VOL. LXX. No. 3 SEPTEMBER, 1956

THE ROYAL ENGINEERS JOURNAL

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PUBLISHED QUARTERLY BY THE INSTITUTION OF ROYAL ENGINEERS
CHATHAM, KENT Telephone: Chatham 2669

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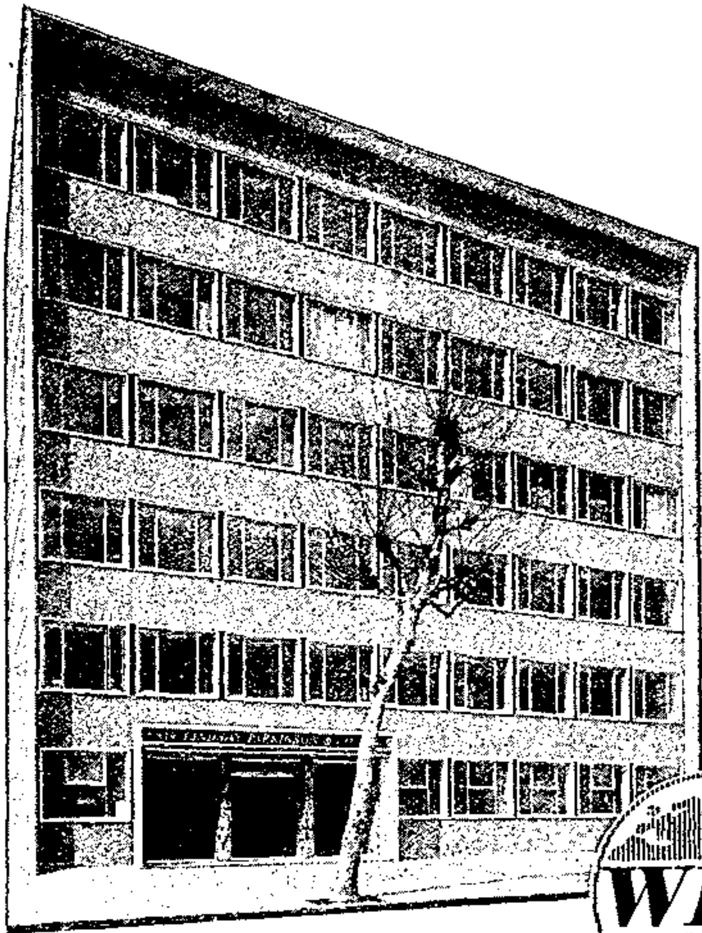

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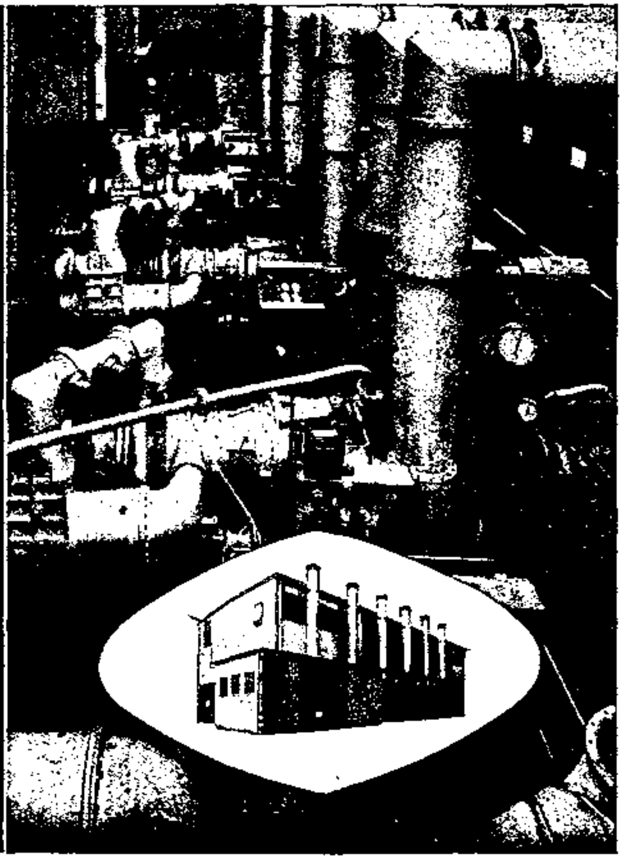

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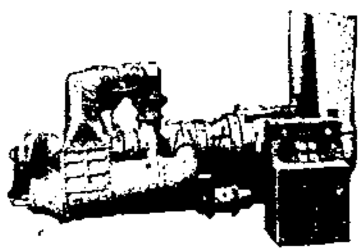

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THE ROYAL ENGINEERS JOURNAL

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Photo 1.—A short span bridge capable of carrying tanks, which can be put in position by an operator in the tank.

Photo by Signal Corps, U.S. A

Photo 2.—World War I. 1st Division Engineers had the almost impossible task of keeping passable this muddy track to the Argonne battlefield.

Photo by Signal Corps, U.S. Army

Photo 3.—World War II. Army Engineers performed herculean tasks under incredible conditions in opening up the Ledo and Burma Roads.

Photo by Signal Corps, U.S. Army

Construction Power Is Combat Power 2,3.

CONSTRUCTION POWER IS COMBAT POWER

By Lieutenant-General S. D. Sturgis, Jr.
Chief of U.S. Army Engineers

A FEW of our journalistic prophets of doom and disaster are warning us that if Detroit continues to produce automobiles faster than the construction industry can pour concrete paving, the day will come when all automotive traffic in the nation will grind to a halt, paralyzed from coast to coast by highways bumper-to-bumper with cars.

This omen is no more fantastic than the grim possibility of a military stalemate in any future war if our military construction power fails to keep in balance with other elements of combat power.

To understand this there must be an appreciation of the role of the engineer in modern warfare. In part, World War I bogged down in the trenches of France because construction equipment that could lift World War I armies out of the mud had not been developed in 1917–18. French roads were tortuous channels of mud through which military columns crawled or stalled while engineer troops labored with hand tools to spread rock in almost futile attempts to keep essential traffic moving.

When World War II began, the American construction industry had come of age and Army engineers were able to build the roads and bridges, airfields and ports that our World War II forces demanded. We had construction power adequate to the requirements of the maximum combat power of our armed forces. True, our construction resources were never more than barely adequate, and occasionally were less than that. Throughout the Pacific area after mid-1943, the timing of our amphibious assaults was determined very largely by the rate at which bases could be built at the scene of previous assaults. The security of our tenuous beachhead at Leyte hung in the balance for many weeks because we lacked the construction resources—troops and rock aggregates—necessary to build quickly the all-weather roads and airfields needed to support a breakout from the perimeter. Similarly, in Asia, the application of military pressure on the Japanese from the mainland, which would have been of immeasurable benefit to our combat operations in the Pacific, was severely restricted by the shortage of military supplies, particularly gasoline, which prevailed until the Ledo Road and its parallel pipeline were completed relatively late in the war.

Thus the construction power of our Army engineers was, more often than not, the limiting factor affecting combat operations on the ground and in the air. Consequently, it was necessary for our field commanders in World War II and later in Korea, where engineer resources always were in short supply, to make the most efficient possible use of their scarce construction means. This conservation was effected in several ways.

First, at all command levels engineer requirements and capabilities were carefully integrated into operational and logistical plans. The most important single factor in making this possible was the universally accepted policy that gave the engineer of each Army command direct access to the commander and the principal members of the staff.

Second, the age-old principles of mass and economy of force were applied to the employment of engineers just as to other members of the Army combat team. Within the field army, for example, the army engineer commanded or otherwise exercised direct control over all engineer units not assigned to subordinate commands. By limiting the number of units assigned to subordinate commands to the minimum necessary for performance of normal missions, the army commander, through his engineer, was able to maintain direct control over a substantial portion of the construction power available to the army, and could shift that construction power almost as quickly as he could shift the fire power of his artillery in response to the shifting tides of battle.

Third, at each command echelon, responsibility for the total engineer mission was vested in a single individual who also was given control over the resources available to accomplish that mission. To appreciate the importance of this concept it must be understood that the engineer in effect must fight a battle within the larger battle being fought by the command as a whole. While infantry, armor and artillery concentrate their attentions wholly on the enemy, the engineer member of the team must concentrate partly on the enemy but primarily on the natural obstacles of terrain and weather which must be overcome. This battle of the engineer against Nature, while an integral part of the total battle, frequently bears very little apparent relationship to it, either space-wise or time-wise. For example, the concentration of engineer effort on the preparation of stream-crossing sites for an uncommitted corps while almost all other resources of the field army are supporting an already committed corps, is a good illustration of the apparent divergence of effort which can exist at a given time. These characteristics of the engineer mission require centralized control over engineer operations at each command echelon to achieve flexibility and preservation of unity in the engineer organization and to give it the capability of performing independent operations. If during the Second World War or the Korean conflict, vital construction power had been fragmented by dividing responsibility for the several elements of the engineer mission, it is questionable whether the limited construction resources available to our army commanders would have proved adequate to the task of sustaining the mobility of our armed forces in battle.

Looking to the future, new problems loom on the horizon. Just as the imaginative reader can visualize the possibility of all traffic coming to a halt if a solution to our highway problem is not found, so the military engineer can visualize the possibility of military stalemate if the construction power of our armed forces is not kept in balance with the other elements of our combat power.

Larger Requirements but Lowered Effectiveness

At the present time, two complementary trends give cause for serious concern. On the one hand, trends in the development of weapons and other items of military equipment are increasing requirements for construction in support of combat operations. On the other hand, certain trends in the formulation of organizational doctrine will, if continued, decrease the effectiveness of engineer operations in the field. This seeming paradox deserves most careful consideration.

The fact that mass destruction weapons are available to our potential enemies means that we must be able to avoid large concentrations of men and material that would offer lucrative targets. For the Army, this requires that we be able to operate with relatively small dispersed units having a high degree of mobility so as to be able to concentrate for decisive action and then disperse again for safety. The heightened mobility of the Army required by these concepts, in turn, requires the use of substantially greater numbers of ground vehicles by combat elements and increased dependence by the Army upon air movement of troops and supplies. As vehicle density increases within the field army so also will requirements for the roads and bridges necessary to maintain tactical mobility. At the same time, expanded use of aircraft for moving and supporting combat elements will generate requirements for the development of landing areas in ever increasing numbers and at ever increasing speed. Inevitably these trends point toward augmented engineer support for field armies.

In addition to achieving [illegible] tactical mobility, our future field commanders must kee[illegible]istical facilities dispersed so as to mini[illegible] the [illegible]ining supply losses which could cripple combat operations. [illegible]is requirement, coupled with the necessity for expanding our supply activities to sustain the mobility of combat elements, means that we must have more and better air and land routes of communications for logistical as well as tactical purposes. At the same time, the recognized vulnerability of our military installations to serious damage from high yield enemy weapons requires that we maintain an increased capability for restoring or replacing critical ports, depots, and other key facilities which might be knocked out by enemy action. Moreover, we must be prepared to construct in combat areas substantial numbers of protective works to insure against the loss of vital command posts and communications facilities without which the Army could not operate effectively. These requirements call for more construction power—not less!

There is another aspect of nuclear war that will have a profound effect upon the engineer mission. Just as our forces must develop superior mobility in the face of enemy atomic capabilities so also must the forces of the enemy if they are to avoid being destroyed by our atomic weapons. From our standpoint, therefore, it is just as important for us to hinder enemy mobility and force him into untimely concentrations as it is to maintain mobility and achieve timely dispersion of our own forces. One of the principal ways to disrupt enemy operations is to use engineer troops in their classic secondary role of hindering the advance of the enemy. By judicious use of minefields, demolitions and other obstacles, enemy movements can be retarded and channelized to present lucrative targets for our nuclear weapons. In the past this type of action by our engineers has been important; in the future it may well be critical to our success in battle. In any event, it is certain to require the employment of more of our available engineer means than ever before.

In addition to the impact of nuclear weapons, other developments are placing increased demands upon our military construction capabilities. During World War II, our Army engineers were able to provide operating airfields for fighter aircraft in from one to 30 days. Even with the advent of the B-29, four battalions of engineers on Saipan were able to meet minimum operating requirements in 114 days. Now, however, there is hardly an aircraft in the Air Force arsenal that does not require an airfield built to at least B-29 standards, and many require much more; the day when a tactical airfield could be built in 36 hours has long since faded into history. Even Army helicopters are generating construction problems. In the early days of helicopters, prepared surfaces were never thought necessary for landing or take-off. However, new and heavier models have developed serious maintenance problems when consistently operated from other than prepared pads of heavy duty pavement. These are by no means the only developments in military hardware that threaten to overtax available construction resources, but they do indicate the trend toward increased construction requirements.

Efforts are, of course, being made to offset these increased construction loads. For example, the Army is continuing research for

Photo 4.—Caterpillar tractor drawing a scraper to provide fill for approach to a bridge in Korea.

Photo by Signal Corps, U.S. Army

Photo 5.—Four foot trench, eighteen feet deep, being cut in the snow in Greenland.

Photo by Signal Corps, U.S. Army

Photo 6.—A trench digger that can dig a fox hole in ten seconds.

Photo by Signal Corps, U.S. Army

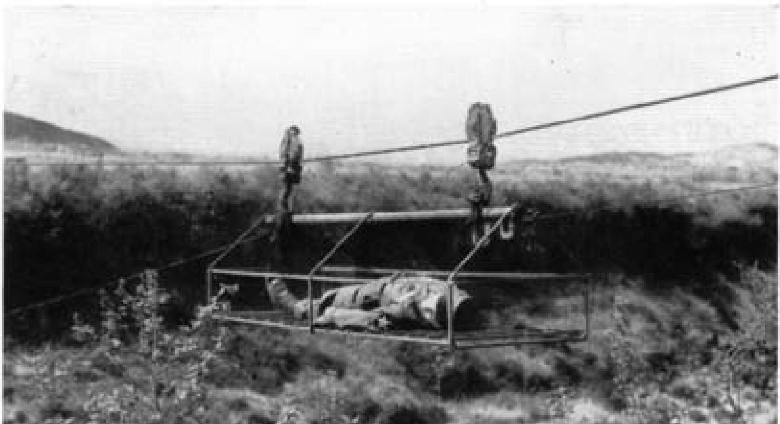

Photo 7.—Army Engineers built this suspension system for carrying wounded across a deep ravine in Korea.

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combat vehicles having increased cross-country mobility and, almost certainly, will eventually achieve some measure of success along these lines. However, recent field exercises have demonstrated rather clearly that the new vehicles available to us at present have less, rather than more, cross-country mobility than their World War II counterparts. Moreover, the improved capabilities of our potential enemies in the techniques of mine warfare, coupled with the knowledge that cross-country operations often detract from our ability to conceal our actions from enemy aerial photography, raise many valid questions as to whether improved cross-country maneuverability is, in fact, an answer to our mobility problem.

Similarly, it is often argued that increased air-transportability and the resultant placing of maximum reliance upon aircraft for tactical movement of Army combat units and supplies will go far toward reducing requirements for construction on the ground. While this argument might have some validity if we had transport aircraft capable of operating regularly from unprepared landing areas, it is reduced to absurdity when, as a matter of cold practical fact, today's transport aircraft are even more demanding than those of World War II in their requirements for the runways and other operational facilities needed to assure all-weather operation. Despite experiments with vertical take-off and other aircraft of unusual design there are no developments presently in sight that point toward anything but increasing construction requirements to support air operations. If we are to be realistic, therefore, we must face up to the fact that for the foreseeable future we will be confronted with the necessity for more, rather than less, construction support of combat operations in the field.

In the face of a national shortage of engineers and a trend toward increased construction support requirements for our armed forces, it would be logical to expect that there would be a concerted effort to develop means for improving the capabilities of engineer elements. Such efforts are in fact being made and in certain areas give promise of fruitful results. For example, in December 1955 the Secretary of Defense ordered abolishment of the SCARWAF category of engineer troops and returned the aviation engineers and their mission to the Army. This action by the Secretary of Defense was taken not only to eliminate costly duplications in time of peace but, more importantly, to minimize competition for critical construction resources in time of emergency and provide greatly increased flexibility in the use of available construction power in wartime theaters of operations.

Progress is also being made in other areas. For example, our engineer troops are being equipped with bigger and better items of earthmoving equipment; new bridging equipment is providing faster and more effective means for crossing streams and other obstacles; flexible pipelines are making it possible to deliver petroleum to forward combat elements more rapidly than ever before. All of these steps, representing positive actions taken to increase the effectiveness of construction power in war, are encouraging. However, concurrent with these actions, there are developing within the Army certain doctrinal trends which could, if carried into combat, undo much of the good accomplished by these positive improvements.

In the successful exploitation of construction power in World War II, there were three principal prerequisites to effective employment of the engineer component of the Army combat team: first, full participation by the engineer in all operational and logistical planning; second, centralized control and direction over assigned engineer forces; third, maintenance of the integrity of the engineer mission. These concepts, which proved so necessary in conserving scarce engineer resources during World War II and the Korean conflict, will be even more important in the future. Despite this, it is alarming to find that there is currently a tendency within the Army to ignore these tried and true concepts in developing doctrine for the future.

Subordination of Engineers in Planning and Operations

Today's sporadic trend toward exclusion of the engineer from operational planning has produced a number of episodes in field exercises which could have been disastrous in actual combat operations. One recent maneuver incident, although never officially confirmed, is indicative of the inevitable end result of such a policy. In this case, the commander of an Army unit made up of the combined arms happened to encounter his staff engineer in the headquarters area a few days before a planned attack. When he casually mentioned his plan to attack down a certain road net he was surprised to have his engineer reply that the bridges on that route would not support the combat vehicles to be used. Upon further questioning, the commander learned that the engineer, who was assigned to G4 and thus did not have access to the commander or G3, had furnished data on bridge capacities to the G4 some days before but that these data, through inadvertence or improper interpretation, had not been considered in planning the operation. Moreover, the engineer had not been brought in on the planning and thus had been unable to undertake, in advance, the preparatory measures necessary to permit the Army unit to move over the proposed route—or any other route. While this projected example may seem extreme, it is not by any means an exaggeration of what can happen when a commander subordinates his engineer wholly to a general staff section having responsibility for only one phase of the operation. If this pattern of organization is adopted on a wide scale for the future (and there are many who think it should be) it could cost us many battles if not an entire war.

Dissipation of Engineer Resources

Another disturbing trend which is currently manifesting itself in tentative Army doctrine points toward dissipation of engineer resources by a policy which parcels out engineer units to subordinate commands and leaves commanders at higher echelons with few if any engineer means under their direct control. The ostensible purpose of this doctrine is to make each small combat element capable of independent action by giving to it a little of each of the combat resources available to the Army as a whole. Laudable as the objective of this doctrine may be, the effect is much the same as if the conventional artillery of a division were parcelled out on the basis of one gun section per infantry company. Just as such a dissipation of conventional artillery pieces would nullify the potential firepower of the army, so also would a parallel dissipation of engineer resources nullify its potential construction power. Since victory in war is achieved by a combination of firepower and mobility and since the latter depends largely upon the effective exploitation of available construction power, dissipation of either firepower or construction power would appear to be military suicide. For nuclear war a policy of dividing and spreading artillery pieces can, perhaps, be justified on the basis that with atomic shells we have the ability to achieve mass firepower with a single weapon and thus are not, in fact, dissipating our artillery resources. However, no such argument can be seriously advanced with respect to engineer resources until the improbable day dawns when we can exchange our conventional bulldozers for nuclear powered tractors having capacities in the megaton range. Yet, while our professional military men would never advocate a policy of shrinking our capability to lay down mass artillery fires against the forces of the enemy, there are some who seemingly would cancel out our ability to mass our foreseeable construction resources against the obstacles of nature which must be overcome before the enemy can be engaged. This, too, could cost us battles and even a war.

Fragmentation of Engineer Mission

The third trend which is evident in the current evolution of Army doctrine is at least as serious as the other two. This is fragmentation of the engineer mission. The engineer mission involves a battle against nature within the framework of the over-all battle against the enemy. Because the engineers' battle frequently is out of phase with the main action, with respect to both time and place, engineer operations must be conducted on an independent, or quasi-independent basis. This characteristic of the engineer mission, in turn, requires that engineer forces be capable of sustained action with a minimum of dependence upon other combat and support elements of the Army.

In the past, this capability for independent action has been achieved by retaining under engineer control substantially all the resources necessary to accomplish the engineer mission—construction personnel, equipment, and supplies. Now, however, there is a tendency on the part of Army planners to develop organizational doctrine on the basis of functions rather than missions. In the case of engineer organization, this functional concept separates engineer supply and maintenance and, sometimes, other engineer activities such as mapping, from engineer construction functions and places each under separate command. The effect of such a separation is to charge the engineer construction commander with responsibility for the execution of missions without giving him authority over functions which are essential to the execution of those missions.

In support of this fragmentation policy it is frequently argued that the infantry commander must depend upon ordnance, quartermaster, and other services for the supply and maintenance support he needs; therefore why cannot the construction commander depend upon other service elements for the supplies and equipment needed to accomplish his mission? The answer, of course, is that he can and does. However, there is one important difference between the engineer supply and maintenance function and similar functions of the Ordnance and Quartermaster Corps. Engineer supplies and engineer maintenance are used predominantly in the performance of engineer missions, whereas the Ordnance and Quartermaster Corps provide equipment and supplies primarily to the combat arms including engineers.

Moreover, the engineer at any given echelon of command, is responsible for conducting operations which, as pointed out before, are both sustained and independent in nature. Within the field army, for example, the responsibilities of the army engineer can be likened to those of a division commander. He must be able to close with and defeat the forces of nature just as the division must close with and defeat the forces of the enemy. Consequently the army engineer must have control over those supply and maintenance activities which are most intimately related to his mission to much the same degree as the division commander has control over the supply and maintenance activities which are vital to successful accomplishment of the division's mission. Both can rely upon support elements of higher echelons. Neither can afford to rely upon parallel echelons for furnishing support which is integral to accomplishment of the assigned mission.

No responsible commander has yet been convinced that a division should be shorn of the supply and maintenance functions most intimately linked with its success in battle. Yet there are those who seriously propose that the engineer should be divested of his control over those supply and maintenance functions upon which successful accomplishment of the engineer mission depends. It can only be hoped that these commanders will recognize in the future, as they have in the past, that such fragmentation of construction power can only lead to reduced combat power on the field of battle. In the face of the almost overwhelming manpower resources of our potential enemies, it would certainly appear fool hardy for us to dissipate the one key advantage that we still retain—superior technology. Yet if we divide and dilute our construction resources we most certainly will be dissipating a large and crucial element of the technological strength which is our keystone to victory in war.

Construction Power is an Essential Element of Combat Power

In the future, as in the past, victory will be achieved by the commander who makes the most effective use of firepower, mobility and shock action on the battlefield. Since at any given point in time firepower and the capability of the command for shock action are fixed to a considerable extent by tables of organization and equipment, supply levels, and similar factors over which the commander has little or no control, it follows that mobility is the one real variable among these three elements of combat power. Stated differently, any commander who could achieve 100 percent mobility would have little difficulty in developing the full combat power of the forces available to him; conversely, with no mobility the combat potential of his force would remain virtually untapped. In the future the success of field commanders in achieving mobility is going to depend increasingly upon the effectiveness with which they exploit their engineer resources in overcoming the obstacles imposed by weather and terrain. Like the traffic on our national highways, our military operations could grind to a halt if we do not make provision for timely and effective application of construction power to problems of mobility in the field. New weapons and new techniques in warfare are creating new demands for construction which will strain our engineer resources to the limit. It is imperative, therefore, in developing doctrine for the future that we recognize construction power as an essential and integral element of combat power and avoid any action which would fragment, dissipate, or otherwise detract from its effective employment in furtherance of the over-all mission of victory in war.

THE COOPER'S HILL WAR MEMORIAL PRIZE ESSAY 1956

"The Application of Mobile Machine Power to Field Engineering Tasks in Nuclear Warfare"

By Captain M. J. W. Wright, R.E.

Subject Set for Essay

UNDER conditions of nuclear warfare field engineering tasks in connexion with route provision, crossing of obstacles, creation of obstacles and construction of field defences are likely to increase in scope and may have to be executed under more difficult conditions and in less time than in the past.

Having regard to the need for economy in manpower and equipment provision, discuss the extent to which further application of mobile machine power to the above tasks is practical and desirable, and indicate in general terms the form in which such additional machine power should be provided.

Introduction

The object of this paper is to consider the provision of mobile machine power to assist in the carrying out of certain engineer tasks under conditions of nuclear warfare.

The engineer tasks under consideration are:—

(*a*) Route provision.
(*b*) Crossing of obstacles.
(*c*) Creation of obstacles.
(*d*) Construction of field defences.

It will be necessary first to discuss the probable nature of a nuclear war, the organization that land forces will require to fight such a war, and the organization and equipment that engineer units would require to enable land forces to carry out their tasks.

The Nature of a Nuclear War

Any nuclear war in which this country might become involved would differ in several ways from any war fought in the past.

Hitherto, there has always been time, after the outbreak of the fighting, to organize the nation for war. This has meant that although the opening months of the conflict may have been full of hard fighting for the professional army, there has been time to organize and train a reserve army to take a decisive part in the fighting. In any nuclear war it is likely that the decisive land battles in each theatre would be fought by the Regular Army in that theatre at the outbreak of war. Attacks on the United Kingdom with nuclear weapons would almost certainly prevent mobilization and the movement of reserve divisions to Europe as occurred in 1939. Furthermore, the very extensive damage which would be caused in the United Kingdom would necessitate the reserve army assisting the Civil Defence Organization and the Mobile Defence Corps in maintaining the will to resist among the civil population.

The second way in which a future war would differ from past conflicts is that from the very beginning the defensive potential of Western Europe would be co-ordinated by a comprehensive command structure. The command and supply organization of N.A.T.O. bears little relation to the *ad hoc* arrangements of 1914 and 1940.

The greatest difference between a nuclear war and past wars would, however, not be on the ground, but in the air. The decisive battle of the war would be fought for air supremacy. Within a few hours of the outbreak of hostilities, attacks would be launched by both sides against each other's air potential. Attacks with nuclear weapons would be made on airfields and aircraft factories. These attacks would probably be combined with a general atomic attack on centres of population, industry and communications.

While the battle for air supremacy was being fought all over the world, land forces, using tactical atomic weapons, would be fighting for possession of vital ground. In the present political situation, this vital ground can be considered as the whole of Western Europe.

The present most likely enemy of this country is communism, whether European or Asiatic. It is a characteristic of communism that it thrives on economic unrest. The expenditure by a nation of an undue percentage of its national income on armaments may well lead to national economic difficulties which greatly weaken the nation, and increase the strength of the Communist Party.

It is essential, therefore, that the needs of economy be borne in mind at all times when considering organizations and equipment.

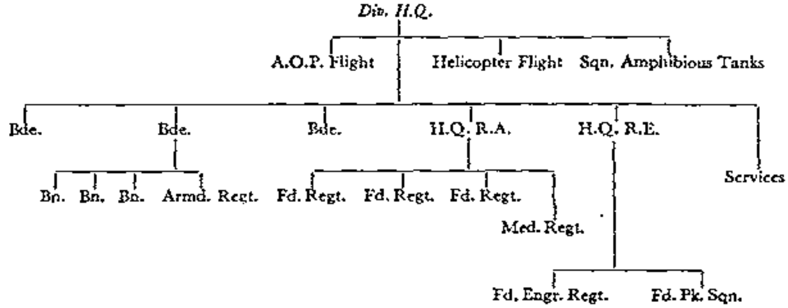
Organization of Land Forces

In most types of country, and in most phases of war, it would be normal for infantry and armour to work together. In the latter stages of the last war, it was normal to provide this armour by having an independent armoured brigade attached to an infantry division.

Bearing in mind the probability of active operations starting within a few hours of the start of the war, it is desirable that armoured units should form an organic part of all divisions so that infantry and armour can train together in peacetime. The inclusion of armoured units in the infantry division raises the problem of whether it is necessary to retain more than one type of division, or whether a "standard" division would be suitable for all phases of war.

Table 1

Proposed Outline Organization of the Standard Division



The organization of such a division is shown in Table 1. It is not proposed in this paper to argue about the details of this organization. It is based on the organization used in the Northern Army Group exercises in 1955, and on the organization shown by Field-Marshal Viscount Montgomery at his R.U.S.I. lecture in October, 1955.

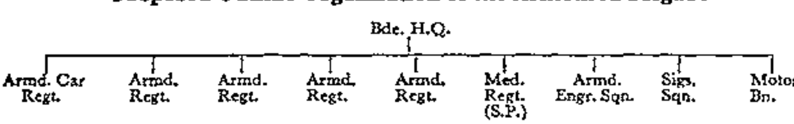
These standard divisions, well dug in and dispersed, would be deployed on frontages of up to fifteen miles. Between brigade sectors there would be wide gaps, and enemy infiltrating into these gaps would be engaged by tactical atomic weapons.

There would still be need for an armoured formation of some sort. Its task would be to counter-attack against large-scale infiltration, and to break out. In the words of General Sir Richard Gale, "the rôle of the armoured division would be to hit hard and go like hell once the decision was made to break out".

This armoured formation would need to be very small and compact and have good cross-country mobility. It would be nearer the size of a brigade than a division, and its proposed organization is shown in Table 2.

Table 2

Proposed Outline Organization of the Armoured Brigade



The third type of division, the airborne, must also be considered. In peacetime, airborne forces are very expensive to train and maintain, and their use in their primary rôle depends on a large air transport force being available. In the opening phases of the war, while the battle for air superiority was being fought it is unlikely that an airborne division could be launched into battle. It is suggested, therefore, that the existing Independent Parachute Brigade Group should be maintained, if only as a constant threat to the enemy, as a "force in being", but that no further airborne forces should be raised.

It is likely, therefore, that land forces would be organized in two standard formations only, the standard division and the armoured brigade.

Organization of Engineer Units

The required organization can only be considered now in very general terms. After consideration later in this paper of the work involved in the four tasks under discussion, a more detailed study will be made of the organization units will need to make full use of the machine power it is suggested should be introduced.

Assault Engineers

The term "Assault Engineers" is an unfortunate one, as it conjures up visions of the Atlantic Wall and 79th Armoured Division; the existence of such an offensive force in the opening phases of a nuclear war seems rather incongruous.

A more apt term is Armoured Engineers, and in a new rôle these have a vital part to play in carrying out the engineer work which the new formations would require.

The characteristics and use as a source of mobile machine power of a new Armoured Vehicle Royal Engineers (A.V.R.E.) are discussed later in this paper, but it seems certain that this vehicle would be required in both the standard division and armoured brigade.

The Assault Engineer Regiment as such would probably disappear, and tanks would be provided by armoured squadrons.

