and at jungle or water defiles. An R.C. cover, sunk flush with the roadway, enabled traffic to proceed unimpeded. In the event of demolition being required, these pipes could be loaded with cylindrical sheet metal canisters containing the explosive. The canisters could subsequently be charged by insertion of detonators and leads, fixed to light wooden laths, by threading through a central chimney in the canister, which extended to just below the surface of cover. To prevent deterioration of the charge after loading, the canisters were easily sealed, an important feature in a country like Malaya where the general water table is abnormally high.

Engineers also laid controlled minefields to seaward of possible river approaches, the necessary equipment being obtained from Royal Naval sources. The provision of communications for defence systems included the construction of new roads through virgin jungle, a task involving accurate survey and comprehensive drainage layout. Similar problems were introduced in the making of M.T. harbours in jungle (loop-road type), and in rubber plantations (herring-bone design), and owing to their natural cover from air observation these paid excellent dividends during the campaign. Laterite, quarried locally under sapper supervision, provided a suitable road metal for water macadam construction, soling being hand-packed and varying from 6 to 9 in. according to the constitution of the formation.

A particularly interesting job perhaps worthy of mention was the building of a Class 9 floating bridge over a 300-ft. water gap, with an average tidal range of 12 ft., at Kota Tinggi in Central Johore, where the existing road bridge on the line of communication from Mersing to Singapore constituted a somewhat precarious bottleneck. All of the required timber for transoms, road bearers and abutment piles were felled by sappers from adjoining jungle, and sawn to required sections on the site. Most of the necessary iron fittings were fabricated on field forges locally by sapper craftsmen. Impressed Chinese 20-ton "tongkangs" were utilized as floating piers. Anchorages were provided by casting solid concrete blocks on the river bank, and later sinking these in position. The design, provision of stores, and execution were the responsibility of one

Sapper and Miner Field Company. The construction of anti-assault craft floating booms across the estuaries of several large rivers was another interesting sapper occupation. Major problems met included transportation of the required stores to the site in view of the absence of other than water communication, and also the provision of adequate land anchorages. The latter constituted a particular headache, since the "land" frequently was a mangrove swamp. A workable solution was to drive a nest of some forty to sixty 3-in. wooden piles, and to cap this with a cast in situ R.C. block with bollards.

It will be appreciated that in support of forward defence works a great deal of Engineer work was required in L. of C. and base areas. The rapid expansion of the Malayan garrison also produced an acute accommodation demand, which was met largely by the construction of temporary wooden boarded huts with attap covered roofs. Most of this work devolved on the R.E. Works Services organization, which was kept extremely busy. Work projects were mainly put out to contract with local European and native contractors, the latter being principally domiciled Chinese. British officers of the Malayan Public Works Department assumed responsibility for a number of projects on behalf of the R.E. Works Services, and this assistance, which they so willingly and efficiently gave, was of great value at a time when the skilled man-power situation was so critical. Most of these officers accepted R.E. commissions on the outbreak of hostilities, and a few were absorbed into Field Companies, which were under strength.

This pre-invasion picture would be incomplete without mention of Operation "Matador." This was a plan devolving on 11 Indian Division for an advance into Thailand, with the object of forestalling a Japanese assault in the Singora–Patani area. The British Government laid down that this operation could be undertaken only provided a Japanese invasion of Thailand was imminent, or in the event of military assistance being requested by the Thai Government. The plan, the scope of which was dictated by the limited resources available, involved an advance by road and rail from the north-west coastal area of Malaya with objective the capture of Singora, combined with an advance from Kroh, a village further inland on the frontier, with the object of occupying a commanding position known as "The Ledge," astride the Kroh–Patani road approximately 40 miles inside Thailand. Permission was given and appropriate papers and money provided for officers in plain clothes to carry out the necessary reconnaissances in South Thailand. Sapper officers from the forces earmarked took part in these covert journeys, disguised as rubber planters or mining engineers.

(*c*) *Engineer Order of Battle—Malaya, 8th December, 1941*

This can be shown in tabular form as follows :

COMMAND	TERRITORIAL RESPONSIBILITY
Malaya Command C.E. : Brigadier I. Simson D.C.E. : Colonel H. A. Urquhart	MALAYA, SARAWAK, BRUNEI AND CHRISTMAS ISLANDS
3 Indian Corps C.E.: Brigadier K. B. S. Crawford D.C.E. (Works) : Colonel B. D. Peake	MALAYA, NORTH OF JOHORE AND MALACCA STATES
9 Indian Division C.R.E. : Lieut.-Colonel T. H. Lindesay, R.E. 19 Field Coy. (Bombay) S. & M.—(8 Indian Inf. Bde.) 22 Field Coy. (Bombay) S. & M.—(22 Indian Inf. Bde.) 42 Field Park Coy. (Bombay) S. & M.	NORTH-EAST MALAYA
11 Indian Division C.R.E. : Lieut.-Colonel J. F. D. Steedman, M.C. 3 Field Coy. (Bengal) S. & M.—(6 Indian Inf. Bde.) 17 Field Coy. (Bombay) S. & M.—(28 Indian Inf. Bde.) 23 Field Coy. (Bombay) S. & M.—(15 Indian Inf. Bde.) 43 Field Park Coy. (Bombay) S. & M.	NORTH-WEST MALAYA
Corps Troops 1 Artisan Works Coy. (Bombay) S. & M. 45 Army Troops Coy. (Bombay) S. & M., with one Bridging Section under command. 46 Army Troops Coy. (Madras) S. & M., with one Bridging Section under command. F.M.S.V.F. Engineer Sections (Volunteers)	
Australian Imperial Forces Malaya (A.I.F. Division) C.R.E. : Lieut.-Colonel J. O'Donnell, R.A.E. 2/10 Field Coy. R.A.E.—(22 Australian Inf. Bde.) 2/15 Field Coy. R.A.E.—(27 Australian Inf. Bde.) 2/5 Field Park Coy. R.A.E.	JOHORE AND MALACCA STATES
Singapore Fortress C.R.E. : Lieut.-Colonel H. M. Taylor, R.E. 35 Fortress Coy. R.E.—(1 Malayan Inf. Bde.) 36 Fortress Coy. R.E.—(Penang Fortress) 41 Fortress Coy. R.E.—(2 Malayan Inf. Bde.) S.S.V.F. Engineer Sections (Volunteers)	SINGAPORE AND ADJOINING ISLANDS

Command Reserve 15 Field Coy. (Madras) S. & M.—(12 Ind. Inf. Bde.)	PREPARED TO OPERATE ANYWHERE IN MALAYA

NOTES :—

(1) Brigadier I. Simson, C.E. Malaya Command, held concurrently the appointment of Director General of Civil Defence from 31st December, 1941.

(2) Affiliated brigades are shown above in brackets, but these changed as re-grouping occurred during the campaign.

(3) R.E. Works Services organization is omitted from above table.

(4) "S. & M." is an abbreviation for "Sappers and Miners," now Indian/Pakistan Engineers. Until separation there were three Sapper and Miner Groups (Bengal, Madras and Bombay). All the other ranks were Indians, and the Officers were found from R.E. and R.I.E. Officers, the latter comprising both British and Indian personnel.

(5) F.M.S.V.F. and S.S.V.F. are abbreviations for Federated Malay States Volunteer Forces, and Straits Settlement Volunteer Forces respectively. These organizations recruited both European and Native volunteers.

(6) In accordance with current nomenclature :—
For "Field Coy." read "Field Sqn."
For "Field Park Coy." read "Field Park Sqn."

Subsequent Reinforcements

On 3rd January, 1942, 13 Field Coy. (Madras) Sappers and Miners arrived at Singapore with 45 Indian Infantry Brigade Group. This brigade group had been earmarked for the Middle East and was dispatched to Malaya before completion of its training.

Between 13th and 29th January, 1942, the Divisional Engineers of 18 British Division reached Singapore. This division had also been destined for the Middle East and was diverted to Malaya *en route*. The voyage from England took eleven weeks. One of the transports *Empress of Asia* was sunk by dive bombers as she approached Singapore.

PART II—OUTLINE OF ENGINEER EMPLOYMENT DURING HOSTILITIES (8th December, 1941 to 15th February, 1942)

In outlining how Engineers were employed during the Malayan campaign it is necessary to sketch this picture against a background of the principal military events. For clarification a map of Malaya is given as a folding plate facing page 454, showing pictorially how the campaign developed.

Phase I—Battle for Northern Malaya (8th to 24th December, 1941)

On the night of 7-8th December, 1941, motorized columns of 11 Indian Division were standing by on the Malaya/Thailand border prepared to implement Operation "Matador." Although up to this time Japan's contribution to the Axis effort was still confined to a sleeping partner rôle of moral support, tension in the Far East had become acute. The situation had worsened with the detection by air reconnaissance on 6th December of strong Japanese invasion forces of two convoys, comprising warships and transports, south-east of Cape Cambodia in Indo-China. Owing to bad weather, contact with these forces had been broken, and it still had been impossible to establish the required political conditions for initiation of Operation "Matador." Just after midnight, the uncertainty of the situation was dispelled, and war in the Far East begun, by an opposed amphibious landing of Japanese troops on the beaches at Khota Bahru in North-East Malaya, subsequent to an artillery duel of about half an hour's duration. Simultaneously the Japanese landed without resistance at Singora and Patani in Thailand, and the same night bombed aerodromes on Singapore island.

These events resulted in the implementation of an enforcedly modified Operation "Matador." A road column, co-operating with an armoured train, penetrated 10 miles into Thailand along the Kedah–Singora road, when it was forced back to the frontier by Japanese armoured units by the evening of 10th December. Field Engineers accompanied both thrusts, and succeeded in demolishing several road and rail bridges inside Thailand. Along the Kroh–Patani road our motorized column continued to advance in the face of strong resistance by units of the Thai military forces. It failed to reach its objective, "The Ledge," by only 1½ miles, through encountering a strong force of Japanese armour. On the 11th December Japanese pressure forced a withdrawal, and until this column recrossed the frontier on the evening of 12th December, its accompanying sappers effected a series of bridge demolitions throughout the 35 miles of road inside Thailand.

On the Kelantan front, in North-East Malaya, heavy fighting continued against the Japanese invasion forces. These were strongly supported by land-based fighters operating from aerodromes in Thailand. By the evening of 9th December, the superior weight of the attack had forced our troops away from the vicinity of Khota Bahru aerodrome. With further unimpeded landings, the situation progressively deteriorated, until on 16th December, withdrawal from Kelantan was ordered to avoid the loss of the entire force. The precarious line of communication in the form of the single line railway into Central Malaya dictated this decision, and the withdrawal was completed by 22nd December. 9 Divisional Engineers carried out considerable demolition work in the face of the advancing Japanese troops, including the disruption of Guillemard bridge—the longest railway bridge in Malaya. In the final withdrawal, the railway line of communication was most effectively neutralized as an axis for further Japanese advance. With its multitude of bridges, defiles and other natural bottlenecks, this railway might well be described as the demolition engineer's dream. Personnel of R.E. transportation units did yeoman service in evacuating vast quantities of military stores, and one or two of the final trains carrying rear-guard troops were driven by R.E. officers.

Returning to the Kedah front, where Operation "Matador" had been seriously compromised before it began, the Japanese thrust continued, and by the evening of 11th December, had reached the outposts of the Jitra position. During the same night an attack in force was launched against the two brigades (6 and 15 Indian Infantry Brigades) holding the main defence area. 11 Divisional Engineers successfully completed demolitions previously prepared on approach routes. Owing to the confused fighting which developed throughout the 12th December, one demolition was exploded prematurely on the left of the Jitra position, and this resulted in a number of infantry carriers and vehicles having to be destroyed, to prevent their falling into enemy hands. By the evening of 12th December the Japanese were in possession of the Jitra position, where the defence works had never been completed owing to the limited time and resources available. 11 Indian Division now took up a stand in the Gurun area, some 40 miles south of Jitra, where positions had previously been reconnoitred but not prepared. By the 14th December a strong Japanese assault with armour had developed, and a deep penetration on the morning of the 15th December virtually annihilated one of the brigade headquarters (6 Indian Infantry Brigade). Sappers carried out many hasty demolitions under difficult conditions but, in spite of hard fighting by the defenders, the Japanese gained control of the Gurun position by the afternoon of 15th December. With the continued maintenance of momentum of the invasion forces, the danger developed of Penang Island being outflanked, and its garrison of one Indian Battalion and Fortress units being defeated in detail. During the evacuation of Penang on the night of 16th–17th December, Fortress Royal Engineers carried out considerable denial operations, including demolitions on the island airfield, and destruction of the Fixed Defences. It was unfortunate that for a number of reasons an appreciable quantity of small vessels and barges escaped destruction, in view of the subsequent use to which these were put in assisting Japanese amphibious operations on the west coast.

It is appropriate here to mention two developments, one relating to the air, and one relating to the sea operations, which had a profound effect on the military campaign as a whole. In the air, the superiority, both in numbers and quality, of the Japanese "Navy O" fighters over our Buffalo fighters discredited our intelligence

No. 1.—"The jungle is neutral." Malayan jungle is characterized by heavy overhead cover all the year round, combined with prolific growth of parasite and other vegetation at ground level.

By courtesy of The Malayan Information Agency.

Sappers In The Malayan Campaign 1

No. 2.—A typical Malayan rubber plantation. The well drained subsoil is easily traversed by wheeled vehicles, and the evergreen foliage affords good cover from air observation.

By courtesy of The Malayan Information Agency.

Sappers In The Malayan Campaign 2

No. 3.—A beach in north-east Malaya. The gentle gradient, good going, and easy access to the hinterland are typical of most Malayan beaches.

By courtesy of The Malayan Information Agency.

No. 4.—A tin dredge at work in central Malaya. Weighing over 800 tons, it floats in the pond which it creates by dredging virgin soil for extraction of tin.

By courtesy of Malayan Tin Dredging Limited.

Sappers In The Malayan Campaign 3,4

No. 5.—The causeway across the Straits of Johore as seen from the air. About three-quarters of a mile in length and carrying the main road and railway, this constitutes the only link between Singapore Island and the mainland of Malaya.

By courtesy of British Overseas Airways Corporation.

Sappers In The Malayan Campaign 5

appreciations. By 11th December the Japanese had achieved air supremacy over the battle area, and maintained this throughout the campaign. Absence of offensive air support was perhaps not as serious a weakness as lack of air reconnaissance, in a country like Malaya where ground observation was limited usually to under 100 yds. At least matters were simplified by our not having to cope with the vexed problem of identification. We were fortunate also in having available so much excellent natural air cover. The practice of Japanese pilots of making a practice run before commencing a low-level bombing or strafing attack used to aggravate us badly, and, once we were observed, we used to open up with S.A. rifle fire (usually all that was available), which although somewhat ineffective at least relieved our feelings. The naval situation was equally unfortunate. The battleship *Prince of Wales* had arrived in Singapore from England on 2nd December, 1941, accompanied by the battle cruiser *Repulse*. These two ships, with a meagre escort of only four destroyers, had put to sea on the night of 8th December, with the intention of engaging Japanese shipping in the Gulf of Thailand. The following day surprise was lost when this fleet was detected by Japanese air patrols, and thus forced to abandon its mission. While returning to Singapore a report was received of a new Japanese landing at Kuantan on the Pahang coast—this report was later proved incorrect. As a consequence, the Fleet gallantly headed for Kuantan, and on 10th December, when about 60 miles off, ran into a strong air striking force. Within about two hours both the *Prince of Wales* and the *Repulse* had been sunk, and our naval power in the Far East reduced to a negligible proportion. Having thus achieved undisputed command of the sea communications in the China Sea, the Japanese were now capable of making amphibious landings anywhere on the east coast of Malaya. The absence of any submarines in our Far Eastern Fleet further increased Japanese naval potentialities.

