THE ROYAL ENGINEERS JOURNAL—SEPTEMBER 1960 VOL LXXIV. No 3

THE ROYAL ENGINEERS JOURNAL

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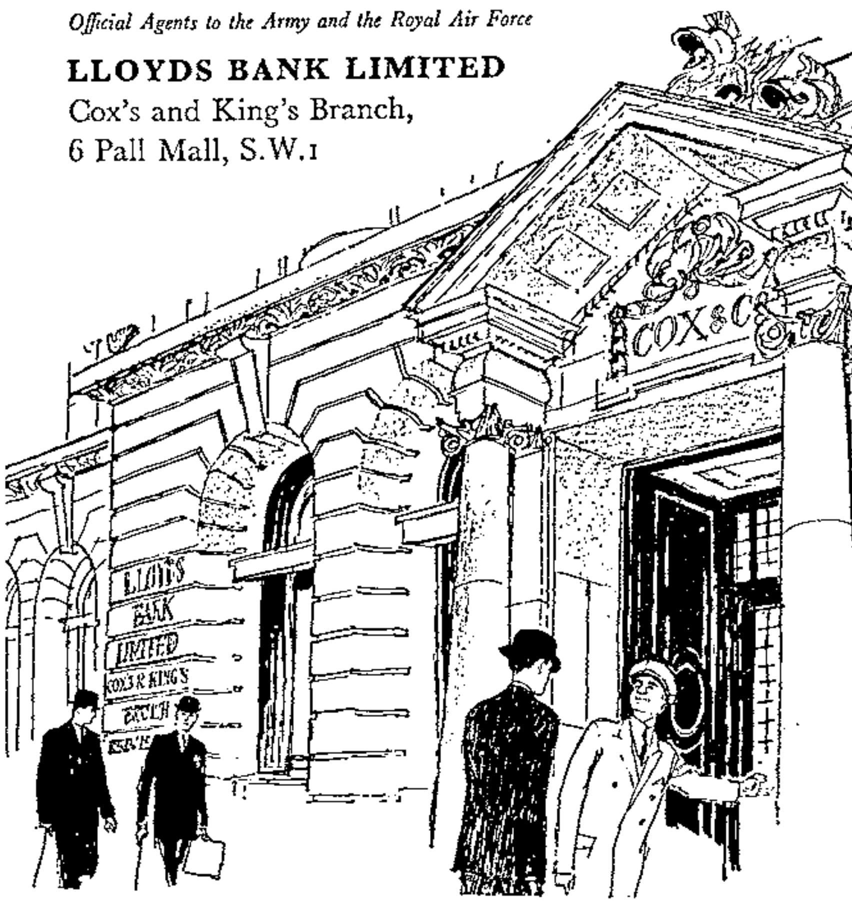

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SEPTEMBER, 1960

The Engineer-in-Chief's Address to the General Meeting of the Corps 1960

Introduction

The Corps, not for the first time in its history, is in a period of rapid evolution. Three major changes are taking place in the Army simultaneously, all of which have a profound effect upon us. First is the reduction of the Army, by early 1963, to its all-regular size. Second is the complete civilianization of Works, which has relieved us of most of our responsibilities for the construction and maintenance of accommodation in peace. And third is the rapid development of the means of waging war and the changing character of the Army required to use the new, and future, weapons. This has already altered, to some extent, the particular tasks which it requires of its Engineers.

Later on I will tell you what I believe to be the main implications of this upheaval, but before I do so, let me mention some of our world-wide activities. My statement will not have quite the same authority as those of Sir Henry Sugden, to whose wisdom, foresight and tenacity the Corps owes so much; because, when it comes to travelling, he leads me by about three circuits of the Globe. I myself am concentrating first on things near home, but later in the year I shall be visiting the United States, Canada and the Far East. (The Engineer-in-Chief here reviewed the various world-wide commitments of the Corps and described some of the main achievements of units and detachments.)

Organization and Equipment

Let me now turn to more general matters. Two events in the sphere of organization deserve special mention. First, there have been changes in the E-in-C's directorate in the War Office. The three separate directorates of Fortification and Works, Transportation, and Engineer Stores have disappeared and what is left of their activities is now carried out by various branches of my staff. I am, therefore, directly responsible for all the activities of the Corps except Survey, Postal and Movement Control (though they also come under my wing in some respects) and I thus possess a degree of control that has not been known since the abolition of the Inspector-General of Fortifications in 1904. There is something to be said for having a single helmsman—instead of one operator at each corner of the raft; especially at a time when striking the proper balance between the military and technical functions of the Corps is of such great importance.

Secondly, we have now got approval for our new field squadron establishments. These have considerable improvements both in rank structure for OR and in the plant available to assist each troop. The aim is to increase the horse-power available to the working sapper without reducing his mobility. We have also looked farther ahead and produced tentative field squadron establishments for the period 1965–70. These have some novel features but it would be premature for me to discuss them now. In the important field of Transportation I am considering, among other things, a small but significant reorganization of the Port Regiment, to make it more adaptable to its likely tasks. The future of the Reserve Army has not yet been decided but it is of special interest to the Corps because of the important gaps in our RE order of battle which only the AER and TA can fill.

The issue of Gainsborough medium wheeled tractors to field squadrons has just begun, and fifty of them will be in service within the year. In fact, I christened the first the other day. Troop trials with a new light wheeled tractor, the Michigan 75A, have started and if they are successful, issues to units can be expected from early 1961. Trials are also being done with a new super-heavy crawler tractor—the Caterpillar D8(H). If accepted, this should come into service next year.

Production of the post-war range of bridging equipment is continuing, and I hope the first of the Heavy Assault Floating Bridges (HAFB) will be in service in the next year or so. A variety of new assault bridges are being developed, with a view to more and more rapid construction, and we are also buying for evaluation a set of the French Amphibious Bridge equipment.

"A" Matters

The reduction of the Army, and its related problems of reorganization and redundancy, has been going on for a long time, but we are still less than half-way through the five-year run-down period. All the same, the main "A" problem of the Corps will have been largely decided by the end of this year.

The civilianization of Works Services has proceeded steadily for the past year and will be complete by the end of 1960. All Royal Engineers of the Military Works Service have been doing their utmost to send off the new organization to a good start, while rendering the best possible service to the Army up to the last moment of responsibility. But civilianization has been a major cause of the upset to postings and careers in this middle period. It is necessitating a steady runout of the older Extended and Short Service officers who have been employed mainly in Works, and many of their contracts are having to be terminated prematurely.

There has been a lot of redundancy, too, among Quartermaster GEs and E and MOs, and among Clerks of Works, Engineer Clerks and Engineer Draughtsmen. All QSAs have become redundant. With the exception of the QSAs, it is something for me to be able to say that most of this redundancy has been met by voluntary retirement.

But to understand the present situation of the Corps it is essential to recognize both that we have withstood worse surgical operations in the past and also that some grisly amputations would have been necessary in any case, because of the reduction of the Army. Even now our field force units, of various kinds, are very thin on the ground from the acute overall shortage of manpower.

Civilianization has caused a major change of career planning in that it will no longer be so normal for an officer to do his stint in Works, or to find employment as a Works CRE. Some alternative outlets, beside the limited sphere of ESSE and work on research and development, are being found in Resources and Movements, but whether this will be enough to develop the talents and experience of the military engineer in peace-time, even when units become all-regular and can be given suitable engineering tasks as part of their normal training programme, needs most careful watching. It is my intention to get as much practical engineering as possible, both for units and individuals. Meanwhile ESSE, the pool of officers and ORs acquiring technical experience outside the normal establishment of the Corps, is having a difficult birth, but will, I am sure, become a sturdy child.

Officers

Redundancy has been cleared—all but about 100. About 170 officers have already been given the terms, the majority of whom were volunteers. Most of the hundred who have still to go will be told by next September whether they will be redundant in 1961–62 or 1962–63, and Section C for officers will then be ended. Many of these hundred captains will, I am afraid, be retired against their own wishes. I am very conscious of the inconvenience, hardship, and depression, caused by keeping officers and ORs on a string, and I can assure you that their fate would have been decided long ago if it had been at all possible to do so. I sympathize very strongly with officers and other ranks who are made redundant against their wishes. I also feel for the many excellent ROs who are being swept clean out of Works. None of this would have happened if it could possibly have been prevented.

Turning now to the future, and on a more cheerful note, those of us who are not in close contact with the Service, as well as some who are, should notice the substantial improvements in conditions which have been granted in recent years, particularly as a sequel to the Grigg and Goodbody Committees. First, there is the scheme for careers to 55 which means that the brighter officers will get their promotion to Lieutenant-Colonel at much the same age as now, while others will be carried forward for promotion later on. Second, large increases in pay, pension and terminal grant. Third, much better education allowances. And fourth, and perhaps most important in the long run, the promise of a biennial review of pay and allowances. And that is not the end of this schedule of blessings.

Those of you who know boys who are thinking about commissions in the Corps should remember what Sir Henry Sugden said last year about the good prospects of young men who come in behind lean times. I would also remind you of the scheme for scholarships to the RMA, Sandhurst, which seems to have received less attention than it deserves, presumably because it sounds too good to be true. It is also being made easy and attractive for suitable people to get a regular commission direct from the Universities and the Reserve Army, and to obtain a Short Service Commission.

Our overall strength has been maintained by a steady flow of Short Service, and of course National Service, officers; but the proportion of young Short Service officers is still too high, and National Service officers will soon disappear. The Corps will be short of captains for some years. Meanwhile, Sandhurst is not producing enough young regular officers. It is of course, of paramount importance to raise the standard of entrant to the Corps to the highest possible level.

Other Ranks

During the last twelve months there have been some major changes in the rosters and trade structure of the Corps to meet the requirements of the long-term Army. The net result is to reduce the number of rosters from thirteen to ten. In addition, we have cancelled certain obsolescent trades and combined some others. It is now Corps policy that all field engineers on the General

Roster shall have a second trade, in order to provide the reserve of tradesmen who are so necessary to flexibility when our establishments and order of battle are so small. This new emphasis on trade training may prove, incidentally, to be an inducement to RE recruiting. In parallel with this, we have introduced trade qualifications for promotion in addition to the existing qualifications in education and military efficiency. Promotion to sergeant, corporal and lance-corporal will require first, second and third class trade rating respectively. Alternatively, sergeants in the General, Transportation and Survey rosters may have two second class trades instead of one first.

Redundancy among other ranks has been steadily reduced, and there are now only about 179 left in Section C out of 973, when the scheme started, i.e., about 18 per cent. I hope that most of the remainder will be settled by September next, and by March 1961 we may see the end of redundancy. A feature of the present rundown period is the premature loss of some very good WOs 1 due partly to a temporary slowing-down of commissioning to Quarter-Master and partly to the need to restrict continuance under present circumstances.

We are now exercising much closer control over the careers of WOs and NCOs on the General Roster, largely as a result of a valuable study by our late Officer in Charge of Records, Tom Wright. This control ensures, among other things, that the most able men are trained and selected for RSM and that all WOs 1 are of high quality. At the same time, I myself am very much impressed by the general rise in professional knowledge of our sergeants since I handed over my unit seven years ago.

Regular Recruiting

During 1959 we found we were recruiting rather more men than we could cope with in spite of raising the minimum entry standards; so, since the beginning of the year we have been exercising a further measure of control with the object of reaching the correct trade balance as well as our long-term strength. This may have been overdone. The quality of recruits has steadily improved and we are now getting about 85 per cent with an intelligence rating above the median. Recruiting of boys is also going well. Our apprentice tradesmen will soon be concentrated at Chepstow, except for a few vehicle mechanics at the REME school at Carlisle. We are now just short of the planned capacity of 840 apprentices. The Junior Leaders Regiment at Dover is now only about 15 per cent below authorized capacity, and the quality of intake has improved a lot during the year. The boys units are providing about a quarter of our regular recruits and this will rise to a third, eventually.

Corps Matters

Dress

A Corps instruction on dress is being prepared and, with the approval of the Corps Committee, I will issue it during the year. It is at least ten years since the last Corps instruction on this subject came out and a number of important decisions on dress have been made by the War Office in the interval, and various problems of detail have arisen from time to time, both at home and overseas. And the Army's post-war attitude to dress has crystallized. So this new instruction should help.

Corps Funds

The proposed reorganization of the funds was explained this time last year, and at a subsequent meeting in December Chief Engineers reported an overwhelming measure of support from the Corps. It is, therefore, being put into effect, and you will have received the new blue booklet: "Activities and Funds of the Corps of Royal Engineers", with an important foreword by the Chief Royal Engineer. The period of discussion is now over, and the support and co-operation of the whole Corps is expected.

Corps History

Volumes VIII and IX, covering World War II, were published last year in a very readable and instructive form. I suppose I am the only officer in the Corps who has read all nine volumes from cover to cover, but I hope as many as possible will read these last two. It was only in 1952 that World War I was covered, and I am sure the Corps has been the poorer for the lack of an up-to-date history book. Those who do read it will learn a lot about the Branches to which they have not belonged and thereby acquire a much better sense of proportion; they will learn how some of our perennial problems have been solved in the past; they may acquire a stronger sense of purpose; and they will certainly get inspiration from the deeds of their predecessors, and—for that matter—of their contemporaries. I only wish it did not require so much stamina to read the whole of our history.

Conclusion

As the Army shrinks and competition for manpower within it becomes more cut-throat, a critical eye is bound to be turned on the importance of the functions of each arm and service; as is only right and proper; the sole justification for our existence being our value to the Army as a whole. Thanks to the very able exertions of my predecessor, we have so far been allotted, in the long term, about half as many Officers again and more than twice as many Other Ranks as we had in pre-war conditions. But there are always, in peace-time, those who, for lack of experience or imagination or both, like to think that modern improvements in equipment are making Engineers obsolete. You will be glad to know that such studies as have been made in my Directorate by no means support that view, either now or as far ahead as anyone can see. Indeed, the opposite is much more likely to be true in a world where engineering science is crowding out the traditional forms of learning, where men are increasingly dependent on machinery, and where the physical problems of the battlefield have emphatically not been solved.

All the same, having lost the whole Works Service, I believe that, as previously in our history, it is essential for us to re-appraise our future functions with the utmost care, to make sure that we are always able to do what the Army most needs of us. Our studies—started before I assumed my present appointment—are not yet complete, but one of the truths which I believe will emerge is that, while maintaining a suitable interest in constructional engineering, we should increase our knowledge and experience of things electrical and mechanical; for example only, POL engineering, which is rapidly growing in military importance. Beyond this, we should as a Corps be very ready to take over and sponsor any new scientific activity which shows signs of being valuable to the Army. This indeed, is one of our traditional functions. Now that we are no longer over-committed to Works, and provided our officers have the necessary technical ability and experience, the present times ought to be offering us new opportunities of applying science to war.

You may conclude from this long discourse that the problems I am handling on behalf of the Corps are a trifle complicated and perplexing, and I would agree with you so far as to say that without a well organized and well staffed Directorate they would be impossible to manage. The machine I have inherited is good and the staff excellent. As for perplexities, I firmly believe that the future of the Corps depends on maintaining the traditional concept of the military engineer, upon which its achievements and renown have always been founded. Not a mere pioneer, nor a poor imitation of an infantryman and apology for some civilian specialist, but a member of a distinct and time-honoured profession in its own right. A good soldier, ready and able to make sound military appreciations and earning the respect of the best soldiers, as a military engineer: and at the same time a good and versatile engineer, valued by the best engineers, again, as a military engineer. This is the true essence of the corps, and a corps of this nature will continue in future as in the past, to throw up, on the one side some soldiers, and on the other some engineers, who are second to none; to the immense advantage of the nation. It is therefore my fundamental aim to obtain the proper balance between our military and technical functions.

As we contract and the Corps becomes a more close-knit family, I believe we ought to be able to ensure these special standards, and to have a general level of behaviour and bearing in our Messes, and in the sporting and social life of the Army, which must command the respect, and envy, of all those who haven't the luck to be Sappers.

RE Demonstration 1960

By CGS

PERFECT weather again favoured the annual RE Demonstration at the SME, Chatham, held this year at the end of May. Under blue skies and a blazing sun over 2,000 spectators watched the live demonstrations of the main engineer battle tasks on the fieldworks and dry bridging training grounds at Gordon Barracks, and on the Gundulph Pool and River Medway at Upnor. Static displays, more extensive even that last year, covered a wide variety of many other activities of the Corps in its overall task of helping the other arms of the Army to live, to move and to fight.

The main days, 30, 31 May and 1 June, were primarily for this year's course at the Staff College, regular officers of all arms, and cadets from the RMA Sandhurst respectively. An extra performance on 27 May, additional to the dress rehearsal on 26 May, was laid on to meet the demand from the Junior Leaders' Regiment RE, the Apprentice Schools and Cadet Forces, It was also performed for Reserve Army Officers on the weekend 28/29 May, when families of the SME staff and units taking part were also invited to see the show; its popularity with the latter resulted in crowds of almost Bank Holiday proportions.

Notable spectators included Lieut.-General J. D'A. Anderson, Director General of Military Training, Lieut.-General I. H. Riches, Commandant General Royal Marines, Lieut.-General Sir Alexander Drummond, Director General of Army Medical Services, Admiral Sir Robin Durnford-Slater, C-in-C the Nore, the MP for Rochester and Chatham and two other MPs, the Mayors of Rochester, Chatham and Gillingham, and members of the RE Advisory Board.

Among overseas visitors we welcomed Brigade-General Dorn, Inspector of Engineers, West German Army, Colonel Koller-Kraus, Commandant of the Pioneer School, Munich, and three other German engineer officers; some thirty-six officers from the CENTO nations, twelve military attachés from allied and friendly countries and officers from Commonwealth Liaison Staffs.

The demonstration followed a similar course to previous years, starting with a static exhibition of field unit and signal equipment during assembly at Gordon Barracks, followed by live demonstrations of mine warfare, field defences, dry bridging, demolitions and armoured engineer devices. After lunch and move to Upnor an extensive static display was followed by live demonstrations of plant and road construction, methods of constructing rafts and bridges, and finally of river crossing equipments. An excellent film[1] was made of the 1959 Demonstration which many sappers may have seen. In this article mention will therefore only be made of new items and changes from last year.

In mine warfare, besides the normal methods of laying minefields a technique was shown of speeding up the digging in of mines by using a scoop on the blade of a light wheeled tractor, the new troop machine, to make the holes. This method was previously tried with dozers, but found too slow; the wheeled tractors which can move to the site at convoy speed should be more effective. A Whirlwind helicopter, besides demonstrating the rapid method of laying mines on the surface by means of a chute, also showed replenishment of a mechanical minelaying train by delivering a dispenser of mines to the mine lorry.

In the field defences demonstration, emphasis was placed on rapid digging by explosive and mechanical means in the battle shelter concept[2]. From a Saracen armoured personnel carrier an infantry section debouched; two men with a Cobra manpack excavator spitlocked out each two-man slit in turn, two more with a tube and thumper drove three holes into which the future occupants dropped the ready prepared small charges which every man carried. In little longer than this takes to read the explosive charges had been fired and the occupants returned to complete the slit with pick and shovel. Some of the flexible revetting material under development to replace corrugated iron was displayed in the various types of battle shelters and other field defences on view. Among the plant for rapid digging the Cleveland wheel bucket trencher attracted most attention. This commercial machine, loaned by John Allen & Sons, on its tracked chassis is too immobile for military use as it stands, but it was shown to illustrate the principle of the continuous operation wheel-type excavator. If a Cleveland wheel can be satisfactorily

[1]WO Code No B/C 1132.
[2]Described in Major Fursdon's article in the March 1960 *RE Journal*.

mounted on a vehicle of the cross country performance and road speed of a wheeled tractor, a very useful machine for quick digging in the field should result. (Photo 1.)

Concealment and camouflage are now again the responsibility of the Corps, and the SME has taken over the responsibility for advising the other arms of the Army and running courses in this important subject. Some of the modern concealment sets for artillery weapons were shown, besides various materials under development for the camouflage and thermal protection of field defences.

Dry bridging showed again the sequence of construction and launching of the heavy girder bridge. A pair of ingenious MEXE developed davits were used to place in position the final crib cross beam of a 50 ft high pier. Armoured engineer devices were demonstrated in crossing short gaps. On the two main days on which it appeared by arrangement with Westlands Aircraft, a Wessex helicopter lifted and placed in position over a dry gap a 70 ft long light fixed span bridge, developed by MEXE (Photo 2). As the Wessex was a production model destined for the Royal Navy, its effective lift was reduced by the weight of built-in anti-submarine gear, so the decking of the bridge had to be omitted. The same principle was successfully demonstrated last year at the Farnborough Air Show, when a Westminster "flying crane" carried a 100 ft length of the same bridge, with trackway, and a light vehicle was passed over the bridge to prove it.

The static exhibition was so extensive this year that it is difficult to select particular items for comment. In contrast to all the traditional skills of sapper tradesmen, and particularly that of the painters and signwriters, Masson-Seeley's were invited to demonstrate their electrically operated machine for stamping and marking all kinds of materials by a heat transfer process. Another new item was a hydraulic underpass boring equipment, which showed how pipes may be passed under roads without disturbing the surface or interrupting traffic. This equipment may be of value in the increasingly important sapper task of the construction of oil pipelines. In this sphere also aluminium alloy pipes and a welding machine for joining them in the field, as well as inflatable aluminium pipeline, showed trends towards lighter materials. The Twynham Hut and a 10 ton transportable cold store also attracted much attention. Transportation and Survey exhibits were considerably increased in scope, and Bomb Disposal put on their usual excellent and popular show.

In the plant demonstration, besides the new wheeled tractors and the normal conventional crawler types, new items included the Michigan 175A heavy duty cross-country fork-lift truck, the Caterpillar D8 (Series H) British built size I crawler tractor which is undergoing trials at the SME, and the high mobility road roller. The latest version of MEXE's high speed road surfacing unit (or gritter) was prevented by a technical hitch from showing in practice its ability to lay a bitumen strip at convoy speed.

On the Gundulph Pool helicopters, operating from the new heliport on Tower Hill, showed the carriage and delivery of light rafts. In addition to a Whirlwind delivering a single assault boat and superstructure comprising one-third of an assault boat raft, the Wessex showed how the complete raft could by carried in one lift by a larger helicopter. This raft was also towed on a simple trailer behind a Champ or Land Rover, the three boats nesting within each other, with the superstructure in the top one and the outboard motor in the vehicle. It appears to have distinct possibilities for use by the

Photo 1. Cleveland Wheel Trencher

Photo 2. Westland Wessex helicopter carrying the MEXE lightweight bridge to place across the dry gap in the foreground

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Photo 3. Infantry Assault Boat Raft manned by detachment from Queens Own Royal West Kent Regiment

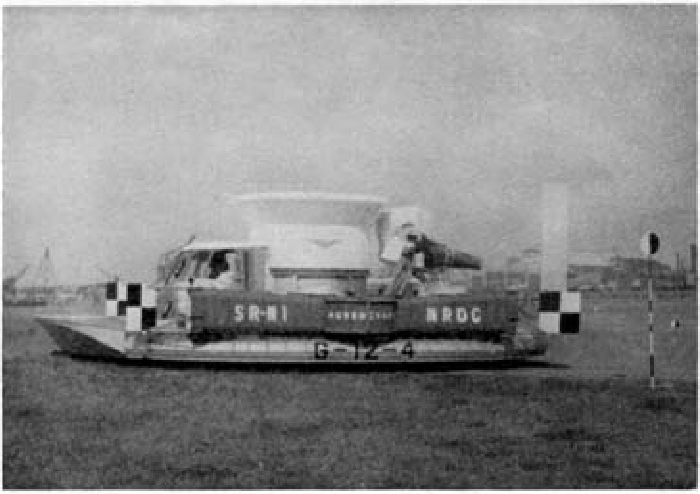

Photo 4. The SRN 1 Hovercraft coming ashore on Upnor Hard. Note the additional jet engine mounted at the stern for greater forward speed

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strategic reserve when operating on a light air-portable basis in undeveloped countries. Its construction and operation were shown by an infantry party from the QO Royal West Kent Regiment. (Photo 3.)

The Heavy Assault Floating Bridge made its first appearance at this Demonstration. It is built on assembly line principles like its lighter brother the LAFB, which was also demonstrated fully; despite its greater weight and size, it is no more difficult to construct. Similar methods of pre-assembly of the pontoon piers, outrigging of panels, launching from the trailer, and coupling into bridge were shown.

On the Medway the display of river crossing equipments in operation was generally similar to former years. Sapper frogmen were seen reconnoitring the river bank and laying charges to clear underwater obstacles; the ensuing spectacular under-water explosion did not this year soak the Staff College—or anybody else! After the usual succession of reconnaissance and assault boats and rafts, a Conqueror on the heavy ferry looked as impressive as ever.

Two unusual items closed the show. A 40 ton Dracone, filled with kerosene and towed by the Transportation tug "Tulagi" was manoeuvred in the river to show how petroleum fuels may in future be transported to beaches and smaller ports overseas. Finally the prototype SRN 1 Hovercraft, built by Saunders-Roe under the auspices of the National Research and Development Corporation, showed its paces in the Medway. Recently fitted with an additional external jet engine it reached 50 knots up and down the river in straight runs, then carried out some turns to show its manoeuvrability, before finally coming ashore up the bank on to the Hard beside the main stand (Photo 4) where it was soon surrounded by an interested crowd. Although this Hovercraft is only a prototype, and it has not been adopted by the Army, its potentialities are obvious for such military uses as ship to shore and over the beach work, up river transport where it would be independent of currents and sandbanks, for river crossing operations, and for crossing swampy ground.

The SME was assisted in carrying out the demonstration by 59 Field Squadron, and by 20 and 24 Field Squadron of 36 Corps Engineer Regiment, as well as by detachments from 26 Armoured Engineer Squadron, 9 Airborne Squadron, 1st Battalion the Queen's Own Royal West Kent Regiment, and in various ways by small detachments from numerous other units and establishments. 225 Squadron RAF provided Whirlwind helicopters to demonstrate their use in various engineer roles. To all of these as to the many individuals who collectively made up the team must go the credit for what was generally agreed to be a most successful demonstration, which in the words of one senior sapper officer, "made me feel proud to belong to the Corps".

Conferment of Civic Honours on the 101st (London) Field Engineer Regiment (TA)

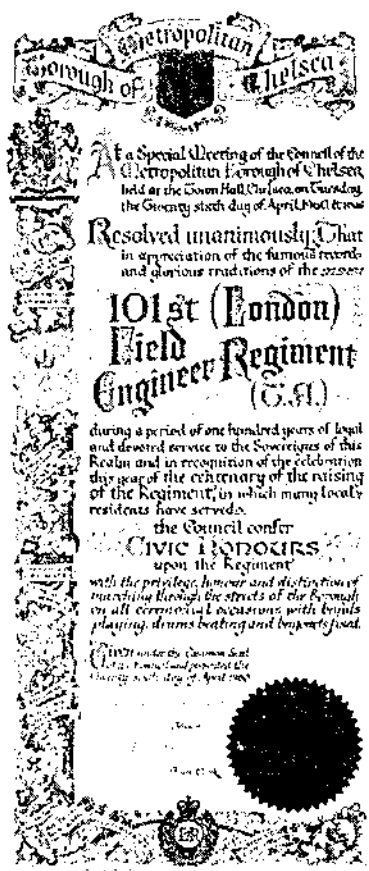
On 26 April 1960 the Metropolitan Borough of Chelsea conferred civic honours upon the Regiment.

The ceremony, at which the Mayor, Miss Katherine Ackland, OBE, TD, JP, presented an illuminated scroll, was held at the Chelsea Town Hall.

Among the guests were Field Marshal Sir William Slim, GCB, GCMG, GCVO, GBE, DSO, MC, Major-General Sir Douglas Campbell, KBE, CB, DSO, MC, Major-General C. M. F. Deakin, CBE, Brigadier A. H. G. Dobson, OBE, MC, Brigadier J. H. D. Bennett, OBE, Brigadier G. L. Galloway, DSO, OBE, GM, Colonel A. R. Mais, OBE, ERD, TD, DL (Honorary Colonel), Colonel R. E. Owen, OBE and Lieut-Colonel M. J. Grafton, MBE, TD, RE (Commanding Officer).

The string orchestra of the Corps played at the ceremony.

A reproduction of the scroll is shown below:—



Presentation of the freedom of entry of Liverpool to the Corps of Royal Australian Engineers

By Captain F. G. H. Clark, RL

On 5 September 1959 the Corps of Royal Australian Engineers was honoured by a ceremony which had its origin in Britain, so following one of the traditions of its parent Corps, the Royal Engineers.

On that date, the Corps was granted the Freedom of Entry to the Municipality of Liverpool, and thus earned the distinction of being the first Corps to have been so honoured in Australia.

It was fitting that the honour should have been conferred by Liverpool because it had been one of this country's early settlements, being founded by Governor Macquarie in 1810. The British Army's association with Liverpool began at about this date when certain units built their barracks in the township and engaged in the road and bridge construction which helped to develop the surrounding country. The old stone barrack building is still in good condition and is now part of the local hospital.

Australian sapper units became acquainted with Liverpool during the First World War, although the RAE Barracks were not permanently established until 1940. Since that year they have grown and now accommodate the School of Military Engineering and 7 Independent Field Squadron, which is part of a regular brigade group. The Corps has always co-operated with the citizens of the town and has assisted on several occasions when serious floods or bush fires have threatened life and property. For several years now it has provided the honour guard for the dawn service on Anzac Day and so has established itself as a part of the community.

On the day before the ceremony the sky was heavy with cloud and there was much discussion among the self-styled weather prophets. However, the gods were kind and produced a sunny, spring day. As a start to the proceedings, the Mayor, Aldermen and other representatives of the Municipality were entertained at a luncheon given by the Corps in the RAE Officers' Mess. Engineer officers representing the Regular Army and the Citizen Military forces attended. The mess was beautifully decorated for the occasion with vases of flowers providing a background for the Corps mottoes: "Facimus et Frangimus" (We make and we break) and "Ubique".

The ceremony itself was held in Bigge Park, opposite the Liverpool hospital, and within view of the original British Army Barracks. The dais had been erected in front of the Memorial Clock and was flanked by enclosures for official guests and other spectators. The Chief Instructor SME, Lieut-Colonel W. P. C. Curlewis commanded the parade which was 450 strong. It was a composite group consisting of three squadrons made up from SME, and 7 Independent Field Squadron with detachments of officers and men from the Regular, Citizen Military Force and National Service units in Eastern Command.

The parade moved into Bigge Park at 2.30 pm played on by the RAE Band, whose members made a striking picture in their ceremonial dress of scarlet jackets, blue trousers and spiked white helmets. As the National Servicemen did not possess blues it had been decided that all officers and men should wear battledress and the familiar felt slouch hat. This choice of dress proved to be sound; the neat and uniform khaki providing an effective contrast to the colour of the Band. The formation adopted was close column of squadrons, facing the dais, with the Band at the centre rear.

Shortly after the parade had been dressed, the distinguished guests began to arrive at Bigge Park. As each guest arrived he was escorted to the foot of the dais where he was received by the Colonel Commandant of the RAE, Brigadier L. C. Lucas, DSO, OBE, MC, VD. After being received, the distinguished guests mounted the dais while their wives were escorted to an adjacent enclosure. By this time Aldermen and Members of Parliament had taken their seats near by. The dais party consisted of the Honourable J. O. Cramer, MP (Minister of State for the Army), Lieut-General R. G. Pollard, CB, CBE, DSO, (GOC Eastern Command), Major-General D. Macarthur-Onslow, CBE, DSO, ED, (CMF Member to the Military Board), Major-General J. R. Stevenson, CBE, DSO, ED, (GOC 2nd Infantry Division) and Colonel A. E. Ross, OBE, (CE Eastern Command).

The Colonel Commandant RAE then received His Worship the Mayor of Liverpool, Alderman R. A. Dunbier and the Town Clerk. After mounting the dais and being introduced to the guests, the Mayor inspected the parade and Band, accompanied by the GOC Eastern Command and the Colonel Commandant. On his return to the dais, His Worship the Mayor addressed the assembly. In his speech he traced the history of Liverpool and explained how for many years it had been the town best known to the troops stationed in Eastern Command. The influence of the Army in the Liverpool Municipality had existed since Australia became a source of fighting soldiers. From the Boer War and continuing through both world wars, Korea and Malaya, troops had trained near Liverpool before proceeding overseas. Today, many servicemen and their families resided in the town and made a fair proportion of the community. However, while he fully recognized and appreciated the harmony which existed between the Municipality and other arms and services, the Sappers had been outstanding in their willingness to assist in community projects and in times of emergency. He then called on the Town Clerk to read the Grant which was worded:—

"To the Officers, Warrant Officer, Non-Commissioned Officers and Men of the Corps of Royal Australian Engineers, Greetings.

"We, the Mayor, Aldermen and Citizens of the Municipality of Liverpool, in appreciation of the glorious traditions created by the Corps of Royal Australian Engineers in loyal and devoted service in peace and war to our beloved Sovereign and Country and in recognition of your long and happy association with this Municipality, do by these Presents confer upon you The Freedom of Entry to the Municipality and thereby the right, privilege, honour and distinction of marching through the streets of the Municipality on all ceremonial occasions with bands playing, drums beating and bayonets fixed.

"In Witness whereof we have caused our Common Seal to be hereunto affixed this Fifth day of September, One Thousand Nine hundred and Fifty-Nine in pursuance of a Resolution unanimously passed by the Municipal Council on the First day of December, One Thousand Nine Hundred and Fifty-Eight."

R. A. Dunbier, *Mayor*
H. J. Gill, *Town Clerk*

The Grant was then replaced in the Casket and presented by the Mayor to the parade commander, who replied:—

"The Worshipful the Mayor, Aldermen of the Municipality, The Honourable the Minister of State for the Army, The General Officer Commanding Eastern Command, distinguished guests, Ladies and Gentlemen—

"It is with great pride that I acknowledge on behalf of the Corps of Royal Australian Engineers the honour which has been conferred on us today. For this is the highest honour a municipality can bestow.

"This is indeed an historic occasion. It is not only the first time in Australia that the Freedom of Entry has been presented to any Corps of the Australian Military Forces but it is also the first time that the Municipality of Liverpool has made this presentation to anyone, and we are doubly proud on that score.

"On behalf of all the Royal Australian Engineers I thank you, Mr Mayor, Aldermen and Citizens of the Municipality of Liverpool, and I thank you too for this magnificent Scroll and Presentation Casket which will bear witness for all time of this memorable and historic occasion.

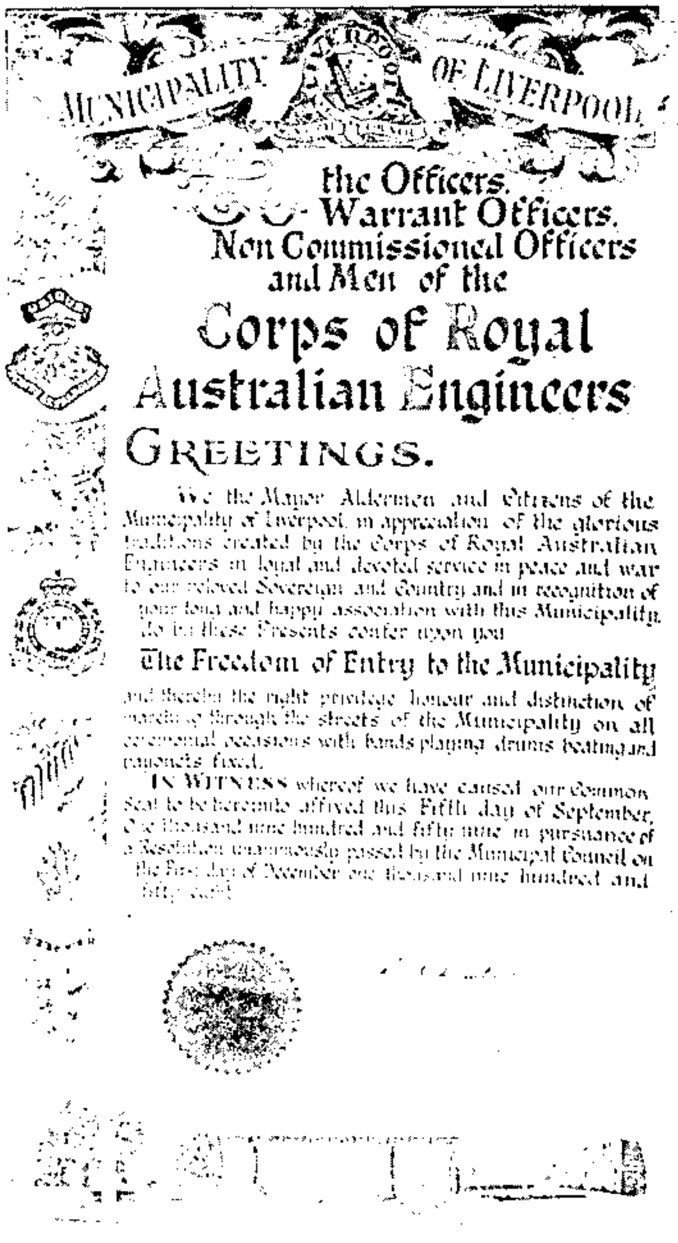
"The illustrious records and glorious traditions of The Corps of the Royal Australian Engineers will be enhanced by this Ceremony, and I pledge the Corps to be always worthy of the right and privileges which you have given to us today, and mindful of the additional obligations we now incur."

The Parade Commander then handed the casket to the Colonel Commandant Royal Australian Engineers who acknowledged the honour conferred upon the Corps. The assembly stood while the parade gave a general salute to the citizens of the Municipality. The main ceremony was now completed and both the official party and spectators moved off to witness the challenge ceremony, which was to take place outside the near by Town Hall, where a saluting base had been erected. The Municipality had been fortunate enough to obtain the services of sixteen troopers from the New South Wales Police Force. This detachment was positioned near the challenge point and was split into two sections, facing each other, but off the roadway. They were equipped with the lances and pennons recently presented by the Indian Government and by their presence provided a very suitable background for this part of the proceedings. At 3 40 pm the parade swung into Moore Street and was challenged by the Acting Marshal, Police Inspector F. M. Lynch. In a perfectly executed movement the mounted police wheeled into line behind him and effectively blocked the roadway.The parade was halted and the Parade Commander having replied to the challenge in the approved manner, the Acting Marshall spoke saying, "I acknowledge your right and privilege—Pass Corps of Royal Australian Engineers with the Mayor and Corporation's authority."

The mounted escort then reined back, permitting the engineer column to pass the saluting base and proceed through the streets of Liverpool to its dispersal base at the showground.

Official guests and parading officers were then given afternoon tea by the Mayor and Aldermen in the Town Hall and the casket was placed on a central table where it was inspected and admired by all present. After speeches by the Mayor and the Honourable the Minister for the Army, the Colonel Commandant RAE presented to the Municipality the silk Corps flag which had been flown at the parade. This is to be kept in the Council Chambers in a case built for it by the Engineers of Eastern Command.

So ended the day. Later comments by senior officers and civic dignitaries praised the ceremony and the dress and deportment of the parading troops, who, though drawn from so many regular and non-regular units had welded themselves into a single well-drilled body.



MUNICIPALITY OF LIVERPOOL

The Officers, Warrant Officers, Non Commissioned Officers and Men of the

Corps of Royal Australian Engineers

GREETINGS.

We the Mayor Aldermen and Citizens of the Municipality of Liverpool in appreciation of the glorious traditions created by the Corps of Royal Australian Engineers in loyal and devoted service in peace and war to our beloved Sovereign and Country and in recognition of your long and happy association with this Municipality do by these Presents confer upon you

The Freedom of Entry to the Municipality

and thereby the right privilege honour and distinction of marching through the streets of the Municipality on all ceremonial occasions with bands playing drums beating and bayonets fixed.

IN WITNESS whereof we have caused our Common Seal to be hereunto affixed this Fifth day of September, One thousand nine hundred and fifty nine in pursuance of a Resolution unanimously passed by the Municipal Council on the First day of December one thousand nine hundred and fifty eight.

Photo 1. The Scroll

MUNICIPALITY OF LIVERPOOL

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Photo 1. The Scroll

Presentation of the freedom of entry of Liverpool 1

Photo 2. The Corps luncheon to the Municipality, in the RAE Officers Mess

Photo 3. Mayor of Liverpool, Alderman R. Dunbier inspecting parade at Bigge Park

Presentation of the freedom of entry of Liverpool 2 & 3

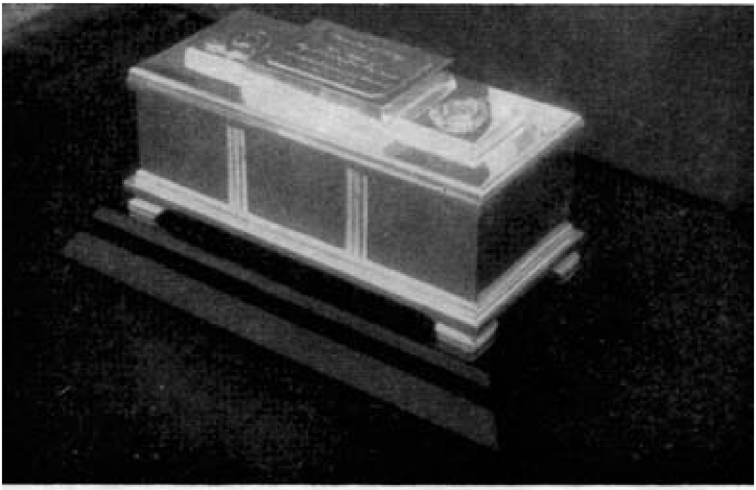


Photo 4. The Silver Casket

Photo 5. Brigadier L. C. Lucas, DSO, OBE, MC, VD, acknowledges the honour conferred on the Corps. Others present are: The Mayor, Alderman R. A. Dunbier, The Honourable the Minister of State for the Army, the Honourable J. O. Cramer, MP, Lieut-General R. G. Pollard, CB, CBE, DSO, General Officer Commanding Eastern Command, Major-General D. Macarthur-Onslow, CBE, DSO, ED, Citizens Forces Member to the Australian Military Board, Major-General J. R. Stevenson, CBE, DSO, ED, General Officer Commanding 2 Infantry Division.

Presentation of the freedom of entry of Liverpool 4 & 5

Photo 6. Parade Commander (Lieut-Colonel W. P. C. Curlewis) leading parade past the mounted detachment of N.S.W. Police Force, after challenge

Photo 7. The RAE Band passing the Challenge Point

Presentation of the freedom of entry of Liverpool 6 & 7

Photo 8. The Mayor acknowledges the salute by the Parade

Photo 9. After the troops have passed the Town Hall, Brigadier Lucas and the Mayor inspect the Grant and the casket

Presentation of the freedom of entry of Liverpool 8 & 9

The Construction of a Slipway at Port London, Christmas Island

By Major E. J. Sharp, RE and Capt P. W. Hutchings, RE

Introduction

General. The entrance to Port London, Christmas Island, is through a gap in the fringing reef. The channel is both narrow and shallow and can only be used by small craft. Freighters and tankers moor outside the reef, and their cargoes are ferried to the wharf. Craft used for this task include landing craft, naval supply tenders, pontoons and lighters. Because of the climatic conditions, a great deal of maintenance has to be carried out on the underwater parts of the hulls of these vessels. In the past, the smaller craft were occasionally hoisted on to the decks of visiting freighters but at such times they could be least spared for maintenance as they were required for the unloading operations. Maintenance on the larger craft involved towing them 1,200 miles to Pearl Harbour—an expensive and costly process. Approval was, therefore, given to construction of a slipway at Port London to facilitate maintenance work on the underwater parts of these craft.

Design. The slipway was designed by the Admiralty Engineer-in-Chief's Department, and the design was presented at a meeting in London in March 1959. This meeting was attended by representatives of the RN and RE, including the OC designate the unit which had been given the task of constructing the slipway.

Description of the Slipway

General. The general layout is shown on the key plan—see folding plate. The slipway can be briefly described as follows:

(*a*) Overall length 380 ft with, approximately, 240 ft of underwater work.

(*b*) Slope 1 in 16.

(*c*) Mass concrete piers, 3 ft by 3 ft in sections, positioned in pairs at 10 ft centres.

Superstructure. Steel superstructure, consisting of rails bolted to RSJs which in turn are clamped to channels secured to the concrete piers.

Winch. A winch with a 10-ton pull mounted on a concrete block at the top of the slipway, with a downhaul snatch-block at the lower end.

Depth. The minimum depth of water at the off shore end, to enable the slipway to be used under all conditions of tide, was calculated as follows:

Maximum draft of craft	5 ft 9 in
Add $\frac{1}{3}$ for sue	1 ft 11 in
Height of carriage	1 ft 3 in
Blocks	1 ft 6 in
Damaged craft allowance	2 ft 0 in
Height of steelwork	1 ft 5 in
	13 ft 10 in

Siting and Survey

Alignment. The slipway alignment is shown on the key plan—see folding plate. This alignment was adopted by the Admiralty Civil Engineer-in-Chief's Department after a study of soundings taken in the area adjacent to the existing naval workshops. The main factors affecting the decision were:

The bottom end of the slipway had to reach water deep enough for slipping craft in the shortest possible distance, in the interests of economy and ease of construction.

Approaches to existing facilities such as the small boat harbour and jetties had to be left reasonably clear.

Following a detailed and accurate survey of the area, the final alignment was selected to give the best compromise solution. The profile along the selected line of the slipway is shown in folding plate. Levels on this profile are related to mean tide level.

Survey. The next step was to survey-in theodolite stations and targets to enable the centre-line, concrete faces, etc., to be established quickly and accurately. Establishing a bench mark with reference to mean tide level was done by taking a series of readings of successive high and low tide levels over a number of days. The mean levels were averaged, and the bench mark related to this. It was convenient to base all level calculations on mean tide level. Half the spring range deducted from mean tide level had to give a sounding of at least 13 ft 10 in at the position selected for the offshore end of the slipway.

Stores Layout

Steelwork. The steelwork was laid out in a manner similar to that used when constructing an equipment bridge. The steelwork was placed at the top of the beach, adjacent to the line of piers in which it was to be incorporated. Cross members, sway bracing, etc., were placed in the centre.

Small Stores. The very large variety of nuts, bolts and clamps were placed in a 6 ft by 5 ft flat box suitably divided into compartments. The issue of small stores was carefully controlled by the OIC work through his stores NCO.

Construction

Concrete Construction above Water Level

Control of line. The theodolite sight-lines for the outer concrete faces of the piers were offset 12 in on the North side and 6 in on the South side. The extra amount on the North side was to accommodate a turn out in the winch foundation block. Robust profiles were erected at convenient intervals, and the sight-lines transferred on to them. In every case the distances were measured inwards to enable formwork to be aligned on the inside faces.

Control of level. When the formwork had been positioned for line, the anchor rails, or screeds in the case of the winch foundation block, were fixed at the correct height. The centre line of each block was marked on the formwork by measuring from fixed chainage stations with an engineer's steel band. The height of the anchor rails was also marked on the formwork. Using a mason's level, a slope of 1 in 16 was drawn on either side of the formwork and grout checks were positioned along these lines. The anchor rails were bolted in pairs to angle-sections, then positioned and secured on the grout checks. The forms were then ready for the concrete to be placed.

Winch block. The winch block was constructed in mass concrete, using Kwikform shuttering. Formwork for the starting course was shored and the subsequent 3 ft lifts were cantilevered vertically using 6 ft aligners. The final lift was complicated, having raised sections and screeded slopes. The top surface had to accommodate the winch, engine, roller fairleads and the snatch-block anchorage. Timber was used for the top 2 ft of the final lift, and the face was lined with hardboard to give a clean finish to the concrete. Timber shuttering had to be used whenever it was necessary to fix grout-checks, screed boards, or to hang intermediate shutters, as these can not readily be fixed to steel shutters.