Standard Divisions

Few changes would be necessary in the basic organization of divisional engineers. At least three squadrons would still be required because the three brigades would each need an affiliated squadron. The provision of more machine power would allow a reduction in the total manpower, and so the Regiment would be smaller and more compact.

The main problem would be the handling of the Armoured Engineers. It would be easier to carry out routine maintenance if the tanks were kept centrally as a fourth squadron or as part of the park, rather than allocating one troop per field squadron. Making the Armoured Squadron a separate squadron under H.Q. R.E. would seem to be the best solution. It would have the added advantages of concentrating this very useful equipment directly under the C.R.E., to use as he saw fit; the problem will be considered again later.

Armoured Brigades

The main assistance the armoured squadron would be able to give to the armoured regiments would be to maintain their mobility by bridging small obstacles, improving tracks and clearing minefields.

As an economy, certain engineer tasks now carried out by the Royal Armoured Corps should be carried out by the armoured squadron. These tasks are:—

(*a*) Handling of the Giant Viper
(*b*) Handling of bridge layer tanks
(*c*) Handling of Centurion tank dozer.

The requirement for the A.V.R.E. itself will be considered later in this paper, but whatever the design of the actual vehicle, some field engineers would be required.

Other Engineer Units

The main point to bear in mind when considering what assistance could be expected from the rear by sappers in divisions and brigades is that normally other sapper units would not be there to help.

Outside divisional units, the present engineer order of battle consists of a few Corps and Army Engineer regiments and a very few specialist units such as plant troops, workshop and park squadrons, and works sections.

It is at present intended that the majority of specialist units required would be provided from the Army Emergency Reserve and the Territorial Army. As has been stated above, it is most unlikely that these units of the reserve army will have time to mobilize, train and move to Europe in time to take part in the decisive battles.

It is essential, therefore, that since engineers will be extremely thin on the ground, the maximum possible use is made of the limited manpower available by using machine power wherever possible.

Engineer Equipment

Before considering in detail the equipment requirements for the four tasks under discussion in this paper, it is necessary to consider very briefly the requirements of future engineer equipment in general.

The use of men alone has certain advantages, i.e., they can carry out tasks of all kinds in all climates, but this has of course many drawbacks—for instance, they require food even when not working, and the amount of physical work one man can do is so small that the large tasks met in conditions of nuclear warfare would need far more manpower than the total engineer strength available.

It is essential, therefore, that as much mechanical assistance as possible be provided for all engineer units.

It was realized as far back as 1926* that one of the chief snags in introducing machines into field companies to replace manpower was that the unit tended to become lumbered up with a number of machines each capable of carrying out only one or possibly two tasks, but no more. What is required is one or two machines versatile enough to carry out a large number of tasks.

The second requirement for a piece of engineer equipment is that it must be mobile. Before the advent of organic armour in the infantry division, the largest loads in the division were the D7s

**In the Wake of the Tank*, by Lt.-Gen. Sir Giffard Le Q. Martel, Chap. XII.

in the Field Park, on their transporters. There have been many occasions in war, and even in peacetime on divisional exercises on Salisbury Plain, when Field Park transporters have played havoc with a divisional movement table. Furthermore, it is very uneconomical to provide such a transporter primarily to move one dozer. The machine should be designed to be able to maintain convoy speed on its own wheels or tracks.

The third requirement for a piece of engineer equipment is that its production must be an economic proposition. This means that it must be required in large numbers, or else be readily adaptable from a standard civilian equipment. If the item is required in large numbers it is possible to apply mass-production techniques to its manufacture and so reduce the over-all cost per machine.

It may not be possible to mass-produce equipment for the engineer units of the small British regular army, but it may be possible to adopt the item as standard equipment for all N.A.T.O. divisions, making mass-production of that item economically feasible.

It is very important, therefore, that as much standardization of equipment as possible should be carried out by N.A.T.O. forces. The alternative—modification of a standard civilian machine—would not normally be so satisfactory as a machine produced specially to meet a military requirement.

To sum up, a piece of engineer machinery must be versatile enough to carry out a number of different tasks, mobile enough to move at convoy speeds without a transporter, and required in sufficient numbers to make its design and production worthwhile.

Route Provision

It has been stated that the land battle in each theatre would be fought with those formations in the theatre at the outbreak of war, and that the Engineer order of battle in the regular army contains few specialist units. Therefore, there would be very little construction of new routes because the resources required would not be available. The most that could be done would be construction of a few alternative routes round possible defiles and the maintenance of existing routes. The latter in itself would be a very large engineer task.

There is no doubt that the application of mobile machine power in the correct form would greatly increase the route mileage that a given labour force would be able to maintain, and there is no doubt also that the damage caused by tactical atomic weapons will make the work of 1944–5 seem a very small task in comparison.

Tasks that are likely to be met under the term "route maintenance" are listed below:—

(*a*) Replacement of damaged bridges and culverts.

(*b*) Strengthening of existing bridges.

(*c*) Clearing of rubble that has fallen into the road from damaged buildings.

(*d*) Filling of craters.

(*e*) Widening of roads and cutting of corners to carry bigger loads.

(*f*) Repair of deteriorating surfaces caused by heavy traffic.

The repair, replacement and strengthening of bridges will be considered later in this paper when considering crossing of obstacles. Equipment must be provided for all engineer units to enable them to carry out the remaining tasks.

Load Carriers

A characteristic of all the above tasks is that they require movement of bulk loads such as rubble, stone and surfacing material. For ease of unloading, the load carrier used for this task should be a tipper.

At present, the 3-ton vehicles in field units are of two main types; tippers and G.S. The tippers can of course be used as load carriers, but the proportion of tippers to cargo vehicles is at present far too low. A study of Part VI (organization) of the Higher Establishment Table for a field squadron shows that the cargo vehicles are used for the carriage of personnel, G.1098 stores, rations and clothing.

It is easy to see the great increase in flexibility that would be achieved if there was one vehicle to combine the carriage of personnel and tasks on a works site which require a tipper.

The requirement for such a vehicle would be:—

(*a*) It should tip.

(*b*) It should have a body equal in volume to the present cargo vehicle.

(*c*) It should have removable sides and tailboard so as to be able to carry Heavy Girder Bridge parts.

(*d*) It should have 4 × 4 drive, and a good cross-country performance.

(*e*) It should have a canopy and so be suitable for troop carrying.

(*f*) Its centre of gravity should be sufficiently low to make it stable enough to carry personnel across country.

(*g*) Providing the cost is not too high, it should have a power take off and a winch.

The present tipper, like its predecessor the Bedford, meets few of the above requirements, but it should be possible to design such a vehicle, and replace all the present tippers and cargo vehicles in field units with it; such a vehicle should have a 5-ton capacity.

The main snag would not be in its design but in its use; the body will be so large that when loading with stone or rubble, there will be a great danger of overloading the vehicle. Troop officers would have to be taught exactly how much the vehicle could carry.

Further reference to the power take-off as a source of power for smaller machines and tools will be made later in this paper.

Certain other load-carriers have been developed since the war, and the chief of these are the new 10-ton tipper and various sizes of dumpers. The new 10-ton tipper is a very fine piece of equipment, but is not a suitable vehicle for divisional units because it is too large for use in forward areas, and is only 6 × 4 drive. It is recommended that this vehicle should be the standard equipment of R.A.S.C. tipper platoons.

Dumpers are vehicles with a very limited use and should not be part of the equipment of divisional or corps units. A large number of civilian pattern would be available on mobilization, and would be useful for the reserve army clearing routes in bomb-damaged towns in the United Kingdom.

Cranes

A mechanical loader would be required to load the tippers, and as some kind of quarry would be set up, an excavator with the various front end attachments would be desirable. A crane for use on other tasks would also be required.

At present these two requirements are met in the division by providing two separate equipments, the four Coles cranes and the two lorry mounted excavators, all located in the field park squadron.

It would probably be possible to combine the conflicting requirements of these two equipments and design a composite machine to carry out both tasks. Such a machine would be very expensive to produce and would probably suffer from inherent limitations of a compromise.

It is suggested that a better solution would be to develop a light and a medium wheeled tractor each with a shovel loader and a back acting and face shovel ancillary equipment. These machines would also be capable of having a dozer blade fitted, together with fork lift attachments and lifting boom. It would still be necessary to have conventional excavators available for really large quarries, but these should not be held in regiments, but in a plant park squadron in each theatre. There would also be a need for Coles cranes, and this need will be considered when dealing with equipment required for bridging.

The new light wheeled tractor, with ancillary equipments, should be provided on a scale of one per troop.

Crushers

The repair of the great damage to communications likely to be caused by nuclear weapons would require large quantities of stone for road maintenance. Rubble from buildings would partly meet this requirement, but it is probable that in addition quantities of stone would have to be quarried. Existing civilian quarries and equipment would partly meet this need, but some sort of mobile crusher would also be needed so that additional quarries could be opened if necessary.

The new "Parker", 25 tons per hour, stone crusher has been designed to meet army requirements and it is recommended that a number of them be held in the plant park squadron and that plant operators in divisional and corps regiments should be trained to use this machine so that they could be called on if required. The machine itself is not mobile enough and has too limited a use to be incorporated in the equipment table of any field unit.

Dozers and Graders

The loading and carriage of the bulk stores required for route maintenance has already been discussed. Unloading would present no problem because the load carrier would be a tipper. The next requirement would be for plant to spread, compact and grade the stone and rubble on the road. The same type of plant will also be required to clear rubble from blocked streets in towns, and for carrying out any earthworks which diversions, improvement of tracks or new routes require.

At present, there are a number of machines in corps and divisional units which can carry out these tasks. These are dozers of various sizes and motor graders. In the future a dozer blade fitted to the A.V.R.E. would allow the A.V.R.E. to be also used for this task. The policy at present is to give a small amount of plant to each squadron but to concentrate the bulk of the plant in the park, to be used as a pool. There is little doubt that this is the correct solution; a squadron commander obviously needs some earth-moving plant, but to give him much more than he has now would reduce the flexibility of the whole.

A new medium wheeled tractor with an earth-moving performance approximately equal to a size III machine has now been developed. In addition to a cable operated dozer blade, it can be fitted with a front-mounted shovel, a P.C.U., and a pneumatic tyre or steel-wheeled rollers. Its great advantage is its mobility, because it does not need a transporter. It is recommended that this machine should replace all the size IV and size III dozers in the Army.

From the point of view of the field squadron, the change would be advantageous for they would receive a more powerful machine and it would not require a transporter. There are few small tractors outside field squadrons, and so this change would have little effect in rear areas.

It is recommended also that the medium wheeled tractor should replace the size II tractors in the field park. It is true that the new machine has not the output or tractive power of the D7, but to compensate for this there will be about twenty A.V.R.E. dozers in the division. Size I and size II tractors should be held in the plant park squadron, to be drawn for a really large project if required.

The proposed light wheeled tractor would also be available to assist in this task.

The use of the A.V.R.E. as a piece of plant has already been mentioned and it will now be discussed in more detail. The present

A.V.R.E.—the Mark VII Churchill—has a bulldozer blade which can be removed if not required. The vehicle has a good reserve of power and good traction. The only snags to its use are that the blade cannot be angled and that the driver finds it hard to see what he is doing.

The specification of a new A.V.R.E. will be considered later, but two of the requirements will be:—

(*a*) Fitting of a dozer-blade that can be angled.

(*b*) Good vision for the driver.

It is probable that any new A.V.R.E. would be based on the Centurion chassis, if not on the tracks. This tank has a powerful engine, and so the new A.V.R.E., when used as a dozer, would have an output at least equal to the D7. It is considered that although the A.V.R.E. will often be available for use as a dozer, the two dozers (now to be wheeled) in the plant troop should be retained as there will often be dozing tasks on which it would not be suitable to employ an A.V.R.E.; in any event, an A.V.R.E. will never be able to work as a dozer for days on end, as a D7 can. The A.V.R.E. must be considered as the best means of dozing under fire and under atomic attack, but a "bonus" on dozing tasks at other times.

The last piece of equipment to be considered under the heading of "route maintenance" is the motor grader. This vehicle, in addition to being a very useful machine, has two other important assets:—

(*a*) It is mobile on its own wheels.

(*b*) It is a standard civilian machine and therefore comparatively cheap.

It is suggested that the present machine is satisfactory, and that the present allocation of two per division should not be changed.

Summary

To sum up, machine power can economically save manpower in the task of route provision in the following ways:—

(*a*) Standardization of load carrying vehicles, so that all can be used as tippers.

(*b*) Provision of a new general purpose light wheeled tractor with fork lift, dozer blade, face shovel and front loader, and trench digging attachment, on a scale of one per troop.

(*c*) Provision of a new medium wheeled tractor with ancillary equipments, to replace the class IV dozer in field squadrons, and the class II tractor in field park squadrons.

(*d*) Use of A.V.R.E. dozers to help out the limited plant available in the divisional area.

(*e*) Use of motor graders on the present scale.

(*f*) Provision of a plant park squadron in each theatre to hold crushers, size I and II dozers, excavators and other more specialized plant.

By far the most important innovation would be the general purpose light wheeled dozer, and this machine will be considered again when discussing other tasks later in this paper.

Crossing of Obstacles

The maintenance of the mobility of land forces by the crossing of obstacles is likely to be a large engineer task in all phases of a nuclear war.

In defence and withdrawal, the task would be the rebuilding of bridges destroyed by enemy air attack; in attack, pursuit and advance to contact, the problem would be to overcome artificial obstacles and demolitions left behind by the retreating enemy.

Artificial obstacles, such as minefields, would be even more important in conditions of nuclear warfare than before, because the enemy would use these to canalize an advance into killing grounds for his tactical weapons.

Furthermore, the crossing of an obstacle of any sort would entail concentration of forces as they cross the obstacle. To prevent this concentration producing a worth-while atomic target it would be necessary to cross the obstacle in as many places as possible at the same time.

Phoney crossings might also be required so that the enemy would not know on which crossings his atomic missiles should be directed.

It would not be possible to bring forward the heavy stores that additional bridges over wide rivers would require, and so greater use may have to be made of amphibious tanks, vehicles and rafts.

The engineer tasks involved in the maintenance of mobility by the crossing of obstacles are:—

(*a*) *Bridging*. This will range from crossing anti-tank ditches to a major task such as building a floating bridge over a wide river. Bridging will also include rafting.

(*b*) *Clearing minefields.*

(*c*) *Clearing other obstacles* such as "dragons teeth", road blocks and barbed wire.

Bridging

The decisive land battle of a future war would probably be fought in Western Europe. A study of the bridging work carried out by 21st Army Group in North-West Europe in 1944–5 will give some indication of the probable extent of the problem in a future war.

Between 6th June, 1944 and May, 1945, a total of 1,445 Bailey bridges were built by 21st Army Group. Of these, the majority were 80 ft. or less in length. The percentages of bridges which were 80 ft. or less in length would be even higher if non Bailey bridges such as tank bridges, fascines, stock spans and improvised bridges are added to the total.

It seems a fair conclusion, therefore, that if an 80 ft. span bridge capable of very rapid mechanical launching were available within the division then most of the unforeseen bridging could be met, and furthermore, the required bridges could be built very quickly and with a great saving in manpower.

The requirement therefore is for a method of building an 80 ft. bridge capable of carrying the heaviest loads in the division, and capable of being built very quickly.

The most promising solution seems to be some kind of tank bridge, and since the Centurion tank is now the standard tank in the army, such a bridge should be based on the Centurion hull.

The new bridge would be the standard method of crossing minor obstacles in both the standard division and in the armoured brigade. It would be R.E. manned and replace both the present bridge troop in the field park squadron and the bridge layer troop in the armoured brigade.

There would still be a need for the heavy girder bridge to replace tank bridges and release them for further tasks as the route is improved and also to construct larger spans. This bridge would be brought forward in the R.A.S.C. bridging company and constructed by corps and sometimes divisional units.

The present method of building by a bridging crane should be replaced by the use of a light or medium wheeled tractor with its forklift and other ancillaries, since it has already been recommended when considering route provision that the present 10-ton crane is a piece of equipment the expense of which cannot be justified.

There will sometimes be occasions, however, when the site will make construction of the heavy girder bridge by humper from each side very difficult. In such cases the Coles crane would still be required, and so it is suggested that one crane should be retained in the plant troop of the park squadron. It would also be required for mounting assault devices.

The crossing of wide river obstacles would entail the use of more flotation equipment. It is suggested that a proportion of all tanks in the division should be capable of being converted to D-D tanks. This would limit the engineer problem to the construction of light ferries, such as the close support or F.B.E. raft, and the tonnage of stores required would be much less than if heavy ferries were required for tanks.

Minefield Clearing

There are at present three ways of clearing mines:—

(*a*) By hand.
(*b*) By explosives—i.e., the giant and baby vipers.
(*c*) By mechanical means, i.e., the flail.

Clearing by hand is the most effective method but is very slow and requires a great deal of manpower. It may also be expensive in casualties, and if attempted under aimed small arms fire will be practically impossible to carry out. Therefore, for large-scale clearance in forward areas, hand methods are not really suitable.

Clearance by explosives would be very useful in forward areas, especially during an assault. In particular, the present giant viper can clear a tank lane through a minefield without exposure of any of the operators. It is at present operated by the R.A.C., but since the development of the gap into a through route is a sapper task, and the trailer can be towed behind any A.V.R.E., the operation of the giant viper should be a normal task for armoured squadrons both in the standard division and in the armoured brigade.

There would, however, be occasions when the giant viper would not be a suitable method to use; it causes a considerable blast when fired and so any supporting infantry in the open would have to be kept out of its danger area. In close country this would be a serious handicap to the tanks because they would require the infantry to be well forward to deal with enemy rocket launchers and other small anti-tank weapons.

There would therefore be a requirement for an armoured mechanical mine-clearing device. This should not be a specialist vehicle, such as the flail, because it would not be economical to have large numbers of specialized vehicles to carry out one task only.

What would be required is a device that could be fitted to any A.V.R.E. There are several lines of research possible to produce this:—

(*a*) A simple flail fitted in place of the dozer blade and driven by the tank engine.

(*b*) A device similar to the Canadian indestructible roller device.

Whatever equipment is produced would not be required on a scale of one per A.V.R.E., but sufficient numbers of the device should be held within the division to produce three gaps.

Summary

Machine power can replace manpower in the task of crossing obstacles in the following ways:—

(*a*) Provision of an improved ark as the standard method of crossing short gaps.

(*b*) Use of fascines.

(*c*) Use of general purpose wheeled dozer for bridge building.

(*d*) Use of Viper for mine clearing.

(*e*) Use of a new mechanical mine-clearing device to fit to the A.V.R.E.

Creation of Obstacles

To avoid presenting a single missile target, units and formations larger than battalions would frequently be dispersed with wide gaps between them. Such gaps would have to be blocked as far as is practical by the creation of obstacles in depth.

The conventional methods of mines and demolitions would continue to be the chief means of strengthening natural obstacles to create a barrier, but consideration would also have to be given to the use of prepositioned tactical atomic charges.

The use of prepositioned atomic weapons would have several limitations, such as time required for positioning, lack of choice of height of burst, and vulnerability to enemy detection and neutralization or destruction. Locations which might prove suitable for use of prepositioned weapons are mine shafts or specially prepared excavations for use against vital administrative installations such as an army maintenance area, airfields, communication centres or ports.

Minefields

The mines themselves would require modification in order to be able to resist the blast wave caused by atomic weapons, and the laying of large numbers of mines, which the barriers between battalion positions would require, would be a major engineer task.

There is at present no means of laying mines mechanically without giving away the position of the minefields on air photos. However, laying by hand is so slow that more than the existing labour force would be needed to lay the large number of mines required. It is suggested that a solution to the problem would be to lay barrier and defensive minefields by mechanical layers, with large numbers of phoney minefields laid as well.

To do this, two machines would be required—one for the barrier and defensive minefield and one for the phoney minefields. For the barrier and defensive minefield a machine similar to the present minelayer should be used. This could be towed behind a wheeled dozer or any other available prime mover, and should be available in the plant park squadron for issue when required. For the phoney minefields a second machine would be required—this should consist of a shallow plough towed behind any powerful prime-mover, its action being to dig a shallow trench and fill it in again. The appearance of this on an air photo would be similar to a real minefield.

There would be occasions when the use of the mechanical minelayer could not be accepted because of the need for concealment, or because of the hard ground. It would probably be possible to produce a mobile mechanical earth auger that would overcome the hard ground, and dig a small hole for the mine, but the provision of a special piece of equipment for such a limited use would not be justified. It is therefore probable that laying by hand would still be necessary on occasions. The only mechanical assistance that would be possible in such cases is the parcelling of the minefield stores, and the use of fork-lift trucks to distribute the parcels on the site of the minefield.

Types of Mines

It would be possible to save manpower and carrying capacity by using lighter mines. A much lighter mine, easily carried and laid, should be developed, so that areas could be saturated with mines and so be virtually impossible to clear.

It is probable that the advent of guided missiles would reduce the size of tanks and this in turn would reduce the size of mines required to stop them.

A lighter anti-tank mine should therefore be developed.

Barbed Wire

Barbed wire, because of its very small surface area, would be little affected by the blast or heat wave caused by an atomic explosion. It would therefore continue to have an important use as a barrier. Little could be done to lay the barrier by mechanical means, but a great deal of manpower could be saved by parcelling of stores and use of fork-lift trucks to distribute them.

Concrete Obstacles

Concrete obstacles such as solid road blocks, dragons teeth and concrete anti-tank ditches would be likely to stand up very well to atomic attack. They might be required in a limited war which could easily become static, as happened in Korea, but in a full scale nuclear war the logistical support would not be available to move the large tonnages of engineer stores such defences require. Furthermore, the tactical situation would probably not be sufficiently static to allow time for their construction.

Demolitions

Under certain conditions, use of an atomic charge for demolitions might well be justified. Rapid demolition of a bridge over the Rhine, for example, would be very expensive in material if current rapid demolition devices were used. However, atomic charges would be very few and far between, and the main problem is to discover means by which conventional demolitions can be carried out using machine power to save manpower wherever possible.

The demolitions required to produce an obstacle would fall into the following categories:—

(*a*) Destruction of bridges and culverts.
(*b*) Destruction of routes, i.e., roads and railways.
(*c*) Destruction of civil resources.

Destruction of Bridges

The preparation of bridges on a river line for demolition is always bound to entail use of a large number of small parties of men to place charges and to fire them. There is little that can be done mechanically to assist in this task except the use of fork-lift trucks to distribute the large quantities of stores required.

The present scale of compressors may not give a sufficient number of pneumatic tools to fully use the available manpower in a field regiment; the introduction of a new range of small power tools is discussed later in this paper. One very useful new tool would be the new bolt fixing hammer: this would save many man-hours when fixing charges on to bridges.

Destruction of Roads

There would be considerable assistance, apart from the use of pneumatic tools, that machine power could give in the task of destroying roads. The task would entail large numbers of small parties each responsible for several craters.

Two pieces of equipment that would be useful are the Benoto hammer grab and the Greenlee pipe-pushing machine. The Benoto grab would be useful to dig boreholes for cratering charges. Since this machine would also be useful in the construction of field defences, it is worth considering whether it should be available to field units from the plant park squadron.

The Greenlee pipe-pushing machine, while producing considerable damage to a road or runway, is slow to use. It has such a specialized use that its employment in field units would not really be practicable.

The use of plant for the destruction of roads must also be considered. In many locations, such as when a road is built on a low embankment, the dozing away of part of the road and the embankment and disruption of the drainage system would in the course of a few days of wet weather produce a quagmire that would be a good obstacle to vehicles.

Destruction of Local Resources

No special or new plant would be required for this task. Any available dozers or compressors could be used, but again, this would be a matter of large numbers of small parties. There could be a great economy in the amount of explosives used on this type of task if demolition parties were taught where to place their charges to produce maximum damage.

Rooters

The use of rooters to damage roads and airfields should also be considered, but it should be remembered that rooters require a powerful prime-mover, which would not be available if the D7s in divisional units were replaced by wheeled tractors. Also, the damage they cause would be no obstacle to tracked vehicles, and in dry weather would be little hindrance to wheeled vehicles. It is recommended, therefore, that while use should be made of any rooters (towed behind an A.V.R.E.) that were in the theatre on the outbreak of hostilities, undue faith should not be placed in them, and they should not be provided for this one task alone.

Summary

To sum up, manpower could be saved in the construction of obstacles by the following innovations:—

(*a*) A mechanical minelayer to lay mines.

(*b*) A machine to produce a phoney minefield.

(*c*) Fork-lift trucks to distribute mines, wire and defence stores.

(*d*) Introduction of the new range of rational demolition accessories which take less time to fit together.

(*e*) Use of the bolt fixing hammer.

(*f*) Production of a lighter type of anti-tank mine, without loss of power.

(*g*) Possible use of Benoto hammer grab in placing cratering charges.

FIELD DEFENCES

This task differs from other tasks under discussion in this paper in that construction of field defences is not primarily an engineer task. Sapper assistance is at present limited to advice, supply of stores and prefabrication of components for standard emplacements.

In conditions of nuclear warfare, the task of providing defences and overhead protection would be so large that other arms would not be able to carry out their own tasks and provide their own defences unless some engineer assistance were provided.

The tactical background to the provision of field defences is likely to feature increased protection, mobility and dispersion, together with a greater need for deception, concealment and duplication. Since some of these requirements cannot be reconciled with each other, they will now be considered in more detail.

Protection

The effects of an atomic explosion would necessitate the provision of overhead protection on all defences, and the defence structure itself would have to be of a robust construction in order to resist the high blast wave.

These two requirements could lead to a very great increase in the required tonnage of defence stores, which would not be acceptable. The design of defences would therefore have to be kept flexible so that full use could be made of local timber and other resources.

A new light form of nesting revetting material would also be required.

Much manpower would be saved if a number of mobile power tools were available to cut down trees and prefabricate parts of defence structures with the timber so obtained. A large number of humpers would also be required to distribute the prefabricated parts, and other defence stores, to the defended areas.

Mobility

The increased mobility that would be likely in a nuclear war would mean that units would have to move more frequently and so would have to dig field defences more often. Moreover, the atomic threat, even when in rear areas, would necessitate provision of protection at all times.

While it would still be axiomatic that every man would dig his own foxhole in the first instance, H.Q. and specialist units would require assistance in digging in if they were required to function with a reasonable degree of protection. To provide this, a digging attachment should be available to be fitted to the light and medium wheeled tractor. This would provide the division with fifteen to eighteen machines of the "Dinkum Digger" type and would save many hours of digging.

The replacement of class II and IV crawler tractors by wheeled tractors with digging attachments would mean that there would be fewer conventional dozers available for such tasks as digging in tanks and guns, but this could be overcome by the use of A.V.R.E. dozers on these tasks.

Dispersion, Concealment and Deception

Concealment of the defences in most types of soil would be difficult to achieve, and the tracks left behind by the humpers would also be hard to hide. It is suggested therefore that every effort should be made to confuse the enemy by means of a large number of phoney defences.

Dispersion would be achieved by dispersing the force according to the tactical plan within the maze of dummy and real defences.

The plant already suggested would be very useful in carrying out this deception. The wheeled tractors, with their front loading attachments, would be able to load the spare soil into 5-ton tippers, which would carry it away and dump it in areas where phoney defences were required.

Duplication

Certain vital installations, such as headquarters, would require duplicate positions constructed. This would be an additional engineer task, but would not entail provision of separate or additional plant.

Signals services might require engineer assistance to duplicate buried line communications, and it is suggested that a small number of mole ploughs should be available in each theatre for this purpose. These would be towed behind a medium wheeled tractor or an A.V.R.E.

Summary

Machine power could economically assist in the construction of defence works by the following innovations:—

(*a*) Use of A.V.R.E. dozers to dig in tanks and guns.

(*b*) Fitting of "Dinkum Digger" type attachments to the light and medium wheeled tractor.

(*c*) Development of a light revetting material, which can nest together for ease of transport.

(*d*) Provision of more power tools for prefabrication of parts of defence structures.

(*e*) Use of fork-lift trucks to distribute stores.

Equipment Proposals

When considering the tasks in this paper, several suggestions have been made about new sources of mobile machine power. Some of these suggestions have already been fully discussed, but suggestions with regard to other items require more justification.

It is now proposed to consider these new equipments, and later, to discuss how engineer units should be reorganized so as to be able to make full use of the new equipment.

The Ark

On first consideration, the ark appears to be a very expensive method of crossing an obstacle. It is true that the tanks are very expensive to produce, but it must be borne in mind that tanks converted to arks are always old tanks, which would probably be sent for scrap if not used as arks. One ark crossing can replace the bridge troop in the park squadron, with its large number of vehicles and expensive bridging equipment. The ark crossing could produce a bridge, suitable for A and B vehicles with less than ten men in a matter of minutes, whereas construction of a conventional bridge over the same gap would take a troop many hours. The ark would be an old tank, and conservation of its track mileage would not be important; it could therefore move on its own tracks, without a transporter.

By using arks as the normal method of bridging small gaps there would therefore be a very great saving in cost, road space, manpower and in total weight of engineer stores to be moved.

It is suggested therefore that the ark should be accepted as normal equipment in both the standard division and in the armoured brigade. There should be no set scale of tanks, but they should be held as required for a particular operation. There would have to be an adequate re-supply system so that a crew would ditch their tank and then go back to the plant park squadron or the forward delivery squadron and pick up a new tank. The first tank would be left in position for several days and as soon as corps engineers could build an alternative route, it would be recovered and prepared for further use.

The A.V.R.E.

The consideration of the A.V.R.E. in this paper has been mainly confined to its use as a dozer. It must be admitted that it is unlikely ever to be a very efficient dozer, but its output could be increased if it had an angled blade. Other uses of the A.V.R.E. have also been considered above; its carriage and use of fascines for the crossing of obstacles, its use for mine clearing both with a giant viper and with a new flail device, and its use as a source of power for towing the machines. The demolition gun would also be a valuable tool, in withdrawal, for creating obstacles and in the advance for destroying the enemy's obstacles.

While it is considered that the A.V.R.E. should be normal engineer equipment in both types of formation, it is not considered that there is justification for a complete squadron in the infantry division.

Tipper

Provision of a standard engineer load carrier to replace the present tippers and G.S. vehicles was considered in detail when discussing route provision. The production of the new all-purpose vehicle would probably allow a reduction in the total number of 3- and 5-ton vehicles in engineer units.

Wheeled Tractors

It is proposed that there should be two wheeled tractors, a medium and a light. The medium tractor would replace the D4 and the D7. Its primary task would be as a dozer, and although "Dinkum Digger" face-shovel and fork-lift attachments could be fitted, these would be subordinate to its main rôle of dozing.

The light tractor would have a dozer blade, but its main tasks would be loading of tippers, mechanical handling of stores and digging defences.