In view of the grave situation, Command Reserve (12 Indian Brigade Group) had been fully committed by 12th December. With the development later of a strong Japanese thrust from Kroh towards Grik, this brigade was given the task of containing this threat to the envelopment of the right flank of 11 Indian Division. Contact was established north of Grik on the night of 16th–17th December, and during the ensuing five days and nights a fierce battle waged down the Grik road to the junction with the main road at Kuala Kangsar. By repeated counter-attacks, the progress of this main body of the Japanese Patani force was so delayed that 11 Indian Division was enabled to withdraw successfully over the Perak river on the night 23rd–24th December. During the withdrawal down the Grik road, sappers with the brigade group effected successfully a number of delaying demolitions, and the field company concerned received gallant assistance from a small Engineer detachment of volunteers of the F.M.S.V.F. At one of the demolitions we were able to catch a platoon of Japanese on an R.C. bridge at the moment of firing, killing outright some thirty men.

There were three bridges over the River Perak—at Enggor, just south of Kuala Kangsar on the main road, " Iskandar " bridge, the longest in Malaya, was flanked by a through girder railway bridge, and at Blanja, a few miles downstream, a pontoon bridge was located. The successful demolition of these three bridges was acheived under the trying conditions of limited preparation time, difficulty of access to main girders owing to the scale of the structures (temporary staging had to be suspended), interference during preparation by enemy bombing and strafing, and finally, execution by sappers already tired through having worked long and exhausting hours without respite since hostilities began. One unusual feature at Enggor was that the Field Company Commander responsible for the preparation of the demolition was delegated by the rearguard Brigade Commander to order the final blowing.

Phase II—Battle for Central Malaya (25th December, 1941–13th January, 1942)

With all our troops now across the River Perak, a determined effort to stem the invasion tide was to be made at Kampar, about 30 miles south of Ipoh, one of the strongest natural defence positions in Malaya. The unusual long fields of fire, up to about 1,200 yds., afforded by local cultivated and tin mining areas, for the first and only time in the campaign, gave our artillery observers an excellent chance of exploiting that weapon to the full, an opportunity they seized most effectively. Again, only two brigade groups (*6/15 and 28 Indian Infantry Brigades) were available to man the position, and only forty-eight hours could be spent on its preparation, carried out as usual in face of unopposed air harassing attacks. The battle of Kampar began on 29th December, when our delaying troops were forced through the outposts of the position, and fierce fighting developed. Two main demolition belts, an outer and inner ring, were organized around the Kampar area, and all demolitions were executed successfully in the face of heavy enemy opposition. It was at this time that we first became aware of a surprise weapon at the disposal of the Japanese. This was a .256 calibre armour-piercing bullet encased in brass, which proved capable of penetrating what armour we had up to an angle of 45 deg. Apart from the infantry Bren carrier, the only armour available in Malaya was one armoured car regiment of partially trained Indian personnel, and a few

* Owing to the heavy casualties sustained, 6 and 15 Indian Infantry Brigades were amalgamated into one brigade about 19th December.

armoured cars of obsolete pattern manned by volunteers. In spite of gallant handling, the extreme vulnerability of these vehicles seriously impaired their effectiveness, and indeed constituted an unfortunate contrast to the generous proportion of tanks which invariably accompanied the attacking Japanese infantry. In the midst of the Kampar battle, where the troops were fighting magnificently and inflicting heavy casualties, the Japanese made an amphibious landing on 1st January on the west coast near the Perak estuary, and on 2nd January a force came down the River Perak in boats to attack Telok Anson. The build up proved too strong for the opposing troops (12 Indian Brigade), and endangered the security of Kampar. With further landings developing to the south, and armoured thrusts making inroads on the main position, we were forced to evacuate Kampar on 3rd January. In view of enemy pressure, the withdrawal was difficult to execute, and heavy hand-to-hand fighting ensued with parties infiltrating behind the position. One demolition executed by rearguard sappers on the main axis of withdrawal was particularly successful. A site for road cratering in a deep cutting was selected, and prepared within an hour. When the demolition was blown, two forward tanks were destroyed, and others put out of action by an anti-tank gun covering the site. The success was all the more creditable in that the firing party was under close S.A. and mortar fire for several hours before an opportunity occurred to fire, and the demolition leads were twice severed by shrapnel.

After an attempted amphibious landing further south on the west coast near Kuala Selangor, which was repulsed on 2nd January, the Japanese succeeded in landing in this area on the night of 3rd–4th January. The opposing brigade group (6/15 Indian Brigade) was able to localize the effect of this threat up to the night of 10th–11th January, when it was forced to withdraw through Kuala Lumpur, the Federal capital of Malaya. The accompanying sappers had effected a considerable number of hasty demolitions, which contributed in no small way to the delay imposed. At times, the speed with which demolitions had to be reconnoitred, prepared and executed made exacting demands on physically wearied sappers, who still had obtained no relief since hostilities had begun. In this connection the 12 in. earth augur proved a great boon. The berms of roads in the coastal areas were easily penetrable by this tool, and two holes astride the roadway were more effective, and much less costly in time and effort, than the conventional central camouflet.

On the east coast, an isolated brigade group (22 Indian Brigade), denying the airfield at Kuantan, had long distance patrols in contact with a Japanese push from Khota Bahru along the coastal track. By 26th December these patrols were pushed over the Trengganu/Pahang border, and an attack on Kuantan in strength developed on

30th December. During the night 31st December/1st January, 1942, sappers destroyed the ferry, west of Kuantan, on the Jerantut road. In view of the weakness of this water gap on the line of communication of the Kuantan garrison, a swinging pontoon bridge had been under construction, but had not been completed owing to difficulty in obtaining suitable materials. Our troops now re-deployed in close defence of Kuantan airfield. The serious turn of events on the west coast resulted in a withdrawal of this force commencing on the night of 3rd January. Very heavy fighting ensued, during which Lieut.-Colonel Cummings, C.O. 2/12 Frontier Force Regt., Indian Army, won the Victoria Cross. The brigade finally reached Jerantut on the night of 6th–7th January, its sappers having completed a number of delaying demolitions on this road.

On the west coast, the enemy advance continued, and by 14th January all 3 Indian Corps troops had been forced into Malacca and Johore States. Sappers had successfully completed demolitions on all withdrawal routes. It might be worth mentioning here that although the vast majority of road bridges in Johore are of timber (Chengal) construction, it is not possible to destroy these by fire, even when they are treated with petrol, " molotov cocktail," or other highly inflammable mixture. One interesting sapper job was the destruction of a trainload of military supplies, which had been abandoned north of Malacca. It was located well to the flank of our retreating forces, and no infantry protection was available. Rather than sacrifice these stores to the Japanese, sappers formed their own escort, proceeded to the site, laid explosive charges on bearing blocks of wagon axles, distributed charges throughout the stores, and left the train a mass of flames.

Since the retreat down Malaya had begun, sappers had energetically implemented a " scorched earth " policy. In accordance with political directives, water supply and power plants serving the civilian population were precluded from this programme, but a host of other material of potential use to the invader was destroyed—railway stock and plant, ferry facilities, telephone exchanges, petrol and oil stocks, tin mining and rubber production plant, engineer store dumps, etc. In view of our limited resources and very heavy commitments on essential military delaying operations, considerable ingenuity was demanded of sapper units to effect maximum damage with minimum effort. Destruction by fire was frequently most desirable but often impracticable, either because the material refused to burn, or because of the disastrous effect the conflagration might have on the military situation, by demoralization of local troops or civilians, or by indication to the enemy of intended military action. Generally the solution lay in concentrating on the demolition of comparatively small but vital parts which could only be replaced with the greatest difficulty, e.g., top tumblers of mining dredges, injection pumps of prime movers, transformers, electronic equipment, etc. The value to the Japanese of the existing reserve dumps of food for the civilian population was appreciated, and these were effectively disposed of by inviting the local populace to help themselves free of charge. It cannot be denied that the implementation of "scorched earth" measures tended to have a depressing and demoralizing influence on all troops who participated in the execution. Nevertheless, unit commanders were able effectively to counteract any such tendency by timely "pep" talks and personal example. Actually this was easy, as we all firmly believed the tide would soon turn, and that our destructive rôle would be reversed to one of constructive support.

Phase III—Battle for Southern Malaya (14th–31st January, 1942)

At this time we were all fully conscious that any continued appreciable advance by the Japanese would nullify the fundamental object of the Malaya Forces—protection of Singapore Naval Base. It must be "thus far, and no farther." Although 3 Indian Corps, and in particular 11 Indian Division and 12 Indian Brigade Group, had fought continuously without relief from the Thailand border, suffering heavy casualties, morale was good. It was particularly encouraging that fresh troops were now entering the struggle. During our retreat down Malaya it had not been unusual for one battalion to be opposed by three different Japanese battalions within a period of twelve hours. Now the A.I.F. Division of two brigades was available, a keen, well-trained and acclimatized formation. Two fresh battalions from Singapore Fortress had been moved into the battle area. 45 Indian Infantry Brigade Group, semi-trained and destined for the Middle East, had reached Malaya on 3rd January, and 18 British Division was on its way. Our forces were now grouped as follows :—

Westforce (Commander—Major-General Gordon Bennett, A.I.F.)

A.I.F. less 22 Australian Brigade.
9 Indian Division.
45 Indian Brigade Group.
2 Bn. Loyal Regiment (ex-Singapore Fortress).

3 Indian Corps (Commander—Lieut.-General Sir Lewis Heath)

11 Indian Division.
22 Australian Brigade.
2/17 Dogra Regiment (ex-Singapore Fortress).
3 Indian Corps Troops.

Westforce would deny the line Muar–Segamet, while 3 Indian Corps would be responsible for eastern Johore inclusive Endau and Mersing.

On the evening of 14th January the Japanese main push had reached Gemas on the northern border of Johore State. There a well-timed demolition of a bridge by Australian sappers resulted in about 500 Japanese being killed in a pre-arranged ambush. The following night the enemy forced a crossing of the River Muar on the west coast, and heavy fighting ensued in this area. On 18th January a strong Japanese force landed on the west coast just north of Batu Pahat. Fighting at Muar continued until the night of the 21st–22nd January with heavy casualties to both sides, and for heroic leadership during this engagement Lieut.-Colonel Anderson, A.I.F., was later awarded the V.C. In spite of strong resistance, Japanese armoured thrusts forced a withdrawal from Segamet on the night of 18th–19th January. By midnight of 23rd January rear-guard troops from the Segamet front had passed through a defence position in the area about Yong-Peng, an important road centre in central Johore. Again sappers completed successfully all required demolitions on the enemy front. On the night of 25th–26th January we were forced out of Batu Pahat, and the Japanese captured Kluang airfield in central Johore, the last remaining airfield on the mainland of Malaya.

On the east coast, the Brigade Group in the Endau/Mersing area had made contact north of Endau on 14th January with a Japanese force moving along the coast from Kuantan. In a subsequent withdrawal from Endau, Australian sappers blew a number of craters on the road to Mersing, the effectiveness of these demolitions being enhanced by the numerous swamps defiles on that route. By 21st January the Japanese were being held north of Mersing. Fresh troops were landed by sea from Singora on 26th January at Endau, a port with which the Japanese were very familiar on account of their having held mining concessions there prior to the war. This strong reinforcement enabled the enemy to capture Mersing, and force our troops back about 10 miles to a defensive position at Jemuluang, on the Singapore road, by 27th January. Withdrawal demolitions were again completed successfully, as well as "scorched earth" measures in the Mersing area.

The gravity of the military situation on the west coast resulted in the initiation of a co-ordinated withdrawal of all our troops in Johore, through an outer and inner bridgehead defence, over the causeway to Singapore Island. The fact that 18 British Division had not yet arrived contributed to this decision. To continue to offer further resistance on the mainland against overwhelming odds would undoubtedly have resulted in an early defeat in detail. Delaying demolitions were completed on all approaches to Johore Bahru, situated at the Johore end of the causeway, and by the morning of 31st January our rearguard troops had reached the island, when the link with the mainland was severed. The denial of the causeway, some 1,100 yds. in length, was the largest and probably the most vital demolition in the campaign. Its successful completion was a tribute to the excellent teamwork of the sappers concerned—an Indian Sapper and Miner Company of four sections, with under command a Fortress Company Royal Engineers and one additional section Sappers and Miners, the equivalent in all of approximately eight sections at about 70 per cent strength. The plan embraced the destruction of a steel road and rail bascule bridge and lock system at the north end ; then a clear 60 yd. water gap ; followed by a strong anti-tank obstacle in depth, along the remainder of the causeway consisting of anti-tank mines, steel rails set in concrete, and mass concrete blocks ; and finally the demolition of an R.C. road bridge over the railway, and two subsidiary road and rail bridges at the south end. The completed demolitions and tank obstacles were liberally surrounded with concertina wire attached to booby traps, which operated anti-personnel mines. For the blowing of the section of causeway, we used naval depth charges. These were placed in position inside water channels, some 30 in. in diameter beneath the causeway, by sappers in bathing costumes, and packed with additional charges of gelignite in waterproof rubber sacks. The north end demolitions and causeway water gap were exploded electrically simultaneously, a number of vehicle wet batteries being used to overcome the considerable resistance of the multitudinous circuits. Final wiring was then completed on the anti-tank obstacle, and booby traps were activated. The remaining demolitions at the south end of the causeway were exploded later in conformity with the military situation.

Phase IV—Battle for Singapore Island (1st–15th February, 1942)

The Singapore Naval Base situated on the north-east shores of the island was now under observed artillery fire. An indefinite denial of the island, some 35 by 15 miles, was of the utmost importance in the strategy of the Far East War. In spite of the floating dock having been scuttled and many vital naval stores evacuated, the possession of the Naval Base, the three island airfields (Tengah, Seletar and Kallang), and the extensive Singapore harbour, would place the Japanese in a paramount position for further aggression in the South Pacific. During the withdrawal down Malaya our troops had inflicted heavy casualties on the enemy. Although the long and exhausting hours of continuous fighting had exacted its toll on the vitality of our men, morale generally was quite high. In sapper units particularly morale was very good, a contributory factor having been that the constant demand for Engineer assistance during hostilities had been generally met satisfactorily. As an example, during the retreat from the Thailand border, one field company had completed more than 150 demolition projects, without a failure or premature blowing, in addition to executing "scorched earth" measures and sundry Engineer work in support of military operations.

For the defence of Singapore, the island was organized into three areas as follows :—

Northern Area (Commander—Lieut.-General Sir Lewis Heath)

From exclusive Changi on the extreme east of the island to exclusive the causeway :—

3 Indian Corps (which was now reduced to less than one division).

18 British Division (which had arrived Singapore on 29th January).

Southern Area (Commander—Major-General F. Keith-Simmons)

From inclusive Changi to inclusive Singapore city, and inclusive River Jurong on the west coast :—

1 and 2 Malayan Infantry Brigades.