Winch block holding down bolts. The 3 ft 6 in long holding down bolts for the winch and engine presented a problem. These had to be positioned accurately to ensure correct alignment of the winch and engine. In addition, they had to protrude unequal distances from the top of the concrete, to allow for the varying thickness of the base plates. The method adopted was to weld the holding down bolts to a heavy framework. The bolts were thus accurately located. The framework was surveyed into position, and fixed firmly in place. The placing and vibrating of the concrete for the final lift did not disturb the bolts at all.

Ring bolt box-out. A deep box-out was necessary to accommodate a ring bolt which did not arrive from the UK in time to be incorporated at this stage. A light gauge XPM cylinder was used with complete success. No bottom was needed, and very little grout entered the box-out even when the vibrators were in use.

Placing concrete. All concrete above water level was placed using portable elevators and compacted with poker vibrators.

Concrete Construction below Water Level

Underwater work. The task was to construct thirty-eight piers and the back-haul block. It was found that the easiest way to do this was to construct two piers at a time. Construction plant was mounted on three pontoons. See Photo 2.

Setting out. An angle iron setting out frame was placed approximately in position. The bottom of a 20 ft aluminium pole was held by a diver at a position corresponding with the outer face of the concrete. The pole, and hence the frame, were surveyed into place with a theodolite. The corners of the frame were then marked by pegs.

Excavation. The frame was replaced by two 4 ft by 4 ft steel digging boxes. A diver excavated sand from the inside of each box which gradually sank down into the sea bed. In sandy soil, spoil was removed by an airlift, but hand tools were used when rocks were encountered. The airlifts worked more efficiently as the depth of water increased. The minimum depth for satisfactory working was found to be 7 ft. When working at full efficiency, the airlifts could suck up stones of 2½ in diameter. The excavation of pier foundations took from four to eight hours, depending upon the type of soil encountered.

Formwork. When an excavated depth of 1 ft 6 in was reached the level of the bottom of the excavation was taken. This level subtracted from the required level of the top of the pier gave the height of the formwork required. Two formwork boxes were then made with the top 1 ft in timber, and the remainder in Kwikform. A final check of the excavations was made with the

Photo 1. Slipway partially complete showing winch and ramp.

The Construction Of A Slipway at Port London 1

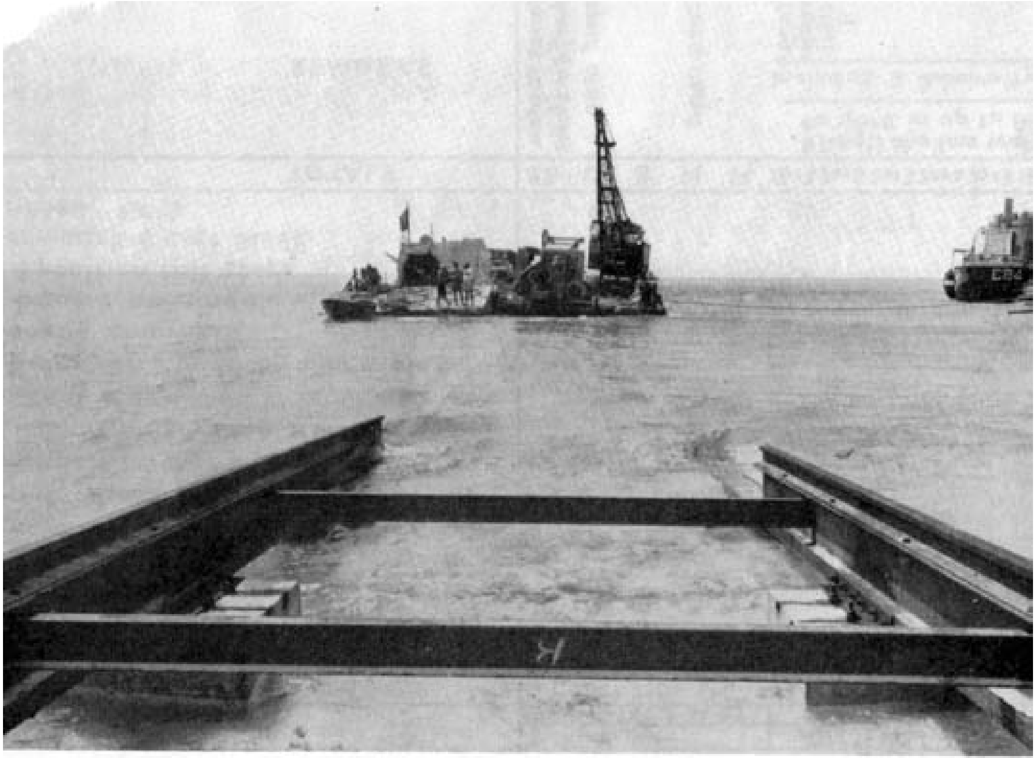


Photo 2. Underwater construction from pontoon raft.

The Construction Of A Slipway at Port London 2

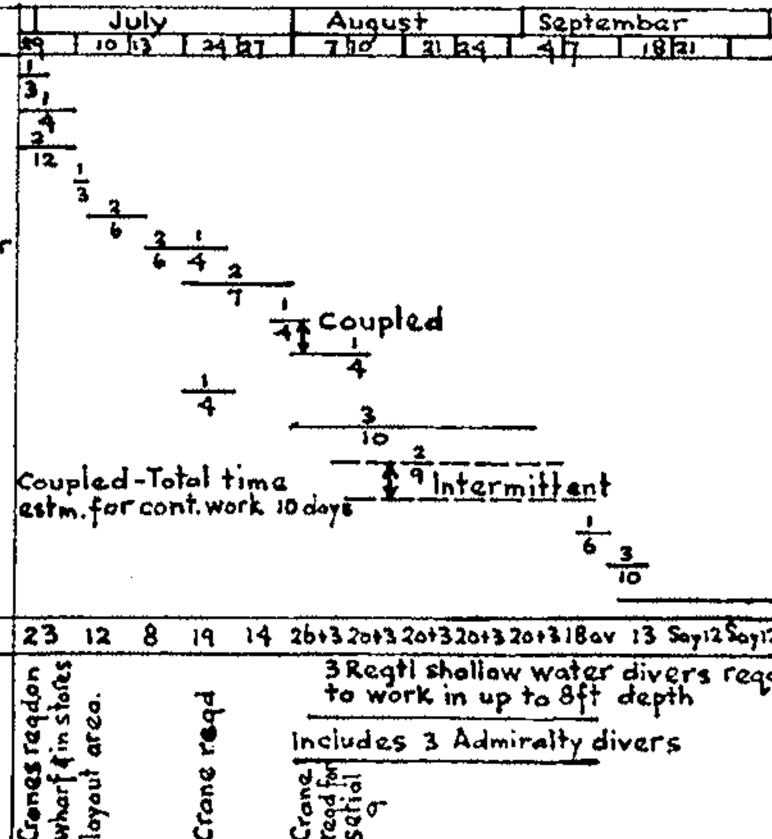
WORKS PROGRAMME - 125 TON LIGHTER SLIPWAY

ANNEX

NO	TASK
1	Est BM'S, theodolite stas & Tgt's
2	Prepare pontoon, cranes & mixers
3	Assemble & prepare stores
4	Set-out winch block
5	Erect winchblock, boxout & pour
6	Winch Blk cont walls set-out, erect fm/wk & pour
7	Set-out & pour shore piers
8	Position channels on shore piers
9	Position I Beams on shore piers
10	Position & erect winch
11	Set-out & pour even 1ST/odd offshore piers
12	Place offshore channels
13	Position I beams, bracing etc. offshore
14	Assemble & position rail stops
15	Position formwork & cast block
16	Contingencies 25%

TOTALS: 23 12 8 19 14 26+3 20+3 20+3 20+3 20+3 18ov 13 Sey12 Sey12

REMARKS



NOTES :- 1) One Surveyor reqd daily 2) Total m/days 213 ie 6 Tp wk 3) Allowing for contingencies 8 Tp Weeks.

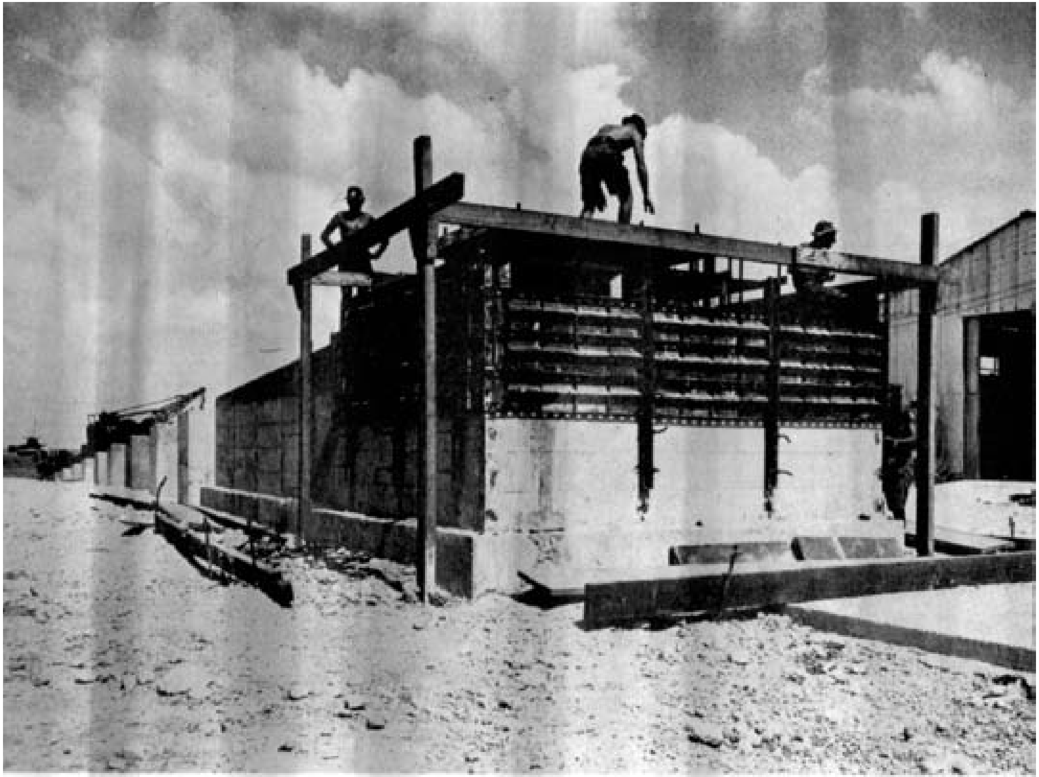


Photo 3. Winch base and concrete piers being constructed.

The Construction Of A Slipway at Port London 3

Photo 4. Slipway complete with cradle in position.

The Construction Of A Slipway at Port London 4

setting out frame, and the formwork placed in position. The grout checks and anchor rails were placed in position as for the landward piers. Before the concrete was placed, four ¾ in diameter bars, 4 ft long were driven into the ground by a special monkey to provide an anchorage.

Placing concrete. Concrete for underwater work was a nominal 1: 2 : 3 mix with a water/cement ratio of 0.4, and was produced in a Goodwin Barsby 7 cu ft mixer. The concrete was placed at about 1 cu yd per hour using a 12 in diameter tremie. The tremie was initially 8 ft long, but as the work moved seawards and the depth of water increased, extra 4 ft lengths were spot welded on. Initially a bayonet type fitting was used for fixing additional lengths, but proved unsatisfactory, and welding was adopted. The tremie, with a canvas cover secured over the bottom, was suspended by a crane and lowered into the water. It was then filled with concrete and positioned until it was just above the excavation level. The canvas cover was removed by a diver and the concrete then started to flow. The rate of flow was controlled by the speed at which the tremie was raised. The only difficulty was to get a screeded slope underwater. The method adopted was to pour about 1 in of concrete above the rail level. This surplus concrete was chipped away to the correct slope when the formwork was removed before the strength of the concrete had fully developed. The formwork was removed three days after the concrete had been placed.

End block. The original plan called for two wing walls at the offshore end of the slipway. In practice it was decided to have one large block to give additional stability because the sea bed at that position had a cross-fall of 6 ft in a distance of 14 ft. This block was constructed after all the piers had been completed and the steelwork placed in position. The last 10 ft of the channels and I-beams, together with the backhaul beam, were cantilevered into space. The block formwork was then lowered, and fixed in position around the steelwork. The concrete for the end block took 17 hours to pour, and when finished was 6 ft high on the North side and 12 ft on the South side. The tremie had to be shortened half-way through the concrete placing, because of the decreasing height of the lift.

Survey checks. The chainage of every third pier was checked using a steel band. Slope distances were measured along the I-beam.

Concrete quality control. Concrete test cubes were taken at intervals and cured underwater. The average strength was 2,800 psi at 7 days. (Note that in the prevailing high average temperature initial gain of strength was more rapid than normal.)

Steelwork

Description. The main load carrying members are 12 in × 6 in × 44 lb I-beams bolted to 10 in × 3 in × 19.28 lb channels. The channels are secured to the piers by means of lindaptor bolts and 3 in × 3 in × ⅜ in angles. A flat bottomed rail mounted on the top flange of the I-beam takes the slipway trolley.

Erection on land. The erection of the steelwork on land was straightforward and no problem was encountered.

Erection under water. The channels were laid continuing from the completed shorework. As each channel was positioned under water, the next section was pulled along it to the required position. When all the channel sections were in position, I-beams bolted in 80 ft lengths, were pulled down and along them. They were then positioned, working backwards from the seaward to the shore end. This order was once again reversed when the fixing of the I-beam took place, each I-beam being fixed successively from those already in position on the shore.

Survey control. A final check was made for line, level and gauge, when all the steelwork was in position. Where necessary, special packing plates supplied by the manufacturer were placed underneath the channels.

Conclusions

The work on land went very much as forecast. The only problem was to ensure correct positioning of the winch and engine holding down bolts. The method adopted is frequently used for major tasks of this nature and it was probably easier than using "box-outs".

The seaward construction was much slower than estimated. Originally it had been thought that two piers per day was a fair figure, but in practice this could only be achieved by working for 12 hours continuously, which was not practicable. The placing of the concrete was easier than expected. It appeared that a 12 in diameter tremie is the minimum size for satisfactory pouring of a stiff mix when the length of the tube is greater than 6 ft.

Mention must be made of the exceptionally hard work carried out by the divers. They worked for long hours and contributed very greatly to the success of the job. Using natural air diving helmets they often stayed under water up to 1½ hours without a break and put in over eight hours underwater a day.

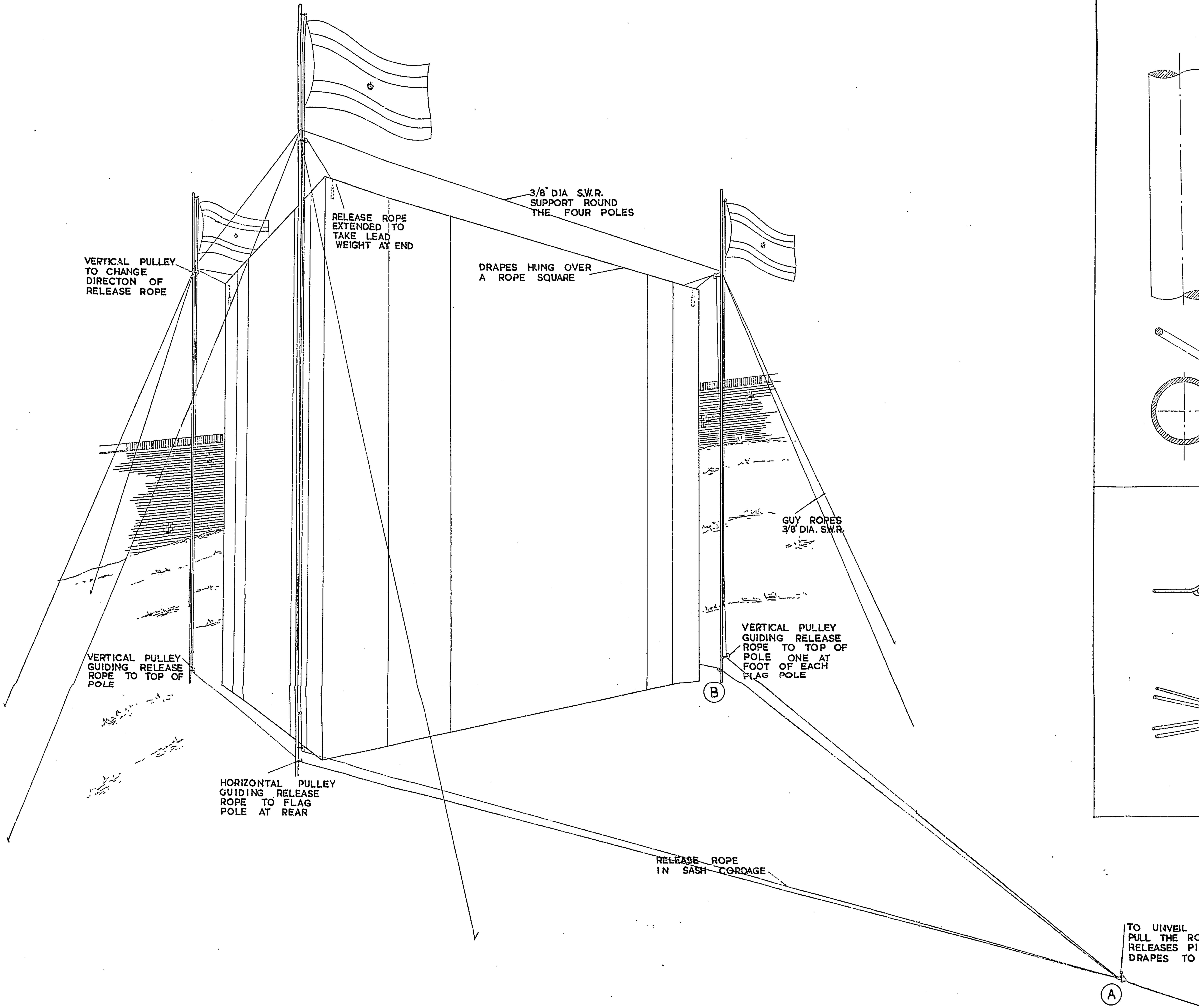
Finally, when planning the construction of the slipway, Headquarters Task Force Grapple allowed 8 troop weeks to complete this task. In practice, this worked out to be exactly the case. The detailed works programme is shown at page 258.

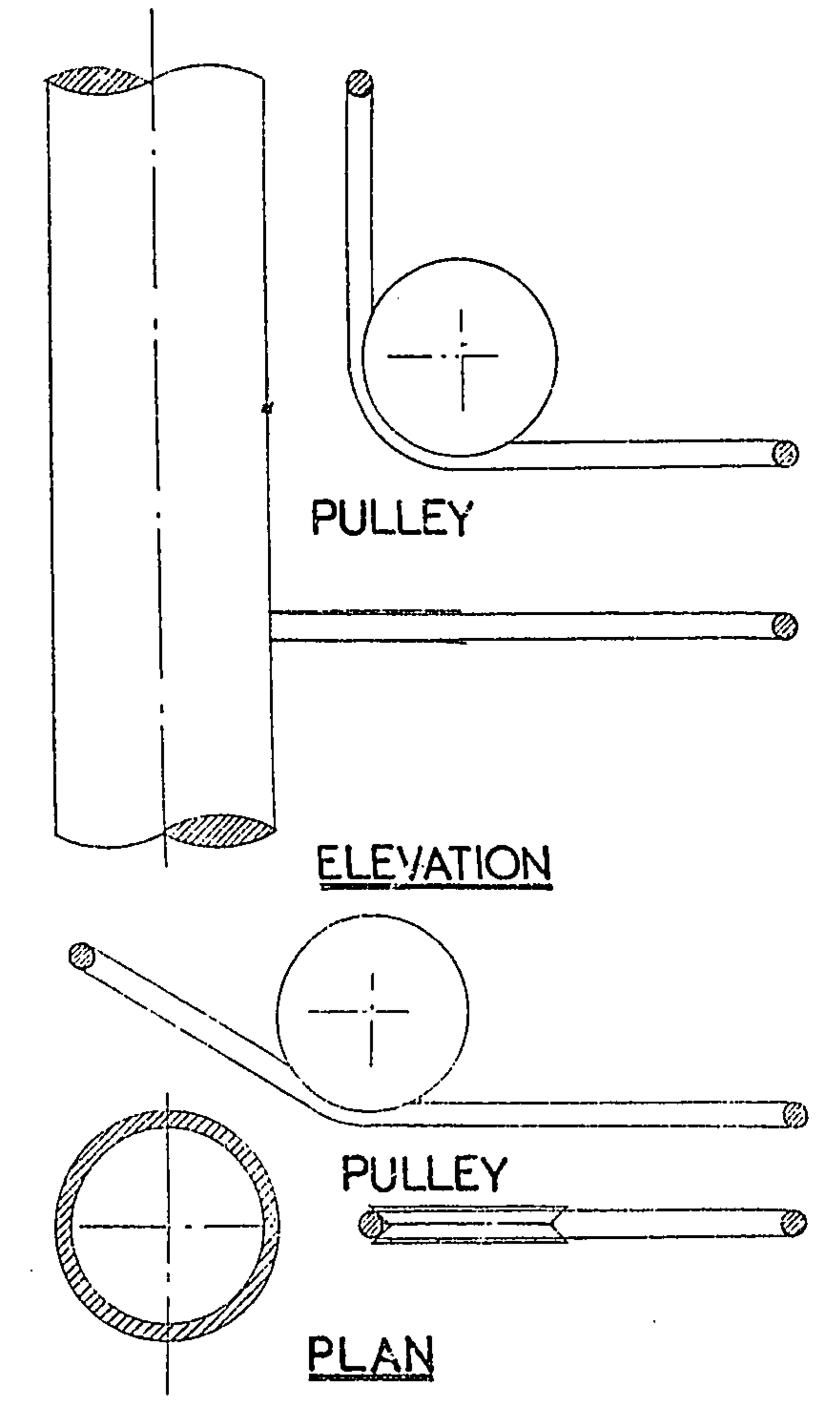
The following notes amplify the above article:

Initiation of Design. In August, 1958, it was decided that proper facilities must be provided on Christmas Island for the maintenance and repair of small vessels. An appreciation was written which proved conclusively that it would be more economic to construct a slipway costing £16,000 in materials than to continue to send vessels 1,200 miles to Pearl Harbour for maintenance which was costly in both effort and in dollars. Only the smallest of the craft could be repaired at Port London by lifting them on to the decks of a heavy lift freighter and the presence of a ship of this type could not be depended on. The possibility of a sideways-on slipway was considered as it would have been cheaper, but was rejected because of the lack of space in the harbour.

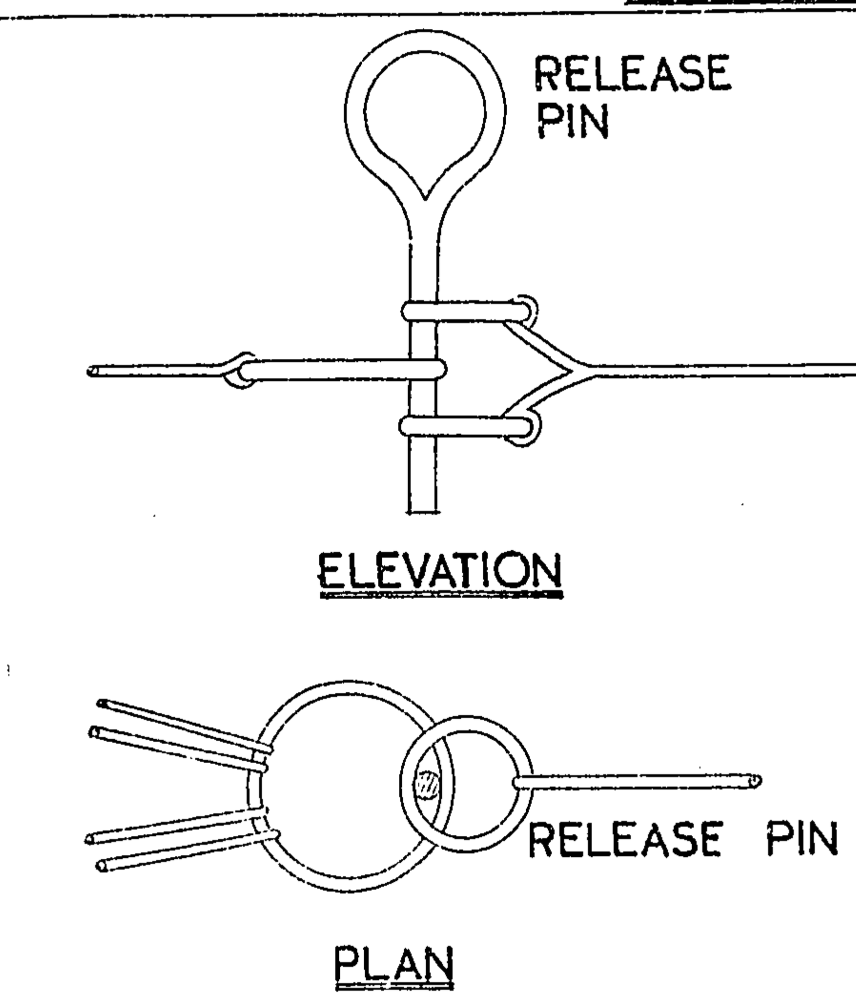
Design. The slipway was designed to slip vessels of up to 125 tons. The collapsible cradle and the superstructure were designed by Admiralty engineers. The superstructure was designed in consultation with the Royal Engineers Planning Team to ensure that the maximum use was made of pre-fabrication and that the construction would be within the capacity of the units and of the equipment on the island. Owing to a delay in obtaining financial approval, the production of the components was finally hastened to such a degree to be in time for loading on a particular ship that a complete trial assembly was not possible, though one 80 ft section was put together at the steelworks. As a consequence of this haste it was found on erection that the bottom of the cradle caught on the diagonal bracing of the superstructure and a modification had to be made on the site.

10·250' D
8·375'
1ST PIER
7·125'
3
5·875'
5
4·625'
7
3·375'
9
2·128'
11
0·875'
13
-0·375'
15
-1·625'
17
-2·875'
19
-4·125'
21
-5·375'
23
-6·625'
25
-7·875'
27
-9·125'
29
-10·375'
31
-11·625'
33
-12·875'
35
THEODOLITE STATIONS
END OF BEAM A9
CONCRETE LINE
SLIPWAY PROFILES
VERTICAL SCALE 1/10" = 1 1/2"
HORIZONTAL SCALE 1/10" = 1/2"
DECLIVITY 0·625' PER 10' HORIZONTAL DISTANCE
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430
115° 0' East of chart north
To Port Camp
N
KEY PLAN
From Main Camp
380' 0"
NORTH LINE
SOUTH LINE





DETAIL B



DETAIL A

UNVEILING LORD KITCHENER STATUE.

SME CHATHAM

LORD KITCHENER STATUE
METHOD OF UNVEILING

APPROVED BY	DATE.	DRG NO.
	8' - 7 - 60	2775

Method of construction. The design incorporated features such as anchor rails and lindaptors to facilitate the alignment of the steelwork. Not only had the slipway to be precisely straight, it also had to be in one plane exactly to prevent damage to slipped craft. It was appreciated that for the underwater section these requirements could be most difficult to achieve. A suggestion was made that, as an alternative to using a tremie for placing the concrete, it might be easier to use colloidal concreting methods. By this means it would have been possible to do all the concrete mixing ashore and to pump the colloidal mix into the aggregate previously placed within the formwork of the piers. An interesting demonstration of this technique was specially laid on at Chatham Dockyard. In the event however it was decided on the island to use conventional methods which proved entirely satisfactory. Fortunately the beach gradient was approximately the same as the desired slope of the slipway so that most of the piers were comparatively low.

Improvements. Three additional measures have been taken since the slipway was put into use:

(*a*) The steelwork between the tidal range has been carefully treated with anti-corrosive paint.

(*b*) Dolphins have been pile-driven to guide vessels on to the slipway.

(*c*) A concrete apron has been laid under the head of the slipway to facilitate the clearance of the rust and other debris from vessels under repair.

Conclusion. The slipway has been a great success and is in constant use. It has already repaid its cost many times over.

The Code of Practice for the Structural Use of Prestressed Concrete in Buildings

By MAJOR W. COOK, BSc, MINucE, RE

PRESTRESSED concrete has been in use some twelve years in Britain during which time designers were guided in the initial stages by intuition and later by a draft code. A new code of practice CP 115 : 1959 has now been produced and was issued in November 1959. No text book on the new code has yet been issued but *Military Engineering*, Volume XIV Part III, now being written, will be based on the new code.

The new code contains various alterations from the draft code issued in January 1957 due to further information on the behaviour of prestressed concrete; the major changes include:—

(*a*) Changes in permissible stress in concrete.

(*b*) New recommended values for calculating loss of prestress (e.g. due to creep).

(*c*) An increase in the amount of cover required over the steel reinforcement.

(*d*) A new set of limiting values for principal tensile stresses used in calculating shear.

(*c*) A new set of design values for depth of neutral axis for calculating ultimate strengths of beams.

Changes in the Permissible Stresses in Concrete

The new stresses are set out in tables 1, 2, and 3 and are self explanatory. The draft code did not include table 3, and the values for maximum working stress, both compression and due to bending, were slightly greater in value, hence a design under the new code will be larger in section than hitherto.

Table 1. Permissible Compressive Stresses in Concrete

Nature of Loading	Permissible Compressive Stress
Maximum working load In bending	$0.33U_w$ (U_w-works cube strength at twenty-eight days) In continuous beams and other statically indeterminate structures this may be increased to $0.4U_w$ within the range of support moments
In direct compression	$0.25\ U_w$
Wind loading	As for maximum working load plus 25 per cent, provided the excess is solely due to wind forces.
Transfer[1]	$0.5U_t$ (U_t-works cube strength at transfer) for a triangular or roughly triangular distribution of prestress. $0.4U_t$ for a uniform or approximately uniform distribution of prestress or 3,000 lb/sq in whichever is the less.

[1]Where the stress at transfer approaches the limit given in Table 1, the allowance for losses must be carefully considered and working stresses restricted to proper values.

It is recognized that with high works cube strengths compression stresses of over 3,000/lb/sq. in. may be obtained and the new code suggests that these stresses be used with caution.

Table 2. Permissible Stresses in Concrete Due to Bending

Nature of loading	Permissible bending tensile stress (lb/sq in)				
	With pre-tensioning and specified works cube strength (U_w) (lb/sq in) of:		With post-tensioning with adequate grouting and bonding and specified works cube strength (U_w) (lb/sq in) of:		
	6,000	7,500	4,500	6,000	7,500
Maximum working load often occurring and/or of long duration	300	325	175	200	225
Maximum working load rarely occurring and of short duration e.g. wind and snow loading on roofs	450	500	275	300	325

TABLE 3. PERMISSIBLE STRESSES IN CONCRETE IN TENSION AT TRANSFER

Cube strength of concrete at transfer U_t (lb/sq in)	Permissible tensile stress (lb/sq in)
3,000[2]	150
4,500	175
6,000	200
7,500	225

[2]Included for interpolation purposes, for post-tensioning only.

Tensile stresses at transfer may be increased, at the discretion of the engineer, for a short period not exceeding 48 hours; the increased stresses should preferably not exceed twice the values given in table 3.

NEW RECOMMENDED VALUES FOR CALCULATING LOSS OF PRESTRESS

Relaxation of both the concrete and steel result in a loss of prestress. The new code gives values to be used in calculating these losses.

Loss of prestress due to creep of steel or relaxation.

Type of steel	Loss on 70% tensile strength stress	% loss
Hard-drawn steel wire in the "as drawn" condition	15,000 lb/sq in	9.6
Heat treated hard-drawn steel wire	10,000 lb/sq in	6.36
Hard-drawn overstressed by 10% for 2 minutes during tensioning	10,000 lb/sq in	6.36

Experimental figures based on tests of at least 1,000 hours duration will be accepted. Some manufacturers supply steel of 2 per cent guaranteed loss.

The figures given below are obtained using constants given in the new code and applied to a post-tensioned system with a works cube strength of 6,000 lb/sq in, assuming the concrete stress at steel level is 1,800 lb/sq in, and the steel stress is 70 per cent of the ultimate tensile strength of the steel (Ultimate tensile strength = 100 ton/sq in). Loss figures in general use are 20 per cent for post-tensioned systems and 30 per cent for pre-tensioned.

Additional losses may occur due to anchoring in post-tensioned systems steam curing, or friction of the steel tendon in the cable duct.

Loss of prestress due to elastic deformation of the concrete.

$$\frac{\triangle l}{l} = \frac{\text{stress in concrete}}{Ec}$$

$$\therefore \quad \triangle l = \frac{\text{stress in concrete}}{Ec} \text{ when unit length is considered}$$

For steel

$$\triangle l = \frac{\triangle p}{Es}$$

$$\therefore \frac{\text{Stress in concrete}}{Ec} = \frac{\triangle p}{Es}$$

or $$\triangle p = Es \times \frac{\text{Stress in concrete}}{Ec}$$

$$= 28 \times 10^6 \times \frac{1800}{5 \times 10^6}$$

$$= 10{,}000 \text{ lb/sq in}$$

For post-tensioning system where the wires are not stressed simultaneously the loss is taken as 50% of this value

loss = 5,000 lb/sq in

= 3.2 per cent

Loss of prestress due to shrinkage of the concrete

Ultimate shrinkage per unit length two to three weeks after concreting $= 200 \times 10^{-6}$

$= \triangle l$

As before $\triangle p$ = 5,600 lb/sq in

Loss = 3.6 per cent

Loss of prestress due to creep of concrete

Creep per unit length $= 0.25 \times 10^{-6}$ per lb/sq in

Shortening $= 0.25 \times 10^{-6} \times 1{,}800$

$= \triangle l$

As before $\triangle p$ = 12,600 lb/sq in

Loss = 8 per cent

Total loss

Concrete:

Elastic deformation	3.2 per cent
Shrinkage	3.6 per cent
Creep	8.0 per cent
Total	14.8 per cent

Steel

Creep 2–10 per cent

Total concrete and steel: 16.8–24.8 per cent.

Increase in the Amount of Cover Required

Cover required for internal work (exclusive of plaster or finishes) should be not less than 1 in and for external work should be not less than 1½ in for all steel including stirrups, links, etc. This brings the prestressed code in line with CP 114 (1957) for reinforced concrete.

Values of Principal Tensile Stresses

Prestressing applied to a cable curved in a vertical plane has a component in this plane. The effect of this component is to reduce the shear force.

The shear stress due to loading is given at any point by

$$f_s = \frac{S}{Ib}\int_{y}^{y_1} ybdy$$

which, in a beam becomes

$$fs = \frac{SA_1y}{Ib}$$

The value of this stress is diminished if there is a vertical component of prestress. The principal tensile stress f_t is given by the expression

$$f_t = -\frac{f_h}{2} + \sqrt{(f_h/2)^2 + f_s^2}$$

where f_h is the horizontal stress due to prestress and f_s is stress derived above. Limiting values for f_t are given in table 5.

TABLE 5. LIMITING PRINCIPAL TENSILE STRESSES AT WORKING LOADS

Specified works cube strength for concrete (lb/sq in)	Principal tensile stress (lb/sq in)
4,500	125
6,000	150
7,500	175

A NEW SET OF DESIGN VALUES FOR DEPTH OF NEUTRAL AXIS FOR CALCULATING ULTIMATE STRENGTH OF BEAMS

The basis of design is that steel and concrete should not exceed the tabulated stresses and that the member should be capable of carrying 1½ times the dead load plus 2½ times the imposed live load.

As an alternative the new code specifies that the ultimate strength need not exceed twice the sum of the dead and imposed live load provided certain assumptions are made. These assumptions are:—

(*a*) The mean compressive stress in the concrete of the compressive zone is 0.4 times the specified works cube strength at 28 days.

(*b*) The depth of the centroid of the resultant compressive force in the concrete is 0.4 times the depth of the neutral axis.

(*c*) Concrete has no tensile strength.

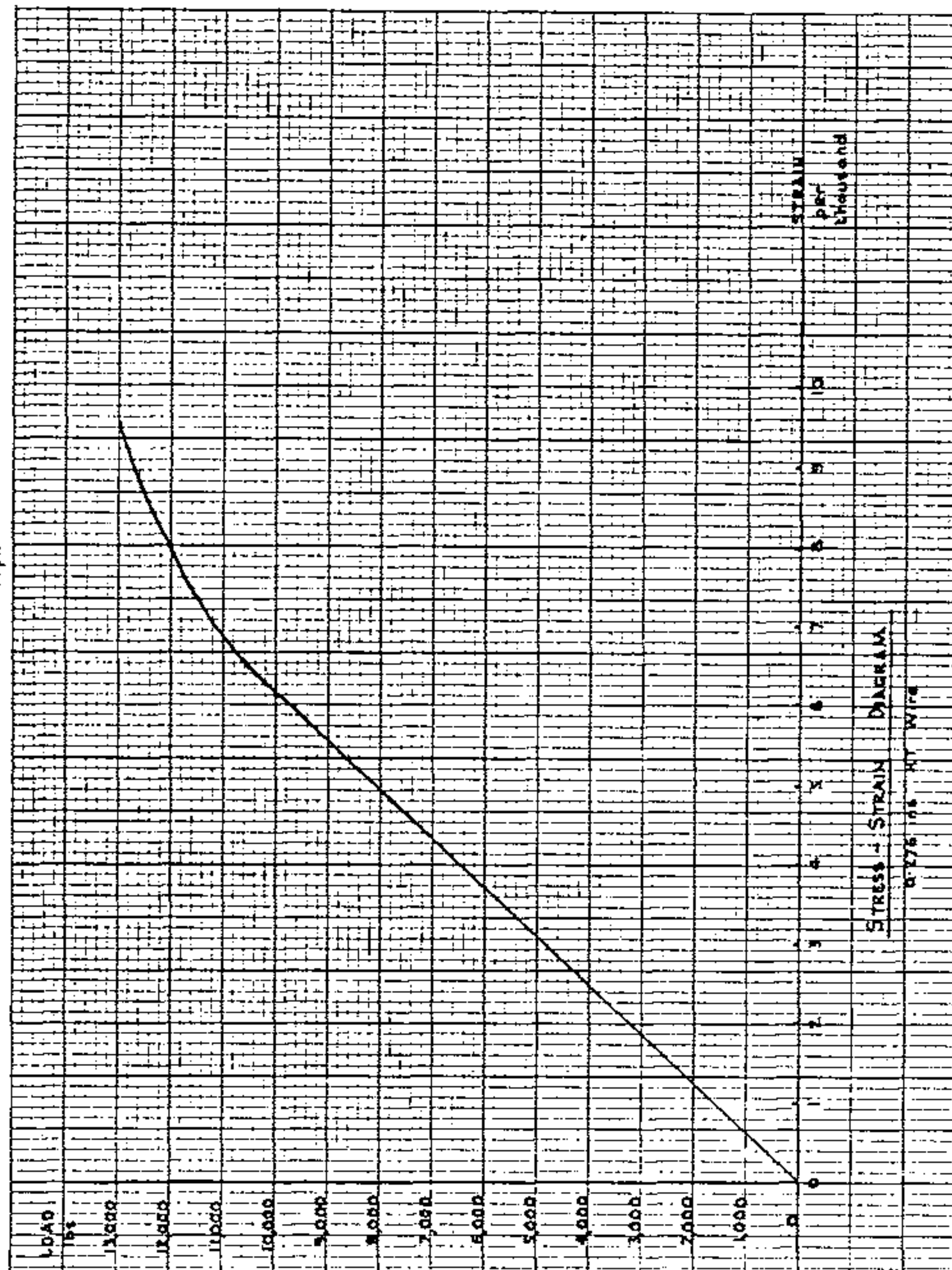
(*d*) For the purpose of calculating the stress in any steel in the compressive zone, the compressive strain in the concrete is proportional to the distance from the neutral axis and has a maximum value of 0.002.

These assumptions generalize very freely, the depth of the centroid of the resultant compressive force is going to be somewhere between 0.38 and 0.48 times the depth of the neutral axis; 0.4 times the works cube strength at 28 days is low for the mean compressive stress; concrete has some tensile strength, and the compressive strain in concrete may vary from 0.0025 to 0.0037.

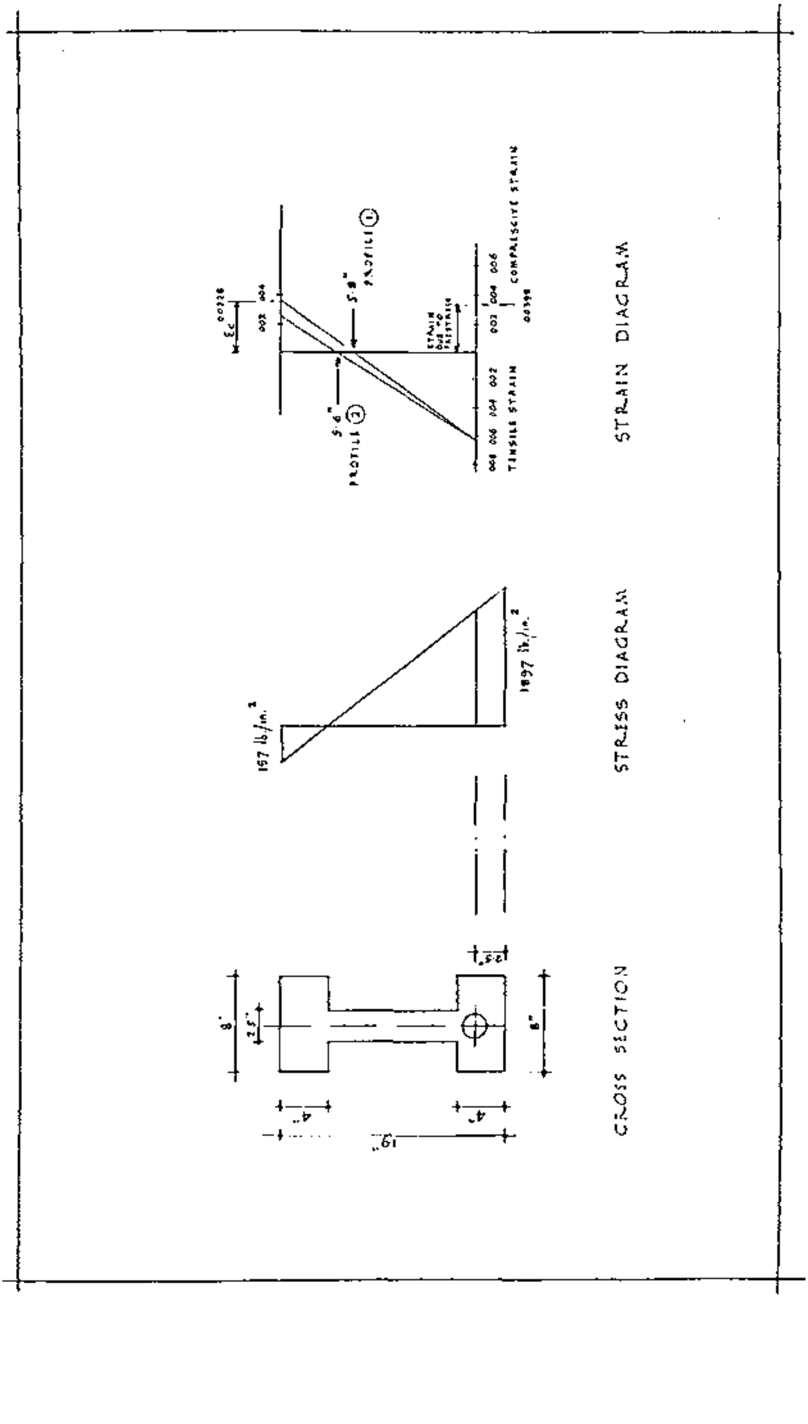
However these assumptions together with the values in table 7 give a very reasonable estimate of the ultimate strength as is shown in the example at the end where values are obtained for ultimate strength by rigorous methods and by using the empirical methods given in the new code.

The stress in the prestressed steel at failure, f_m, should be related to the ultimate tensile strength as given in table 7.

For prestressed concrete beams, rectangular in section above the neutral axis at failure, and without steel in the compressive zone, the failing moment is expressed as $M_u = f_m A_{st} (d_1 - 0.4\, d_n)$ where f_m and d_n are obtained for table 7.



Stress-Strain Graph



Section of Beam and Stress and Strain Profiles

For any other prestressed concrete members the ultimate moment can be obtained by considering the stress distribution and drawing a strain profile. The profile gives strain values, hence forces in the steel and concrete, and distances from neutral axis, hence moments.

TABLE 7. CONDITIONS AT FAILURE FOR BEAMS WITH PRE-TENSIONED STEEL, OR WITH POST-TENSIONED STEEL HAVING AN EFFECTIVE BOND

$\frac{f_u A_{st}}{U_w bd_1}$	Stress in tendons at failure as a proportion of the tensile strength f_m/f_u		Ratios of depth of neutral axis to that of the centroid of the tendons in the tensile zone d_n/d_1	
	Pre-tensioned	Post-tensioned with effective bond (Upper limit)	Pre-tensioned	Post-tensioned with effective bond
0.025	1.0	1.0	0.06	0.06
0.05	1.0	1.0	0.125	0.125
0.10	1.0	1.0	0.25	0.25
0.15	1.0	1.0	0.375	0.375
0.20	1.0	0.95	0.50	0.475
0.25	1.0	0.90	0.625	0.56
0.30	1.0	0.85	0.75	0.64
0.40	0.9	0.75	0.90	0.75

OTHER CLAUSES

Safety precautions are specifically dealt with in the new code and it is worth remembering that there is a considerable amount of energy stored in a stressed cable. Until it is anchored and grouted up it is potentially dangerous and should be treated with respect.

Designs of mixes have remained as specified in the draft code and it is interesting to note that quality control is at last recognized in a code of practice. Cubes are taken on each of the first four days of concreting and are tested at 7 and 28 days. Mean strengths and standard deviations are obtained and control graphs plotted for checking all subsequent test cubes.

No restriction is placed on the use of prestressed and reinforced concrete in the same composite structure, and where this occurs the stresses in the reinforced concrete due to bending may be increased.

EXPERIMENTAL EVIDENCE USED INSTEAD OF CALCULATIONS

The following experimental evidence, in place of calculation, is allowed in the new code:—

Tensile stresses due to bending

The stress in table 2 may be increased by up to 250 lb/sq in provided that it is shown by tests that such enhanced stress does not exceed three-quarters of the tensile stress calculated from the loading in the performance test corresponding to the appearance of the first crack. Where such an increase is permitted, the maximum prestress in the concrete should be at least 1,500 lb/sq in and steel should be well distributed throughout the tensile zone; post-tensioned steel should be supplemented where necessary by reinforcing steel near the tension zone.

Ultimate Strength

Where production of similar articles permits systematic testing of the finished product, the tests in certain circumstances can be offered instead of calculations.

Omissions

No mention, anywhere in the new code, is made on design of end blocks. This is an unfortunate omission, particularly as much of the original literature on the subject has been shown to be too optimistic in the evaluation of the tensile stresses developed.

Little is said about steel for prestressing and for values of stresses one must turn to the various British Standards dealing with steel.

Conclusions

The provision of this initial code of practice has at last given design engineers something tangible on which to base their calculations. It has, by decreasing concrete stresses, and increasing loss values, in effect made sections larger, but on the other hand it has merely put into words the feeling generally held, that the previous values were too optimistic for practical work.