It would therefore require several accessories, and a trailer, which it could tow, in which to carry them.

Range of Power Tools

The present allocation of power tools in a field squadron is two compressors with tools in squadron headquarters and a danarm saw in each troop. It is considered that to make maximum use of the available manpower, much more would be required. Tools would be needed for sawing timber and making parts of field defences, for sawing up the large number of trees that would block roads after an atomic attack, and for preparation for demolitions. It is suggested that the third compressor should be brought back into the squadron and that a range of saws, augers, drills, etc., driven by flex drive from a power take-off on the 5-ton tipper should be developed.

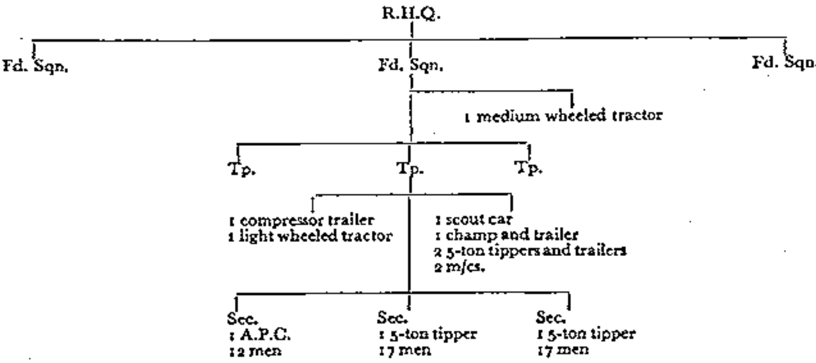
Organization Proposals

Plant Park Squadron

It is suggested that a number of the less versatile machines should be withdrawn from field and corps regiments and held in a plant park squadron in each theatre. This unit would also hold machines such as crushers, rooters, crawler tractors, etc., to be issued as required.

Table 3

Outline Proposed Organization of Field Engineer Regiment, showing Plant



Field Engineer Regiment

The proposed organization for the regiment in the standard division is shown in Table 3. The present basic organization would be little changed except that each troop would have a compressor trailer and one of the proposed all-purpose light wheeled tractors.

The replacement of the D4 by a medium wheeled tractor and of the present 3-tonner by a new 5-ton tipper/G.S. vehicle would reduce the total numbers of vehicles and drivers. A further reduction in the scale of A.F.G.1098 stores carried in troops, squadrons and in the regiment would allow a further worth-while reduction in the number of vehicles and drivers.

The three main points to be resolved when considering the organization of this regiment are:—

(*a*) Are three squadrons still required?

(*b*) Should park squadrons be provided on a scale of one per regiment, and again become part of the regiment?

(*c*) If the park squadron remains outside the regiment, should A.V.R.E., if required at all, be organized as a fourth squadron within the regiment, as a troop in each squadron or as part of the park squadron?

It is considered that three squadrons are still required, because there will be many occasions when the three brigades will be deployed some distance apart, and will require intimate sapper support which only an affiliated squadron could provide.

It is not considered necessary to alter the present organization of the divisional engineer command. In the unlikely event, in the opening weeks of a war, of a corps or army regiment being placed under command of a divisional C.R.E., they would not require a separate park squadron because they would have a call on some of the plant in the park squadron in their own engineer group. Furthermore, they could call forward plant from the plant park squadron. The number of plant operators in divisional, corps and army regiments should therefore be increased, so that full use could be made of the plant park squadron.

It is considered that there is a requirement for the A.V.R.E. in the standard division, but all that is required is a large troop. This troop should be part of the park squadron.

Field Park Squadron

The proposed organization is outlined in Table 4. It incorporates several major changes, and these will now be discussed in more detail.

Table 4

Proposed Organization of Field Park Squadron, showing Plant

Sqn. H.Q.

Wksp. Tp.	*A.V.R.E. Tp.*	*Plant Tp.*	*Br. Tp.*	*Stores Tp.*
1 lorry machy. R.E. 2 welding trailers 2 generators 10 KVA 1 generator 27.5 KVA 1 circular saw	Scout car Comd. A.V.R.E. 5 A.V.R.E. (with ancillaries) 2 A.P.C.	1 Coles crane 2 medium wheeled dozers 2 motor graders 2 315 cfm. compressors 3 water purification trailers 2 lorry mounted excavators	Scout car 1 A.R.V. Pool of ark drivers	An accounting and convoying organization. Also carries Div. reserve of tools

Bridging Troop

It has been proposed above that the present troop should be replaced by an ark troop. The number of arks held would vary, but assuming a new ark would be capable of making a bridge singly, and not in pairs as at present, a total of six arks would be about the required number.

The troop would have a scout car, for the troop commander, as he would require to be well forward, with the field squadron, to supervise the launching of the arks, and an armoured recovery vehicle, to recover the tanks as soon as an alternative route had been completed.

Stores Troop

The rôle of this troop would be to organize dumps of defence and other stores and to organize, with provost, the delivery of stores to these dumps, in R.A.S.C. transport.

The plant at present held in the troop, that is, the cranes and water purification trailers, would be transferred to the plant troop, and the troop would have a small number of N.C.Os. to run dumps and a small number of motor-cyclists to guide convoys to the dumps.

Workshops and Plant Troops

Few changes would be required in the workshops troop but in the plant troop the number of machines held would be as shown in Table 4. This troop would act as a pool from which plant would be taken for use by field squadrons.

A.V.R.E. Troop

This troop would have six A.V.R.Es., and so would, if necessary, be capable of clearing three gaps in a minefield; it would, however, be normal for the troop to operate in two sections, each of an A.P.C. and three tanks.

Armoured Engineer Squadron

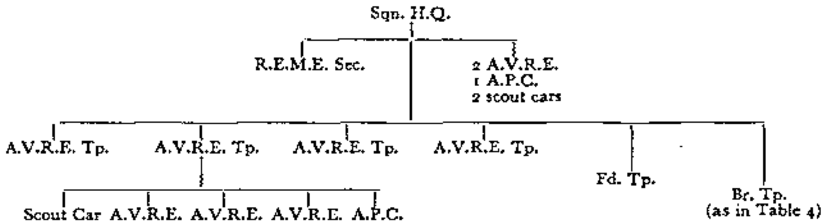
In the armoured brigade, sappers would be required with each armoured regiment. It is considered, therefore, that there should be four A.V.R.E. troops in the squadron, so that basis would exist on which to build four specialized teams, one for each armoured regiment.

These teams would consist of A.V.R.E. dozers, giant vipers, arks and perhaps wheeled dozers. The proposed organization is shown in Table 5.

As the squadron would be the only engineer unit in the brigade, a field troop would be required for routine engineer tasks, and each A.V.R.E. troop should have a section of field engineers mounted in an A.P.C.

Table 5

Proposed Organization of the Armoured Engineer Squadron



Corps and Army Units

This paper has been concerned very largely with divisional units. Any suggestions regarding equipment in divisional units apply to a great extent to corps and army units, although the decreasing need for mobility would mean plant with a higher engineer efficiency could be used in these units.

Conclusion

The proposals outlined above would allow the engineer units likely to be available in a nuclear war to deal with the great increase in the amount of engineer work that would have to be carried out. There would not be sufficient manpower or time available to increase the output of the engineer units other than by the use of more machines, and the machines suggested, except for the tanks, would not be expensive to produce in terms of money or man hours. The tanks used would be "second-hand tanks" converted to their special uses and would replace the tank dozers and bridge layers at present manned by the Royal Armoured Corps. There would therefore only be a very slight increase in the total number of tanks employed on engineer tasks, and the cost of this increase could be accepted.

These proposals would increase the output and decrease the tail, and so help to produce the army mentioned in the House of Commons recently, "a division with no tail, which bites all the way round, so that no one knows whether it is coming or going."*

**Hansard*, 1st March, 1956.

TWO BUSY DAYS

22nd August, 1914, and 28th May, 1940

By DONALD PORTWAY
(Master of St. Catharine's College, Cambridge)

FEW men can have had the good fortune to have been in command of British troops as a regimental Sapper officer both in the early days of the retreat from Mons in 1914 and in the Dunkirk evacuation in 1940. It may be, therefore, that the contrasting description of a single day in each of these vital times by such a person is not devoid of interest.

Before World War I the Institution of Civil Engineers required of its budding members three full years of practical experience. One of these years might however be in whole-time service as a subaltern in the Special Reserve of the Royal Engineers. It was by this means that the Corps of Royal Engineers secured many of the additional officers required in its field units on mobilization for World War I. I spent a happy fifteen months at this in 1910–11, serving first at the School of Military Engineering, Chatham, and then with a Sapper unit in Ireland; the latter in particular was an ideal station both for sport and for soldiering in those halcyon days. Later on I was on the teaching staff of the Royal Naval College, Dartmouth, doing my annual military training in Ireland during part of my summer vacations.

In July, 1914, the whole Naval College, Officers, Cadets and civilian staff joined the fleet for the experimental mobilization which, by a lucky chance, had replaced the more normal annual manœuvres. By the time we got back to Dartmouth war clouds were piling up thick on the horizon. On Saturday, 1st August, naval mobilization was ordered and all cadets in the college were sent on service. This was a grave mistake and within a few weeks the cruisers *Hogue*, *Aboukir* and *Cressy* had been sent to the bottom crowded with cadets much too young to be of any effective use. All but the senior cadets should have continued their studies.

The emptying of the college enabled me to slip off without delay to my mobilization job and on Sunday, 2nd August, I made a bee-line for Limerick to take command of "P" Cable Section of R.E. Signals, although actual Army mobilization did not take place until the outbreak of war on 4th August. A cable section consisted of two horsed cable detachments, each capable of laying ten miles of heavy cable and with two terminal and one intermediate telegraph offices (telephones were not favoured by the Army in those early days).

On arrival at the Sapper barracks at Limerick I found things almost distressingly normal. The Curragh incident was still a burning issue with the army in Ireland and Mr. Asquith's Government was not exactly popular. Opinion among the officers was that the Cabinet would much rather fight Carson's army than the Germans. On 4th August, the normal weekly tennis afternoon was held at the town tennis club—strongly supported as usual by the officers of the garrison and their wives and with the band of the York and Lancaster Regiment in attendance. During the proceedings news arrived that a state of war existed between Britain and Germany as from midnight. The band at once played "God Save The King" and we all returned to our barracks to carry out the duties of the first day of mobilization.

Mobilization proceeded very smoothly and fully justified the Haldane reforms. One of our most important duties was the purchase of suitable civilian horses for the much increased War Establishment. Every officer in a telegraph unit had two chargers and it can be well imagined that a suitable choice was of the first importance. Telegraph units in those days consisted of Cable Sections and Air Line sections, the latter comprising more static material involving slightly more technical routine. The senior Regular Subalterns were all given Air Line sections, though owing to the fluidity of the early operations hardly a mile of air line was laid until the armies reached the Aisne and trench warfare began, many weeks after the fighting had started.

"P" Cable Section was unfortunately the last of the Limerick sections and certain important items were lacking. In particular, I never had a proper shoeing-smith. It was rather typical of the occasional lack of serious thinking in those days that the reservist officer should be given the least adequately provided unit. However, we got along fairly well and in France when a horse cast a shoe it could nearly always be quickly replaced for a franc or two at a village forge.

The Limerick telegraph units were attached to 2nd Corps Headquarters and in due course we found ourselves at Landrecies, a pleasant town with ancient fortifications in northern France. On the way to the front, Corps Headquarters received an unpleasant shock in the sudden death on 18th August of its experienced Commander, Lieut.-General Grierson. Rumour had it that he had been poisoned, but the real fact was that he died of a heart attack in the train while performing a very normal after-breakfast function. Signal units were on the train and got busy at a wayside station and when the train steamed into Amiens a detachment of British troops was awaiting to receive the body. He was replaced by Lieut.-General Sir H. L. Smith-Dorrien, a fine soldier, but one who was not on cordial terms with the C.-in-C., General Sir John French.

At Landrecies the headquarter troops had time to shake down and even to do a little training, so necessary with many reservists in the ranks. Such time was all too short and we were very soon up against the more serious business of war, with the Germans springing many surprises and the French making many mistakes.

22nd August, 1914. In the early hours of the morning "P" Cable section was ordered to proceed to Cavalry Division H.Q. near Bavai to lay a line to 5th Cavalry Brigade, the outpost brigade commanded by Brigadier-General Chetwode. This was stated to be in the neighbourhood of Binche. It involved a long trek and a very early start in the dark. After some hours on the road it was necessary to halt for refreshment of both horse and man, and we fell out in a small village with a monument in it which turned out to be Malplaquet. Meals in these days consisted uniformly of bully-beef and biscuits; indeed it was only when the retreat became an advance and we reached the Aisne that more palatable items such as the Maconochie ration began to arrive.

The cable-laying order had contained the slightly ominous item "adopt military precautions", and with a cable-laying detachment hard at work at its job the only possible interpretation of this was that the subaltern should ride ahead and keep his eyes skinned. The countryside was of the typical Flanders variety with fertile fields, many already harvested, and occasional villages. From time to time patrols of British cavalry were to be seen searching the countryside in a seemingly rather aimless fashion. The detachment laying its cable passed one of these shortly before reaching a village where the inhabitants showed signs of excitement with cries of "Les Boches". Beyond the village was a straight stretch of road and as I reached this I caught sight of lances and spiked helmets some 300 yds. away and realized that they must be Uhlans. I galloped back to the detachment, got them turned round and sent a mounted member with a message to the cavalry who were, I seem to remember, the 20th Hussars. Their reply was immediate as they rode hard and fast into the stubble fields by the side of the road towards the Uhlan picquet. In less than half an hour they returned to the village with three dejected looking Germans, one of whom had had his arm nearly severed with a sabre cut. It must have been one of the earliest brushes with the enemy in the whole war. The villagers howled almost like wolves at the sight of the Germans—stories of the massacre of innocent civilians by the Hun at Dinant and elsewhere were no doubt already reaching all parts of unoccupied Belgium.

From the cavalry we learned that Brigade Headquarters was near at hand and well behind us, as we had laid our cable on into what was for the time being no-man's land. We soon reached Brigade H.Q. with the news that we were in telegraphic contact with Divisional H.Q. Brigade H.Q., whether Cavalry or Infantry, in those early days were of very modest proportions, consisting of the Brigadier-General, his Brigade Major, Staff Captain and Signal Officer—with a few signallers with mainly visual equipment in the case of cavalry. Brigadier-General Chetwode was far from welcoming even a temporary addition to his H.Q., but we necessarily kept in his vicinity as he rode about the countryside. I cannot recall that he ever made use of us at all, though G.H.Q. must have wanted every scrap of information. I heard next day that our own report of the whereabouts of his headquarters had been of value. Commanders in those days evidently did not realize the importance of even negative information.

Towards evening we received orders to reel up and proceed to Maubeuge, which had become Advanced G.H.Q. Maubeuge is a fortress city of the Vauban type with roads entering by a narrow drawbridge approach. The section had just reached the narrow entrance when they were waved aside by red-caps as a whole Division was marching out in full-strength in the direction of Mons. A Division in those days was nearly 20,000 strong, horse, foot and artillery, and it took several hours to pass, so that it was dawn when the tired cable-section staggered into the city and bivouacked in some public gardens.

Later that day, the dull rumble of artillery reverberating from the direction of Mons made it plain that the main armies were in contact. In Maubeuge the citizens, unconscious of the ordeal in store, were proceeding to church in their Sunday best. "P" cable section after a few hours' rest was ordered to lay a line to the Flying Corps H.Q.—the last line that we laid in a forward direction for many a long day.

II

With twenty years' military service between 1919 and 1939 as Commander of the Sapper unit and later 2nd i/c. in the Cambridge University O.T.C., and with civilian experience as a university lecturer on engineering throughout this period, my obvious mobilization appointment in World War II was on the staff of a Sapper Officer Cadet Training Unit, and I joined one of these at Aldershot soon after the outbreak of war. Inasmuch, however, as the technical instruction of young engineers is much the same whether in peace or war I pulled every string at my disposal to get a more operational command. Success crowned these efforts before very long and, with the rather unusual rank of Brevet Lieut.-Colonel R.E., I was given command of the 209th Field Company of the 44th Divisional Engineers (the Home Counties Division) then in training at Bridport. Soon after my arrival the Division had its royal inspection and His Majesty graciously remembered one who had had some slight responsibility for his instruction when he was a naval cadet at Dartmouth some twenty-seven years before. Training in that chilly winter proceeded apace followed by a cross-Channel journey to Cherbourg. The Division, after a long trek through France, came to a halt on the Franco-Belgian frontier in the neighbourhood of Bailleul. It was a district that I knew full well in the fighting of 1914–15 when its towns and villages had wilted away under German shellfire. They were to do the same at much faster tempo under air bombing in a few weeks' time.

A Sapper Field Company in World War II was of about the same strength in men as in World War I. Motor vehicles had replaced the horses and compressors saved the sappers many manual operations. In some respects, however, such as demolition, the means employed were substantially the same. Facilities for bridging were much improved. Our work was mainly the construction and improvement of field defences. The enemy cleverly avoided these by the mechanized thrust of his Panzer formations through the French Army at Sedan so that our labours on the Belgian frontier were all wasted.

When the enemy attacked on 10th May the 44th Division moved rapidly to the River Escaut (Scheldt), the main Sapper responsibility being the mining and ultimate demolition of the fine bridges over that river in and around Oudenarde—another of Marlborough's battlefields. During this short but busy period 209th Field Company was mainly under the direct command of its affiliated infantry brigade commanded by Brigadier J. S. Steele (now General Sir James S. Steele, G.C.B., K.B.E., D.S.O., M.C.). This led to the individual platoons being attached to infantry battalions—a wasteful use of Sapper personnel, but one which enabled one of my platoons to distinguish itself in infantry combat—here as ever an essential feature of Royal Engineers activity.

As the days passed by, conditions steadily deteriorated and in particular the return from Belgium back to France was depressing though morale was still high. On 27th May the platoons were returned to company headquarters and that afternoon the Commander of a French Cavalry Corps informed Brigadier Steele that next morning his Corps was to bring off a brilliant counter-attack—a promise that Brigadier Steele accepted at its true valuation! In war even when affairs are so serious the lighter side of life is still evident and that evening I attended a cheery little party at one of the battalion headquarters to celebrate the award of a D.S.O. to its C.O. (Colonel A. A. E. Merlott-Chitty, D.S.O., C.B.E.). Rations were already short, but a sucking pig from a near-by farm formed the *pièce de résistance* and it was a thoroughly enjoyable function. In spite of unhappy rumours I returned to my headquarters in a comfortable farm to what I hoped would be a quiet night.

28th May, 1940. The quiet night was not to be, as I was awoken by the duty officer in the very early hours with orders to proceed to Divisional Headquarters at once to receive urgent instructions from the C.R.E. (now Brigadier B. T. Godfrey-Faussett, C.B., D.S.O., O.B.E., M.C.). It was reported that the roads were likely to be blocked with traffic and I decided to go on the back of the motor cycle of one of the dispatch riders who knew the way. He was told to get a move on, but not to indulge in a head-on collision with an ambulance coming the other way, which is what actually happened. His leg was broken in two places and other injuries were received (he returned from a German prison camp after the war). I was pitched head-first into a shallow pond, getting off with minor damage to a knee and a head injury that turned out to be a mild concussion. The ambulance took the motor-cyclist as a patient and I got a lift to Divisional Headquarters in a passing truck, though feeling far from well.

The orders were rather startling—that the Company was to abandon its transport forthwith and to proceed to Mont des Cats to take part in a divisional rearguard. Mont des Cats is a hill in Flanders, its summit crowned with a Trappist Monastery, and is well known to most old soldiers of World War I and many of World War II. Here the divisional engineers, with assistance from one or two Army engineer units, were to hold the hill as a rearguard while the rest of the division, tired out from heavy fighting, proceeded towards Dunkirk.

A truck was provided for my return to my unit and after a unit conference it was decided that we should abandon and immobilize most of our transport, retaining just enough to get the men to the Mont des Cats at the appointed time.

With all the men squeezed into a minimum of transport we moved off from our comfortable farm at about 0600 hrs., arriving at the Mont des Cats about two hours later. The only casualties at the farm were caused by the bombing of the pigsties, and the place was much as we left it nearly five years later when Pannett, my 2nd i/c., visited it in the closing months of the war.

We were one of the first of the rearguard units to arrive at the rendezvous and here a conference was arranged between the various unit commanders and the C.R.E. and each unit was given a sector with orders to dig in—orders that were obeyed all the more readily as German aircraft were already using dive-bombing tactics, at which the men had the satisfaction of seeing one plane shot down.

After the conference the C.R.E. ordered me to report to the Divisional R.E. medical officer, which I readily did with an excruciating headache. The M.O. piled me into an ambulance already fairly full and as we moved off to Dunkirk more casualties were taken on and it was a very full house. From a window in the ambulance one could see that things were in a bad way. At times pathetic efforts were made by civilians in the bombed villages *en route* to persuade the M.O. to accept casualties including small children, but these of course had to be refused. Belgian troops on the road—many devoid of all leadership—added to the chaos.

Dunkirk was a depressing sight covered with a pall of smoke from burning oil tanks and the ambulance was directed to various parts of the city before finding its way to the jetty. Some German planes were overhead, but powerful French A.A. guns were pumping lead into the air in an effective manner. Our M.O. (Captain Stevens, R.A.M.C.) promptly unloaded his ambulance on the quayside and went back at top speed to Mont des Cats for more casualties. A well-earned M.C. was awarded him for his services.

Near the jetty a long line of British troops were waiting in an orderly manner and in the late afternoon a destroyer came alongside. I had been given charge of the wounded in the ambulance, and with the help of others of the walking wounded we got the more serious casualties on stretchers aboard and then followed ourselves. Night had fallen when the destroyer moved off with her crowded human cargo. It was a fine night with fires raging near the coast in Boulogne and other French towns to the south. The sailors were magnificent and soon cups of tea were being passed round to all and sundry. In return we made a collection of our French and Belgian currency as some reparation for the mess we had made of a spotlessly-clean ship.

The run to Dover was quite uneventful and here the railway service—still in private hands—put up a wonderful show. Trains were available almost as though a large excursion had been planned and at occasional stations on the route we stopped and were given refreshment by hastily arranged local civilian organizations. No one knew where the trains were going, but after a seemingly endless journey the train I was in fetched up at Wool in Dorset—we detrained at the station and transport was available to take the wounded to the Armoured Corps Headquarters at Bovington Camp. By degrees a considerable number of evacuated troops including many Frenchmen arrived at this military station.

After a few days I was passed fit by the doctors and rejoined my unit at Oxford, receiving a particularly warm welcome from the allied College to St. Catharine's College, Cambridge, Worcester College, Oxford, accommodation in those lovely precincts being a great improvement on a crowded tent on Port Meadow. About fifty of the original unit failed to return, some being casualties and others prisoners. The rest were in good heart and we soon moved near the coast on anti-invasion duties.

One of the biggest advantages of the British soldier in time of war is his lack of imagination. Neither in the Mons retreat nor in the Dunkirk evacuation had my Sappers any idea that the British Army had suffered a major setback. After Dunkirk in particular there was no lack of optimism. It was taken for granted that the British would win in the end and the prevailing feeling was one of thankfulness that the next match with Hitler's hordes was likely to be on the home ground.

The Company put up a fine performance throughout the war, including Alamein and the invasion of France. Not long before the war was over they were in action not far from the farm at which we received our evacuation orders on 28th May, 1940, and Pannett, my former 2nd i/c. and later in command of the unit, visited it as previously stated. The unit is still in active being as a Field Park Squadron of the 44th Divisional Engineers at its peace-time station at Brighton.

PRESENTATION TO 26 FIELD ENGINEER REGIMENT BY THE ROYAL DANISH ENGINEERS IN GERMANY

DURING one of the coldest winters in living memory, in January and early February 1956, a Field Company of the Royal Danish Engineers lived under canvas at Hameln and carried out bridging training. They earned the admiration of 25 Field Engineer Regiment by refusing to abandon their spartan existence for the steam-heated comfort of Gordon Barracks.

Every evening, however, they came up to our lines to thaw out and their officers were made honorary members of our mess, where they soon made many friends.

Towards the end of their stay, Major P. I. Sorensen, the Company Commander, asked our C.R.E., Lieut.-Colonel R. H. Walker, R.E., and several of the officers of the Regiment to a memorable party conducted in true Danish style. At this party, Major Sorensen presented the Regiment with the magnificent flint axe which is illustrated opposite.

The axe was made in the late Neolithic period between 3000 and 1800 B.C. It is beautifully proportioned, fashioned with great skill and has a smooth, polished finish which could only have been achieved after much painstaking effort. The cutting edge is slightly chipped, indicating that the axe was a finished product and that it had been used. It may, perhaps, have been wielded by a pioneering farmer when the forests were first cleared to bring the land under the plough.

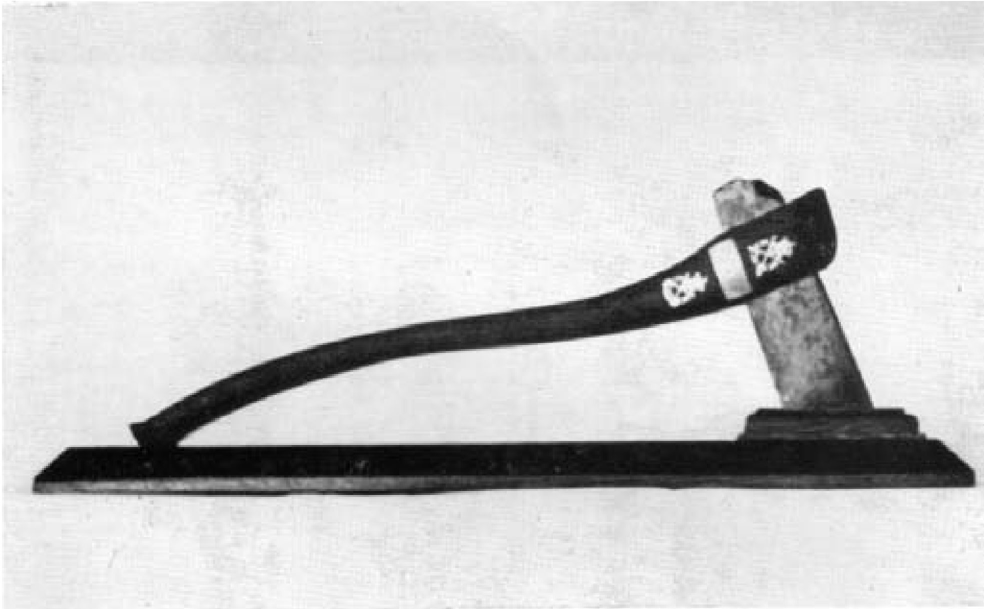
Together with other domestic remains, the axe was found in 1940 on the site of a Neolithic dwelling at Aalborg in northern Jutland. It is thought, however, that it originally came from another district. Dark markings on the flint show that it must, at some period, have been submerged for several centuries.

The handle of the axe has been copied from a specimen which was found in a Danish peat bog and is now in the National Museum at Copenhagen. It is made of oak and has been stained to resemble the original. The flint axe head is fitted into a slot in the handle and would originally also have been secured by leather thongs.

The handle is embellished with the badges of the two existing Danish engineer regiments, the Sjaellandske (Zeeland) Ingeniørregiment and the Jydske (Jutland) Ingeniørregiment.

Both badges consist of a ring (a template for making gabions), a crossed spade and rifle and the Crown and Cipher of King Christian V (1760–99), during whose reign the Danish Engineers were formed.

We feel that not only this Regiment, but also the Corps as a whole has been greatly honoured by this fine gift which we will cherish as a token of a very real friendship.



Presentation To 26 Field Engineer Regiment

Fort Chabai. The airstrip is about 300 yards long overall.

Muar River Bridge after completion.

Field Engineering With Gurkha Sappers In Malaya

FIELD ENGINEERING WITH GURKHA SAPPERS IN MALAYA

By LIEUT.-COLONEL J. H. CARVER, R.E.

INTRODUCTION

THE aim of this article is two-fold; firstly to give a brief picture of the development of Gurkha Sappers and secondly to recount some experiences of recent Field Engineering activities in Malaya. The latter covers work done by the Gurkha and British Sappers, but it should be realized that the Malayan Sappers have also done a great deal of excellent work.

HISTORY OF THE GURKHA SAPPERS

In June, 1950, an article describing the formation of Gurkha Sappers appeared in the *R.E. Journal*, but much water has flowed under the bridge since then, and at the risk of some duplication, it is thought appropriate to give here a brief but comprehensive story.

When, on the partition of India, part of the Gurkha Brigade of the old Indian Army was transferred to the British Army, it was decided to form units of Sappers, Signals and Provost.

A Gurkha Field Squadron R.E., the first Gurkha Sapper unit, was raised at Kluang in 1948 from volunteers from the Infantry and from re-enlistments (i.e., soldiers with previous infantry service). No doubt there were very good reasons for this method of raising, but it had serious disadvantages. Firstly the Queen's Gurkha Officers and N.C.Os. had no more knowledge of Field Engineering than the men and this has made training difficult for many years. Secondly, as a formed body of skilled infantry, they were continually being called on to interrupt their engineer training and help with the jungle war. In consequence, very little engineer training was possible initially, though the situation gradually improved. In 1949 a second Field Squadron was raised and in 1951 a Regimental Commander and Adjutant were posted and the two squadrons, which had previously been independent, were brought into the same camp and under one command. A Field Engineer Regiment was officially established the next year, the third Field Squadron and the Field Park being Malayan—these did not, however, join the regiment.

In 1953, the squadrons were at last given the opportunity to get down to almost uninterrupted Engineer training, which continued until autumn 1954 when the regiment assumed their correct rôle as the Div. Engr. Regt. of 17 Gurkha Division. In the meantime, the Malayan element had been constituted into the basis of a Divisional

Engineers for the Federation Division and thus "severed" from the regiment. The balance of engineers for 17 Gurkha Division were made up of an Indep. Fd. Sqn., R.E. and an Indep. Plant. Troop, R.E. (both British)—a somewhat unusual command.

The Gurkha Engineers are now a part of the Gurkha Brigade and not of the Corps of Royal Engineers and they conform to Brigade customs in dress and in many other ways. They do rifle drill, march past at 140 paces to the minute, and have pipes and drums. At the same time they retain many R.E. characteristics and insignia.

The units forming the Gurkha Engineers Regiment are commanded and officered by officers of the Royal Engineers on normal postings and there are also a number of Warrant Officers and N.C.Os. similarly posted. These Officers, W.Os. and N.C.Os. are in addition to the Gurkha Officers, W.Os. and N.C.Os.