Straits Settlements Volunteer Force.

Fortress Troops.

Western Area (Commander—Major-General Gordon Bennett, A.I.F.)

From exclusive River Jurong to inclusive the causeway :—

A.I.F. Division.

44 Indian Infantry Brigade.

Although the actual strength of troops on Singapore Island was in the region of 85,000, a large number of these were administrative and non-combatant personnel, manning the base facilities. We had the equivalent of four weak divisions, and were opposed by three enemy divisions with two in reserve. The Japanese had virtually undisputed control of the air and sea.

During the first week of investment of the island, artillery on both sides was very active, Japanese observers operating from balloon sections located in Johore Bahru. Work on forward field defences had to be restricted normally to hours of darkness, owing to the volume and accuracy of enemy fire. Officer patrols crossed the Straits nightly into Johore, and acquired valuable information on Japanese preparations for the assault. Sappers provided technical assistance to infantry parties working on the defences, and in addition laid anti-tank minefields, placed naval mines across water approaches, and built gun emplacements for the close defence of airfields against paratroop or air landing assault. One interesting job was the destruction of an R.C. pier on the north shore of an adjoining island, within a few hundred yards of the mainland. The demolition was planned from blue-prints of the pier, and charges packed into square kerosene tins and specially constructed wooden boxes. The sapper officer in charge also commanded the infantry escort. Approach to the site was made at night from Changi by motor launches, which were propelled by muffled oars during the latter stage of the journey. The charged containers were quickly placed in position by securing with lashings previously prepared. Silence was essential to avoid inviting close range small arms fire. The pier was completely demolished within half an hour of arrival, and the troops withdrew across the island to the south shore, where they re-embarked on the motor launches.

Following an intense artillery barrage of about seven hours' duration, the Japanese launched an offensive against the north-west shores of the island (Western Area) during the night of 8th–9th February. The initial assault was made by two divisions, troops crossing the Straits of Johore from the mainland in armoured assault craft, each carrying about forty men. There were about fifty assault craft in each wave, and the attack met with heavy defensive fire which sank many boats and inflicted severe casualties. Our troops were unable to prevent the Japanese obtaining a foothold, and confused hand-to-hand fighting developed in forward areas. It is now known that about 13,000 Japanese troops landed during the night, and a further 10,000 the following morning. By about eight o'clock on the morning of 9th February, the assaulting troops had pushed southwards to Tengah airfield, where bitter fighting developed. The same day the remnants of the one squadron of Hurricane fighters, which had constituted the only air element in the garrison, were withdrawn to the Netherlands East Indies, and for the remainder of the fighting no Allied aircraft appeared again over Singapore. A successful counter-attack re-established our troops on high ground dominating the causeway. The following day the enemy push from the north-west shores of the island had reached Bukit Timah village, a road junction in the centre of the island. Heavy fighting continued during the 11th and 12th February, and in spite of local counter-attacks Japanese penetration persisted, largely through weight of enemy armour and offensive air support. By the morning of 13th February, Changi had been evacuated, after the Fixed Defences had been immobilized, and all forces were re-grouped in a perimeter defence of Singapore town. During the 14th and 15th February, desperate fighting ensued, and our troops were pushed further back on to the town environs. With hospitals and improvised dressing stations filled to overflowing, water reduced to one day's supply, and acute shortages in 25 pounder, mortar, and Bofors ammunition, the G.O.C. ordered all fighting to cease at 2030 hrs., 15th February.

During the incipient stages of the assault, sappers had been engaged on demolition work, both delaying operations on approaches, and also denial of stores, plant and equipment of potential use to the enemy. In the final stages, R.E. tradesmen had been employed in an uphill fight of effecting repairs to the town water mains, necessitated by extensive bomb and shell damage. When it became apparent that the Japanese foothold on the island would be maintained, in an endeavour to mobilize maximum defensive fire power, a composite R.E. Battalion was formed to augment the 1st Malaya Infantry Brigade. The C.R.E. Singapore Fortress Royal Engineers, Lieut.-Colonel H. M. Taylor, R.E., assumed command of this battalion, which comprised one Fortress Company R.E. and three Sapper and Miner field units. The R.E. Battalion acquitted itself well in the fighting, and on the last afternoon suffered heavy casualties in preventing a break-through.

Part III—Conclusions

The lessons of this campaign to the sapper appear to be as follows :—

Air Support

Because of the concentration of all available air power in winning the battle for air superiority, there inevitably will be areas where troops will have to operate without air support in the incipient stages of a war. Consequently it is suggested that regular sapper units in particular should include training in the face of strong enemy air opposition. Emphasis should be laid on speed of operation, and on accuracy during night work. A high degree of skill in passive measures, such as concealment from the air of working sites, vehicles and dumps, should be attained, and efficient air sentry drill and air attack discipline inculcated.

Demolitions

In common with other obstacles, demolitions are largely dependent for their effectiveness on their being adequately covered by fire. This is an old adage, but needs constant emphasis. When training with other arms, sapper officers should seize every opportunity to impress this fundamental principle on the troops taking part.

During confused fighting, the risk of a premature or unsuccessful demolition, with its attendant dissipation of resources, is ever present. Whilst a high standard of training of firing parties is essential, the best insurance derives from good liaison with fighting units in the area concerned. The sapper officer should himself take the initiative in establishing such liaison, and should never fail to obtain timely clarification in all cases where the intention of the local force commander is not clear, or where ambiguity exists in orders received. A demand is likely to grow for little apparent indication that a structure has been prepared for demolition, and for more effective concealment of firing parties.

Demolition training should include the use of whatever commercial explosives are available locally. Sapper units should also familiarize themselves with Royal Navy and Royal Air Force explosives, which might be improvised to sapper use in emergency.

Employment as Infantry

The mobility of modern war, combined with paratroop and air landing developments, demand the highest standards of skill in the use of personal and support weapons within field units. In the incipient stages of a war, sappers should be prepared to provide their own protection for firing parties, even although such practice violates the principle of economy of force.

With the introduction of the regimental organization and the development of wireless communications within sapper units, the situation regarding the employment of sappers as infantry has changed considerably since the Malayan campaign. Should, however, individual squadrons, which have been divorced from their regimental headquarters, be required to fight as infantry, these should be put under command of a battalion headquarters rather than an *ad hoc* Engineer headquarters, in order to obtain maximum benefit from the existing support organization.

General Training

However low may be the priority of the theatre in which the sapper officer is serving when a war breaks out, two features of training can be promoted enthusiastically, which are independent of shortages of equipment or training stores. The highest standard of physical fitness should be cultivated in units as a first essential. The limits of human endurance of fit troops, even under severe tropical conditions, are indeed very considerable. Again, all ranks should be trained to acquire an intimate knowledge of the country they are stationed in, particularly the terrain, but also the habits and psychology of the local populace. A physically fit unit, well versed in local conditions, will enjoy many advantages over an invader, even one who is numerically superior and better equipped.

Finally it is suggested that emphasis in the training of regular sapper units should be laid on developing the capacity, resourcefulness and confidence of individual sappers. With the outbreak of a war, considerable dilution at all levels is to be expected, and hence the aim should be to make every sapper a potential junior leader.

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THE SUNDAY TIMES

THE LEADING SUNDAY NEWSPAPER IN MALAYA

Brownout time 6.49 p.m. to 6.46 a.m.
Moonrise 6.48 p.m. to 6.25 a.m.

No. 328 Sunday, February 1, 1942 Price 10 Cents.

CAUSEWAY BLOWN: BATTLE OF SINGAPORE BEGINS

Imperial Troops Leave Johore For Island

THE defence of Singapore Island has begun. Yesterday, after the Imperial forces had been withdrawn across it, the already mined Johore Causeway was blown sky-high by our sappers.

Thus, in the words of Lieut.-General A. E. Percival, General Officer Commanding, Malaya, the Battle of Malaya has come to an end and the Battle of Singapore has started.

The Combined Headquarters' communique issued in Singapore yesterday disclosed that on Friday night, in accordance with a pre-arranged plan, the Imperial forces which had been operating in southern Johore were withdrawn to the Island.

Although the enemy had the advantage of a bright moon, he made no effort to hamper the withdrawal movement. There was no bombing and no machine-gunning throughout the entire operation which was accomplished without the exchange of a shot.

"Our Task To Hold This Fortress Till Help Comes"

The last forces to cross the Causeway were the Argylls, who marched over it to the accompaniment of the bagpipes. When these troops had reached the Island the northern half of the Causeway was completely destroyed, huge mines already placed by our sappers being detonated about 8 a.m., yesterday.

With four tremendous explosions, the 1,155-yard-long structure was blown. Thus, the famous link with the Malayan mainland was destroyed.

The determination of the Imperial forces to defend Singapore to the utmost was emphasized last night by Lieut.-General A. E. Percival, G.O.C., Malaya.

In the course of his message, General Percival said: "The Battle of Malaya has come to an end and the Battle of Singapore has started. For nearly two months our troops have fought an enemy on the mainland who has had the advantage of great air superiority and considerable freedom of movement by sea. Our task has been both to impose losses on the enemy and to gain time to enable the forces of the Allies to be concentrated for this struggle in the Far East.

"Today, we stand beleaguered in our Island fortress. Our task is to hold this fortress until help can come, as assuredly it will come.

"This we are determined to do. In carrying out this task we want the active help of every man and woman in the fortress. There is work for all to do."

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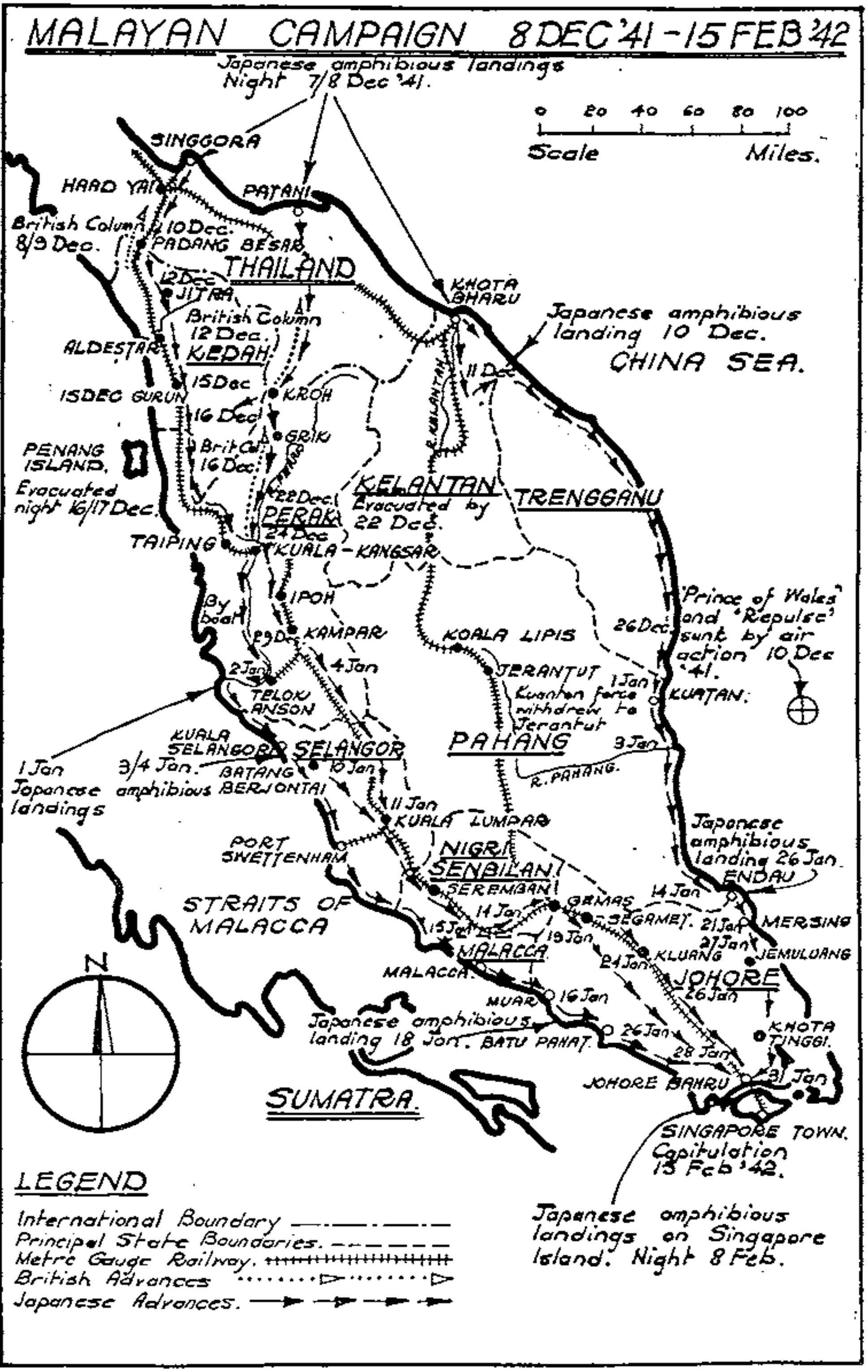


MALAYAN CAMPAIGN 8 DEC '41 - 15 FEB '42
Japanese amphibious landings Night 7/8 Dec '41.
0 20 40 60 80 100
Scale Miles.
SINGGORA
HAAD YAI
PATANI
British Column 8/9 Dec.
10 Dec.
PADANG BESAR
THAILAND
12 Dec
JITRA
KHOTA BHARU
British Column 12 Dec.
ALDESTAR
KEDAH
Japanese amphibious landing 10 Dec.
CHINA SEA.
11 Dec
15 Dec
15 DEC GURUN
KROH
16 Dec
GRIK
PENANG ISLAND.
Evacuated night 16/17 Dec.
Brit Col. 16 Dec.
R. KELANTAN
R. PERAK
22 Dec.
KELANTAN
Evacuated by 22 Dec.
TRENGGANU
PERAK
24 Dec
TAIPING
KUALA - KANGSAR
IPOH
By boat
'Prince of Wales' and 'Repulse' sunk by air action 10 Dec '41.
29 Dec
KAMPAR
KOALA LIPIS
26 Dec
4 Jan
2 Jan
JERANTUT
1 Jan
TELOK ANSON
Kuantan force withdrew to Jerantut
KUATAN.
KUALA SELANGOR
SELANGOR
PAHANG
3 Jan
1 Jan
3/4 Jan.
BATANG BERJONTAI
10 Jan
R. PAHANG.
Japanese amphibious landings
11 Jan
KUALA LUMPAR
Japanese amphibious landing 26 Jan.
PORT SWETTENHAM
NIGRI SENBILAN
ENDAU
SEREMBAN
14 Jan
STRAITS OF MALACCA
GEMAS
SEGAMET.
14 Jan
21 Jan
MERSING
15 Jan
19 Jan
27 Jan
MALACCA.
24 Jan
KLUANG
JEMULUANG
MALACCA.
JOHORE
26 Jan
MUAR
16 Jan
KHOTA TINGGI.
Japanese amphibious landing 18 Jan.
BATU PAHAT.
26 Jan
28 Jan
JOHORE BAHRU
31 Jan
SUMATRA.
SINGAPORE TOWN.
Capitulation 15 Feb '42.
LEGEND
International Boundary
Principal State Boundaries.
Metre Gauge Railway.
British Advances
Japanese Advances.
Japanese amphibious landings on Singapore Island. Night 8 Feb.
N

SIAMESE JOURNEY

By Brigadier J. C. T. Willis, O.B.E.