Acknowledgement

The information contained in tables 1, 2, 3, 5, and 7 from CP 115 *The Structural Use of Prestressed Concrete in Buildings* is produced by permission of the British Standards Institution, 2 Park Street, London, W.1 from whom official copies of the complete Code may be obtained, price 8*s* 6*d*.

References

As far as I know there are no text books on prestressed concrete written or revised to conform with the new code. The Cement and Concrete Association have issued various technical reports dealing with different aspects, Ultimate Flexural Strength of Reinforced and Prestressed Concrete Beams, by L. L. Jones, MA, AMICE.

The theory of prestressed design has not been altered and is well covered in *Prestressed Concrete Design and Construction* by F. Walley, MSc, AMICE, published by H.M.S.O.

Symbols

A_{st}	Cross-sectional area of tendons in tensile zone
b	breadth of compressive zone
C_c	permissible compression stress in direct compression
C_t	permissible bending tensile stress
C_{At}	stress in top fibre due to applied load
C_{Ab}	stress in bottom fibre due to applied load
C_{db}	stress in bottom fibre due to dead load
C_{dt}	stress in top fibre due to dead load
d_1	distance from outer surface of compressive zone to centroid of tendons

d_n	distance from outer surface of compressive zone to neutral axis
e	eccentricity of the tendons relative to the centroid of the section
Ec	modulus of elasticity of concrete
Es	modulus of elasticity of steel
Σ_c	strain in concrete
Σ_s	strain in steel
f_m	maximum stress which would be reached in the tendon at failure of the beam
f_u	tensile strength of the prestressing steel
k	radius of gyration
M_u	failing moment of beam
U_t	specified minimum concrete cube strength at transfer
U_w	specified minimum concrete cube strength at 28 days
C	total compressive force
T	total tensile force

Example on Design of a Prestressed Concrete I Beam and the Estimation of its Ultimate Strength

Design a beam to carry 500 lb per ft run over 29 ft clear span with 1 ft bearing at each end.

Design constants

$U_t = 4{,}000$ lb/in²
$U_w = 6{,}000$ lb/in²
$C_c = 2{,}000$ lb/in²
$C_t = 160$ lb/in²

Stressing wire 0.276 in diameter

$f_u = 95$–105 ton/in²

Maximum anchoring load is 9,000 lb
Beam will be post-tensioned.

Beam section

From trial calculations, or from tables, select I beam, flanges 8 × 4 in, web 2½ in thick and overall depth 19 in.

Area = 91.5 in²
$I = 3{,}963$ in⁴
$k^2 = 43.3$ in²

$$\frac{k^2}{y} = 4.55$$

Stresses due to dead and applied loads

$$M_D = \frac{91.5 \times 150}{144} \times \frac{30^2}{8} \times 12 = 128{,}500 \text{ lb/in}$$

$$M_A = 500 \times \frac{30}{8} \times 12 = 675{,}000 \text{ lb/in}$$

$$\frac{I}{y} = \frac{3{,}963}{9.5} = 417 \text{ in}^3$$

$$C_{Dt} = C_{Db} = \frac{128{,}500}{417} = 308 \text{ lb/in}^2$$

$$C_{At} = C_{Ab} = \frac{675{,}000}{417} = 1{,}620 \text{ lb/in}^2$$

Maximum value of eccentricity

By calculation $\frac{k^2/_y - e}{k^2/_y + e} = \frac{N k^2/_y\,(C_t + C_{Dt})}{k^2/_y\,(C_{Db} + C_{Ab} - C^t)}$

$$\frac{4.55 - e}{4.55 + e} = \frac{-0.8\,(160 + 308)}{308 + 1{,}620 \times 160} = -0.212$$

$$e = 7 \text{ in}$$

By available depth $e = 9.5 - 1.5$ (cover) $-$ (half diameter of prestressing cable)

$= 7$ in

Prestressing force for e = 7 in

$$n\frac{P}{A}\left(1 + e\frac{y}{k^2}\right) = -C_t + (C_{Db} + C_{AB})$$

$$\frac{0.8P}{91.5}\left(1 + 7 \times \frac{1}{4.55}\right) = -160 + (308 + 1{,}620)$$

$$P = 79{,}500 \text{ lb.}$$

Nine wires stressed to 8,850 lb give a prestressing force of 79,500 lb.

Check stresses due to force of 79,500 lb

Stress in top fibre due to dead load and prestress

$$= \frac{P}{A}\left(1 - e\frac{y}{k^2}\right) + C_{Dt} = \frac{79{,}500}{91.5}(1 - 1.54) + 308$$

$$= -162 \text{ lb/in}^2$$

Stress in bottom fibre due to dead load and prestress

$$= \frac{P}{A}\left(1 + \frac{ey}{k^2}\right) - C_{Db} = \frac{79{,}500}{91.5}(1 + 1.54) - 308 = +1{,}902 \text{ lb/in}^2$$

Stress in top fibre under working conditions

$$= \frac{nP}{A}\left(1 - \frac{ey}{k^2}\right) + (C_{Dt} + C_{At}) = \frac{0.8 \times 79{,}500}{91.5}(1 - 1.54) + (308 + 1{,}620)$$

$$= +1{,}552 \text{ lb/in}^2$$

Stress in bottom fibre under working conditions

$$= \frac{nP}{A}\left(1 + \frac{ey}{k^2}\right) - (C_{Db} + C_{Ab}) = \frac{0.8 \times 79{,}500}{91.5}(1 + 1.54) - (308 + 1{,}620)$$

$$= -158 \text{ lb/in}^2$$

The calculated stresses are inside the allowable limits in Tables 1, 2, and 3 of the new code.

Loss of prestress

Stress due to direct compression $= \frac{A}{P} = \frac{79{,}500}{91.5} = 870$ lb/in²

Stress due to prestressing moment $= \frac{Pey}{I} = \frac{79{,}500}{417} \times 7 = 1{,}335$ lb/in²

Stress due to dead load moment $= \frac{M_d y}{I} = \frac{128{,}500}{417} = 308$ lb/in²

Stress in top fibre $= -870 + 1{,}335 - 308 = 157$ lb/in² tension

Stress in bottom fibre $= -870 - 1{,}335 + 308 = 1{,}897$ lb/in² compression

Stress at CG of prestressing cable $\left(\frac{16.5}{19} \times 2{,}054 - 157\right)$ = 1,626 lb/in

E_c for U_t of 4,000 lb/in² = 4×10^6

Elastic deformation $= \frac{1}{2} \times \frac{1626}{4 \times 10^6}$ = 2.03×10^{-4}

Shrinkage = 2.5×10^{-4}

Creep $= \frac{1{,}626 \times 0.25 \times 6{,}000}{10^6 \times 4{,}000}$ = 6.10×10^{-4}

Creep of steel ($E_s = 28 \times 10^6$ and relaxation = 10,000 lb/in²)

$= \frac{10{,}000}{28 \times 10^6}$ = 3.56×10^{-4}

∴ Total loss of strain = 14.19×10^{-4}
= 0.001419

Find depth of neutral axis at ultimate failure

From graph strain in wire for force of 8,800 lb	= 0.0054
Loss of strain from calculations	= 0.001419
∴ Strain due to prestress	= 0.00398
From tables: Average concrete stress for U_w of 6,000 lb/in²	= 3,300 lb/in²
Maximum concrete strain	= 0.00328
Depth of compression force	= 0.442 d_n

Strain profile:—

A strain profile with $d_n = 4$ in (i.e. thickness of flange) gives

$\Sigma_s = \frac{12.5}{4} \times 0.00328 \times 0.01025$

Total strain = 0.01025 + 0.00398 = 0.01423

This exceeds ultimate strain in wire (0.01)

Draw profile (1) with $\Sigma_c = 0.00328$ and $\Sigma_s = 0.01 - 0.00398 = 0.00602$

d_n becomes 5.8 in

Force per wire (from graph)		= 13,200 lb
Compressive force in flange	= 3,300 × 8 × 4	= 105,600 lb
Compressive force in web	= 3,300 × 2.5 × 1.8	= 14,850 lb
Total force in concrete ΣC	= 105,600 + 14,850	= 120,450 lb
Total force in steel ΣT	= 13,200 × 9	= 118,800 lb
	∴ $\Sigma C > \Sigma T$	

In fact the values are within 2 per cent of each other and for most purposes would be taken as equal.

Adjust profile:—

Draw profile (2) with d_n	= 5.6 in
$\Sigma_s = 0.00602 + 0.00398$	= 0.01
Force per wire	= 13,200 lb
ΣT	= 118,800 lb
Compressive force in flange	= 105,600 lb
Compressive force in web	= 3,300 × 2.5 × 1.6
	= 13,200 lb
ΣC	= 105,600 + 13,200
	= 118,800 lb
∴ ΣC	= ΣT

Ultimate Moment of beam

From calculations:

Depth of compressive force $= 0.442 d_n = 0.442 \times 5.6 = 2.47$ in

Lever arm $= 16.5 - 2.47 = 14.03$ in

Ultimate Moment $= 118{,}800 \times 14.03 = 1{,}666{,}000$ lb/in

From *CP* 115/59

$A_{st} = 9 \times 0.06 = 0.54 \text{ in}^2$

From Table 7: $\frac{f_u}{U_w}\frac{A_{st}}{bd_1} = \frac{2{,}240 \times 100 \times 0.54}{6{,}000 \times 8 \times 16.5} = 0.152$

$$\frac{f_m}{f_u} = 1.0$$

$$\frac{d_n}{d_1} = 0.375$$

$\therefore$ Ultimate Moment $= 2{,}240 \times 100 \times 0.54\,(16.5 - 0.4 \times 0.375 \times 16.5)$
$= 1{,}694{,}000$ lb/in

Conclusion

Value of ultimate moment by calculation = 1,666,000 lb/in.

Value of ultimate moment by *CP*115/59 = 1,694,000 lb/in.

The value derived from *CP*115/59 is higher, as would be expected, as the assumption made was that the beam is rectangular in section above the neutral axis. However, the difference is small (1.7 per cent) and for all practical purposes the code of practice gives a quick method of determining the ultimate moment.

Pipe-Bridge Crossing of River Teme at Graham's Cot

By R. P. Ashton, BEng, AMICE[1], *and* Captain K. V. Randall, RE

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THE CIVIL ENGINEER'S TASK

The Elan Aqueduct

The laying of the fourth main of the Elan Aqueduct completes the final stage of the Elan Supply Scheme for the City of Birmingham which was designed by the late Mr James Mansergh, FRS, a Past President of the Institution of Civil Engineers, and was commenced in 1893. The first stage of the scheme included the construction of three impounding reservoirs in the Elan Valley, and two 42 in pipelines on the siphon sections of the aqueduct. The aqueduct

[1]Elan Supply Office, Ludlow, City of Birmingham Water Department.

is about 73½ miles long and, in aggregate, half this length consists of pipelines and half of conduit or tunnel. The conduits and tunnels were constructed of sufficient size to carry the ultimate reliable yield of the gathering grounds which is 75 mgd, and the two 42 in pipelines on the siphon sections were to be followed by a further four 42 in pipelines at a later date. The first stage of the scheme was brought into commission in 1904.

As the demand for water in the City of Birmingham increased, so by 1920 it became necessary to increase the capacity of the aqueduct. During the intervening years, and in conjunction with firms of steel and concrete pipe manufacturers, a 60 in diameter welded steel pipe with a spun concrete lining had been developed. The use of this pipe was adopted for the third main, and later for the fourth main on the aqueduct. The two 60 in mains have a slightly greater carrying capacity than the further four 42 in mains originally envisaged by Mansergh. The laying of the fourth main, composed of 60 in diameter pipes, which was started in 1949, is now nearing completion; and it was in conjunction with this work that the crossing of the River Teme at Graham's Cot had to be carried out.

River Crossing at Graham's Cot

The Downton Siphon of the Elan Aqueduct is some 9 miles in length and runs from Knighton in Radnorshire to near Leintwardine on the south border of Shropshire, where it crosses the River Teme at Graham's Cot. The original two 42 in pipelines were carried over the river by a lattice-girder steel bridge having two spans of 85 ft. The masonry abutments and central pier were built with sufficient width to accommodate a further two girders to carry four future pipelines on the aqueduct. At the time of laying the third 60 in main, an additional girder was added on the south side, and the pipes were supported by cross-girders connecting the new girder to the original girder which had been designed to carry this additional load. The girder for the third main was also designed to be utilized in carrying a fourth main at a later date.

Improved welding techniques made possible the construction of a self-supporting pipe-bridge with an estimated reduction in cost from £7,800 for a girder bridge to £5,200.

The intention was to design the self-supporting pipe as a continuous beam over the central support with freely supported ends at the abutments. For a 60 in pipe to span gaps of 85 ft., considerable loads would be applied at the supports, and the stresses in the steel of the pipe shell at the points of support had to be closely investigated.

Design of Self-supporting Pipe-bridge

Bending stresses in the pipe shell were ascertained by means of a conventional beam analysis and by additional calculations following the method described by Herman Schorer.[1]

The total distributed load was found to be 0.882 ton per foot run, including pipe, lining, water content of pipe, footwalk, and live load.

A bending moment diagram would illustrate that the negative moment, over a distance of 8 ft either side of the central support, exceeds the positive

[1]Schorer, Herman, 1933, *Trans. Am. Soc. C. E.*, vol. 98, p. 101, "Design of Large Pipe Lines".

moment. For this reason the pipe over the central pier was fabricated out of $\frac{3}{4}$ in steel plate, all the other pipes having $\frac{5}{8}$ in thick steel.

The bending stresses were calculated for $\frac{11}{16}$ and $\frac{9}{16}$ in thick steel, that is, $\frac{1}{16}$ in less than the actual pipe steel. This follows a practice adopted on the Elan aqueduct, in which all steel pipe thicknesses are $\frac{1}{16}$ in greater than the design thickness at places where the pipes are exposed to the weather. The thickness of pipe steel varies on the different siphons according to the working head. Over the central pier the actual pipe dimensions are as follows:—

Outside diameter of steel: $62\frac{3}{4}$ in.
Inside diameter of steel: $61\frac{1}{4}$ in.
Inside diameter of concrete lining: $59\frac{1}{4}$ in.

Following the conventional beam analysis at the point of maximum bending, the stresses in the pipe steel are as follows:—

Shear stress: 0.319 ton per sq in.
Bending stress: 4.65 tons per sq in.

The pipe contains water under a head of 350 ft, which gives a ring stress in the steel of 2.93 tons per sq in.

The greatest direct stress in the steel is the maximum principal stress, which is 4.70 tons per sq in.

Schorer's method of calculation for the stresses in the pipe where it is continuous over the central pier gives a maximum longitudinal beam stress of 4.17 tons per sq in, and to this must be added the bending stress at the rim where the pipe shell is enclosed by the supporting rings. The latter stress is confined to a limited zone where bending deformation of the pipe is restrained by the supporting rings and in this particular case amounts to 3.48 tons per sq in. Hence the maximum combined longitudinal shell stress is 4.17 + 3.48 = 7.65 tons per sq in. This stress exceeds the maximum safe stress adopted, which was 6 tons per sq in, and indicates the necessity of further strengthening at the point of support.

It was calculated that the rim bending stress became negligible at a distance of 18 in away from the centre of the supporting rings, so a belt 3 ft wide of $\frac{1}{2}$ in steel was welded round the pipe to provide the necessary additional strength over the support. This resulted in the following reduced stresses:—

Longitudinal beam stress	2.90 tons per sq in
Bending stress at rim	1.48 tons per sq in
Maximum combined longitudinal shell stress	4.38 tons per sq in

Again following Schorer's method, the stresses in the $1\frac{1}{4}$ in thick by 6 in wide steel supporting rings were calculated and found to be as follows:—

Maximum ring bending stress	3.18 tons per sq in
Ring stress due to radial forces	1.21 tons per sq in
Ring stress due to shear	1.56 tons per sq in
Total tensile stress in ring	5.95 tons per sq in

The three stresses are added arithmetically, since all are combined at a maximum in the same plane on the horizontal diameter.

Calculations were also carried out to determine the stresses in the pipe shell at the point of maximum positive bending, and the ring stresses at the freely supported ends. In each case these were less than 6 tons per sq in.

The pipe-supporting rings at the central pier and end abutments provide distinct advantages over the conventional type of saddle support (Fig 1). The rings, which are welded to the pipe and tied together with plate diaphragms, transmit the load to the pipe shell and at the same time prevent distortion of the shell. The pipe, being thus held to a circular shape, provides a good beam to support itself and the contained water.

The deflexion of the pipe as a beam when charged with water was calculated as being $\frac{5}{8}$ in, and the bridge was designed to have an initial camber of $2\frac{1}{2}$ in at the centre of each span, which would result in a camber of about 2 in when loaded. It was decided to provide this camber in order to guard against a possible optical illusion of sagging which might occur if the loaded pipe was dead flat.

The bridge pipes were designed to have an effective length of 15 ft $10\frac{1}{4}$ in, a convenient length which provided pipes of a weight within the limits of the lifting gear available on the aqueduct works. The weights of the pipes of 60 in nominal internal diameter are as follows:—

$\frac{5}{8}$ in thick pipes spanning the gaps: 4 tons 8 cwt.

$\frac{5}{8}$ in thick pipes at abutments with supporting rings welded on: 5 tons 6 cwt.

$\frac{3}{4}$ in thick pipe at central pier with supporting rings welded on: 6 tons.

The pipes have a spun concrete lining 1 in thick which is painted with two coats of bituminous paint, one coat being applied at the works and one after laying and making-up the concrete lining at the joints. The outside of the pipes was shot-blasted at the works and painted with one coat of "Detel" metal undercoat. After laying, the outside was again painted with an undercoat and finishing coat.

The special welded joints (see Fig. 2) have steel collars $\frac{5}{8}$ in thick and 8 in wide. These collars have a reasonably tight fit over the pipe ends, one end being shop-welded and the other site-welded both inside and out. Each joint was provided with three pairs of brackets spaced radially at 120 deg, and by means of bolts through the brackets the joints were easily drawn together on the site. Following assembly of the pipes, the bolts have been left in position, as they will provide a useful means of suspending scaffolding for future maintenance and painting.

The site-welding of the joints was carried out with "Vodex" electrodes, and the weld applied was as follows:—

(1) Inside joints:—

1 run of No 10 gauge electrode.

3 runs of No 8 gauge electrode.

(2) Outside collar joints:—

1 run of No 10 gauge electrode.

2 runs of No 8 gauge electrode.

As a first step in welding, a short run of weld was applied on the outside of each joint on each side of the horizontal diameter, the purpose being to minimize any possible movement of the pipes during the welding operations. It was feared that, should one side of the pipe become warmer than the other due to heat from the sun, the pipe would bow in a horizontal plane. No movement of this nature was detected, and it was not necessary to shade the pipe or to cool it by spraying with water.

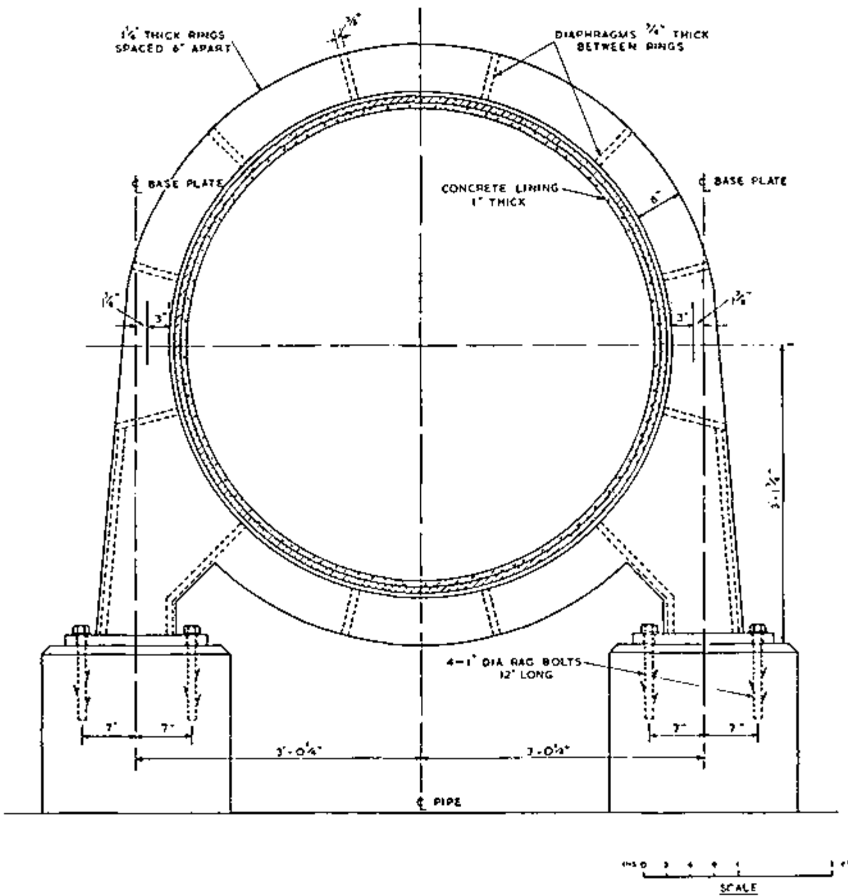


Fig 1. Details of welded joint

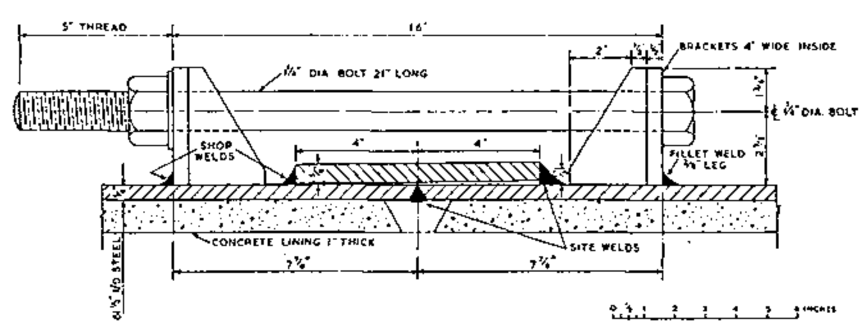


Fig 2. Fixed support at centre pier: two supporting rings with diaphragms welded between

Longitudinal expansion of the pipe is allowed for at the freely supported ends where the pipe supporting rings are carried by combined roller and rocker bearings. The temperature movement on an 85 ft span is ½ in for a temperature range of 70°F., and 1 in of movement is permitted in each of the gland collars fitted just beyond the bearings.

The hydraulic thrust on the 24° bend at the west abutment is 85 tons, and a substantial anchorage was provided to restrain the pipe in this respect.

Site Construction Methods

Owing to fluctuating river-level and the nature of the river bed, various temporary methods of support were considered and rejected and finally the possibility of using a Bailey Bridge, which would span the gap without needing intermediate supports, was adopted.

After completion of the Bailey Bridge, the laying and jointing of the special bridge-pipes was relatively easy. The pipes were hauled on to the bridge by a light tractor winch, the pipes running on wheels on light-gauge railway lines. The wheels were fitted to cradle-shaped axles, the pipe fitting into the cradle and forming its own chasis. The pipes were then lifted into position by means of a block and tackle cantilevered out from the existing bridge truss. A little difficulty was met with in laying the pipes to the desired camber, for when the load on the Bailey Bridge was increased, pipe by pipe, so the bridge deflected downwards over the loaded span and arched over the unloaded span. However, before welding, there was still sufficient play in the pipe joints to permit the necessary adjustments in level to be made. When the self-supporting bridge had been completed, and when an appropriate number of pipes had been laid from it up the adjoining hillside, the pipes were filled with water in order to restrict temperature movement to a minimum until such time as the main was brought into commission.

THE MILITARY ENGINEER'S TASK

Design Problems and Methods

In November 1958, Birmingham Corporation Water Department approached the military authorities for help in bridging the River Teme near Leintwardine. This task was eventually allocated to 127 Construction Regiment, RE (TA), Birmingham's own Engineer Regiment.

The present-day military engineer solves nearly all his bridging problems with standard military equipment, because it is so much quicker than normal constructional methods, and time is a most important factor in war. When faced with bridging the Graham's Cot Crossing, an attempt was made to fit in one of the normal equipment bridges available. As with all such problems, a number of limiting factors controlled the design of the supporting bridge for the 170 ft long 60 in diameter steel pipeline. The main factors were as follows:—

(1) The minimum clear horizontal distance between the existing bridge and the outside of the new pipe was only 2 ft 6 in.

(2) The vertical distance between the bottom of the new pipeline and the top of the central pier and abutments was 2 ft. 3¼ in.

(3) The maximum total dead weight for each span during construction of the pipe was estimated at approximately 26 tons, uniformly distributed.

(4) The distance from the edge of the existing bridge to the outside edge of the central pier was 15 ft 9 in.

(5) The pipes to be supported were 15 ft. 10 in. in length, so that, provided the two end-pipes to be fixed on the abutments were supported at some other point along their length, the supporting bridge need not fill the complete gap.

(6) The bridging site was restricted by the masonry abutments of the existing bridge on the far and near bank so that normal methods of Bailey bridging with a "tail" or "nose" were not possible. However, the gap under the east span was dry, except during abnormal floods.

(7) When constructed, the bridge had to allow ample working room for assembling the steel pipes, with welded joints.

(8) The dismantling of the bridge had to be possible, once the pipes were in their final position and were self-supporting.

(9) The bridging equipment was being hired by Birmingham Corporation Water Department, and the design which involved the least amount of equipment would be the most desirable.

As a normal through bridge would not meet the conditions enumerated, an improvised structure, based mainly on bridging equipment, had to be used. The eventual design consisted of 150 ft of "double single" (double-tress and single storey in height) Bailey girder launched alongside the existing pier and abutments, resting in its final position approximately at ground level. The girder was braced with normal bracing frames on the top, rear, and underside of each 10 ft bay, and extra widened Bailey bridge transoms (19 ft 11 in × 12 in × 5 in) were used as the cross-girders, also at 10 ft spacing. The transoms were fixed underneath the compound girder of the existing bridge by special hangers (Photo 1), consisting of two bolts and four angle-irons. The minimum design requirements were known for the various parts of these hangers, but stocks of available materials were used to save extra expense for the Elan Supply Office, which produced them. The transoms were supported vertically at these points, but were free to move horizontally, and therefore it was considered necessary to fix them vertically and horizontally on to the Bailey girder. It was done by seating the girder in an "overhead bracing support". This was unusual, as the equipment is designed as a seating for a transom acting as overhead bracing in a triple-storey bridge, and not to take a load. However, the maximum load on any one support was approximately 4 tons, and it did not have to withstand the stresses of a normal bridge carrying traffic, so it was considered perfectly safe. Only three stringers were used per bay instead of the normal seven (this was to save equipment). These stringers were placed in the two outside positions and under the centre line of the pipe.

The design adopted fulfilled all the necessary requirements. The deck was completely free for constructional work, the deck level allowed clearance for packing underneath the pipes, the temporary bridge could easily be dismantled after completion of the pipeline, and a minimum of equipment had been used.

Construction

Launching rollers can be overstressed by the momentary transfer of the girder weight to one roller during launching. The RE Training Manual recommends rocking rollers for launching all girders over 60 ft. In this case twin rocking-rollers were used as launching rollers, together with pairs of

Photo 1. Moving transoms into position.

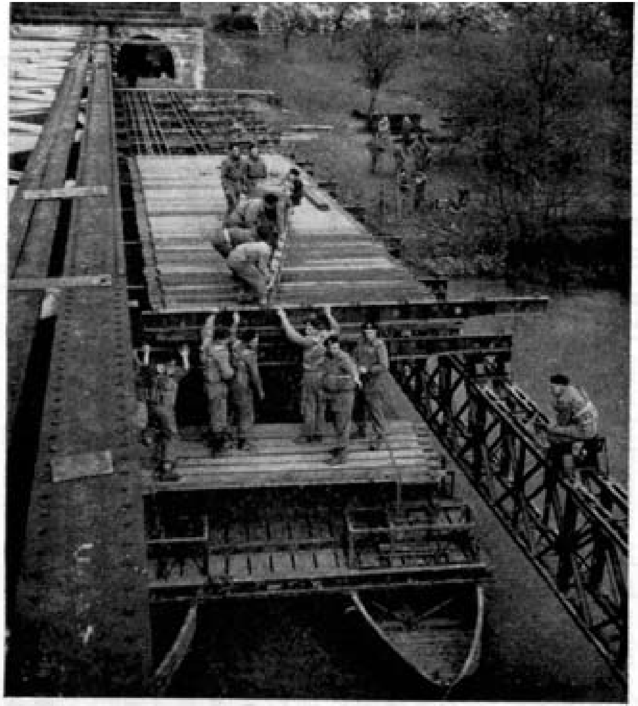


Photo 2. Boat raft, with superstructure used in placing transoms.

Pipe Bridge Crossing of River Teme At Grahams Cot 1,2

Photo 3. Pipeline resting on Bailey Bridge.

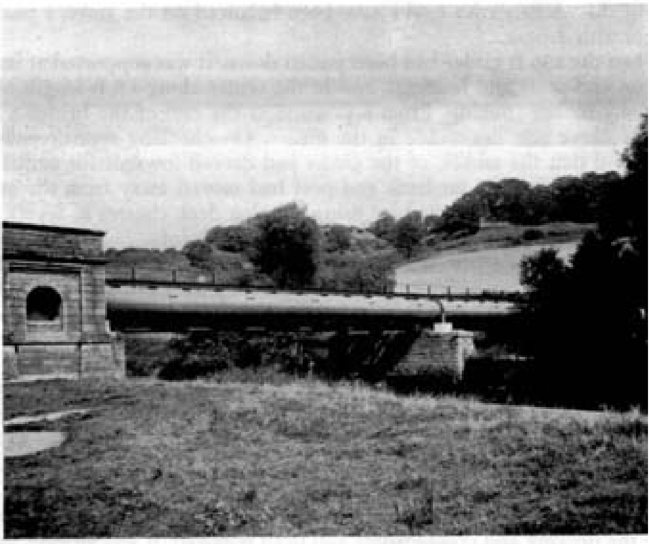


Photo 4. The completed pipe-bridge.

Pipe Bridge Crossing of River Teme At Grahams Cot 3&4

plain rollers at 27 ft and 52 ft back from the launching rollers. The landing rollers were also plain.

The site was restricted by the existing east-end masonry abutment on the dry gap, so that a tail could not be built to act as a counter-weight; but some safe form of counterweight had to be found. This launching problem was overcome by leaving out the overhead bracing supports (weight 150 lb each) from the bays of bridge to be cantilevered over the wet gap, and placing them on the bays that were to span the dry gap. This was much better than using any other form of counterweight, as it was known that the bracing supports were centrally loaded along the line of the girder, and would not therefore tend to turn the girder over as other added weights might have done. In addition, a preventer tackle was attached to the end of the girder.

The building and launching of the girder was fairly simple once the important work of setting out and levelling up of rollers had been completed. The sag in the nose of the cantilevered girder was taken as being the same as a "single/single" Bailey Bridge, i.e. 16 in. This proved to be the exact figure, as when the end posts were added the end of the girder fell straight into its bearings, and the landing rollers were not used.

Once the far bank end-posts were seated on their bearings jacking was begun on the home bank, in order to remove the building rollers and seat the girder in its final position. This was the most hazardous part of the construction, as the whole girder started to sway, and it was even more vital than usual to keep the two jacks in phase. During jacking operations all men were kept completely clear of the girder, and packing was only replaced or removed when the girder was still. On no account should the girder be jacked at any point other than at the ends; if, for instance, the jacking had taken place near the launching rollers (the approximate point of balance of the girder), the whole girder could have been balanced on the jacks, a position fraught with danger.

When the 150 ft girder had been jacked down, it was supported at its two ends on end-posts and bearings, and in the centre along a 3 ft length of the girder by timber packing. From a position at the end of the bridge a very definite curve was noticeable in the girder. On checking measurements it was found that the middle of the girder had curved towards the centre line of the bridge, and the far bank end-post had moved away from the centre line. This was soon corrected by using wooden deck chesses as levers, and applying them in the right direction at the relevant points.

Having fixed the line of the girder, the transoms were quickly manhandled into position over the dry gap. A folding boat raft was built with a superstructure of cribs and timber, to ease the positioning of transoms over the wet gap (Photo 2). By the good fortune of nature, there was heavy rain on the day before the transoms were positioned over the wet gap, and the River Teme was in flood. This raised the level of the raft in relation to the girder, and made the placing of these transoms comparatively easy. The final decking-down of the bridge was a simple matter once the transoms were in position (Photo 3).

Dismantling

The dismantling was carried out in the reverse order to the construction. Once the decking and cross-girders had been removed, it was an easy matter to "delaunch" the Bailey girder as it was well clear of the pipeline. Photo 4 shows the completed pipe-bridge.

Administrative and Miscellaneous Problems

The bridge was built during two week-ends and dismantled in a third week-end by the Territorial Army soldiers of 127 Construction Regiment, RE(TA). Before any work could be started agreement had to be obtained from the Transport and General Workers' Union and the Federation of Civil Engineering Contractors for the use of military engineers on this task. Then, as only a limited number of Territorial soldiers were being used, all extraneous administrative tasks which would interfere with construction work had to be cut to a minimum. This was done by arranging for the catering to be carried out by a local fishing hotel and for accommodation in the village hall.

Conclusion

This project was extremely interesting for the Regiment, as it provided an exercise in design outside normal-equipment bridging, and also in an unusual construction. Some excellent military training was obtained, but in addition a useful service was also rendered to the community and in particular to the Regiment's own City (Birmingham), which made the work seem even more worth while.

Acknowledgments

Acknowledgment is due to the Water Committee of the Birmingham City Council and to the chief engineer, Mr C. A. Risbridger, BSc, MICE, for permission to publish the information given in this paper.

G E Salonika

By G. H. Richards, Esq.

(An Amateur's Effort at Deep Sea Diving)

It was early in 1916 that I, a temporary Lieutenant in the Royal Engineers, was sent from Alexandria to Salonika, to report for duty to the Engineer-in-Chief.

At that time the campaign in Macedonia was in its infancy. The British and French GHQ had requisitioned houses on the outskirts of the town for their offices, and for quarters for the staffs; and other base units had offices and quarters in the town. When I first arrived I was given quarters with one or two other officers in a Greek house; we got our meals at a restaurant, and had to go to public baths for our ablutions. I had my office in the RE Base HQ which was another requisitioned house. The job that was assigned to me was Works Officer Kalamaria, a large district about three miles outside the town.

My duties, among other things, were to construct an aerodrome, heavy repair workshops, and light repair workshops for the ASC Motor Transport, a complete general hospital with roads and all accessories, and one or two roads. I had many other minor works, and was always at the beck and call of the OCs of various units in the district. None of this work had been started, and there was no military help available, I was just left to carry on with what

Greek labour I could find. Incidentally I could speak no Greek, and only school-boy French. I was technically qualified for the job, as I was a qualified civil engineer, and had spent ten years in the Public Works Department Malaya before coming home for the war.

The transport given to me, in the first place, was an ancient motor cycle, one of the brand that you started by running along until it fired, and then leapt into the saddle when it got going, sometimes a painful operation. The first week or so I had to ride along a terrible road made of very uneven setts, from Salonica to Kalamaria, where my work was.

One day I was holding a conversation in execrable French with a Greek contractor. A young ASC officer, Captain Morris, who had lived in France for some years, overheard the conversation and was most impressed, he said afterwards that my French was a most extraordinary mixture of Latin, English, German, a little French and another unknown language. I told him that was probably Malay. Morris let the conversation continue for some time before he butted in and asked me if he could help me. I gladly accepted his offer, and he told the contractor all I had been trying to do.

Morris was the OC of the ASC dump in Kalamaria, and when I told him my story, he kindly invited me to share his mess, and offered me a hut in the dump for my office and quarters, which, needless to say, I was most pleased to accept. After that Morris and I were great friends, and I enjoyed the hospitality of him and his fellow officers for some months.

All building work, such as workshops, I let out to Greek contractors, and spent a lot of time rushing about on the ancient motor bike, inspecting work. The aerodrome was a ploughed field, and I collected a large labour force at once to level it off. On the first day that work was started on the earthwork, two or three very exalted red tabs paid me a visit. They said the aerodrome was wanted in two weeks, with road to take heavy lorries, pier to land aeroplanes and stores from steamers, tent hangers erected, dark room and photography hut, etc.

They asked me what help I required in the way of troops. I told them I didn't want any troops, I could get all the labour I wanted locally, all I required was a steam roller. This request dismayed them, they said there wasn't a steam roller in the country—"Yes there is, Sir," I replied, "The French have got one!" They didn't ask me if I wanted anything else, but I told them that I couldn't do the job in a fortnight unless I had a steam roller to consolidate the aerodrome. I really wanted it for the entrance road but thought it might be considered more urgent for the landing ground. However it worked and I got the steam roller the next day.

The big problem was the pier. I set to work in my office in the ASC dump and designed a timber one, piles with cross bracing, bolted together, about 300 feet out from the shore, as far as I can remember, and about 100 feet beyond that, a dolphin, of similar construction, with bollards for tying vessels to.

I then went to the RE dump, with an estimate of my requirements, and told the OC what timber, etc, I required.

I found him in a state of bewilderment. He was terribly under-staffed, and timber was being shot at him in all directions from a large ship, which had just arrived from Halifax, Nova Scotia. I told him the pier was wanted in thirteen days and I must have the timber at once. He said it would take thirteen days to measure it up, and check it out to me. "Look here," I said.

"Let me go on to the ship, and pick out the stuff I want, and have it put into barges alongside, never mind what goes in, I will sign afterwards for anything you give me to sign—it is a matter of extreme urgency." He sensibly agreed to my proposal, and I got the timber sent along that day in barges to the site of the aerodrome, the other side of the bay.

Incidentally it was then May in Salonika and the temperature about 100°F. In the ship down below there was still snow, as it had been winter when she left Halifax; the workmen were enjoying themselves snow-balling one another in the hold.

During the construction of the pier the officers and men of the RFC were most helpful to me in every way, and I could never have completed the work in the time without their wonderful assistance. We worked day and night. Pile-driving went on continuously, the RFC providing search-lights.

The bolting of the bracing under the sea was done by divers, the diving apparatus being provided by the contractor. I told him that, when the work was finished, I would go down and inspect it, to see that the bolts were properly secured. What I didn't tell him was that I had never been down in a diving suit in my life.

In the meantime work was going on with the levelling of the aerodrome. I had a very efficient Armenian overseer, who mustered his men at 5.30 am. I often put in an appearance at muster. The men were spread over a very large area and well organized. The test I employed for the surface was to ride the motor bike at full speed in all directions. By the end of the fortnight I could do this without being bumped off and the surface was hard enough to satisfy the RFC.

Other labour gangs and the steam roller were busy on the entrance roads, and the photography hut was being built by contract. The tent hangers were erected by the RFC.

As far as I can remember all this work was completed in time and handed over to the RFC.

The pier was now completed and I had to carry out my promise to the contractor to inspect the bracing under sea.

He took me to a boat, occupied by two or three other men and the diving apparatus, and we went alongside the pier.

The diving helmet was put over my head, this was a miniature glass house, a thing of appalling weight, with tube and pumping machinery attached. Leaden boots were put on my feet. I was then given instructions in French, which I misunderstood. I was shown a valve, and, as I thought, told to press it when I was not going down fast enough, actually I was intended to press it when I wanted to come up quickly in an emergency.

I got over the side and proceeded to go down a ladder hooked to the gunwale and jumped in. After descending a few feet I was feeling extremely uncomfortable, and thought it would be a good thing to get the job over quickly, so pressed the button to help things along. The result was most alarming. I shot up to the surface instantaneously, upside down. The boots were of no avail if their purpose was to keep me right side up, the helmet outweighed them. I think the effect of pressing the button must have been to fill me with air, like a balloon. A great surprise.

The men in the boat had all their work cut out to haul me back, as I was mixed up with the piping and other apparatus. They expressed great surprise that this was my first attempt at diving, actually it was also my last, as I decided that I would take their word for it that the bolts were well and truly secured. Anyway the pier was used till the end of the war, and the bolts were not responsible for its demise, and did good service in landing stores for the RFC for three years, when it was no longer required. This I learnt in May 1919 when I was returning to England for demobilization through Salonika, and called on the Officer who was then Works Officer Salonika. He told me that the pier had recently collapsed completely, owing to sea worms. He showed me a bit of one of the piles, which was riddled with holes, and looked like a sponge.

There was no time, when the pier was built, to construct anything of a permanent nature, or to treat the timber with creosote, or any other material, against the ravages of the toredo navalis, the sea insect, which attacks timber.

After the aerodrome was completed I was taken up on a few flights and was shown photographs of the trenches, and the process of piecing photos together to make one picture of a series of photos.

At that time hutments for the hospital, which were to be erected in my district, were on their way to Salonika, and the preparation of the hospital site was urgent. A survey of the site was required at once, but I had no staff to make one, and had no time to do it myself.

When I was shown the aerial photos of trenches, I knew that the problem of the survey of the hospital site was solved, if the RFC would take the necessary photos for me. I therefore approached the CO, Colonel Dawes, who promptly agreed to do it for me, and produced the aerial survey in a very short time.

Actually the hospital was taken out of my hands, and given over entirely to a very capable officer, who had just arrived. He told me later that he had found the survey invaluable.

My experiences as an officer in the RE during the first World War were various, but, never again was I given such a free hand and allowed to get on with the job, as I was as Works Officer, Kalamaria, with the rank of Lieutenant.

Compressed Air Work in Civil Engineering

By Captain J. H. Joiner, BSc (Eng), AMICE, RE

Introduction

Although compressed air work, particularly in caissons, is fairly common in the civil engineering world, it has no great military application. It has, nevertheless, been thought worth while writing this article, which may prove of general interest to officers of the Corps.

The article deals with the use of compressed air in tunnel construction and caisson work, making only passing reference to diving bells and deep sea diving, both of which, of course, involve the use of compressed air.

The Historical Background

Early in the nineteenth century, Brunel constructed the tunnel under the Thames between Rotherhithe and Wapping, just below Tower Bridge. This tunnel was rectangular in section, with a height of 22 ft 3 in and a width of 37 ft 6 in; it took eighteen years to complete, although in fact work ceased for seven years due to lack of funds. Many difficulties were met during construction, and these were due in part to the considerable influx of water to the working.

As a result of these difficulties, it was suggested by Admiral Sir Thomas Cochrane that compressed air might be used to reduce the influx of water during shaft sinking and tunnel construction; in 1830 Cochrane took out a patent for what is, in effect, the modern air-lock, although the term "air-lock" was not used until 1851, when it was used in a description of the work of sinking the caissons for the Rochester Bridge over the Medway.

Compressed air was first used in tunnelling in 1879. In that year it was used for driving a small tunnel, 5 ft high by 4 ft wide, in connexion with some dock work in Amsterdam. In the same year work commenced on a railway tunnel under the Hudson, in New York, and compressed air was again used; work was very intermittent, and the tunnel was not opened until 1905.

Soon after Cochrane patented his air-lock, Augustus Siebe introduced his closed diving dress and helmet, which was the forerunner of the modern diving suit. Among the first users of the suit were Cpl Harris and two sappers, under the supervision of Colonel Pasley RE, (later General Sir Charles William Pasley), who was at the time Director of the RE Establishment, Chatham. This work was in connexion with the disposal of the wreck of the "Royal George" by the firing of under-water charges of gunpowder placed against the hull of the ship; further details of this exploit are given in Vol. II of the Corps History.

The diving bell, which also relies on compressed air for its successful operation, is said to have been in use since 332 B.C., when one was used by Alexander the Great at the Siege of Tyre. However it was not until 1690 that a bell was used in which the original air supply was replenished under water; this was Haley's bell, the supply of air being lowered in a lead lined barrel and fed up through the bottom of the bell by means of a leather tube.

The first modern type of bell was designed and used in 1788 by Smeaton; it was not intended to be wholly submerged, and was fitted with a force pump on its roof to supply its occupant with a continuous supply of fresh air.

The caisson, which may be likened to a tube with its bottom end open and its top end above water or ground level, differs from the diving bell in that the worker can make his way from the surface to the working chamber directly, without the need to raise the chamber to the surface or for the worker to wear special equipment.

In 1779 Coulomb designed a three-compartment caisson, the outer compartments forming a flotation unit to float the caisson into position, after which they were to be flooded; the centre section was to be filled with compressed air to form a working chamber.

By 1859 Saint-Denis had proposed the forerunner of the modern compressed air caisson, complete with air-locks for the workmen and materials.

Thus it can be seen by this brief survey that for very many years the engineer has been active in his attempts to make use of compressed air to ease his work, both underground (in water-bearing soils), and beneath the sea.

The Provision of Compressed Air

The provision and maintenance of low pressure compressed air plant, required on a project purely as temporary works, can be a major item. The plant must obviously operate on a twenty-four hour cycle, which necessitates first-class maintenance, and since failure of the plant could cause not only considerable damage to the working, but also possible loss of life, standby plant is necessary to safeguard against such a failure, and to allow repair work to be carried out on the main plant. A continual supply of air must be maintained for two reasons; firstly there is a constant leakage of air from the working; and secondly, the air must be continually replaced to allow adequate ventilation for the men in the working chamber. In tunnel construction the replacement of air to compensate for leakage is usually far in excess of ventilation requirements; on the other hand, in caissons the reverse is true, and ventilation is the prime requirement.

Air Leakage: Although some loss of pressure is caused by the constant use of air-locks, the main source of leakage in a tunnel is at the working face and through the annular ring between the outside of the tunnel lining and the tail of the shield. Obviously these losses will be governed by the state of the ground, the more open the ground the greater being the leakage. Hewett and Johannesson, in their book "Shield and Compressed Air Tunnelling", suggest that for tunnelling through fairly average open ground the required plant capacity to overcome leakage losses may be expressed by:

$$C=12D^2$$

where C is the plant capacity in cu ft of free air per min, and D is the external diameter of the tunnel in ft.

In open sand and gravel they suggest:

$$C=24D^2$$

Richardson and Mayo, in their book "Practical Tunnel Driving" quote a contractors rule: "Provide 20 cu ft of free air per min for each sq ft of face area". This in fact works out at:

$$C=15.7D^2$$

In the caisson, the working face is horizontal (i.e. the whole face is under the same head of water), and leakage at the face and under the cutting edge can be kept to a minimum by adjustment of the caisson air pressure.

Ventilation: The Compressed Air Regulations—1958 lay down a minimum requirement of 10 cu ft of air per min for each workman, at the pressure in the working chamber. This may be expressed as:

$$C=10N(P/15+1),$$

where C is the plant capacity, and N is the number of workmen working at pressure P. (It may be noted here that the working pressure in compressed air work is always a positive or gauge pressure, that is the pressure in excess of the atmospheric pressure of 14.7 psi.)