As regards precedence, detachments of Gurkha Engineers parading with other detachments of the Brigade as part of the Brigade of Gurkhas take precedence after the 10th Gurkha Rifles, as being more recently raised. When parading with other arms, units of Gurkha Engineers take the normal precedence of the engineer arm next to the artillery.

Characteristics

Everyone knows something about Gurkhas, but the knowledge is sometimes rather hazy and inaccurate and it may be worthwhile to give some details of these remarkable and unique people. Nepal can be divided lengthways into three zones. The "plains", a strip contiguous to India and similar in character: the "terai", a parallel strip of jungle and foothills: and the "hills" which comprise the bulk of the country and are the portion that really concerns us. In the centre lies the "valley" which the Gurkhas call "Nepal". The "valley" is not very large, about thirty miles long, but it is about the only considerable area of fertile land in the "hills". In it lies Katmandu, the capital. The valley is now gradually being opened up to the world and Indian influence is strong: the people of the valley are not enlisted in the British Army. The "hills" proper comprise the remainder of the country. Here nature makes one of her last stands against the inroads of civilization. A series of deep, steep-sided valleys, with passes over 10,000 ft. high connecting them, makes up the terrain and movement is on foot only, with a certain limited use of pack animals. It will be many years before these remote districts can be opened up by even jeep-track or airfield. In the meantime, a child can grow to manhood without seeing even anything so modern as a horse and cart. There is an old story of an aeroplane landing in the country of some remote central Asian tribe; the natives were not so awed by the flying machine—they had seen birds—but they were fascinated by its wheels—here was something entirely new. In a similar manner Gurkhas joining the British Army move into a new world for them, in which the latest jet fighter is no more surprising than their first sight of the sea; radar and wireless are possibly less mysterious than a railway train.

The term Gurkha is a corruption of, or comes from a similar root to, the Indian "Gaekwar" and there are in Nepal many descendants of the old Rajput conquerors who made Hinduism the official religion and suppressed Buddhism. But the peasant class come almost entirely from the original Mongolian inhabitants and the result is the sturdy warrior of the hills. Nepali (Gurkhali), akin to Hindustani, is the official language and Hinduism the official religion, but Buddhist influence is still strong and many tribal dialects are similar to Tibetan.

Nepal is fundamentally a poor country and a major factor in the economy of the country is the money brought in by pensioners and "leavemen" from the British and Indian Armies. Tradition in the recruiting areas is strong and many fine men, including often the village headmen, are old soldiers. Small wonder that the young men are easily moved by tales of a new and fabulous world and there is no lack of recruits for the Army. Old soldiers with their pensions are usually also among the richest members of the community; something of a contrast to the situation in England.

The Gurkha as a Sapper

The main characteristics of these fine men as infantry soldiers are well known. The query as to whether or not they can make Sappers is often raised. Here are some brief comments on their abilities and limitations. Firstly the popular idea that all Gurkhas are boneheaded must be debunked. The stolid, dull look, which sometimes gives rise to this impression, is normally due to a failure to understand his interlocutor's meaning, whether because of insufficient knowledge of English or because of the extremely bad Gurkhali in which he is being addressed. The Gurkha is comparatively slow to learn because of his background and lack of previous education, but he is capable of absorbing at least as much knowledge as the average countryman anywhere in the world. Several Gurkhas brought to Malaya comparatively young and educated there are considered up to absorbing the instruction of the R.M.A. Sandhurst. These are unlikely to shine at Sandhurst academically, but when the extremely broken nature of their education is taken into account—few of them started regular education using English as a medium until they were 11 or 12 and subsequently continuity was broken by long leave in Nepal—it is likely they will be found to be well up to the standard of other Oriental peoples in intelligence. Few Gurkhas have the ability to become really first-class tradesmen; on the other hand, they all make up for many deficiencies by their enthusiasm, desire to learn and application. Many "flash" individuals of other nationalities are much quicker on the uptake but they lose interest and are often unreliable. The Gurkha plods on night and day until he has mastered his subject. A certain amount of knowledge he inevitably acquires parrot-wise, but he is inquisitive and he is not really happy unless he is sure that he himself understands what he is doing (sometimes of course he gets hold of the wrong end of the stick). He is inclined to be hamfisted and over-conscientious—for instance, instructions to tighten bolts on a vehicle tend to lead to stripped threads (or used to in the early days). He can carry immense loads on his back but is comparatively weak when lifting in front of him—this has repercussions on bridging but can, I believe, be overcome by correct P.T. He is not a natural waterman but he learns surprisingly fast both as a swimmer and in boats.

One of the great things about a Gurkha that endears him to the heart of any good instructor is his terrific wish to learn—he is not easy to teach, great patience is required, but he repays eventually any effort put into him in very full measure. He is a tireless worker and he does not lack initiative.

To sum up, the Gurkha is some way off being the perfect field engineer and tradesman as yet, but given time he will make it and he is in many ways the ideal raw material. Top-rate tradesmen will be few, but otherwise in ten years' time or so there appears no reason why a Gurkha Field Squadron should not be the most efficient Field Engineer unit we have—and many reasons why it should be.

Fieldworks in Malaya

Under the peculiar "aid to the civil power" background of operations, various factors were originally held to indicate that there was no place for the Field Engineer in Malaya. For one thing, there was no financial cover for work in direct support of operations and such requirements for roads and airfields as were essential were dealt with by the P.W.D. However, it is now realized what a vast field there is for engineering activity and that this can contribute possibly more than anything else to the ultimate control of the emergency. The whole problem of Malaya is of course based on the enormous difficulties of movement and the opportunities for concealment offered by the terrain. It is fairly obvious that the multiplication of roads and airfields must lead in general to the ability to control with less forces.

Helicopter L.Zs.

Owing to lack of numbers the helicopter has in the past been used mainly for the evacuation of casualties, movement of V.I.P.s and so on. As numbers increase, however, opportunities arise to use helicopters more directly to help to give security forces an advantage in jungle mobility over their adversaries, and it is considered in some quarters that systems of helicopter L.Zs. could be developed in likely areas to this end. Aggressive bandit incidents must take place in populated areas, on roads or in the jungle fringes. It is suggested that L.Zs. should cover the get-away routes in the jungle from such danger areas and that this would greatly facilitate the likelihood of contacts in the follow up. This is a complicated question and it is not within the scope of this paper to argue the pros and cons; there is no doubt, however, that there is a brisk demand for helicopter L.Zs.

Generally the preparation and construction of L.Zs. is no great engineering problem and is well within the capabilities of infantry. However, in certain cases sapper advice and participation are desirable. In primary jungle, clearance will probably include one or two "jungle giants"—trees 100 ft. or more in height and 3 ft. or so in diameter. Air effort to drop stores to parties engaged on such work is often undesirable or unjustified and therefore equipment and stores required have to be carried. The optimum organization for this work has not yet been reached, but in general a section of sappers and a platoon of infantry can complete a L.Z. in two days, including carrying out their own protection. In loading the party, the rival claims of explosives against cutting-tools, food etc., have to be carefully worked out. In general a combination of explosive and hand-cutting tools seems to produce the most economic answer—explosive being used for the larger trees and for clearing stumps from the actual landing platform.

In an early operation, two parties each of an infantry platoon with a section of Gurkha Sappers (including British Officer) built L.Zs. in a swamp area. The trunks of felled trees were used as a foundation on which a rough round timber and brushwood platform was built. These L.Zs. took about three days each to construct, working conditions being, of course, very unfavourable.

Landing Strips for Light Aircraft

The helicopter is an exceedingly expensive aircraft not only to build but also to run and maintain. Wherever therefore there is a requirement for anything like routine air communications, there is great pressure to replace the helicopter by the much cheaper aeroplane. Attempts are now being made to control the deep jungle and influence to our cause the aboriginal inhabitants by means of a series of "jungle forts", which can only be maintained by air, and the construction of landing strips at jungle forts is a priority requirement. The light aircraft which appears most suitable for this purpose is the Pioneer, which is a first-class machine and has a remarkably short landing/take-off requirement and a steep angle of approach. The minimum standard length of runway is 200 yds., but 150 yds. is acceptable under good conditions at sea level.

Constructing these air strips at jungle forts has been an interesting job—if not one of great technical difficulty. The main unusual factor has been that all equipment and stores have to be air-dropped or taken in by helicopter. Both Ferguson and Fordson agricultural tractors have been used with success—both being transportable by helicopter when dismantled. The dropping of these machines was not considered practical from the type of aircraft available in Malaya.

The R.E. detachment for each airstrip was small (eight to twelve), being responsible for plant and control of the work only. The bulk of the manual labour was provided by the locals, often aborigines. The latter cannot be claimed to be enthusiastic workers, but the job gets done in time. A very simple economic system governs the remuneration of these labourers who have no need for money in the ordinary course of their lives. A trading post is established in the fort and the local inhabitants arrive to inspect the knives, parangs and other useful articles displayed. When a man decides what he wants, he proceeds to work for exactly the number of days necessary to earn the required amount to make his purchase; he then stops, gets his money, takes it to the trading post and then goes off into the jungle with his prize. Numbers at work therefore fluctuate continuously.

Airstrips are surfaced with grass, as this has been found to be the most satisfactory system. Air supply circles were somewhat surprised initially on being asked to produce grass seedlings—bags of these were, however, supplied and dropped satisfactorily. The latter stages of airstrip construction are predominantly agricultural, disc harrowing, planting and watering.

The main problems that arise when a field squadron undertakes a number of airstrips of this type are administrative and morale ones. Air supply methods are first class in Malaya, but even so the additional load placed on the squadron 2IC by the complications of supplying (for instance) N.A.A.F.I. stock to a number of small detachments by air and collecting payment later is enormous. A first-class British squadron undertook these tasks last year, but they were severely stretched.

The problem of morale is an interesting one. There is no better task for a young officer than being on his own, right out in the blue, with a party and a clear-cut job of work to be done. But it is not easy, particularly where the party consists of an officer, a corporal and eight or ten men. Over-familiarity is a strong temptation, for instance. It is a risk to put an inexperienced officer in charge of such a job. But it is a risk that a commander must take and one usually well justified by the enormous amount learnt and progress made by the officer concerned. In fact, however, it is a risk that is all too rarely undertaken.

Roads and Bridges

There are three factors that particularly influence the pattern of road building in Malaya; these are:—

(*a*) Jungle clearance.
(*b*) Omnipresence of jungle timber.
(*c*) The ready availability of laterite.

Jungle Clearance

The main features of primary jungle vary little throughout Malaya. The layer of organic soil is thin, seldom exceeding 1 ft. 6 in. and often much less; undergrowth is not dense, but there is enough to limit visibility and rate of movement. The majority of trees are 1 ft. to 18 in. in diameter and rise, with few lower branches and good straight trunks, to the canopy at about 60 ft. where the bushy tops effectively shut out the daylight. Piercing the canopy at varying intervals are taller trees, the "jungle giants", which may rise to 120 ft. and be up to 3 ft. in diameter, with large strong buttress roots. The number of different species of tree is enormous, something of the order of 250 different varieties in the same area being not uncommon. Clearance by bulldozer is the standard method, though some initial clearance of undergrowth by hand is often advocated to enable the tractor driver to see what he is doing. A skilled operator can, however, normally manage reasonably well without such pre-clearance, guided only by a narrow survey trace. The heavier the tractor, the better for this job. The P.W.D. had TD24s which were most suitable. For the Army, however, plant was by no means unlimited and its age, coupled with the extremely rough nature of jungle clearance work, made casualties inevitable; a 50 per cent off the road figure was regarded as good. Thus smaller machines like TD14s had often to be used and did in fact stand up to the job, though really too light.

Large trees were left for felling with explosive, which is quick and efficient; the P.W.D., however, fell even the "jungle giants" with their heavy tractors, first digging out and cutting the buttresses and then ramping up to get a good leverage.

Jungle Timber

The availability of limitless round timber on site is in many ways the Field Engineer's dream. Owing to the presence of laterite, corduroy road construction is not often required, but timber crib causeways over swamps, timber culverts and timber bridges of all types abound. For temporary work over gaps up to 20 ft., the P.W.D. advocate the world's simplest bridge pattern—round timber road bearers side by side, anchored to prevent splaying and earth dozed on top. This is simpler, quicker and less bother all round than building a culvert. Such bridges were found to be good and were up to Class 40.

Laterite

Laterite is a mixture of red clay, gravel and some decomposing rock. All over the country are deposits of this mixture, so well graded that it can be put straight on a compacted earth formation to act as a surfacing and to some extent as a metal foundation. Three or 4 in.

are enough to give an all-weather road, provided traffic is not too heavy, and the road is well cambered. Laterite has very good waterproof properties and will thus keep dry an earth formation, even under tropical rain.

Bridging

The experience on which the notes above were based has been mainly gained on a road from Rompin to Gemas on the Johore-Negri Sembilan border which was constructed by the Gurkha Engineers last year. This road crossed two major rivers on which full semi-permanent P.W.D. specification pile bridges were required; these were 300 and 150 ft. long respectively. They were constructed of square timber, brought to site by P.W.D. contractors.

The experience gained in heavy piling by all concerned was enormous and emphasized the value of the R.B.19 for this type of job. Both jobs, particularly the 300-ft. bridge over the Muar River, were far from straightforward, one of the main complications being that deck level was some 30 ft. above normal water level and some 20 ft. above ground level on the home bank.

It is hoped to publish an article on this bridge in the next issue of the *R.E. Journal*.

On these bridges, of which all the superstructure was also timber, the Gurkha Engineers had no lack of experience in woodwork with compressor and hand tools. The majority of the piles had to be cut to shape and lap jointed in the centre. This was a tricky job demanding considerable accuracy and not aided by a tendency to warping in the piles. Some of these joints had to be made *in situ*, and the drilling of the timbers in a confined space to take steel fishplates was by no means easy. A trellis-work of bamboo scaffolding was essential to provide working platforms and the Gurkhas were adept at making such scaffolding. But the whole road-making and bridging job was a wonderful school for the acquisition of that instinct for what is practical which the Sapper officer is inclined (wrongly) to call common sense. Vehicles had to be kept moving during the construction over completed, semi-completed, and merely cleared portions of the road in every type of tropical weather. Squadrons were concentrated to some extent on the bridges but, apart from this, were distributed over several miles of road, quite apart from protective patrols. There was every scope for initiative on the part of the junior leader and the opportunity to learn; the Gurkhas were not slow to profit from these experiences.

Conclusion

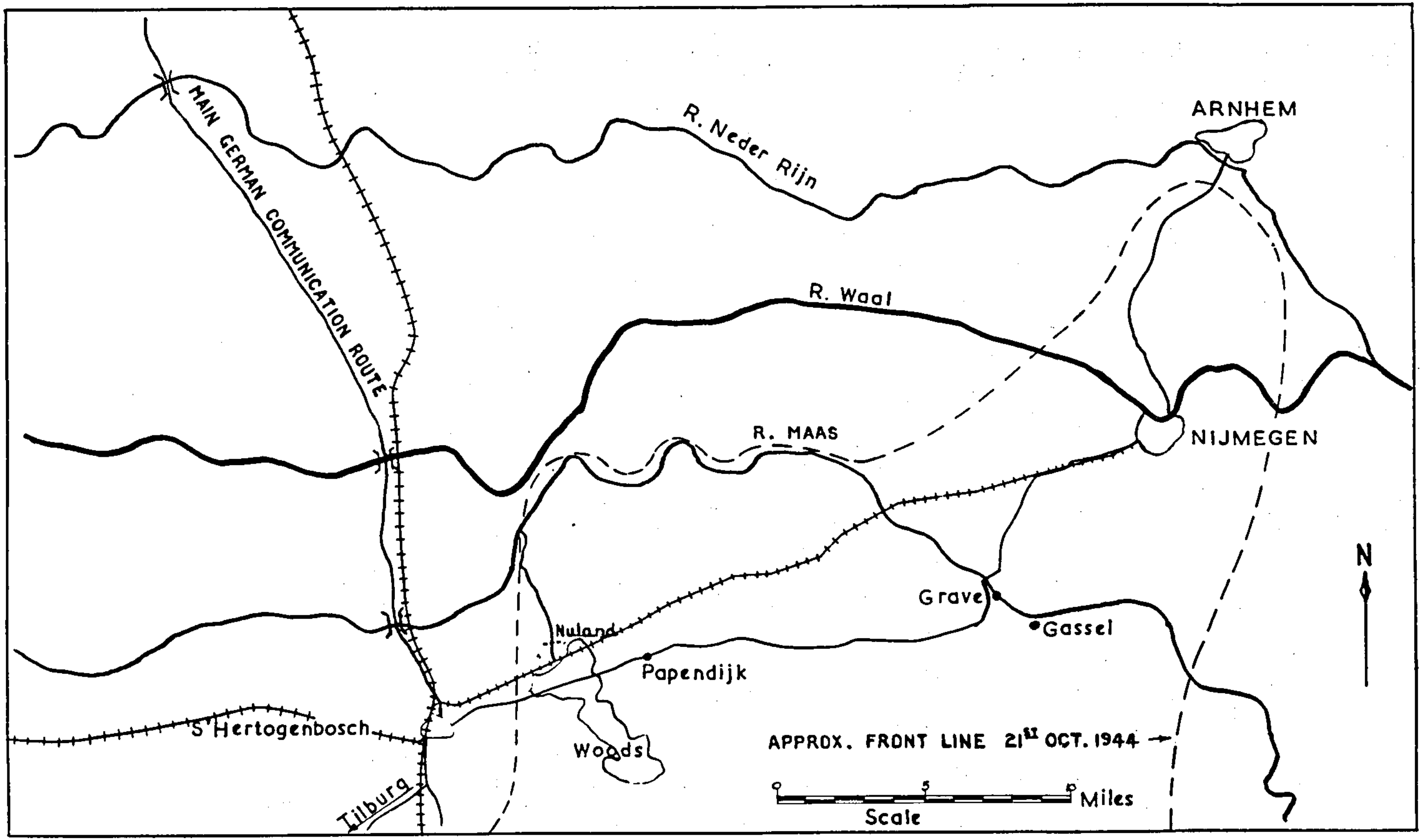
This article has necessarily been a brief and somewhat sketchy survey of Gurkha Engineers and their activities. In considering the Gurkha Engineers it is usual to connect them with the old Indian Army and the three Corps of Sappers and Miners, and indeed they are the natural heirs of Sapper and Miner tradition, though of course at present in a small way. Perhaps the most unique feature of the Indian Army system was the importance and status of the Viceroy's commissioned officer, and that tradition and status are carried on by our Queen's Gurkha officers. These magnificent and experienced soldiers, rightly handled, form the pivot on which the discipline and efficiency of the unit rests.

It would be very inappropriate to conclude this article without reference to the help given to Gurkha Sappers by the rest of the Brigade of Gurkhas. It is only recently that the Sappers have officially become part of the Brigade, but from the very first we were dependent on the Brigade and battalions for advice and assistance in innumerable matters: these have always been unstintingly given. The officers of the Brigade form a closely-knit and happy family, of very high quality. R.E. officers with the Gurkha sappers consider it an honour to be fully accepted into this community. It was a happy event when the friendship between the Corps and the Brigade was expressed by the presentation to the Brigade described in the March 1955 issue of the *R.E. Journal.*

Much more could be said of the charm and steadiness of these fine natural soldiers and their potentialities as Sappers; for instance their care of detail, patience and complete lack of imagination make them probably the best mine clearers in the world. The Corps has welcomed this first experiment in Gurkha Engineers (and it is still some ten years more—i.e., when the first men whose full service has been in the Sappers become Q.G.Os.—before the complete value of these troops can be appreciated) and it is certain that the Corps will never regret any encouragement it may give to their development and expansion.

As a conclusion, the following celebrated quotation of Professor Turner's sums up the feelings of those who know the Gurkhas well.

"As I write these last words, my thoughts return to you who were my comrades, the stubborn and indomitable peasants of Nepal. Once more I hear the laughter with which you greeted every hardship. Once more I see you in your bivouacs or about your fires, on forced march or in the trenches, now shivering with wet and cold, now scorched by a pitiless and burning sun. Uncomplaining you endure hunger, thirst and wounds: and at the last your unwavering lines disappear into the smoke and wrath of battle. Bravest of the brave, most generous of the generous, never had a country more faithful friends than you."



Sketch 1.—General sketch of area.

244th FIELD COMPANY, R.E., AT S'HERTOGENBOSCH—1944

By Lieut.-Colonel J. E. L. Carter, M.B.E., M.C., R.E.

LIFE was really not too unpleasant on the Island—the popular name for the low-lying area between the two branches of the Rhine which flow through Arnhem and Nijmegen respectively. The battle for Arnhem had been fought and lost a month before, and our Division, the 53rd (Welsh), having taken a part on the left flank, had now been brought in to relieve the 43rd (Wessex) Division which had been heavily engaged in attempts to succour the airborne troops.

Order of Battle—244th Field Coy., R.E., 21st Oct., 1944

O.C.	Major J. E. L. Carter	
2 i/c	Capt. J. R. de G. Pilkington	(John P.)
RO	Lieut. B. C. Elgood	(Bruno)
RO	Lieut. M. R. Plummer	(Mark)
1 Pl.	Lieut. R. Stallworthy	(Roy)
2 Pl.	Lieut. J. T. Cosgrove	(John C.)
3 Pl.	Lieut. R. Brown	(Dick)

We worked mostly on roads, and ate apples and played bridge in our loft in the evening.

On the 15th October we were told we would definitely be on the Island for two months, on the 16th we had a concert in one of the barns, a most successful improvised show given on a stage built of fruit boxes and attended by the local Dutch family. On the 18th we received urgent and immediate warning orders to move.

A big and most secret operation was in the air, and we were to play a leading part in it. What was it to be?

When our movement orders came they directed us to an area a few miles east of Grave. Bruno and the C.S.M. went off first, I followed a little later, and the Company moved at the unearthly hour of 1.30 a.m. We found ourselves billets in a school and a number of farms in and around the peaceful village of Gassel. There was no sign of fighting and we could hardly even hear the sound of the guns. We took our furniture with us from the Island and made ourselves comfortable enough.

On the 20th we were told that we were to take part in the big battle for the opening of Antwerp and the driving out of the enemy from all Holland south of the Meuse. The Canadians were to fight around the Scheldt and Walcheren, other formations to take Turnhout and Tilburg, and we were to capture S'Hertogenbosch, some ten miles west of Grave (see Sketch 1).

S'Hertogenbosch was a town of the greatest importance to both sides. To the Germans because one of their main supply routes from Germany and Northern Holland came through the town and then radiated out to Tilburg and all the front facing south-east, while to us the town was an essential link in the vital routes from Antwerp to Nijmegen, which at the time had to be diverted through Eindhoven. From the tactical point of view S'Hertogenbosch was the northern pivot of the German line facing the left flank of our salient.

The front line which ran roughly north-east and south-west between S'Hertogenbosch and Grave was on our side a somewhat nebulous affair. It had been established almost accidentally a month previously by the armoured reconnaissance troops of the main forces thrusting towards Arnhem, and had been held very lightly since then by us. The Germans on the other hand had brought up the best part of a division for the defence of S'Hertogenbosch and had established a well dug-in line with its forward posts on the eastern edges of the wood around Nuland.

They were known to have laid mines in some quantity, and on the whole were pretty well placed. We had a few armoured cars and tanks in the woods around Papendijk. The front was quiet; not a shot was fired normally in a whole day.

The country as a whole was flat, tree-sprinkled heathland with here and there patches of thick coniferous woods. From Nuland to S'Hertogenbosch there were two main lines of approach, the road and the railway; also a number of sandy tracks of doubtful quality.

On the 21st, quite unknown to the enemy, the situation opposite him changed completely. The woods and heathland, instead of holding just a few tanks and armoured cars, were suddenly packed with a formidable concentration of infantry, tanks, artillery, engineers, armoured assault vehicles, flame throwers, armoured troop carriers, and armoured bridgelayers; and in the country behind, the far-flung administrative services, with their hundred and one dumps and their channels of supply, intercommunication and evacuation, turned their attention to the west.

At about two o'clock on the 21st we arrived in our concentration area, a pleasant piece of dry sandy heath far enough away from the main road to be out of the way of any harassing fire the enemy might lay down. It was a sunny afternoon when we pitched our tents and bivouacs. Bruno, Mark and I and the rest of my tactical headquarters joined brigade headquarters, while the company bivouacked about a quarter of a mile away. All around there was a buzz of activity; signallers running out wires, commanders going to last-minute conferences, men pitching tents and digging shell slits, cooks cooking, drivers camouflaging their trucks, more and more troops streaming into the area, and gunners setting up their guns and working out their programmes.

C.R.E. had been wounded by shell-fire while standing watching an A.V.R.E. laying a bridge at *E*. The senior company commander was on leave at the time, and I had to take over command until he returned. This did not involve doing much about the present battle, as it was practically over, but gave me a few hours of furious thinking and arguing about the engineer aspects of some proposed fighting in the most unpleasant, flat, open, marshy country just west of the town. I had an excellent dinner with the General and other commanders in Div. H.Q., but was happy to get back to the company the next day, when I was relieved by the senior company commander hastily recalled from Brussels.

This was the 27th. We were all tired and were looking forward to a real night's rest. The gunners who had been firing from the fields close to us moved away, and even Div. H.Q. came into the area during the afternoon.

There we were, all nice and comfortable, my Tac H.Q. and Dick's platoon on one side of the road, Company H.Q. and the other two platoons about a quarter of a mile away, next to Div. H.Q. on the far side of the road.

It was evening, a bit cold but pleasant enough, and anyway for us at least the battle was over; Bruno, Dick, Mark and I were talking comfortably in my tent; the batmen, drivers and others were comfortable in theirs.

There was a faint thud in the far north, then another, then another; suddenly we were all conscious of a whistle, two whistles, three whistles, low at first but rising in intensity. Over went the lamp, chairs and telephone, and four officers hit the floor of the tent simultaneously with three majestic, crumping crashes in the next field.

This was big stuff, coming from an immense distance away, but landing a microscopic distance from our inoffensive caravanserai. Even as we shook ourselves we heard the thud of the guns again; in one dive we disappeared into our shell slit; dug by force of habit rather than a belief in its necessity. This was beyond a joke. It went on all the evening, but after the first few salvos we began to realize that the bursts were in fact a safe though short distance away.

In one of our rushes, as there was no room for him anywhere else, Dick ended up lying more or less on top of the heads of the rest of us, who were crouching in the bottom of the shell slit. We remonstrated with him for making us so uncomfortable. His reply brought fits of laughter.

"Talk of discomfort! It's all right for you, you've got six inches of human headcover above you to keep the bits out. What about me?"

After this we passed a comparatively uneventful night in my tactical headquarters; not so, however, Company H.Q. farther up the road. They had rolled up comfortably during the afternoon, and, secure in the knowledge that they were miles behind the line and next to Div. H.Q., had done little about digging in. Neither they, nor for that matter Div. H.Q., appreciated that their pleasant camping ground had been the main gun area for the last phase of the attack on the town.

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The Division's orders were to leave no enemy south of the Maas, so even as the battle for the town was finishing plans were being considered for capturing the high ground west of the town, high only in that it stood a few feet above the surrounding marshy meadows. The prospect was uninviting. There were only two possible approaches, one along the direct road from the town, horribly open to view and to fire from the objective, and also to artillery fire from north of

We were soon on the main telephone system and in wireless touch with the C.R.E., our own platoons and the armoured R.E., who were to work with us.

The plan was simple; one brigade was to attack on the right using the railway as an axis, one on the left using the road, the third was to go through later and take the town itself. We were in support of our usual brigade, the 71st, which was the left-hand one. We had two tasks; to help it to its objectives, which meant breaching the main defence line, and to clear the main road as far as we could.

The attack started at 6.30 on the morning of the 22nd, when the infantry crossed their start lines, and under cover of heavy artillery moved along the sandy tracks and hedgerows toward the woods held by the enemy. Roy and his platoon were with a battalion on the left of the main road, and Dick with another on the right. Everything went very well indeed. The enemy, caught completely off his guard, put up a poor fight. His communications broke down, and the first objectives in the forward defence line were soon taken. However, as the vehicles supporting the leading infantry moved forward, we started to meet trouble from mines. Dick saved one column from running on to a minefield by spotting some twigs and wire which the Germans had used to mark it, a bright bit of work. He and his party lifted that particular bunch (ten to twelve Holtzmines), but there were plenty more in the neighbourhood, and it was not long before several vehicles were blown up. Just about then I arrived in the area with John C. to try to get a glimpse of the obstacles on the main road, which was about 400 yds. away on the left. We had had an interesting journey up. We left Brigade Headquarters in my scout car and drove slowly forward past supply vehicles, tanks and marching infantry, all moving up in fits and starts to take their turn in the battle. The track was the battalion axis, a spear which was being gradually forged and driven into the enemy's vitals, and a lifeline along which the fighting spearhead was sustained and reinforced. It twisted and turned across the fields, and towards the menacing woods in front. Along the axis were signs of the battle. Here a house was burning, here a carrier, there a truck. By a house with weapon slits around it lay a few bodies hastily covered with groundsheets; we could not tell whether they were friend or foe. There were shell craters in the fields each side of the track, and many of the trees were gashed by the flying splinters. Signallers with telephone cables moved up the axis; ambulances came jolting slowly down it. In a group of houses, less damaged than most, was battalion headquarters and a first aid post; farther along towards the enemy was a reserve company headquarters, just a few vehicles halted on the track. Here too was a pile of mines, those lifted by Dick and reported over the wireless a little earlier, and telephoned back and sideways until everyone knew what kind of mines they were. We had passed Dick's heavier and softer trucks farther back, and here, parked by a ruined building, were his two armoured half-tracks. Tired and dirty infanteers, whose job was over for the moment, were resting in the ditches or brewing tea; others, heavily laden and apprehensive, sat waiting patiently for their turn to join the battle. A fatigue party was already busy digging six or eight graves in a triangular patch of grass where a little country road about 10 ft. wide crossed the axis. A few yards up the country road was a crater, and a carrier burning fiercely. There had been a mine buried under the pavé, and there were probably plenty more. Some pioneers with mine detectors were checking a diversion through the ruins of a barn.

Vehicles were not allowed any farther forward yet, so John and I got out and walked up the track towards the woods. Dick was some distance ahead with the leading rifle companies, and there were sounds of firing in front of us. The woods were eerie, dark and lonely, and we could see nothing once we got inside them. However, we had not come to see Dick, but to look at the obstacles on the main road, so we came out of the woods and walked back towards where we had left the car. We had a fairly good view of the road blocks, which consisted of trees felled across the road and probably mined and booby-trapped. We were not prepared to go up to them yet though, as the infantry had not yet occupied the area by the blocks, and it was well known that the enemy had a number of posts along the main road.