IN a way, I didn't mind when they shut my hand in the car door at the end of the day. It somehow seemed to round off the whole incident. Anything more would have been too painful. Anything less, an anti-climax.

We were all very grateful to the Siamese Government for arranging such a nice party for us, for putting three special cars at our disposal and for organizing a start at the eminently reasonable hour of seven o'clock, with breakfast at Ayuthia, some fifty miles away. This to be followed by sightseeing and a return journey down river by launch, with luncheon and tea thrown in. We were confident of a really successful day. Our confidence was not however, shared by our British hosts, who, with their greater knowledge of Siamese organizing ability, had clearly reviewed the programme with a cynical smile. The result of their review manifested itself in the unobtrusive addition at the tail end of the procession of cars, of two jeeps, a twelve-seater bus and a breakdown truck complete with crane. Within an hour we were to need them all.

Situated as I was in the second car of the procession, I had every opportunity of speculating on the probable reasons for the dense clouds of blue smoke which were emerging at intervals from the General's car immediately in front. My neighbour in my own car, the Siamese Minister for Education, made no great demands on my duties as a guest, for he proved utterly unable to speak or understand a word of English. Clearly his qualifications for the job were more those of close relationship with the Ruling House, rather than profundity of learning. I thus had plenty of leisure to assess my chances of defeating the car sickness which was stealing over me, caused no doubt by the surface of the road and the apparent lack of springs in the car.

Within half an hour the expected happened and the General's car bumped uneasily to a standstill. Each car-load moved into the car immediately behind it, somewhat after the manner of the Mad Hatter's tea party and the procession moved on again. I employed my leisure on speculating whether the General was more—or less—prone to car sickness than I was. If, however, he was in about the same category, I was not giving the new arrangement more than about twelve minutes at the outside. The matter was not put to the test, for, but ten minutes later, the leading car in the procession decided to follow the example of its predecessor and it, too, came to rest. The " all-move-back-one-car " operation proceeded with the ease born of practice and with an enthusiasm based on the assumption that we were to have ample opportunity in the future of improving our technique. I was now about to work through the jeep strata of the convoy, before coming finally to rest in the lorry at the back, which was clearly my ultimate destination, and which was already, I felt, beginning to get uncomfortably full ! The General, however, with the effect of his previous car's springs firmly implanted in his mind—if nowhere else—invited me to come forward with him and act as some measure of ballast and packing.

The convoy struggled on and two-thirds of our journey were completed. We stopped at a small group of huts to allow the stragglers to rejoin the column and resisted the temptation of buying prawns, fresh caught from the local drainage system, which, together with lotus seeds " on the hoof " as it were, were pressed upon us by the local business instincts. We moved on. It was now half past nine and I had long ago decided that a cup of tea, made as only an untrained Sepoy can make it, eight cigarettes and five lotus seeds make an unsatisfactory substitute for eggs and bacon.

After a further half-hour, during which the road rapidly deteriorated, we came to the place where it declined into a sort of morass, about twelve inches deep and of viscous mud. The Siamese driver appreciated the situation rapidly, drove with deliberation into the worst part and stalled his engine. We lightened the ship and inspected our hub caps, just visible above the mud. We pushed, and I smile quietly now when I think that at that stage of the journey I was concerned that my shoes were getting so muddy before reaching a formal reception. I little knew. O gosh, I little knew ! The first jeep nosed up and joined the party. The second jeep nosed up behind the first and all three cars began to swim slowly forward. Well, no ; " forward " is the wrong word, as the driver of the General's car at the front of the procession decided that he could best help matters by locking his wheel hard to port. The liquid mud of the padi, four feet below road level on the port side, looked very uninviting. He was exhorted by word and gesture, and finally replaced by a self-confident Police Corporal who took the wheel with all the determination of a man who has made up his mind to get the car through or perish in the attempt—alternatives which appeared to present an approximately even chance. The car slowly emerged on to more stable ground and came to rest.

The convoy was through ; and "A" gave the order to get clear quickly. Of course I know now that the four inches of mud in which the car was standing was bound to produce wheel spin. I also know that "A" and I were unwise to stand immediately behind the car as it started up. Somehow, four inches seemed so little after the eighteen through which we had just struggled. It didn't seem so little after it had been transferred, *in toto*, to our clean uniforms. "A" emerged looking like a new form of camouflage. I rather favoured the Dalmatian motif. We moved on, and I crouched in the corner of the car like a leper, as far from the General as I could. After all it was my mud, and there seemed no reason why he should have it. He could smell it as much as he liked, as its fragrance spread througout the car, but I thought it best to keep myself to myself. And thus we came to Ayuthia, where breakfast and a posse of Siamese officials in spotless white were awaiting our arrival ; and had probably been doing so for the previous two and a half hours.

I pass over the breakfast, which sat lightly on my lotus seeds, and over the sightseeing, which was not greatly to be distinguished from much else of its kind. I forebore to have my fortune told by shaking out a numbered stick at the feet of an immense Buddha in a roofless, ruinous temple. I travel much by R.A.F. Transport Command, and there are some things 'twere best not to know. We duly admired the museums, bestowing our encomiums equally on priceless jade, with the sheen of centuries upon it, and on the 1918 gas mask, with book of instructions, in the adjoining cabinet ; we settled down to await the arrival of the launch which our Siamese hosts had kindly offered to take us down the river to the rendezvous with the launch of the plan as originally conceived. A half-hour passed, and then another. The General inspected a girl's school. I passed the time with gloomy forebodings as to the launch's existence, and its age, if it ever materialized. Thoughts of lunch crossed the mind, only to be dismissed as too problematical at that stage. The launch appeared and we piled in. I admired the plush curtains with the green bobbles round the edges, which hemmed in every port of the cabin, and the engine cleared its throat and broke into wheezy life; an obvious martyr to asthma. I decided not to try and sketch river craft, as we should pass them by too quickly. The fates must have smiled quietly as I registered this impression. Someone asked our Siamese liaison Colonel how long it would take to reach the rendezvous. He replied "About an hour." The engine overheard, and stopped with a muffled report. Three times this happened, and three times it was coaxed back into wakefulness by the crew, who treated it with marked deference, born of their own ignorance and as a rightful tribute to the advanced age of the machinery.

An intentional stop next, to view another temple in the half-light of which a golden Buddha brooded, a full sixty feet in height, its pedestal crowded with tawdry ornaments and the main wall decorated by a cheap reproduction of a lifeboat harpooning a whale. We bowed our thanks and re-embarked.

A further half-hour brought us to the "proper launch" and to our long overdue lunch, both welcome, and we reckoned that our troubles were over. More of a yacht than a launch, it was clearly of a different class to that we had just unregretfully left and we settled down to a pleasant luncheon of assorted cold meats and sausages handed round on a tray. I was hungry and did full justice to it, and felt that perhaps an ice and a cup of coffee would round matters off nicely. No ice : not yet anyway, not perhaps until we had finished the very liberal portion of fish which made an unexpected appearance. It was only after I had dealt with it, and saw large dishes of steak and vegetables being handed round that I realized that my cold meats were merely hors d'œuvres. I struggled through the steak and gasped with relief. Short lived, for there was a large curry to follow. Of the next two or three hours I have no clear recollection. My outraged digestive organs battled on while I slept fitfully.

Soon it came dusk—then quickly dark, and the lights of Bangkok came into view. The General, several hours late for important engagements, maintained his courtesy unimpaired—tho' I suspect at the cost of some inward struggle. It wasn't till we were within five minutes of the landing stage that the monsoon rain came down with a crash, blotting out our surroundings, drawing attention to the utter inadequacy of the roof of the launch and providing an excuse, if not a reason, for our fouling the mooring lines of a submarine at anchor in the river. A mere twenty minutes sufficed to remedy this, and we stepped ashore to our cars, I, for one, drenched to the skin and not a little conscious of a bright red and white crane's feather fan presented to me as a souvenir at the breakfast table. The driver whirled us through the blinding rain to our mess. I got out. I thanked him. He admired my fan. It was his, ten seconds later. It was then that he shut my hand in the car door ; but he doesn't know that.

POSSIBLE MILITARY APPLICATIONS OF THE GAS TURBINE

By MAJOR (TEMP. LIEUT.-COLONEL) A. L. HICKS, O.B.E., R.E.

PART I—INTRODUCTION

THE remarkable performance of gas turbine engined aircraft during the war has focused attention upon this type of power plant and has tended to give the impression that it is a war-time invention. In fact, this is far from the truth, the earliest gas turbine to perform useful work being the medieval "smoke-jack" which is attributed to Leonardo da Vinci (1452–1519). This apparatus is described by Bishop Wilkins in his book *Mathematical Magick* published in 1648 in which he says :—

> "But there is a better invention to this purpose whereby a spit may be turned (without the use of weights) by the motion of the air that ascends the Chimney ; and it may be useful for the roasting of many or great joynts : for as the fire must be increased according to the quantity of the meat, so the force of the instrument will be augmented proportionably to the fire. These sails will always move both day and night, if there is but any fire under them, and sometimes though there be none. For if the air without be much cooler than that within the room, then must this which is more warm and rarified, naturally ascend through the Chimney, to give place unto the more condensed and heavy which does usually blow in at every chink and cranny as experience shews."

After this, progress on the gas turbine lapsed until 1791 when Barber took out British Patent No. 1833 which anticipated many of the developments of modern gas turbine design. A further hiatus followed till early in this century when various experimenters were at work, since when the development of a practical gas turbine progressed slowly until the recent war gave it a tremendous impetus in its application to jet propelled aircraft.

In considering future military applications (as distinct from naval and aerial use) it is necessary to survey probable civilian uses, since, unless the gas turbine offers some outstanding benefit in performance, it would not be practical to specify a gas turbine, for neither industrial capacity to manufacture nor trained personnel to operate them would be available in time of war. In such comparisons, care is necessary since the criteria which decide whether to use a gas turbine or some other prime mover are different in the civilian sphere. For civilian use, capital and operating costs are predominant; for military use other factors will be of greater importance. For example, simpler maintenance, lightness (chiefly in its effect on air portability), freedom from interference by frost, ability to operate without water in desert areas, use of a not easily inflammable fuel, will all be of greater value to an army in the field than a small difference in capital or fuel costs.

Before discussing such employment it is necessary to understand the general construction of a gas turbine power plant, the cycle on which it works, the factors affecting its efficiency and the type of performance it may be expected to provide. These are set out in Part II.

The three main civilian fields in which experiments with the employment of the gas turbine instead of other prime movers are now in progress are :—

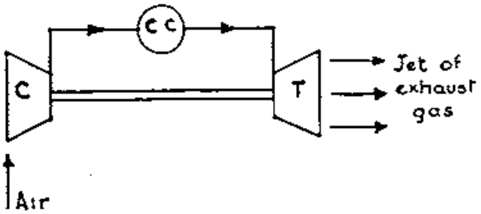
Road vehicles
Railway locomotives
Electricity generating plant.

The particular advantages or otherwise of the gas turbine for military use in these fields are discussed respectively in Parts III, IV and V, and in Part VI certain specialized military applications, to which gas turbines built for other uses could be readily adapted are put forward.

PART II—THE GAS TURBINE AND ITS CHARACTERISTICS

In its simplest form the gas turbine comprises only an air compressor, a combustion chamber and burner, and a turbine wheel; the compressor and turbine being mounted on a single shaft (see Plate 1). Air is drawn into the compressor, raised there to about four times atmospheric pressure and delivered to the combustion chamber where a continuous flow of fuel is injected into it. The fuel burns at constant pressure (compressor delivery pressure) in an excess of air, totalling about four times that required for complete combustion, and is then admitted to the turbine where the energy of the gas, or a portion of it, is converted into useful work. (The greater part of the excess air by-passes the burner and is mixed with the products of combustion just before leaving the combustion chamber, the object being to reduce the temperature of the burnt gas before admission to the turbine.)

PLATE 1



— FIG. I. —

LEGEND

C Compressor
T Turbine.
CC Combustion chamber
═══ Shaft
—►— Duct (Arrow shows direction of flow of gas)

SIMPLE GAS TURBINE LAYOUT

The amount of energy converted by the turbine depends on the type of power output required. If the engine is to be used for jet propulsion, only sufficient power will be taken to drive the compressor, this in itself however may amount to almost three-quarters of the total available. For land use, the heat and velocity of the jet are such as to cause considerable disturbance to personnel or material in its path and so render it unsuitable as a source of motive power (except for special uses dealt with in Part VI).

In this paper, therefore, unless stated to the contrary, it is to be assumed that the useful power output of the gas turbine will be supplied in the form of shaft horse-power rather than in thrust. If shaft output is required all the energy can be converted by the turbine, from which the gas is then released to atmosphere with the minimum residual velocity and only just above atmospheric pressure.

The gas turbine power plant can comprise any number of compressors, turbines, heaters, coolers and heat exchangers and is therefore not so much an engine as a thermal system. These various components can be connected in very many different ways according to the type of power output required. It can produce a stream of high velocity gas to propel an aircraft, a stream of compressed air for ventilation or alternatively shaft power with the torque characteristics required for traction or the generation of electricity.

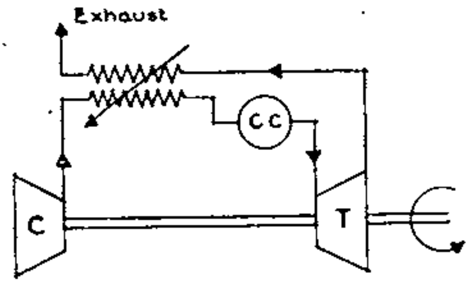
Other prime movers have, as a result of experience, each found their own particular field of application. The reciprocating steam engine has shown itself cheap and reliable and to have long life, but at the expense of high fuel consumption and great weight and bulk. The steam turbine has proved to be a power plant of great reliability and long life, but one in which high efficiency can only be obtained in very large units involving great weight and bulk. The diesel engine can give good efficiency in all the sizes in which it can be made, but really large powers involve excessive weight, bulk and complication and very small sizes are not practicable owing to limitations in fuel pump design. Its reliability and length of life are inferior to those of the steam turbine. The petrol engine is less efficient but lighter than the diesel and has been developed mainly for low powers. Its reliability and length of life are comparable to those of the diesel.

By the adoption of a suitable cycle, the gas turbine can be made in a form which is lighter and simpler than the petrol engine and as efficient. By the adoption of another cycle it can be made even more efficient than the diesel engine. Moreover, since it has no reciprocating parts, its life and reliability will far exceed those of petrol and diesel engines and will compare with the steam turbine. The gas turbine may well therefore become a power plant of almost universal application. Before this can come about, considerable improvement in efficiency must be made compared with the power plants at present in service.

