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Editorial

The Defence White Paper in February 1968[1] firmly directed the National Defence effort to the support of NATO. While 1 (Br) Corps was clearly established as part of Northern Army Group before that date, there was not necessarily any particular impetus to fully integrate British thought, philosophy and tactics with those of our NATO Allies. We, the British, still had other problems which, at least in our minds, were as important as any need to foster harmonious and healthy dialogue on military matters relating to central Europe. This might be hotly disputed by anyone who served in Germany during the last decade. However, for those serving elsewhere, Europe was just one of a number of possible theatres of war. Since the Berlin airlift in 1948, and the erection of the Berlin Wall in 1961, the Cold War had become possibly not so cold. Malaya, Borneo and even American action in Vietnam had turned our thoughts elsewhere. Action, the likelihood of the need for action, seemed least likely in Europe. NATO shield forces had fulfilled, and continued to fulfil, their role. Absolute priorities were lacking.

The impact of 1968 Defence White Paper was not immediate. It has needed time to clear the cobwebs of post-imperial problems. In addition the rapidly escalating costs of modern weapons and weapon systems has forced all nations to a degree of inter-dependence and co-operation with each other in a common cause. But the search for areas where such co-operation is possible is not easy. Political difficulties and attitudes create differing approaches to national military problems and this in turn leads to evolution of military thought along different routes. It would be strange if this were not so.

It is therefore not surprising that there is now a mounting urgency to rationalise military requirements within NATO and Northern Army Group. The first step must be understanding of friendly, though sometimes opposing, military points of view.

Late in 1970, the Engineer-in-Chief Army, Major-General R. L. Clutterbuck, invited the Chief Engineer of Northern Army Group to bring to the RSME Chatham senior officers of all arms, from each of the four Corps in Northern Army Group. The idea was accepted and a study period was held at Chatham from 4–6 May 1971 at which officers from Germany, Belgium, Holland and the United Kingdom were present. Other observers also came from CENTAG and from AFNORTH, as well as from The Staff College, The Arms School and Research and other establishments within the United Kingdom.

The theme for these discussions was the role of engineers within the tactical battle as envisaged in Central Europe. It would be quite wrong to suggest that agreement was reached on all points discussed since certain differences of concept were crystalised. Nevertheless the value of these discussions was clearly apparent to all those who attended the study period, and the interest engendered seemed apparent among all arms and all nationalities represented. We, as a Corps, can be truly grateful to them for their wholehearted participation throughout the three days. We hope that they will have gained some further insight into the ways in which Military Engineers, of whatever nationality, can help them in a most difficult and potentially rigorous task. And perhaps this study period may prove to be the forerunner of similar international meetings of the future.

[1] Cmnd 3540

Engineers in General Management—The Army's Experience

On 23 November 1970 Major-General R.L. Clutterbuck, OBE, MA, C Eng, FICE, then the Engineer-in-Chief, presented a paper for discussion to the Engineering Management Group of the Institution of Civil Engineers. The paper was published in the December 1970 issue of the RE Journal.

A report of the presentation and discussion, prepared by Colonel P. F. Aylwin-Foster, MA, C Eng, MICE, is printed below by kind permission of the Institution of Civil Engineers.

IN his introduction General Clutterbuck compared the relative roles played by civil and military engineers in their respective fields of higher management. He claimed two proprietary interests in his subject. First, as the Army's Engineer-in-Chief he counted himself a "B"-stream general because the Royal Engineers lost their "A"-stream generals to command of organizations other than engineers. Second, he was about to hand over his job and become the senior Army instructor at the Imperial Defence College, now called the Royal College of Defence Studies, the Services' senior management school, and therefore had to confess that his paper was a big plug for the Army's management training.

Civil engineers were inclined to point out, with some truth, that because too few of them reached higher management posts in industry or in government, there was inadequate professional consideration of engineering factors in decision-making and in the formulation of policy. This lack of representation at top level, the level which included both the most lucrative and the most influential posts, had also resulted in engineering graduates having to face an expectation of a lower average income at all stages of their careers than those of graduates in other disciplines, especially of lawyers and accountants. The engineering profession in competition with other professions therefore attracted a lower standard of entrant in terms of both academic and managerial ability. Linked to this had been the tendency to over-specialize the training of engineers at university, though happily there were now trends towards a wider education.

The blame for this state of affairs lay largely with the engineers themselves. Too many of them got more satisfaction from their technical achievements than from handling administrative problems or winning victories in board-room politics. In some countries technically trained men did reach the top, but in the UK, with its long tradition of non-technical arts-trained Boards of Directors, civil engineers would not achieve similar success unless they were more willing to become administrators and to prove themselves able to compete successfully in the open market for higher management.

The situation with military engineers appeared to be rather different. The Corps of Royal Engineers provided only 9 per cent of the strength of the Army, but the Army's "Board of Directors", although containing no engineering post, had never for the last twenty-five years been without at least one Royal Engineer amongst its five military members. This Army Board managed about 150,000 men and had an annual budget of just under £700 million. In higher management posts as a whole, embracing the ranks of brigadier and above, the Royal Engineers also had a higher proportion than any other arm; and because this had been so for more than a generation the Corps had consistently attracted the highest average quality of intake for its officers. A brigadier—a one-star general—could be equated to a man managing a labour force of around 5,000. In the hierarchy of the Ministry of Defence, both in the Army Department and in the tri-Service Defence Staff as a whole, the Royal Engineers were currently represented in every main branch or department by at least

one man at one-, two- or three-star level. Consequently no major decision was reached without the participation of an officer trained and experienced as an engineer. Possibly the only other body which could claim to have its representative in every corner of an organization would be the Communist Party!

This happy situation could broadly be ascribed to three reasons. First, although the Corps was small compared with some of the very large organizations in the world, it was widely spread. Its 15,000 men were currently spread over nineteen countries and involved in over thirty relatively small scale operations. These embraced a wide variety of tasks, ranging from supervisory roles for individual officers to sizeable construction tasks for field squadrons of 200 men. This sort of commitment, involving as it did small organizations, meant that junior RE officers gained much independent responsibility when young, and this was the essence of basic management training. Second, and this perhaps would be the key with which to open general discussion, the best officers of all arms in the Army spent much more time than their civilian counterparts on junior, middle and higher management courses. This resulted not only in better management throughout but in giving the engineers the chance to compete on equal terms for the top jobs. Third, it was RE policy to "spare" its best officers whenever they were in demand for general staff or management posts, and indeed to consciously push them for such posts.

To illustrate the career pattern of an RE officer rising to the highest management, General Clutterbuck compared the careers of three specific officers currently serving who had either reached the top or looked like so doing. The most significant point to emerge from this comparison was the large proportion of their time which these officers had spent either attending management courses or instructing on them. In the example of the four-star general, who was now on the Army Board, out of a total of thirty-five years' service he had spent three years on such courses and five years instructing on them. Another significant point to emerge from the pattern was that an RE officer destined for the very top seldom, if ever, filled an engineering post after the age of about forty-two. Thereafter he would alternate between staff and command appointments which involved the management of all arms rather than of engineers alone.

The system of training Army officers for general management included attendance at two or three management courses at appropriate intervals in their careers. Staff College, which the officer attended in his early thirties, was the Army's own middle management school. This provided courses of one year's duration for officers of all arms, and was specifically aimed at widening their horizons and at training them for general management outside their specialist arm of the service. About 25 per cent of Army officers went to Staff College. Those who were likely to be in the running for top management jobs not only attended this course but were always instructed there by officers who themselves were likely to be going fairly high. Another course of one year's duration was provided by the erstwhile Imperial Defence College, now called the Royal College of Defence Studies. This was the senior management school for all three Services and was attended in their late forties by officers destined for the highest management posts. It was also attended by representatives of the Civil and Foreign Services and of Commonwealth and European countries and the United States.

The question which would undoubtedly be asked was whether any organization in industry, be it engineering or otherwise, could afford to divorce some of its best men from productive work for a year at a time in order to study or teach management. Obviously the problem would be greater for small firms. In the Army a man was written off completely while attending one of these courses but he still drew his full pay. The only conceivable way in which similar practice could be followed by small civil firms would be for such courses to be run and financed by some central body such as the Confederation of British Industry, or by the Government in the interests of industry as a whole. But even this would not work unless the manager who was struck off one job to attend a long course was assured that the status and

prestige he would acquire from that course would get him a better job than he would have got without it. Clearly there had to be an incentive. In the Army's case, unless an officer attended some kind of management course he would not attain higher management, either in engineering or otherwise. This was the contrast.

Experience in the Royal Engineers had shown that, as in the civil engineering profession, good management pays more than it costs. The Royal Engineers, like the Army as a whole, had to work on a very tight budget, and any mistake in management could cost a great deal. Indeed the cost of bad management could be so much higher than the entire salary consumed by a man in his whole service that it was better to write off, say, 15 per cent of his time in educating and re-educating him at regular intervals than to risk the cost of bad management. Difficult as it was, therefore, to "lose" some of the best officers by pushing them on to management courses, the question in the case of the Royal Engineers was not whether or not the Corps could afford to do this, but whether they could afford not to. In General Clutterbuck's view the answer was not in doubt. Moreover the "loss" of so many of the best RE officers into general management appointments held every advantage for their Corps in the long run.

The first speaker referred to the Introducer's comment on the civil engineer's apparent lack of effect in policy-making and decision-making in industry. In their military equivalent the Royal Engineers overcame this problem by driving firmly into the newly commissioned officer's head the importance of being not merely a good engineer but a good soldier. Success in this regard meant that the young engineer officer's advice was respected by officers of other arms, whereas failure would have resulted in his advice being ignored. The lesson here for civil engineers was that their younger members must be encouraged to take wider interest in things going on around them and not just act as hired experts to do the technical work when someone else had completed the planning.

The second speaker pointed out that there was a long history behind the comparative success of military and civil engineers. Armies were the foundation of engineering; they had invented it. Not so many centuries ago the name "engineer" had been exclusively a military term. Civil engineering on the other hand had been invented twice, first by the French in the mid-eighteenth century and again by the British some fifty years later. The French version had been exclusively a para-military affair as a result of which engineering in France had always enjoyed great prestige. French engineers had proved themselves perfectly capable of holding high office in the State and had risen even to the ranks of Premier and President of the Republic. The later British version, however, was the product of tradesmen on the make, which undoubtedly accounted for the current popular image of grimy hands and a spanner in the hip pocket.

The third speaker deprecated the protestations of the civil engineers referred to by the Introducer and suggested that those who complained most loudly about being under-valued would be better employed in getting on quietly with their job. There was of course no reason why engineers should not seek higher management appointments, if such was their ambition, but they would surely do more for the profession at large if they first made a success of their chosen calling.

It was important to test the validity of the Introducer's argument and the assumptions underlying it, because any intended comparison between the Army and industry might be misleading for a number of reasons. The Army was not a commercial undertaking, and was concerned neither with competition to stimulate nor with trade unions to exasperate. Certainly budgetary limitations might exist but the pressures could not be compared with those in industry. The internal discipline was probably better and sanctions other than salaries were undoubtedly operative. Army officers undertaking long management courses were bound to serve for at least a further five years, but this sort of restriction could never work in a civil firm. Younger engineers should certainly be sent on management courses, indeed this was now standard practice; but it would startle many professional engineers, and many

general managers too, to suggest that the best engineers should leave their strictly engineering activities in the early forties and confide the direction of professional matters to a "B"-stream of older men.

The fourth speaker believed that since only about one per cent of the engineering profession or any other profession could expect to attain a top management job, certainly in local government, the remainder would do well to concentrate on the achievement and subsequent maintenance of professional excellence. In his own case, given the choice between his present job of leading a team of twenty dedicated professionals, all belonging to his own discipline, and a top management job involving the control of 800 council workers with their attendant strike problems, he would not take the latter for an extra £500 per year; but he might for an extra £3,000. Even the leader of a small professional team must be a pretty good manager if he was to deploy his team's skills with maximum efficiency, but he must never avoid carrying the can technically on the pretence that he was only a manager. The study of management, therefore, should never be allowed to swamp professional excellence. Regrettably in local government at the moment the management doctrine was being flogged without any reference to the different levels at which management must be applied. There was a danger of creating a race of super-managers who would have no super-professionals to manage because the young men who would have preferred to be professionals would be looking elsewhere for a proper use of their skills.

The fifth speaker applauded the decision of the Council of Engineering Institutions to institute a paper called "The Engineer in Society", its object being to give the young engineer an insight into management and persuade him to go further. He did not agree with the previous two speakers. The trained engineer who became so interested in his job that he had no time to concern himself with general management was taking a short-sighted view. All too often it was the application of engineering knowledge at the higher level which was sadly lacking. However, there was no doubt that we also needed the specialist, and the real difficulty would be in deciding who to make specialists and which budding specialists to lead away from the purely technical side into general management. The CEI's new paper was a step in the right direction and might induce more men to go for the management side.

The sixth speaker doubted whether the Introducer's interpretations of the terms "management", "higher management" and "general management" were the same as in industry, and therefore whether his analogy could be correctly drawn. Young RE officers undoubtedly controlled the security of enormous assets, but their civil counterparts had the additional task of making a return on these assets, moreover against competition. If the paper's title had read "General Production Management" instead of "General Management" the whole problem would have been much clearer and the difficulties in the civil world emphasized. When a professional engineer was working on a large project, say a motorway, how was he to be trained in the skills of general management which must include industrial relations, planning cost control and accountancy and, most important of all, marketing and selling? The Army's system of interchange between staff and field operations was excellent, and was one which industry should try to emulate however difficult.

The seventh speaker said he had been a Sapper for twenty-eight years and was now a director of a civil engineering firm. In his view all Army officers automatically committed themselves to be managers the moment they joined the Army, but the same was not true of civil engineers, the great majority of whom were far more interested in being engineers than in being involved in general management. Research and development attracted them much more than production engineering. In industry the majority of companies were small specialist companies who inevitably were interested in specialists, whereas by and large the Army was interested in "generalists". A Sapper officer must know and talk the language of a wide variety of civilian engineers, especially in war-time, but he could not expect to attain the same degree of expertise in any particular line. Many civil firms believed in management instruction but could not send anybody away on a long course for fear that as soon

as the man was better qualified he would leave them to join a competitor. They therefore relied on the short courses run by the British Institute of Management, or if they needed a specialist went into the market and bought him.

The eighth speaker felt that much of the discussion was following the wrong line. Instead of considering whether or not the country would benefit if engineers were managers, speakers had tended to argue about whether or not this would be profitable for the engineering profession. A study of the twenty-two million incomes in the country and the percentage of the higher among these held by engineers would reveal that overall engineers were already doing pretty well. An earlier speaker had described nineteenth-century engineers as tradesmen on the make, but this was precisely what top businessmen were today. It was the motivation to have a large income coupled with the ability to attain it which produced today's managers.

The real problem had been well put by Anthony Wedgwood-Benn in an article in *The Engineer*. Talking about the place of the engineer, he had said: "For my part, I should like to see more qualified engineers on local authorities and as Members of Parliament. They could make a unique contribution, and we are pitifully short of them. But what is more important is to have more engineers assuming their full responsibility as citizens and saying loudly and clearly what they think needs to be done. There is so much they could be saying and yet so little of it seems to be said. In the end the community will take as much interest in the engineers as the engineers seem to be taking in the community. The problem of the image is almost as simple as that."

Another aspect of the problem lay in the selection of potential engineers and in what type of person made a good technical engineer. The Introducer believed that good engineers could make good managers, but there was growing evidence in the psychological field that the sort of mental abilities that make a good engineer in the sense of the designer will almost inevitably make a poor general manager.

The ninth speaker, introducing himself as the Management Development Officer of his company, said that the real aim of his work was to teach men to be ready to deal with a situation, which basically was the prime purpose of the Army. In the civil world the situation was with us all the time while in the Army it turned up in varying forms at various intervals, but the difference between the two was not as great as it was sometimes made out to be. He agreed absolutely with the Introducer's contention that the "loss" of some of the best engineers into general management could only lead to long term benefit for the profession; and, disagreeing with the last speaker, he firmly believed that an engineering approach to management problems was very often a very valuable approach to set alongside the approach of the accountant or the lawyer. It was often more positive. The present lack of engineers in industry's top management, apart from the historical reasons mentioned by a previous speaker, was due largely to a lack of engineers in government, civil service and politics. Few large firms could exist without being on proper terms with the government, and a non-technical government produced non-technical industry.

Promising managers were already being sent on courses, but a course duration of even three or four weeks was considered excessive. A year would be unthinkable. Internal courses within the firm were valuable, but did not provide the great advantage of a staff college which enabled people to unhook themselves completely from the hurly-burly of day-to-day problems for long enough to generate some real, useful thinking. There was more than a grain of truth in the saying that "Managers do not have time to think".

Industry always took the view, already expressed by several speakers, that the Army and industry were totally unalike, that the Army was not commercial and was not concerned with profit. This argument was not entirely convincing. Clearly the Army was concerned with setting objectives, using resources without wasting them, and getting results; and although industry was not quite in the same business the two were more alike than industry was willing to admit. There was much to learn from the Army's system of training its senior managers, and perhaps the Army could

help by spending a little more time in showing how much there was in common between it and large industrial organizations.

The tenth speaker thought the Introducer had laid insufficient stress on the useful management training that every Army officer acquired from his ordinary command responsibilities at regimental duty. For two weeks every year he himself was a junior commander in General Clutterbuck's organization, in charge of a small RE management team, usually in the Mediterranean; and there was no doubt he had gained enormous benefit from this experience, albeit at a fairly junior level. Over sixteen years he had now enjoyed some thirty-two weeks of this useful management training. Some form of voluntary training could be extremely valuable to any junior civil engineer, and the TAVR Royal Engineers offered excellent opportunities for progressive management experience.

There was a tendency to underestimate what the civil engineering profession had done in the past in preparing its members for general or higher management. The CEI's new paper for the professional interview was entirely commendable, but at least twenty years ago the engineering students at London University were spending 20 per cent of their final year, one day a week, at the London School of Economics, broadening their outlook away from engineering and technology.

The eleventh speaker interpreted the moral of the Introducer's paper as being that successful progress in an engineering career was best achieved by going into management as early as possible. This was certainly true of men who had spent their careers abroad. But important as the management aspect might be, it must be remembered that both civil and military engineering needed a very strong scientific side. Other professions recognized sheer professionalism as distinct from management, for example medical consultants and lawyers; so apart from encouraging men to go into management, steps should also be taken to encourage them to enter the scientific side of the profession. There tended to be a weakness here in civil engineering organizations abroad. Looking at another aspect of the problem, it was a pity that engineers were so reluctant to promote their work, tending to regard this as unprofessional conduct. Using the law as an analogy, any counsel retained to look after one's interests was expected to present his case not only in proper legal form but skilfully and fairly. Engineers were too prone to weight the legal aspect, at the expense of promoting their work with skill and complete fairness.

As twelfth speaker, the Chairman mentioned that one of his problems as the man currently responsible for UK operations of his firm was the provision of staff for overseas contracts. It was always a wrench to have to give up good people for contracts outside his own concern, but he had found in recent months that the man returning from a year or two overseas, having worked on jobs completely different from the normal run, had benefitted greatly. The apparent "loss" of good men had, therefore, paid off as good policy. Several speakers discussing the failure of engineers to reach the boardroom had referred to the comparative success of the lawyer and the accountant, but perhaps even stronger competitors in the future would be the quantity surveyor and the procurement manager.

In reply General Clutterbuck expressed gratitude for the very interesting and stimulating discussion which apparently his paper had provoked. It was far greater than he had anticipated and he had learnt a great deal.

The speaker who had corrected him for undervaluing the importance of regimental duty was of course absolutely right. It was the young man in charge of a job on the ground who was really learning basic management. This was where the good managers were picked and where they proved themselves; their performance there was the basis of their selection for management courses and higher management.

Replying to the comment about the value of part-time soldiering to the civil engineer, General Clutterbuck said that the Royal Engineers in their turn were enormously grateful to the TAVR and the civil engineering profession as a whole, and this applied as much in peacetime as in war. Not a month went by without the Corps receiving invaluable assistance somewhere in the world from its voluntary

spare-time soldiers. At this moment there was in Oman a TAVR geologist, who at fourteen days' notice had dropped his job for three weeks and gone off in uniform to make a survey which would enable the Sappers to get on with a project at great speed.

Another speaker had mentioned the value of management teams overseas. There was no doubt that small teams of men operating in remote parts of the world and managing large numbers of local people, either as directly employed labour or as contractors, had tremendous opportunities for picking up the techniques of good management.

The most controversial point in discussion had undoubtedly been "Do good engineers make good managers?" Some speakers thought they did, others thought not. The facts and figures quoted in the paper proved conclusively that in the case of the Army they did. In open competition with other arms the Royal Engineers had attained a greater proportional percentage of the higher management posts—brigadier and above—than any other arm. This applied equally at the highest level, the Army Board. If, then, good engineers did make good managers—and there was overwhelming proof that they did when they wanted to—did the engineering profession wish to contract out in favour of lawyers, accountants or other professions? Was the profession content to leave its management and the direction of its affairs and finances to people of other disciplines? Two of the speakers had declared themselves content; perhaps a number were content. But quite a number were not. In the engineering department of a certain firm of 7,000 employees, the chief mechanical engineer and his deputy were the only two engineers drawing more money than the skilled fitters on the floor. Was the engineering profession content with this sort of situation? The chief mechanical engineer in question certainly was not, and nor should his profession be. In this situation, would the profession attract the best from amongst the young? Few of the engineers who had graduated at Cambridge five months previously had gone into civil engineering in the United Kingdom. It was not lack of money which had deterred them but lack of prospects. They had gone into other fields.

On the subject of long management courses it was of course indisputable that any firm's successful candidates would be tempted to transfer their allegiance to a rival firm. This problem would only be overcome when centrally-run and centrally-financed courses were available, carrying with them a status which would both enable the candidate to get a good job elsewhere and enable the firm which had lost him to pick up someone else with the same qualification.

Concluding, General Clutterbuck said he was convinced that engineers did make good managers, and indeed could make the best. The real question was whether they wanted to contract out.

Those taking part in the discussion were:

Messrs Broad, Cantrell, Duke, Glover, Greenfield, Hancock, Harris, Hill (Chairman), Knill, McGarey, Nicholson and Winston.