As we approached my scout car there was a loud explosion from the direction of the road blocks we had been studying, and a great black cloud of smoke went up. "Mine," we said. "Someone must have gone down the main road and hit one." A minute later there was a similar bang and a column of smoke from the cross-roads where the pioneers were clearing the diversion. This was only a hundred yards or so away, and John and I hurried down to see what had happened. We found that some carriers had just come up and started to park on a nice-looking bit of ground alongside the track close to where the pioneers were working. One had hit a mine and blown up. John, who had a nose for mines, and could find them rather like a pig finds truffles, soon unearthed two or three Tellermines 42. We warned everyone to keep off this bit of ground and arranged for it to be marked with tape and the usual notices. We then went round the corner to see what we could on the little road where the first carrier had been blown up. John soon found a mine, then another; then he found one under my feet, then one under the feet of Dick's platoon sergeant who was with us; then we found one under his feet; then we decided this was quite enough of a good thing, because though they were anti-tank mines and reasonably safe to stand on, they might not have been. So we left and arranged a proper party to clear them.

By now a little excitement was developing on the air about clearing the main road. Brigade H.Q. thought that it was quite safe to start work. I ordered up the working parties, and got back on to the main road with John and the armoured car. We drove gingerly down the centre of the road until we came to the first obstruction, the wreckage of two British tanks in front of a fairly solid obstacle of trees felled across the road.

Apart from the tanks, we were the third vehicle to visit this spot. The history of the other two is interesting. The first was a wild three-tonner driven by some nameless idiots. It had come down the road from Grave several nights before the battle, travelling fast with its headlights on, and, apparently quite unaware of the tactical situation, had driven through our outpost position in spite of every effort to stop it. It then passed through a British minebelt on the road, a possible, though improbable, manœuvre, and disappeared straight towards the enemy. It eventually reached the road block, realized there was something wrong, turned around pretty quickly, missing all the enemy mines, and beat a hasty retreat up the road. The enemy, whether from surprise or caution, took no action, and the three-tonner would have survived its adventure had it not hit our minefield on its way back.

The second vehicle, a jeep, had also wandered down the road in mistake and had met its end from a mine in the road verge when it had tried to turn. The occupants had been injured and evacuated. This was the mine we had heard go off an hour or so previously.

We had a good look at the obstacles and decided we could move them fairly easily, specially with the help of our "thick-skinned friends", the armoured engineers. These were already on their way, and having seen the job started, I left it to John and made my way back to Brigade Headquarters.

The battle was still going strong. Roy, away on the left, was getting on without much trouble; in fact the difficulties there were bad ground and roads more than the enemy. The A.V.R.Es. had a better performance than the fighting tanks and were busy helping to keep them going through the mud. On the right, Dick had disappeared in the forest, and we had little news except that the track was still open and that he hoped to get on the main road some time later. Then we heard that John C. had found a mine the wrong way. This was where the carriers had been blown up. His party had cleared the area of mines, or so they thought, and then driven on with an armoured half-track to pull the wreckage of one carrier off the road. That was that—no one was hurt, but the "half-track" was rather the worse for wear, and the mine clearance party, who were standing round rejoicing in their handiwork, were more than a little shaken.

Night came; the battle went on; the sky in front of us glowed with the flames of the eastern suburbs of the city. Dick got out on to the main road a mile beyond John and turned with his party clearing back towards John's. It was a slow business in the dark, with the constant threat and occasional presence of mines and booby traps among the tangled trees felled in scores across the main road. By dawn the parties met; and the road was opened as the main supply route for the considerable force which was now fighting in the outskirts of the city.

I remember driving down the road and finding Dick and his platoon, all looking very tired and dirty, quite comfortably installed in a couple of battered houses at the place where they had come on to the main road. There were still a certain number of frightened German troops around, hiding in shell slits and cellars, waiting for a suitable opportunity to surrender. In fact three or four came out of the houses Dick's platoon was occupying shortly after I left.

We were still busy checking for mines in the area, but our main task was done, so after lunch (this was D plus 1, the 23rd) I decided I would drive across to try and find Roy. I went down to where the ruined tanks had been blocking the main road, and turned left down a track on which some of Roy's men were working. They assured me there were no mines on it; not only had they checked it, but a great deal of traffic had passed that way. So, with one of the party sitting on the tail of the armoured car to act as a guide, away we went. A few hundred yards along we met a signals' jeep coming along slowly laying cable. We passed it and followed the track along which it, and numerous other trucks, had gone.

Suddenly we were flying through the air in a red thundering cloud of smoke and sand. With some surprise I noticed the sapper who had been sitting behind me a moment before, rapidly overtaking me on the right and about 5 ft. up, while the hedge which had been alongside was now some distance below. I thought to myself "Mine!" and added "Well, we've got up here all right; if we get down as well as we got up we won't do too badly." Meanwhile our mine-propelled car was going through the variety of movements involved in turning over sideways and also end for end while travelling through the air, until eventually it hit the ground, bounced slightly and rolled sideways into the ditch. The engine stopped, the wireless stopped, there was a considerable readjustment in the position of the truck's contents, and then silence. I disembarked with a sort of wriggle and scramble, to be followed a moment later by my driver, looking a little surprised, but otherwise unhurt. The wireless operator appeared to be rather mixed up with his set, several batteries and various leads, and failed to answer our inquiries about his welfare. So we pulled and pushed and managed to drag him out. To our delight he was none the worse for wear either, though temporarily stricken speechless by the shock. The sapper, who had parted company with us, was sitting in the ditch about 30 ft. away, and looked surprisingly undamaged too.

By now the signallers from the jeep had arrived on the scene. Their idea of helping was to tell us loudly exactly where the nearest ambulances were, and it took me quite a while to persuade them that, not only were we in no need of an ambulance, but that we were quite unhurt. I was interested to find out whether the wireless still worked, so we dragged it out and set it up as a ground station. While the operator was proving that it wouldn't work, though only slightly damaged, the driver and I pulled out the remainder of our belongings.

Just in time too, for a moment later the car surprisingly burst into flames, and, in spite of all our efforts with the extinguisher from the jeep, was soon reduced to a ton or so of scrap iron.

There was a biggish crater in the track some 20 ft. from the car, and around it we soon found a number of Tellermines. It appeared that all the traffic which had gone down the track had run in the wheel-marks of the first vehicle, which itself had run along the two ruts which most country tracks have. The majority of the mines lay outside these ruts and as a result had not been run over. Our mine, however, had been buried very deeply right under the rut. All the preceding vehicles had passed over it safely, but the armoured car had just done the trick. Quite a memorable experience, and a complete vindication of the policy of sandbagging vehicles.

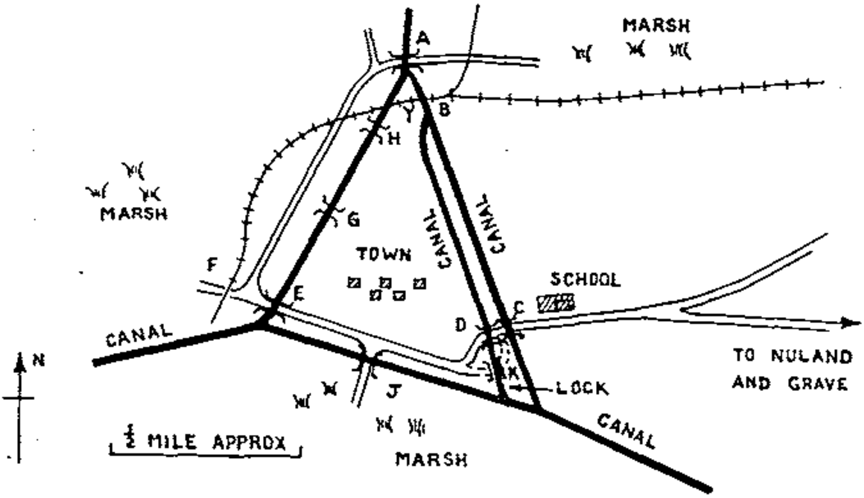
I remember rummaging about in the bottom of the crater and finding a great trophy, the remains of the igniter of the mine, very much a hair of the dog which bit me. How the mines had been missed by the mine clearance party was never satisfactorily explained. It seemed that they "knew" there were no mines there because they had seen so much traffic pass over the track.

The rest of the day was comparatively uneventful.

The next day, the 24th, was pretty quiet too, except that Brigade H.Q. moved a couple of miles up the road towards S'Hertogenbosch and we followed. It was an amusing move as my half-track was still being rebuilt and my armoured car was *Kaput*. So all we had to move my quite substantial headquarters were two jeeps and a borrowed three-ton "tipper". The Brigade H.Q. convoy looked very impressive going down the road, a great concourse of command vehicles, armoured cars and goodness knows what. At the tail came "R.E.", the two jeeps and this awful tipper, loaded with the most amazing collection of wireless sets, telephones, tents, cooking utensils, buckets, bren guns, rifles, mapboards, picks and shovels, and riding on top the batmen, wireless operators, cook and other odd bodies of my Tac H.Q. staff. We looked like the poorest of poor relations.

On the 24th October the battle for the town itself was raging full blast. To understand this it is necessary to study Sketch 2.

The town was surrounded by marshes except to the east and was drained by a triangular system of canals. These were all formidable



Sketch 2.—Layout of town of S'Hertogenbosch.

obstacles, and enclosed a densely built-up area which had sides about three-quarters of a mile long.

There were two routes across the town, a by-pass route to the north which had to cross only one canal, at *A*, and a through route to the south which had to cross three canals, at *C*, *D* and *E* respectively and a railway line at *F*. There was also a railway bridge at *B* and some bridges on minor routes at *G* and *H*. The main route south crossed the canal at *J*.

The main attack to the north aimed at capturing bridge *A* intact. It went very well at first. An infantry platoon actually got across the bridge, but was then cut off by an enemy counter-attack. No more was heard of this platoon and the enemy succeeded in blowing the bridge. To the south we captured bridge *C* which the enemy did not attempt to blow. He destroyed *B*, *D*, *J* and *E*, leaving himself exits by *G* and *H*.

By the 24th we had managed to get into the south-east corner of the town and on the night of 24/25th one of the other companies managed to build a 40-ft. S.S. Bailey across the lock at *K*. Very early in the morning of the 25th, I sent Bruno and Mark down to reconnoitre the wrecked bridge at *D*, as we had been told to stand by for rebuilding it. Hidden by the mist they managed to get right down on to the bridge, in spite of the fact that the enemy were holding a house just the other side. Everything was pretty quiet then and a certain amount of traffic was getting into the south-east corner of the town across the bridge at *K*.

A little later in the morning I decided to run down in an armoured car and have a look myself. Bruno came along as well to show me the way. As I had lost my wireless two days before, I took our rear link wireless truck along, a sedate old-fashioned box-like vehicle of great character and determination. It was driven and operated by the Signals and normally travelled next to our office truck and talked continually to H.Q. R.E.

When we arrived at Brigade H.Q., which was in a school a few hundred yards from bridge *C*, we were a little disconcerted to find that the situation was by no means as quiet as it had been. We could hear shells bursting steadily just in front of us, and almost as soon as we went into the building they started bursting just outside. It was a modern school, all windows and glass, and without any nice, dark, damp cellars. No one was quite prepared to lie on the floor and stop business, but everyone was trying to stand clear of the windows, an almost impossible task.

We had a chat with the Brigade staff, who told us that enemy self-propelled guns had moved up to the canal bank to the north at *Y* and were shelling the area around bridge *C* pretty accurately with good observation. We decided to leave the wireless truck behind and make a dash for *D* in the armoured car. There were about a hundred yards of open running involved in crossing bridge *C*. The traffic had stopped; not a vehicle or sign of movement could be seen in the area. The driver put his foot down on the accelerator and away we went. As we emerged from the houses the enemy must have seen us; nothing happened for a moment; we had one quick peaceful glimpse of the canal stretching each way under our feet as we crossed the bridge; then we heard the familiar angry whistle of approaching 88 mm. shells. As I ducked and shut the lid, a shell hit the road in front of us, another burst on the canal bank, another in the house tops, another behind us on the bridge and we were over, and having to brake hard to stop before reaching the second bridge, which was only a hundred yards beyond the first. We had stirred up the enemy all right, and shells were coming over too fast to make us want to get out and linger round the wreckage. We had a quick look at it from the car, decided that it was a formidable task, and that there was no prospect of doing anything unless the shell-fire was reduced either by darkness or by dealing with the guns. All this took a matter of seconds, while the driver turned round, and away we went out of it as fast as we could go, still pursued by a storm of shells. That was quite enough of that, we thought, as we picked up the wireless truck and went back up the road to our bivouac.

The C.R.E. decided not to build a bridge at *D* but instead to build a second one at *K*, so that the diversion would take two-way traffic. By the evening of the 25th the infantry had managed to filter along the south of the town almost as far as *E* and were also spreading northwards. The shelling at *C* had died down, and after dark vehicles started moving again.

Dick and his platoon, who by now had had quite a good rest, were to build the bridge after dark that evening.

It must have been nine or ten o'clock when Dick, Bruno and I went down to reconnoitre the site. The darkness was broken by the glare of innumerable fires in the burning town. Everything was quiet except for an occasional shot in the distance. We went down in Dick's half-track, across the first bridge and then through a back street to the lock. There was not much traffic about except an occasional ambulance or light truck, and little groups of tanks moving up slowly in the darkness. The small maintenance party of sappers from the company which had built the first bridge were living comfortably in the basement of an adjoining house. From this they could dart out when it was necessary to do any work on the bridge; they had been very thankful for the arrangement earlier in the day; but now that everything was quiet, they and the other subterranean inhabitants of that part of the town were beginning to poke their noses out again.

There was no particular snag in building the bridge, except that on the far side there were some iron railings and a lamp standard which got in the way. We decided that blowing these down might attract unwelcome attention to the area, so we sent for an oxy-acetylene cutter to do the job instead. It was not long before the platoon section trucks, each with its load of men, rolled up, followed a few minutes later by the bridging lorries and then the oxy-acetylene cutter.

While the bridging stores were being unloaded we set the cutter to work, but the showers of brilliant sparks from his torch were altogether too conspicuous; so we stopped him working until the bridge was ready for launching. After this Bruno, Dick and I walked up the west bank of the canal to the main road bridge. This was only a few hundred yards away, but it seemed miles.

There was an infantry post on the first corner, quite invisible in the half-light of the fires. We almost jumped out of our skins at the whispered challenge from an invisible sentry not more than a yard or two from us. We reached the bridge and spent a minute or two looking at the wreckage. It would certainly take some time to clear that away; we were much happier about our own job. We decided to explore no further and went back to the lock, finding great relief in the activity of the sappers as opposed to the silent streets running away from the canal bank.

After an hour or so, as everything was going well, Bruno and I went back to Company H.Q., leaving Dick to finish the job. This was done at about 4 a.m. without any incident.

In the morning Company H.Q. moved up, and the whole company was together for the first time since the battle began, in a little group of fields about a mile or so east of the town.

The fighting was still heavy, but had reached the western canal. I was hoping to have a quiet day, but at four o'clock in the afternoon was suddenly summoned to Div. H.Q. Here I found out that the

C.R.E. had been wounded by shell-fire while standing watching an A.V.R.E. laying a bridge at *E*. The senior company commander was on leave at the time, and I had to take over command until he returned. This did not involve doing much about the present battle, as it was practically over, but gave me a few hours of furious thinking and arguing about the engineer aspects of some proposed fighting in the most unpleasant, flat, open, marshy country just west of the town. I had an excellent dinner with the General and other commanders in Div. H.Q., but was happy to get back to the company the next day, when I was relieved by the senior company commander hastily recalled from Brussels.

This was the 27th. We were all tired and were looking forward to a real night's rest. The gunners who had been firing from the fields close to us moved away, and even Div. H.Q. came into the area during the afternoon.

There we were, all nice and comfortable, my Tac H.Q. and Dick's platoon on one side of the road, Company H.Q. and the other two platoons about a quarter of a mile away, next to Div. H.Q. on the far side of the road.

It was evening, a bit cold but pleasant enough, and anyway for us at least the battle was over; Bruno, Dick, Mark and I were talking comfortably in my tent; the batmen, drivers and others were comfortable in theirs.

There was a faint thud in the far north, then another, then another; suddenly we were all conscious of a whistle, two whistles, three whistles, low at first but rising in intensity. Over went the lamp, chairs and telephone, and four officers hit the floor of the tent simultaneously with three majestic, crumping crashes in the next field.

This was big stuff, coming from an immense distance away, but landing a microscopic distance from our inoffensive caravanserai. Even as we shook ourselves we heard the thud of the guns again; in one dive we disappeared into our shell slit; dug by force of habit rather than a belief in its necessity. This was beyond a joke. It went on all the evening, but after the first few salvos we began to realize that the bursts were in fact a safe though short distance away.

In one of our rushes, as there was no room for him anywhere else, Dick ended up lying more or less on top of the heads of the rest of us, who were crouching in the bottom of the shell slit. We remonstrated with him for making us so uncomfortable. His reply brought fits of laughter.

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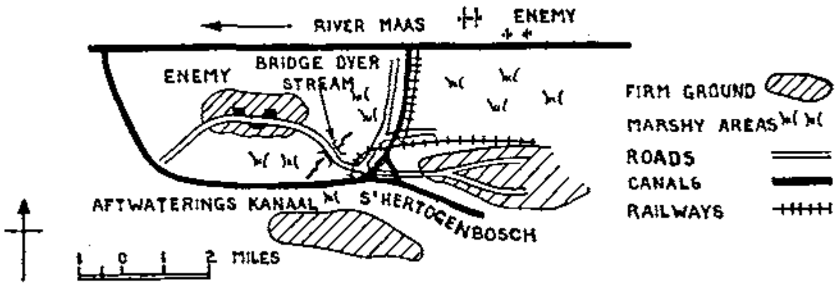


Sketch 3.—Area N.E. of S'Hertogenbosch.

Maas; the other from the south, where the canal was a formidable obstacle 200 ft. wide with high flood-banks. Equipment for crossing this in strength was not available, so attention had to be turned to the road.

The only physical obstacles were a stream about a mile outside the town, and the soft ground, which would prevent deployment off the road. Over the stream was a bridge, and it was clear that the one chance of an easy entrance into the area was to capture the bridge intact. It was still all right, but the chances of taking it seemed remote. However, it was decided to try, and orders were given for a reconnaissance in strength to be made by infantry of X battalion and a small sapper party, after dark on the evening of the 27th, to attempt to seize the bridge and remove any charges, or, if it were blown, to reconnoitre the gap.

It was a lovely afternoon then; everything was quiet; the town was ours and there was no sign of any enemy to the west. I went to X Battalion headquarters at about 4.30 p.m. to tie up the arrangements for the R.E. recce party. The battalion commander was not there. At five o'clock his officers assembled for their orders. We knew the Colonel had gone into the town to see what he could of the ground beyond; by 5.30 everyone began to get anxious; at 6 we heard some shocking news. The Colonel and the two officers with him had decided to take a chance on the enemy not being at the bridge, and had driven straight up to it in their jeep. The enemy were there; they allowed the jeep to come right up before opening a murderous fire at short range at the occupants, who were armed only with revolvers; they killed the Colonel and one of the officers, and wounded the third. A small infantry patrol of ours which had worked its way up along the road and happened to be quite close joined in the fight and enabled the wounded officer to escape. The patrol then withdrew, leaving the jeep burning, and reported two not very heavy charges as having been fired on the bridge.

This was a pretty state of affairs; a deep gloom settled on everyone. The second-in-command of the battalion took over. Orders came through that the operation had to be carried out, as there was a chance that the enemy might not have destroyed the bridge completely, and in any case might have been frightened away.

The sapper party was to consist of two officers and two sergeants, one officer and one sergeant from my company and the same from the Assault Squadron, which might have the task of putting an assault bridge across the gap. I will let my recce officer, Mark, tell the story.

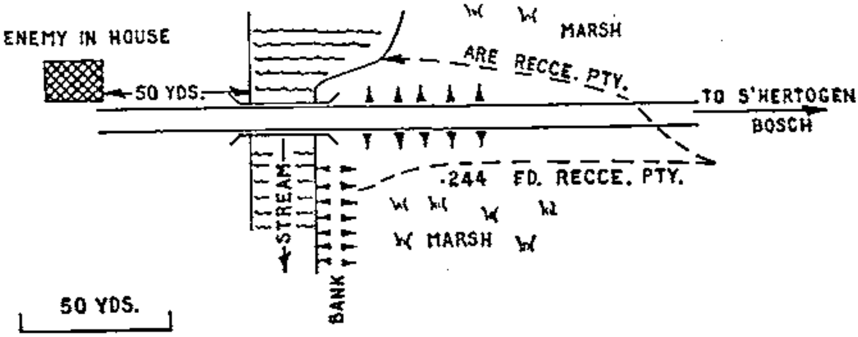
"I suppose it was about nine o'clock when we moved out of the town. It was a lovely night, with a bright moon and you could see for miles across the country. It was a frightful business walking down this road feeling that we were in full view of the enemy. The artillery and machine gunners were supposed to be creating a diversion. I thought they were doing nothing but draw attention to us; if we needed any attention drawn. The whole battalion seemed to be there; all thumping along in great big Army boots when they walked on the road; or cursing and swearing as they fell into ditches when they tried to move off the road. After a while our own shells started falling amongst us. This certainly created a diversion and it took quite a while to stop the fire. Fortunately no one was hit. After this it was better, but the closer we got to the bridge the more conscious were we that we were making fools of ourselves. Little packets of infantry kept dropping off to 'protect' us and when we came to about 400 yds. from the bridge the four of us and about a dozen infanteers were ordered forward. I felt more and more foolish and acutely conscious of an alert enemy waiting for us by the bridge. When we reached to within about fifty yards of it the infantry stopped. 'You go and look at it,' they said. 'We will cover your advance from here.' After a hurried whispered consultation I decided to go forward with my sergeant on the left of the road while the other two went upon the right. There was a low bank running out from the bridge to the left as we approached. See Sketch 4.

My sergeant and I crawled up to it and looked over the top. There was the bridge only a few yards away; quite all right; not a sound.

At that moment there was the most terrific explosion, accompanied by a blinding flash and a blast which flung us back off the bank and lifted me clean into the marsh some distance away.

I didn't know quite what had happened at first; then I realized the enemy had blown the bridge in our faces; the A.R.E. officer was wounded, but the rest of us were all right. Jerry had not been quite as clever as he thought; but the bridge was completely demolished.

Deafened, sore and thoroughly shaken we trudged wearily back to our bivouacs, feeling that though we had achieved little, we were lucky to get away so lightly."



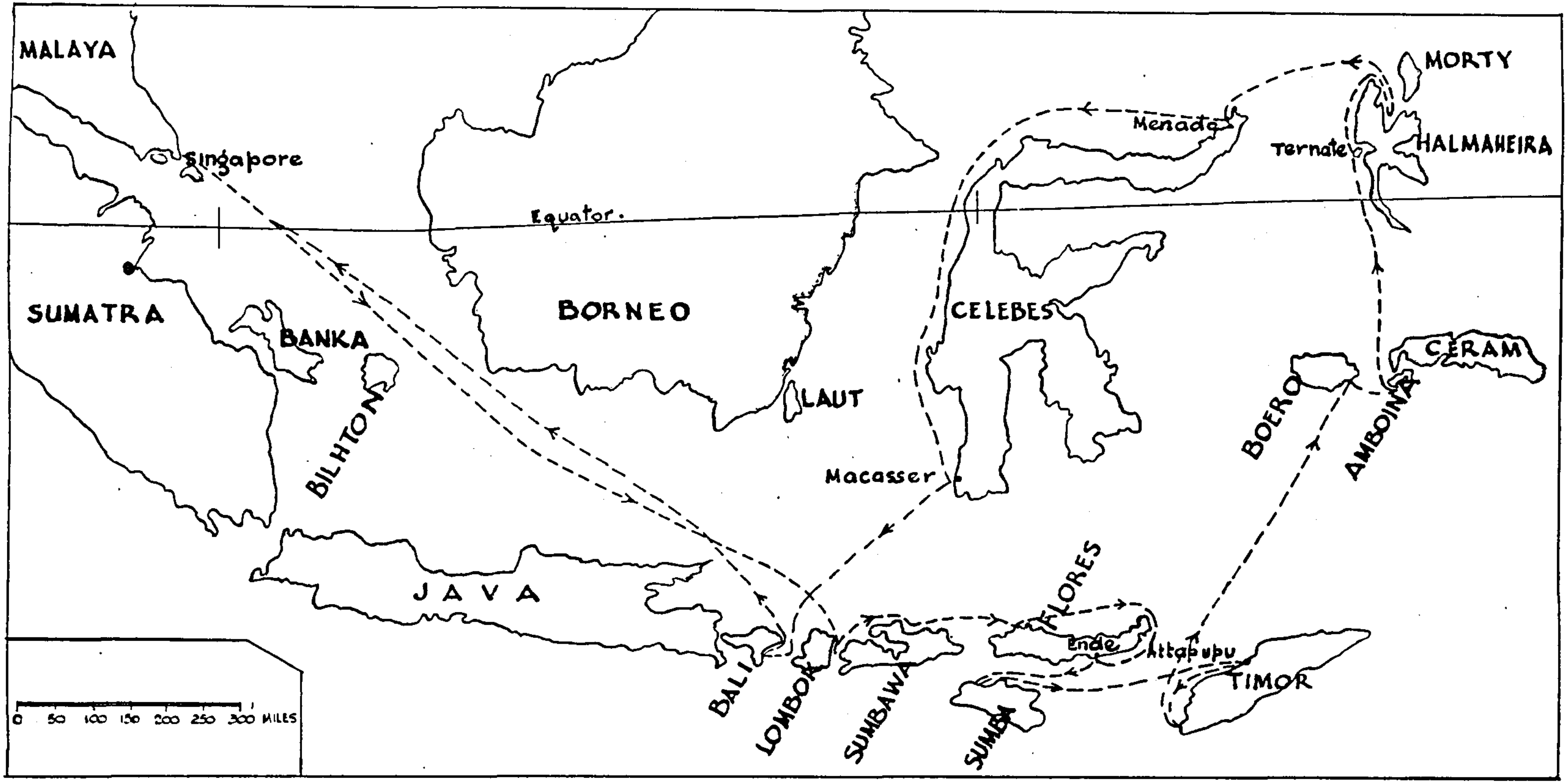
Sketch 4.—The Bridge site N.E. of S'Hertogenbosch

After this set-back we as a Division felt rather like Lars Porsena before the gates of Rome after the bridge had been hewn down, and much furious though fruitless thought was given to the problem of getting at the enemy in his island citadel rising out of the marsh.

An amusing incident happened the next night. I and my little tactical H.Q. were living with Brigade H.Q., leaving the company some distance away with my second in command. We were on the brigade telephone and really very conveniently situated for keeping "in the picture". Everything was quiet when we went to bed in our tents, but I was woken next morning by a slight disturbance involving my batman and two Dutch civilians who had a complaint to make. They were brought into the tent, and I explained they should go to Brigade Headquarters in the house outside which the tent was pitched. They looked blank; I pointed and gestured. My batman was looking pretty blank too. He suggested diffidently that Brigade Headquarters had disappeared. I said "Nonsense, we're on their exchange and of course they haven't moved. Why should they move?" I rang them up. No answer. I peered sleepily out of the tent. Not a sign of them. The whole elaborate array of caravans, tents, trucks, bivouacs, armoured cars and wireless sets had vanished like some remarkable disappearing scene in a pantomime. Our telephone wires lay lifeless. We had been abandoned.

We learned later that at about 2 a.m. the Brigade had received orders to move some twenty miles to help our friends on the left. We had been degrouped from Brigade by Division, and rather summarily, as we thought, abandoned without a word. By the time we discovered our loss the Brigade was getting into position twenty miles away.

So ended for us the battle of S'Hertogenbosch; for just as we were wondering even more furiously about how to cross the marshes, a major German thrust south-east of Eindhoven developed. Before we knew what had happened we found ourselves streaming south-east to meet this threat.



MALAYA
Singapore
Equator.
SUMATRA
BANKA
BILHTON
BORNEO
LAUT
CELEBES
Macasser
Menado
MORTY
HALMAHEIRA
Ternate
CERAM
AMBOINA
BOERO
JAVA
BALI
LOMBOK
SUMBAWA
SUMBA
FLORES
Ende
Attapupu
TIMOR
0 50 100 150 200 250 300 MILES

CHRONICLE OF THE "CRAB"

By MAJOR G. H. McCUTCHEON, R.E.

WE were never really certain who it was decided we should take a raft on Operation "Shufti". We who took part in the operation were charged with making an engineer reconnaissance of the Lesser Sundas, Moluccas, Celebes and Timor; given a brand new L.C.T., a promise of numberless tropical beaches and a raft seemed a waste of space.

But "E" Branch of ALFSEA had its way, and when *L.C.T.* 4040 sailed from Singapore on 23rd July, 1946, she had among her stores "Rafts Tracked, Class V, Sets One (complete)". The "Crab" had come amongst us. On board also was a navy crew of four officers and fifty ratings, eight Army and one R.A.F. officer and twelve other ranks. Of these latter the Sapper strength comprised four officers and a sergeant draughtsman. Between us we thought we knew just enough to be able to put the raft together, but for labour we would have to rely on clerks, drivers and a half-section of the Royal Sussex. We had no pamphlets!

Time, however, was on our side. During the five-day passage to the western tip of Sumbawa, our first objective, we shook off our fear of the "thing" and checked it over. We weren't sure of the nomenclature, but the total of bits and pieces tallied. The set was, in fact, complete. The Petters were also tried out and worked admirably.

By the time we came to anchor off Sumbawa all the "what comes nexts" and "what goes heres" had been thrashed out. We were keen to try the contraption in the sea. Our hour, however, was not yet. The Skipper ran "4040" gently ashore at half-tide on a perfect beach and the vehicles, jeeps and Dodges were driven ashore down the ramp. Only the first jeep had bogged. After that the others quickly got the knack of going in with the breakers and this first landing was voted a fair success.

Although the set still had to prove itself, one of the boats and a prop unit were now brought into use. "4040's" launch was holed beyond repair as she was being slung aboard. There was no other small craft aboard apart from a two-man dinghy and the folding boat which was hastily rigged did duty as the ship's barge for the remainder of the trip except when she was in raft.

The first real chance to put the Crab together came when we attempted a landing on the north-west coast of Flores. Here, although the beach was ideal, a bar of coral 200 yds. out made it impossible to run in straight for a landing. The Crab, we thought, was the obvious answer and while "4040" swung on a stern anchor the ramp was lowered. We launched the two boats quite easily. The breeze was light, as yet, but a tremendous swell made it almost impossible to get the superstructure aboard and fastened down. We struggled and swore but, in the end, a freshening breeze made conditions much too hazardous and the Skipper, reluctantly, took "4040" out into safer water. As we Sappers had, anyhow, to go ashore that afternoon there was nothing for it but to put out in the ship's dinghy. In spite of her flimsy appearance she was quite seaworthy and made several crossings of the surf line without difficulty. Once ashore we moved off on recce in the welcome luxury of a 1940 Ford V-8, the island's only taxi!