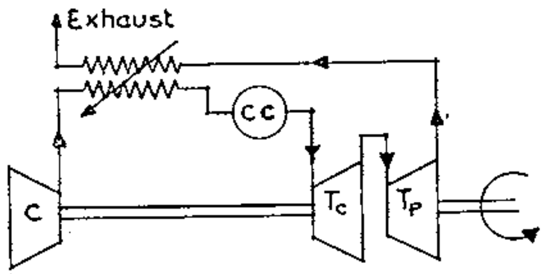
A brief summary of the directions in which this improvement may be achieved will assist in appreciating the extent to which the gas turbine can replace other prime movers. In the gas turbine system the only rejection of heat (apart from minor radiation losses) is in the exhaust gas. The amount of heat so lost can be reduced by increasing the pressure ratio of expansion so that a larger temperature drop occurs in the turbine or by transferring exhaust heat back to the compressed air by means of a heat exchanger. This second method is only possible when the pressure ratio of compression is low because above a certain pressure ratio (between 8 and 10 : 1) the temperature of the compressed air will be above that of the exhaust gases. Thus either a high pressure ratio without heat exchange or a low pressure ratio with heat exchange may be used.

Since the useful power developed is the difference between the power generated in the turbine and that absorbed by the compressor, more power and therefore higher efficiency will be achieved by any change which increases the former and reduces the latter. Turbine output can be increased by raising the gas temperature or by improving the turbine efficiency. Since the maximum gas temperature is limited by the inability of the turbine blading material to with-

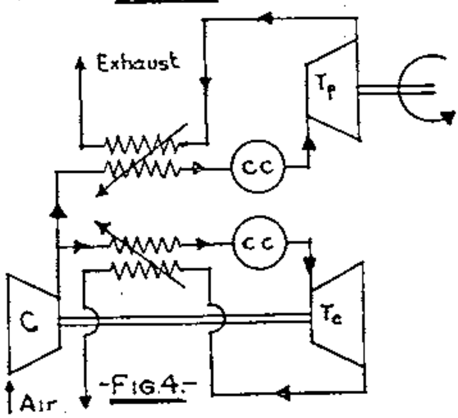
PLATE 2



— FIG. 2. —



— FIG. 3. —



- FIG. 4. -

LEGEND

C Compressor
C_{LP} " low pressure
C_{HP} " high pressure
T Turbine
T_c - driving compressor only
T_p - providing power only
T_{LP} - low pressure
T_{HP} - high pressure
CC Combustion chamber

Heat exchanger (Arrow shows direction of flow of heat)
Duct (Arrow shows direction of flow of gas)
Shaft
Power output shaft

GAS TURBINE SYSTEMS

PLATE 3

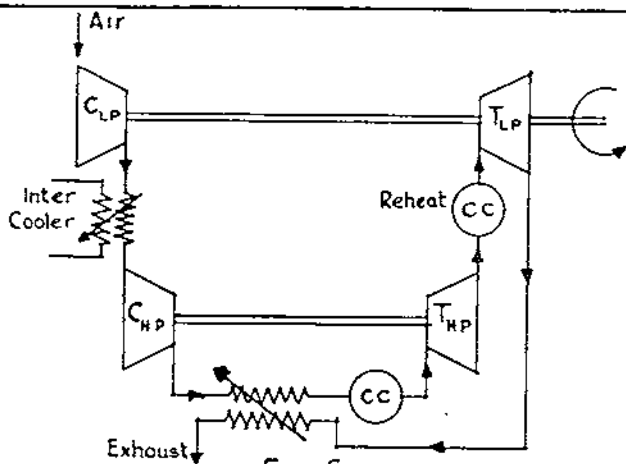
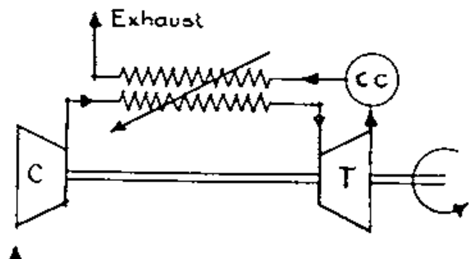
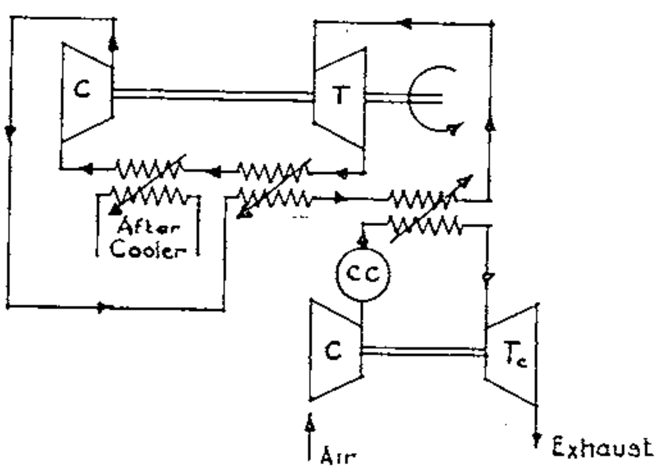


FIG. 5.



— FIG. 6. —



— FIG. 7. —

GAS TURBINE SYSTEMS

FOR LEGEND SEE PLATE 2.

stand high temperatures indefinitely without failure (the present limit is about 800° C.), an alternative is to expand the hot gases through part of the turbine to a lower temperature, then to reheat the gases by burning more fuel and again expand them. Provided that this reheating is effected before too much pressure is lost, an increase in efficiency will result.

As far as the compressor is concerned, the power absorbed can be reduced by an increase in compressor efficiency, reduction in air inlet temperature, or, for a given pressure ratio, by compressing in stages with inter-cooling. The saving in power input to the compressor in this latter case exceeds the amount of heat rejected in the inter-cooler. Unfortunately compressor and turbine efficiencies are susceptible to changes in speed, air mass flow and temperatures so that additional complications of the thermal system are necessary to provide good efficiencies at varying loads.

A number of specimen systems of increasing complexity are shown in Figs. 2–7 on plates 2 and 3.

Fig. 2 shows a simple low pressure cycle with a heat exchanger, this has a higher efficiency than the elementary cycle shown in Fig. 1 (which is that used in aircraft jet propulsion engines), particularly at part loads.

Where power output is required at a speed independent of that of the turbo-compressor, a mechanically separate power turbine must be added. This is shown in Fig. 3. This gives the same efficiency at the design point as the system shown in Fig. 2, but the part load efficiency is lower. An alternative method is the parallel system shown in Fig. 4. This provides good results for both variable and constant speed applications. The efficiency remains reasonably constant at about 35 per cent from full load to 40 per cent load, falls slowly to 27 per cent at 10 per cent load and then drops rapidly.

If higher pressure ratios than about 4 : 1 are required, compounding must be employed, this lends itself to inter-cooling and reheating. A typical arrangement is shown in Fig. 5, this is a " straight-compounded " system (where the LP compressor is driven by the LP turbine) as opposed to " cross-compounding " (where the LP compressor is driven by the HP turbine). The former method gives a more flexible low load performance than the latter.

All the above systems are "open cycle," i.e., the products of combustion pass through the turbine. If, due to corrosion, this is not acceptable, an external combustion cycle can be employed, the simplest form of which is shown in Fig. 6. The principal disadvantage of this arrangement is the excessive size of the heat exchanger required to give a reasonable efficiency.

Fig. 7 shows a further development of this theme using a completely closed main cycle and an open secondary cycle. This system requires the inclusion of an " after cooler " to reduce the temperature of the working fluid in the closed cycle before its return to the compressor.

It will be realized that there is infinite flexibility in the design of a gas turbine system and that for any given application, it should be practicable to arrange a layout that will give the required performance.

One point that does require attention on a gas turbine for land use is filtration of the incoming air. Axial flow compressors are prone to collect dust on their blading with a resulting loss in efficiency. Centrifugal compressors on the other hand will throw off all such particles and bombard the diffuser vanes causing erosion which will also lead to a loss of efficiency. Whatever type of compressor is employed, thorough filtration of the air without causing an appreciable throttling of the flow is therefore essential. It must be remembered that the flow is several times that of a piston engine of equal power so that this is a bigger problem than it appears at first sight.

Part III—Road Vehicles, including Motor Cycles, A.F.Vs. and Small Stationary Plant

In applying the gas turbine to these fields, the first consideration is whether the reduction in size, to produce the lower power required, from the present size of aircraft gas turbine of, say, 2,000 h.p., can be achieved successfully. This scaling down will be likely to reduce efficiency in two ways. Firstly, it will be difficult to manufacture to comparable limits in respect of blade profiles and tip clearances ; secondly, the aerodynamic losses will be increased if the Reynolds number is reduced.

The Reynolds number is equal to :—

$$\frac{VD\rho}{U}$$

where V = gas velocity
D = typical dimension
ρ = gas density
U = gas viscosity.

Since the small turbine will work under the same conditions of gas velocity, density and viscosity as the aircraft turbine at sea level, the actual size is the only variable. Now for similar engines, the power output is proportional to the square of comparable dimensions, hence for motor cycles and portable power plant requiring an output of 20 brake horse-power a gas turbine would be one-tenth the size of a 2,000 h.p. aircraft gas turbine. This implies the use of a rotor of only 4 in. diameter running at 120,000–150,000 r.p.m. The difficulty of manufacturing turbine blades of the size required, the relatively large tip clearances involved, the very high speed of rotation and the increased aerodynamic losses consequent on the reduction of the Reynolds number to one-tenth make it improbable that gas turbines, at any rate in their present form, will replace the piston engine in such small sizes as this.

Increasing the size to provide 100 b.h.p. reduces the manufacturing difficulties and brings down the maximum speed to 65,000–70,000 r.p.m. An experimental engine of this size has in fact been built and run. Since this engine is of a size suitable for use in Army vehicles let us consider its merits and shortcomings in comparison with a conventional piston engine.

This gas turbine unit comprises a centrifugal single stage compressor, a small heat exchanger of 60 per cent thermal ratio, one combustion chamber, a turbine to drive the compressor and a separate contra-rotating turbine to provide the power output. It will be seen therefore that it follows the simple layout shown in Fig. 3 (on page 463). The reason for the provision of a separate power turbine is that the compressor itself requires a high torque at low speeds ; if therefore a single turbine were used to drive both the compressor and the road wheels a clutch would be necessary between turbine and road wheels and very little starting torque would be available at low turbine speeds. By using a power turbine, mechanically separate from the compressor turbine, not only is the need for a clutch obviated but a high torque is made available when most required, i.e., for starting and at low speeds.

Fig. 8 (on page 469) shows the relative values of the output torque provided by :—

(*a*) a piston engine
(*b*) a gas turbine engine with a single turbine
(*c*) a gas turbine engine with a separate power turbine.

It will be seen that with a separate power turbine, the starting torque is three times the full speed torque. The high starting and low-speed torque thus available obviates the need for a gear box for normal road use, for Army purposes an emergency low speed range could be provided by a simple two speed epicyclic gear. In addition a reverse gear will be required.

Elimination of clutch and gearbox will leave the driver to control his vehicle solely by the accelerator and the brake. There are, however, other differences in the driving technique. Idling speed for the compressor is 20,000 r.p.m., at this speed the vehicle may tend to creep and braking may be necessary on the level. Equally it will be possible to hold the vehicle stationary on an upgrade without use of the brakes and to make a perfectly smooth getaway since the power turbine acts as a fluid flywheel as well as a torque converter. On the open road, the compressor would cruise at 50,000 r.p.m., maximum r.p.m. being 65,000–70,000.

A peculiar and rather unpleasant feature of the performance is that when the throttle is opened there is a delay of from 1–5 seconds whilst the compressor speeds up before increased torque is provided by the power turbine. Similarly there will be a lag when closing the throttle, moreover the engine can exert no braking effect on the vehicle so that it is similar to driving a car with a free wheel.

Starting presents a further difficulty since the compressor must be run up to at least 6,000 r.p.m. before sufficient pressure is generated for combustion to become effective. The chief resistance to motion is the friction in the ball bearings of the engine shaft since the air compressed by the compressor motors the turbine. Provided that suitable oil is used, starting under arctic conditions will be no more difficult than in normal temperatures, a considerable advantage over piston engines ; moreover, full load can be applied within 2–3 minutes of starting from cold.

This rate of revolution for starting and its associated power requirement of about 1 h.p. cannot be achieved by direct winding by hand. An electric starter motor of the normal type will, however, run the gas turbine up to this speed in 10–15 seconds without taking the heavy currents normally used in starting piston engines from cold. In spite of the long time that the starter is in operation there is therefore no excessive demand on the battery. In the event of battery failure, there would be no other means of starting since, there being no mechanical connexion between road wheels and compressor, towing by another vehicle would be useless. Provision of batteries of adequate capacity will therefore be essential, together with means whereby the battery of one vehicle can be readily connected to the starter motor of another. Alternatively each vehicle could be fitted with a hand-operated inertia starter.

In a gas turbine, since all heat rejection is in the exhaust gases, no cooling system is required. Consequently there is no water requirement, the engine cannot freeze up in cold weather and the over-all weight is reduced.

Taking into account the virtual elimination of clutch, gear box, cooling system, and the lighter sections which can be employed due to the smoothness of the power delivery, the gas turbine engine and transmission can be expected to weigh only half that of a conventional petrol piston engine of equal power and less than half that of a diesel. Similarly bulk is less. A minor point of interest is that, owing to the large volume of excess air required for internal cooling purposes, a 100 b.h.p. gas turbine would need two 5 in. diameter exhaust pipes in order to avoid any jet effect.

PLATE 4

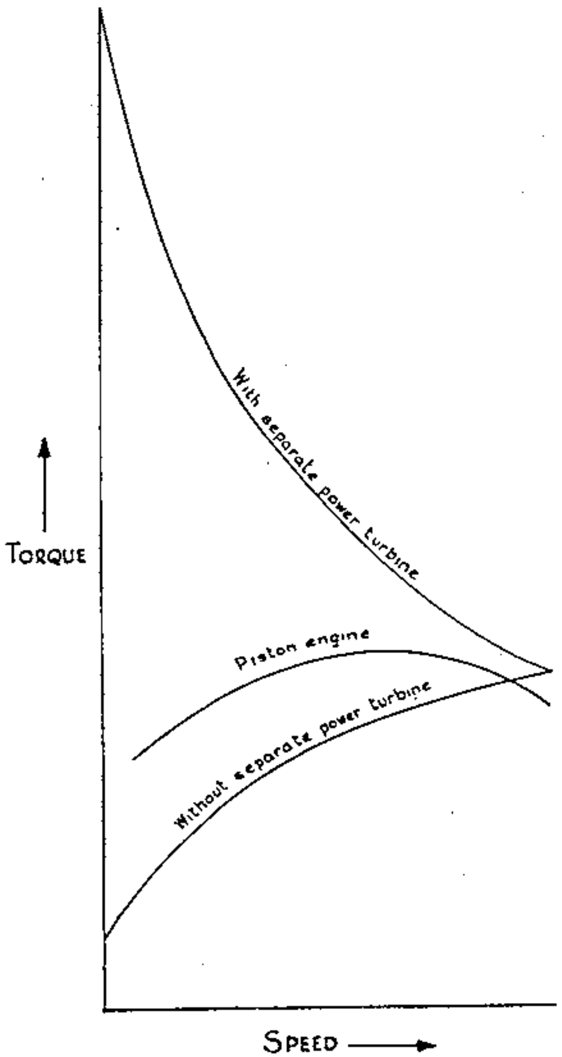


FIG. 8.