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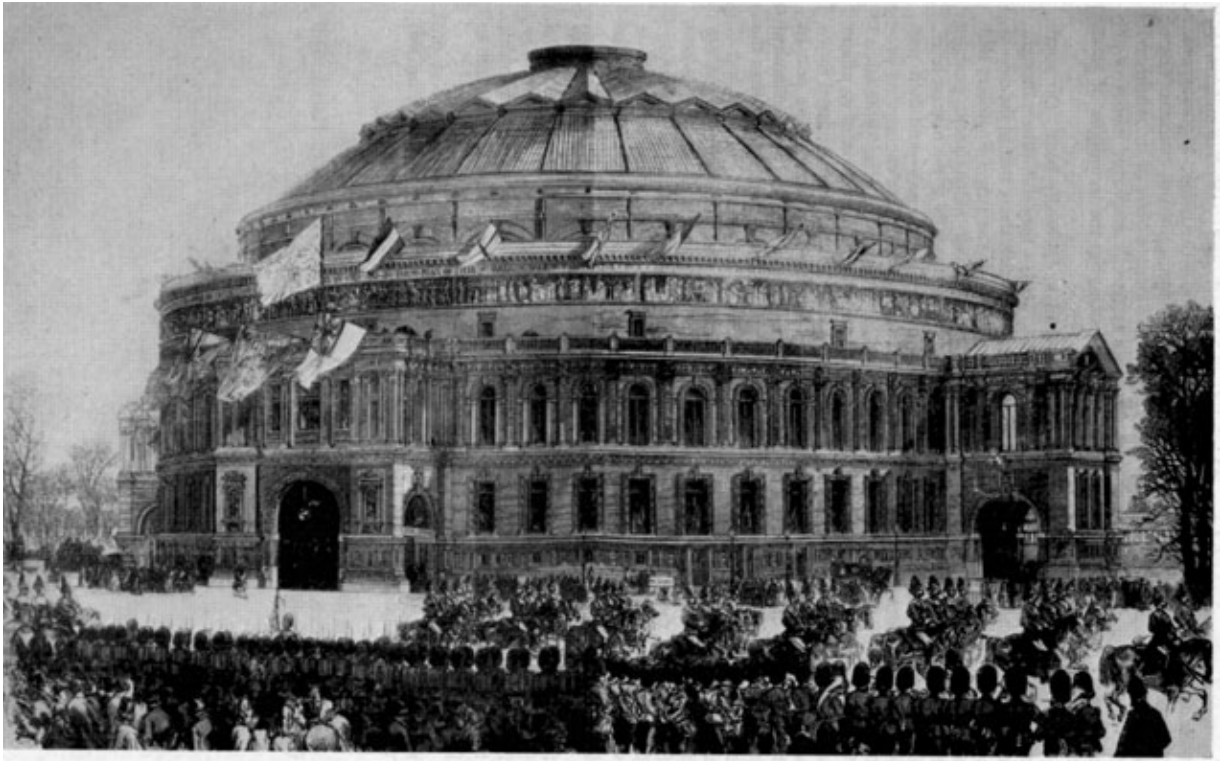


29 March 1871

Engineers In General Management - The Army Experience

29 March 1971

Reproduced by kind permission of Mr Frank Munday, Manager Royal Albert Hall.

Her Majesty Queen Victoria wrote in her diary on the evening of 29 March 1871: 'At a little after twelve, started in nine dress closed carriages (mine a pair of creams) for the Albert Hall for its opening. I drove with dear Alix and Ernest Coburg. Immense and very loyal crowds out. Bertie received us at the door and then we walked up the centre of the immensely crowded Hall, 8000 people were there, which made me feel quite giddy. Bertie read the address from the dais to which we had been conducted, very well, and I handed him the answer, saying: "In handing you this answer, I wish for its complete success". This was greatly applauded. The National Ahthem was sung, after which Bertie declared the Hall open. Good Mr Cole was quite crying with emotion and delight. It is to Colonel Scott of the Engineers, who built the Hall, that the success of the whole is due.'

This was indeed a great tribute to Colonel (later Major-General) H. Y. D. Scott, CB, Royal Engineers, and it is perhaps worth recording why a Sapper officer, rather than a practising civilian architect, should have been chosen to design and build the Hall erected for "the advancement of the arts and sciences and the works of industry

of all nations in fulfilment of the intention of Albert, Prince Consort", and what caused the Prince to express that wish.

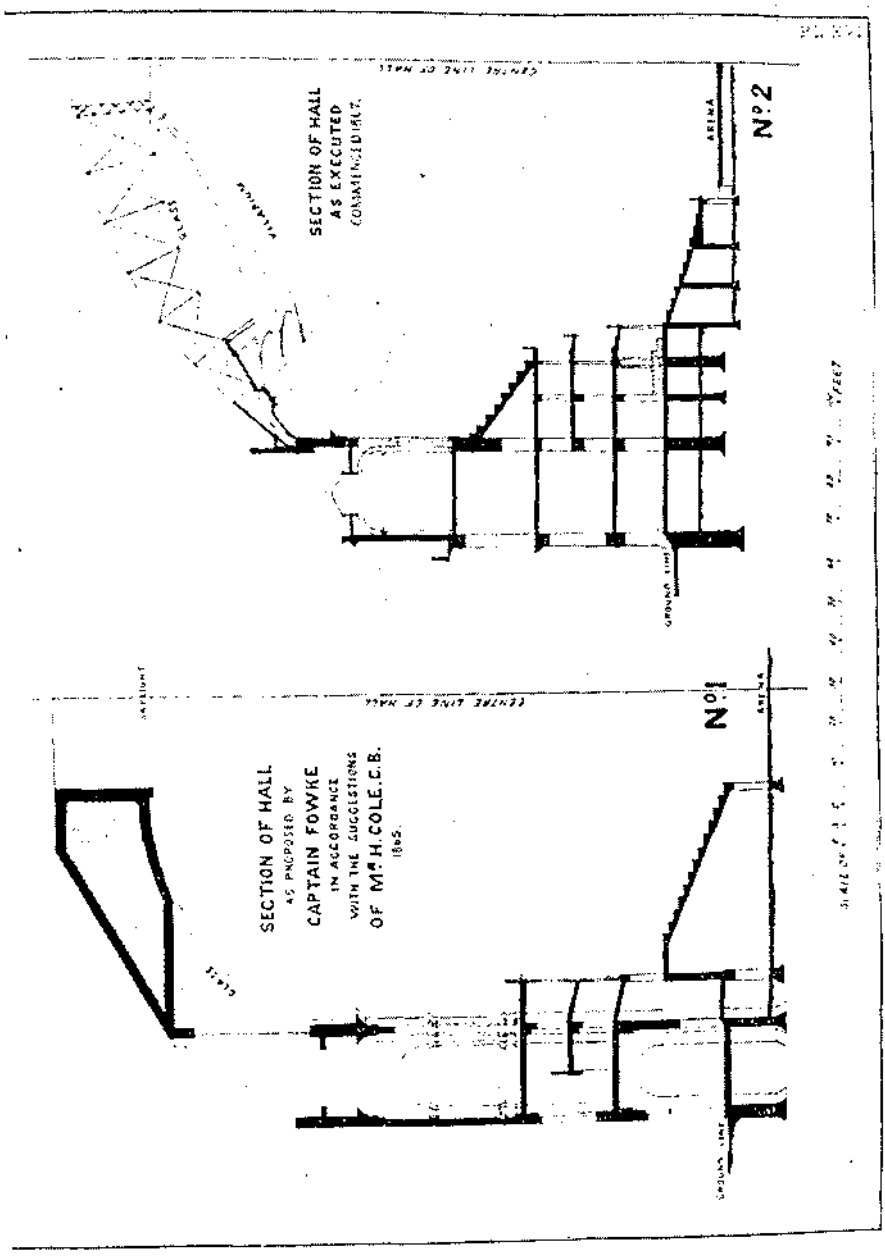
The story dates back to the International Exhibition of 1851, instigated by the Society of Arts of which the Prince Consort was President and Mr (later Sir Henry) Cole a prominent Member. Lieut-Colonel W. Reid the CRE at Woolwich, which was then the Depot of the Royal Sappers and Miners, was appointed Chairman of an Executive Committee of the Society charged with producing an International Exhibition for the display of "the Industry and Art of all Nations". By the time the Exhibition opened on 1 May 1851 Lieut-Colonel Reid had twelve Royal Engineer officers working under him superintending various departments of the Exhibition and two Companies of Royal Sappers and Miners employed on a whole host of varied duties. In a note to the Master General of the Ordnance the Prince Consort expressed his gratitude for the admirable conduct of the whole body whilst engaged in this novel, delicate and responsible duty and stated that their employment afforded another instance of the useful manner in which a military body might be employed in civil services in time of peace. The redoubtable Richard Cobden, arch-enemy of the Whitehall Hawkes, went even further by announcing that in his advocacy for military retrenchment and reduction in the strength of the Army he would never seek to carry out these views in the Corps of Royal Engineers. None of the criticisms he had levelled against the "popinjays in uniform" could, in an era of gathering scientific momentum, be applied to them.

Our stock stood high and, after the Exhibition closed, a number of Sappers continued to be employed by a newly-formed Science and Art Department at South Kensington.

Among them was Captain Francis Fowke who, until he died on 4 December 1865 at the early age of 42, continued to work there. He was employed as Secretary to the British Commission to the Paris Exhibition of 1854, and he designed the buildings for the International Exhibition of 1862 (our EXPO II). He also designed the Victoria and Albert Museum at South Kensington and many other museums, picture galleries, libraries and horticultural gardens throughout the country. During Fowke's time with the Science and Art Department a large museum and educational complex grew up in the Kensington area and, before his death in December 1861, the Prince Consort had expressed a wish to Mr Cole that a building should be erected that would be its focal point. Mr Cole drew a rough sketch for the building which was passed to Captain Fowke who prepared preliminary designs and a model of what was to become the Albert Hall.

Colonel H. Y. D. Scott succeeded Fowke as Architect to the Science and Art Department and at once took up his predecessor's unfinished work. He made many alterations to the original design which are clearly shown in the drawing accompanying this article. The main change was the introduction of the enormous dome that roofed the building. The novelty and daring of the design caused much stir at the time and many leading architects, and indeed several of his brother Sapper officers, doubted its safety. However Scott was undismayed and, when the time came for removing the scaffolding supporting the roof, he so arranged matters that he knocked away the last support, everyone else having been ordered out of the building. It is perhaps a sign of the times in which the Hall was built that it was completed on schedule and the building costs were kept within the estimate of £175,000. Inflation and labour difficulties were practically unknown a hundred years ago.

The Opening Night was a great occasion. Edward Prince of Wales, on behalf of the Queen, declared the Hall open. The Archbishop of Canterbury said a prayer and a chorus and orchestra of 1,200 gave a powerful rendering of a cantata composed by the late Prince Consort. Among the large audience there were fifty members of the Royal Family, Ambassadors, Mr Gladstone and Mr Disraeli, Civic Dignatories in full regalia and a vast host of the Aristocracy and commoners with their ladies. Many gentlemen sported light or dark blue favours to show their allegiance to the contenders in the Boat Race held three days later.

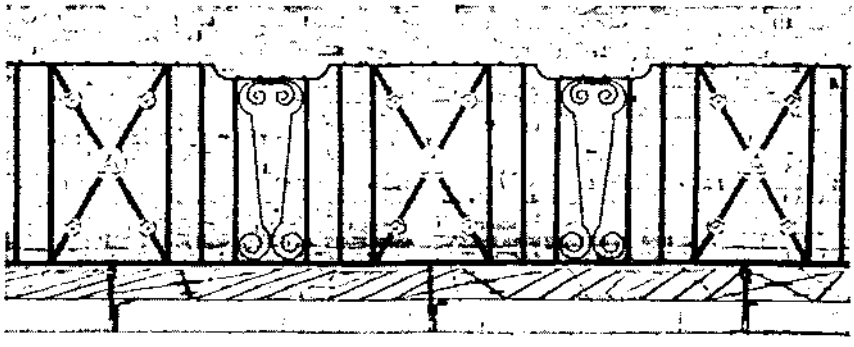

SECTION OF HALL
AS EXECUTED
COMMENCED 1867.
ARENA
No 2
SECTION OF HALL
AS PROPOSED BY
CAPTAIN FOWKE
IN ACCORDANCE
WITH THE SUGGESTIONS
OF Mr H. COLE, C.B.
1865.
No 1
ARENA

The infamous echo plagued the Opening Night and architectural verdicts ranged from "a monstrosity" to "the finest building in Europe since the Pantheon". The Hall has now been cured of its echo and has become an integral part of the London landscape and a national heirloom. The varied uses to which it has been put would have surely delighted, and at times horrified, that wise and far-seeing Prince whose wish it was that it should be built and in whose memory it was named.

A hundred years of weathering, London's fog and smog and near misses from German bombs, V1s and V2s have left their mark on the famous Hall and a Restoration Appeal was opened last year to raise £500,000, just under 2½ times the cost of building it a century ago. About £3,500 has already been raised and it is hoped that the target figure will be realised. The Chief Royal Engineer was one of the sponsors of the Appeal and the Corps Committee proposed to Sir Louis Gluckstein, President of the Council of the Royal Albert Hall, that—rather than responding to the Appeal by a monetary gift—it might support the cause by manufacturing in Royal Engineer workshops some item of the Hall's structure or its furnishing as was done in the case of Coventry Cathedral.

The proposal was willingly accepted and, as a result, a Commemorative Plaque, to a design agreed by the Royal Society of Fine Arts, was made in the E & M School Workshops by Mr R. Thomas. The Royal Albert Hall Management Committee also agreed to the production of a wrought iron screen to protect the plate glass window in the Main Entrance and the Commemorative Plaque. The screen was made to an E & M School design incorporating scroll work and a phospor bronze A (Albert) motif and a rose motif, copied by epoxy dough moulds from those used originally in the Hall. Over the next two years successive basic blacksmith courses at the Royal School of Military Engineering will produce sections of an ornamental screen to enclose the forecourt of the building used as a private car park and Royal Entrance.

By 29 March 1971 the Hall had received an external grime-removing, face-lift and an enormous internal spring clean and redecoration so that a concert to celebrate the centenary of its opening could be held that evening with traditional pomp and circumstance. Her Majesty The Queen honoured with her presence the Grand Centenary Concert and unveiled the Commemorative Plaque.



The Transmission of Power

BRANCH MEETING OF THE INSTITUTION OF ROYAL ENGINEERS PRESENTATION

ON 16 February 1971 the President of the Institution of Royal Engineers, Major-General Sir Gerald W. Duke, KBE, CB, DSO, introduced the first of what he hoped would be a series of Branch Meetings held at various centres throughout the country.

The Meeting consisted of a presentation, arranged by the Electrical and Mechanical School of the Technical Training Group, followed by a discussion. It was held in the Brompton Study Centre and was attended by officers of the Royal School of Military Engineering and some guests from HM Dockyard, Chatham and from the Department of The Environment.

After opening the meeting, General Duke introduced Major J. G. Lauder, MBE, RE who began the presentation. He reviewed the reasons for requiring to transmit power, summarised the various sources of power available and showed how they were rarely in the form best suited to their application. He then went on to explain that the presentation to follow was not intended to cover the subject in depth. A few topics only had been selected which should be of general interest and have possibilities for application in military engineering. Each would be discussed by a different member of the Electrical and Mechanical School staff.

WOI G. Sedman, RE described mechanical drives, and with the aid of working models on an overhead projector, demonstrated their applications and mode of operation. Although few developments were taking place in the principles of mechanical drives, he showed how the use of plastics was leading to greater efficiencies and less noise. New materials were also making it possible to use old ideas and methods efficiently. In connexion with mechanical drives he looked at the developments in the bearings used to carry them. Once again, plastics were being used in an increasing number of applications as were the various forms of gas bearings. These were necessary to deal with the higher loads and speeds placed on modern machinery and the adverse conditions under which it was expected to operate.

Major W. W. Stewart, RE introduced hydraulic transmission explaining how this could overcome the main disadvantages of the internal combustion engine with a conventional transmission. These were the need for a clutch to start most equipments from rest, and the fact that they operate efficiently and develop useful power only over a fairly narrow speed range. They can be overcome with the torque converter which, however, operates most efficiently under relatively constant operating conditions. Most recent development had been concerned with hydrostatic drive which gives positive transmission at all speeds and can be reversed without shock to either the engine or transmission. It is, therefore, well suited to earthmoving plant but is still rather expensive in comparison with conventional transmissions. The hydrostatic transmission becomes less efficient at high speeds in contrast to the better performance of the torque converter as speeds rise.

Captain F. H. Meredith, RE discussed the merits of compressed air and produced some rather startling figures showing the very low efficiencies normally obtained with it. He showed that, despite its high cost, compressed air was an essential form of power transmission which justified efforts to improve the efficiency of its production and use. He stressed the necessity for correct design, installation and maintenance and went on to describe three methods of extracting moisture from the compressed air. Water in the air is one of the main problems which, when removed, takes with it the other contaminants such as dust and oil.

WOI A. C. Brett, RE led into a discussion of linear motors with some demonstrations of the phenomena of electromagnetic induction transmitting both mechanical force and electricity across a space. He 'unzipped' a model of an induction motor to

show how the linear motor was derived from the standard rotating machine. He went on to demonstrate working models of linear motors and discussed their use for high speed traction. In this application, present power systems are approaching their limits because of the problems connected with picking up power and transmitting the force through mechanical contacts. A linear-motor-driven hovertrain needs have no contact with the track. In this connexion he mentioned methods of transmitting power from the trackside to the vehicle without physical contact.

Major Lauder summed up the presentation by stressing that the power transmission system was but one element in the application of power. A designer had also to consider the prime mover and the application in which the power was to be used. He then went on to look at some of the power sources being developed which could be of considerable military interest. These included the small nuclear reactor, the fuel cell and a resurrection of an old concept, the Stirling Engine. This engine is attractive militarily because of its silence and true multi-fuel capability.

Before closing the presentation, he suggested that one more development worth watching was the transmission of electricity by microwaves. This could, in the long term, eliminate the unsightly power line and pylons which presently disfigure the countryside.

Elementary Soil—Vehicle Mechanics

R. G. POPE, J. M. HAWKES AND R. DAVIES

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PART I

SOILS—COMPOSITION, CLASSIFICATION AND IDENTIFICATION

Introduction

THE land vehicle gets its propulsion from the reaction of the soil or ground over which it is travelling. The importance of this part of the over-all vehicle system should not be overlooked since however sophisticated the internal mechanical design the cross-country performance will ultimately depend on what is happening at the interface between the wheel or track and the soil. This relationship is particularly important to the Army since the vehicles are armoured and heavy yet also expected to travel cross-country—an undesirable combination. Lack of understanding of vehicle capabilities has been demonstrated many times, particularly in the two World Wars when many vehicles, especially tanks, were immobilized in bad ground. Perhaps this old American Army Communique of 1899 (quoted by Bekker[1]) sums up the situation,

"Three horseless carriages have been purchased by the War Department for the use of officers. Each is equipped so that a horse may be hitched to it, should it refuse to run."

The first serious attempts at an understanding of the soil vehicle relationship were started during the Second World War[2, 3]. At this point British research was mainly confined to the difficult soil types of the Northern European plain i.e. saturated clays and peats with low load carrying capabilities.

Because soil types are so numerous it is necessary to have a classification system such that experience gained on a soil type in one locality may be intelligently used on a similar soil type in another locality. Before discussing soil classification it will be worth while taking a brief look at the origin of soils and their composition.

Origin of Soils

Most soils are derived from the physical and chemical weathering or breakdown of rocks though some, such as peat, are of organic origin. Soil is a mixture of assorted

mineral grains of different sizes and shapes and in its natural state contains air, water and humus. Physical and mechanical processes such as attrition and erosion are responsible for the breakdown of rocks to particle sizes of about 0·002 mm diameter, i.e. the largest clay particle size. Chemical breakdown, such as solution and recrystallization, may result in particles smaller than 0·002 mm diameter but the particles do not possess the unaltered crystalline structure of the parent rock.

The products of rock weathering will be found as either residual or transported soils. Residual soils are soils that are still located in their place of origin, such as the Chalk Downs, and comprise only a small percentage of the world's soils. Transported soils form the bulk of the world's soils and are characterized by the agent which has transported them.

Wind transported soils are fine and usually graded and include sands, silts and clays. Water transported soils are often segregated into gravels, sands, silts and clays. Ice transported soils are heterogeneous mixtures of all sizes of particles from boulders to clay, e.g. Boulder Clay.

Composition of Soils

The constituent materials of soils are inorganic solids derived from rock weathering, organic solids, water and air.

The inorganic solids may be broadly divided into two groups, coarse grained or fine grained. Coarse grained particles, such as sands and gravels, resist deformation solely by frictional contact, whereas fine grained particles (clays) resist deformation partly by frictional contact and partly by cohesion. This cohesion of fine grained soil is due to intermolecular bonds between the adsorbed water surrounding each grain. The "adsorbed layer" of water molecules is intimately held to the clay mineral particles by a surface electrical charge and it is the ionic bonds in the clay pore water which tend to hold the particles together in a solid mass as long as the moisture content of the clay is not too high.

The presence of large amounts of organic matter, water or air, will have adverse effects on the soil behaviour. They must, therefore, be considered when classifying the soil.

Classification of Soils

Classification systems have been developed by Civil and Agricultural Engineers but neither is ideally suited for the vehicle situation. More relevant are the important points of the Civil Engineering Classification System[4] but we must bear in mind that the Civil Engineer is not concerned with topsoils which may be of major concern to us.

Particle size distribution is a useful method of classifying soils. The distributions for typical soils are shown in Figure 1. The separation of soils into gravels, sands, silts and clays are useful divisions since the properties of the various soil types are different. The behaviour of a soil is strongly influenced by the finer fraction and soils containing as little as 20 per cent clay particles will behave essentially as clays. It is important to remember that sands and gravels behave as frictional materials whereas clays exhibit cohesion. The behaviour of fine grained soils will depend greatly on the moisture content (m):

$$\text{where } m = \frac{\text{weight of water}}{\text{weight of soil particles}} \%$$

and it is therefore essential to know the relationship between soil state and moisture content (Plate 1). It is possible that one clay soil may be liquid at a moisture content of 30 per cent whereas another similar clay may still be stiff, depending upon the different clay minerals present. Because of this a subsidiary classification based on the minimum moisture contents at which the soil behaves as a liquid (Liquid Limit) and as a plastic (Plastic Limit) is used to describe the soil (Figure 2).

The third important factor which affects the behaviour of a soil is the state of packing of the grains. A dense packed soil structure will give greater bearing capacity (the ability to support load) and shear strength than a loose packed structure.