Five days later we stood at Ende, on the southern shore, and watched "4040" make a good run in at half-tide. The Crab had still to prove itself. Now, however, our army boats became the only boats aboard. An unseamanlike sailor had made the dinghy fast between a steel jetty and the L.C.T. During the night a rising tide lifted "4040" and the morning watch found the dinghy neatly torn apart. We became conscious again of the shortness of our acquaintance with the Crab and quietly crossed our fingers.

Time was still on our side. Sumba followed with a good beaching and cold nights for those who had to sleep on deck. After that Timor and an exciting but very wet drive down "4040's" ramp at Attapupu. Then on to Boero and another good landing; a win for the football team and a successful stag hunt at 2 a.m. by jeep across a badly cratered airfield.

On thence through oily seas to Amboina and Queen Wilhelmina's birthday celebrations. And the launching of the Crab! There were no alternatives here. No beaches, no cranes to take the vehicles off and no taxis. Our berth alongside gave us the shelter we needed particularly for our first attempt and an hour's co-operative effort saw the Crab afloat for the first time and a jeep perched aboard. The two Petters were put in place and, with some variations from the *Manual of Watermanship*, we cast off and got under way for a small concrete ramp about half a mile to the south. All went surprisingly well and by nightfall we had put four jeeps and a Dodge ashore without loss.

The Crab was a great success. The ship's crew were enthralled by its quaint motion and there was no shortage of volunteers to run the Petters. Ashore, as soon as we touched down, there was always a rush of small excited boys up the ramp. Then the balancing gear would come into action and the resultant panic invariably left the odd brown head bobbing in the sea.

It was at Amboina also that the Crab completed her longest non-stop cruise. There was some prospect of our having to cross a five-mile wide bay on the east coast of Halmaheira. With the bay reported infested with Japanese and Australian mines the Crab, with her shallow draught would be ideal. As a first test, therefore, we now took her out with something less than the planned full load and the five-mile trip across the bay and back was a complete success.

The Crab's reputation as a seagoing craft now stood high with our naval colleagues. How high we were soon to see when all the officers aboard "4040" were invited to a sherry party aboard the Dutch destroyer *Bankert*. The point of the invitation being to celebrate the Dutch Queen's birthday there was no refusing; there being no ship's boat of any sort there was nothing for it but to use the Crab. We of the army would have jibbed at the idea of taking out one of her boats and the navy were broad-minded enough not even to suggest it. Promptly at 11.30 a.m., therefore, the Skipper rigged a White Ensign amidships on the treadway and we opened up with both Petters.

The effect on those aboard the *Bankert* was magical. There was a wild rush to the deck-rail by guests and crew. There they hung, pop-eyed and unbelieving, as the Crab made her oblique passage of the intervening water. The destroyer's captain was at the head of the gangway as we came shyly alongside. He was kind enough to say he had barely felt the bump and then let loose with a broadside of questions on the Crab's pedigree and her association with H.M. Fleet.

With such a start it was not surprising that, thereafter, the party never looked aft. The Dutch were childishly intrigued with the Crab and equally so on discovering, by a simple test, that the two beards sported by her crew were both real, both army growths and both basically illegal. When, at last, we came to fend off, the *Bankert* was listing appreciably towards us under the weight of our well-wishers. Many of them stood there enthralled as we set out on a return voyage which was decidedly more oblique than our outward trip.

The Crab had had a great day. "E" Branch at ALFSEA must surely have blushed at the many eloquent tributes to her versatility. My Lords of the Admiralty, conceivably, might have felt otherwise about our raising the White Ensign and, even more so, by the assertion by a majority of "4040's" crew that these rafts were "just the job for an L.C.T."!

One more chore ferrying ashore the dumbfounded crew of an Australian Catalina and then Amboina was astern. We steamed on north-east to Ternate, a simple volcanic cone rising green and lovely from the very calmest of seas. The Crab rested. We ran ashore on a good beach and then two days later moved on north between Morty and Halmaheira. Then south to the edge of Kaioa Bay where we hoped to give the Crab her greatest test. It was not to be. Local opinion, even without seeing her, counselled against such a crossing at that time of the year by small craft of any kind. We were disappointed. Our faith in the Crab now had something of a classic devotion. Five days later, however, when, in the same latitude, a screaming gale carried away one of "4040's" twin rudders we were all quite glad that the frail but gallant craft had been spared such a blow.

After Halmaheira we steered south-west to Menado at the north end of Celebes. We beached easily here also and, with the aid of some Dutch friends, made and rigged a second rudder. Then on west and south to Macasser. The triumph of Amboina was repeated on a smaller scale, though another invitation from another Dutch destroyer, the *Piet Hein*, this time found us strolling down the quay to go aboard.

The large island of Laut off the east coast of Borneo was scheduled as our next call. Between us and it lay a hazily-defined Japanese minefield with, as yet, only a single gap swept through it. This was no more than 250 yds. wide and not guaranteed. We had lost another rudder between Menado and Macasser and our chances of slipping through were reckoned to be remote.

Singapore was consulted and, the risks being judged unacceptable, we turned south again to Lombok. Here with our one rudder and the swell of the Bali Strait sweeping us south it looked like another day for the Crab. But the Skipper was on his mettle and our beaching between a jetty and a row of derelict piles was impressive and exciting.

There remained now only Bali. Between islands we had read Viki Baum's *Tale from Bali* from the ship's library. This was a true chronicle of the period of the Dutch Army's arrival early in the century. The immediate excuse for their landing had been the pillaging by locals of a Dutch-registered ship which had foundered on a reef on the island's south-east coast. The Balinese had refused demands for compensation and when Dutch marines were landed the entire local population marched slowly on to the beach and were shot down *en masse*. Some ten or twelve only had survived of whom one, a woman of about 65, was still living at the time of our visit.

We had now arrived off the same shore and a recce of the most promising beach showed deep water close in to a steeply shelving shore. The swell was heavy as we ran in at "half-ahead" but "4040" rode up smoothly on the steep slope. Then, in an instant, the swell had rolled in again and lifted her clear. We went slowly astern again and then turned west where a long low headland gave promise of some shelter. Time was getting on now and the recce of this beach had to be a hurried one. While it was going on "4040" cruised slowly up and down about half a mile off-shore. Then the recce party's flag was seen to be waving and "4040" was brought round and headed in.

We went below into the tank deck as she came on course. The jeep engines were started and we were standing by when after a minute or two, the deck lifted suddenly and the noise of metal grinding upon rock drowned all others. We had found the Dutchman's reef.

Back on the bridge again we could see a forlorn Sapper standing thoroughly downcast upon the beach. Aboard "4040", however, after the first shock, our Navy hosts embarked upon a period of anxious but intense activity. Sailors scurried about the ship like ravenous rats. Some jittery minutes passed, then came a cry that all was well for'ard. Then a cry that all was well aft. We had had the best of luck. The coral had crumbled easily under a glancing blow and not a rivet or plate had sprung.

Our relief was soon tempered by the reflection that we were aground in a freshening breeze with no more than a couple of hours light to come. There was a hurried joint service consultation. The Navy would like us to take all the vehicles ashore to help lighten "4040". We wanted them ashore anyhow so there were no quibbles. The Crab must be recreated.

The bow doors were hardly opened and the ramp down before the two boats were launched. Everyone who could be spared was mustered on the tank deck to lend a hand. But our greatest worry was the rising swell which was now causing "4040" to pound with almost every wave. As the boats rose and fell it was well-nigh impossible to align pin-holes. There was much swearing but no slackening of the pace. The fate of "4040" and the whole expedition now depended entirely on the Crab.

Then after an age she was suddenly complete. Two lines were made fast to the boats and another run ashore from her deck across the 200-yd. gap. The first vehicle, a Dodge more than fully laden, was driven aboard and the lines paid out gently. The Crab rode away on the swell like a circus roundabout. Surely no more precarious contraption was ever committed to the Great Waters! But she stayed afloat and the spray which splashed inboard seemed only to help steady her.

And then, suddenly, we were worried again. We had had no clear idea as to how best to advise the driver on de-rafting. It was so clearly not on to do it when the Crab was aground that we did no more than warn against that particular technique at any cost. In the event, of course, the swell gave the driver no option. It took the raft high and dry in a welter of surf and he was driving off the beach while we still struggled to reconcile theory and practice.

Our worst worry was over. Thereafter we had only to bale, load and pay out on the lines. The lighter jeeps and trailers gave us no trouble and ninety minutes after the ramp had gone down we had put one Dodge, four jeeps and five trailers ashore.

The Crab's greatest hour had come and gone. We had now to pull her to pieces for what turned out to be the last time. "4040" herself was still in danger but the rising tide and her reduced load soon picked her off the reef and she went slowly astern into deeper waters. Ten days later she beached well to the east in a slight swell and the vehicles were driven aboard without trouble.

Our course was set north-north-west for Singapore. There were no more islands to lure us from the prospect of more conventional sappering. We were content. "4040" had steamed 10,000 miles in a hundred days. No other L.C.T. had ever gone so far or for so long. But it was the Crab which drew most heavily upon our reflections. Her frame may have been just a little strained and distorted but she had served us far better than our poor watermanship had deserved. We were depressed to think so good a friend was so soon again to lose her identity behind the drab utilitarian designation of "Rafts, Tracked, Class V, Sets, One (Complete)".

EXERCISE "PRIME-CUT"

By Major B. S. Jarvis, M.C., R.E.

THE Northern Command Tattoo was held last year at York. The arena lay on one side of the River Ouse, which was about 200 ft. wide, and the barracks where the performers lived on the other, about a mile away, with no bridge in between.

A bridging exercise named "Prime-Cut" was duly arranged for 36th Army Engineer Regiment who were in support of the tattoo, and the purpose of this article is to describe briefly how this simple but unusual bridge was built.

Design of the Bridge

The Ouse is used continuously by heavy river traffic and this meant that somewhere over the navigation channel a clear span 40 ft. wide and 20 ft. high was required. There was also a chance that vessels more than 20 ft. in height might need to pass, and the design had to allow for splitting the bridge in half at twenty-four hours notice. (As it happened, no such vessel came up the river while the bridge was in position.)

The Chief Engineer outlined the form of the bridge and made all the arrangements with the River Board. The final design of the bridge is shown in Fig. 1. The main points are that the central "portal" frame was chosen for stability and the approach spans were hinged to 10-ft. cantilevers projecting from the central frame in order to reduce the bending moment at the middle. Very little counter-weighting or pumping would have been required to free the panel pins at the centre.

The bridge was Class 9—the limit of the 90-ft. approach spans.

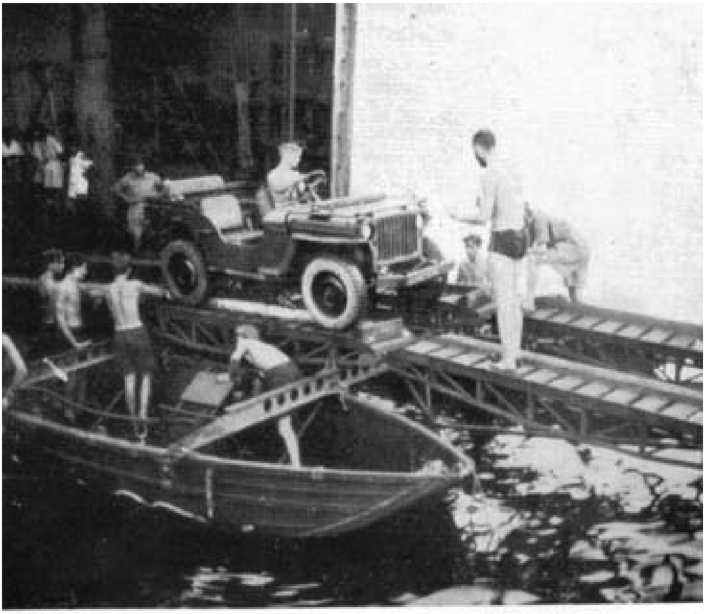


Photo 1.—Jeep on "The Crab" ready to leave the L.C.T.

Photo 2.—Jeep embarking on "The Crab" from the shore.

Chronicle Of The Crab 1,2.tif

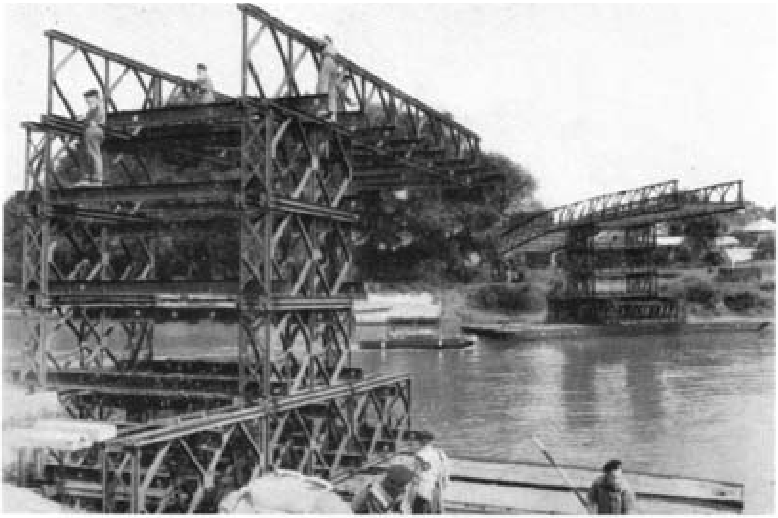


Photo 1.—Building the piers on the pontoon rafts, showing the cantilevered portions of the bridge.

Photo by Yorkshire Post

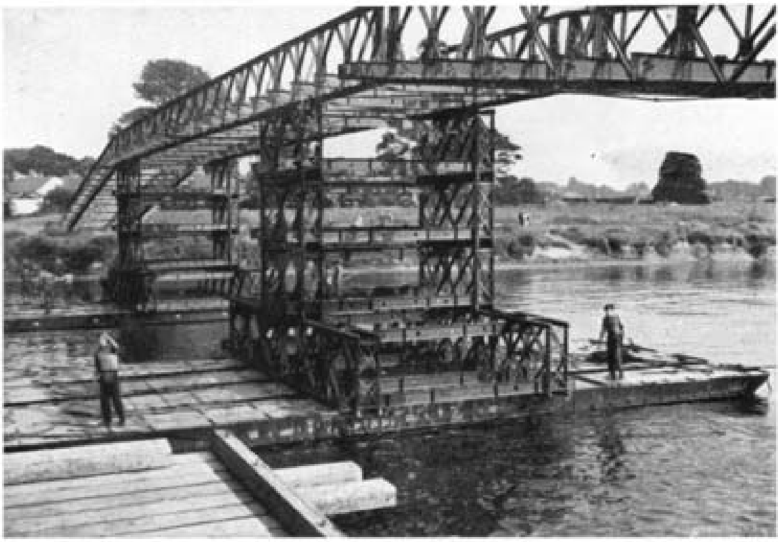


Photo 2.—The bridge in position, but decking not yet fixed.

Photo by Major B. S. Jarvis, M.C., R.E.

Exercise Prime Cut 1,2

Method of Construction

The first and obvious method of construction that was considered was to build the two floating piers, four storeys high, and to boom out from the bank, but a little investigation revealed some drawbacks to this method. The sag in long lengths of single-storey Bailey is very large, and the piers would have to have been tilted to receive the superstructure.

Any variations in water level—and the Ouse can rise 10 ft. in two hours even in summer—would have held up the work while jacking and pumping took place. Furthermore, the construction of launching piers on the bank some three storeys high, would have been so much wasted work as far as the bridge was concerned and would soon have got in the way. We wanted to build the bridge quickly without any delays.

The other possibility was to build most of the superstructure directly on to the floating piers, join them in mid-stream and add the extremities of the approach span afterwards. This method was most attractive, as it was independent of any variations in water level, but no chances could be taken on a navigable waterway and all depended on whether each 80 ft. floating bay, which looked so top-heavy on paper, was in fact stable.

After some searching for Cambridge notes, followed by a little mathematics, it was established that the meta-centre of each floating bay was about 50 ft. above water level. In other words, four tripartite pontoon piers, fixed side by side, and loaded to a third of their total buoyancy will not capsize unless the centre of gravity of the whole structure is nearly 50 ft. above the water. Our piers could have been made twice as high and would still have been safe. This method of construction was therefore adopted and the sequence of construction is shown in Fig. 2.

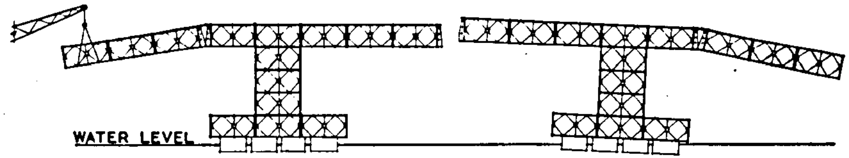
The Work on the Site

The task was given to 24th Field Squadron, who incidentally took part in the Tattoo to celebrate their centenary. The stores were collected in the Regiment's transport and laid out on the bank. Decking was kept on wheels.

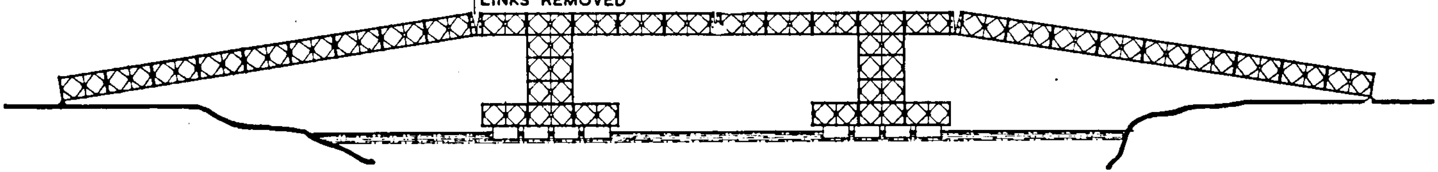
The Coles crane was brought up to within a few feet of the water's edge on a small platform of decking, on 20-ton bridging cribs, in order to provide the necessary reach.

Work started at 0400 hrs. on 5th July, 1955, each troop of thirty-three working numbers and one crane operator working a five-hour shift in turn.

Construction went slowly at the beginning of each shift until the pin-men and crane operator got to understand each other, and then went ahead fast.



TWO FLOATING BAYS TO BE CONNECTED



COMPLETE BRIDGE

FIGURE 1.

EXERCISE 'PRIME CUT'

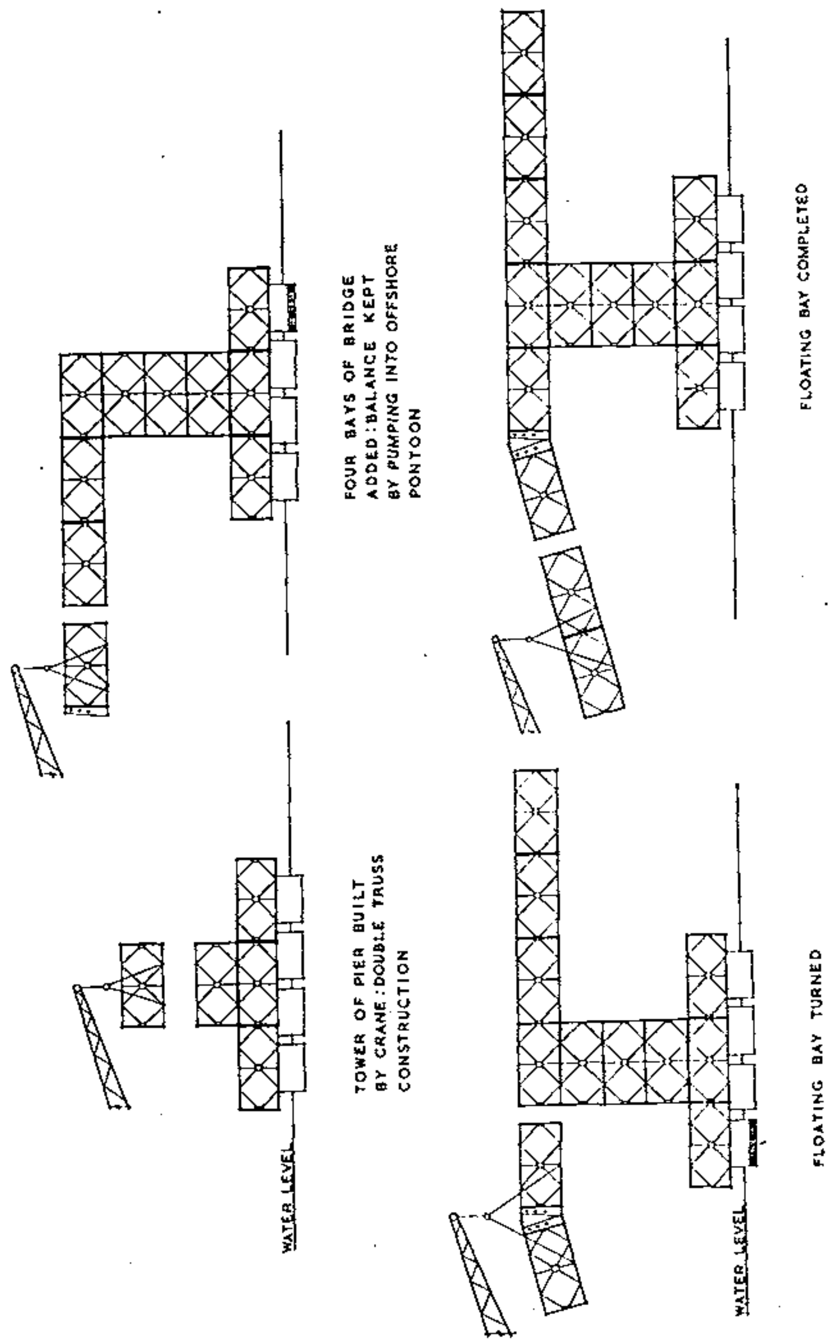

FOUR BAYS OF BRIDGE
ADDED: BALANCE KEPT
BY PUMPING INTO OFFSHORE
PONTOON
FLOATING BAY COMPLETED
TOWER OF PIER BUILT
BY CRANE: DOUBLE TRUSS
CONSTRUCTION
WATER LEVEL
FLOATING BAY TURNED
CANTILEVER BAY AND FIRST
BAY OF APPROACH SPAN
ADDED
WATER LEVEL

FIGURE 2.

Each undecked bay was assembled, slung and pinned in about eight minutes.

The bracing of the piers with modified rakers and bracing frames caused most delay. To save turning the whole structure every time a portion of cantilever was added, water was pumped into the off-shore pontoons, to balance the overhang, and pumped out again as bays were added to the other side. By 1600 hrs. the two floating bays, each 80 ft. in span, were ready to be connected. Bottom pins went in easily and the top pins were knocked in without much difficulty while the crane lifted the tail of the bridge.

The whole operation of joining up took ten minutes. The cantilevered approach spans were now extended to 70 ft., the maximum length for safety, by adding 40 ft. to one side and then turning the whole bridge round with a tug before adding to the other.

The junction links were then removed and the approach spans increased to their full length of 90 ft. while the ends were resting on packing. Jacks were never used, the lorry-mounted excavator (rigged as a crane) being used for lifting on the far bank. Decking-down started from both ends at about 2000 hrs., a second troop having been called out for the final shift, and the first vehicle crossed the bridge at about 2200 hrs., some eighteen hours after the start.

Conclusion

"Prime-Cut" was a welcome task to the squadron. It exercised the officers in design and organization and practised the men in special construction. Those who watched the work were impressed most by the practical common sense of the ordinary sapper and by the capabilities of a good operator with a bridging crane. To those of us who took part, the exercise demonstrated yet again the excellence of normal Bailey equipment.

KEEPING WARM ELECTRICALLY

By LIEUT.-COLONEL I. B. C. TAYLOR, R.E.

ONCE upon a time I bought a house—not a large house, possibly a rambling house—but one which would provide the necessary firm base for my family whilst I was serving and a peaceful retreat when I retired. Looking towards the latter eventuality, I decided that my house must be centrally heated as I had no intention of spending my declining years in the never ending task of stoking up fires and cleaning out ash. Anyway I had just returned from a three-year tour of duty in the U.S.A. where they don't believe, like the British, that one must be cold and uncomfortable to be good, or that constant mortification of the flesh in this world is to our everlasting advantage in the next. And I had been converted. So I called in a firm of heating engineers, explained my simple needs, gave them full drawings of the house and sent them away. The results were appalling and—for the sake of space—indescribable. My visions of fully automatic warmth flooding through the house at the touch of a switch or the twiddle of a thermostat had vanished midst a welter of pipes and boiler; and somebody still had to stoke the "Thing". The scheme and estimate (equally large) were politely declined and I went into business for myself.

It takes some time for the uninitiated and almost technically illiterate to master the intricacies of heat losses, humidity, radiation, convection, ambient temperatures, thermal insulation, etc., but after a time and greatly aided by more knowledgeable friends and an ample supply of illustrated literature, I began to know my way through the patter. I think, on reflection, that I surveyed the possibilities of some fourteen methods of house heating; and in the end found what I was looking for.

With domestic harmony and warmth thus assured I was left with the "unexpended portion" of my hardly gained knowledge. Could I, I thought with characteristic Sapper altruism, put this information and these ideas at the disposal of the War Department? I couldn't. But time, as we oft said during the war, was on my side and it is because official sanction has just recently been given to a small experimental (I prefer the word "pilot") scheme in Highland District embodying some of these ideas, that I am venturing this article to the *Journal*.

The last year or so has resulted in a slow appreciation that the supply of coal is becoming throughout the country neither cheap nor abundant, and that alternatives must be found for producing heat and warmth. But our heating engineers are reluctant to leave the well worn paths. Here they tend to be bogged down in a morass of hot-water pipe work and solid fuel boilers and will not realize that such methods are becoming more and more out of date and costly for many installations. In my own case the financial bogy has already struck, with the cost of coal north of the Grampians at £9 a ton. However it is not as a Prophet of Doom that I write, but rather as an Apostle of Comfort. Electricity in the Highlands, thanks to the activities of the North of Scotland Hydro-Electricity Board, was relatively cheap and therein lay my future warmth. Now with the latest, but by no means final increase in the cost of coal comes the news for the South that atomic power stations will within a decade generate electricity at approximately 0.6d. per kW. This should at least point the way to the "shape of things to come" and while we wait for the advent of atomic power, a rich harvest of data and experience can now be harvested by utilizing the large programme of new construction and barrack modernization at present planned for Caledonia where, as I have suggested, conditions are even now favourable This programme of construction has not been equalled since General Wade littered the same area with his forts and barracks over 200 years ago. Although I would hesitate to guarantee to our new barracks the length of life achieved by some of Wade's structures, I certainly feel that it may be questionable policy to design their heating on the basis of solid fuel systems, which, though possibly just acceptably efficient and economical today, may in the course of a small fraction of the life of the buildings, be reckoned wasteful and expensive.

It is in the field of space heating that most advances can be made and particularly in the use of electricity. One system which I suggest for fuller investigation and even large scale trials is that of electrical low temperature radiant heating and in particular as applied to floor warming. There are of course many other methods using this form of heat, such as wall panels and ceiling panels, but I prefer to consider them only as possible ancillaries, to be used where it is not feasible to install all the required heating in the floor.

Before you can understand how it is that an electrically heated floor can keep you comfortably warm without burning a hole in either your bank balance or your shoes, it would be well to take a look at the problem of keeping warm in general. This involves considering why one feels cold. Until I began to get involved in all these investigations I don't think I ever gave this much thought. I just turned up my collar and stamped about and cursed and, like any other Highland cateran, accepted my sad condition as a visitation of Providence capable only of mitigation by a bowl of soup or a nip of whisky, or both. This of course was an unscientific view. Science, after plugging away at it for years, has at last persuaded me that I feel cold because by body is giving off heat. In the course of keeping me more or less alive, my body generates quite an amount of heat which it dissipates into the surrounding atmosphere, and I will continue to feel cold until the loss is made good. This, I learn, I can do either by surrounding myself with a mass of warm air or by radiating heat right back at my body. Conventional central heating practice almost invariably uses the warm air principle with convected heat, but the alternative is, as I have said, radiation. Radiant heat is like light or sound, a transmission of energy in the form of wave motion and consequently can pass through air without materially altering the air-temperature. A certain amount of air, of course, is in direct contact with the heat source and this air will naturally be warmed by conduction, but about half of the heating effect comes from direct radiation. As everyone knows who has crouched over an electric fire in a big room, there is small comfort outside the actual beam. General heat does eventually become perceptible through the circulation of air over the red hot element and over the warmed surfaces of objects on which the beam falls, which as they warm up, also become secondary radiators themselves. But a lot of current is used up in that time; hence the immediate reaction of "But look at the expense!" when electrical space heating is mentioned.

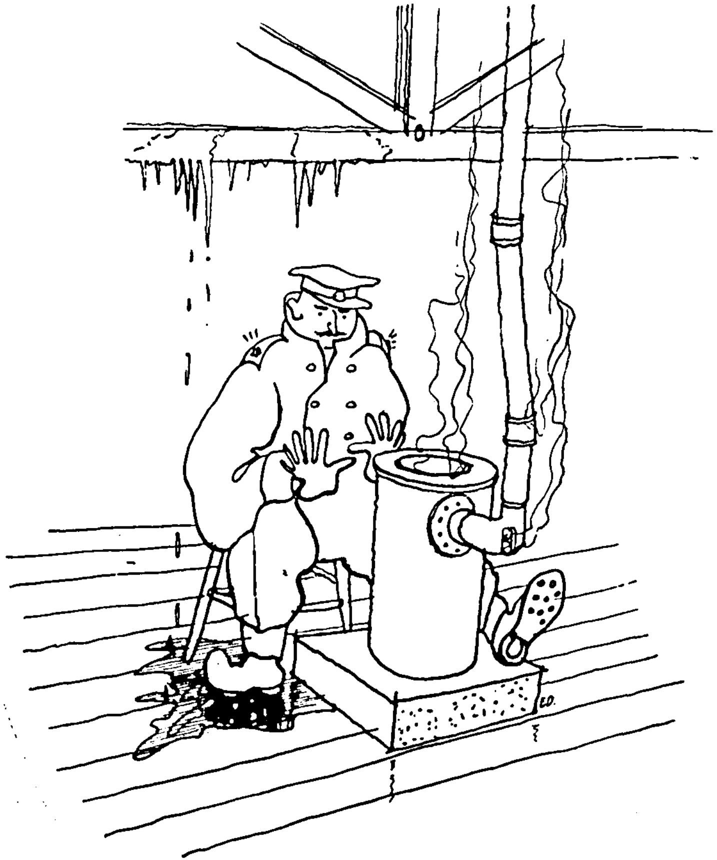
Space heating by floor warming is not new. It was used by the Koreans 4,000–5,000 years ago. It was also in use extensively in the Roman era some 3,000 years later and even today some examples of their systems can be seen in the remains of Roman dwellings. These wily ancients knew, what we have recently rediscovered, that a very large radiating surface at a low temperature provides as much heat as a small radiating surface at a high temperature and distributes it much more effectively. Floor heating using embedded hot water pipes of course has been used quite extensively in this country and elsewhere, but it is an expensive system although a more economical future may lie in the wider adaption of the heat pump to such a use. Even this latter method cannot yet compete for installation costs with electrical floor warming.