COMPARISON OF OUTPUT TORQUE CURVES

With regard to fuel, the gas turbine can be designed to burn any liquid fuel, including heavy bunker fuel. Use of the heaviest fuel not requiring pre-heating will reduce the fire risk in comparison with a petrol or diesel engine, an important consideration particularly in the case of A.F.Vs. In the present state of development of simple gas turbine engines fuel consumption is not comparable with that of petrol or diesel piston engines, the consumption of of the turbine being about double that of the petrol piston engine under optimum conditions and relatively worse over the remainder of the working range. The turbine is, however, still in the embryonic stage and further development may enable it to equal the petrol piston engine in thermal efficiency even for mobile units.

In the maintenance field the turbine has many advantages to offer. Apart from auxiliaries such as fuel and oil pumps, dynamo and starter, it has but one moving part. In place of the carburettor or diesel fuel pump and injector it has simply a burner similar to but simpler than the diesel injector. A simple electric heater plug in the combustion chamber is all that is required for initiating combustion. There are no valves to grind and decarbonizing is not required since the working temperature of the combustion chamber and turbine blading is so high that no carbon is deposited. If fitted, heat exchangers may, however, tend to soot up. Oil consumption is very low since the chief bearings to be lubricated are the ball bearings of the main shaft ; there is no sliding friction to be dealt with. Experience in the R.A.F. has already shown that maintenance staffs can be drastically reduced where gas turbines have replaced piston engines.

With regard to cost, there is no reason why the gas turbine should not be produced as cheaply as a comparable piston engine. The actual weight of material, always a useful yardstick in costing, is reduced by half though admittedly a proportion of this lesser weight is composed of special steels required for the turbine blading and combustion chambers. Modern production methods, provided that large enough numbers are required to warrant comprehensive tooling up, can produce the articles at an economic price.

The above discussion may be summarized as follows :—

1. In its present form, the gas turbine cannot be made in sizes small enough to replace the piston engine as the prime mover of motor cycles and small portable power plant.

2. Gas turbines can be produced economically in sizes suitable for use in military vehicles including A.F.Vs. and offer certain advantages for such use. Equally, they have certain disadvantages. These are set out below :—

(*a*) *Advantages*

- (*i*) Light weight (50 per cent of petrol piston engine).
- (*ii*) Small bulk.
- (*iii*) Reduced fire risk compared with petrol engines.
- (*iv*) Reduced maintenance compared with piston engines.
- (*v*) No cooling water required.
- (*vi*) No risk of damage by frost.
- (*vii*) Operate more efficiently in an arctic than in a temperate climate.
- (*viii*) Ease of starting in arctic conditions is not impaired as is the case with piston engines.
- (*ix*) Full load can be applied within 2–3 minutes of starting from cold.
- (*x*) Low oil consumption.
- (*xi*) Simplified driving controls.

(*b*) *Disadvantages*

- (*i*) High fuel consumption.
- (*ii*) Operates less efficiently in a tropical than in a temperate climate.
- (*iii*) Driving technique requires greater degree of anticipation.

In conclusion, therefore, bearing in mind the magnitude of the fuel supply problem and their higher fuel consumption the use of gas turbines for military vehicles is at present best limited to :—

- (*a*) all vehicles, other than motor cycles, for arctic operations ;
- (*b*) vehicles, other than motor cycles, of airborne troops in any operations (since the subsequent supply of greater quantities of fuel will be more than balanced by the greater ease of the initial fly-in with lighter vehicles) ;
- (*c*) A.F.Vs. not required to have a large radius of action (i.e., where the saving of weight and bulk of engine is not less than the extra tankage required to balance the higher fuel consumption).

PART IV—RAILWAY LOCOMOTIVES

In this field, the competitors of the gas turbine as a power plant are the reciprocating steam engine and the diesel.

Operating experience to date is limited to a single experimental 2,200 h.p. gas turbine loco with electric transmission built during the war for the Swiss Federal Railways and working on a simple low pressure thermal cycle with a heat exchanger of low thermal ratio, as shown in Fig. 2 (on page 463). The capabilities of this gas turbine-electric locomotive in comparison with those of a reciprocating steam loco and a diesel electric loco can be shown most easily in a tabular form as set out below :—

Table 1—Comparison between 2,200 h.p. Reciprocating Steam, Diesel-Electric and Gas Turbine-Electric Locomotives

ITEM	Steam	Diesel Electric	Gas Turbine Electric
Approximate cost per h.p.	£7	£17	£13
Expected life in years	30	15–20	30
Availability (miles per annum)	180,000	250,000	More than 250,000
Efficiency at draw bar per cent	8	27	15
Maintenance need	Low	High	Least
Time for tank filling and refuelling	Greatest	Least	Small
Oil requirement	Low	Higher	Very low
Water requirement	Very high	Low	Nil
Weight	108 tons	95 tons	92 tons
Track wear	High	Low	Lowest
Power braking	No	Yes	Yes

It will be seen from the table that the gas turbine has many advantages over its competitors. The chief factor militating against its general adoption in this country is the fact that it cannot, at least at present, be run on coal. Research into the use of pulverized coal for gas turbines is being undertaken, chiefly in the United States.

In comparing the performance of this experimental gas turbine loco, it is essential to remember that great advances in gas turbine technology have been made since it was designed in 1939. A modern design employing a high pressure double compound engine without a heat exchanger or alternatively a low pressure single unit in conjunction with a heat exchanger of high thermal ratio should be capable of a thermal efficiency of 27 per cent. An independent power turbine used with either of these engines, instead of electric transmission, would reduce the total weight by 15 per cent and cut out the losses in the generator and motors resulting in an efficiency at the rail of 25 per cent, a figure close to that of the diesel-electric power plant.

As in the case of the road vehicle, starting the turbine remains a problem. Some form of donkey engine or else the provision of a considerable electric battery would be required. Even so, the turbine is ready to accept full load within 10–15 minutes of starting from cold, a big saving of time compared with raising steam. A further problem, not encountered in the small rotors required for road vehicle use, is the prevention of distortion in the rotor during cooling after shutting down. This is due to the heat in the rotor rising and causing hogging ; the cure is either to rotate the rotor slowly or to give it a series of half turns at intervals by some external mechanical means until the majority of this heat has been dissipated.

In considering the use of the gas turbine as a prime mover for small locomotives, as for shunting, these problems of starting and care after shutting down become of greater importance when viewed against the background of the low no-load efficiency of the gas turbine power plant. For shunting, diesel locos with mechanical transmission have already proved their worth ; to give a comparable efficiency a gas turbine loco would need the assistance of a complicated thermal system. Space for such a system would not be available on a small engine nor, in view of the small annual mileage, would the extra cost be justifiable.

The small gas turbine is, however, a very attractive proposition as the power plant for a rail car since here its smooth acceleration, silence and absence of vibration will recommend it to passengers. Starting and shutting down difficulties are here of minor importance since a rail car would be in reasonably continuous operation throughout the working day.

In summing up the above arguments, the conclusions are :—

1. The gas turbine cannot compete with the diesel engine as a prime mover for small locos for shunting purposes.
2. The gas turbine is eminently suitable as the power plant of rail cars and should supplant the diesel engine for this purpose.
3. The gas turbine locomotive is economic for main line use where the difference in cost between coal and oil fuel is low or where water supply is difficult or expensive.

In considering the purely military applications of the gas turbine, use in rail cars is ruled out since it is unlikely that a requirement of this nature would exist. Military use is therefore limited to the main line locomotive. In this rôle, the gas turbine is particularly suited for operations :—

(a) in any overseas theatre where coal is not available locally, since it would be easier to supply oil fuel by tanker and pipeline than coal by collier and rail haulage ;

(*b*) in an arctic theatre, since there is no danger of interference by frost and moreover the efficiency of the gas turbine is improved by the low air temperature at the compressor inlet ;

(*c*) in a desert theatre since there is no requirement for a water supply. Some loss of efficiency due to high air temperature at the compressor inlet must be accepted.

Part V—Application to the Generation of Electricity

Present experience with gas turbines in this field is very limited. Only two sets are in actual operation, a 4,000 kw. set at Neuchatel installed as long ago as 1940, and a 13,000 kw. set at Beznau which only came into operation in 1948. Other sets are, however, on order in sizes ranging from 1,650 kw. to 27,000 kw., the majority being intended for peak load or standby service in conjunction with hydro-electric schemes. It will be realized then that the gas turbine has already a footing in this field, in which its competitors are the diesel engine for small plants and the steam turbine in major installations. These competitors can be expected to show efficiencies at the generator coupling of 30–35 per cent and 22–29 per cent respectively.

As has already been stated, the gas turbine can reproduce efficiencies of this nature as a base load power plant provided that an appropriate cycle is selected (that shown in Fig. 5 is the simplest that would be suitable). This necessarily involves the provision of intercoolers, reheat combustion chambers and heat exchangers of high thermal ratio, say 75 per cent. (In small gas turbine plants, in which high speed of rotation is unavoidable, reduction gears would also be necessary.)

However, a simple gas turbine power plant running on heavy fuel oil will still be cheaper to run than the thermally more efficient diesel plant and it will require less maintenance. In view of the light weight of the turbine plant it should be possible to design skid-mounted or trailer-mounted sets in sizes up to 500 kw.

For static sets above 500 kw. and up to and beyond the limiting size for diesel plant (about 2,000 kw.) the gas turbine offers considerable savings in maintenance and operating costs and greater reliability. Those advantages are enhanced where the sets are in regular use rather than held as emergency equipment.

For arctic operations the over-all efficiency of the turbine plant would be increased by the low air temperature at the compressor inlet and the practicability of using an air-cooled inter-cooler, so that its thermal efficiency would compare less unfavourably with the diesel plant.

As a power plant for base load electricity generation, the gas turbine has many advantages, particularly in the military sphere, over the steam turbine. A comparison of the space required in a power station per kw. generated is shown in Table 2 below :—

Table 2—Comparison of space required per kw. generated in Steam and Gas Turbine Power Stations

ITEM	Steam Turbine	Gas Turbine
Turbine House	16 cu. ft.	20 cu. ft.
Boiler House	29 cu. ft.	Nil
Offices	5 cu. ft.	5 cu. ft.
Total	50 cu. ft.	25 cu. ft.

In plant required there is a 66⅔ per cent saving in dead weight compared with a steam plant and the heaviest crane lift for a 15,000 kw. set would not exceed 12 tons, or for a 30,000 kw. set, 22 tons. Fuel storage for an oil-fired gas turbine will be simpler than for coal-fired steam plant. Not only will the area required be but one-fifth of that required for coal stacks, but coal conveyors, grabs, scrapers and other coal handling plant will be eliminated. The freightage, labour and time required for the construction of a gas turbine power station will therefore be much less than for a steam turbine station of equal output.

Since inter-coolers are used in the gas turbine plant, there will be a requirement for cooling water but the amount of heat to be rejected is only one-third of that involved in a steam plant and, since the air entering the inter-cooler will be at 150°–200° C. (as opposed to about 30° C. in a steam condenser) a much greater temperature rise in the cooling water is permissible. Consequently the cooling water requirement will be far less than for a steam turbine.

In operation, gas turbine sets are more flexible than steam sets since they can be put on load from cold in from 30–45 minutes whereas a steam set takes 4–10 hours. This renders them eminently suitable for standby or peak load plants. The only factor militating against the general adoption of gas turbines for base loads in this country is the cheapness of coal compared with oil fuel.

Summarizing the above arguments, the possible military applications of the gas turbine for electricity generation are :—

(*a*) for portable plants up to 500 kw., particularly in arctic operations ;

(*b*) for static plants from 500 k.w. upwards in any conditions ;

(*c*) for standby or peak load plants in conjunction with steam or hydro-electric base load plant, particularly for installation during the first phase of the construction of such a project ;

(*d*) as base load plant where :—

  (*i*) natural gas or oil is as cheap as coal ;
  (*ii*) water supply is difficult ;
  (*iii*) site of power station is restricted ;
  (*iv*) speed of erection and minimum freight to an overseas theatre of war are important.

Part VI—Miscellaneous Military Applications of the Gas Turbine

Snow Clearance

During the hard winter of 1946–7 in this country an attempt was made to clear railway lines of snow using two aircraft jet engines fixed to a locomotive, with their jets facing forwards. This experiment was not an unqualified success as it was found that the wooden sleepers caught fire !

However there seems no reason why, by the use of less fierce jets and by varying the angle of attack, satisfactory results should not be obtained in clearing roads, railways and airfield runways.

Mine Clearance

Similarly it might prove possible, by the use of fiercer jets mounted on an A.F.V. and pointing downward, to detonate all mines in the path of the A.F.V. and so to clear a well-defined lane through a minefield. (Since writing this the author has learnt that trials are proceeding but that mines tend to be thrown clear rather than be destroyed.)

Smoke Screening

By the injection of suitable chemicals into the combustion chamber or, to avoid fouling of the turbine, into the exhaust, it should be possible to produce an effective smoke screen. If a simple device of this type could be produced it might become part of the equipment of any gas turbine-engined A.F.Vs. ; alternatively, if the apparatus necessary should be complex and bulky, a special vehicle could be devised.

Propulsion of Vehicles on Snow

Track laying vehicles are not very satisfactory on snow and the tracks themselves add considerably to the dead weight. As an alternative, ski-mounted vehicles with jet engines would be cheap and simple to produce and would require infinitely less maintenance. Danger to personnel and material from the jet would be difficult to avoid but might prove an acceptable risk.

Propulsion of Floating Bridges and Rafts

Weight for weight, a jet engine can produce two or three times the thrust of any other power unit. The aircraft jet engine provides a static thrust of 3 lb. per lb. dead weight of engine, but this high ratio of thrust to weight would become less as the size was reduced. However it should be possible to build a simple but admittedly not economical jet unit to provide a thrust of 250 lb. without exceeding a dead weight of the same amount.

Each such unit would have the propulsive effect of a 100 h.p. motor boat and a number of units could be mounted on a section of floating bridge or on a raft. They would be independent of depth of water and of weed.

To reduce the danger from the jet to personnel or material the traverse of each unit would have to be limited.

Fire-fighting

The gas turbine is the ideal power unit for fire pumps since it is light in weight and able to take full load as soon as started. When built in its simplest form for this purpose, its high specific fuel consumption is of little consequence.

PART VII—CONCLUSION

The gas turbine power plant has a big future in military, as well as civilian, use as a general purpose prime mover in all except the smaller horse powers.

It is light in weight, free from vibration and cheap to run on heavy fuel oil although the specific fuel consumption of light mobile plants may never be as low as that of petrol or diesel engines.

Its general adoption in the Army will necessitate the introduction into the Service of two new grades of oil fuel ; for use in static plant a cheap, heavy and viscous oil requiring pre-heating and for mobile plant a more refined oil of just sufficiently low viscosity to obviate the need for pre-heating. However, as gas turbines replace other prime movers it should ultimately be possible to eliminate other grades of fuel so that the total number of different grades to be handled by R.A.S.C. in the field will not be increased.

In the interim period before gas turbines predominate, and in emergencies the ability of the gas turbine to operate, with only minor adjustment, on a wide range of fuels will be of inestimable advantage, but the economic future of the gas turbine lies in its being operated on the heaviest fuel that can conveniently be supplied.

MEMOIRS

BRIGADIER-GENERAL SIR SAMUEL H. WILSON, G.C.M.G., K.C.B., K.B.E.

SIR SAMUEL HERBERT WILSON, who died at his home in London, in his seventy-seventh year, on 5th August, 1950, was one of a small band of distinguished R.E. officers who found the best scope for their abilities in the administrative field. At the somewhat early age of 48 Wilson, Sammy to all his friends, was appointed successively Governor of Trinidad, then of Jamaica and, not long afterwards, Permanent Under Secretary of State for the Colonies.