Figure 1 shows the three curves mentioned above for plant capacity based upon leakage losses, and a fourth curve for capacity dependent upon the ventilation requirement when the working pressure is 30 psi. (This latter curve assumes a reasonable figure for the number of men that would be working at one time in tunnels of various diameters; from a study of the labour force on many tunnelling projects, Hewett and Johannesson suggest a figure for the probable labour force per shift of between $(4+0.05D^2)$ and $(6+0.075D^2)$, depending upon the difficulty of the tunnelling and the skill

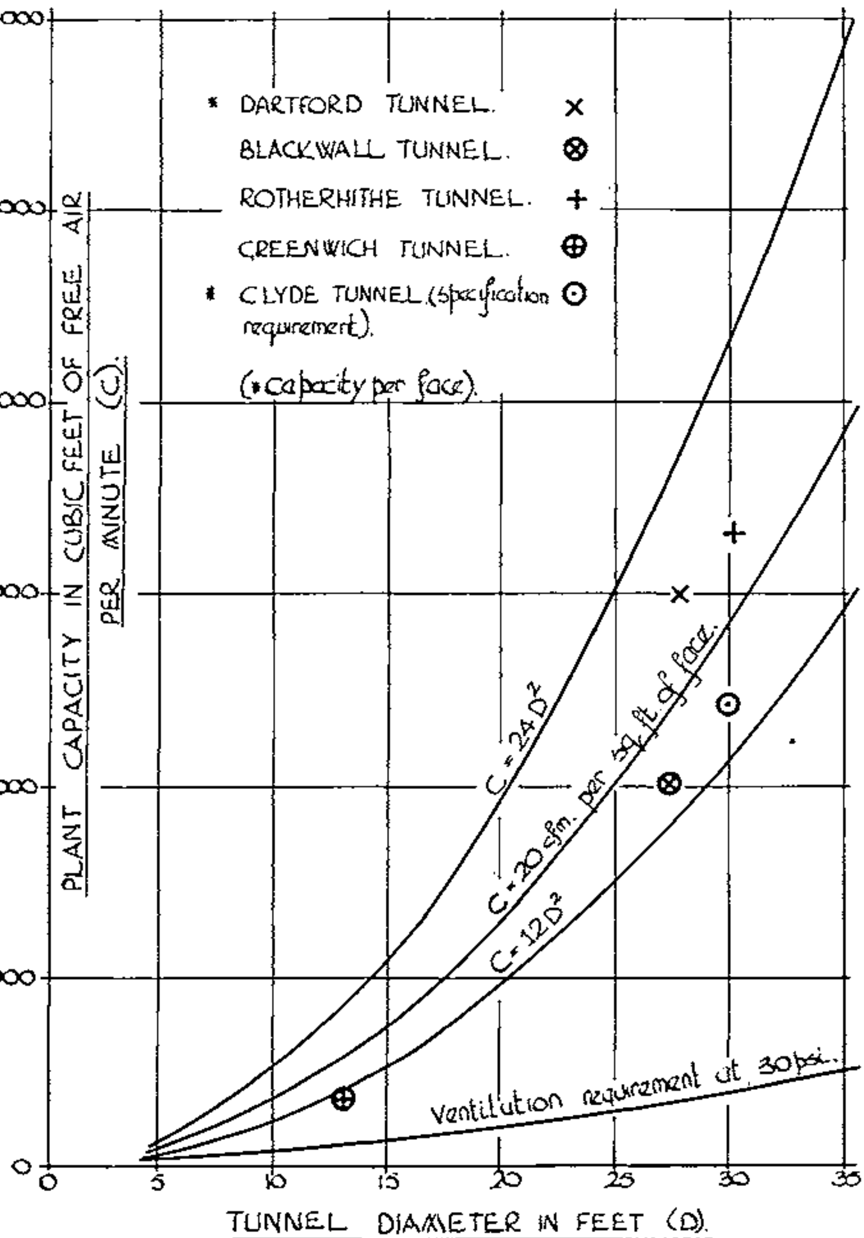


FIG. 1. VARIATION OF REQUIRED COMPRESSOR CAPACITY WITH TUNNEL DIAMETER.

J.K.J.

and experience of the men.) The actual installed plant capacity for various tunnels has also been marked on the graph.

When considering the capacity of compressor plant, it is useful to remember that for pressures up to 50 psi, each 6 to 7 cfm of free air delivered requires one horse-power. (For high pressure compressors up to 150 psi, which are considered later, each 4 to 5 cfm of free air delivered requires one horse-power.)

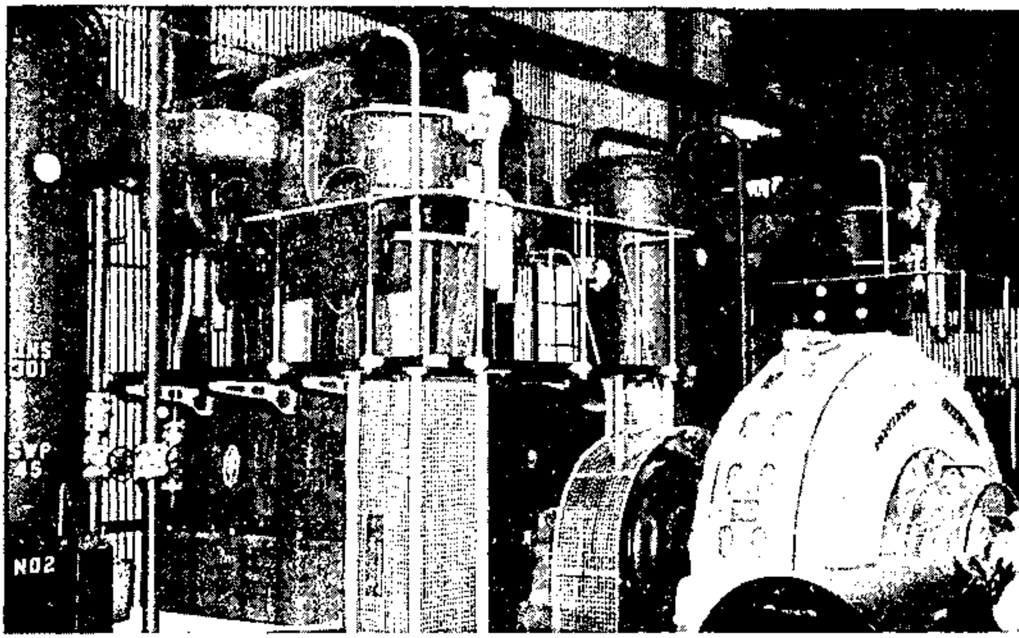


Photo 1. One of the main LP compressor sets used on the Dartford tunnel.

The Dartford Tunnel Plant: To give a more practical aspect to all these figures, the plant installed for the Dartford-Purfleet Tunnel will be considered in more detail. The three main compressors installed for the Kent working provided a total capacity of 15,000 cfm of free air; one of the three sets is shown in Photograph 1. Since the tunnel diameter is 28 ft 2 in, this corresponds to a capacity of:

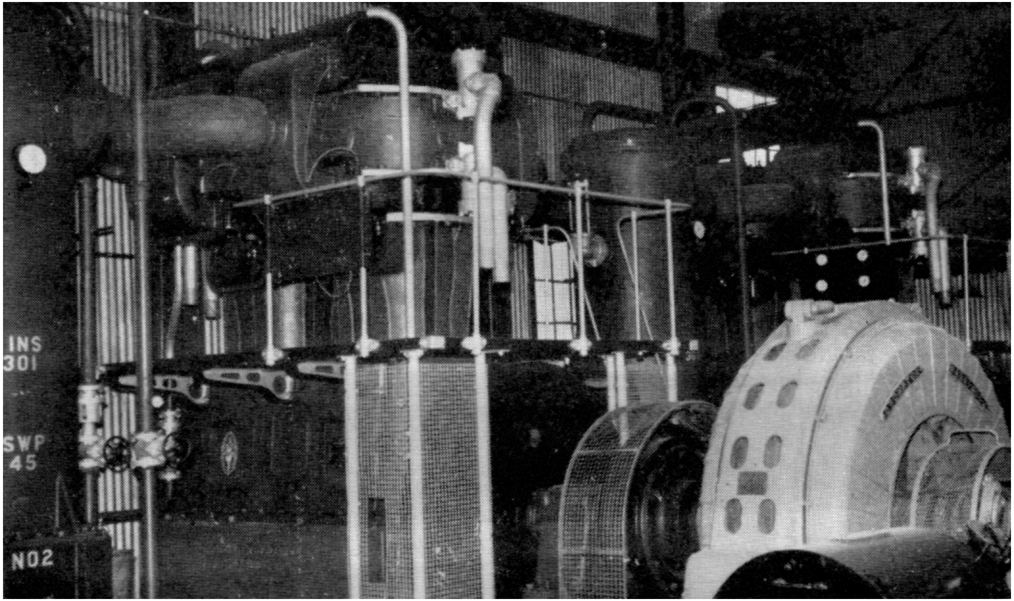
$$C = 18.9D^2$$

The average number of workmen per shift was about thirty (this is equivalent to $(4+0.032D^2)$), and the ventilation capacity for such a labour force working at 30 psi, based upon the above quoted formula, would only be 900 cu ft of free air per minute.

In addition, standby plant of 5,700 cfm capacity was installed, and the complete installation of main and standby compressors was repeated for the Essex working. Full details of the plant is given in Appx. "A".

The Calculation of the Required Air Pressure

The object of using compressed air in a working is to balance the hydrostatic pressure, due to a head of water above the excavation, by an increase of



Compressed Air work in civil engineering 1

the air pressure in the excavation, and thus reduce or eliminate the flow of ground water into the working.

Thus the required air pressure under a static head of water will approximate to the pressure equivalent of that head (i.e. $P=0.435H$ where H is the depth in ft of the working beneath the water table). The nature of the soil however will have some bearing upon the pressure required and adjustment for this may have to be made on site; for example, a heavy London clay may prove quite impervious to water and little or no air pressure would be required, whilst on the other hand, a very silty soil may require an air pressure in excess of the hydrostatic head, the ground acting as a liquid more dense than water.

Air pressure with tidal waters: Having decided upon the basic pressure required for a static head of water, adjustment must sometimes be made for the effect of the tide. Thus if the pressure is kept constant to balance the head of water at mean tidal level, at high tide there will be an increased influx of water to the working, and at low tide an unbalanced excess of pressure in the working, which may cause a "blow". Depending upon the permeability of the soil, there is a tendency for the effects of the change of tidal level to be delayed at the working face, and for the change in pore pressure to be somewhat less than the change in water level. This is taken into account when the working pressure is calculated; for example, maximum air pressure may be required half an hour after high tide, minimum air pressure half an hour after low tide, and so on. The actual relationship between the change of tidal pressure and the change of pore pressure can only be determined experimentally on site.

Since, for example, on the Thames the daily variation between high and low water levels may be 17 ft or more, it is obvious that with such variations the working pressure must be adjusted hourly. The required pressure is normally calculated for hourly intervals and marked on a twenty-four hour chart; the chart may then be passed to the control house, where the working chamber pressure is adjusted accordingly, and by using the chart as a recording graph in a recording pressure gauge, a permanent record is made of the actual and the desired pressures over each twenty-four hour period.

Figure 2 shows diagrammatically the typical hourly variation of tidal level and tunnel pressure for the Kent face of the Dartford Tunnel during the early stages of construction.

Pressure differential across the working face: In caisson work the working face is horizontal, the whole face is under the same head of water, and thus there is no difficulty in deciding the required air pressure on the lines mentioned above. In tunnel construction however, a considerable difference of head can occur across the face. Thus, as can be seen from Figure 2, on a tunnel the size of the Dartford or the Clyde tunnels, if the pressure is adjusted to balance the head at the crown of the tunnel, then the unbalanced head at the invert is about thirty ft of water; on the other hand, if the head at the invert is balanced, then the excess air pressure at the crown is about 13 psi, which would not only cause a constant escape of air from the tunnel, but might also cause a blow through the river bed, with the consequent flooding of the tunnel.

The position is therefore always one of unstable equilibrium, and with large tunnels it is usual to balance the head at or near the crown of the tunnel and accept a flow of water at the bottom of the face.

One result of this pressure differential across the face is to limit the diameter of a tunnel driven through normal types of soil to about thirty ft. A greater diameter would result in an excessive pressure differential across the face. One method of increasing the traffic capacity of a tunnel without increasing the pressure differential during construction would be to adopt an elliptical cross section, with the major axis of the ellipse horizontal. Apart from having less strength than the circular section, the shape introduces many new difficulties, and has seldom been used; for example in the elliptical tunnel any tendency for the shield to roll must be eliminated or corrected, whereas with a circular shield moderate roll is not serious; again all segments of a circular tunnel are interchangeable, but this is not so with an elliptical tunnel.

Air-Locks

Apart from the compressors required for the supply of compressed air, the air-lock is the most important piece of equipment used in compressed air work. The lock forms an access to and from the working chamber so that men and materials may pass to and fro between conditions of atmospheric pressure and working pressure. All locks consist basically of a pressure chamber, capable of withstanding working pressures up to 50 psi, which is fitted with two doors, both of which operate in the direction of the high pressure. Thus one door is always kept closed by the difference of pressure across its faces, and when the lock is at an intermediate pressure (i.e. the lock is being used for transit), both doors are kept closed.

The operation of an air-lock is shown diagrammatically in Figure 3, the reverse process being used to leave the working chamber. It may be noticed that although a person entering the working chamber may pass himself through the lock, on leaving the chamber he has no control over the decompression rate, which is controlled from outside the lock, except in the case of an emergency, when the emergency decompression valve may be used.

Tunnel locks: Man-locks, used for the transit of labour, are usually in the region of six to seven ft in diameter, varying in length with the size of the tunnel and thus the working shift. Once the working pressure exceeds 28 psi, the shift will have to spend more than an hour in the lock for decompression after an eight-hour shift, and the lock must therefore be provided with adequate seating and lighting. During the first rapid phase of the decompression there is usually a temperature drop of about 15°C or even more, which, with 100 per cent relative humidity, results in the formation of dense mist. This gives rise to severe chilling of the occupants and adequate heating must be provided to overcome this.

Material or "muck" locks are similar to man locks, but have no seating or heating arrangements and are usually fitted with large diameter air valves (i.e. about four inch in diameter) so that the lock may be rapidly compressed and decompressed.

Caisson locks: Caisson locks may be similar to tunnel locks, or may be designed to fit vertically above the caisson access trunking; the lock may then be removed by crane to extend the trunking as the caisson is sunk. The basic details of two such locks in common use in this country are shown in Figure 4; many minor details have been omitted for simplicity (eg. valves, gauges, muck-lock lid clamps, and the counterweight for the muck-lock door).

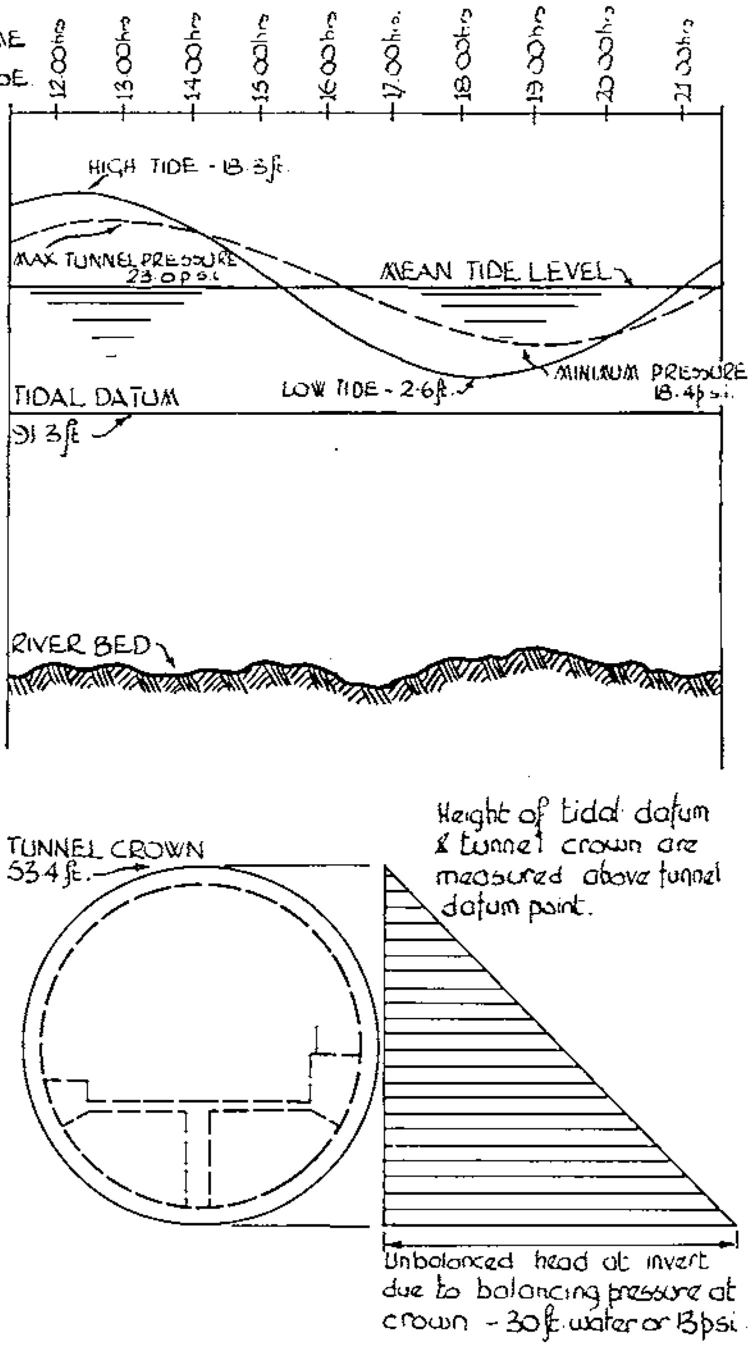


FIG. 9. TYPICAL VARIATION OF TUNNEL PRESSURE WITH TIDE - DARTFORD.

J.W.J.

The lock shown on the left is the Dorman Long lock, of riveted construction, which has one man-lock capable of passing up to four men at one time. The type of air shaft normally used with this lock has a figure eight cross section, and can accommodate a cylindrical bucket up to 2 ft 10 in in diameter and 4 ft deep, with a capacity of 24 cu ft, as well as providing an access ladder for the workmen. Photograph 2 shows a modified Dorman Long lock used for the caissons on the Dartford Tunnel; the lock is lying on its side prior to being placed in position on the access trunking.

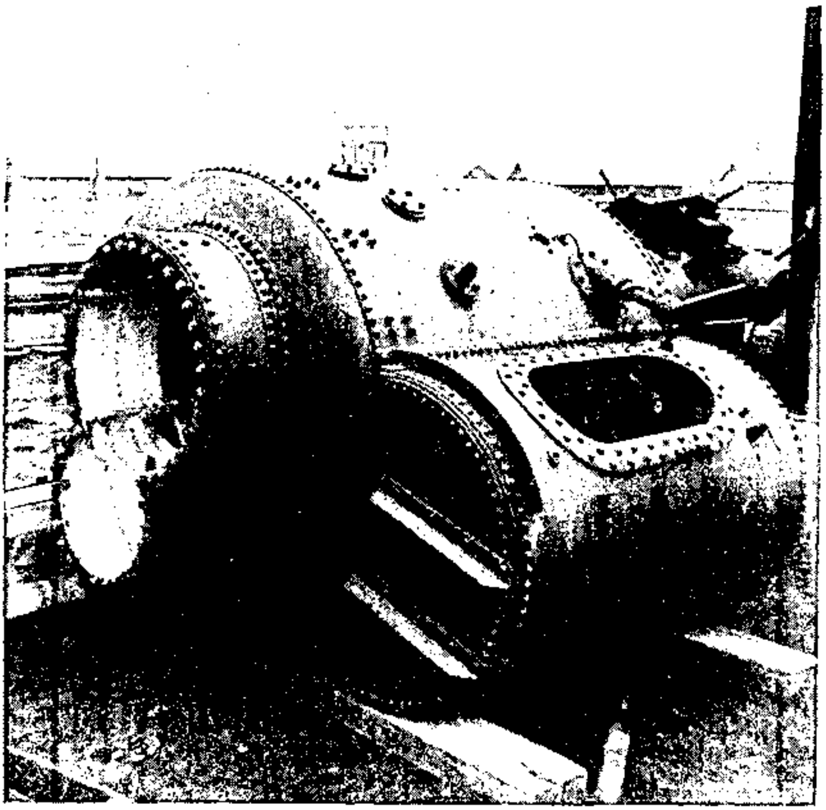


Photo 2. A caisson lock of the Dorman Long type used on the Dartford Tunnel.

The second lock is the Gowring all welded lock, which incorporates many improvements on the Dorman Long lock, including double man-locks, each of which can accommodate up to six men at one time, and a larger muck-lock. The muck-lock is in two parts, with a connecting flange at the level of the roof of the main chamber; this is for convenience of transport, and also to allow an extension piece to be inserted in the lock if required. The air shaft in use with the Gowring lock can be seen clearly on the right-hand side of Photograph 3; the shaft will accommodate buckets up to 3 ft 3 in in diameter and 4 ft deep, with a capacity of 33 cu ft. The photograph also shows one lock in position on the caisson, and the derrick which serves this lock. The photograph, which is of one of the caissons for the Uskmouth Generating Station, is reproduced by kind permission of Holloway Brothers (London)

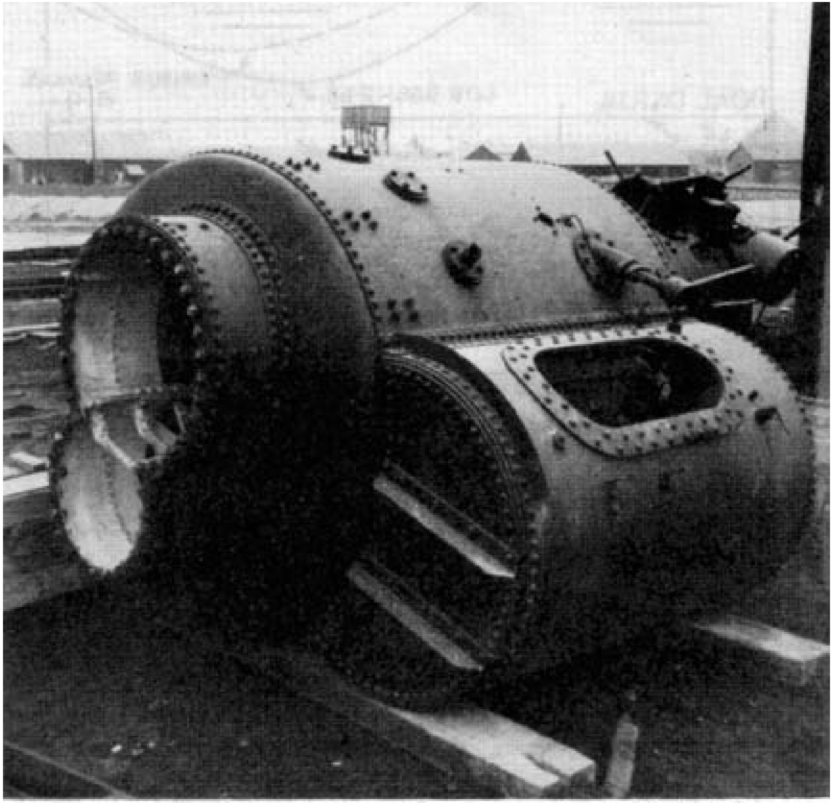


Photo 2. A caisson lock of the Dorman Long type used on the Dartford Tunnel.

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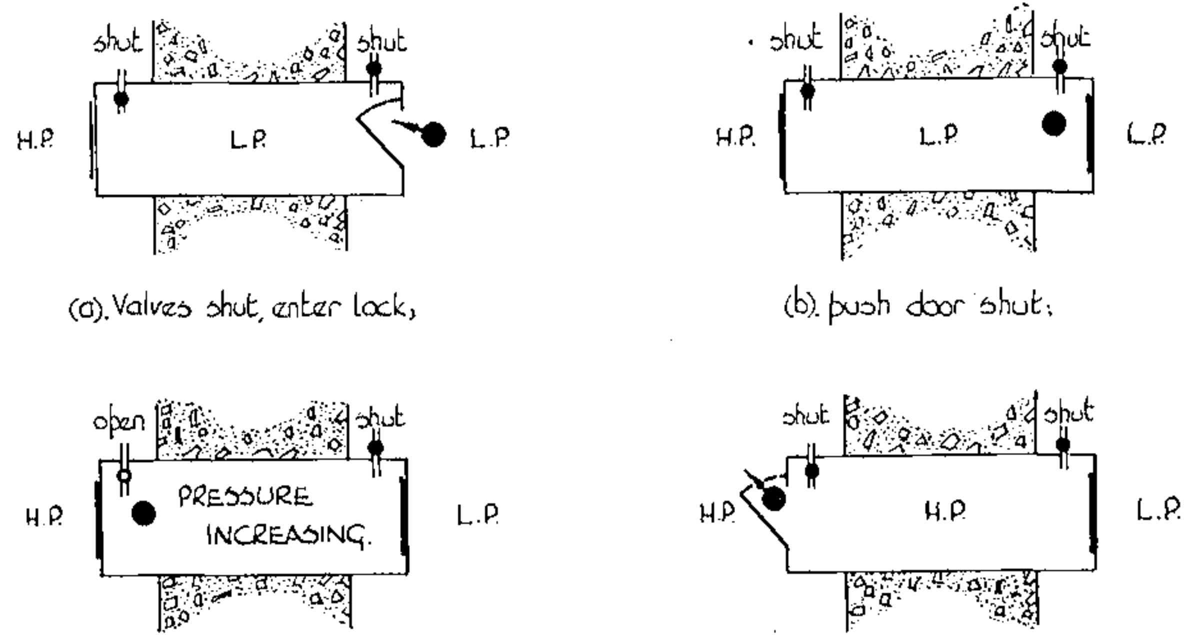

(a). Valves shut, enter lock;

(b). push door shut;

(c). open valve to H.P.; pressure builds up, forcing L.P. door tightly closed;

(d). when lock pressure equals working pressure, H.P. door swings open freely; close H.P. valve, & leave lock.

FIG. 3. THE OPERATION OF A TUNNEL AIR-LOCK.

JHJ.

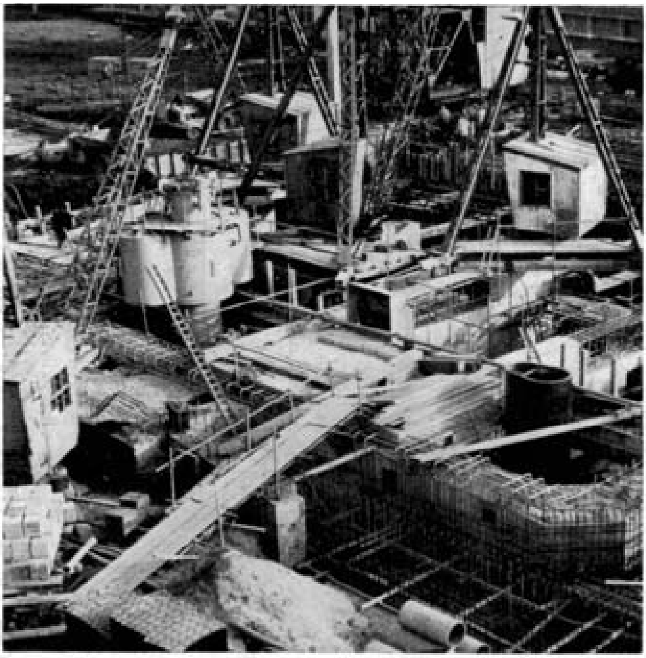

Photo 3. A Gowring caisson lock in use on the Usknouth Power Station.

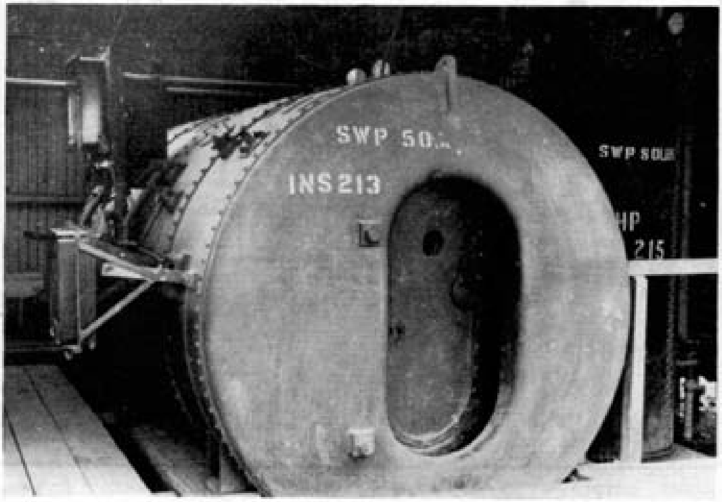

Photo 4. A medical lock used on the Dartford Tunnel.

Compressed Air work in civil engineering 3 & 4

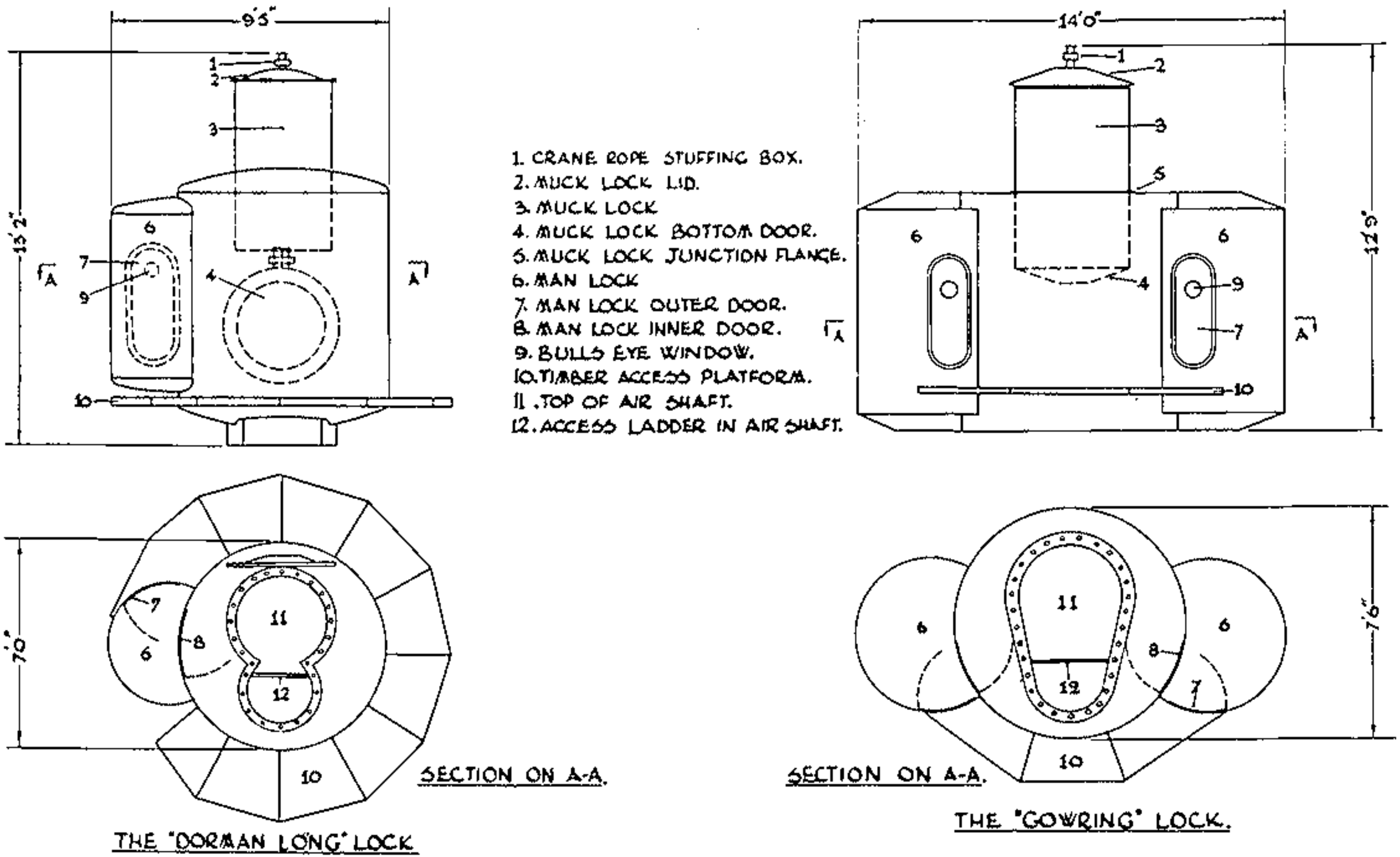

FIG. 4. BASIC DETAILS OF TWO CAISSON AIR-LOCKS.

Ltd., main contractors for the contract. The copyright for the Gowring lock is also held by Holloway Bros. by permission of whom the description here and the drawing in Figure 4 are reproduced.

Wilson and Sulley, in their paper "Compressed Air Caisson Foundations", suggest a requirement of one air-lock to every 1,000–1,200 sq ft of excavation. Even so, when lengthy decompression is necessary, the lock could form a bottle-neck at change of shift; should this occur, the men are sometimes rapidly decompressed in the lock and are then transferred to a large horizontal type lock, in which they are recompressed and then decompressed a second time at the correct rate. Such a method of decompression is known as "de-canting".

Medical locks: A medical lock is a requirement of the Compressed Air Regulations once the working pressure exceeds 18 psi, although experience at Dartford suggests a need for a medical lock at pressures above 15 psi. Photograph 4 shows one of the locks used on the Dartford Tunnel project, about 7 ft in diameter and 15 ft long. Such locks are fitted with an internal bulkhead and door to allow access to the patient under treatment without lowering the pressure within the inner section of the lock; normal equipment would include adequate lighting and heating, a stretcher or bunk, blankets, etc. so that the patient may be kept warm and comfortable whilst under treatment, which at times may be lengthy, (one patient at Dartford spent no less than nine days being decompressed and recompressed many times in the effort, eventually successful, to cure him of paralysis in the arms and legs).

Other Compressed Air Equipment

High pressure air equipment: High pressure air is used in tunnel and caisson work not only to drive the normal pneumatic tools but also to drive compressed air motors, hoists and grout pumps. Since pneumatic tools normally operate at pressures of 90 to 100 psi above atmospheric pressure, a somewhat higher supply pressure is needed when the tunnel pressure itself may be up to 50 psi. The high pressure compressors used normally operate at a pressure of 150 psi, which provides an adequate working pressure for tools, even taking into account some supply loss, when the chamber is at the maximum pressure.

By-pass piping is sometimes fitted, so that in an emergency the high pressure air supply can be used to boost the tunnel air pressure.

Electrical installations: To reduce the danger of accidents, electrical installations in workings usually operate at voltages of 25 or 50 volts. This also minimizes the risk of fire, which is obviously much greater in compressed air, and would prove very much more dangerous than a normal fire (wet wood or hay will burn fiercely in the excess oxygen of compressed air).

Recording and control gear: The use of compressed air involves a considerable amount of control and recording gear. Tunnel or caisson pressure is normally controlled from a control house, and this may contain gauges to record tunnel pressure, main compressor and standby compressor pressures, the man-lock pressure, and possibly shaft pressure, together with recording gauges to record variations of tunnel and lock pressures, and possibly tidal level, over a twenty-four hour period.

Additional gauges would also be required at the entrances to the medical locks and to the working chamber man-locks to show lock pressure, and to record lock pressure whilst decompression is taking place; this provides an accurate record of each decompression that is carried out. Finely adjusted control valve must also be provided for each medical or man-lock so that decompressions may be as accurate as possible. The decompression is quite often carried out automatically by a cam operated valve; the rate of decompression is controlled by the shape of the cam, which in turn depends upon the time of exposure and the working pressure.

Drainage and ventilation: Because of the pressure differential across the working face of a tunnel, there is always an accumulation of water in the invert. To remove this water a 3 in or 4 in pipe may be laid in the invert and connected into a sump by means of a flexible pipe, strainer, and valve. When the valve is opened, the air pressure forces the water through the pipe to discharge into free air, possibly into a second sump, from whence it may be pumped to the surface by normal means. Such a system is usually referred to as a "snorer" because of the odd noise it makes whilst in action. The snorer may also be used to remove foul air or blasting fumes.

Compressed Air Sickness

Mention has already been made of the use of accurate and sometimes lengthy decompressions, but before fuller details are given of decompression rates, it will be as well to consider the reason for the accuracy.

The nature of compressed air sickness: It has long been known that too rapid decompression of divers and compressed air workers causes the formation of bubbles of gas in the blood stream and fatty tissues of the body. This condition is commonly known as "The Bends" in the case of divers, and as "Caisson Sickness" in the case of compressed air workers. Medically the condition is known as "Compressed Air Sickness", although a more modern term "Decompression Sickness", which covers the symptoms following high altitude flying, is becoming widely used.

The cause of the sickness is believed simple. Under conditions of compressed air, the nitrogen in the air passes into solution in the blood stream; if the subsequent decompression is slow, the nitrogen will normally pass out of solution, but following a rapid decrease in pressure the nitrogen becomes super-saturated, and eventually escapes to form bubbles in the tissues of the body.

Symptoms: In about ninety-five per cent of cases of the sickness, the symptoms are pains in the limbs, usually the lower limbs. They are known as simple "bends" and vary in intensity from mild "niggles" to agonizing pain. The remainder are much more serious and include many syndromes such as tightness of the breath ("chokes"), giddiness, ("staggers") and various muscular and limb paralyses. An intense irritation of the skin, occasionally associated with a purplish discoloration, is a common symptom.

The sickness in aviation: It is perhaps of interest to note that a similar condition is found in aviation. To give an example, early in the Second World War three Spitfire pilots pursued some German pressurized reconnaissance planes flying at 42,000 ft over North Africa. Although three of the enemy planes were shot down, two of the British pilots suffered almost incapacitating bends, due to the rapid decompression experienced in climbing to such an altitude in a short time.

Although the use of pressurized cabins has almost eliminated these effects, the very real danger of what is known as "explosive decompression" still exists; this would occur if the pressurized cabin of an aircraft were pierced by a projectile, or if the window of the cabin should burst, whilst the plane was flying at a high altitude.

The Tyne Tunnel investigation into Compressed Air Sickness: In 1946, when safety regulations for compressed air work were being revised, it was realized that very little was known about the true distribution of compressed air sickness, or the causes and conditions of its appearance in particular individuals. It had been apparent for some time that a number of factors contribute to the ease or difficulty of bubble formation in the body tissues; some of these factors are intrinsic, such as excessive fatty deposits in the body, the tissue permeability, and the solubility of gases in the tissues of the patient. Other factors are external, such as working pressure and temperature, degrees of fatigue, and the rate and extent of decompression.

It was known that even when decompression was carried out at the slow and recommended rate, cases of bends still occurred, the incidence being somewhere about one per cent of all decompressions.

The Medical Research Council therefore decided to carry out an investigation into compressed air sickness. and when work was started on the Tyne Tunnel in 1948, a research team was set up. On a large scale subject such as the one under investigation, it was not possible to investigate the intrinsic factors, and the research team confined their attention to possible connexion between the sickness and such factors as meteorological conditions (many miners express the view that local weather conditions, particularly damp and cold frosty weather, increases their susceptibility to bends), working pressure and conditions, the age and weight of the workers, and variations in decompression rate.

Points from the Tyne research team's findings: A total of 40,000 decompressions were reviewed, involving some 376 men; a total of 350 cases of compressed air sickness were recorded (that is an overall percentage of 0.875 of all decompressions), which involved 187 of the men. Three serious cases were recorded, two of which resulted in permanent spinal paralysis, and in each of these cases some normal precaution had been ignored (for example, a foreman who had been working for two hours at a pressure of 34 psi, let himself out of the muck-lock, probably in a few minutes, instead of being decompressed at the normal rate, which would have taken forty minutes; within fifteen minutes he had collapsed, and was still paralysed in the lower regions one year later).

Bends incidence was largely borne by shift workers, of whom 95 per cent had one or more attacks at one time or another. On the other hand, of all other workers, only 8 per cent had an attack of bends. Each group had roughly the same number of compressions, but the actual time in air was much longer in the case of shift workers, who spent the full eight hours per shift in air, compared with the much shorter periods for other workers such as engineers, chain-men, fitters, etc.

The investigating team found that workers rapidly became acclimatized to compressed air work, the rate of incidence dropping from about twelve per cent on the first day of employment, to five per cent of the fifth day and three per cent on the tenth day; a further drop in incidence was also caused by the elimination of the more susceptible workers by natural selection.

The team also found that there was no connexion between the incidence of sickness and the working pressure, apart from the general observation that no cases occurred when the pressure was below 18 psi.

However the bends rate was found to vary with the rate of decompression; thus, taking random samples of decompressions, when the decompressions were correctly timed, a rate of 1.4 per cent was observed, whereas the rate rose to 2.9 per cent when the decompression rate was increased to the extent that the lock pressure was at times $2\frac{1}{2}$ psi or more below that laid down in the decompression tables.

With regard to meteorological conditions, no important connexion could be found between the weekly incidence of bends and the weekly averages of rainfall, barometric pressure, humidity, wind velocity, hours of sunshine, or the maximum and minimum temperatures.

Compressed Air Sickness on the Dartford Tunnel Project: Work on the main tunnel under the Thames at Dartford was resumed in 1956, after a delay of seventeen years due to the War and the financial state of this country in post-war years. The Medical Research Council decided to continue the investigation started on the Tyne Tunnel and set up a research team which consisted of Prof W. D. M. Paton and Dr D. N. Walder, who conducted the Tyne Tunnel investigation, Dr P. D. Griffiths who was the site doctor, (a full time appointment), a Naval Surgeon from the RN Diving Establishment, a Radiologist, and an administrative member of the Medical Research Council.

A complete report will be published by the Medical Research Council in due course; meanwhile I am indebted to Dr Griffiths for making the information given below available.

Some 122,000 compressions were reviewed involving 1,225 men working at pressures up to 28 psi; 685 cases of sickness were recorded of which 35 were classified as Type 2 cases (the patient being actually ill or even temporarily paralysed), and the remainder as Type 1 cases (the patient experiencing pain only, usually in the lower limbs).

As would be expected from the Tyne Tunnel investigation, 92 per cent of the Type 1 cases occurred after a full eight-hour or longer shift in compressed air; this would seem to point to the fact that the body becomes more susceptible to bends when tired and when muscle tissues are fatigued and strained. This view is strengthened by the fact that many cases occurred when slight injuries, such as pulled muscles or bruises which resulted in a straining of tissues, were followed by the occurrence of bends in the afflicted limb; and also by the fact that a rate some fifty per cent higher than the average was recorded for a group of fitters who had been working in a particularly cramped and kneeling position.

Experiments in America have definitely shown that muscular activity increases the incidence of bends, but this has been in controlled tests in the laboratory. The points seem to be confirmed by practical experience, and it may well be that the bends rate could be reduced by working say four six-hour shifts a day, instead of three eight-hour shifts. More will be said on this matter when the Compressed Air Regulations are discussed.

The second point to be noted is that there were 45 cases of bends (including 4 Type 2 cases) at a working pressure below 18 psi, 6 occurring at $16\frac{1}{2}$ psi, and 1 as low as 15 psi. It has long been accepted that 18 psi was the limit below which bends was unlikely to occur; indeed the Regulations for Compressed Air Work are in the main only applicable at pressures above this limit and do not include decompression rates below 18 psi. The possibility of error in the highly accurate pressure gauges can be ignored.

This finding is of course contrary to that of the research committee on the Tyne Tunnel project, where there were no recorded cases below 18 psi; the reason for this is not at present apparent.

The treatment of bends: Basically, the immediate treatment for any case of compression sickness is to recompress the patient to a pressure in excess of the working pressure. This should remove all symptoms and is followed by a very slow decompression. A suggested procedure for the treatment of both normal and serious cases is given in Appx. "B"; this was used on the Dartford Tunnel project, but was subject to variation in individual cases. It is emphasized that recompression should take place as soon as possible if it is to be successful; paralysis is often permanent unless the recompression is carried out without delay.

The Factories Act Applied to Compression Air Work

The Factories Act is applicable to compressed air work through the statutory instrument of The Work in Compressed Air, Special Regulations, 1958, laid before Parliament on 21 January 1958, and effective from 21 April 1958.

The regulations cover all aspects of compressed air work, including supervision of work, construction and maintenance of equipment, the volume of air required for ventilation purposes, the size of and equipment for man-locks, medical supervision and health facilities, including provision of a medical lock, and working chamber temperatures.

Decompression rates: Also included in the regulations are full decompression rates laying down the decompression rates for all pressures from 18 psi to 50 psi for working periods ranging from half an hour to over four hours; any period over four hours falls into the general decompression category of "Four hours and over".

Basically all decompressions are carried out in two phases; the first is a rapid reduction of pressure, over a two-minute period, to a limit laid down in the regulations; this is followed by the second phase, a gradual reduction to atmospheric pressure at a rate which is also laid down in the regulations. To give two examples at the opposite ends of the scale:

Example I: A shift worker has just completed six hours work at a pressure of 50 psi. The lock pressure is reduced to 17 psi in the first two minutes; the pressure is then further reduced to atmospheric pressure at a rate of 1 psi in eight minutes, taking a further 139 minutes. Thus the worker spends a total of 2 hours 21 minutes in the lock.

Example 2: A visitor to a project spends just under half an hour in a working at a pressure of 27 psi. The lock pressure is reduced to 6 psi in the first two minutes, and then at a rate of 1 psi per minute, taking a further 6 minutes and giving a total decompression time of 8 minutes.

Figure 5 shows the variation of decompression time with pressure for various lengths of exposure. The values used have been taken from Table I of the C.A. Regulations, which is in fact the same as that compiled for the Compressed Air Committee of the Institution of Civil Engineers and the Ministry of Labour by G. C. C. Damant and W. D. M. Paton. Haldane's decompression times for deep sea divers have also been shown on the graph, and the close agreement between these times and those for compressed air workers can be seen.

Pressure limits of the Regulations: The normal upper limit for compressed air work laid down in the regulations is 50 psi. With regard to the lower limit, the regulations are not wholly applicable at pressures below 18 psi; for example, the need for monthly medical examination of workers, the need to

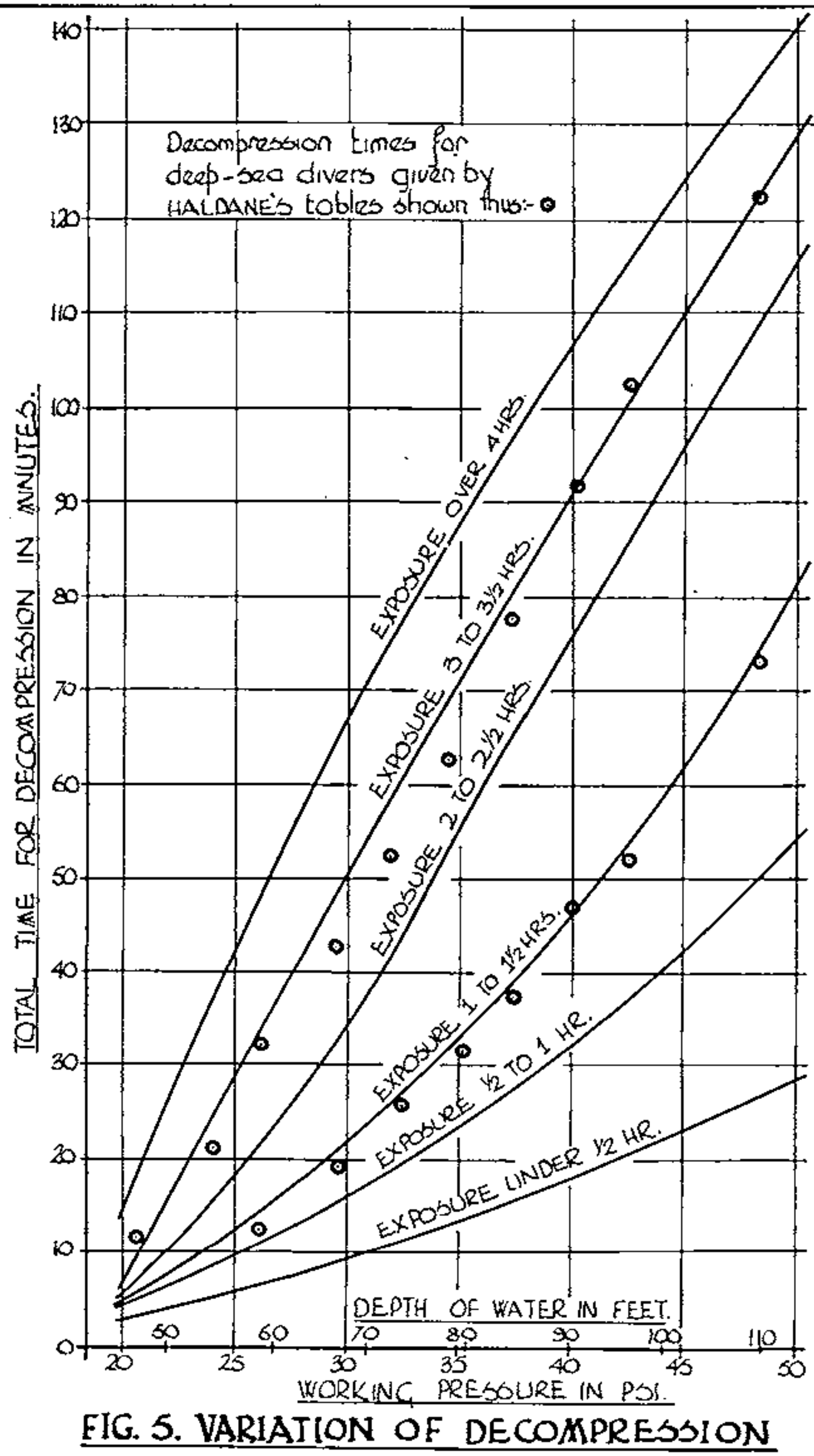

FIG. 5. VARIATION OF DECOMPRESSION TIMES WITH WORKING PRESSURE.

provide medical attendants and locks, the need to provide hot drinks after decompression, the need to maintain lock registers, and other requirements of the regulations are not mandatory at pressures below 18 psi.