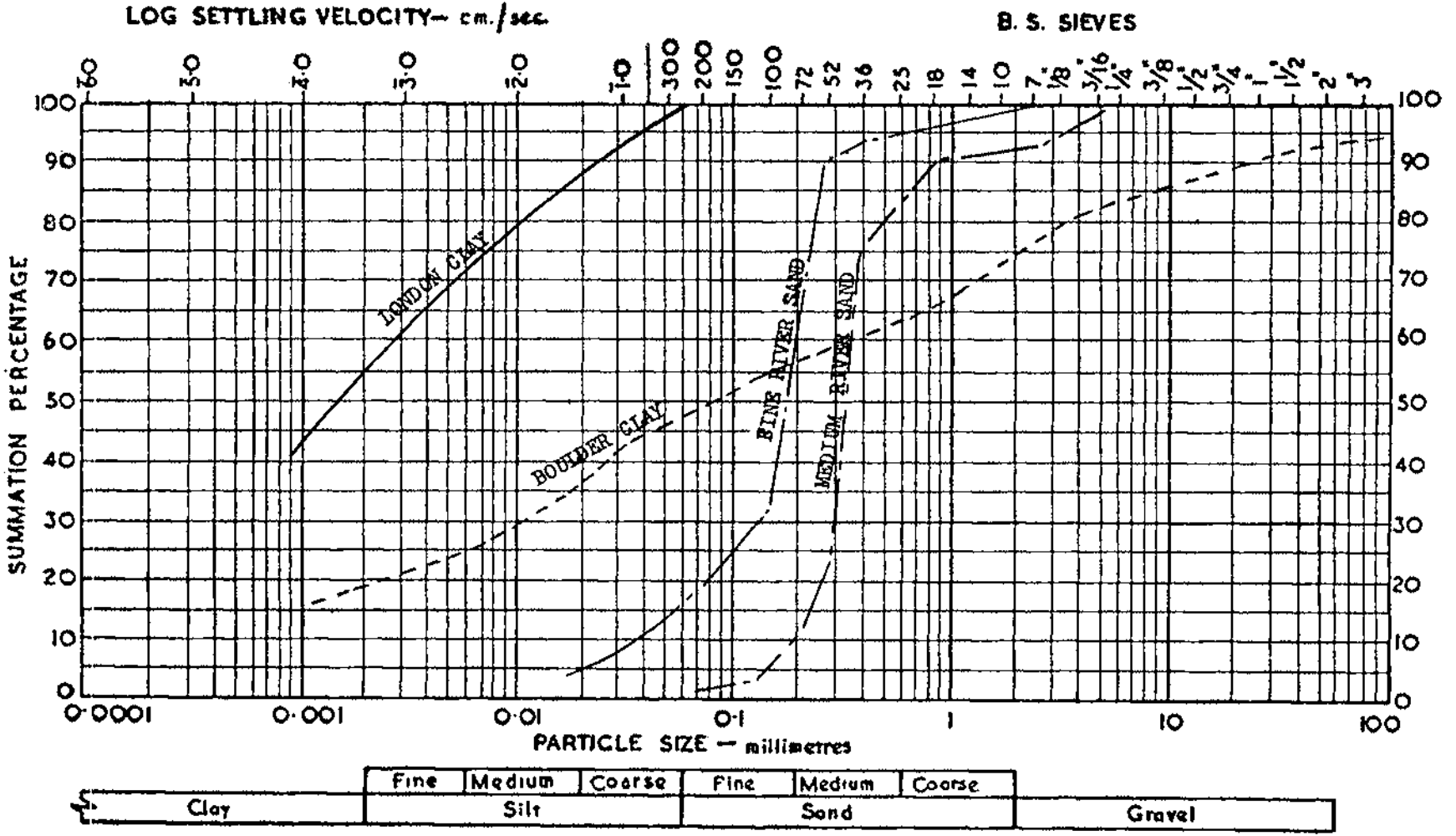
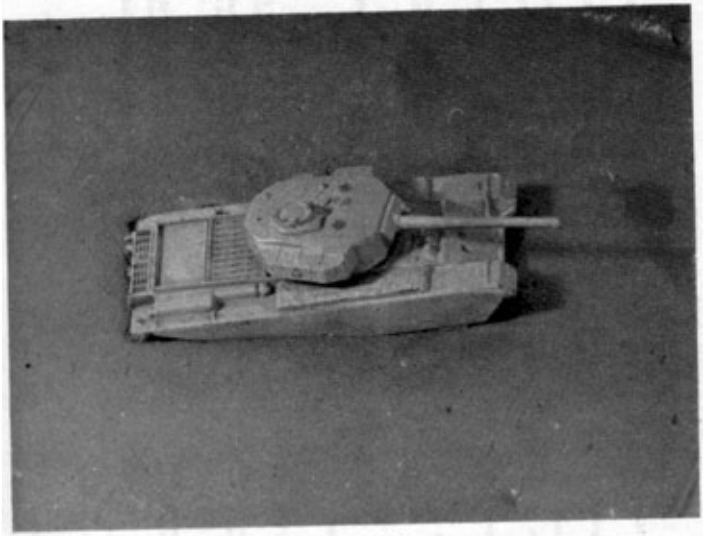


Figure 1. Particle Size Distribution of Typical Soils

(a) m = 33·8%



(b) m = 38·8%

Plate 1. The effect of moisture content on the load carrying capabilities of a clayey sand

NOTES ON OVERPRINT

(1:200,000 TUNISIA. Sheets 8, 9, 11, 12, 14, 15, 17, 18, 19, 21, 22 and 23)

	NAME	DEFINITION	IMPLICATIONS
			Very Good Going.
A.	Firm Flat gravel.	Pebble less than egg size. Firm ground beneath.	Very fast going for all vehicles, aircraft can land almost anywhere.
B.	Flat dried mud.		As above, but dangerous in wet weather
C.	Sand-Sheet.	Undisturbed flat sand.	As for A, until disturbed by many vehicles.
			Good Going.
D.	Firm uneven gravel.	As for A, but surface broken by shallow water runnels, undulations, etc.	Speed reduced, but no damage to vehicle if encountered at night.
E.	Loose sand.	Sand surface less firm than C.	Top gear doubtful, but little danger of sticking, passable with difficulty with non-desert tyres.
			Fair Going.
F.	Stony.	Stones up to 6 in. diameter.	Speed much reduced, much wear and tear, bad for springs.
G.	Low hummocks.	Grass or scrub growing from mud or sand mounds less than 12 ins. in height.	As for F.
H.	Gravel overlying soft ground.		Speed much reduced, low gear necessary, but sticking infrequent, much dust.
J.	Broken country, boulders larger than 6 in. Rocky.	Steep-sided hills, scarps, etc.	Slow going, but easily passable with careful choice of route, dangerous at night unless well marked.
			Bad Going.
K.	Broken country, Boulders, Rocks, High hummocks.		Passable with difficulty in places, bad for vehicles. Very slow. Impossible at night.
L.	Soft Sand		Much sticking of all wheeled vehicles.
M.	Continuous dunes.		
N.	Continuous steep scarp.		
P.	Very rocky.		Impassable for all vehicles.
Q.	Impassable Vegetation.		
R.	Lava.		

MAP "D"

GOING MAP

KEY ARRANGEMENT FOR MOVEMENT OF MIXED MECHANISED FORCE

Generally impassable.

Reconnaissance essential before movement.
Continuous low gear to 8 M.I.H.

Fair going.
Delays by detours and/or soft patches or rocks. 5-10/12 M.I.H.

Firm and fast.
Some yellow patches.
8 M.I.H. and over.

Unsafe in wet weather.

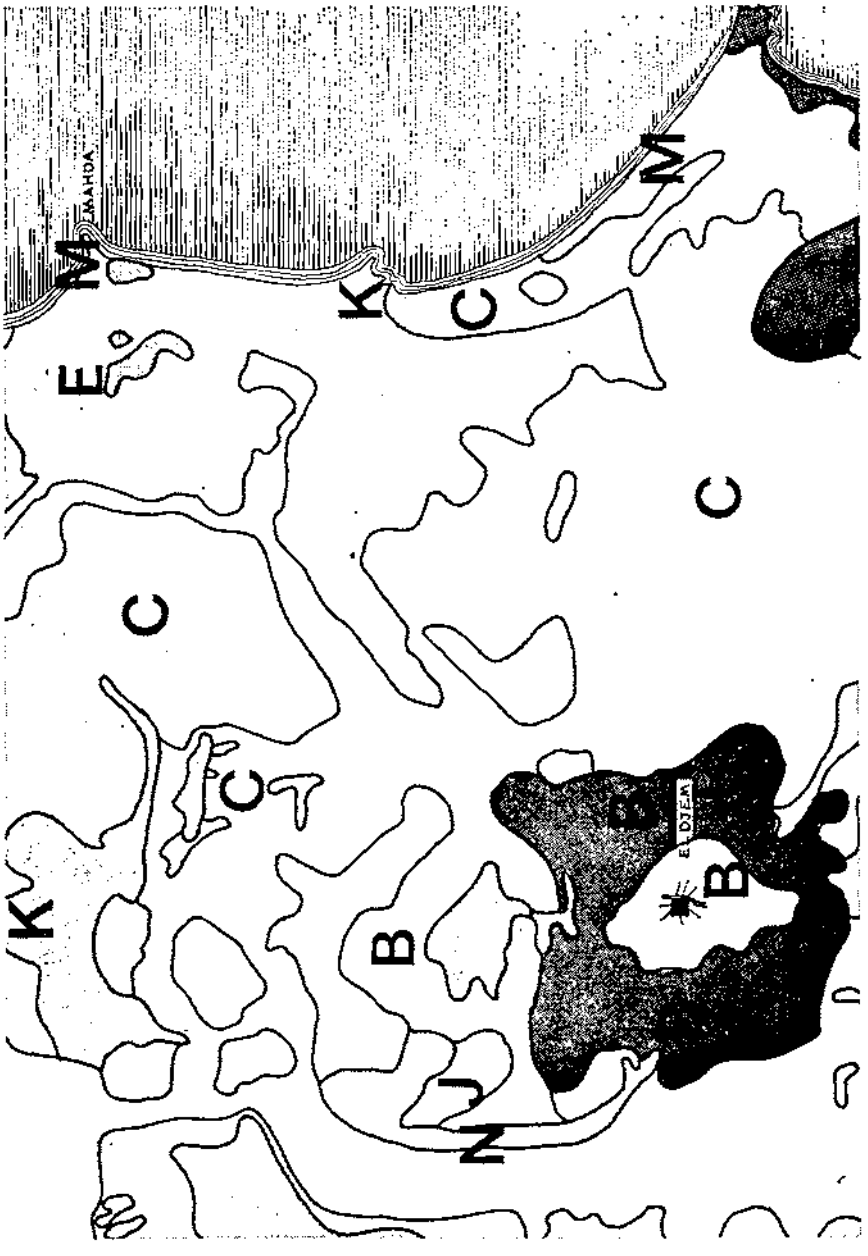


Plate 2. Going Map

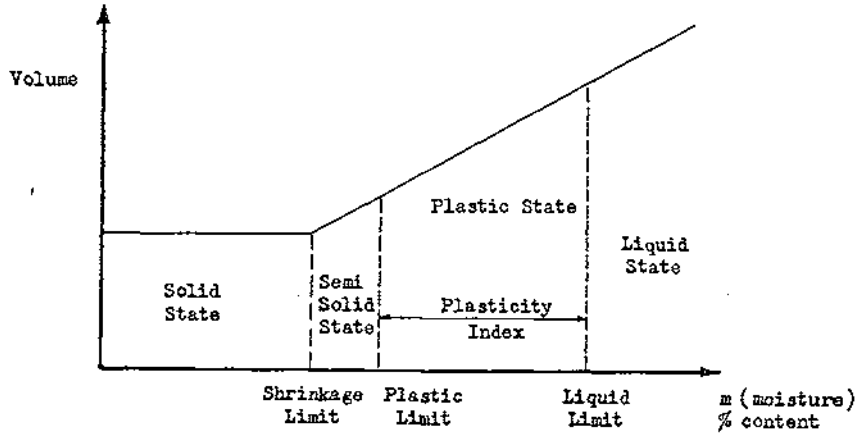


Figure 2. Soil Consistency Limits

Terrain Evaluation and Going Maps

Soil maps have been prepared for agricultural purposes but are based on characteristics important to agriculture, such as acidity or alkalinity, which are of no concern to us. The Military Engineer has, therefore, started to prepare his own maps.

For strategical and tactical planning there is a vital need to know where vehicles will be able to travel across country and where they will become immobilized. Attempts were first made in North Africa and the Middle East in 1941 to prepare maps of the terrain on a qualitative basis and these were known as "going" maps[5] (Plate 2).

Although "going" maps have to show all obstacles whether artificial, such as canals and ditches, or natural, such as forests and escarpments, they must also show regions where the soil is not trafficable under differing climatic conditions.

Although soil trafficability cannot be exactly evaluated, since it is liable to seasonal variations causing changes in moisture content, some attempt must be made. It would be impracticable to test the soil with vehicles in each case so we must find some other simple form of evaluating the terrain. The most fundamental properties of the soil which will affect the vehicle are bearing capacity and shear strength and we shall study these in more detail.

PART II

SOILS UNDER STRESS—SHEAR STRENGTH AND BEARING CAPACITY

To support vehicular passage a soil must possess two basic properties:

(*a*) Adequate bearing capacity, to prevent deep sinkage of the wheel or track which would cause excessive resistance to movement.

(*b*) Shear strength sufficient to provide reaction for vehicle thrust. It has been demonstrated that bearing capacity is a function of the shear strength of the soil[6]. The fundamental property of a soil, therefore, in trafficability considerations, as in general civil engineering, is shear strength.

Shear Strength

As already stated the shear strength of soils is considered to be made up from two factors, friction and cohesion. This is expressed by Coulomb's Law (Figure 3):

$$\tau_u = c_u + \sigma \tan \phi_u$$

τ_u = shear strength N/mm^2
σ = compressive stress N/mm^2
c_u = cohesion N/mm^2
ϕ_u = angle-of-shearing resistance (internal friction)

The suffix u denotes the "undrained" strength characteristics of the soil. We are primarily concerned with the undrained strength since the vehicle loading is transitory and any particular area of the soil is loaded only briefly, thus consolidation of the soil is small and may be neglected. (Consolidation is the expulsion of water from the soil voids causing an increase in soil density and shear strength.)

Non-Cohesive Soils (e.g. Sands and Gravels)

Some soils exhibit purely frictional behaviour, the shear strength increasing in direct proportion to the loading intensity. The angle of shearing resistance, ϕ, for a soil increases with increasing density of packing and is commonly between 30° and 45° depending upon the soil packing (Figure 4). A simple test for the angle of friction in the loose state is to heap the dry soil and measure the angle of repose, that is the angle to the horizontal at which a heap of dry sand will stand without support (Plate 3).

The shear strength of these soils is not appreciably affected by moisture content although certain conditions of water pressure and flow may have considerable effect, e.g. Quicksand conditions caused by upward flow of water through fine sands (Plate 4), or, relatively firm going of a damp sand beach caused by surface tension of water in the voids.

Cohesive Soils (e.g. Clay)

Clay soils under undrained loading conditions may exhibit purely cohesive behaviour, the shear strength, c_u, being independent of the loading intensity (Figure 5). The cohesion of clay soils will decrease as the percentage moisture content rises and at high moisture contents the soil will behave as a liquid. An important strength characteristic of cohesive soils is sensitivity (Plate 5):

$$\text{Sensitivity} = \frac{\text{Undisturbed Strength}}{\text{Remoulded Strength}}$$

When cohesive soils are disturbed from their natural state (remoulding) the cohesion may be reduced. A sensitivity as high as 150 has been recorded for a soil deposit at St Thuribe, Canada, although this is exceptional. This strength loss due to remoulding may be an important factor when considering the ability of a soil to support the repetition of passes caused by many vehicles.

Deformation

Like other materials the shear strength of soils is only developed after some deformation (strain) has occurred. It can be seen from Figure 6 that the shear stress will increase with deformation to a maximum value and in some cases may reach a peak and then decrease with further displacement.

Pressure-Sinkage Relationships

The ultimate or maximum bearing capacity of a soil is generally estimated, by civil engineers, from Terzaghi's bearing capacity equation for a continuous strip foundation[8]:

$$q = c_u N_c + \gamma . z N_q + 0.5 \gamma B . N_\gamma$$

c_u = cohesion

N_c, N_q, N_γ = bearing capacity factors dependent on ϕ_u

z = depth of foundation/sinkage

γ = soil density

B = width of foundation

This equation is derived from the static equilibrium of a shallow continuous foundation at the point of failure and assumes that the soil is incompressible (Figure 7). It is not particularly suited to the soil-vehicle situation where we are concerned with pressure-sinkage effects at loads other than the ultimate bearing capacity, when the sinkage (z) may be quite high compared to the width (B) of the wheel or track, and the effects of elastic compression are to be included.

The approach adopted in soil-vehicle mechanics is to fit an empirical equation to the pressure-sinkage relationship found from pushing a plate, or footing, into the soil (Figure 8). The first empirical equation was proposed by Bernstein[7] and is of the form:

$$p = k z^n$$

p = pressure
k = pressure sinkage modulus
z = sinkage
n = sinkage exponent

Since the constant k was found to vary with the shape and size of footing used, Bekker[8] suggested an improved equation of the form:

$$p = \left[\frac{k_c}{B} + k_\phi\right] z^n$$

k_c, k_ϕ pressure sinkage moduli
B width of footing

The soil constants k_c, k_ϕ and n may be evaluated by testing two similar footings of different width.

As this equation is dimensionally unattractive it has again been modified by Reece[9] who proposed the following equation which is dimensionally correct and has a sound theoretical basis agreeing with bearing capacity theories.

$$p = (ck_c + \gamma B k_\phi)\left[\frac{z}{B}\right]^n$$

Cone Penetrometer

The cone penetrometer (Plate 6) is a simple and convenient field test for assessing the ability of a cohesive soil to support vehicle loading. By pushing the cone into the soil the cohesive strength variation with depth may be found. The instrument, however, cannot be applied satisfactorily to sands since the shear strength of the sand is a function of the imposed loading. The resistance of the soil is recorded as the Cone Index and to assess the suitability of the soil to support the passage of many vehicles the Cone Index should be reduced by a factor, appropriate to the type of soil, called the remoulding index. The corrected Cone Index is then termed the Rating Cone Index (RCI).

To each class of vehicle a Vehicle Cone Index (VCI) is assigned and providing the soil RCI is greater than the VCI then the soil should be able to support at least fifty successful passes of that class of vehicle. A single vehicle pass should be possible if RCI = ¾ VCI.

Because the RCI of a soil may vary widely with seasonal and climatic conditions the RCI assessment should be made as closely as possible before the actual time of vehicle passage.

PART III

DRAWBAR PULL, THRUST AND ROLLING RESISTANCE

Having briefly considered the behaviour of soils it is now possible to apply these principles to the interaction between soil and vehicle.

The soil reaction forces which drive the vehicle forward will be termed "Soil Thrust" (H). This thrust is expended in overcoming soil losses, called "Rolling Resistance" (R) caused by rut forming and bulldozing soil ahead of the wheel or track. Any excess of soil thrust over rolling resistance is the Drawbar Pull (DP) which is the force available for acceleration, hill climbing or pulling loads. This may be represented by a simple and basic equation:

$$DP = H - R$$

Thrust

An elementary equation for vehicle thrust may be derived from Coulomb's Law and provides some important fundamental concepts about vehicle behaviour and

soil type. If the area of the wheel, or track, in contact with the ground is A and it carries a load W (Figure 9) then the soil thrust is given by:

$$H = A.c_u + W \tan \Phi_u$$

Although this equation is not rigorous, since it takes no account of soil deformation and assumes c_u and Φ_u are constant along the contact path, the important vehicle factors affecting the thrust become immediately apparent. For vehicles moving on purely granular soils ($c_u = 0$) the requirement for traction is heavy weight independent of contact area.

$$H = W \,.\, \tan \Phi_u$$

NB. The contact area should be sufficient to prevent excessive sinkage.

Alternatively if the vehicle is to operate on a saturated plastic clay ($\Phi = 0$) then large contact area is required for high traction and heavy weight will only cause increased sinkage and rolling resistance.

$$H = A \,.\, c_u$$

Slip

In order to develop the shear strength of the soil the soil must be displaced beneath the wheel or track. Because of this displacement, which will vary along the contact path, the shear stress distribution will not be uniform and slip will occur. The effect of slip will be to reduce the actual velocity of the vehicle and the rate of slip (i_o) is defined as (Figure 10):

$$i_o = \left(\frac{V_R - V}{V_R}\right) + 100\%$$

V_R = peripheral speed of wheel or track
V = ground speed of vehicle.

It is desirable to obtain the maximum drawbar pull at low values of slip so that the ground speed of the vehicle may be kept high but in many cases the maximum thrust is only reached at high slip values and consequent reduction in vehicle ground speed. In some instances, usually when attempting steep slopes or pulling heavy loads in weak soils, the maximum drawbar pull may only be attained at 100 per cent slip i.e. when the vehicle is slip-stalled. Increase in engine power will not rectify this situation but will lead to excessive "digging in" and eventual engine-stall.

Shear Strength and Deformation

As has been already shown (Figure 6) the shear strength of a soil will not be mobilized until some displacement has occurred. Since the amount of soil displacement will vary along the contact path (Figure 10) then it is evident that for soils exhibiting peak and residual shear strength the peak strength will not be mobilized along the whole length of the contact path. A rigorous analysis of thrust must therefore express the shear strength along the contact path in terms of the soil displacement. Bekker[6] has proposed an equation to do this but since the shear strength equation and derived thrust are both unwieldy and in Bekker's own words[9] "unsatisfactory to use" we will not consider them here.

Rolling Resistance

Micklethwaite[2] quotes the story of a village idiot who when asked what a tank was for replied "that it was to squash down two strips of ground, each about a foot wide and many miles long, to a depth varying from an inch or two to a foot or more". Although this rut forming is an unavoidable effect of the cross-country vehicle it is certainly not a desirable one and is the main cause of Rolling Resistance. The Rolling Resistance equation which we shall consider depends upon the assumption that the work expended by the wheel in Rolling Resistance is equal to the work done in making the rut.