His most striking characteristic was his spontaneous geniality, combined with dignity and self-effacement. This, to some extent, disguised a strong and tenacious character, endowed with a fund of common sense. He had a hatred of pretence and of over elaboration, especially if it led to unnecessary paper work.

These qualities fitted him admirably for the high posts, both civil and military, that he was destined to occupy.

Born in 1873, the son of Dr. James Wilson of Dublin, he was privately educated and received a commission in the Royal Engineers through Woolwich, in February, 1893.

After the usual two-years' course at Chatham he was posted to Aldershot, serving in the 17th Field Company.

The opening of the South African War, in 1899, found him quartered at Gibraltar, in the 20th Fortress Company, R.E., and with that unit he went to the front before the end of the year.

There he was shortly transferred to the Railway Pioneer Regiment, which consisted chiefly of Engineers from the mines in Johannesburg, and worked mainly on repairs to the wrecked railway bridges.

At the close of hostilities he returned home, and was posted to Chatham, as Assistant Adjutant for Musketry.

It was at this time, in 1902, that he married Ida, daughter of F. T. Gervers, a happy union which contributed greatly to his success in after life.

This preoccupation did not prevent his working successfully for the Staff College Examination, passing in second of 200 competitors. He had just been promoted Captain.

The war had disclosed prominently the weakness of our Military Education and the instructors chosen for the Staff College were the pick of the intellectual officers of the Army, with the object of infusing a new spirit into what had hitherto been rather an academic institution.

At the close of the course Wilson was given the command of the 3rd Field Troop at Aldershot, but soon left to become Staff Captain to the Director of Operations at the War Office. After four years, the usual tenure of all such appointments, he went to Salisbury as Staff Officer to the Chief Engineer Southern Command. He was there less than a year, when he was sent to Sandhurst to command a company of gentlemen cadets.

That same year Wilson had to move a second time when he was appointed Assistant Secretary to the Committee of Imperial Defence (C.I.D.), and Secretary to one of its most important standing sub-committees, namely the Overseas Defence Committee (O.D.C.).

This was the turning point in his career. He had found his vocation.

The year of his appointment was a momentous one in the history of Imperial Defence. The misgivings that had been growing up since the beginning of the present century, as to the attitude of Germany, culminated in the Agadir incident. This gave a tremendous impetus to the work of defensive preparation, which had been started by the C.I.D. a few years earlier.

All this reflected on the work of the new Secretary. First, as Secretary of the O.D.C., he had to help the Colonial Office to guide and co-ordinate the defensive organization of the numerous colonies, and next he had to assist the Secretary of the C.I.D. in insuring that the result of its activities were properly applied and brought to the notice of the Dominions and India.

At that early stage in the development of Empire relations, Wilson's work required a light touch and much tact, but his genial and kindly manner, his obvious sincerity and mastery of his subject, surmounted every obstacle. The highest tribute that can be paid to him is to record the result of his labours. For not only did each of the Dominions make its pre-war preparations on lines similar *mutatis mutandis* to our own, but when the emergency arose they put them promptly and efficiently in force. Wilson, to the delight of his many friends, received a well-earned C.M.G. in 1914.

Within a few days of the outbreak of the war, Captain Hankey, who had replaced Sir Charles Ottley as Secretary of the C.I.D. in 1912, found Wilson a new and more congenial job. The best defence is offence, and the Cabinet decided, in principle, to attack the German Colonies all over the world, in order to forestall their use as naval or military bases for the attack of British territory and trade routes. Wilson was appointed secretary of a committee, set up under the chairmanship of Admiral Sir Henry Jackson, to report what could properly and usefully be done.

When that was accomplished, Wilson applied for release, with a view to active service, and in spite of the immense value of his services to the C.I.D., where he had become a key man, Hankey felt that he could not stand in his way, and to his reluctant advice, Mr. Asquith assented. In his three years at Whitehall, Wilson had made a host of friends, many of whom were to prove useful later on.

On joining the forces, Wilson, now a Major, was appointed G.S.O. III in the 27th Division, formed of units from overseas and commanded by Major-General T. D. O. Snow. On completing their training in December, 1914, the division went to France.

The following month Wilson was promoted G.S.O. II for special service at the Headquarters of the First Army, commanded by Sir Douglas Haig. The staff was then engaged in preparing for an attack against the salient of Neuve Chapelle, which was carried out in March with some success. There followed, in May, the Battle of Festubert, with a preliminary action against Aubers Ridge, which was not very fruitful. The main battle, however, on a wide front, resulted in the capture of the enemy's first lines, but did not lead to the hoped for break-through.

This activity entailed heavy work for the Headquarter Staff, but there was no let up, for plans for the battle of Loos were already under consideration, and in spite of the shortage of heavy guns and gun ammunition, but on direct orders from London, the battle took place in September, in conjunction with the French, with varying success and disappointments; the casualties were very heavy.

In December Sir Douglas Haig succeeded Sir John French as Commander-in-Chief and Sir Charles Monro was appointed to the command of the First Army.

Wilson had been mentioned in Despatches and was promoted Brevet Lieut.-Colonel for his services, and advanced to G.S.O. I.

The year 1916 opened with the German attack on the French at Verdun and it was necessary to extend the front of the First Army, then around Arras, to relieve French troops.

In October Wilson was appointed B.G.G.S. of the Second Corps, under Lieut.-General Sir Claud Jacob ; a post he held to the end of the war. The Corps was at that time in the Reserve Army, commanded by Sir Hubert Gough, and engaged in the battles for the Thiepval Ridge and the Scheraben Redoubt on the Somme front.

The Corps then took part in the battles of the Ancre and the withdrawal of the Germans to the Hindenburg Line.

In March, 1917, the II Corps was withdrawn, and moved to the extreme left of the British front, held by the Second Army, under Sir Herbert Plumer. It was in touch with the Belgian Army. Wilson having again been mentioned in Despatches was promoted Brevet Colonel.

In September the Second Army was engaged in the grim offensive called the Third Battle of Ypres. It advanced on both sides of the

Menin Road and by October it occupied Polygon Wood and Gheluvelt.

The following year, 1918, which was such a critical yet fateful one for the Allies, was comparatively quiet on the Second Army front, until the final and victorious advance in September. The II Corps, still in touch with the Belgian Army, fought its way as far as Courtrai by 14th October, and, crossing the Escaut, reached Grammont on 11th November, the date the Armistice was signed.

Wilson, for his services, was mentioned in Despatches for the sixth time, and awarded the C.B. He had meanwhile received several foreign decorations, including the French Legion of Honour.

On his return to England he rejoined the C.I.D. as Senior Assistant Secretary and Secretary to the O.D.C. (his former job).

From 1918 to 1921 he frequently deputized for Sir Maurice Hankey who, besides having become Secretary to the Cabinet, was constantly absent with Mr. Lloyd George at International Conferences.

Wilson consequently bore the brunt of reorganizing the C.I.D. in accordance with the lessons of the war. For much of that time he was associated with Mr. A. J. Balfour, the original founder of the C.I.D., and who was asked by the Prime Minister to take charge of the day to day work of the Committee, on his behalf.

In 1920 Wilson accompanied him to the first meeting of the League of Nations at Geneva, acting as secretary to the British Empire Delegation, which was composed of the Prime Ministers of the self-governing Dominions. Mr. Balfour much appreciated Wilson's high qualities as did other Ministers and the Chiefs of Staff, and Lord Hankey says of him that he was his "guide, philosopher and friend."

In 1921, on Mr. Winston Churchill's recommendation, Wilson was appointed Governor and Commander-in-Chief of Trinidad and Tobago. This was greeted, all over Whitehall and beyond, as a just reward for his invaluable services to the State. He was given a K.B.E.

Trinidad with Tobago, a small island about eighteen miles distant, together form a Crown Colony under the Governor, who is assisted by a local council and a Commissioner for Tobago, appointed by himself.

The period of Wilson's appointment was one of comparative quiet and prosperity. He and his wife were very happy there in the Government House at Port of Spain and at a small house in the lovely island of Tobago, which they visited from time to time.

They were very much liked by all sections and classes of the population. As an instance of this may be quoted the fact that, on a Sunday before they left, the Bishop gave as a text to his sermon "The smile of the Governor."

Wilson was given a K.C.M.G. in 1922, and retired from the Army in the following year.

In the meantime there had latterly been much trouble of a semi-political nature in Jamaica, and in 1924 Wilson, much to his and his wife's regret, was transferred there, with the hope that his calm and genial personality would act as a restraint upon the turbulent elements.

This no doubt it did, to some extent, but Wilson found the task a very difficult one, the more so as the climate at Kingston, his headquarters, did not agree with him and his health began to suffer. After not many months, the doctors advised that he should apply for leave to recuperate for a time in England.

This was granted, but he did not return to Jamaica, because he was given meanwhile the post of Under Secretary of State for the Colonies. As such he became *ex officio* Chairman of the O.D.C. and was brought again into close contact with the C.I.D.

From personal experience he had noticed that no one paid any attention to a Governor on arrival at home and the result was rather disillusioning. One of his first actions therefore was to make it a rule that all Governors should be met on arrival at the station or airport. He himself took on the task when possible.

That Wilson was popular with his staff in Whitehall may be gleaned from the fact that he was called "Sammy" by practically every member of the Office.

In the spring of the following year he was required to go to East Africa to report on the possibility of closer union between the various territories, a subject that is still being hotly debated. Accompanied by his wife he made an extended tour of the East Coast Colonies, and in the autumn of the same year they visited the West Coast Colonies. In 1927 he was given a K.C.B. and two years later the G.C.M.G.

In 1933 he was asked to go to Malaya to advise on the possible centralization of the different types of territory, namely Federated and Unfederated Malay States and the Strait Settlements, a question which was still under discussion at the outbreak of war.

Not long after his return, on completion of five years of office, he resigned because he thought that from a national point of view, it was advisable that a change should be made. On retirement he was still kept busy with several directorships, including the Standard Bank of South Africa and the Consolidated Goldfields.

His latter days were clouded by the death of his only son, who was killed on active service in 1943, and by crippling ill health. This, however, did not prevent his welcoming his many friends, with all his customary geniality and charm.

F.G.F.

Brigadier- General Sir Samuel H.Wilson, GCMG, KCB, KBE

Colonel RJ Done DSO

COLONEL R. J. DONE, D.S.O.

WITH the death in a London hospital of Colonel R. J. Done on 7th June this year, there passed away one of the real old school sappers. A brilliant "works" officer, he was always a soldier first. He was a strict disciplinarian, and being very industrious, expected those under him to work as hard as he did. Perhaps slow in praise, he did not suffer fools gladly, but he was very fair minded and intensely just, and a kinder man at heart would be difficult to find.

Reginald Done was born on 10th April, 1874, and was educated at Harrow and the R.M.A. He was gazetted in the Royal Engineers in 1894, and after serving at Chatham and Aldershot, he was one of those specially chosen few, who, in 1898, were selected by Kitchener, then Sirdar of the Egyptian Army, to serve under him in the Sudan. Done remained with the Egyptian Army for eleven years, during which time he was employed in building the Law Courts of Khartoum and rebuilding the Palace and principal Mosque there. He also supervised the construction of the Anglican Cathedral and was Assistant Director of Military Works, Khartoum, in 1903, becoming Director of Military Works, Khartoum, in 1908, at the age of 34. He rejoined the British Army in 1909, having been awarded the medal and clasp of the Nile Expedition of 1899 and the Order of Medjidie, fourth class.

In the 1914–18 War he had a distinguished record, having been appointed C.R.E. 25th Division in 1916 and winning the D.S.O. in 1917. He was mentioned in Despatches four times and gained the Croix de Guerre avec Palme and was made a Chevalier of the Legion of Honour. After the war he went to Cologne with the Rhine Army as C.R.E. Northern Division, and became C.R.E. Rhine Garrison in 1920. From there to Dublin in 1921 as C.R.E., and in 1923 he was C.R.E. North Aldershot and 2nd Division. He was Assistant Director of Fortifications and Works at the War Office from 1925–8, having been promoted substantive Colonel with seniority from June, 1922.

In 1915 he married Marjorie Douglas, daughter of Mr. James Douglas Broadfoot of Edinburgh.

Things did not always come easily to Done, but when difficulties or troubles arose he brought a grim determination, coupled with a quiet sense of humour to deal with them, and aided too by a gift for improvisation he was always able to surmount any obstacle.

General Sir Reginald Wingate, who followed Lord Kitchener as Sirdar, wrote in *The Times*—"Done was also one of a small commission I sent to examine Sheikh Barghut—afterwards called Port Sudan. It is interesting to note, that at this place Done worked with an ancient theodolite, borrowed at Suakin—having measured a base, they planted flags at intervals round the harbour and made a trigonometrical survey of it—a most difficult task owing to the mirage."

Again I remember when Done himself used to tell the story of how as a very nervous young officer, just out from England, he was given a large working party and told by Kitchener to get on and build the Law Courts, Khartoum—he found there were no bricks, and the few that they were eventually able to obtain would not stand up to the job. So there and then he had to start experimenting in brick making, until a brick was eventually turned out that was strong enough. No, Done was never daunted, and he was indeed a very fine example of what every Sapper officer should be nowadays.

H.D.M.

BOOK REVIEWS

SWORD AND PEN

By MAJOR-GENERAL A. C. DUFF, C.B., O.B.E., M.C.

(Published by Gale & Polden. Price 7s. 6d.)

Sword and Pen is a collection of essays, some of which readers may have seen before in the *Army Quarterly* and the *R.E. Journal.* The titles of the essays are : " The Shortage of Officers," " The Shortage of Recruits," " The Problems of Organization," " Professional Competence," " The Staff," " The Teeth and the Tail," " Administration in Peace Time," " Morale," " The Commonwealth at War," and " The Partnership."

The service reader will find much that he knows already. Occasionally he will find a statement—such as the length of National Service—which has ceased to be correct ; but on the whole, the facts as set forth have not altered since they were first written. It is the author's deductions from his facts that are interesting. With some, one will heartily agree—such as the palliatives (the author does not claim them as cures) for the evils of centralization and overloading at the War Office. Perhaps it is worth while quoting one of them. He proposes that a C.O. should be allowed to spend at his own discretion each year 1 per cent of the cost of his command. This works out at £2,000 a year per C.O. What an excellent plan ! And how cheap at the price would the improvements be !

With some of the author's ideas, the reader may find himself in doubt, such as the wisdom of allowing officers to cross the line that separates them from the men. For while the officer can easily cross one way the soldier may not cross the other way.

And with some of the author's views the reader may well be in violent disagreement ; such as the statement that in future wars Great Britain may, in the early stages, be " compelled to surrender and drop out of the fight." This in my view is a terrible suggestion. Nations should not surrender, still less should they " drop out of the fight." When unarmed and alone a man may honourably surrender ; (he usually regrets it later, but it is human to err, and when more likely than with a pistol to your head ?) but no leader should ever surrender his troops or his country. When Britain departs from the maxim that " Britains never shall be slaves " it were better to be born to some sterner breed.