Perhaps of more importance is the absence of decompression rates for working pressures below 18 psi, and it may be that the regulations should be amended on this score, in view of the experience gained at Dartford when forty-five cases of sickness were recorded at pressures below 18 psi. It may be noted here that after the first case below 18 psi at Dartford, a timed decompression was introduced for a working pressure of 17 psi; the subsequent forty-four cases occurred despite this decompression.

Period of work: It is also noteworthy that the regulations place no restriction on the periods worked by the men. It has already been stated that it is considered that a reduction of the daily working period from eight hours to, say, six hours might well reduce the incidence of bends; this is not however a very economical proposition, but a definite limitation of the working period to eight hours a day would be a step in the right direction, rather than leaving it completely unrestricted, as it is at present.

Such restrictions do exist for deep-sea divers; for example, a diver operating at a depth of from 84 to 90 ft (i.e. 37 to 40 psi), is limited to a maximum dive of 60 minutes, excluding the 30 minutes necessary for the ascent to the surface.

Regulations for Compressed Air Work in America

Having considered the regulations applicable to compressed air work in this country, it is of interest to have a brief look at the regulations used in America, of which the Industrial Code No. 22 of the State of New York is typical. The regulations currently in force, adopted in 1922, are at present being revised because of the general shortening of work hours and because the decompression requirements were considered obsolete; the draft of the new Code No. 22 is similar in many ways to the special regulations applicable in this country but differ in two main respects. These are the restriction of working hours and the system of decompression.

The restriction of the daily shift: The total time spent each day under working pressure is divided into two equal shifts, with a rest period in free air between the shifts. The two shifts are restricted in length according to the working pressure, as is shown in the table below.

Working pressure	Total working time	First shift	Minimum rest period	Second shift
0–22	6	3	$2\frac{1}{2}$	3
22–30	4	2	$3\frac{1}{2}$	2
30–35	3	$1\frac{1}{2}$	4	$1\frac{1}{2}$
35–40	2	1	$4\frac{1}{2}$	1
40–45	$1\frac{1}{2}$	$\frac{3}{4}$	$4\frac{3}{4}$	$\frac{3}{4}$
45–50	1	$\frac{1}{2}$	5	$\frac{1}{2}$
psi	hours	hours	hours	hours

It has just been mentioned that the British Regulations do not restrict the working period in any way, and there is thus a sharp contrast with American practice. Although British employers often do cut down the length of the daily shift from the normal eight hours to possibly six hours at higher pressures, I can not imagine many employers being particularly happy using their workers, for example, for only two hours a day when the pressure reaches 35 psi.

Decompression rates: Three types of decompression are detailed. When the working pressure is below 6 psi a single stage decompression is used; between 6 and 21 psi a three stage decompression is used, and above 21 psi a slower three stage decompression is used; in addition the decompression after the second half of the daily shift is longer than that after the first. It is not easy to compare the decompression times of the two sets of regulations because of the limiting and splitting into two of the American working hours; thus British Regulations give decompression times for pressures up to 50 psi for a full eight-hour working shift, whereas at that pressure the working period in New York is restricted to one hour in twenty-four. However it does seem that the American times are somewhat longer for short periods at high pressures, whilst at lower pressures the two sets of decompression times are comparable. It should also be noted that Industrial Code No. 22 lists decompression times for pressures from 1 psi upward, whereas our lower limit is 18 psi.

It has not been possible to obtain recent figures for compressed air sickness expressed as a percentage of total decompressions for recent American projects, but it is known that on the third tube of the Lincoln Tunnel under the Hudson, which was recently completed, the incidence of accidents and compressed air sickness was very low; the standards laid down in the draft of Industrial Code No. 22 which have been mentioned above were observed on that project.

Ventilation requirement: One other point may be mentioned; Code No. 22 lays down a requirement for 30 cu ft of free air per min for each shift worker. Our requirement is for 10 cu ft per min at the pressure of the working. The two requirements coincide at a working pressure of about 30 psi; at higher pressures we require rather more ventilating air than Code No. 22, whilst at lower pressures the reverse is true.

Some Economic and Labour Aspects of Compressed Air Work

The use of compressed air on a project involves many additional items of expenditure over and above the normal costs that would be involved on a major project.

Equipment costs: The prime cost is obviously the initial provision of the main and standby compressor plant, together with air receivers and scrubbers, air locks, pipe mains, control gear, and so on. The cost of running and maintaining this equipment is also considerable, remembering that the working must be kept under pressure for twenty-four hours a day, necessitating the employment of plant attendants and maintenance men for the whole period.

Medical costs: The medical and welfare requirements for compressed air work include a medical centre or hut, medical locks, and trained medical orderlies; on a large project the full-time employment of a doctor is usually an advantage. Changing and shower rooms are also required, and a canteen or rest room must be available for the men to stay on site for a period after decompression (men are encouraged to stay on site for one hour after decompression, or for an hour and a half if the pressure exceeds 40 psi, because any serious cases of sickness will usually develop soon after decompression; this fact was confirmed by experience at Dartford).

Shift work: It is a long standing practice of tunnel work that work is carried out continuously by day and by night; this is obviously the most economical method, since the working pressure must be continually maintained. No extra pay is allowable for this shift work under The Working Rule Agreement, apart from a shift differential of 3d an hour. Shifts are normally of eight-hour duration, working from Sunday night to the following Saturday afternoon or evening, giving seventeen or eighteen shifts a week; medical attendants, lock keepers, and the like often work a twelve-hour shift. Typical eight hour shifts are:

Morning shift:	7 am to 3 pm
Back shift:	3 pm to 11 pm
Night shift:	11 pm to 7 am

Rates of pay: The basic rate of pay for a London super grade labourer is 4s 5½d an hour; to this can be added the 3d an hour shift differential and a plus rates of 7d an hour for tunnel miners, giving a total of 5s 3½d an hour. No rate is given in The Working Rule Agreement for compressed air work, and systems of payment differ. One well-known firm of contractors pays its men time and a half for all time spent in compressed air, including decompression time in the lock, but does not pay the men for remaining on site after decompression; another large firm pays its men on a sliding scale rising to time and five-eighths when the pressure exceeds 30 psi, and this firm, although not paying the men for time spent being decompressed, pays them double time for time spent on site after decompression for a period of one hour at pressures up to 30 psi, and an hour and a half at higher pressures.

Thus a miner working five eight-hour shifts for this latter firm at a pressure of 32 psi, would, for his forty-hour week, be paid for sixty-five hours in compressed air, and for fifteen hours time spent on site after decompression, a total of eighty hours pay. Pay packets of from £20 to £30 are quite common, even without taking into account any bonus or incentive scheme that may be operative.

Working conditions: In general, working conditions in compressed air are no worse than conditions on any mining or tunnelling project. There is however the continual possibility of suffering from an attack of compressed air sickness, and it is for this reason that rates of pay are high; as has been said previously, 95 per cent of all the shift workers on the Tyne Tunnel suffered an attack at one time or another.

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APPENDIX "A"

Details of the Compressed Air Plant for the Dartford Tunnel

The following plant was that installed for the Kent working only; the plant was completely duplicated for the Essex working.

The main plant consisted of three Alley MacLellan compressors each giving 5,000 cu ft of free air a min at pressures up to 45 psi. Each compressor was driven by a Crompton Parkinson 750 HP, 3,300 volt electric motor.

The standby plant consisted of six Broomwade compressors each giving 950 cu ft of free air a minute at pressures up to 40 psi. These compressors were each driven by a Ruston Hornsby 170 HP diesel engine.

APPENDIX "B"

The Treatment of Compressed Air Sickness Used on the Dartford Tunnel

Two types of treatment were used at Dartford, and these are detailed below. The first was for normal cases of sickness, or those resulting in pain only; the second was for serious cases, or those in which the patient was actually ill or even paralysed.

Normal cases. The patient was recompressed to a pressure 3 psi above the working pressure, and was kept at that pressure until all pain had gone. Ten minutes later the rapid stage of decompression was carried out, according to the Compressed Air Regulations; the remaining pressure was then reduced at a rate of 1 psi in fifteen minutes. If this procedure was followed, a second recompression was seldom necessary.

Serious cases. The patient was recompressed to working pressure and kept at that pressure until all symptoms had gone. After a further half-hour the pressure was reduced at the rate of 1 psi in fifteen minutes until it reached 12 psi. The patient was then "soaked" at that pressure for a period of four hours, after which the pressure was finally reduced at a rate of 1 psi in thirty minutes, with additional halts for an hour and a half at 8 psi, an hour at 4 psi, and an hour at 2 psi.

The Bertrand Stewart Essay, 1959

By Colonel M. W. Biggs, OBE

(The views expressed are the author's own and do not in any way reflect official opinion)

(This article was the runner-up for the Bertrand Stewart Prize Essay 1959. The winning essay was written by Major RE Simpkin, MC, Royal Tank Regiment and was published in the Army Quarterly and Defence Journal, January 1960.)

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THE BERTRAND STEWART PRIZE ESSAY, 1959

Subject

"As a nation we have to be prepared for cold war, limited war and global war. In each case the individual soldier is the same, and in one if not two of the cases we will be involved in an exchange of nuclear weapons. Though we have always had training problems in preparing men for warfare in environments different from their own, the preparation of the soldier for the unknown quality of nuclear war will be an infinitely greater problem than equipping the townsman for the jungle. It is likely to need psychology as well as military instruction.

Moreover, recently it has been said that some of our methods are out of date (eg drill to instil discipline) as a different kind of soldier will be needed on the nuclear battlefield.

Discuss these problems from the Regimental officer's point of view and give your views as to how they can best be met."

Kinds of Future War

There has been no peace in the world since the total victory of the Grand Alliance over Germany and Japan was completed in 1945. It seems unlikely we shall see real peace in our time. In the past eighteen years six hundred million people and over seven million square miles have fallen under Communist domination. Their basic philosophy is one of continuing expansion with the eventual aim of world domination. In the immediate post-war years it was only the United States' possession of the atom bomb, and their declared intention to use it, which saved North-West Europe from being overrun by the Russians.[1]

Today we live in a state of precarious balance. The nations of the free world, led by the United States and Britain and allied in NATO, SEATO and CENTO, face the joint strength of Russia, Communist China and their satellites in an uneasy peace. The uncommitted nations sit on the fence, clinging to a neutralism which they hope will save them from being drawn into either bloc, playing off one against the other to their economic profit, and hoping not to become nuclear battlefields if war should break out between them. The Western Powers cannot match the USSR in military manpower and conventional strength—or at least are not willing to make the sacrifices which would enable them to do so—and have made clear that NATO policy is to use atomic weapons to redress the imbalance. Similar policies must support SEATO and CENTO, in the former to offset the Chinese millions and in the latter because distance and geography inhibit speedy deployment of large Anglo-American ground forces to the aid of their allies.

The original "nominal" atom bombs which shook the thinking world when dropped on Hiroshima and Nagasaki, have been succeeded by a wide range of nuclear and thermo-nuclear weapons ranging from those of fractional yield to monsters of destruction in the megaton range. The Americans' short-lived monopoly of these weapons was shattered when the Russians exploded their first atom bomb. The USSR are now believed to have virtual parity in nuclear and thermo-nuclear weapons with the USA, in quality if not in quantity. They have made great strides in the field of rocket missiles, and their satellite successes indicate that Mr Kruschev's boast of having inter-continental ballistic missiles which can strike at the heart of America may be in the main true. The UK is the third member of the "nuclear club", though she cannot compete in quantity or range with the other two. France and a dozen other countries have the capacity to produce their own nuclear weapons,[2] and may eventually do so or obtain them from their major allies.

[1]Churchill speaking in the House of Commons. *Hansard.*
[2]US report quoted in Press 14 June 1959.

There is a temporary suspension of nuclear tests, which may or may not be confirmed by agreement into a more permanent one, but both sides probably already have enough weapons in store to devastate each other. Continuing production will turn "nuclear sufficiency" into "nuclear plenty".

The cold war is always with us, and is likely to continue; it is not relevant to our subject and is not discussed further. Uneasy peace from hot war is maintained by the deterrent effect of the knowledge that any major aggression will be met by nuclear retaliation by aircraft of the USAF's Strategic Air Command from their ring of bases encircling the Sino-Soviet bloc, and to a lesser degree by the RAF's Bomber Command. Both sides now realize, from the published statements of their leaders, that an all-out nuclear war would mean mutual suicide.[3] Neither side wishes to start such a war, but the greatest danger is that it might start by mistake, or from a probing operation getting out of hand as the result of a miscalculation.[4] If the deterrent fails to deter, or if a chain of events starts which neither side can stop, we shall face the appalling reality of an all-out global war, with the unrestricted use by both sides of thermo-nuclear and nuclear weapons on each other's homelands.

There is, however, a school of thought which believes that because unrestricted global war will so clearly be suicidal to both sides, and as self-preservation is the most powerful human instinct, all-out hot war will disappear completely as an instrument of national policy. Both sides may indulge in what has been variously described as "atom bomb rattling" and "brinkmanship" to bluff their opponents into surrendering territorial or other advantages, but some limitation of warfare is inevitable because both will realize it is the only way to national survival. Such limitation might take the form of tacit agreement between the main contestants not to attack each other's "heartlands", for fear of immediate and devastating reprisals, but to fight their wars in other people's countries. Limited wars might then occur in overseas countries far removed geographically from the metropolitan areas of the great powers, most likely in Asia or Africa, but in them there would be no limitations on the weapons and techniques which might be used to obtain the most effective results. Alternatively, it is possible that some form of international agreement might emerge to limit either the size of nuclear weapons or their use against centres of civilian population distant from the battlefield, similar to The Hague Convention which outlawed the use of gas and was surprisingly observed in World War II. Whether such agreement, if achieved, would be honoured, or whether it would be broken by the side which found itself losing, or felt strong enough not to fear enemy retaliation, is arguable. Thus, although the West has pinned its defence efforts to nuclear deterrence and, if this fails to deter, to nuclear retaliation, there is a possibility that a hot war may be limited in one form or another. However, because of Western comparative weakness in numbers and conventional armaments, it is most unlikely that it can be limited to the extent of banning all nuclear weapons altogether.

The soldiers of our Army serving overseas must therefore expect to be involved under conditions of limited or global war in battle involving at least the exchange of tactical nuclear weapons. Their bases and lines of communication will probably also suffer nuclear attack, and in the worst case

[3]Churchill, Eisenhower, Kruschev at various times and places.
[4]General Norstad reporting to the Atlantic Congress, *Sunday Times*, 7 June 1959.

they may have to fight on in the knowledge that "Home" has been devastated and not knowing what has happened to their families. All armed forces in the United Kingdom at the outbreak of global war will be drawn into the grim struggle for survival in support of the Civil Defence Services, and in aid of the civil authorities.[5]

The Unknown Quality of Nuclear War

Only two atom bombs have so far been dropped in anger. The citizens of Hiroshima and Nagasaki, which were the targets, were largely unprepared for the cataclysms which struck them down in tens of thousands and destroyed their cities. All other nuclear and thermo-nuclear weapons which have been exploded by the Americans, the Russians and the British since the end of the war have been tests. From them a great deal of practical information about the destructive effects on materials of the heat and blast from these weapons has been obtained. Animals have been used to determine their effects and those of radiation and fall-out on living creatures, from which deductions as to the effects upon humans have been to supplement the data obtained from examination of the victims of Hiroshima and Nagasaki. But apart from a few Japanese fishermen who were accidentally caught in the fall-out from an American test, no human beings are known to have been the subject of experiment. In particular nobody knows for certain what men will be able to stand up to or how troops will react to the threat of nuclear attack upon them.

The lethal effects of fission and fusion weapons are too well known to need detailed description. They have been described often enough in writing and speech; films, newspaper articles and photographs in the popular press have partially educated the people of this country. The blast effect does not perhaps seem so different, except in degree, to a nation which endured Hitler's blitz against her cities, or to soldiers who have faced bombing and shelling. Even the heat does not perhaps seem so frightful to those who endured fire-storms raised by incendiaries in that same blitz, though its intensity will be far greater, and the prospect of being incinerated or horribly burned literally in a flash is an unpleasant one. To many Britons probably the most beastly aspect of nuclear warfare is the invisible and unfelt danger from radio-activity in its various forms, bringing incurable sickness and lingering death. Whether it be in the form of immediate or residual radiation, of neutron induced gamma activity in the immediate vicinity of ground zero, or radio-active fall-out carried by the winds and deposited miles away, this secret, stealthy, creeping death seems particularly repellent. We have learnt that there is nothing sporting or civilized about modern warfare, but this sort of thing seems beyond the pale together, un-British and as barbaric as the poison gas which was outlawed after World War I.

Popular sentiment apart, the radiation effect is the one which is peculiar to nuclear weapons and has no counterpart in conventional explosives. The military consequences are considerable. Although in the brief time of an explosion of a nuclear weapon in the kiloton range, or a thermo-nuclear one in the megaton range, very many more casualties will be caused by heat to man unprotected in the open, or by blast to men even in trenches or buildings, than by immediate radiation, areas of ground in the vicinity of the explosion will be grossly contaminated with radio-activity, whilst the fall-out from a ground burst will contaminate large areas downwind. Men cannot stay in

[5]Statement on Defence 1956.

these areas and live, although they may cross them without incurring a fatal dose if they do so quickly, especially on wheels or tracks. Innumerable and vexatious problems of monitoring, decontamination and protection are raised by this hazard alone. It has often been said that fear of the unkown is the worst fear: nuclear warfare itself is one unknown, and radiation is another. The radiation threat in nuclear war is therefore doubly fearsome.

Despite all that has been said, written and filmed about atomic explosions, it is difficult for any but the most imaginative to visualize what one is really like. Those of us who have been present at the explosion of nuclear weapons of even nominal size have great difficulty in conveying in sober prose our impressions of the awesome spectacle. To say that the brightness of the explosion is many times stronger than the sun is not vivid enough. On a hot clear afternoon in the Australian desert the very light of the sun itself was extinguished by the intensity of the flash, as the dark shadows in the shade of buildings disappeared in a white blaze of light. Perhaps another description will bring it home better:—"An explosion of a nuclear warhead on Johnson Island startled thousands of residents in Hawaii (700 miles away). The explosion also temporarily blinded passengers and crew in an Australia bound Qantas airliner 800 miles away".[6] Translating these distances to Europe, the residents of Venice would have been startled by the burst of such a warhead over London, and aircrews over Danzig and Vienna temporarily blinded.[7] At night such an unexpected flash has far greater blinding effect on an eye with iris open widest to see in the dark. Flash blindness can be suffered even at considerable distances and when not looking directly at the explosion. It may last for several minutes to over an hour. The heat from one of the explosions of the "Buffalo" series at Maralinga in 1956 felt to the necks of observers over six miles away as if they had been standing by the door of a furnace which had been opened. The charred and burned clothes on the bodies of dummies exposed nearer ground zero testified even better to its intensity. Although the blast and shock wave in clear weather conditions do not seem at a distance so much more formidable than medium artillery, with cloudy weather the blast can be as shattering as a clap of thunder at close quarters. The damage to equipment of all kinds exposed for "target response", the devastation nearer ground zero and the completely cleared area immediately around it, gleaming greenish where the sand had been fused into glass pebbles by the great heat, and the huge crater formed by a ground burst have all been described before, but they have to be seen for their scale to be appreciated.

Nuclear weapons are not only deeply impressive in their vast power and direct effects; they have had a revolutionary impact upon the strategy and tactics of future war. In the worst event, that of an all-out global war in which both sides use thermo-nuclear weapons to devastate each other's cities, civilian morale may crumble and such government as survives may lose the will to continue the struggle in the face of appalling destruction and loss of life. The role of the armed forces in overseas theatres may then be brief, and unimportant to the outcome. Alternatively after the initial exchange a period of "broken-back" warfare may ensure, in which armies in the field will have to fight on as best they can with what they have.[8] At best, if the war

[6] *The Times*, 13 August 1958.
[7] "Field Engineers in Atomic War" by Major Younger in the *RE Journal*, June 1959.
[8] Churchill in the House of Commons, *Hansard*.

is limited geographically or otherwise, the tactics of armies must be radically revised in the light of the nuclear weapons which will be available to them and the threat posed by their possession by our potential enemies. Atomic war-heads can already be delivered by guided missile, free-flight rocket and heavy artillery as well as by aerial bomb. The Americans claim[9] to have developed fractional yield weapons which can be employed by forward armour and infantry. The Russians may well have them too. When these are in service atomic weapons in the hands of armies will range from these, the equivalent of mere scores of tons of TNT for use at close quarters, to those of up to a megaton to attack bases and lines of communication, and the means to deliver them accurately. The power of these weapons is vastly greater than anything previously employed. Their use can make drastic and sudden changes in the course of battles. Old tactical concepts must be completely changed. The nuclear weapon will be the battle winner; all other arms will support the nuclear artillery. Dispersion and concealment will be vital to avoid presenting nuclear targets. Concentration will invite nuclear destruction if it is discovered. Great mobility will be needed to concentrate quickly for action and to disperse again before discovery and retaliation, and to move forces swiftly from one part of the battlefield to another. There will be no "front line" but a fluid battle zone of much greater depth and width than formerly. Battles will be fought by fast-moving mobile forces concentrating only to strike a blow at the enemy, dispersing again quickly to avoid destruction. Their aim will be to force the enemy to concentrate and to locate any such target so that it can be destroyed by a nuclear strike.

The Kind of Soldier Needed on the Nuclear Battlefield

One school of thought maintains that there will only be two kinds of soldiers on the nuclear battlefield: those who are useless because they are dead, and those who are useless because they are cowering dazed in the bottom of holes in the ground. Others believe that a nuclear war, like any other, will be won in the long run by men. The result of it will depend upon their qualities of endurance and fortitude, their will to continue the struggle even when all seems lost and in the face of wholesale destruction and carnage.

A soldier is clearly useless if he is dead, or incapacitated by shock or radio-activity. To survive at all on the nuclear battlefield a soldier must be alert to the dangers, equipped to give him the maximum chance of survival, and trained to look after himself at all times without orders. Physically he must be tough and tireless, able to endure discomfort, constant movement, little sleep and to fight on until he drops. He must be tough mentally as well as physically to take the tremendous strain of facing up to the terrifying power of nuclear weapons, to endure anxiety and fear in the presence of widespread destruction and heavy casualties around him, and to resist the psychological weakening of his resolve through the feeling of being "cut off" and fears of the hidden dangers of radio-activity. Even if he survives, he still will not be able to do his job of defeating superior numbers of the enemy by sitting in the bottom of his comparatively safe hole, or in his protected vehicle in its hide. The infantryman must still have the guts to leave his safe hole or armoured personnel carrier, and engage the enemy on foot in the open. Tank crews seek out the enemy to destroy him, despite the new

[9]US Atomic Energy Commission report in *The Times*, 12 March 1959.

hazards of guided anti-tank weapons and neutron induced gamma activity from which their armour will not protect them. Gunners must keep on firing and moving their atomic artillery, in the knowledge that theirs is the battle-winning weapon, and therefore also the prime target for enemy counter-action. Engineers must continue to support the other arms, although most of their work has to be done in the open, and they are therefore even more vulnerable to the thermal and other effects of nuclear strikes than those arms which can operate from inside armoured vehicles or fight from holes in the ground at least part of the time. A high degree of cold courage will be called for in those men left behind to observe enemy movement and call down nuclear strikes on suitable targets. In the rear administrative services must carry on their essential tasks in the expectation of nuclear bombardment by much heavier weapons than can be used in the zone of close combat, where forces of both sides will be intermingled and comparatively close to each other, and under the threat of airborne attack or break-through by enemy armoured forces at any time in the fluid battle. For all these roles soldiers must be aggressive, resourceful, resilient and able to carry on when dispersed in small detachments, isolated physically and by communication failure and the destruction of headquarters. Men must be highly self-disciplined to "take it" and good junior leadership in these conditions will be of the utmost importance.

The men we have to prepare for this ordeal by fire will be the sons and grandsons of those who won two world wars. In some respects they will be much like their fathers and grandfathers—after all they are of the same British stock with the same basic character—but in others they are markedly different. On the credit side they are better educated and more intelligent; they are physically stronger and their health is better through good food and better standards of living. On the other hand they are softer, accustomed to easier living conditions, amenities, "NAAFI breaks", bright lights and "flicks". They have been brought up with the Welfare State outlook of being looked after by the State from the cradle to the grave as a right. Their responsibilities and duties have not received equal prominence in their up-bringing. In their home life and in school they have had little discipline and little religious training. They marry much younger and are burdened with the cares of marriage and children early. A popular press, generally hostile to the Services, avid for sensational news but irresponsible as to the long-term effects of its activities, has not helped to predispose the nation's youth or their families to service in the armed forces. Pacifist activities like "Ban the H-bomb" movements have tried to undermine national resolution. National Service has, however, given the people a much greater knowledge of the forces on which they depend for their safety, and has had the good effect of making the Services adjust their ideas to modern public opinion. In Korea and Malaya, and in other parts of the globe where they have been tested, national servicemen have risen to the challenge and shown that, when properly led and trained, they could fight and endure as well as their forbears. In the words of a recent commander's report "The British troop of to-day is well capable of maintaining and enhancing the reputation of his predecessors. . . . There is practically no limit to the enthusiasm with which a good British unit will respond to challenging conditions".[10]

This affords no grounds for complacency. The foe they will have to

[10]Brigadier Muir, draft article on Op Grapple.

face is hard, tough and ruthless. He has not been softened by good living and a high standard of civilization. The Russians are more Asiatic than European in outlook as in national composition. In the past the barbarian hordes of Genghiz Khan and the Tartars from the steppes of Russia laid waste to civilized Europe. Their descendants may try to do so again. Millions of Russians and Chinese lead a hard life only just above subsistence level; they have the Oriental fatalism about life and death. In Field-Marshal Slim's words[11] "The Asian fighting man is at least equally brave, normally more careless of death, less encumbered by mental doubts, little troubled by humanitarian sentiment, and not so moved by slaughter and mutilation about him. He is, by background and living standards, better fitted to endure hardship uncomplainingly, to demand less in the way of subsistence or comfort, and to look after himself when thrown on his own resources. He has a keen practised eye for country and the ability to move across it on his own feet. He has not the inherent disinclination to climb hills that the city bred, motor-riding white man has. . . . While field-craft comes naturally to the Asian, he can learn as well as the white man how to handle new weapons, even complicated ones. The European, on the other hand, can at present more readily design such equipment and find the vitally important skilled men to maintain it. He is superior, not so much in natural intelligence, as in education, and thus is able to find a higher proportion of potential officers. He should be able to understand better what he is fighting for, be capable of higher training, and, if it is properly developed, of more sustained morale. Yet with all these advantages, it is foolish to pit white men against Asians and expect them to win just because they are white; to win they must be better trained, better disciplined and better led. If they are not, even superior armament will not overcome the advantages of the Asian". Much of what he wrote about the Japanese is equally applicable to the Chinese and Russians.

Let us examine more closely what we must do to prepare our soldiers for the unknown quality of nuclear war against semi-barbarian enemies in greater numbers and equipped with modern weapons. There is much we can do, from selecting the right men and equipping them fully, in giving them discipline and realistic physical and nuclear training to building up their mental strength and morale. These will be considered separately for convenience, but they are inter-related aspects of preparation for nuclear war.

Preparation of Men for Nuclear War

Selection. In a few years National Service will end and the Army will be entirely dependent upon regular recruiting. Latest recruiting figures are most promising and indicate that the Army will reach its target of long term regular by 1962.[12] If the emphasis had to continue to be, for political as well as military reasons, on getting the numbers at all costs, there would be little chance of selection. Better recruiting figures will allow the Regular Army to be more selective; the standard of recruits admitted will rise and as it becomes known that it is harder to get into the Army so it will seem a more desirable career and more men will seek entry. Then the "Are you good enough for the Regular Army?" approach will really be a challenge to the nation's youth.

[11] *Defeat into Victory*, p. 538.

[12] Reports in national press, 10 June 1959, of Army being well over half-way (112,000) to target of 180,000.

Post-war research into the causes of failure of men and units in battle laid first emphasis on personnel selection. The presence of even a few unstable officers and men, who are likely to fail under stress, can undermine a unit's morale by their bad example. These men should be able to be detected by psychiatric methods during recruit intake procedure. This is mainly a matter for the psychiatrists, but regimental officers can be of assistance in weeding out those who pass this net by spotting unreliable types during subsequent recruit training. Even in regular units company and platoon commanders, and their equivalent in other arms, should be on the look-out for weaker types whose morale falters under rigorous training. Regimental officers and junior leaders should therefore have some training on the signs of breakdown to look for in their men, and know how psychiatrists can help them to confirm their suspicions and get rid of the suspects, or help the men concerned to overcome a temporary weakness.

Recent correspondence in a national newspaper[13] on the subject of psychiatry in the Army also emphasized the necessity for careful selection of men who are to be trained as soldiers. One contributor[14] pointed out that while this was obvious in the case of the fighting soldier, it was equally necessary for the administrative tail which is there to maintain, nourish and support the fighting man. Teeth and tail are one, especially in a future nuclear was. The men in the tail often work very long hours; they too must be soldiers, armed, drilled and ready to fight on occasion.

Equally, if not more important, is the selection of junior leaders, which is almost entirely the province of regimental officers. Groups of men have a habit of selecting their own leaders, who unfortunately are not always the ones authority would prefer. Just as the shop stewards chosen by the men on the factory floor are not always those men the management would have chosen as foremen, so the unofficial leader in a section or platoon is not necessarily the "blue-eyed boy" the officer would choose for an NCO. In such an event the officer should try to win the unofficial leader to his side and develop his other powers. As many regimental officers know from experience, even a man of bad character but strong personality can often become a good NCO when given the responsibility and the encouragement to show his worth and exercise his leadership. This "poacher turned gamekeeper" approach has been tried with success often before, and has proved better than promoting the smart "yes-man" who will have to rely upon discipline rather than natural leadership for his authority over the men.

Officer selection is more important still. A recent series of newspaper articles[15] has drawn attention to the shortage of candidates for commission in all the Services. Steps to remedy this and comments on methods of officer selection are outside the scope of this paper. It is enough to stress that the Army must have regular officers of high calibre and in sufficient numbers to train and lead the all-regular troops if we are to have a reasonable chance of meeting and beating our enemies in battle.

Equipment. To be able to take on the enemy with the best chance of success our Army must have first-class conventional weapons and other equipment, be trained to use them to the best effect, and have confidence in them and in their own skill in using them. We are not concerned here further with this

[13] *Daily Telegraph* on and circa 25 May 1959.
[14] G. W. B. James, MB.
[15] "Officers and Gentlemen" by Hugo Charteris; *Daily Telegraph*, 10–12 June 1959.

obvious fact in general, but the following seven equipment aspects special to nuclear warfare are important to preparing men for it.

First, our forces must be equipped with nuclear weapons in quantity, range and quality more powerful than those possessed by the enemy, to counterbalance their superiority in numbers and conventional armaments, and be fully trained in their employment. Our means of obtaining and passing back intelligence of nuclear targets presented by enemy concentrations must be speeded up, as must our nuclear response time, if fleeting opportunities are to be seized. Our means of accurate delivery of nuclear warheads to the right place at the right time must be perfected. The speed of delivering strikes must not be delayed by the procedure of warning our own troops of the imminence of them.

Second, soldiers must not feel themselves naked on the nuclear battlefield. Man has a thin vulnerable skin, which is easily burnt. It must be covered by suitable non-inflammable heat-resistant clothing which will protect him completely from flash-burn without making him unable to move and fight. Battle dress is quite good, but face, neck and hands are at present vulnerable and must be covered. Some form of protection for the eyes should not be beyond the wit of man to devise. Pending the invention of something like flash-proof spectacles, a patch over one eye is an expedient. Future combat clothing must embody these requirements and troops must be trained to wear the full range in all conditions and climates. All other practical means of giving soldiers personal protection from the physical effects of nuclear explosions must be investigated and developed. The feeling of being as fully protected as possible will help to maintain morale and fighting spirit.

Third, for the mobility which will be needed on the nuclear battlefield, troops must have vehicles which give them protection on the move from most of the effects of nuclear explosions. Armoured vehicles give good protection to those inside against blast, heat, flash and radiation (except for small fractional yield weapons). The infantry are demanding 100% armoured personnel carriers for their cross-country movement. Unless a high proportion of them can be so mounted in vehicles which have at least full thermal protection, and in which they can if necessary live, they will be ineffective in nuclear battle. Engineers and others who have to support the armour/infantry battle groups must also be so mounted. These vehicles must be provided or the tactical concept will fail for lack of protected mobility for the troops.

Fourth, emphasis on mobility must not lead to discarding properly constructed field defences, which can give a greater degree of protection than thermally protected vehicles and personal protective clothing. It has been pointed out that there is nothing less mobile than a hole in the ground. The nearest approach to a "mobile hole" is a hole which can be dug very quickly. Speed of getting below ground with a thermal shield overhead will save many casualties. Rapid progress is being made in techniques of digging infantry slits by explosives and light mechanical tools, and designs of infantry defences are being revised for quicker digging by these means. Augers might be fitted to APCs and other prime movers in the forward area to assist the infantry to dig in quickly. Light mobile plant, to the extent it is acceptable in the battle zone, can be used for rapid digging-in of headquarters, signal centres, medical posts and the like. Light revetting materials are needed to replace cumbersome corrugated iron pickets; these should be recoverable on moving for use again. The accent on these field defences will be for protection; their main object will be for troops to take cover in, as hides to rest safely in rather than as defensive positions to fight from, which role will be secondary.

Fifth, there will be a greater need for materials for camouflage and deception, with which troops can conceal their own positions, and deceive the enemy into wasting his nuclear strikes elsewhere. The new camouflage materials must deceive radar, infra-red, panchromatic photography and other modern methods of detection. An urgent need is the provision of a combined camouflage net and thermal shield, which can be quickly erected and will both hide and protect men under it; beneath it men can carry on with the digging and development of their slit trenches as may be necessary.

Sixth, the whole range of radiac instruments for detecting radio-activity, which have already been developed, must be provided on a liberal scale. In addition, the Army requires other instruments, which have been developed for civil defence use, such as "Bangmeters", to determine instantly the location and approximate yield of nuclear explosions. By their aid probable effects can be quickly estimated and commanders advised, and in the case of a ground burst the staff can work out from meteorological data the probable area of contamination by fall-out, and warn units which may be affected through the nuclear information and warning system. Most desirable also, but probably impossible of attainment, are instruments which can detect the approach of enemy nuclear missiles and give instantaneous warning for troops to take cover.

Lastly, explosives and equipment should be provided for the realistic simulation of nuclear explosions during the curtailment of nuclear tests. Such simulation should give at scaled ranges effects similar to real atomic explosions in all except radiation effects. Fall-out can be simulated separately for realistic training by such devices as the Canadian Simulated Radio-activity Training Set[16]. This claims to cut both the hazards and cost of training with radio-active sources, by using VHF transmitters to produce radiation patterns like those produced by fall-out in receivers similar to operational radiation survey meters.

These matters of equipment provision are largely outside the province of the regimental officer, but the first six will be vital to him and his men in war, and the last will be important in peace for their indoctrination.

Discipline. A lot is spoken and written, often in letters to the Press, about "old fashioned obsolete discipline" being unnecessary in these enlightened modern times. This may be arguable in respect of normal civil life—though the increasing rates of juvenile delinquency and crimes of violence do not support the argument—but it is certainly not true of the training of men for war.

Field-Marshal Sir William Slim has written[17] "The more modern war becomes, the more essential appear the basic qualities that from the beginning of history have distinguished armies from mobs. The first of these is discipline. We very soon learnt in Burma that strict discipline in battle and in bivouac was vital, not only for success, but for survival. Nothing is easier in jungle or dispersed fighting than for a man to shirk. If he has no stomach for advancing, all he has to do is to flop into the undergrowth; in retreat, he can slink out of the rearguard, join up later and swear he was the last to leave. A patrol leader

[16] *Canadian Army Journal*, January 1959.
[17] *Defeat into Victory*, pp 542–3.

can take his men a mile into the jungle, hide there and return with any report he fancies. Only discipline—not punishment—can stop that sort of thing; the real discipline that a man holds to because it is a refusal to betray his comrades. The discipline that makes a sentry, whose whole body is tortured for sleep, rest his chin on the point of his bayonet because he knows that, if he nods, he risks the lives of the men sleeping behind him. It is only discipline too, that can enforce the precautions against disease, irksome as they are, without which an army would shrivel away. At some stage in all wars armies have let their discipline sag, but they have never won victory until they made it taut again, nor will they."

Every serviceman who has experience of being under fire, except perhaps the very few who are literally without fear, will agree with the Field-Marshal whole-heartedly that discipline and the innate sense of duty born from it have helped many in the past to overcome their natural fears amid the confusion of the battlefield and to go forth to do their duty regardless of safety and self. Discipline not only assures an officer that his men will obey his orders, it gives the individual soldier the confidence to do his duty in the knowledge that his comrades will do likewise. Discipline alone does not win battles, but lack of it can easily lose them.

Nuclear war will not lessen the need for discipline in the Services. It will increase it. The greater the terrors and dangers a man is called upon to face, the greater will be his need of self-discipline to conquer his fears, to fight on and to survive. As in the jungles of Burma, so in the dispersed fighting of a nuclear battlefield it will be easy for a man to shirk, to stay in his slit trench or APC when he ought to get out and fight. The lone stay-behind observer will be tempted to slink away from his observation post before it gets too hot, the nuclear sentry on guard while his comrades sleep in comparative safety, to keep his head down out of harm's way. It will be discipline which saves them from letting down their comrades, just as discipline will make them keep on their protective clothing even in the heat and discomfort of the tropics, or stay in undergound shelters for long periods in fall-out conditions.

A Canadian writer[18] has summed it up succinctly thus: "If the soldiers under Wellington needed iron discipline to win the Iron Duke's battles, how much more do they need it to-day, with a modern battlefield in prospect? . . . This is a point about which there can be no compromise. But let us get the term straight. It is not synonymous with brutality, or callousness, or cruelty. It is in the end, humane. It is a stark fact that we must train our soldiers to kill our enemies, and not to flinch when confronted with a similarly trained adversary."

Discipline then is vital to the cohesion and survival of an army, and to the men in it. It may have to be even stricter than formerly, as the odds to be faced are more formidable. But it should be possible to move with the times and develop a more intelligent type of discipline, one that is based more upon understanding and reason to suit the more thinking soldier of to-day. Men must be taught the necessity for it, and how it will help them in battle: British soldiers will respond better than to Prussian methods. We need soldiers of initiative and self-reliance in modern war, not automatons taught only blindly to obey orders who will be lost without their leaders to shout them. At the present time we have fallen between two stools in that our

[18]Lieut-Colonel H. F. Wood in the *Canadian Army Journal*, October 1958.

discipline is not strict enough where it ought to be in things which matter, whereas the private soldier of to-day is under constant supervision and direction. National Servicemen often say after leaving the Army that they enjoyed never having to think for themselves. Many irksome and senseless restrictions which masqueraded as being "good for discipline" have rightly been abolished in recent years, as they did far more harm in making men "browned off" with the Army. But constructive measures have not been substituted and the general climate is now in many respects too lax. It is right that soldiers should be allowed to wear plain clothes off duty, sleep out of barracks and go away for weekends when they are not required. It is wrong if they are allowed to get away with slack performance, disobedience of orders, or dereliction of duty in any degree. When they are on duty only the best is good enough.

One curse of modern times is paper. In the Army the number of written orders and instructions of all kinds and from all levels of command which assail a Commanding Officer is legion. Compliance with all of them is time consuming and next to impossible. This breeds evasion of orders and excuses. If members of the Army Council or Generals in whose name they are issued had personally to certify that each one was essential their number could be reduced to one-tenth, those which were issued could be rigorously enforced, discipline would improve and there would be more time for officers to concentrate on their real job, training their men for war. Officers, especially senior officers, too frequently set a bad example of obedience to orders: they should not be surprised if their example is followed at lower levels.

We must raise the standards and tighten up the strictness of military discipline in military training, whilst reducing it, off duty, to the minimum required for orderly living and decent behaviour. Harsh measures, shouting and cursing are utterly out of date, but there must be an iron hand in the velvet glove.

Drill. While not admitting therefore for one moment that discipline can be discarded, let us examine critically and constructively the traditional methods of instilling it. First and foremost is drill necessary to instil discipline? Anyone who has seen a batch of recruits arriving in a training unit knows that there is no better way than drill of getting some semblance of order into the rabble. Recruits must be taught to hold themselves properly, to move about in an alert and soldierly manner, and to obey the orders of their superiors instantly and unquestioningly. On the firm foundation of their "square bashing" should be built the further training which will in time develop a raw recruit, needing supervision at every turn, into a self-disciplined trained soldier who can be trusted to carry on doing his duty within the spirit of his orders. But while drill is essential basic training for recruits, it becomes less necessary for trained soldiers, and should only be required occasionally as a refresher if standards of bearing and movement fall off. A properly trained soldier should seldom require refreshing, particularly if his officers and NCOs set a smart example and are quick to check any slackness. Saluting is another target of the anti-militarists, and apologists have made a lame case of explaining it as a mutual act of salutation between comrades. This is only half the truth: it is also the outward and visible sign of allegiance and respect of a fighting man for his leader. As such it must be insisted upon whenever troops are in uniform, and the insistence will improve the alertness of all ranks. Smart turn-out is another outward sign of a smart soldier; experience has shown that men trained to turn themselves out smartly as recruits will form the automatic habit of keeping themselves, their weapons and their equipment clean in their later service, and continue to do so in war. Just as we teach our children good habits, so must recruits be taught good military habits, which will hold them in good stead later.

To quote Field-Marshal Slim again[19] "We found it a great mistake to belittle the importance of smartness in turn-out, alertness of carriage, cleanliness of person, saluting or precision of movement, and to dismiss them as naïve, unintelligent parade-ground stuff. I do not believe that troops can have unshakable battle discipline without these outward and formal signs, which mark the pride men take in themselves and their units and the mutual confidence and respect that exists between them and their officers. It was our experience in a tough school that the best fighting units, in the long run, were not necessarily those with the most advertised reputations, but those who, when they came out of battle at once resumed a more formal discipline and appearance."

Having agreed upon the necessity of these traditional soldierly virtues, it must however be admitted that there is room for reform in some of the methods of teaching them, and the detail of what is taught. For example in drill the position of "attention" is a rigid unnatural posture which was all right for Frederick the Great's grenadiers, but medical opinion will say causes unnecessary strain and back-ache. The stiff-legged, short-stepping, arms swinging straight from the shoulders as high as the hips, style of marching taught to recruits, looks as ridiculous as it is unsound. The need is for a purposeful swinging pace which will devour distances on foot with least fatigue. The "slow march" is of even less practical use. Old-fashioned musketry movements like the "present arms" still linger on in arms drill. An opportunity of putting this right was missed when the FN rifle was introduced into service; alas! the Guards were allowed to produce the new drill for it on the good old lines, rather than asking Operational Research to "work study" it and evolve something more functional, possibly on the lines of the arms drill which Rifle and Light Infantry regiments have been doing for years. Occasional ceremonial parades with martial music, on such national occasions as the Queen's Birthday, are good for esprit de corps, but if the preparation for them involves excessive practice and rehearsal, and troops are kept on parade too long, the good is undone. "Five minutes early" is an old form of military "punctuality", but the result of this kind of over-insurance at all levels is cumulative, so that troops sometimes parade initially for the first of a series of inspections hours before the big parade is due. This is bad training for war where exact punctuality and speed in turning out are needed. Training should aim at getting a unit on parade ready to move in five minutes from the order, and soldiers who need no inspection to ensure their complete readiness. Over-insistence on the more extreme forms of cleaning and polishing for no practical purpose have rightly earned the two older Services a bad press for "bull"—that dreadful word which has become synonymous in the public mind with everything unpopular in the way of making men smart, clean and tidy. It is futile that recruits should ever have been made to clean floors with boot-polish, cut grass with nail scissors and shine boot-polish tins with Brasso, as the press has alleged from time to time.

[19] *Defeat into Victory*, p. 543.

A ludicrous custom which needs to be stamped on ruthlessly, if it still survives, is the keeping of specially prepared sets of kit, mounted on cardboard, padded with paper and sewn into the correct shapes for kit lay-outs. It is also a waste of time and effort, when there is so much to learn in the time available, that recruits should have had to spend so much time in profitless brass-polishing. The introduction of "stay-bright" buttons is a step in the right direction: the next is the replacement of web equipment by something which does not need constant blancoing and polishing of brasses.

These and similar abuses teach bad lessons, annoy by their senselessness those they are intended to instruct, and bring the Army into popular disrepute. They must be overhauled in the light of common sense, putting emphasis on teaching what is important and discarding the unimportant and senseless. Rigid parade ground drills and marching might with advantage be modified on the lines of Physical Training; indeed the two should be merged, and parade marching be preparatory and akin to road work. It is unnecessary to have two styles of doing virtually the same thing, taught by different sets of instructors. Arms drill should be modernized, new "nuclear drills" devised and practised.

Physical Endurance Training. Physical fitness has always been of prime importance to fighting men. We shall need fit, tough, tireless soldiers of great physical endurance in future nuclear war. The fitness of the men is bound up with the efficiency, esprit de corps and fighting spirit of a unit. The old cry of the APTC of "mens sana in corpore sano" still holds good: a fit and healthy body is the essential foundation upon which to build up an efficient soldier. The physical training of troops must be progressive from their recruit days onwards, with the aim of developing in them the stamina and ability to meet and overcome the exacting demands and physical strains of nuclear battle. Physical training is complementary to other forms of military training and must feature in and be related to the other items in a balanced training programme.

Although armies will be even more mechanized than formerly, mobility of vehicles on the battlefield may be severely restricted by blow-down, terrain or mere shortage of petroleum. Infantry, although hoping to be carried in APCs, must nevertheless be trained for movement heavily laden over long distances across-country on foot, as the Roman legionaires did before them, and be able to dig in or fight at the end of it. They must overcome physical obstacles such as rivers, mountains and jungle. Recent mobility trials in this country have shown what can be done by infantry on foot with light trolleys for their heavier equipment. Tank crews must be able to drive and fight their tanks for long periods and then get down to maintaining it at "rest". Other arms have their peculiar problems. All must be trained for continuous activity with little sleep.