Considering the wheel shown in Figure 11:

Work Done in Rolling Resistance $R1 = Bl \int_0^{z_o} p \, dz$

But p is a known function of z from the pressure-sinkage equation.

$$p = (ck_c + \gamma B\, k_\phi) \left(\frac{z}{B}\right)^n$$

hence

$$R = B \int_0^{z_o} (ck_c + \gamma B\, k_\phi) \frac{z^n}{B^n} \cdot dz$$

$$R = \frac{(ck_c + \gamma B\, k_\phi)}{B^{(n-1)}} \frac{z_o^{(n+1)}}{(n+1)}$$

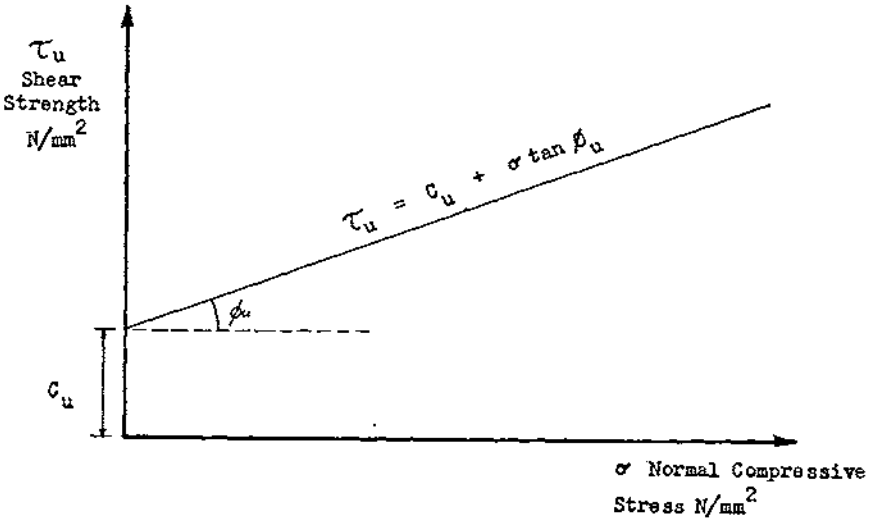


Figure 3. Coulomb's Law

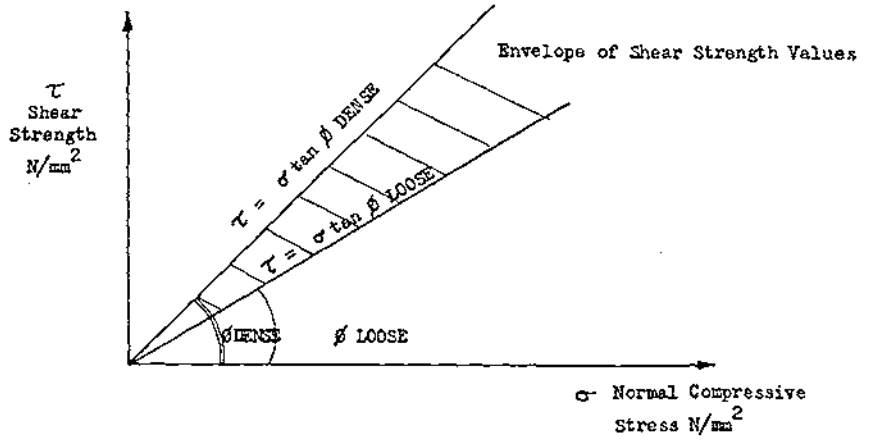


Figure 4. Effect of Packing upon Shear Strength of a Granular Material

To solve this equation in terms of the wheel load W we must find z_o in terms of W. This may be done by resolving the vertical forces around the wheel perimeter

$$W = B \int_0^{z_o} p \, dx$$

When this expression is integrated we arrive at the following result:

$$\text{Rut Depth } z_o = \left[\frac{B^{(n-1)} 3W}{(3-n)(ck_c + \gamma B k\phi)\sqrt{D}}\right]^{2/(2n+1)}$$

and Rolling Resistance

$$R_{\text{wheel}} = \frac{B^{(n-1)/(2n+1)}}{(n+1)(ck_c + \gamma B k_\phi)} (1/(2n+1)) \left[\frac{3W}{(3-n)\sqrt{D}}\right]^{(2n+2)/(2n+1)}$$

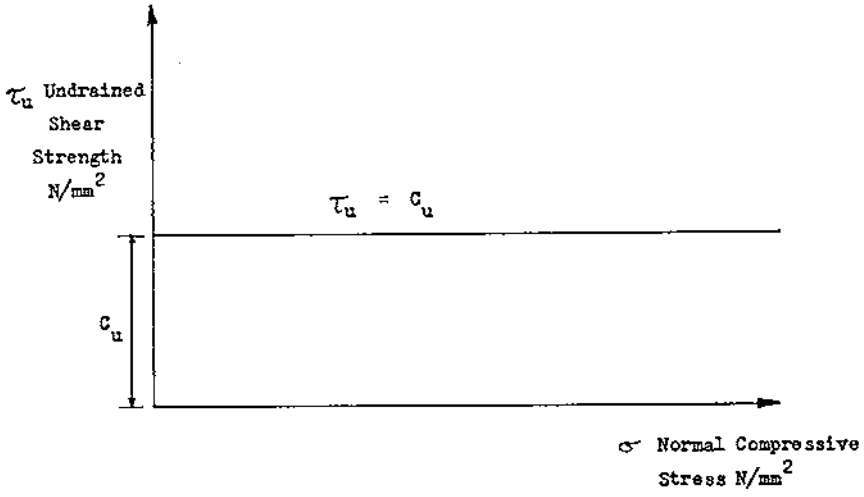


Figure 5. Undrained Shear Strength of Saturated Clay

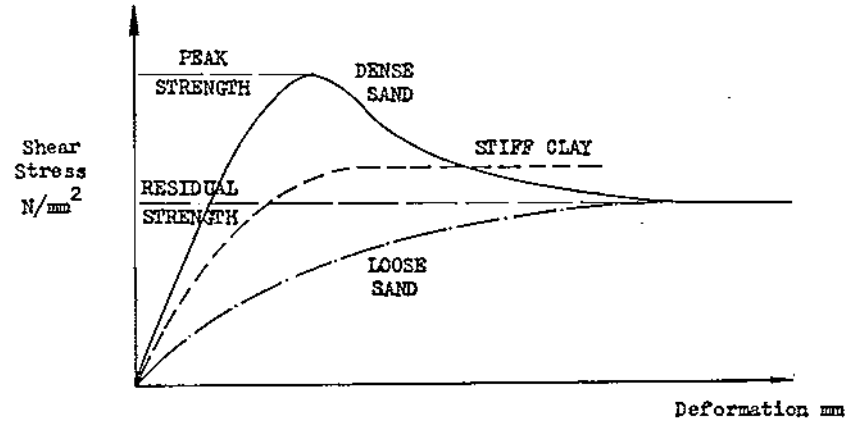


Figure 6. Shear Strength - Deformation Characteristics of Soils

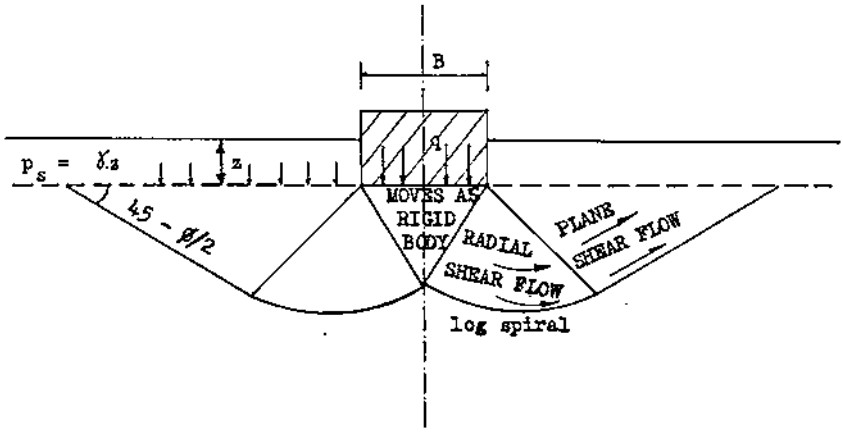


Figure 7. Failure Surface for Terzaghi's Bearing Capacity Solution

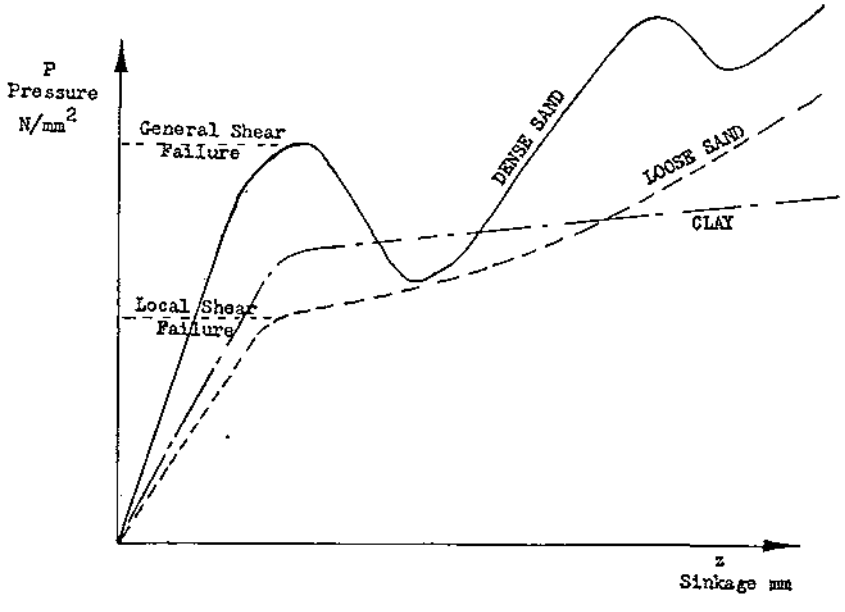


Figure 8. Typical Pressure-Sinkage Curves

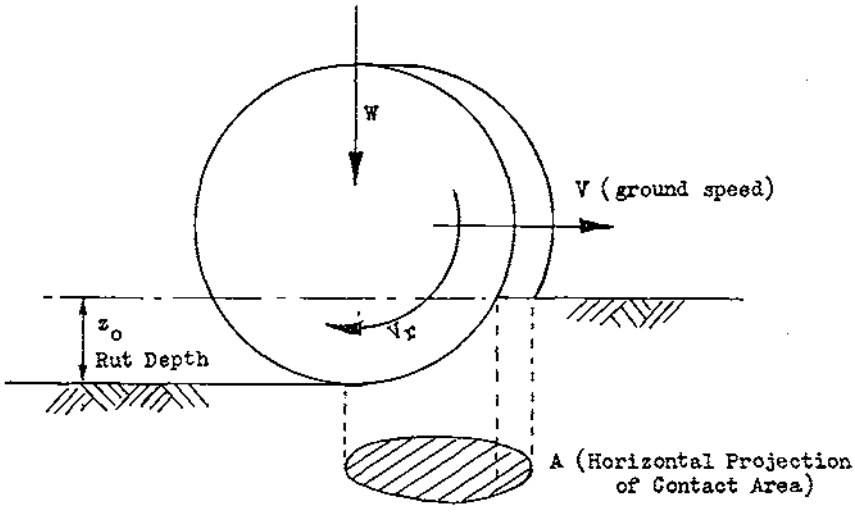


Figure 9. Wheel on Ground

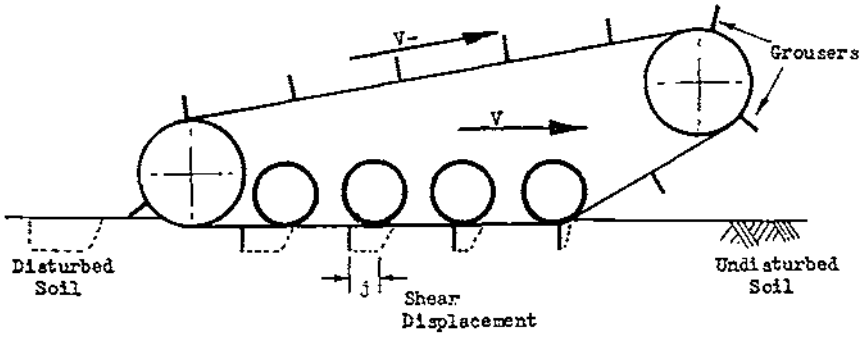


Figure 10. Variation of Soil Displacement Along Contact Path

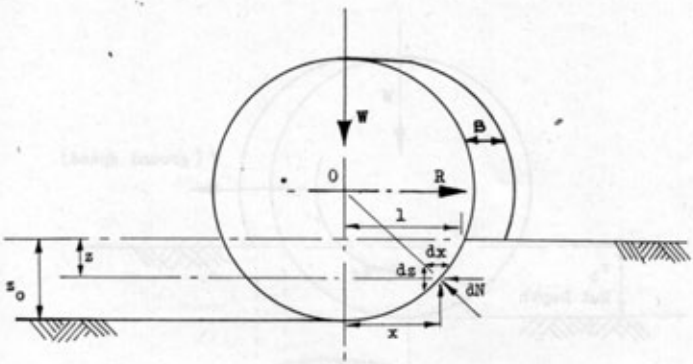


Figure 11. Rolling Resistance

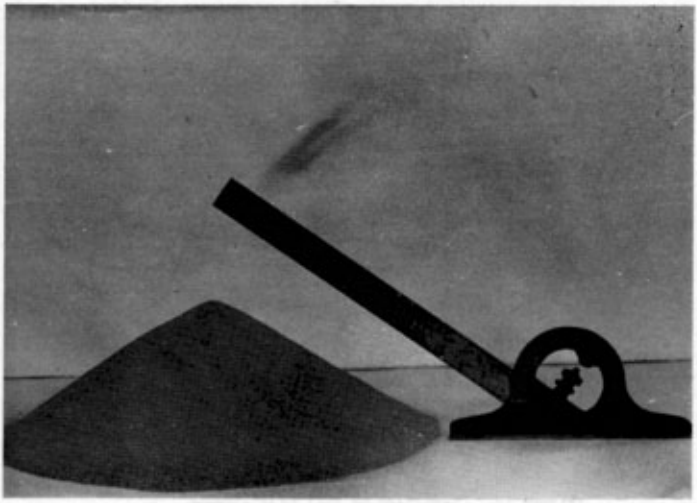
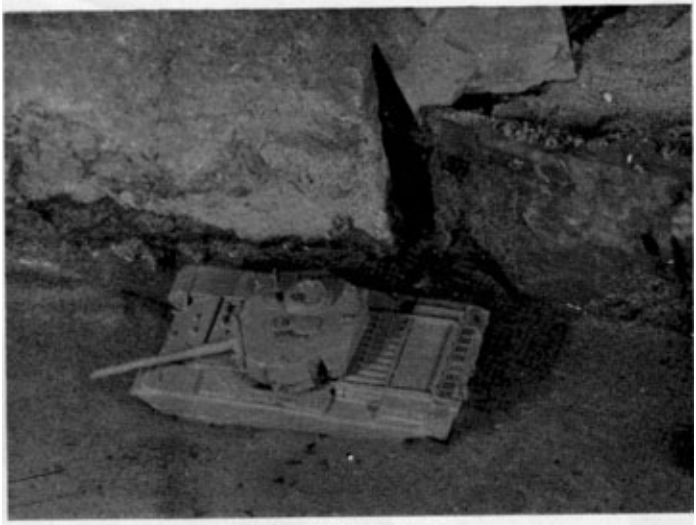


Plate 3. Angle of repose of dry sand

(a) Before Quicksand Condition



(b) After Quicksand Condition

Plate 4. Immobilisation of model tank caused by quicksand conditions on beach due to upward flow of water through sand

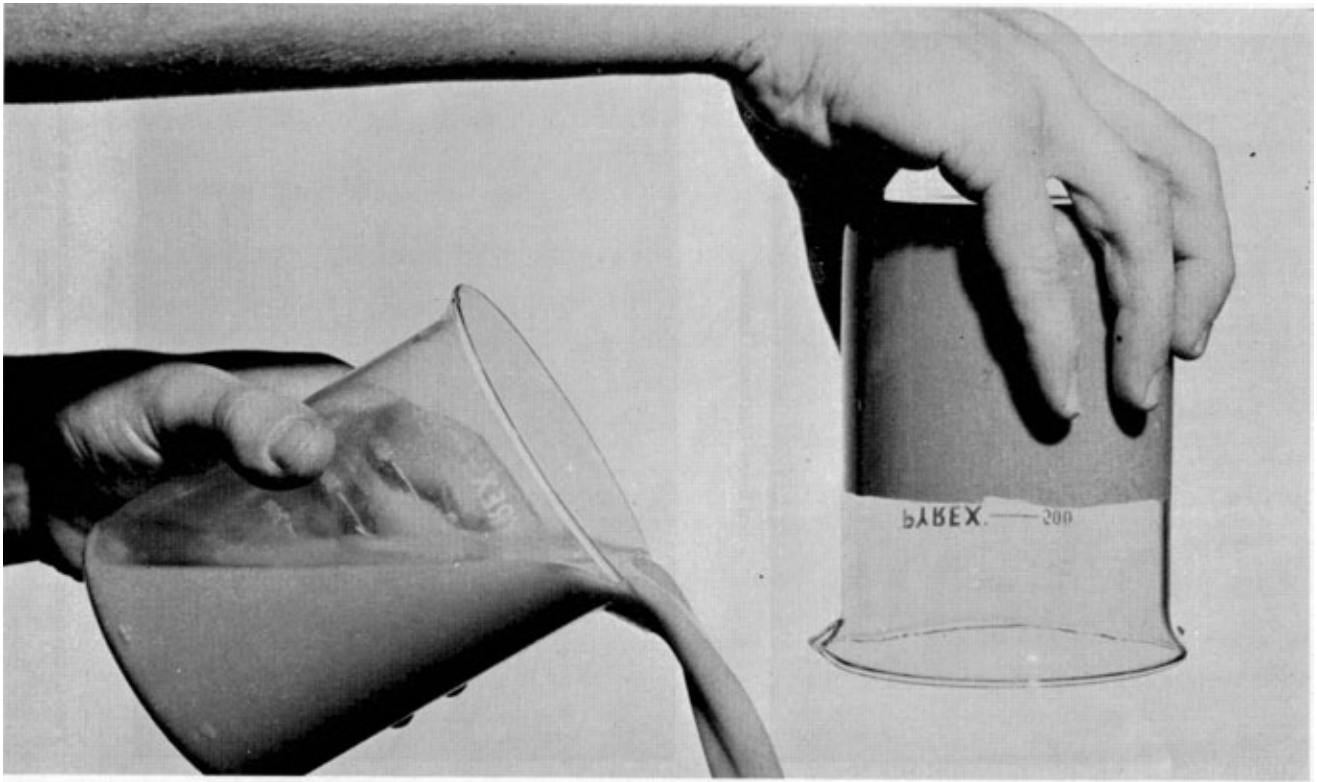


Plate 5. Sensitivity of clay loss of strength due to disturbance causes sample to become liquid

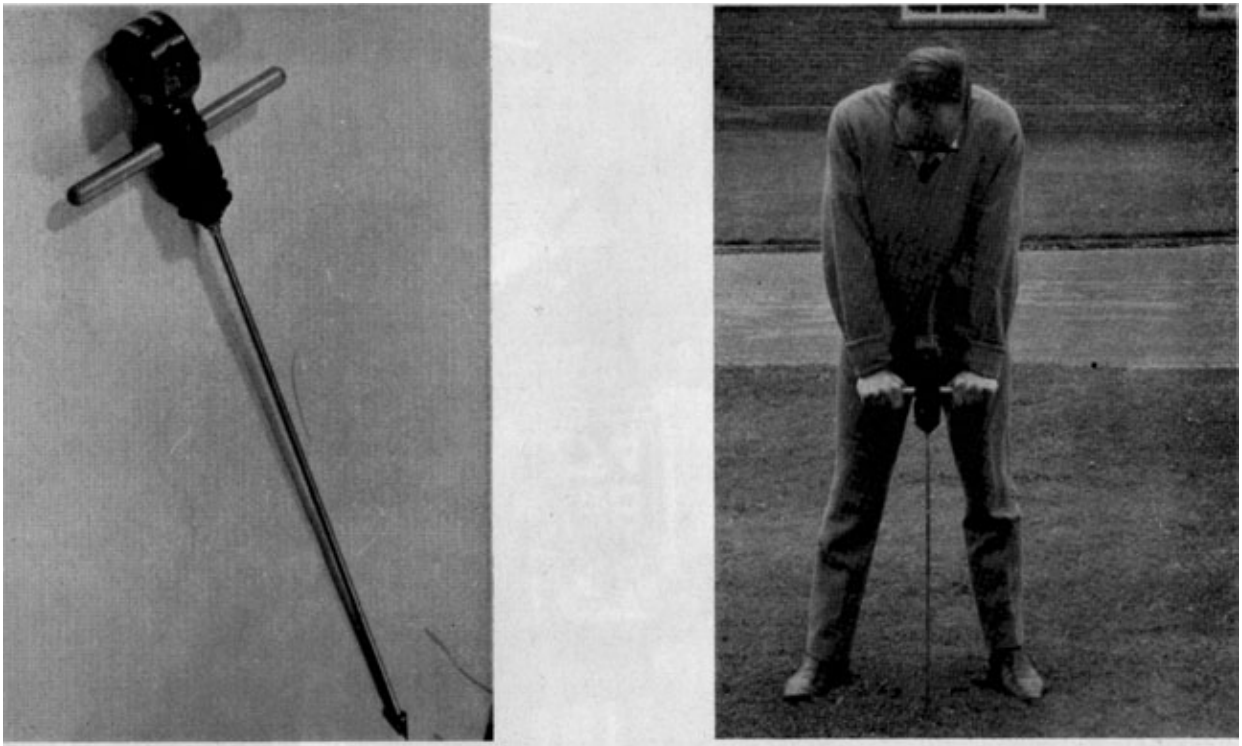


Plate 6. Mexe Cone Penetrometer

Plate 7. Bevameter mounted on Land Rover

The Rolling Resistance of a track may be evaluated in a similar manner.

Some additional rolling resistance may be caused by bull-dozing of soft soil in front of the vehicle, side cohesion and drag produced by soil particles adhering to the vehicle suspension etc.[10]

Bevameter

The soil values that the vehicle investigator is interested in are the shear strength characteristics c, and ϕ, and the pressure-sinkage characteristics k_c, k_ϕ and n. Having obtained these soil values we have shown that it is then possible to express the expected performance of a known vehicle in terms of the thrust and rolling resistance. To obtain these soil values a field instrument called the Bevameter has been developed, initially by the Land Locomotion Research Laboratory of the Ordnance Tank-Automotive Command, US Army and later in England.[11]

The Bevameter (Plate 7) measures the soil shear strength-deformation characteristics by means of the torsion of a spudded annular ring which is lowered on to the soil surface and loaded prior to shearing. Pressure-sinkage characteristics are found by pushing two similar different sized plates into the ground at constant rate and plotting the resulting pressure-sinkage curves on a logarithmic basis.

Concluding Remarks

A brief introduction to the theory of soil-vehicle mechanics has been given in this article.

It has been shown that an attempt may be made to predict the performance of a vehicle in a soil if the relevant soil and vehicle characteristics are known.

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* * * * *

The Supply of Petrol in Bulk to 21 Army Group

MAJOR-GENERAL SIR EUSTACE F. TICKELL, KBE, CB, MC

(The complete story of the work carried out by the sapper pipeline units during 1944 and 1945 has not (I think) been published in detail, and for historical purposes it is perhaps worthwhile to collate the facts, even at this late hour)

THE PLAN

BEFORE the Allied landing in Normandy on 5 June 1944 it had been planned to supply both British and American Forces during the first three weeks with petrol in jerricans, but as soon as possible to run pipelines out to sea for pumping ashore from tankers moored off Port en Bessin. This tiny harbour, the only one on the invasion beaches, was at the junction of the British and American sectors. Tankage would be erected there to feed pipelines running east and west to supply the two Armies as they advanced. When Cherbourg had been captured the American pipeline would be used in the reverse direction to supply the British Army with their share of the petrol which was to be fed into the port by "Pluto". This word is now to be found in most modern English dictionaries, being defined for instance as—"The code name for a system of pipes laid across the Channel to meet the petrol requirements of the Allied Forces operating in NW Europe during 1944 and 1945. (From the initials of the words Petrol Lines Under The Ocean.)" We shall see however that such a definition is not strictly accurate. Pluto was to consist of a number of 3-in pipes laid on the sea bed from the Isle of Wight, where it would be fed by pipeline from a refinery near Liverpool, supplemented later by supplies from Avonmouth, Shellhaven and the Isle of Grain. Working at 1,500 lb per sq in, each pipe was expected to deliver about 250 tons per day to Cherbourg.

PORT EN BESSIN AND PLUTO

At first all went according to plan. Port en Bessin was cleared of enemy after considerable opposition, the sea-lines were run out in spite of very bad weather,

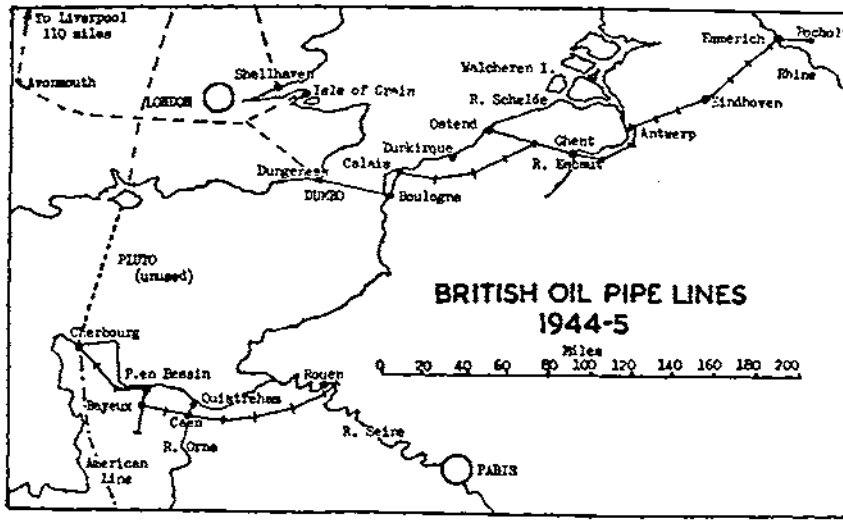

Figure 1. Map

bolted tankage was erected with facilities for filling tank-lorries and jerricans, and the two pipelines were started. The first petrol was landed on 30 June, three and a half weeks after the landing. Cherbourg harbour had been captured the day before, and was quickly repaired by American Engineers, who used piles supplied by the British and Canadian Forestry Companies. As soon as mine-sweeping had been completed the laying of the Pluto pipes began, but the first two leaked badly and it was not until the fourth, starting on 12 August, had been laid and tested that any petrol arrived at Cherbourg. By then tankers were discharging at the port and the Americans were piping southward, so Pluto was closed down, having delivered no petrol to the Allied Forces. The line from Port en Bessin was completed as an insurance but was never used to supply the British Army. In addition to this line, five others were laid from Port en Bessin—three to the main tank-lorry and can-filling area south of Bayeux, one for filling rail tankers, and another to suplpy aviation spirit to the airfields concentrated in the beach-head. Port en Bessin was merely a fishing village with a small harbour whose entrance was restricted by a bar and rocks, but eventually could berth four very small shallow-draught tankers. The off-shore anchorage was far from ideal owing to the hard bottom, but combined imports rose to 3,000 tons per day, and could have been increased if required. Storage for 15,000 tons was erected ashore.