Indeed, it is here that one senses the weakness of these essays. They are dictated by the head not the heart. There is an occasional passage where one feels the warm heartbeats of the human breast, such as the description of a rum issue to the patient soldiery on the banks of the Struma in 1916. This is a moving passage, and there seems no need for the author's apology for it as a digression. But passages like this are rare. Mainly we have the cold logic of the staff brain. The dish comes hygienically from the ice-box, not smoked and dripping from the spit. Some prefer it this way, and they will like this collection of well balanced and well informed military essays.

M.C.A.H.

Editorial Note

In his Foreword, General Sir Brian Robertson comments on the author's statement that it might only be a coincidence that he did not know of any Under-Officers at R.M.A. or R.M.C. thirty or thirty-five years ago, who reached the rank of Major-General.

General Robertson points out that he himself was an Under-Officer and many other officers have also questioned this statement and given the names of a large number of U.Os. who became Generals, although most of the names do not come within the limit of time specified by the author. It might be interesting if some officer at the R.M.A. Sandhurst could check the actual figures concerned.

A SHORT HISTORY OF THE SECOND WORLD WAR

By "STRATEGICUS"

(Published by Faber & Faber, 24 Russell Square, London, W.C.1. Price 16s.)

Many readers will remember the series of volumes by "Strategicus," describing the contemporary events of the war, and will know his sound appreciation of values. In the present book he recounts the whole story of World War II; dwelling not only on the tumultuous events, that day by day ticked out on the tape-machines; but also the trends and tendencies during it, which seem to have bedevilled our civilization to-day.

The author begins with a prelude, for neither battles not war can be studied in a vacuum. In it he steers a middle course between the theory (enunciated by Tolstoy in *War and Peace*) that man is the servant of events, and the opposite view that events are made by man. In fact, history makes men great, no less than great men make history; and in the prelude the author shows how men and events led step by step to World War.

Then in the bulk of the book, he describes the long series of events from the outbreak of the war in Poland to the final victory in Japan. This is in every way admirable: accurate, comprehensive and relatively short. Of course one knows a lot of it from having lived through the very years; but there is much that one does not know.

Then there is an "Inquest." This is in many ways the most absorbing part of the book. It gives the author's considered opinions on the effects of the war and its conduct. Many hotly debated questions are discussed; the wisdom of unconditional surrender, the value of strategic bombing, and the leadership of the principals on both sides.

There is an ample chronology at the end and an adequate index.

Many readers will feel that the days of national prayer had some effect upon the fortunes of Britain in the war, and it seems strange that a history which deals so fully with the social and political significance of the struggle should make no mention of them. They were demonstrations of that piety and fear of God animating the people and their leaders, from which flowed such abundant fortitude, endurance and strength: and these things should not be forgotten.

It would be wrong to recommend this book for general reading. Rather is it one for study. And the immense amount of meat in it is made palatable by the skill of the author.

M.C.A.H.

HANDBOOK OF AERIAL MAPPING AND PHOTOGRAMMETRY

By L. G. TROREY

(Cambridge: University Press, 1950. Price 25s.)

There are all too few books dealing with the science of photogrammetry and any new publication that will further this important science is well needed.

Photogrammetry involves the determination of the spatial co-ordinates of a point by means of two or more photographs containing that point. The most important application of photogrammetry is in mapping from air photographs.

Air photographs should therefore be considered as an indispensable record to assist, among others, the surveyor, the engineer, the geologist and the planner.

The first fifty-five pages of Dr. Trorey's book presents a detailed account of early graphical methods of dealing with oblique air photographs. This is followed by the elementary principles of stereoscopy, the determination of parallax and its relation to ground height measurement.

There are chapters on Radial Line Plotting, Rectification and a brief description of the principles governing stereoscopic plotting instruments with special reference to the Multiplex. There are two appendices, the first giving an account of the standard mapping procedure of the Royal Canadian Engineers in the last war, while the second gives factors relating flying height to contour interval.

It must be mentioned that Dr. Trorey's figures for the heighting accuracy of the S.P.3 Multiplex equipment should be treated with considerable reserve. At the very best the probable error is twice that given by Trorey. If it were possible to obtain Multiplex images equal in definition to that of the original negative then the figures given would be correct. As this is not possible, the pointing accuracy of the observer will decrease through the loss of definition in the Multiplex model.

The book contains no information on Air Survey Cameras, the most important instruments in photogrammetry. No mention is made of the application of Radar techniques, both for navigation of the Survey aircraft and for the fixation of ground control. Interpretation of air photographs is dismissed in a few short sentences.

This book adds little to what has already been published. Nevertheless, Dr. Trorey has covered a limited field with the utmost clarity. Examples have been worked out in careful detail and the application of formulae is made very clear. The map-making process is presented in fully explained stages.

It is a book for the drawing office and as such the title of the book is misleading. If the title were changed to read *Handbook of Drawing Office Procedure in Surveying from Air Photographs* it would convey to the would-be reader the true contents of the book.

W.H.J.

ELECTRICAL INSTALLATION WORK

By T. G. Francis, M.I.E.E.

(Published by Longmans, Green & Co., Ltd. Price 12s. 6d.)

This publication is expressly designed to enable those engaged on electrical installation work to obtain a clear picture of the technical side of their work.

To Military students and instructors studying for the City and Guilds Certificate of Electrical Installation Work this book will prove of immense value. The author has throughout this book used clear-cut diagrams which admirably illustrate each chapter.

The most important I.E.E. Regulations are quoted, simply explained and, where possible, illustrated by a clear diagram. Testing and fault finding on normal domestic circuits constitutes a complete chapter, amply illustrated and clearly written. Worked examples on sizing cables for domestic installations in order to comply with the relevant I.E.E. Regulations are clear and well set out.

The chapter on Illumination gives a clear conception of the terms used and adequately presents the law of inverse squares and cosine law. Neon, H.P.M.V., sodium and L.P.M.V. lamps are briefly described, each type being clearly shown in diagrammatic form with complete wiring diagrams.

Electric heating is well presented, clearly setting out the best system to adopt to suit specific conditions. The table showing the electric loading required for rooms up to approximately 10,000 cu. ft. capacity under intermittent and continuous heating conditions is extremely useful.

In the latter part of the book the author deals with direct and alternating current machines and, although the various types of machines covered are well illustrated by schematic diagrams, too much attention has been paid to operational theory at the expense of the actual installation problems.

Power factor improvement is a subject that necessitates a sound knowledge of A.C. theory and it is doubtful whether all students will be able to follow confidently some of the examples set out under this chapter.

This book can be thoroughly recommended for its clarity of text and adequate use of good clear diagrams, and will prove most beneficial to those undergoing electrical courses in the various Service establishments.

D.B.

A MEDICAL HANDBOOK FOR ATHLETIC AND FOOTBALL CLUB TRAINERS

By W. D. JARVIS

(Published by Faber & Faber, Ltd. Price 10s. 6d.)

In a foreword to this book Dr. Currie has stated that it is "ambitious," and with this opinion we entirely agree, in fact the trainer who absorbs all the information contained in it would appear to require comparatively little assistance from either the medical profession or the Chartered Society of Physiotherapists. Mr. Jarvis does, however, indicate that it is an advantage to refer certain injuries to a surgeon with the minimum delay, and it is presumed that some of the treatments to which reference is made would only be carried out by those who have a recognized qualification.

The section on anatomy and physiology is well illustrated and should give the reader an elementary but undoubtedly useful knowledge of these subjects. It is obvious that the trainer who wishes to carry out his duties efficiently must have some knowledge of the mechanism of the machine for which he is responsible and the author has made a successful attempt to impart this knowledge in a readable and interesting manner.

Due emphasis has been paid to the importance of the early recognition of a variety of injuries, and the first aid treatment for these injuries is described. The value of the book might have been enhanced if even greater attention had been drawn to the value of efficient first aid, while the probable after treatment carried out by the doctor could have been omitted without disadvantage.

Advice is given on a variety of subjects from the fitting of football boots to the harmful effects of alcohol, which is said to cause heart strain, nervous digestion, impaired nutrition, and loss of muscle tone. Mr. Jarvis insists that the only successful defence against the insidious attack of this enemy is complete teetotalism, an opinion which may well spread despondency and alarm among a section of readers.

The advisability of a trainer carrying out some of the treatments which are described is open to question unless skilled supervision is available. Trainers of unit teams would be well advised to obtain the opinion of a medical officer before instituting any course of treatment, and should appreciate the value of the old adage that a little learning may be dangerous.

A.A.E.

BUILDING CONSTRUCTION

By G. A. and A. M. Mitchell

(Published by B. T. Batsford, Ltd., 15 North Audley Street, London, W.1., Price 10s. 6d.)

Mitchell's *Elementary* and *Advanced Building Construction* is well known to almost all sappers. The new 20th edition of the Elementary Course will enhance its reputation as a reference book in building construction and as a textbook for students.

All the old illustrations have been re-drawn and brought up to date with many additions and all construction conforms to modern codes of building practice. There are innovations, among which there is a chapter on Elementary Statics, and at the end of each chapter dealing with Building Trades, a typical specification is provided. The book is particularly recommended for use in drawing offices and with the "Advanced Course," when published, would make two comprehensive and not unwieldy books of reference suitable for the junior officer and the Engineer draughtsman.

R.C.N.S.

EXPLANATORY HANDBOOK ON THE B.S. CODE OF PRACTICE FOR REINFORCED CONCRETE

By

W. L. Scott, M.I.C.E., M.I.Struct.E.

W. H. Glanville, C.B.E., D.Sc., Ph.D., M.I.C.E., M.I.Struct.E.

F. G. Thomas, Ph.D., B.Sc., M.I.C.E., M.I.Struct.E.

(Published by Concrete Publications Ltd. Price 9s.)

This handbook sets out to explain the clauses in the *B.S. Code of Practice for the Structural Use of Normal Reinforced Concrete in Buildings* (C.P. 114, 1948) ; it does this by reproducing the code in its entirety with the author's comments following the clauses.

This treatment has produced a readable and very informative book, which should have a place on every designer's shelf.

Section 3, "Design Considerations," which occupies about two-thirds of the book is outstanding in the explanation of the clauses and for the excellent tables it incorporates, particularly those referring to bending moments (Clause 309). The tabular information in this section illustrates the use of tables at their best, from one of about a dozen tables one can read off the bending moment coefficients for continuous beams, with or without 15 per cent factor, and for any of a series of continuous slabs supported on all four sides with or without considerations of torsion at corners (depending on whether one is Marcus or Westergaard minded !). Similarly, the four tables on column design virtually give the answer without having to do any design at all. Although the resource to tables for design cannot always be considered an improvement, the tables tend to become very complicated if an economic design is to be produced, this is an exception.

As this book costs 9s. and the Code itself normally costs 5s., it is an excellent 4s. worth.

E.E.P.

TECHNICAL NOTES

THE MILITARY ENGINEER

(Published by the Society of American Military Engineers)

July-August, 1950. Engineers in Atomic Offence and Defence. LIEUT.-COLONEL DAVID B. PARKER, Corps of Engineers.

(The author served with the military operations divisions of the Manhattan Project prior to his present appointment as Deputy Assistant Chief of Staff G-3 for Atomic Energy, U.S. Army. He is one of the editors of the *Weapons Effects Handbook*, a compendium of all information on atomic weapons which can be released to the public, published in August this year.)

While the Corps of Engineers at present has no specific responsibilities in the operational or offensive use of atomic weapons, it is concerned in atomic defence, principally protective construction and water decontamination. The author believes that the bomb will prove a major factor in the tactical support of Army ground operations and that engineer officers will be required as specialist advisers to commanders particularly in the two specific fields: analysis of effects of atomic weapons used tactically, and radiological defence.

Although the theory of using atomic weapons for tactical support is new, and depends on atomic stock piles available, the author proceeds on the assumption that the weapons will be available and will be so used. The subject of atomic weapon effects is extensive and still in its infancy. Two interesting tables are then given of data at present available. The first table covers " Effects of an Atomic Bomb exploded in the air 2,000 ft. above the Target " under the headings, Blast, Gamma Rays, Heat, with typical protection required at various ranges under the two headings: Bomb of 20,000 tons T.N.T. energy equivalent and Bomb of 100,000 tons T.N.T. energy equivalent. The second table deals with the effects of an underwater burst. In this case figures are given only for a bomb of 20,000 tons T.N.T. equivalent energy.

These tables alone are not sufficient to answer a commander's two important questions (i) At what time should an atomic weapon be used to give maximum effect? and (ii) What can be done with our own troop dispositions to minimize the effectiveness of any atomic weapon the enemy may use? After discussing factors affecting the answers and problems yet to be solved the author considers that eventually something like a *Commanders' Field Manual for Use of Atomic Weapons* will be issued.

Under " Radiological Defence," R. W. weapons are discussed. The defence against the radiological effects of either an atomic bomb or a straight Radiological Warfare weapon are substantially the same. The Army's Rad. Defence Plan calls for the training of Radiological Defence Engineers, highly trained specialists who advise senior commanders on every aspect of Rad. Defence. An R.D. Engineer spends three years in training, including two academic years in a post-graduate nuclear physics (or similar) course which leads to a degree. He is then given additional training in the field and in laboratories with the Atomic Energy Commission or the Armed Forces Special Weapons Project. These specialist appointments are not restricted to the Corps of Engineers although it provides most of them. If R.W. weapons are eventually used tactically the R.D. Engineer, with his specialist training, will be able to act as adviser to a field commander on their most effective use.

The work of the Protective Construction Section of the Chief of Engineers is discussed and may be summarized in the decision to date that it is not economically feasible to construct above ground structures capable of resisting an atomic blast closer than half a mile.

Under "Water Decontamination" the author records that the difficulties of removing radio-active material from water supplies, particularly in large cities, have been greatly over-estimated. Radio-active contaminants tend to be absorbed by suspended and colloidal matter, which is always present, and by the walls and bottom of the reservoir, and by the rusted iron of the distribution system. When the system also includes a purification process, with sedimentation, filtration, and coagulation, even a very large amount of radio-active material placed in the reservoirs should be so attenuated by the time it comes from the distributing taps in the city as to be harmless. This, if correct, should relieve the anxieties of the Water Boards of cities like London and Birmingham.

Decontamination of water supplies for troops in the field is dealt with and held to be no more difficult than ordinary purification, so long as careful monitoring is effected during the process. Where chlorination only is used for purification the possible introduction of cationic and anionic exchange columns is suggested. Distillation removes all radioactivity but boiling is useless. Well water, even in contaminated areas, should be safe.

The author concludes with the opinion that while the Corps of Engineers has at present specific responsibilities only in atomic defence, it will be used eventually in almost all aspects of the military application of atomic energy.

The article is illustrated by the usual photographs of assorted rubble entitled "Atomic Bomb Damage."

ROAD RESEARCH

The Road Research Laboratory of the Department of Scientific and Industrial Research have recently issued an Index of their publications covering the period 1933-49. The Index contains brief summaries of the contents of the longer papers and a complete list of all other papers issued.

The Laboratory has published a most comprehensive list of pamphlets dealing with all aspects of Roadwork and the new Index should prove of great value to all officers who have to undertake the construction or maintenance of roads, and who wish to know what information on the subject is available.

The Index can be obtained from H.M.S.O. for 1s. 2d. including postage.

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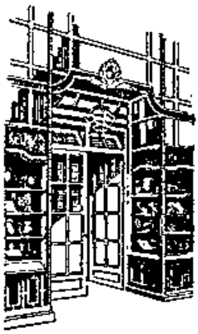

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