The scientific approach towards the progressive building up of stamina and strength is based upon conservation of energy and correct use of the muscles. Scientific research into the correct methods of walking and running across undulating country has produced a technique and methods of teaching it which have been promulgated.[20] Similar research could with advantage be applied to other common forms of fatiguing activity. The progressive development of physical training through boys', and basic training to battle efficiency training, with tests of increasing severity at all stages, has been worked out in

[20]Basic and Battle Physical Training.

detail and published.[21] What is needed is for unit commanders and officers to take physical training seriously as their own responsibility, and not merely that of the APTC, and integrate it properly into military training programmes. As already argued, physical training and drill ought to be much more closely linked into one subject. In this respect, and in that of realistic endurance training, the Parachute Regiment has set itself a target, and developed methods of producing tough soldiers which could be applied more generally in the Army. One reason why PT has not been given serious enough attention in the past is that unlike drill the unit officers, except the most junior, seldom partake in it, and the instruction is the prerogative of a special brand of "india-rubber man". All company and platoon officers, and NCOs, should take a pride in being as fit as their men, and reaching the same standard of endurance and ability; they should also have the responsibility for this form of training, as of others, with the PT staff as their advisers and assistants. Field-Marshal Montgomery created a sensation in 1940 when he insisted on all officers in his division below 40 running a mile, and doing other tests of physical endurance.[22] How right he was! There will be no more a place for soft flabby officers in nuclear war than there will be for soft flabby soldiers.

One different type of endurance training which is certain to be required for nuclear warfare is that of living largely or even completely underground or enclosed. It has been pointed out that owing to the complete absence of warning of an atomic strike and of time to take cover, physical protection of men, whether by covered trenches or in armoured vehicles, will only be effective provided the men are in them at the random instant of the detonation. Therefore men must be trained to stay under or inside cover, unless they have to be exposed in the open on some duty. Furthermore, ground bursts, which may be accidental owing to fusing errors even if neither side perpetrates them deliberately, will cause large areas to be contaminated by radio-active fall-out. Units in those areas must either move out of them quickly or go to ground in totally enclosed shelters until the activity has decayed to a safe level. Successful trials have been carried out of incarcerating soldiers in simple fall-out shelters, with make-shift ventilation systems which will filter out radio-active dust; after 48 hours men emerged quite happy. More protracted trials of a week or more are needed to study the extent of deterioration of men's spirit and fighting ability in such cramped conditions, where even the elementary processes of life will be difficult, and to determine what measures are required to keep up their spirits and physical condition. Training must then follow on the lines indicated. We have always had training problems of preparing men for warfare in environments different from their own, such as equipping the townsmen for the jungle, but this is an unusual training problem of its own; it is bound to be unpopular and it may be difficult to enforce it strictly without an effective substitute for fear of death.

Games and sports have their place in the physical fitness training programme, especially those like cross-country running and football of both codes which develop endurance. All team games help to develop team spirit and the feeling of playing for the side rather than self, those which are played collectively more obviously than those where individuals compete

[21] The Organization and Control of Physical Training in the Army.
[22] *The Memoirs of Field-Marshal The Viscount Montgomery*, p 72.

alone or in pairs in the ring, at the crease or on the court, and yet for the team. Others like mountaineering, ski-ing and yachting have an added spice of danger and develop other desirable qualities of adventure and initiative. Competition in all games and sports is desirable in putting an edge of keenness on them and fostering esprit de corps; but abuses must be guarded against. Over keenness in "pot-hunting" leads to packing of unit teams and concentration upon the gladiators to the detriment of the many ordinary players. A good sporting unit is not necessarily the one which wins the most cups but the one where all the men get plenty of games regularly, and where all the Officers and NCOs play with their men in their sub-unit games. The latter is yet another way in which the leaders get to know their men and the the men their leaders.

Mental and Psychological Training. Our more robust forefathers branded as a coward any soldier who ran away or deserted, and shot him. This was effective, if rough, justice and discouraged others from doing the same. In World War I "shell shock" became recognized as an ailment: it affected thousands and required long treatment to cure. In World War II similar nervous collapse under the strain of battle was known as "battle exhaustion". Cases of individual failure in battle were far more numerous than is admitted.[23] In future wars it may be called "nuclear neurosis", but it will be basically the same disease. According to the pundits anxiety neurosis is a specific malaise which must not be confused with common "funk".[24] It is likely to be even more of a problem than before because of the unknown terrors of nuclear attack initially, the impact of high casualties occurring in an instant of time, the shocking nature and extent of these casualties from heat and blast, or the more lingering death by radiation sickness, the feeling of impotence and the shock to the nervous system of these colossal explosions. Enemy psychological warfare will play upon these fears and do all it can to undermine morale.

The problem is a difficult one—how to sort out the genuine case from the malingerer, to maintain discipline and yet be fair to the individual victim of it. Skilled psychiatrists are needed for this; they are available in the RAMC as an essential part of the Army health service but they are few in number. Regimental medical officers may be able to help, but some knowledge and training of junior regimental officers and NCOs in elementary psychology and psychiatry appears to be desirable.

Although the nervous stresses and strains of war cannot be reproduced in peace, there is much which can be done in training to build up that vital mental robustness which will prevent or greatly reduce the incidence of "nervous" casualties in battle. Good initial selection and early weeding out of the weaker brethren and the maintenance of a high standard of physical fitness have already been discussed. Men need to feel confidence in the effectiveness of their arms and equipment, the unit of which they are part and its leadership; this should naturally follow from the training they have carried out in peace, the strength of esprit de corps which has been fostered and the man management and administration to which they have become accustomed. Education and indoctrination to reduce as much as possible of the element of surprise, and practical knowledge of measures to minimize the effects of nuclear explosions, training in drills for self-protection and

[23] *Army Quarterly*, April 1959, Editorial.
[24] Correspondence in the *Daily Telegraph*, 25 May 1959.

first aid will all help to keep confidence high. These are all primarily matters for the regimental officer; psychiatrists, psychologists and other specialists may advise and assist, but the overall responsibility is squarely upon commanding officers and regimental officers. In war itself science may be able to produce pills, like those available on the civilian market which claim to do so, which will really reduce nervous tension, banish fear, restore energy and prevent sleepiness, but such tranquillizers and stimulants should never be used in training.

Leadership. A distinguished soldier recently wrote[25] of the failure of a British battalion in early action in the Middle East that the cause was mainly bad leadership. It is often said that there are no bad soldiers, only bad officers. This may be an over-simplification, but the fundamental truth is there, that soldiers fight only as well as they are trained and led by their leaders. The junior leaders have always borne the brunt of the war, and do so still; but their intelligent initiative, and its cultivation, have now become vital factors in determining the issue.[26] The standard of leadership in a nuclear war must be of the highest order at all levels, but nowhere will it be more important than among junior Officers and NCOs; it is they who will have to battle on in the fog of war, when command and communications have broken down.

Selection of junior leaders has been discussed; their training and development is of high priority. Young soldiers of high potential should be given training of the "Outward Bound" type to develop their powers of initiative and to give them confidence. Responsibility should be placed on their shoulders increasingly as they progress, care being taken not to overload and break them by expecting too much too quickly. Their authority must be upheld even if they falter or make mistakes, until with patience and understanding they take their places among those who have always been the backbone of the British Army, the warrant and non-commissioned officers.

Good leadership shows itself in many ways and pays high dividends in the confidence and ready following of the men. The good leader sets an example at all times, especially in things which are unpopular or dangerous. The more arduous or unpleasant the conditions, the more important it is that not only is the burden, or the danger, shared equally by leaders with their men, but that it is apparent to all that it is so.

Nuclear Education and Training. All soldiers must be thoroughly educated in all aspects of nuclear warfare. New weapons always have a profound effect when they are first introduced, until their limitations as well as their powers are known. Every soldier must therefore be taught the "Bible" on nuclear war[27] as thoroughly as children used to be taught their Catechism. Every use must be made of available films, pictures and other literature. From this he will learn the characteristics and effects of nuclear weapons, the dangers from them and how he can protect himself. Cynics have said that the best protection against an atom bomb is not to be there when it goes off. Soldiers must be convinced that although their chances of survival close to ground zero may be small, there is a great deal they can do to protect themselves from near-misses. It must be impressed upon them that sensible

[25]Lieut-General Sir Arthur Smith in the *Daily Telegraph*, 25 May 1959.

[26]Liddle Hart "The Growing Importance of the Junior Officer" in the *Infantryman*, August 1958.

[27]Precautions Against Nuclear Attack, 1957.

precautions, like always wearing their protective clothing, digging in and staying under cover, as habits rigorously practised will save them from becoming casualties.

As new information becomes available it must be widely disseminated so that it reaches every man. To ensure they do learn this vital subject thoroughly, tests and written examinations should include nuclear questions, and special tests should be held periodically.

To know the theory is only the start. There must be realistic practical training to supplement book knowledge. Drills for self-protection must be developed and taught, and practised at any time of the night or day. In a well-trained unit it should be possible to fire a maroon to represent an atomic explosion at any random moment, and have every man flat on his face with his hands tucked under him in an instant, whatever he was doing. It would be an impressive sight if the unit were on parade. There must be realistic training in carrying out all ordinary tasks in full protective clothing; this may be most uncomfortable in tropical climates, and performance will fall off, but it is only by getting accustomed to it in peace training that we will find ourselves not too handicapped in war.

Monitoring teams, and sentries for manning nuclear observation posts, must be trained in their duties and in the use of all the instruments which may be available. Decontamination of men and equipment must be taught and practised realistically. This training must be widespread so that any soldier can undertake these duties, as reliefs and relays will be wanted in war, especially as men's radiological life gets expended in fall-out conditions. First aid for burns and blast injuries, as well as more normal wounds, must be taught to all: if a unit is caught by a nuclear strike the numbers of casualties will overwhelm the medical services on the spot, but many deaths may be prevented by the prompt attention of comrades with a modicum of skill.

It must be made quite clear to soldiers that they must expect to face attack by nuclear missiles as a normal risk of war, but the protective instruction given should be balanced by emphasizing that the allies possess larger numbers of these weapons than their enemies.

Indoctrination. Book learning, lectures, films, pictures, drills and practices are all very well up to a point, but there is no substitute for the real thing. Orders that all ranks must be educated in the real effects of nuclear weapons so that they will have personal knowledge to withstand the psychological shock are mere platitudes unless soldiers can cap their theoretical knowledge with practical indoctrination. Those who have been fortunate enough to attend atomic trials, either as part of the task forces concerned, as members of an indoctrinee force, or as guests at American tests, reckon the experience as one of the most vivid and important of their lives.

The only organized indoctrination carried out by the British Army was at the "Buffalo" series of trials at Maralinga in 1955. Then some 150 British Officers flew out to Australia and after many delays due to wind and weather, attended an atomic explosion; some officers stayed for a second test. They subsequently had the opportunity of seeing the effects on targets at close quarters. Despite the long wait in the Australian desert, all felt it was an unforgettable and invaluable experience, which gave a vivid personal impression which no amount of reading and seeing films could have provided. They learnt at first hand all the effects they had read about, but also many other small practical points such as the mushroom cloud looking as if it were coming toward you to deposit fall-out when it is really receding. The pity is that only a few officers, besides those of all ranks in task forces at Monte Bello, Maralinga and Christmas Island, have so far had this experience. With the suspension of nuclear tests by the Great Powers the opportunity has gone, at least temporarily.

If nuclear testing is resumed more indoctrination must be carried out at every opportunity. Battle indoctrination was accepted in World War II as an essential means of giving soldiers their baptism of fire before committing them to battle, so that they would be accustomed to the noise and sensation of being under fire of bullets and shells. Soldiers are used to the sound of rifle and artillery fire from range firing, demonstrations, and blank on ceremonial occasions and manoeuvres, but only the very limited few have ever seen or heard an atomic explosion. Indoctrination in atomic explosions is most important, to remove the elements of fear of the unkown and surprise. All higher commanders should certainly undergo it, so that they can really appreciate the power of the weapons at their command as well as what their troops are up against. Regimental officers and junior leaders would benefit immeasurably from it, and ideally all soldiers should undergo it as the culmination of their nuclear training. It is so important that troops should be properly prepared in this manner for what they will have to face, that special test firings should be made for this purpose. Troops could be variously indoctrinated, many observing from the nearest safe distance standing or lying in the open, some in slit trenches and others in armoured vehicles at closer range. They could try different kinds of protective clothing, eye protectors, and different postures against blast, while monitoring and decontamination could be practised realistically, always subject to the proviso that nobody should be exposed to danger of major injury. Cost and distance will be argued as ruling out such a programme of wholesale indoctrination, but these are difficulties which can be overcome. For example, it might become part of a normal tour in the Far East for all units and individuals serving out there to attend an indoctrination explosion at Maralinga. Transport Command RAF could provide the air-lift from Singapore and Hong Kong, as for a strategic troop movement; the Australian Army could be asked to lay on the administrative arrangements for a bivouac near the range, which they would probably be happy to do. Within a week or ten days the equivalent of a brigade could be indoctrinated.

If, however, nuclear testing is not resumed we must devise other means of indoctrination. Elsewhere in this paper a requirement has been stated for nuclear simulation equipment and explosives, which could give similar effects to real atomic explosives in all except radiation. Very large scale simulating devices could be used for indoctrination, and for target response tests, at Maralinga and Christmas Island, whose ranges are at present lying idle. Canada has a high explosive testing ground which might be made available for indoctrination tests. But it should also be possible and worthwhile to carry out indoctrination with smaller devices on the more remote ranges in the United Kingdom; the distance at which troops were exposed being scaled to give generally similar blast and heat effects.

Lastly, it is suggested that troops might be given a form of simulated indoctrination indoors in buildings which might have to be built or converted for the purpose. An imaginative combination of modern cinema techniques, including stereophonic sound and wide screen, with the explosions of magnesium and charges in a confined space, and realistic representation of the heat, could give an effective imitation of the real thing. Its advantage would be cheapness and accessibility, and it could be used repeatedly, with varying films and effects.

The dividends of indoctrination in removing fear of the unknown and surprise are so great that no efforts should be spared to ensure that every regular soldier undergoes it.

Faith. Our enemies have a burning faith in their atheistic and materialistic cause. Communism is to them a religion. Europe is threatened by a torrent of steel, controlled by men whose spiritual outlook is not far removed from that of Attila or Genghis Khan.[28] The Communists know no God but force, no devotion but its use.[29]

In the Victorian days of our greatness we British believed in ourselves, our country and in our civilizing mission to spread Christianity and light among the heathen. The decline in our position in the world has been parallelled with the decline in our faith. This is no coincidence. Increase in material prosperity and scientific advances have not been matched by moral improvement. The tone of the masses of our country is materialistic and irreligious. Our recruits generally have little knowledge or interest in religion, patriotism or the world struggle between freedom and slavery, good and evil.

Men will not fight well unless they believe in the cause for which they are fighting. They need a powerful faith to face fearsome destruction and threat of annihilation posed by nuclear weapons. In the Army we must inspire our soldiers with belief in God, the survival of the soul and the Christian example. We must explain to them the rights and wrongs of the world struggle, and convince them of the justice of the Western cause and of the part which Britain has to play.

This is not the concern just of the padre's and education wallahs to be relegated to occasional padre's hour and ABC periods. It should be the priority task of all regimental officers to educate and indoctrinate their men in the strength and rightness of the Christian cause. Field-Marshal Montgomery is reputed to have said that he would rather go into battle without his artillery than without his padres, but they are few in number. Officers should aim to be the spiritual as well as military leaders of their men, as Cromwell's were. We must arm our soldiers with a faith stronger than their enemies', which will strengthen them in battle, uphold them in adversity and sustain them in death.

Conclusion

The practical application of the measures outlined in this paper should go far to prepare our soldiers for the unknown quality of nuclear war, and to send them forth to battle with high morale. In the words of Field-Marshal Montgomery[30] "High morale is a pearl of great price. The more I see of fighting the more I am convinced that the big thing in war is morale; it is probably the most important single factor". If that was true of previous wars, it is even more so of nuclear war. Morale does not grow of itself, it needs deliberate cultivation and sustenance. These measures, many of them in the power of regimental officers, will build up that high morale.

[28] Major-General von Mellenthin.
[29] General Eisenhower.
[30] Quoted in "Morale" by Brigadier O'Donnell in *RUSI Journal*, February 1945.

"There comes a moment in every battle when the result hangs in the balance, and the general must hand over to his soldiers, to the men in the ranks and to their regimental officers. . . . The issue then rests with them, on their courage, their hardihood, their refusal to be beaten. . . . Then only will, discipline and faith can steel them to carry on".[31] Properly trained, prepared and indoctrinated and with their morale high in consequence, British troops will again show on the nuclear battlefield the qualities which have won the victory in previous wars.

[31]Field-Marshal Slim in *Defeat into Victory*, p 551.

The Unveiling of the "Khartoum" Statue of General Gordon at the Gordon Boys' School, 14 May 1960

THE Statue of General Gordon which stood for fifty-five years in Khartoum was unveiled on 14 May 1960 on its new site at The Gordon Boys' School. The statue is an exact replica of that at the SME Chatham but it has had a far more adventurous career. It was first erected in St Martin's Place, near the site now occupied by the statue of Nurse Cavell, in 1902, and late in that year was dismantled and sent to Khartoum. It was involved in two collisions on its journey and was twice under water, once in the Thames Estuary and once in the Nile. It was finally erected in Gordon Avenue in Khartoum early in 1904, and stayed there until December 1958, when it was dismantled with due ceremony and sent home to England.

From the many claimants to the statue, Her Majesty's Government finally decided that it should be presented to The Gordon Boys' School, which is the National Memorial to Gordon. The school received this decision with consciousness of the honour done to them, and with the greatest pleasure, a little mixed with feelings of slight apprehension of what lay ahead. It was arranged that a civilian transport contractor would collect it from Chatham docks, where it had arrived in company with the Kitchener statue. There was, however, some discussion between the contractor and the dock authorities as to which statue was which. No one could easily understand why the packing case of a statue of a major-general was so much heavier than that of a field-marshal! The statue arrived in the school during the Easter holidays, on 2 April 1959.

A well-known architect was then asked to prepare a layout and site for the statue. This proposal, though admirable from the aesthetic point of view, was, however, far more than the school, with its limited financial resources, could afford. Somewhat regretfully his scheme was abandoned. It was then decided to ask the Brookwood Necropolis Company to prepare a design of a suitable plinth and layout for the statue to be erected on the corner of the main cricket field of the school, where, to quote the words used at the unveiling ceremony, Gordon would be "forever gazing down on the boys he

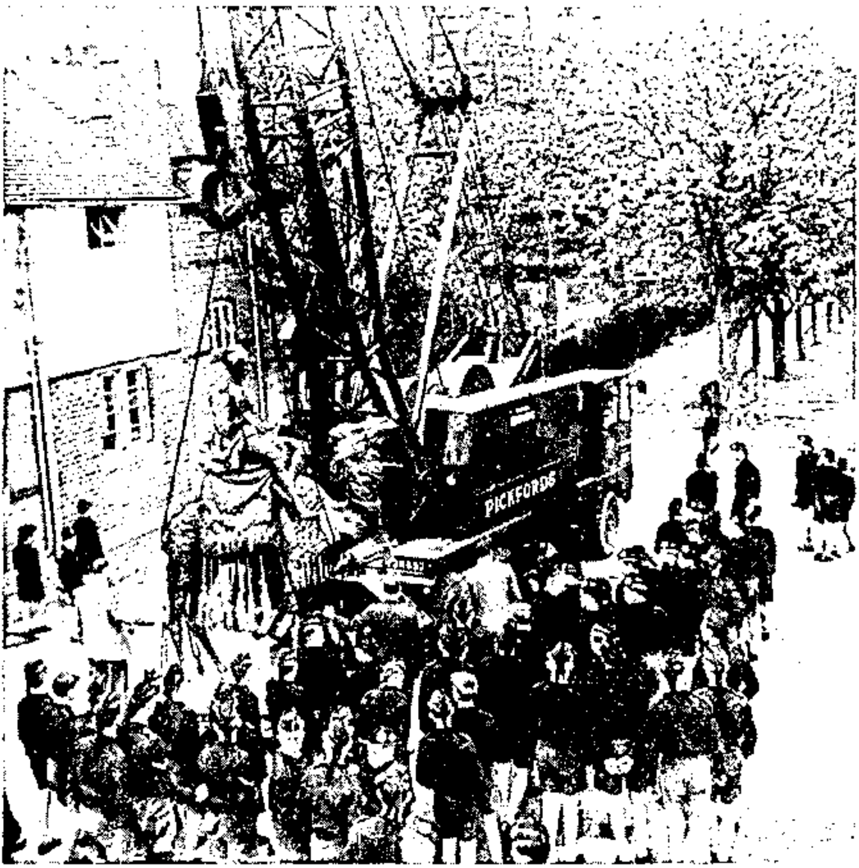


Photo 1. Statue being transported to the new site, escorted by Gordon Boys. He would have liked that!

loved so well". Most people who have seen the two sites are of the opinion that the site finally decided upon was really to be preferred, which indicates that sometimes second thoughts are best. There is, however, no truth in the rumour, suggested by one distinguished sapper officer who was present at the unveiling, that the site was chosen in order that negligent boys could be told to run round the playing field and "report to Gordon", in the same way that equally negligent cadets at "The Shop" in the old days were told to "report to the Prince Imperial"!

Work on the site started on 15 March 1960 and the plinth was finished, awaiting the statue, by 4 May. Meanwhile, the firm who cast the statue in 1902 had been engaged to unpack and repair it. They found a lot of minor damage, but fortunately most of the broken parts had fallen off in transit, and were still inside the case. The move of the statue on its plinth was placed once more in the hands of the firm who transported it to the school from Chatham. Gordon's final journey was a comparatively rapid affair. One driver and his mate arrived in a crane lorry, slung the statue on a sling, and moved it without fuss on to its plinth, the whole operation taking less than forty-five minutes.

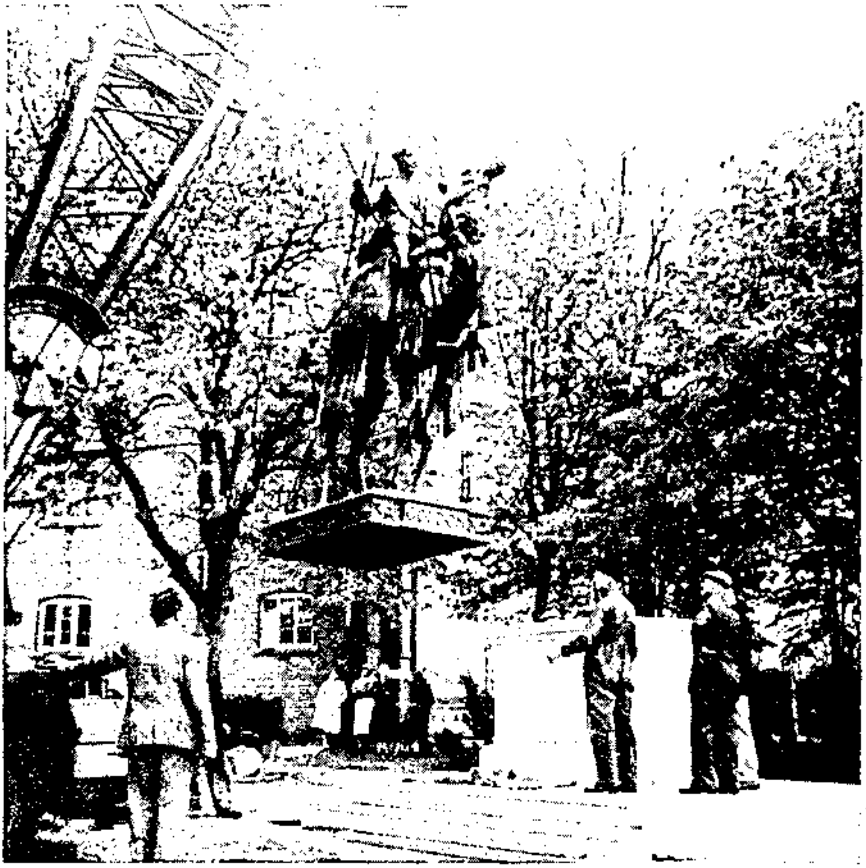


Photo 2. Lowering the statue on to the plinth.

There remained the problem of the unveiling. The arrangements for unveiling statues are not to be found in the usual books of reference, whether they are military or civilian. Much thought was given to decide the best way of unveiling a statue with so many protuberances. It was later realized that the Corps of Royal Engineers had to solve the same problem with the Kitchener statue and it was with great relief and a feeling of thankfulness that their offer to take over the arrangements for the Gordon statue was accepted. (The unveiling ceremony followed closely on that of the Kitchener statue.)

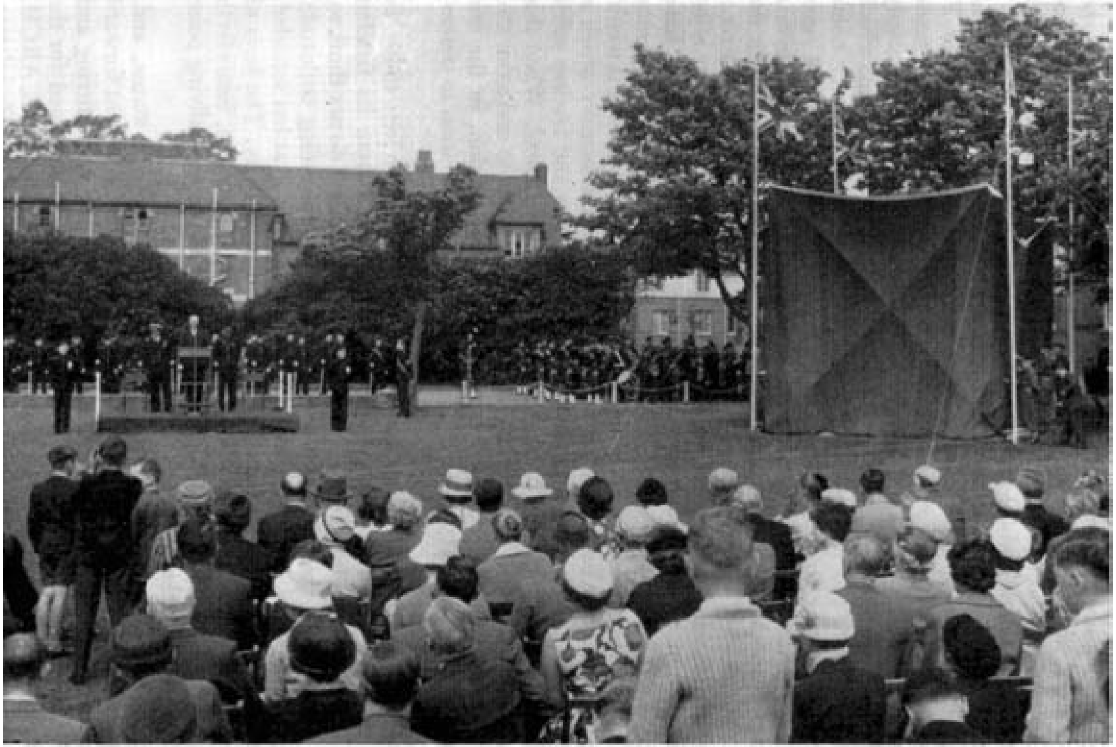
The weather before 14 May was atrocious, but the day itself dawned clear and bright and remained so all day. Gordon deserved the fine weather. The Guard of Honour and the Band was found by the boys of the school. The Rt Hon the Lord Rugby, GCMG, KCB, KCVO, CSI, the senior surviving Governor-General of the Sudan, agreed to make the unveiling speech and the actual unveiling was to be done by Lady Huddleston, whose husband Major-General Sir Hubert J. Huddleston, GCMG, GCB, CB, DSO, MC, was Governor-General in 1940–7. She had very generously presented the plinth to the school in his memory.

A large and distinguished company of over 1,500 people assembled on the

Photo 1. Statue being transported to the new site, escorted by Gordon Boys. He would have liked that!

Photo 2. Lowering the statue on to the plinth.

Unveiling the Khartoum Statue of General Gordon 1 & 2



By courtesy of The Times

Photo 3. General view before the unveiling, with Lord Rugby making the unveiling speech.

Unveiling the Khartoum Statue of General Gordon 3

school field. The Corps were represented by the Representative Colonel Commandant, Major General Sir Douglas Campbell, KBE, CB, DSO, MC, and by the Engineer-in-Chief, Major General T. H. Foulkes, OBE, and the DPS Major-General G. W. Duke, CBE, DSO. There were RE representatives from Chatham and Aldershot also present. The Sudan Embassy was represented by its Counsellor, Sayed Fakhradin Mohamed, and among many other distinguished guests were Lord Kitchener and Viscountess Broome, and Lieut-General Sir Ronald Scobie, KBE, CB, MC. A very large number of men and women who had served in the Sudan travelled down from all over the kingdom to attend and to see the statue in its new setting.

Lord Rugby was received by the Chairman of the School, Admiral Sir John Edelsten, GCB, GCVO, CBE and the Commandant, Brigadier F. C. Nottingham, DSO, OBE, and after inspecting the Guard of Honour made the unveiling speech. He said: "My chief claim to the honour so graciously accorded me today is that I am a living link with those dramatic events which seventy-five years ago cast a shadow over the land, when in every home people were waiting anxiously for news from Khartoum. I was then 8 years old. I have myself followed Gordon in two appointments—first as Private Secretary to the Viceroy of India and secondly as Governor-General in the Sudan. The news of Gordon's death resulted in a nation wide cult of Gordon —stained glass windows, statues, sermons, pamphlets, books and papers on the soldier saint, a national day of mourning, etc. What would Gordon have thought of it all? He once wrote 'Human glory is composed of nine-tenths twaddle'. But there was one outcome, which could he have known it would have given him great happiness, for the one tribute to his memory which is in complete harmony with all that we know of that eager and restless spirit is this great memorial to his name, The Gordon Boys' School. When this statue is unveiled in this English setting we must determine to make this day a new starting point for strengthening the Gordon Tradition, in the one place where it is still living, and can be passed on from generation to generation.

"One last question may be in the minds of some who are here today. Is there reason to regret that this statue has been moved from its familiar Khartoum setting and brought to his homeland? Personally I do not think so. There it could only speak of a dead past to an uncomprehending multitude. There, night has fallen on the Gordon legend and the Last Post has sounded. But here the Reveille can ring out for the dawn of a new day. The boys of the Gordon School will take a pride in this unique possession, henceforth to be a central feature of their daily life and an inspiration and rallying point for loyalty to their old school."

Lord Rugby then invited Lady Huddleston to unveil the statue, and, accompanied by the head boy of the school, M. L. Green, she went forward and released the lever. The school band then played the very stirring and exhilarating "Fanfare for a Hero", which was specially composed for the occasion by the School Director of Music, Mr E. R. G. Palmer, MBE, ARCM.

Brigadier Nottingham, the Commandant, in thanking Lady Huddleston for unveiling the statue and for her gift of the plinth, said: "This is an historic occasion for this school. We are greatly honoured by the presentation to us of this famous statue, which during the fifty-five years it stood in Khartoum was a source of affection and pleasure to many thousands of people, of all races and colour. It had perhaps a special niche in the hearts

By courtesy of The Time

Photo 4. The statue after unveiling.

Unveiling the Khartoum Statue of General Gordon 4

of those men and women from these islands who spent so much of their lives in helping and guiding the peoples of the Sudan. For to them it stood for so much. It stood for courage of a kind rarely found in human nature; for faith and belief in God in its most devoted form; for determination to succeed under the gravest difficulties; and for faithfulness and duty even unto death. It was their inspiration. It was, indeed, *their* statue.

"It has now been given to this school and erected here, in these grounds, in which we hope is a fitting site and its final resting place. Now it has become part of the living memorial to Gordon which is this, the Gordon School.

"The school was founded by public subscription at the instance of Her Majesty Queen Victoria and the present buildings were begun in 1885, shortly after Gordon's death. Its original objects were to educate and train for a life of usefulness boys of known good character who were in necessitous circumstances. But in the course of years, with changing and improving social conditions, the number of boys precisely filling the conditions of the Charter gradually decreased and the decision was made some years ago that the school would accept *any* boy of good character and reasonable education on payment of fees, scaled to the capacity of the parent to pay. But I would stress that we are still willing to accept any boy of good character for nothing, if need be, should his financial circumstances merit it.

"The school has always had a military tradition. It is extremely proud of this. Although the system has its critics—it has many critics—it has also many more supporters, and we try our hardest to ensure that every boy who comes here is taught the manly virtues and Christian duty of which Gordon was probably the outstanding example of the last century.

"We hope you will look round the school. Any boy will gladly take you round, talk to him and see what he has to say about it all! I can assure you that they have not been primed! You may think that some of the buildings are Victorian and not up to modern requirements. We are conscious of our defects and have made out a programme for improvements, which will be carried out when our resources permit. If you like to help an establishment where the old-fashioned virtues—discipline, loyalty, good manners and behaviour—are not despised, then may I humbly suggest that your example is on his pedestal, before you, forever gazing down on the boys he loved so well."

The inscriptions on the plinth are, on the front panel 'CHARLES GEORGE GORDON'; on the left side 'BORN WOOLWICH 28th JANUARY 1833, KILLED KHARTOUM 26th JANUARY 1885;' on the right side 'THIS STATUE WAS ERECTED AT KHARTOUM IN 1904. REMOVED AND PRESENTED TO THE SCHOOL IN 1959.' On the base of the right side of the plinth, 'THE PLINTH HAS BEEN PRESENTED IN MEMORY OF MAJOR GENERAL SIR HUBERT J. HUDDLESTON, GCMG, GCB, CB, DSO, MC, WHO SERVED THE SUDAN FOR 23 YEARS AND WAS GOVERNOR GENERAL 1940–47.'

After the ceremony was over most of the 1,500 visitors had lunch at the school and went over the buildings afterwards. The Gordon Museum, which is entirely devoted to Gordon relics, attracted much interest, and over 1,000 people visited it during the afternoon.

Royal Indian Engineering College Coopers Hill

THE repatriated statue of yet another famous Engineer Officer, General Sir Alexander Taylor GCB, was unveiled at the Shoreditch Training College on 23 July 1960.

Sir Alexander Taylor was educated at Addiscombe and commissioned into the Bengal Engineers in 1843. He served in the Second Sikh War 1848–49, and he was present at the Siege of Delhi during the Indian Mutiny where his daring reconnaissances over enemy held ground greatly assisted the preparation of the plan for the successful assault on the city. He was later seriously wounded at the siege of Lucknow. After the Mutiny he was, together with other officers of the East India Company Engineers, absorbed into the Corps of Royal Engineers. He continued to serve in India until his retirement as a General in 1878, holding successively the appointments of Chief Engineer the Punjab, Deputy Inspector-General of Military Works and President of the India Defence Committee.

In 1880 he succeeded General Sir George Chesney KCB, CSI, CIE, (late RE originally commissioned into the Bengal Engineers) as the second President of the Royal Indian Engineering College, which had been formed at Coopers Hill (some twenty miles from London) in August 1871 for training civil engineers for service in government public works in India. He held this post for sixteen years and expanded the scope of the College to include training for the Indian Telegraph and Forestry Departments and for civil engineering appointments in Egypt. Some graduates of Coopers Hill obtained nominations for commissions into the Corps of Royal Engineers.

Sir Alexander Taylor died in 1910, aged 87 years, leaving two sons and two daughters. After his death brother Officers of the Royal Engineers, Coopers Hill graduates, friends and relatives subscribed for a statue of him which was erected in 1915 outside the walls of the old city of Delhi, the site of his daring reconnaissances nearly sixty years earlier. Shortly after the British withdrawal from India in 1947 the statue was removed from public view and it was recently recovered from the Government of India at the suggestion of surviving members of the Taylor family and the Coopers Hill Society. The statue was brought home from India free of charge by the P & O Steam Navigation Company and by permission of the London County Council, to whom it had been assigned by deed of gift; it was re-erected at the Shoreditch Training College.

The Unveiling Ceremony on 23 July 1960 was attended by the President of the Coopers Hill Society, Sir Alexander Rouse, CIE, FCH, Members of the Coopers Hill Society and their guests and descendants of General Sir Alexander Taylor. Major-General Sir Douglas Campbell, KBE, CB, DSO, MC, Representative Colonel Commandant RE, and Lady Campbell were amongst the guests of the Society.

The President of the Coopers Hill Society gave a short account of the services of Sir Alexander Taylor as soldier, engineer, administrator and President of the Royal Indian Engineering College and a short history of the statue itself. He then called upon Lieutenant A. W. Taylor, 16th/5th The Queens Royal Lancers, a great grandson of General Sir Alexander Taylor, to unveil the statue.

After the unveiling Major-General Sir Douglas Campbell spoke on the close connexions between Coopers Hill and the engineers trained there and the Corps. Finally Mr. R. McKennion Wood of the London County Council and Chairman of the Governors of the Shoreditch Training College spoke.

The connexions between the Royal Indian Engineering College, Coopers Hill, and the Corps were very close and they still exist to this day. It was largely due to the efforts of General Sir George Chesney KCB, CSI, CIE that the college was first established in 1871 to meet the ever growing need for engineers in India after the Mutiny when the government of the sub-continent passed from the Honorable East India Company to the Crown. The demand for more railways, roads, irrigation schemes and all manner of public works rapidly outgrew the capacity of the Royal Engineers until then the only civil engineers in India. Chesney became the first President of Coopers Hill. He was followed by General Sir Alexander Taylor GCB, President 1880 to 1896, and by Colonel John Pennycuick, CSI, (late RE originally commissioned into the Madras Engineers) who was President 1896 to 1899, and finally by Colonel (afterwards Sir John) Ottley CIE (late RE) who was President from 1899 until, due to the establishment of engineering faculties in the old established Universities, the Royal Indian Engineering College closed in 1903. Sapper Officers also served on the staff of the College including Colonel (later Major-General) W. H. Edgcome 1871–1885, Captain (later Major-General) G. S. Clarke 1871–1880, Lieutenant T. J. W. Prendergast, 1885–1886, Captain J. Stewart 1888–1894 and Lieutenant F. M. Browne 1902–1903. Three Sapper Officers served on the Board of Visitors to the College, namely Lieutenant-General Sir Richard Strachey, GCSI, Colonel Sir Henry Yule, KCSI, CB and Colonel Sir William Bissett KCIE.

There is also a close connexion between the Corps and the Coopers Hill Memorial Prize. In 1921 the Coopers Hill Society, composed of previous graduates of the Royal Indian Engineering College, raised a sum of money to commemorate the name of the College and those past members who fell in the 1914/18 War. The sum was devoted to the endowment of prizes, known as the Coopers Hill Memorial Prize, consisting of a bronze medal, a parchment certificate and a sum of money, to be competed for annually for papers written on appropriate engineering subjects. The prizes are awarded annually to Members of the Institution of Civil Engineers and triennially in rotation to the Institution of Royal Engineers, the Institution of Electrical Engineers and the Imperial Forestry Commission.

In the case of our Institution the prize is awarded for the best paper on a military engineering subject to be selected by the Council of the Institution. The Prize which fell to us in 1959 is being competed for this year, for the conditions see the April 1960 Supplement. Previous prize-winners have been: 1923 Captain (later Major-General) C de L Gaussen, CB, MC; 1926 Captain (later Major-General) H. P. W. Hutson, CB, DSO, OBE, MC; 1929 Captain (later Colonel) C. P. Worsfold, MC; 1932 Captain (later Colonel) C. M. Singer; 1935 Lieutenant (later Brigadier) H. P. Drayson, CBE; 1938 Lieutenant (later Brigadier) J. Innes, CBE; there were no awards during the war years 1941 and 1944; 1947 Major (now Colonel) A. C. Lewis, OBE; 1950 Major (now Lieutenant Colonel) M. L. Crosthwait, MBE; 1953 Major T. W. Tinsley; and 1956 Captain M. J. W. Wright.

Monumental Masonry

By Lieut-Colonel J. H. Frankau, MC, RE

Introduction

The moving and erection of statues and similar memorials has frequently been a task of the Corps. The combination of landscape gardening, architectural design, minor field engineering, trades training and mechanical ingenuity presents a number of problems: this account of how they were solved in unveiling the statue of Lord Kitchener on his pedestal outside Kitchener Barracks may be of assistance in similar circumstances in the future.

The Site

The Corps Committee approved a recommendation that the statue should be sited outside the main entrance to the barracks in Dock Road where the public could see it. The area was not attractive as it consisted of tarmac and rough grass and included an ugly concrete wall, a bus stop, some decrepit buildings and stunted trees. It was owned partly by the WD and partly by Chatham Corporation and was on a steep slope.

The Corporation possessed a pigeon-holed plan to improve the flow of traffic by moving the bus-stop and building an island, but this was a plan in the strict sense and took no account of the slope of the ground. The first step was therefore a contoured survey of the site which was carried out by the Civil Engineer School.

Negotiations

Now followed an exasperating period of negotiations, mainly financial, which affected the scope of the project but which were happily concluded on the day when bulldozers were biting into Corporation land, mainly by the good will of the Borough Surveyor.

A Part II Work Service was approved for a wall and railings round the site, but funds were sufficient only for the provision of materials and all work had to be carried out as trades training. A new home was found within the barracks for the branch of the National Association for the Employment of Regular Sailors, Soldiers and Airmen, which occupied the buildings which had to be taken down. It was agreed that the Corporation would supply and lay the pavements, but that the Army would carry out all other work regardless of who owned the ground.

Design

The final simple but dignified setting is a justification of the theory that a conscious acceptance of the discipline imposed by limitations of site, material and craftsmanship will often produce an artistically satisfying result.

Initially an architect produced a number of sketch designs for the plinth: these were all rejected as being either too pretentious or too difficult for the masons likely to be available. The trade of mason is obsolete in the Corps, but RE Records managed to post in two National Service men who had civilian experience and later they did some excellent work which extended them to the limit of their skill.

Meanwhile the forts forming part of the Thames and Medway defences during the Napoleonic Wars were being searched for suitable stone. Eventually an excellent Portland stone was found very close at hand in Fort Amherst, but the thickness of it varied considerably. This suggested that diminishing courses should be a feature, in order to make use of the best pieces. The Foreman Bricklayer in the RE Park also suggested a pick finished surface, rather than a smooth one, in order to reduce the number of stones which would have to be rejected for surface blemishes. This also had the advantage that the joints could appropriately be fairly wide and the stone could thus be bedded using techniques familiar to bricklayers.

The proportions and height of the plinth were now determined and a model was made. This looked satisfactory except that the top seemed unfinished. It was then noticed that the brick bastions of Fort Amherst were capped with a half-round course of Portland stone and it was decided to use this inverted as a coping. The working drawings were produced at this stage and were approved by Mr Sydney March, the sculptor of the statue. The design provided for channels and a drain-pipe through the concrete filling of the plinth leading to a soak-away and a mass concrete foundation bedded in the virgin chalk which was found some eight feet below the original ground level.

In practice it was found that the coping stones were difficult to bed as they were not uniform in section and one new corner-stone had to be made. An afterthought is a square stone in the centre of the side facing Dock Road cut with the inscription, "KITCHENER 1850–1916". One of the masons who had never before tackled lettering volunteered to copy this from the war memorial in front of the SME Main Building and achieved success at his first attempt.

In order to orient the statue a model was made of the whole site. It was decided that Kitchener should look towards the Sun Pier on the Medway, and it was found that a position exactly on the axis of the nave of St. Mary's church would achieve this and give an impressive three-quarter view of the statue from the crown of the rise when approaching the barracks from the Town Hall.

The architecturally-minded wanted to make a "feature" of the banks bounding the level platform round the plinth; practical men wanted to keep the subsequent lawn-mowing easy. The latter won the day and it was decided to balance the cut and fill exactly within the tarmac roads and to make all slopes as flat as possible with gentle transition curves. Again, the result has been happy, perhaps fortuitously, perhaps a practical design is also a good one.

Construction

The earth work was set as an exercise to a Plant Foreman's course. It was so accurately carried out that the sole movement of earth necessary from outside the site was three loads of top-soil for bedding the turf.

The retaining wall was built by bricklayers courses from the RE Park and the railings were made by blacksmiths under instruction. These were of the same pattern as the existing boundary fence of the barracks; it proved difficult to match the special bricks used, but Medway Towns' soot has now toned down the slight difference.

The bronze plaque giving a short history of the Field-Marshal's life was cast in the SME foundry. It was necessary to cast it in two pieces because of the lengthy inscription.

It proved very simple to lift the statue on to the plinth using a bridging crane. A photograph of this operation appeared in the last issue of the *Journal*.

Turfing the site was started as early as possible with the aim of having a clear month for the grass to become established before the unveiling ceremony and this was achieved in spite of some interference by other work. However, rehearsals of the unveiling mechanism and the ceremonial scarcely gave the grass much chance in the vicinity of the statue. A text book on the care of lawns which was consulted stated that, "Sulphate of Iron . . . has a wonderful effect on the colour of grass, a light dressing turning the yellowest of lawns a bright green in a few days". Accordingly, on the Tuesday six days before the ceremony the lawn was treated with ferrous sulphate and by Thursday it was—black. However, after watering, cutting and rolling it soon recovered and it was, on the Monday, an excellent dark green which it did not again achieve by natural growth for another two months after this had faded.

Unveiling

It was realized very early that the mechanics of unveiling the monument would be difficult as the curtains would have to enclose a box 25 by 25 by 12 ft, if the whole statue and plinth were to be unveiled and as the site is very exposed to the wind. It was considered that it would not be very impressive if the statue alone was unveiled and even this would be an operation liable to hitches because the very realistic sculpture had a large number of points on which the curtains could catch such as the horse's ears, the plumes of the Field Marshal's helmet and the waving tail.

The first set of unveiling gear was of aluminium tubing pivoted at ground level which dropped completely and left no masts or rigging standing. This went through many trials and modifications but it was always difficult to erect and to set the two triggers which controlled the release. The distinguished yachtsman who had the responsibility for approving the device had it demonstrated to him in a force five wind and ruled that the factor of safety in a mechanism which restrained over 1,800 sq ft of canvas was not high enough.

The next attempt to unveil the statue alone by releasing a close-fitting drape by a rip-cord along the crest line had four trials. It was foredoomed to failure because of the irregular outline, as had been foreseen.

It was finally decided that four neatly-guyed masts left standing after the unveiling would be acceptable and the gear shown in the drawing was produced. After all the experience of the Mark I version, this was surprisingly easy to design and make and it worked at every trial including the first.

The four outsize Corps flags which covered the curtains were made from unserviceable RN sheets dyed locally and stiched in the Dockyard.

The equipment was cut down in size and used subsequently for unveiling the smaller statue of General Gordon at the Gordon Boys' School.

Sabotage

It was forecast that the erection of a large ceremonial object would be the target for would-be humorists: nor were we disappointed.

There was a minor incident when the unveiling gear undergoing wind trials was ripped; only a few of those involved were caught.

The next incident was caused by an infantry soldier attending a carpenters course who may have pawned his field marshal's baton to pay for his drink, but in any case wanted to know what it felt like to share a field marshal's saddle. Unfortunately, in trying to climb up he grasped the sword which, since it was already cracked, came away in his hand. This was easily repaired at trifling cost, but unfortunately the occurrence reached the National press who displayed great interest in how the man was to be dealt with. In fact he was charged with wilfully damaging public property and the cost of repair was inflated as far as possible by overheads and departmental expenses. Whether the award was legal is still in some doubt because at the time of the damage it was not clear whether the statue was in fact public property, or property of the Institution of Royal Engineers or still owned by the Sudan Government.