BAYEUX TO ROUEN

The town of Caen was captured on 9 July, and preparations were made to extend the pipelines from Bayeux towards Germany as soon as the situation allowed, but this did not occur until the operations north of Falaise had had the effect of clearing the area east of Caen. Then, starting in mid-August, twin pipes were laid across the river Orne and pushed eastward for a total of 90 miles to reach the captured tankage west of Rouen. Two pipes were pulled across the Seine by Caterpillar tractor, and by 18 September ample road, rail and can-filling facilities had been established east of the river. The German retreat through France and Belgium was extremely rapid, and it was clear that one or more of the Channel Ports would soon be in our hands. No attempt was therefore made to extend the pipeline, but the opportunity was taken to increase our storage by making a 15-mile connection to the civilian tankage at Ouisterham, north-east of Caen. In spite of some delays caused by land mines, the Bayeux–Rouen line had gone well. There had however been some diversion of effort at the start, when we were asked to lay a pipe *southward* to support the operations north of Falaise. This was completed, with terminal tankage etc, by 23 August, but was used very little because the enemy was in full retreat a few days later. With our equipment it was not economical to use pipelines as tactical weapons, but this may not be true if modern light-alloy pipes and more quickly erected storage materially reduce laying speeds.

OSTEND AND DUMBO

Ostend was captured on 9 September, but the town was heavily booby-trapped and the harbour badly damaged. Pipes and tankage were soon landed and the first petrol was received from tanker on 2 October. This was cleared by road until three pipes (one later reserved for aviation spirit) had been laid on one of the carriageways of the autobahn to Ghent, where there was large existing storage. Ostend imports were reduced when those through Antwerp rose.

Meanwhile Boulogne had been cleared of enemy on 22 September, and as soon as possible the first of a number of Pluto pipes, here called "Dumbo", was laid from Dungeness. There was however considerable delay while a new technique was developed for bringing the end ashore on a beach inside the harbour, where at low watermark the responsibility passed to the Sappers. On 28 October the first useful cross-Channel petrol began to flow at about 250 tons per day. It was nearly five months since the Normandy landing. By the end of the year delivery had risen to 1,300 tons per day, using four pipes, but by then Ostend and Antwerp combined had been averaging 7,000 tons per day for more than four weeks. They were 45 and 115

miles respectively nearer the front. From mid-March onwards Dumbo kept up a steady delivery of 3,100 tons per day using ten or eleven of the seventeen pipes. After the German surrender on 4 May it became increasingly obvious that it was far simpler to import direct to Antwerp, and the system was eventually closed down. The reception and disposal of Dumbo petrol involved very considerable work on land at a busy time. There was a very complicated manifold on the beach, with tankage on the cliff, supplying road and rail filling points. Three pipes were laid to Calais where there were better rail facilities for transport to the American Army who for some time received the majority of the output. The Ostend–Ghent system was then connected to Calais by 70 miles of twin pipe. This was of course heading away from the enemy, and it had to keep clear of Dunkirk, still full of Germans, and to skirt a large area occupied by dumps of reserve ammunition.

While it is easy to minimize the net advantages that we received from Pluto and Dumbo, it cannot be denied that Dumbo was eventually a technical triumph, and to some extent reduced our demands upon tankers, which were in short supply at this period of the war. It also provided a partial insurance against the closure of Antwerp, which for some time was under very heavy V2 bombardment. This did in fact cause two fairly serious fires in the tank-farm, but by the time that Dumbo had reached full delivery the bombardment was very nearly over. On the other hand critics of the whole conception of the project might point out with some truth that it is comparatively easy, as we found in North Africa and Italy, to discharge petrol in bulk from a tanker at a very badly damaged port, and that this is far quicker than the laying of sufficient pipes to give the same discharge. Moreover in mobile operations the system is far more flexible. At Port en Bessin there was not even a deep-water harbour, but discharge from tankers worked well.

ANTWERP TO THE RHINE

British troops had entered Antwerp on 4 September, but it was not until 28 November, after the clearance of Walcheren Island, that large ships could enter the Schelde and reach the port where the oil-berths and storage tanks were but slightly damaged. Development had been carried out jointly by British and American Engineers, and a British pipeline had been started. During December imports averaged 5,000 tons per day, and the pipeline with tankage and filling points had covered the 60 miles to Eindhoven by the end of the month. At the beginning of March the success of the Battle of the Rhineland allowed the pipes to be pushed forward another 20 miles. The Rhine was crossed by British troops on 24 March, and during April two pipes were pulled across the river and ample storage, with filling facilities, established at Emmerich on the far side. In June and July a further 15-mile extension was made to Bocholt.

During March, 35 miles of twin pipeline had been laid, crossing the Escaut, to link Ghent to Antwerp, with the result that on the opening of Emmerich it was possible to pump from Liverpool, via Dumbo, to east of the Rhine. The final link in this line was put in by the QMG, General Sir Thomas Riddell-Webster, and is now in the RE Museum. He had previously inspected (without batting an eyelid) a "Guard of Honour" composed of men drawn from every unit that had been employed on the pipelines. It contained British, Canadian and French Canadian Sappers, RASC drivers and oil personnel, and of course Pioneers whose keenness had gained universal praise. This link was to a large extent redundant for, so long as Antwerp operated, it was carrying coals to Newcastle. It was lucky that it was on this length that we received our only really direct hit on a filled pipe under pressure during the V2 bombardment. To deal with imports from Dumbo we had now laid a twin pipeline longer than either that from Port en Bessin to Rouen or from Antwerp to across the Rhine. When most of our petrol was coming up the Schelde direct from Arabia and the Carribean, it was difficult to explain to the pipelayers that they were saving valuable tanker tonnage by making it possible to route crude oil to the Mersey, where it would be refined and then pumped for 520 miles by land and sea to Antwerp.

STATISTICS

Consumption of M.T. petrol and aviation spirit by 21 Army Group was about 4,000 tons per day (except during semi-static periods), with an accumulation of a 30-day reserve.

Length of pipe laid was 1125 miles[1] with 26 pumping stations.

Tankage was erected to hold 103,000 tons.

Weight of stores landed was 92,000 tons (about 14 per cent of the total weight of all engineer stores imported).

The average through-put during the campaign was about 160,000 ton-miles per day, but it touched a peak of 500,000 during April. The total for the whole campaign up to VE Day was thus about fifty million ton-miles.

Personnel employed was about 650 men with 120 lorries, increased by part of a French Canadian battalion during the busy period. These figures do not include the men and lorries employed in moving the stores from ship to Base Depot and their handling there.

[1] This was almost exactly the same total length as that of the principal twin pipelines laid in the Middle East: Western Desert (water) 320 miles, Suez to Port Said (naval fuel) 110 miles, Suez to Cairo (petrol and paraffin) 90 miles, and Suez to the Canal Zone airfields 30 miles.

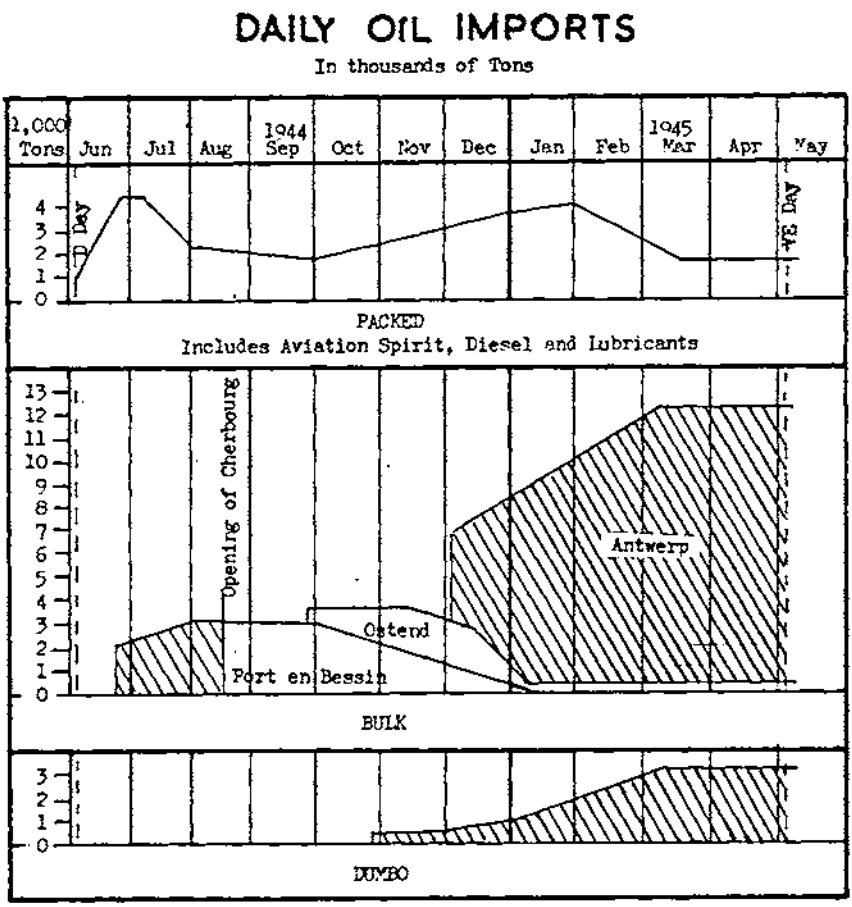

Figure 2. Chart Shaded areas include imports allotted to the U.S. FORCES

TECHNICAL

Pipes. These had Vitaulic couplings and were of two very slightly differing sizes—British, 6 in internal diameter, and American, 6¼ in external diameter. There were three different types of groove or flange. They were painted with different coloured rings and every effort was made to keep them apart on the beaches and in store, but rogues with the rings obscured by mud did get in, and there was at least one case of the couplings withstanding the water test but pulling apart later. Each pipe was 20 ft long and weighed about 300 lb. They were carried on 10-ton articulated lorries.

The ship-to-shore lines at Port en Bessin were 6 in oil-well casings, with quick-thread tapered screw joints. A 1,000-ft length was made up on the beach and towed out, extra lengths being added as towing proceeded.

The Pluto and Dumbo pipes were of two kinds, each 3 in internal diameter. One was virtually a hollow submarine cable, paid out in more or less the normal manner from horizontal figure-of-eight coils in the hold of the cable ship. The other consisted of long lengths of steel pipe welded together continuously and wound vertically on 30-ft diameter drums, which floated and unwound as they were towed forward at speeds that sometimes reached 6 knots. Both types of pipe worked at 1,500 lb per sq in, and each pipe could in theory deliver 270 tons per day to Cherbourg, or 400 to Boulogne.

Pumps. These were of reciprocating type, working at 600 lb per sq in, and with stations 20 miles apart could maintain a combined delivery of 1,000 tons per day per pipe.

Tanks. These each held 1,200 tons, and were assembled with rubber gaskets and very numerous small bolts. The holes in the top and bottom sectors were often very difficult to register.

Personnel. The Sapper, RASC and Pioneer Companies had been carefully trained and were very efficient, the employment of Pioneers being a great success. Our casualties from mines, V2s and accidents were surprisingly light.

Conditions. During the busiest period there was bitterly cold weather, which made the handling of steel and the bolting of tankage very difficult, and the water-testing of long lengths of exposed pipe became a hazardous process. With the advent of warm weather there was some spectacular snaking, especially on the smooth surface of the autobahn, but with very few failures of the joints.

Control. General supervision of the construction programme was exercised by the ADW Oil (Lieut-Colonel W. A. Smailes, OBE) in the Office of the Director of Works, but policy directions, sometimes rather puzzling, were issued by Supreme Allied Headquarters because petrol was a common-user item. At each pumping station Sappers ran the pumps and with pioneer assistance maintained their length of pipeline, but RASC personel controlled the pumping programme. In April the War Office wanted the RASC to take over the pumping and maintenance, but owing to shortage of suitable men this was never done.

CONCLUSIONS

1. The supply of petrol by pipeline to a fixed installation such as a large airfield is a very paying operation, because every 50 miles of pipe (of the type we used), weighing a few thousand tons, once laid, will continue to discharge 1,000 tons every day, thus doing the work of 100 10-ton road-tankers working on a 100-mile turn-round. Piped supplies to mobile formations will pay much smaller dividends because of fluctuations in demand and the necessity to replace a line whose useful life has ended. In order to produce an average through-put of 160,000 ton-miles per day we had to employ continuously at least 650 men and 120 lorries, many of them 10-tonners. If we had had modern aluminium pipes and plastic "pillow" tankage these figures would of course have been very different.

2. There must be close and constant liaison between the RE, the RASC (now the RAOC) and the Staff.

3. It is important to concentrate pipe laying on those routes that will probably have a long useful life and be used to the full.
4. Except for short hauls rail transport, if available, is preferable to road, and facilities for filling rail tank-wagons should always be provided.
5. Pipe-laying at speed requires careful specialist training, and must be supported by a very good stores organization both at home and in the theatre.
6. As things turned out, we gained extremely little from Pluto and Dumbo, and the task of disposing of petrol discharged so far away as Boulogne was very considerable.

Silver Jubilee

LIEUT-COLONEL E. E. STENHOUSE, DSO

Victory Day Parade Royal Engineers contingent marching down Oxford Street

We all have our jubilees commemorating personal achievements, such as when we got our first Rugby cap at school, the date of our first commission, and for those of later years our silver wedding anniversary.

I am writing about this particular jubilee as not only was it an occasion I was particularly proud to take part in, but it may also be of interest to others who took part or watched it.

Lieut-Colonel E E Steinhouse,DSO

It all began in a cinema in Bournemouth in April 1946. I was on leave and staying with my father. An usherette appeared and said that Colonel Stenhouse was wanted on the telephone. We were both lieut-colonels and as my father had been a resident of Bournemouth for some seventeen years and as far as I knew nobody knew I was even in the town, he somewhat unwillingly went to the telephone only to return to say it was I who was required. It was my wife. She had just received the news that I had been appointed to command the RE contingent in the Victory march in London which was due to take place on 8 June 1946.

This was very exciting, but what did it all involve. I soon collected the following information:

(1) The strength of the RE contingent was to be 61 files of 12 with an officer on the left of each file and the CO marching in front. This was to be provided by 48 officers and 537 ORs from units and 14 Officers and 154 ORs from the RE TA. This included 20 ORs spare.

(2) The RE contingent, less the TA, were to concentrate at Aldershot for training on 22 May.

(3) The length of the marching route was 4½ miles.

A visit to the old Mounted Depot—which was then commanded by the late Colonel "Pop" Stroud, who had been detailed to look after us—quickly relieved me of anxiety. The forty-eight officers were all to live and feed in the RE Mess and the ORs were allocated four barrack blocks and fed centrally regardless of rank in the Men's Dining Hall.

The composition of the contingent forming up at Aldershot was rightly extremely representative including detachments from Airborne Formations, Transportation, BAOR and all the UK Commands SME, TBs RE, RE Depot etc.

My job was to mould this somewhat disparate collection into a marching force we could all be proud of and I had a week to do it in before we moved up to Kensington Gardens on 2 June. Despite the fact we had recently concluded a six-years-war fought in all parts of the globe, there was still administrative chaos when personnel from thirty-seven different RE units arrived in Aldershot, some without rifles which had been removed by enthusiastic embarkation staff. Practically every man had to be issued with something whether it was a complete suit of battle dress or service chevrons.

May 24 therefore was the earliest date it was possible to assemble the whole contingent together properly equipped.

Training was naturally based on the file of twelve formation and it soon became apparent that the wheel caused difficulty. Fortunately, at this time the Training Battalion I was commanding was being disbanded so I was able to call on the TB SDI to come and assist. I also arranged for a pass off on the afternoon of the 31 May at Aldershot to be taken by the E.-in-C's representative.

Great improvement and interest helped matters considerably and we were in good shape on 31 May for the inspection by Brigadier Eaton Matthews. We even managed to borrow a band from the Royal Army School of Music for the occasion. However the weather intervened. In the morning the first practice parade with the band was sandwiched between showers. At 1 pm it was raining steadily and continued to do so. The end was no band and a march past in ground sheets!

KENSINGTON GARDENS

Now we could begin to enjoy ourselves. The contingent was accommodated in reasonably waterproof tents, there was an ample supply of duckboards and the food was good. Sleeping Out passes were allowed and those who lived in camp had to be in by 0100 hrs.

Our camp was by the Broadwalk and as the lines filled up, it was fascinating to watch units and individuals from all over the world practise in front of us—different races, creeds and colours who had all supported us and fought so gallantly during the previous five years.

—Camp Routine was not very arduous.

0945 hrs Parade in camp.

March down the Broadwalk.

Out into the Bayswater Road, turn left.

March through the west gate the other side of Kensington Palace.

Here we practised various movements for about an hour and had the place to ourselves. On return to the lines the contingent were at the disposal of their officers for administrative matters and were free to enjoy themselves.

The RE band arrived on 4 June and were of great value on the morning parades.

There was one incident I remember vividly. We had just finished training on our private road and with the RE band at the head were marching back to camp. As we got to the gate leading on to Bayswater Road, the pipers of the 51st Highland Division marched in at the head of their contingent. Both bands played full blast passing each other, but by this time the Scottish contingent was occupying the full width of the gateway, so the RE contingent was brought to a halt.

There remained one more problem. This was the arrival of the RE TA. They were not due until 7 June and the Victory March was the next day. This meant they would be completely untrained in marching in twelves and in the procedure of saluting at the Cenotaph and the Saluting Base. The only hope was to infiltrate them among the trained members of the contingent and trust they would not create confusion and disturbance. They didn't.

A final upset was the loss of an officer through flu three days before the march. However in the best Airborne tradition he made it on the day without any ill effects.

Now we come to the great day itself.

8 JUNE 1946

Bits and pieces of the TA continued to arrive through the night, so, with the help of some reserves brought up from Aldershot we were able to muster our full quota of sixty-one files with an officer on the left of every file except one. This one vacancy was occupied by a gallant RE TA corporal who had a false arm and was therefore excused carrying a rifle.

At 0915 hrs. the RE contingent together with the RE band and the R Signals band formed up in the Broad Walk. We then moved off to the Assembly Area which was in the north-east corner (by Marble Arch) of Hyde Park about 1½ miles distant.

The Assembly Area was a large area, mostly grass which had been covered with chestnut paling or canvas, but fortunately it was dry at the time. There was an adequate supply of latrines. Contingent areas were roped off and we were told by a Marshal that the contingent could fall out within the ropes, smoke and have tea at mobile canteens.

As all the 21,000 troops comprising the marching column were assembled in this area it was a masterpiece of organization. However, around us, it failed in one respect in that the mobile canteens were not available for the military. This produced for me a somewhat bizarre incident. I was told by one of my officers that Corporal X, a RE TA NCO wished for an interview. When I gave it to him, he asked for permission to fall out of the march, giving as his reason that he could not get any tea. He was now a civilian and entitled therefore to an issue. Of course I told him not to be silly, which he took in good spirit, and the incident was closed. At the time I was astonished that anyone having got as far as the assembly area to take part in one of the greatest events in their lives should wish to back out. In retrospect, this was the first instance of the civilian's post-war outlook on life, which I had become involved in, and I suppose it hasn't changed much during the subsequent twenty-five years which have intervened. It also illustrates the folly of letting the TA representatives join so late. He probably arrived during the night (a lot of them did), had very little idea what it was all about, and became confused when he saw the huge cheering crowd through the railings surrounding the assembly area.

After about three-quarters of an hour at ease, the Chief Marshal gave the order to move off.

Immediately in front of the RE contingent was the combined RE and R Signals band (sixty strong). In front of them was the RA band (120 strong). Behind us was the R Signals contingent and behind them there was the Guards band. So we had plenty of music.

At 1103 hrs. the head of the RE contingent passed through the gate into Marble Arch. My immediate concern was getting them into the route. This was rather tricky as it involved splitting into sixes for passing through the two gates, wheeling left immediately afterwards, followed by a right wheel round Marble Arch itself.

A most magnificent and impressive scene opened before us. Looking down the whole length of Oxford Street the road was empty except for marching men, but flanking it on either side were houses and shops decorated with bunting and flags, union jacks everywhere, people hanging out of every window with the pavements thronged behind those lining the route. But the most vivid impression of all was the noise. The cheering was fantastic and continued to be so all along the route. As evidence of its volume, the RE band struck up "Wings" opposite the Mount Royal Hotel, but it could not be heard at the rear end of the column. That this should have happened where it did was the result of a little conspiracy between myself and the RE band. My wife had secured a room overlooking the route in the Mount Royal Hotel which was crammed to bursting point by members of the family including my son who had been extracted from his prep school. I have no doubt the playing of the regimental march was much appreciated by them, but its effect was lost on the main target (my son) who subsequently joined another arm of the service.

We now had a straight run down Oxford Street marching in two columns of sixes each side of the centre islands. "Run" it nearly became, as there was a lot of leeway to make up due to the two wheels at the start. It was especially difficult for the rear of the contingent, who, if they heard any band at all, heard the Guards band behind the contingent behind them. One officer told me afterwards that despite changing step many times, he was never on the right foot until he got to Selfridges. However by the time we turned right down Charing Cross Road, the intervals were correct and the contingent were marching in twelves for the first time.

The head of the marching column was due to halt on arrival at Parliament Square for twenty minutes, which meant that we would be halting in Charing Cross Road. By Leicester Square underground station, the RA contingent in front halted, ordered arms and stood at ease. We did the same. The Marshal assured me this was the proper halt, so I went to the rear of the RE contingent to find out how they had been getting on. I was having a friendly chat when there was a sudden change in the range and volume of the noise coming from the crowds. It was easy to see why. The Airborne units at the head of the RE contingent, distinctive in their red berets, were sloping arms and marching off leaving the CO in the rear in no position to exercise any control. His efforts to regain his position by a sharp double up the flank roused the crowds to even greater enthusiasm. A few minutes later the column stopped again. This was the real thing, but I took no more risks and remained at the head of the contingent. Again I was overwhelmed by the gaiety, good humour and generosity of the great British people. Cascades of apples, cigarettes and even eggs came pouring down from windows on to our heads. All this and rationing too!

The RE band had their adventures as well. They happened to have halted with a traffic island in their midst which was being used as a RAP. The St Johns detachment were pretty pushed at this time and a number of cases of all ages and sexes were being laid out on the island. This had a somewhat depressing effect on the band until the Bandmaster told them to look the other way.

We were off again after about three-quarters of an hour and reached our peak along the Embankment and, I like to think, kept it up until past the Saluting Base.

Excitement increased as we marched up Whitehall and turning left through Admiralty Arch into the Mall the sight was overwhelming. Coloured banners on white and gilded poles the whole length of the Mall, masses of frantically cheering people, Buckingham Palace with flags flying as a back cloth added to which the

supreme moment of the day was now approaching when the RE contingent would salute the Monarch and our Colonel-in-Chief H.M. King George VI.