It was natural that this low temperature radiant system of heating should have been adapted for operation by electricity, for an electrical resistance-element is the most direct way of turning energy into radiant heat, and if a low temperature only is required, the element will last indefinitely. Since a solid floor absorbs a lot of heat, to give it out by cooling later on—acting, in fact, as a heat accumulator—the system can also be designed to store heat at cheap off-peak rates and to bridge power cuts.

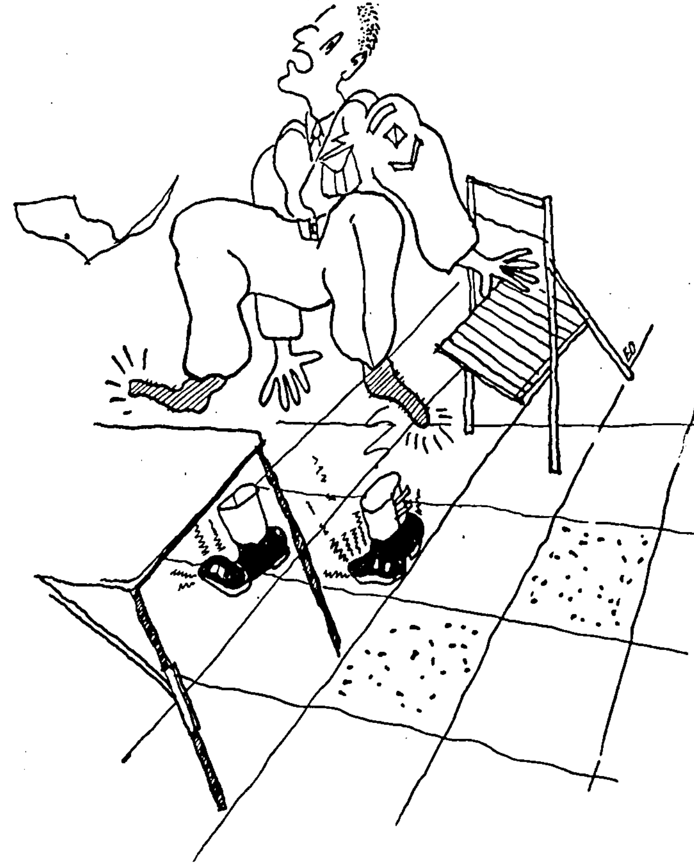
Although electrical floor heating was first tried out in some private houses in London before the war, it has only recently come into widespread favour, and moreover, been economically justified. A large number of installations are now functioning in southern Scotland, including schools, factories, banks, warehouses, garages, shops, offices and canteens. A fair number are also operating in England, including one but a sabbath day's journey from the S.M.E. All these installations operate where "off peak" tariffs (sometimes with midday boost) cater specially for this type of consumption. It is however in the north of Scotland (in the Hydro Board's area) that the system has first been widely adopted for domestic use in private houses and local authority housing. This domestic example has now been followed in the south of Scotland by other local authorities, and recently Glasgow Corporation has announced that work would soon start on the first sixty of 390 electrically floor-heated dwellings. From my position north of the border I am unable to check the facts, but the *Electrical Review* of September, 1954, stated that most of the development in this field was being carried out in Scotland, and a recent issue of a New York electrical journal particularly commended the remarkable progress which, it said, was ahead of U.S. Although I would refute the suggestion that the Highlander is lazy, there's a lot to be said for the man who prefers to let the rain, which falls so liberally around him, warm his house instead of stoking the fires himself.

It is not intended in this article to go into technical details which are now becoming readily available elsewhere. It is sufficient here to say that the basis of electric floor heating is the spreading of a heating cable uniformly over a solid floor slab with or without a wire mesh distributor and then covering it with a top screed. There are at the moment four types of cable installations, all proprietary products and some covered by patents, and they vary in price for a complete installation including thermostatic control from 3s. 6d. to 6s. per square foot. A floor temperature of not exceeding 73° is aimed at to give an equivalent air temperature of 65° and the loading requirements generally vary between 10 and 15 watts per square foot. The latter figure would be more suitable for rooms where one is at rest, i.e., sitting-rooms, but these rule-of-thumb figures are given only as a rough indication. Calculation of the correct loading is vital and of course depends on many factors, but the crucial mid-point must be achieved between a floor that is too cool to be effective and one that keeps you hopping like a cat on hot bricks.

In some of the examples I have seen the floor heating was laid on the ground floor only and although the first floor was of concrete construction, it was used as a secondary radiator only, i.e., by absorbing heat through the ground floor ceiling and then re-radiating it in the bedrooms. Thermostatic control in the bedrooms is of course not possible in such conditions and although the chill is undoubtedly removed, additional topping up by panel fires should be resorted to. The electrical system is capable of installation in normal wooden floors, but is not however recommended as it entails difficulties over fresh kiln-dried boarding and low moisture content sand packing. For the remainder of this article I shall consider ground floor



The British attitude to winter



Like a cat on hot bricks

installations only, as I think this most nearly meets the War Department's requirements and it entails less structural modification to existing designs for housing. Undoubtedly in barrack blocks, where concrete floors are laid for two or three storeys, floor heating on each floor would be essential.

The effect of a heated floor on floor covering has often been questioned, but recent exhaustive tests carried out in an installation at Falkirk, with the co-operation of the various manufacturers, have shown that the normal finishes, e.g., cork tiles, Accotile, P.V.C., Semastic tiles, heavy linoleums etc., have given every satisfaction. I have also inspected a house where close carpeting was laid direct over the concrete screed, with excellent results.

I feel that it would be as well at this stage to list some of the advantages of an electric floor heating system as I see them and have discussed them with users:—

(i) Building is considerably simplified by the elimination of chimneys, flues, fireplaces, boilers and fuel storage.

(ii) The heating system is completely out of sight and the floor and wall spaces are unobstructed in any way.

(iii) There is no danger of burning to children or furniture. (Reduced insurance rates?)

(iv) Floor warming enables a building to be heated in the most efficient and economical way as the heating is uniformly distributed over the whole floor and is greatest in the room where it is most needed, i.e., at one's feet.

(v) Internal decoration lasts longer than with an open coal fire or even with a convected heat system.

(vi) It is cheaper to install and is generally cheaper to operate than any other comparable heating system.

(vii) It possesses all the general advantages associated with the use of electricity in that no labour costs are involved in delivering and handling the fuel or in maintaining equipment such as boilers.

(viii) Smoke, dust and grit from the handling of coal, coke or ash are completely eliminated.

(ix) By using radiant heat and a relatively low air temperature healthier conditions are produced, and rooms are draught-free.

(x) It maintains the house or building at an adequate temperature to prevent freezing up of pipes, taps and rising mains, hence reduces maintenance costs and repair costs. (I had thirteen burst pipes during one winter in my last W.D. quarter.)

(xi) The ease of installation and the location of the heating element means that the heat can be switched on in a new building as soon as, or before, the plasterer has finished and the "dry" trades following, i.e., joiner and painter, can move faster. This obviously speeds construction and may reduce costs.

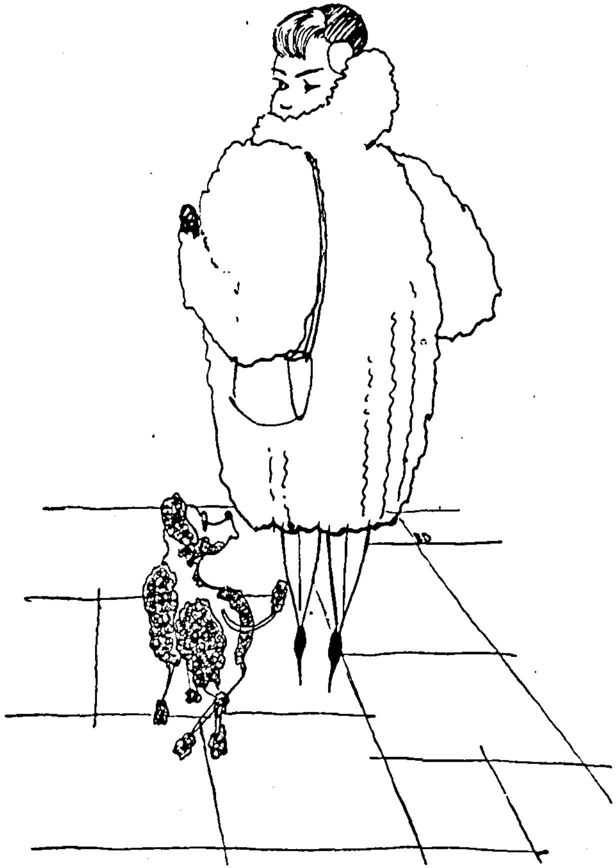
Undoubtedly these days the most important single factor to the War Department (or to any other authority for that matter) when considering such an installation is that of costs. Taking capital or installation costs first, it is here that the electrical floor heating system scores most heavily. To build a Group IV Quarter as an all-electric house would cost *no more* than the present standard one, because the cost of the heating installation can be offset by the savings achieved by omitting chimneys, flues, fire-places, solid fuel boiler, L.P.H.W. radiators and piping and also the fuel store. It might even show a slight saving if adequate thermal insulation was already allowed for. The installation, therefore, as I see it for W.D. housing will mean that the living space, i.e., hall, dining-room, sitting-room and kitchen, are at all times adequately heated and independently thermostatically controlled. The upper floor will be heated by limited secondary radiation plus some convected heat (as air temperatures rise) through the stairwell and will be topped up by electric fires or even by radiant panel heaters embedded in the walls. But to ensure that installation costs are cut to a minimum, the electrification must be carried to its logical conclusion. The hot water must be electrically heated in a system expressly designed for use of electricity (and not as is regrettably so often done—merely by plugging an immersion heater into the hot water tank of a solid fuel system). Cooking must be by electricity and provision made for electric laundry facilities instead of the present gas ones. In other words we deal with one "Utility" only, as the Americans say, and thus cut separate service installation costs and time wasted in drawing up additional agreements.

When setting down the advantages of electric floor heating above, I was primarily considering W.D. housing but it is obvious, if you turn back, that most of the advantages apply equally to much larger installations, such as a complete all-electric barracks. Compared with a conventional heating scheme for barracks the all-electric costs are extremely favourable and figures for large comparable civilian schemes so far show savings of as much as 40–50 per cent. The need for boiler-houses, chimneys, fuel yards, steam piping, condensate piping, ducting and radiators is eliminated. That the resultant barracks will look considerably better and cleaner goes without saying.

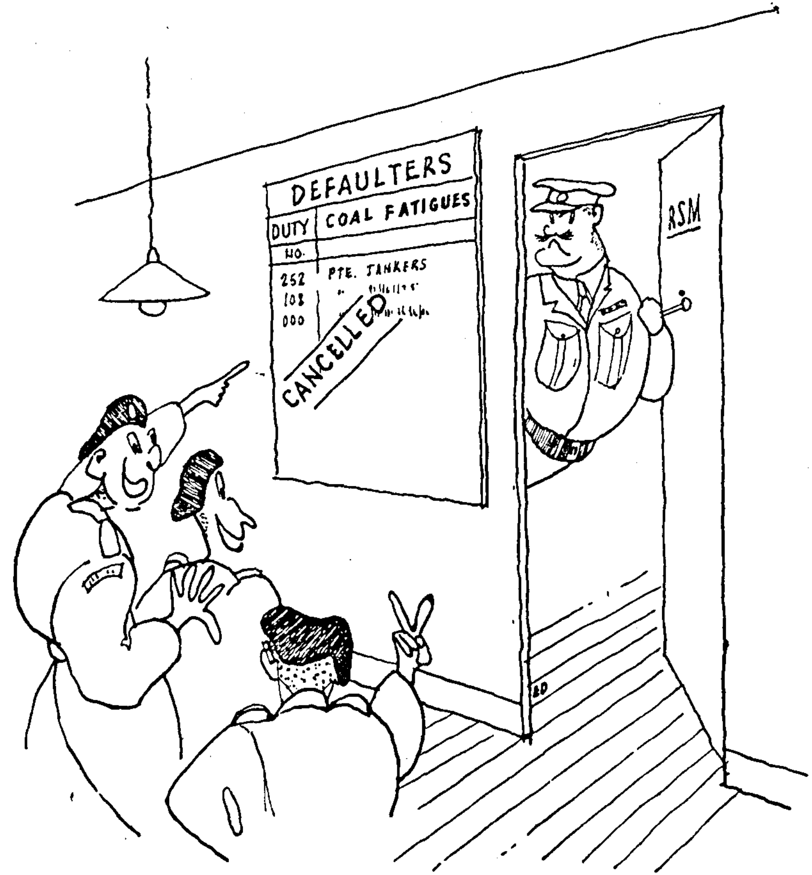
It may be argued that a floor heating scheme postulates a higher standard of comfort than is normally catered for in W.D. housing, and that if we've survived so far, then why change? But, apart from high solid fuel costs and shortages, why not improve? It is known that the capital costs are at least comparable with the construction of the present standard designs and moreover leave a superb bonus to be divided equally between the occupant, in the added comfort inherent in such a system, and the War Department in the form of the goodwill and satisfaction of the customer!

Turning to operating costs. Although this, in the case of housing, is to a large extent not reckonable in Treasury budgets and outlay, it must, nevertheless, if we are to maintain the goodwill etc. of the customer, be well within the scope of his carefully calculated emoluments. Let me quote some examples. One private house I looked through in Inverness was comparable to a rather roomy "C" type M.S.Q., i.e., three bedrooms, living-room with dining annexe and kitchen. Floor heating was installed in the ground floor only and the bedrooms had electric fires. The estimated annual consumption of electricity for cooking, space heating, lighting, hot water, washing and ironing was £60, and the actual cost for the year 1954 was £46. A comparable figure using solid fuel for hot water and (very limited) space heating; electricity for lighting and gas for cooking and washing is, at W.D. subsidized rates for the same period, about £54. I calculated that for a Group IV Quarter on an all-electric basis the annual operating cost would be approximately £60 and this figure certainly compared very favourably with my own, admittedly old but solid, Group IV Quarter where the total conventional "mixed fuel" costs, for little comfort, ran to nearly £90. It is difficult to give comparative costs with present solid fuel houses, because the standard of comfort in the electrically-heated houses is so much higher. But based on calculated heat losses and making these good by conventional means to maintain a room temperature within the comfort zone in a Standard Group IV Quarter, the theoretical fuel consumption for all purposes would be here in the north £136 at civilian rates or £101 at W.D. rates. I say theoretical because it is extremely doubtful, with the thermal efficiency of the average domestic fire, if it could in fact be done. I should make it clear that in calculating operating costs for housing I have used the Hydro-Electric Board's winter tariff which, after allowing for normal consumption for lighting, cooking, etc., was basically 0.6d. per unit for heating throughout the day or night with no "off-peak" periods. This is roughly equivalent to what we may expect from atomically generated power.

For larger installations such as a barracks, the cook-houses and hot water for ablutions should also be electrified. Annual operating costs must, of course, be calculated on industrial tariffs. Here the basis of charges differs from the domestic rate and the maximum peak load is involved which necessitates, for economy, a careful staggering during the day of individual peaks for water heating, space heating and cooking. Figures produced for an earlier test case show that the operating costs at *present rates* would be one-and-a-half to two times that for the conventional barracks heating and cooking. But the initial saving in capital costs would cover the difference in operating costs for nine or ten years, by which time, in view of present tendencies, an entirely new relationship between solid fuel and electricity rates will have been established. Finally, on the



Insulation is the crux



Eliminating all coal fatigues

financial side there are the maintenance costs. I have touched on some of the savings already—plumber repairs and boiler replacements, but I must add the elimination of chimney sweeping, lower painting costs for the W.D., savings to occupant in cleaning of furnishings, etc. I am sure other economics will also occur to a reflective mind.

The snags of an electric floor-heating system or even anything electric have already often been ventilated. Firstly the chap who wants a coal fire to gather round with his family as a central altar in his sitting-room, in spite of its ensuing dirt, labour and occupation of valuable space. Well, this is largely psychological and can be remedied by education. In any case the T.V. set has largely supplanted the fireplace now as the centre of attraction. Another complaint is "nowhere to burn the rubbish". I have lived for years in houses where such was the case and with even less adequate refuse collection than we enjoy in most places in this country, and cannot really consider this as a detrimental factor. Anyhow, Barrack Synopsis may yet be amended to include an electric garbage disposer for each kitchen sink. There are some tricky things to dispose of, but even individual incinerators can be incorporated in each quarter for approximately £7 a time. It has also been suggested that previous schemes of district heating have proved uneconomic and had to be curtailed because the occupants tend rapidly to require a far higher standard of comfort than that to which they were previously accustomed, or for which the system had been designed. But where the consumer pays directly for what he consumes as in floor heating and whisky, he soon finds his own economic level. In a barrack installation all heating control would be automatically time switched, or thermostatically controlled out of reach of the troops. And finally there was the officer who, when I regaled him with tales of manpower saved by eliminating all coal fatigues around barracks, said in horror, "Good God, man, you can't do that. We'd never find any jobs for the men."

I realize that any quasi-technical article submitted to the *Journal* should be liberally sprinkled with tables and graphs. Many of these have been produced in the course of the last year or so, but for the sake of space, one only must suffice. This table shows comparative costs for an all-electric barracks as compared with one equipped on more conventional lines. The same barracks (which is due for modernization shortly) has been used in each case so that any assumptions made regarding designs not yet settled apply equally to both estimates.

To conclude. Thousands of people are using electric floor heating, not just a few affluent and comfort-minded citizens, but efficient industrial firms who, whatever they produce, also have to make profits. Hard headed local authorities are also seeing the light for housing, schools and hospitals. At the moment, owing to the high coal costs, the north of Scotland is the most favourable area for such electrical development and could easily, with the present constructional programme, be the scene of the first all-electric barracks. A recent radio speaker stated that coal is rapidly becoming a precious substance to be used, firstly where no other fuel or material will suit, or secondly where it can be burned with the maximum thermal efficiency—as in a large modern power station. I am not convinced that the burning of it in married quarters and barracks even comes today into either of these categories.

APPENDIX

Comparison of Costs for Modernization of a Barracks in Scotland, including provision of District Heating by (i) Conventional means and (ii) all-electrically. Constructional items are not shown.

Assumptions

1. The Barracks to consist of an infantry depot, a R.E.M.E. Command Workshop, and R.A.S.C. Supply Depot, the Garrison Engineer's Offices, a Garrison Chapel and Education Centre and a T.A. Centre. No district heating has been allowed for M.O.Qs. and M.S.Qs.

2. At present only the depot buildings exist, but an additional barrack block, together with a new cookhouse and small ancillary buildings are required to bring the depot up to scale. All other buildings required as in para. 1 above to be provided in permanent construction.

3. Calculations for the conventional system have been based on existing schemes and on D.F.W.T.Is. Equipment throughout, e.g., lighting, cooking etc. is up to Barrack Synopsis Scales (1948).

	Conventional	*All-electric (a)*	
Initial Costs	(*A*)	(*B*)	(*C*)
	£	£	£
(i) Space heating (approx. 2 million cu. ft.) } (ii) Hot water supply }	86,530	28,793	31,665 (*b*)
(ii) Hot water supply		2,519	2,519
(iii) Boiler house, coal and coke yard	9,405	—	—
(iv) Cooking equipment	10,678 (*c*)	10,939	10,939
(v) Gas installation	300	—	—
(vi) Sub-station, transformers, external cables and capital contribution	5,700	15,600 (*f*)	15,600
	112,613	57,851	60,723
Annual Recurring Charges			
(i) Steam supply	10,523	—	—
(ii) Operating labour	1,290 (*d*)	—	—
(iii) Gas supply	963	—	—
(iv) Electricity supply	2,487	18,838	19,228
(v) Depreciation	3,106	3,133 (*e*)	2,749
(vi) Ash removal	75	—	—
	18,444	21,971	21,977

Explanatory Notes

(*a*) Two scales are shown under "all-electric"—*B:* where convection heaters have been used throughout in existing buildings and *C:* where floor heating has been installed in ground floors of existing buildings with convection heaters on upper storeys.

(*b*) This includes £4,500 for structural alteration to existing ground floors to take floor heating.

(*c*) Cooking in conventional scheme is by gas and steam. It is not thought that in any barrack modernization solid fuel cooking would be continued.

(*d*) No figure has been included here to allow for military coal fatigues.

(*e*) Depreciation is calculated thus:—

2 per cent on conventional heating and floor heating.
10 per cent on convection heating.
10 per cent on cookhouse equipment.

(*f*) Compiled from D.F.W's. "E. and M. Yardsticks".

Summary

Scheme "*B*"

Comparison with conventional barracks

Difference in initial costs = − £54,762
Difference in recurring charges = + £3,527

∴ Number of years before all-electric exceeds cost of conventional system = Approx. 15 years.

Scheme "*C*"

Comparison with conventional barracks

Difference in initial costs = − £51,890
Difference in recurring charges = + £3,533

∴ Number of years before all-electric exceeds cost of conventional system = Approx. 14 years.

No account of interest on initial capital savings has been taken.

Note.—The figures given in this Appendix are based on those in force in June, 1956, but those used in the article itself are based on figures for 1954, when it was written.

Acknowledgements

I should have liked to say, like the pavement artist, that this is all my own work. Obviously it isn't. Much has been culled from the pages of *Building Industries and Scottish Architect* and some from the *Electrical Review*. But my thanks are really due to Messrs. Moule and Stevenson of the South of Scotland Electricity Board, to Messrs. Gauldie and Wright, Architects, of Dundee, to N. A. S. Campbell, Esq., and other officials of the North of Scotland Hydro-Electricity Board, to J. Blackburn, Esq., A.R.I.B.A., Burgh Architect of Inverness, and to my long-suffering E. and M. Staff at Highland District.

The sketches were drawn by Sergeant E. Duncan, R.E.

MEMOIRS

COLONEL M. STAGG, O.B.E.

MONTAGU STAGG was born on 4th November, 1886, educated at Berkhamstead School and the R.M.A. Woolwich, and was commissioned in the Corps in July, 1905.

After the usual course at the S.M.E. Chatham, and qualifying in addition in musketry and defence electric lighting, he joined the 6th (Fortress) Company at Weymouth, and in 1908 was with the 41st (Fortress) Company at Singapore.

In 1912 he married Miss Violet Mainwaring, who survives him with three of their four children.

In that year also he joined the 3rd Sappers and Miners in India, and was posted to command the section at Aden.

He served throughout the 1914-18 War in the Aden Field Force, and at General Headquarters, India, being mentioned in despatches and awarded the O.B.E. for war services.

In 1920 he joined the Indian Mints as Deputy Mint Master, Calcutta, and was confirmed in the appointment of Master of the Mint, Calcutta, in 1926, and he held this till he retired in 1940.

Promoted Major in 1922, Lieut.-Colonel in 1930 and Colonel in 1934, he finally left India in 1938 on long leave pending retirement, to live at Swanage.

At the outbreak of the 1939-45 War, he volunteered for A.R.P. work, and in 1940 he joined the Home Guard, commanding the Swanage platoon until the end of the war.

He was untiring in his support of local associations, including the Parochial Church Council, the Isle of Purbeck Hospitals Aid Association, the Purbeck Society, and above all, the British Legion, and what time he had left from these various causes, he devoted to his garden.

The British Legion, however, was his main interest, and as Secretary of the Services Committee, he did outstanding work until his health failed.

The Legion was strongly represented at his Memorial Service at All Saints Church, New Swanage, where the Swanage Legion Standards were taken to the church, and another British Legion member stood escort to the urn which contained his ashes.

Stagg was one of those who form the backbone of the Corps. Although in a civilian appointment for many years, he was intensely interested in all Corps affairs, and a deeply religious man. He always kept up to date in military matters and when he did a course at the Senior Officers School after more than twelve years of duty at the Mint, he astonished his instructors with his military knowledge. It was this capacity to combine both civil and military duties which made him an outstanding personality. A.J.R.

MAJOR-GENERAL P. J. MACKESY, C.B., D.S.O., M.C.

(The following notice is reprinted by permission from *The Times* of 11th June, 1956.)

PIERSE JOSEPH MACKESY was born on April 5, 1883, the younger son of the late Lieutenant-General W. H. Mackesy of the Bengal Staff Corps. He was educated at St. Paul's School and the Royal Military Academy, Woolwich, and was commissioned in the Royal Engineers on August 23, 1902. In 1911 he was selected for survey duty under the Colonial Office in the Gold Coast, and carried out surveys in Ashanti and the Northern Territories until appointed Deputy Director of Surveys, Gold Coast in 1913. He was promoted captain in the same year.

On the outbreak of war in 1914 he was immediately given the task of getting together an many horses as he could on which to mount police and others to swell the force that set off to Togoland and the Cameroons. He served with this expedition until he fell sick at the end of the year and was sent back to Accra, where he tidied up the survey office before being invalided back to England. He later served in France with the 15th and 1st Divisions. In the spring of 1918 he went to the staff course at Cambridge but was out again in France soon after the German attack in March, as a G.S.O.2, first at VI Corps and then at General Headquarters.

He was next at Murmansk as a staff officer and, on the withdrawal of the forces from North Russia, he joined the military mission to Denikin in the Black Sea. Soon after his return home in 1920, he went to the Staff College at Camberley. In the spring of 1935 he took over command of the 3rd Infantry Brigade at Bordon, and took the brigade out when the 1st Division went to Palestine. He was promoted Major-General in 1937. He returned to England early the following year to command the 49th (West Riding) Division of the Territorial Army at York and was created a C.B. In 1939 he was sent to the Defence Conference in New Zealand, and remained, at the request of the New Zealand Government, to advise on their Defence Forces. He returned to this country, and the outbreak of war found him with his Territorial Division to embody and train.

When the Germans invaded Norway in April, 1940, he was designated commander of the land forces destined for Narvik. On April 15, Admiral of the Fleet Lord Cork and Orrery, the Naval Commander, met Mackesy at Harstad, where the expedition had landed. It was at once evident that the two commanders took opposite views of the task ahead. Lord Cork, who had received his orders in London in talks with the First Sea Lord and a final chat with the First Lord, Mr. Winston Churchill, in his car on the way to the House, was quite clear that an immediate assault on Narvik should be staged, shaken as it must be by the action of the destroyers two days before: Mackesy was equally clear that his instructions did not warrant an opposed landing for which, without artillery, mortar ammunition or landing craft, his force was not prepared, and argued stubbornly that in the appalling snow conditions against unsilenced machine-guns, the outcome would be disaster.

Lord Cork was placed in supreme command at Narvik on April 21, but after a personal experience of the snow ashore, accepted the advice of both naval and military officers not to order an attack. An experimental bombardment on April 24, after four days of blizzard, disappointed both Lord Cork and Mackesy, but the same day news came that a half brigade of Chasseurs Alpins was leaving Scapa. This allowed Mackesy to plan his alternative attack, to assault Narvik by land from the north and from the south. Preliminary moves took place, but by the first week of May Lord Cork and he agreed that the Guards Brigade should be sent south to stem the German advance, leaving the Chasseurs Alpins, who were suitably trained troops, to carry out this plan. On May 7 Mackesy considered the time ripe for the attack on Ojford, but Lord Cork put this off to May 12.

When General Auchinleck, who had been appointed as Corps Commander on April 28, arrived at Narvik he exercised the discretion given him by the C.I.G.S. to assume command at once under Lord Cork. Macksey returned to England and was placed on the retired list in July although re-employed at the War Office for the remainder of the year. In the spring of 1941 he went to the offices of the War Cabinet and, with a small staff from the three services, carried out a study of possible enemy operations. This was his last official employment. For a year he was Military Correspondent to the *Daily Telegraph*, and then retired to his home at Southwold to busy himself in local government. He was elected to the borough council in 1945 and was Mayor of the Royal Borough of Southwold four years in succession from 1949. He was elected to the East Suffolk County Council in 1949.

He was a soldier of wide experience and had a full career of successful achievement as a regimental officer, a staff officer, and a commander before he came into the public eye as the commander of the land forces in the expedition to Narvik in April, 1940.

A man of trained intelligence, with wide interests, he will be remembered as a loyal and steadfast friend, an entertaining and cheerful companion, and a man of great courage and integrity.

Mrs. Jocelyn Howard, the Secretary of the East Suffolk Branch of S.S.A.F.A., wrote in *The Times* of 14th June, 1956, as follows:—

"I would be glad if you would allow me to pay my tribute to Major-General P. J. Mackesy's work for the Soldiers', Sailors' and

Airmen's Families Association in East Suffolk. Throughout his life as a serving soldier he had great knowledge, understanding and complete sympathy with S.S.A.F.A., and its work. On his retirement he undertook and carried out with great success the financial changes necessitated by the transition from war to peace conditions in this branch. In spite of his endless public duties as borough councillor, Mayor of Southwold, and county councillor, the work of S.S.A.F.A. was his everyday concern.

"His official position was county honorary treasurer, but in reality he was the mainspring of all S.S.A.F.A.'s work in the county. Last year, when his life was despaired of, I made arrangements for someone else to take over his job. Both his wife and I hoped he would then retire and give up work, which, in his failing health, was becoming a burden. We might have known better! Long before he was fit for it he was back in the saddle, and he died with his little tin box, in which were all his precious S.S.A.F.A. papers, under his bed, from which the day before he died he had dispatched the necessary cheques.

"His heart was irrevocably given to the old, the ill, the children, the young, the bewildered and often the plain muddlers, among the Service families, who for one reason or another though in trouble could not be helped by our welfare State, or by the other benevolent funds. Although in incessant pain from his arthritis, he was always ready to listen to the troubles of others, to advise and to help. The sight of his short, lame figure, stick in hand, and two beloved Cairns on leads will be missed not only by us who were privileged to be his friends but by very many of those he helped in East Suffolk and who have cause to bless him and mourn his passing."

He died suddenly in the Isle of Wight on 8th June, 1956, at the age of 73.