Shortly before the great day some members of Pembroke's wardroom mess were overheard hatching a plot. The guard on the site were therefore told to throw any suspicious characters into the guardroom and to be in no hurry to summon the orderly officer, especially if the suspects claimed to be officers. However, perhaps our precautions were a little too daunting, for nothing came of this.

Nevertheless, the writer of this article, who had not been sleeping too well for several weeks, felt a great deal of relief when no unseemly object was revealed when, at the first pull by the Secretary of State, the curtains fell neatly on to the smooth and green lawn.

The Gurkha Engineers — 1960

By Colonel W. G. F. Jackson, OBE, MC

My only qualification for writing this article is that I have just handed over command of The Gurkha Engineers. I was the first CO who had neither Indian Sapper and Miner experience, nor previous service with Gurkha Troops, so my impressions of the latest offspring of the Corps may be interesting and reasonably unbiased.

When I received my posting order to join the Gurkha Engineers, I had no mixed feelings. It meant escape from the War Office. It also meant command of a long service regular regiment instead of the treadmill of a National Service unit in Germany. The prospect could not have been better. My arrival in the regimental lines in Malaya made me realize that I was joining a unit which wanted to soldier for soldiering's sake. The Quarter Guard, the troop lines, the messes, the Gurkha officers, and the Gurkha soldiers all reflected the best traditions of the old British and Indian regular armies.

After a few days, doubts began to be sewn in my mind; not by anyone or anything within the regiment, but by people outside.

"Oh! You've just arrived to take over command of the Gurkha Sappers, haven't you? I hope you won't mind if I say, a complete waste of damn good infantry. . . ."

"Excellent infantry; why try to make Sappers of them—the Gunners failed."

"Can't see how it can work. Turn chaps, who have always looked down on blacksmiths and so forth as menials, into tradesmen. . . ."

"You'll never train an illiterate hillman into an electrician, plant fitter or any of the sophisticated trades which you Sappers need. . . ."

And so it went on. The Sapper officers in British units doubting the Gurkhas ability to master the trades which we need; and the officers of the Brigade of Gurkhas feeling that we were wasting good infantry.

At first I thought that this was idle cocktail party gossip, but when I met it again only a few days before I handed over command two years later, I felt that it was time to clear up some of the misunderstandings and misrepresentations which are current about The Gurkha Engineers.

In this article I will try to set out their strength and weakness, and to describe something of their work in the last two years. I hope that in the near future this Journal will publish some of the Troop Commanders' detailed accounts of tasks which I will only outline here.

Their Strength

The Gurkha Sapper has all the virtues of the Gurkha Rifleman. He is a soldier by tradition and inclination. Military duty, drill, personal discipline, barrack life and meticulous turnout do not irk him as much as they do the British soldier. Added to this he is strong, adaptable, has tremendous stamina and personal pride, and is prepared to accept lower standards of comfort than his British counterpart. He is far better with his hands than would be expected, and once trained can produce extremely accurate work.

Above all these fine qualities he has one which offsets most of his weaknesses. He has an overwhelming desire to learn and to excel in anything that he does. Visiting a sick bay you usually find the British soldier reading strip cartoons. The Gurkha, on the other hand, will be trying to master his next educational qualification by thumbing through his Gurkhali/English text book. Whereas a British soldier will get bored before he has really learned to handle the "prop" units of a raft, the Gurkha will practise until he has mastered the job.

Nepal is no longer the closed country that it used to be. The Gurkhas realize how much must be done to raise the standards of life in the Hills. They are keen to learn so that they can be more useful when they go back to their villages on pension, and, probably more important, so that they can earn more money. The younger Queens Gurkha Officers and senior NCOs, who have been brought up in the Sapper tradition, will undoubtedly take back to Nepal valuable organizing and engineering ability, which they show every intention of using. With this urge to learn, and with the Gurkhas desire to excel, there is very little that he will not be able to master—*in time*.

Their Weaknesses

"In time" is the key to the main Gurkha weakness. Nepal is a "Rip van Winkle" country which is just waking up. There is no real education, as we know it, in the Hills. You cannot expect a hill boy, who joins the Brigade at the age of eighteen with only his native common sense behind him, to compete with a British soldier who has been schooled until he is fifteen. On the other hand, those Gurkhas, who have by chance received some education, can often beat the British soldier at his own trade.

The Gurkha is just as good with his hands as the average British soldier, especially at trades which are akin to the rural skills used by countrymen the world over. Bricklayers, carpenters, welders and similar trades, which require manual skill, are quickly mastered by the Gurkhas; but any trade requiring theoretical work, calculation or mechanical background, tends to be beyond him because of his poor educational upbringing. Fitters, electricians, surveyors and draughtsmen are all difficult Gurkha trades.

Lack of education produces other important weaknesses. The Gurkha cannot, as yet, plan ahead. Forward planning remains one of the important tasks of the British officers. Anything more than about three days in advance is beyond the mental range of many Gurkha officers and senior NCOs. Moreover, it takes far longer for Gurkha Sappers to learn a new operation. They cannot be thrown at an unexpected task without very thorough training and rehearsal; but when they have mastered the particular task they excel at it. There is often a period in training for a new task, when the British instructors feel that the Gurkha field troop concerned will never learn the job. The NCOs and men look vague; their eyes glaze; and they say that they understand, but it is soon apparent that they do not. Then gradually they begin to realize what they are about and why. From then onwards the men speed up, their eyes brighten, they look happy and the work goes forward smoothly and efficiently; but it will have taken the Gurkha field troop twice as long as a British troop to grasp the essentials of the task.

To sum up, my impression is that the Gurkha Sapper will master any field engineer task provided he is given adequate training. It may take him twice as long as the British equivalent to master it; but he will do it as well, if not better, once he understands what he is doing.

Background

Before describing the work of the Gurkha Engineers over the last two years, it is essential to know something of their background. The first squadron, 67 Gurkha Field Squadron, was raised twelve years ago in Kluang, and was followed shortly afterwards by 68 Gurkha Field Squadron. No attempt was made to convert an existing Gurkha Rifle Regiment into Sappers as was done by the Gunners. The squadrons were formed from a small cadre of Queen's Gurkha Officers and NCOs posted from all units of the Brigade. The majority of the men came from the re-enlistment of those who had not joined the British Gurkha Rifle Regiments when the partition of India occurred. Every man had some war service and was keen to form a new Corps instead of looking over his shoulder to the traditions of a converted Rifle Regiment.

No sooner were the squadrons formed than the Korean War started, and they were shipped to Hong Kong, not as Sappers, but as infantry with normal battalion supporting weapons. Sapper training was only intermittent in those early days, and it was not until they returned to Malaya that the squadrons began to gain Sapper experience. Anti-terrorist operations were at their height, and squadrons gained valuable and realistic training in road, track and airstrip construction all over Malaya; culminating in the major road construction project in the Kedah described by Colonel Blakeway, who at the time was Chief Engineer Federation Army, in the March 1960 issue of this *Journal*.

The recruiting of the Gurkha Sapper is no different to the Rifleman. We have a slightly higher minimum weight and height standard, but otherwise we receive our recruits in exactly the same way as the rifle regiments. From the Recruiting Depots in Nepal they are sent to the Brigade of Gurkhas' Depot in Malaya, where they receive eight months' basic training as riflemen alongside the rifle regiment recruits. From there they go to the Engineer Training Centre at Kluang for a further five months' field engineer training. Most of them reach the regiment as FE IIIs, after, it should be noted, a total of thirteen months' recruit training, compared with sixteen *weeks*' training given to a British Sapper.

The Gurkha soldier, Rifleman or Sapper, serves for an average of fifteen years, because at fifteen years he qualifies for a pension. Those who become Queen's Gurkha officers can serve on up to thirty-two years in the case of Gurkha Majors. Soldiers are signed on at 4, 7, 10, 12 and 15 years. If at any time up to fifteen years a man's discipline or work declines, the CO can recommend his discharge. Since the aim of every man is to obtain his pension at fifteen years, discipline and standards of work are easier to maintain than in a British unit.

The Rifle Regiments are predominantly recruited from Western Nepal (2nd and 6th Gurkha Rifles) or Eastern Nepal (7th and 10th Gurkha Rifles), but Gurkha Engineers are recruited from both West and East, and the men are deliberately mixed right down to section level.

After a Sapper has served two years he can be selected for basic trade training at the Engineer Training Centre. Later he can be sent back for upgrading, or, if he is outstanding, he may be sent to Chatham. The biggest problem, in trade training, is language. Until such time as English is more universally spoken by the Gurkha soldier, the language barrier will place him at a disadvantage. Great strides are being made in teaching English, particularly to the Boys' Company at the Brigade Depot. These boys, like British Army Apprentices, are educated at the Brigade Depot with the aim of providing all units of the Brigade with young soldiers who can learn the more difficult trades.

Expansion

In May 58 the regiment was still only two field squadrons strong, supported by the 74 Field Park Squadron and a LAD which were entirely British. Plans were already laid for expansion to a full regiment of three Gurkha field squadrons and a Gurkha Field Park. The first new squadron to form was 70 Gurkha Field Park Squadron which was to replace the 74 Field Park Squadron. As 74 Squadron were to disband, Gurkhas were posted in to replace individual British ORs when they were due for release. The gradual conversion was accomplished successfully thanks to the wholehearted co-operation of all ranks of 74 Field Park Squadron, who had the unenviable task of breaking up their own squadron in which they were rightly proud for the benefit of the Gurkha Engineers. On 1 Apr 60, 74 Field Park Squadron's flag was lowered and 70 Gurkha Field Park Squadron's was run up in its place. Next year the third field squadron will start forming, and by 1962 the Gurkha Engineer establishment should be complete. In each field squadron there will be only two British NCOs, the SQMS and MT Sgt; but in the Field Park about ten skilled British tradesmen will be kept for some years to come.

1958–1960

The great difference between engineer training in Europe and the Far East is realism. In Germany many hundreds of tons of bridging equipment are thrown into the Weser each year only to be pulled out again. Dozers trundle on transporters across the North German Plain in the wake of armoured and infantry brigade groups, but rarely get off to do a proper job of work. They are presented to the umpires who decide how long the job would have taken, and then they move off back to barracks. Units stay in the field for perhaps ten days. In the Far East the engineer work is real. When bridges are built they stay. When dozers arrive and crawl off their low loaders they work until the workshop detachment can keep them going no longer; only then do they return to a transporter for backloading to the base workshops. Field Squadrons when they leave the base camp rarely return in under four to five months, and often much longer. They must live in the jungle in as much comfort as they can devise, and there is no return until the job is completed.

Working for six or seven years under these conditions the Gurkha Engineers, together with British and Federation Engineer units in Malaya, have become experts in how to live and to work for long periods away from civilization. They have become highly skilled at jungle road and airstrip construction— not just jungle tracks, but major roads built to open up and develop large areas of country. In the Gurkha Engineers the design of the roads and the initial trace are the work of the British officers, but Gurkha officers take over the actual work of cutting of the access tracks using Size I and II Dozers for the jungle clearance, explosive to remove rock outcrops and large trees, and cutting the jungle timber for the temporary bridges and culverts. For the actual construction of the road, British officers do the forward planning and distribution of plant and resources, but the Gurkha officers are again in charge of the day to day work in each sector.

Availability of plant is the limiting factor in all engineer work in undeveloped countries. Officers arriving from Europe always under-estimate the amount required. They cannot bring themselves to think big enough. In a Gurkha Field Squadron there are many more plant operators than there are G1098 machines, because they are needed to man the Pool plant allotted to a project by the Chief Engineer. The strength of the Gurkha Engineers *vis-à-vis* their counterparts in Europe is that they have more experience in handling large quantities of earth moving machinery. Their training has not been carried out in the well turned earth of a plant training area, but rather in the jungles of Malaya and North Borneo. Moreover, the supporting REME workshops detachments and the RAOC spares organization have also been thoroughly run in to meet Sappers needs.

In 1958, while 67 Field Squadron worked on the Kedah Road Project, 68 Field Squadron was building tracks and airstrips in South Johore which indirectly brought about the surrender of the last organized terrorist units in South Malaya. After a short retraining period in the autumn of 1958, the squadrons changed round, 68 Squadron taking over in Kedah while 67 Squadron prepared for a new project in North Borneo.

The North Borneo Training Area Project will be described in detail later by one of the officers concerned. Briefly the project consisted of gaining access to and building training facilities in the large area of rolling downland which stretches from Kota Belud up to the slopes of Mount Kinabalu. This magnificent training area had one major disadvantage. Units could not reach it by normal means. There was a narrow one-way road from the port of Jesselton, sixty miles south, which was considered unsafe for continuous military traffic. It ran for twenty-three miles through steep hill country with bends and gradients too difficult for large military vehicles. The only other way into the area was from the sea up the Abai River, but here again the route was not straightforward. The bar at the mouth of the Abai prevented sea-going military craft from entering the river. To use this river L of C, LSTs had to anchor in Usukan Bay to the south; equipment and stores had to be landed on the beaches and moved over the isthmus between the bay and and river before they could be rafted up the river to Kota Belud.

The eventual plan, adopted and carried out, was to land all heavy equipment in Usukan Bay and to use the Jesselton road for light vehicles only. Ultimately the Jesselton road would be widened to Class 30, but tanks and heavy guns would continue to be brought in up the Abai River.

The only raft available for landing plant from the LST and for rafting it up the river was the old Class 55/65 raft. The Gurkhas had not been trained in its use; and having seen so many 55/65 exercises go wrong on the Weser, I doubted the Gurkhas' ability to handle it in the sea alongside an LST or up the twisting tidal Abai with its mud banks and half submerged trees washed down during floods. There was, however, nothing else available. The field troop detailed for the job was sent down to Singapore harbour to train under a QMSI from the Engineer Training Centre. Nothing went right at first, but then things began to fall into place and by the end of the period, 67 Field Squadron had at their disposal an efficient 55/65 raft crew. Under their Gurkha officer they worked from ship to shore and up the river for four months. They weathered several nasty storms in Usukan Bay, took the raft out to sea and round into the river every time an LST called, and proved themselves extremely competent.

After reaching Kota Belud, there are two further obstacles to be crossed before the Training Area is reached—the Tempasuk River from 400 to 500 ft wide, and the narrower but marshier Wariu River. The former has been spanned by constructing an underwater gabion causeway which has since been named after Lady Mountbatten who crossed it in a Landrover just after it had been completed the day before she died. A paper describing this novel crossing will appear in due course. A LAFB raft is also available on the Tempasuk to carry traffic when the river is in flood and when the water over the causeway is too deep for fording vehicles. The Wariu has been bridged by Class 70 Bailey with built up approaches made by tipping quantities of river gravel into the soft paddy fields either side.

In the training area itself camps for a brigade group have been constructed, and it is intended to build a Beverley airstrip as soon as the RAF designs are agreed. Building tracks and roads through the area to allow guns to deploy, cleaning up the mess made by tanks, expanding the tracks to reach the combined operations training beaches farther north, and innumerable other development tasks will keep Sappers employed in the area for many years. The scope is infinite—but that is another story.

67 Gurkha Field Squadron carried out the initial landing in May 1959 and were relieved by 68 Field Squadron in November. 11 Independent Field Squadron of the Commonwealth Brigade are relieving 68 Squadron in May

1960. We hope then to be free from major projects for nine months so that the Gurkha Engineers can catch up on "Meccano" engineering of the BAOR pattern. I handed over to my successor plans for the bridging gallop from Mersing to Kuantan by each squadron in turn, but not quite in the German style. Each squadron would have only fourteen Landrovers (the Far East light scales; equipment is carried in the Landrovers and the men march). There is no proper road. There are five tidal rivers to cross. Supply has to be by air because once the squadron is across a river and has picked up its rafts, there is no means of supplying it by road. By the time these gallops are over, the Gurkha Engineers should be able to take on any other field squadron on level terms.

Conclusion

I have often been asked which I would rather command—a Gurkha or a British Engineer Regiment. The answer which I would give is "either". They both have their strengths and weaknesses. The Gurkha Engineers still need time in which to gain more experience, but when they have gained it, they will be hard to beat.

The Durand Medal

The Durand Medal is one of the oldest established Institution Prizes. It was instituted as a Memorial to Major-General Sir Henry Durand KCSI, CB who died as a result of an accident on 1 January 1871 whilst holding the appointment of Lieut-Governor of the Punjab.

Henry Durand was educated at Addiscombe and commissioned into the Bengal Engineers of the Honourable East India Company's Army in 1828 and, as was the custom in those days, he received his Young Officer training at the Royal Engineers Establishment, Chatham. He so greatly impressed the Commandant, Major-General Sir Charles Pasley, as to cause him to write that Durand was one of the most distinguished young Engineers whom he had ever had serving under him, both in respect of diligence, ability and conduct.

On posting to India he served with Napier (late Field-Marshal Lord Napier of Magdala), who had been commissioned into the Bengal Engineers in 1828, in the North West Provinces where he was employed on irrigation schemes and where he began to take a deep interest in the economic conditions of the country. It was not long before his ability and political insight brought him the appointment of Secretary to the Agra Board of Revenue. He was recalled to military service on the outbreak of the First Afghan War 1839–1842, and with Captain Peat and Lieutenant McLeod, also of the Bengal Engineers, he blew the gates of the Fortress of Ghanzi at Kabul on 23 July 1839. In this task Durand performed his part in the demolition with great gallantry, coolness and self-possession; although fully exposed to aimed enemy fire he applied the match to the fuse, which he had some difficulty in lighting, and remained to ensure that the fuse was burning properly before returning to cover.

At the conclusion of the Afghan War he was made ADC, and later Private Secretary, to the Viceroy. In 1848 he became Commissioner of Tennasserim but was once again recalled for military service during the Second Sikh War 1848–49 and he took part in the battles of Chilianwala, 13 January 1849, and Gujarat on 21 February 1849. After the annexation of the Punjab, Durand was sent as Political Agent to the Native State of Scindia at Gwalior where he guided the delicate complications of Mahratta politics with consummate skill. In 1854 he was appointed Political Agent at Indore and he was serving there when the Bengal Army mutinied at Meerut on 10 May 1857. Durand's firmness, however, prevented the Ruler of Indore from joining forces with the mutineers. Nevertheless a withdrawal of the few native troops who had remained loyal and of the European families who had not been massacred had to be made to Mhow and Mrs. Durand, who throughout the arduous march had done much to sustain the spirits of the families, died there as a result of fatigue and hardship. Durand collected together a force of 1,400 men and by the defeat of the mutineers at Dhar and Mandlesur prevented a southward spread of the Mutiny.

After the suppression of the Mutiny in 1859 Durand was sent home to become a Member of the Council of the Secretary of State dealing with the transfer of the Government of India from the Honourable East India Company to the Crown and the numerous changes, reforms and amalgamations consequent on that important conveyance of responsibility. His statesmanlike grasp of the complicated situation was recognized by Lord Canning who appointed him Foreign Secretary at Calcutta. In 1865 he was made Military Member of the Viceroy's Council which appointment he held for five years. On 1 June 1870 he was sworn in as Lieut.-Governor of the Punjab, a post second only in importance to that of the Viceroy himself. The Punjab was India's barrier against Central Asia. The people were warlike, brave, hardy and self-reliant requiring a firm and vigilant ruler. Unfortunately Durand was not destined to live long enough to justify his appointment. On 31 December 1870, whilst on a tour of inspection through the Province, the howdah of the elephant on which he was riding struck the gateway of the city of Tonk. Durand fell heavily to the ground. He died the following day without recovering consciousness. By his death India lost one of her ablest men and wisest administrators.

After his death money was raised by Royal Engineer Officers for a Durand Trust Fund. In 1879 the Institute of Royal Engineers (as it was then called) became the trustee of the Fund and it was decided that the Memorial to Major-General Sir Henry Durand should consist of a Bronze Medal to be given annually in rotation to the Indian Officer, NCO or Sapper of the three Indian Corps of Sappers and Miners who, in the opinion of the Commandant of his respective Corps had most "distinguished himself as a Soldier and a Sapper by good and efficient service." The obverse side of the Medal bears the General's head and on the reverse is depicted his gallant exploit at the blowing of the gates of the Fortress of Ghanzi in 1839.

The first Medal was presented in 1882 and a complete record of recipients since then is maintained in the Royal Engineers' Library at Chatham. As a result of the handing over of power in India in August 1947 to the new Governments of India and Pakistan it was decided that the Durand Medal would be awarded on a basis of two years to the Indian Engineers and one year to the Corps of Engineers, Pakistan. In 1958 Pakistan declined further awards and it was decided to make the award to the Gurkha Engineers, the Major-General Brigade of Gurkhas to nominate the Gurkha Engineer candidate for the award.

It is of interest that the award of the Durand Medal, made to the Indian Engineers in 1959, was for an act of gallantry, and that the award to the Gurkha Engineers was made for the first time this year.

On 6 November 1959 at a Ceremonial Parade, held during the Bombay Group celebrations, Major-General R. E. Aserappa, Engineer-in-Chief India, presented the Durand Medal to Lance Naik Shri Krishan of 7 Field Company. The citation read:

"L/Nk Shri Krishan had shown conspicuous bravery and outstanding courage when in order to save a suspension bridge from being washed away during high floods in Assam, he crawled along a steel wire rope and placed a small demolition charge on the wind guys. The cutting of the wind guys saved the bridge and thereby communications were maintained."

The Durand Medal was presented by General Sir Richard Hull, Commander-in-Chief Far East Land Forces, on 30 August 1960 to Captain Kalusing Libmu, the Gurkha Engineers. The citation read:

"Gurkha Captain Kalusing Limbu has distinguished himself during the past three years as a Soldier and as a Sapper by good and efficient service.

During this period, which has seen great development of the Gurkha Engineers as military engineers, Gurkha Captain Kalusing has on several occasions planned, organized, commanded and controlled an engineer task with outstanding success, showing that he has the qualities of leadership and the technical background which the newly-formed Corps of Gurkha Engineers is looking for in this formative period.

By his example he has helped considerably to raise the standards of military engineering efficiency amongst all Gurkha ranks.

In the past three years, the last years of the Emergency in Malaya, Gurkha Captain Kalusing has taken part in several engineer operations in support of the Security Forces; he has been responsible for directing engineer tasks as diverse as the construction of jungle roads, reinforced concrete bridges and camps, for the control of engineer plant and for the construction and operation of a ferry.

As a soldier, Gurkha Captain Kalusing has always lived up to the highest standards expected of a Queen's Gurkha Officer and has been an inspiration to those serving under him."

Memoirs

BRIGADIER SIR CHARLES FREDERICK CARSON, Kt, CBE, MC

CHARLES FREDERICK CARSON was born at Kingston, Ontario on 10 February 1886, the son of Robert James Carson of Romily House, Kingston. He was educated at Kingston Collegiate Institution, Queen's University and at the Canadian Royal Military College where he won the Sword of Honour and the Governor General's Gold Medal.

He was commissioned into the Corps of Royal Engineers on 26 June 1908 and after his Young Officer training at Chatham he was attached for a year to the London and South Western Railway thus beginning a long and distinguished connexion with railways. Canadians have often achieved fame as railway engineers outside their own country, and this is not surprising since they came from a vast land where the railroad has played so vital a part in national development. Two names that will long be remembered are the French Canadian Sapper Colonel Sir Percy Girouard and his brother Canadian Sapper Brigadier Sir Frederick Carson who were both knighted for their outstanding work on railways in distant lands in peace and war.

On posting to India in 1911 Carson served with 9 Railway Company Sappers and Miners at Sialkote and as an Assistant Engineer with the North Western Railway at Lahore. Twenty three years later he was to become Managing Director of that Railway, the largest railway system in India.

On the outbreak of the First World War Carson, then a Captain, reverted to military service in France. In July 1915 he was made a Temporary Major. He commanded 130 Field Company in 25 Division from January 1916 to May of that year when he was transferred to command 78 Field Company in 17 Division. In June 1917 he became Staff Officer to the Chief Engineer XVII Corps and in April 1918 he was posted to command 3 Field Squadron of 3 Cavalry Division. He won the Military Cross and a bar to it and he was twice mentioned in dispatches.

In April 1919 Carson returned to India and the North Western Railway in which he held a wide variety of appointments on the constructional and operating side before being appointed General Manager in October 1938. He held that appointment until his retirement at the age of 54 in 1940 when he returned to England.

During the fateful winter of 1940/41 the whole railway and dock systems in and around London were being threatened with complete disruption by the *Blitz*. Carson volunteered his services and he was made Chief Engineer of a Special Force, consisting of twelve General Construction Companies and five Dock Maintenance Companies, entrusted with the task of aiding the overwhelmed civilian organizations in repairing bomb damage and getting the trains and docks back into operation again. Such men as Sir Frederick Carson were of the sort who could be entrusted with these difficult assignments in time of crisis and could be counted upon to see them through, and in this most prodigious and arduous task he did not fail.

The Battle of Britain having been won, Carson was appointed Director of Transportation in Iraq which post he held until his retirement in 1943. For his services in the Middle East he was awarded the CBE.

On retirement from the Service he returned to live in Montreal. He was appointed Executive Vice-President of the Montreal Locomotive Works and, in addition to his general management duties, he was in charge of the tank arsenal, which post he held until 1951.

He took great interest in the Herbert Reddy Memorial Hospital becoming its Honorary President in 1952, and he undertook the chairmanship of an appeal for funds. He also served as a Warden of the Church of Saint James the Apostle and was on the Advisory Committee of the Church at the time of his death on 3 May of this year aged 76.

Always interested in sports and games Carson played ice hockey and football for the Royal Military College Kingston and for the Queen's University, and when serving in the Corps he was a keen Rugger player and fond of sailing.

He was married first in 1913 to Dorothy Brownfield of Kingston who died in 1944. They had three sons and a daughter who survive him: Colonel R. J. Carson CD, Commandant Royal Canadian School of Military Engineering, his twin brother Major F. S. Carson MC, who served in the Corps from 1934 until 1948, Major P. J. Carson who also served in the Corps from 1945 until January of this year and Patricia Dorothy Carson who in 1951 married J. B. Claxton son of the late Brook Claxton, one time Canadian Minister of Defence. In 1949 he married a second time Nadine Kerr, widow of E. F. Osler of Toronto whose son James Osler also served in the Corps and was killed at Dunkirk.

BRIGADIER S. G. HUDSON, CBE

STANLEY GREY HUDSON, or "John" Hudson as he was better known to the Corps, was born on 21 March 1902, the son of Dr Frank Horace Hudson. He was educated at Epsom College and passed into RMA Woolwich in 1919. He received a commission in the Royal Engineers in 1921.

In 1924, shortly after finishing his SME courses, he was posted to India and joined the Royal Bombay Sappers and Miners with whom he served for the next six years, proving himself a first-rate regimental officer. After a period with the Military Engineer Service in India and Burma he returned to the UK in 1934.

In January 1935 he took over command of 19 Field Survey Company RE, and so began his connexion with the Survey Branch of the Corps which was to continue for the rest of his life.

In 1938 he was appointed to the Geographical Section of the General Staff, then a branch of the Directorate of Military Operations and Intelligence and known as M I 4. There his sound judgement and general imperturbability were to prove of inestimable value in the hectic days when the maps needed

Brigadier SG Hudson CBE

by the British Expeditionary Force were under preparation, and subsequently during the confusion caused by the loss of nearly all the existing field survey equipment at Dunkirk. In 1940 the branch was moved lock, stock and barrel from Whitehall to Cheltenham and the fact that its activities continued with little or no interruption can be attributed in no small measure to Hudson's efforts.

From 1941 to 1943, as Assistant Director of Survey First Army, he was engaged on planning the mapping requirements for the assault on North-West Africa. This operation, the most ambitious of its kind up to that time, called for the most elaborate security precautions, particularly where the vast quantity of operational maps were concerned. It is very much to the credit of all those engaged on the preparation of these maps, and in particular of Hudson himself, that no leak occurred.

In May 1943 he became AD Survey Eighth Army and was with the planning staff in Cairo, accompanying them to Malta in June 1943. From there the survey detachment followed the Advanced Army HQ to Sicily, and in April 1944 Hudson became DD Survey Eighth Army in Italy, where he remained until the end of hostilities when he received the following message from the Army Commander:—

"I want to thank and congratulate all ranks of the Survey Service for the splendid work you have done throughout the whole Italian Campaign, especially during the last great battle, and since the end of hostilities when you have been as busy as ever. Your success in providing whatever maps have been required has only been achieved as the result of the greatest forethought, energy and hard work on the part of all concerned. During the planning stages and during the mobile phases, the pressure has been intense, and the strain on your organization has been great. But with the best possible will you have surmounted every difficulty and you have never failed to meet the most far reaching demands, often at the shortest notice.

Well done indeed; you have played an essential part in the final defeat of the enemy."

For these services he was mentioned in despatches in September 1943, March 1944 and November 1945, and was awarded a CBE in September 1945.

After the war he filled various survey appointments in the UK until, in 1952, he was appointed Director of Survey at GHQ, MELF. Having spent only a year in the Middle East he was brought back to the Ordnance Survey as Director of Map Publication, an appointment he held until his retirement in 1954.

On his retirement he was selected to fill a civilian appointment as Head of Establishment of No 1 Survey Production Centre. This Centre, which expanded during the war from the small drawing and printing organization previously housed in the main building in Whitehall, had become the main source of map compilation, drawing and printing for the War Office and Air Ministry. As ever, Hudson's selfless devotion to duty, sympathy for his subordinates, and utter refusal to be thrown off his balance by any of the demands made on his organization stood him in good stead, and by his sudden death in June of this year the Corps as a whole, and the Survey Branch in particular, has suffered a very great loss.

He married in 1939 Constance Mary Bouchier and had one son and two daughters all of whom survive him.

L.F.deV.C.

BRIGADIER R. C. N. JENNEY, CBE

Reginald Charles Napier Jenney, always Rex to his many friends, died very suddenly on 1 June 1960. He was the second son of Colonel G. W. Jenney, IMS, born at Quetta on 24 January 1906. Educated at Dover College, he passed out fourth from the Shop and was commissioned into the Corps on 3 February 1926.

After the usual YO courses and two years at Sidney Sussex College, Cambridge, he returned to India in April 1929 to join the Bombay Sappers and Miners. After a brief spell as Assistant Adjutant at Kirkee, he moved to the Frontier where he was employed on the Wana Road Project and later as Assistant Garrison Engineer at Manzai.

On 2 January 1930, he joined the Survey of India to start the career he was to follow for the rest of his service. The next five years, after training at Dehra Dun, took him to Nagpur, Waltair, Murree, Bangalore and Quetta and brought him experience of many parts of India with a spell of active service in the Mohmand Operations of 1935. From 1935 to 1939 he specialized in the rapidly developing techniques of mapping from air photographs, including a short course with the Swiss firm of Henri Wild of Heerbrugg.

In August 1940 he mobilized the first (No 1) Indian Field Survey Company, which he commanded until December 1942. His Company was the first Indian Survey Company to go overseas, and carried out extensive mapping projects in Iraq and Persia, in addition to providing the main map production resources for PAIFORCE.

In December 1942 he was recalled to India where he became responsible for the technical planning and production of at first part, and later the entire map drawing and printing output of the Survey of India. In the peak year of 1944–45 this output reached 22 million copies of maps averaging five colours.

At the end of the War, in April 1946, he became Deputy Director and, five months later, Director of the Frontier Circle of the Survey of India. At this time he was responsible not only for all surveys in Northern India but also for the intensive post-war training of all new officers and field surveyors of the Department at Abbotabad, until riots and other troubles forced the transfer of training to Dehra Dun.

On the partition of India on 15 August 1947, he was selected as the first Director-General (T/Colonel) of the newly formed Survey of Pakistan. It was very largely due to his personal strength of character and untiring efforts that by the time he handed over early in 1950, the Survey of Pakistan was firmly established and hard at work with a staff of about 2,000, properly equipped Drawing Offices, Map Reproduction Offices and a Training Unit.

In May 1950, he returned at long last to England, to join the Ordnance Survey as Assistant Director, Field. A year later he moved to the Directorate of Military Survey, War Office and Air Ministry as Assistant Director in charge of map production, map records and distribution. On 1 May 1952, on promotion to Colonel, he became Deputy Director, with special responsibilities for matters affecting the Air Ministry. On 23 May 1955 he returned to the Ordnance Survey as Deputy Director, Field Division, responsible for the planning and execution of field and air surveys. On 6 May 1957 he was promoted to Brigadier and became Director, Field Surveys, in the Ordnance Survey, the post he held until his retirement on 26 October 1959. He was created CBE in 1960.

Brigadier RCN Jenney CBE

On retirement, he took up the post of Retired Officer (Grade I) in charge of Research and Development in the Directorate of Military Survey, War Office and Air Ministry, for which his unusually wide experience of all branches of survey, and air survey in particular, made him exceptionally well qualified.

Rex Jenney was gifted with a quick brain, a very good eye for a ball and unbounded energy. Throughout his life he was a keen cricketer, tennis and hockey player, but he was prepared to tackle any form of sport available with such energy and enthusiasm that he rapidly became a performer above average, although his chosen career rarely permitted him to reach the limelight. He did, however, get cricket and hockey blues at the Shop and gain an Army Cap for Hockey in 1928. After his return to England in 1950 he devoted the same unflagging energy and enthusiasm to the maintenance of his house and garden. Roses were his favourite flowers and for quality and size his blooms reached standards envied by his friends. Rex was always cheerful, but the quality which endeared him most to his friends was his moral honesty. He never did a dishonest or mean act and his opinions, frankly given, were his honest beliefs unbiased by any ulterior motives.

In December 1932, he married Violet Rochfort, eldest daughter of George Flowers, ICS, Commissioner of Jhansi. They had five children, four boys and one girl.

R.A.G.

COLONEL R. F. A. BUTTERWORTH, CMG, DSO*

Reginald Francis Amherst Butterworth, who died on 14 June 1960, aged 84 was born on 4 January 1876, the son of R. W. Butterworth, Esq of Rockwell near Bristol. He was educated at Eton and the Royal Military Academy, Woolwich and commissioned into the Corps on 6 August 1895.

After completing his Young Officer training at Chatham he went on a Submarine Mining Course at Portsmouth in 1897 and was then posted to 5 (Fortress) Company at Portsmouth and later to 21 (Submarine Mining) Company at Landguard Fort. From 1899 to 1902 he was a Company Officer of the Singapore (Submarine Mining) Company. On returning home he was posted to 35 (Submarine Mining) Company at Pembroke Dock, and he stayed with this unit until 1905 when the Royal Navy took over all work in connexion with submarine mining from the Royal Engineers. In 1904 he had been promoted Captain and for the last year of his service with 35 (Submarine Mining) Company he commanded the unit. Shortly after his promotion he married Margaret Elaine, third daughter of J. W. Morison of Portclew, Pembroke.

Besides being an expert "submarine miner", Butterworth's interests lay also in aeronautics and he was among the early balloonists; his next two postings, namely as Adjutant 2nd Yorkshire RE (Volunteers), formerly The Leeds Rifles, and as Adjutant Northern Command Telegraph Companies RE, allowed him the time to practise this novel form of transport and to study the finer points of navigating lighter-than-air craft. He was selected as

Colonel RFA Butterworth CMG DSO

navigator for Griffiths Brewer's balloon Vivienne in the International Balloon Race, sponsored by the Royal Aero Club, on 22 May 1909 from Hurlingham to Billericay. His account of this eventful race was published in last September's *RE Journal.*

His next foreign service tour took him to Malta where he stayed for four years, part of which was spent in command of 28 (Fortress) Company and part as Staff Officer to the Chief Engineer and Division Officer WD Lands. In October 1914 he was promoted Major.

A period of training followed his return to the United Kingdom after the outbreak of war in August 1914. In July 1915 he was posted to command 82 Field Company in France, and in October 1916 he was promoted to become CRE 16 Division which appointment he held until July 1918. During this eventful period his Division was engaged almost continuously in bitter trench warfare in the battles of Messines, Picklem Ridge, Langemarck, Menin Road, Broodseinde and as part of the British Fifth Army it had to withstand the German offensive in the spring of 1918 when all three of Butterworth's Field Companies fought as infantry in many desperate delaying actions. For his services in these operations he was made a Brevet Lieut-Colonel, awarded the CMG and DSO and bar and five times mentioned in despatches.

From the end of 1918 until mid 1920 Butterworth was employed as Assistant Director Engineer Stores at Headquarters Rhine Army, and in July 1920 he was posted as Assistant Director of Works, Mesopotamia. After a year in that appointment he became Deputy Director of Works, Tigris Circle Baghdad. He was mentioned in despatches for his services during the Iraq Operations of 1920.

A short period at the Senior Officers' School was followed by another three year overseas posting as CRE Hong Kong, after which he spent just over a year as CRE Salisbury Plain East and 3 Division.

On promotion to full Colonel in July 1926 Butterworth was posted to the War Office for three years where he held several appointments in the DFW Directorate.

In April 1930 he assumed the appointment of Chief Engineer Malaya which he held for eighteen months; for six months of this period he commanded the Troops in Malaya with the rank of Brigadier. Whilst in that appointment, and at the age of 55 years, he studied for and passed the Interpretership examination in Malay to set an example and to encourage the young officers to do likewise.

On returning home in October 1931 he commanded 28 Air Defence Brigade (TA) Eastern Command until he retired on 4 January 1933 after thirty eight years' service, in which he had been a submarine miner, aeronaut, telegraphist, field company commander, a most gallant fighting divisional CRE, a stores officer, a works officer, Chief Engineer and formation Commander.

Shortly after retirement Butterworth went to live at Fareham. He was made Director of the British Legion Poppy Day Factory in 1938, and when war came again he served in the Royal Observer Corps from 1939 to 1941, after which he was employed under the Ministry of Information until 1945.

After the war Colonel Butterworth, although by no means young, took an active interest in local affairs and continued to do so until a few weeks before his death. He was the Honorary Treasurer of the Fareham Branch of the

Hampshire Association for the Blind and he belonged to the Friends of the Fareham Hospitals, being particularly interested in Saint Christopher's Hospital. He was an enthusiastic follower of cricket and an honorary life member of the Hill Head Sailing Club, having been Club Secretary for many years.

Colonel and Mrs Butterworth celebrated their Golden Wedding in 1956. Mrs Butterworth died two years ago. His only son died of wounds received when commanding a battalion of the Gloucestershire Regiment in 1944. He leaves a daughter, Mrs Francis Buckle, wife of Major-General D. H. V. Buckle, CB CBE, Colonel Commandant RASC, to whom our sympathies are extended.

Correspondence

MEMOIRS

Major-General B. C. Davey and Brigadier D. Forster

Below is an extract of a letter from Major-General Sir Stephen Weir, Chief of the General Staff New Zealand Army to Major-General R. W. Ewbank, on the deaths of Brigadier David Forster, CB, CMG, DSO and Major-General Basil C. Davey, CB, CBE:—

"I was very distressed to read in the *Journal of the Royal Engineers* of March, 1960, of the death of your father-in-law[1], and I write to extend to Joyce and to yourself my very deepest sympathy. As you know, I met your father-in-law on several occasions whilst in London, mostly with you; but he did come once when he was visiting New Zealand to make a call on me. Although my acquaintance with him was brief, I recognized in him as a man of the old school, a man of outstanding character and quality, and I am very sorry indeed to learn of his passing.

"He certainly lived to a ripe old age and had a most distinguished career, in the course of which he rendered much service to the Corps of Royal Engineers, to the Army and to the Commonwealth.

"I would be glad if you would accept from Bett and myself our very deep sympathy.

"I was also very sorry to see, in the same issue of the *Journal*, the death of Basil Davey. He was a very distinguished Sapper. I knew him principally in Eighth Army days, when he was Chief Engineer of the Eighth Army; but I met him several times right up to the close of his active career, and both the Army and the Corps of Royal Engineers have suffered a big loss through his going."

[1]Brigadier David Forster, CB, CMG, DSO.

The Package Deal

The following letter has been received from Sir Arthur W. H. Dean, Kt, CIE, MC.* BSc, MICE, a Member of the Institution of Royal Engineers, commenting upon the article by Major D. M. R. Esson that appeared in the June 1960 issue of the *Royal Engineers Journal*.

Libyan Public Development & Stabilization Agency
59 Sharia Turkia
Post Office Box No. 386
Tripoli, Libya.
26 June 1960.

The Editor,
RE Journal.

Dear Sir,

I would wish to comment on Major Esson's article in the June 1960 *Journal* on "The Package Deal". I would first say I am a civilian who has appreciated the privilege of membership of your Institution for many years though I have served in the Corps only in Territorial, Temporary and Reserve capacities and never as a Regular. I would further explain that I am not a Consulting Engineer nor have I been on the staff of any, on the other hand I have never worked for a contractor. My professional work has been for the Government of India thirty years, the British Government, Foreign Office, three years and currently for the Libyan Government rising nine years.

In India it was most unusual for the Public Works Department either Irrigation Branch or Buildings and Roads Branch, I served for some years in a province where they were combined, to employ consultants. For the type of construction we were concerned with we had a large and diversified staff of engineers and architects with draftsmen, estimators, surveyors etc. and could produce detailed designs and estimates with bills of quantities to go out to competitive tender or to execute departmentally.

In a smaller organization, however, it is quite impossible to provide the necessary experience to cater for all problems, bridges, dams, harbours, airfields, power stations, water supplies, hospitals, schools have all come my way in the last eleven years. For some the broad design or, given time, possibly the detailed design could be managed but with very few draftsmen, estimators, etc, the working drawings, etc, would be seriously delayed. Again site investigations, hydraulic testing of models, etc, for which in India we had various specialized research stations available, are quite beyond any but the largest engineering department. It is here that the Consulting Engineer comes in and in recent years I have engaged the services of several for various specialized projects. This is much cheaper than attempting to engage staff who can cover adequately the various types of work involved and gives one the services not only of say six or eight partners all with established reputations but also of a technical staff of all grades often numbering several hundred.

The architectural competition Major Esson mentions is for a *design* and the remuneration to the successful architect is the premium offered by the body organizing the competition. The client goes out to tender on the design and awards the contract. It is usual for the successful architect to be engaged by the client to supervise construction of the building he has designed and for this he gets the standard fees prescribed by the RIBA.

The tied architect who has an obligation to give the contractor by whom, unknown to the organizers of the competition, he is employed the contract for executing the work is certainly guilty of unprofessional conduct. It is, however, difficult to see how he can in fact ensure that the client will give the job to that contractor who is unlikely to submit the lowest tender in open competition.

If an engineering project were thrown open to consulting engineers and contractors engineers to design and submit to clients who were, as in the case of an architectural competition, advised by a published panel of engineers for an advertised premium this might well throw up interesting alternative ways of tackling a problem. Until, however, the client has had quotations for the execution of the work from contractors it is on suitability rather than on estimated price, often markedly different from tendered price, that selection will be made.

It is surely obvious that it is only when contractors are tendering to the same design and specifications that a difference in price, and time, has any real meaning.

Where contractors submit their own designs and specifications the price comparison has no real validity.

The "package deal" put forward by a contractor has two disadvantages. First, few contractors maintain a design staff with anything approaching the qualifications and experience of most consulting engineers, or for that matter of the larger bodies who carry out major engineering enterprises. It is unlikely therefore that equally satisfactory designs will be put forward by them.

The second, which is fundamental, is that contractors are in business to make a profit. Independent engineering supervision of the design, specifications, quality of materials and workmanship and measurement is essential if the profit motive is not to take charge to the detriment of the finished work. This supervision is given for large organizations by their own professional staff and for smaller bodies, who cannot afford the large and experienced staff this postulates, by their consulting engineers.

To rely on the contractors engineers for all these essentials involves them in a conflict of interest which is more likely to be resolved in their employers interests than the clients.

It seems to me that the importance of the quantity surveyor is exaggerated in this article. His work is of value in preparing the bill of quantities from the detailed drawings though much more so in building work than in civil engineering. But to call him "the most important of the consultant's assistants" is certainly inaccurate. Still less does it follow that the "package dealer's" invitation to the client "My work may be supervised from outside, in fact I would like you to employ a quantity surveyor" provides any real safeguards. The quantity surveyor can record the measurements of the work but neither by training nor experience has he the knowledge to check the adequacy of the design nor assess the quality of the materials and workmanship.

The whole tone of Major Esson's article seems to denigrate the profession of which he is a member and in particular the tale of consulting engineers making fortunes from shares taken in "the enterprise for whom they are working" strikes me as most improbable. A very high proportion of their work is for clients who don't issue shares!

I am, Sir,

Yours faithfully,

SIR ARTHUR DEAN,

General Manager.

N.B. This expresses my personal views which are not necessarily the views of the Libyan Public Development and Stabilization Agency.

The Editor,
RE Journal

Headquarters
British Army of the Rhine
British Forces Post Office 40
15 June 1960

The Employment of Sapper Officers in Movements

Dear Sir,

Brigadier-General Sir H. Osborne Mance's letter published in your June issue, and your editorial note, prompt me to amplify Brigadier R. E. Bagnall-Wild's account in your March issue of what happened in the 1930's, and to explain why the "Staff Captain in the Transportation Directorate said he knew all about it"; the change that took place in Movements between World Wars I and II; and, how the "Royal Engineers became embroiled in Movements" not from a chance development, but quite deliberately.

In 1932 and succeeding years, Lieut-Colonel L. Manton (now Brigadier (retd)) as Commandant of the then Railway Training Centre RE ran a series of Movement Exercises on the theme of the "Movements Twin". The teaching, as now recollected, was that the muddle in World War I resulted, partly from the Movements Staff being in a Commanders HQ, which was not sited for its suitability for controlling movement nor for liaising with transport operators, and partly because RTOs were not Staff Officers speaking in the name of the Commander, but Transportation Service Officers. Movement Control units as now understood did not then exist. The "Movements Twin" was designed to overcome these handicaps by sitting Staff Officers and Transportation Officers down together near to a centre from which transport was controlled, and in a single organization, which was to include RTOs who would be Staff Officers giving orders in the name of the Commander. (In case it is of interest, appended is a list of those at Brecon in 1932, who took part in the first of this series of annual exercises.)

As an impressionable junior subaltern I ascribed all the thought and teaching to the Commandant and his staff. The outcome showed that the War Office approved of these ideas, for after the Saar episode (in which the only forms provided for use by the RTO Calais was a sack full of small rectangular sheets of brown paper) was that two Movement Control Groups, Royal Engineers Supplementary Reserve were formed in the years immediately preceding the outbreak of World War II, and at their head was a "Movements Twin", a DAQMG(M) and a DAD Tn. The latter was envisaged as an interpreter between the DAQMG(M) and the transport operator.

That it was sound to base the organization on an intimate relationship between the staff and the transport operator was proved by World War II. It also rapidly, but not surprisingly, confirmed that Staff Officers are adaptable and that, having had the organization worked out and trained by Transportation Sappers, they do not need one constantly at hand to help them get together with transport operators. It also proved the ability of both the Regular and Reservist Sapper Officers to do Movements Staff Work without having been to Staff College.

The idea of a special relationship between the Movements Staff and the Transportation Service was carried further; for example, World War II was begun with a Director General of Movements and Transportation in the War Office, and the Staff and Service were most successfully unified for much of the Middle East campaign. The Commandant of the Transportation Training Centre, RE still carries out the training of Movements Officers and Other Ranks, the latter are all Sappers, to the requirements of the Director of Movements, War Office; but Transportation has been taken firmly under the wing of the E-in-C, and CE's overseas, leaving the Movements Staff and Movement Control Units RE in a unique relationship with one another, the Corps of Royal Engineers, and the Army.

Yours faithfully

R. S. Grant, Brigadier.

DQMG(M).