For various reasons when the saluting base was reached, there was a large gap between the tail of the RE band and the head of the RE contingent. I don't think this really mattered and it gave ample time for His Majesty to see that his Royal Engineers were approaching. The number of Royalty and distinguished persons was so great that it was impossible to take them all in. Talking to others afterwards, we were all tremendously impressed, but no two impressions were similar. It was essentially a personal matter. As far as I was concerned I was completely entranced by the dress worn by Her Majesty the Queen and almost failed to take in anybody else.

Going up towards Hyde Park Corner, the rifles suddenly became much heavier, it became more difficult to remain in step, and it started to rain. The RE band was a great morale raiser here and played us back to camp—a further half-hour's march from Hyde Park Corner—with the rain becoming heavier all the way. However it did not cause us a great deal of discomfort, and this was completely forgotten when we were all sitting down to a hot meal at about 1345 hrs. The high standard of camp administration continued to the end, so the pattering of the rain on the tent roofs was ignored during our discussions about the exciting events of the morning.

A Hundred Years Ago

MATA KACHA

THE total strength of the Corps proposed in the Army Estimates for 1871–72 was 5,169, representing an increase of 333 over that of the previous year. There were then no first-line reserves and no sapper units in the "constitutional force" of the Militia, but the Volunteers included Engineer Battalions, the administration and instruction of which provided employment for some of the 572 officers on the amalgamated list published in the *RE Journal* for April, 1871. If we add the 207 remaining on the unamalgamated Indian lists, we arrive at the total of 779, giving the remarkable proportion of one officer to every 6 or 7 men in the ranks. Here is statistical evidence of that enlightened policy, referred to in previous reviews, under which a numerous variety of extra-regimental appointments, civil as well as military, administrative as well as scientific, were at that time open to Royal Engineers. At the head of the Roll still stood, as senior of the Colonels Commandant and Constable of the Tower, the aged General Sir John Burgoyne, commissioned more than seventy years before, in time to see his first active service at the blockade of the French in Malta. Last but one in the list of young officers undergoing their first Course of Instruction at Chatham appears the name of Horatio Herbert Kitchener, future Sirdar of Egypt, Commander-in-Chief in South Africa and in India, Field-Marshal, and Secretary of State for War.

The contemporary obsession with fortification, and in particular with the seaward defences of the south coast and the naval ports, is reflected in the same Estimates, though the greater part of the current programme of heavy construction work was now nearing completion. An article in the May number gives us a comprehensive account of the Breakwater Fort which formed the main feature of the outer line of the harbour defences at Plymouth and was at that date deemed to be the strongest fort in the world. Work had been commenced some nine years earlier, when the contractors, Messrs Lee and Son, working from a diving bell, began to raise the foundations from the surface of the Shovel Rock some forty feet below low water mark. The work was quite solid up to high water level and consisted of courses of concrete blocks surmounted by granite facing-blocks with rubble masonry hearting above low water. The armament of this fort was to be eighteen 10 inch (18 ton) and four 25 ton guns, the latter mounted in two turrets, and its armour a complicated combination of 5 inch

rolled iron plates, 5 inch rolled iron bars, 12 inch teak baulks and cement- and-iron-concrete. This last material seems to have been made of iron filings and tar "thoroughly mixed". The entire cladding added up to a thickness of three feet and was so designed that it could be doubled to six feet. "This" comments the writer "may be considered equal to any increase in the power of artillery for a long time to come". In fact, this fort and those like it "executed" elsewhere along the coast represented the climax in that particular phase of the endless war of *gun-v-armour*. The domed cupolas of Liège marked the culmination of the next round, and the galleries of the Maginot Line, sixty years later, that of the last. Experiments continued, nevertheless, to be conducted at Shoeburyness on the effect of field guns against enclosed works "such as field redoubts" and on various forms of deck and head cover, including the use of plate iron. If a description in the *Journal* of June 1871 is anything to go by, these experiments were not always wholly successful. Of twenty rounds fired by the new 16 pounder MLR gun on a wrought iron field carriage, only one burst in the target enclosure and seven above it, producing 131 internal hits from splinters. Another trial had to be postponed owing to the target structure "falling on its face". The technical details given in this article of projectile, charge, angle, penetration and effect show, however, that the whole question of protection both in fixed and field defences was attracting a great deal of attention a hundred years ago.

Notable increases, both in the Vote for stores and that for works, signalled substantial developments in the use of submarine mines and controlled torpedoes as adjuncts to the defence of ports. "By this we argue" says our Editor "that other stations than Chatham will have equipments and experiments, and thus employment for the Royal Engineers of a large and important nature is at once created". Considerable space was accordingly devoted in two successive numbers to articles by Major R. H. Stotherd on these subjects, which were to absorb the effort of a considerable proportion of the Corps for the ensuing three decades until, in 1904, responsibility for them was transferred to the Royal Navy.

Among the new works provided for in the Estimates for 1871–72 were improvements to the RE Mess at Chatham, the buildings for an RE Institute, and a Chapel for the cadets at Woolwich. In 1869, a Royal Commission on Military Education under the presidency of Lord Northbrook had recommended the foundation of a Royal Engineers Institute, following the lines of the Royal Artillery Institute, as a centre for engineering research and instruction. The new Institute was to provide class-rooms (then somewhat pompously styled Halls of Study), a library, a laboratory and a museum, as well as offices for the Secretary of the RE Committee and his staff. The building was designed by Lieutenant M. F. Ommanney at an estimated cost of £21,000, to be spread over the Votes for 1871 and 1872. Tenders were called for by Colonel J. W. Lovell, then CRE at Chatham, and accepted in November 1871. It looks as if preliminaries ate up all the appropriation for the current financial year, but the foundation stone was duly laid on 28 May, 1872, by Field-Marshal HRH the Duke of Cambridge, and the work was completed by 31 December 1873. The Institution stands on the site formerly occupied by hutments erected during the Crimean War and is remarkable for the use of terra cotta instead of stone for its enrichments. This material yielded a small reduction in cost, allowed of finer detail in ornamentation, and was unaffected by frost. The contractors for the terra cotta were none other than Messrs Doulton, of Lambeth, who cashed-in on the occasion by exhibiting examples of their work from Ommanney's designs at the Vienna Exhibition in 1873.

The Mess buildings at Brompton were to undergo considerable enlargement to cope with the bigger numbers of officers to be stationed at Chatham. The original building had been opened in 1807, at which date the dining members comprised 6 or 8 gunners and only 3 or 4 sappers, and became an RE Mess in 1848, when the gunners moved out. The centre portion of the mess-room was completed in 1861, but it is not clear from the "History" what additions were made at the time of which we are writing. Whatever they were, a notice here explains that, at the Corps General Meeting in May 1871 the decision was taken that the Chatham mess should become the Head-

quarters Mess and that all officers "be required to contribute thereto one day's pay per annum", a resolution which duly found its way into the King's Regulations.

Struggling out of the concrete and the enmeshments of mines and torpedoes, a contributor in the June number introduces a breath of fresh air from the field with the reminder that "rapidity of movement is now more than ever requisite" in an army, and proceeds to describe the new Pontoon Train just put into service. (The number of horses assigned to the Corps had gone up from 198 to 422, mostly by increments to "A" Troop at Aldershot). The RE Committee, it seems, had been occupied in examining alternatives to the existing equipment, which had been found "inadequate to fulfil (sic) the conditions which it would have to encounter in war". In their search for suitable materials for the pontoons they had, using the money authorised on last and this years' votes, made two of steel, three of canvas, and (at the instigation of the Constable of the Tower) one of "Mr Clarkson's patent cork materials". On the age old principle of report writing of setting up ninepins, only to knock them down, Mr Clarkson alone remained standing at the end of the day, when his material was pronounced "undeniably the best of all". In the course of exhaustive trials the Committee caused a crowd of men to mark time over the pontoon when grounded on a bed of flints and, when they found that that did not injure it, rained upon it a series of heavy blows from a sledge hammer, fired musket balls through it, and subjected it to radiant heat in which the thermometer stood at 150 degrees, without any noticeable effect. Having thus determined the material of which the pontoons should be made, they began to consider the design of two bridges, the first and lighter of which was "to afford safe passage for an army composed of troops of all arms, with its guns, ammunition, stores etc, over a river or stream in any condition under which the necessities of war require such an operation to be effected". The specification arrived at for this called for a 9 foot roadway capable of normal loading at 560 lbs per lineal foot and, "as an extraordinary load, infantry retreating in a disorganised mass, also crowded in consequence of a check", which it was calculated might amount to 756 lbs per lineal foot of bridge. The heavy bridge had to carry "the heaviest loads that can be brought upon it by horses, which it may safely be assumed will never exceed the 64 pounder breech loading gun, weighing when complete 99½ cwts, of which 78½ are on one pair of wheels". As an extraordinary load, this bridge also was to be capable of supporting "disorganised bodies of troops, armed or unarmed, crowded by some sudden check and even in a state of panic". Well might the Committee consider these as the most unfavourable conditions conceivable! The expression "infantry in fours crowded at a check" was to pass into the manuals; the disorganised masses and the state of panic were to be swept under the carpet together with all the other disagreeable accompaniments of retreat which successive generations of professional soldiers were left, in the harder school of experience, to find out for themselves. The sombre realism of this report is not without its perhaps unconscious humour:

> "It has been found that 76 unarmed men can stand on every 100 square feet of roadway, causing a load of 990 lbs per lineal foot of bridge; but such close packing being inconsistent with motion, or even with efforts at motion, the Committee consider that such a load can never practically be brought upon a bridge, but that if attempted the bridge would find relief by the precipitation of numbers into the water."

The same equipment, with the floating piers at 15 foot centres, was to form the basis of both classes of bridge, additional road-bearers being incorporated as necessary for the heavier loading. The pontoon and the whole of the stores for one bay of the lighter bridge would be carried on one wagon, so that a multiplication of units could adapt the equipment to any breadth of gap. A novel component of the equipment was the trestle, with an arrangement for adjusting the saddle piece to any required height, which in one form or another has remained with us ever since.

Nameless writers in the *Journal* for April, May and June 1871 gave out their

thoughts on the sapper's place on the staff and on the conditions of his service in India, while one looked back to "*Ninety Years Ago*" for the view of the engineer taken by a certain Major Griffith Williams, a gunner:

> "I could wish that their duty was entirely confined to forts and garrisons, and leave the duty of the field to the commanding-officer of the artillery, under whose direction all works for attack and defence should be carried on . . . Nor, indeed, have I ever been under the necessity of calling any of the engineers to my assistance, neither have been able to come at that the real duty of an engineer is in the field".

In a "hasty sketch" a forward looking contributor advances the naughty thought that the cadets for the Royal Artillery and Royal Engineers might profitably be removed from the RMA at Woolwich to the RMC at Sandhurst, which would then become the one school for all branches of the Service. "Would not all gain by being brought up together in unity? Might not the services of engineer officers be more appreciated for high army commands? What is there in the nature of Artillery and Engineers that should isolate them from the rest of the Army?" Three-quarters of a century were to elapse before this man's dream was fulfilled; meanwhile, the isolation of Woolwich was to be reinforced by the construction of a Chapel, as provided for in the current Estimates.

Apart from the regular notices of postings and reversions, these three numbers contain no mention of activities at the "foreign" stations. To those who think that the 1st Company RE always belonged to Gibraltar, it comes as a surprise to find it then located in Bermuda, while the 11th, 20th and 25th Companies were in garrison on the Rock. At home, Herr Josef Sauerthal, a native of Bohemia, became Bandmaster to the Corps and set about forming the string orchestra. Amateur theatricals seem to have been a popular diversion at Chatham, the performances being attended invariably (if one may credit the reporters) by "a full and fashionable" audience. Certainly the *Journal* could be congratulated on the frankness of its dramatic critic, who could comment cruelly (of a certain Mr Davis) that "neither *his* songs, nor anybody else's, had been properly rehearsed" and of another, Mr Martin, that "he meant well".

Perhaps these gentlemen were too busy digesting the munificence of the Army Estimates, familiarising themselves with the mixing of iron filings with tar, the properties of Mr Clarkson's material, and the niceties of terra cotta; probably they prayed for a posting to the Pontoon Train, or to Poona. Meanwhile, the committee of the RE Charitable Fund, formed in 1868, went about its humane business on a more slender budget. The accounts of the local branch at Chatham, amounting to £17 3s. 3d. for disbursements in the past quarter, were approved; an allowance of 3/6 a week was granted to the widow March and, on the recommendation of Captain Palmer, £5 was awarded to Mrs Barnes, wife of the late Sapper Barnes, to purchase a sewing-machine and some other necessaries for the purpose of assisting her to obtain a livelihood.

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Correspondence

Brigadier P. St. B. Sydenham, CBE,
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29 March 1971

TOO LITTLE AND TOO LATE

Sir,—How pleasant it is to read again the mellifluous and kind-hearted periods of our most prolific contributor to Maga.

Firstly I should like to add my tribute to Brigadier Simson who was given a task more impossible than that given to most "Sappers". I must admit that I found the opening paragraph of J.L's review quite fascinating.

Your December number, in addition to the review under reference, contained an article on the role of engineers in war, written albeit circa 1870, and another article which contained several references to "cost-effectiveness". The Corps List of September 1939 showed 20 RE generals on the "active list"; and the names of several other RE officers in "posts of importance", who subsequently attained that rank. Perhaps they had never heard about "cost-effectiveness"; perhaps they thought the extant ideas on the role of engineers in war "out of date".

Is it possible that better "military engineer" results might be produced, if the senior ranks of RE officers were paid more highly? For example RE brigadiers the same pay as infantry major-generals. I understand that such a change is contemplated for the RAMC. Are the RE less technical and less important?

The Japanese opened their war against Russia with a "minor incident"; why was it assumed that "the leopard had changed its spots" in less than 40 years? On the morning of the 9 December 1941 (local dates) I took my pre-breakfast walk on the deck of the US Transport Wakefield to see if any icebergs were visible 3 days steaming South of Cape Town. I was greeted by the ship's officers, members of the US Coastguard Service, with a frozen hush. One might have concluded that "those God-damn Limeys" had engineered the whole affair to ensure that the USA did "come in".

On the morning of the 30 January I stood on the ship's bridge, in company with General Beckwith-Smith, the CRA, the GSOL, and the A & Q to watch those of the men of 18 East Anglian Division disembark at Keppel harbour and then unload their light equipment; the Asiatic stevedores were absent. Forty Japanese bombers flew overhead in formation, attacked by one solitary British "fighter". Two of the bombs fell into the hold just in front of the bridge—the hatches were "off"; fortunately the hold was full of blankets, which had been used by the troops on the voyage.

The division had arrived still "loaded for a long sea voyage, NOT tactically". We had left Liverpool early in November. I learnt later that our "gunners'" guns, travelling by "slow" convoy, were unloaded in Rangoon some weeks later, just in time to be captured by other Japanese forces.

As I stood on the bridge I wondered why the country bothered to pay for a Staff College at all; I recalled the instructors saying on more than one occasion, "Never try to plug up holes".

Late in the following week, when the RAF had abandoned Seletar, I and one of my company commanders released 90,000 gallons of "aviation" spirit into the Johore Strait, between the Causeway and Changi; there was a certain amount of sporadic shelling going on. I had NOT asked permission. The Japanese *noticed* this, *as was recorded* in the diary of the Japanese Chief of Staff. Whether this contributed to their decision to cross West of the Causeway, I do not know. There were at that time millions of gallons of fuel of several sorts on the island of Pulau Bukum; the storage tanks were set alight during the course of the following week and burnt for days continuously.

In May and June onwards, as GSO1 Ceylon Command HQ, I arranged exercises at divisional level in "jungle warfare". The first exercise came to a stop after 60 hours because the Gurkha division, which was supposed to be defending Colombo, was trying to fight its way back there through 18 British Infantry Brigade which was "landed" North of Trincomali to invade the island. 18 Brigade was trying to fight its way back through the Gurkhas to regain contact with its supporting brigade and its beach-head.

"Quis ipsos custodes?" The GOC Gurkha Division thanked the directing staff for the lessons learnt. I was told that they did very well in Burma later.

Amongst my souvenirs I hold receipts—in my name from a Dutch shipping company in Sumatra for 83,740 guilders for passage money to India for 36 officers and 477 ORs and another receipt for 5,385 guilders for passage money for 5 officers and 105 ORs. I was NOT able to obtain from the station-master a receipt for the money which I paid him some days later for a special train from the town to the harbour for some 900 all ranks. After the last party of 110 had sailed I sent—and paid for—a "coded" signal by W/T to A.B.D.A.C.O.M. setting out the local situation. About 60 hours later the destroyers *Scout* and *Tenedos* came in to refuel; they had not sufficient to enable them to get back to India. At that time we were the only bunkering port in JAVA or SUMATRA still clear of the Japanese, as had been shown in my signal, though they were flying periodical "recces" over us. They embarked the 900 all ranks after sunset in less than 30 minutes.

A Lieut-Colonel, Royal Marines, engaged on some "I" work, insisted on staying behind. I gave him money to buy a small Malay sailing ship. The ship arrived off Ceylon, some two months later, having sighted the Japanese battle-fleet "en route".

Perhaps the Staff College has some value.

My experiences bore out those of my great-grandfather in the Peninsular, 1809;1814, that it always pays to carry as much "folding money" with you on service as you can afford; you will receive much better co-operation from the indigenes, if you are prepared to pay reasonably, even those who are nominally your allies.

Many of the men of our machine-gun battalion, the 6 Royal Northumberland Fusiliers, and of the divisional Field Park Company RE, swam ashore from their sinking transport which had been bombed and set on fire before it reached the quay. A number of them, including the field park company commander, were taken straight to hospital. If they had been able to hear a speech made later by the Prime Minister, in which he said "that the troops had fought indifferently and that was the most shameful episode of his life", I feel sure they would have been greatly heartened during their three years of captivity.

I have been told there is an old Turkish proverb, "The fish stinks from the head."—Yours faithfully, P. Saint Baste, Sydenham.

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Memoirs

BRIGADIER-GENERAL SIR GODFREY RHODES KT, CB, CBE, DSO, K ST J, MICE, M INST T, M (SA) SOC CE

GODFREY DEAN RHODES was born in Canada on 18 July 1886, the eldest son of Mr and Mrs H. Rhodes of Vancouver, British Columbia.

He was educated at Trinity College School, Port Hope and at the Royal Military College, Kingston where he became Senior Under Officer and was awarded the Sword of Honour and the Gold Medal. From Kingston he was commissioned into the Royal Engineers on 27 June 1907.

During his Junior Officer training at the School of Military Engineering, Chatham, he was awarded the Silver Haynes Memorial Medal given in those days to the most distinguished young officer in Military Engineering in each batch.

By specializing in railway engineering after completing his Chatham courses he followed in the footsteps of another famous Kingston Sapper officer, Colonel Sir Edouard Girouard, KCMG, DSO who, as a subaltern, was one of Kitchener's Band of Boys during the River War of 1897–8 and responsible for the construction and operation of the desert railway and later, during the South African War of 1897–8, was Director of Railways controlling the mainenance and extension of over 4,600 miles of railways and the operation of armoured trains. From 1907 to 1912 he was Governor of the East Africa Protectorate.

Rhodes' first association with railways began in 1909 with an attachment to the London and South Western Railway at Eastleigh, Hampshire. When he was posted to India in 1911 he took a Railway Course at Sialkot before joining the 26th (Railway) Company Sappers and Miners which was engaged on the building of a line through the North West Punjab.

Shortly after the outbreak of war in 1914 he went to France as Adjutant of the Railway Construction units sent from India.

On 11 August 1915 he was married by the Venerable Archdeacon Wilberforce at St John's Westminster to Molly, the only daughter of the late W. F. Topping and Mrs Darley-Bentley. They had two sons and a daughter.

When the Indian troops were withdrawn from the Western Front towards the end of 1915 Rhodes went in command of the 117th (Railway Construction) Company to Salonika. He rapidly became Assistant Director of Railways and then Director of Railways Salonika with the temporary rank of colonel. He was awarded the DSO in 1917 and was created CBE in 1919. He was also decorated by the French, Greek and Serbian Governments. In 1920 he became Director of Railways at GHQ Army of the Black Sea at Constantinople, with the temporary rank of brigadier-general, responsible for the operation of the Turkish railways in Asia Minor and Thrace.

At the end of 1920 he left the Army of the Black Sea and became Chief Engineer of the Kenya and Uganda Railway, then called the Uganda Railway. This ran from Kilindi to Lake Victoria, across which there was a ferry service extended by short links to Kampala and Lake Kioga. When he arrived the rail system was suffering from lack of maintenance and shortage of funds. The post-war growing prosperity in East Africa however led to the expenditure of over £10 million between 1920–8 in extending and increasing the track mileage from under 700 to more than 1,600 miles, building a modern port at Kilindi and improving and enlarging the marine services on Lake Albert. Rhodes retired from the Army on 4 December 1926 and took up the appointment of General Manager Kenya and Uganda Railways and Harbours and became responsible for the development and operation of this vast transportation system. He was created a Knight Bachelor in 1934.

He was recalled for service during the Second World War.

On the collapse of the pro-Axis revolt in Iraq in May 1941 the country was occupied by a British force under the control of the C-in-C India and a small transportation staff was attached to the Force HQ. Later in the year, as a result of the German thrust into Russia, British and Russian troops occupied Persia and Sir Godfrey Rhodes was appointed Director of Transportation Persia. In February 1942 the forces in Iraq and Persia were transferred from the control of C-in-C India to that of C-in-C Middle East, and in August of that year the Persia and Iraq Command (PAIC) was established as a separate Command and a combined Movements and Transportation Headquarters, under Sir Godfrey as DQMG (Mov and Tn), was set up in GHQ PAIC at Baghdad. At that time the route through Persia was the only safe line of supply to the Russian Armies and supplies were urgently needed. As a result the port, inland waterway, road and rail capacities had hastily to be increased. This involved a great deal of port, road and railway construction and demands for additional locomotives, rolling stock, port equipment, craft, etc which, as time went on, came largely from American sources. By the end of 1943 the Americans took over the responsiblity for the operation of the Gulf ports and of the Persian Railways to Teheran which had then been built up to handle all "Aid to Russia" traffic. At the same time the removal of the German threat to the Middle East reduced the importance of PAIC which was abolished in February 1945 and the forces in Iraq and Persia reverted to Middle East Command. For his contribution to the build up of the vast transportation net work in Iraq and Persia Sir Godfrey was created CB in 1943.

After the close down of PAIC Sir Godfrey was employed under the Government of India as Regional Port Director Calcutta, and in 1948 he returned to Kenya to become Special Commissioner of Works and Chief Engineer of the Government of that country. After his retirement from this post in 1951, on reaching the age of 65 years, he continued to live in Nairobi. He was greatly interested in the Boy Scout Movement and became the Chief Commissioner for Scouts in Kenya. He was also a Knight of St John and a Commander of the St John Ambulance Brigade.

He died in Nairobi Hospital on 21 February 1971 in his eighty-fifth year after a full life, crowded with achievements, which surely must have surpassed the wildest ambitions of the young Canadian reporting at the SME Chatham on 27 June 1907 to become a Sapper officer even though he had been the Senior Under Officer at Kingston and in his luggage were a Gold Medal and a Sword of Honour. To his widow and family our deepest sympathies are extended.

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HENRY PATRICK CAVENDISH, a famous "Royal Bo", died on 13 January 1971, aged 69 years.