He married, in 1923, Dorothy, the only daughter of James Cook, of Enfield, Cults, Aberdeenshire, who is known as a novelist under her pen name of Leonora Starr. She survives him with two sons of the marriage.

Major-General P J Mackesy CB DSO MC

Colonel S W Sackville Hamilton DSO MBE.

COLONEL S. W. SACKVILLE HAMILTON, D.S.O., M.B.E.

SACKVILLE WILLIAM SACKVILLE HAMILTON was born on the 3rd November, 1882, the eldest son of Sackville Berkeley Hamilton, a former Deputy Inspector General of the Royal Irish Constabulary and a cadet of one of the most ancient and distinguished Anglo-Irish families. His mother was a daughter of the late General Charles Annesley Benson. Sack, as he was called by his many friends, passed into the "Shop" in the summer of 1899, joining at Woolwich at the beginning of 1900 and receiving his commission in July, 1901. On completing two years at Chatham he was posted to India and soon after joined the Survey of India in which, with the exception of World War I and a tour of duty at the R.M.A. as Chief Instructor, he served throughout his career.

On the outbreak of war in 1914, Sack was sent home from India and served with high distinction in France, where he made a great reputation for his exploits in the front line trenches with the 70th and 90th Field Companies. He was three times mentioned in despatches, received the D.S.O. and bar and was selected for employment as a General Staff Officer, but this work was not active enough for his ardent spirit and, at his own request, he returned to take command of a field company in the front line.

For a short time after the armistice he was a Chief Instructor at Woolwich but, though his fighting record would have insured him a military career at home, his early love called him and he returned to the Survey of India, becoming Director of Frontier Surveys in 1927 and officiating for some time as Surveyor-General. He retired in 1937 to Bayard House at Upwey in Dorset, but he was not left unemployed for long, in 1939 he was appointed Chief A.R.P. Officer for Dorset, a job he carried out with his usual apparently effortless efficiency.

In 1920 he made what was to be an ideally happy marriage with Margaret Dowell, only daughter of S. C. Hester of Laleham, Northdown in Thanet. He died on 11th May, 1956, and he leaves, besides his widow, two children, Lieut.-Colonel James Sackville-Hamilton, R.E., now a British Liaison Officer with the U.S.A. Army, and Anne, wife of David MacEwen, of Stuckeridge House, Oakford, Devon. His younger son, Peter, a most promising Naval officer, gave his life when piloting a Firefly in May, 1952.

Sack was not the man to rust in idleness and after the war he and Mrs. Sackville Hamilton travelled widely both in Africa and in the almost unexplored interior of British Guiana, including a 200-mile voyage in an open boat up the Barama River.

Sack had all the charm, the wayward gaiety and the flawless courage of his race and preserved to the end his striking good looks. His death will be deeply regretted, not only by his many old friends in the Services, but by the village of Upwey in which he took the keenest interest.

E. P. LeB.

R. G. PRICHARD, C.B.E.

RICHARD GRAHAM PRICHARD was serving in the Sudan as Assistant Director of Works at the outbreak of war in 1914, whence he returned to the U.K. and was granted an Emergency Commission in the Royal Engineers, being posted to the 131st Field Company as a Subaltern. He went with the Company to France in September, 1915. In November of the same year the Company, forming part of the 26th Division, was moved from France to Salonika.

In 1916, Prichard was made Second in Command of the Company, and in 1917 was posted to Command 108th Field Company until 1918 when he was promoted C.R.E. of the 26th Division, and was awarded the O.B.E.

On demobilization at the end of the war he returned to the Sudan P.W.D. and in 1920 was appointed Director of Works, Egypt, a post from which he resigned in 1926 due to acceleration of the policy of giving local appointments to Egyptians.

In 1928 the appointment of Civil Engineer in the Directorate of Fortification and Works, War Office, in connexion with the design of permanent fortification, became vacant, and for this Prichard was selected from a large number of candidates.

He joined the War Office at a time when the Coast Defences at home and abroad were being reorganized and modernized and the Singapore defences planned. He therefore started his new job at a most important time, when his engineering experience combined with his war experience in the Corps were to prove of the utmost value throughout the Empire.

During the recent war he made his contribution to anti-aircraft defence and radar.

His personality made him universally popular, while his ability, sound judgement and appreciation of the difficulties of others, led to his advice being sought on an ever increasing scale.

His work at the War Office was recognized by the award of the C.B.E. at the termination of hostilities.

Prichard resigned his appointment, on account of ill health, on 1st November, 1955, after a total of thirty-two year's service either in the Corps or in the D.F.W's. office at the War Office, and so was well known to many officers of the Corps.

He died on 17th March, 1956, and leaves a widow to whom our sympathy is extended.

E.J.B.B.

BOOK REVIEWS

OKINAWA—VICTORY IN THE PACIFIC

(Published by the Historical Branch—H.Q. U.S. Marine Corps)

This fifteenth monograph of the Historical Branch U.S. Marine Corps gives a detailed account of the last and biggest of the "island-hopping" operations of the U.S.A. in the Central Pacific. Okinawa, in the Rynkyns islands, lies 325 miles south-west of Japan and 500 miles north-east of Formosa. Its capture by the U.S.A. was destined virtually to end the Pacific War. Sixty-five miles long and divided into two parts by a narrow isthmus, it had half a million inhabitants, most of whom lived in the richer southern half of the island. The geographical position of the airfields of Okinawa made it supremely important for the U.S. approach to Japan across the Central Pacific. It proved a hard nut to crack. The Japanese Thirty-Second Army consisted of two infantry divisions and a mixed brigade, which artillery and supporting arms brought up to a strength of about 100,000 men. The U.S. Tenth Army, commanded by Lieut.-General Buckner, attacked southern Okinawa from the east in the grand manner with four divisions abreast on 1st April, 1945. Seven U.S. divisions in all were landed before the end came on 21st June. The U.S. Commanding General was killed almost at the moment of victory. The American losses were 7,374 dead and 31,807 wounded, of which the share of the Marine Amphibious Corps of two divisions and supporting troops was about one half. The Japanese fought with their customary devotion. Over 130,000 of them were killed, of which about 42,000 were civilians: prisoners numbered only 10,755. The two senior Japanese generals committed hara-kiri—Japanese Karin Kaze (suicide) aircraft, to the number of 135, sank 24 U.S. ships of various kinds and caused 500 casualties. The great battleship *Yamato* (31,000 tons), which had fuel sufficient only to get her to Okinawa, was set upon by 380 U.S. planes and finished off in one hour at a cost of ten U.S. aircraft and sixteen U.S. lives. Altogether it was a famous victory. Notable points are that escort carriers supplied most of the air support and that a Corps of two divisions has no margin for resting and refitting. Amongst many magnificent photographs, it is pleasing to see one of a Bailey bridge. A list of abbreviations would be helpful. A fine tale, well told. B.T.W.

SOLDIER'S GLORY

By Sir George Bell

with a foreword by Sir Arthur Bryant

(Published by G. Bell & Sons, Ltd. Price 21s.)

In *1811* when he joined the 34th Foot (now the Border Regt.) as an ensign, George Bell started a diary, and he wrote in it almost daily for over fifty years. *Soldier's Glory* consists largely of extracts from the diary—notably those covering the Peninsular War and the Crimea. He does not attempt to describe the course of a battle or a campaign; he writes of what he himself saw and experienced; and in so doing he unconsciously reveals himself as a delightful personality, and a remarkably fine soldier.

The first half of the book describes Bell's experiences as a subaltern in the Peninsular War. His accounts of famous events, such as those describing the appalling scenes after the Fall of Badajoz, must be unique in their authority, for they were written on the spot. He introduces us to unforgettable characters such as Biddy Skiddy who, on her donkey, led the "multitude of soldiers' wives—averse to all military discipline". And to Quill the doctor who, for a bet, "touched" the Duke of Wellington for the loan of a pound. At Vittoria, Bell came upon King Joseph Bonaparte's baggage wagons being looted (their contents included the enormously valuable collection of pictures now at Apsley House, Piccadilly). Bell, who had a great liking for his food (it was to get him into trouble many years later), could not resist a cold fowl and a flask of wine—"the sum total of the plunder I touched that day". Altogether, Subaltern Bell got a lot of fun out of the war in Spain; and he writes so well that the reader shares in it.

The Crimea was not such fun. For one thing Bell, who was now Commanding the 1st Foot (Royal Scots), was over 60 years of age; for another, there was no "Iron Duke".

Readers of Miss Woodham Smith's *The Reason Why* may have gained the impression that senior officers campaigned luxuriously in the Crimea. (She recounts for instance how Lord Cardigan, at Balaclava returned each night to a champagne dinner and a soft bed on his yacht.) Colonel Bell as often as not collected his own fuel, made his own fire and cooked his own dinner. For forty-six days at a stretch he never had a change of clothing, and slept each night in the open.

During the siege of Sebastopol, Bell commanded a brigade for a time, but was "de-moted" because of a letter he wrote to *The Times* suggesting that some decent food be sent out. He was forgiven later and eventually became a General.

Bell was a Commanding officer for over ten years and was greatly loved by his soldiers; "but any officer can be that," he says, "if he has common sense and the feelings of a Christian".

For his own men he provided education classes, recreation rooms, libraries and organized games—long before such things were officially authorized. He knew his soldiers by name and by sight and often their family histories. Most remarkable of all perhaps for those days, he never had a man flogged. He doubtless never heard of "man-management", but he knew how to command men. In his book, there are a good many side-lights on this subject and on this score alone it should be of very great interest to serving officers. J.M.L.

CONCRETE MATERIALS AND PRACTICE

By L. J. Murdock

(Published by Edward Arnold (Publishers) Ltd. Price 40s.)

This book, comprising some 350 pages, provides an excellent broad outline of practice in all fields of concrete work, and is the second edition, the first having been published in 1948.

The chapter on mix design has been completely revised, and short chapters on Prestressed Concrete and Admixture have been included.

Much of the text is covered in M.E. Vol. XIV, Pt. I, but the revised chapter on mix design departs from the method set out in the M.E. volume, based on Road Note No. 4 produced by the Road Research Laboratory. As pointed out by the author good concrete can be produced using aggregate gradings deficient in the middle sizes, providing care is taken to prevent segregation. Again any change in the grading of the sand will produce greater influence on the mix than changes in the larger aggregate sizes. The revised method bases the mix design on consideration of a surface area factor, calculated from the sieve analysis of the aggregate and surface area coefficients. These are related by a number of curves and nomographs. This new system is regarded as superior to the older method because it has a wider application.

The book is exceptionally well illustrated, and particular attention has been made throughout to relate laboratory and site conditions. The defects common in concrete practice, their cause and prevention, are particularly well presented. A.J.L.

U.S. MARINE OPERATIONS IN KOREA, 1950–53
Vol. II. The Inchon–Seoul Operation

(Published by the Historical Branch U.S. Marine Corps, 1955
Price $2.50.)

The Korean War was notable for two great decisions. The first was that of President Truman when he at once decided to resist aggression on land, as well as by sea and in the air. The second was that of General MacArthur on 10th July in Tokio, when he decided that he would cut off the North Korean People's Army by a seaborne attack on Inchon–Seoul and so end the campaign. What is more, he fixed 15th September as the D day of his counterstroke. On 10th July the battle on land was already becoming desperate and many experienced observers thought that the South Korean Army and its backing of U.S. troops would be driven into the sea.

The readers of this interesting volume will note and admire the dogged way in which MacArthur stuck to his plan, in spite of severe conflicts of opinion, the 29-ft. tide and the tortuous channel through the mud flats of Inchon.

The 1st Marine Division under Major-General Smith duly carried out three landings at Inchon on 15th September. Within 24 hours General Smith established his command post on shore and pressed on to the capture of the airfield at Kimpo. He emerges as a tried and experienced commander, who was adept at dealing with impractical plans and bad orders. On 21st September the X Corps arrived on the mainland, but it is rather difficult to understand exactly how the Command arrangements worked. The 32nd Regiment of the 7th U.S. Infantry Division crossed the Han River and took part with the Marines in the capture of Seoul. On the 29th September, just over three months from the start of the Communist invasion, General MacArthur was able to stage a liberation ceremony in Seoul in the presence of President Syngman Rhee and other high officials.

The Marine Division handed over to the Eighth Army on the 7th October and reverted to Amphibious Group No. 1 for a possible attack on the east coast port of Wonsan, north of the 38th parallel. At that time the N.K.P.A. was so disrupted, that this operation seemed unlikely to be necessary.

Although the onslaught of the Marine Division was brilliantly successful, the enemy counter attack at Kimpo airfield and the first crossing of the Han River provided some tense moments. To the military engineer it seems curious that no pontoon bridge was available for over a week to span the Han River. The divisional casualty bill for the Inchon-Seoul operation was 2,450, of which 415 died. Thanks to surgical teams landed on the beaches, a wounded Marine's chance of survival was 199 to 1, which is a pleasing piece of information. Vol. II does not read quite so clearly as Vol. I. No doubt the orderly confusion of a landing is difficult to sort out, when it comes to describing it on paper. The photographs are superb. B.T.W.

TECHNICAL NOTES

CIVIL ENGINEERING

Notes from *Civil Engineering*, February, 1956

THE FORMATION OF SAND DUNES AS A MEANS OF COASTAL PROTECTION

The erosion by the sea in the Estuary of the River Exe between Exeter and Dawlish Warren had begun to endanger the railway running along the shore of the estuary. Examination of old records proved that the shape of Dawlish Warren had been undergoing considerable change for a long period.

Based on the war-time research of Brigadier R. A. Bagnold on the theoretical aspects of sand movement, and field investigation carried out in the area; it was established that:—

(*a*) The direction and speed of the wind was favourable for the formation of dunes.

(*b*) Conducive conditions existed for assuring a natural supply of sand.

(*c*) There was an optimum size and shape of fence suitable for the formation of dunes.

The theoretical considerations proved that for the sand, and average wind conditions in this region, a fence 3 ft. high with a density ratio of 45 per cent, would deposit 80 per cent of the transported sand. The density ratio is defined as the ratio of the frontal area of the material of the fence to the total frontal area.

Fences formed from stiff shrubs or brush were arranged in a stair leg pattern roughly parallel to the coast and approximately at right angles to the predominant wind; when these fences were covered up, new fences were planted slightly to windward of the earlier fences until the desired height of dune was achieved. In this way a dune 20 ft. high along the length of the coast was achieved. It was found to be essential to protect the dunes during formation from strong winds by sowing grasses and lupins: the grass to bind the sand, and the lupins to provide constituents for grass growth. The article contains theoretical formula and diagrams showing relationship between dune shapes and fence types.

ORESUND BRIDGE SCHEME

Plans to connect Malmö in Sweden to Copenhagen in Denmark by bridge or tunnel were first mooted in 1936. The scheme was shelved as a result of the second World War; but two years ago a combination of six civil engineering firms resubmitted plans for the project. The paper is in two parts. The first reviews the economic factors to determine if there is a real demand for the scheme, if the scheme would be well founded from an economical point of view, and also the prospects of it being realized. The second part of the paper describes the scope of the work which consists of 11 miles of roadway, made up of 2 miles of tunnel and a multi-span bridge 4 miles long. The road is designed to take motor-cars only, on two traffic ways each 23 ft. wide divided into two lanes. The capacity of the road is estimated at 10 to 15 million vehicles per year; only 2 million vehicles per year are sufficient to make the scheme economical. The total cost is estimated at £22.5 millions. Diagrams included in the article show typical cross sections of tunnels, and embankments. The estimate of quantities of building materials is given.

Engineering Projects in West Africa

The opening up of West African countries has led to a programme of major engineering construction by their respective governments. The work is stated to be mainly concerned with development of new roads, bridges, and railways and latterly electrical power stations.

The first article in the series describes the problem of setting up a large power station deriving its power from steam fired boilers. It relates how the peculiar problem was solved of founding the large Ijora power station at Lagos on a low lying sandy site only 8 ft. above mean sea level with an almost fluid sub soil. Investigation showed that piles 100 ft. long would have had to be driven over the whole site if adequate foundations were to be provided.

An alternative solution was provided by constructing a reinforced concrete raft 250 × 200 ft. on the egg crate principle with cells 10 × 7 ft. and walls 15 in. thick; except at the perimeter where they were thickened to 18 in. The depth of the raft varies between 14 ft. and 16 ft. 6 in., and has an oversite slab of 18 in. deep with a top slab 15 in. thick which forms the floor of the building. The raft was designed as a sealed off buoyant mass, so that the weight of sand excavated was made approximately equal to the weight of the completed structure, which it is considered precludes the possibility of the building heaving.

Some idea of the complexity of the problem may be arrived at by considering that 2,500 tons of steel went into the raft, while only 1,650 tons went into beams and stanchions in the above ground building. The article is to be concluded.

Extracts from *Civil Engineering*, March, 1956

Local Effects of Concentrated Loads on Bridge Deck Slab Panels

The author draws attention to the problem of the effect on deck panels of vehicles with abnormal wheel loads. With the aid of expressions derived by Westergaard he shows how these results may be applied to determining the bending that may be experienced in a simple slab supported on main beams. He also shows how the ultimate strength of a slab panel, based on Johansen's yield line method, may be determined. Both cases of freely supported slabs and fixed ended slabs are considered.

Much of the work is simplified by the practical consideration that the load is not close to the boundary. This case is dismissed, since only those loads near the centre are likely to cause maximum stresses.

The rather surprising result is reached that the collapse load is given by:—

$$P = 4M_1 \left(\frac{l_1}{l}\right)$$

Where P = The collapse load.

M_1 = The moment of resistance per unit length of the slab about the axis parallel to l_1.

l_1 = Length of slab parallel to abutment.

l = Span between abutments.

It is pointed out that the ultimate load is independent of the absolute values of l and l_1.

The article is to be concluded.

The Influence Coefficient Method Applied to Design of a Steel Roof Structure

The article describes the step by step process of designing a large steel roof truss as a space frame using the notation of influence coefficients. The roof illustrated in the article has the aesthetically pleasing and highly useful feature that the interior of the building is unobstructed by lateral ties between the eaves.

The roof covering does not form an integral part of the stress system; but merely spans between transverse frames. The tendency of the frames to spread outwards is resisted on central frames by horizontal trusses. The end thrust of which is taken by ties provided within the gable ends.

The article includes a tabular method of arranging the calculation.

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, March, 1956.

Applications of High Alumina Cement

This paper contains some interesting figures relating to various mixes using high alumina cement. Besides outlining the origin and qualities of this material the author explains that, owing to its cost, its use is only justified where the requirement demands one of its main characteristics. These are stated as:—

(*a*) Great rapidity of hardening after normal setting time.

(*b*) Resistance to a wide variety of chemical agents.

(*c*) Production of a "refractory" concrete which can withstand white heat.

(*d*) Normal hardening in low temperatures without applying external heat.

"Refractory" and "insulating" concretes are contrasted and discussed in comparative detail.

Strain Gauge Analysis

The stress pattern and shock loads applicable to earth-moving plant are impossible to calculate in practice, and this paper gives an interesting example of the use of electrical strain gauges in design. Tests carried out on an overhead loader-dozer are described, and the results are summarized. The possibility of improving efficiency and reducing manufacturing costs, by using this testing technique, is clearly shown.

Automation to Date

Statements by M.P.s and opinions expressed in the daily press demonstrate a marked difference in interpreting the meaning of the term "automation". Every engineer, at least, should understand not only what the word means in general, but how its principles can be applied to groups or sequences of operations to create a continuous system or automatic batch production. The Editor of *Automation Magazine* (U.S.A.) defines automation as "manufacturing, processing or performing of services as automatically as economics permit or demand". The critical importance of the economic factor is clearly brought out throughout his interesting and informative paper, which provides a most valuable introduction to a fascinating subject. Automation is not merely an extension of ordinary mass-production techniques. Essentially, it applies principles evolved over many years. Quality is improved and maintained by automatic control of ingredients or components, and the essential simplification and improvement of component design usually also improves performance, uniformity and service life and reduces maintenance.

Automation is not a panacea. Great flexibility is possible in applying its principles and, as in many engineering problems, a compromise between mechanized and hand production and assembly may provide the most economical solution.

Highway Problems in Ontario

This description of methods adopted in Ontario to decide the principles of improving the provincial highway system is of particular interest in view of the congestion of many main routes in this country. Though not necessarily applicable here, some of the factors disclosed surprised the planning engineers, and some modifications of design standards were found to be desirable.

Notes from *The Engineering Journal of Canada*, April, 1956.

Bersimis—Lac Cassé Hydro-Electric Power Development

Several hydro-electric projects in Canada have already been the subject of technical notes in the *R.E. Journal*. This well-illustrated paper deals with the general aspects of a major engineering achievement, involving *inter alia* the construction of two dams, each 200 ft. high, nearly nine miles of tunnel work and the transport of some 300,000 tons of equipment, materials and supplies. The reservoir area is 290 square miles and the annual primary energy output is put at nearly 5,000 million kwh.

The general organization is unusual, in that contracts were let to six different firms under the direct control of the Hydro-Electric Commission itself. By acting as the main contractor and providing all stores and services, it is claimed that the Commission have achieved considerable savings, and that both standard of work and performance have been improved. This alone is a great tribute to the Commission's organization and staff.

Construction of a New Cement Plant

This paper contains practical details of the cement manufacturing process, and the general layout of the plant is described. The most interesting construction feature is that the plant was erected on very poor subsoil, 15 ft. of heavily-fissured and highly plastic clay over 7 ft. of silty clay, below which was a considerable depth of glacial till. The main structures had therefore to be founded on piles and all foundations were taken at least 8 ft. below ground level to avoid frost damage. Slurry and cement silos, built of concrete, were constructed by using sliding formwork raised by hydraulic jacks.

Engineering for a New Petroleum Refinery

The construction of this refinery, which incorporates the latest techniques and a marked degree of automatic control, posed some unusual engineering problems. The outstanding planning achievement was the erection of the catalytic cracking unit, 24 ft. in diameter and nearly 300 ft. high. This unit was prefabricated in eighteen main sections, weighing from 35 to 85 tons, all sections being pre-fitted and prealigned to facilitate field erection. Lifting and securing each section in position for welding in no case took longer than 45 minutes, speed being all-important in view of the capricious weather conditions experienced in the Canadian winter.

The complete success of the whole operation, involving much complicated fitting to fine tolerances and over 10,000 feet of highly skilled welding, was due to meticulous planning, the description of which is well worth study.

Notes from *The Engineering Journal of Canada*, May, 1956.

THE MACKINAC BRIDGE

The design of the Mackinac bridge, a suspension bridge 8,614 ft. long, with a main span of 3,800 ft., is revolutionary. Since the destruction of the Tacoma Narrows bridge by cumulative oscillations in 1940, much thought has been given to suspension bridge design, and two papers touching on this subject were reviewed in the *R.E. Journal* for June 1954 and September 1955. Both those papers considered means of stiffening the hanger system to resist longitudinal thrust and local distortion of the main cables. The Mackinac bridge has been made the most stable suspension bridge ever designed, not by building up weight and stiffness to resist the effects, but by elimination of the causes of aerodynamic instability.

The design of the bridge cross-section has several original features. The outstanding innovation is the provision of open spaces, 10 ft. wide, between the outer edges of the roadway and the longitudinal stiffening trusses. Further, the equivalent of a wide longitudinal opening is provided in the middle of the roadway, the two outer 12-ft. traffic lanes being solid and the two inner lanes being of open grid construction. The transverse stiffening trusses incorporate open-web, trussed floor beams instead of the solid web members normally employed.

The success of this design and its complete stability against all forms of oscillation at all wind velocities from whatever angle have been proved by independent wind tunnel tests on a 1/50 scale model. This paper, despite its author's rather egotistic style, is of interest to all engineers.

THE MILITARY ENGINEER

(JOURNAL OF THE SOCIETY OF AMERICAN MILITARY ENGINEERS)

MARCH–APRIL, 1956

"Sage." The New Aerial Defence System of the United States.

The advent of the atom and hydrogen bombs, for a short period, appeared to some to present a destruction potential to which there was no answer. This article on SAGE—the Semi-Automatic Ground Environment System of air defence—should restore their confidence. Hardly has the nuclear scientist perfected his weapons of offence before the electronics engineer has gone into production with a counterbalancing defensive system, by linking up the air defence radar-scope network with electronic digital computors to control semi-automatically that wide variety of high performance defensive weapons such as interceptor, ground-to-air guided missiles, and anti-aircraft guns. The radars are linked by ultra high frequency telephone lines directly to high speed digital computors. The computors automatically calculate the most effective application of the various available weapons and these, through radio data link, are guided to targets automatically by the computor. The SAGE system represents one of the most spectacular advances yet made in electronics technology and reduces to a minimum the human effort required for rapid assimilation and processing of information, the basic demand of modern air defence.

MAY–JUNE, 1956

"Cracking the Thought Barrier," by Professor Frank Rochwell Barnett.

The author is an expert on Russian affairs and psychological and economic warfare. This article is based on a paper he gave at the Military–Industrial Conference in February 1956, the theme of which was "National Survival in the Nuclear Age." Professor Barnett deplores the fact that although America has held the lead over the Soviets in nuclear science and engineering for the past eleven years this has not prevented major Soviet victories by irregular methods. He considers it not impossible that American civilization could be disoriented and destroyed with its technical resources intact, unless it is realized in time that nuclear fire power can be spiked with nuclear politics which he defines as the science of splitting the opposition. American political and psychological warfare techniques today stand in relation to those of the Soviets as a sixteenth century cannon ball compares to the atomic warhead of a guided missile. The situation is, he considers, far from hopeless as Soviet capability in psycho-social combat is matched by Soviet vulnerability to those same weapons. American psychological warfare, properly developed, should be the reverse of the Soviet counterpart. It should be overt, not covert. Soviet methods must be understood, not emulated. The correct basis of the American ideological weapon was defined by Washington when he said, "Let us raise a standard to which the wise and honest can repair. The event is in the hands of God."

CHIMIE ET INDUSTRIE

Notes from special supplement dated February, 1956.

Nuclear Energy

In August, 1955, several thousand scientists from all over the world met in Geneva for the International Conference for the peaceful use of atomic energy. At the same time and in the same town two exhibitions were held, one scientific and one industrial, the latter entitled "Atoms for Peace".

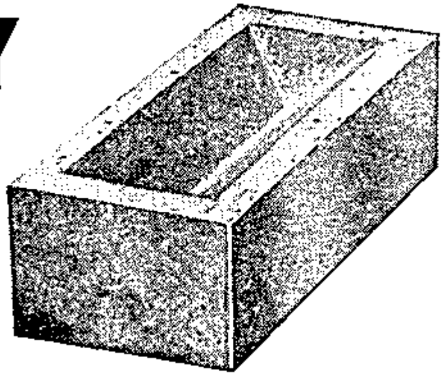
In a special supplement dated February, 1956, the French Journal *Chimie et Industrie* published some sixteen articles dealing with nuclear energy and summed up the results of the conference, broadly, as follows:—

"The coming of the atomic power-station will undoubtedly enable the world, within a few years, to satisfy the ever increasing need for energy. At present such power stations exist as prototypes, but it is expected that within five or ten years the atomic unit will be as cheap as power from other sources."

Unfortunately, although at the Geneva Conference the production of zirconium, beryllium, graphite, heavy water, etc., and the use of the radio elements in chemical industry, biology, medicine, etc., were studied freely, in other fields, such as the preparation of U-235, the resources and levels of uranium production in the different countries remained unreleased.

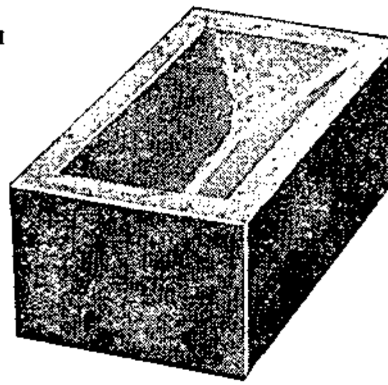
In addition to the military security restrictions, the industrial secrecy hampers the way to a quick development of the peaceful applications of atomic energy.

DRY



5 lbs
6 ozs

WET



6 lbs
12 ozs

A common brick can absorb up to 1 lb. 6 ozs. of water. This penetration of moisture can be prevented by the use of Cementone No. 3 Colourless Transparent Waterproofing Liquid.

Damp walls are ruinous to buildings and health. Thousands of damp buildings have been rendered habitable by an application of Cementone No. 3, and it is used and specified by over a hundred municipal authorities in this country.

A two-coat application of Cementone No. 3 by brush or spray, applied externally over porous brick, stone work, or cement rendered surfaces, seals the surface pores and voids to prevent the penetration of rain and dampness. A report issued by the Building Research Station following tests carried out with Cementone No. 3 may be seen on request.

THE WATERPROOFER THAT HAS WITHSTOOD THE MONSOON RAINS OF INDIA AND THE GALE-FORCE RAINS OF NEWFOUNDLAND

JOSEPH FREEMAN SONS & CO., LTD. — **CEMENTONE WORKS, LONDON, S.W.18**

Telephone: VANdyke 2432 (5 lines) — *Telegrams: Cementone, Wesphone, London*

Careers in Electricity Supply

This is an extract from a recorded interview with F. P. Harwood, a third year student apprentice with the London Electricity Board.

"... and I should like to see myself in his position at his age."

F. P. Harwood

C.E.A. Question Master

Harw.: After I passed in physics at Advanced level I wasn't sure what I wanted to do – chemical, electrical or mechanical engineering. Then my father got hold of the training scheme of the London Board, and that seemed to me a very comprehensive training.

Q.M.: **And so you started training at North Western Sub-Area?**

Harw.: Yes. I was fortunate in being with a man who was a natural instructor. Later I found that work outside interested me more than in the office and since then I have had about 7 months with an Assistant Distribution Engineer who had himself been a graduate trainee. He knew what I wanted from his own experience, and he has done well for himself – he's not 30 yet – and I should like to see myself in his position at his age.

Q.M.: **Weren't you chosen to go to France last summer?**

Harw.: Yes, with a party of apprentices. We went out to Electricité de France. Very interesting.

Q.M.: **Strenuous?**

Harw.: Very! 3,000 miles in 17 days. We were the guests of the French Electricity Authority who made us feel very much at home.

Q.M.: **You find the training flexible?**

Harw.: Oh yes. I asked if I could have more time – in basic mechanical training – and I was able to. You are not being trained to *do* the job, but to know *how* to do it; how, later on, to expect other people to do it. We have a period in a domestic repair shop and I'm hoping to spend two months in a cable factory, two months in switchgear and two months in another factory.

We'd like to publish more of this interview, but there isn't space. For details of the many careers in Electricity open to you, and the salaried training schemes available, please write to:

The Education and Training Officer,
Central Electricity Authority,
10 Winsley Street,
London, W.1.

CEA