Officers Taking Part in Transportation Exercise No 2
Wales 3–7 October 1932

Directing Staff

Lieut-Col L. Manton, DSO, OBE, RE	Commandant, Rly Trg Centre, RE
Maj J. P. S. Greig, RE	Senior Instructor
Bt Lt-Col W. F. Hanna, MC	Staff College Instructor
Maj H. A. Joly de Lothiniere, MC, RE	
Maj D. J. McMullen, DSO, RE	
Maj G. R. S. Wilson, RE	

Staff College Students

Maj H. P. W. Hutson, DSO, OBE, MC, RE

Maj R. O'D Carey, 1st Bn DWR

Capt A. N. Venning, MC, RA

Capt J. J. Burke-Gaffney, MC, 2nd King's R

Lt R. H. H. Osborne, 2nd Bn Beds & Herts

Lieut L. S. Sheldon, 2nd Bn The Queen's R.

OFFICERS OF RAILWAY TRAINING CENTRE RE

Maj R. F. O'D Gage, MC, RE	Lieut A. T. de Rhe Philipe, RE
Capt F. J. Biddulph, MC, RE	Lieut A. E. M. Walter, RE
Capt D. Bathe, RE	Lieut B. S. Armitage, RE
Capt C. G. B. Greaves, RE	Lieut I. W. B. Edge, RE
Lieut G. A. Palmer, RE, Adjutant	Lieut C. H. Barnett, RE
Lieut J. S. Howe, RE	Lieut A. R. Jesty, RE
Lieut I. L. H. Mackillop, RE	Lieut R. S. Grant, RE

Of the RE officers:—

(*a*) Two became Director of Movements War Office; Major-General Greaves, and Major-General de Rhe Philipe who had been the Senior Movements Staff Officer in the Madagascar, North Africa, and Italian campaigns.

(*b*) Four became Director of Transportation War Office; General McMullen after some nine months as D Tn BEF, was D Tn War Office for the rest of World War II being largely responsible for the Mulberry Harbours; and Brigadier Gage after being D Tn throughout the N. African and most of the Italian campaign before becoming D Tn 21 Army Group for the whole of the NW Europe Campaign.

(*c*) Brigadier McKillop was Senior Movements Staff Officer 21 Army Group at the opening of the NW Europe Campaign in 1944.

(*d*) Colonel Wilson retired early, and died when serving as Chief Inspector, Ministry of Transport.

Book Reviews

THE OTHER SIDE OF THE MOON

(Issued by the USSR Academy of Sciences; translated by J. B. SYKES.)
(Published by Pergamon Press 1960. Price 10*s* 6*d*)

Here is a plain statement of the facts of the establishment of an important milestone in the progress of science.

To the intelligent man in the street the placing of an artificial satellite in orbit was merely a result of that little extra power applied to a vehicle; an achievement of the order of a new record in high speed flight. The admiration for the skill and ability which enabled a space vehicle to be guided to an impact with the moon's surface was tempered with doubt regarding the value of the operation and the philosophic doubt regarding the act of observing altering the situation observed. But to send a messenger vehicle out, to cause it to take up a particular station in space and to scan photographically the invisible area of the moon's surface and in due course develop and televise the photographs to earth, here was an entirely new tool perfected for revealing innumerable secrets of the universe.

This book lists very briefly the component parts of the scientific apparatus involved and the way in which they were brought into operation and the data finally transmitted safely to earth. The extensive and numerous technical difficulties at every stage are indicated but there is no indication of the method of operation of the all-important orienting mechanism which is merely referred to as "the motors" for the "solar orientation units" and the "lunar orientation devices".

The book is extremely well produced with nine full page illustrations. It is directed to the general reader and is of value in completing the picture of the operation "in the round" rather than in providing any hitherto unannounced details. D.R.C.

A HISTORY OF GREEK FIRE AND GUNPOWDER

By J. R. PARTINGTON

(Published by W. Heffer & Sons, Cambridge. Price 70s.)

This is a most scholarly and meticulously written book as one would expect from the author, who is Emeritus Professor of Chemistry at London University. He has clearly spared no pains in research, every possible source of information having been consulted. These sources are clearly tabulated after each section or chapter in sufficient detail for students to plan further studies.

The book covers the early developments in the field of incendiaries and explosives, including the methods used for their discharge against the enemy. There are a few references to mine warfare but, for the most part, the book is more likely to appeal to gunner or ordnance officers than to sappers.

The first two chapters deal mainly with incendiaries, going back to the time of the Greco-Persian Wars. We are introduced to that remarkable collection of chemical and incendiary recipes known as the "Book of Fires" by Mark The Greek. Far from having any real connexion with Greek fire, Mark The Greek was apparently a pseudonym for a Spanish Jew with an interest in alcohol.

The remainder of the book is devoted to gunpowder. The author shows that explosive mixtures of saltpetre, sulphur and charcoal were known well before the thirteenth century, particularly in China, but real gunpowder and cannon were not in regular use anywhere before the fourteenth century. It often happens that after many years of incomplete knowledge suddenly the breakthrough occurs in widely separated areas in the world. It was so in this case. Whether Europe learnt from the Chinese via the Arabs or the knowledge spread from Europe cannot now be determined. We do know, however, that as regards Europe, the breakthrough was achieved by Rober Bacon in the thirteenth century when he showed the importance of using only *purified* saltpetre and of *intimately* mixing the three ingredients. The claims of the German monk, Berthold Schwartz (Black Berthold), are shown to be legendary as indeed is his very existence.

The book contains some delightful reproductions of old woodcuts and there is much to interest the general reader. It is not, however, an easy book to read because the text includes many quotations from books written in languages other than English. Some of these extracts are of considerable length; some are translated, some not. In any case, translations or précis would usually have sufficed and much space (and a lot of irritation to the reader) saved thereby. As it is, the book will be useful as an up-to-date and well-documented book of reference.

There is a spirited and thoughtful Foreword by Lieut-General Sir Frederick Morgan. The author is to be congratulated on the excellence of the Index and the publishers on the good clear type used and general get-up of the book. J.T.S.T.

THE MEDITERRANEAN AND MIDDLE EAST—VOLUME III

By MAJOR-GENERAL I. S. O. PLAYFAIR, CB, DSO, MC*

(Published by Her Majesty's Stationery Office, London, 1960. Price 50s.)

Even although the last battle of a campaign is to end in victory, the serious reader must study the preliminary mistakes and misfortunes with keen attention lest the loser learn more from them than the winner. Touching North Africa, Major-General Playfair's careful record of events between September 1941 and September 1942 provides precisely what is required for the critical research, which the headlong retreat of the Eighth Army to El Alamein seems to demand.

Recognizing that victory in the desert depended to a greater measure than ever before on the balanced action of the three Services, the author has been at pains to interpolate in the narrative important paragraphs and sometimes whole chapters on the prodigious efforts of the RN and the RAF. Malta, whose importance for the control of the Mediterranean was even greater in 1939–45 than it had been in the Napoleonic wars, earns a special account of her ordeal in 1942, when her effectiveness as a base dropped to almost nothing. At this crisis, Winston Churchill, always careless of the dictates of mere prudence, was savagely unremitting in the despatch of reinforcements and weapons of war not only to Malta but to Egypt also. So by the time Rommel's nearly exhausted army reached El Alamein, Malta re-armed was once more taking heavy toll of Axis shipping and the Eighth Army found at its back new tanks, fresh aircraft and more reinforcements with which to continue the struggle.

It seems possible that the unfortunate capitulation at Tobruk in June 1942, might not have happened if General Auchinleck had acted in accordance with his declared policy of avoiding a second investment and had given timely orders for its evacuation. Yet the knowledge that the Prime Minister would set great store on its retention must have made any explicit order very difficult. In the event Tobruk seemed to go by default which was a pity, although at that juncture there were weighty reasons for not getting saddled with a most difficult additional commitment.

The desert victories of the Commonwealth and the Axis in 1942 were none of them walk-overs and they proved to be very exhausting to the participants. The British and Dominion forces fought on the whole with commendable toughness during their long retreats. On several occasions there were notable break-outs to freedom, particularly by the 50th Division right round south of Bir Hacheim and by the 4th New Zealand Brigade eastwards to enable the rest of the Division to pass through the gap. Some 800 men under a field officer of the Guards also broke out S.W. from Tobruk and so escaped the misery of capitulation. A large percentage of the Eighth Army succeeded in getting back to the El Alamein position somewhat bewildered but not demoralized. In this connexion a summary of the casualties sustained by both sides during this critical year would be a valuable commentary on the vicissitudes of the struggle.

The daily forward lift of stores for the Eighth Army was said to be 1,400 tons per day. An interesting comparison with this figure is the 700 tons a day said to be required by the German Sixth Army (300,000 men) when it was surrounded at Stalingrad. The desert Army was clearly well supplied . Of criticism General Playfair, as befits an official historian, is admirably sparing. Towards the end of the volume he does gently imply that when our battered and exhausted troops finally stood at bay a "backs to the wall" order of the day would not have been out of place. This suggestion is perhaps fair, but by the same token it would also have been fair to commend with more warmth General Auchinleck's two great achievements, namely the calling of Rommel's bluff when he struck at the Egyptian frontier in November 1941 and his resolute command of the Eighty Army at Al Alamein in September 42. On both of these occasions he displayed the qualities of a leader of the highest class. When he gave up his command the long battle in the North African was approaching *l'événement* which Napoleon used so eagerly to await and which General Montgomery turned to the British advantage with such consummate skill.

The calm excellence and easy style of the first two volumes are well maintained in this one and the author must feel relieved that half his great task is now done and the worst of the war is behind him. BTW

THE STORY OF BISLEY

By Howard N. Cole

(Published by Gale and Polden Ltd. Price 7*s* 6*d*)

The book, marking the centenary of the National Rifle Association and sixty-nine years of Bisley meetings, traces the history of Bisley of today from the first meeting held on Wimbledon Common in 1860.

It was a wave of national alarm against the prospect of invasion by the French that produced the Volunteers Rifle Corps in 1859. From the Volunteer Rifle Corps was formed the National Rifle Association some six months later, with the object of "the encouragement of Volunteer Rifle Corps and the promotion of Rifle Shooting throughout Great Britain."

The inaugural Association meeting for the Queen's prize commenced on Wimbledon Common on 2 July 1860 and was opened by Queen Victoria firing a fixed rifle by trip cord on a 400 yds range.

In no way does the book attempt to be a history of the National Rifle Association, but to record the story of Bisley and provide a guide to the Common and Camp of today it is necessary to record the reasons for the selection and move to Bisley from Wimbledon in 1890.

Further chapters are devoted to the development of Bisley and describe the construction and opening of the Camp Railway, together with the use of the Ranges by the NRA School of Musketry and the Small Arms School Hythe during two World Wars. An account of the Bisley Scene 1939–59, and Bisley today, completes the major portion of the book that is well illustrated by original photographs, and engravings. There is a complete list of the Queen's/King's Prize Winners from 1860, together with a short history of certain NRA Prizes and Competitions.

This book will be widely read by the marksman, and others, who require a full and comprehensive guide and history to the Bisley scene. J.H.T.

THE FOXES OF THE DESERT

Translated from the German of Paul Carell

(Published by Macdonald and Company London. Price 30*s*)

The Foxes of the Desert purports to be the story of the Afrika Corps. Its author is a West German journalist who has obtained most of his material from interviews with old Afrika Corps men of all ranks. An attempt to provide continuity by the introduction of imaginary characters is—at least in translation—not altogether successful.

Those who took part in the desert fighting of 1941–3 will read, or at least dig about in, this book with a good deal of curiosity to discover what their old adversaries were doing and thinking at the time.

The main interest of the book to sappers lies in the emphasis given by the author to mine warfare. To quote Sir Brian Horrocks, "he is the first author to portray accurately the vital part played in this war by minefields."

The Germans, we are told, considered their minefields at Alamein to be impregnable. Rommel had demanded minefields "through which no British soldier can pass and no mine-sweeping squads can clear." And Hecker his Chief Engineer had obliged with new designs which Rommel, with reluctant admiration, named "Devils' Gardens". Hecker's sappers spent most of the summer of 1942 constructing them.

One reads with some astonishment that the credit for breaching these minefields at the Battle of Alamein was given by the Germans to our artillery. According to Mr. Carell, "Montgomery was strong enough to shoot corridors through the minefields with a wealth of American-made shells. Rommel had not envisaged this." Nor, one imagines, did he believe it.

In the account of the Battle of Alam Halfa (August 1942) the vital part played by our tactical minefields is, for the first time, given full weight.

When the Afrika Corps set out on this "lightning thrust", which was intended to finish the war in Africa, the 21st Panzer Division was directed on Alexandria and the 15th Panzer and 90th Light Divisions on Cairo—and they had enough petrol in their tanks to get there. But both Panzer divisions whilst advancing on a broad front towards Alam Halfa ran into "unsuspected minefields" in the darkness; and this started the confusion and delay which was so admirably exploited by the 7th Armoured Division and the RAF. Three out of the four German generals leading the attack were killed that night and a good many of their 200 tanks were disabled. The lightning thrust had thus been blunted more or less at the outset and had lost the impetus which might conceivably have taken it to the Nile. This seems to provide a classic example of the value of a surprise obstacle when the means to exploit it are at hand.

It is a pity the book is so long. It could be shortened with advantage by omission of a good deal of journalistic padding—such as tales of supposed treachery, spying and leakages of plans, and the imagined conversations—none of which seem very real. (We even find repeated that old fiction about the British soldiers singing "Lili Marlene".)

Of the characters, that of Rommel comes fitfully to life, and there are interesting accounts of his interviews with Hitler whom he visited, without enjoyment, on several occasions. It was only Rommel apparently who knew that Hitler's "Victory or Death" order during the Battle of Alamein was an order and not, as his staff thought, "just pep-talk to keep up morale". J.M.L.

DETERRENT OR DEFENCE

By CAPTAIN B. H. LIDDELL HART

(Published by Stevens & Sons Ltd., New Fetter Lane, London. Price 30*s*)

Captain Liddell Hart puts one in mind of the Red Queen. He seizes you by the hand and whirls you over the battlefields of the past and of those to come. During your breathless journey he points so many morals and adorns so many tales, that your fainting ear can hardly take them all in. Like old Moore, too, he mentions such a multitude of possibilities, that some of them are bound to come to pass and will then qualify for his triumphant reference to them later on. If generals are ever right, they are seldom British ones, whilst British politicians get just as severely caned as their military advisers. Nevertheless all of them would miss the stimulating exasperation which Liddell Hart's fulminations often inspire. Long may he continue to illuminate the art of war with his books! This one—*Deterrent or Defence*—seems to lack a question mark in the title to make its object abundantly clear. But it is of vintage quality and, as so often with the author's publications, appears at a psychological moment. For at long last, it now seems to be accepted by all concerned, that the possession of the H bomb by both West and East has turned it into a weapon of desperation, i.e. "an ultima ratio regum" which would plunge the whole civilized world into chaos and which should therefore never be used. Moreover, the tactical A bomb as the remedy of the West for the lack of conventional forces is almost as desperate, since its power and its range are of an order of destructiveness which far exceeds tactical requirements. As such, its use would, by a chain reaction, soon bring about a nuclear war *à l'outrance*. An atomic bullet, which could penetrate armour and earth parapets as though they were so much butter, would be of novel tactical importance. But until A weapons are truly tactical in some such way, they seem to confer doubtful advantages, except to counterbalance their possession by the East.

Thus Europe now faces an impasse which recalls the Berlin blockade of 1948–9 and the consequent formation of NATO. At that time the nuclear deterrent gave the West a dominating advantage and the USSR had to climb down. Today Kruschev holds most of the high cards and will probably make himself extremely disagreeable, in the near future, again about Berlin. Even so there is more to prevent war than to cause it, chiefly because the people of Europe have had enough of massive destruction and want to live in peace. For all that the West now seems under-insured in conventional forces and may have to reconsider this aspect of their defences.

Liddell Hart discusses with admirable conciseness all the factors of this difficult situation. On the whole he is conservative and calm, holding no brief for the wild men of any persuasion. Like Clausewitz, he sees much merit in local militia or Home Guards. About the modern defensive battle he is perhaps a trifle theoretical and apt to overlook the tremendous advantages which accrue to a well-planned offensive against raw troops at the beginning of a war. Readers must judge for themselves. In *Deterrent or Defence* they have at their disposal a brilliant and timely exposé of a continually changing security problem which will require attention for a very long time. B.T.W.

ARMY EXPLORATION IN THE AMERICAN WEST 1803–1863

By William H. Goetzmann

(Published by Oxford University Press. Price 52*s*)

On 5 July 1838 Colonel John James Abert, Chief of the United States Army's Topographical Bureau, saw his ambition fulfilled—the formation of a Corps of Topographical Engineers separate from, and of equal status to, the regular Corps of Engineers. It is this new Corps' short life from 1838 to 1863 which forms the main subject of the book under review, although the author dates from 1803 the period that he covers.

After an introductory chapter, Mr Goetzmann sets out to show that to the Corps of Topographical Engineers, and not to other more famed but often legendary figures, belongs the true credit for helping the inheritors of the West to take possession of their undreamt of empire.

Although the life of the Corps was so short, it coincided with those years when America began fully to realize the magnitude of her inheritance. The Corps, represented by an organized and professionally skilled group of officers, led the advance into the unknown, and, as it led, it mapped, observed and recorded. Those officers were presented with a unique opportunity, and they served their country well.

We are told of men such as Frémont, a legend in his own time and now part of American lore, and shown how harsh and dangerous was the land into which he and others like him went. And if one concludes that their work as explorers outshone their role as map-makers that in no way detracts from what they did.

The Corps was, of course, also employed in roles whose primary purpose was technical rather than exploratory—the Mexican Boundary Survey is a particular example—but always one is left with the impression that its heart really lay in exploration. As with all armies, the Topographical Engineers operated in the midst of the powerful pressure of economic and political factions. But in spite of its troubles it acted as the vanguard of settlement, cleared away the Indian barrier, laid out the lines of communication, totalled up the national resources and above all "brought the element of trustworthiness inherent in scientific method to the making of Western maps where before there was only myth."

Many books dealing with the West contain an inseparable mixture of romanticized fact and pure myth, but that is one criticism that cannot be made of Mr Goetzmann's study: in fact, the author goes into such well-referenced and unimpeachable detail that one almost begins to wish for a leavening of myth. He was, no doubt, compelled to present his story in this way if it were to be told in a book of reasonable length, and, of course, he writes for the American reader who is already acquainted with the outlines of the story. To the British reader, however, unversed in Western exploration and unable to visualize the juxtaposition of previously unheard of places, rivers and mountains, the book is often hard going. To follow the story and to appreciate its significance a modern small-scale map of America west of the Mississippi is essential, and the book would have been improved by such an inclusion.

Finally, the surveyor who reads the book to discover something about the methods and techniques of the Topographical Engineers will be disappointed. Technical problems are seldom explained and never discussed and one can only visualize what they must have been. But, even without this information, many a modern surveyor, knowing what the problems must have been, will envy the opportunity which came to the Topographical Engineers but which can never come again. C.W.F.

REINFORCED CONCRETE CHIMNEYS

By C. Percy Taylor, FCGI, MICE and Leslie Turner BSc, MICE, PPI Struct E.

(Published by Concrete Publication Ltd., 2nd Edition 1960. Price 12*s*)

This is another of the "Concrete Series" books brought up to date after the revision of CP 114 in 1957. The 1st edition was published in 1940 and in this new edition, Leslie Turner (the other author having died) takes the opportunity of replacing the former method of analysing annular sections (Chapter III) with a new and simpler method and he introduces an entirely new chapter on deflection of chimneys. Reference is also made to the USA Standard for RC Chimneys (No 505–54).

The style of writing is straightforward and readable; illustrative drawings, of which there is a generous supply, are admirably clear when drawn specifically for the book; but where these have been reproduced from other sources the reader with average eyesight might have difficulty in reading dimensions and other written data.

This is a good text book, dealing fully but concisely with a limited field of RC design. The twenty-one references contained in the bibliography and the logical development throughout the text convince the reviewer that the subject has been thoroughly explored, sensibly sifted and plainly presented.

J.D.E.

Technical Notes

CIVIL ENGINEERING

Notes from *Civil Engineering and Public Works Review*, June 1960.

Building by Helicopter. The firm of H. Hoskings Ltd., Langport, Somerset recently conducted an interesting experiment with a Westland Whirlwind Helicopter, in conjunction with Messrs Concrete Ltd. The helicopter was used to lift, and set in position, precast concrete purlins for the roof of a new secondary school. Each purlin was 23 ft 1 in long and weighed 15 cwts. The task was shown to be possible, provided that a good working platform could be arranged, for men with guidelines to bring the units accurately into position. A cycle time of 4 min could be achieved over a level distance of 250 yds. The advantages are that the 250 yds may be impossible to traffic, and that the member lifted can be much longer than is usually easy to handle by cranes. The disadvantage is the need for an adequate working platform for men to get a grip on the load as it is lowered—a task made more difficult by the down-draught of the rotor blades.

New Structural Models Laboratory at The Queen's University of Belfast. The new laboratory is described from the point of view of the terms of reference which guided the planning and design. The aims of the instruction to be given are clearly described, and from this point of view one can get a clear picture of many of the uses for model experiments, and many ideas for training aids for similar instruction.

Preliminary Study of Ultimate Load: Moment-Shear Interaction in RC Beams. In this article the authors discuss experiments which were carried out to investigate the effects of shear on the moment of resistance of RC beams. The conclusions reached indicate that there is a connexion between ultimate moment and shear for a particular beam. If this relationship were known, the mechanism of failure would be much easier to calculate, and better design would be possible.

Field Method of Measuring the Forces in HT Steel Wires. It is important to stress the wires used for prestressed concrete correctly. It is customary to check the gauge reading of the jack against the extension of the wire, relating the two readings by means of the modulus of elasticity of the wire. If this value (E) is not guaranteed by the makers, and if it is not safe to assume a value (usually taken as 28×10^6 psi) it may be desirable to carry out a physical test to check the behaviour of the wire under load. The author describes a very simple field method he used in connexion with prestressed concrete work in Burma. A micrometer gauge is set up to read deflections of the wire under different loads suspended at the mid point between fixed abutments (one end anchored off; the other held by the jack at varying readings of the gauge on the jack).

By working out the triangle of forces, a true stress/strain relationship can be established in the wire to check against the readings of the jack. The method can also be extended to indicate the loss of stress in the wire due to creep, by taking readings at various time intervals.

Notes from *Civil Engineering & Public Works Review*, July 1960

Anchoring Unstable Foundations. An eight-storey office building, under construction on a mountain side at Altena in Western Germany, was saved from destruction by means of anchor bolts drilled into a secure rock strata deep below the designed footings. As the structure was being built, deep cracks appeared, and the whole strata on which the foundations rested began to slip downhill. One hundred and fifty 20-ft deep boreholes, in three rows of fifty, were drilled, filled with reinforced concrete and joined at the top by capping beams. The result was to pin the upper loose layer firmly and successfully to bedrock.

Protecting a Pipeline in the USA. More than 41.5 million square feet of polythene tape have been used to wrap the 1,616 mile long natural gas main linking Texas with Florida. The film is waterproof, thus combating corrosion, and acts as an electrical insulator, thus making galvanic protection easier and cheaper. There is no "drying time", and all these factors are claimed to have resulted in saving £180 per mile over other types of protective coating.

Novel Use of Dry Ice and Latex. Two features are described in one article. In Chicago a completed structure was reconstructed, using new steel columns. The new columns were set up alongside the original columns. They were inserted, ready for use, a few thousandths of an inch shorter than the originals. The old columns were then packed with dry ice—and contracted on cooling. As the old columns contracted, the new columns took the strain of the building—and the old columns were cut out while fully contracted.

The second note is of the use of latex as an additive to concrete cast *in situ* as a paving on bridges. The slight added resilience reduces vibration, thus prolonging the useful life of the paving.

The Relationship between Dry Density; Voids/Cement Ratio; and the Strength of Soil-Cement Mixtures. The water/cement ratio is related to strength for concrete only when all air-voids are expelled. A material such as soil-cement is never fully compacted in the field, and thus the water/cement/strength relationship is not strictly applicable. However, there certainly is a relationship of some sort, and the author of this article describes a series of experiments to analize the relationship. Both flexural strength and compressive strengths were measured for a number of specimens, each group being made up under well-controlled conditions of moisture, cement content and compaction. The results show that there is a relationship between the voids/cement ratio and compressive strength—and also that there is a relationship between flexural strengths and compressive strength.

Elastic Buckling of Columns in Structures. Practical columns in structures are never pin-ended, and are seldom straight and rarely loaded without some eccentricity. The method of solution described lies somewhere between the Elastic Method, and the Load Factor Method of Plastic Design. It can best be described as being similar to the standard code method, but possesses the merit that the empirical factors have been obtained from actual test, rather than from mere assumptions. It must be noted that this is an experimental method . . . a great many tests would be needed on models, or prototypes, before real production was put in hand.

Snow Compaction Technique in USA. Methods of improving and preserving the qualities of a car park under heavy snow falls are described. These were used at Squaw Valley during the VIII Olympic Winter Games, and proved very effective.

Notes from *Civil Engineering and Public Works Review*, August 1960.

"Engineering Developments in the USSR": Four types of prestressed concrete sheet piles are illustrated. Each has its own method of interlocking and achieves a moment of resistance suitable for a particular job. An interesting feature is the method suggested for ensuring that tightness of the interlock is maintained. This is by means of suspending a trolley to run vertically up the side of the relatively thick concrete pile where it stands above ground. The trolley is pulled by a winch from the side and the horizontal component of this tension can be adjusted as required.

"New Bridge over the River Medway": Details are given of the new £2½ million bridge over the Medway which will have by far the greatest unsupported span of any bridge in the world. Construction will take about 2½ years, and its completion will be eagerly awaited by all who suffer from the traffic congestion in Chatham.

"Sinking a Shaft in Artificially Frozen ground": This article is well illustrated and simply written. It shows what can be done by this method, and how a particular problem was solved. It is not a rapid method, but in a case where dewatering cannot be employed (for fear of subsidence) it is a particularly useful technique. A point of view expressed is that even water, when frozen, becomes an engineering material developing 300 lb per sq in!

"MEXE Facilities for the Testing of Construction Equipment": The facilities of MEXE were developed for military needs after 1945, when it became necessary to make factual physical tests of a variety of equipments in order to place orders for the right items for service use. This article describes how a manufacturer's item of construction equipment might be tested at MEXE.

"The Stability of Long Welded Rails": This is the first of a series of articles which will show how field and laboratory tests have been used to investigate the behaviour of long welded steel rails under full scale conditions. As a preliminary, the author discusses the theory of long welded rails with regard to the interesting point that movement and stresses battle it out in the end sections of a long rail, and the middle portion takes no part in the argument. So that there is no difference between a long welded rail and an even longer welded rail, apart from the difficulty of handling it.

"Plastic Sheeting for Waterproofing Earth Banks": The new plastics are cheap and available in rolls which can cover large areas. Earth (especially clay) is a material which is strong when dry, but often weak when wet. A temporary, or even semi-permanent, cover can be laid, using plastic sheeting, which can solve tricky problems. The article gives some very useful tips. One such piece of advice is to use an opaque plastic sheet so as to inhibit plant growth. T.W.T.

THE CONTRACT JOURNAL

Notes from *The Contract Journal*, 7 July 1960

OXFORD SOUTHERN AND WESTERN BYPASS. The article is particularly interesting for the description and photographs which illustrate the launching of 120 heavy precast reinforced concrete beams. The beams weigh up to 38 tons, and are mostly 73 ft in length. They are launched by means of a light aluminium alloy truss of triangular section which was specially designed for the purpose. The truss, which only weighs 9 tons, is cantilevered out from one finished span until it rests on the next pier. It is supported on legs which are high enough to permit the heavy precast beams to be slid out on monorail runners along the bottom member of the triangular truss. The precast beams are then jacked down into position using four 15-ton hydraulic jacks.

T.W.T.

ENGINEERING JOURNAL OF CANADA

Notes from *The Engineering Journal of Canada*, March 1960.

This issue contains no papers of particular value to the military engineer, but some technical details of interest to specialists are given. The titles of papers, with indications of their scope, are as follows:—

"*Nuclear research reactor operations.*" The basic working principles of nuclear reactors are very clearly described. In research reactors the heat produced is put to no useful purpose, their object being to produce neutrons for experimental purposes, and the essential feature is reliable and immediate means of shutdown when the coolant becomes unsafe. This short paper will enable the general reader to appreciate the very real value of the Chalk River experimental reactors.

"*Engineering studies of the Fraser River basin*" and "*Rainfall data analysis in Ceylon*". These two papers demonstrate the complexity of the preliminary work necessary to establish reliable meteorological and hydrological data. The determination of the appropriate "design storm" data, and of the maximum discharge from flood or snow-melt, is essential for road and airfield design, as well as for planning hydro-electric installations.

"*Interpretation of rheological data*". This is a technical disquisition, of interest primarily to pipeline engineers.

"*Test rigs and facilities at Orenda Engines Ltd Nobel test establishment.*" Mechanical engineers seeking technical information about the efficiency of the gas turbine will find this paper valuable.

"*Aluminum in rolling stock*". Canada is rich in aluminium. The use of light-weight wagons, particularly of the hopper type, reduces the overall number of trainloads for bulk transport, and saves both time and labour for maintenance. High resistance to corrosion obviates painting. A convincing paper with well set out conclusions.

"*Industrial design in Canada*" and "*Engineering for export*". Though parochial in concept, both these papers are worth the attention of the general reader with an inquiring mind.

Notes from *The Engineering Journal of Canada*, April 1960.

There are two papers relating to power projects, which are of fairly general interest and which are briefly reviewed below. The other four features, of more restricted appeal, are:—

"*Engineering progress,* 1959." A summary, under eight main headings, of Canadian engineering achievements during 1959. Those not already aware of the virility of the Dominion would do well to read this concise report.

"*Chemical recovery boiler and back pressure turbine*". A rather technical description for the mechanically inclined. The boiler operates at 1,250 psig and 850°F. The turbo-generator associated with it is a Ljungstrom turbine rated at 8,750 kVA.

"*Unattended pumping station.*" A description of a major municipal water-supply improvement project, incorporating an automatic control system, which is not yet completed. There is a lot of technical detail.

"*Application of microwave radio links.*" Radio-relay systems are now widely used in telecommunications circuits. Though primarily for the specialist, this paper should help the general reader to appreciate the economic and technical factors involved.

Silver Falls Project: The outstanding feature of this hydro-electric project is the very long period of investigation preceding the final decision as to siting and layout. The first site surveys were made in 1906, and various proposals were examined over a period of years, but it was not until 1956 that intensive study led to the final solution.

Seismic survey and an extremely comprehensive drilling programme were necessary to determine the complicated geological features of the area.

Hydraulic power is derived from the 350-ft head between Dog Lake, which forms the storage reservoir, and Little Dog Lake, and the single unit powerhouse has an installed capacity of 45,000 kW. The structural features of the project are in no way abnormal, but the description of construction work includes several points of interest, notably as regards drilling and concreting the 2-mile tunnel, with a finished diameter of 14 ft 6 in (see also *RE Journal*, March 1960, page 110), and the erection of the surge tank, 180 ft high and 38 ft in outside diameter, and the penstock. Mechanical and electrical features of the installation are very clearly summarized.

Selkirk Generating Station: The siting of this lignite coal burning plant, about twenty miles north of Winnipeg, presented no difficulty. Overall planning was based on a plant capacity of 400 MW, but only two 66,000 kW units are at present being installed. Layout and structural design are described only in relation to their effect upon the planning of the mechanical installation, as the paper is concerned primarily with mechanical design and equipment. Coal-handling equipment, water treatment and storage, and steam-generating plant are of chief interest.

Notes from *The Engineering Journal of Canada*, May 1960.

Steel Plant engineering: In an integrated steel plant, converting the basic raw materials into ingots, bars, and sheets of steel, materials handling absorbs 40 per cent of all production costs. This most interesting paper is primarily concerned with the handling aspect, but its presentation follows the sequence of steel-making processes from the delivery of ore and coal to the finished steel ingot. A recent development, the "Sinter" process, which is simply described, has involved large changes in plant layout and handling systems, but its elaboration within the last two years has increased iron production by 60 per cent, and reduced the coke requirement by 20 per cent, at a 35 per cent reduction in overall cost. It is interesting to learn that, in Canada at least, only 25 per cent of steel production goes into the most conspicuous markets, bridges, buildings, and motor cars. The greater part is absorbed in ironmongery, domestic apparatus, and other secondary industries.

South Saskatchewan River dam: It is a hundred years since the damming of the South Saskatchewan River was first mooted. The present project, of which some design details have yet to be finally decided, is a big-scale conception which will include:—

(*a*) A large hydro-electric power development in an area at present dependent on thermal plants,

(*b*) The provision of unlimited water supply for urban centres which are now ill provided for,

(*c*) Comprehensive flood control along a 400-mile reach of the river,

(*d*) Irrigation of half a million acres at present subject to severe losses through drought, and agricultural improvement over a much larger area.

Owing to the prevalence of deep river sand and soft shale, the design of the dam itself is unusual, with side slopes of about 1 in 8, increasing to 1 in 2 towards the crest. Completion is expected in 1965.

Deep pumping station for the Ottawa sewage treatment plant: This is a general description of a sewage treatment plant to deal with 40 million gallons of raw sewage per 24 hours, with a more detailed account of the design of the main pumping station. This station will extend to a depth of some seventy-five to eighty feet below ground level. Soil conditions and structural design are discussed, and the proposed mechanical and electrical equipment are briefly described.

PORT MANN GAS TURBINE GENERATING STATION: The Port Mann station is probably the largest gas turbine plant in the world, and the largest thermal plant to be fully automatic and operated by remote control. The installation comprises four 25,000 kW units, of which the first came into operation in February 1960. Its main functions are to supplement the existing 778,000 kW hydro-electric system under adverse water conditions, and to provide a standby for essential services. The primary fuel is natural gas, but the turbines will also run on crude oil, both types of fuel being immediately available by pipeline. The plant is to be unattended, fully automatic, and self-protecting, "push-button" control being exercised from Vancouver, 15 miles away. This quite short paper contains a lot of meat, and it is easy to read.

REMOTE CONTROL OF DUFFERIN FALLS GENERATING STATION: To those who are interested in, but puzzled by, the operation of remote control and supervision systems, this carefully planned and clearly written account will provide welcome information. The authors start with a convincing analysis of the pros and cons of remote operation, and clearly show that they are in no way bigoted. The descriptive text should be readily comprehensible to any engineer, as unnecessary technicalities and specialist jargon have been avoided, and the presentation is always interesting.

VEHICLES IN MUSKEG: This paper appears to add little of practical value to one published in *The Engineering Journal* for July 1959 (see *RE Journal*, September 1959). It is claimed that muskeg can now be regarded as a known engineering material, and that vehicles capable of all-season transportation, with payloads up to 20 tons, are available. These appear to be based on two fairly conventional tracked vehicles connected by an articulated joint, but very little practical data is given. The special "slipe" vehicle, referred to in the earlier paper, is not mentioned.

Notes from *The Engineering Journal of Canada*, June 1960.

This issue of *The Engineering Journal* is a symposium on the subject of water pollution and its control in Canada. The problem of water pollution, whether by oil, by sewage, or by chemical or other industrial wastes, is one which is exercising engineers in many parts of the world where population densities are increasing, and where industrial development gives rise to effluents which were not even considered when existing drainage and disposal systems were planned.

Many of the papers in this issue are necessarily parochial, since there is no standard combination of methods of measurement, nor standard method of treatment, which is applicable to all types of waste product, and to the varying proportions in which they are found in different localities. A great deal of information is, however, contained in the nine papers in this issue. The titles are:—

"Pollution in the boundary waters of Canada."
"Pollution control in the Lower Mainland communities of British Columbia."
"Stream pollution and its control in Alberta."
"The Greater Winnipeg sanitary district and river pollution abatement."
"Advances in sewage and waste treatment."
"The Ontario plan for water pollution control."
"Aspects of river pollution in the Province of Quebec."
"A study of the use, conservation and pollution of water resources."
"The measurement of industrial water pollution."

Notes from *The Engineering Journal of Canada*, July 1960.

DESIGN AND ERECTION OF STRUCTURAL STEEL FOR THE THOMPSON PROJECT: Thompson is the site of a mining development, some 450 miles north of Winnipeg. The main process buildings are a concentrator, built round the lower part of the headframe, so as to minimize the handling of ore, a smelter, and a refinery. All buildings except the reinforced concrete headframe are steel structures. Auxiliary buildings and the actual townsite, to accommodate a population of 8,000, are not discussed in this paper.

The first constructional task, in the spring of 1957, was the laying of a railway spur, 30 miles long, which still remains the only land connexion with the rest of the world. Since then all the steel work for the project has been completed, despite the difficulty of attracting labour to such a remote area, where sub-zero temperatures as low as 50 below are experienced in the three winter months. The main design problems were:—

(*a*) The very heavy loading due to equipment to be installed, some items weighing up to 300 tons.

(*b*) Necessarily generous allowances for snow loads, wind pressure, and the corrosive effect of fumes.

(*c*) The very high temperature differential between structural members exposed to atmosphere and those in the vicinity of smelter flues.

This short paper is so compressed that it is somewhat indigestible, and its illustrations are merely general view photographs, but the deliberate and thoughtful reader will find some interesting ideas.

MICROWAVE RADIO APPLICATION TO AN ELECTRIC UTILITY LOAD DESPATCH SYSTEM: This paper deals with the improvement of communications throughout a widespread and expanding system of power supply. Long sentences and a rather professorial approach make it difficult to read, and it is unlikely to stimulate the interest of the military engineer.

THE EVOLUTION AND APPLICATION OF LARGE SYNCHRONOUS AND INDUCTION MOTORS IN CANADA: Canada's consumption of electrical energy, per head of population, is rated the second highest in the world. Industrial expansion has created a demand for more and larger motors for pulpwood and other specialized machinery, as well as for motor-generator sets, and auxiliaries such as compressors, blowers, and pumps. Motor ratings of 5,000 to 10,000 h.p. are not uncommon. The historical background of modern development is interesting; the characteristics of synchronous and squirrel cage motors are clearly set out; and typical applications are instanced, with some good illustrations. For the electrical specialist there is a useful discussion of constructional and design aspects.

THE POTENTIAL IN THE FREE-PISTON ENGINE PRINCIPLE: This paper compares the efficiency and practical advantages of the gasoline engine, the diesel, the gas turbine, and the free-piston engine. The free-piston engine, though still in an early development stage, already has a higher actual efficiency than the more advanced designs of gasoline and IC engines. The author has successfully combined theoretical and practical considerations in a very clearly set out paper. He indicates the possibilities of improvements in design, but makes no claim that progress will be either rapid or startling.

LIQUID PETROLEUM GASES AS FUELS FOR AUTOMOTIVE ENGINES: It is desirable to find new markets for the use of butane and propane, which are by-products of oil and gas refineries. Attempts to use them in farm engines, to dispose of the summer surplus, do not appear to have been very successful, as performance is inconsistent, and the fire-risk due to leaks is unduly high. This rather theoretical paper does, however, indicate that research may achieve operating characteristics of practical value.

LOAD-FREQUENCY CONTROL SYSTEM OF THE MANITOBA HYDRO-ELECTRIC BOARD: The linking of neighbouring power systems confers on each of the participant generating systems the advantages of economy and increased reliability, especially when the respective peak loads are staggered. The regulation of tie-line flows is of course essential, especially at periods of unforeseen load disturbances. Corrective measures cannot be implemented quickly enough by manual operation, and an automatic system must be provided to deal with deviations in load or frequency. This paper describes such a system.

R.P.A.D.L.

THE MILITARY ENGINEER

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"Saline Water Conversion," by J. W. O'Meara. The increasing population of the United States is threatening many areas of the country with serious water shortage, now and in the future, and the development of methods of obtaining fresh water from either sea water or inland sources of brackish water has been entrusted to a special organization the Office of Saline Water of the Department of the Interior.

This article describes clearly, with diagrams, the basic principles of the methods being tried, distillation through artificial heat, nuclear atomic energy, or solar heat, demineralization by electrical and chemical means, and freezing. The cost factor is all important and considerable reductions have already been achieved. Large scale conversion plants of different kinds are in production some designed to give as much as 1 million gallons a day.

"Military Engineer Field Notes. Field Fortifications." A brief account with illustrations of the equipment available or under test for the rapid excavation of trenches and weapon pits. It consists of a portable firing stand for shaped charges and an air-transportable trench digger. Also described are a semi-rigid plastic dome and a similar article like an umbrella as alternative means of providing overhead cover, for weapon pits.

"Class 100 Heavy Raft." Brief description with illustrations of a specially constructed heavy raft which was developed in Germany by an Engineer Regiment.

"Land Navigation System." A description of a new light weight land navigation system which is being tested at the Engineer Research and Development Laboratories at Fort Belvoir. Capable of being mounted in almost any vehicle it provides a very valuable aid to navigation over poorly defined or unmapped areas such as the arctic, desert, or jungle.

"French Amphibious Ferry. (B.A.C.)". A short illustrated account of this amphibian which was tried out by the 3rd Engineer Regiment on manoeuvres in January. It can carry any class 20 vehicle, or 170–200 troops, or 20 tons of stores. A crew of four is needed and the B.A.C. can be prepared for water operation in 45 minutes.

"Labour Time Data for Construction Work" by Robert A. Olsen. The varied nature of the work on engineer construction and the absence of any large amount of purely repetitive work makes the assessment of the labour content of a job by the time and motion study system, so easily applied to factory work, inappropriate. This article describes methods developed in the USA which provide data which can be used as a guide when estimating the labour required and the timing of engineering construction works.

"Flood Damage Prevention in the Tennessee Valley", by Colonel James E. Goddard, Corps of Engineers Reserve. The Tennessee Valley Authority (TVA) is responsible for flood control in the Tennessee River system but cannot prevent all flooding. In order to limit damage from flooding data has been compiled from which local communities can see the areas which are liable to flood with the probable maximum extent. This data should enable them to plan preventive measures, prepare evacuation schemes and control building. The article is well illustrated and makes the methods by which the information supplied clear.

"Trussed Rafters", by E. George Stern. A description with illustrations of various types of light weight timber trussed rafters giving dimensions and details of the methods of jointing and fastening. Although there is nothing startlingly new there are interesting details which might be of use to anyone designing mass produced hutting or requiring rapidly erected groups of small buildings.

"Radio-active Waste Disposal," by Captains Raymond J. Einecigl and George E. Lear, Corps of Engineers. A useful clear summary of the problems involved in the disposal of radio active waste of all kinds and from different potential sources with a description of the solutions being adopted in the USA and Canada.

"Auger Drills for Foundation Shafts", by William A. Heath. A British firm, Economic Foundations Ltd, has developed equipment by means of which foundation shafts can be drilled using augers supported by booms attached to mobile excavators, which also supply the power, for operating the augers. Depths of 80 ft are reached and three sizes of augers are used, 3, 4½ and 7 ft in diameter. The article which is well illustrated describes the equipment and method of working and claims that great economies are effected.

"Asphalt Slurry Seal Operations," by Elmer G. Yemington. This is a very detailed and thorough account of the repairs carried out to the badly eroded surface of the runway at Cuba Point US Naval Air Force Station in the Philippines. Specifications of the materials used are given with detailed instructions on the methods to be followed in carrying out the work. The article has been written to give information on a method of maintenance and repair of asphaltic cement pavements which has proved quick and economical.

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"Assignment Suez Canal," by Colonel Charles M. Duke, Corps of Engineers. A description of dredging operations in connexion with the deepening of the Canal in Port Said and the Bitter Lakes carried out as a contract between the US and Egyptian governments under which the sea going hopper dredger *Essayons* operated by the Corps of Engineers was hired to the Suez Canal Authority.

Essayons is the largest of the dredgers operated by the Corps of Engineers and has been designed to function anywhere in the world under ocean conditions. There are good maps and illustrations with a brief description of the salient points of the design of the *Essayons*.

"Combat Engineers 3. Rescue at Wheeler Point," by Kenneth J. Deacon. A short spirited account of an action in the course of the recovery of the Philippines from the Japanese in which the Engineers of the Boat and Shore Regiment manning LCT's acted with conspicuous gallantry.

"Engineers at Agadir," by Lieutenant Perin Mawhinney, 1st Lieut, Corps of Engineers. The earthquake at Agadir took place at about midnight on 1 March 1960. A US engineer unit was sent with mechanical equipment and transport by air from Pirmasens in Germany starting to arrive in Morocco early on 3 March. This well illustrated article describes the arrangements made for the move and the work carried out by the unit.

"Nuclear Power for Navy Shore Bases", by Commander Wayne J. Christensen, Engineer Corps, US Navy. This article gives an outline description of various projected nuclear power plants suitable for use at remote shore installations of the US Navy to overcome the difficulties of the supply of fuel to many widely dispersed places. One requirement is that the power unit must be transportable and relocatable and for this non-self-propelled barge units have been designed of 5,000 and 200–400 kW respectively.

A requirement for a 20,000 kW nuclear power plant for the Island of Guam has been a subject of study by the Navy Bureau of Yards and Docks and a barge mounted plant and a plant mounted on a mobile pier like Mulberry have been considered.

Another requirement is for nuclear power plants in Antarctica where a temperature range of plus 35°F to minus 100°F is experienced. A study of the economics of the problem showed that for outputs of over 1,200 kW, even allowing for 100 per cent diesel standby, the nuclear plant is cheaper.

The article ends with a description of the probable features of a proposed skid mounted set for Antarctica which can be packaged and transported by air.

"High Temperature Water Systems", by Owen S. Lieberg. This article which is illustrated by diagrams and photographs describes the design and operation of high temperature systems and gives a summary of their advantages. Recent improvements in design, particularly the control of pressure by the use of compressed nitrogen, are described in some detail.

"Protective Coatings for Shell Structures," by Alfred J. Northam. Describes a synthetic rubber, Hypalon, a recent product of du Pont high polymer research. The article opens with a description of its use as a protective coating for thin shell concrete construction, of which a great deal has been carried out in the United States since the war, and goes on to detail other uses for it. It is highly resistant to most chemicals, can withstand high temperatures and can be applied as a protection covering by all commercial methods. It has been used for hoses and tank lining.

"Hasty Demolition of Concrete Bridge Piers," by Howard J. Vandersluis. A description of experiments carried out at the Army Engineer Research and Development Laboratories to determine the most effective ratio between the thickness of the explosive and the explosive-target contact area, and the best point at which to apply the charge. As a result of the experiments considerable reductions in the amount of explosive required for any particular target can be made provided the thickness area of contact ratio for the dimensions of the pier to be attacked is correct. The results have been worked out in terms of units of service army explosive packs.

The article is illustrated with photographs and tables.

"The Army Mobility Research Centre," by Colonel S. J. Knight, United States Army Reserve. A detailed account, well illustrated with photographs, of a laboratory and its equipment which has been established by the Army Corps of Engineers to study the basic principles and the fundamental laws that govern movement on the ground surface. It is believed that this study will lead to the production of Army ground vehicles with the highest mobility characteristics across country. The author stresses how development in vehicular movement on land has lagged behind air transport which he attributes to lack of basic knowledge of the factors. Cross country movement must be far freer than ever before to meet the needs of future war.

"Impasse or Opportunity," by Lieut-Colonel John E. Burke, Corps of Engineers. This article describes two suggested designs of assault bridging capable of taking heavy equipment and which can be installed by small numbers of troops in the least possible time. Both designs are based on the use of float positioned piers a combination of the trestle, spud and jack using an amphibian vehicle to move it into place. Two, transoms or more are built around or into the chassis of an amphibious truck which carries decking, posts with footings and other auxiliary equipment both on land and in the water. In one design the roadway is made up by each pier butting on the next; in the other, which is considered the most economical, the piers are connected by spans of the Armoured Vehicle Launched Bridge. There is nothing to show in the article whether either scheme is under active examination. J.S.W.S.

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