Educated at Christs' Hospital and the Royal Military Academy, Woolwich he was commissioned into the Royal Engineers on 13 July 1921. Following his Young Officer Courses at Chatham he spent two years on a Long Electrical and Mechanical Course and between 1925 and 1928 he was employed as a Garrison Engineer (E & M) at Agra, Lucknow, Bareilly and Meerut.

Brigadier H P Cavendish CBE DSO

In October 1928 he was posted to Kirkee as Assistant Superintendent of Parks and began his long connexion with the Royal Bombay Sappers and Miners, holding successively the following appointments during the next ten years: Officer Commanding 42 Divisional Headquarters Company at Quetta and F1 Depot Company at Kirkee, Adjutant the Training Battalion, Corps Adjutant, and Officer i/c Workshops.

Due to the threat of war it was decided in 1939 to send reinforcements to the Middle East. Among these was the 4th Indian Division comprising 12 Field Company and 11 Field Park Company, Madras Sappers and Miners, and 18 Field Company, Bombay Sappers and Miners, commanded by Cavendish. His Company was the first unit to leave India for Egypt, arriving at Suez on 15 August 1939. The remainder of the Division arrived by Brigade Groups to complete its concentration in Egypt by the end of October where it prepared to defend the Nile Valley in the event of Italy entering the war by the construction of defences and minefields at Mersa Matruh and the improvement of communications and water supply. The Division took part in General Wavell's successful operations in the Western Desert during the winter of 1940–1. For his distinguished services during these operations Cavendish was awarded the OBE.

After the battle of Sidi Barrani on 11 December 1940 the Division was sent to Eritrea to join the 5th Indian Division. The success of General Platt's operations in the rugged precipitous mountains and deep valleys of Eritrea depended largely upon the speed and skill with which the Indian Sappers built roads and mule tracks, cleared vast road blocks, constructed bridges and ford crossings, dealt with a profusion of mines laid by the Italians and, when called upon to do so, fought ferociously as infantry. The crowning glory of the "Royal Bos" in the campaign was the Victoria Cross awarded to 2nd Lieutenant (now Lieut-General) Premendra Singh Bhagat who for a period of fourteen days and over a distance of 55 miles detected and supervised the clearance of fifteen minefields working at high pressure from dawn till dusk. His carrier was blown up on two occasions and on another occasion he narrowly escaped being ambushed and, although worn out with strain and fatigue and suffering from an ear drum punctured by an exploding mine, he refused to leave his task until it was completed.

The 4th Indian Division was not to be present for the final stages of this fiercely fought campaign as the formation was ordered back to the Western Desert to reinforce troops retreating before Rommel. However in recognition of his distinguished services during the Eritrean campaign Cavendish was awarded the DSO.

By now Cavendish was CRE 4 Indian Division and, after his return to Egypt, his Sappers principal task was the laying of extensive minefields near the coast to the east of Mersa Matruh where a defensive position—the "Bagush Box"—had been constructed during the previous autumn. They were later, during the Battle of Sollum, heavily engaged in mine clearance often in face of intense fire. There were few mine detectors available in those days and clearance drills had to rely on prodding for mines with bayonets. For the rapid laying and recording of minefields Cavendish developed what he termed the knotted cord method. It soon became standard practice in the desert and was nicknamed the "Indian Rope Trick". The Division was also engaged in General Auchinlech's offensive in November 1941 and Rommel's counter-offensive in January 1942 which culminated in his capture of Benghazi, before being temporarily halted at the Gazala Line. The Divisional Sappers carried out extensive demolitions, fought on numerous occasions as Infantry and suffered heavy casualties.

The war-weary Division was relieved in the Desert by the 5th Indian Division, and in September 1942 Cavendish returned to India to become Commandant of the Bombay Sapper and Miner Centre and Group at Kirkee after fourteen years continuous service with Indian Sappers and Miners. As a result of the enormous wartime increase in the size of the Group the entire Recruit Training Organization, consisting of three Training Battalions and a Boys Battalion, had been moved to Dighi early in 1942. Shortly after Cavendish's arrival the system of training, which

had up till then catered mostly for the requirements of North Africa or Italy, was reoriented to meet the needs of the Burma Front and a jungle training centre was set up at Supa. Cavendish remained as Commandant until shortly after the Japanese surrender, handing over to L. O. Clark in July 1945 when he took up the appointment of Deputy Director Military Training, India dealing with technical training.

Following a long leave on returning from India after Partition he became Deputy Commandant of the School of Military Engineering, recently returned to Chatham after its wartime exile at Ripon.

On promotion to Brigadier in 1950 he became Chief Engineer Land Forces Hong Kong. He was created CBE in the 1951 Birthday Honours' List. His last appointment, before retiring in September 1953, was that of Chief Engineer Northern Command at York.

Many tributes have been received from India, including ones from Major-General M. M. Nath, Commandant, College of Military Engineering Poona, Brigadier R. L. Anand and Colonel Godbole, expressing their admiration for Brigadier Cavendish—"a true Royal Bo who contributed so much towards the efficiency and *esprit de corps* of the Group".

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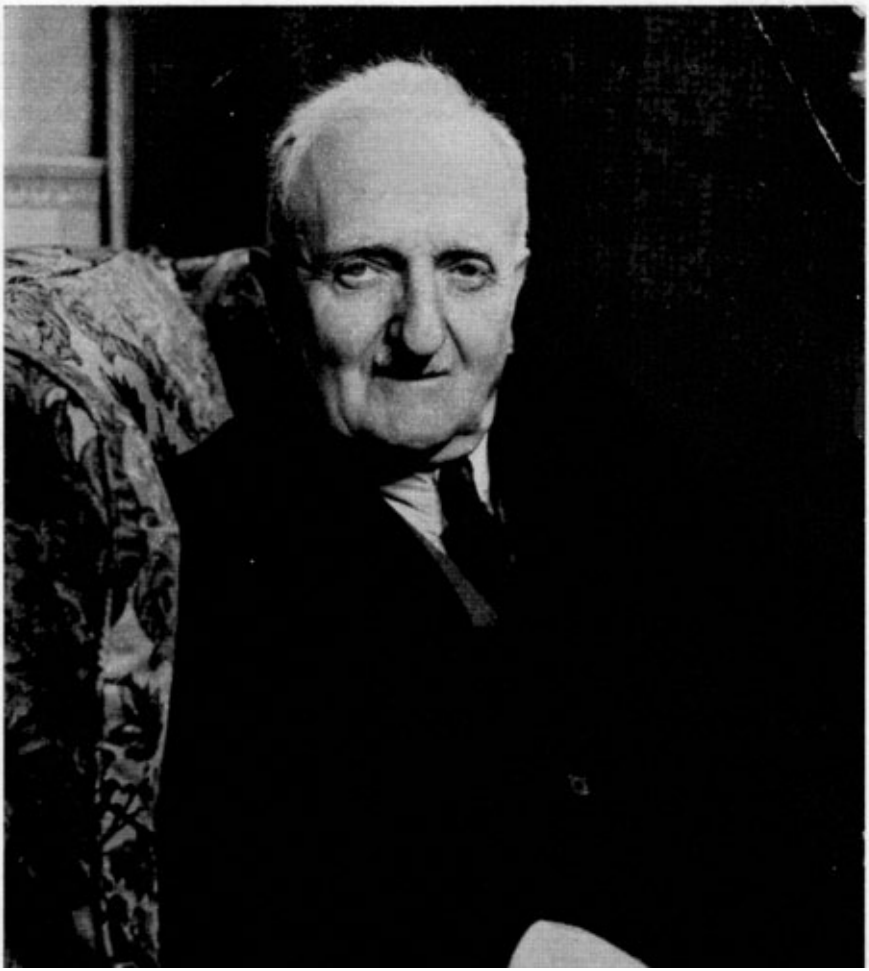
BRIGADIER IVAN SIMSON

IVAN SIMSON, Chief Engineer and Director-General Civil Defence Malaya at the time of the fall of Singapore in February 1942, died suddenly at his home on 4 February 1971, aged 80 years.

Born in India, he was educated at Eastbourne College and the RMA Woolwich and commissioned into the Royal Engineers in July 1910. After completing his YO training at Chatham he was posted in 1913 to the Railway Training Centre RE at Longmoor and sent to Derby on a course with the Midland Railway.



Brigadier Ivan Simson.

On the outbreak of the First World War he went to France with the 8th (Railway) Company RE. In June 1915 he was put in charge of a detachment loading mine earth at Noeux les Mines, near Lens, using rail-mounted steam shovels—the first time that such equipments had been used by the Royal Engineers in war or peace. A very considerable output was achieved, one steam shovel with a 2¾-yds bucket loaded up to 2,500 tons of mine earth from a 30-ft face during nine hours of darkness with screened lights and occasional interruptions from enemy shelling. The mine earth was used as ballast in new railway construction. He later became OC the 279th (Railway Construction) Company RE, raised in France from tradesmen in Infantry Battalions for work in the 1st Army Area under the Chief Railway Construction Engineer. However when there was a lull in railway construction work he volunteered for other jobs and spent short periods with several Field Companies and Tunnelling Companies RE. On one occasion he was wounded.

From 1919 to 1924 he served as a Staff Captain in the War Office, and in 1921 he married Freda, daughter of the late A. Betts of London. They had a son and a daughter.

Towards the close of 1924 he returned once more to the 8th (Railway) Company RE at Longmoor, and the following year he became Adjutant of the Centre. For the next two years he was an Instructor at Longmoor and engaged on the construction of the Longmoor–Liss Railway extension. For this project, which involved a great deal of earth moving, the War Office was persuaded to purchase a rail-mounted steam-powered face shovel and later to hire two Ruston & Hornsby diggers (face shovels) on caterpillar tracks. An article, written by Major Simson, entitled "Heavy Earthworks using Diggers or Steam Navvies" was published in the March 1928 issue of the *RE Journal*. The article described the organization employed for getting, carrying and off-loading earth and the supply of fuel and water to the equipments so that each digger could reach and maintain its maximum output. It caused more excitement outside than within the Corps, and it was eagerly read by many contractors engaged on starting work on new motorways and railway construction. Many of them visited Longmoor and offered fantastic wages to Sapper digger operators when they reverted to the Reserve, and one was, with War Office permission, bought out of the Army.

From Longmoor Simson was posted in 1929 to India where he became Garrison Engineer Jhansi and later ACRE (Works) Calcutta. From 1932 to 1933 he was CRE Burma Independent District, AHQ, Maymyo, Burma.

On returning to the home establishment he became CRE (Works) South Midland Area with his headquarters at Oxford and in 1937 he was made a brevet Colonel and became an Assistant Director Engineering at the War Office and later the Ministry of Supply when the Master General of the Ordnance moved with his branches from the War Office to the Ministry. In this capacity he had close contact with the General Staff and the Training Directorate and with the RE and Signals Board at that time engaged on research, development and production of RE offensive and defensive equipments of all kinds.

For the first five months of 1941 he was Deputy Chief Engineer (Operations) at Headquarters Scottish Command charged with the construction of airfields and defences against sea borne and parachute attack. On promotion to Brigadier later in the year he was selected to become Chief Engineer Malaya Command and he was sent out with verbal instructions to install the most modern type of defences throughout Malaya and Singapore Island and to bring all existing defences up to date. In his recently published book *Singapore too little, too late* he described his frustrating struggle to build up defences before and during the ten-week offensive that led to the surrender of Singapore on 15 February 1942, how at the last moment he was appointed Director-General Civil Defence, Malaya, with no resources to carry out any civil defence in any shape or form, and what he considered to be the general unpreparedness, apathy and incompetence that brought about the worst disaster and largest capitulation in British history.

Taken prisoner by the Japanese he endured three and a half years in their hands. The first six months were spent in a PW camp at Changi on Singapore Island, then followed two and a half years in three different camps on Formosa from where he was flown to Japan and later transferred to Manchuria. He was finally liberated by the Russians from a camp at Mukden. During his time at Changi he secretly made notes on his experiences during his time as Chief Engineer Malaya, subsequently incorporated into his book, whilst his mind was fresh and facts could be corroborated with other prisoners of war before ill-treatment and semi-starvation had mentally and physically weakened them all. While in a Senior Officer Prisoner of War Camp at Kwarenko in Formosa he compiled a directory containing in alphabetical order the names of over 500 American, Australian, British and Dutch officer and civilian prisoners together with their appointments and signatures. The names included Lieut-General J. M. Wainright the Commanding General US Forces in the Philipines, Sir T. Shenton Thomas the Governor and Sir Percy McElwaine Chief Justice of the Straights Settlements, Sir Mark Young Governor Hong Kong, Lieut-General A. E. Percival GOC Malaya and Sir Harry Trusted Chief Justice Federated Malay States, Major-General C. A. Callaghan GOC 8 Australian Division after the escape of General Gordon Bennett, Lieut-General Sir Lewis Health Commander III Indian Corps, A. I. Spits Dutch Governor of Sumatra, Major-General H. D. W. Sitwell Commander British Troops in Java and Mr R. B. Webb Red Cross Representative British and Australian Forces in the Far East. Brigadier Simson very kindly recently presented this unique directory to the Corps Library.

After his retirement in July 1946 he was re-employed under the Foreign Office in the Control Commission Germany until 1951.

Shortly after the Mau Mau rebellion in 1952 Brigadier Simson spent six months in Kenya where he was asked by HQ East Africa Command to broadcast on the technique of self defence in the home against terrorists. The text of his broadcast was published in several papers by the Kenya Police for cutting out and implementation by individuals living in danger areas in their homes. As can be imagined his down-to-earth, common-sense, advice was never to let action be taken "to little and too late".

He published in the September 1955 issue of the *RE Journal* an article on the use of plastics for the protection of old stone and brick in buildings based on his experiments on a small scale in 1952 and, as a result of the success of these experiments, further trials were carried out by him at Christ Church, Oxford in 1954.

He also wrote a series of *Queer but true stories of a Lifetime* which included strange stories of his experiences in France during the First World War and of others during his time as a Prisoner of War of the Japanese 1942–5. The series was intended chiefly for his family and was reproduced and bound by the Bodleian Library, Oxford. A number of the Japanese PW episodes were however published in the Army Quarterly. Some of these stories were amusing, but others definitely were not. Shortly before his sudden death he was about to start on another series of stories about his time in Germany from 1946 to 1951. To the end of his 80 years his mind was agile and alert, his hand-writing firm and legible and his memory remarkably clear. To his grandchildren he was a wonderful grandfather. Our deepest sympathies are extended to his widow and family.

G. S. writes:

As schoolboys at Eastbourne College Ivan and I met some sixty-five years ago. We went on to the Shop and the SME together.

From there he did a Railway Course. During the First World War he served in Transportation in France and was wounded. Between the wars he went to India for five years and was for some time at the War Office, all in the same line of business. I kept up with him and we met often when we were at home at the same time.

During the Second World War he was employed at the Ministry of Supply and later, for about five months, he was Deputy Chief Engineer, Scottish Command.

In the summer of 1941 he was ordered to Singapore as Chief Engineer, Malaya.

Here he had a most unhappy time. He had been specifically ordered by the War Office to take active steps in improving the defences of Singapore from the land side, though, unfortunately, he was given nothing in writing to this effect. On arrival he discovered that General Percival, the commander in Singapore, had peculiar ideas as to the use of defences, maintaining that the mere fact of digging trenches and building obstacles in front of them, even against tanks, was apt to give troops a Maginot Line obsession. Consequently, all Ivan's proposals for such were strenuously opposed, even while the enemy was progressing down the Malay Peninsula. He did manage, however, to get some anti-tank obstacles made of concrete and distributed at positions on the main road, but, though he tried hard to persuade the defenders to use them, very few were put in position.

Practically nothing had been done in Singapore about Air Raid Precautions. Not until the enemy were well down the Peninsula did the Governor, Sir Shenton Thomas, advised by the Rt Hon Duff Cooper the Resident Minister for Far Eastern Affairs, decide that some Civil Defence measures should be taken. The local War Council came to the incredible conclusion that Ivan, who had had some CD experience in Scotland, should take over the job of Director-General Civil Defence in addition to his full-time work as Chief Engineer. This he rightly objected to do, but he received definite orders in spite of his protestations.

Most of his efforts as Chief Engineer, and many as Director-General Civil Defence, were frustrated by the lamentable lack of drive on the part of the Army Commander and the Governor. However he continued to do what he could in both jobs until the end, when he was taken prisoner by the Japanese.

He had a pretty hard time as a prisoner-of-war in Formosa and China and developed beri beri due to starvation diet. However, he survived and on retirement after the War he joined the Control Commission in Germany.

When that closed down, he started to write a book about his experiences in Singapore mainly because he felt that the lessons from the Singapore disaster should be in the minds of political and military leaders at that time and in the future. As much of what he wanted to say might well have been considered to be libellous, he had great difficulty in getting a publisher. Finally, with the help of the late Sir Liddell Hart, who was his keen supporter, *Singapore, Too Little, Too Late*, was published by Leo Cooper of London. Liddel Hart had promised to write a foreword but, unfortunately, he died before this could be done.

Ivan Simson leaves a widow, a son and a daughter, and several grandchildren. He was remarkable for his absolute integrity, his great determination and his wish to do all in his power to help his fellow men. The Corps has lost a good sapper and a fine gentleman.

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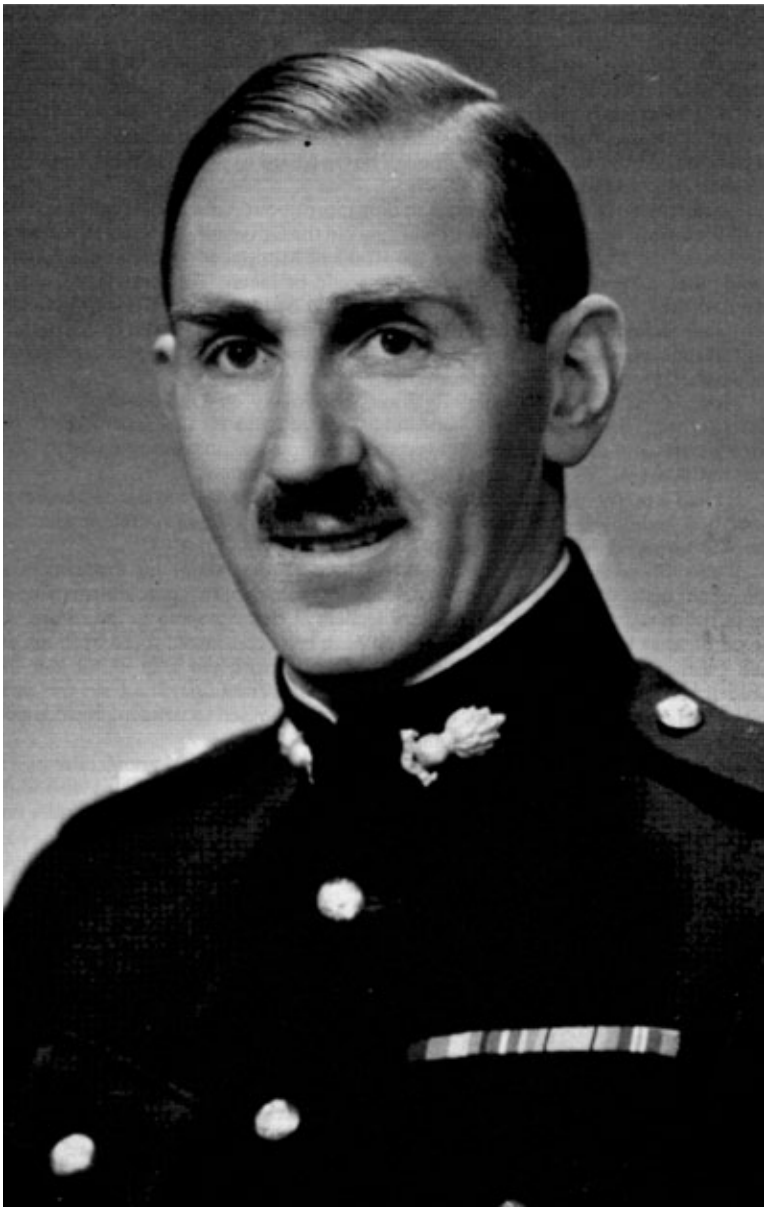

Colonel HCG Cartwright- Taylor BA C ENG FICE

HUGH CECIL GODFREY CARTWRIGHT-TAYLOR was commissioned from the Royal Military Academy Woolwich, where he was awarded the King's Medal, into the Royal Engineers on 30 August 1934.

As a YO he became an Undergraduate at Gonville & Caius College, Cambridge University where he successfully sat the Mechanical Sciences Tripos and obtained his BA. Early in 1938 he was posted to Hong Kong and was employed as Garrison Engineer (Roads) Kowloon Area. At the fall of Hong Kong on Christmas Day 1941 he was taken prisoner and spent the rest of the war in captivity in Japanese hands.

Shortly after being repatriated he was employed for a year in the Director of Fortification and Works Directorate at the War Office before becoming a DCRE (Works) in Eastern Command. In 1948 he became an Instructor in the Construction School of the SME and the following year he became a Student on No 3 Long Civil Engineering Course. A short period of military duties with 9 Training Regiment, RE then followed before he returned in 1952 to Chatham to become the Chief Instructor of the Civil Engineering School with the rank of Lieut-Colonel—an appointment he held until 1955.

He spent the next three eventful years as a CRE (Works) in Cyprus where accommodation was being completed to house Middle East Headquarters and units evacuated from the Canal Zone of Egypt and base installations were being constructed on the island. This work was often carried out under great difficulties due to attacks by EOKA bands which were the militant element of a political faction demanding union with Greece. Later considerable works projects had to be carried out hastily to turn the island into an advanced base for the Port Said operation of November 1956.

In 1958 he was selected to attend No 1 Special Civil Engineering Course which lasted two years. During that time the responsibility for Works Services for the Army, both at home and overseas, passed from the Royal Engineers to a civilian works organization headed by Sir Donald Gibson. The Royal Engineers, however, retained responsibility for works in war and in areas where the civilian organization could not operate in peace time. On completing his Special Course Cartwright-Taylor was appointed Colonel (E5) at the War Office responsible for war works planning and the training of RE officers, Warrant officers and senior NCOs to undertake civil engineering tasks in war and in emergency situations in peace by attachments to the civilianised Works Service organization and consulting engineers, contractors and public authorities in all parts of the world. He was also involved in lecturing at Universities on the opportunities for civil engineering graduates taking permanent commissions in the Royal Engineers. An article, based on a talk given by him to the Engineering Society of Queen's University Belfast, was published in the June 1962 edition of the *RE Journal* which set out the career prospects of a Sapper subaltern with a University degree, the diverse field of engineering undertaken by the Sappers world wide, the early age compared with his civilian counterpart at which he found himself in a position of responsibility and how, throughout his service, his emoluments generally exceed the average income of fully qualified professional engineers of graduate status.

After his retirement he was employed by C. S. Abbot & Son, Consulting Engineers of Sale, Cheshire, and rose to become an Associate of the firm. He died on 5 February 1971, aged 56 years, while still in the firm's employment.

He leaves a widow, two sons and a daughter to whom our deepest sympathies are extended.

G. H. writes:

The rising generation of officers, whose interesting articles on world-wide engineering projects now fill the pages of the Journal, owe much to Hugh Cartwright-Taylor, for he probably did more than anyone to create a strong post-war link between Chatham and Victoria Street; a link that weathered successfully the years of

upheaval and change so that now, more than ever, do the letters FICE and MICE appear in the Corps List.

I first met Hugh as a fellow student on No 3 "Long Civils", and then served as his Senior Instructor in the Civil Engineering School during those halcyon days before the word "civilianization" had been invented. There is no doubt that, had the Corps not lost "Works", Hugh would have become Director of Fortifications and Works. A brother, General Sir Malcolm Cartwright-Taylor, became Commandant General, Royal Marines. We met again in Cyprus and then, during our final years in the Corps, in that post-works cadre that was known by the cumbersome title of "The Engineer Specialist Services Establishment"—or ESSE.

Hugh was a wonderful "master" who knew what he wanted, clearly told one what to do and then left well alone. He was the most helpful and approachable of "Colonels" when difficulties arose, and had that invaluable knack of getting straight to the heart of a problem. He was also wisely opposed to the widely held theory that equates hard work with the rapid transference of masses of paper from "In" to "Out", so that all those proposals and ideas circulated around departments merely achieve a hasty initial. With Hugh they acquired valuable and carefully considered comment while I was told—"You are the one whose job it is to keep the routine paper flowing, I am paid to think!"

The Corps lost an outstanding officer when Hugh Cartwright-Taylor retired so early and now, with his premature death, the profession has lost a fine engineer while we who knew him mourn a much loved and highly respected colleague and offer our sympathy to his family; a sympathy coupled in my case with gratitude for the unfailing hospitality shown to me by Hugh and Muriel during my bachelor days in Chatham, and later to "P" and I in Cyprus.

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Book Reviews

GEODESY (THIRD EDITION)

BRIGADIER G. BOMFORD, OBE, MA, DSc

(Published by Oxford University Press, Ely House, London W1. Price £10)

At a time of accelerating scientific and technological advance the task of keeping a standard text book, such as this, up to date becomes both increasingly necessary and increasingly difficult. A large number of new developments must be studied and those which are considered significant incorporated; yet the work cannot be allowed to swell unduly and inevitably difficult problems of selection and abbreviation arise. Bomford's *Geodesy* first appeared in 1952 and for the second (1962) edition the author was able to incorporate the new material within the framework of the old with little omission. But for the third (1971) edition so much change has been required that it has been necessary to rearrange the work entirely, with extensive addition, excision and rewriting.

The changes made fairly reflect modern developments in theory and practice. It is accepted that, for geodetic frameworks, triangulation has now been replaced by traverse using electromagnetic distance measurement (EDM); and sixty pages of the text and a ten-page Appendix are now devoted to EDM. The general adoption of electronic computing for large networks has been recognized by including a nineteen page section on the method of adjustment that is considered most suitable for it, variation of coordinates. Electronic computing is not itself dealt with except by reference to other published works. The treatment of satellite geodesy (although not claimed to be comprehensive) is considerably amplified: a complete chapter of forty pages (Chapter 6) being devoted to geometrical uses and a section of fourteen pages in the chapter on Physical Geodesy (Chapter 7) to dynamical uses for determining the external gravity field. A particularly welcome addition is the very full treatment of atmospheric refraction in the section on EDM and of ionospheric refraction in the chapter on artificial satellites; this recognition of the importance of this subject to modern geodesy is overdue.

Additions have been largely offset by omission and compression. For example references to theodolites other than the "glass arc" type have been eliminated; but abbreviated accounts are retained of a number of outdated processes on the ground that they must be understood until all old geodetic work has been replaced by new. Subjects dealt with thus include triangulation, invar base measurement and traditional computation methods. A number of new appendices have been added including three dealing with subjects of pure mathematics: matrix algebra, vector algebra, and complex numbers, especially as applied to conformal mapping. These will be welcomed by students who are not already masters of these subjects, now so important to geodesy. The other new appendices are:— Appendix C "Cartesian coordinates in three dimensions" (dealt with in the text of the second edition), Appendix G "Modulated waves and tellurometer ground swing", and Appendix I "Rotating axes. Coriolis force". Three former appendices have been dropped, their contents, where necessary, being transferred to the text. They are: Appendix III "The stability of Laplace's azimuth equation", Appendix IV "Condition equations", and Appendix VII "The refractive index of damp air". The net result of all these changes is to make the volume 170 pages longer (731 pages against 561).

The revised works bears throughout the characteristic stamp of its author, notably in its conciseness, clarity and accuracy of expression and in the meticulous and thorough manner of its compilation. The bibliography which, with the exclusion of some 200 old items and addition of 300 new, now totals 531 gives some idea of the research involved. Characteristically also the treatment is always practical rather than pedantically consistent; as witness a remark in the preamble to Chapter 6 "Gravity and seismic surveys" that "Lacking a place elsewhere, a section on gyro-theodolites is included in this chapter". The purist may cavil at this sort of thing or, for example, at the exclusion of the former section on magnetic surveys on the ground that "a geodetic survey department is no longer the natural agency" for carrying them out. Considerable space is devoted to consideration of the Earth's interior structure to which the same reason for exclusion might equally apply. However the verdict of most readers will be that reliance of commonsense rather than fine logic in deciding what to include and what to omit has resulted in a balanced work which admirably meets the need both from the practical and scientific standpoints.

Minor criticisms can be made. The proprietory names "geodimeter" and "tellurometer" are in general used as though they included respectively all electro-optical and all microwave distance measuring instruments. This is unfortunate especially now that many different makes of both types exist (including a "Tellurometer" which employs the electro-optical principal!)

and it would have been preferable (and a welcome encouragement to others) to use the terminology adopted by the International Association of Geodesy with the authorized abbreviations "E-ODM" for electro-optical methods and "MDM" for microwave methods. A similar criticism applies to the treatment of the airborne systems Shoran and Aerodist. The loss of the former discussion of continental drift is also to be regretted. Final proof of this phenomenon can only come from geodetic measurement, and a fuller account giving the possibilities for this might well have been included. For a work such as this the text is by no means overburdened with mathematics, a result achieved by generally omitting proofs or derivations of formulae used. The seeker for complete understanding must, therefore, often have recourse to the quoted references. This could be a cause for criticism, although it is difficult to see how to avoid it in a volume of manageable proportions.

The book is commendably free from errors and misprints (only one or two minor instances were noted) and has been produced to the same very high standards of typography and finish as earlier editions, to which it is an eminently worthy successor. It will ensure that "Bomford's Geodesy" remains for many years the principal standard work on this subject in English.

R.C.A.E.

THE RACE FOR THE RHINE BRIDGES, 1940, 1944, 1945

ALEXANDER MCKEE

(Published by Souvenir Press, London. Price £3·25)

It was Xenophon who observed that even the greatest river can be crossed without getting your knees wet if you follow it to its source; but he was denied the opportunities offered to the belligerants in the Second World War of capturing bridges intact. On three occasions—1940, 1944 and 1945—there were chances of so doing where the Rhine is at its widest; and a study of these occasions forms the subject of *The Race for the Rhine Bridges, 1940, 1944, 1945.* By Alexander McKee.

In 1940 Hitler was determined to over-run Holland and Belgium quickly so as to safeguard the Ruhr and to secure the North Sea coast facing Britain. He therefore had to cross the Rhine where it is both very wide and where it is divided into the arms of a delta. From an engineering point of view this was quite the most difficult length of the river to cross, so he was forced to tackle the problem by gaining surprise; by boldness, and by the unorthodox nature of the conception. The stratagem adopted was as old as the Siege of Troy, and was known by the German General Staff colloquially as Trojan Horse. However much one disapproves of Hitler and all his works one must give him and his advisers credit for their originality, and his picked troops for their daring.

Psychology plays an important part in warfare, and a stratagem that might not succeed against a war-hardened enemy might well succeed against a nation such as the Dutch, who had not been at war for 100 years. It is like robbing a bank: the cashier does not expect the customer, with whom he has conversed daily, to produce a pistol and so he is taken by surprise. It is what happens next that counts. The Germans had thought this out. During the six months of Phoney War they lulled the French and British Allies and the Belgian and Dutch neutrals into a sort of torpor, so that when they struck on 10 May 1940, it came as a bolt from the blue—a *blitzkrieg* in fact. Your reviewer was on leave from France on 10 May 1940, and as he trundled from Cherbourg to Brussels in a railway vehicle designed for *40 Hommes ou 8 Chevaux*, he found himself in the company of so many Brass Hats—he was himself a Captain—that he feels sure that surprise was complete.

The Author reminds the reader of this and proceeds to describe very well how the German Trojan Horse was worked. First, small bands of German troops with a few Dutch speakers, all in Dutch uniforms and with counterfeit papers to gain access to bridge defences, parachute and glider-borne troops landed with speed and daring so close to their objectives that surprise was assured, aircraft landing apparently regardless of risk on Dutch airfields and disgorging specially trained troops, all this was but the first wave. Next came fast moving and small (they had to be small to avoid traffic problems) columns of tanks and armoured cars miles ahead of their Second Echelons, accompanied sometimes by motor cyclists. Finally the slower moving hordes, to hold the prizes, came sometimes by train. In each case the stratagem was fitted to the task. The wonder is that the Dutch resisted so well. There was tough fighting, and although the Germans were successful in the campaign they had some very anxious moments.

In 1944 the boot was on the other foot. It was the Anglo-Americans who wanted to encircle the Ruhr and free the Dutch and Belgian coasts. Hitler had played into their hands by imprudently fighting the battle in France to a finish west of the Seine. In the Falaise area

he lost an army, and nothing but a host of disorganised and defeated remnants were left to find their way back to Germany. Now was the time for the Allies to repeat the manoeuvre in reverse, to capture intact the same Dutch and Belgian bridges and drive like a knife in hot butter into Germany. Such was the conception of the operation known as Market Garden, whereby two American Airborne Divisions and one British were to lay a sort of carpet across the Delta area of the Rhine for Second Army to caper across.

The Author, who has consulted innumerable witnesses and read many documents tells one that the last date when this was possible was about 5 September. After that date the Germans had got to grips with the situation, had regrouped their remnants, had called in reserves and re-equipped a fair proportion of them. Until 5 September a dash into Germany was a reasonable proposition; but Market Garden did not begin till nearly a fortnight later. The Author goes into the causes for this and lays much of the blame at the very top. Here there was an American with many agreeable qualities, but lacking the flair and decision needed. Your reviewer feels that the reasoning rings true. He certainly agrees (from his own experiences of the time) that the leading troops of Second Army had a very difficult assignment when it came to capturing Nijmegan and advancing to Arnhem.

From Nijmegan to Arnhem seems a short distance today in a motor car; but in 1944 it seemed much farther. The few roads run on high embankments with soggy fields on either side. A tank column is a single file and when the leader is "brewed-up" there is little the next one can do but reverse and hope to spot the gun that did it. The Author gives full credit to the Guards Armoured Division that led the way to Nijmegan, and from the evidence available now he acquits 43 Division that followed it of a charge of lack of drive. He gives full marks to the assault crossing of the Nedr Rijn by an American parachute battalion in Royal Engineers' assault boats supervised by our present Chief Royal Engineer, then CRE of Guards Armoured Division.

It has often been claimed that the Arnhem operation was compromised by traitors, but the Author holds no brief for this. He blames the tardy start of the operation and the tactics of First British Airborne Division in landing so far from their objective. The Author also gives the Germans credit—and deservedly so—for their attack upon Nijmegan Bridge by frogmen while guarded by your present reviewer. At the time it was popular for War Correspondents to pooh pooh the Germans and give praise to the British who quickly repaired the damage. He also records the exploits of our own parachute and glider-borne troops at Arnhem. There was not much wrong on the lower levels, he thinks, and the reader will probably agree with his findings.

So much, then, for the accounts of 1940 and 1944. These were exploits in the Homeric mould: daring, guile, speed and surprise, these were the requisites of the time. We next come to the final campaign of 1945, the Crossing of the Rhine. Geography played its part and, for the main, compelled the Allies to cross the Rhine in most of the same places—Arnhem still had to be taken—but now a totally different set of circumstances prevailed. There was some chance of "bouncing" a Rhine bridge in February; and certainly Raemagen was taken intact; but your reviewer's recollection of the feelings of the time is that while some of the Generals were prepared to bet on it, no-one lower down the scale was inclined to lose money that way.

In the actual crossing of the Rhine in March 1945 there was certainly heavy fighting, but everyone felt that we were sure to succeed. It was largely a logistic matter to get the enormous resources of the Anglo-American Armies across the river in the shortest possible time. This was the kind of thing that the Allies excelled at. The equipment was plentiful, the Staff knew how to handle it, and the troops could be relied upon to do what was required of them. The airborne lessons of Market Garden had been learnt, and the whole operation went "according to Cocker". But let no-one think the Germans did not fight. Right up to the end they fought bravely; but it was a lost cause they fought for. The Author gives a fair picture of all this, and his account should be read, but there was no longer a chance for brains to rise superior to brawn. It was a matter of "hard slogging".

Your reviewer commends this book for the insight it gives to these three campaigns. He much regrets, however, to award lower marks for proof reading—there are many misprints: guns are cited (sic) on page 203 and a misprint in a statement by the U.S. General Gavin on page 382 makes his sentence meaningless. Nor are maps what the narrative deserves. This is probably inevitable today with the cost of publishing; but what you want to read this book with is a good map, perhaps from a folder, covering the Rhine from (say) Strasbourg to the North Sea, so as to follow the Author in his appraisement—which he does well—of what is popularly known as the "big picture". Alas, the reader must supply his own map.

M.C.A.H.

Technical Notes

THE MILITARY ENGINEER JANUARY–FEBRUARY 1971

Mobility has always been in the forefront of the military mind. An article on the work being done at the Army Engineer Waterways Experimental Station gives an account of the relationship between Mobility, Terrain characteristics and vegetation, and discusses the use of the aerial penetrometer. It also deals with the effect of terrain on munition performance.

Military Engineer Field Notes give two short interesting articles, one on the design, construction and use of a re-usable bunker for two or four men and the other on the rapid construction of a bridge capable of carrying heavy track vehicles across a small stream.

The construction of a project camp by an Engineer Battalion in Vietnam is described in an article titled "Hackberry Inn" Vietnam. Some of the problems encountered in camp construction under tropical conditions are given and measures taken to overcome them are described.

MARCH–APRIL 1971

An article on the need for Industrial Preparedness Planning to ensure the availability of production capacity for essential items of equipment and materials in wartime, uses experiences gained from World Wars I and II and the Korean war. It proposes theories for the use of computer and management techniques.

The use of the Hydra Sea-fix System for river, harbour and near-shore surveys is described. Some details of the system is given, together with the Data Processing system and the results of early field tests.

Military Engineer Field Notes provide short reports on the Pumping tests for fast setting Gypsum for the rapid repair of concrete runways, the field construction of a vibrating screed and rapid bunker emplacements in Vietnam. An article describes the British Mexeflote equipment. An article on Engineering in the Mekong Delta describes engineering problems encountered in tropical conditions. It suggests measures that need to be taken either to eliminate or reduce the effect of water, etc, in engineering works.

M.F.R.C.

CIVIL ENGINEERING

Review of Civil Engineering and Public Works Review, January 1971

WATER SUPPLY AT SELETAR. The name of Seletar brings to mind an RAF station for high performance jets, but this article describes the construction of a reservoir requiring 1 million cubic yards of clay fill. Mr Arah of Binnie and Partners describes how this material was placed in only 300 days under the very wet conditions of the Singapore climate and how the whole project was completed in just over 3 years at a Contract sum of $16.64 million.

The scheme consists principally of two dams, of which the larger is ¼ mile long and a maximum height of 100 feet above its foundations. The weather during the contract was worse than average but in no way abnormal, rainfall ranging from a minimum of 1.76 ins in February 1968 to 26 ins during December 1967. All alluvial material under the old reservoir was found to be lenticular sands including silts, soft clays and organic matter and some 300,000 cu yd had to be removed. The fill was placed during 300 days of which 140 contributed 61 ins of rain.

Horizontal pressure relief sand blankets, vertical sand drains and fill moisture contents up to 8% wetter than Proctor optimum all contributed to permitting an average rise of 10 ft per month. The contractor made use of heavy rollers which compacted 12 ins layers of fill in only three passes.

At the peak of activity the contractor employed 250 men with 10 staff, three 24 yd^3 towed scrapers, eleven motor scrapers and eighty tippers fed by eleven tractor shovels. 24 hour working was employed and the best weekly rate achieved was 55,000 yd^3 in 1 week.

50—STOREY OFFICE BLOCK IN HONG KONG. Tall buildings have become so commonplace that it is easy to forget that local conditions may produce unusual loading conditions. The 50-story block, 600 ft high and weighing 85,000 tons in the Central District of Victoria is a case in point and is described by W. E. A. Skinner, C Eng, FICE, FI Struct E of Mitchell, McFarlane and Partners.

The very high wind loadings caused by typhoon gusts of 155 mph produced a situation where a central core design was sufficiently strong but deflected so much as to make the

building unusable during extreme wind conditions. The external wall is designed as a pierced shear box thus utilising the full inertia of the structure. The building is supported on a piled raft thus overcoming the difficulties of unacceptably large pile loads, sinking caissons in a subsoil containing boulders and a very high water table.

SUBMARINE BRIDGE FOR SICILY. Crossing a water gap usually requires a bridge with adequate clearance for shipping or else a tunnel so that the depth of water is not reduced, thereby restricting the use of large vessels. Alan Grant and Partners in consortium with Covell, Matthews and Partners and Inbucon International Ltd have been awarded one of six first prizes in an international competition sponsored by the Italian government.

Their scheme is based on three tunnels built in 12 mm thick steel each surrounded by reinforced concrete and all three enclosed in an outer casing also 12 mm thick and specially shaped to resist the 6 knot currents of the Straits of Messina.

As the site has a minimum water depth of 4 m, clearance for deep draught vessels is no problem and the tunnel, which is buoyant, is anchored to the seabed with cables or chains splayed to impart stability. Moving loads will reduce the anchorage stresses so there seems little likelihood of overloading the structure. Construction time is estimated at three years and costs are hoped to be substantially lower than for a conventional bridge.

March 1971

BRIGHTON MARINA. The idea of a properly organised yachting port on the South Coast midway between Dover and Southampton will appeal to many Corps yachtsmen. The scheme involves an area of length 1000 m and width 500 m which is grandiose by present standards in this country.

Yachts will lie at pontoons, with car parking for 1200 nearby and the site is reached by tunnels driven through the cliffs. The main road through the centre divides the marina with a tidal section and a locked basin.

An unusual feature of the design is that the site juts out from an otherwise unbroken coastline. For this reason the action of storm wave action was analysed by a 1:96 model.

The total cost in likely to be around £30 million and it is hoped that this will not result in unrealistically high charges for temporary berths.

April 1971

RIVER MANAGEMENT. This collection of eight articles covers a wide variety of techniques and designs. Flood alleviation for the rivers Lyn, Parrett, Tone, Avill and Mole is described in some detail.

The second article deals with Underwater excavation by explosives. It outlines the method of drilling a cased shothole and removing the casing before firing. Other methods including the use of hammer and wagon drills underwater by divers as well as the selection and quantity of explosives are also described. An article on the Flood Defence of London shows how 200 ft wide rising sector gates would meet the requirement for the passage of ships to the Port of London.

W.G.C.

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Forthcoming Events

23 June	Corps Meeting and Dinner	London
24 June	Colonels Commandant RE Garden Party	Hurlingham
25 June	School of Military Survey Summer Ball	Newbury
2 July	RE Summer Ball	RE HQ Mess
22–25 July	Medway Regatta	River Medway
24–25 July	REA Weekend	Aldershot
28–30 August	Medway International Hockey Festival	All Garrison Grds
7 September	Civil Firms Guest Night	RE HQ Mess
11–12 September	REA Weekend	Chatham
16–19 September	RESA Regatta	River Medway
26 September 3–10 October	REYC/RNSA Series Race	River Medway

SPORTS AND GAMES FIXTURES 1971

RE CRICKET CLUB

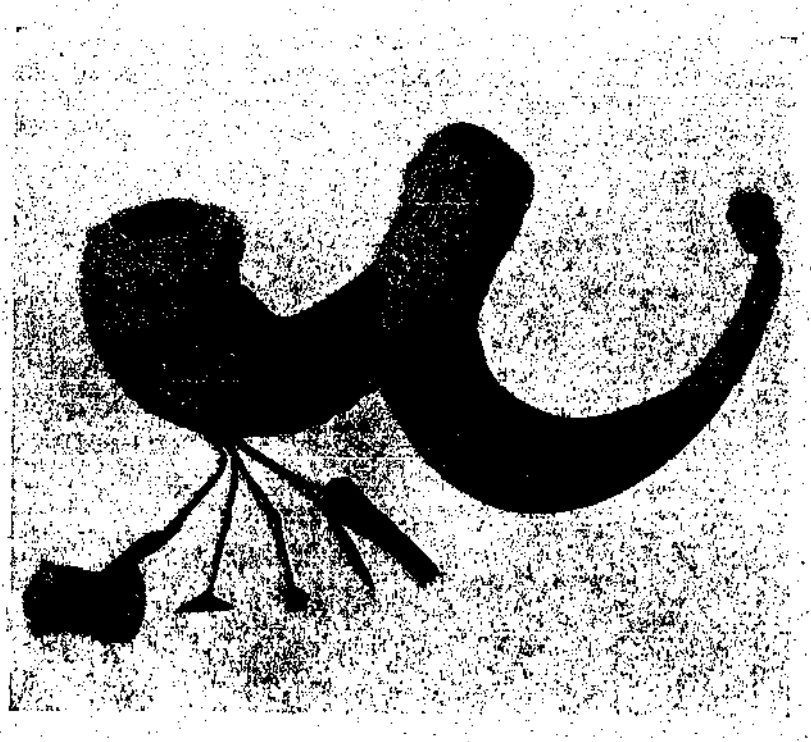
16 June	RMCS	Shrivenham
25 June	RCT	Aldershot
9 July	RAC	Bovington
11 July	Free Foresters	Chatham
13 July	Infantry	Chatham
14–15 July	R Signals	Chatham
16 July	Beckenham	Beckenham
17 July	RM	Chatham
23–24 July	RA	Woolwich
7–8 August	Band of Brothers	Chatham
11–12 August	Oxford Harlequin	Chatham

RE GOLFING SOCIETY

17 June	ACC GS	West Hill
18 June	REME GS	North Hants
23 June	RAMC GS	Woking
26–27 June	RYE GS	Rye
8 July	RCT GS	Worplesdon
17 July	Chartered Surveyors GS	Hankley Common
21 July	RM GS	Liphook
3 September	RE Veterans *v.* RA Veterans	New Zealand
14–15 September	AGS Autumn Meeting	Berkshire
28–29	Autumn Meeting	North Hants
14–15 October	RE *v.* RA	R St Georges Sandwich
16 October	RMCS GS	Huntercombe
20 October	RMA GS	North Hants

RE HOCKEY CLUB

11–12 September	RE Inter Unit Knockout Competition	Aldershot
15 September	Staff College	Minley
18 September	Guildford	Guildford
24–26 September	Training Weekend	Longmoor
26 September	Bournemouth 6s	Bournemouth
2 October	Trojans (L)	Southampton
10 October	Hamble Old Boys (L)	Longmoor
17 October	Dorset	Longmoor
23 October	Beckenham	Gillingham
30 October	R Signals	Blandford



This snuff box was presented to the Mess in 1844 by George Sim, Bengal Engineers. It is one of the many historical pieces of the RE HQ Mess collection. Photographs and descriptive details, written by the Late Colonel J. M. Lambert, of fifteen Mess portraits and forty-one pieces of Mess silver are included in a beautifully illustrated booklet entitled

THE PORTRAITS AND SILVER OF THE RE HQ MESS

The book is obtainable from the Secretary, Institution of Royal Engineers, Chatham, Kent. Price £1·50 post free in the United Kingdom.